AIR QUALITY ASSESSMENT
OF THE SUNSHINE OILSANDS LTD.
WEST ELLS SAGD PROJECT

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EXECUTIVE SUMMARY

Millennium EMS Solutions Ltd. (MEMS) was retained by Sunshine Oilsands Ltd. ("Sunshine") to estimate ambient ground-level concentrations of NO_2, SO_2, CO and $PM_{2.5}$ as a result of the operations of the proposed West Ells SAGD facility (the Project).

Sunshine proposes to develop and operate a SAGD Project in the West Ells area with a production capacity of approximately 1600 m^3 (10,000 barrels) of bitumen per day. The proposed Project will be located in Sections 30 & 31, Township 94, Range 17, W4M. The proposed Project is situated within the Municipal District of Wood Buffalo and is located approximately 60 km northwest of the community of Fort McKay.

The operations of the Project will result in emissions to the atmosphere. These emissions consist of combustion products such as carbon monoxide (CO), fine particulate matter ($PM_{2.5}$), sulphur dioxide (SO_2) and oxides of nitrogen (NO_x). These substances may be harmful to human health at sufficiently high ambient ground-level concentrations and, as such, should not exceed Alberta ambient air quality objectives (AAAQOs).

Results of the dispersion modelling for the West Ells SAGD Project for normal and upset operating conditions show that there are no predicted AAAQOs exceedences for SO_2, NO_2, CO or $PM_{2.5}$ emission concentrations and that the operation of the proposed facility is not expected to compromise the air quality in the study area. NO_2 predictions for normal operating conditions are 28%, 43% and 40% of hourly, 24-hour and annual AAAQOs, respectively. Similarly, SO_2 predictions for normal operating conditions are 46%, 39%, and 21% of the hourly, 24-hour, and annual AAAQOs, respectively; $PM_{2.5}$ predictions are approximately 80% and 50% of hourly and 24-hour AAAQOs, respectively; and CO predictions are less than 6% of hourly and 8-hour AAAQOs.

Table of Contents

Page

1.0 INTRODUCTION 1

2.0 AIR QUALITY OBJECTIVES 2

2.1 Relationship Between NO_x and NO_2 2

3.0 PLANT LOCATION 4

4.0 EMISSION PARAMETERS 5

5.0 DISPERSION MODELLING APPROACH 6

5.1 Model Parameters 6

5.2 Meteorological Data 7

5.3 Background Concentrations 8

6.0 DISPERSION MODEL PREDICTIONS 10

6.1 Nitrogen Dioxide Model Predictions 10

6.2 Sulphur Dioxide Model Predictions 11

6.3 Carbon Monoxide Model Predictions 12

6.4 $PM_{2.5}$ Model Predictions 13

7.0 UPSET CONDITIONS ASSESSMENT 14

8.0 SUMMARY AND CONCLUSIONS 15

9.0 CLOSURE 16

10.0 LITERATURE CITED 17

LIST OF TABLES

Table 2.1 Alberta and Canadian Ambient Air Quality Objectives 2
Table 2.2 Background Ozone for NO_2 Conversion 3
Table 4.1 Sunshine West Ells Typical Stack and Emission Parameters 5
Table 4.2 Building Information Used to Evaluate Downwash 6
Table 5.1 Ambient Background Concentrations of Modelled Compounds[1] 9
Table 6.1 Summary of NO_2 Maximum Ground-Level Concentrations 10
Table 6.2 Summary of Predicted SO_2 Maximum Ground-Level Concentrations 11
Table 6.3 Summary of CO Maximum Ground-Level Concentrations 12
Table 6.4 Summary of $PM_{2.5}$ Maximum Ground-Level Concentrations 13
Table 7.1 Flare Stack and Emission Parameters – Emergency Flaring 14

LIST OF FIGURES

Figure 4.1 Buildings and Structures Considered in the Dispersion Modelling F-2
Figure 6.1 Predicted 99.9th Percentile Hourly NO_2 Concentrations (µg/m^3) F-3
Figure 6.2 Predicted Maximum 24-hour NO_2 Concentrations (µg/m^3) F-4
Figure 6.3 Predicted Annual Average NO_2 Concentrations (µg/m^3) F-5
Figure 6.4 Predicted 99.9th Percentile Hourly SO_2 Concentrations (µg/m^3) F-6
Figure 6.5 Predicted Maximum 24-hour SO_2 Concentrations (µg/m^3) F-7
Figure 6.6 Predicted Annual Average SO_2 Concentrations (µg/m^3) F-8
Figure 6.7 Predicted 99.9th Percentile Hourly CO Concentrations (µg/m^3) F-9
Figure 6.8 Predicted Maximum 8-hour CO Concentrations (µg/m^3) F-10
Figure 6.9 Predicted Maximum Hourly $PM_{2.5}$ Concentrations (µg/m^3) F-11
Figure 6.10 Predicted Maximum 24-hour $PM_{2.5}$ Concentrations (µg/m^3) F-12

1.0 INTRODUCTION

Sunshine Oilsands Ltd. ("Sunshine") proposes to develop and operate a SAGD project in the West Ells area (the Project) with a production capacity of approximately 1600 m^3 (10,000 barrels) of bitumen per day. The proposed Project will be located in Sections 30 & 31, Township 94, Range 17, W4M. The proposed Project is situated within the Municipal District of Wood Buffalo and is located approximately 60 km northwest of the community of Fort McKay.

The continuous emissions from the plant will be emitted from two high pressure steam boilers and one natural gas-fired gas turbine cogeneration unit. Intermittent sources of emissions include one glycol heater and one utility boiler, both of which were modelled as continuous sources for conservatism. .

Operations at the plant will result in emissions to the atmosphere. These emissions include combustion products such as sulphur dioxide (SO_2), carbon monoxide (CO), fine particulate matter ($PM_{2.5}$) and oxides of nitrogen (NO_x). These substances may be harmful to human health at sufficiently high ambient ground-level concentrations, which should not exceed Alberta ambient air quality objectives (AAAQO).

Millennium EMS Solutions Ltd. (MEMS) was retained by Sunshine to provide a dispersion modelling assessment of NO_2, SO_2, CO and $PM_{2.5}$ emissions associated with the expected operations of the facility. The modelling followed Alberta Environment (AENV) dispersion modelling guidance (AENV, 2003), using the CALMET and CALPUFF models. This report outlines the assumptions, methodologies, dispersion modelling approach, model input data, and the dispersion modelling results.

2.0 AIR QUALITY OBJECTIVES

Table 2.1 presents the AAAQOs and the Canadian federal air quality objectives for regulated compounds. The compounds relevant to the facility include NO_2, SO_2, CO and $PM_{2.5}$. The objectives refer to averaging periods ranging from one hour to one year.

Table 2.1 Alberta and Canadian Ambient Air Quality Objectives

Substance	Period	Alberta Objectives	
		($\mu g/m^3$)	(ppb)
NO_2	Annual	60	32
	24-hour	200	106
	1-hour	400	212
SO_2	Annual	30	11
	24-hour	150	57
	1-hour	450	172
CO	8-hour	6,000	5,000
	1-hour	15,000	13,000
$PM_{2.5}$	24-hour	30	-
	1-hour	80	-

2.1 Relationship Between NO_x and NO_2

Oxides of nitrogen (NO_x) are comprised of nitric oxide (NO) and nitrogen dioxide (NO_2). High temperature combustion processes primarily produce NO that in turn can be converted to NO_2 in the atmosphere through reactions with tropospheric ozone:

$$NO + O_3 \rightarrow NO_2 + O_2$$

Conversion of NO_x to NO_2 is estimated using the AENV (2003) recommended Ozone Limiting Method (OLM). This method states that if the ambient ozone concentration is greater than 90% of the predicted NO_x, then it is assumed that all the NO_x is converted to NO_2. Otherwise, the NO_2 concentration is equal to the sum of the ozone and 10% of the predicted NO_x concentration. That is:

$$\text{If } [O_3] > 0.9\,[NO_x], \text{ then } [NO_2] = [NO_x]$$
$$\text{Otherwise, } [NO_2] = [O_3] + 0.1\,[NO_x]$$

These guidelines were established through the consideration of lowest observable effect level on a sensitive receptor.

Conversion from NO_x to NO_2 was made using the OLM. AENV recommended ozone concentrations for rural locations were used in the conversion (Table 2.2). AENV requires that if the OLM method is used, NO_2 concentration results assuming total conversion of NO_x to NO_2 also be presented.

Table 2.2 Background Ozone for NO_2 Conversion

Averaging Period	AENV Default - Rural Locations (ppb)
1 hour	50
24 hour	40
Annual	35

3.0 PLANT LOCATION

The proposed Project will be located in Sections 30 & 31, Township 94, Range 17, W4M. The proposed Project is situated within the Municipal District of Wood Buffalo and is located approximately 60 km northwest of the community of Fort McKay.

The proposed facility will be located at an elevation of approximately 547 m ASL. The terrain near the proposed central processing facility site is predominately flat within 3 km. Outside of the immediate Project vicinity, the terrain elevation increases to the northwest to approximately 775 m, 10 km away, and decreases to the south to approximately 500m, 4 km away. Most of the lands surrounding the Project are wetlands and muskeg.

4.0 EMISSION PARAMETERS

Emissions from the facility will be continuous from two high pressure steam boilers and a natural gas-fired gas turbine cogeneration unit. In addition to the continuous sources, there are intermittent sources consisting of one glycol heater and one utility boiler. For the purpose of this conservative assessment, it was assumed that all intermittent sources run continuously. Modelled stack parameters and emission rates are presented in Table 4.1.

All physical stack parameters and SO_2 emission rates were provided by AMEC BDR Ltd. NO_x, CO, and $PM_{2.5}$ emissions were calculated by MEMS. NO_x and CO emissions for the boilers and heaters were based upon the assumption that these sources will be designed to meet the CCME guidelines for Commercial/Industrial Boilers and Heaters (CCME, 1998). Similarly, NO_x emissions for the gas turbine were based upon the assumption that the gas turbine will meet the Best Available Technology Economically Achievable (BATEA) standards set by AENV for natural gas fired gas turbine units (AENV, 2005). CO emissions for the gas turbine and $PM_{2.5}$ emissions for all sources were calculated using U.S. EPA AP-42 emission factors (section 1.4 for the boilers and heaters and section 3.1 for the gas turbine).

Table 4.1 Sunshine West Ells Typical Stack and Emission Parameters

Source Description	UTM Coordinates (m)		Stack Height (m)	Stack Diameter (m)	Exit Velocity (m/s)	Exit Temp (K)	Emissions (t/d)			
	Easting	Northing					SO_2	NO_x	CO	$PM_{2.5}$
HP Boiler Exhaust 1	395777	6341089	30	1.54	15.6	450	0.35	0.28	0.86	0.035
HP Boiler Exhaust 2	395783	6341073	30	1.54	15.6	450	0.35	0.28	0.86	0.035
Utility Boiler	395665	6341283	8.5	0.514	4.8	494	0.00	0.01	0.04	0.001
Glycol Heater	395666	6341288	8.2	0.61	3.4	700	0.00	0.02	0.05	0.001
Cogen GT Exhaust	395716	6341054	20	1.08	12.0	484	0.00	0.18	0.08	0.007
Total Emissions							**0.70**	**0.77**	**1.90**	**0.08**

The generation of downwash by buildings located within the proposed Project compound were considered in the modelling. Figure 4.1 depicts the buildings and structures included in the dispersion model for the Project and Table 4.2 gives the building dimensions.

Table 4.2 Building Information Used to Evaluate Downwash

Building	Length (m)	Width (m)	Height (m)
BU000 Office/Warehouse	33.5	27.4	7.6
BU006 Electrical Building MCC-310	20	7	5.5
BU020 Inlet Building	31	19.4	10
BU021 Treater Building	59	17.5	9.8
BU022 Tank Building	83.4	26	13
BU023 Glycol Building	16	20	6.6
BU024 E-421A Glycol Cooler	18.4	6.8	4.9
BU025 E-421B Glycol Cooler	18.4	6.8	4.9
BU026 E-421C Glycol Cooler	18.4	6.8	4.9
BU027 E-421D Glycol Cooler	18.4	6.8	4.9
BU028 Source Water Building	29.5	19.5	10
BU030 Evaporator Building	33.2	26.9	14
BU032 Steam Generator Building	32.6	31.2	17
BU037 Cogen. Building	50	25	17
BU038 Fuel Gas Building	12.3	6	5.7
BU061 T-727 Steam Generator Blowdown Tank	-	7.16[1]	7.9

[1] Tank Diameter

5.0 DISPERSION MODELLING APPROACH

5.1 Model Parameters

To ensure consistency with air quality modelling conventions carried out in the oil sands region of Alberta, CALMET and CALPUFF models were used for the West Ells SAGD Project air quality assessment. Use of both the CALMET and CALPUFF models are recommended by AENV for regulatory air quality assessments (AENV, 2003). CALMET is a diagnostic three dimensional meteorological model and CALPUFF is an advanced non-steady state air quality dispersion model.

The dispersion model was run to ensure that the receptor grids described below were considered in this assessment as per the latest AENV Model Guidelines (AENV, 2003). The model origin (395777, 6341089) was centred on the northern high pressure steam boiler stack. Receptor grids were set according to the following spacing:

- Grid A = 20 x 20 km, 1 km spacing, centred on 395777 m E, 6341089 m N;
- Grid B = 10 x 10 km, 500 m spacing, centred on 395777 m E, 6341089 m N;
- Grid C = 4 x 4 km, 250 m spacing, centred on 395777 m E, 6341089 m N;
- Grid D = 1 x 1 km, 50 m spacing, centred on 395777 m E, 6341089 m N; and
- Grid E = 20 m spacing along the plant fenceline.

The southwestern corner of the computational domain (study area) is located at UTM 385.777 km E and 6331.089 km N. The northeastern corner is located at 405.777 km E, 6351.089 km N. The size of the study area is 20 km by 20 km.

Upset conditions for the Project are discussed in Section 7.0.

5.2 Meteorological Data

The CALMET modeling domain is 50 km long west to east and 50 km long north to south. The UTM coordinates (NAD 83, Zone 12) for the modelling domain ranges from 375,000 m to 425,000 m easting, and 6,317,000 m to 6,367,000 m northing (latitude 56.980° to 57.440° and longitude 112.249° to 113.057°). Horizontal grid cells of 1 km X 1 km were adopted for the modelling. This combination of grid size and number of cells was chosen to minimize run time while still capturing major terrain feature influences on wind flow patterns.

The 2002 MM5 regional meteorological dataset provided by Environment Canada was used as the meteorological data source. No surface stations are located within the modelling domain and, as such, no surface meteorology was included in the model.

Terrain data were obtained from the Shuttle Radar Topography Mission (SRTM -3 Arc Second - 90 m) website. The terrain heights for meteorological grid points, receptors, and sources are processed through the TERREL CALMET pre-processor program.

To determine meteorological parameters in the boundary layer, the CALMET model requires a physical description of the ground surface. The geophysical parameters used for this assessment include land use category, terrain elevation, roughness length, albedo, Bowen ratio, surface heat flux parameter, anthropogenic heat flux and leaf area index (LAI). Values for all land use parameters except land use category and elevation were determined for the following periods:

- Winter – January 1 to March 31 and November 15 to December 31 2002.
- Spring – April 1 to June 14, 2002.

- Summer – June 15 to August 31, 2002.
- Fall – September 1 to November 14, 2002.

5.3 Background Concentrations

According to guidance (AENV, 2003), appropriate compound concentrations due to natural sources, and unidentified, possibly distant sources are to be used as background, and added to predicted values from the facility and nearby sources. For the Project, background emissions due to distant industrial sources (approved and planned) as well as emissions from roadways and the Fort McMurray area were considered by adding concentrations predicted in the Deer Creek Joslyn North Mine Project Update submitted in June 2007 (DCEL, 2007) to the Sunshine CALPUFF predicted concentrations. Predictions (future development case) from the DCEL Project Update model results at the receptor nearest the West Ells Project were obtained and applied uniformly throughout the model domain as a background concentration. A summary of the background values used in this assessment is provided in Table 5.1. The use of future emissions to estimate background concentrations is expected to result in a conservative assessment.

Table 5.1 Ambient Background Concentrations of Modelled Compounds[1]

CAC Compounds	Hourly (μg/m³)	8-Hour (μg/m³)	24-Hour (μg/m³)	Annual (μg/m³)
NO_x	125	N/A	48	3.0
SO_2	41	N/A	18	0.93
$PM_{2.5}$	38	N/A	9.9	0.52
CO	103	87	42	2.8

N/A: Not Applicable
1: from DCEL, 2007

6.0 DISPERSION MODEL PREDICTIONS

6.1 Nitrogen Dioxide Model Predictions

The CALPUFF modelling predictions for NO_2 are listed in Table 6.1 and illustrated in Figures 6.1 to 6.3, which show the contours of maximum NO_2 concentration for the hourly 99.9th percentile, 24-hour average, and annual average concentrations. All predictions include the addition of background concentrations. The key result is that the model predicts no NO_2 exceedences of the AAAQOs, for any averaging period using the Ozone Limiting Method (OLM) for NO_x conversion. AENV (2003) specifies that if the OLM is used to determine the relationship between NO_2 and NO_x, then the results using the Total Conversion Method must also be reported. In the Total Conversion Method, it is assumed that all the NO_x is converted to NO_2. This method is considered to be a conservative screening approach and will produce gross overestimations of NO_2 concentrations, especially near emission sources. The results using the Total Conversion Method are also shown in Table 6.1.

Table 6.1 Summary of NO_2 Maximum Ground-Level Concentrations

	NO_2 Ozone Limiting Method (µg/m^3)	NO_2 Total Conversion Method (µg/m^3)	AAAQO (µg/m^3)
99.9th Percentile 1-hour Average	112	325	400
Maximum 24-hour Average	85	119	200
Annual Average	24	24	60

Detailed modelling results for NO_2 are as follows:

- The predicted 99.9th percentile hourly, maximum 24-hour, and annual average NO_2 concentrations outside of the plant site boundary are 112 µg/m^3, 85 µg/m^3 and 24 µg/m^3, respectively.
- The maximum 99.9th percentile hourly concentration is predicted to occur approximately 100 m outside of the plant site boundary along the northeastern side (Figure 6.1)
- 24-hour and annual maximum concentrations are predicted to occur on the southeastern edge of the plant site boundary (Figures 6.2 and 6.3).
- Predicted NO_2 concentrations are well below AAAQOs for every averaging period.

6.2 Sulphur Dioxide Model Predictions

The CALPUFF modelling predictions for SO_2 are listed in Table 6.2 and presented in Figures 6.4 to 6.6, which show the contours of maximum SO_2 concentration for the hourly 99.9th percentile, daily maximum, and annual average concentrations. All predictions include the addition of background concentrations. The key result is that the model predicts no SO_2 exceedences of the AAAQOs, for any averaging period.

SO_2 impacts from emergency flaring are discussed in detail in Section 7.0.

Table 6.2 Summary of Predicted SO_2 Maximum Ground-Level Concentrations

	SO_2 Predicted GLC (µg/m^3)	AAAQO (µg/m^3)
99.9th Percentile 1-hour	207	450
Maximum 24-hour average	58	150
Annual Average	6.2	30

Detailed results from the CALPUFF dispersion modelling for SO_2 indicate:

- The predicted 99.9th percentile hourly, maximum 24-hour, and annual average SO_2 concentrations outside of the plant site boundary are 207 µg/m^3, 58 µg/m^3, and 6.2 µg/m^3, respectively.
- The maximum 99.9th percentile hourly concentration is predicted to occur along the southeastern edge of the plant site boundary while the maximum 24-h concentration is predicted to occur approximately 150 m east of that location (Figures 6.4 and 6.5, respectively).
- The predicted annual average concentration is predicted to occur at the northeastern corner of the plant site boundary (Figure 6.6).
- Predicted concentrations are well below the AAAQOs in each averaging period.

6.3 Carbon Monoxide Model Predictions

The CALPUFF modelling predictions for CO are listed in Table 6.3 and seen in Figures 6.7 and 6.8, which show the contours for the 99.9th percentile hourly and the 8-hour maximum concentrations, respectively. Predictions include the addition of background concentrations. The key result from the following table and figures is that the model predicts no hourly or 8-hour exceedences of the AAAQOs within the modelling domain.

Table 6.3 Summary of CO Maximum Ground-Level Concentrations

	CO Predicted GLC($\mu g/m^3$)	AAAQO ($\mu g/m^3$)
99.9th Percentile 1-hour	547	15,000
Maximum 8-hour average	358	6,000

The detailed results from CALPUFF modelling for CO are as follows:

- The maximum hourly and 8-hour average CO concentrations are 547 $\mu g/m^3$ and 358 $\mu g/m^3$, respectively. These maximums are predicted to occur approximately 75m east of the eastern edge of the plant site boundary (Figures 6.7 and 6.8).
- Both the hourly and 8-h averages are well below the AAAQOs of 15,000 $\mu g/m^3$ and 6,000 $\mu g/m^3$, respectively.

6.4 $PM_{2.5}$ Model Predictions

The CALPUFF modelling predictions for $PM_{2.5}$ are listed in Table 6.4, and the contours for the predicted maximum hourly and daily $PM_{2.5}$ concentrations are shown in Figures 6.9 and 6.10, respectively. It can be seen from the table and figures that the model does not predict any 1-hour or 24-hour $PM_{2.5}$ exceedences of the AAAQOs for $PM_{2.5}$ within the modelling domain.

Table 6.4 Summary of $PM_{2.5}$ Maximum Ground-Level Concentrations

	$PM_{2.5}$ Predicted GLC(μg/m^3)	AAAQO (μg/m^3)
Maximum 1h-Average	64	80
Maximum 24-hour average	15	30

Detailed results from dispersion modelling for $PM_{2.5}$ indicate:

- The predicted maximum hourly $PM_{2.5}$ concentration outside of the plant site boundary is 64 μg/m^3. There are no predicted exceedences of the 1-hour AAAQO of 80 μg/m^3.
- The predicted maximum 24-hour average outside of the plant site boundary is 15 μg/m^3. There are no predicted exceedences of the 24-hour $PM_{2.5}$ AAAQO of 30 μg/m^3.

7.0 UPSET CONDITIONS ASSESSMENT

According to AENV (2003), the impact due to emergency and upset releases must be considered in environmental assessments for air quality. It is the design intent that the Project flare stack be used as an emergency system only. All normal gas production is consumed in the steam generators. Emergency flaring will occur if a static overpressure situation arises in the system for any of the following reasons:

- Blocked flow
- Fire
- Liquid expansion within the blocked-in side of heat exchangers

The worst-case emergency flaring scenario would occur when there is a release from the pressure safety valve that protects the fuel gas delivery system to the steam generators. The stack and emission parameters for this scenario are shown in Table 7.1. The maximum flow rate of 15 mmscfd would occur for a maximum duration of 30 seconds, which is equal to the estimated time for the emergency shut-down valve (ESDV) to activate, including a reasonable safety factor.

CALPUFF modelling was performed for this upset scenario and results are presented below. Background concentrations are included in model predictions.

Table 7.1 Flare Stack and Emission Parameters – Emergency Flaring

Parameter	Emergency Flaring
Flare Height (m)	39
Exit Diameter (m)	0.25
Release Height[(a)] (m)	58.4
Exit Velocity (m/s)	98.3
Pseudo Diameter[(a)] (m)	2.41
SO_2 Emission Rate (g/s)	10.4
Max. Flaring Duration	30 seconds
Stream type	Produced gas
Flow Rate [(b)] ($10^3 m^3/d$)	424
Mole Fraction:	
H_2	0.0000
He	0.0000
N_2	0.0090
CO_2	0.0220
H_2S	0.0008
H_2O	0.0000
C1	0.9655
NH_3	0.0000
C2	0.0007
C3	0.0002
iC4	0.0001
nC4	0.0001

Table 7.1 Flare Stack and Emission Parameters – Emergency Flaring

Parameter	Emergency Flaring
iC5	0.0001
nC5	0.0001
C6+	0.0002
C7+	0.0012
CO	0.0000
Methanol	0.0000
COS	0.0000
HCN	0.0000
Total	1.0000

(a) Effective release height of plume for CALPUFF modelling.
(b) At 15 °C and 101.3 kPa.

The predicted 99.9th percentile hourly SO_2 prediction of this worst-case upset release scenario is 45 μg/m^3. This concentration is 10% of the hourly AAAQO of 450 μg/m^3.

8.0 SUMMARY AND CONCLUSIONS

The CALMET meteorological model and the CALPUFF dispersion models were used to assess the dispersion of SO_2, NO_x, $PM_{2.5}$ and CO emissions associated with the expected operation of the Sunshine Oil Sands West Ells SAGD facility. To account for future growth in the area and the operation of other nearby facilities, background concentrations were obtained from the future development case presented in the Deer Creek Joslyn North Mine Project Update (DCEL, 2007).

The facility has a total of three stacks with continuous emissions and two stacks with intermittent emissions, all of which were modelled as continuous for conservatism. The total SO_2, NO_x, $PM_{2.5}$, and CO emissions from the facility have been estimated to be 0.70, 0.77, 0.08, and 1.90 tonnes per day, respectively.

The results of dispersion modelling for typical operations showed there were no predicted exceedences for SO_2, NO_2, CO or $PM_{2.5}$ and that the operation of the proposed facility is not expected to compromise the air quality in the study area.

9.0 CLOSURE

This report has been prepared for the exclusive use of Sunshine Oilsands Ltd., its affiliates and authorized users for specific application to this project site. The environmental investigation was conducted in accordance with the proposed work scope prepared for this site, and generally accepted assessment practices. No other warranty, expressed or implied, is made.

Respectfully submitted,

Millennium EMS Solutions	*Reviewed by:*
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Air Quality Engineer	Senior Air Quality Engineer

10.0 LITERATURE CITED

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FIGURES

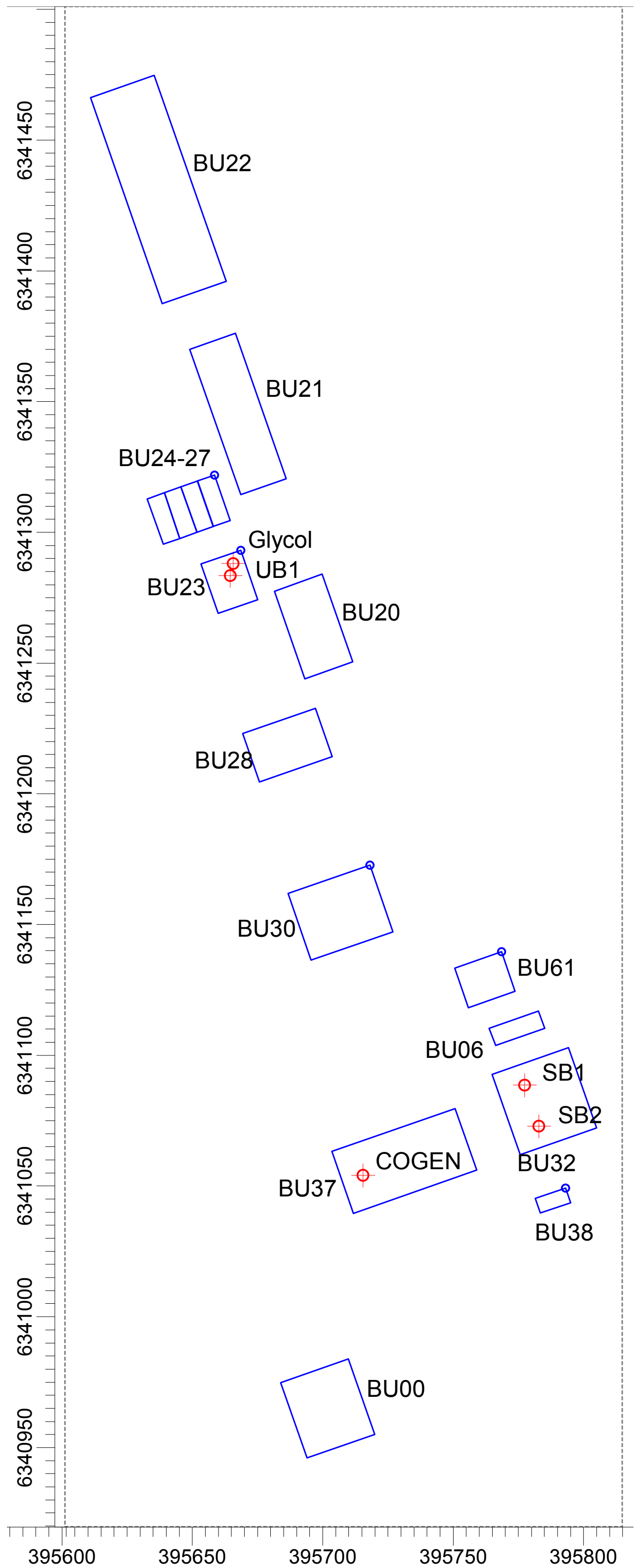
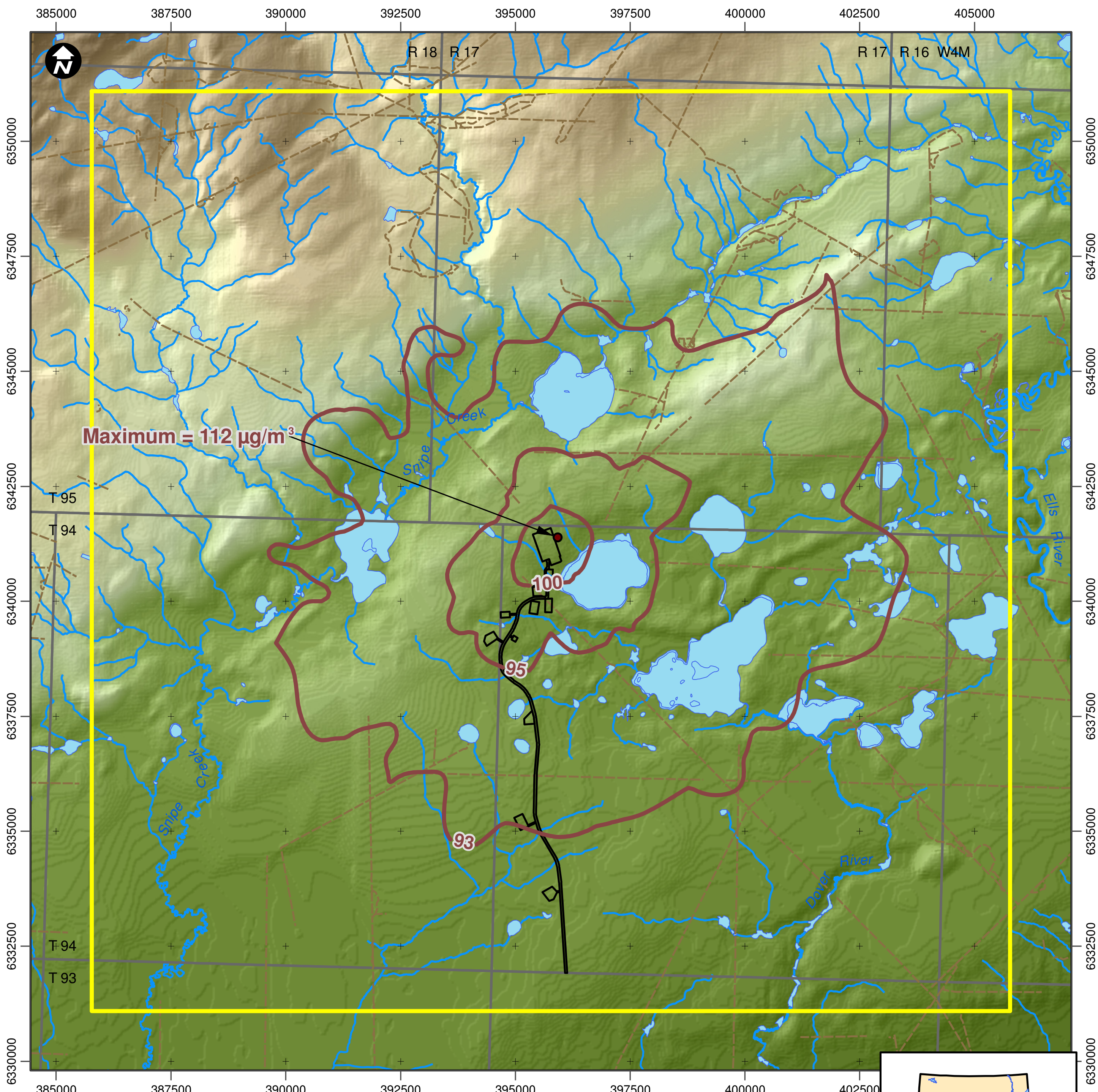


Figure 4.1 Buildings and Structures Considered in the Dispersion Modelling



Legend

- Project Footprint
- Cutline
- Study Area
- Concentration Isopleth

Topography (masl)

High : 775

Low : 500

0 2 4

Kilometres

REF: Geobase, 2008.

SUNSHINE OILSANDS LTD.

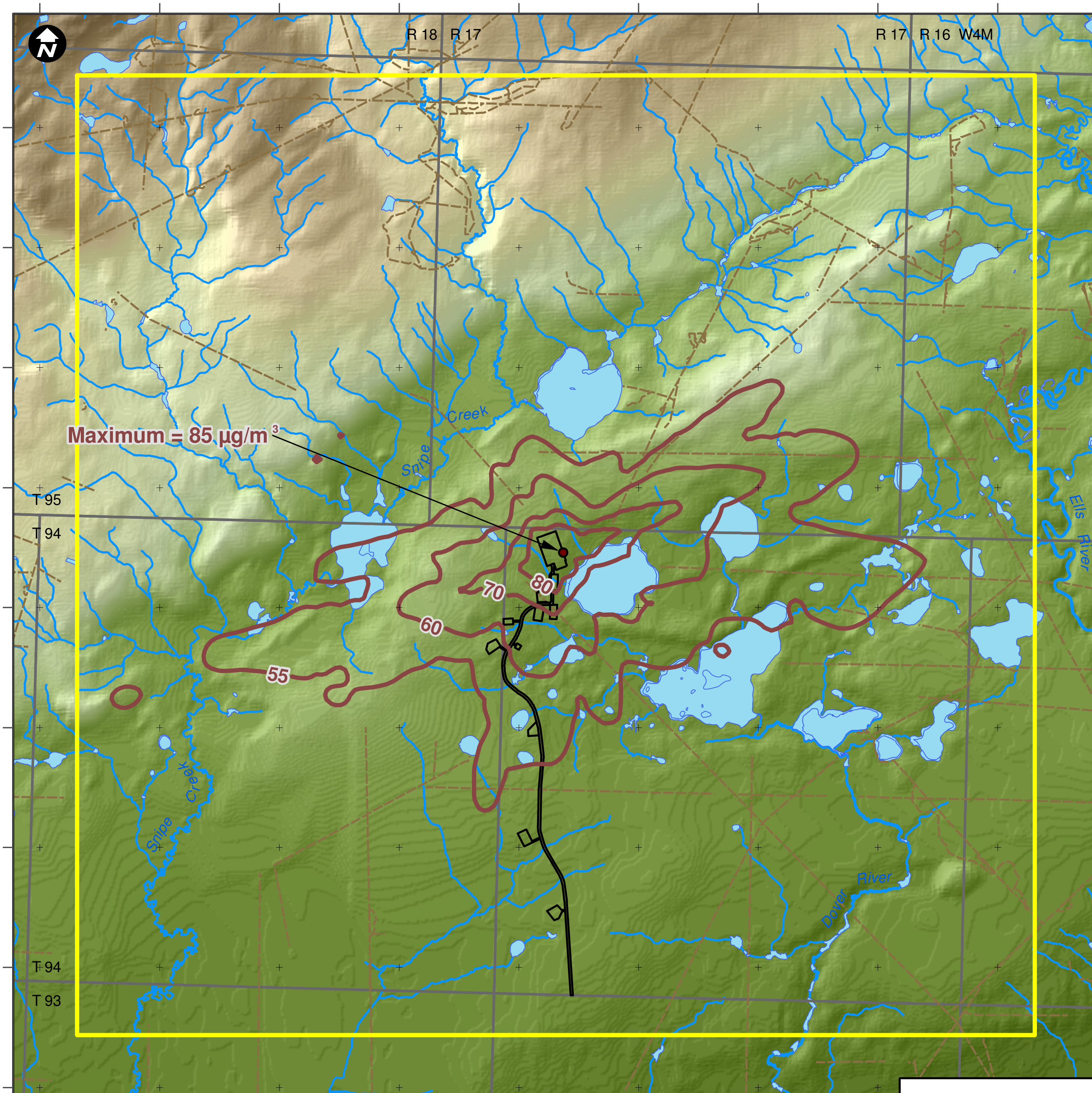
West Ells SAGD Project

TITLE:

Predicted 99.9th Percentile Hourly NO_2 Concentrations ($\mu g/m^3$)

DRAWN:	SL
CHECKED:	HJ
DATE:	Oct 22/08
PROJECT:	08-015

FIGURE: 6.1



Legend

- Project Footprint
- Cutline
- Study Area
- Concentration Isopleth

Topography (masl)

High : 775

Low : 500

0 2 4

Kilometres

Map Document: (K:\Active Projects 2008\Projects 08-001 to 08-050\08-015 Sunshine SAGD\Final Docs\Air Quality\Fig 6.2 Predicted Maximum NO2 Concentration.mxd) 22/10/2008 -- 11:36:22 AM

REF: Geobase, 2008.

SUNSHINE OILSANDS LTD.

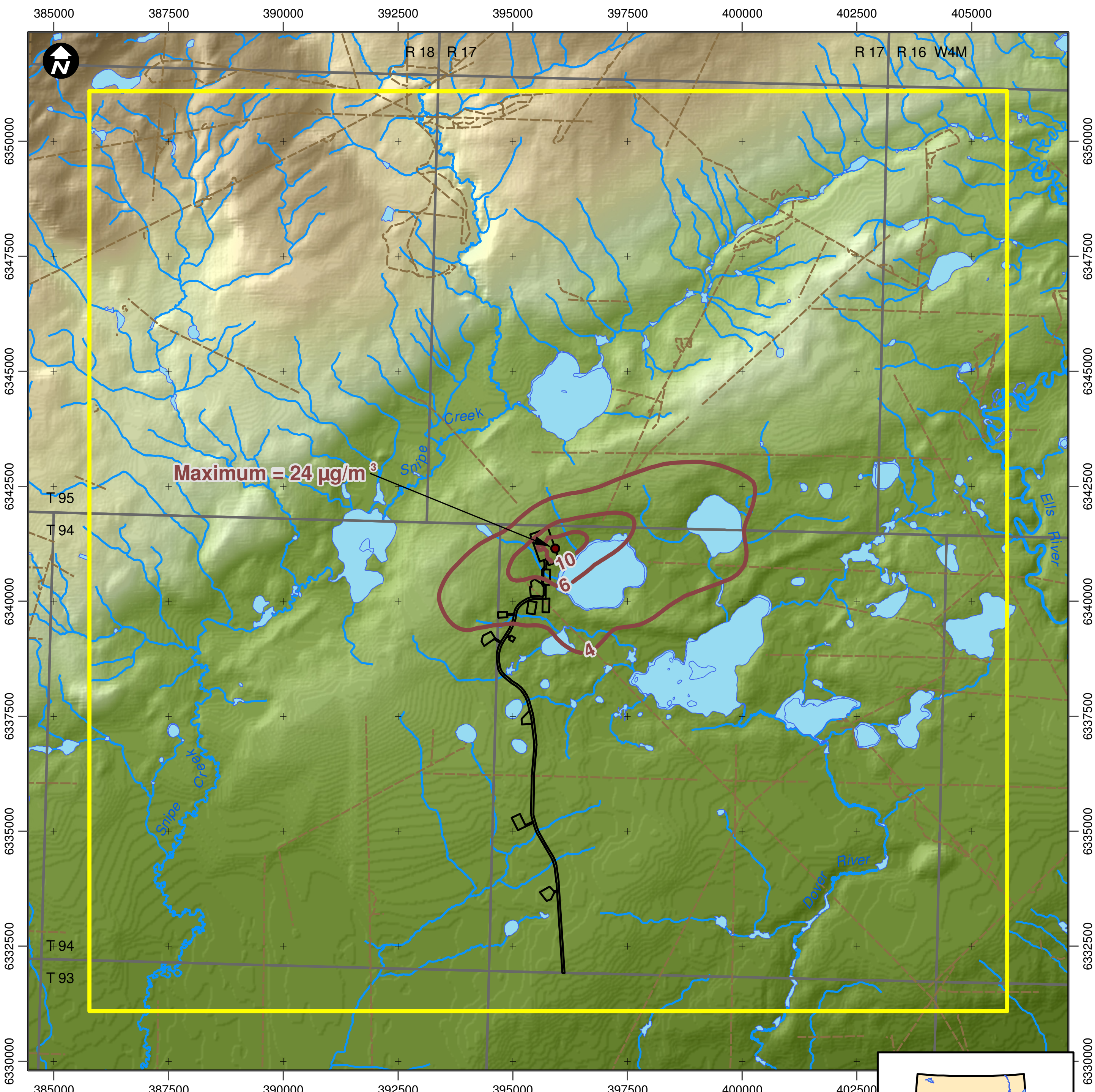
West Ells SAGD Project

TITLE:

Predicted Maximum 24-hour NO_2 Concentrations ($\mu g/m^3$)

DRAWN:	SL
CHECKED:	HJ
DATE:	Oct 22/08
PROJECT:	08-015

FIGURE: **6.2**



Legend

- Project Footprint
- Cutline
- Study Area
- Concentration Isopleth

Topography (masl)

High : 775

Low : 500

0 2 4

Kilometres

Map Document: (K:\Active Projects 2008\Projects 08-001 to 08-050\08-015 Sunshine SAGD\Final Docs\Air Quality\Fig 6.3 Predicted Average NO2 Concentration.mxd) 22/10/2008 -- 11:44:03 AM

REF: Geobase, 2008.

SUNSHINE OILSANDS LTD.

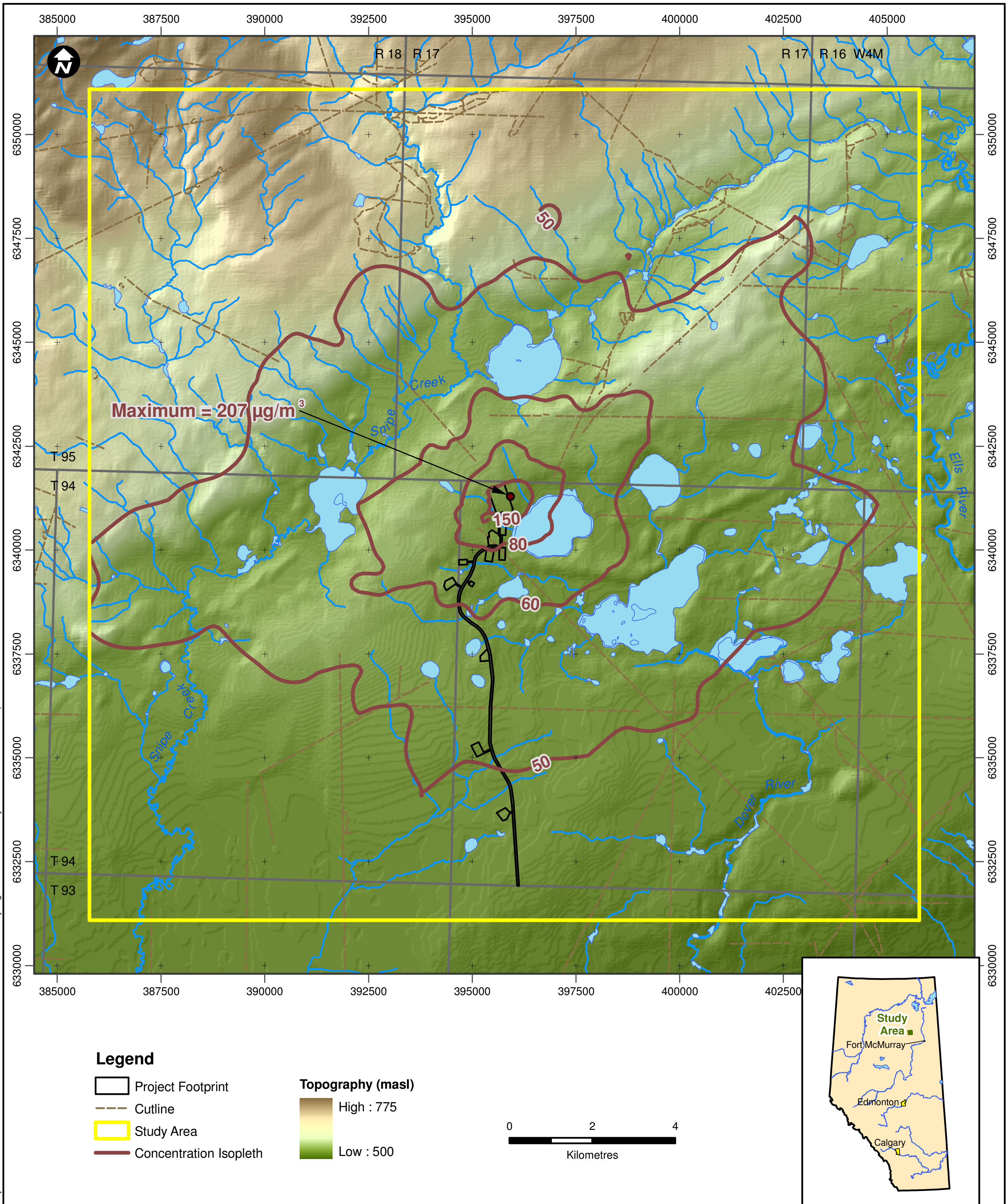
West Ells SAGD Project

TITLE:

Predicted Annual Average NO_2 Concentrations ($\mu g/m^3$)

DRAWN:	SL
CHECKED:	HJ
DATE:	Oct 22/08
PROJECT:	08-015

FIGURE: **6.3**



Legend

- Project Footprint
- Cutline
- Study Area
- Concentration Isopleth

Topography (masl)

High : 775

Low : 500

0 2 4

Kilometres

Map Document: (K:\Active Projects 2008\Projects 08-001 to 08-050\08-015 Sunshine SAGD\Final Docs\Air Quality\Fig 6.4 Predicted Hourly SO2 Concentration.mxd) 22/10/2008 -- 11:52:07 AM

REF: Geobase, 2008.

SUNSHINE OILSANDS LTD.

West Ells SAGD Project

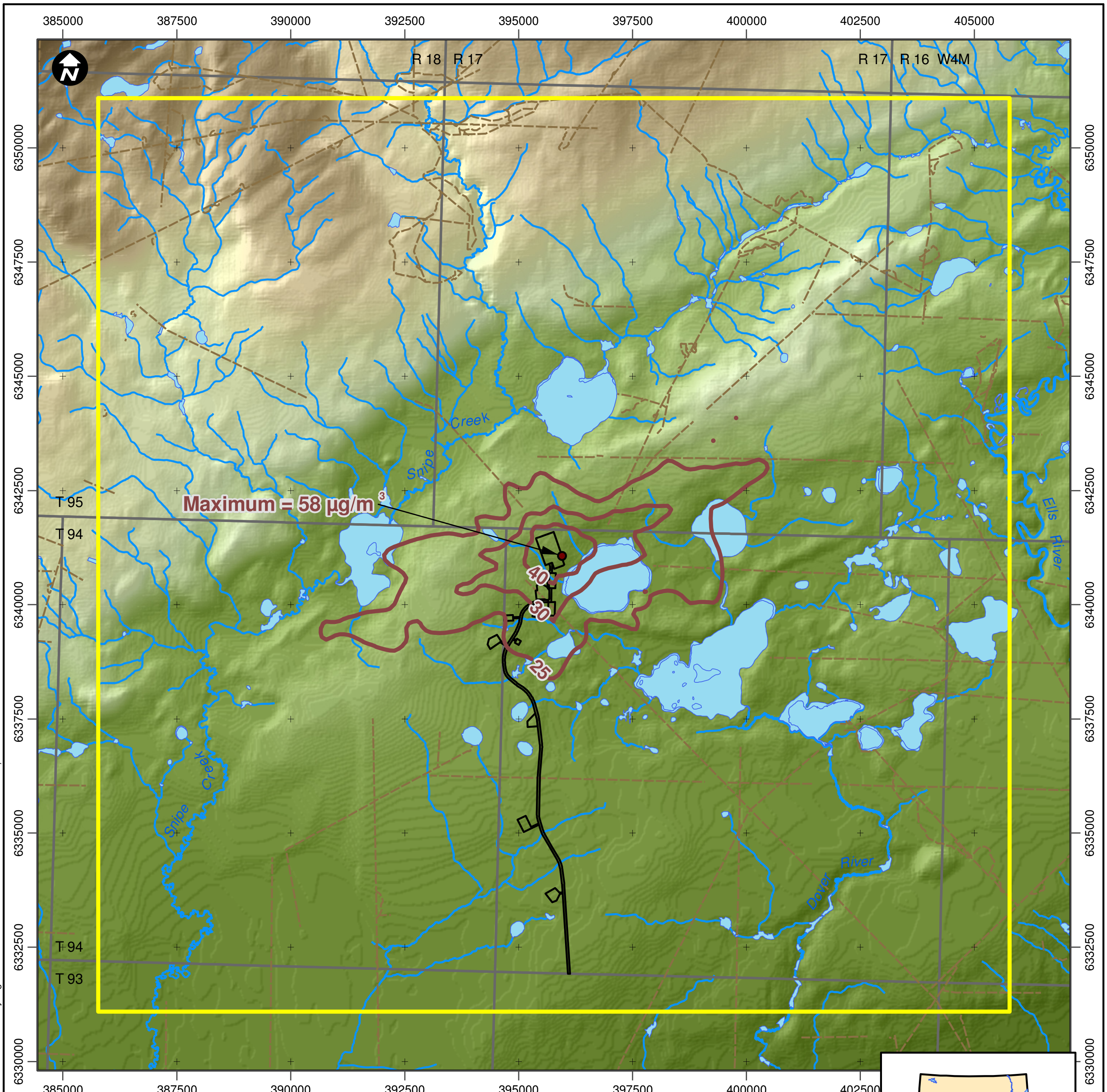
TITLE:

Predicted 99.9th Percentile Hourly SO_2 Concentrations (µg/m^3)

DRAWN:	SL
CHECKED:	HJ
DATE:	Oct 22/08
PROJECT:	08-015

FIGURE:

6.4



Legend

- Project Footprint
- Cutline
- Study Area
- Concentration Isopleth

Topography (masl)

High : 775

Low : 500

0 2 4

Kilometres

SUNSHINE OILSANDS LTD.

West Ells SAGD Project

TITLE:

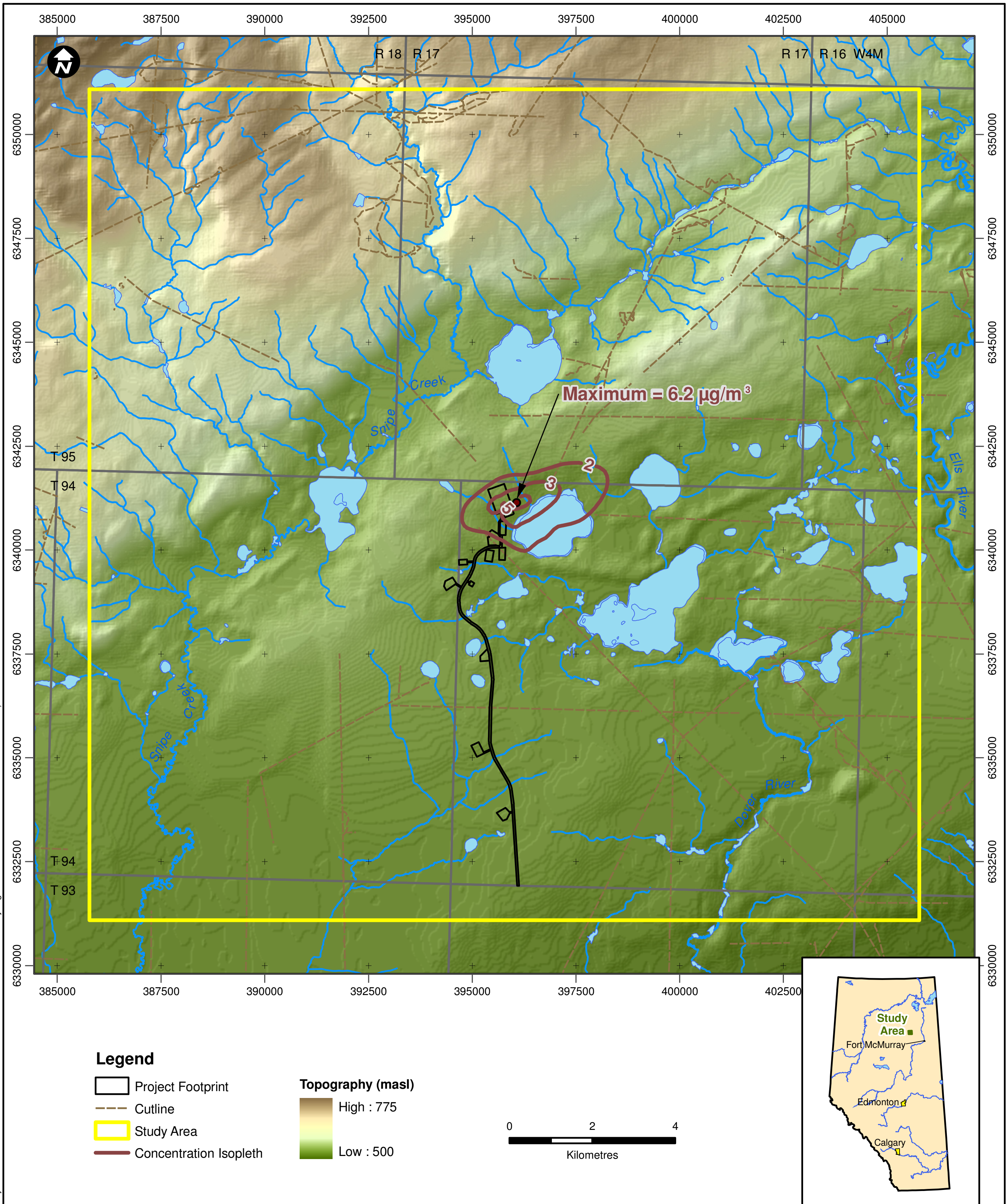
Predicted Maximum 24-hour SO_2 Concentrations (µg/m^3)

DRAWN:	SL
CHECKED:	HJ
DATE:	Oct 22/08
PROJECT:	08-015

FIGURE: 6.5

REF: Geobase, 2008.

Map Document: (K:\Active Projects 2008\Projects 08-001 to 08-050\08-015 Sunshine SAGD\Final Docs\Air Quality\Fig 6.5 Predicted Maximum SO2 Concentration.mxd) 22/10/2008 -- 4:48:05 PM



Map Document: (K:\Active Projects 2008\Projects 08-001 to 08-050\08-015 Sunshine SAGD\Final Docs\Air Quality\Fig 6.6 Predicted Annual SO2 Concentration.mxd) 22/10/2008 -- 4:56:02 PM

REF: Geobase, 2008.

SUNSHINE OILSANDS LTD.

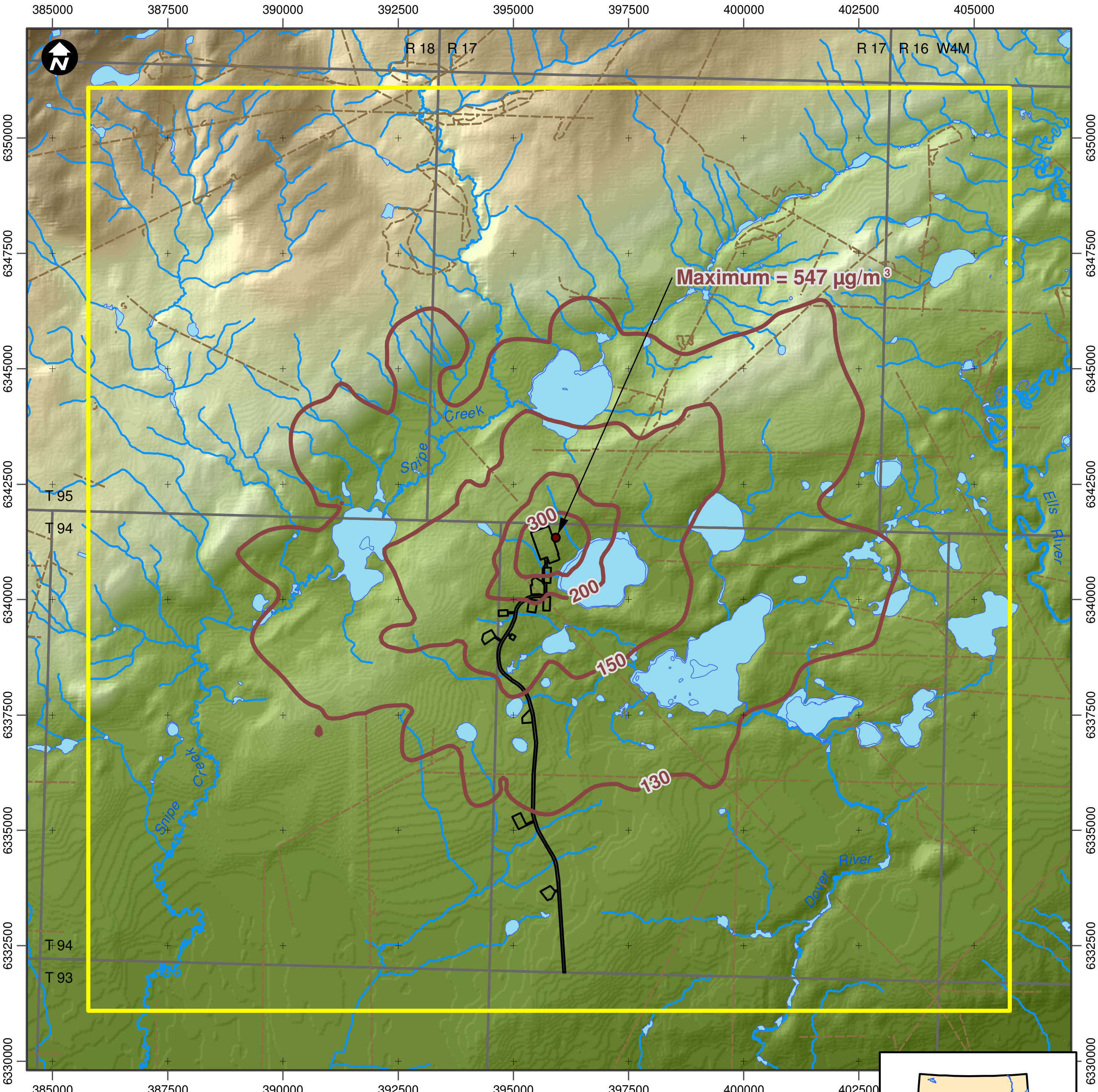
West Ells SAGD Project

TITLE:

Predicted Annual Average SO_2 Concentrations ($\mu g/m^3$)

DRAWN:	SL
CHECKED:	HJ
DATE:	Oct 22/08
PROJECT:	08-015

FIGURE: **6.6**



Legend

- Project Footprint
- Cutline
- Study Area
- Concentration Isopleth

Topography (masl)

High : 775

Low : 500

0 2 4

Kilometres

West Ells SAGD Project

SUNSHINE OILSANDS LTD.

TITLE:

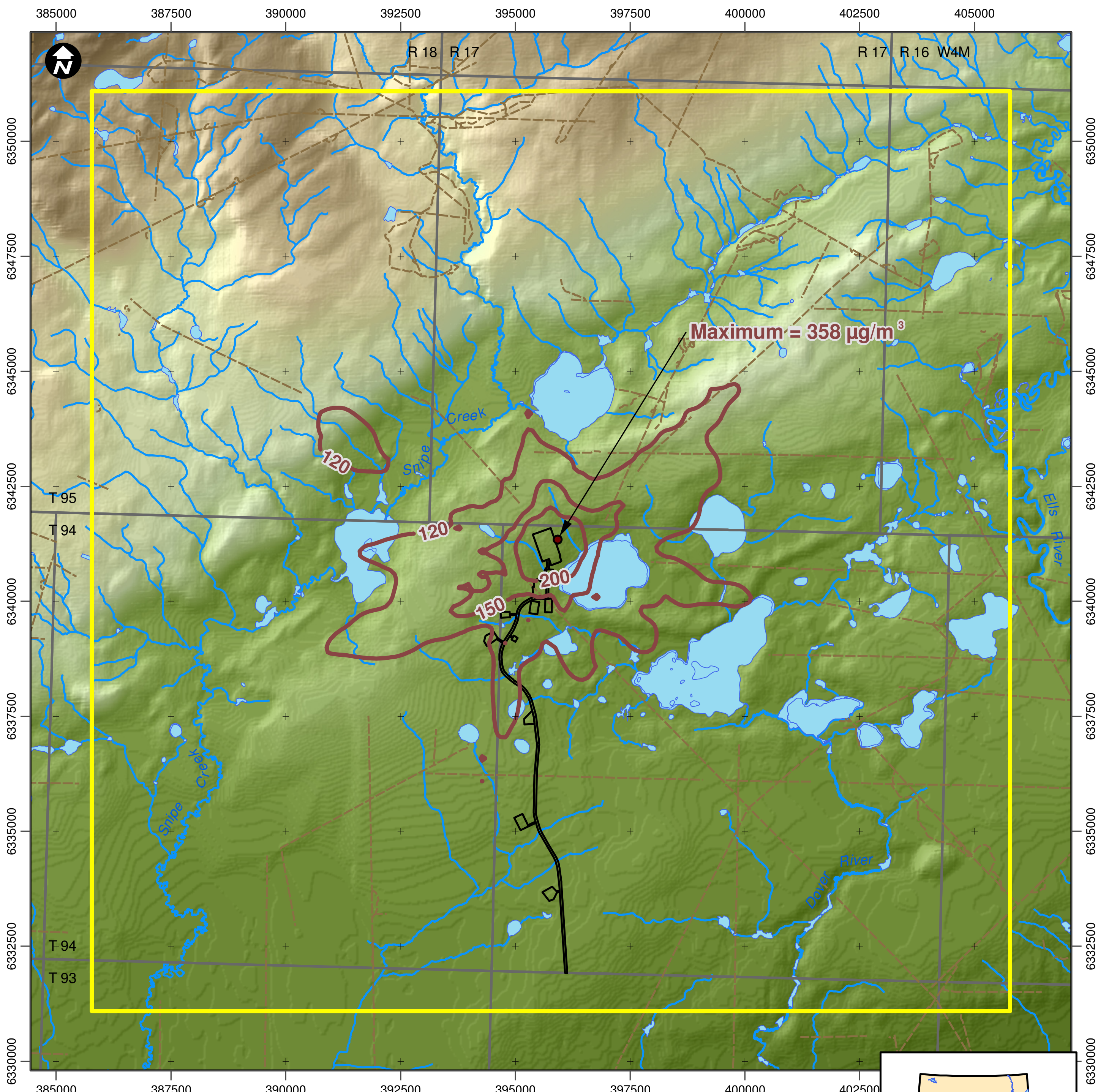
Predicted 99.9th Percentile Hourly CO Concentrations (µg/m³)

DRAWN:	SL
CHECKED:	HJ
DATE:	Oct 23/08
PROJECT:	08-015

FIGURE: **6.7**

REF: Geobase, 2008.

Map Document: (K:\Active Projects 2008\Projects 08-001 to 08-050\08-015 Sunshine SAGD\Final Docs\Air Quality\Fig 6.7 Predicted Hourly CO Concentration.mxd) 23/10/2008 -- 12:56:07 PM



Legend

- Project Footprint
- Cutline
- Study Area
- Concentration Isopleth

Topography (masl)

High : 775

Low : 500

0 2 4

Kilometres

West Ells SAGD Project

TITLE:

Predicted Maximum 8-hour CO Concentrations (µg/m³)

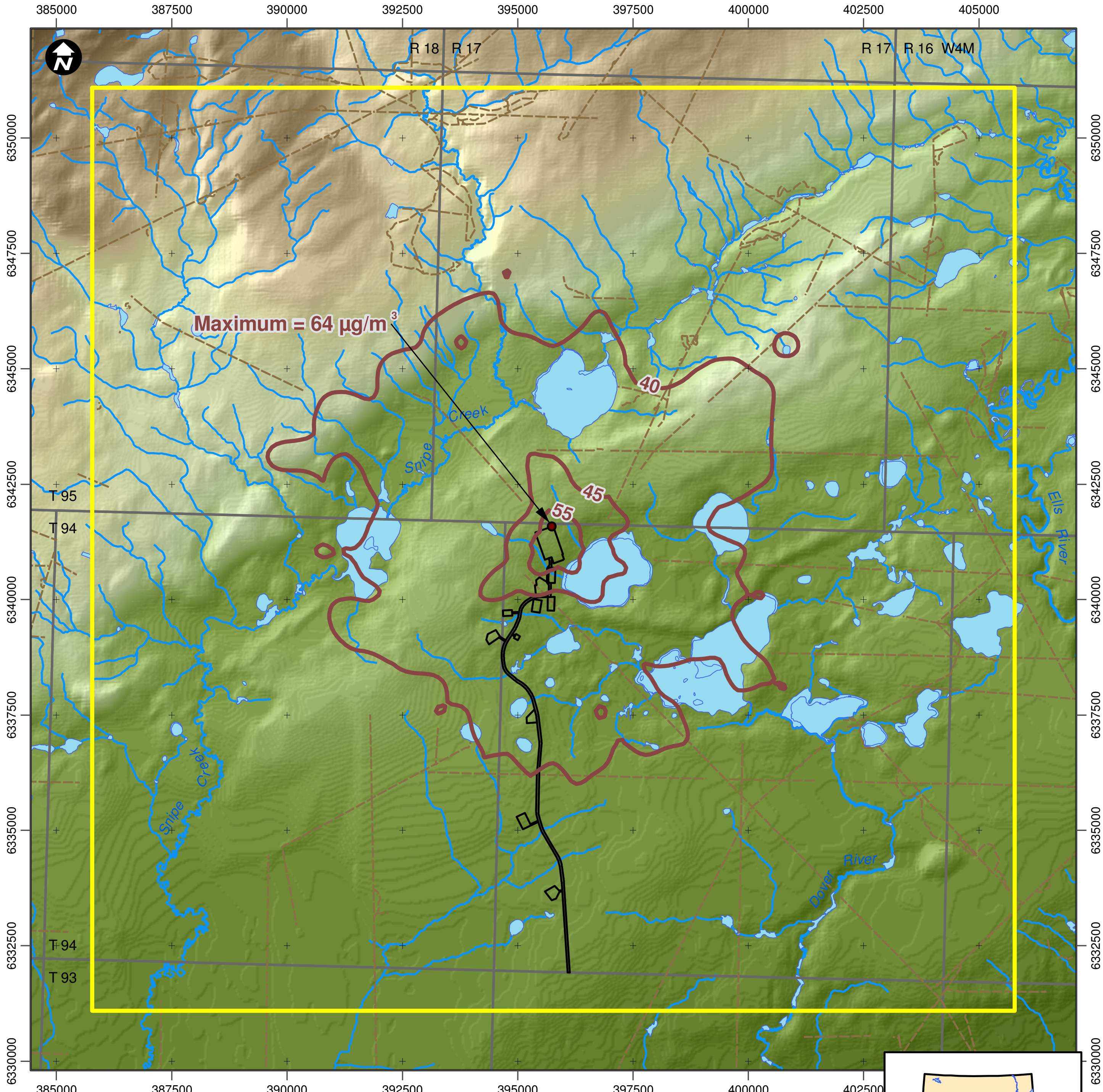
DRAWN:	SL
CHECKED:	HJ
DATE:	Oct 23/08
PROJECT:	08-015

FIGURE:

6.8

REF: Geobase, 2008.

Map Document: (K:\Active Projects 2008\Projects 08-001 to 08-050\08-015 Sunshine SAGD\Final Docs\Air Quality\Fig 6.8 Predicted Maximum CO Concentration.mxd) 23/10/2008 -- 1:07:48 PM



Legend

- Project Footprint
- Cutline
- Study Area
- Concentration Isopleth

Topography (masl)

High : 775

Low : 500

0 2 4

Kilometres

West Ells SAGD Project

TITLE:

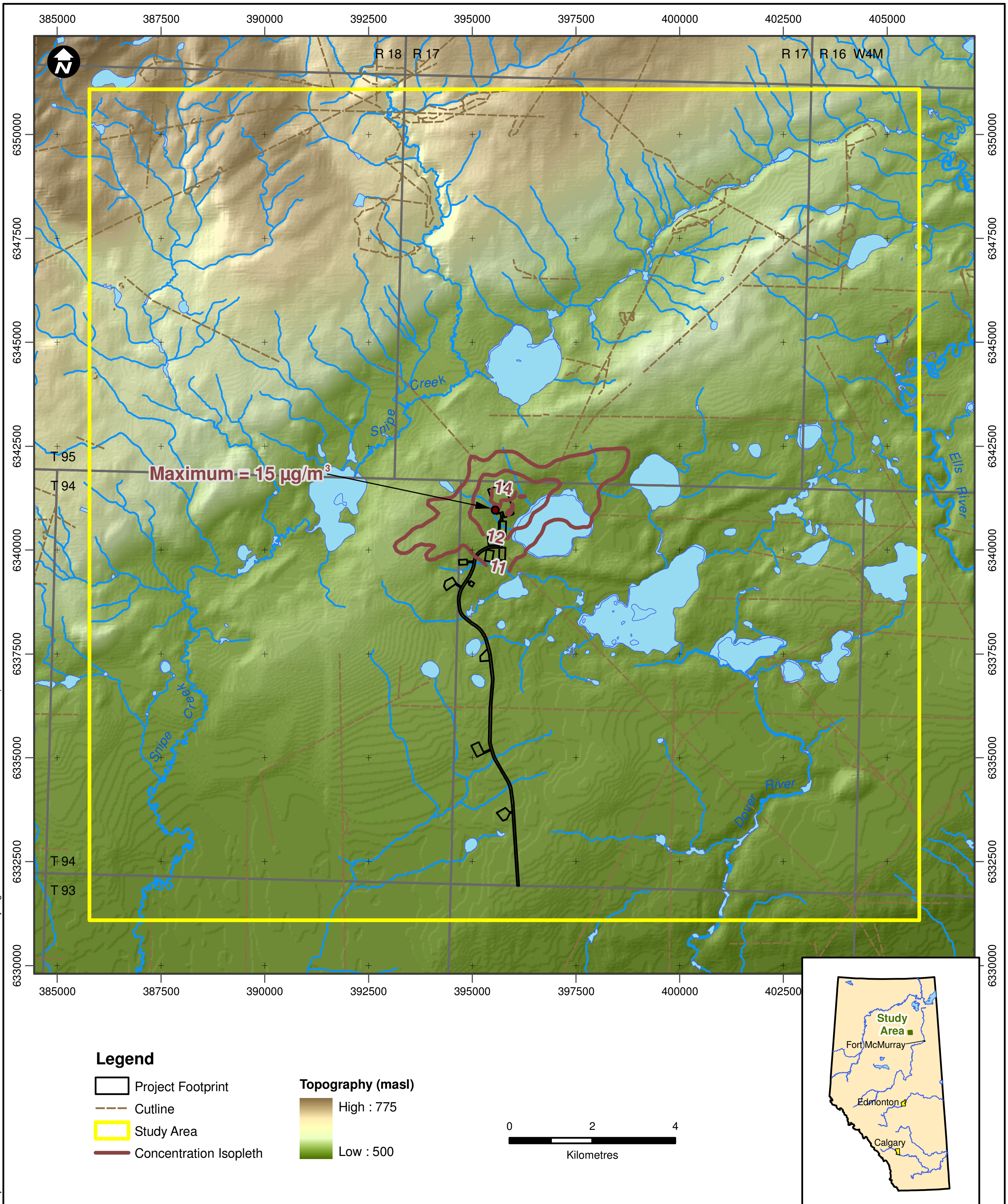
Predicted Maximum Hourly $PM_{2.5}$ Concentrations ($\mu g/m^3$)

DRAWN:	SL
CHECKED:	HJ
DATE:	Oct 23/08
PROJECT:	08-015

FIGURE: **6.9**

REF: Geobase, 2008.

Map Document: (K:\Active Projects 2008\Projects 08-001 to 08-050\08-015 Sunshine SAGD\Final Docs\Air Quality\Fig 6.9 Predicted Hourly PM25 Concentration.mxd) 23/10/2008 -- 1:10:58 PM



Map Document: (K:\Active Projects 2008\Projects 08-001 to 08-050\08-015 Sunshine SAGD\Final Docs\Air Quality\Fig 6.10 Predicted 24-Hour PM25 Concentration.mxd) 23/10/2008 -- 1:21:12 PM

REF: Geobase, 2008.

SUNSHINE OILSANDS LTD.

West Ells SAGD Project

TITLE:

Predicted Maximum 24-hour $PM_{2.5}$ Concentrations (µg/m³)

DRAWN: SL		FIGURE:
CHECKED: HJ		6.10
DATE: Oct 23/08		
PROJECT: 08-015		

West Ells SAGD Project
Conservation and Reclamation Plan

Prepared for:
Sunshine Oilsands Ltd.

Prepared by:
Millennium EMS Solutions Ltd.
#208, 4207 – 98 Street
Edmonton, Alberta
T6E 5R7

November 2008

File # 08-015

Table of Contents

Page

Table of Contents i
List of Tables ii
List of Figures ii

1.0 INTRODUCTION 1

2.0 RECLAMATION GOALS AND OBJECTIVES 2

2.1 General Reclamation Procedures 3
2.2 Reclamation to Equivalent Capability 4
2.2.1 Land Capability for Forestry 4
2.2.2 Drainage Systems 5
2.2.3 Fisheries 5
2.2.4 Wetlands 6
2.2.5 Traditional Land Use 6
2.2.6 Vegetation 6

3.0 CONSERVATION AND RECLAMATION PLAN 8

3.1 Soils Handling 8
3.1.1 Soil Resources 8
3.1.2 Soil Salvage 10
3.1.3 Subsoil Salvage 11
3.1.4 Soil Storage 11
3.1.5 Final Site Grading and Re-contouring 12
3.1.6 Soil Replacement Plan 12
3.1.7 Reclamation of Compacted Areas 16
3.1.8 Post Reclamation Land Capability 17
3.2 Revegetation 18
3.2.1 Revegetation Practices 19
3.2.2 Woody Species Planting 21
3.2.3 Post Reclamation Ecosites 21

4.0 RECLAMATION MONITORING PROGRAM 23

4.1 Monitoring Objectives 23
4.2 Monitoring Schedule 23
4.2.1 Revegetation Monitoring 24
4.2.2 Terrain and Soils Monitoring 24
4.2.3 Wildlife Monitoring 24

5.0 ABANDONMENT AND CLOSURE 25

6.0 REFERENCES 27

List of Tables

		Page
Table 1.0.1	SAGD Project Components – Phase 1 Development	2
Table 1.0.2	Access Road Components	2
Table 2.2.1	Pre-disturbance Land Capability for the Phase 1 Footprint	4
Table 2.2.2	Pre-disturbance Land Capability for the Access Road Footprint	5
Table 2.2.3	Pre-disturbance Ecosites for the Phase 1 Footprint	7
Table 2.2.4	Pre-disturbance Ecosites for the Access Road Footprint	7
Table 3.1.1	Baseline Soil Map Units located within the Phase 1 Footprint	9
Table 3.1.2	Baseline Soil Map Units located within the Access Road Footprint	10
Table 3.1.3	Reclamation Material Balance for the Phase 1 Footprint	13
Table 3.1.4	Reclamation Material Balance for the Plant Site	14
Table 3.1.5	Reclamation Material Balance for the Access Road Footprint	15
Table 3.1.6	Predicted Reclaimed Land Capability for the Phase 1 Footprint	17
Table 3.1.7	Predicted Reclaimed Land Capability for the Access Road	17
Table 3.2.1	Reclaimed Ecosites for the Phase 1 Footprint	22
Table 3.2.2	Reclaimed Ecosites for the Access Road Footprint	22

List of Figures

Figure 1.0.1	West Ells SAGD Project Development Area
Figure 2.2.1	Forest Soil Capability Rating – Pre-disturbance
Figure 2.2.2	Pre-disturbance Ecosite Phases
Figure 3.1.1	Pre-disturbance Soil Types
Figure 3.1.2	Forest Soil Capability Rating – Reclaimed
Figure 3.2.1	Post-disturbance Ecosite Phases

1.0 INTRODUCTION

The West Ells SAGD Project (the Project) is a Steam Assisted Gravity Drainage (SAGD) Project proposed by Sunshine Oilsands Ltd. (Sunshine) to extract bitumen from their oil sands leases in northeastern Alberta. The Project Area is located in Sections 30, 31, 32, and 33 Township 94, Range 17; and Sections 25 and 36, Township 94, Range 18, West of the 4th Meridian on Oil Sands Lease (OSL) No. 7407060175, 7407020023 and 7407070311. The Project is relatively small in scale and will produce 1600 m^3/day (10,000 bpd) of bitumen per day for 25 years.

This report presents the Conservation and Reclamation Plan for the Project. The Conservation and Reclamation (C&R) Plan serves many purposes:

- it provides the regulatory review agencies with the information needed to assess whether, upon completion of the Project, the land can be reclaimed and returned to the equivalent land capability that was present prior to commencement of the Project;
- it provides information about the ongoing reclamation activities that the Project proponent will carry out during the life of the Project to ensure that environmental impacts are kept to a minimum and end land use objectives and goals are attained;
- it provides conceptual information about the ultimate closure and abandonment plans for the facilities once the Project has ceased operations; and
- after considering landforms, soils, vegetation and the hydrological regime, the C&R Plan identifies the reclamation practices and mechanisms that will be carried out to ensure that a sustainable post-Project landscape meets the equivalent land capability of the pre-Project landscape.

The footprint for Phase 1 of the SAGD Project will include the development of a central processing facility (CPF), utilities corridor (i.e. access roads, surface pipelines, powerlines), well pads and borrow areas which will disturb 60.7 ha (Table 1.0.1). An access road footprint will also be required to support the Project and will disturb an additional 67.8 ha over approximately 9 km (Table 1.0.2). The SAGD and access road footprints are shown in Figure 1.0.1.

Table 1.0.1 SAGD Project Components – Phase 1 Development	
Area	**Area (ha)**
Plant Site	29.3
North Pad	4.9
South Pad	4.4
Construction Camp	4.9
Operator's Camp	2.9
Supervisor's Camp	1.2
Borrow Pit #1	8.9
Utility Corridor	4.2
Total	**60.7**

Table 1.0.2 Access Road Components	
Area	**Area (ha)**
Borrow Pit #2	5.6
Borrow Pit #3	4.5
Borrow Pit #4	6.5
Borrow Pit #5	6.0
Access Road	45.3
Total	**67.8**

To supplement this C&R Plan, once the Project is operational, Sunshine will prepare an Annual C&R Report that will outline development work that was completed in the previous year and activities that are planned for the following year. In compliance with the EPEA approval, an abandonment and reclamation plan will be submitted to AENV six months before decommissioning of the surface facilities.

2.0 RECLAMATION GOALS AND OBJECTIVES

The reclaimed landscape of the Project is predicted to be a mosaic of forest, wetlands and pond habitats that will be compatible with the surrounding landscape.

The reclamation goal for the Project is:

- developed lands will be reclaimed to achieve equivalent capability to pre-disturbance conditions resulting in reclaimed landscapes that are compatible with the surrounding landscape, including forested areas, wetlands and streams. The reclaimed lands will provide a range of end uses including forestry, wildlife habitat, traditional use and recreation.

The reclaimed landscape will be biologically self-sustaining and have a land capability at least equivalent to that of the pre-disturbance landscape to allow for:

- re-establishment of merchantable forests; and
- establishment of diverse upland and peatland wildlife habitats that are compatible with the surrounding ecosites.

Post-development land uses will be determined in consultation with stakeholders including aboriginal groups, local community representatives, regulators and other members of the public.

2.1 General Reclamation Procedures

The Project reclamation plan will include implementation of the following procedures to reclaim the sites to an equivalent capability:

- meeting with local reclamation inspector, prior to the initiation of the reclamation programs, to confirm the land use and reclamation procedures that are planned;
- determination of pre-disturbance capability prior to construction;
- removal of facilities;
- completion of appropriate reclamation of peat lands as per the end land use objectives;
- remediation of contaminated areas;
- recontouring and re-establishment of natural drainage patterns;
- ripping well pads, roadways, and facility pad areas, as required, to alleviate surface compaction;
- placing subsoil over the disturbed area of the CPF prior to soil placement;
- placing salvaged topsoil (i.e. litter and mineral A horizons) over the disturbed area with replacement depths similar to what existed prior to development;
- promoting natural recovery as the primary means of ground cover re-establishment. Where necessary, specific sites will be seeded with either a nurse crop or longer-lived, non-invasive vegetation cover and planted with tree species consistent with the revegetation plan;
- undertaking regular monitoring and maintenance activities following reclamation in order to assess reclamation success and identify areas of concern and;
- undertaking a post-reclamation site assessment to determine the status of the site prior to applying for a reclamation certificate.

2.2 Reclamation to Equivalent Capability

Sunshine is committed to reclaiming the Project footprints to a level of capability equivalent to pre-development conditions. The following sections reference and compare the anticipated pre-disturbance and reclaimed capability changes for forestry, wildlife, recreation and traditional land use. The final landscape and vegetation communities will be similar to existing conditions and there will be opportunities for different land uses following reclamation.

2.2.1 Land Capability for Forestry

The presence of the different forest communities existing in the Phase 1 SAGD and access road footprints are determined by parent material, topography and drainage. The potential for commercial forestry in the development area has been assessed using the Alberta Vegetation Inventory (AVI).

Forest communities that develop on the reclaimed SAGD sites will be determined by the degree of disturbance to the original site and by the success of the revegetation efforts. The pre-disturbance forest soil capabilities of the Phase 1 SAGD and access road footprints are provided in Tables 2.2.1 and 2.2.2 respectively, and shown on Figure 2.2.1.

Table 2.2.1 Pre-disturbance Land Capability for the Phase 1 Footprint

Project Footprint (ha)	Forest Soil Capability Rating					
	Class 1	**Class 2**	**Class 3**	**Class 4**	**Class 5**	**Total Area**
Plant Site	-	-	12.4	6.4	10.5	**29.3**
Access/Utility Corridor	-	-	1.5	1.1	1.5	**4.2**
North Pads	-	-	-	0.6	4.3	**4.9**
Borrow Pit 1	-	-	8.5	0.4	-	**8.9**
Construction Camp	-	-	3.7	-	1.3	**4.9**
South Pad	-	-	2.9	-	1.5	**4.4**
Supervisor's Camp	-	-	1.2	-	-	**1.2**
Operator's Camp	-	-	2.4	-	0.5	**2.9**
Total	**0**	**0**	**32.6**	**8.5**	**19.6**	**60.7**
% of Footprint	**0.0%**	**0.0%**	**53.7%**	**14.0%**	**32.3%**	**100.0%**

Table 2.2.2 Pre-disturbance Land Capability for the Access Road Footprint						
	Forest Soil Capability Rating					
Project Footprint (ha)	**Class 1**	**Class 2**	**Class 3**	**Class 4**	**Class 5**	**Total Area**
Borrow Pit 2	-	-	5.6	-	-	**5.6**
Borrow Pit 3	-	-	4.5	-	-	**4.5**
Borrow Pit 4	-	-	4.3	-	2.1	**6.4**
Borrow Pit 5	-	6.0	-	-	**-**	**6.0**
Main Access Road	-	0.7	23.6	5.3	15.8	**45.3**
Total	**0.0**	**6.7**	**38.0**	**5.3**	**17.9**	**67.8**
% of Footprint	**0.0%**	**9.8%**	**56.0%**	**7.8%**	**26.4%**	**100.0%**

Phase 1 of the SAGD footprint is covered by predominantly Class 3 (50.7%) and Class 5 soils (32.2%). Limitations to Class 3 soils within the Phase 1 footprint are similar to those of the surrounding LSA (pH, consistence and drainage). Class 4 soils cover approximately 14.1% of the Phase 1 footprint and are limited by poor drainage. Class 4 Soil Models represent transitional areas between the uplands (Class 2 and 3) and organic soils (Class 5).

The access road footprint is predominantly Class 3 soils (56.0%) limited by soil pH (subclass V), subsoil soil consistence (subclass D) and to a lesser extent drainage issues (subclass W). Class 4 and 5 soils account for 34.2% of the access road footprint, which corresponds to Organics and poorly drained transitional landscapes between the upland and organic landscapes. Limitations are predominantly poor drainage (subclass W).

2.2.2 Drainage Systems

The Project has been designed to minimize impacts to surface waters. Preservation of site drainage patterns during operations will facilitate return of the area's drainage patterns upon closure. Integral to the development of a sustainable reclaimed landscape is the re-establishment of drainage systems that serve to channel surface runoff waters to wetlands and eventually to the Dover River drainage system.

2.2.3 Fisheries

The primary drainage or watercourse in the Project area includes the Dov1 and Dov2 watersheds which drain into Lake L1 and towards the Dover River (NHC 2008). Four species of fish were found in Lake L1 adjacent to the Project area, but no fish were found within the Project disturbance area. The Project area crosses a mapped drain way upstream of L1 (NHC 2008). The flow in this drain way disperses into a wetland, where there is no defined stream channel.

2.2.4 Wetlands

Wetlands in the Project area will have drainage patterns maintained to minimize the impact on hydrology. With the use of geotextile materials, minor alteration will occur on portions of the plant site and segments of access roads.

2.2.5 Traditional Land Use

The Athabasca Oil Sands Region has a long history of use by aboriginal peoples. First Nations and Métis within the region include the communities of Fort McMurray and Fort Mackay. Traditional resource use in the region includes hunting, trapping, fishing, berry picking, collecting medicinal plants, and the use of trail networks, cabins and special sites (e.g., sweat lodges). Further information on Traditional Environmental Knowledge (TEK) and use within the region is being gathered through the TEK committee within CEMA (Cumulative Environmental Management Association). Sunshine is also working directly with the local communities to identify site specific TEK information for this Project area. This information will be used to enhance the capability of the C&R process to return these values to the land.

2.2.6 Vegetation

An assessment of vegetation for the Project has been conducted (GDC 2008). Delineation of vegetation communities was based on Alberta Vegetation Inventory (AVI) map units that were classified using “The Field Guide to Ecosites of Northern Alberta” (Beckingham and Archibald 1996). ELC (ecological land classification) units are determined from the site’s placement on an edatopic grid (from nutrient and moisture regimes), while dominant tree species or tallest vegetation layer (e.g. trembling aspen) determines ecosite phase units. Subdivision of plant community types is determined from understory species composition and abundance (e.g. low-bush cranberry).

Tables 2.2.3 and 2.2.4 provide the pre-disturbance ecosites for the Phase 1 SAGD footprint and the access road footprint. The pre-disturbance ecosite phases are shown on Figure 2.2.2.

Table 2.2.3 Pre-disturbance Ecosites for the Phase 1 Footprint

Ecosite	Footprint (ha)									
	Plant Site	Borrow Pit #1	Construction Camp	North Pad	Operator's Camp	South Pad	Supervisor's Camp	Utility Corridor	Total	% of Footprint
d	9.5	8.7	2.8	0	2.5	1	0.9	1.5	**26.9**	**44.2**
h	1.3	0.2	1.5	0.6	0	2	0	0.6	**6.2**	**10.2**
i	1.1	0	0	0	0	0	0.3	0	**1.4**	**2.3**
j	11.9	0	0.6	4.3	0.3	1.4	0	1.8	**20.3**	**33.4**
k	5.5	0	0	0	0.1	0	0	0.4	**6**	**9.9**
Total	29.3	8.9	4.9	4.9	2.9	4.4	1.2	4.3	60.8	100

Table 2.2.4 Pre-disturbance Ecosites for the Access Road Footprint

Ecosite	Footprint (ha)						
	Access Road	Borrow Pit #2	Borrow Pit #3	Borrow Pit #4	Borrow Pit #5	Total	% of Footprint
c	2.8	0	0	0	0	**2.8**	**4.1**
d	11	5.4	2.7	3.5	6	**28.6**	**42.2**
g	5.6	0	0.4	1.8	0	**7.8**	**11.5**
h	0.5	0	1.4	0	0	**1.9**	**2.8**
i	21.8	0.2	0	1.1	0	**23.1**	**34.1**
j	2.2	0	0	0	0	**2.2**	**3.2**
k	1.4	0	0	0	0	**1.4**	**2.1**
Total	45.3	5.6	4.5	6.4	6	67.8	100

3.0 CONSERVATION AND RECLAMATION PLAN

Sunshine will use the following objectives as the basis for operational and reclamation program design:

- facility development, well pads, roadways, pipelines, and other landscape alterations will be constructed to be geotechnically stable;
- all construction and operational activities will be designed with final reclamation objectives in mind to ensure that the necessary natural resources are conserved to allow for end land use objectives to be met;
- reclamation is designed to create a landscape that is self-sustaining and capable of supporting soils and vegetation processes similar to the adjacent undeveloped areas with no subsequent management input required;
- following soil placement or de-compaction, vegetation communities will establish and will be capable of ecological succession processes similar to those found within the region;
- on those localized sites that are sensitive to erosion (i.e. steeper erodable slopes, coarse textured soils (sands), or disturbances immediately adjacent to watercourses), watershed protection will take priority over other vegetation objectives;
- water discharges during development and following reclamation will be managed to ensure an acceptable level of input into the streams that flow into natural watershed and;
- reclaimed lands will meet the criteria for certification.

The areas disturbed by construction activities will be progressively reclaimed to minimize post-construction impacts such as soil erosion. Final reclamation will be undertaken when the Project is abandoned and all of the facilities removed.

3.1 Soils Handling

3.1.1 Soil Resources

An assessment of Soil Resources for the Project has been conducted in the baseline soil and terrain assessment (MEMS 2008). A total of 36 map units (two of which describe disturbed lands and/or water bodies) were used to describe the soils located in the local studies areas (LSAs) around the SAGD and access road footprints. Table 3.1.1 displays the soil map unit inventory within each component of the Phase 1 footprint and Table 3.1.2 shows the soil map unit inventory along the access road footprint. These baseline soil map units are shown on Figure 3.1.1.

Table 3.1.1 Baseline Soil Map Units located within the Phase 1 Footprint

Soil Map Unit	Total Area of each map unit per Disturbance Area (ha)	Dominant soil type (Organic/Mineral)
Borrow Pit 1 (8.9 ha)		
HRLV9/U1h	6.7	Mineral
HRLVgl2/U1l	1.3	Mineral
MISU18/U1h	0.5	Mineral
MNWH21/L1	0.4	Mineral
Construction Camp (4.9 ha)		
HRLV9/U1h	3.4	Mineral
MISU18/U1h	0.3	Mineral
MRN1m-G/O1	1.3	Shallow Organic[1]
North Pad (4.9 ha)		
MNWH21/L1	0.6	Mineral
MRN1m/O3	4.3	Shallow Organic
Operator's Camp (2.9 ha)		
HRLV9/H1l	2.0	Mineral
MLD2m/O2	0.2	Organic[2]
MRN1m-G/O1	0.3	Shallow Organic
HRLV9/H1l	0.4	Mineral
Plant Site (29.3 ha)		
BMT21/L1	6.4	Mineral
HRLV9/U1h	1.6	Mineral
HRLVgl2/U1l	0.5	Mineral
MISU18/U1h	9.3	Mineral
MNWH21/U1l	1.0	Mineral
MRN1m/O1	1.0	Shallow Organic
MRN1m/O3	1.1	Shallow Organic
MRN1m-G/O1	8.4	Shallow Organic
South Pad (4.4 ha)		
HRLV9/H1l	1.0	Mineral
MISU18/U1h	1.9	Mineral
MRN1m/O3	1.5	Shallow Organic
Supervisor’s Camp (1.2 ha)		
HRLV9/H1m	1.0	Mineral
HRLV9/H1m	0.2	Mineral
Utility Corridor (4.2 ha)		
BMT21/L1	0.4	Mineral
HRLV9/U1h	0.2	Mineral
MISU18/U1h	1.5	Mineral
MNWH21/L1	0.7	Mineral
MRN1m/O3	1.5	Shallow Organic

[1]Shallow organic – contains 40 - 100 cm of peat.
[2]Organic – Contains >100 cm of peat

Table 3.1.2 Baseline Soil Map Units located within the Access Road Footprint

Soil Map Unit	Total Area of each map unit per Disturbance Area (ha)	Dominant soil type (Organic/Mineral)
Borrow Pit 2 (5.6 ha)		
HRLV9/H1l	5.4	Mineral
HRLV9/H1m	0.1	Mineral
Borrow Pit 3 (4.5 ha)		
LVPE2/U1h	3.6	Mineral
MNWH20/U1l	0.9	Mineral
Borrow Pit 4 (6.4 ha)		
HRLV9/U1h	4.3	Mineral
MRN1m/O1	2.1	Shallow Organic[1]
Borrow Pit 5 (5.9 ha)		
DOV9/U1l	5.9	Mineral
Main Access Road (45.3 ha)		
DOV9/U1l	0.7	Mineral
HRLV9/H1l	0.4	Mineral
HRLV9/H1m	5.1	Mineral
HRLV9/U1h	4.8	Mineral
HRLV9/U1l	1.4	Mineral
LVPE2/U1h	6.8	Mineral
MKW1/O5	3.3	Shallow Organic
MLD2m/O2	NEG	Organic[2]
MLD2m/O3	0.5	Organic
MNWH20/U1l	5.0	Mineral
MNWH21/L1	4.1	Mineral
MNWH21/U1l	1.2	Mineral
MRN1f-G/O1	3.6	Shallow Organic
MRN1m/O1	0.9	Shallow Organic
MRN1m/O2	0.2	Shallow Organic
MRN1m-G/O1	4.2	Shallow Organic
MRN1m-G/O2	0.4	Shallow Organic
MUS2m/O3	1.5	Organic
MUS3/O3	1.1	Organic

[1]Shallow organic – contains 40 - 100 cm of peat.
[2]Organic – Contains >100 cm of peat

3.1.2 Soil Salvage

Within Project disturbance footprints, topsoil material will be salvaged from all upland soils, which are those defined as having less than 40 cm of surface peat. Topsoil material will be salvaged with the overlying litter material/shallow surface peat in one lift. Total topsoil salvage depths will typically vary between 15 to 40 cm for mineral soils, depending on soil type and landscape position. This depth includes the litter/shallow surface peat layer and the A horizon. The detailed soil information including soil depths is provided in CR#8.

Sufficient soil volumes will be salvaged and replaced to ensure that the reclaimed areas will support revegetation activities, allow ecological succession and achieve land capability equivalent to the pre-development conditions. Details with respect to assessing baseline soil conditions, soil mapping, and determining suitable soil salvage depths for the Project are provided in the baseline soil survey and terrain assessment (MEMS 2008).

All landscapes within the footprints that have peat thicknesses greater than 40 cm will either have the peat material partially salvaged, padded over, or completely salvaged. Appropriate procedures will be based on site specific characteristics and best construction practices, which will be determined at the field level by a qualified site construction specialist. Each potential peat handling option is defined below:

- **Option A - partially salvaging** – the top 0.3 – 0.4 m of peat is salvaged and stored for use at reclamation, leaving some of the underlying peat and/or mineral material intact such that geo-textile can be placed on top of the lower material, and fill material placed on the geotextile.
- **Option B - no salvage** – all peat material will be left intact, with geo-textile placed on top, and fill material placed on the geotextile. Fill material will be obtained from borrow pits, which will have all the soil salvaged, whether they are upland or organic.
- **Option C - complete salvage** – in some instances areas of relatively shallow peat (40-100 cm) may be completely salvaged for construction of Project components, the salvaged material would be stockpiled for use at reclamation and fill material obtained from borrow pits.

3.1.3 Subsoil Salvage

Subsoil will be salvaged and replaced, from the central processing facility (CPF), to a maximum depth of 30 cm.

3.1.4 Soil Storage

All topsoil and shallow peat (<40 cm) material salvaged will be stored in stockpiles for the duration of the Project life. Additionally, peat material salvaged from areas of deep peat deposits (> 40 cm of peat) for use at reclamation (options A and C) will also be stored in stockpiles for the duration of the Project life. Soil stockpiles will be constructed with maximum 3:1 slopes and stored in designated soil storage areas. Along access routes, salvaged soil material will be windrowed along the right-of-way and then replaced along the ditchlines once the roads have been constructed. All excess salvaged soil material will be left in a windrow on the edge of the right of way for use at reclamation.

Within the CPF, a second-lift consisting of upper subsoil will be salvaged, stockpiled and replaced upon reclamation to ensure that the reclaimed rooting zone will be similar to that which existed prior to disturbance. A maximum depth of 30 cm of subsoil material will be salvaged for replacement upon reclamation of the CPF. All salvaged subsoil material will be stored separately from salvaged topsoil material.

3.1.5 Final Site Grading and Re-contouring

Progressive reclamation will be undertaken where possible to minimize the amount of active surface disturbance. For example, well pads will be reclaimed as they are decommissioned over the life of the Project. Once a particular component of the site infrastructure is no longer required (e.g. well pads, borrow pits, sumps, construction camp, etc.) final site grading and re-contouring activities will take place.

The majority of the SAGD footprint is located in undulating to hummocky terrain with slopes ranging from 2-10%. The access road footprint is located in subdued gently undulating to level terrain with slopes ranging from 0-5%. Final contouring of the footprints will be carried out so that the reclaimed terrain blends into the natural landscape and proper site drainage is maintained. Where possible, final site preparation will be re-contoured to near natural drainage patterns and topography.

During final reclamation, side slopes of the borrow areas will be graded to a 3:1 slope. It is anticipated that wetlands will form within these areas.

3.1.6 Soil Replacement Plan

For surface pipelines, powerlines and road ditches, following construction and installation, soil will be immediately replaced and revegetated on the right of ways to minimize impacts related to erosion.

With respect to other Project infrastructure, soil will be placed once final re-contouring and de-compaction of the surficial materials is complete. The goal of soil replacement is to establish a soil profile that permits the establishment of an initial vegetation cover, subsequent natural recovery of the plant community and initiation of natural soil processes such that land capability equivalent to that which existed prior to disturbance is achieved. The reclaimed soil profile will provide:

- adequate moisture supply;
- adequate nutrient supply;
- a native seed bank; and

- capability to support a self-sustaining vegetative cover similar to pre-disturbance conditions.

Soil handling practices are designed to follow the guidelines provided in "Land Capability Classification for Forest Ecosystems in the Oil Sands Region, Working Manual" (CEMA 2006). Equivalent forest capability is the primary consideration for soil reclamation. This focus is not expected to drastically alter soil salvage criteria, but it will assist in managing the placement of better-suited reclamation material.

The reclamation material balance is provided in Tables 3.1.3 and 3.1.4 for the Phase 1 footprint and 3.1.5 for the access road footprint.

Table 3.1.3 Reclamation Material Balance for the Phase 1 Footprint

Project Component	Total Area (ha)[1]	Area of Mineral Soil Salvage (ha)[2]	Topsoil Lift Materials Available		Typical Replacement Depth of Topsoil Lift Layer (m)[3]	Total Volume of Topsoil Lift Replaced (m^3)
			Litter (m^3)	Topsoil (m^3)		
Borrow Pit 1	8.9	8.9	8,987	8,722	0.2	17,709
Construction Camp	4.9	3.6	3,581	3,765	0.2	7,346
North Pad	4.9	0.6	1,652	551	0.4	2,203
Operator's Camp	2.9	2.4	2,429	2,429	0.2	4,858
South Pad	4.4	2.9	2,522	3,835	0.2	6,357
Supervisor's Camp	1.2	1.2	1,200	1,200	0.2	2,400
Utility corridor	4.2	2.7	4,832	3,517	0.3	8,349
TOTALS	**31.4**	**22.3**	**25,203**	**24,019**		**49,222**

[1] Includes total areas of disturbance including deep peat deposits.
[2] Areas include soil material that will be salvaged for replacement. Includes litter/surface peat, A horizon, and shallow organics (peat <40 cm).
[3] Typical estimated replacement depth for areas where soil materials were salvaged.

Table 3.1.4 Reclamation Material Balance for the Plant Site

Project Component	Total Area (ha)[1]	Area of Mineral Soil Salvage (ha)[2]	Topsoil Lift Materials Available		Typical Replacement Depth of Topsoil Lift Layer (m)[3]	Total Volume of Topsoil Lift Replaced (m^3)	Upper subsoil Materials Available (m^3)	Typical Replacement Depth of Upper subsoil (m)[3]	Total Volume of Upper subsoil Replaced (m^3)
			Litter (m^3)	Topsoil (m^3)					
Plant Site	**29.3**	**18.8**	34,671	29,385	0.3	**64,056**	**56,425**	0.3	**56,425**

[1] Includes total areas of disturbance including deep peat deposits.
[2] Areas include soil material that will be salvaged for replacement. Includes litter/surface peat, A horizon, and shallow organics (peat <40 cm).
[3] Typical estimated replacement depth for areas where soil materials were salvaged.

Table 3.1.5 Reclamation Material Balance for the Access Road Footprint

Project Component	Total Area (ha)[1]	Area of Topsoil Lift Salvage (ha)[2]	Topsoil Lift Materials Available		Typical Replacement Depth of Topsoil Lift Layer (m)[3]	Total Volume of Topsoil Lift Replaced (m^3)
			Litter (m^3)	Topsoil (m^3)		
Borrow Pit 2	5.6	5.6	5,583	5,583	0.2	11,166
Borrow Pit 3	4.5	4.5	4,897	6,259	0.3	11,156
Borrow Pit 4	6.5	4.3	4,313	4,313	0.2	8,626
Borrow Pit 5	6.0	6.0	8,922	5,948	0.3	14,869
Access Road	45.3	29.5	53,794	30,350	0.3	84,143
TOTAL[4]	**67.8**	**49.9**	**77,509**	**52,453**		**129,962**

[1] Includes total areas of disturbance including deep peat deposits.
[2] Areas include soil material that will be salvaged for replacement. Includes litter/surface peat, A horizon, and shallow organics (peat <40 cm).
[3] Typical estimated replacement depth for areas where soil materials were salvaged.

Within the Phase 1 footprint (including the plant site), approximately 19.6 ha are covered by organic map units (> 40 cm of surface peat). The remaining 41.1 ha are covered by mineral soils, including peaty Gleysols which will be stripped and stockpiled for use at reclamation. The access road footprint contains 49.9 ha of mineral soils and 17.9 ha of organic map units. An estimated 37.5 ha of organics will be disturbed as a result of Phase 1 of the Project.

As discussed in Section 3.1.2, Soil Salvage, various options are available with respect to the handling of deep peat deposits (> 40 cm) during construction of the Project and final soil salvage and handling methods are likely a field level decision at the time of construction. With respect to reclamation of site disturbance on deep organic/peat soils (>0.4 m of peat material), different methods of reclamation may be used depending on the method of soil salvage at the time of construction, as discussed below.

- **Option A - partial peat salvage will result in partial fill removal -** portions of fill and geo-textile may remain in place, as sufficient soil material will be available for replacement over this material, after de-compaction and re-contouring has been completed. Portions of the fill material will likely be removed in this scenario as well, exposing the underlying organic soils;
- **Option B – no peat salvage will result in full or complete fill removal -** all fill and geo-textile material will be removed exposing the underlying peat surface will be de-compacted to allow for revegetation and water movement; and
- **Option C – complete peat salvage will result in no fill removal -** most of the fill material will remain in place, as sufficient soil material will be available for

replacement over this material, after de-compaction and re-contouring has been completed.

The appropriate reclamation method with be based on site specific characteristics at the time of reclamation. For the purpose of determining the reclamation material balances, the calculations assume that all peat material > 40 cm thick will be padded over for construction of the Project.

In general, the following reclamation practices will apply to all borrow pits proposed for the Project. All borrow pits will be sloped to 3:1 and soils replaced once all necessary borrow materials have been removed. Approximately one half of each borrow pit will contain a pit area that will likely fill with water and function as a wetland. The remainder of the area will have soil spread near the tops of slopes, then mulch and woody debris spread over this to help prevent soil erosion.

Within the Phase 1 footprint (including plant site), approximately 113,278 m^3 of salvaged soil will be replaced (Tables 3.1.3 and 3.1.4). A range of soil replacement is required to meet equivalent capability. Sunshine is committed to replace sufficient soil materials to ensure that equivalent capability is returned on the reclaimed landscape. If deep organic materials are salvaged, as discussed in Options A, B, C, the reclamation will be conducted as described above. Approximately 56,425 m^3 of upper subsoil material will be replaced over the re-contoured CPF (Table 3.1.4).

Along the access road footprint and associated borrow pits, approximately 129,962 m^3 of soil material will be salvaged and replaced (Table 3.1.5). Soil material salvaged from surface pipelines, powerlines and road ditches will be immediately replaced and revegetated on the right of ways post-construction to minimize impacts related to erosion. Soil salvage and replacement activities for the borrow pits associated with the access road will be identical to the borrow pit located within the SAGD footprint.

3.1.7 Reclamation of Compacted Areas

Surfaces receiving gravel treatments, such as the working surface of access roads, central facilities and well pads, will all be subjected to significant load applications and traffic over their life. These areas will become relatively compacted compared to undisturbed soils.

Sunshine will ensure that compacted subgrades along the access roads are deep-ripped or "subsoiled" prior to replacement of soil. These activities will help ensure that densities of the formerly compacted soils are not significantly different from that of nearby undisturbed lands.

In areas where it is decided to remove all geo-textile and fill material used to pad over deep organic materials, the peat surface will be de-compacted to allow for vegetation establishment and water flow throughout the peat landforms.

3.1.8 Post Reclamation Land Capability

The post reclamation land capabilities will be similar to the ratings determined for the baseline soil map units, as shown on Figure 2.2.1 and listed in Tables 2.2.1 and 2.2.2. In areas where the soil profile was disturbed as a result of the Project, appropriate reclamation activities will be undertaken as discussed in Section 3.1.5 Soil Replacement Plan. Once the reclaimed soil profiles have been created and appropriately conditioned, the site can be revegetated to near original patterns. Tables 3.1.6 and 3.1.7 display the anticipated reclaimed forest soil land capability classification system (LCCS) rating of the reclaimed soils post reclamation, and Figure 3.1.2 displays the reclaimed ratings within the Phase 1 footprint and access road footprint, respectively.

Table 3.1.6 Predicted Reclaimed Land Capability for the Phase 1 Footprint

Project Footprint (ha)	Forest Soil Capability Rating						
	Class 1	Class 2	Class 3	Class 4	Class 5	Wetland*	Total Area
Plant Site			12.4	6.4	10.5		**29.3**
Access/Utility Corridor			1.5	1.1	1.5		**4.1**
North Pad				0.6	4.3		**4.9**
Borrow Pit 1			5.8	0.4		2.6	**8.8**
Construction Camp			3.7		1.3		**5.0**
South Pad			2.9		1.5		**4.4**
Supervisor's Camp			1.2				**1.2**
Operator's Camp			2.4		0.5		**2.9**
Total	**0.0**	**0.0**	**30.0**	**8.5**	**19.6**	**2.6**	**60.7**
% of Footprint	**0.0%**	**0.0%**	**49.4%**	**14.0%**	**32.3%**	**4.3%**	**100.0%**

* Predicted area of shallow wetlands created as a result of borrow development.

Table 3.1.7 Predicted Reclaimed Land Capability for the Access Road

Project Footprint (ha)	Forest Soil Capability Rating						
	Class 1	Class 2	Class 3	Class 4	Class 5	Wetland*	Total Area*
Borrow Pit 2			3.8			1.8	**5.6**
Borrow Pit 3			3.3			1.2	**4.5**
Borrow Pit 4			3.4		1.5	1.5	**6.4**
Borrow Pit 5		3.8				2.2	**6.0**
Main Access Road		0.7	23.5	5.3	15.8		**45.3**
Total	**0.0**	**4.5**	**34.0**	**5.3**	**17.3**	**6.7**	**67.8**
% of Footprint	**0.0%**	**6.6%**	**50.2%**	**7.8%**	**25.5%**	**9.9%**	**100.0%**

* Predicted area of shallow wetlands created as a result of borrow development.

Although the shape of the soil polygons will be altered as a result of the development, the reclaimed capability will be similar to pre-existing patterns. The forest soil land capability classification system (LCCS) ratings assigned to the baseline soil map units and reclaimed LCCS ratings are not meant to imply that the identical soil profiles and distribution of soils determined in the baseline case will exist upon completion of reclamation. The reclaimed LCCS values were calculated using the physical and chemical characteristics of representative soil series and variants recorded in the baseline conditions of each map unit, blended as appropriate, and based on the anticipated soil salvage, storage and eventual replacement. Examples of the LCCS calculations are provided in the baseline soil survey and terrain assessment - Appendix F (MEMS 2008).

The reclaimed LCCS ratings are not meant to mimic or represent duplication of the baseline conditions, but rather represent the likely composition of expected reclaimed soil profiles based on the original soil types within the baseline map units. For example, the WHMaapt soil contains a thick surface peat layer over medium textured material (B & C horizon), it is expected that the reclaimed profile will contain a similar profile orientation (peat layer over mineral) and contain blended physical and chemical characteristics similar to the baseline profile with respect to horizons expected to become admixed during salvage and storage (i.e. topsoil material “blended” with overlying litter material). It is possible that the soil capability may be improved as a result of the mixing that will occur at the final reclamation stage, which may create a more favourable growth medium for vegetation.

The reclaimed suitability ratings anticipated for the Phase 1 footprint and the access road footprint are similar to the baseline ratings calculated. In many instances the ratings of the reclaimed map units varied slightly (2-5 points) from the baseline LCCS ratings as a result of the assumptions (decreased organic matter, firmer soil structure, changes in soil nutrient regimes); however, none of the reclaimed map units dropped a rating class. The only changes associated with the post reclamation ratings are due to the creation of wetlands/shallow water bodies in the borrow pits.

3.2 Revegetation

Sunshine will follow the recommendations provided by the Oil Sands Vegetation Reclamation Committee. The committee’s report, “Guidelines for Reclamation of Terrestrial Vegetation in the Alberta Oil Sands Region” (Oil Sands Vegetation Reclamation Committee 1998), forms the basis for future revegetation activities on reclaimed sites within the SAGD and access road footprints.

The primary objective of the revegetation program is to provide a range of site conditions suitable to support plant communities capable of developing into self-sustaining forest ecosites that will provide for watershed protection, traditional land uses, wildlife habitat and commercial forest production, with possibilities for recreation and other end uses.

To meet this objective, Sunshine is committed to a reclamation program that will promote the development of a diversity of self-sustaining vegetation communities throughout its reclaimed leases. The revegetation plan is intended to follow an ecosystem-based approach for establishment of suitable reclaimed site conditions for the Project area.

Natural recovery of the plant community can be a viable and effective revegetation strategy. The level of revegetation effort and the time required for natural recovery to adequately revegetate these sites is determined in large part by the degree of disturbance. For the Project, the degree of site disturbance will be used as an integral part of reclamation and revegetation to maximize the effectiveness of the natural recovery strategy. Each of the Project developments is described below in terms of the relative degree of disturbance they are expected to generate.

3.2.1 Revegetation Practices

Revegetation practices are designed to enhance the natural recovery of vegetation communities. On those sites where the level of disturbance is low, natural recovery is expected to occur without additional revegetation activities. Where the degree of disturbance is higher, additional revegetation activities may need to be employed.

On those sites with higher degree of disturbance, landform and soil texture and drainage become important factors in determining revegetation practices. Site characteristics such as slope, aspect, topography, and slope position become important in determining the most effective methods to encourage natural recovery.

Salvage and direct placement of soil onto reclamation sites normally enhances natural recovery of vegetation communities because of the relatively large volume of viable seed, roots and other plant material fragments transferred with the soil. Directly replaced soil requires less revegetation effort to achieve reclamation objectives. Soil replacement type is also an important factor in determining a revegetation strategy.

Most soil to be used in the reclamation program for this Project will be either peat or mineral soil, and most will have been in stockpile or covered by fill material for extensive periods prior to placement or refurbishment. This material will have little viable seed or root material remaining, and will need more revegetation effort to achieve objectives. Opportunities for direct replacement, as with most SAGD Projects will be limited to ditches along access roads and surface pipelines.

Revegetation practices to be employed as part of the reclamation program are discussed in terms of the degree of disturbance experienced:

- **Low degree of disturbance** - seismic lines, power lines and road/corridor rights-of-way. On these sites, rollback will be completed (unless it is determined that access is to be maintained to meet other land use objectives). Natural recovery is expected to redevelop native plant communities that are similar in composition to those of adjacent undeveloped areas. No further revegetation activities will be conducted unless site-specific conditions warrant, e.g. a steeper, potentially erodable slope that needs runoff diversion work and/or revegetation;
- **Moderate degree of disturbance** - pipelines and corridor soil stockpile sites. When the pipeline or soil stockpile is removed from these sites, the capability of the underlying native soil is expected to recover quickly. On these sites, rollback will be brought back (if available) and a short-lived nurse crop may be seeded. This nurse crop will provide short-term erosion control and leave a protective layer of organic matter that will help to encourage natural recovery of the vegetation communities. On those sites where erosion is not an issue, a nurse crop may not be necessary. Tree planting will be conducted on those upland reclaimed disturbances that had a tree cover prior to disturbance. On poorly drained sites, natural recovery will be relied upon for woody species re-establishment. Tree planting will reduce the time needed for these sites to regain a forest cover; otherwise, it is expected that a full range of herbaceous and shrub species will re-establish naturally; and
- **Highest degree of disturbance** - well pads and the central processing facility. After the soil profile on these sites has been reclaimed, natural recovery will be encouraged through the application of a short-lived nurse crop of barley or other agronomic species and subsequent planting with tree seedlings. The nurse crop will provide short-term cover, a protective organic layer, and conditions that will encourage the natural ingress of locally native herbaceous plants, shrubs and trees.

Some areas located in the vicinity of streams or watercourses may be sensitive to soil erosion. In such areas, the value of watershed protection supersedes other vegetation objectives, and special measures are required to stabilize soils including the use of agronomic species that are effective due to their quick establishment. In consultation with the department of Sustainable Resource Development (SRD), Sunshine will select an approved seed mix that will be used in such areas.

Weed control, by picking or spraying, will be undertaken as required. Revegetation of disturbances will be phased to coincide with construction activities to limit the area of exposed soil at any one time.

As reclamation proceeds, monitoring of reclamation and revegetation performance over time allows land use objectives to be reviewed and adjustments made to site conditions according to natural revegetation processes. The intent of adaptive management is to facilitate and respond to the soil replacement and revegetation process to meet specific objectives.

3.2.2 Woody Species Planting

Establishment of woody plants in reclamation areas is an important part of revegetation activities. Selection of species and the proportion of each species in the supplemental planting mix are based on:

- expected growth of woody-stemmed species from seeds and root fragments in the replaced soil;
- woody-stemmed species common to the ecosites;
- existing field conditions;
- vegetation type or types desired for development on the site, based on end land use objectives and landscape terrain features; and
- the ability to produce the species at a practical scale.

The planting prescription for establishing woody species on the Project's footprints will consider ecological site characteristics, land use objectives for the site, the degree of disturbance, and the likelihood that woody plants will recover naturally. Where feasible, the planting prescription will use those species that are present within the adjacent ecosite.

3.2.3 Post Reclamation Ecosites

With the incorporation of the reclamation and revegetation practices previously discussed, Tables 3.2.1 and 3.2.2 provide the predicted post disturbance/reclaimed ecosites for the Phase 1 footprint and the access road footprint, respectively. The post disturbance ecosite phases are also shown on Figure 3.2.1 for the Phase 1 and access road footprints.

Table 3.2.1 Reclaimed Ecosites for the Phase 1 Footprint

Ecosite	Footprint (ha)									
	Plant Site	Borrow Pit #1	Construction Camp	North Pad	Operator's Camp	South Pad	Supervisor's Camp	Utility Corridor	Total	% of Footprint
d	12.3	6.3	3.1		2.9		1.2	1.6	**27.4**	**45.1**
h			0.9			2.9			**3.8**	**6.3**
i				0.6				0.7	**1.3**	**2.1**
j	9.4			4.3		1.5		1.6	**16.8**	**27.7**
k	7.6		0.9					0.3	**8.8**	**14.5**
ponds		2.6							**2.6**	**4.3**
Total	**29.3**	**8.9**	**4.9**	**4.9**	**2.9**	**4.4**	**1.2**	**4.2**	**60.7**	**100.0**

Table 3.2.2 Reclaimed Ecosites for the Access Road Footprint

Ecosite	Footprint (ha)						
	Access Road	Borrow Pit #2	Borrow Pit #3	Borrow Pit #4	Borrow Pit #5	Total	% of Footprint
c	3.3					**3.3**	**4.9**
d	11.6	3.8	2.7	3.5	3.7	**25.3**	**37.3**
g	5.9			0.3		**6.2**	**9.1**
h	1.9		0.6			**2.5**	**3.7**
i	20.5			1.2		**21.7**	**32.0**
j	1					**1.0**	**1.5**
k	1.1					**1.1**	**1.6**
ponds		1.8	1.2	1.5	2.2	**6.7**	**9.9**
Total	**45.3**	**5.6**	**4.5**	**6.5**	**5.9**	**67.8**	**100.0**

4.0 RECLAMATION MONITORING PROGRAM

As the life of the Project progresses and production decreases, reclamation will be carried out as components of the Project are no longer required so that the active footprint within the Project area is minimized. Reclamation monitoring will be incorporated into an annual report to be used to document the success of reclamation efforts and, over time, to refine measures according to site-specific conditions.

4.1 Monitoring Objectives

The objectives of the reclamation monitoring program are to evaluate the success of reclamation measures and to adjust or modify those measures where necessary to ensure:

- natural recovery of desired plant communities;
- erosion control and slope stability;
- self-sustaining vegetation cover on all disturbed areas;
- noxious weed control;
- establishment of the designated end land uses; and
- reclamation certification.

The objectives will be met through regular site inspection of the Project area, implementation of additional reclamation measures (if necessary), and evaluation of the results of monitoring programs on all reclaimed areas and extrapolation of data from other oil sands and heavy oil projects.

Sunshine will produce an annual C&R report. This report will summarize the year's activities in terms of development activities, assessments completed on facility areas to be constructed in the following year, reclamation activities, reclamation monitoring, and planned activities for the following year. This report will be submitted to Alberta Environment.

4.2 Monitoring Schedule

Reclamation monitoring will be consistent with the Project development schedule to ensure that reclaimed sites are fully documented according to the types of reclamation measures employed in the area. Information on each reclamation site will include:

- a description of the type of development (e.g., central plant sites, well pads, roads);
- a description of the reclamation activity (e.g., re-contouring, soil depths, seeding, tree planting);
- the date when the reclamation activities took place; and
- the end land use objectives that were established for each site.

4.2.1 Revegetation Monitoring

Each reclaimed area will be inspected after the first growing season following site landscaping, soil replacement and revegetation. The inspections will be used to gauge the success of initial revegetation activities and to evaluate conditions designed to encourage natural recovery. The assessments will include information regarding soil stabilization, erosion control and the status of herbaceous vegetation growth, including dominant species composition.

Subsequent annual inspections will be undertaken to monitor the continued establishment of the vegetative cover and progress towards natural recovery of plant communities, as well as to identify requirements for follow-up activities. The annual program will include a routine maintenance component to address any site erosion repair and control as well as any supplemental seeding and fertilizing needs for the reclaimed sites. Noxious weeds will also be identified and removed in consultation with the local reclamation inspector.

Assessments of older reclaimed areas will be conducted on a less frequent basis if deemed necessary at the time. For example, stocking and growth measurements will be recorded for all commercial tree species, including planted stock and naturally established seedlings.

Information collected from the monitoring program will allow further evaluation of the reclamation techniques and measures used for various sites. The data will be incorporated into the reclamation database for subsequent reference on the status of all reclaimed sites.

4.2.2 Terrain and Soils Monitoring

Soil and slope stability monitoring of all reclaimed sites will be undertaken in conjunction with the revegetation assessment, using a combination of site observations and systematic transects. The performance of reconstructed soils is a key element in erosion control, watershed protection and ecosystem sustainability. Sunshine will monitor the capability of reclaimed soils to support vegetation growth by comparing soil physical and chemical parameters on the reclaimed sites with the *Land Capability Classification System for Forest Ecosystems in the Oil Sands* (CEMA, 2006).

4.2.3 Wildlife Monitoring

Sunshine will include a wildlife monitoring program as a component of its reclamation activities. Monitoring wildlife use of both natural and reclaimed areas within the study areas will provide information on the success of re-establishing wildlife habitat. Previous experience from other developments in the region has shown that wildlife will begin using the reclaimed area as soon as the herbaceous vegetation cover has been established. The diversity of wildlife use tends to increase over time as the vegetation cover increases and as shrub and tree species colonize the area.

Initially, the wildlife monitoring program will largely be confined to observational recordings and incidental information on general wildlife use of the reclaimed areas. More systematic approaches to monitoring the reclaimed sites for wildlife will be considered as the reclaimed areas mature.

5.0 ABANDONMENT AND CLOSURE

At the end of the 25 year life of the Project, project facilities will be decommissioned. In compliance with the Alberta Environmental Protection and Enhancement Act (EPEA) Approval, an abandonment and reclamation plan will be submitted to AENV six months before decommissioning of the surface facilities. It is envisioned that abandonment and closure plans will address the following:

- the use of an adaptive management approach that incorporates knowledge learned during the operation of the Project;
- undertaking site assessments on all facilities to characterize and delineate any soil or groundwater contamination present. Remediation will also be undertaken, as required;
- removal of surface structures and equipment. Wells will be cemented, cut off 1.2 m below the surface, and blanked off. Steel piping will also be cut off 1.2 m below the surface;
- abandonment of all production, geotechnical and hydrogeological monitoring wells in accordance with ERCB and AENV standards;
- reclamation of mud pits and the oily waste holding facility by relocating all contents of these facilities to an agreed upon location then addressing any remaining soil or groundwater contaminant issues;
- abandonment of access roads and removal of culverts;
- re-contouring all sites to restore natural drainage patterns and topography;
- ripping, as required, to alleviate surface compaction of well pads, roadways, and facility pad areas;
- replacement of subsoil on the central processing facility;
- placement of soil over the disturbed area followed by revegetation activities;
- reclamation of peat landscapes to ensure reclaimed landscapes are appropriate for successional vegetation to eventually achieve the desired ecosite community;
- promotion of natural recovery of vegetation as the primary means of ground cover re-establishment. Where necessary, specific sites will be seeded with either a nurse crop or longer-lived, non-invasive vegetation cover and planted with tree species consistent with the revegetation plan;

- undertaking regular monitoring and maintenance activities, following revegetation, to assess reclamation success and identify areas of concern; and
- undertaking a post-reclamation site assessment to determine the status of the site prior to applying for a reclamation certificate.

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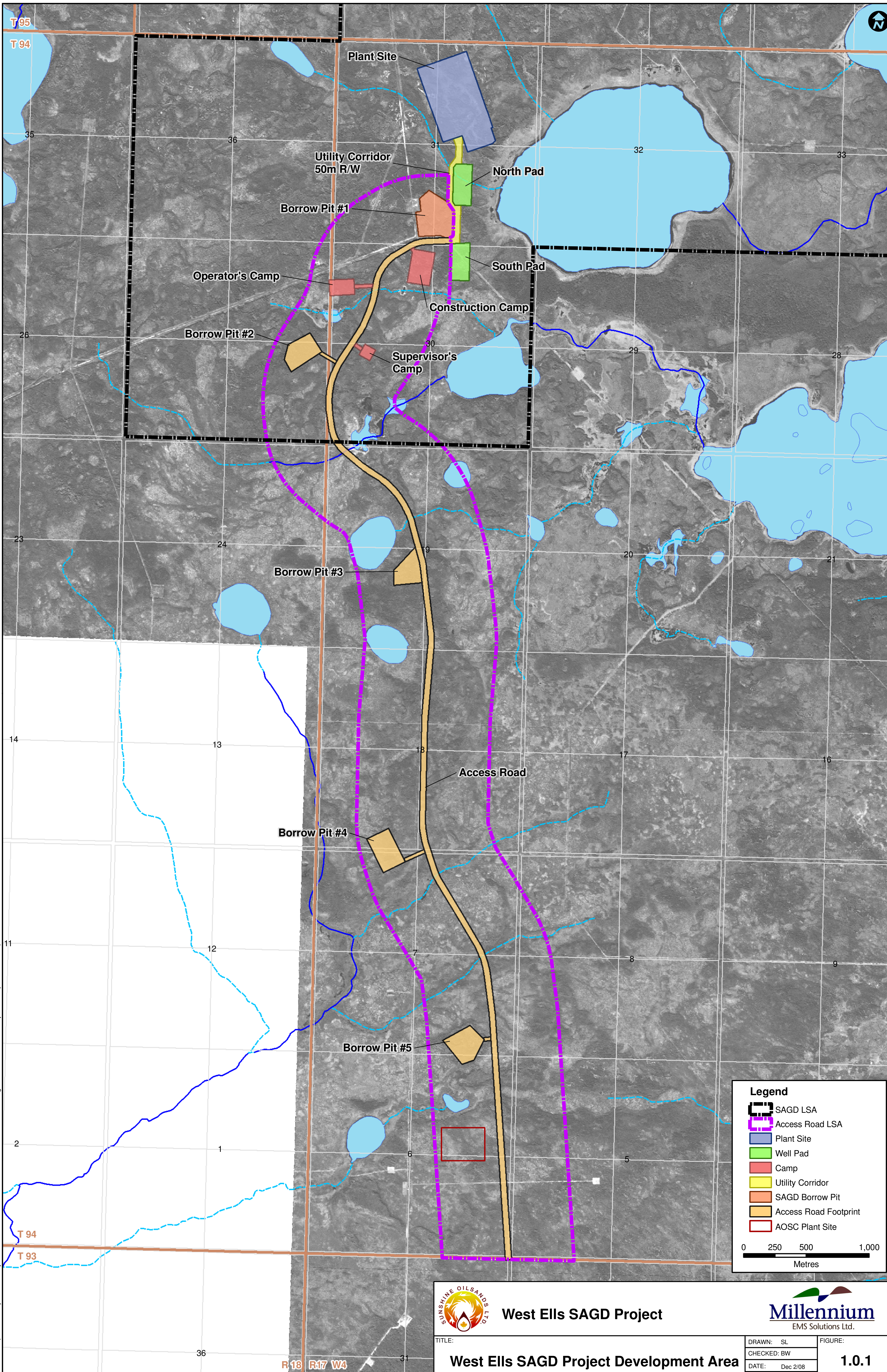
FIGURES



SUNSHINE OILSANDS LTD

West Ells SAGD Project

Millennium EMS Solutions Ltd.

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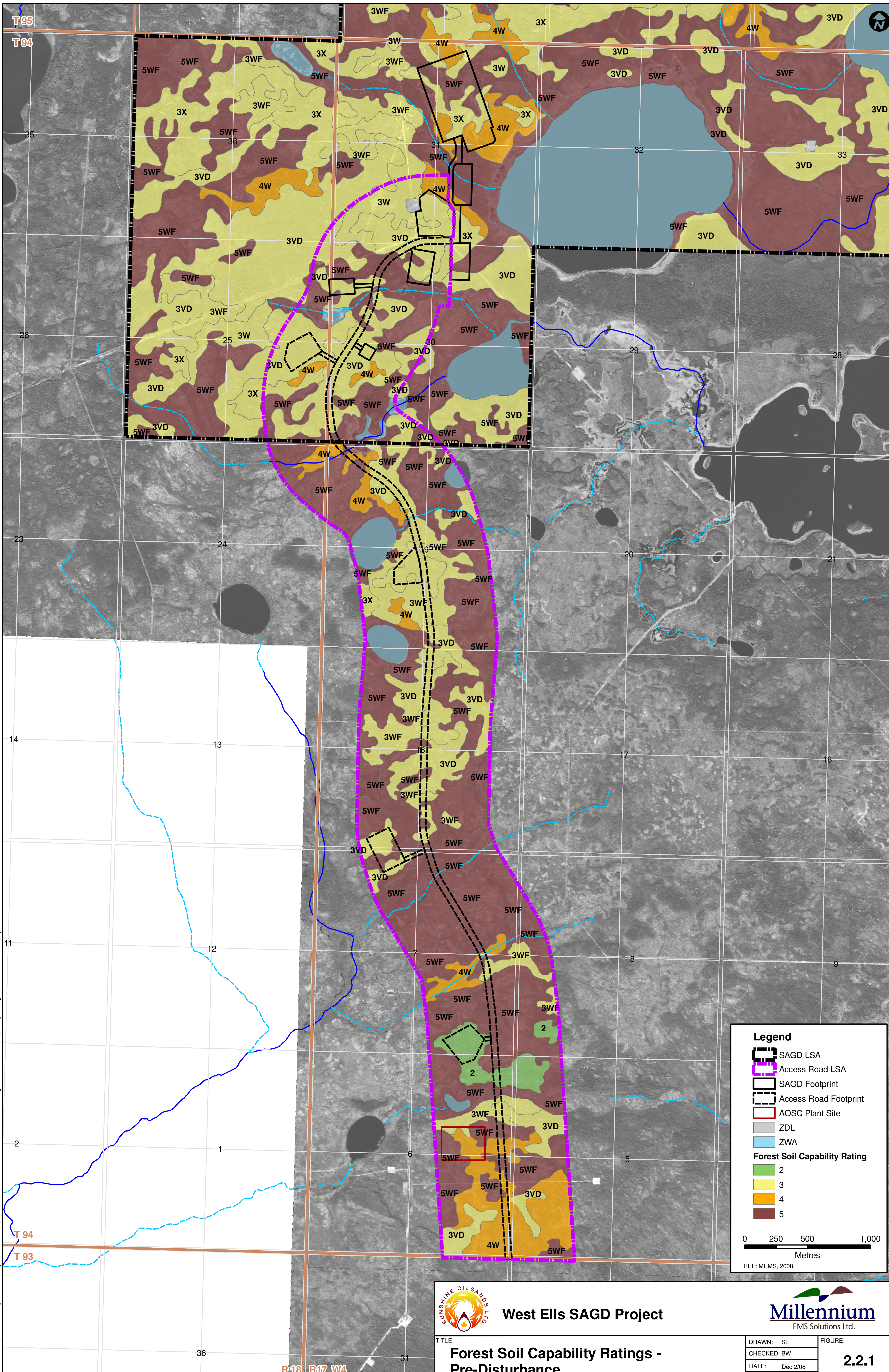

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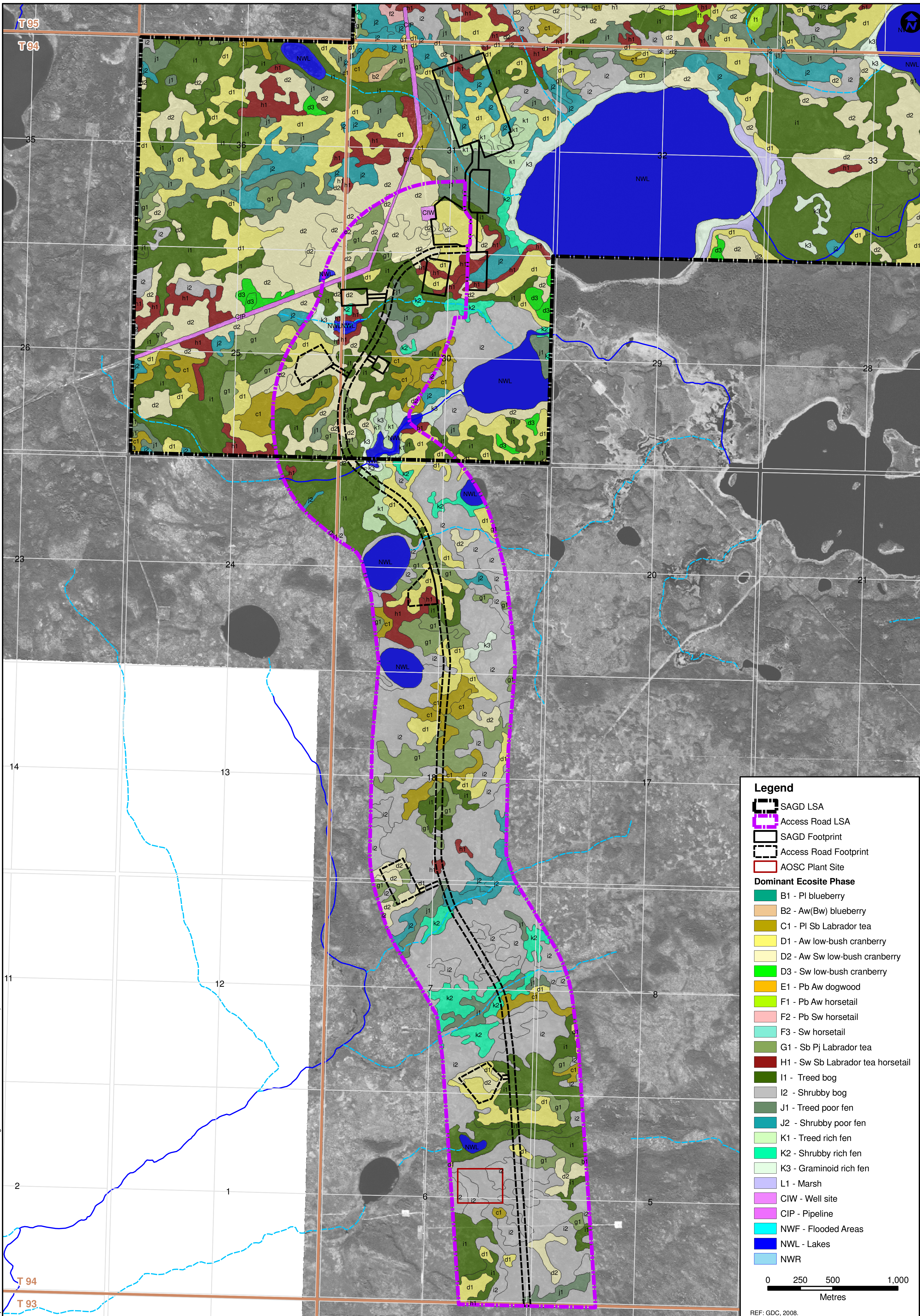

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West Ells SAGD Project

Millennium EMS Solutions Ltd.

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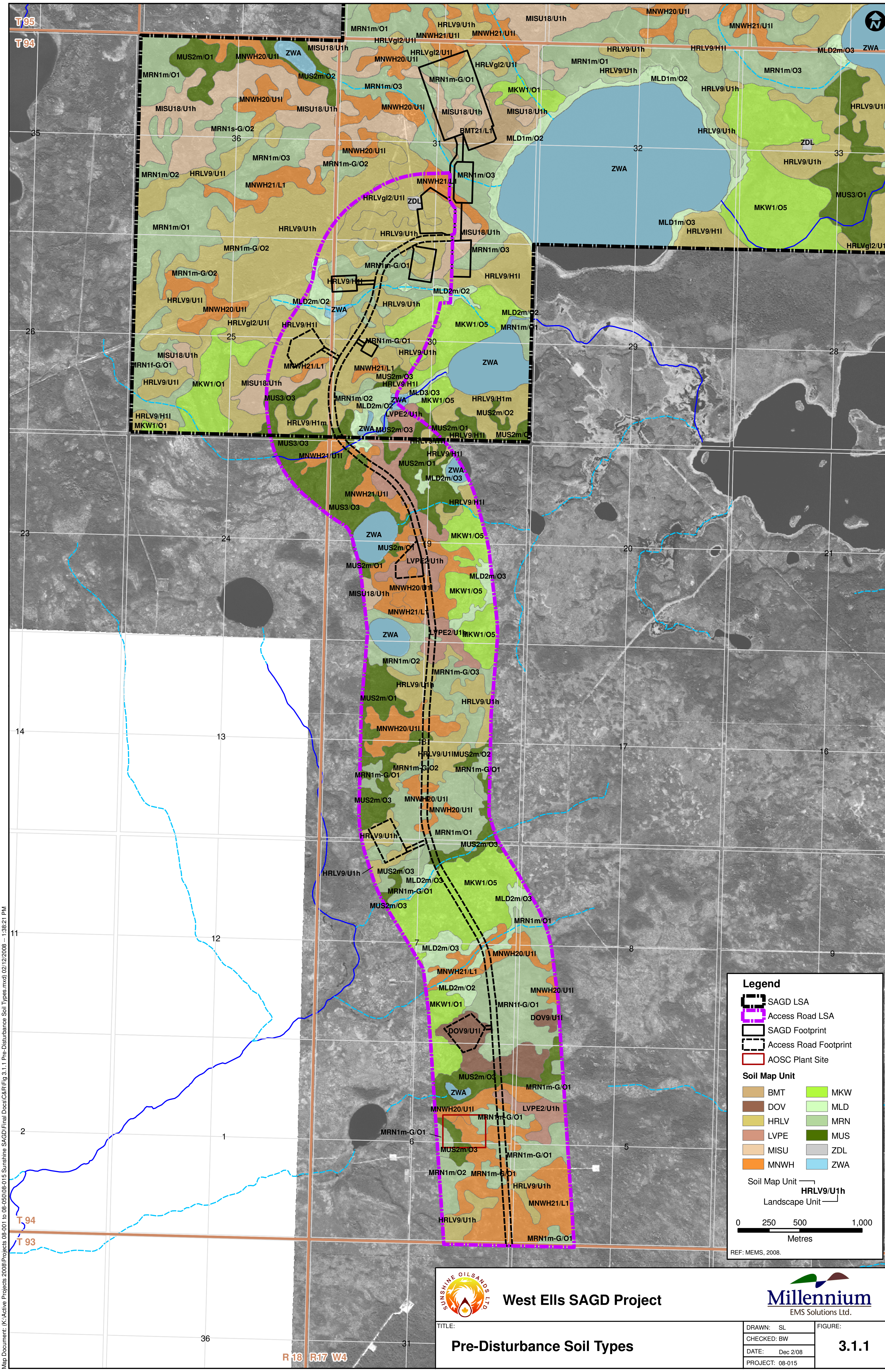
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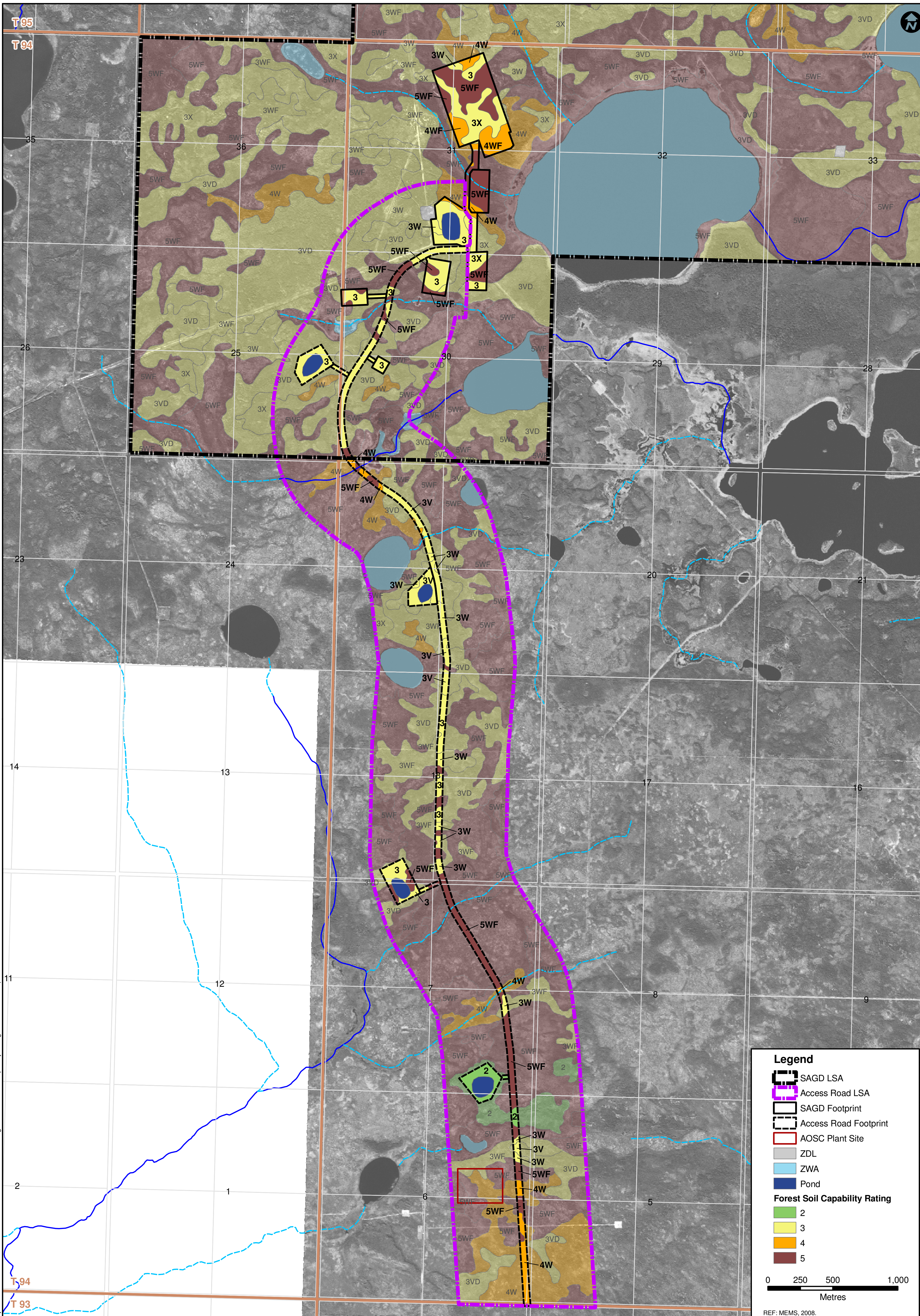

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Millennium EMS Solutions Ltd.

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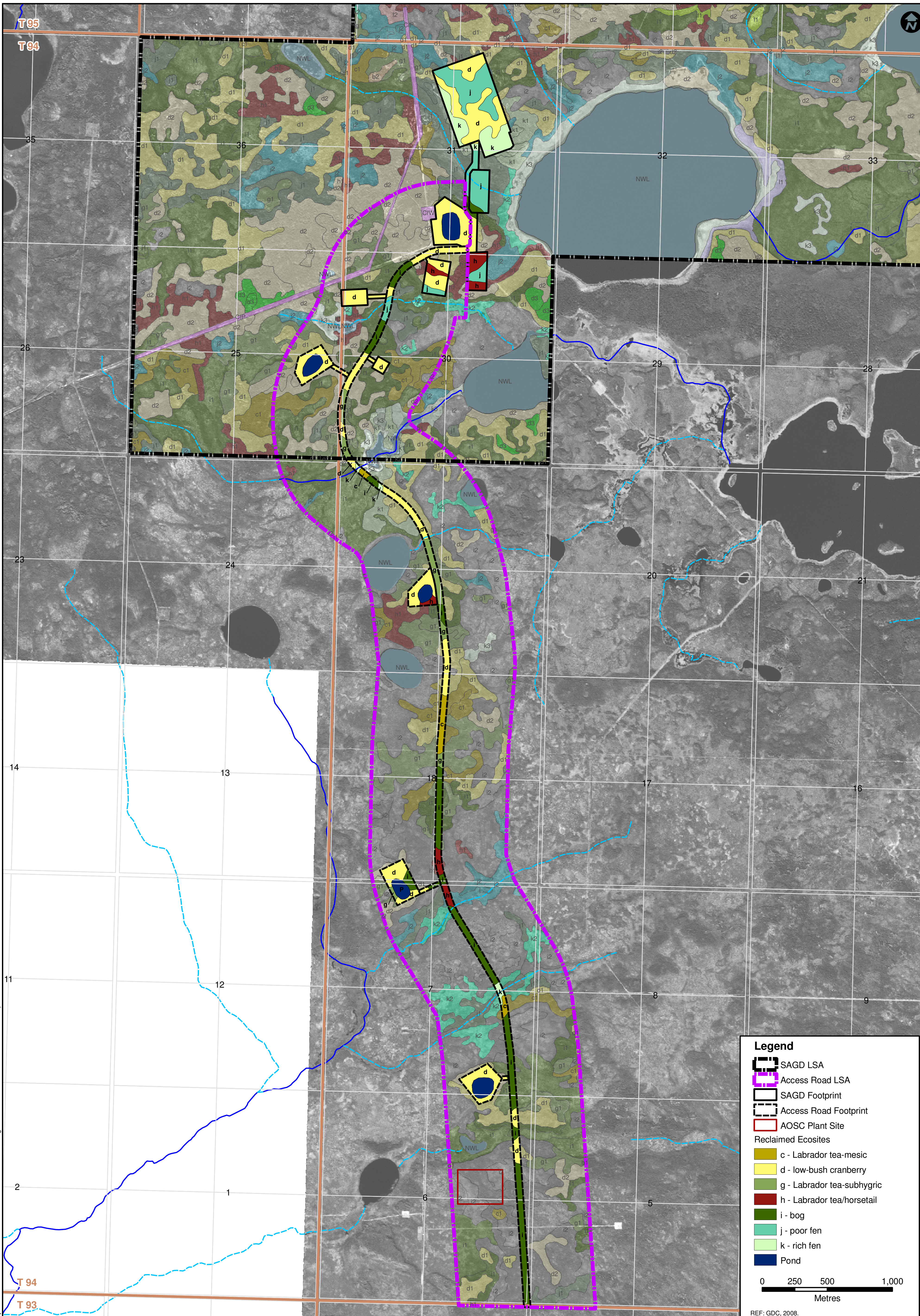

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Hatfield
CONSULTANTS

Surface Aquatic Resources Baseline and Environmental Assessment for Sunshine Oilsands West Ells Project

December 2008

Prepared for:

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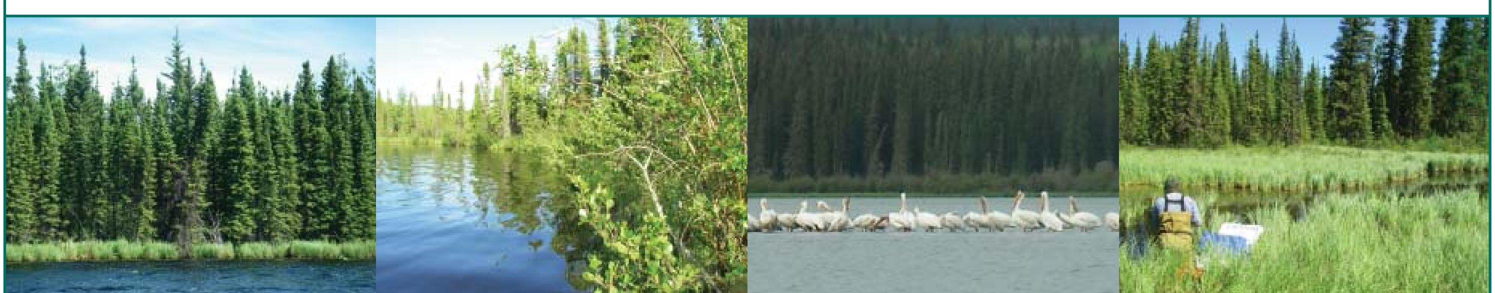

SURFACE AQUATIC RESOURCES BASELINE AND EFFECTS ASSESSMENT FOR SUNSHINE OILSANDS WEST ELLS PROJECT

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DECEMBER 2008

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TABLE OF CONTENTS

LIST OF TABLES ii
LIST OF FIGURES ii
LIST OF APPENDICES iii

1.0 INTRODUCTION 1
1.1 PROJECT LOCATION AND SCOPE 1
1.2 LOCAL STUDY AREA 1
1.3 GOVERNMENT REGULATION AND POLICY 1
1.4 DATA SOURCES 2

2.0 FIELD METHODS FOR BASELINE STUDIES 2
2.1 SURFACE WATER QUALITY SURVEYS 2
2.2 AQUATIC HABITAT SURVEYS 3
2.3 FISH INVENTORIES 3

3.0 SURFACE AQUATIC RESOURCES BASELINE CONDITIONS 4
3.1 REVIEW OF EXISTING INFORMATION 4
3.2 FISH RESOURCES 4
3.2.1 Minnow Trapping 5
3.2.2 Backpack Electrofishing 7
3.2.3 Gillnetting 7
3.2.4 Fish Size 8
3.3 SURFACE WATER QUALITY 9
3.4 AQUATIC HABITAT 10
3.4.1 Lakes 10
3.4.2 Streams 10

4.0 EFFECTS ASSESSMENT 13
4.1 IDENTIFICATION OF KEY ISSUES 13
4.2 LOCAL EFFECTS ASSESSMENT FOR SUNSHINE PROJECT 13
4.2.1 Effects of Project Activities on Surface Aquatic Resources from Changes in Groundwater Quantity 13
4.2.2 Effects of Project Activities on Surface Aquatic Resources from Changes in Groundwater Quality 13
4.2.3 Effects of Project Activities on Surface Aquatic Resources Caused by Input to Surface Waters via Surface Runoff and Sediment Loading 14
4.2.4 Changes in Fisheries Resources Caused by Increase in Fishing Pressure and Harvest 15
4.2.5 Effects of Sunshine Access Road Stream Crossing on Surface Aquatic Resources 16
4.3 EXPECTED REGIONAL EFFECTS OF THE PROJECT 17

4.4 ENVIRONMENTAL MONITORING..17
4.4.1 Construction Monitoring 17
4.4.2 Effects Monitoring 17

5.0 REFERENCES...18

LIST OF TABLES

Table 1 Summary of fish species collected during aquatic resources baseline field studies, June 2008. 5

Table 2 Minnow trap fish inventory results from aquatic resources baseline field studies, June 2008. 6

Table 3 Electrofishing fish inventory results from aquatic resources baseline field studies, June 2008. 7

Table 4 Gillnet fish inventory results from aquatic resources baseline studies, June 2008. 8

Table 5 Mean length, weight, and Fulton's condition factor (± 1SD) of all fish measured during baseline field studies, June 2008. 9

Table 6 Water quality results from surface aquatic resources baseline field studies, June 2008. 11

LIST OF FIGURES

Figure 1 Sunshine Oilsands Ltd., West Ells Project aquatic resources study area. 20

Figure 2 Sunshine Oilsands Ltd., West Ells Project footprint and June 2008 aquatic resources baseline sampling locations. 21

Figure 3 Summary of FMIS historical sampling locations and fish species captured, 1996 to 2003. 22

Figure 4 Aquatic habitat survey results for Lake 1, June 2008. 23

Figure 5 Aquatic habitat survey results for Lake 2, June 2008. 24

Figure 6 Aquatic habitat survey results for Lake 3, June 2008. 25

Figure 7 Aquatic habitat survey results for Lake 4, June 2008. 26

Figure 8 Aquatic habitat survey results for Lake 5, June 2008. 27
Figure 9 Aquatic habitat survey results for Lake 6, June 2008. 28
Figure 10 Aquatic habitat survey results for Lake 7, June 2008. 29
Figure 11 Aquatic habitat survey results for Lake 8, June 2008. 30
Figure 12 Aquatic habitat survey results for Lake 9, June 2008. 31
Figure 13 Aquatic habitat survey results for stream sample site 1, June 2008. 32
Figure 14 Aquatic habitat survey results for stream sample site 2, June 2008. 33
Figure 15 Aquatic habitat survey results for stream sample site 3, June 2008. 34
Figure 16 Aquatic habitat survey results for stream sample site 4, June 2008. 35
Figure 17 Aquatic habitat survey results for stream sample site 5, June 2008. 36
Figure 18 Aquatic habitat survey results for stream sample site 7, June 2008. 37
Figure 19 Aquatic habitat survey results for stream sample site 8, June 2008. 38
Figure 20 Aquatic habitat survey results for stream sample site 9, June 2008. 39

LIST OF APPENDICES

Appendix A1 QA/QC Water Quality Analysis

1.0 INTRODUCTION

This report presents results of a baseline study and effects assessment for surface aquatic resources (water quality, fish, and fish habitat) for the proposed Sunshine West Ells SAGD Project – Phase 1 ("the Project") in the Athabasca oil sands region of Alberta. The report was prepared by Hatfield Consultants for Sunshine Oilsands Limited (Sunshine) as a component of an integrated formal application by Sunshine to the Alberta Energy Resources Conservation Board (ERCB) and Alberta Environment (AENV).

1.1 PROJECT LOCATION AND SCOPE

The proposed Project will be located in Townships 94-95 and Ranges 17-18 W4M, within the Dover River and Snipe Creek drainages of northeastern Alberta (Figure 1). Dover River and Snipe Creek are both tributaries to the MacKay River watershed, a well-studied tributary of the Athabasca River. The Project development area (Sections 30 and 31, Township 94, Range 17 W4M) will include two well pads, a processing plant, one borrow pit, a camp, a utility corridor, and associated infrastructure and facilities. In addition, an access road and associated borrow pits will be constructed south of the Project development area to connect the Project to the provincial highway network (Figure 2).

1.2 LOCAL STUDY AREA

The Local Study Area (LSA) used in this report encompasses the uppermost portion of the Dover River watershed, and a small section of the upper-Snipe Creek watershed (Figure 2). The LSA was developed based on the locations of the proposed Project infrastructure components, with the objective of incorporating significant aquatic features in proximity to the Project development area. The LSA extends to the north to include a reference station (site S1), which was selected to provide baseline data for any future aquatic monitoring activities.

1.3 GOVERNMENT REGULATION AND POLICY

This report has been prepared in consideration of the following key government laws, regulations, and standards:

- *Alberta Environmental Protection and Enhancement Act* (AEPEA), with associated regulations and amendments in force;
- *Alberta Water Act* (1999), with associated regulations and amendments in force, particularly the Alberta *Code of Practice for Watercourse Crossings*, (AENV 2000);
- The *Canada Fisheries Act*;
- Surface Water Quality Guidelines for Use in Alberta (AENV 1999); and

- Canadian Council of Ministers of the Environment (CCME) Canadian Water Quality Guidelines (CWQG) (CCME 2007).

1.4 DATA SOURCES

Data sources used in the preparation of this report included specific field studies undertaken in support of this Project and previous EIAs completed for oil sands projects in the Athabasca oil sands region of northeastern Alberta. In addition, a review of existing data present in the Fisheries Management Information System (FMIS) was completed for the Snipe, Dover, MacKay and Ells watersheds.

2.0 FIELD METHODS FOR BASELINE STUDIES

Baseline fieldwork was undertaken between June 20 and 25, 2008 and consisted of aquatic habitat surveys at all 18 sampling locations (Figure 2), and included surface water quality collections (17 locations) and fish inventories (15 locations). Lake sampling was completed from a 16-foot aluminum boat outfitted with a 9.9 horsepower outboard engine. Stream assessments were conducted on foot. All sites were accessed by helicopter, staged from Namur Lake Lodge.

An aerial reconnaissance of the proposed sampling locations was undertaken at the start of the field program. This preliminary assessment resulted in the relocation of S5 to a more substantial tributary, a “no visible channel” site designation for S6, and the addition of S9 to the sample design. Site S9 was selected because of the proximity of the watercourse to the Project footprint. Sunshine will conduct all required formal stream crossing assessments prior to construction, as per Alberta Environment’s *Code of Practice for Watercourse Crossings*.

2.1 SURFACE WATER QUALITY SURVEYS

Water quality sampling was conducted at all 17 wetted sampling locations (Figure 2), according to the standard operating procedures for water quality sampling used by the Regional Aquatics Monitoring Program (RAMP 2005). Water sampling involved the collection of single grab samples by submerging sample bottles to a depth of at least 30 cm, uncapping and filling the bottle, and recapping at depth. Bottles were not rinsed with ambient water prior to sample collection, with the exception of ultra-trace mercury, which was triple-rinsed before sample collection.

At each lake sampling location, *in situ* water quality profiles were collected at 10% intervals of the total depth. At stream sampling locations, near-surface *in situ* water quality measurements of pH, temperature, dissolved oxygen and conductivity were collected using a YSI-650 multi-meter; some temperature and conductivity measurements were collected with a LaMotte Tracer Pocketester. Dissolved oxygen levels were also determined in the field by titration using a LaMotte Winkler titration kit (Code 5860). Turbidity was estimated using a LaMotte 2020 turbidity meter. With the exception of the lake profiles that utilize the YSI-650 field measurements, laboratory-derived pH values have been presented in this report for all sampling locations.

Water samples for laboratory analysis were collected, preserved and shipped according to protocols specified by the consulting laboratories. ALS Laboratory Group (ALS) in Fort McMurray and Edmonton analyzed samples for standard water quality variables, as well as organics/hydrocarbons. Metals (dissolved and total, including ultra-trace total mercury) analysis was carried out by the Alberta Research Council (ARC) in Vegreville, Alberta. A field blank, trip blank, and field split were also collected for quality assurance and quality control (QA/QC) purposes. QA/QC results for water quality are provided in Appendix A1.

2.2 AQUATIC HABITAT SURVEYS

Aquatic habitat surveys were conducted at 18 locations in June 2008 (Figure 2). The survey procedure, adapted from British Columbia Ministry of Fisheries procedures (Anon 1998a, 1998b), evaluates specific habitat elements to provide an overall description of suitability for fish use. Aquatic habitat information recorded at each location included: channel width and dominant bed material; mean water depth; type and proportion of different riparian vegetation classes; proportion of overhead cover and instream cover; proportion of different aquatic macrophytes; and, characteristics of channel morphology. The methodology used took into consideration survey and assessment procedures recommended in a number of Alberta environmental codes of practice, including: (i) *Code of Practice for Pipelines and Telecommunication Lines Crossing a Waterbody*; and (ii) *Code of Practice for Watercourse Crossings*, as well as their associated guidelines.

2.3 FISH INVENTORIES

Fish inventories were undertaken at 15 of the aquatic habitat survey sites (Figure 2), and consisted of a combination of minnow trapping, gillnetting, backpack electrofishing and angling. A Fisheries Research License (#08-0441 FRL) was obtained from Alberta Sustainable Resource Development (ASRD) and endorsed by Hatfield prior to all fish inventory activities.

Fishing gear and deployment procedures at lakes consisted of a combination of:

- Gillnets, each consisting of a set of 50-ft panels, set perpendicular from shore towards the middle of each study lake (three nets consisting of four panels each with mesh sizes of 25, 38, 63, 89 mm);
- Minnow traps deployed around the lake perimeter; and
- Spin-cast angling using a variety of tackle, baited with worms or other fish attractants (where time allowed).

Fish sampling at stream sites consisted of Gee-type minnow trap deployments near the stream banks and electrofishing using a Smith-Root 12B POW backpack electrofisher. Voltage, frequency and pulse settings were adjusted based on site water conductivity. Stunned fish were collected on the anode ring or by the accompanying dipnetter and placed in a bucket for subsequent measuring. Where conditions allowed, all representative habitat types were sampled; however, the depth at three sites (S2, S4 and S5) constrained electrofishing to the stream margins.

Start and end times (i.e., effort), and start and end locations, were recorded for each of the fish inventories conducted. All fish caught were enumerated and identified to the species level when possible. Total lengths (± 0.1 cm) and weights (± 0.1 g) of a representative sub-sample of each captured fish species were recorded for each sampling site. Individual fish conditions were calculated using Fulton's condition formula, as follows:

$$K = \left(\frac{Weight(mg)}{TotalLength(mm)^3} \right) * 100$$

All fish were returned to the location where they were captured, with the exception of three voucher specimens retained for confirmatory identification by a taxonomic specialist. Mr. Wayne Roberts of the Museum of Zoology, Department of Biological Sciences at the University of Alberta, was contracted to provide these taxonomic verifications.

3.0 SURFACE AQUATIC RESOURCES BASELINE CONDITIONS

3.1 REVIEW OF EXISTING INFORMATION

Alberta Sustainable Resource Development (ASRD) maintains the Fisheries Management Information System (FMIS), a database of fisheries data collected under approved fisheries research licenses. No information is available for fish species distribution within the LSA; however, data from two studies (RL&L 1999; Bjornson and Allen 2000) have documented lake chub (*Couesius plumbeus*), white sucker (*Catostomus commersonii*) and brook stickleback (*Culaea inconstans*) in the Dover River watershed. Regionally-relevant historical sampling locations and fish species are presented in Figure 3.

3.2 FISH RESOURCES

A total of 4,124 fish from six species were captured during the Sunshine fish inventory, including three small-bodied fishes (lake chub, fathead minnow [*Pimephales promelas*] and brook stickleback), juveniles of two large-bodied fish species (lake trout [*Salvelinus namaycush*] and white sucker) and adult longnose sucker (*Catostomus catostomus*). Lakes were found to contain four species of fish, and streams contained three species; only one species (brook stickleback) was found in both lakes and streams (Table 1).

Table 1 Summary of fish species collected during aquatic resources baseline field studies, June 2008.

Common Name	Latin Name	Number Captured	% of Total Catch	Lakes	Streams
Brook Stickleback	*Culaea inconstans*	2189	53.1	✓	✓
Fathead Minnow	*Pimephales promelas*	1638	39.7	✓	
White Sucker	*Catostomus commersonii*	13	0.3		✓
Lake Chub	*Couesius plumbeus*	6	0.2		✓
Lake Trout	*Salvelinus namaycush*	2	< 0.1	✓	
Longnose Sucker	*Catostomus catostomus*	275	6.7	✓	
Total		4124			

Brook stickleback was the most common fish species encountered during the inventory, comprising 53.1% of all fish captured. Minnow trapping and electrofishing efforts resulted in brook stickleback captures at both stream and lake sampling locations (Table 2 to Table 4). Although fathead minnow were captured at only one site (L2), it was the second most common fish species, comprising 39.7% of all fish captured. Longnose sucker was the third most common species (6.7%), with all but one individual captured in gillnets at sample site L1 (Table 4).

Minnow trapping, gillnetting and electrofishing conducted in support of this baseline all yielded relatively low fish captures (Table 2 to Table 4). Over 70% of all lakes and streams sampled (sites L3 through L9, and sites S1, S3, and S6 through S9) resulted in no fish captured. No small-bodied fish were captured in gillnets, and no juveniles of large-bodied fish were captured in the minnow traps throughout the duration of the sampling program (Table 2 and Table 4). Based on both relative abundance (catch-per-unit-effort, or CPUE) and total capture numbers, fish were more common in streams than in lakes; this result was strongly influenced by the high numbers of fish captured at sites S2 and S4.

3.2.1 Minnow Trapping

Minnow trapping was conducted at all sampling locations, with the exception of stream sites S3, S6, and S7 (Table 2), which exhibited either inadequate stream depths for effective trap deployment or no visible channel. Minnow trap deployment times in study lakes varied from 17.3 to 179.6 hours, with CPUE ranging from 0 to 9.81 fish/trap-hour. Seven of nine lakes had no fish captured in minnow traps. On average, 5.3 fish were captured per hour of minnow trapping. Species captured in lakes consisted exclusively of two forage fish species (brook stickleback and fathead minnow).

Minnow traps were more efficient at capturing fish in streams than in lakes. The highest CPUE for stream minnow trapping was at site S2 (35.4 fish/trap-hour).

On average, approximately 4.9 fish/trap-hour were captured at stream sampling locations. Two species of fish (brook stickleback and lake chub) were captured in the minnow traps deployed in streams.

Table 2 Minnow trap fish inventory results from aquatic resources baseline field studies, June 2008.

Site	Species	No. Fish Captured	Number of Traps Set	Effort (Trap-Hours)	CPUE (No. Fish/Trap-Hour)
Lakes					
L1	BRST	1219	10	179.59	6.79
L2	BRST	58	9	167.02	0.35
	FTMN	1638			9.81
L3	-	0	10	35.02	0
L4	-	0	9	35.92	0
L5	-	0	9	17.28	0
L6	-	0	9	23.18	0
L7	-	0	10	20.75	0
L8	-	0	10	33.85	0
L9	-	0	10	34.76	0
Mean		**291.5**	**9.56**	**60.82**	**5.32**
Streams					
S1	-	0	3	53.42	0
S2	BRST	806	4	22.78	35.38
S3	no minnow traps set (insufficient water depth)				
S4	BRST	74	3	24.33	3.04
S5	BRST	14	3	8.05	1.74
	LKCH	2			0.25
S6	no minnow traps set (no visible channel)				
S7	no minnow traps set (insufficient water depth)				
S8	-	0	3	70.27	0
S9	-	0	3	5.22	0
Mean		**128**	**3.17**	**30.68**	**4.87**

BRST = brook stickleback; FTMN = fathead minnow; LKCH = lake chub

3.2.2 Backpack Electrofishing

Backpack electrofishing was conducted exclusively at stream locations where conditions (i.e., depth and bank stability) facilitated data collections and ensured field crew safety (sites S4, S5, S8 and S9). Relative abundance of fish captured by electrofishing was highest at site S4, with approximately 115 fish captured for every hour of electrofishing. Electrofishing at site S5 resulted in an abundance estimate of 83 fish/hour, consisting of juvenile white sucker, lake chub, and brook stickleback (Table 3). No fish were captured using backpack electrofishing at sites S8 or S9. Across all sites, approximately 44 fish were captured per hour of electrofishing.

Table 3 Electrofishing fish inventory results from aquatic resources baseline field studies, June 2008.

Site	Species	No. Fish Captured	Effort (Hours)	CPUE (No. Fish/Hour)
S1	no electrofishing conducted			
S2	no electrofishing conducted			
S3	no electrofishing conducted			
S4	BRST	9	0.078	114.91
S5	WHSC	13	0.315	41.26
	LKCH	4		12.71
	BRST	9		28.58
S6	no electrofishing conducted (no visible channel)			
S7	no electrofishing conducted (insufficient water depth)			
S8	-	0	0.329	0
S9	-	0	0071	0
Mean		**5.83**	**714**	**44.14**

BRST = Brook Stickleback; WHSC = White Sucker; LKCH = Lake Chub

3.2.3 Gillnetting

Gillnetting was employed only at lake sampling locations during this study. Gillnets were deployed at all nine lake sites, but were only successful at capturing fish at sites L1 and L2. Two species were captured with gillnets: longnose sucker (sites L1 and L2) and lake trout (site L2 only). Fish captures utilizing gillnets were much more successful at site L1 than they were in site L2 (Table 4). Gillnetting was the only fish sampling method utilized during the program that successfully captured lake trout.

Table 4 Gillnet fish inventory results from aquatic resources baseline studies, June 2008.

Site	Species	No. Fish Captured	Number of Gillnets Set	Effort (Net-Hours)	CPUE (#/fish/Net-Hour)
L1	LNSC	274	3	9.71	28.22
L2	LKTR	2	3	12.32	0.16
	LNSC	1			0.08
L3	-	0	3	11.12	0
L4	-	0	3	10.65	0
L5	-	0	3	4.62	0
L6	-	0	3	7.87	0
L7	-	0	2	2.6	0
L8	-	0	3	11.45	0
L9	-	0	2	7.25	0
Mean		**27.7**	**2.78**	**8.62**	**3.57**

LNSC = Longnose Sucker; LKTR = Lake Trout

3.2.4 Fish Size

Fish captured at each site were measured for length, weight and condition (Table 5). The longest and heaviest fish (longnose sucker) were captured at site L1 using gillnets, while the smallest fish captured were juvenile white sucker from site S5; both white sucker and longnose sucker are considered to be large-bodied fish.

Brook stickleback captured at sites L1 and L2 were of similar lengths, but stickleback captured at site L2 were almost 1 g heavier on average, resulting in an 80% higher mean condition estimate than at site L1. At stream sampling locations, brook stickleback were of similar mean length, although site S4 stickleback were slightly smaller; this difference resulted in a higher mean condition estimate at site S4 compared with sites S2 and S5.

All small-bodied fish captured that were measured were, on average, less than 65 mm and weighed less than 4 g.

Table 5 Mean length, weight, and Fulton's condition factor (± 1SD) of all fish measured during baseline field studies, June 2008.

Site	Species	Length (mm)	Weight (g)	Fulton's Condition Factor	Capture Method
L1	BRST	49.08 ± 6.63 (98)	1.32 ± 0.55 (98)	1.12 ± 0.31 (98)	MT
	LNSC	170.33 ± 57.63 (251)	76.08 ± 86.51 (74)	1.44 ± 0.51 (74)	GN
L2	BRST	48.12 ± 7.21 (58)	2.20 ± 0.36 (3)	2.01 ± 0.34 (3)	MT
	FTMN	60.33 ± 4.88 (100)	3.75 ± 0.9 (100)	1.71 ± 0.37 (100)	MT
	LKTR	120 (2)	-	-	GN
	LNSC	285 (1)	-	-	GN
S2	BRST	53.09 ± 5.48 (100)	1.26 ± 0.32 (100)	0.84 ± 0.16 (100)	MT
S4	BRST	49.01 ± 0.57 (83)	1.15 ± 0.31 (83)	0.98 ± 0.17 (83)	MT, EF
S5	BRST	53.04 ± 7.05 (23)	1.32 ± 0.43 (23)	0.86 ± 0.08 (23)	MT, EF
	LKCH	50.17 ± 31.97 (6)	3.18 ± 4.78 (6)	1.11 ± 0.12 (6)	MT, EF
	WHSC	38.23 ± 3.32 (13)	0.69 ± 0.19 (13)	1.21 ± 0.23 (13)	EF

BRST = brook stickleback; LNSC = longnose sucker; FTMN = fathead minnow; LKTR = lake trout; LKCH = lake chub; WHSC = white sucker

MT = Minnow Trap; GN = Gillnet; EF = Electrofishing

Numbers in brackets indicate sample size.

3.3 SURFACE WATER QUALITY

Field and trip blank results were generally near or below detection limits, although four total metals (copper, lead, manganese and molybdenum) measured in the field blank, and one total metal recorded in the trip blank (boron) exhibited concentrations greater than five times the detection limit (Appendix A1). These results are indicative of low level sample contamination, which may have been introduced during either sample collection or analysis. These results are not atypical, with many water samples collected in other programs exhibiting similar results (e.g., RAMP 2006). The analytical variables measured from the field split samples collected at site L1 showed good agreement, indicating that there is no concern for data accuracy or precision at ambient water concentrations.

Surface water quality results obtained from the aquatic resources baseline field studies are presented in Table 6. The ionic composition of the sampled watercourses was dominated by bicarbonate, sulphate and calcium. Stream waters were generally characteristic of brown-water systems, with sampled true color never below 100 TCU. Sampled watercourses were generally neutral to slightly acidic, while lakes were neutral to slightly alkaline. Both lakes and streams exhibited DOC near to or greater than 30 mg/L, with low levels of TSS, conductivity, TDS, and hardness. Naphthenic acids and recoverable hydrocarbons were consistently below detection limits (Table 6).

Concentrations of total phosphorus, sulphide, and total nitrogen exceeded water quality guidelines for the protection of aquatic life at 8, 10, and 14 of the 17 sample locations, respectively (Table 6). Concentrations of total aluminum, total chromium and total copper exceeded water quality guidelines for the protection of aquatic life at two locations, while concentrations of total iron and total mercury exceeded water quality guidelines at 10 and 1 location(s), respectively. Exceedences of dissolved metals, which are biologically available and therefore toxic to aquatic organisms, were much less frequent. Concentrations of dissolved copper and dissolved mercury both exceeded guidelines at one location, and dissolved iron concentrations exceeded guidelines at nine locations. These results are similar to those observed in regional monitoring initiatives in the Athabasca oil sands region (RAMP 2007).

3.4 AQUATIC HABITAT

3.4.1 Lakes

Lakes sampled for this assessment (Figure 2) have surface areas ranging from 13 to 335 hectares, with maximum depths between 0.9 m and 4.2 m. Littoral zone substrate at all sampling locations was comprised of fines, and shorelines were generally vertical with depths at the banks ranging from 0.5 to 0.7 m. Riparian areas were generally flat, with vegetation consisting of bands of grasses and cattails. Lake habitat summaries are provided in Figure 4 through Figure 12.

3.4.2 Streams

Stream reaches surveyed for this assessment (Figure 2) were generally small to moderate in width and velocity, with riparian vegetation comprised of sedges, shrubs, and immature to established coniferous or mixed forest. Four of the stream sites (sites S2, S3, S7, and S8) had sections within the sampling reach exhibiting characteristics representative of wetlands (diffuse borders with limited to no flow and extensive instream vegetation). The watercourse at site S7 exhibited only an intermittent stream channel, while the watercourse at site S6 did not exist. Site S9 was located at the outlet of a small unnamed lake, where a small, defined channel was observed. A detailed evaluation of this watercourse was completed downstream of site S9, at the north-south oriented cutline visible in Figure 2. This field assessment determined that the mid-section of this drainage consisted of a non-channelized wetland. A more detailed description of this drainage can be found in the surface hydrology component assessment of the Project (nhc 2008).

Crown closure on the sampled reaches was minimal, but stream cover was generally high, with most sites exhibiting greater than 70% total cover for small-bodied fish. Cover was dominated by deep pools and instream and overhanging vegetation. Bed material at all stations consisted of fines (silt and sand) while stream bank shape varied among sites, ranging from nearly-flat wetland areas to steeply sloped banks. Water levels were moderate at the time of survey. Figure 13 through Figure 20 provide summaries of aquatic habitat at each stream sampling location.

Table 6 Water quality results from surface aquatic resources baseline field studies, June 2008.

Water Quality Variable	Units	Guideline	Conversion	Detection Limit	SITE																
					L1	L2	L3	L4	L5	L6	L7	L8	L9	S1	S2	S3	S4	S5	S7	S8	S9
Alkalinity, Total (as $CaCO_3$)	mg/L	-	1000000	5	109	85	74	72	53	79	117	41	55	48	124	74	45	41	37	58	24
Ammonia-N	mg/L	1.37[b]	1.37	0.05	0.09	<0.05	<0.05	0.35	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	0.06	<0.05	<0.05	<0.05	<0.05	<0.05
Bicarbonate (HCO_3)	mg/L	-	1000000	5	114	103	87	88	65	93	143	50	67	59	152	90	55	50	45	71	29
Biochemical Oxygen Demand	mg/L	-	1000000	2	12	3	3	2	<2	2	4	<2	<2	<2	<2	3	<2	<2	<2	<2	2
Calcium (Ca)	mg/L	-	1000000	0.5	28.5	20.7	16.9	18.2	16.9	25	24.6	13.5	26.8	16.1	40.5	27.6	16.2	15.2	11.6	15.4	9.4
Carbonate (CO_3)	mg/L	-	1000000	5	9	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5
Chloride (Cl)	mg/L	230[f]	230	1	2	2	2	2	2	1	2	2	1	2	2	2	2	2	2	2	2
Color, True	T.C.U.	-	1000000	2	71	23	40	68	190	50	40	240	79	100	170	260	190	200	300	190	200
Conductivity (EC)	μS/cm	-	1000000	0.2	228	165	162	144	123	203	225	131	219	106	318	375	117	109	98.9	116	64.8
Dissolved Organic Carbon	mg/L	-	1000000	1	25	21	32	29	34	27	33	40	31	24	37	47	26	28	40	37	36
Dissolved oxygen (*in situ*)	mg/L	5[j]	5		5.74	7.81	**4.47**	6.03	**2.89**	**0.65**	5.48	**3.97**	9.67	10.89	5.59	6.36	9.76	10.57	**1.38**	**0.85**	**1.03**
Hardness (as $CaCO_3$)	mg/L	-	1000000		104	79	66	69	66	103	95	58	104	61	151	104	59	56	48	59	37
Hydrocarbons, Recoverable (I.R.)	mg/L	-	1000000	1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Hydroxide (OH)	mg/L	-	1000000	5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5
Magnesium (Mg)	mg/L	-	1000000	0.1	8	6.6	5.7	5.6	5.9	9.8	8.1	6	9.1	5	10.7	8.4	4.6	4.4	4.7	5.1	3.3
	mg/L	-	1000000	1	<1	<1	<1	<1	<1	<1	<1	<1	1	<1	<1	<1	<1	<1	<1	<1	<1
Nitrate+Nitrite-N	mg/L	[n]		0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
pH	pH	6.5-9.0[o]	1000000	0.1	8.8	8.2	8.5	7.8	7.7	8.5	8.3	7.6	7.9	7.7	7.8	7.4	7.7	7.7	7	7.3	6.9
Phenols (4AAP)	mg/L	0.05[c]	0.05	0.001	0.009	0.006	0.008	0.011	0.017	0.013	0.013	0.019	0.016	0.032	0.021	0.018	0.013	0.012	0.027	0.02	0.034
Phosphorus, Total	mg/L	0.05[r]	0.05	0.001	**0.211**	**0.06**	0.047	0.047	0.027	0.024	0.025	0.042	0.025	0.019	**0.092**	**0.091**	**0.163**	**0.135**	**0.054**	**0.074**	0.045
Phosphorus, Total Dissolved	mg/L	-	1000000	0.001	0.025	0.011	0.026	0.021	0.016	0.01	0.01	0.032	0.016	0.012	0.05	0.041	0.038	0.049	0.038	0.018	0.026
Potassium (K)	mg/L	-	1000000	0.5	1.7	2.6	1.5	1	<0.5	2.7	2.2	1.1	1.1	<0.5	<0.5	0.6	0.7	0.6	0.7	1	0.7
Sodium (Na)	mg/L	-	1000000	1	12	8	12	6	4	5	11	8	9	4	18	44	4	4	6	5	3
Sulfate (SO_4)	mg/L	100[p]	100	0.5	14	4.9	7.7	2.2	7.7	25.5	3.3	14.9	41.5	10	42.3	97.9	13.3	13	10.3	3.8	4.9
Sulphide	mg/L	0.014[s]	0.014	0.002	<0.002	0.006	**0.016**	<0.002	**0.034**	0.012	0.003	**0.039**	**0.026**	0.006	**0.042**	**0.185**	**0.022**	**0.015**	**0.175**	0.01	**0.057**
Temperature (*in situ*)	°C	-	1000000		17.33	19.65	19.69	19.81	19.38	19.64	19.28	18.94	19	8.5	14.7	12.4	12.9	12.6	13.8	15	11.6
Total Dissolved Solids	mg/L	-	1000000	10	180	140	160	140	140	180	190	150	180	110	260	370	130	120	150	130	110
Total Kjeldahl Nitrogen	mg/L	1	1.0	0.2	**3.3**	**1.3**	**2**	**1.8**	**1.2**	**1.6**	**2**	**1.3**	**1.4**	0.6	**1.4**	**1.6**	1	0.9	**1.5**	**1.3**	**1.5**
Total Organic Carbon	mg/L	-	1000000	1	34	22	34	32	35	29	35	40	33	29	37	48	26	27	41	34	39
Total Suspended Solids	mg/L	+10 mg/L[t]	1000	3	16	5	<3	<3	4	6	5	3	4	<3	<3	5	42	31	<3	4	<3
Turbidity (*in situ*)	NTU	-	1000000		7.9	2.7	0.8	3.5	0.3	0.8	1.3	0.4	0.4	0.7	1.1	1.7	16	0.7	1	0.6	1.2
Total Metals																					
Aluminum	mg/L	0.1[a]	0.1	0.002	0.0172	0.0152	0.00725	0.0128	0.0111	0.00893	0.00913	0.0345	0.00977	0.0629	0.0241	0.0684	**1.72**	**1.58**	0.046	0.0344	0.0476
Antimony	mg/L	0.02[h]	1000000	0.000001	0.0000573	0.0000324	0.0000324	0.0000197	0.0000221	0.000032	0.0000246	0.0000259	0.0000254	0.0000336	0.00024	0.0000372	0.0000835	0.0000788	0.0000289	0.000029	0.0000187
Arsenic	mg/L	0.005[c]	0.005	0.00006	0.00205	0.000913	0.000686	0.000498	0.000429	0.00107	0.000631	0.000693	0.000503	0.000425	0.00122	0.000949	0.00233	0.00226	0.000604	0.000767	0.000272
Barium	mg/L	5[h]	5	0.0001	0.0222	0.0247	0.0158	0.0243	0.0133	0.0222	0.0275	0.0102	0.0187	0.0157	0.0282	0.0183	0.0444	0.0444	0.012	0.0232	0.0119
Beryllium	mg/L	0.0053[h]	0.0053	0.00001	0.0000121	<0.000003	0.0000068	<0.000003	0.0000076	0.0000036	0.0000031	0.0000122	0.0000036	0.0000145	0.0000178	0.0000102	0.000082	0.0000756	0.00001	<0.000003	0.0000049
Bismuth	mg/L	-	1000000	0.00001	0.0000026	<0.000001	0.0000018	0.0000018	0.0000014	0.0000037	0.0000033	0.0000025	0.0000064	0.0000026	0.0000038	0.0000047	0.0000205	0.0000112	0.0000032	0.0000028	0.0000049
Boron	mg/L	1.2[d]	1.2	0.0008	0.0687	0.0399	0.0556	0.0478	0.0435	0.0671	0.0843	0.0466	0.0406	0.0301	0.0863	0.0901	0.0374	0.0372	0.0326	0.0312	0.0146
Cadmium	mg/L	[e]		0.000006	0.0000038	0.0000021	<0.000002	0.0000073	0.0000045	0.0000038	0.0000021	0.0000081	0.000002	0.0000072	0.0000069	0.0000069	0.0000473	0.0000386	0.0000173	0.0000168	0.0000053
Calcium	mg/L	-	1000000	0.1	27.7	20.3	17.1	17.8	16.4	25.6	26.8	13.4	26	14.7	38	26.3	14.6	15	11.1	15.7	9.55
Chlorine	mg/L	-	1000000	0.3	0.396	0.249	0.156	0.141	0.138	0.166	0.395	<0.1	0.649	0.464	0.28	0.845	<0.1	<0.1	<0.1	0.131	0.183
Chromium	mg/L	0.001[g]	0.001	0.0003	<0.00004	<0.00004	<0.00004	<0.00004	<0.00004	0.000083	<0.00004	0.000075	0.000211	0.000276	0.00027	0.000424	**0.00236**	**0.00223**	0.000315	0.000156	0.000102
Cobalt	mg/L	0.0009[h]	0.0009	0.00001	0.0000857	0.0000483	0.0000753	0.0000797	0.0000965	0.0000625	0.0000573	0.0000736	0.0000371	0.0000794	0.000142	0.000162	0.000702	0.000642	0.000379	0.000225	0.000111
Copper	mg/L	[i]		0.0001	<0.00005	<0.00005	<0.00005	**0.00913**	<0.00005	0.000055	<0.00005	0.0000597	<0.00005	0.000325	0.000356	0.000357	**0.00219**	0.00188	0.0000575	<0.00005	<0.00005
Iron	mg/L	0.3	0.3	0.004	0.274	0.163	0.0482	**0.444**	**0.444**	0.0194	0.0435	**0.421**	0.0317	0.254	**0.678**	**0.878**	**2.26**	**2.14**	**0.714**	**1**	**0.43**
Lead	mg/L	[k]		0.000006	0.0000106	0.0000063	0.0000115	0.000391	0.0000198	0.0000125	0.000039	0.0000427	0.0000033	0.0000302	0.0000257	0.0000137	0.000809	0.000786	0.0000349	0.0000425	0.0000209
Lithium	mg/L	0.87[n]	0.87	0.0002	0.0163	0.0109	0.0148	0.0107	0.01	0.0145	0.0163	0.0108	0.0156	0.00826	0.021	0.0417	0.00914	0.00907	0.00963	0.00765	0.00307

1 Alberta Environment Guidelines for the Protection of Freshwater Aquatic Life (1999), unless otherwise specified

a at pH ≥ 6.5; Hardness ≥ 4mg/L; DOC ≥ 2mg/L (CCME 2006)

b at pH 8.0, 10°C (CCME 2006)

c CCME (2006)

d BC ambient water quality guideline for boron (BC 2003)

e Is equal to $10^{(0.86*LOG(Hardness))-3.2}$ (CCME 2006)

f Set to US Environmental Protection Agency continuous concentration guideline

g Guideline for chromium III is 0.0089 mg/L; guideline for chromium VI is 0.0010 mg/L (CCME 2006). Most stringent guideline (0.001 mg/L) is used

h BC working water quality guidelines (BC 2006a)

i Guideline is hardness-dependent: 0.002 mg/L at hardness = 0 to 120 mg/L; 0.003 mg/L at hardness = 120 to 180 mg/L; 0.004 mg/L at hardness > 180 mg/L (CCME 2006)

j Alberta acute guideline for dissolved oxygen (AENV 1999); guideline is a minimum value

k Guideline is hardness-dependent: 0.001 mg/L at hardness = 0 to 60 mg/L; 0.002 mg/L at hardness = 60 to 120 mg/L; 0.004 mg/L at hardness = 120 to 180 mg/L; 0.007 mg/L at hardness > 180 mg/L (CCME 2006)

l For acute concentrations (AENV 1999)

m Guideline is hardness-dependent: 0.025 mg/L at hardness = 0 to 60 mg/L; 0.065 mg/L at hardness = 60 to 120 mg/L; 0.11 mg/L at hardness = 120 to 180 mg/L; 0.15 mg/L at hardness > 180 mg/L (CCME 2006)

n CCME (2006) guideline for nitrate is 13 mg/L; CCME (2006) guideline for nitrite is 0.06 mg/L

o CCME (2006). AENV (1999) guideline: "To be in the range of 6.5 to 8.5 but not altered by more than 0.5 pH units from background values"

p BC approved water quality guideline (BC 2006b)

q BC Acute guideline is hardness-dependent: 0.8 mg/L at hardness= 0 to 25 mg/L; 1.1 mg/L at hardness= 25 to 50 mg/L;1.6 mg/L at hardness= 50 to 100 mg/L; 2.2 mg/L at hardness= 100 to 150 mg/L; 3.8 mg/L at hardness= 150 to 300 mg/L (BC 2006b)

r Guideline is for chronic total (organic and inorganic) phosphorus

s US Environmental Protection Agency continuous concentration guideline (as H_2S)

t AENV (1999) acute and chronic guideline for suspended solids states: "Not to be increased by more than 10 mg/L over background value"

[Variable] Below Detection Limit

[Variable] Guideline Exceedance for Protection of Freshwater Aquatic Life

Table 6 (Cont'd.)

Water Qu	Units	Guideline	Conversion	Detection Limit	SITE L1	L2	L3	L4	L5	L6	L7	L8	L9	S1	S2	S3	S4	S5	S7	S8	S9
Total Metals (Cont'd.)																					
Manganese	mg/L	q	1.00E+06	0.00003	0.113	0.0527	0.0298	0.0625	0.015	0.0222	0.0386	0.0214	0.00769	0.0172	0.0479	0.0431	0.0923	0.0787	0.0998	0.0992	0.167
Mercury	mg/L	0.000013^{l}	0.000013	0.00005	**<0.00001**	**<0.00001**	**<0.00001**	**<0.00001**	**<0.00001**	**<0.00001**	**<0.00001**	**<0.00001**	0.0000119	**<0.00001**	**<0.00001**	**0.0000201**	0.0000114	**<0.00001**	**<0.00001**	**<0.00001**	**<0.00001**
Molybdenum	mg/L	0.073^{c}	0.073	0.000008	0.000617	0.000165	0.000129	0.0000145	0.0000196	0.0000237	0.0000353	0.0000483	0.0000429	0.000179	0.000294	0.000904	0.000641	0.000613	0.000029	0.0000466	0.000018
Nickel	mg/L	m		0.00006	0.00017	0.000189	0.000095	0.000059	0.000161	**<0.000005**	**<0.000005**	0.000457	0.0000246	0.000755	0.00106	0.00189	0.00282	0.00268	0.000757	0.000448	0.000145
Selenium	mg/L	0.001^{c}	0.001	0.0003	**<0.0001**	**<0.0001**	**<0.0001**	**<0.0001**	**<0.0001**	**<0.0001**	**<0.0001**	**<0.0001**	0.000142	**<0.0001**	0.000377	0.000162	0.000321	0.000306	0.000137	0.000173	0.000161
Silver	mg/L	0.0001^{c}	0.0001	0.000005	0.000004	0.0000007	0.00000074	0.0000025	0.0000009	0.0000007	0.0000014	0.0000011	0.0000043	**<0.0000005**	0.0000026	**<0.0000005**	0.0000254	0.0000132	**<0.0000005**	0.0000042	0.0000029
Strontium	mg/L	-	1000000	0.000008	0.15	0.0966	0.0938	0.0939	0.087	0.139	0.152	0.0807	0.128	0.0679	0.215	0.154	0.0868	0.0808	0.0568	0.0767	0.0482
Sulphur	mg/L	-	1000000	0.6	5.46	1.57	3.05	1.28	2.56	9.17	2.3	4.57	14.3	2.69	14.4	33	5.51	4.9	4.19	1.69	2.69
Thallium	mg/L	0.0008^{c}	0.0008	0.000003	0.0000006	0.000001	0.0000012	0.0000008	0.0000005	0.0000019	0.0000011	0.0000005	0.0000018	0.0000018	0.0000011	0.0000026	0.0000379	0.0000326	0.0000012	0.0000014	0.0000021
Thorium	mg/L	-	1000000	0.00003	0.0000033	0.0000036	0.0000008	0.0000023	0.0000029	**<0.0000003**	**<0.0000003**	0.0000141	0.0000017	0.0000309	0.0000321	0.0000684	0.00035	0.000262	0.0000231	0.000018	0.0000213
Tin	mg/L	-	1000000	0.00007	**<0.00003**	**<0.00003**	**<0.00003**	**<0.00003**	0.0000408	**<0.00003**	**<0.00003**	**<0.00003**	**<0.00003**	0.0000555	**<0.00003**	0.00004	0.000054	**<0.00003**	**<0.00003**	**<0.00003**	**<0.00003**
Titanium	mg/L	0.1^{h}	0.1	0.00007	0.00168	0.000763	0.000482	0.000469	0.000494	0.00049	0.00037	0.000845	0.000516	0.00127	0.000994	0.00193	0.0296	0.029	0.00147	0.000979	0.000583
Ultra-Trace Mercury	mg/L	0.000013^{l}	0.000013	0.0000012	**<0.0000006**	**<0.0000006**	**<0.0000006**	**<0.0000006**	0.0000008	**<0.0000006**	**<0.0000006**	**<0.0000006**	**<0.0000006**	0.0000018	0.0000008	0.0000014	0.0000075	0.0000063	**<0.0000006**	0.0000038	0.0000012
Uranium	mg/L	0.3^{h}	0.3	0.000003	0.000254	0.0000945	0.0000147	0.0000097	0.000011	0.0000575	0.0000962	0.0000238	0.0000325	0.0000604	0.000207	0.000187	0.000252	0.000226	0.0000131	0.0000173	0.0000085
Vanadium	mg/L	-	1000000	0.00005	0.000399	0.000102	0.000184	0.000154	0.000119	0.000281	0.000204	0.000413	0.000252	0.00025	0.000264	0.000278	0.00593	0.00543	0.00023	0.000268	0.000298
Zinc	mg/L	0.03^{c}	0.03	0.0002	0.000271	**<0.0001**	0.000269	0.0062	0.000576	0.00056	0.000376	0.00331	0.00041	0.00161	0.00136	0.00385	0.00796	0.00729	0.00148	0.00231	0.002
Dissolved Metals																					
Aluminum	mg/L	0.1^{a}	0.1	0.001	0.00454	0.000499	0.00499	0.00603	0.00666	0.00447	0.00396	0.0284	0.00403	0.0354	0.0112	0.0526	0.0821	0.0963	0.0405	0.0244	0.0401
Antimony	mg/L	0.02^{h}	1000000	0.000001	0.0000567	0.0000321	0.0000321	0.0000195	0.0000219	0.0000317	0.0000244	0.0000256	0.0000251	0.0000333	0.000238	0.0000368	0.0000827	0.000078	0.0000286	0.000029	0.0000185
Arsenic	mg/L	0.005^{c}	0.005	0.00006	0.00164	0.000833	0.000657	0.000473	0.000425	0.00101	0.000598	0.000659	0.000467	0.000376	0.00103	0.000882	0.00123	0.00124	0.000587	0.000645	0.000254
Barium	mg/L	5^{h}	5	0.0001	0.0175	0.0216	0.0148	0.0224	0.0128	0.0212	0.0262	0.00976	0.0183	0.0145	0.0252	0.0159	0.0196	0.0195	0.0106	0.0202	0.011
Beryllium	mg/L	0.0053^{h}	0.0053	0.00001	0.0000038	**<0.000003**	**<0.000003**	**<0.000003**	0.0000037	0.00000357	**<0.000003**	0.0000036	0.0000036	0.0000065	0.0000151	0.0000101	0.0000158	0.0000202	0.0000079	**<0.000003**	0.0000049
Bismuth	mg/L	-	1000000	0.00001	0.0000025	**<0.000001**	0.0000018	0.0000018	0.0000013	0.0000037	0.0000032	0.0000017	0.0000063	0.0000026	0.0000037	0.0000047	0.0000173	0.0000027	0.0000031	0.0000022	0.0000048
Boron	mg/L	1.2^{d}	1.2	0.0008	0.0649	0.0368	0.0539	0.0474	0.0429	0.0643	0.0829	0.0458	0.0366	0.0286	0.0835	0.0806	0.0335	0.0335	0.03	0.0307	0.0136
Cadmium	mg/L	e		0.000006	0.0000031	**<0.000002**	**<0.000002**	0.0000052	0.0000044	0.0000027	0.0000021	0.0000071	**<0.000002**	0.0000049	0.0000053	0.0000061	0.0000103	0.0000106	0.0000157	0.0000107	0.0000032
Calcium	mg/L	-	1000000	0.1	26.4	19.7	16.6	17.4	16.1	25	26.3	13.2	25.4	14.3	37.1	25.3	14.3	14.3	10.8	15.1	9.21
Chlorine	mg/L	-	1000000	0.3	0.392	0.247	0.154	0.14	0.137	0.164	0.391	**<0.1**	0.64	0.459	0.277	0.84	0.699	0.297	**<0.1**	0.13	0.181
Chromium	mg/L	0.001^{g}	0.001	0.0003	**<0.00004**	**<0.00004**	**<0.00004**	**<0.00004**	**<0.00004**	0.000082	**<0.00004**	0.000074	0.000209	0.000256	0.000267	0.00042	0.000284	0.000219	0.000312	0.000154	0.000097
Cobalt	mg/L	0.0009^{h}	0.0009	0.00001	0.0000621	0.0000408	0.0000745	0.0000789	0.0000859	0.0000579	0.0000569	0.0000729	0.0000367	0.0000648	0.0000855	0.000122	0.000144	0.000144	0.000359	0.0000722	0.0000483
Copper	mg/L	i		0.0001	0.000845	0.00141	**<0.00005**	0.00162	0.000783	0.0000548	**<0.00005**	0.000059	0.00125	0.000322	0.000352	0.000353	**0.00217**	0.00186	0.000057	0.00176	0.00112
Iron	mg/L	0.3	0.3	0.004	0.033	0.00844	0.0337	0.245	**0.357**	0.00628	0.0127	**0.36**	0.0294	0.152	**0.416**	**0.548**	**0.561**	**0.57**	**0.577**	**0.411**	**0.316**
Lead	mg/L	k		0.000006	**<0.000001**	0.0000032	0.0000114	0.0000399	0.0000177	0.0000094	0.0000082	0.0000404	0.0000033	0.0000299	0.0000174	0.0000136	0.0000725	0.0000701	0.0000346	0.0000185	0.0000093
Lithium	mg/L	0.87^{h}	0.87	0.0002	0.0153	0.0108	0.0145	0.0106	0.00976	0.0143	0.0161	0.0107	0.014	0.00777	0.0204	0.0368	0.00739	0.00758	0.0089	0.00743	0.00304
Manganese	mg/L	q	1.00E+06	0.00003	0.00752	0.000508	0.00915	0.0447	0.00603	0.00162	0.00242	0.0175	0.00532	0.00443	0.00192	0.0224	0.00977	0.0133	0.0871	0.00205	0.019
Mercury	mg/L	0.000013^{l}	0.000013	0.00005	**<0.00001**	**<0.00001**	**<0.00001**	**<0.00001**	**<0.00001**	**<0.00001**	**<0.00001**	**<0.00001**	0.0000118	**<0.00001**	**<0.00001**	**0.0000199**	**<0.00001**	**<0.00001**	**<0.00001**	**<0.00001**	**<0.00001**
Molybdenum	mg/L	0.073^{c}	0.073	0.000008	0.000547	0.000148	0.000128	0.0000128	0.0000106	0.0000235	0.0000349	0.0000442	0.0000413	0.000165	0.000289	0.000898	0.000598	0.000551	0.0000235	0.0000409	0.0000173
Nickel	mg/L	m		0.00006	0.000096	0.000088	0.000094	0.000058	0.000159	**<0.000005**	**<0.000005**	0.000441	0.000024	0.000702	0.00105	0.00187	0.00156	0.00149	0.000749	0.000437	0.000136
Selenium	mg/L	0.001^{c}	0.001	0.0003	**<0.0001**	**<0.0001**	**<0.0001**	**<0.0001**	**<0.0001**	**<0.0001**	**<0.0001**	**<0.0001**	0.000097	**<0.0001**	0.000374	0.00016	0.00027	0.000256	0.000136	0.000153	0.000126
Silver	mg/L	0.0001^{c}	0.0001	0.000005	**<0.0000005**	**<0.0000005**	**<0.0000005**	**<0.0000005**	**<0.0000005**	**<0.0000005**	**<0.0000005**	**<0.0000005**	**<0.0000005**	**<0.0000005**	0.0000008	**<0.0000005**	0.0000014	0.0000022	**<0.0000005**	**<0.0000005**	**<0.0000005**
Strontium	mg/L	-	1000000	0.000008	0.142	0.0933	0.0931	0.0909	0.0848	0.136	0.149	0.0789	0.126	0.0668	0.209	0.151	0.0865	0.0767	0.0562	0.0751	0.0469
Sulphur	mg/L	-	1000000	0.6	5.13	1.55	3.02	1.27	2.53	9.06	2.28	4.5	13.8	2.53	14.1	31.4	4.89	4.36	4.15	1.67	2.66
Thallium	mg/L	0.0008^{c}	0.0008	0.000003	0.0000006	0.0000008	0.0000011	0.0000008	0.0000005	0.0000018	0.0000011	0.0000005	0.0000018	0.0000018	0.0000011	0.0000026	0.0000068	0.0000032	0.0000012	0.0000007	0.000002
Thorium	mg/L	-	1000000	0.00003	0.0000033	0.0000036	0.0000008	0.0000023	0.0000029	**<0.0000003**	**<0.0000003**	0.000014	0.0000017	0.0000306	0.0000318	0.0000677	0.000177	0.0000637	0.0000229	0.0000178	0.0000211
Tin	mg/L	-	1000000	0.00007	**<0.00003**	**<0.00003**	**<0.00003**	**<0.00003**	**<0.00003**	**<0.00003**	**<0.00003**	**<0.00003**	**<0.00003**	**<0.00003**	**<0.00003**	**<0.00003**	**<0.00003**	**<0.00003**	**<0.00003**	**<0.00003**	**<0.00003**
Titanium	mg/L	0.1^{h}	0.1	0.00007	0.000947	0.000331	0.000399	0.000246	0.000269	0.000357	0.000245	0.00075	0.00029	0.000759	0.000674	0.00113	0.00222	0.00209	0.00108	0.000635	0.000582
Uranium	mg/L	0.3^{h}	0.3	0.000003	0.000236	0.0000888	0.0000137	0.0000078	0.0000093	0.0000548	0.0000918	0.0000221	0.0000301	0.0000539	0.000194	0.000175	0.000126	0.000111	0.0000121	0.000013	0.0000073
Vanadium	mg/L	-	1000000	0.00005	0.00031	0.0000493	0.000174	0.000097	0.000104	0.000279	0.000164	0.000369	0.000249	0.000177	0.000218	0.000275	0.00046	0.000418	0.000218	0.000206	0.000241
Zinc	mg/L	0.03^{c}	0.03	0.0002	0.000268	0.000054	0.000266	0.00159	0.00057	0.000554	0.000372	0.00152	0.000406	0.00159	0.00135	0.00381	0.00233	0.00193	0.00147	0.00229	0.00198

1 Alberta Environment Guidelines for the Protection of Freshwater Aquatic Life (1999), unless otherwise specified

a at pH ≥ 6.5; Hardness ≥ 4mg/L; DOC ≥ 2mg/L (CCME 2006)

b at pH 8.0, 10°C (CCME 2006)

c CCME (2006)

d BC ambient water quality guideline for boron (BC 2003)

e Is equal to $10^{(0.86*LOG(Hardness)-3.2)}$ (CCME 2006)

f Set to US Environmental Protection Agency continuous concentration guideline

g Guideline for chromium III is 0.0089 mg/L; guideline for chromium VI is 0.0010 mg/L (CCME 2006). Most stringent guideline (0.001 mg/L) is used

h BC working water quality guidelines (BC 2006a)

i Guideline is hardness-dependent: 0.002 mg/L at hardness = 0 to 120 mg/L; 0.003 mg/L at hardness = 120 to 180 mg/L; 0.004 mg/L at hardness > 180 mg/L (CCME 2006)

j Alberta acute guideline for dissolved oxygen (AENV 1999); guideline is a minimum value

k Guideline is hardness-dependent: 0.001 mg/L at hardness = 0 to 60 mg/L; 0.002 mg/L at hardness = 60 to 120 mg/L; 0.004 mg/L at hardness = 120 to 180 mg/L; 0.007 mg/L at hardness > 180 mg/L (CCME 2006)

l For acute concentrations (AENV 1999)

m Guideline is hardness-dependent: 0.025 mg/L at hardness = 0 to 60 mg/L; 0.065 mg/L at hardness = 60 to 120 mg/L; 0.11 mg/L at hardness = 120 to 180 mg/L; 0.15 mg/L at hardness > 180 mg/L (CCME 2006)

n CCME (2006) guideline for nitrate is 13 mg/L; CCME (2006) guideline for nitrite is 0.06 mg/L

o CCME (2006). AENV (1999) guideline: "To be in the range of 6.5 to 8.5 but not altered by more than 0.5 pH units from background values"

p BC approved water quality guideline (BC 2006b)

q BC Acute guideline is hardness-dependent: 0.8 mg/L at hardness= 0 to 25 mg/L; 1.1 mg/L at hardness= 25 to 50 mg/L;1.6 mg/L at hardness= 50 to 100 mg/L; 2.2 mg/L at hardness= 100 to 150 mg/L; 3.8 mg/L at hardness= 150 to 300 mg/L (BC 2006b)

r Guideline is for chronic total (organic and inorganic) phosphorus

s US Environmental Protection Agency continuous concentration guideline (as H_2S)

t AENV (1999) acute and chronic guideline for suspended solids states: "Not to be increased by more than 10 mg/L over background value"

[Variable] Below Detection Limit

[Variable] Guideline Exceedance for Protection of Freshwater Aquatic Life

4.0 EFFECTS ASSESSMENT

4.1 IDENTIFICATION OF KEY ISSUES

Key surface aquatic resource issues (water quality, fish, and aquatic habitat) considered in this report were identified from three sources:

- Issues considered in and findings of EIAs conducted for previous Athabasca oil sands *in situ* projects;
- Findings of research and monitoring conducted under regional aquatics monitoring programs, particularly RAMP; and
- Findings of primary field data collection for baseline studies for the Project.

4.2 LOCAL EFFECTS ASSESSMENT FOR SUNSHINE PROJECT

4.2.1 Effects of Project Activities on Surface Aquatic Resources from Changes in Groundwater Quantity

4.2.1.1 Description of Potential Effects

Sunshine is planning to use groundwater sources to make steam for injection into the bitumen reservoir. This withdrawal of water can have an effect on surface aquatic resources if there is a hydrologic connection between the groundwater being used as a source of water for the Project and surface waters.

4.2.1.2 Potential Effects Assessment

The final source of groundwater to be used for the Project will be determined after further investigation. Based on initial testing of sources of groundwater, it is expected that the Project will use a source of groundwater that has no hydrologic connectivity with surface waters (K. Young, Millennium EMS Solutions, pers. comm., 2008). Surface aquatic resources are therefore not expected to be influenced by groundwater withdrawals for the Project. There are therefore expected to be no effects of Project activities on surface aquatic resources from changes in groundwater quantity.

4.2.2 Effects of Project Activities on Surface Aquatic Resources from Changes in Groundwater Quality

4.2.2.1 Description of Potential Effects

During normal operating conditions, accidental releases may occur and the contents may enter surficial groundwater. Upset conditions may also result in accidental release of substances into surficial groundwater, which may then seep into surface waters and affect surface water resources.

4.2.2.2 Mitigation Measures and Potential Effects Assessment

MEMS (2008) describes a set of mitigation measures for proper handling, treatment, and disposal of materials that could potentially have negative effects on groundwater quality. The report also addresses mitigation of leakage resulting in the contamination of potable aquifers through the operation and production of injections wells.

On this basis, Consultant Report No. 4 - Groundwater concludes that the implementation of these mitigation measures should ensure the operation of the Project will have no effect on groundwater quality under normal operation conditions, and that a groundwater response plan to be implemented during upset conditions will be effective in avoiding significant effects on groundwater quality. Therefore, on this basis, effects of the Project on surface aquatic resources caused by possible changes in groundwater quality are expected to be negligible.

4.2.3 Effects of Project Activities on Surface Aquatic Resources Caused by Input to Surface Waters via Surface Runoff and Sediment Loading

4.2.3.1 Description of Potential Effects

Project activities conducted near watercourses or waterbodies in the LSA may increase sediment transport to surface waters, change the water quality of surface runoff to these aquatic systems, and may alter aquatic habitat through direct physical changes.

4.2.3.2 Mitigation Measures and Potential Effects Assessment

Project-related activities will not be conducted within 150 m of the high water mark of the lakes located within the LSA (Figure 2).

With the exception of access road crossings, Project-related activities will not be conducted within 30 m of the high water mark of any of the watercourses located within the LSA. The width of this buffer is in compliance with AEP (1994) guidelines for small permanent watercourses.

The central processing facility located in the Project development area will be graded to direct surface water runoff to a containment pond. Containment pond water will be allowed to evaporate, and excess water will either be used for Project operations or tested for key chemical parameters and released to the environment if criteria are met. In addition:

- Wastewater from the water treatment process will be handled so that it does not pose a risk to aquatic surface resources, either through deep well injection or by trucking to an offsite location for appropriate handling;
- Domestic solid waste will be disposed of off-site; and
- Domestic sewage will be piped to on-site septic tanks and then to a septic field, in accordance with provincial regulatory requirements.

The storage and handling of hazardous materials for the Project will be conducted in compliance with CCME guidelines as well as the Transportation of Dangerous Goods Act, and other applicable environmental legislation, regulation, standards or codes. These will include at a minimum:

- Secondary containment designed and constructed to ensure that spills from storage containers will be fully contained;
- Regular inspections of all hazardous materials storage equipment for signs of degradation and/or leakage. Any remediation works required will be completed in accordance with applicable legislation, regulation and codes of practice;
- Continued training of applicable personnel in the handling and transportation of all hazardous materials on the West Ells Project site as defined under the *Transportation of Dangerous Goods Act* and of controlled substances as defined under the *Occupational Health & Safety Regulation*;
- Ongoing inventory of all controlled substances on the West Ells Project site;
- Designation of specific areas and locations for the transfer and limited temporary storage of hazardous materials and wastes with controlled access;
- Maintenance of appropriate spill clean-up equipment and materials;
- Prompt removal of any hazardous wastes and surplus materials to an approved facility using a licensed hazardous materials handler; and
- Provision of berms around above-ground storage tank areas, and lining of berms with impermeable material.

In addition, Sunshine will implement watercourse crossing-related mitigation measures during the construction of all Project infrastructure facilities located near surface aquatic features; specific measures are presented in Section 4.2.5.1.

4.2.3.3 Potential Effects Assessment

The residual effects of Project activities on water quality, fish, and aquatic habitat via surface run-off, sediment loadings, or direct physical alteration are expected to be negligible with the effective application of the mitigation measures described above.

4.2.4 Changes in Fisheries Resources Caused by Increase in Fishing Pressure and Harvest

4.2.4.1 Potential Effects Assessment

Sport-fish species were captured in one lake (L2) during the baseline fish inventories of the LSA (Table 4). The number of sport-fish captured during the inventory was low (one juvenile lake trout), indicating that this waterbody would not be considered productive enough to warrant recreational fishing. Additionally, no Project-related infrastructure is planned in the proximity of site L2; therefore, it is expected that there will be a negligible effect on fish abundance in the LSA as a result of increasing fishing pressure related to Project construction and operation.

4.2.5 Effects of Sunshine Access Road Stream Crossing on Surface Aquatic Resources

All watercourses to be crossed by the access road are designated as Class C watercourses under the Alberta *Code of Practice for Watercourse Crossings*. Sunshine will undertake all necessary stream crossing assessments and will use the results of these assessments to design and implement appropriate mitigation measures during construction to enable compliance with the Alberta *Code of Practice for Watercourse Crossings*. This approach will help achieve the objective of no-net-loss of productive fish habitat for Alberta (ASRD 2006).

4.2.5.1 Project Mitigation Measures to Be Implemented

Sunshine will implement a number of mitigation measures during construction of stream crossings, as outlined below:

- Earthworks contractors will be required to submit a sediment control plan. Sediment control methods will be minimized at the stream crossing according to methods such as those described in Alberta Infrastructure and Transportation (1999, currently under revision) and will include, as required: the use of cutoff trenches, silt fences, flow barriers, temporary and/or permanent sediment control ponds and/or traps, and ditches to minimize or eliminate sediment transport from exposed soil areas into receiving waterbodies and watercourses;
- Minimization of the time interval between clearing/grubbing and subsequent earthworks, particularly at or in the vicinity of watercourses or in areas susceptible to erosion;
- Upon completion of construction, disturbed areas will be revegetated to stabilize soils and minimize erosion (to be done as soon as practicable after construction is complete). Interim vegetative cover will be established where necessary or appropriate to bridge the interval between disturbance and reclamation;
- Sunshine will ensure that all water releases are compliant with application guidelines and regulatory approvals;
- Special provision will be made for protection of surface watercourses and waterbodies from concrete works. This will include: prohibition from discharging concrete wash water into any watercourse or waterbody, and containment and isolation of any concrete-affected water for either treatment until it meets water quality criteria suitable for discharge to the natural environment, or else transported to a facility approved for related containment and/or disposal; and

- Sunshine will engage the services of a qualified aquatic environmental specialist during the construction of the stream crossing in accordance with the Alberta *Code of Practice for Watercourse Crossings*.

4.2.5.2 Potential Effects Assessment

The residual local effects of the access road on water quality, fish, and aquatic habitat are predicted to be negligible with the application of the mitigation measures described above.

4.3 EXPECTED REGIONAL EFFECTS OF THE PROJECT

With the application of the mitigation measures listed above, the effects of the Project on surface aquatic resources (water quality, fish, and aquatic habitat) are expected to be negligible. Therefore, the effects of the Project on these surface aquatic resources are also expected to be negligible or insignificant at a regional scale.

4.4 ENVIRONMENTAL MONITORING

4.4.1 Construction Monitoring

Contractors will be required to submit environmental management plans as part of construction agreements that will outline acceptable methods for each activity as well as for the post-construction period. Routine audits and associated surface aquatic resources monitoring will be conducted during construction periods. In particular, suspended sediments will be routinely monitored (upstream and downstream) during construction periods for all instream construction activities.

4.4.2 Effects Monitoring

Monitoring requirements will be carried out in accordance with the terms and conditions of Project approval.

5.0 REFERENCES

Alberta Environment Protection. 1994. Alberta Timber Harvesting Planning and Operating Ground Rules. Pub. No.: Ref. 71. ISBN: 0-86499-919-4. 47 pp. plus appendices.

Alberta Environment. 1999. Surface Water Quality Guidelines for Use in Alberta. Environmental Assurance Division, Science and Standards Branch. 25 pp.

Alberta Environment. 2000. Code of Practice for Pipelines and Telecommunication Lines Crossing a Waterbody. located at http://www.qp.gov.ab.ca/documents/codes/PIPELINE.CFM (incl. 2001 and 2003 amendments).

Alberta Environment. 2000. Code of Practice for Watercourse Crossings. Located at http://www.qp.gov.ab.ca/documents/codes/CROSSING.CFM (incl. 2001 and 2003 amendments).

Alberta Environment. 2001. Guide to the Code of Practice for Watercourse Crossings, Including Guidelines for Complying with the Code of Practice.

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Figure 1 Sunshine Oilsands Ltd., West Ells Project aquatic resources study area.

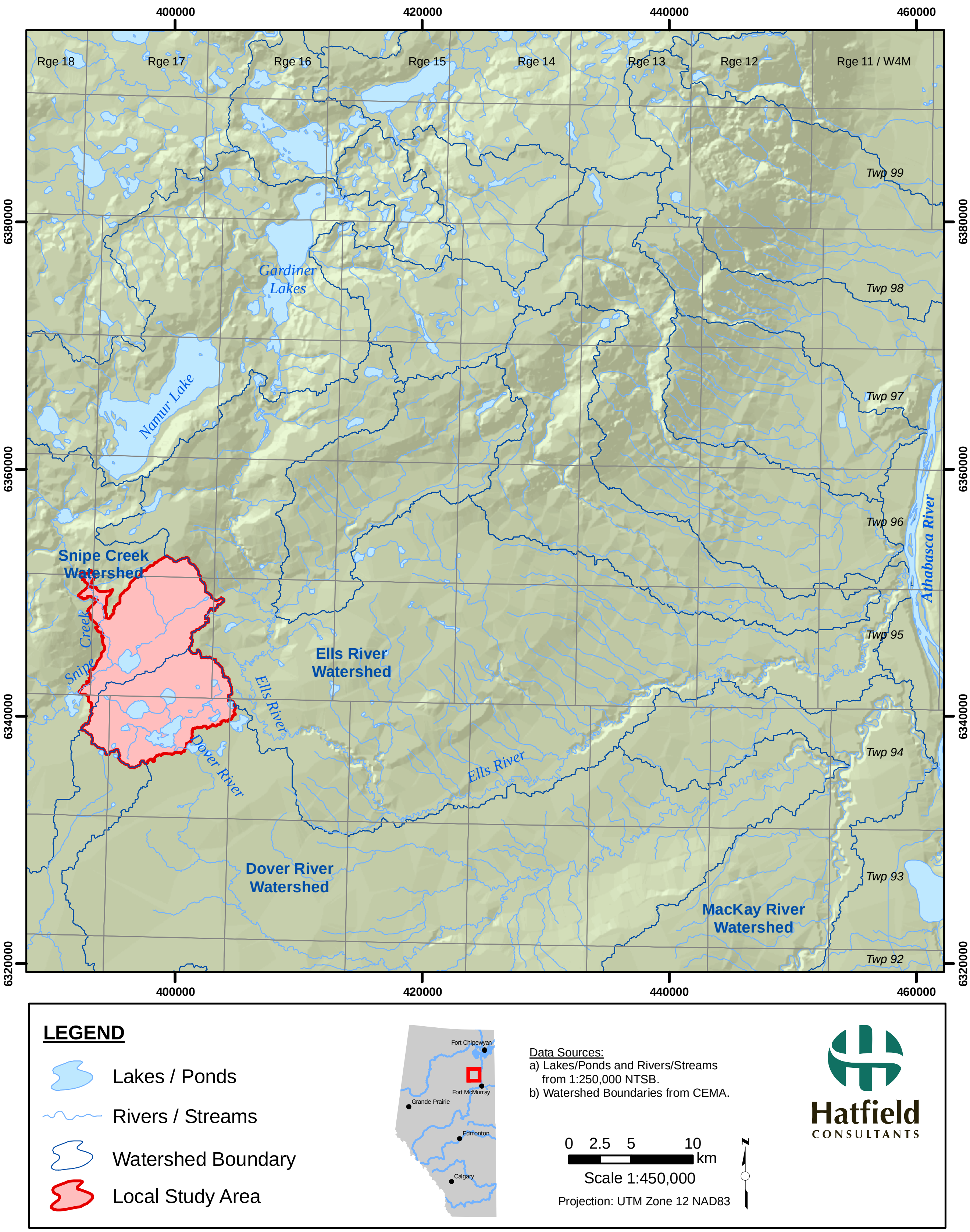

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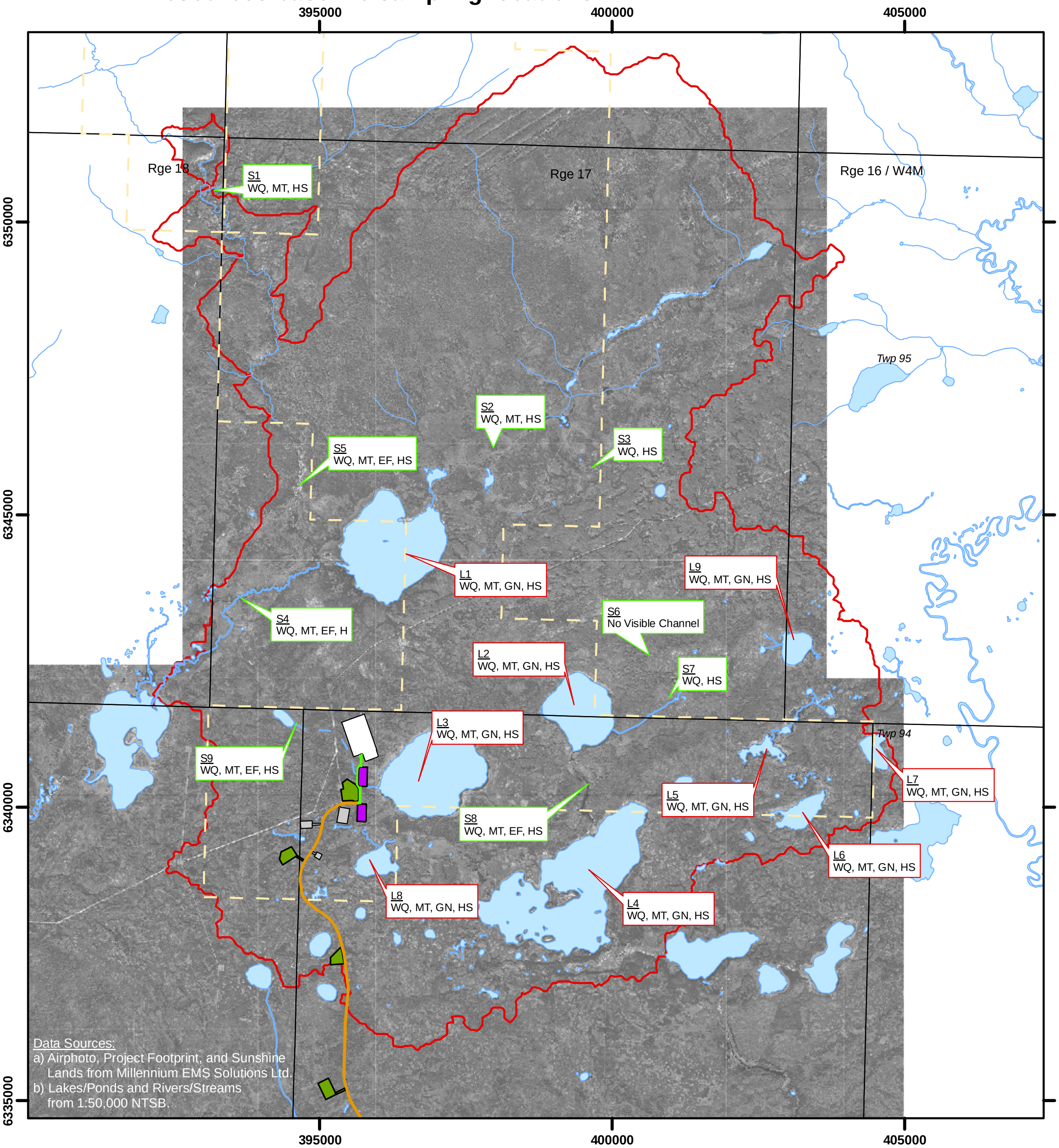
Figure 2 Sunshine Oilsands Ltd., West Ells Project footprint and June 2008 aquatic resources baseline sampling locations



LEGEND

Lakes / Ponds	Access Roads	Plant Site
Rivers / Streams	Borrow Pit and Access	Utility Corridor
Sunshine Lands	Camp and Access	
Local Study Area	Well Pads	

Sampling Types:
WQ = Water Quality
MT = Minnow Trap
GN = Gillnet
EF = Electrofishing
HS = Habitat Survey

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0 0.5 1 2 km
Scale 1:105,000
Projection: UTM Zone 12 NAD83

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Figure 3 Summary of FMIS historical sampling locations and fish species captured, 1996 to 2003.

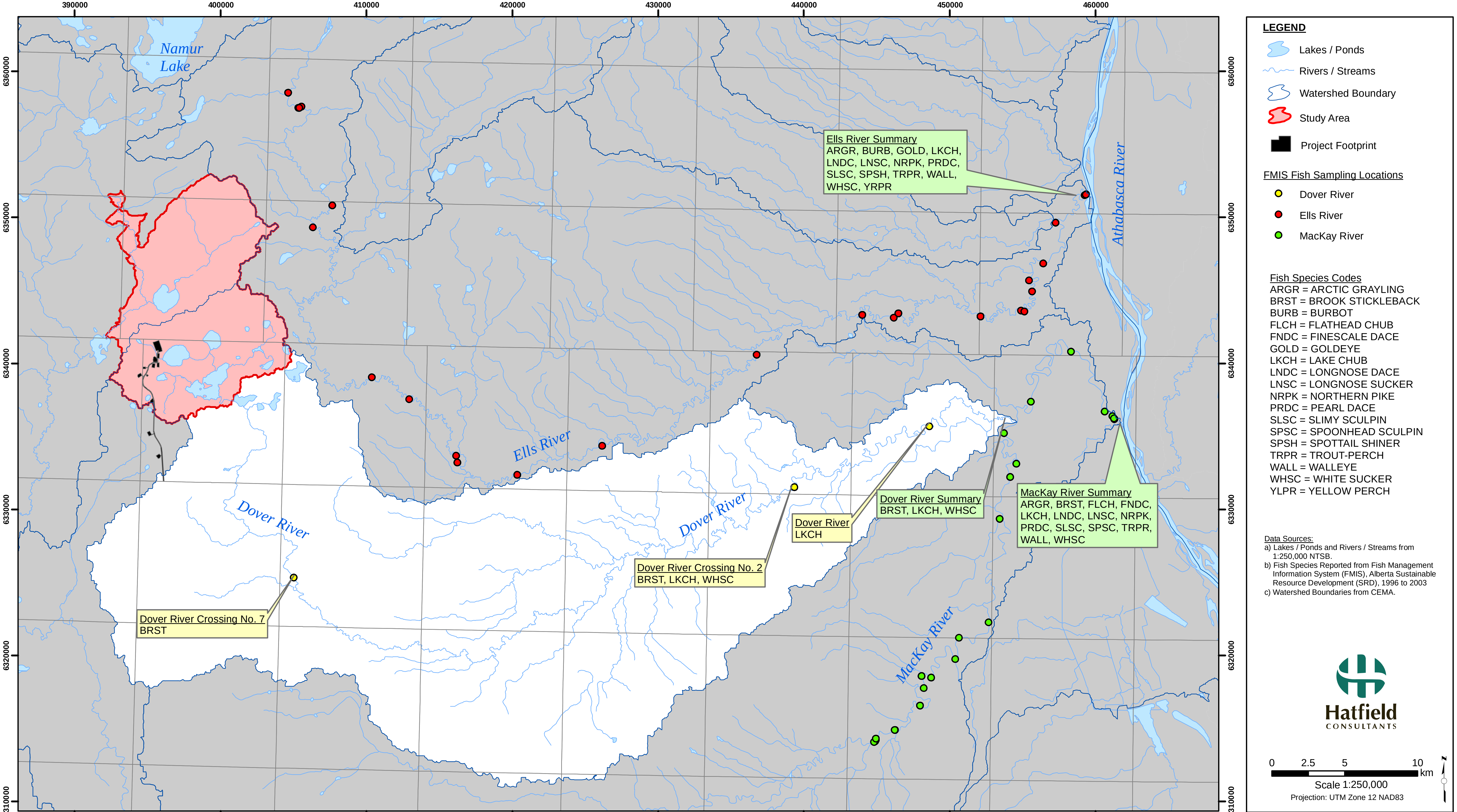

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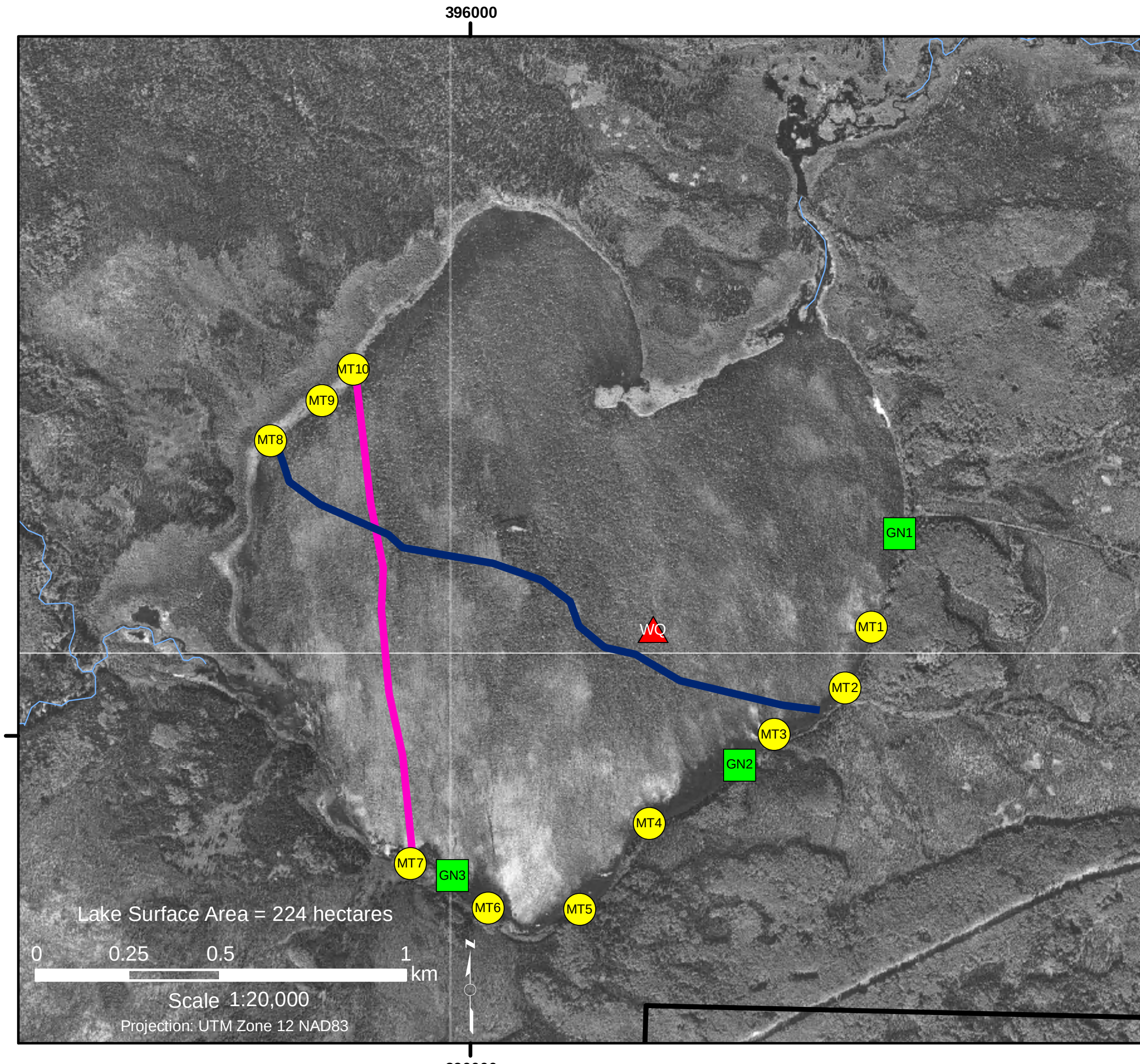
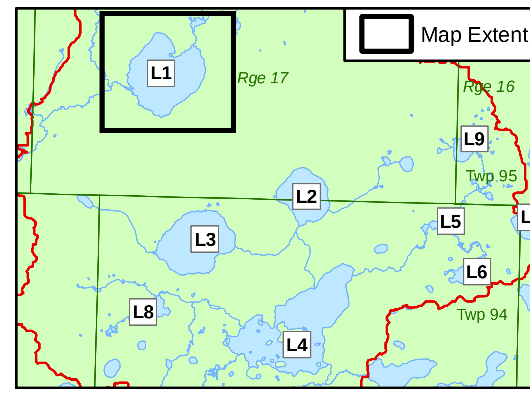
Figure 4 Aquatic habitat survey results for Lake 1, June 2008.



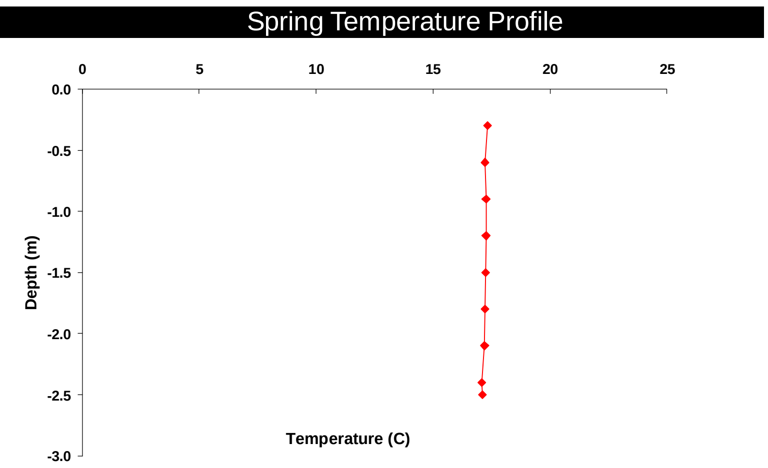


LEGEND

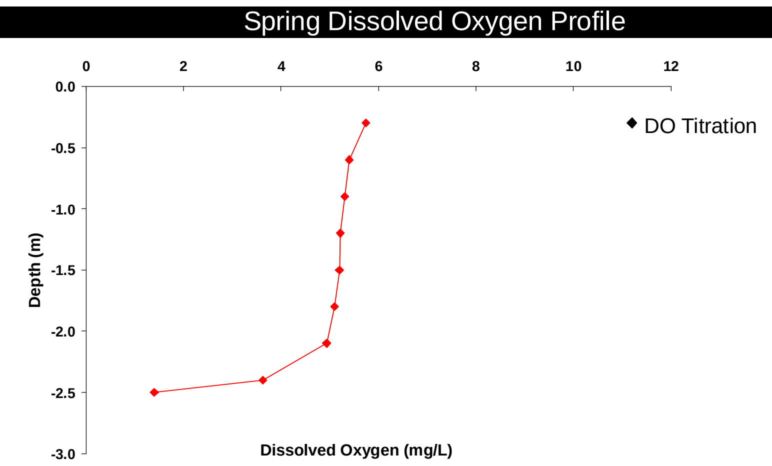
- Rivers / Streams
- Local Study Area
- Minnow Trap Sampling Site
- Gillnet Sampling Site
- Water Quality Sampling Site
- Bathymetric Transect

Data Sources:
a) Airphoto and Study Area from Millennium EMS Solutions Ltd.
b) Lakes/Ponds and Rivers/Streams from 1:50,000 NTSB.

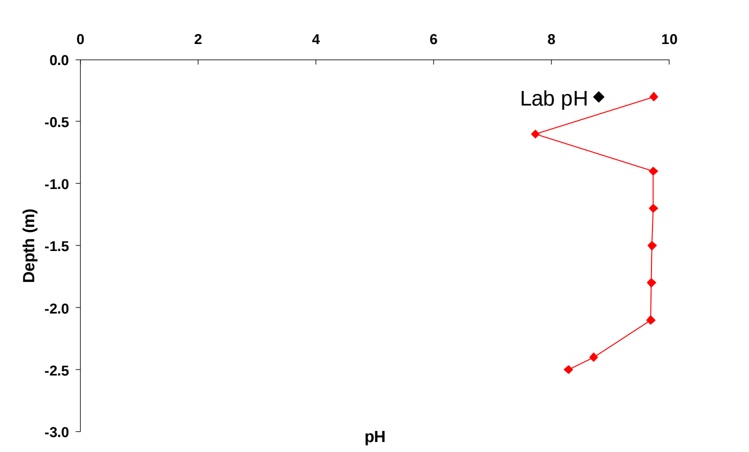
Spring Temperature Profile



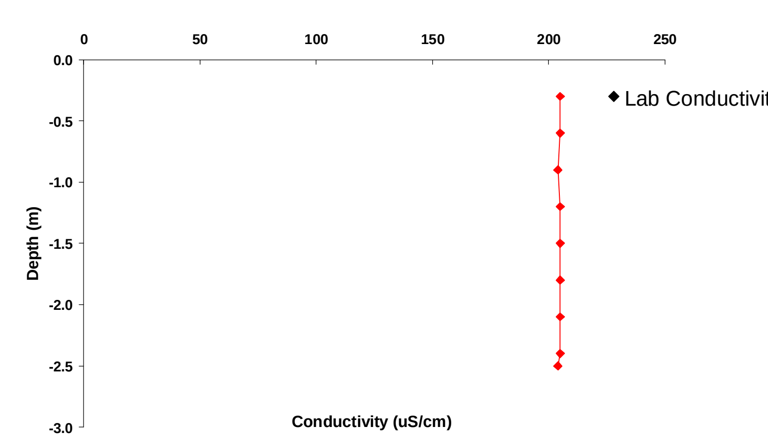
Spring Dissolved Oxygen Profile



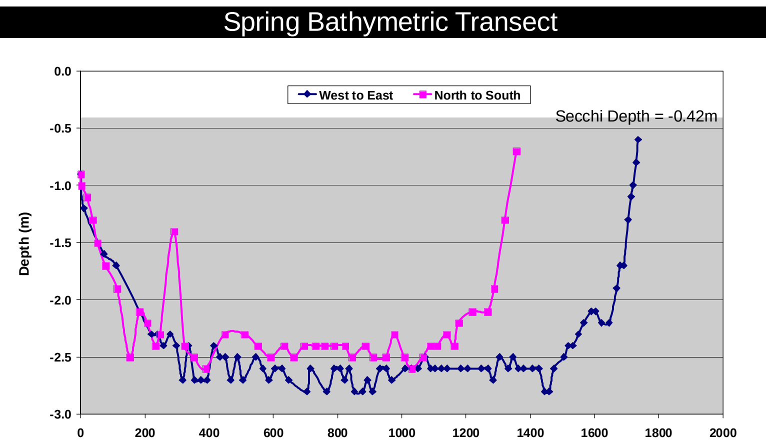
Spring pH Profile



Spring Conductivity Profile



Spring Bathymetric Transect



Spring Lake Habitat Assessment

Site ID	Water Depth (m)	Secchi Depth (m)	Substrate	Large Woody Debris	Small Woody Debris	Undercut Bank	Overhanging Vegetation	Slope (%)	# / fish caught
MT1	0.46	0.18	Organic	Present	Present	Present	Present	10	79 BRST
MT2	0.52	0.15	Organic	Present	Present	Present	Present	5	63 BRST
MT3	0.48	0.18	Organic	Present	Present	Absent	Present	<1	143 BRST
MT4	0.8	0.22	Organic	Present	Present	Present	Present	1	126 BRST
MT5	0.75	0.19	Organic	Present	Present	Absent	Present	1	1 BRST
MT6	0.63	0.2	Organic	Present	Present	Absent	Absent	<1	126 BRST
MT7	0.55	0.35	Organic	Present	Present	Absent	Absent	<1	69 BRST
MT8	0.94	0.47	Organic	Absent	Present	Absent	Absent	<1	320 BRST
MT9	0.85	0.45	Organic	Absent	Present	Absent	Absent	<1	54 BRST
MT10	0.92	0.48	Organic	Absent	Absent	Absent	Absent	<1	238 BRST
GN1	-	-	-	-	-	-	-	-	161 LNSC
GN2	-	-	-	-	-	-	-	-	67 LNSC
GN3	-	-	-	-	-	-	-	-	46 LNSC

* BRST= Brook Stickleback; LNSC=Longnose Sucker

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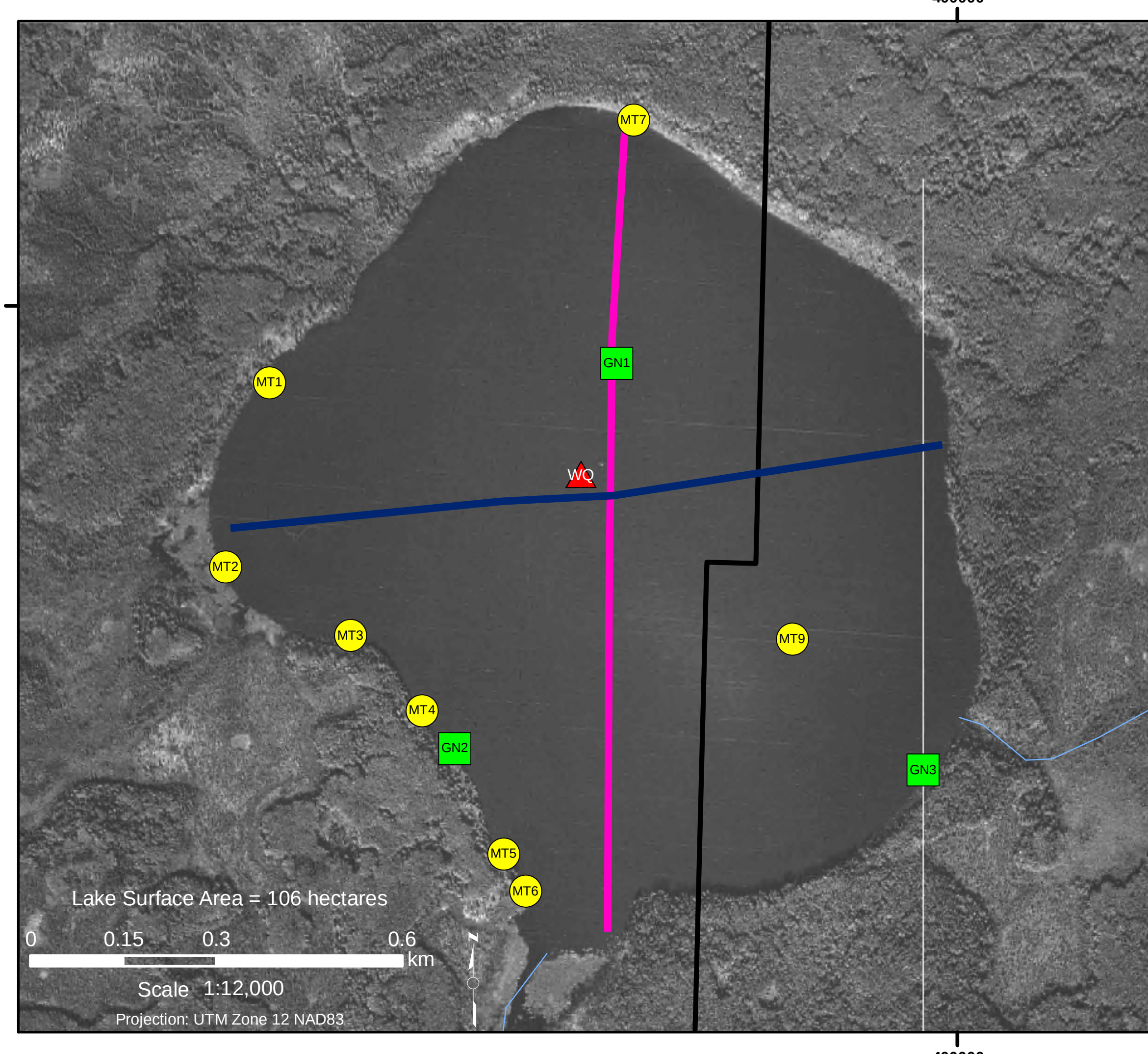
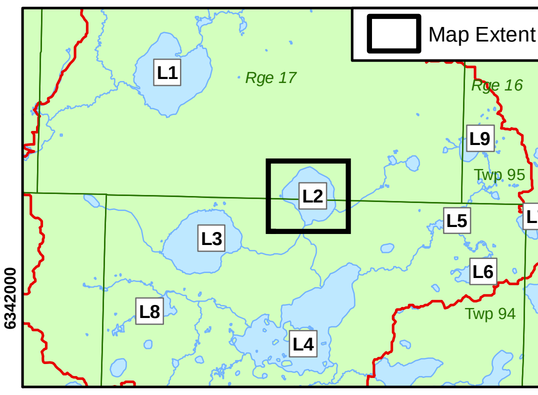
Figure 5 Aquatic habitat survey results for Lake 2, June 2008.





LEGEND

Rivers / Streams

Local Study Area

Minnow Trap Sampling Site

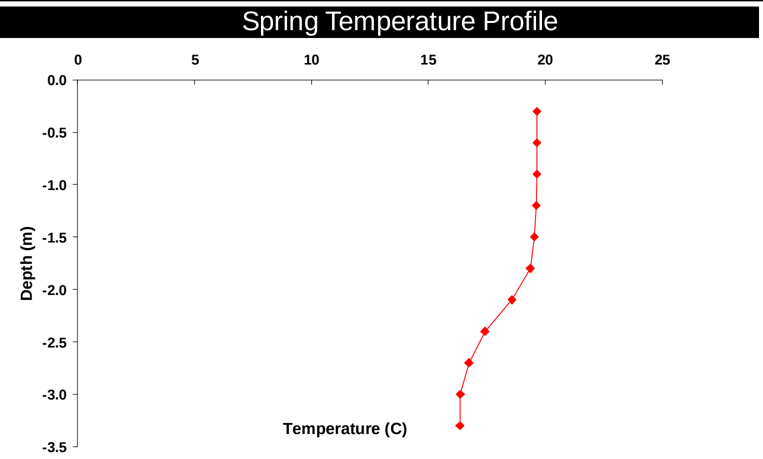
Gillnet Sampling Site

Water Quality Sampling Site

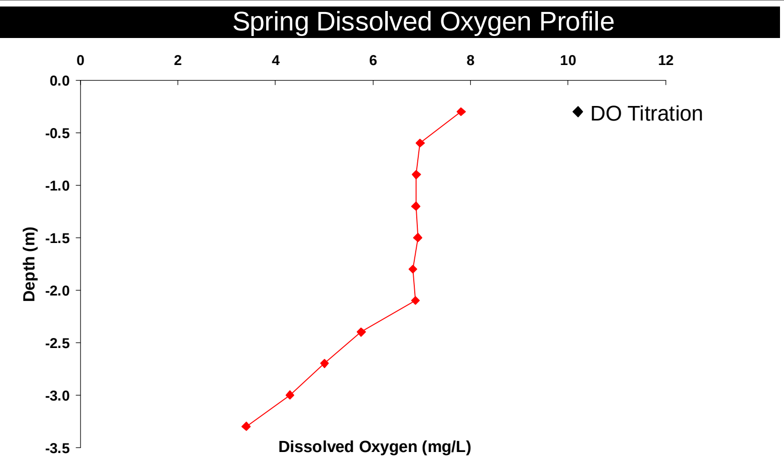
Bathymetric Transect

Data Sources:
a) Airphoto and Study Area from Millennium EMS Solutions Ltd.
b) Lakes/Ponds and Rivers/Streams from 1:50,000 NTSB.

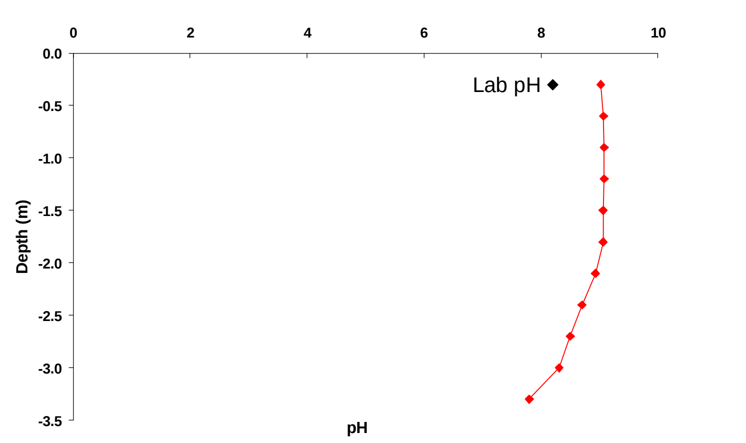
Spring Temperature Profile



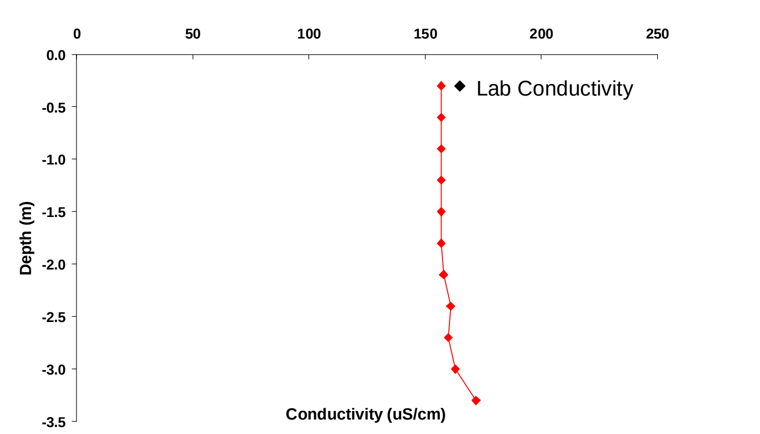
Spring Dissolved Oxygen Profile



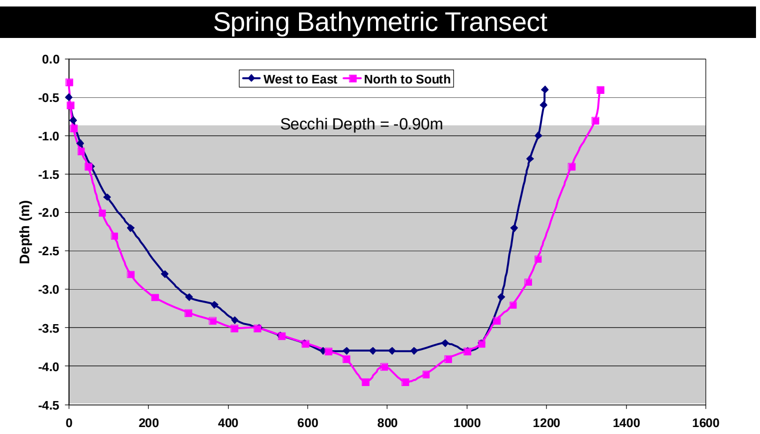
Spring pH Profile



Spring Conductivity Profile



Spring Bathymetric Transect



Spring Lake Habitat Assessment

Site ID	Water Depth (m)	Secchi Depth (m)	Substrate	Large Woody Debris	Small Woody Debris	Undercut Bank	Overhanging Vegetation	Slope (%)	# / fish caught
MT1	0.52	0.52	Organic	Present	Present	Absent	Present	<1	275 FTMN; 3 BRST
MT2	0.75	0.75	Organic	Absent	Present	Absent	Present	<1	17 BRST; 1 FTMN
MT3	0.45	0.45	Organic	Present	Present	Absent	Present	45	270 FTMN
MT4	0.75	0.75	Organic	Present	Present	Absent	Present	30	289 FTMN; 1 BRST
MT5	0.72	0.72	Organic	Present	Present	Absent	Present	45	378 FTMN, 1 BRST
MT6	0.52	0.52	Organic	Present	Present	Absent	Present	1	0
MT7	0.45	0.45	Organic	Present	Present	Absent	Present	<1	213 FTMN, 3 BRST
MT8	0.47	0.47	Organic	Present	Present	Absent	Present	10	81 FTMN; 9 BRST
MT9	0.44	0.44	Organic	Present	Present	Absent	Present	10	131 FTMN; 24 BRST
GN1	-	-	-	-	-	-	-	-	1 LKTR
GN2	-	-	-	-	-	-	-	-	1 LKTR
GN3	-	-	-	-	-	-	-	-	1 LNSC

BRST=Brook Stickleback; FTMN= Fathead Minnow; LKTR=Lake Trout; LNSC=Longnose Sucker

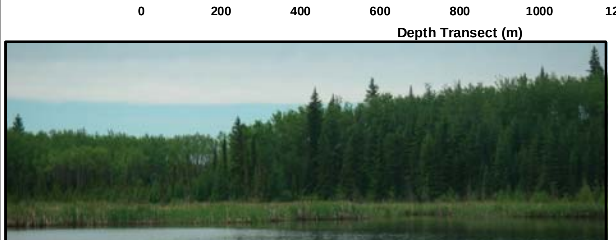


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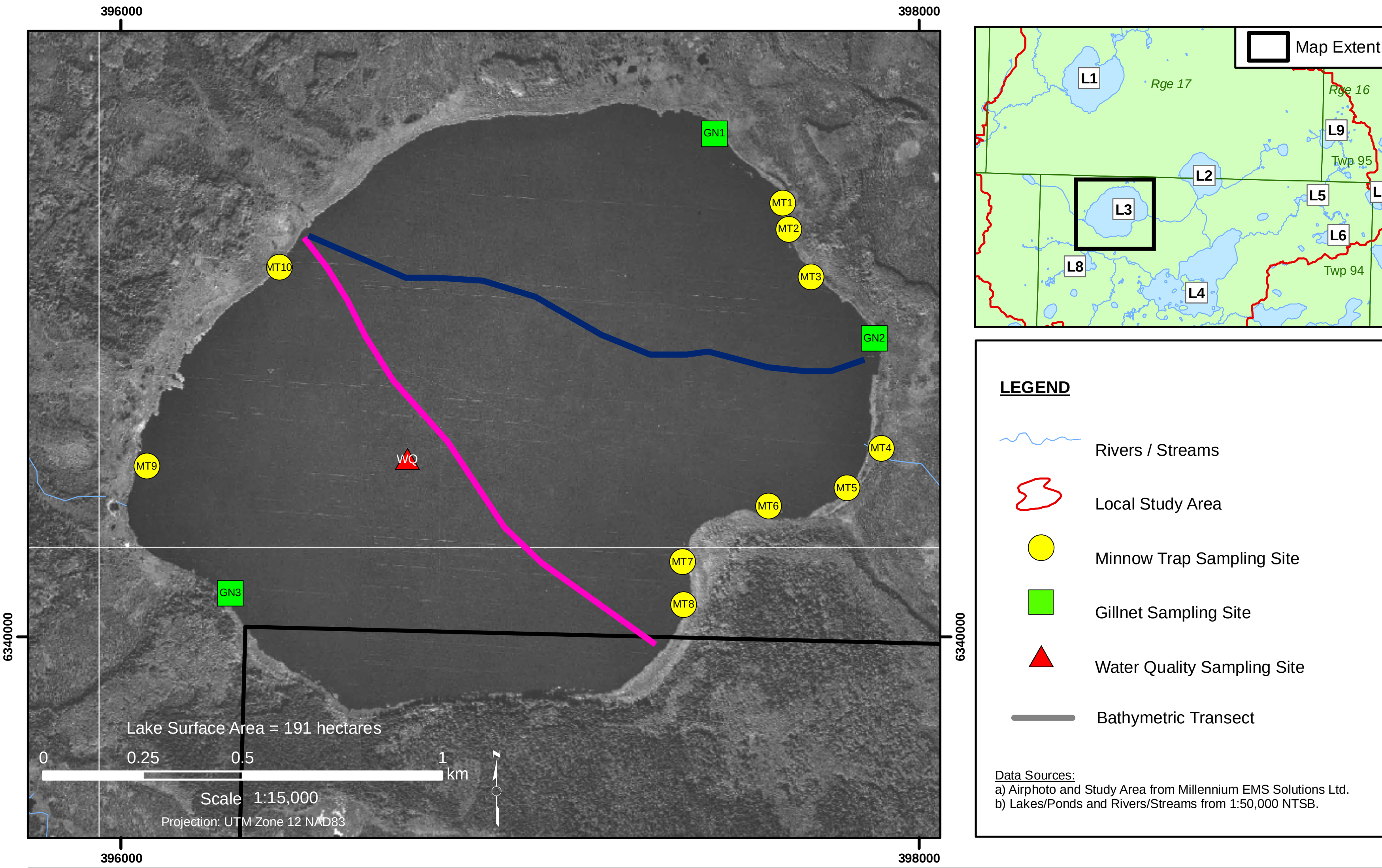
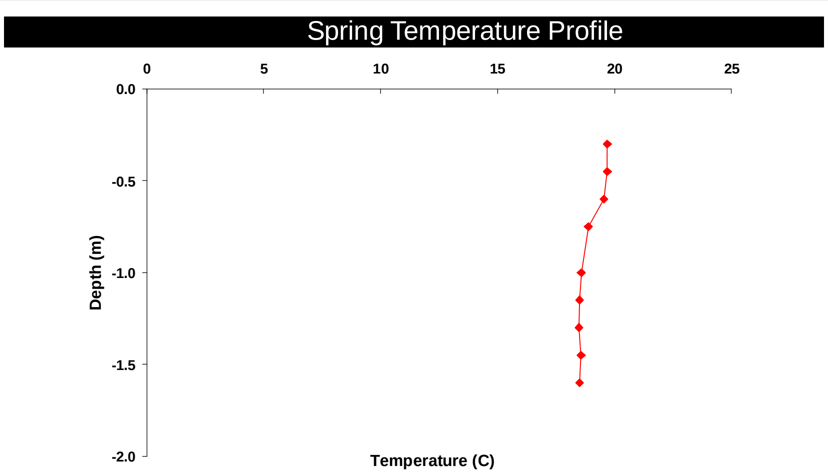
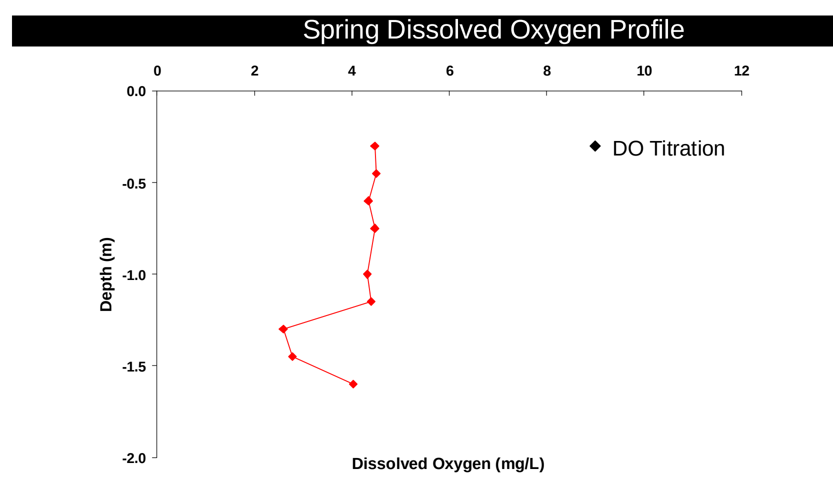
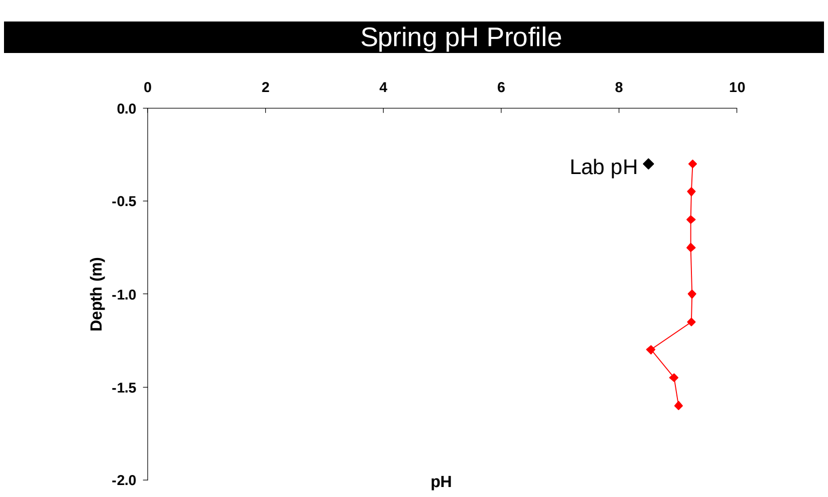
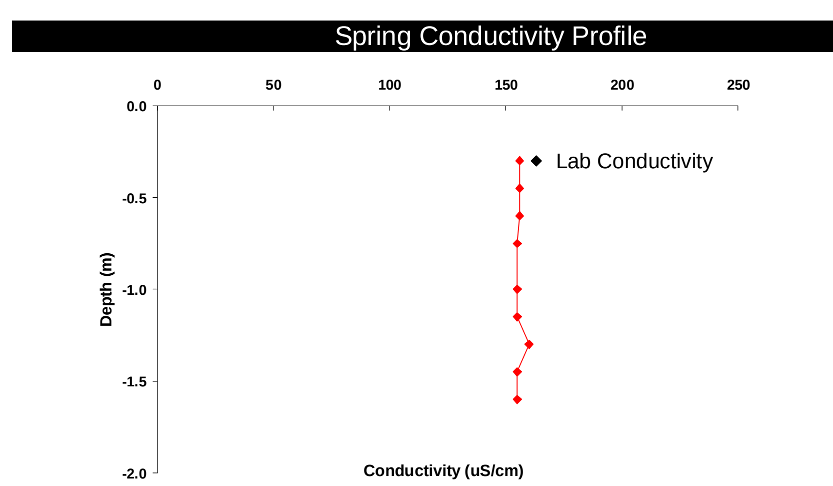
Figure 6 Aquatic habitat survey results for Lake 3, June 2008.

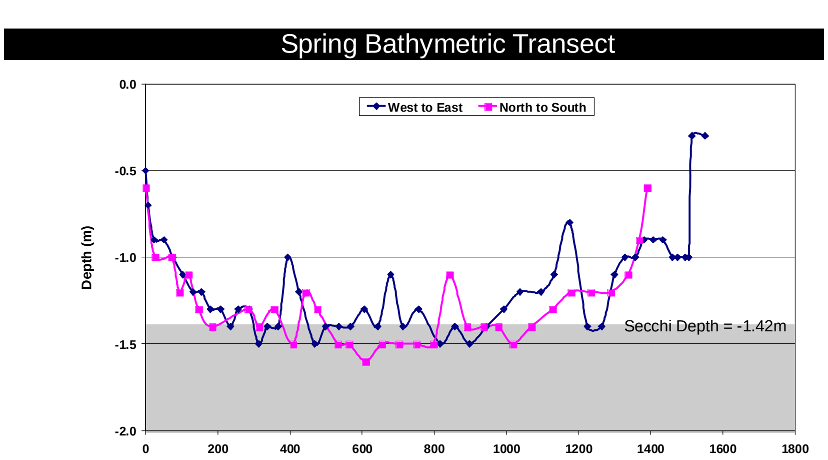












Spring Lake Habitat Assessment

Site ID	Water Depth (m)	Secchi Depth (m)	Substrate	Large Woody Debris	Small Woody Debris	Undercut Bank	Overhanging Vegetation	Slope (%)	# / fish caught
MT1	0.53	0.53	Organic	Absent	Absent	Absent	Absent	<1	0
MT2	0.7	0.7	Organic	Absent	Present	Present	Present	100	0
MT3	0.4	0.4	Organic	Present	Present	Present	Present	100	0
MT4	0.46	0.46	Organic	Absent	Present	Present	Absent	<1	0
MT5	0.75	0.75	Organic	Absent	Absent	Present	Absent	<1	0
MT6	0.63	0.63	Organic	Absent	Absent	Absent	Absent	<1	0
MT7	0.55	0.55	Organic	Absent	Present	Absent	Absent	<1	0
MT8	0.7	0.7	Organic	Absent	Absent	Absent	Absent	<1	0
MT9	0.73	0.73	Organic	Absent	Absent	Present	Absent	<1	0
MT10	0.57	0.57	Organic	Absent	Absent	Absent	Absent	<1	0
GN1	-	-	-	-	-	-	-	-	0
GN2	-	-	-	-	-	-	-	-	0
GN3	-	-	-	-	-	-	-	-	0

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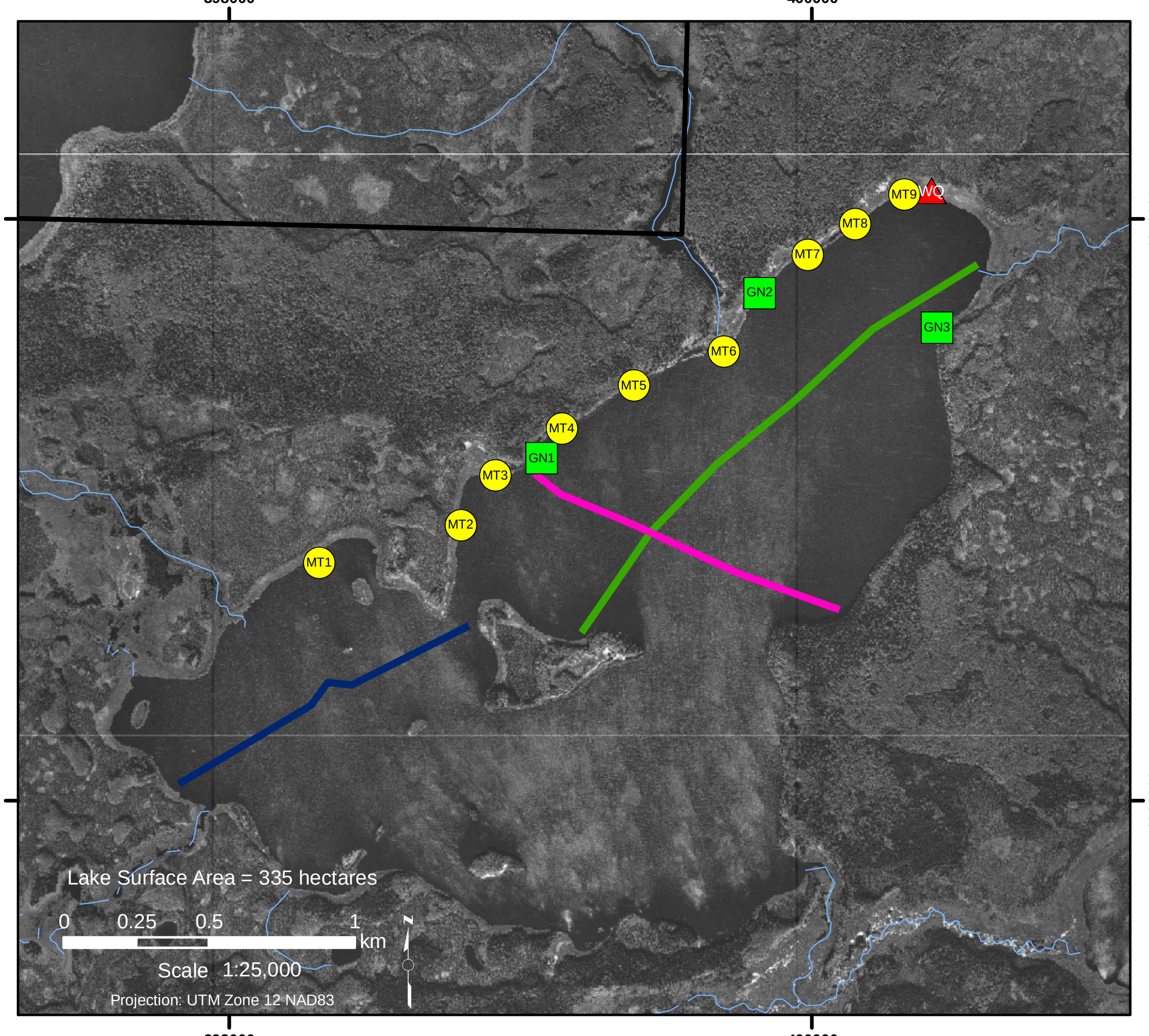
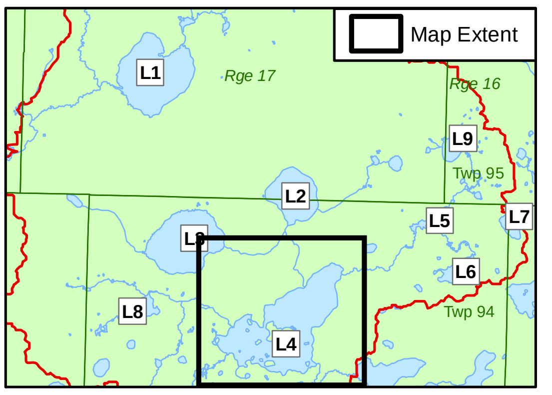
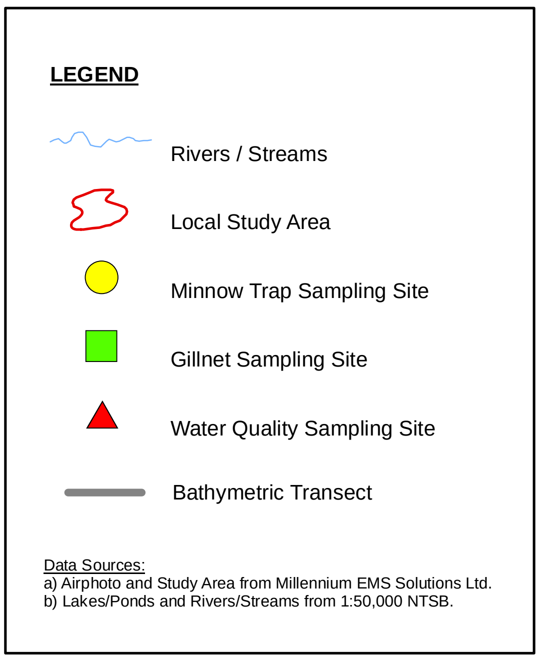
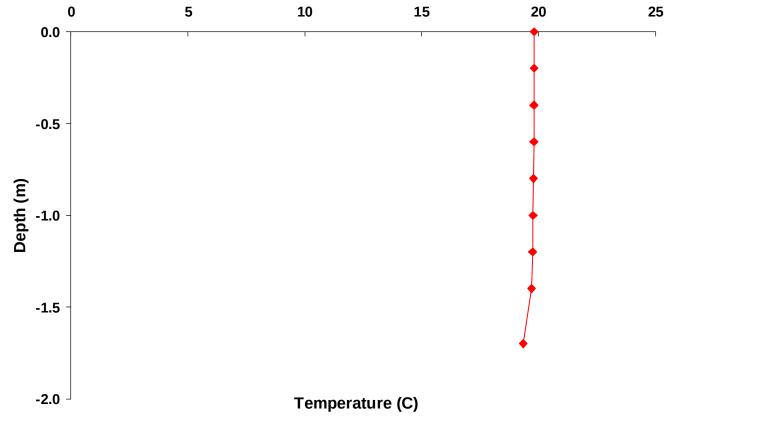
Figure 7 Aquatic habitat survey results for Lake 4, June 2008.



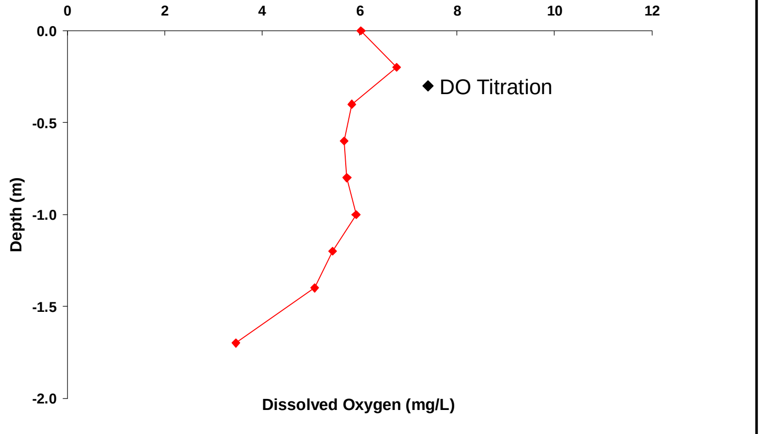




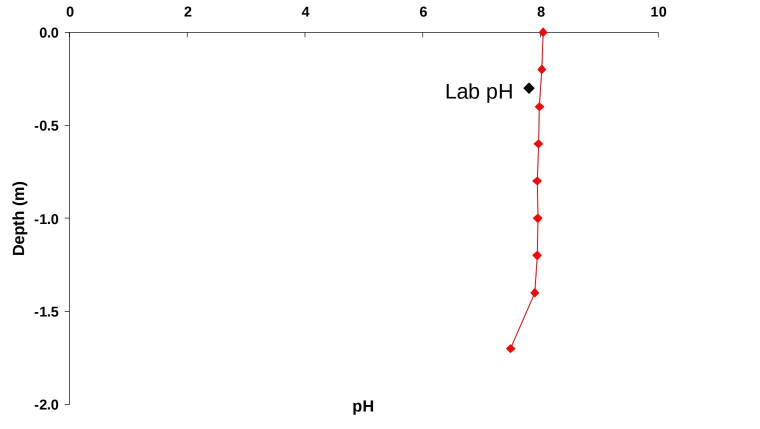
Spring Temperature Profile



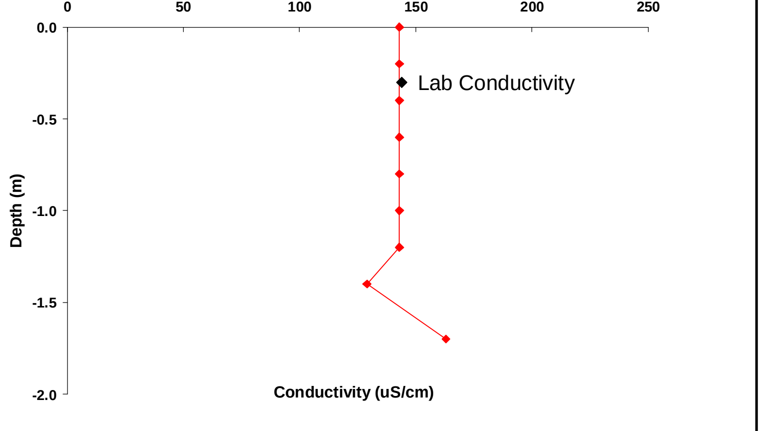
Spring Dissolved Oxygen Profile



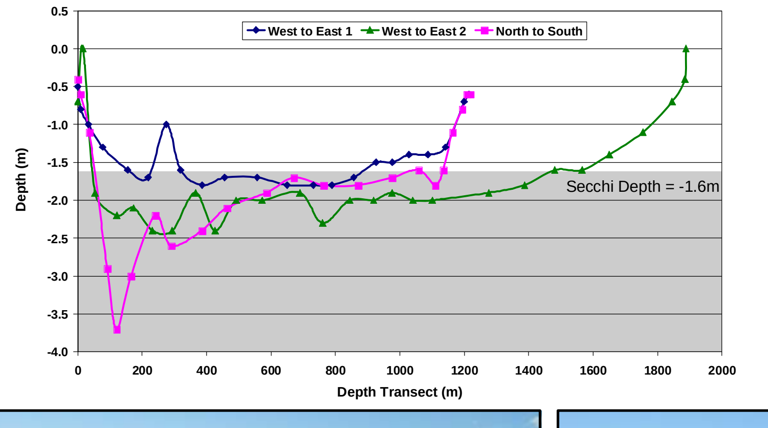
Spring pH Profile



Spring Conductivity Profile



Spring Bathymetric Transect



Spring Lake Habitat Assessment

Site ID	Water Depth (m)	Secchi Depth (m)	Substrate	Large Woody Debris	Small Woody Debris	Undercut Bank	Overhanging Vegetation	Slope (%)	# / fish caught
MT1	0.9	0.9	Organic	Absent	Absent	Absent	Absent	<1	0
MT2	0.7	0.7	Organic	Absent	Absent	Absent	Absent	<1	0
MT3	0.7	0.7	Organic	Absent	Absent	Absent	Absent	<1	0
MT4	0.8	0.8	Organic	Absent	Absent	Absent	Absent	<1	0
MT5	0.7	0.7	Organic	Absent	Absent	Absent	Absent	<1	0
MT6	0.6	0.6	Organic	Absent	Present	Absent	Absent	<1	0
MT7	0.7	0.7	Organic	Absent	Absent	Absent	Absent	<1	0
MT8	0.7	0.7	Organic	Absent	Absent	Absent	Absent	<1	0
MT9	0.6	0.6	Organic	Absent	Absent	Absent	Absent	<1	0
GN1	-	-	-	-	-	-	-	-	0
GN2	-	-	-	-	-	-	-	-	0
GN3	-	-	-	-	-	-	-	-	0

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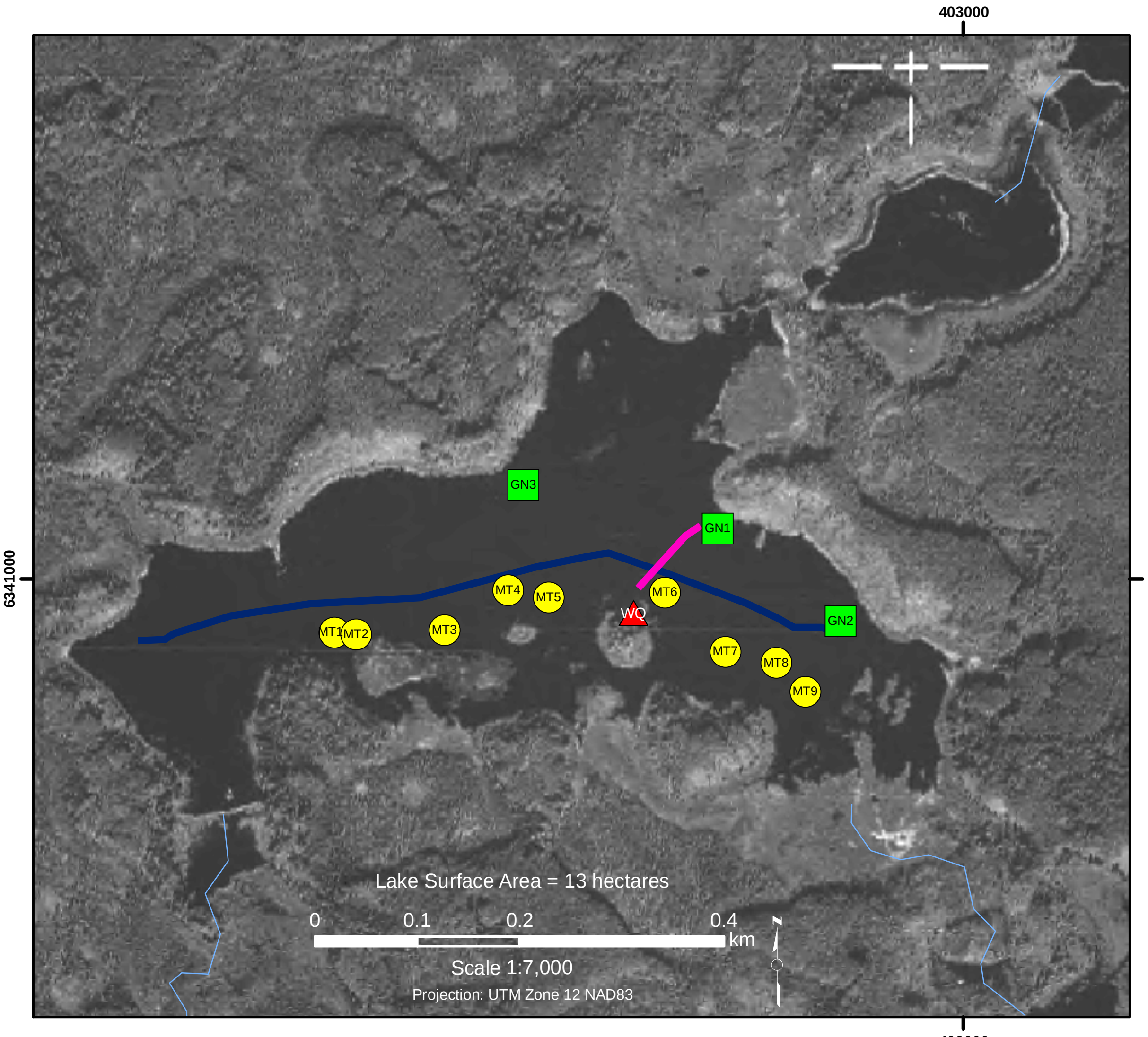
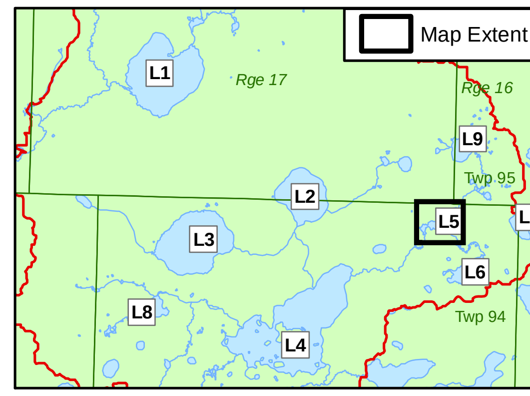
Figure 8 Aquatic habitat survey results for Lake 5, June 2008.





LEGEND

Rivers / Streams

Local Study Area

Minnow Trap Sampling Site

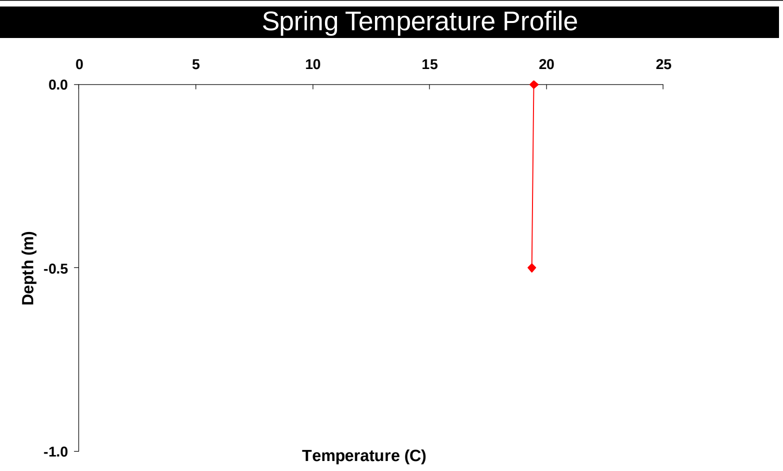
Gillnet Sampling Site

Water Quality Sampling Site

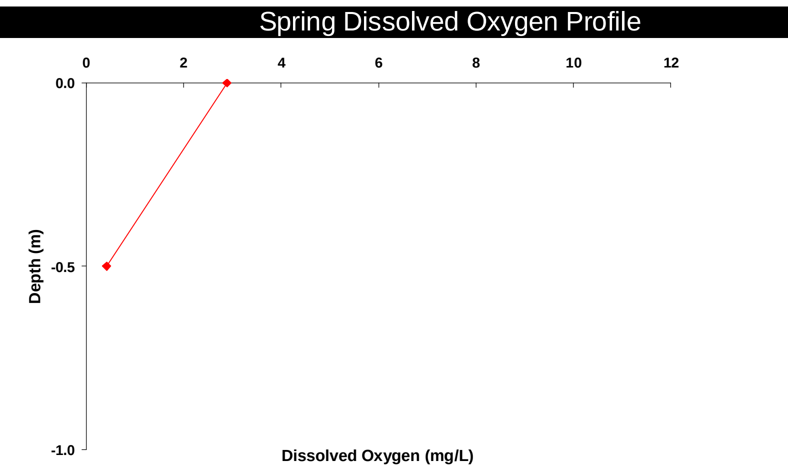
Bathymetric Transect

Data Sources:
a) Airphoto and Study Area from Millennium EMS Solutions Ltd.
b) Lakes/Ponds and Rivers/Streams from 1:50,000 NTSB.

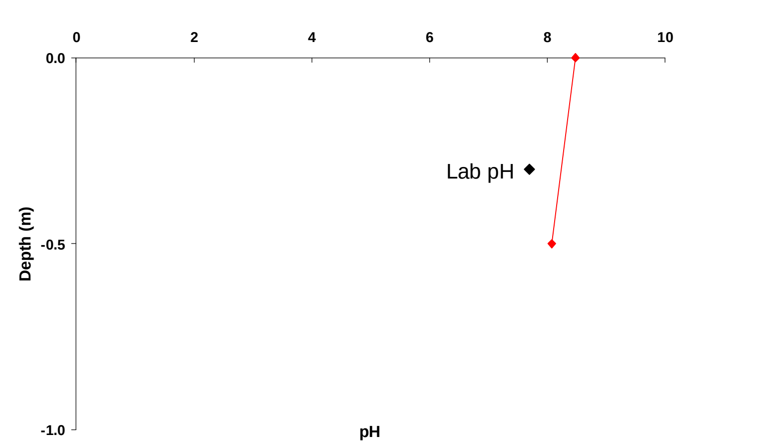
Spring Temperature Profile



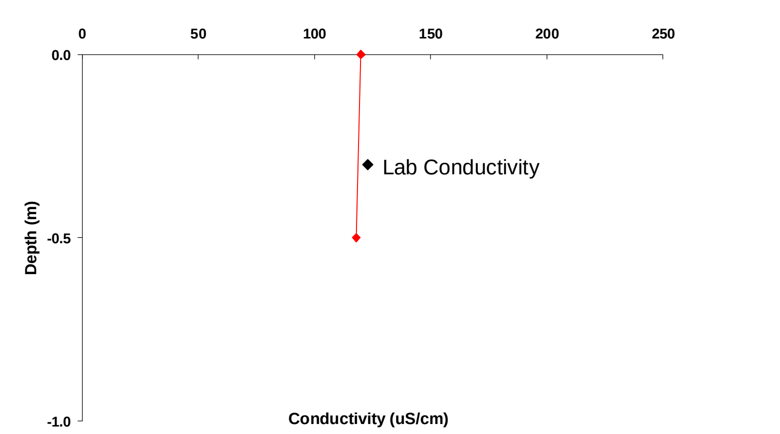
Spring Dissolved Oxygen Profile



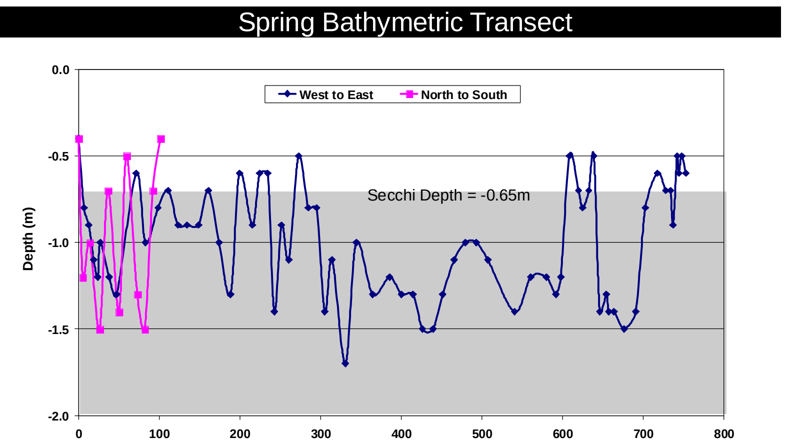
Spring pH Profile



Spring Conductivity Profile



Spring Bathymetric Transect



Spring Lake Habitat Assessment

Site ID	Water Depth (m)	Secchi Depth (m)	Substrate	Large Woody Debris	Small Woody Debris	Undercut Bank	Overhanging Vegetation	Slope (%)	# / fish caught
MT1	0.4	0.4	Organic	Absent	Absent	Absent	Absent	<1	0
MT2	0.6	0.6	Organic	Absent	Absent	Absent	Absent	<1	0
MT3	1	1	Organic	Absent	Absent	Absent	Absent	<1	0
MT4	0.7	0.7	Organic	Absent	Present	Absent	Absent	<1	0
MT5	0.5	0.5	Organic	Absent	Absent	Absent	Absent	<1	0
MT6	0.4	0.4	Organic	Absent	Present	Absent	Absent	<1	0
MT7	0.4	0.4	Organic	Absent	Absent	Absent	Absent	<1	0
MT8	0.5	0.5	Organic	Absent	Absent	Absent	Absent	<1	0
MT9	0.5	0.5	Organic	Absent	Absent	Absent	Absent	<1	0
GN1	-	-	-	-	-	-	-	-	0
GN2	-	-	-	-	-	-	-	-	0
GN3	-	-	-	-	-	-	-	-	0

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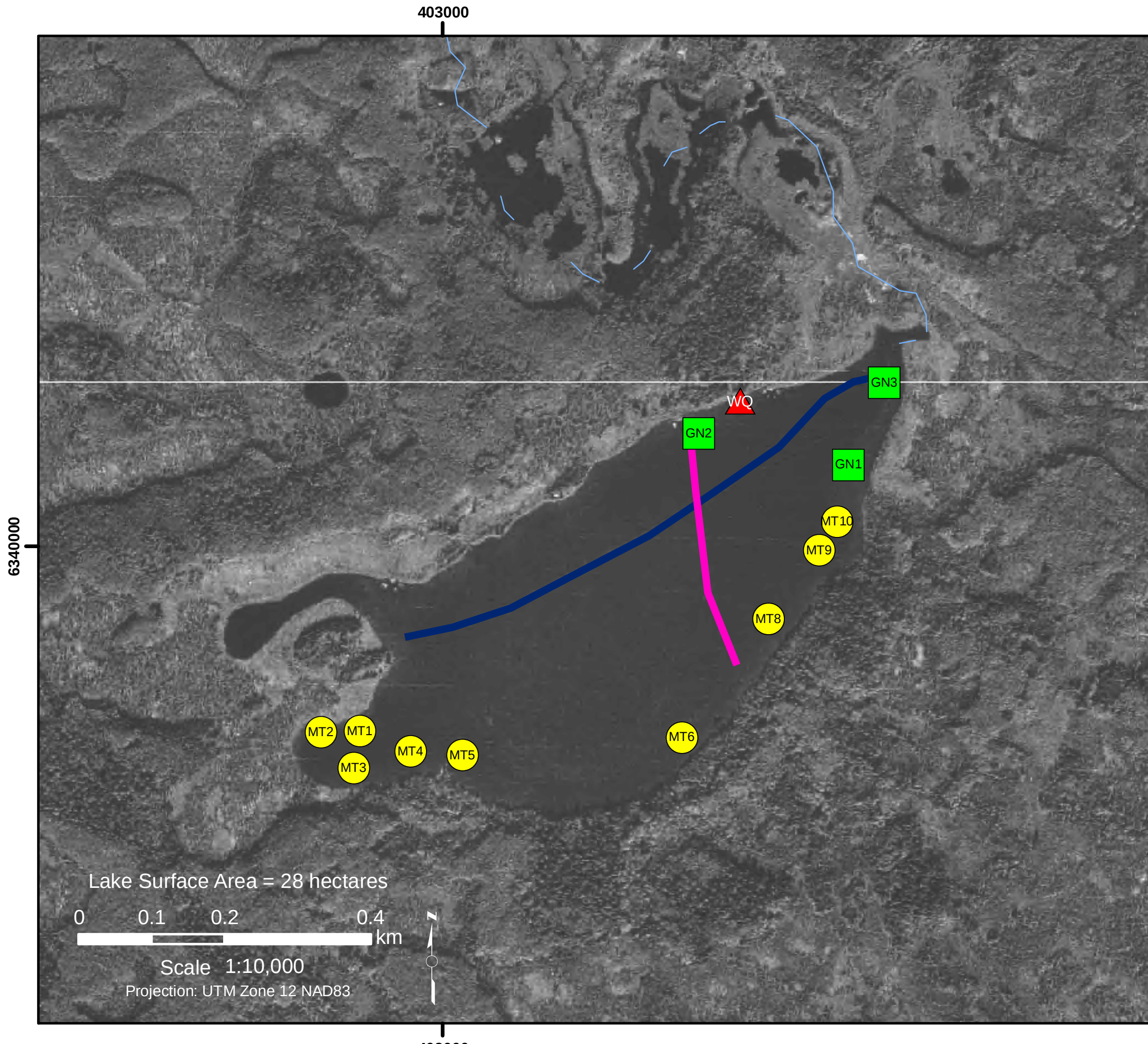
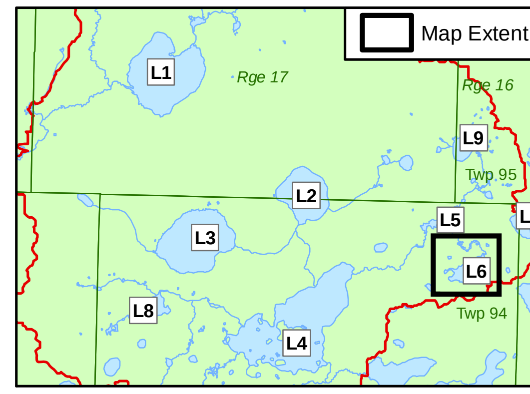
Figure 9 Aquatic habitat survey results for Lake 6, June 2008.





LEGEND

Rivers / Streams

Local Study Area

Minnow Trap Sampling Site

Gillnet Sampling Site

Water Quality Sampling Site

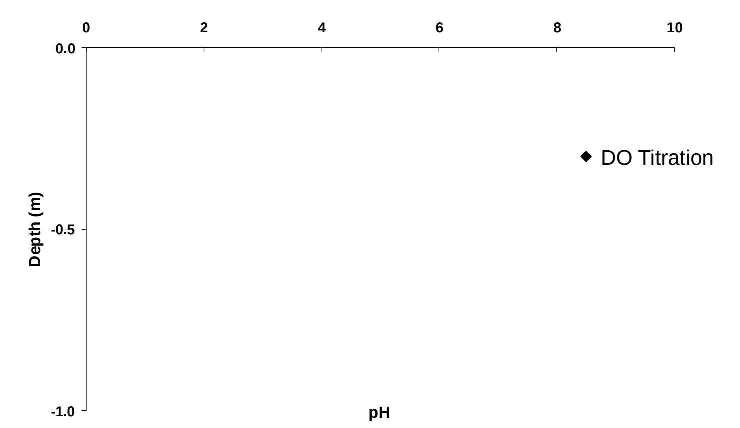
Bathymetric Transect

Data Sources:
a) Airphoto and Study Area from Millennium EMS Solutions Ltd.
b) Lakes/Ponds and Rivers/Streams from 1:50,000 NTSB.

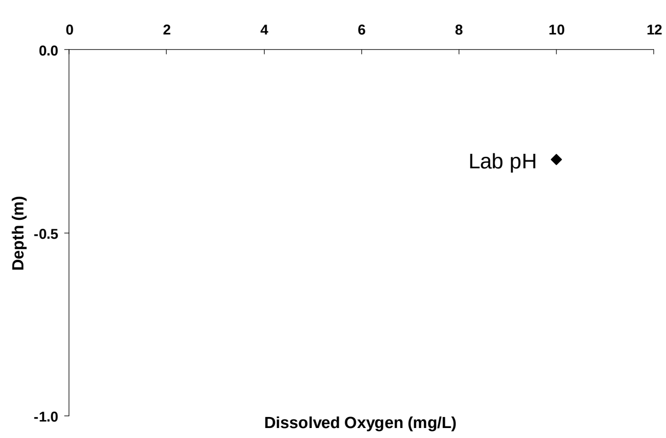
Spring Temperature Profile

Lake too shallow to create profile.

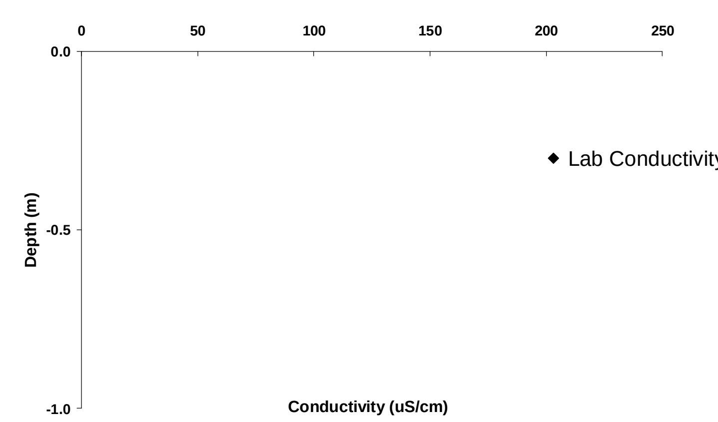
Spring Dissolved Oxygen Profile



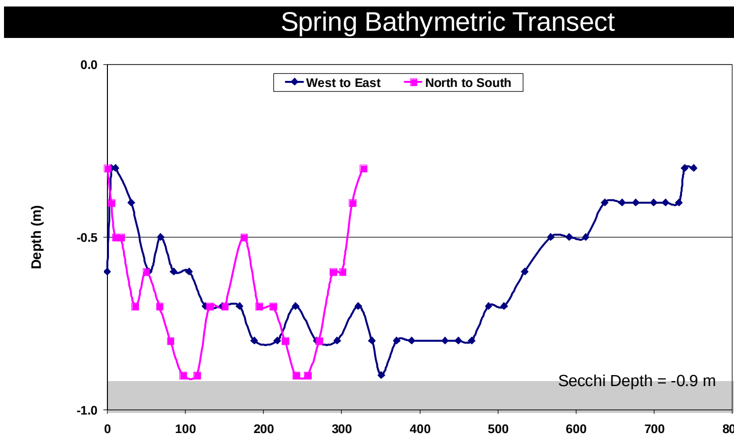
Spring pH Profile



Spring Conductivity Profile



Spring Bathymetric Transect



Spring Lake Habitat Assessment

Site ID	Water Depth (m)	Secchi Depth (m)	Substrate	Large Woody Debris	Small Woody Debris	Undercut Bank	Overhanging Vegetation	Slope (%)	# / fish caught
MT1	0.5	0.5	Organic	Absent	Absent	Absent	Absent	<1	0
MT2	0.3	0.3	Organic	Absent	Absent	Absent	Absent	<1	0
MT3	0.2	0.2	Organic	Absent	Absent	Absent	Absent	<1	0
MT4	0.3	0.3	Organic/Slit/ Clay	Absent	Absent	Absent	Absent	<1	0
MT5	0.6	0.6	Organic/Slit/ Clay	Absent	Absent	Absent	Absent	<1	0
MT6	0.4	0.4	Organic/Slit/ Clay	Absent	Absent	Absent	Absent	<1	0
GN1	-	-	-	-	-	-	-	-	0
GN2	-	-	-	-	-	-	-	-	0
GN3	-	-	-	-	-	-	-	-	0

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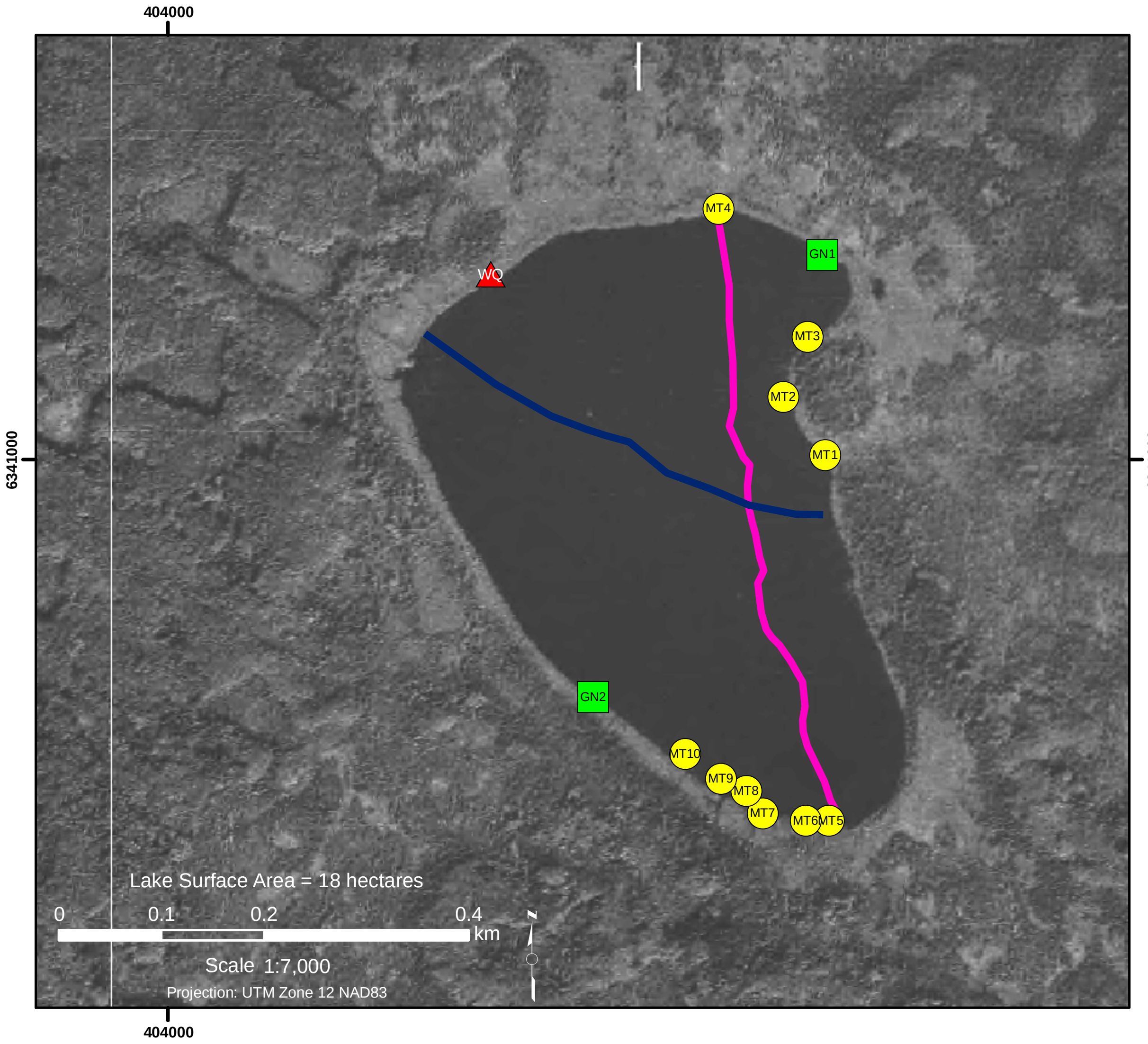
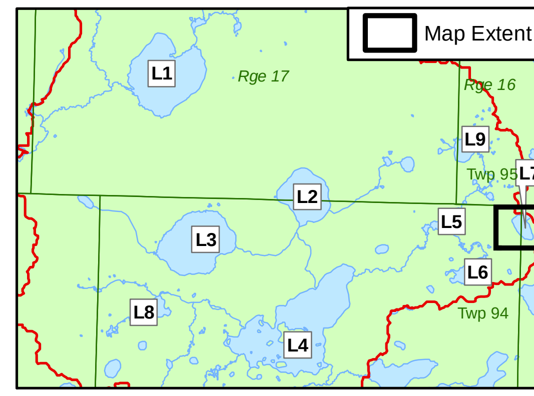
Figure 10 Aquatic habitat survey results for Lake 7, June 2008.



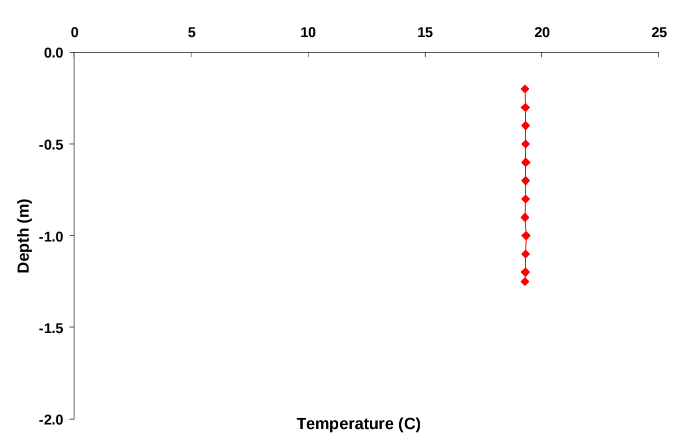


LEGEND

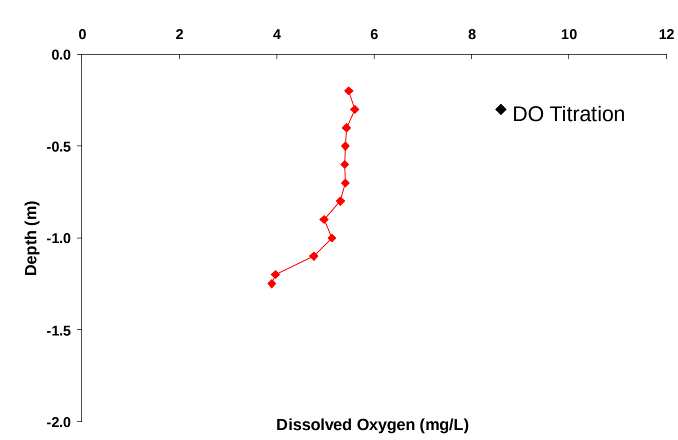
- Rivers / Streams
- Local Study Area
- Minnow Trap Sampling Site
- Gillnet Sampling Site
- Water Quality Sampling Site
- Bathymetric Transect

Data Sources:
a) Airphoto and Study Area from Millennium EMS Solutions Ltd.
b) Lakes/Ponds and Rivers/Streams from 1:50,000 NTSB.

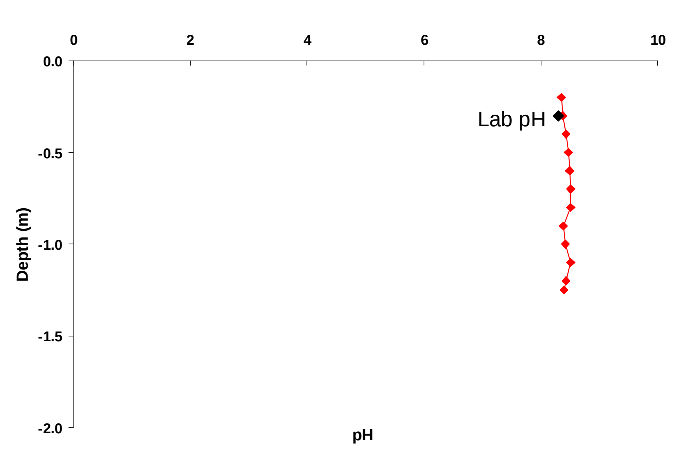
Spring Temperature Profile



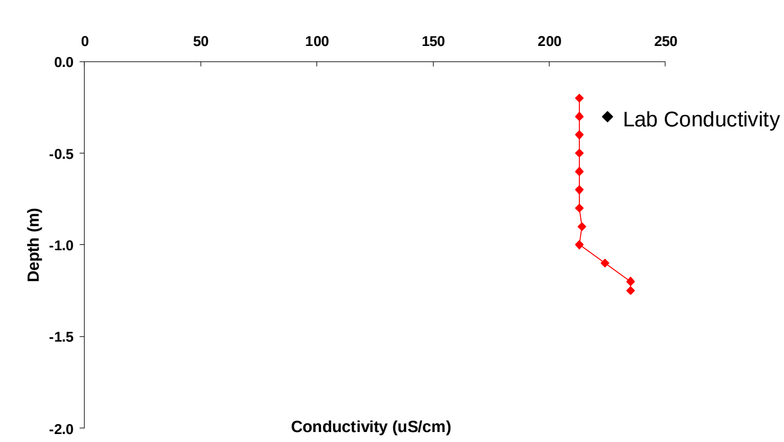
Spring Dissolved Oxygen Profile



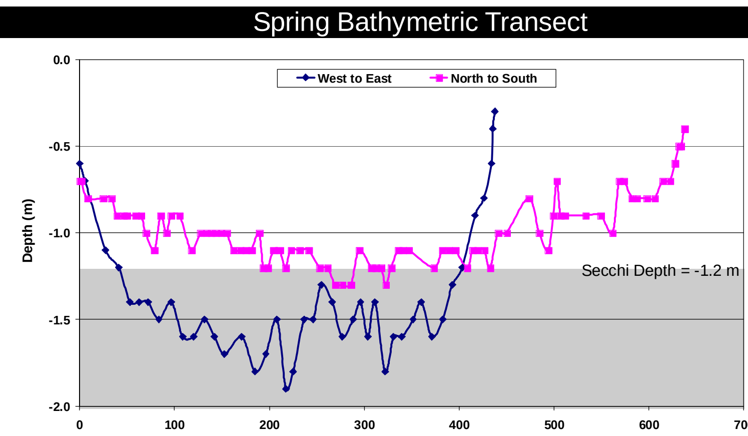
Spring pH Profile



Spring Conductivity Profile



Spring Bathymetric Transect



Spring Lake Habitat Assessment

Site ID	Water Depth (m)	Secchi Depth (m)	Substrate	Large Woody Debris	Small Woody Debris	Undercut Bank	Overhanging Vegetation	Slope (%)	# / fish caught
MT1	0.5	0.5	Organic	Absent	Present	Absent	Absent	<1	0
MT2	0.55	0.55	Organic	Absent	Present	Absent	Absent	<1	0
MT3	0.63	0.63	Organic	Present	Absent	Absent	Present	<1	0
MT4	0.48	0.48	Organic	Present	Absent	Absent	Absent	<1	0
MT5	0.5	0.5	Organic	Present	Present	Absent	Present	<1	0
MT6	0.6	0.6	Organic	Present	Present	Absent	Present	<1	0
MT7	0.5	0.5	Organic	Present	Present	Absent	Present	<1	0
MT8	0.5	0.5	Organic	Present	Present	Absent	Present	<1	0
MT9	0.4	0.4	Organic	Present	Present	Absent	Present	<1	0
MT10	0.5	0.5	Organic	Present	Present	Absent	Present	<1	0
GN1	-	-	-	-	-	-	-	-	0
GN2	-	-	-	-	-	-	-	-	0

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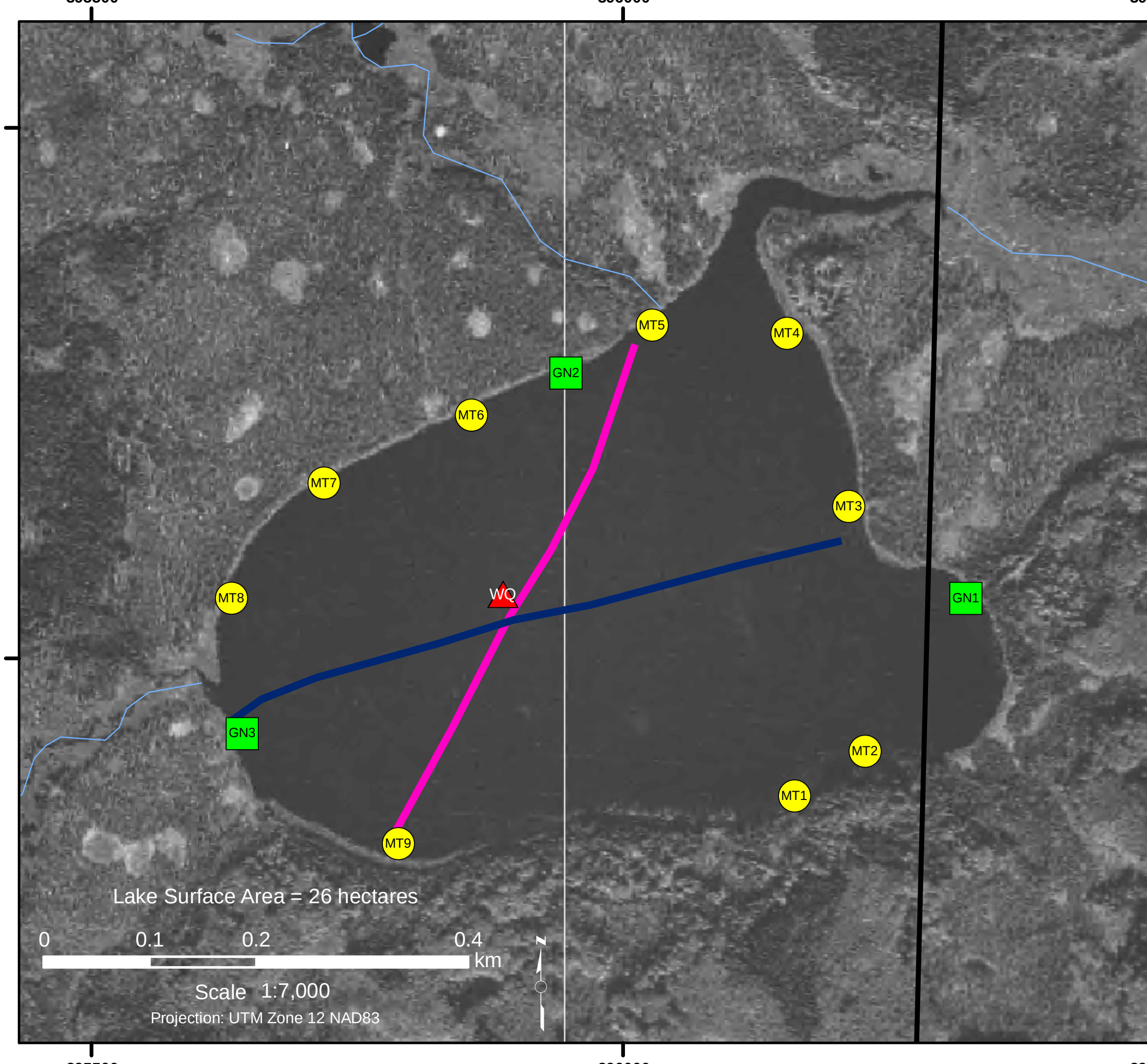
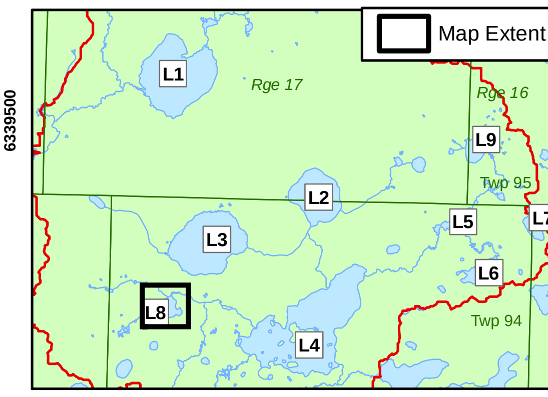
Figure 11 Aquatic habitat survey results for Lake 8, June 2008.



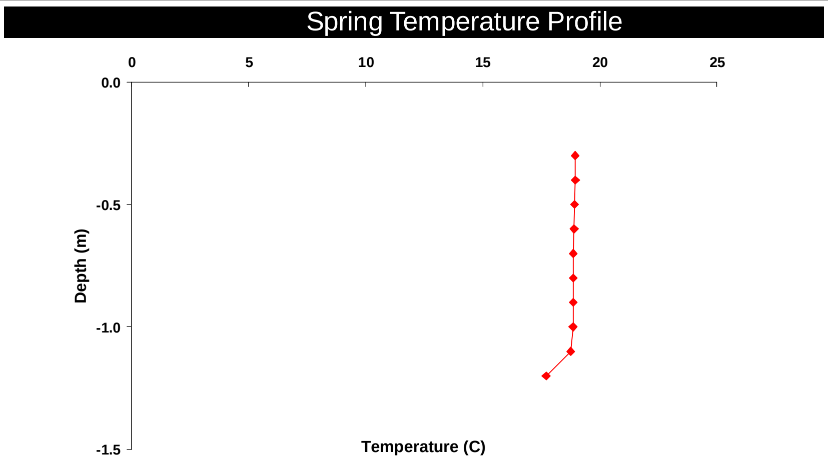


LEGEND

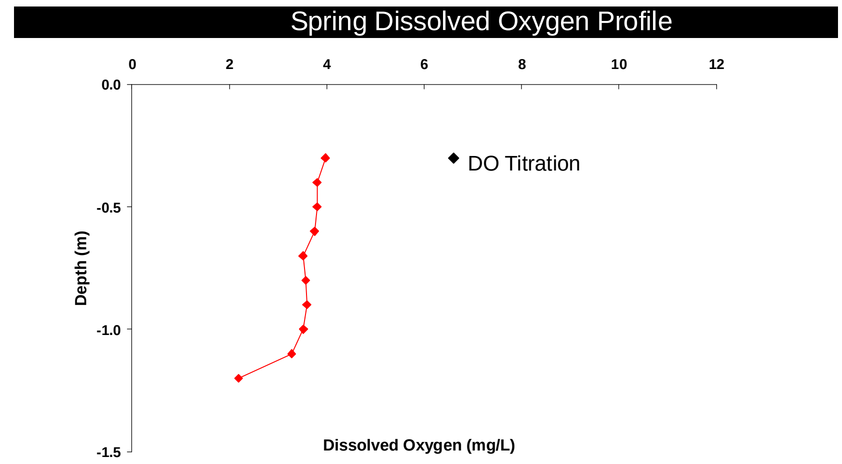
- Rivers / Streams
- Local Study Area
- Minnow Trap Sampling Site
- Gillnet Sampling Site
- Water Quality Sampling Site
- Bathymetric Transect

Data Sources:
a) Airphoto and Study Area from Millennium EMS Solutions Ltd.
b) Lakes/Ponds and Rivers/Streams from 1:50,000 NTSB.

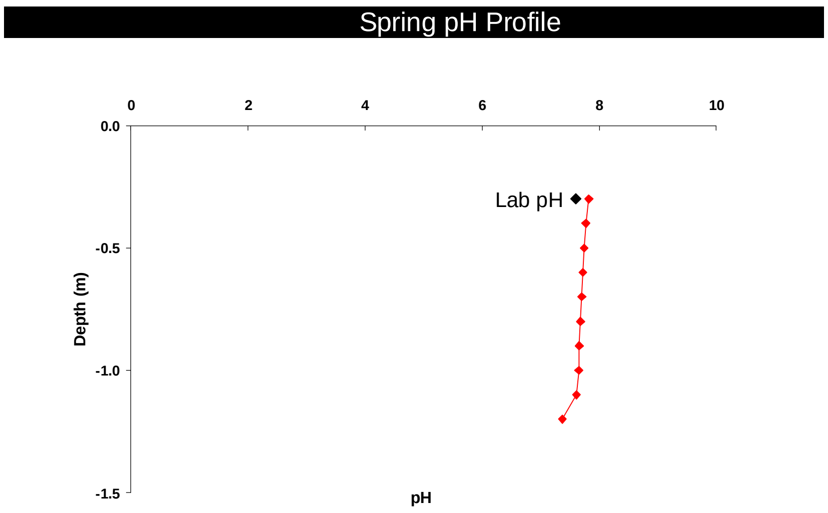
Spring Temperature Profile



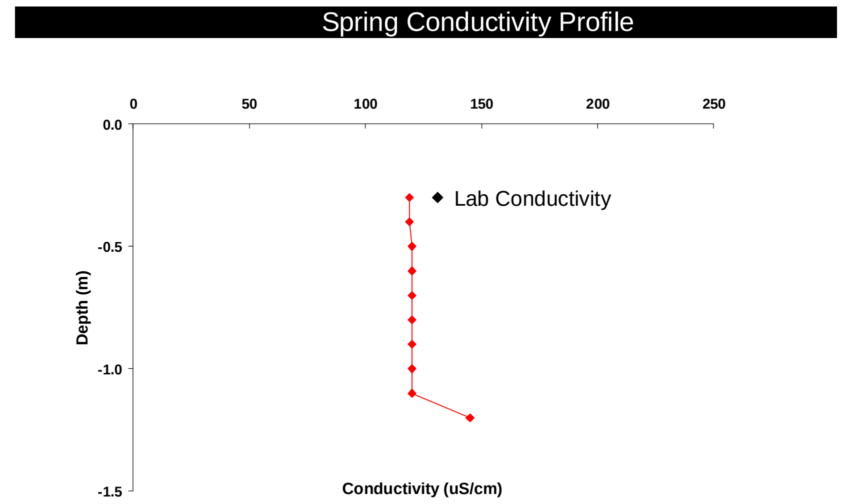
Spring Dissolved Oxygen Profile



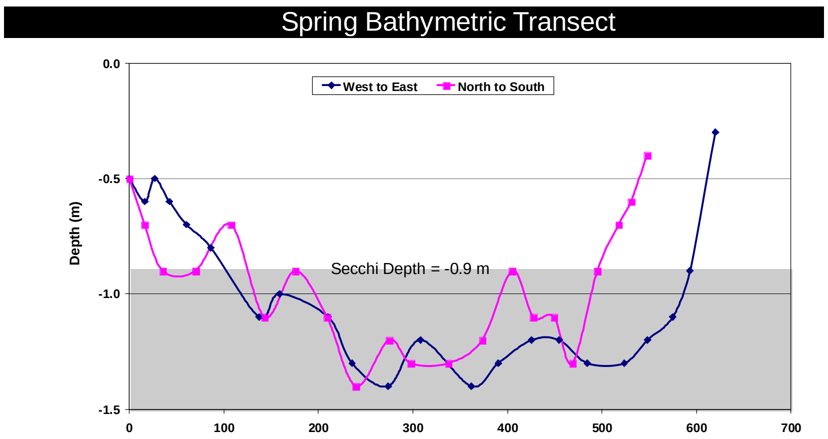
Spring pH Profile



Spring Conductivity Profile

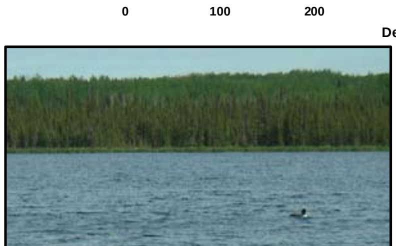


Spring Bathymetric Transect



Spring Lake Habitat Assessment

Site ID	Water Depth (m)	Secchi Depth (m)	Substrate	Large Woody Debris	Small Woody Debris	Undercut Bank	Overhanging Vegetation	Slope (%)	# / fish caught
MT1	0.4	0.4	Organic	Absent	Present	Absent	Absent	<1	0
MT2	0.3	0.3	Organic	Absent	Absent	Absent	Absent	<1	0
MT3	0.5	0.5	Organic	Absent	Absent	Absent	Absent	<1	0
MT4	0.5	0.5	Organic	Absent	Absent	Absent	Absent	<1	0
MT5	0.3	0.3	Organic	Absent	Absent	Absent	Absent	<1	0
MT6	0.5	0.5	Organic	Absent	Absent	Absent	Absent	<1	0
MT7	0.4	0.4	Organic	Absent	Absent	Absent	Absent	<1	0
MT8	0.5	0.5	Organic	Absent	Absent	Absent	Absent	<1	0
MT9	0.5	0.5	Organic	Absent	Absent	Absent	Absent	<1	0
GN1	-	-	-	-	-	-	-	-	0
GN2	-	-	-	-	-	-	-	-	0
GN3	-	-	-	-	-	-	-	-	0



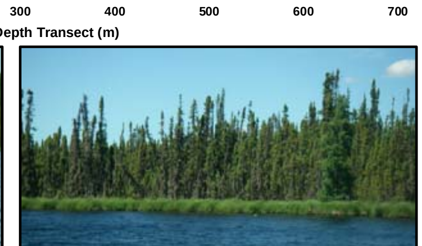


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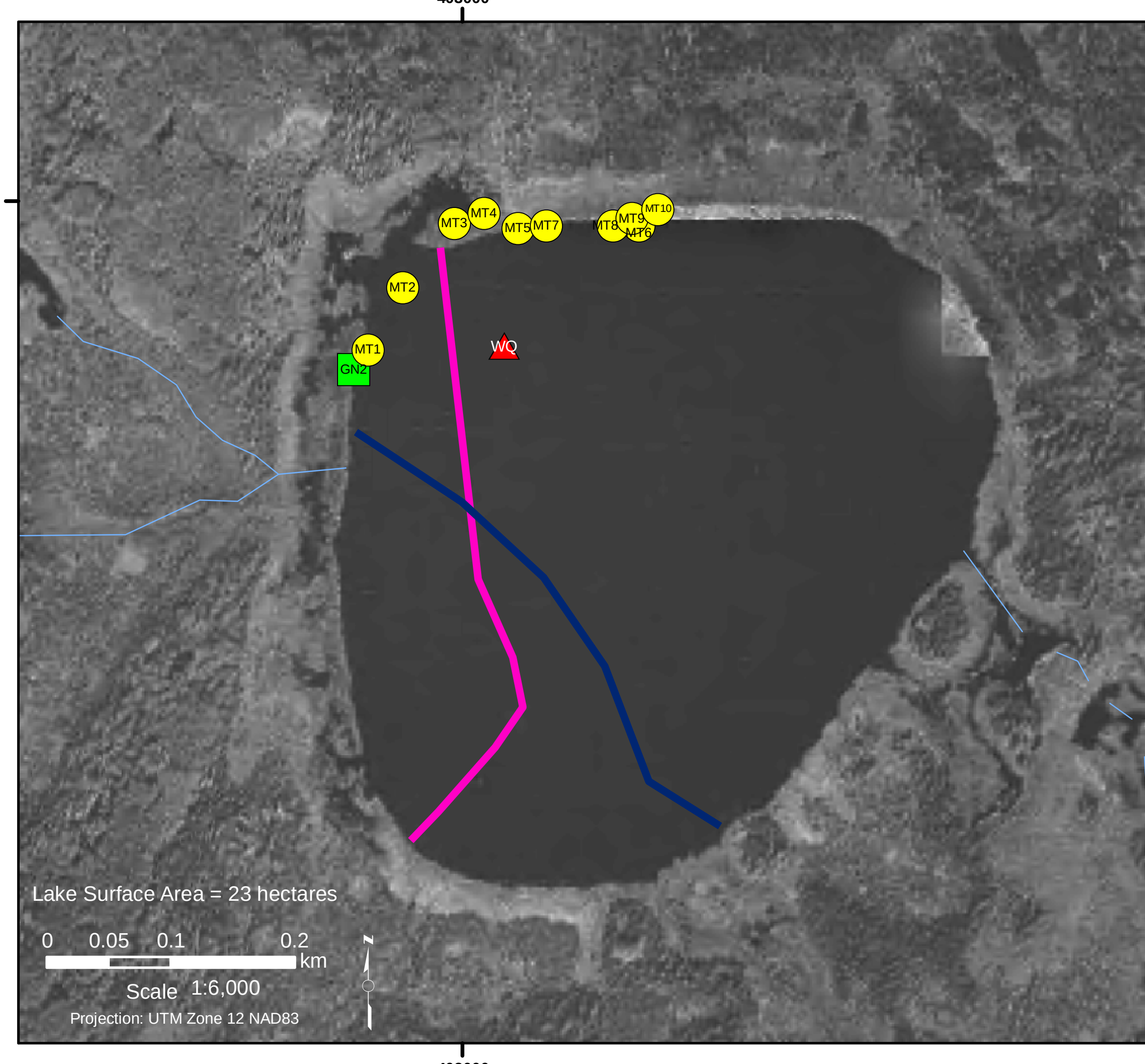
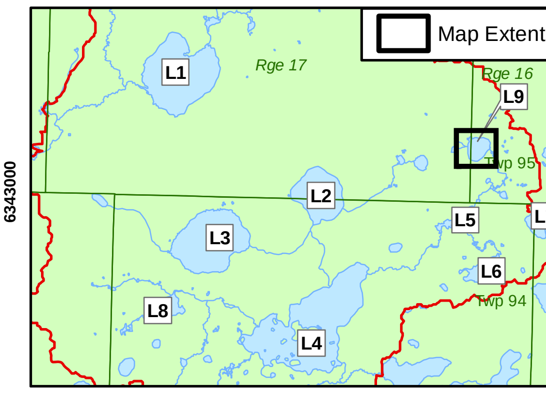
Figure 12 Aquatic habitat survey results for Lake 9, June 2008.





LEGEND

Rivers / Streams

Local Study Area

Minnow Trap Sampling Site

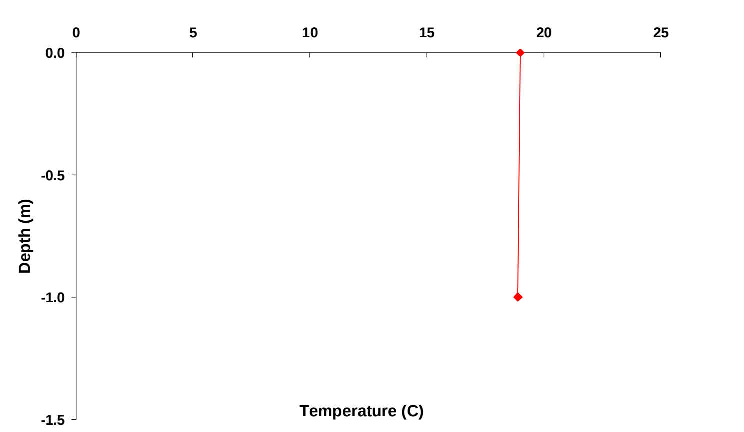
Gillnet Sampling Site

Water Quality Sampling Site

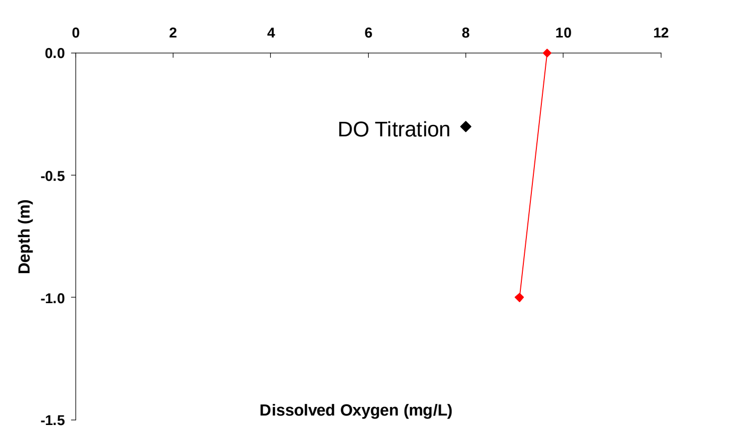
Bathymetric Transect

Data Sources:
a) Airphoto and Study Area from Millennium EMS Solutions Ltd.
b) Lakes/Ponds and Rivers/Streams from 1:50,000 NTSB.

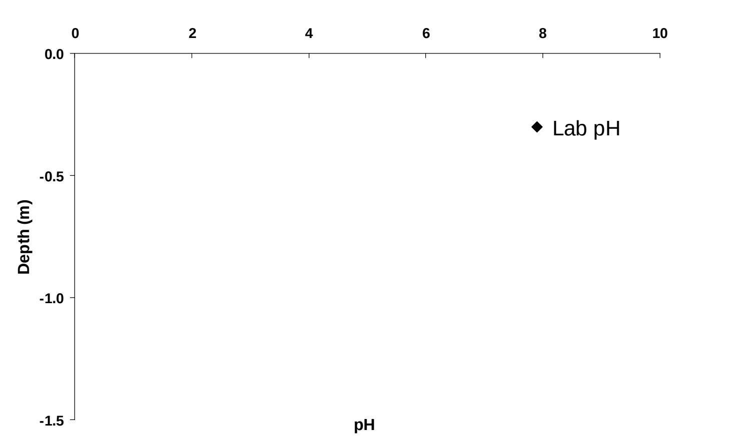
Spring Temperature Profile



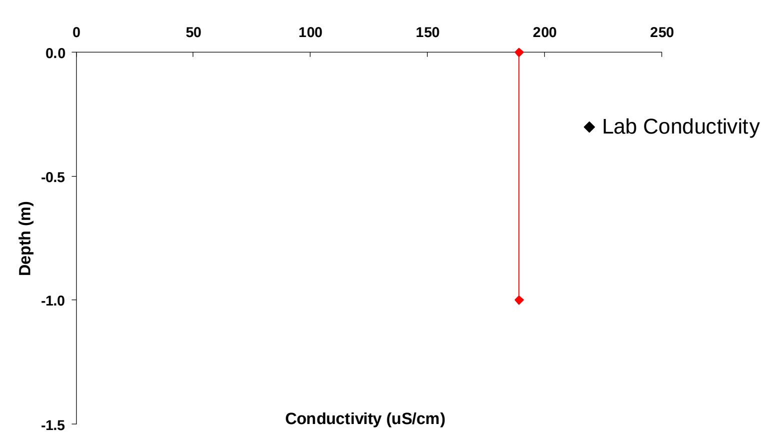
Spring Dissolved Oxygen Profile



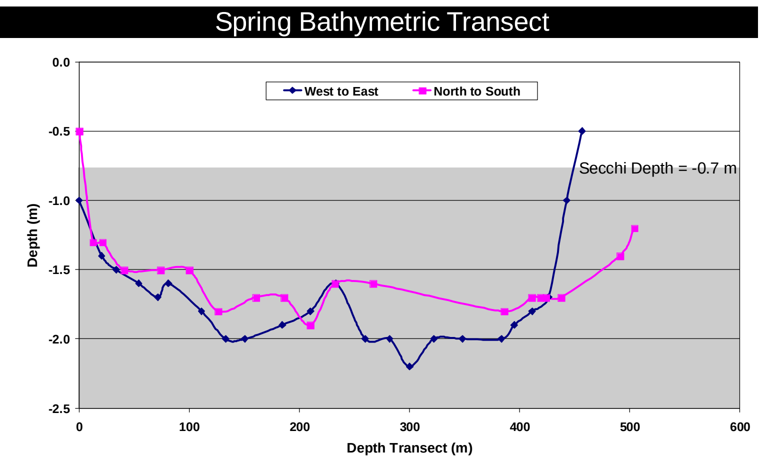
Spring pH Profile



Spring Conductivity Profile



Spring Bathymetric Transect



Spring Lake Habitat Assessment

Site ID	Water Depth (m)	Secchi Depth (m)	Substrate	Large Woody Debris	Small Woody Debris	Undercut Bank	Overhanging Vegetation	Slope (%)	# / fish caught
MT1	0.8	0.8	Organic	Present	Present	Absent	Absent	<1	0
MT2	0.6	0.6	Organic	Present	Present	Absent	Absent	<1	0
MT3	0.7	0.7	Organic	Present	Present	Absent	Absent	<1	0
MT4	0.5	0.5	Organic	Absent	Present	Absent	Absent	<1	0
MT5	0.8	0.8	Organic	Absent	Present	Absent	Absent	<1	0
MT6	0.8	0.8	Organic	Absent	Absent	Absent	Absent	<1	0
MT7	0.5	0.5	Organic	Absent	Absent	Absent	Absent	<1	0
MT8	0.7	0.7	Organic	Absent	Present	Absent	Absent	<1	0
MT9	0.6	0.6	Organic	Absent	Absent	Absent	Absent	<1	0
MT10	0.7	0.7	Organic	Absent	Absent	Absent	Absent	<1	0
GN1	-	-	-	-	-	-	-	-	0
GN2	-	-	-	-	-	-	-	-	0

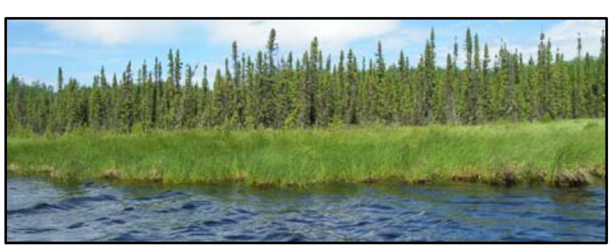


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Figure 13 Aquatic habitat survey results for stream sample site 1, June 2008.

Referencing Information		
Watershed:	Snipe Creek	
Map Location:	S1	
Date Assessed :	21 June 2008	
Time Assessed:	1430	
UTM (NAD83, 12V):	393258E, 6350560N	
Access:	Helicopter	
Water Quality		
	Spring	
Temperature (°C):	8.5	
Dissolved Oxygen (mg/L):	10	
pH:	7.7	
Turbidity (NTUs):	0.7	
Conductivity (µS/cm):	84.2	
Channel Characteristic		
	Spring	
Channel Width (m):	3	
Wetted Width (m):	2.3	
Residual Pool Depth (m):	0.7	
Flow Velocity (m/s):	0.11	
Stage:	Moderate	
Cover and Streambanks		
Crown Closure (%):	<20	
Cover:	80	
Sources of Instream Cover:		
Small Woody Debris:	Sub-dominant	
Large Woody Debris:	-	
Boulders:	-	
Undercut Banks:	-	
Deep Pools:	Dominant	
Overhanging Vegetation:	Trace	
Instream Vegetation:	Trace	
Functional Large Woody Debris:	None	
Aquatic Vegetation:	Vascular	
	LDB	*RDB*
Bank Shape:	Undercut	Undercut
Bank Texture:	Fines	Fines
Bank Riparian Vegetation:	Grasses, Shrubs	Grasses, Shrubs
Vegetation Stage:	Shrub	Shrub
Channel Morphology		
Dominant Bed Material:	Fines	
Sub-Dominant Bed Material:	Fines	
Morphology:	Run	
Disturbance Indicators:	-	
Pattern:	Sinuous	
Islands:	None	
Bars:	None	
Coupling:	Decoupled	
Confinement:	Unconfined	
Fish Observations		
No fish captured.		




Figure 14 Aquatic habitat survey results for stream sample site 2, June 2008.

Referencing Information		
Watershed:	Snipe Creek	
Map Location:	S2	
Date Assessed :	21 June 2008	
Time Assessed:	0940	
UTM (NAD83, 12V):	398032E, 6346061N	
Access:	Helicopter	
Water Quality		
	Spring	
Temperature (°C):	14.7	
Dissolved Oxygen (mg/L):	7.6	
pH:	7.8	
Turbidity (NTUs):	1.1	
Conductivity (µS/cm):	302.5	
Channel Characteristic		
	Spring	
Channel Width (m):	30.75	
Wetted Width (m):	8.25	
Residual Pool Depth (m):	No pools	
Flow Velocity (m/s):	0	
Stage:	-	
Cover and Streambanks		
Crown Closure (%):	-	
Cover:	90	
Sources of Instream Cover:		
Small Woody Debris:	Trace	
Large Woody Debris:	-	
Boulders:	-	
Undercut Banks:	-	
Deep Pools:	Dominant	
Overhanging Vegetation:	Trace	
Instream Vegetation:	Sub-dominant	
Functional Large Woody Debris:	None	
Aquatic Vegetation:	Algae, Mosses, Vascular	
	LDB	*RDB*
Bank Shape:	Sloping	Sloping
Bank Texture:	Fines	Fines
Bank Riparian Vegetation:	Grasses, Shrubs	Grasses, Shrubs
Vegetation Stage:	Shrub	Shrub
Channel Morphology		
Dominant Bed Material:	Fines	
Sub-Dominant Bed Material:	Fines	
Morphology:	Run	
Disturbance Indicators:	Beaver Dam	
Pattern:	Sinuous	
Islands:	None	
Bars:	None	
Coupling:	Decoupled	
Confinement:	Unconfined	
Fish Observations		
Fish species captured: Brook Stickleback		

Figure 15 Aquatic habitat survey results for stream sample site 3, June 2008.

Referencing Information		
Watershed:	Snipe Creek	
Map Location:	S3	
Date Assessed :	20 June 2008	
Time Assessed:	1405	
UTM (NAD83, 12V):	399694E, 6345791N	
Access:	Helicopter	
Water Quality		
	Spring	
Temperature (°C):	12.4	
Dissolved Oxygen (mg/L):	4	
pH:	7.4	
Turbidity (NTUs):	1.7	
Conductivity (µS/cm):	256.1	
Channel Characteristic		
	Spring	
Channel Width (m):	32.5	
Wetted Width (m):	4.5	
Residual Pool Depth (m):	>1.5	
Flow Velocity (m/s):	0	
Stage:	Moderate	
Cover and Streambanks		
Crown Closure (%):	<20	
Cover:	80	
Sources of Instream Cover:		
Small Woody Debris:	Trace	
Large Woody Debris:	-	
Boulders:	-	
Undercut Banks:	Trace	
Deep Pools:	Dominant	
Overhanging Vegetation:	Subdominant	
Instream Vegetation:	Trace	
Functional Large Woody Debris:	None	
Aquatic Vegetation:	Algae, Mosses, Vascular	
	LDB	*RDB*
Bank Shape:	Sloping	Sloping
Bank Texture:	Fines	Fines
Bank Riparian Vegetation:	Grasses, Conifers	Grasses, Conifers
Vegetation Stage:	Young Forest	Young Forest
Channel Morphology		
Dominant Bed Material:	Fines	
Sub-Dominant Bed Material:	Fines	
Morphology:	Run	
Disturbance Indicators:	-	
Pattern:	Irregular, wandering	
Islands:	None	
Bars:	None	
Coupling:	Decoupled	
Confinement:	Unconfined	
Fish Observations		
No fish captured.		

Figure 16 Aquatic habitat survey results for stream sample site 4, June 2008.

Referencing Information		
Watershed:	Snipe Creek	
Map Location:	S4	
Date Assessed :	21 June 2008	
Time Assessed:	1140	
UTM (NAD83, 12V):	393685E, 6343608N	
Access:	Helicopter	
Water Quality		
	Spring	
Temperature (°C):	12.9	
Dissolved Oxygen (mg/L):	8.4	
pH:	7.7	
Turbidity (NTUs):	16	
Conductivity (µS/cm):	91.9	
Channel Characteristic		
	Spring	
Channel Width (m):	9.25	
Wetted Width (m):	7.75	
Residual Pool Depth (m):	-	
Flow Velocity (m/s):	0.52	
Stage:	Moderate	
Cover and Streambanks		
Crown Closure (%):	-	
Cover:	90	
Sources of Instream Cover:		
Small Woody Debris:	Trace	
Large Woody Debris:	Trace	
Boulders:	-	
Undercut Banks:	-	
Deep Pools:	Dominant	
Overhanging Vegetation:	Trace	
Instream Vegetation:	Sub-dominant	
Functional Large Woody Debris:	None	
Aquatic Vegetation:	Vascular	
	LDB	*RDB*
Bank Shape:	Undercut	Undercut
Bank Texture:	Fines	Fines
Bank Riparian Vegetation:	Grasses, Shrubs	Grasses, Shrubs
Vegetation Stage:	Mature Forest	Mature Forest
Channel Morphology		
Dominant Bed Material:	Fines	
Sub-Dominant Bed Material:	Fines	
Morphology:	Run	
Disturbance Indicators:	-	
Pattern:	Sinuous	
Islands:	None	
Bars:	Side bars	
Coupling:	Decoupled	
Confinement:	Unconfined	
Fish Observations		
Fish species captured: Brook Stickleback		

Figure 17 Aquatic habitat survey results for stream sample site 5, June 2008.

Referencing Information		
Watershed:	Snipe Creek	
Map Location:	S5	
Date Assessed :	23 June 2008	
Time Assessed:	1336	
UTM (NAD83, 12V):	394656E, 6345478N	
Access:	Helicopter	
Water Quality		
	Spring	
Temperature (°C):	12.6	
Dissolved Oxygen (mg/L):	10.57	
pH:	7.7	
Turbidity (NTUs):	0.7	
Conductivity (µS/cm):	94.6	
Channel Characteristic		
	Spring	
Channel Width (m):	12.75	
Wetted Width (m):	9.25	
Residual Pool Depth (m):	>1.5	
Flow Velocity (m/s):	-	
Stage:	Moderate	
Cover and Streambanks		
Crown Closure (%):	<20	
Cover:	80	
Sources of Instream Cover:		
Small Woody Debris:	Trace	
Large Woody Debris:	Trace	
Boulders:	-	
Undercut Banks:	-	
Deep Pools:	Dominant	
Overhanging Vegetation:	Subdominant	
Instream Vegetation:	Trace	
Functional Large Woody Debris:	Few	
Aquatic Vegetation:	-	
	LDB	*RDB*
Bank Shape:	Sloping	Sloping
Bank Texture:	Fines	Fines
Bank Riparian Vegetation:	Mixed Coniferous & Deciduous Forest	Mixed Coniferous & Deciduous Forest
Vegetation Stage:	Mature Forest	Mature Forest
Channel Morphology		
Dominant Bed Material:	Fines	
Sub-Dominant Bed Material:	Fines	
Morphology:	Run	
Disturbance Indicators:	Beaver Dam	
Pattern:	Sinuous	
Islands:	None	
Bars:	None	
Coupling:	Decoupled	
Confinement:	Unconfined	
Fish Observations		
Fish species captured: Brook Stickleback, Lake Chub, White Sucker		

Figure 18 Aquatic habitat survey results for stream sample site 7, June 2008.

Referencing Information		
Watershed:	Dover River	
Map Location:	S7	
Date Assessed :	20 June 2008	
Time Assessed:	1712	
UTM (NAD83, 12V):	400955E, 6341844N	
Access:	Helicopter	
Water Quality		
	Spring	
Temperature (°C):	13.8	
Dissolved Oxygen (mg/L):	1.2	
pH:	7.0	
Turbidity (NTUs):	1	
Conductivity (µS/cm):	93.5	
Channel Characteristic		
	Spring	
Channel Width (m):	10	
Wetted Width (m):	4.6	
Residual Pool Depth (m):	1.1	
Flow Velocity (m/s):	0	
Stage:	Moderate	
Cover and Streambanks		
Crown Closure (%):	-	
Cover:	90	
Sources of Instream Cover:		
Small Woody Debris:	Trace	
Large Woody Debris:	-	
Boulders:	-	
Undercut Banks:	-	
Deep Pools:	Sub-dominant	
Overhanging Vegetation:	Trace	
Instream Vegetation:	Dominant	
Functional Large Woody Debris:	None	
Aquatic Vegetation:	Algae, Mosses, Vascular	
	LDB	*RDB*
Bank Shape:	Sloping	Sloping
Bank Texture:	Fines	Fines
Bank Riparian Vegetation:	Grasses, Shrubs	Grasses, Shrubs
Vegetation Stage:	Young Forest	Young Forest
Channel Morphology		
Dominant Bed Material:	Fines	
Sub-Dominant Bed Material:	Fines	
Morphology:	Run	
Disturbance Indicators:	-	
Pattern:	Irregular, wandering	
Islands:	None	
Bars:	None	
Coupling:	Decoupled	
Confinement:	Unconfined	
Fish Observations		
No fish captured.		

Figure 19 Aquatic habitat survey results for stream sample site 8, June 2008.

Referencing Information		
Watershed:	Dover River	
Map Location:	S8	
Date Assessed :	22 June 2008	
Time Assessed:	1100	
UTM (NAD83, 12V):	399566E, 6340391N	
Access:	Helicopter	
Water Quality		
	Spring	
Temperature (°C):	15	
Dissolved Oxygen (mg/L):	4.6	
pH:	7.3	
Turbidity (NTUs):	0.6	
Conductivity (µS/cm):	111.3	
Channel Characteristic		
	Spring	
Channel Width (m):	49	
Wetted Width (m):	1.375	
Residual Pool Depth (m):	-	
Flow Velocity (m/s):	0	
Stage:	Moderate	
Cover and Streambanks		
Crown Closure (%):	-	
Cover:	95	
Sources of Instream Cover:		
Small Woody Debris:	Trace	
Large Woody Debris:	Trace	
Boulders:	-	
Undercut Banks:	-	
Deep Pools:	Sub-dominant	
Overhanging Vegetation:	-	
Instream Vegetation:	Dominant	
Functional Large Woody Debris:	None	
Aquatic Vegetation:	Algae	
	LDB	*RDB*
Bank Shape:	Vertical	Vertical
Bank Texture:	Fines	Fines
Bank Riparian Vegetation:	Grasses, Shrubs	Grasses, Shrubs
Vegetation Stage:	Mature Forest	Mature Forest
Channel Morphology		
Dominant Bed Material:	Organic	
Sub-Dominant Bed Material:	Fines	
Morphology:	Pool/Run	
Disturbance Indicators:	Beaver Dam	
Pattern:	Tortuous Meanders	
Islands:	None	
Bars:	None	
Coupling:	Decoupled	
Confinement:	Unconfined	
Fish Observations		
No fish captured.		

Figure 20 Aquatic habitat survey results for stream sample site 9, June 2008.

Referencing Information		
Watershed:	Dover River	
Map Location:	S9	
Date Assessed :	23 June 2008	
Time Assessed:	1012	
UTM (NAD83, 12V):	394580E, 6341448N	
Access:	Helicopter	
Water Quality		
	Spring	
Temperature (°C):	11.6	
Dissolved Oxygen (mg/L):	0.6	
pH:	6.9	
Turbidity (NTUs):	1.2	
Conductivity (µS/cm):	77.3	
Channel Characteristic		
	Spring	
Channel Width (m):	1.32	
Wetted Width (m):	0.8	
Residual Pool Depth (m):	-	
Flow Velocity (m/s):	0	
Stage:	Moderate	
Cover and Streambanks		
Crown Closure (%):	<20	
Cover:	20	
Sources of Instream Cover:		
Small Woody Debris:	Trace	
Large Woody Debris:	-	
Boulders:	-	
Undercut Banks:	Trace	
Deep Pools:	-	
Overhanging Vegetation:	Dominant	
Instream Vegetation:	-	
Functional Large Woody Debris:	None	
Aquatic Vegetation:	None	
	LDB	*RDB*
Bank Shape:	Sloping	Sloping
Bank Texture:	Fines	Fines
Bank Riparian Vegetation:	Grasses, Mixed Conifer & Deciduous Forest	Grasses, Mixed Conifer & Deciduous Forest
Vegetation Stage:	Young Forest	Young Forest
Channel Morphology		
Dominant Bed Material:	Fines	
Sub-Dominant Bed Material:	Fines	
Morphology:	Run	
Disturbance Indicators:	Beaver Dam	
Pattern:	Sinuous	
Islands:	None	
Bars:	None	
Coupling:	Decoupled	
Confinement:	Unconfined	
Fish Observations		
No fish captured.		



APPENDICES

Appendix A1

QA/QC Water Quality Analysis

Table A1.1 Water quality QA/QC results: field split.

Water Quality Variable	Units	Detection Limit	L1	Split for L1 (S45)	Relative Percent Difference
Physical Variables, Nutrients, Ions, and Organics/Hydrocarbons					
Alkalinity, Total (as $CaCO_3$)	mg/L	5	109	106	2.8
Ammonia-N	mg/L	0.05	0.09	0.11	**<u>20.0</u>**
Bicarbonate (HCO_3)	mg/L	5	114	110	3.6
Biochemical Oxygen Demand	mg/L	2	12	12	0.0
Calcium (Ca)	mg/L	0.5	28.5	28.2	1.1
Carbonate (CO_3)	mg/L	5	9	9	0.0
Chloride (Cl)	mg/L	1	2	2	0.0
Color, True	T.C.U.	2	71	72	1.4
Conductivity (EC)	µS/cm	0.2	228	215	5.9
Dissolved Organic Carbon	mg/L	1	25	26	3.9
Hardness (as $CaCO_3$)	mg/L		104	103	1.0
Hydrocarbons, Recoverable (I.R.)	mg/L	1	<1	<1	0.0
Hydroxide (OH)	mg/L	5	<5	<5	0.0
Magnesium (Mg)	mg/L	0.1	8	7.8	2.5
Naphthenic Acids	mg/L	1	<1	<1	0.0
Nitrate+Nitrite-N	mg/L	0.1	<0.1	<0.1	0.0
pH	pH	0.1	8.8	8.8	0.0
Phenols (4AAP)	mg/L	0.001	0.009	0.01	10.5
Phosphorus, Total	mg/L	0.001	0.211	0.251	17.3
Phosphorus, Total Dissolved	mg/L	0.001	0.025	0.028	11.3
Potassium (K)	mg/L	0.5	1.7	1.7	0.0
Sodium (Na)	mg/L	1	12	12	0.0
Sulfate (SO_4)	mg/L	0.5	14	13.4	4.4
Sulphide	mg/L	0.002	<0.002	0.004	-
Total Dissolved Solids	mg/L	10	180	190	5.4
Total Kjeldahl Nitrogen	mg/L	0.2	3.3	3.2	3.1
Total Organic Carbon	mg/L	1	34	32	6.1
Total Suspended Solids	mg/L	3	16	14	13.3
Total Metals					
Aluminum	mg/L	0.002	0.0172	0.0191	10.5
Antimony	mg/L	0.000001	0.0000573	0.0000575	0.3
Arsenic	mg/L	0.00006	0.00205	0.00202	1.5
Barium	mg/L	0.0001	0.0222	0.02	1.3
Beryllium	mg/L	0.00001	0.0000121	0.000004	**<u>100.6</u>**
Bismuth	mg/L	0.00001	0.0000026	0.0000012	**<u>73.7</u>**
Boron	mg/L	0.0008	0.0687	0.07	2.1
Cadmium	mg/L	0.000006	0.0000038	0.0000043	12.3
Calcium	mg/L	0.1	27.7	27.70	0.0
Chlorine	mg/L	0.3	0.396	0.59	**<u>39.7</u>**
Chromium	mg/L	0.0003	<0.00004	<0.00004	0.0
Cobalt	mg/L	0.00001	0.0000857	0.000092	7.4
Copper	mg/L	0.0001	<0.00005	0.000055	-
Iron	mg/L	0.004	0.274	0.29	5.7
Lead	mg/L	0.000006	0.0000106	0.0000259	**<u>83.8</u>**
Lithium	mg/L	0.0002	0.0163	0.02	4.4
Manganese	mg/L	0.00003	0.113	0.116	2.6
Mercury	mg/L	0.00005	<0.00001	<0.00001	0.0
Molybdenum	mg/L	0.000008	0.000617	0.000628	1.8

variable Variables differ by > 20% but one or both concentrations are < 5 times the detection limit.

<u>variable</u> Variables differ by > 20% and concentrations are > 5 times the detection limit.

Table A1.1 (Cont'd.)

Water Quality Variable	Units	Detection Limit	L1	Split for L1 (S45)	Relative Percent Difference
Total Metals (Cont'd.)					
Nickel	mg/L	0.00006	0.00017	0.000322	<u>**61.8**</u>
Selenium	mg/L	0.0003	<0.0001	0.00015	-
Silver	mg/L	0.000005	0.000004	0.0000006	<u>**147.8**</u>
Strontium	mg/L	0.000008	0.15	0.15	0.7
Sulphur	mg/L	0.6	5.46	5.45	0.2
Thallium	mg/L	0.000003	0.0000006	0.0000006	0.0
Thorium	mg/L	0.00003	0.0000033	0.000011	<u>**109.0**</u>
Tin	mg/L	0.00007	<0.00003	0.000066	-
Titanium	mg/L	0.00007	0.00168	0.00191	12.8
Ultra-Trace Mercury	mg/L	0.0000012	<0.0000006	0.0000009	-
Uranium	mg/L	0.000003	0.000254	0.00026	2.3
Vanadium	mg/L	0.00005	0.000399	0.00038	6.2
Zinc	mg/L	0.0002	0.000271	0.000343	<u>**23.5**</u>
Dissolved Metals					
Aluminum	mg/L	0.001	0.00454	0.00548	18.8
Antimony	mg/L	0.000001	0.0000567	0.0000569	0.4
Arsenic	mg/L	0.00006	0.00164	0.00165	0.6
Barium	mg/L	0.0001	0.0175	0.0178	1.7
Beryllium	mg/L	0.00001	0.0000038	<0.000003	-
Bismuth	mg/L	0.00001	0.0000025	0.0000012	<u>**70.3**</u>
Boron	mg/L	0.0008	0.0649	0.0632	2.7
Cadmium	mg/L	0.000006	0.0000031	0.0000022	<u>**34.0**</u>
Calcium	mg/L	0.1	26.4	26.5	0.4
Chlorine	mg/L	0.3	0.392	0.586	<u>**39.7**</u>
Chromium	mg/L	0.0003	<0.00004	<0.00004	0.0
Cobalt	mg/L	0.00001	0.0000621	0.0000642	3.3
Copper	mg/L	0.0001	0.000845	0.000054	<u>**176.0**</u>
Iron	mg/L	0.004	0.033	0.0525	**45.6**
Lead	mg/L	0.000006	<0.000001	0.0000034	-
Lithium	mg/L	0.0002	0.0153	0.0151	1.3
Manganese	mg/L	0.00003	0.00752	0.00968	**25.1**
Mercury	mg/L	0.00005	<0.00001	<0.00001	0.0
Molybdenum	mg/L	0.000008	0.000547	0.000546	0.2
Nickel	mg/L	0.00006	0.000096	0.000189	<u>**65.3**</u>
Selenium	mg/L	0.0003	<0.0001	0.000149	-
Silver	mg/L	0.000005	<0.0000005	<0.0000005	0.0
Strontium	mg/L	0.000008	0.142	0.144	1.4
Sulphur	mg/L	0.6	5.13	5.4	5.1
Thallium	mg/L	0.000003	0.0000006	0.0000006	0.0
Thorium	mg/L	0.00003	0.0000033	0.0000111	<u>**108.3**</u>
Tin	mg/L	0.00007	<0.00003	<0.00003	0.0
Titanium	mg/L	0.00007	0.000947	0.000877	7.7
Uranium	mg/L	0.000003	0.000236	0.000237	0.4
Vanadium	mg/L	0.00005	0.00031	0.000289	7.0
Zinc	mg/L	0.0002	0.000268	0.00034	<u>**23.7**</u>

variable Variables differ by > 20% but one or both concentrations are < 5 times the detection limit.

<u>**variable**</u> Variables differ by > 20% and concentrations are > 5 times the detection limit.

Table A1.2 Water quality QA/QC results: field and trip blanks.

Water Quality Variable	Unit	Detection Limit	Field Blank (S39)	Trip Blank (S43)
Physical Variables, Nutrients, Ions, and Organics/Hydrocarbons				
Alkalinity, Total (as $CaCO_3$)	mg/L	5	**<5**	**<5**
Ammonia-N	mg/L	0.05	**<0.05**	**<0.05**
Bicarbonate (HCO_3)	mg/L	5	**<5**	**<5**
Biochemical Oxygen Demand	mg/L	2	**<2**	**<2**
Calcium (Ca)	mg/L	0.5	**<0.5**	**<0.5**
Carbonate (CO_3)	mg/L	5	**<5**	**<5**
Chloride (Cl)	mg/L	1	**<1**	**<1**
Color, True	T.C.U.	2	**<2**	**<2**
Conductivity (EC)	µS/cm	0.2	0.5	0.5
Dissolved Organic Carbon	mg/L	1	**<1**	**6**
Hardness (as $CaCO_3$)	mg/L		**<1**	**<1**
Hydrocarbons, Recoverable (I.R.)	mg/L	1	**<1**	**<1**
Hydroxide (OH)	mg/L	5	**<5**	**<5**
Magnesium (Mg)	mg/L	0.1	**<0.1**	**<0.1**
Naphthenic Acids	mg/L	1	**<1**	**<1**
Nitrate+Nitrite-N	mg/L	0.1	**<0.1**	**<0.1**
Phenols (4AAP)	mg/L	0.001	**<0.001**	**<0.001**
Phosphorus, Total	mg/L	0.001	**<0.001**	**<0.001**
Phosphorus, Total Dissolved	mg/L	0.001	**<0.001**	**<0.001**
Potassium (K)	mg/L	0.5	**<0.5**	**<0.5**
Sodium (Na)	mg/L	1	**<1**	**<1**
Sulfate (SO_4)	mg/L	0.5	**<0.5**	**<0.5**
Sulphide	mg/L	0.002	***0.002***	**0.12**
Total Dissolved Solids	mg/L	10	***10***	***10***
Total Kjeldahl Nitrogen	mg/L	0.2	**<0.2**	**<0.2**
Total Organic Carbon	mg/L	1	**<1**	**<1**
Total Suspended Solids	mg/L	3	**<3**	**<3**
Total Metals				
Aluminum	mg/L	0.002	0.00396	0.00475
Antimony	mg/L	0.000001	0.0000038	0.0000023
Arsenic	mg/L	0.00006	0.0000037	0.00001
Barium	mg/L	0.0001	0.0000681	0.0000302
Beryllium	mg/L	0.00001	**<0.000003**	**<0.000003**
Bismuth	mg/L	0.00001	0.0000012	0.0000011
Boron	mg/L	0.0008	0.00203	**0.00823**
Cadmium	mg/L	0.000006	0.000014	**<0.000002**
Calcium	mg/L	0.1	0.0218	0.0104
Chlorine	mg/L	0.3	0.202	0.297
Chromium	mg/L	0.0003	0.000106	**<0.00003**
Cobalt	mg/L	0.00001	0.0000078	0.0000013
Copper	mg/L	0.0001	**0.00104**	**<0.00005**
Iron	mg/L	0.004	0.0068	0.00268
Lead	mg/L	0.000006	**0.00018**	0.0000127
Lithium	mg/L	0.0002	0.000084	0.000353
Manganese	mg/L	0.00003	**0.000253**	0.0000354
Mercury	mg/L	0.00005	**<0.00001**	**<0.00001**
Ultra-Trace Mercury	mg/L	0.000008	0.00002	0.0000061
Molybdenum	mg/L	0.00006	**0.00171**	0.0000076

Value Below Detection Limit

Value is at Detection Limit

Exceeds 5 times Detection Limit

Table A1.2 (Cont'd.)

Water Quality Variable	Unit	Detection Limit	Field Blank (S39)	Trip Blank (S43)
Total Metals (Cont'd.)				
Nickel	mg/L	0.0003	**<0.0001**	**<0.00004**
Selenium	mg/L	0.000005	**<0.0000005**	**<0.0000005**
Silver	mg/L	0.000008	**0.00012**	**0.0000658**
Strontium	mg/L	0.6	0.94	0.874
Sulphur	mg/L	0.000003	0.0000008	0.0000005
Thallium	mg/L	0.00003	0.0000546	0.0000117
Thorium	mg/L	0.00007	0.000111	**<0.00003**
Tin	mg/L	0.00007	**0.0007**	**0.000489**
Titanium	ng/L	1.2	**<0.6**	**<0.6**
Uranium	mg/L	0.000003	0.0000013	0.0000005
Vanadium	mg/L	0.00005	**<0.00001**	**<0.00001**
Zinc	mg/L	0.0002	**0.00634**	**0.00119**
Dissolved Metals				
Aluminum	mg/L	0.001	0.000968	**<0.0002**
Antimony	mg/L	0.000001	0.00000373	0.0000023
Arsenic	mg/L	0.00006	0.0000036	0.0000099
Barium	mg/L	0.0001	0.0000395	0.0000125
Beryllium	mg/L	0.00001	**<0.000003**	**<0.000003**
Bismuth	mg/L	0.00001	**<0.000001**	**<0.000001**
Boron	mg/L	0.0008	0.00152	**0.00708**
Cadmium	mg/L	0.000006	0.0000076	**<0.000002**
Calcium	mg/L	0.1	0.0216	0.0091
Chlorine	mg/L	0.3	0.2	0.294
Chromium	mg/L	0.0003	**<0.00003**	**<0.00003**
Cobalt	mg/L	0.00001	0.0000077	0.0000013
Copper	mg/L	0.0001	**0.00103**	0.000242
Iron	mg/L	0.004	0.00402	0.00265
Lead	mg/L	0.000006	**0.0000617**	0.0000055
Lithium	mg/L	0.0002	0.000083	0.000349
Manganese	mg/L	0.00003	0.000143	0.000035
Mercury	mg/L	0.00005	**<0.00001**	**<0.00001**
Molybdenum	mg/L	0.000008	0.0000104	0.0000023
Nickel	mg/L	0.00006	**0.000739**	0.0000075
Selenium	mg/L	0.0003	**<0.00004**	**<0.00004**
Silver	mg/L	0.000005	**<0.0000005**	**<0.0000005**
Strontium	mg/L	0.000008	**0.000119**	**0.0000651**
Sulpher	mg/L	0.6	0.721	0.865
Thallium	mg/L	0.000003	0.0000007	0.0000005
Thorium	mg/L	0.00003	0.000054	0.000004
Tin	mg/L	0.00007	0.0000646	**<0.00003**
Titanium	mg/L	0.00007	**0.000474**	**<0.00004**
Uranium	mg/L	0.000003	0.0000005	0.0000001
Vanadium	mg/L	0.00005	**<0.00001**	**<0.00001**
Zinc	mg/L	0.0002	**0.00333**	0.000816

Value Below Detection Limit

Value is at Detection Limit

Exceeds 5 times Detection Limit

West Ells SAGD Project
Hydrogeology

Prepared for:
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Table of Contents

Page

1.0 INTRODUCTION 1

2.0 METHODOLOGY 1

2.1 Field Investigation 1

3.0 BASELINE SETTING 3

3.1 Physiography and Climate 3
3.2 Geology 3
3.2.1 Glacial Drift 4
3.2.2 Cretaceous Formations 4
3.2.3 Devonian 5
3.3 Hydrogeology 5
3.3.1 Quaternary Drift Aquitard/Aquifer 6
3.3.2 Viking Aquifer 7
3.3.3 Grand Rapids Aquifer 7
3.3.4 McMurray Aquifer 8
3.3.5 Devonian Aquifer(s) 8
3.4 Groundwater Chemistry 8
3.4.1 Quaternary Drift 12
3.4.2 Grand Rapids Formation 12
3.5 Local Groundwater Users 12

4.0 ENVIRONMENTAL ASSESSMENT 13

4.1 Potential Effects of Water Supply Wells on Groundwater Quantity 13
4.1.1 Description of Potential Effects 13
4.1.2 Effects Analysis 14
4.1.3 Mitigation 15
4.2 Potential Effects of the Surface Facilities on Groundwater Quality 15
4.2.1 Description of Potential Effects 15
4.2.2 Effects Analysis 16
4.2.3 Mitigation 16
4.3 Potential Effects of the Production/Injection Wells on Groundwater Quality 17
4.3.1 Description of Potential Effects 17
4.3.2 Effects Analysis 17
4.3.3 Mitigation 18
4.3.4 Monitoring 18
4.4 Effects of the Disposal Well(s) on Groundwater Quality 18
4.4.1 Description of Potential Effects 18
4.4.2 Effects Analysis 19

4.4.3 Monitoring 19
4.5 Groundwater Monitoring Program 19
4.5.1 Shallow Groundwater Quality 20
4.5.2 Water Supply 20
5.0 REFERENCES 21

List of Tables

Page

Table 2.1 Summary of Groundwater Monitoring Well Information within and adjacent to Project Area 2
Table 3.1 Stratigraphic Units at the Project Site. 3
Table 3.2 Summary of Hydrostratigraphic Units and Aquifer Hydraulic Properties 6
Table 3.3 Summary of General Groundwater Chemistry Observed at West Ells 9
Table 3.4 Summary of Hydrocarbon and Selected Metals Groundwater Chemistry 11
Table 3.5 Summary of Water Well Records within 20 km of the West Ells Project Site 13
Table 4.1 Water Volume Requirements of the West Ells Project. 14

List of Figures

Figure 1.1 Project Location
Figure 2.1 Project Development Area and Groundwater Monitor Locations
Figure 3.1 Structure of the Grand Rapids Formation
Figure 3.2 Structure of the Wabiskaw A Sand
Figure 3.3 Structure of the Woodbend Group
Figure 3.4 Groundwater Wells near West Ells SAGD Project

1.0 INTRODUCTION

The proposed West Ells SAGD Project (the Project) will utilize in-situ Steam Assisted Gravity Drainage (SAGD) technology to recover heavy oil at approximately 1600 m^3/d (10,000 barrels per day). Seven well pairs will be drilled on the northern well pad and six well pairs on the southern well pad with a central processing facility located less than one kilometre to the north of the two pads. The processing facility will include inlet separation, oil treating, water de-oiling, waste water treatment, water purification and steam generation facilities.

The Project (Figure 1.1) is located approximately 60 km west of Fort McKay in Townships 94 and 95, Ranges 17 and 18, West of the 4th Meridian. All land locations referenced in this document will be west of the fourth meridian (W4M).

The purpose of this report is to bring together the geological framework with the information that exists with respect to groundwater conditions that are of environmental significance to the Project. This will provide a concept of hydrogeological conditions as they are currently known and enable an evaluation of potential changes to groundwater conditions from the proposed Project.

2.0 METHODOLOGY

The baseline study was completed based on a literature review and field investigations. Key information sources for the baseline study include the following:

- report by Golder Associates (Golder) (2008) describes groundwater monitoring wells installed into the Viking and Grand Rapids Formations;
- site specific geological mapping provided by Sunshine Oilsands Ltd.;
- published regional geological and hydrogeological maps and reports from the Alberta Geological Survey and Alberta Research Council;
- water well drilling reports and groundwater chemical analyses from the Alberta Environment Groundwater Information Center; and
- licenses for groundwater withdrawals under the *Water Act* from Alberta Environment.

2.1 Field Investigation

A shallow groundwater monitoring network was established on behalf of Sunshine Oil Sands Ltd (Sunshine) by Millennium EMS Solutions Ltd. (MEMS). Wells were installed in February 2008 at three locations within the Project Development Area (Figure 2.1). Wells were installed to depths of 5.2 to 17.4 metres below ground level (m bgl), with an additional 5 wells installed to similar depths within 5 km to the north and east. The wells were developed, tested (rising head hydraulic conductivity testing) and sampled in February, June and/or October 2008.

The results of all field investigations completed in 2008 are summarized in Table 2.1.

Table 2.1 Summary of Groundwater Monitoring Well Information within and adjacent to Project Area

Well Location	Unit	UTM Zone	Screened Interval (mbgl)	Measured Water Level (mbgl) Feb-08	Mar-08	Jun-08	Oct-08	Hydraulic Conductivity (m/s)
Wells within Project Development Area								
11-30-94-17	Drift	12	4.3 to 6.3	Dry		Dry	Dry	
14-31-94-17	Drift	12	3.1 to 6.1	Dry		0.56	-	4.8×10^{-9}
07-36-94-18	Drift	12	2.1 to 5.2	Dry		Dry	Dry	
11-30-94-17	Viking		64 to 73		12.49			4.2×10^{-6}
14-31-94-17	Grand Rapids		99 to 108		35.18			9.5×10^{-7}
07-36-94-18	Grand Rapids		100.5 to 109.5		8.18			5.3×10^{-8}
Wells near Project Area								
09-36-94-17	Drift	12	5.2 to 8.2	0.74		***0.35***	***0.50***	3.0×10^{-7}
11-03-95-17	Drift	12	3.1 to 6.1	5.89		***1.81***	**-**	
14-04-95-17 Deep	Drift	12	13.4 to 16.5	Dry		Dry	Dry	
14-04-95-17 Shallow	Drift	12	3.5 to 6.5	5.47		4.26	3.24	4.1×10^{-8}
07-17-95-17	Drift	12	3.7 to 6.7	Dry		1.24	3.83	3.2×10^{-9}
10-15-95-17	Drift	12	3.7 to 6.7	Dry		Dry	Dry	
10-21-95-17	Drift	12	3.1 to 6.1	4.70		0.16	0.74	4.2×10^{-8}

'-' = Not measured
Bold & italicized water levels are frozen
Sources: Golder 2008

3.0 BASELINE SETTING

3.1 Physiography and Climate

The project is located along the northern edge of the McKay Plain physiographic region just south of the Birch Mountains (Andriashek 2001). Ground elevation of the site is about 560 m above sea level (m asl) along the north edge and generally slopping downwards to the southeast, dropping below 540 m asl (Figure 1.1 and Figure 2.1). Just a few kilometres to the northwest, the ground begins to rise steadily onto the Birch Mountains reaching elevations over 700 m asl within 5 to 6 km. The higher ground at the northern edge of the site separates the headwaters of the Dover River, where the site is located, from the headwaters of Snipe Creek to the north. Snipe Creek is a tributary to the Dunkirk River, which then flows into the MacKay River. The site is located approximately 60 km west of the Athabasca River, which is at an elevation of roughly 240 m asl.

Mean monthly temperatures are below zero from November to March with a mean annual precipitation of 456 mm (Environment Canada). Roughly one third of the annual precipitation is snowfall. Annual potential evaporation was estimated at 570 mm (NHC, 2008) and exceeds precipitation for the months of May to August and October as well as annually (Ozoray et al., 1980).

3.2 Geology

The geological setting consists of glacial drift overlying Cretaceous-age sediments which lie unconformably on Devonian-age carbonate sediments. There are heavy oil deposits in the Wabiskaw Member of the Clearwater Formation, which is the subject of the SAGD operations assessed in this report. The following sections provide more detail on the regional and site geological setting, which is summarized in Table 3.1.

Table 3.1 Stratigraphic Units at the Project Site.

Period	Stratigraphic Unit	Description	Thickness (m)
Quaternary	Drift	Mainly till with minor sand	50 to 90
Cretaceous	Colorado Group	Predominantly marine shales	50
	Grand Rapids Formation	Fine grained sandstone, siltstone and shale of deltaic to marine origin	50
	Clearwater Formation	Marine shales, with siltstone	150
	McMurray Formation	Quartzose sand	20
Devonian	Woodbend Group	Limestone and shale	-

3.2.1 Glacial Drift

No regional quaternary mapping is available for the study area. Drift thickness is estimated as 45 to 70 m from regional mapping (Andriashek and Meeks, 2001). Limited well reports in the area indicate a thickness of drift deposits between 25 and greater than 90 m, generally consisting of till with some intervals of sand and gravel noted.

Borehole logs from shallow monitoring wells installed by MEMS and deeper monitoring wells installed by Golder indicate organic deposits up to 5 m thick, with predominantly silty clay or clayey silts to depths of 20 to 60 m.

A small unnamed buried channel is identified about 15 km south of the Project Area running east-west across the southern half of Township 93, Range 18 and just into Range 17 (Andriashek and Meeks, 2001). Little information is available regarding this channel. A Petro-Canada well is located within or adjacent to this channel and the driller's log recorded mostly sand with minor till, sandy till and gravel to the bedrock contact at a depth of 63 m. No other buried channels or valleys have been identified within a 20 km radius of the Project; however, limited information is available regarding Quaternary deposits in this area.

3.2.2 Cretaceous Formations

Local Cretaceous Formations include the Upper and Lower Cretaceous Colorado Group and Lower Cretaceous Mannville Group, which contains the Grand Rapids, Clearwater and McMurray Formations.

The Colorado Group includes the Upper Cretaceous Labiche Formation and Lower Cretaceous Viking and Joli Fou Formations. Both the Labiche and Joli Fou consist of marine shales, while the Viking Formation is a fine to medium grained marine sandstone. Within the Project Development Area the Viking Formation includes up to 45 m of siltstone and sandstone that cleans upward. The Viking Formation dips gently to the southwest and is eroded to the southeast of the project area. These units have been mapped regionally (Mossop & Shetsen, 1994), but are generally poorly understood within this area.

The Grand Rapids consists of deltaic to marine fine grained "salt and pepper" sandstones with laminated siltstone, shale and thin coal seams also present. A structure map illustrating the surface of the Upper Grand Rapids is shown in Figure 3.1.

The Clearwater Formation is largely grey marine shales with minor siltstone and ironstone. The Wabiskaw Member is a glauconitic sandstone at the base of the Clearwater Formation that conformably overlies the McMurray Formation. The structure on the surface of the Wabiskaw A Sand is shown in Figure 3.2. At West Ells, the Wabiskaw Shale Member is 12 to 16 m thick and forms the reservoir cap rock.

The McMurray Formation consists of fluvial and estuarine deposits, typically fine grained sands. The Lower McMurray is identified as containing conglomerate, sand, silt and shale. The Middle McMurray is typically a uniform quartz sand which is overlain by sand and mudstone of the Upper McMurray (Andriashek and Atkinson, 2007). These subdivisions may not be distinct in all areas. Within the Project Area, the lower portion of the McMurray is interpreted as being deposited in a fluvial environment with the upper portion representative of a near shore deltaic environment, as identified in Section 2.2.2 of the West Ells SAGD Project Application (Sunshine 2010).

3.2.3 Devonian

The uppermost Devonian units are the Woodbend Group, which locally includes the Lower Ireton and Cooking Lake Formation. The Ireton consists mainly of shale, while the Cooking Lake is predominantly limestone. The structure on the surface of the Devonian bedrock is shown on Figure 3.3.

3.3 Hydrogeology

The hydrostratigraphy for the Project Area is outlined in Table 3.2 based on regional information with local characteristics for the Quaternary drift, Viking Formation and Grand Rapids Formation. Shallow groundwater, i.e. within Quaternary drift, may discharge into nearby surface water bodies within the Dover River watershed, but on a regional scale most groundwater above the pre-Cretaceous unconformity is expected to flow to the southeast then eastward towards the Athabasca River. Available hydrogeological information for water bearing aquifers at the site is discussed in the following sections.

Table 3.2 Summary of Hydrostratigraphic Units and Aquifer Hydraulic Properties

Stratigraphic Unit	Hydrostratigraphic Unit	Hydraulic Head (masl)	Local Hydraulic Conductivities (m/s)	Average TDS (mg/L)
Quaternary Drift	Aquitard – Non saline water	~549 to 563	3×10^{-9} to 3×10^{-7}	<1,000
LaBiche Formation (Colorado shale)	Aquitard			
Viking Formation	Aquifer	~516	4×10^{-6}	900
Joli Fou Formation	Aquitard			
Grand Rapids Formation	Aquifer – Non saline water	~514 to 546	5×10^{-8} to 1×10^{-6}	1100-1400
Clearwater	Aquitard			
McMurray	Aquifer – Bitumen	NA	7×10^{-6} to 3×10^{-5}	NA

masl = metres above sea level
NA = Not applicable
'-' = Not available

3.3.1 Quaternary Drift Aquitard/Aquifer

In general, the Quaternary drift deposits are expected to form an aquitard with the potential for aquifers within either buried channels or sand & gravel deposits. Existing information suggests the closest buried channel is 15 km away and no sand or gravel deposits are identified in the area, however given the limited information available there is potential for Quaternary aquifers not currently identified.

Variable conductivities are predicted for drift deposits in the region. A well (13-09-093-18) completed in sands within the buried channel to the south was tested at a rate of 230 m^3/day, which is consistent with earlier mapping that suggested expected yields of greater than 160 m^3/day from drift deposits (Ozoray et al. 1980). By contrast, a well (SW-13-095-16) advanced to over 90 m was abandoned, suggesting only low yielding (thus assumed low permeable) materials were encountered. Within the Project Area and vicinity, rising head permeability tests on five wells 7 to 10 m deep indicate low conductivities with a geometric mean of 2.4×10^{-8} m/s (Table 2.1).

Patches of permafrost were encountered within the lease and immediate area, which is consistent with the area characterized as having isolated patches of permafrost (0-10%) (Natural Resources Canada, 1999). The permafrost patches reduce groundwater movement, which was demonstrated by some wells remaining dry where adjacent or nearby wells contained groundwater and by the existence of persistent frozen conditions in a few wells.

In general, groundwater is expected to be close to surface, as indicated by the wet conditions and abundant surface water bodies present within the Project Area. Wells in and near the Project Area had shallow groundwater levels between 0.6 and 3.8 m bgl (Table 2.1). Shallow groundwater flow is expected to be towards the south or southeast, reflecting the local topography. Based on measured hydraulic conductivities and an estimated hydraulic gradient of 0.006 m/m, groundwater flow rates are expected to be slow, i.e. in the order of centimetres per year.

3.3.2 Viking Aquifer

The Viking Formation is a regionally extensive aquifer. One well completed in the lower part of the Viking sandstone within the Project Development Area was tested by falling head permeability test and resulted in a hydraulic conductivity of 4.2×10^{-6} m/s. Further testing of this aquifer is necessary to evaluate the potential yields and ability of this aquifer to meet the project water demands.

3.3.3 Grand Rapids Aquifer

The Grand Rapids Formation forms a regional aquifer, which is typically divided into upper and lower sand aquifers. A well completed in shallow sandstone (12-31-94-18), possibly the Grand Rapids, was tested at 160 m^3/day and has an estimated hydraulic conductivity of 2.4×10^{-6} m/s. A water source well recently completed in the Lower Grand Rapids (1-23-93-17), approximately 13 km to the southeast, was tested at 463 m^3/day for four hours (Matrix Solutions Inc., 2008). Based on this test, a hydraulic conductivity of 6.7×10^{-6} m/s was calculated for the aquifer at this location.

Two wells completed in the Grand Rapids Formation within the Project Development Area were tested by falling head permeability tests producing calculated hydraulic conductivities ranging from 5.3×10^{-8} to 9.5×10^{-7} m/s (Table 2.1) (Golder, 2008).

The direction of groundwater flow cannot be determined from available Project information, but is expected to be to the southeast. This direction is consistent with other mapping completed in the area (Matrix Solutions Inc., 2008). The Grand Rapids Formation outcrops and discharges within the Athabasca River valley.

Shallow drift and Grand Rapids monitoring wells installed together on the same drill pads enable a comparison of vertical gradient. Hydrostatic water levels at one location indicate a downward gradient of 0.40 m/m. At one other location, the shallow well was dry and therefore the gradient could be lower or, in fact, reversed at this location.

3.3.4 McMurray Aquifer

Regional and site specific information indicates that no water bearing McMurray aquifer is present in the immediate area of the Project. A basal McMurray aquifer has been mapped approximately ten kilometres away (Ozoray et al., 1980). Where present, groundwater quality is expected to be saline.

3.3.5 Devonian Aquifer(s)

Devonian units are generally identified as having very low hydraulic conductivity to the east and southeast of this location. Future water source investigations will include testing of Devonian units for potential saline water source and/or disposal zones.

3.4 Groundwater Chemistry

Available groundwater chemistry information from wells within and near the Project Area is summarized in Table 3.3 and Table 3.4 and discussed by geological unit in the following subsections.

Table 3.3 Summary of General Groundwater Chemistry Observed at West Ells

Well Location	Unit	CCME CWQG[1]		9-36-94-17	10-21-95-17	14-4-95-17 (S)	14-31-94-17	7-17-95-17	7-36-94-18	7-36-94-18	14-31-94-17	11-30-94-17
Formation				**Drift**	**Drift**	**Drift**	**Drift**	**Drift**	**Grand Rapids**	**Grand Rapids**	**Grand Rapids**	**Viking**
Analysis Date		**CDWQG**	**AL**	**12-Mar-08**	**12-Mar-08**	**12-Mar-08**	**9-Jul-08**	**9-Jul-08**	**6-Mar-08**	**20-Mar-08**	**19-Mar-08**	**20-Mar-08**
General Chemistry												
Total Dissolved Solids	mg/L	500		279	474	322	**881**	**1630**	**1350**	**1310**	**1080**	**933**
Hardness	mg/L			260	331	307	268	884	4	7	13	3
T-Alkalinity	mg/L			284	365	285	511	1060	680	637	674	494
pH		6.5 - 8.5	6.5 - 9.0	7.78	8.16	8.07	8.1	7.8	**8.7**	**8.8**	8.1	**8.6**
Electrical Conductivity	µS/cm at 25°C			500	766	554	1370	2310	2210	2060	1750	1490
Carbonate	mg/L			<6	<6	<6	<5	<5	47	19	<5	18
Bicarbonate	mg/L			346	445	348	623	1290	733	739	822	565
Nitrate - N	mg/L	10	3	0.02	0.13	0.11	<0.1	1.6	<0.1	<0.1	<0.1	<0.1
Nitrite - N	mg/L	1	0.02	<0.005	0.011	0.007	<0.05	<0.05	<0.05	0.07	0.1	0.09
Nitrate and Nitrite - N	mg/L			0.02	0.14	0.12	<0.1	1.6	<0.1	0.1	0.1	0.1
Sulfate (SO4)	mg/L	500		1	67.3	21	236	373	325	327	153	267
Chloride	mg/L	250		2.1	7.6	6.7	8	27	85	82	86	12
Manganese	mg/L	0.05		**0.247**	0.014	0.05	**0.08**	**0.09**	0.006	0.016	**0.175**	0.07
Iron	mg/L	0.3	0.3	0.14	<0.01	<0.01	<0.05	<0.05	**0.34**	0.153	**6.88**	**2.59**
Sodium	mg/L	200		5.5	53.9	7.3	**230**	**258**	**531**	**514**	**428**	**353**
Potassium	mg/L			5.6	7	5.5	7.2	8.4	4.2	4	5.7	3.2
Magnesium	mg/L			16.2	19.9	18.6	22.3	58.2	<0.1	0.9	1.7	0.5
Calcium	mg/L			77.5	99.8	92.1	70.5	258	1.5	1.5	2.5	0.5
DOC	mg/L									10	11	10

Table 3.3 Summary of General Groundwater Chemistry Observed at West Ells

Well Location	Unit	CCME CWQG(1)		9-36-94-17	10-21-95-17	14-4-95-17 (S)	14-31-94-17	7-17-95-17	7-36-94-18	7-36-94-18	14-31-94-17	11-30-94-17
Formation				**Drift**	**Drift**	**Drift**	**Drift**	**Drift**	**Grand Rapids**	**Grand Rapids**	**Grand Rapids**	**Viking**
Analysis Date		**CDWQG**	**AL**	**12-Mar-08**	**12-Mar-08**	**12-Mar-08**	**9-Jul-08**	**9-Jul-08**	**6-Mar-08**	**20-Mar-08**	**19-Mar-08**	**20-Mar-08**
Phenols	mg/L		0.004							0.003	0.001	0.002
Sulphide	mg/L	0.05								0.011	0.017	0.044

CCME CWQG - Canadian Council of Ministers for the Environment Canadian Water Quality Guidelines

CDWQG - Canadian Drinking Water Quality Guidelines: includes both Maximum Acceptable Concentrations (i.e. nitrate and nitrite) and Aesthetic Objectives (all others)

AL - Freshwater Aquatic Life

Bolded values exceed CDWQG

Boxed cells exceed AL

Table 3.4 Summary of Hydrocarbon and Selected Metals Groundwater Chemistry

Well Location	Unit	CCME CWQG[1]		14-4-95-17 (S)	14-31-94-17	7-36-94-18	7-36-94-18	14-31-94-17	11-30-94-17
Formation				Drift	Drift	Grand Rapids	Grand Rapids	Grand Rapids	Viking
Analysis Date		CDWQG	AL	9-Jul-08	22-Oct-08	6-Mar-08	20-Mar-08	19-Mar-08	20-Mar-08
Hydrocarbons									
Benzene	mg/L	0.005	0.37	<0.00050	<0.001		<0.00050	<0.00050	<0.00050
Ethylbenzene	mg/L	0.0024	0.09	<0.00050	<0.001		<0.00050	<0.00050	<0.00050
Toluene	mg/L	0.024	0.002	<0.00050	<0.001		<0.00050	<0.00050	<0.00050
Xylenes	mg/L	0.3		<0.00050	<0.002		<0.00050	<0.00050	<0.00050
F1(C6-C10)	mg/L			<0.1	<0.2		<0.1	<0.1	<0.1
F1-BTEX	mg/L			<0.1	<0.2		<0.1	<0.1	<0.1
F2 (>C10-C16)	mg/L			<0.05	<0.1		<0.05	<0.05	<0.05
Selected Metals									
Aluminum	mg/L	0.1	0.1			$\boxed{\textbf{0.48}}$	$\boxed{\textbf{0.11}}$	$\boxed{\textbf{0.98}}$	$\boxed{\textbf{0.39}}$
Copper	mg/L	1	0.002			$\boxed{0.002}$	$\boxed{0.007}$	$\boxed{0.008}$	$\boxed{0.002}$
Lead	mg/L	0.3	0.001			<0.005	<0.005	$\boxed{0.006}$	<0.005
Zinc	mg/L	5	0.03			0.01	$\boxed{0.166}$	$\boxed{0.117}$	0.02

CCME CWQG - Canadian Council of Ministers for the Environment Canadian Water Quality Guidelines

CDWQG - Canadian Drinking Water Quality Guidelines: includes both Maximum Acceptable Concentrations (i.e. nitrate and nitrite) and Aesthetic Objectives (all others)

AL - Freshwater Aquatic Life

Bolded values exceed CDWQG

Boxed cells exceed AL

3.4.1 Quaternary Drift

Groundwater chemistry was determined in samples collected from five shallow drift monitoring wells (four outside the Project Area). Variations in the groundwater chemistry are evident from these samples. Three samples from wells in the eastern area (14-4, 10-21 and 9-36) have calcium-bicarbonate type water and have fairly low total dissolved solids (TDS) (279 – 474 mg/L). By contrast, samples from two wells in the western area had more significant concentrations of sodium and one location (14-31) is a sodium-bicarbonate type water. The TDS concentration in water from these two wells was higher, 881 and 1630 mg/L, and both the sodium and TDS concentrations measured are above the Canadian Drinking Water Quality Guidelines ("CDWQG"). One sample had a concentration of manganese that exceeded the CDWQG. Two samples were analyzed for hydrocarbons with no detections of benzene, toluene, ethylbenzene or xylene (BTEX) and (fraction) F1 (C6-C10) or F2 (>C10 – C16) hydrocarbons.

3.4.2 Viking Formation

A groundwater sample collected from the Viking groundwater monitoring well indicates a sodium-bicarbonate type water. The TDS was determined to be 933 mg/L. The concentration of TDS and sodium exceeded the CDWQG. Exceedances were also noted for pH, iron, and aluminum for the CDWQG and nitrite, aluminum, copper and iron for the Freshwater Aquatic Life criteria. There were no detections of BTEX, F1 or F2 hydrocarbons.

3.4.3 Grand Rapids Formation

Groundwater samples collected from two groundwater monitoring wells installed in the Grand Rapids Formation indicate a sodium-bicarbonate type water. TDS from these samples was 1080 and 1350 mg/L. Concentrations of TDS and sodium exceeded the CDWQG. Exceedances were also noted for pH, iron, aluminum and manganese for the CDWQG and nitrite, aluminum, copper, iron, lead and zinc for the Freshwater Aquatic Life criteria. There were no detections of BTEX, F1 or F2 hydrocarbons.

3.5 Local Groundwater Users

Local groundwater users include licensed wells held by Petro-Canada, 15 km away completed in an unnamed Quaternary buried channel, and Paramount, roughly 6 km to the west completed in a shallow sandstone. In addition, Athabasca Oil Sands Corp. has recently installed and tested a water source well completed in the Lower Grand Rapids, approximately 13 km to the southeast (Athabasca Oil Sands Corporation, 2008). A summary of the available water well information for the wells within 20 km of the Project, as discussed in the previous subsections, can be found in Table 3.5 and the well locations are illustrated on Figure 3.4.

Table 3.5 Summary of Water Well Records within 20 km of the West Ells Project Site

AENV ID	Location	Owner	Well Completion Depth (m)	Lithology	Completion Date	Comments
150681	13-09-093-18	Petro-Canada	31.7 to 33.2	Sand	Feb- 1990	Surficial. Tested at 230 m^3/day. Licensed.
293907	12-31-094-18	Paramount Resources Ltd	26.8 to 28.4	Sandstone	Feb- 2000	Licensed for 33 m^3/day.
279598	NW-31-094-18		-			
	01-23-093-17	Athabasca Oil Sands Corp.	77.5 to 99.5	Sandstone (LGR)	Mar- 2008	Tested at 463 m^3/day.
1064983	SW-13-095-16	Chevron (West Ells Camp)	-	Gravel & Sand	Jan- 2007	Surficial. Abandoned.
0925655	01-23-095-17	Shell Canada	-			Chemistry data only.

'-' = Not Available
LGR = Lower Grand Rapids

4.0 ENVIRONMENTAL ASSESSMENT

4.1 Potential Effects of Water Supply Wells on Groundwater Quantity

4.1.1 Description of Potential Effects

The water demands for the Project, including make-up water for steam generation, sanitary and potable water, are summarized in Table 4.1. Recycling will be incorporated into the process and is expected to result in a recycle rate of 97% produced water. Potable water requirements for drinking and cooking will be trucked to the site; all other water (i.e. make-up and sanitary) is expected to be sourced from a network of groundwater supply wells. The total volume of water required for this project is expected to range from 2,041 m^3/day for three months during start-up (assumes 3.3:1 steam to oil ratio) to a long term steady state demand of up to 966 m^3/day.

Table 4.1 Water Volume Requirements of the West Ells Project.			
Project Stage	Water Demand (m^3/day)		
	Steam Generation (Make-up)	Sanitary	Potable
Construction	0	25	4
Start-up	2,041	25	4
Operations	966[1]	3	1

1 Assuming a 10% water loss to the reservoir

Pumping of groundwater from a supply well causes the formation pressure to decrease. This decrease in pressure spreads outwards over time as a cone of depression. The reduction in formation pressure could reduce available production for other wells that are completed in the same formation and could also induce seepage from hydraulically connected surface water bodies or other aquifers.

It is anticipated that non saline groundwater from the Viking Formation will be used as a water source for the Project. Based on regional and local information (Section 3.3.3 and Table 2.1), individual well yields could reasonably equal 300 m^3/day. A groundwater investigation program is planned for the winter of 2009-10 to evaluate the potential of the Viking Formation as a water source zone for the Project. Depending on the results of these investigations, it will be determined whether additional sources will be required to meet the estimated demand. The Viking Formation is situated between low permeability units (Section 3.3) that minimize groundwater movement between this formation and the surface or other aquifers.

Few existing groundwater users are present in the region and none of the existing wells appear to utilize water from the Viking Formation.

Under the Water Conservation and Allocation Guideline for Oilfield Injection (Alberta Environment, 2006) non-saline groundwater use for enhanced recovery is to be reduced or eliminated. Saline groundwater is typically considered the most feasible alternative to non saline groundwater use. For the Project, saline aquifers are not evident at this time. Future investigations will explore potential saline sources, such as Devonian units, in an effort to replace non saline water use with saline sources.

4.1.2 Effects Analysis

Considering the remoteness of the Project location relative to other groundwater users in the region, it is reasonable to conclude that the impacts to other groundwater users will be low. Considering the low permeability materials that separate the Viking Formation and surface water or other aquifers, it is expected that withdrawal of groundwater from this source would have an undetectable impact on these potential receptors.

Once the water source investigation is completed, a detailed assessment of the effects of drawdown will be the subject of the application for a license under the *Water Act*. This application will be prepared to meet the requirements of the Groundwater Evaluation Guidelines (Alberta Environment, 2003) and the Water Conservation and Allocation Guideline for Oilfield Injection (Alberta Environment, 2006). Under the Water Conservation and Allocation Guideline for Oilfield Injection (Alberta Environment, 2006), non-saline groundwater use for oilfield injection is limited to drawdown of 35 % within the first year and 50% over the life of the project, as measured at an observation well 150 m away from the production well.

4.1.3 Mitigation

Mitigation is unlikely to be necessary, but could include the adjustment of production rates or locating alternative water sources, if required.

4.2 Potential Effects of the Surface Facilities on Groundwater Quality

4.2.1 Description of Potential Effects

Details of Project infrastructure and facilities are summarized below.

- The infrastructure will include a central processing facility, the field facilities, the water source and disposal wells, pipelines, powerlines and roads. The field facility will consist of well pads with horizontal well pairs (injector and producer). Pipelines will include steam and product-return lines from the processing facility to well pads.
- The site will be graded to direct surface water runoff to a storm water retention pond. Storm water that collects in the containment pond will be used as make-up water or tested and released in accordance with operating approval conditions.
- The facilities or locations where fluids are handled, transferred or stored include the heads of the production wells and the disposal well, the blowdown tank, glycol coolers, the tank farm and the oil/water separation equipment.
- The tank farm will contain bitumen and produced water tanks. All storage tanks, except the boiler feed water and source water, will have secondary containment and leak detection.
- A waste management plan for the Project will be designed to effectively control waste by minimizing waste generation and the waste disposal required. The over-riding principles of the plan are to reduce, reuse or recycle.

- All wastes will be disposed of in a responsible manner, complying with all appropriate regulations and guidelines, and in accordance with any waste handling requirements specified in the operating approval conditions.
- Sewage will be disposed of through a septic field constructed in accordance with applicable regulations or collected and trucked off site to approved disposal facilities.
- Domestic garbage will be taken from the plant site by a commercial disposal company.
- Other solid waste will be placed in containers and emptied as needed by a commercial disposal company for off-site disposal at an approved landfill.

In consideration of the above mitigation measures and material handling methods, the surface facilities should have no effect on groundwater quality under normal operating conditions. Upset conditions, specifically spills or leaks of fluids, may allow small amounts of fluids to seep into the shallow groundwater. These fluids include bitumen, produced water and small volumes of various process-related organic chemicals such as glycol, lubricants, etc.

4.2.2 Effects Analysis

As stated previously, the plant site is located over an area of 60 m or more of glacial drift composed predominantly of clay rich deposits (Section 3.2.1). Groundwater flow rates have been estimated on the order of centimetres per year (Section 3.3.1). This will act to retard any movement of spilled liquids and allow ample time for clean up and remediation.

The mitigation measures to be implemented should be effective in preventing or minimizing any fluids from adversely affecting the shallow groundwater. In the event that a significant impact on groundwater quality is detected, a groundwater response plan will be implemented. This response plan typically includes determining the magnitude of the impact and undertaking remediation or a risk assessment. The response plan will be effective at avoiding a significant effect on groundwater quality, preventing impacted groundwater from reaching surface water bodies and restoring groundwater quality. As a result, any spills or leaks should have no adverse effect on the groundwater and surface water resources.

4.2.3 Mitigation

Mitigation measures for minimizing or preventing adverse impacts on shallow groundwater quality due to spills or leaks include industry-standard operating practices, preparedness for upset conditions and appropriate management of upset conditions.

4.3 Potential Effects of the Production/Injection Wells on Groundwater Quality

4.3.1 Description of Potential Effects

Annular Leakage

The planned drilling, completion and operational details for the production and injection wells have been provided in Section 2.3 of the West Ells SAGD Project Application (Sunshine, 2010). Injection wells will be operated at pressures well below the hydraulic fracturing pressure of the caprock (the Wabiskaw Shale Member of the Clearwater Formation) and the reservoir (Wabiskaw Sand Member). The facility design includes a maximum steam header delivery pressure below the cap rock fracture pressure and a pressure safety valve design below the reservoir fracture pressure. Should a loss of steam occur during operations (sudden pressure drop and/or injection rate increase will trigger an alarm) the steam injection into the affected and adjacent well pairs would be shut down. Overlying the Wabiskaw shale cap rock is the Clearwater Formation, which is also expected to form a barrier to steam. There is little probability that fracturing could occur and result in fluids being transported into overlying potable aquifers, such as the Grand Rapids.

The production and injection wells will be completed with surface casing set below the base of the Quaternary deposits and the intermediate casing will be installed using standard casing and cementing practices. The intermediate casings will not be subjected to abnormal pressures because tubing is used to conduct fluids into or out of these wells. During operations, well pressures, temperatures and steam flow rates will be monitored continuously to supervise casing integrity. Consequently, casing failures followed by annular leakage into the overlying non-saline aquifers should not occur.

In view of these design and operational factors, the operation of the production and injection wells should not have any effect on the chemical quality of the groundwater in the potable aquifers.

Associated Water Zone(s)

There is no non-saline groundwater identified in association with the Wabiskaw Sand Member in the Project Area.

4.3.2 Effects Analysis

With respect to annular leakage, the operation of the production and injection wells should not have any effect on the chemical quality of the groundwater in potable aquifers. Therefore, an effects analysis is not warranted.

4.3.3 Mitigation

The mitigation measures (i.e., cemented surface casing and cemented production casing) noted above and in the West Ells SAGD Project Application (Sunshine, 2010), should be effective at preventing casing failures and annular leakage from occurring.

4.3.4 Monitoring

Groundwater sampling will be instituted if a casing failure occurs.

4.4 Effects of the Disposal Well(s) on Groundwater Quality

4.4.1 Description of Potential Effects

Concentrated brine from the evaporation – distillation process may be injected into an approved disposal well. A disposal zone has not been identified for the Project.

The ERCB process for approval of disposal wells will be a separate process that will take place only after any approval is issued under this current application.

Wastewater disposal wells are common in Alberta and the ERCB has a rigorous application process along with guidelines on operation. Typically the process is as follows:

- drill through the drift deposits to bedrock;
- land surface casing to the base of groundwater protection;
- drill a testhole and determine a prospective zone through logging and drill stem testing;
- land and cement main string casing through the prospective zone and perforate the casing within the zone;
- conduct injectivity test(s) to confirm the capacity of the zone;
- apply for ERCB approval;
- run tubing with packer(s) into the main string casing isolating the disposal zone;
- put rust-inhibiting liquid in annulus above the upper packer between the tubing and the main string; and
- inject through the tubing into the disposal zone.

Operating requirements are likely to specify that:

- injection pressure is not to exceed a specified amount to avoid fracturing the rock in the injection zone; and
- monitoring the annulus pressure to warn of packer or tubing failure.

4.4.2 Effects Analysis

The probability of an adverse effect of injection is minimal. The reasons for this are as follows:

- injection pressures are limited to below rock fracture pressure, therefore the probability of escape of liquids through this mechanism is very low;
- if the packer or tubing should fail, the injection pressures will be transferred into the casing annulus. Regular monitoring of the casing annulus pressure will observe this quickly, and if it occurs, the well will be shut in;
- since the main string casing above the tubing packer is not subject to internal injection pressures and contains rust inhibiting liquid, the probability of it having a leak is minimal; and
- an additional level of protection is the surface casing, which lies outside the main string casing, to the depth of groundwater protection. This provides additional protection against leaks into non-saline groundwater resources.

The probability that wastewater injection will have an impact on non-saline groundwater is low.

4.4.3 Monitoring

An appropriate monitoring program will be agreed upon with regulators if a leak or other incident occurs.

4.5 Groundwater Monitoring Program

The groundwater monitoring program for the Project will have two main purposes:

- to detect any impacts on the shallow groundwater quality resulting from spills or leaks from surface facilities at the plant site; and
- to evaluate the performance of the water supply well(s) in the Viking Formation.

The details of monitoring programs for either of these two purposes will be the subject of:

- The EPEA Approval coming out of this application; or
- The *Water Act* (in the case of the supply wells).

Therefore, the purpose of this section is to set forth the principles that will be used to develop those monitoring programs – rather than the actual detailed programs. The purpose of this section is to demonstrate that the requirements of either monitoring program are understood.

The following sections discuss the principles of the two monitoring programs.

4.5.1 Shallow Groundwater Quality

The shallow groundwater monitoring network currently includes three monitoring wells within the Project Area. These and any additional wells are intended to be located down-gradient of the plant site or other Project facilities. Monitoring parameters will include major ions, hydrocarbons, metals and selected organics.

4.5.2 Water Supply

A groundwater investigation is planned for the winter of 2009-10 to evaluate potential yields from the Viking Formation. Future investigations will explore potential saline sources, such as Devonian units, in an effort to replace non saline water use with saline sources.

Sunshine will submit an application for a license under the *Water Act* for diversion of groundwater from the Viking Formation to meet the demands of the Project. The Project is familiar with the monitoring requirements within the regulations for these wells and will undertake monitoring in accordance with the *Water Act* licenses. Results will be reported to AENV as required.

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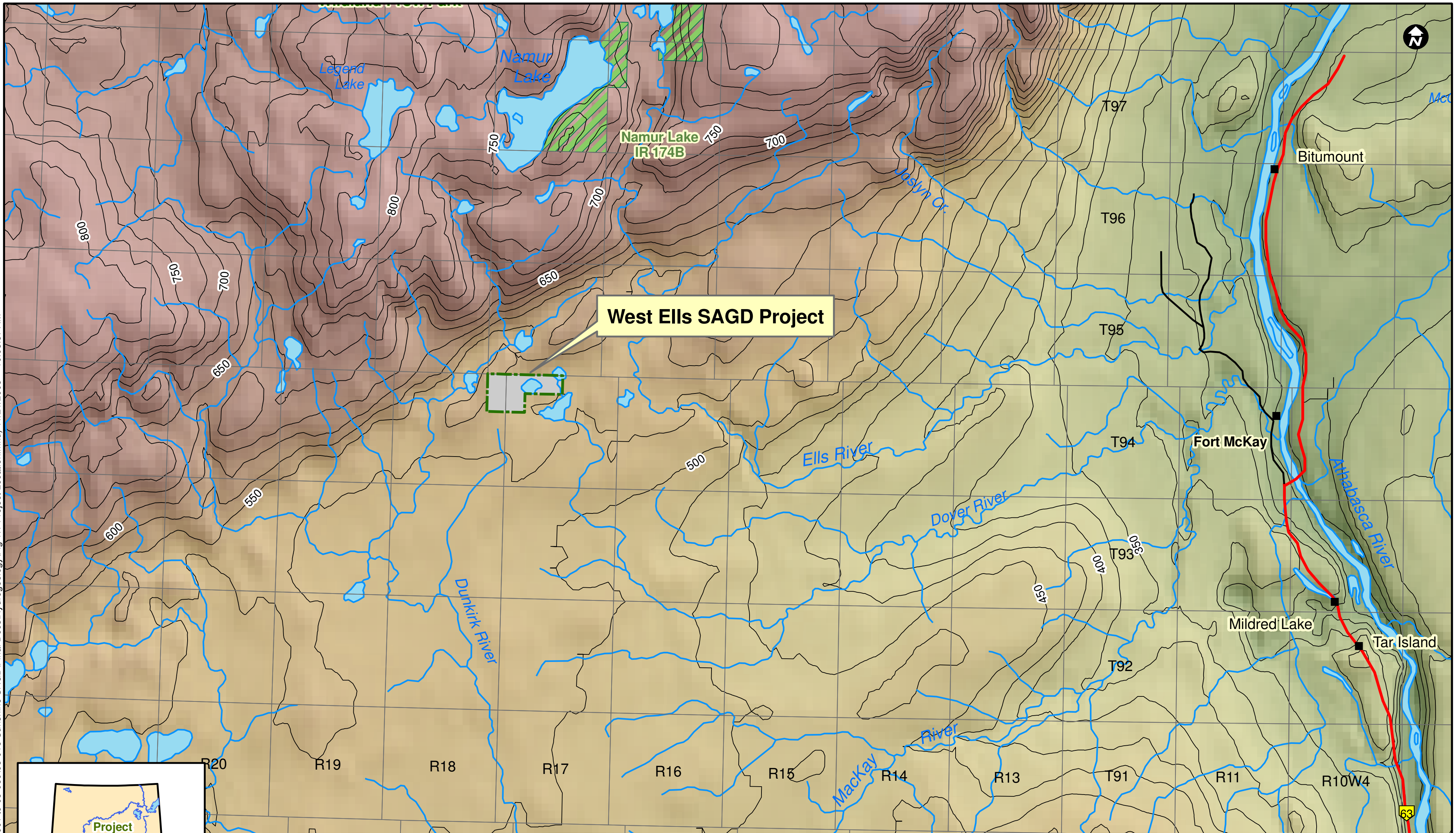
FIGURES



Legend

West Ells SAGD Project Area

Contour (25m interval)

0 6 12

Kilometres

West Ells SAGD Project

SUNSHINE OILSANDS LTD.

Millennium EMS Solutions Ltd.

TITLE:

Project Location

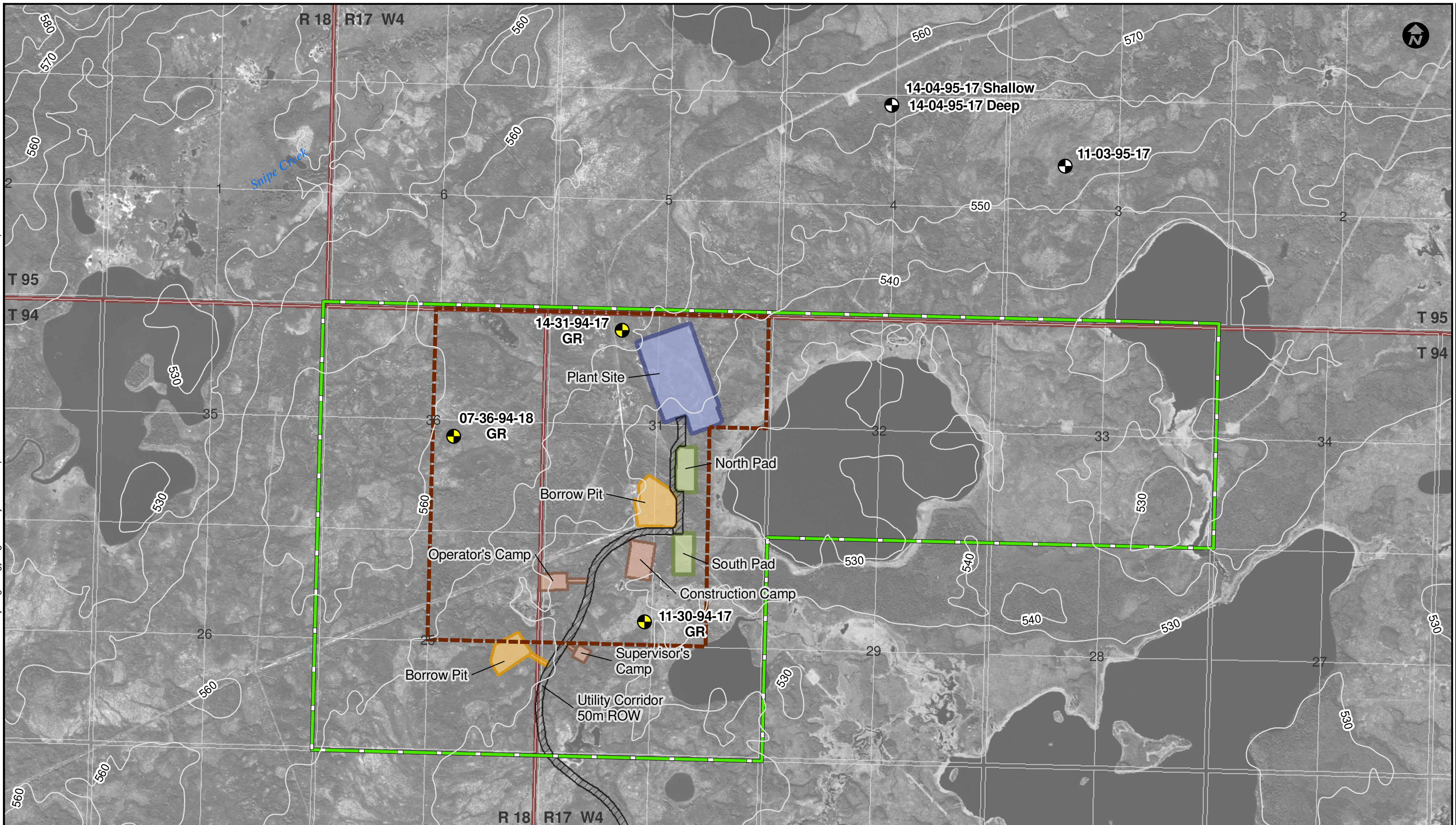
DRAWN:	PS
CHECKED:	NG
DATE:	Nov 26/08
PROJECT:	08-015

FIGURE:

1.1

REF: MEMS, 2008.

Map Document: (K:\Active Projects 2008\Projects 08-001 to 08-050\08-015 Sunshine SAGD\Final Docs\Hydrogeology\Fig 1.1 Project Location.mxd) 11/21/2008 -- 10:08:57 AM



Legend

- Groundwater Monitoring Well
- GR - Grand Rapids well also installed
- Contour (10m interval)
- Project Development Area
- Project Area

0 250 500 1,000
Metres

West Ells SAGD Project

Millennium EMS Solutions Ltd.

TITLE:

Project Development Area and Groundwater Monitor Locations

DRAWN:	PS
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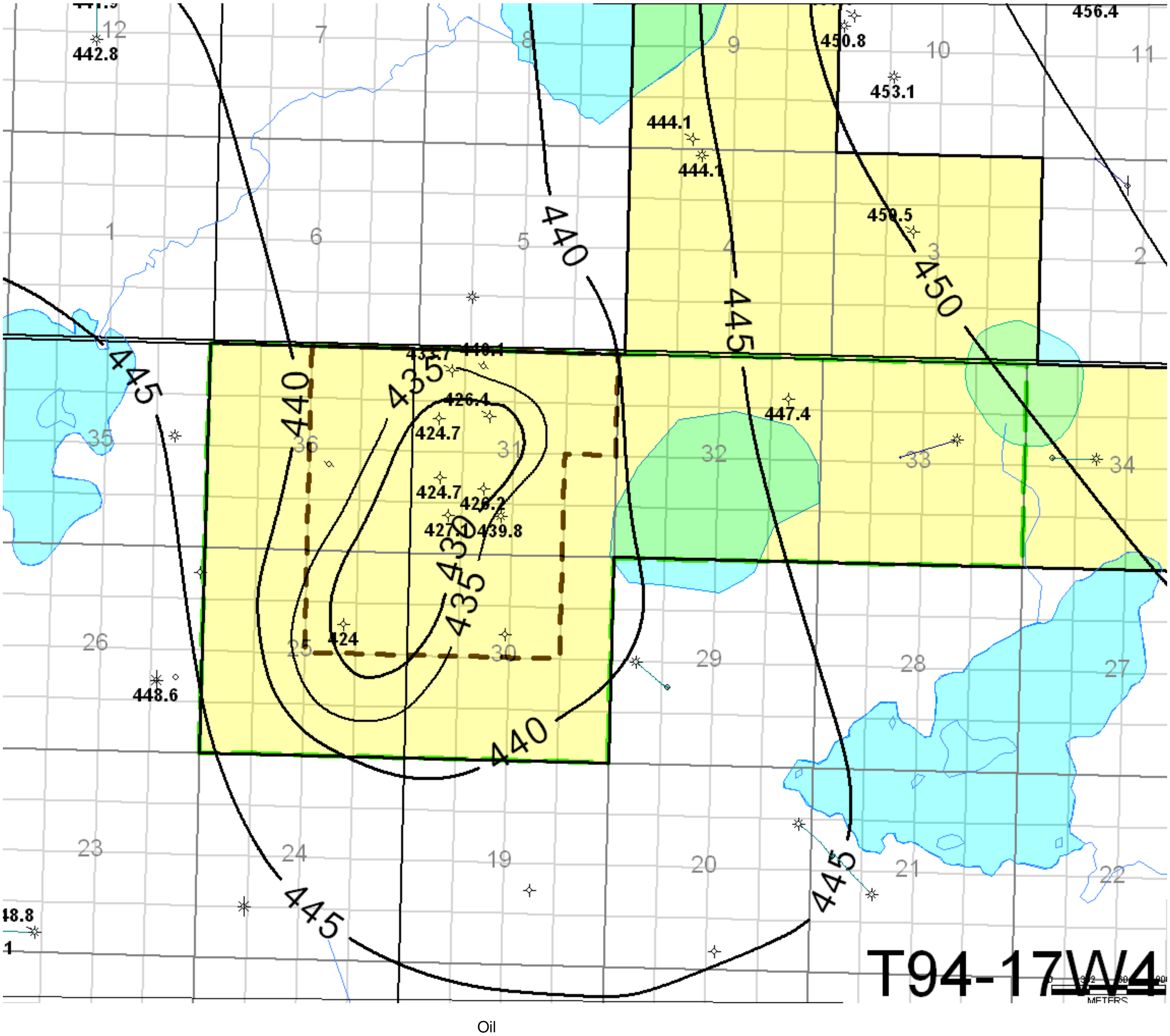
DATE:	Dec 2/08
PROJECT:	08-015
FIGURE:	2.1

Map Document: (K:\Active Projects 2008\Projects 08-001 to 08-050\08-015 Sunshine SAGD\Final Docs\Hydrogeology\Fig 2.1 Project Development Area and Groundwater Monitor Locations.mxd) 02/12/2008 -- 12:12:01 PM



Legend

Project Development Area

Project Area

0 1 2
Kilometres

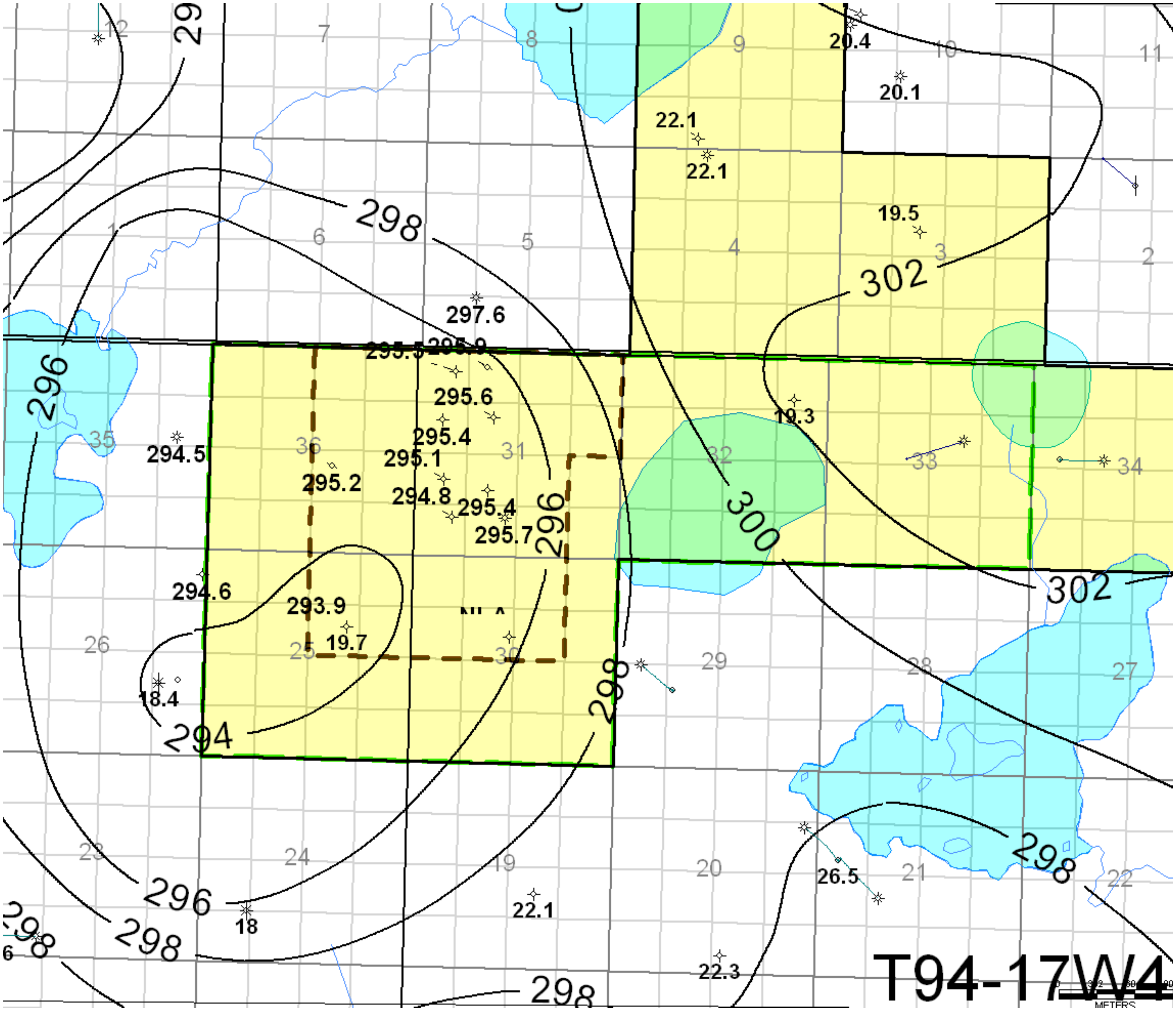
West Ells SAGD Project

Millennium EMS Solutions Ltd.

TITLE: **Structure of the Grand Rapids Formation**	DRAWN: PS CHECKED: KY DATE: Dec 2/08 PROJECT: 08-015	FIGURE: **3.1**

REF: Sunshine Oilsands Ltd, 2008.

Map Document: (K:\Active Projects 2008\Projects 08-001 to 08-050\08-015 Sunshine SAGD\Final Docs\Hydrogeology\Fig 3.1 Structure of the Grand Rapids Formation.mxd) 02/12/2008 -- 11:49:40 AM



Legend

Project Development Area

Project Area

0 1 2

Kilometres

West Ells SAGD Project

Millennium EMS Solutions Ltd.

TITLE:

Structure of the Wabiskaw A Sand

DRAWN:	PS
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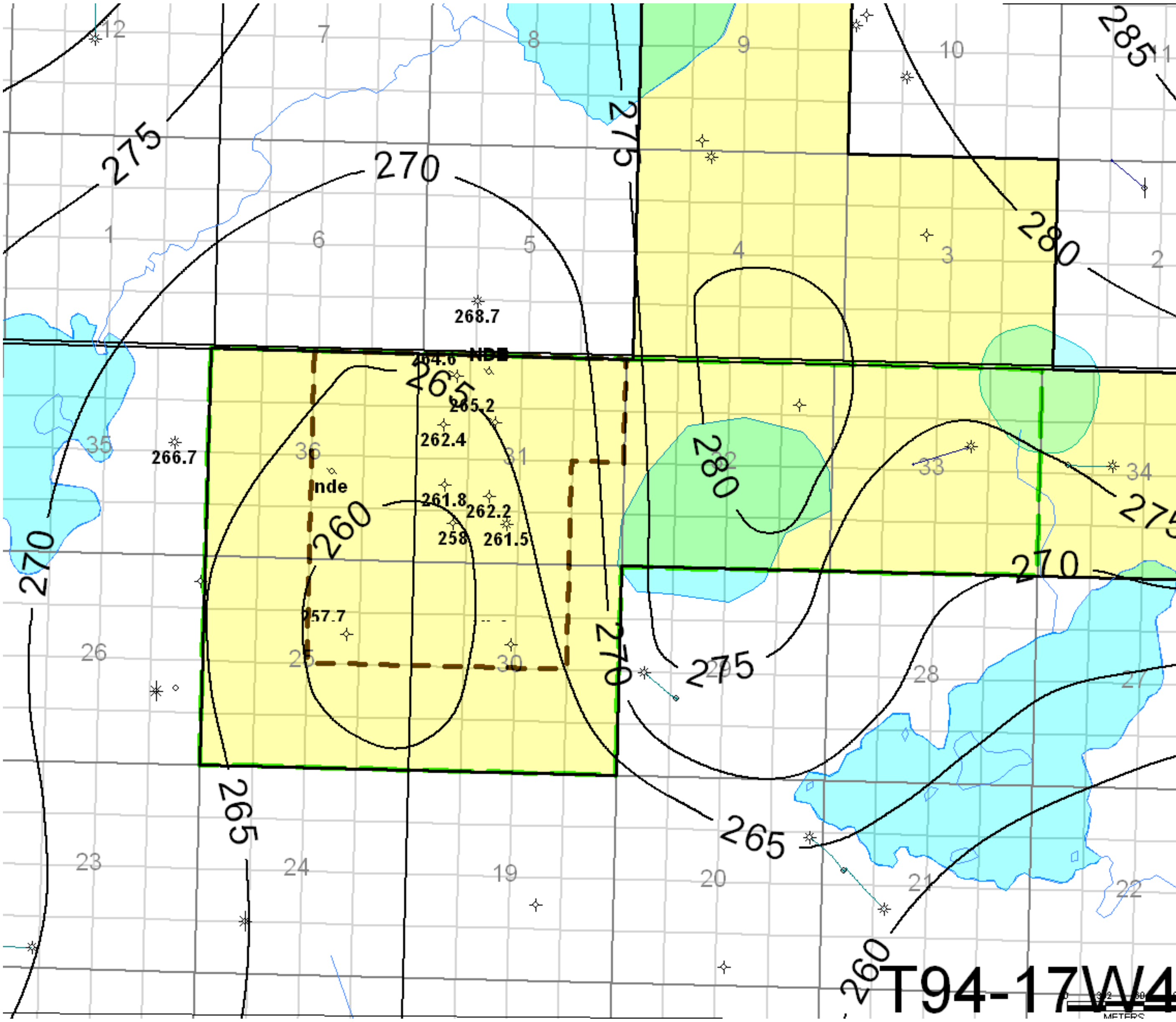
DATE:	Dec 2/08
PROJECT:	08-015

FIGURE: **3.2**

REF: Sunshine Oilsands Ltd, 2008.



Legend

Project Development Area

Project Area

0 1 2

Kilometres

West Ells SAGD Project

Millennium EMS Solutions Ltd.

TITLE:

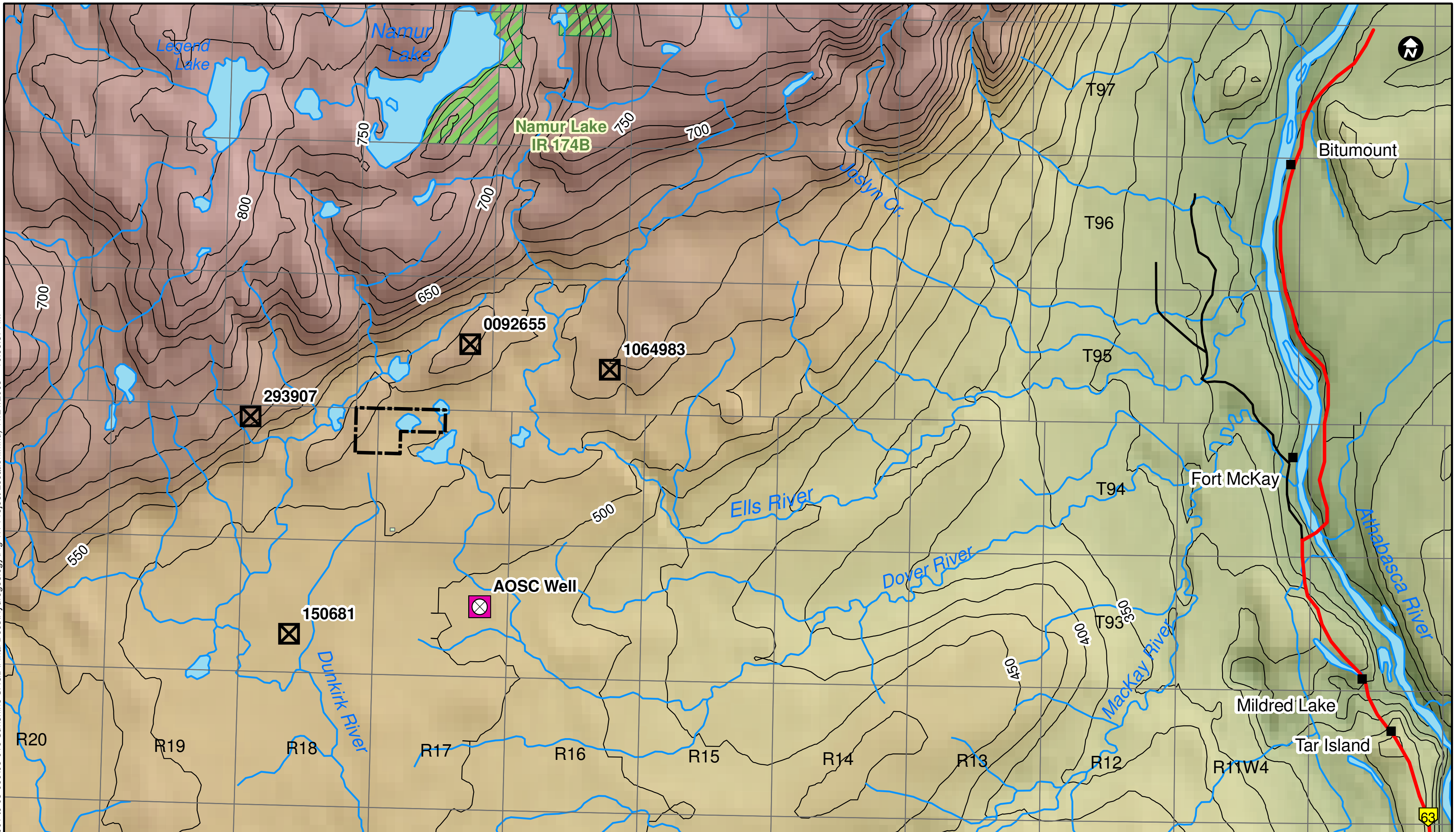
Structure of Woodbend Group

DRAWN:	PS
CHECKED:	NG
DATE:	Dec 2/08
PROJECT:	08-015

FIGURE:

3.3

REF: Sunshine Oilsands Ltd, 2008.



Map Document: (K:\Active Projects 2008\Projects 08-001 to 08-050\08-015 Sunshine SAGD\Final Docs\Hydrogeology\Fig 1.1 Project Location.mxd) 11/21/2008 -- 10:08:57 AM

Legend

150681 ⊠ Well Location and AENV Well ID
⊗ AOSC Well
West Ells SAGD Project Area
Contour (25m interval)

0 5 10
Kilometres

REF: MEMS, 2008.

SUNSHINE OILSANDS LTD.

West Ells SAGD Project

Millennium EMS Solutions Ltd.

TITLE:

Groundwater Wells near West Ells SAGD Project

DRAWN:	PS
CHECKED:	NG
DATE:	Nov 26/08
PROJECT:	08-015

FIGURE: **3.4**

HISTORICAL RESOURCES IMPACT ASSESSMENT

SUNSHINE OILSANDS LTD.

WEST ELLS SAGD PROJECT – PHASE 1

FINAL REPORT

PERMIT 2008-206

FMA HERITAGE INC.

HISTORICAL RESOURCES IMPACT ASSESSMENT

SUNSHINE OILSANDS LTD.
West Ells SAGD Project – Phase 1

FINAL REPORT

PERMIT 2008-206

Prepared For

Millennium EMS Solutions Ltd.
208, 4207 98th Street
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On Behalf Of

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Prepared By

FMA Heritage Inc.
200, 1719 10th Avenue S.W.
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November 2008

November 10, 2008

Millennium EMS Solutions Ltd.
208, 4207 – 98th Street
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T6E 5R7

Attention: Mr. Dane McCoy

Dear Mr. McCoy

Re: Historical Resources Impact Assessment, Final Report, Sunshine Oil Sands Ltd., West Ells SAGD Project – Phase 1

I am pleased to submit to you this report entitled *Historical Resources Impact Assessment, Sunshine Oilsands Ltd., West Ells SAGD Project – Phase 1,* Final Report, Permit 2008-206.

Should you have any questions regarding this project, please do not hesitate to contact me.

Yours truly,
FMA HERITAGE INC.

Alan J. Youell, M.A.
Senior Archaeologist

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Executive Summary

On behalf of Millennium EMS Solutions, agents for Sunshine Oilsands Ltd., FMA Heritage Inc. conducted a Historical Resources Impact Assessment (HRIA) of the West Ells SAGD Project – Phase 1 study area located 60 kilometres west of the community of Fort MacKay.

The HRIA was conducted in June 2008, under archaeological Permit 2008-206. During the HRIA field reconnaissance of the West Ells SAGD Project – Phase 1 study area, locations of limited exposure, deep sediments or high archaeological site potential were assessed by visual inspection and the excavation of 157 shovel tests in order to evaluate the presence and/or nature of surface and subsurface cultural deposits. Assessment included both the June 2008 footprint and selected areas of high archaeological potential within the Lease. During the course of the assessment, no archaeological, historical or palaeontological sites were identified and no previously recorded sites were revisited.

The footprint was subsequently revised in October 2008; revisions included changes to the project component locations as well as the finalization of an access road route. As part of the current study, the revised project footprint was subject to a desktop review to compare the revised footprint with the original assessed project footprint, with those areas assessed as part of the original baseline studies, and with the model of archaeological potential. Although a significant portion of the revised project footprint lies in areas of low archaeological potential, areas of moderate to high archaeological potential fall within the revised project footprint. As such, it is recommended that additional field studies be conducted under summer conditions, prior to

construction, on those areas of moderate to high archaeological potential that will be impacted by the project.

Project Personnel

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ARCHAEOLOGIST	:	Jessica Fahey, B.A.
DRAFTING	:	Keith Wilford, B.A. Eddie Fung, B.Sc.
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Table of Contents

Letter of Transmittal ii
Executive Summary iii
Project Personnel v
Table of Contents vi
List of Figures viii
List of Plates ix

INTRODUCTION 1
PROJECT DESCRIPTION 1
OBJECTIVES 1
SCOPE OF WORK 3

ENVIRONMENTAL SETTING 5
INTRODUCTION 5
REGIONAL ENVIRONMENT 5
PROJECT ENVIRONMENT 8

HISTORICAL RESOURCES 13
DEFINITION 13
POTENTIAL IMPACTS 13
MITIGATIVE OPTIONS 14

METHODOLOGY 15
RECORD REVIEW 15
PREDICTIVE MODELING OF ARCHAEOLOGICAL RESOURCES 15
GROUND RECONNAISSANCE 17

RESULTS 21
RECORD REVIEW 21
GROUND RECONNAISSANCE 21
ARCHAEOLOGICAL SITES 21
HISTORIC SITES 22
PALAEONTOLOGICAL SITES 22
MODEL OF ARCHAEOLOGICAL POTENTIAL 22
REVISED PROJECT FOOTPRINT 22

SUMMARY AND RECOMMENDATIONS 24

REFERENCES CITED 26

List of Figures

Figure 1 Location of study area. 2
Figure 2 Natural Regions and Subregions of Alberta. 6
Figure 3 West Ells SAGD Project – Phase 1 predictive model of archaeological potential. 16
Figure 4 Reconnaissance strategy and shovel tests. 19

List of Plates

Plate 1 View west; aerial view of unnamed lake within study area. 9
Plate 2 View northwest along seismic cut line through mixed forest environment. 9
Plate 3 View southwest from centre of proposed plant site; note dense underbrush. 10
Plate 4 View south along east side of existing well pad; note excellent surface visibility 10
Plate 5 View northeast along bulldozer cut associated with existing well pad. 11
Plate 6 View east along seismic line/well pad access road 11
Plate 7 Aerial view of existing well pads situated within study area. 12
Plate 8 View northeast along existing winter access road; note exposures. 12
Plate 9 Detail view of shovel test showing typical silty clay soil profile. 20
Plate 10 Detail view of shovel test showing typical course sandy soil profile. 20

INTRODUCTION

On behalf of Millennium EMS Solutions, agents for Sunshine Oilsands Ltd., FMA Heritage Inc. conducted a Historical Resources Impact Assessment (HRIA) of the West Ells SAGD Project – Phase 1 study (Figure 1). The proposed Project is situated within the Municipal District of Wood Buffalo and is located approximately 60 kilometres west of the community of Fort MacKay.

PROJECT DESCRIPTION

Sunshine Oilsands Ltd. proposes to develop and operate Phase 1 of their West Ells SAGD Project with a production capacity of approximately 1600 m^3 (10,000 barrels) of bitumen per day (the Project). The construction, operation and reclamation of the Project, will disturb approximately 60.7 ha of land and will include the following components; a central processing facility, utility corridor (access road, surface pipelines and power lines), one borrow pit, two well pads, and construction, supervisors and operations camp. The Project will also require supporting infrastructure including an access road and associated borrow pits. This supporting infrastructure is anticipated to disturb an additional 67.8 ha of land.

OBJECTIVES

The primary objectives of the HRIA were to:

1. inventory historical resource sites within the proposed West Ells SAGD Project – Phase 1 study area;

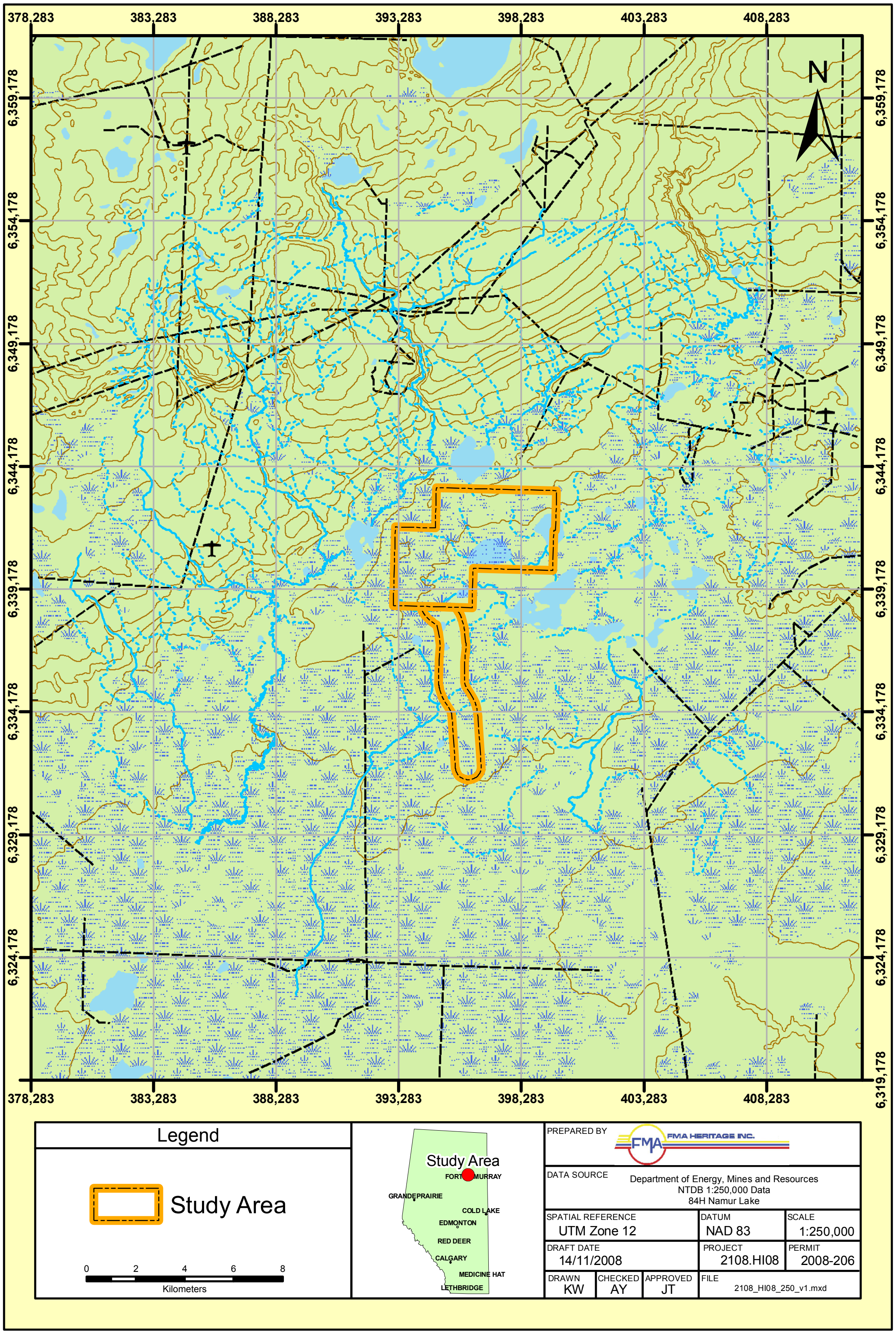

Figure 1 Location of study area

2. evaluate the significance of the individual sites identified;
3. forecast the nature and magnitude of site specific impacts; and
4. design and implement an acceptable site specific mitigation program which would significantly eliminate adverse impacts to identified sites prior to construction.

SCOPE OF WORK

The scope of work for the HRIA undertaken by FMA Heritage Inc. consisted of the following components:

1. **Record Review** - to identify previously recorded sites that could be affected by the proposed development project and to determine the nature of the database in the area.
2. **Ground Reconnaissance** - to relocate, in the field, historical resource sites that may have been previously recorded, as well as to identify and record any new sites within the development zone. Site discovery was based on surficial inspection of exposures and subsurface testing, using a conventional shovel testing program of potential site areas lacking suitable exposures.
3. **Site Evaluation** - to evaluate the nature of the existing resource database, the quantity and quality of observable remains (*e.g.* site condition, content, uniqueness, and complexity) and the potential of the site to contribute to public enjoyment and education. Sites are evaluated by inspection of exposures, or by a standard shovel testing program. Additional controlled assessment may be conducted when a site is perceived to contain potentially significant cultural material. In the event that such sites concealed by sediments are encountered, the need for further evaluation is satisfied through either an extensive

systematic subsurface testing program, a controlled excavation program, or a backhoe testing program.

4. **Impact Assessment** - to delineate the magnitude of forecasted impacts to the individual identified historical resource sites, as well as the local and regional database, and to recommend site specific mitigative measures commensurate with the assigned value of the site.

ENVIRONMENTAL SETTING

INTRODUCTION

Environment has always provided the parameters within which human cultures may develop by providing both opportunities and limitations. As a result, elements of the regional environment are important considerations in the understanding of cultural development, as they influenced not only the types of activities that could be conducted, but the ways in which they could be accomplished. In the archaeological record, testimony to this pattern is witnessed in the type and location of archaeological sites in specific environments. Human populations were not uniformly distributed across the landscape, but were clustered in the most suitable habitats. In Alberta, archaeological sites are found associated with a specific set of landforms (including valley edges, knolls, rivers, lakes and sloughs) which would direct travel, bias routes of communication and enhance or restrict resource procurement and occupation. Due to this close relationship of human settlement and the environment, a brief overview of the regional and local environments is presented.

REGIONAL ENVIRONMENT

The West Ells SAGD Project – Phase 1 lies within the Central Mixedwood Subregion of the Boreal Forest Natural Region of Alberta (Alberta Sustainable Resource Development 2005) (Figure 2). In this Natural Region, the climatic regime is typified by long cold winters and short cool summers. Extensive wetlands and large tracts of deciduous and coniferous forests

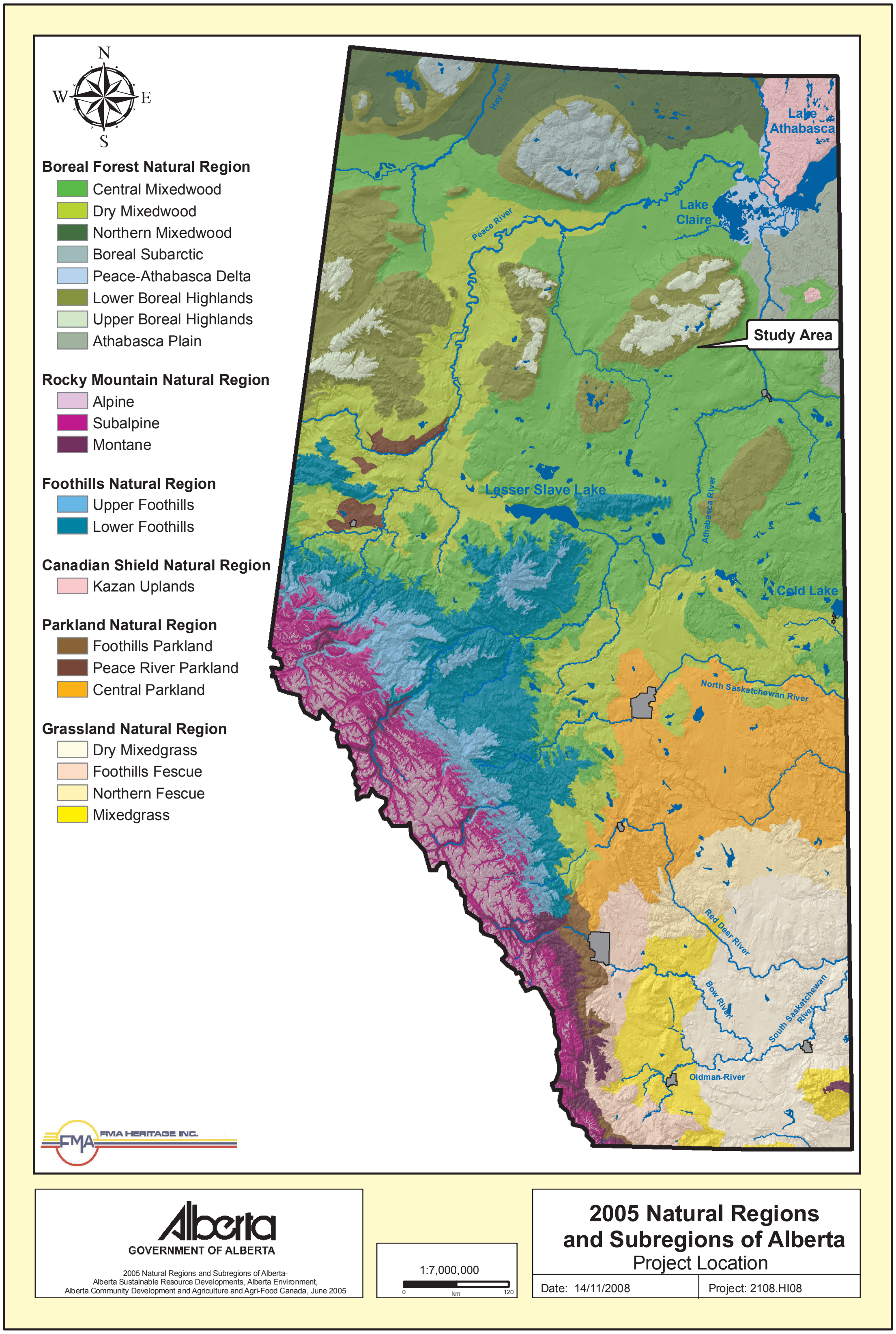

Figure 2 Natural Regions and Subregions of Alberta

characterize the highly diverse Natural Region. Aspen-dominated forests are typical, with mixedwood coniferious forests occupying higher elevations and wetlands.

Within the Central Mixedwood Subregion of the Boreal Forest Natural Region, aspen (*Populus tremuloides*) is dominant, occurring in both pure and mixed stands associated with balsam poplar (*Populus balsamifera*) and with birch (*Betula papyrifera*). Isolated areas that have escaped fires support dense stands of white spruce (*Picea glauca*). Black spruce (*Picea mariana*) and tamarack (*Larix laricina*) dominate the poorly drained regions and treeless muskeg occupies excessively wet areas. Soils within these forests are predominatly Gray Luvisols (Natural Regions Committee 2006).

Wildlife of this Subregion is the most diverse of that found in all Subregions of the Boreal Forest Natural Region. Mixedwoods and shrublands surrounding swamps, ponds, streams and lakes are the richest in species. These habitats support beaver (*Castor Canadensis*), moose (*Alces alces*), snowshoe hare (*Lepus americanus*), black bear (*Ursus americanus*), gray wolf (*Canis lupus*), Canada lynx (*Lynx canadensis*), muskrat (*Ondatra zibethicus*) and a variety of smaller animals. A variety of birds are also supported, including chickadees (*Parus* spp.), nuthatches (*Sitta* spp.), siskins (*Chardonneret* spp.), and juncos (*Junco* spp.). Waterfowl are also common, and include various species of ducks (SuperFamily *Anatinae*) and geese (SuperFamily *Anserinae*) (Natural Regions Committee 2006).

In some areas less common species such as fisher (*Martes pennanti*), wolverine (*Gulo gulo*), river otter (*Lutra canadensis*), and woodlands caribou (*Rangifer tarandus*) may also be found (Natural Regions Committee 2006). Bison (*Bison bison athabasca*), elk (*Cervus canadensis*), deer (*Odocoileus* spp.), moose and black bear would also have been available to precontact and early historic human populations. These occupants would also have been able to make use of a variety of fish present within the water systems of the area, including northern pike (*Esox lucius*), whitefish (*Coregonus spp.*), arctic grayling (*Thymallus arcticus*), perch (*Perca flavescens*), freshwater burbot (*Lota lota*) and walleye (*Stizostedion vitreum*) (Natural Regions Committee 2006).

PROJECT ENVIRONMENT

The area in which the Project is situated is characterized by generally level topography, consisting of numerous bogs and fens within a larger area of aspen and balsam poplar stands and black spruce muskeg. This environment is punctuated by three unnamed lakes and associated feeder creeks (Plate 1). Greater than 70 percent of the development area is open water or muskeg.

In general, the vegetation within the study area consists of large areas of black spruce, augmented with patchy areas of white spruce, aspen and balsam poplar mixed forest (Plate 2). Also present are a few select areas containing jack pine. Other vegetation types associated with the proposed development include tamarack trees, rosebushes, assorted mosses, various species of grasses and a variety of shrubs and willows (Plate 3). Grassland and closed shrub areas are present around the lake margins.

Surface visibility in the area ranges from poor to excellent based on the amount of vegetation present and the quantity of associated deadfall. Within the forested areas the visibility was moderate to poor due to the density of ground cover, however, in the disturbed areas associated with the numerous seismic trails and well pads surface visibility was excellent (Plate 4).

Existing disturbances in the study area include earlier terraforming associated with petroleum exploration (Plate 5). Of particular significance is the extent of the previous disturbance associated with the installation of numerous seismic cut lines, well pads, pipelines and a winter access road (Plate 6, 7 and 8).

Plate 1 View west; aerial view of unnamed lake within study area.

Plate 2 View northwest along seismic cut line through mixed forest environment.

Plate 3 View southwest from centre of proposed plant site; note dense underbrush.

Plate 4 View south along east side of existing well pad; note excellent surface visibility.

Plate 5 View northeast along bulldozer cut associated with existing well pad.

Plate 6 View east along seismic line/well pad access road.

Plate 7 Aerial view of existing well pads situated within study area.

Plate 8 View northeast along existing winter access road; note exposures.

HISTORICAL RESOURCES

DEFINITION

In Alberta, historical resources are protected under the *Alberta Historical Resources Act* (RSA 2000) and are defined as precontact, historic, and palaeontological sites and their contents. Cultural landscapes and traditional use sites may also be associated with historical resources. Precontact sites are comprised of artifacts, features and residues of Native origin. They predate the arrival of Europeans and are typically characterized by modified bone and stone artifacts, as well as stone features or structures. Historic sites are characterized by structures, features and objects of European influence. Buildings and building remains represent the most prominent type of historic sites. A palaeontological resource, or fossil, is any work of nature that consists of or contains evidence of past multicellular life. This includes: body fossils, such as bone, wood and shells, impressions, such as leaves, moulds and casts and trace fossils, such as footprints, trackways and burrows. Traditional use sites are identified in consultation with members of aboriginal communities and may include camping or hunting locales, plant collection locations or areas related to matters of a spiritual nature.

POTENTIAL IMPACTS

Due to the fact that precontact archaeological, historical, palaeontological and traditional land use sites represent discrete episodes of past activities, they are non-renewable and, therefore, are susceptible to alteration or removal by modern industrial development. Precontact and historic archaeological resources are comprised of residues of past cultures or societies. Although the cultural entities responsible for deposition of the archaeological material are unavailable for observation, the preserved context and associations in which the remains functioned can reveal many clues about past human behaviour, adaptations and relationships to the natural world. The key to the interpretation of these resources, however, is in their pattern of cultural deposition, which is extremely fragile, ephemeral and the product of unique processes and conditions of preservation. Consequently, once they are disturbed, they cannot be replaced, re-created or restored. Due to the nature of their origin and preservation, archaeological resources are finite in quantity. As a result, archaeological resources are increasingly susceptible to destruction and depletion through natural and cultural disturbances.

MITIGATIVE OPTIONS

Adverse primary impacts to historical resource sites, identified prior to the construction stage of development, can be significantly reduced or eliminated by avoidance or adequate study. Site avoidance can be achieved through relocation of the proposed project or by restriction of the construction within the development zone. Adequate study of archaeological sites generally involves scientific investigations that are designed to systematically explore and reconstruct the activities that are represented at the site. These investigations may involve the systematic collection of surface sites, detailed mapping, photographic documentation of sites, or the excavation of buried sites. In cases where the interpretive potential of a set of archaeological resources is considered to be low, it may be deemed that photographic documentation, recording, and collection of surface specimens are sufficient mitigative measures. In cases where the archaeological interpretive potential of a set of historical resources is identified as high, however, more detailed mitigative measures, such as controlled excavation, may be necessary. Similarly, adequate study of palaeontological sites may include collection and excavation of specimens, as a means of providing information on past species and habitats.

METHODOLOGY

RECORD REVIEW

The record review consisted of a search of the Archaeological Site Inventory Data records maintained by the Historic Resources Management Branch (Alberta Culture and Community Spirit) to determine the number and nature of previously recorded sites in the project area. The *Listing of Significant Historical Sites and Areas* (March 2008 edition) was also consulted.

PREDICTIVE MODELING OF ARCHAEOLOGICAL RESOURCES

To determine the relative ranking of terrain features in terms of potential to identify precontact historical resources, a predictive model was developed using Geographic Information Systems (GIS) technology. Archaeological sites previously recorded in the oils sands area have generally shown correlation with relatively flat, well-drained habitable landforms such as ridges and knolls. Often, sites have also been associated with water sources such as rivers, streams and lakes. Therefore, the predictive model developed for the historical resources assessment studies databases containing information on vegetation ecosite phases, soil complexes, aspect, slope and proximity to perennial waterbodies to reflect these archaeological associations

The map of archaeological potential produced using the predictive model is shown in Figure 3. Areas of brightest colour (dark red) are of high historical

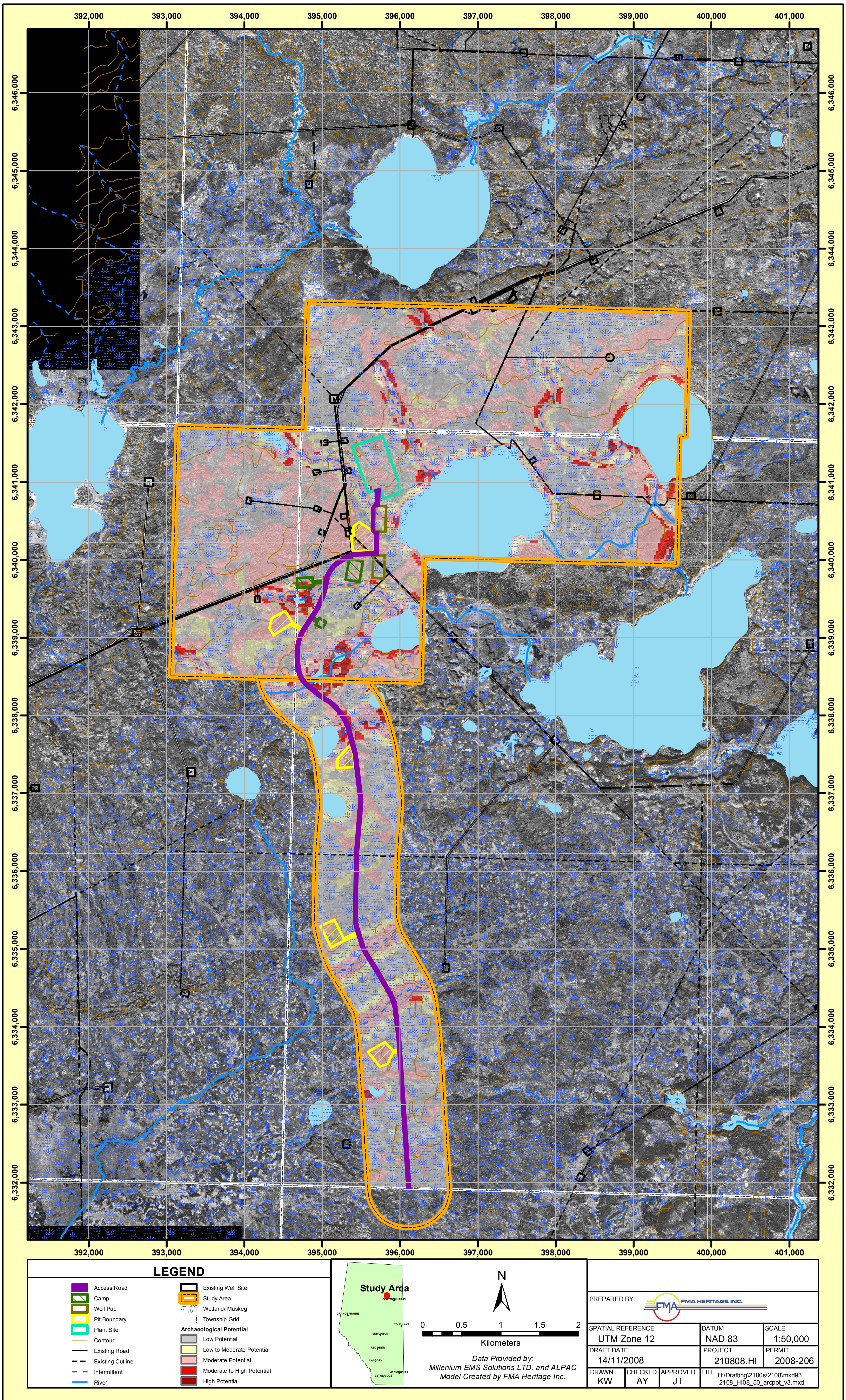

Figure 3 West Ells SAGD Project - Phase 1 predictive model of archaeological potential.

resources potential, while areas coloured red to pink are of moderate to high potential. Areas of yellow are considered to be of low to moderate historical resources potential and grey areas are considered to be of low historical resources potential. Although the predictive model served as a guide to focus the investigation, field archaeologists were not restricted to the model archaeologists used judgement based on experience and in field observations, as well as the predictive model, to select areas of assessment.

GROUND RECONNAISSANCE

The ground reconnaissance consisted of a pedestrian traverse and intensive visual examination of exposures and a shovel testing program within targeted areas of moderate to high archaeological potential within the study area. Summer ground access (roads and trails) in the area are limited, and helicopters were therefore used to access the targeted areas. All fortuitous exposures such as road cuts and seismic lines, game trails, erosional surfaces, and tree throws were examined for cultural materials. Visual inspection of these areas was considered adequate for assessing the presence of near surface cultural remains. Excavation of shovel tests (N=157), each approximately 40 X 40 centimetres (cm) was conducted in areas of limited exposure or in areas deemed to have potential for buried cultural deposits. The depth of each shovel test varied according to local soil conditions, ranging from 40 to 50 cm in depth.

Surface visibility was poor to excellent depending on the amount of vegetation within the West Ells SAGD Project – Phase 1 study area. The initial ground reconnaissance consisted of an aerial overflight followed by a pedestrian traverse and an intensive visual examination of the study area, especially those high potential landforms associated with bodies of water. All fortuitous exposures, such as seismic cut lines, vehicle tracks and disturbance from previous petroleum industry activities were examined for the presence of cultural materials.

During the course of the assessment a total of 157 shovel tests were excavated within the West Ells SAGD Project – Phase 1 study area

(Figure 4). All 157 shovel tests were negative for cultural material. The shovel test soil profiles varied depending on location. Within most of the West Ells SAGD Project – Phase 1 study area, the soil profile consisted of an initial layer of dark brown organic material followed by tan clay or silty clay matrix mixed with pebbles and gravels with a terminus extending beyond the range of shovel testing (Plate 9). At a select few locations the soil profile consisted of an initial layer of dark brown organic material followed by light tan or grey course sand and then a layer of course orange coloured sand mixed with gravels and a terminus extending beyond the range of shovel testing (Plate 10).

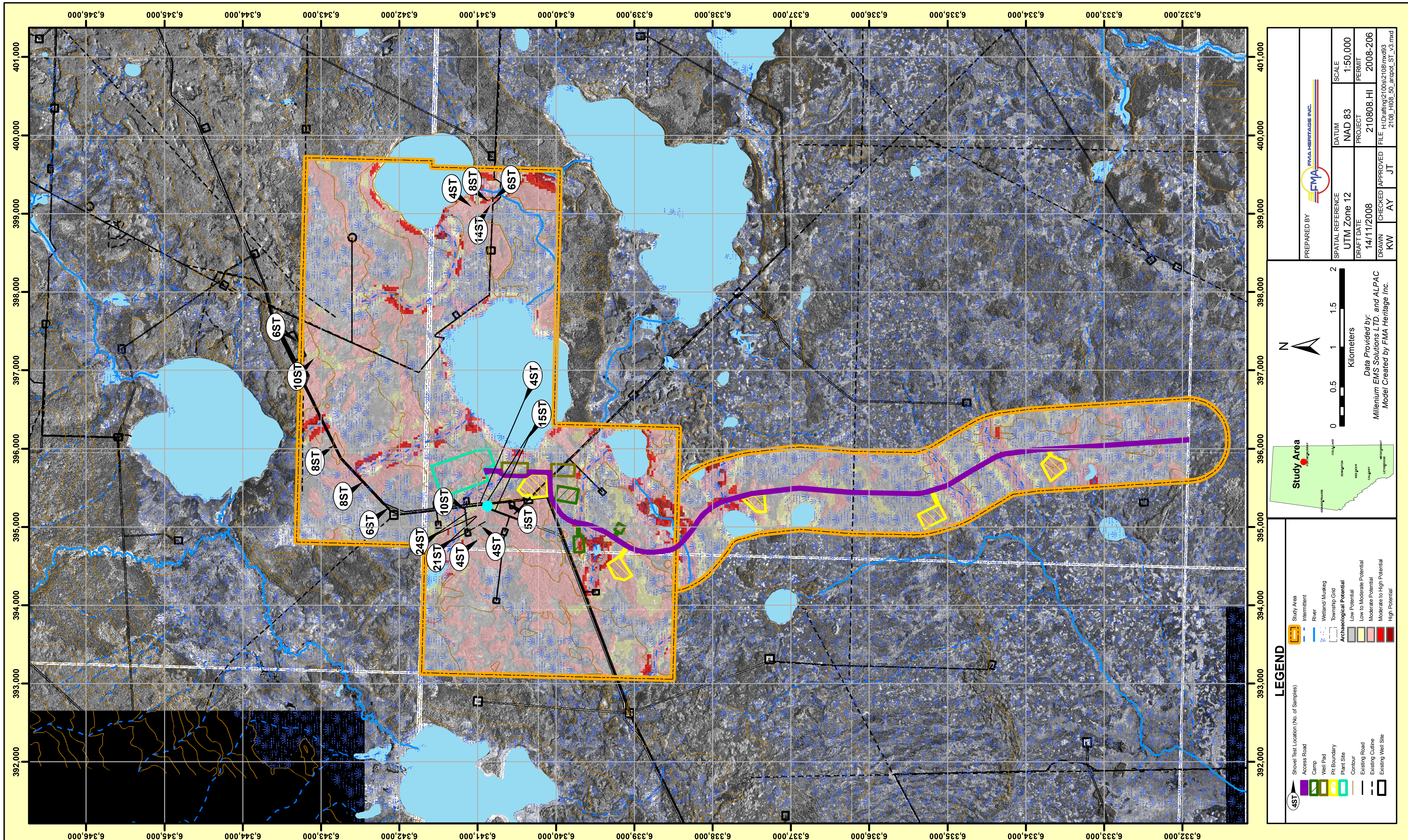

Figure 4 Reconnaissance strategy and shovel tests.

Plate 9 Detail view of shovel test showing typical silty clay soil profile.

Plate 10 Detail view of shovel test showing typical course sandy soil profile.

RESULTS

RECORD REVIEW

Prior to the ground reconnaissance, a record review of the Archaeological Inventory Sites Database was conducted for the proposed development. The record review indicated that the West Ells SAGD Project – Phase 1 study area is located within Borden Block HhPe. There are no previously recorded archaeological sites within Borden Block HhPe. No historic sites have been previously recorded within the West Ells SAGD Project – Phase 1 Legals.

GROUND RECONNAISSANCE

The ground reconnaissance portion for the HRIA of the West Ells SAGD Project – Phase 1 was conducted by a crew of two under the direction of Alan Youell, M.A., of FMA Heritage Inc. The ground reconnaissance was carried out during June, 2008 under ACCS Permit 2008-206. At the time of the reconnaissance the West Ells SAGD Project – Phase 1 was not formally surveyed/staked, however, preliminary site plans and UTM coordinates for the study area were provided. The footprint provided for the June, 2008 ground reconnaissance was subsequently modified in October, 2008.

ARCHAEOLOGICAL SITES

No previously recorded or newly identified archaeological sites were encountered during the HRIA of the West Ells SAGD Project – Phase 1 study area.

HISTORIC SITES

No historic period structures or materials were observed during the HRIA of the West Ells SAGD Project – Phase 1 study area.

PALAEONTOLOGICAL SITES

No palaeontological materials or bedrock exposures were observed during the HRIA of the West Ells SAGD Project – Phase 1 study area.

MODEL OF ARCHAEOLOGICAL POTENTIAL

While no newly identified historical resources were identified, the predictive model was valid as a research tool. Within the West Ells SAGD Project – Phase 1 study area sandy ridges with jack pine and reindeer moss vegetation were positively identified in the model as areas of high potential. However, often mixed forest ridges were not identified as moderate potential when in fact they showed some potential for the presence of historical resources. Numerous modelled high potential areas, especially along the water course margins, turned out to be too waterlogged to shovel test. Often the model indicated areas of moderate to high potential within a greater area low potential and ground reconnaissance provided visual evidence that these are actually low potential in the larger context of the study area. In conclusion, while the predictive model was not a viable stand alone research tool, when used in conjunction with ground reconnaissance it performed admirably in reducing a large study area into smaller target areas that can then be visually accessed on the ground.

REVISED PROJECT FOOTPRINT

Following the June, 2008 field reconnaissance the West Ells SAGD Project – Phase 1 development footprint was modified (October, 2008). While the majority of the October, 2008 footprint is situated in areas of low to moderate potential, often in a bog, fen, muskeg or wetland environment, several areas of untested moderate to high potential are present within the plant site, construction camp and access road route footprints. As such, it is recommended that additional field studies be conducted under summer conditions, prior to construction, on those areas of moderate to high archaeological potential that will be impacted by the project.

SUMMARY AND RECOMMENDATIONS

On behalf of Millennium EMS Solutions, agents for Sunshine Oilsands Ltd., FMA Heritage Inc. conducted a HRIA of the West Ells SAGD Project – Phase 1 study area.

The HRIA was conducted in June 2008, under archaeological Permit 2008-206. During the HRIA field reconnaissance of the West Ells SAGD Project – Phase 1 study area, locations of limited exposure, deep sediments or high archaeological site potential were assessed by visual inspection and the excavation of 157 shovel tests in order to evaluate the presence and/or nature of surface and subsurface cultural deposits. Assessment included both the June 2008 footprint and selected areas of high archaeological potential within the Lease. During the course of the assessment, no archaeological, historical or palaeontological sites were identified and no previously recorded sites were revisited.

The footprint was subsequently revised in October 2008; revisions included changes to the project component locations as well as the finalization of an access road route. As part of the current study, the revised project footprint was subject to a desktop review to compare the revised footprint with the original assessed project footprint, with those areas assessed as part of the original baseline studies, and with the model of archaeological potential. Although a significant portion of the revised project footprint lies in areas of low archaeological potential, areas of moderate to high archaeological potential fall within the revised project footprint. As such, it is recommended that additional field studies be conducted under summer conditions, prior to construction, on those areas of moderate to high archaeological potential that will be impacted by the project.

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HYDROLOGY ASSESSMENT FOR SUNSHINE OILSANDS WEST ELLS SAGD PROJECT

NOVEMBER, 2008

nhc northwest hydraulic consultants

Leaders in water resource technology

HYDROLOGY ASSESSMENT FOR SUNSHINE OILSANDS WEST ELLS SAGD PROJECT

Prepared for:

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Nov, 2008
APEGGA Permit P00654
nhc project# 1-7095
reference#

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Leaders in water resource technology

Nov 24, 2008

Millennium EMS Solutions Ltd.
208, 4207-98 Street
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Attention: Mr. Dane McCoy

Dear Sir:

Subject: Sunshine Oilsands
West Ells SAGD Project
Hydrology Assessment

---

northwest hydraulic consultants (nhc) is pleased to provide the following report detailing the hydrology assessment for the Sunshine Oilsands West Ells SAGD Project. The report contains an assessment of the baseline climate and streamflow characteristics. If you have any questions, please give me a call in our Edmonton office at (780) 436-5868.

Sincerely,

northwest hydraulic consultants

PROFESSIONAL ENGINEER P.G. VanDerVinne ALBERTA

Nov 24, 2008

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CREDITS AND ACKNOWLEDGEMENTS

This project was carried out by Salem Bouhaire, Ph.D., E.I.T., under the guidance and supervision of Gary Van Der Vinne, M.Sc., P.Eng.. Climate data used in this report was obtained from Environment Canada's National Climate Data and Information Archive. Streamflow data was obtained from Environment Canada's Water Survey Canada Archived Hydrometric Data.

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TABLE OF CONTENTS

List of Tables v

List of Figures vi

1 Introduction 1

2 Baseline Setting 1
2.1 Location and Physiography 1
2.2 Climate 1
2.2.1 Air Temperature 2
2.2.2 Precipitation 3
2.2.3 Evaporation 4
2.3 Streamflow 5
2.3.1 Regional Flow Characteristics 5
2.3.2 Local Hydrography 7
2.3.3 Local Channel Characteristics 8

3 Assessment of SAGD Project Impacts 11
3.1 Project Footprint 11
3.1.1 Surface Disturbances 11
3.1.2 Stream Disturbances 13
3.1.3 Water Supply 14
3.2 Hydrologic Impacts 14
3.2.1 Surface Runoff 14
3.2.2 Sediment Concentrations 16

4 Assessment of Access Road Impacts 17
4.1 Access Road Footprint 17
4.1.1 Surface Disturbances 17
4.1.2 Stream Disturbances 18
4.2 Hydrologic Impacts 20
4.2.1 Surface Runoff 20
4.2.2 Sediment Concentrations 21

5 Monitoring and Mitigation 22

6 Summary of Conclusions 23

7 References 24

LIST OF TABLES

Table 1 Summary of monthly temperature characteristics 3
Table 2 Summary of precipitation characteristics 4
Table 3 Summary of WSC gauges in the region.. 6
Table 4 Summary of regional flows.. 8
Table 5 Summary of drainage areas and estimated flow rates for local watersheds 9
Table 6 Summary of channel characteristics on June 24-26, 2008.................................... 9
Table 7 Summary of disturbed areas due to Phase 1 of the SAGD Project...................... 11
Table 8 Summary of spatial extent of disturbances due to Phase 1 of the SAGD Project 12
Table 9 Summary of changes in runoff volume due to Phase 1 disturbances 15
Table 10 Summary of disturbed areas due to access road 17
Table 11 Summary of spatial extent of access road disturbances...................................... 18
Table 12 Summary of drainage areas and estimated flow rates for crossing sites 19
Table 13 Summary of changes in runoff volume due to project disturbances................... 21

LIST OF FIGURES

Figure 1 Project location and regional study area

Figure 2 Local study area

Figure 3 Monthly air temperatures

Figure 4 Monthly precipitation

Figure 5 Annual precipitation and winter snowfall

Figure 6 Variation of discharge with drainage area

Figure 7 Regional flow frequency distributions

Figure 8 Local hydrography and site locations

Figure 9 Channel characteristics at Site 1

Figure 10 Channel characteristics at Site 2

Figure 11 Channel characteristics at Site 3

Figure 12 Channel characteristics at Site 4

Figure 13 Channel characteristics at Site 5

Figure 14 Channel characteristics at Site 6

Figure 15 Channel characteristics at Site 7

Figure 16 Project layout and drainage

Figure 17 Photographs near Crossing 1

Figure 18 Photographs near Crossing 2

Figure 19 Photographs near Crossing 3

Figure 20 Photographs near Crossing 4

Figure 21 Photographs near Crossing 5

1 INTRODUCTION

Sunshine Oilsands is proposing to develop a 10,000 barrel per day Stream Assisted Gravity Drainage (SAGD) Project on their West Ells Project. This report presents the baseline surface water hydrology in the vicinity of the Project and an assessment of the hydrologic impacts of Phase 1 of the development. The baseline hydrology includes an evaluation of the regional meteorological characteristics and the regional and local streamflow characteristics. The assessment of hydrologic impacts includes runoff impacts and channel impacts.

2 BASELINE SETTING

2.1 LOCATION AND PHYSIOGRAPHY

The West Ells Project is located in the Municipal District of Wood Buffalo about 60 km northwest of Fort Mackay. The Project Area consists of six sections (16 km^2) in the following locations: Twp 94, Rge 17, Sections 30-33; and Twp 94, Rge 18, Sections 25 and 36, all west of the 4th Meridian. Figure 1 shows the location of the West Ells Project, watershed boundaries, and the locations of hydrometric and climate stations in north-eastern Alberta. Most of the Project Area is located in the watershed of the Dover River, which is a major tributary of the Mackay River.

The Project lies within the Central Mixedwood Subregion of the Boreal Forest Natural Region in northern Alberta. This low-relief plain is relatively poorly drained, consisting mostly of organic soils. Well drained areas consist of mixed-wood forests of deciduous and coniferous species. The most abundant trees are trembling aspen and balsam poplar with white spruce, black spruce, and balsam fir also occurring. Poorly drained areas consist of wetlands including bogs, fens, swamps and marshes which contain tamarack and black spruce.

The Regional Study Area (RSA) for surface water hydrology is defined as the area in which stream flows and water levels could be affected by development within the Project Area. The RSA is composed of the watershed of the Mackay River as shown in Figure 1. The RSA is limited to this watershed because potential impacts to the larger watershed downstream are expected to be negligible due to the much greater drainage area of the downstream watershed.

The Local Study Area (LSA) for surface water hydrology is defined as the total drainage area of the local tributaries to the Dover and Dunkirk rivers which have portions of their watersheds lying within the Project Area and access road right-of-way. The boundary of the LSA is shown in Figure 2.

2.2 CLIMATE

Climate influences many hydrologic characteristics. Over the long term, the climate and local surficial geology determine the vegetation in the area. Climate, surficial geology and vegetation affect the runoff coefficients and evapotranspiration rates in the area. On a shorter time scale, the magnitude of the winter snowpack and severity of summer rain events affect the severity of spring and summer runoff events.

Environment Canada (EC) operates a climate station in the vicinity of the West Ells Project Area, the Legend LO station (3073792) which is 30 km north of the Project. The location of this station is shown in Figure 1. This station provides air temperatures and precipitation from 1962 to present for the period from May to August. The elevation of this station of 911 m is much greater than the mean elevation in the Project Area of 530 m.

Another EC climate station, Livock LO (3063930), is 86 km south west of the West Ells Project (Figure 1). This station provides air temperatures and precipitation from 1966 to present for the period from June to August. The elevation of this station is 579 m, which is similar to the mean elevation in the Project Area of 530 m.

A long term climate station operated by EC is located at Fort McMurray Airport (3062693) about 110 km southeast of the Project (Figure 1) at an elevation of 369 m. This station provides a long term continuous climate record for the area, reporting measurements as far back as 1944. This station reports air temperatures and precipitation, as well as rainfall intensity, wind speed and direction, atmospheric pressure, hours of bright sunshine, and humidity.

2.2.1 Air Temperature

Air temperature is a significant climatic variable in the hydrologic cycle because it determines the relative proportion of rain and snow within the total annual precipitation and the start and severity of snowmelt runoff in the spring. The monthly maximum, mean, and minimum temperatures at Fort McMurray A, Legend LO and Livock LO for the climate normal period between 1961 and 1990 are shown in Figure 3 and summarized in Table 1. This period was selected for comparison because the more recent climate normals from 1971 to 2000 are not available for Legend LO and Livock LO. The normal air temperatures at Fort McMurray for the 1971 to 2000 period are typically within 1°C of the 1961 to 1999 temperatures.

At Fort McMurray, the mean monthly temperature ranges from 17°C in July to -20°C in January. The extreme monthly temperatures range from 23°C in July to -25°C in January. The mean daily air temperature drops below freezing in November and rises above freezing in April.

Summer air temperatures at Legend LO station are generally 2- 3°C lower than those of Fort McMurray, with temperatures at Livock LO typically falling between the other two sites. The lower temperatures at Legend and Livock LO are likely due to the higher elevations of these sites.

Table 1 Summary of monthly temperature characteristics

Month	Monthly Average Temperatures								
	Fort McMurray A			Legend LO			Livock LO		
	Max (°C)	Mean (°C)	Min (°C)	Max (°C)	Mean (°C)	Min (°C)	Max (°C)	Mean (°C)	Min (°C)
Jan	-15	-20	-25						
Feb	-9	-15	-21						
Mar	-1	-8	-15						
Apr	9	3	-4						
May	17	10	3	13	8	2			
Jun	22	15	8	18	12	7	19	13	8
Jul	23	17	10	19	14	9	21	16	10
Aug	22	15	9	18	13	8	20	14	8
Sep	15	9	3						
Oct	8	3	-2						
Nov	-5	-9	-14						
Dec	-13	-17	-22						
Annual	**6**	**0**	**-6**						

2.2.2 Precipitation

Precipitation is the most important climate variable that affects the hydrologic cycle. Winter snowfall influences the magnitude and duration of the spring snowmelt flows, while summer rain events produce summer peak flows. In general, the annual total precipitation helps determine both the degree of saturation in the near-surface zone of the watersheds and the subsequent annual runoff volume into the streams.

Generally all the precipitation between November and March falls as snow due to the below freezing air temperatures during this period. The winter snowfall at Fort McMurray is relatively constant from month to month, averaging about 20 cm (Figure 4). This precipitation is stored on the ground until April and May, when the snow melts and snowmelt runoff is produced.

Summer precipitation records are also available for Legend LO and Livock LO. The average monthly precipitation for these stations for the climate normal period from 1961-1990 is shown in Figure 4 and listed in Table 2. Both Legend LO and Livock LO have about 20% more precipitation than the Fort McMurray station in June and July but have precipitation similar to Ft. McMurray in May and August. The greatest monthly precipitation occurs in July, averaging about 79 mm at Fort McMurray, 98 mm at Legend LO, and 92 mm at Livock LO.

Table 2 Summary of precipitation characteristics

Month	Monthly Mean Precipitation			Daily Extreme Precipitation		
	Fort McMurray A (mm)	Legend LO (mm)	Livock LO (mm)	Fort McMurray A (mm)	Legend LO (mm)	Livock LO (mm)
Jan	20			16		
Feb	16			13		
Mar	17			30		
Apr	23			27	18	13
May	41	44		39	41	38
Jun	64	75	82	46	46	69
Jul	79	98	92	52	61	62
Aug	72	71	68	95	53	94
Sep	51			61	41	43
Oct	32			29	16	
Nov	26			16	3	
Dec	23			23		
Annual	**465**					

Annual precipitation and winter snowfall for the Fort McMurray period of record are shown in Figure 5. Fort McMurray experienced a maximum winter snowfall of 297 mm in 1972 and a minimum winter snowfall of 46 mm in 1949. The maximum annual precipitation of 675 mm occurred in 1973, while the minimum annual precipitation of 242 mm occurred in 1998.

Table 2 also summarizes the extreme daily precipitation data for both stations for the climate normal period from 1961-1990. The extreme daily precipitation of 95 mm for Fort McMurray is similar than the value of 94 mm at Legend LO but much greater than the 61 mm reported for Livock LO. Rainfall intensity curves provided by Environment Canada for Fort McMurray indicate than the 10-year 24 hour rainfall is 64.1 mm and the 100-year 24 hour rainfall is 95.9 mm.

2.2.3 Evaporation

Evaporation causes lake levels and soil moisture levels to drop during the open water season. Evaporation can be measured by evaporation pans or estimated by changes in lake levels. Lake evaporation tends to be about 70% of the measured pan or potential evaporation due to the higher humidity over the lake, although this percentage varies substantially with location (Linsley, et al, 1982). Evaporation from small ponds may be higher than lake evaporation and may approach the potential evaporation measured by evaporation pans.

Lake evaporation can be calculated from consideration of air temperatures, solar radiation, atmospheric pressure, and humidity; however, the first two parameters are most significant, especially in shallow lakes. Bothe (1981) calculated lake evaporation for Fort McMurray from 1972 to 1980 and found that the average annual lake evaporation for this period was 570 mm.

Evapotranspiration, the combination of evaporation and transpiration from vegetated land, tends to be lower than lake evaporation due to the limitation of soil moisture availability. The median annual evapotranspiration from the vegetated land in the Project Area is estimated to be about 325 mm, based on the method of estimating evapotranspiration from potential and lake evaporation proposed by Morton (1983).

2.3 STREAMFLOW

Both regional and local streamflow characteristics were evaluated. A regional analysis of annual runoff and peak flows was carried out to evaluate flows from the available data in the region. An assessment of the local hydrography and channel characteristics was also carried out to define the local streamflow characteristics.

2.3.1 REGIONAL FLOW CHARACTERISTICS

Water survey of Canada (WSC) maintains a number of streamflow gauges in the region. The locations of these gauges are shown in Figure 1, and a summary of their characteristics is given in Table 3. The gauges listed in Table 3 provide a record of discharges for streams with drainage areas ranging from 165 km^2 for the Beaver River above Syncrude (07DA018) to 5570 km^2 for the MacKay River near Fort MacKay (07DB001).

The longest period of record available is 36 years from 1972 to 2007 for both the Steepbank River near Fort McMurray (07DA006) and Mackay River near Fort Mackay (07DB001). The gauges with the shortest periods of record, three years for the Dover River near mouth (07DB002) and five years for the Dunkirk River near Fort Mackay (07DB003), are included because these watersheds drain the Project Area. Five other gauges listed in Table 3 were discontinued between 1986 and 1993. Four of gauges listed in Table 3 are currently operated seasonally from March to October with discharge data published to the end of 2007. Most of the gauges were operated annually for a period of time before being operated seasonally, so there are some historical winter data available for these sites.

Annual runoff coefficients were calculated for the gauges listed in Table 3 with nine or more years of record. Runoff coefficients define the fraction of precipitation which leaves the basin as streamflow. To provide a meaningful comparison of runoff from the various basins, the median annual runoff from each basin was calculated from the streamflow for the period from March to October, since winter flow data in only available for portions of the periods of record at most of the gauges. When winter streamflow data is available, it is generally about 6% of the total annual flow so the real annual runoff coefficients may be up to 6% greater than the values provided in Table 3.

Table 3 Summary of WSC gauges in the region

Stream	Location	Gauge Number	Gauge Type	Period of Record	Drainage Area (km^2)	Median Annual Runoff Coefficient
Steepbank River	Fort McMurray	07DA006	Continuous Seasonal	1972-1986 1987-2007	1320	0.25
Muskeg River	Fort MacKay	07DA008	Continuous Seasonal	1974-1986 1987-2007	1460	0.19
Hartley Creek	Fort MacKay	07DA009	Continuous Seasonal	1975-1987 1988-1993	358	0.19
Unnamed Creek	Fort MacKay	07DA011	Continuous Seasonal	1975-1981 1982-1993	274	0.10
Joslyn Creek	Fort MacKay	07DA016	Continuous Seasonal	1975-1981 1982-1993	257	0.12
Ells River	Mouth	07DA017	Continuous	1975-1986	2450	0.17
Beaver River	Syncrude	07DA018	Continuous Seasonal	1975-1987 1988-2007	165	0.18
MacKay River	Fort MacKay	07DB001	Continuous Seasonal	1972-1987 1988-2007	5570	0.15
Dover River	Mouth	07DB002	Continuous	1975-1977	963	n/a
Dunkirk River	Fort MacKay	07DB003	Continuous	1975-1979	1570	n/a
MacKay River	Dunkirk River	07DB005	Seasonal	1983-1991	1010	0.12

As presented in Section 2.2.2, annual precipitation records are available for Fort McMurray while at Legend LO and Livock LO precipitation records are only available for May through August. For the runoff analysis, a composite precipitation was developed from the Fort McMurray record, averaged with the records from other two sites when they were available. The annual runoff coefficients were calculated from the November to October annual precipitation to associate the accumulated winter snowfall with the runoff in the following spring and summer. The median annual precipitation of the Nov-Oct composite record was 454 mm.

The median annual runoff coefficients for the region range from 0.10 for an Unnamed Creek near Fort MacKay to 0.25 for the Steepbank River near Fort McMurray, with an average of 0.16. There is no significant trend in the magnitude of the runoff coefficient with drainage area. This average value for the region is expected to provide a reasonable estimate of local runoff in the Project Area.

Mean annual flows were calculated for each of the nine WSC basins listed in Table 4. The mean annual flow ranged from 0.39 m^3/s for Unnamed Creek to 13.3 m^3/s for Mackay River near Fort Mackay. The trend of mean annual flow with drainage area shown in Figure 6 indicates that mean annual flow is directly proportional to drainage area.

Mean annual peak flows ranged from 5.8 m^3/s for Unnamed Creek to 122 m^3/s for the Mackay River near Fort Mackay. The mean annual peak flows tend to increase log-linearly with drainage area as shown in Figure 6.

Extreme flows from the historical records of the nine WSC gauges were also evaluated. These flows are summarized in Table 4. Flow frequency distributions of the annual peak flows from the gauges, normalized by mean annual peak flow, are shown in Figure 7. An adopted regional log-normal distribution which fits the general trend of the data is also shown in Figure 7.

Average minimum monthly flows are also listed in Table 4 for the WSC gauges in the region. These minimum flows include winter flows where available. Minimum flows typically occur during the winter months but can also occur during summer dry periods. The relationship of these minimum flows with drainage area is shown in Figure 6.

2.3.2 LOCAL HYDROGRAPHY

Figure 8 shows the hydrography in the vicinity of the West Ells Project. The Project lies within the watershed of Mackay River which has a drainage area of 5570 km^2. Most of the Project Area lies within the watershed of the Dover River, a major tributary of the MacKay River, which has a drainage area of 963 km^2. A small portion of the Project Area lies within the watershed of another major tributary of the MacKay River, the Dunkirk River which has a drainage area of 1570 km^2. The WSC operated gauges on the Dover River at the mouth from 1975-77 and the Dunkirk River near Fort MacKay from 1975-79; however, the periods of record for these gauges were too short to include the flow data in the analysis of regional flow characteristics.

The watersheds of two small tributaries in the headwaters of the Dover River drain 95% of the Project Area. Both these tributaries, Dov1 and Dov2 flow south-eastward into Lake L1. The Project occupies 595 ha of the watershed of tributary Dov1 and 917 ha of the watershed of tributary Dov2. A small portion of the western edge of the Project, 51 ha, drains into the watershed of Snipe Creek, which is a tributary of the Dunkirk River.

The largest lake in the vicinity of the Project is Lake L1 which has a surface area of 330 ha. Most of the Project Area lies within the drainage area of this lake. Watershed Dov1 contains a small lake, L2 with a surface area of 25 ha, while watershed Dov2 contains two larger lakes, L3 and L4 which have surface areas of 188 ha and 105 ha respectively. Two other lakes, L5 and L6 with surface areas of 162 ha and 230 ha respectively, are located on Snipe Creek just to the northwest of the Project.

Table 4 Summary of regional flows

Stream	Location	Drainage Area (km^2)	Mean Annual Flow (m^3/s)	Mean Annual Peak Flow (m^3/s)	10-Year Peak Flow (m^3/s)	25-Year Peak Flow (m^3/s)	100-Year Peak Flow (m^3/s)	Average Minimum Monthly Flow[1] (m^3/s)
Steepbank River	Fort McMurray	1320	4.60	37.0	68.4	91.0	129	0.37
Muskeg River	Fort MacKay	1460	3.74	26.3	48.2	63.7	89.9	0.36
Hartley Creek	Fort MacKay	358	1.00	8.46	18.6	27.3	43.6	0.011
Unnamed Creek	Fort MacKay	274	0.39	5.79	10.6	14.2	20.3	0.057
Joslyn Creek	Fort MacKay	257	0.62	13.9	27.8	38.7	58.0	0.011
Ells River	Mouth	2450	6.32	71.0	156	237	397	0.81
Beaver River	Syncrude	165	0.50	10.1	23.0	35.9	62.0	0.043
MacKay River	Fort MacKay	5570	13.3	122	260	381	608	0.47
MacKay River	Dunkirk River	1010	2.46	21.0	47.9	72.5	121	0.038

[1]winter flow records incomplete

The mean annual flows for the local watersheds were estimated on the basis of the relationship shown in Figure 6 and the log-normal distribution adopted from the analysis regional flow frequencies was used to estimate the expected flood peaks in the local watersheds. Table 5 summarises the flood peaks for various return periods for these watersheds.

2.3.3 Local Channel Characteristics

Site inspections were carried out at seven sites in the vicinity of the Project on June 24-26, 2008 (Figure 8). A summary of the channel characteristics observed at the sites is given in Table 6. The wetted width ranged from 1.0 m at Site 4 to 56 m at Site 3 and the mean velocity ranged from 0.0 m/s at Site 7 to 0.17 m/s at Site 4. Discharges estimated from the measurements ranged from no flow at Sites 3 and 7 to 0.051 m^3/s at Site 4. As shown in Figure 6, the measured discharges are slightly greater than the mean annual flows expected for these drainage areas. The drainage areas and mean annual flows estimated for the seven sites are summarised in Table 5 along with estimates of extreme flows for the sites. Peak flows for watershed Dov2 may be overestimated because the large percentage of lake area in this watershed may delay the runoff relative to watersheds with less lake area.

Table 5 Summary of drainage areas and estimated flow rates for local watersheds

Stream	Major Watershed	Drainage Area (km^2)	Mean Annual Flow (m^3/s)	Mean Annual Peak Flow (m^3/s)	10-Year Peak Flow (m^3/s)	25-Year Peak Flow (m^3/s)	100-Year Peak Flow (m^3/s)	Average Minimum Monthly Flow (m^3/s)
Dunkirk River	Mackay River	1570	3.93	38.3	77.5	110	168	0.21
Snipe Creek	Dunkirk River	450	1.14	14.2	28.7	40.7	62.3	0.051
Dun1	Dunkirk River	69.6	0.17	3.2	6.5	9.2	14.2	0.006
Dover River	Mackay River	963	2.41	26.0	52.6	74.5	114	0.12
Dov1	Dover River	12.7	0.032	0.83	1.7	2.4	3.7	0.001
Dov2	Dover River	30.7	0.077	1.7	3.4	4.8	7.4	0.002
Dov3	Dover River	67.4	0.17	3.1	6.4	9.0	11.8	0.006
Site 1	Dov2	0.68	0.002	0.082	0.17	0.23	0.36	0.000
Site 2	Dov2	1.47	0.004	0.151	0.31	0.43	0.66	0.000
Site 3	Dov1	2.60	0.007	0.237	0.48	0.68	1.0	0.000
Site 4	Dov1	2.62	0.007	0.238	0.48	0.68	1.0	0.000
Site 5	Dov1	8.93	0.022	0.631	1.3	1.8	2.8	0.001
Site 6	Dov2	2.50	0.006	0.230	0.47	0.66	1.0	0.000
Site 7	Dov2	29.5	0.074	1.630	3.3	4.7	7.2	0.002
Lake L1	Dover River	3.30						
Lake L2	Dov1	0.25						
Lake L3	Dov2	1.88						
Lake L4	Dov2	1.05						
Lake L5	Dov1	0.03						
Lake L6	Dov1	0.11						
Lake L7	Dov1	0.07						

Table 6 Summary of channel characteristics on June 24-26, 2008

Site	Water -shed	Location	Easting (m)	Northing (m)	Wetted Width (m)	Mean Velocity (m/s)	Discharge (m^3/s)
Site 1	Dov2	Upstream of L3	396021	6341866	n/a	n/a	n/a
Site 2	Dov2	Upstream of L3	395247	6341193	16.1[1]	0.04	0.029
Site 3	Dov1	Upstream of L2	395593	6339607	56.0	0.00	0.000
Site 4	Dov1	Upstream of L2	394869	6338431	1.0	0.17	0.051
Site 5	Dov1	Downstream of L2	396259	6339444	6.0	0.01	0.031
Site 6	Dov2	Upstream of L4	398520	6341350	n/a	n/a	n/a
Site 7	Dov2	Between L4 and L1	399564	6340400	41.6	0.00	0.000

[1] multiple channels

Photographs of Site 1 are shown in Figure 9. The site is located in watershed Dov2 upstream of Lake L3. An aerial investigation of the site indicated that there was no distinct channel at this location.

Photographs of Site 2 are shown in Figure 10. This site is also located in watershed Dov2 upstream of Lake L3. Water was flowing across the cut line at Site 2 in five separate channels but these channels were only evident within the width of the cut line. Upstream and downstream of the cut line no distinct channels could be detected. A cross section of these channels is also shown in Figure 10. The shallow channels across the cut line ranged from 1.4 m to 6.0 m wide and had surface velocities from 0.01 to 0.09 m/s. A total discharge of 0.039 m^3/s was estimated for the five channels.

Site 3 is located in the Dov1 watershed upstream of Lake L2. Photographs and a cross section at Site 3 are shown in Figure 11. The wetted width was 56 m across with a maximum depth of 1.4 m but much of the channel was occupied with vegetation. No velocity was detected, even in the areas of open water.

Site 4 is also located in watershed Dov1 upstream of Lake L2. Photographs of Site 4 are shown in Figure 12. The stream has a well defined channel which flows into a beaver pond just downstream of the site. A cross section and slope profile of the channel are also shown in Figure 12. The main channel is small, only 1.0 m wide and 0.30 m deep. A discharge of 0.051 m^3/s was calculated from a mean velocity of 0.17 m/s measured using an electromagnetic current meter on June 26, 2008. The average water surface slope at this location was 0.007 m/m.

Site 5 photographs and cross section are shown in Figure 13. This site is located just downstream of Lake L2 in watershed Dov1. The 6 m wide channel had an average depth of 0.74 m. A discharge of 0.031 m^3/s was calculated from a mean velocity of 0.01 m/s measured using an electromagnetic current meter.

Photographs of Site 6 are shown in Figure 14. The site is located in watershed Dov2 upstream of Lake L4. No distinct channel could be detected during an aerial investigation of the site but there was some evidence of water detected intermittently between the trees.

Site 7 is located in the Dov2 watershed between Lakes L4 and L1. Photographs and a cross section at Site 7 are shown in Figure 15. The wetted width was 42 m with a maximum depth of 1.1 m but much of the channel was occupied with vegetation. No velocity was detected, even in the areas of open water.

3 ASSESSMENT OF SAGD PROJECT IMPACTS

This section of the report describes the assessment of potential hydrologic impacts of Phase 1 of the SAGD Project on the local environment. The Phase 1 footprint is described, the potential impacts identified and their severity assessed. The impacts of the access road are described separately in Section 4.

3.1 PROJECT FOOTPRINT

The development of Phase 1 of the proposed SAGD Project will produce surface disturbances as well as potential stream disturbances. Surface water runoff from the plant site may also be used to supplement the water supply for the Project. Figure 16 shows the layout of Phase 1 of the SAGD Project. The Phase 1 development is located in Sections 30 and 31 of Twp 94, Rge 17, W4M.

3.1.1 SURFACE DISTURBANCES

Surface disturbances will occur from the construction of the plant site, two well pads, three camps, borrow pit, and the utility corridor for access road, powerline and pipeline right-of-ways. These disturbances are summarized in Table 7. The total disturbed area due to Phase 1 of the SAGD Project is 60.7 ha.

All of the Phase 1 disturbances will be located in the Dover River basin where two small watersheds, Dov1 and Dov2, will be affected. Table 8 summarizes the extent of the spatial disturbances within the individual watersheds.

Table 7 Summary of disturbed areas due to Phase 1 of the SAGD Project

Disturbance Type	Dimensions (m)	Total Area (ha)
Plant Site	765 x 415 (irregular)	29.3
North Pad	330 x 150	4.9
South Pad	300 x 150	4.4
Construction Camp	269 x 180	4.9
Operator's Camp	200 x 125 (access 146 x 30)	2.9
Supervisor's Camp	100 x 100 (access 67 x 30)	1.2
Borrow Pit #1	368 x 306 (irregular)	8.9
Utility Corridor	880 x 50	4.2
Total		60.7

Table 8 Summary of spatial extent of disturbances due to Phase 1 of the SAGD Project

Watershed	Disturbance Areas							Percent of Area (%)
	Drainage Area (ha)	Plant Site (ha)	Well Pads (ha)	Camps (ha)	Borrow Pit (ha)	Utility Corridor (ha)	Total (ha)	
Dov1	1267		3.1	9.0	2.0	4.2	18.3	1.4%
Dov2	3070	29.3	6.2		6.9		42.4	1.4%
Dover River Total	245,000	29.3	9.3	9.0	8.9	4.2	60.7	0.025%

Most of the surface disturbance, 42.4 ha, will be located in watershed Dov2; however, 18.3 ha will also located in watershed Dov1. About 1.4% of each watershed area will be disturbed. If the entire Dover River watershed is considered, the disturbance area decreases to about 0.025% of the drainage area. It would be very difficult to quantify the effect of this scale of development on any hydrologic parameter.

3.1.1.1 *Plant Site*

The plant site will be located in Section 31 of Twp 94, Rge 17 W4M (Figure 16). The plant site is located in watershed Dov2. The runoff from the plant site may be poorer in quality than the runoff from natural areas so it will be collected and stored, and will either be used for process water or be discharged after being treated to meet water quality guidelines. The effective runoff coefficient will be 0.0 because if runoff leaves the plant site it will leave well after the surrounding natural runoff so little of this water is likely to reach the stream network. The interception and use of this runoff will contribute to a small decrease in annual runoff from watershed Dov2.

3.1.1.2 *Well Pads*

As shown in Figure 16, the south well pad will have 3.1 ha in watershed Dov1 and 1.3 ha in watershed Dov2 but the north well pad will be located entirely in watershed Dov2. The well pads will likely be constructed of gravel so the runoff coefficient for the well pads is expected to be about 0.60. This is substantially higher than the natural annual runoff coefficient of 0.16. The water quality of the runoff from the well pads is not expected to be substantially different from the runoff from the undisturbed site. However, the surface runoff from the well pads will still be collected and stored away from the working area and will either evaporate or be discharged after it has been determined to meet water quality guidelines. Little of this water will reach the stream network. Thus, the well pads will contribute to a reduction in runoff from the watershed in which they are located.

3.1.1.3 *Camps*

Three camps will be constructed for the SAGD Project, two that are temporary (the construction and supervisor's camps) and one that is permanent (the operator's camp). As shown in Figure 16, all three camps will be located in watershed Dov1. The camp area will likely be constructed of gravel so the runoff coefficient for the camp areas is expected to be about 0.60. This is substantially higher than the natural annual runoff coefficient of 0.16. The water quality of the runoff from the camps is not expected to be substantially different from the runoff from the undisturbed site.

3.1.1.4 *Borrow Pit*

As shown in Figure 16, 6.9 ha of Borrow Pit 1 will be located in watershed Dov2 and 2.0 ha will be located in watershed Dov1. This borrow pit will be used to supply material for construction so the bottom of the pit will be lower in elevation than the surrounding land. Any precipitation falling on the borrow pit area will be contained in the borrow pit where it will either evaporate or seep into the ground. No runoff will be generated from this area.

3.1.1.5 *Utility Corridor*

The location of the utility corridor is shown in Figure 16. This linear feature will have a total length of 0.88 km, with a right-of-way width of 50 m. The total disturbed area of this utility corridor is 4.2 ha. The entire length of the utility corridor is located in watershed Dov2.

The runoff coefficient from the graveled road surfaces is expected to be the same as the well pads, or about 0.60. The runoff from the road surface will flow into the ditches where some of the runoff will be stored. The remaining surface of the access corridor (the pipeline and powerline right-of-ways) will be non-forested vegetation with a runoff coefficient similar to the undisturbed value of 0.16. Thus, it is estimated that about 40% of the precipitation (an effective runoff coefficient of 0.40) will find its way into the stream system from the utility corridor.

There will be no changes in the surface drainage patterns due to the construction of the utility corridor. Appropriate drainage will be provided where the corridor crosses any significant drainage courses. As well, there will be no transfer of water from one watershed to another along ditches and road right-of-ways. However, these ditches and right-of-ways will transport the runoff from the landscape more quickly than the original forested landscape. This water may arrive in the streams before runoff from the undisturbed parts of the watershed; however, Lakes L2 and L1 will tend to store water and release it more slowly so there will be no significant change in flow patterns in the Dover River.

3.1.2 Stream Disturbances

The plant site, south pad, camps, and borrow pit are located where they do not disturb any indentified drainage pathways so no stream disturbances are anticipated from these surface disturbances.

The north pad, however, is located on a mapped drainage pathway upstream of Lake L3 as shown in Figure 16. Investigations of this drainage pathway at Site 2 (Figure 10) indicated that the flow was distributed over a wide area where it crossed the cut line and diffused into a wetland upstream and downstream of the site. There were no defined channels in the undisturbed areas.

The utility corridor crosses this same drainage pathway just upstream of the north pad. There is no defined channel at this crossing of the wetland area so no stream disturbance is anticipated.

3.1.3 Water Supply

The main use of water by the Project is for production of steam that will be injected into the oil bearing formation. This process water will be re-circulated and reused as much as possible. However, some of the water will be lost in the formation and some of the water will be taken up in disposing of unwanted byproducts. This lost water must be replaced from an external supply. It is anticipated that local deep groundwater supplies will be used to provide most of the water for the Project; however, runoff from the plant site may also be utilized so there will be some diversion of surface water runoff.

Runoff from the plant site will be collected in a storm water pond. The required storage for the 29.3 ha area of the plant site is estimated to be about 11,300 m^3 for a 10-year 24-hour rainfall of 64.1 mm. This runoff volume will raise the water level in the 200 by 110 m storm water pond by about 0.5 m. The average flow rate produced by this 10-year 24-hour steady rainfall is about 0.13 m^3/s. This flow can easily be accommodated by a typical small ditch.

The runoff volume stored in the storm water pond contained on the plant site may be used for process water. The median annual runoff volume from the plant site is estimated to be 79,800 m^3. This is the amount of runoff water which may be diverted for process water if sufficient storage is available to capture the runoff when it occurs.

3.2 Hydrologic Impacts

The potential affects of the SAGD Project on surface water within the property boundary include the following.

- Changes to the surface runoff characteristics due to changes to the surface of the landscape and diversion of surface water for plant processes.
- Increased sediment concentrations in the local streams due to the effects of stream channel crossings and changes in surface runoff characteristics.

3.2.1 Surface Runoff

Project disturbances have the potential to cause changes to the surface runoff characteristics. Changes in surface drainage patterns or changes in the runoff coefficients may affect the flow volumes, flow rates, and timing of peak flows in the local streams. Water levels in lakes and wetlands may also be affected. If these changes are significant they may in turn produce changes in the channel regime of the local streams.

To minimize the impacts on surface runoff, there will be no changes in the surface drainage patterns due to construction of Phase 1 of the Project. Appropriate drainage will be provided around the various features of the Project as shown in Figure 16. There will be no transfer of water from one watershed to another along ditches and road right-of-ways.

The effect of development on runoff volumes in each individual watershed depends on the proportion of the areas that are used for plant site, well pads, camps, borrow pit, and utility corridors. The plant site, borrow pits, and well pads will reduce the runoff volumes and flood peaks because runoff water will be contained within these areas. The camps will increase runoff because the runoff coefficient for these areas is greater than that for the undisturbed areas. Utility corridor areas will increase both runoff volumes and flood peaks due to the reduction in vegetation and the addition of less permeable surfaces.

The changes in land use and the runoff coefficients described in Section 3.1 will produce changes in runoff volumes and peak flows. The changes in runoff volume are summarized in Table 9. The greatest change in runoff volume will be in watershed Dov2, which will likely have a small decrease in annual runoff volumes due to the presence of the plant site and portions of the borrow pit and well pads in this watershed. Watershed Dov1 is expected to have a small increase in runoff volume due to the presence of the camps; however, some of this increase will be temporary because the construction camp and supervisor's camp will be temporary. The overall change to runoff in the Dover River will be negligible.

Table 9 Summary of changes in runoff volume due to Phase 1 disturbances

Watershed	Natural Drainage Area (ha)	Mean Annual Flow[1] (m^3/s)	Change in Annual Runoff Volume (%)	Change in Mean Annual Flow (m^3/s)
Dov1	1267	0.032	2.1	0.00067
Dov2	3070	0.077	-1.4	-0.00106
Dover River Total	96300	2.41	-0.017	-0.00041
Mackay River	557000	14	-0.003	-0.00041

[1] March to Oct flows only

Changes to runoff volumes are easier to determine than changes to flood peaks because the volume of runoff is independent of the timing of the runoff, while the effect of timing is very important in determining the flood peaks. Changes in timing are difficult to determine because of a lack of data at sufficiently small spatial scales that represent the scales of the disturbance. Never the less, it is expected that changes in the flood peaks would probably be of similar magnitude to, or less than, the changes in the runoff volumes. Thus, the possibility of any significant changes to the regime of any of the streams in the area is very remote.

There is potential for the SAGD Project to affect lake levels because the Phase 1 footprint is upstream of Lake L2 in watershed Dov1 and Lake L3 in watershed Dov2. As well, both these watersheds drain into Lake L1. The slight increase in runoff in watershed Dov1 may cause a slight increase in peak water level in Lake L2 and the slight decrease in runoff in watershed Dov1 may cause a slight decrease in peak water level in Lake L3. The overall change in level in Lake L1 will be less that the changes in Lakes L2 and L3 because Lake L1 is larger and the overall change in runoff is smaller. These changes in lake levels are not expected to be detectable relative to the natural variability in levels because the change to runoff volumes is small.

In summary, the surface disturbances associated with Phase 1 of the Project will produce some minor changes in runoff volumes and peak flows in the local watersheds. However, at the mouth of the MacKay River, the annual changes in runoff due to the total surface disturbance are expected to be insignificant, about -0.003% of the annual runoff volumes. Changes in the peak flows are expected to be even less than this.

3.2.2 Sediment Concentrations

Sediment concentrations in streams have the potential to increase due to increases in streamflow or from sediment introduced to the stream from disturbances. Sediment concentrations in the streams are not expected to increase due to changes in the surface runoff characteristics. The projected changes in the flow regime due to surface disturbances are small so they will not impact the sediment concentrations significantly. There are no crossings of streams with distinct channels in the Phase 1 footprint so no sediment inputs will occur from local disturbances.

4 ASSESSMENT OF ACCESS ROAD IMPACTS

This section of the report describes the assessment of potential hydrologic impacts of the access road on the local environment. The access road footprint is described, impacts identified and their severity assessed.

4.1 ACCESS ROAD FOOTPRINT

The development of the proposed access road and associated borrow pits will produce surface disturbances as well as potential stream disturbances. The layout of the access road is shown in Figure 16. The access road will be located in Sections 6, 7, 18, 19, and 30 of Twp 94, Rge 17, W4M.

4.1.1 SURFACE DISTURBANCES

The surface disturbances due to the construction of the access road and four borrow pits are summarized in Table 10. The total disturbed area due to the access road is 67.8 ha.

Table 10 Summary of disturbed areas due to access road

Disturbance Type	Dimensions (m)	Total Area (ha)
Access Road	9,060 x 50	45.3
Borrow Pit 2	295 x 179 (irregular) (access 148 x 30)	5.6
Borrow Pit 3	291 x 225 (irregular)	4.5
Borrow Pit 4	300 x 196 (irregular) (access 176 x 30)	6.5
Borrow Pit 5	250 x 245 (irregular) (access 58 x 30)	6.0
Total		67.8

The access road and borrow pits will be located in two watersheds of the Dunkirk River, Dun1 and Snipe Creek, as well as two watersheds of the Dover River, Dov1 and Dov3. The distribution of the access road and borrow pit areas within the individual watersheds is summarized in Table 11. The largest percentage of surface area of a watershed that is disturbed is in the order of 2.6%. If the entire Dover and Dunkirk watersheds are considered, the disturbance decreases to about 0.027% and if the entire MacKay River watershed is considered the disturbance decreases to 0.012%. It would be very difficult to quantify the effect of this scale of development on any hydrologic parameter.

4.1.1.1 Access Road

The location of the access road is shown in Figure 16. This linear feature will have a total length of 9.06 km, with a right-of-way width of 50 m. The total disturbed area of this access road is 45.3 ha. The access road will be located in two watersheds of the Dunkirk River, Dun1 and Snipe Creek, as well as two watersheds of the Dover River, Dov1 and Dov3.

Table 11 Summary of spatial extent of access road disturbances

Watershed	Drainage Area (ha)	Disturbance Areas			Percent of Area (%)
		Access road (ha)	Borrow Pits (ha)	Total (ha)	
Dov1	1267	22.4	10.1	32.5	2.6
Dov3	6740	4.1	0.0	4.1	0.061
Dover River Total	96300	26.5	10.1	36.6	0.038
Dun1	6960	18.8	12.5	31.3	0.45
Dunkirk River Total	157000	18.8	12.5	31.3	0.020
Mackay River Total	557000	45.3	22.6	67.9	0.012

The runoff coefficient from the graveled road surfaces is expected to be about 0.60. The runoff from the road surface will flow into the ditches where some of the runoff will be stored. The remaining surface of the access road right-of-way will be non-forested vegetation with a runoff coefficient similar to the undisturbed value of 0.16. Thus, it is estimated that about 40% of the precipitation (an effective runoff coefficient of 0.40) will find its way into the stream system from the access road right-of-way.

There will be no changes in the surface drainage patterns due to the construction of the access road. Appropriate drainage will be provided at where the access road crosses any significant drainage courses. As well, there will be no transfer of water from one watershed to another along ditches and road right-of-ways as shown in Figure16. However, these ditches and right-of-ways will transport the runoff from the landscape more quickly than the original forested landscape. This water may arrive in the streams before runoff from the undisturbed parts of the watershed, thus the peak flows are expected to occur slightly earlier than it did before the disturbance occurred.

4.1.1.2 Borrow Pits

As shown in Figure 16, Borrow Pits 2 and 3, with surface areas of 5.6 and 4.5 ha respectively, will be located in the watershed Dov1. Borrow Pits 4 and 5, with surface areas of 6.5 and 6.0 ha respectively, will be located in the watershed Dun1. These borrow pits will be used to supply material for the construction of the access roads so the bottoms of the pits will be lower in elevation than the surrounding land. Any precipitation falling on the borrow pit areas will be contained in the borrow pits where it will either evaporate or seep into the ground. No runoff will be generated from these areas.

4.1.2 STREAM DISTURBANCES

Stream disturbances may occur where the access road crosses streams with defined channels. These disturbances usually occur during construction, but the effects may potentially continue indefinitely unless the initial disturbance is properly mitigated. The access road crosses five mapped drainage pathways shown in Figure 16; however, most of these drainage pathways are wetlands which do not have defined stream channels. The drainage areas and estimated flow rates for these sites are given in Table 12. The flow rates are estimated based on the regional analysis given Section 2.2 for stream with defined channel so they may over-estimate the flows in the wetlands.

Table 12 Summary of drainage areas and estimated flow rates for crossing sites

Location	Watershed	Drainage Area (ha)	Mean Annual Flow (m^3/s)	Mean Annual Peak Flow (m^3/s)	10-Year Peak Flow (m^3/s)	25-Year Peak Flow (m^3/s)	100-Year Peak Flow (m^3/s)	Average Minimum Monthly Flow (m^3/s)
Crossing 1	Dov1	166	0.004	0.17	0.34	0.48	0.73	0.0001
Crossing 2	Dov1	260	0.007	0.24	0.48	0.68	1.04	0.0001
Crossing 3	Dov1	52	0.001	0.066	0.13	0.19	0.29	0.0000
Crossing 4	Dun1	186	0.005	0.18	0.37	0.52	0.80	0.0001
Crossing 5	Dun1	106	0.003	0.12	0.24	0.33	0.51	0.0001

Crossing 1 is located upstream of Site 3 on the north tributary of Lake L2 in watershed Dov1 (Figure 16). No distinct channel could be seen in the vicinity of the crossing (Figure 17) and no flow was detected at Site 3. Crossing 1 appears to be a wetland rather than a defined channel. Flow rates for a range of flow conditions were estimated based on the drainage area of 166 ha at this site (Table 12).

Crossing 2 is located upstream of Site 4 on the south tributary of Lake L2 in watershed Dov1 (Figure 16). A distinct channel with flowing water was observed at Site 4 (Figure 12) and photographs taken near the crossing site (Figure 18) indicate that this defined channel exists at the crossing location as well. Flow rates for a range of flow conditions were estimated based on the drainage area of 260 ha at this site (Table 12).

Crossing 3 is located on the south tributary of Lake L1 in watershed Dov1 just downstream of Lake L6 (Figure 16). No distinct channel could be seen in the vicinity of the crossing (Figure 19). Crossing 3 appears to be a wetland rather than a defined channel. Flow rates for a range of flow conditions were estimated based on the drainage area of 52 ha at this site (Table 12).

Crossing 4 is located on a tributary in watershed Dun1 south of Crossing 3 (Figure 16). No distinct channel could be seen in the vicinity of the crossing (Figure 20). Crossing 4 appears to be a wetland rather than a defined channel. Flow rates for a range of flow conditions were estimated based on the drainage area of 186 ha at this site (Table 12).

Crossing 5 is located on a tributary in watershed Dun1 south of Crossing 4 (Figure 16). No distinct channel could be seen in the vicinity of the crossing (Figure 21). Crossing 5 appears to be a wetland rather than a defined channel. Flow rates for a range of flow conditions were estimated based on the drainage area of 106 ha at this site (Table 12).

The borrow pits along the access road are not located near any streams with defined channels so no stream disturbances will occur due to the presence of the borrow pits.

4.2 HYDROLOGIC IMPACTS

The potential affects of the Access Road on surface water within the property boundary include the following.

- Changes to the surface runoff characteristics due to changes to the surface of the landscape.
- Increased sediment concentrations in the local streams due to the effects of stream channel crossings and changes in surface runoff characteristics.

4.2.1 SURFACE RUNOFF

Project disturbances have the potential to cause changes to the surface runoff characteristics. Changes in surface drainage patterns or changes in the runoff coefficients may affect the flow volumes, flow rates, and timing of peak flows in the local streams. Water levels in lakes and wetlands may also be affected. If these changes are significant they may in turn produce changes in the channel regime of the local streams.

To minimize the impacts on surface runoff, there will be no changes in the surface drainage patterns due to access road construction. Appropriate drainage will be provided at crossings of any significant drainage courses. There will be no transfer of water from one watershed to another along ditches and road right-of-ways.

The effect of development on runoff volumes in each individual watershed depends on the proportion of the areas that are used for borrow pits and road right-of-ways. Borrow pits will reduce the runoff volumes and flood peaks because runoff water will be contained within these areas. Road right-of-ways will increase both runoff volumes and flood peaks due to the reduction in vegetation and the addition of less permeable surfaces.

The changes in land use and the runoff coefficients described in Section 4.1 will produce changes in runoff volumes and peak flows. The changes in runoff volume are summarized in Table 13. The greatest change in runoff volume will be in watershed Dov1. This stream will likely see a small increase in annual runoff volumes due to the presence of the access road. Watershed Dun1 is also expected to see a small increase in runoff volume due to the presence of the access road. The overall change to runoff in the Dover and Dunkirk rivers will be very small, as it will be for the Mackay River.

Table 13 Summary of changes in runoff volume due to project disturbances

Watershed	Natural Drainage Area (ha)	Mean Annual Flow[1] (m^3/s)	Change in Annual Runoff Volume (%)	Change in Mean Annual Flow (m^3/s)
Dov1	1267	0.032	1.9	0.00060
Dov3	6740	0.17	0.091	0.00015
Dover River Total	96300	2.4	0.031	0.00074
Dun1	6960	0.17	0.22	0.00039
Dunkirk River Total	157000	3.9	0.010	0.00039
Mackay River	557000	14	0.008	0.00113

[1] March to Oct flows only

Changes to runoff volumes are easier to determine than changes to flood peaks because the volume of runoff is independent of the timing of the runoff, while the effect of timing is very important in determining the flood peaks. Changes in timing are difficult to determine because of a lack of data at sufficiently small spatial scales that represent the scales of the disturbance. Never the less, changes in the flood peaks would probably be of the same magnitude as, or less than, the changes in the runoff volumes. The possibility of any significant changes to the regime of any of the streams in the area is very remote.

In summary, the surface disturbances associated with the Project will produce some minor changes in runoff volumes and peak flows in the local catchments. However, at the mouth of the Mackay River, the annual changes in runoff due to the total surface disturbance are expected to be about 0.008% of the annual runoff volumes. Changes in the peak flows are expected to be even less than this.

Lake levels are not generally expected to be affected by the Project disturbances due to the small changes in runoff which will occur. The access road footprint does not directly affect any lakes within the watershed.

4.2.2 SEDIMENT CONCENTRATIONS

Sediment concentrations in streams and lakes have the potential to increase due to increases in streamflow or from sediment introduced to the water body from disturbances. Sediment concentrations in the streams are not expected to increase due to changes in the surface runoff characteristics. The projected changes in the flow regime due to surface disturbances are small so they will not impact the sediment concentrations significantly.

The access road crosses five indentified drainage pathways; however, only one crossing has a defined channel. Appropriate sediment control will be implemented during construction to minimize the effects of the disturbances. Appropriate sediment control will also be implemented at the intersection of the streams and the access corridor ditches.

5 MONITORING AND MITIGATION

The assessment of impacts in the previous section has identified two potential issues: stream flows and sediment concentrations. Both of these potential impacts were determined to be insignificant if appropriate design and construction procedures are followed.

Impacts on stream flows can be minimized by ensuring that natural drainage paths are not interrupted by the development. This can be achieved by providing appropriate culverts and drainage ditches for the access corridors and providing flow pathways around the plant site and well pads.

Increases in sediment concentrations in the stream channels can be minimized by ensuring that sediment generated by the Project does not enter the channels. This can be achieved by applying proper sediment management techniques during the construction of stream crossings. As well, runoff from the plant site and well pads can be controlled so that poor quality runoff does not enter the streams.

When the Project is complete the disturbed areas will be reclaimed. The landscape will be restored so that surface runoff will be similar to the pre-existing conditions.

6 SUMMARY OF CONCLUSIONS

An assessment of the hydrology in the region of the Project was carried out to evaluate the baseline hydrology and to assess the impacts of Phase 1 of the Project on the local hydrology. The evaluation of baseline hydrology included an assessment of climate and runoff characteristics. The regional climate characteristics can be represented reasonably well by the data from the long term meteorological station at Fort McMurray and the local stations at Legend LO and Livock LO. Data on the hydrologic characteristics of the small streams originating in the Project Area is scarce so a regional analysis approach was used to determine annual runoff coefficients and runoff volumes.

The hydrologic impacts of the Project were classified into two categories: surface disturbances and stream disturbances. The impacts of surface disturbances caused by the development of Phase 1 on the hydrology in the area were investigated and found to be small. The surface disturbances associated with Phase 1 will produce some minor changes in runoff volumes and peak flows but these changes are expected to be undetectable in the larger basins. Runoff from the well pads will be contained, and allowed to evaporate or treated and released into the natural drainage system once water quality objectives have been met. Runoff from the plant site will be contained as well and may be utilized to supplement the process water supply from groundwater. Disturbances to the streams will also be insignificant. Phase 1 of the Project footprint does not disturb any streams with defined channels. The north pad and utility corridor cross a mapped drainage pathway but this drainage was found to be a wetland with no defined channel. Only one crossing of a stream with a defined channel is planned for the access road. Design and construction of this stream crossing will be carried out in a way so as to minimize any in-stream disturbances.

In summary, the impacts of disturbances caused by the development of Phase 1 of the Project on the hydrology were investigated and found to be insignificant. Where impacts could potentially occur, the Project will be designed to minimize the effects of the impacts.

7 REFERENCES

Bothe, R.A., 1981. Lake evaporation in Alberta, 1912 to 1980. Water Resources Management Service, Technical Services Division, Hydrology Branch. Edmonton, Alberta.

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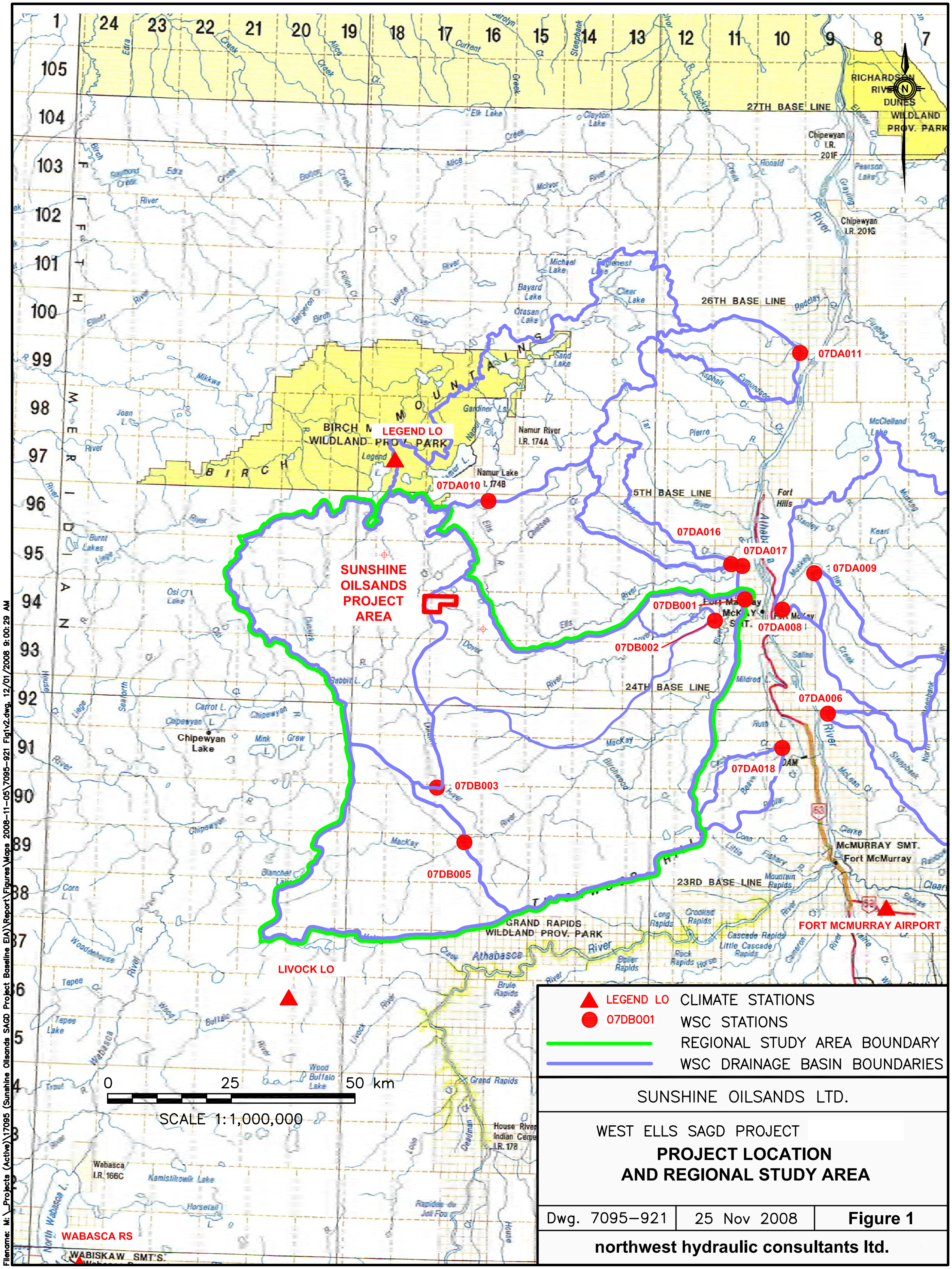


SUNSHINE OILSANDS LTD.

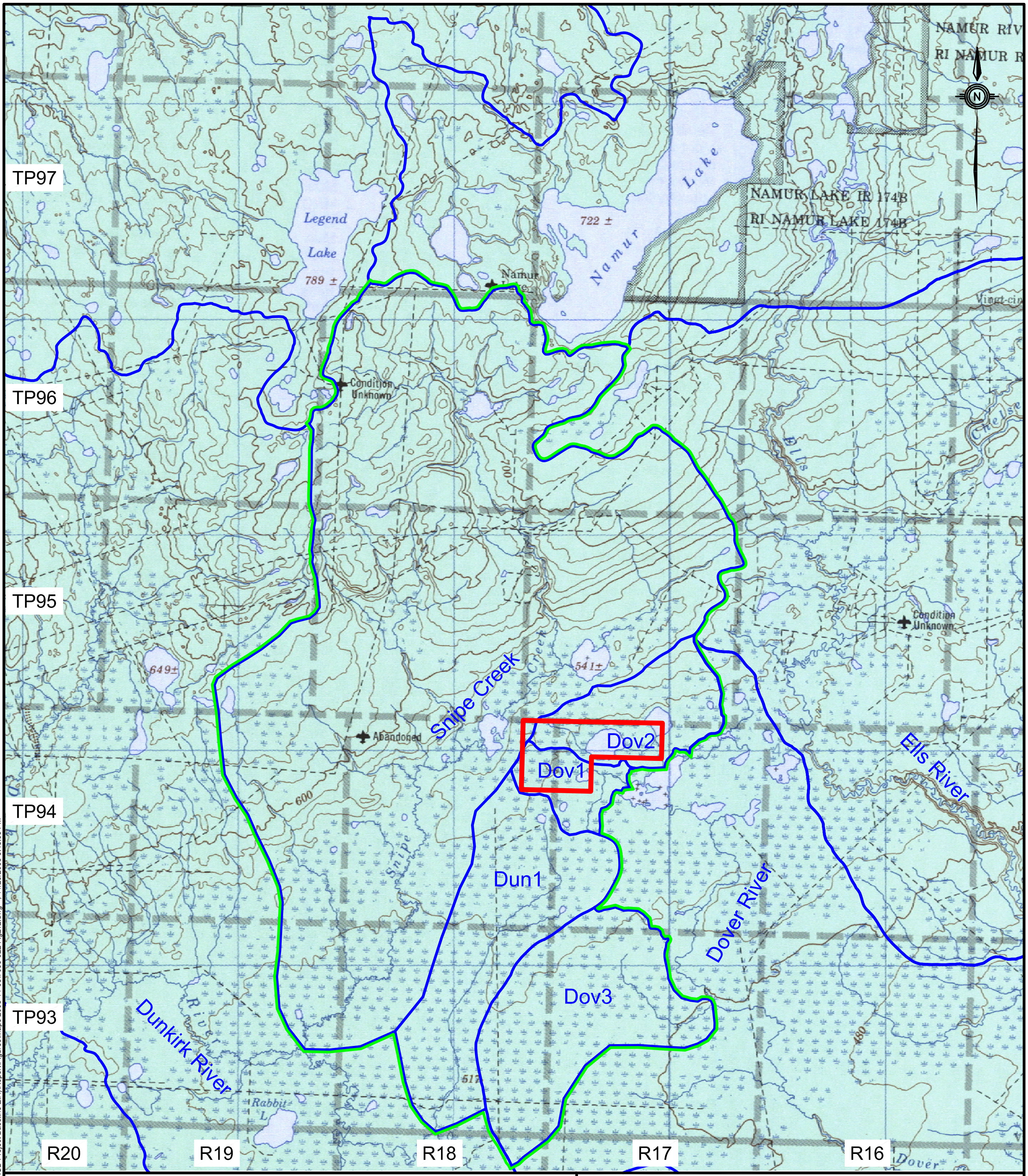
WEST ELLS SAGD PROJECT

PROJECT LOCATION AND REGIONAL STUDY AREA

Dwg. 7095–921	25 Nov 2008	**Figure 1**

northwest hydraulic consultants ltd.

Filename: M:_Projects (Active)\17095 (Sunshine Oilsands SAGD Project Baseline EIA)\Report\Figures\Maps 2008-11-05\7095-921 Fig1v2.dwg, 12/01/2008 9:00:29 AM



5 0 5 10 15 km

SCALE 1:250,000

(red line)	PROJECT AREA
(green line)	LOCAL STUDY AREA BOUNDARY
(blue line)	WATERSHED BOUNDARY
Dov1	WATERSHED LABEL

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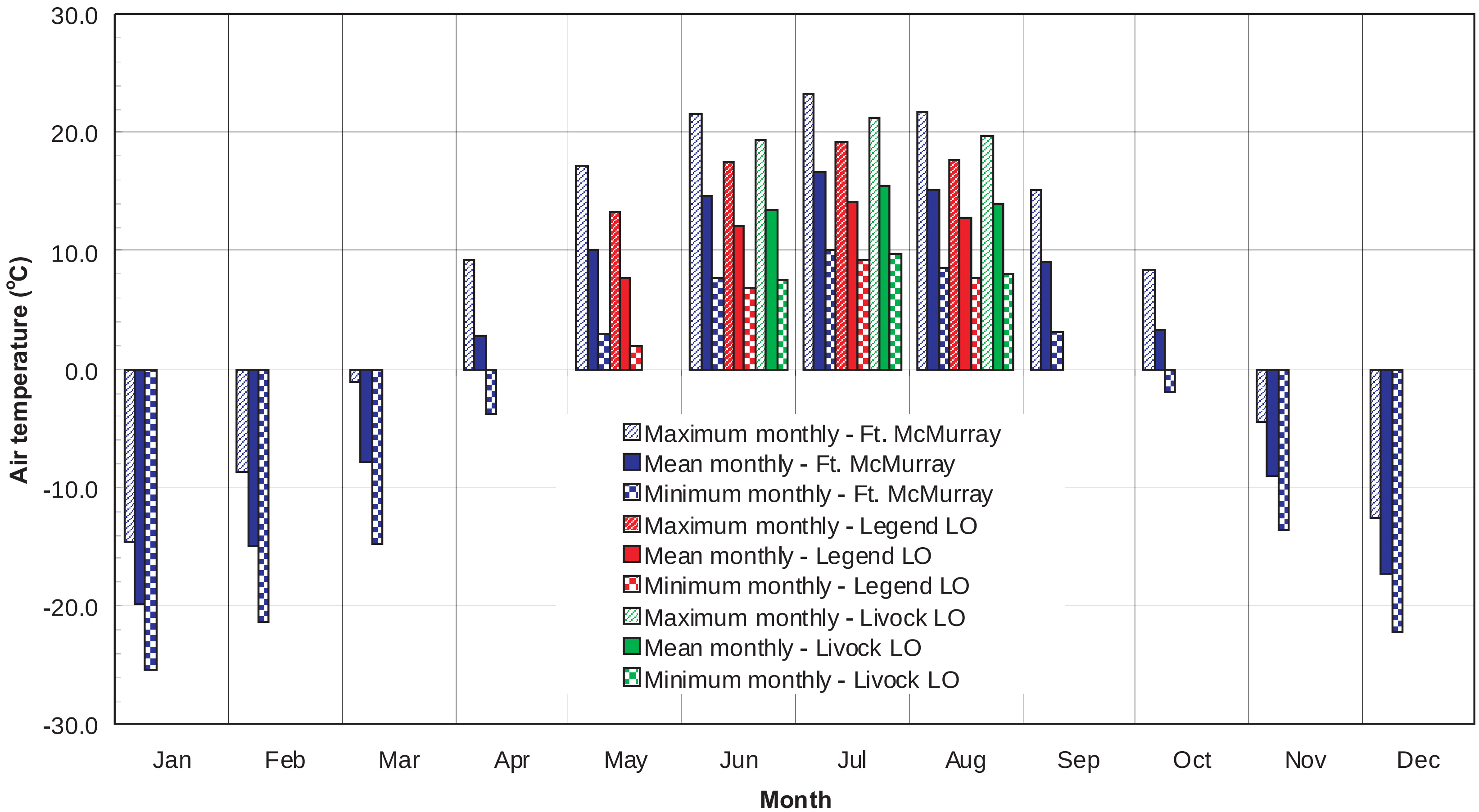
WEST ELLS SAGD PROJECT

LOCAL STUDY AREA

Dwg. 7095–922	25 Nov 2008	**Figure 2**

northwest hydraulic consultants ltd.

Filename: M:_Projects (Active)\17095 (Sunshine Oilsands SAGD Project Baseline EIA)\Report\Figures\Maps 2008-11-05\7095-922 Fig2v2.dwg , 11/25/2008 5:48:33 PM



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WEST ELLS SAGD PROJECT

MONTHLY AIR TEMPERATURES

Project 1-7095	7 Nov 2008	**Figure 3**

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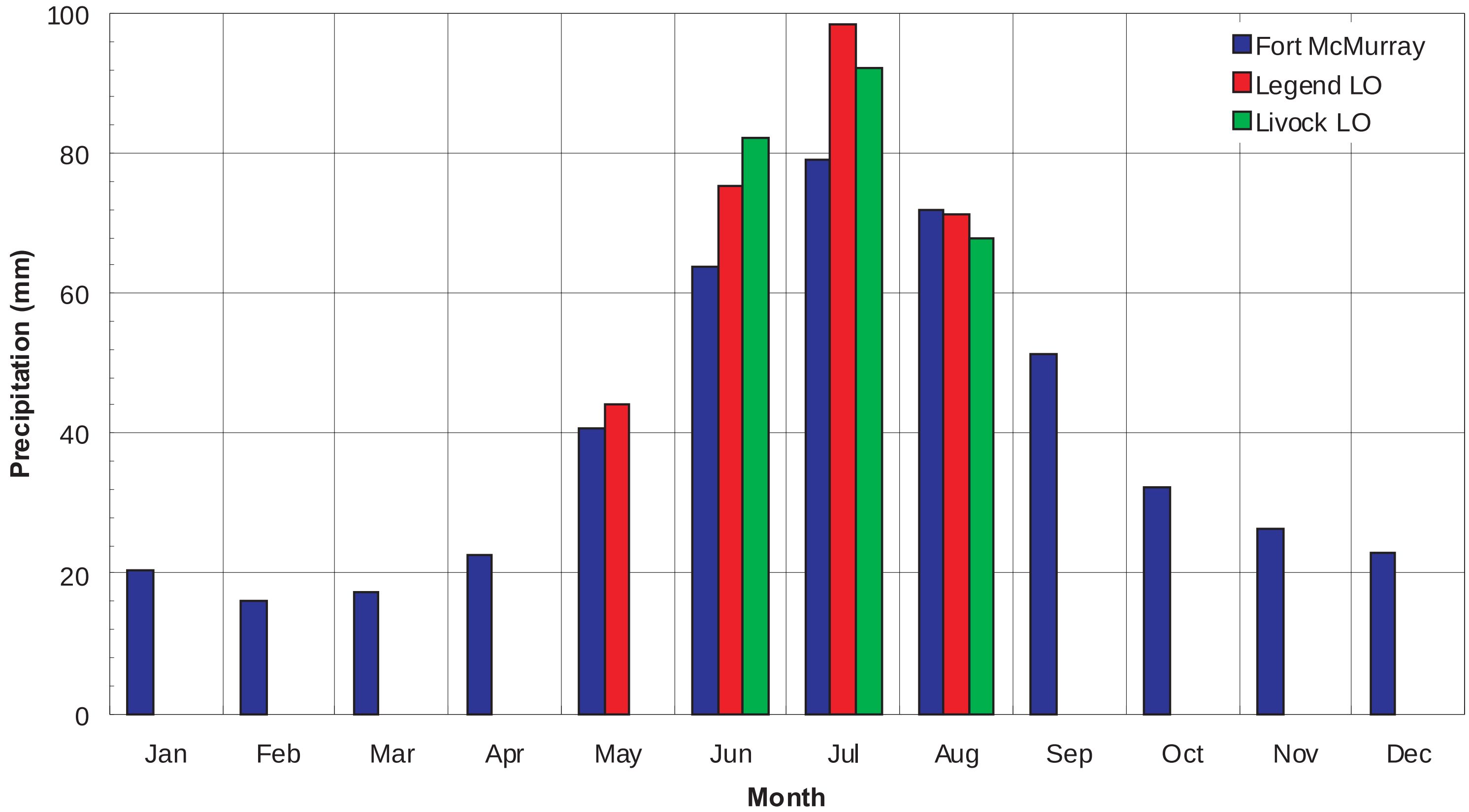
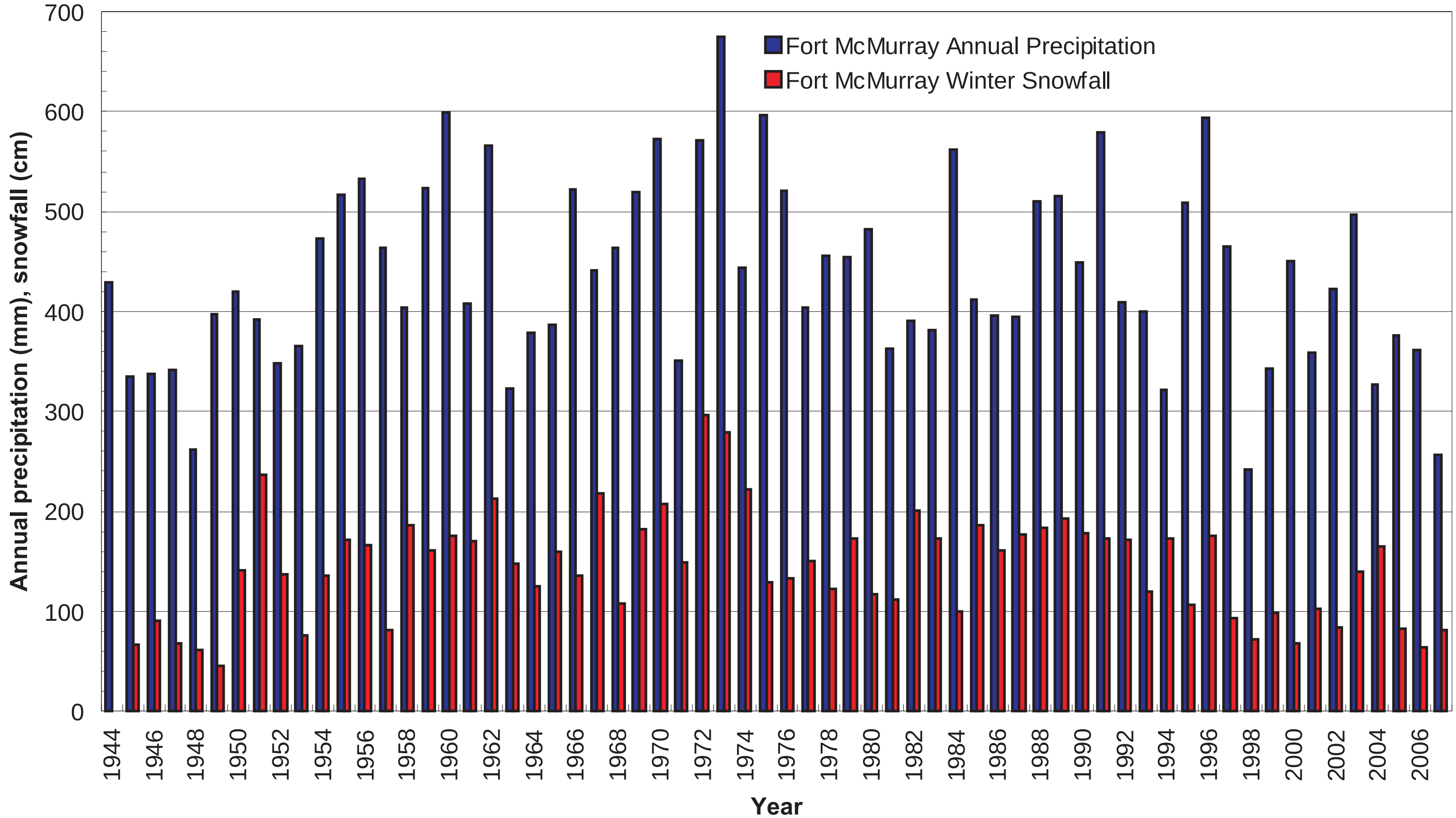


SUNSHINE OILSANDS LTD.		
WEST ELLS SAGD PROJECT		
MONTHLY PRECIPITATION		
Project 1-7095	7 Nov 2008	**Figure 4**
northwest hydraulic consultants		



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WEST ELLS SAGD PROJECT

ANNUAL PRECIPITATION AND WINTER SNOWFALL

Project 1-7095	7 Nov 2008	**Figure 5**

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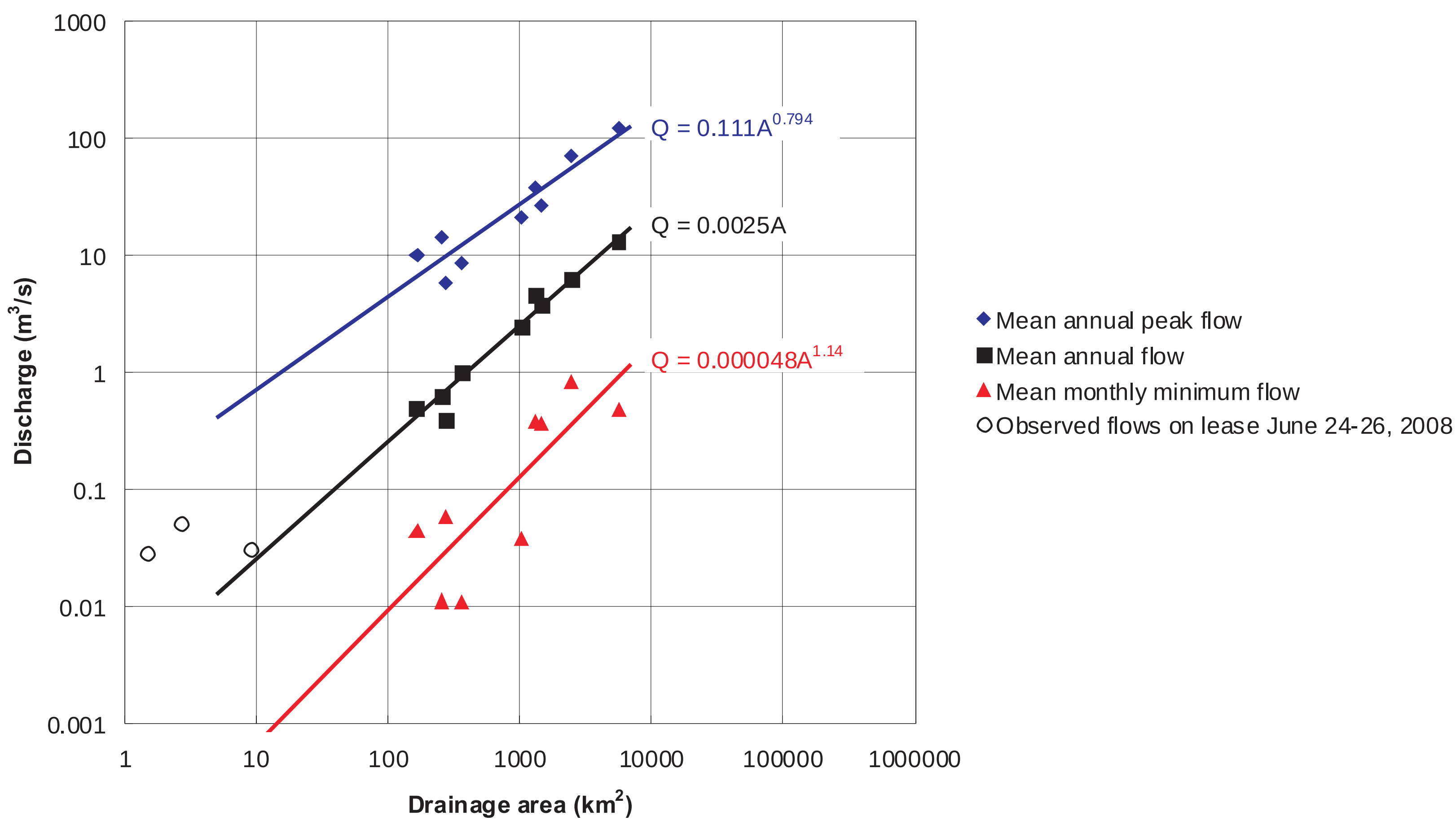

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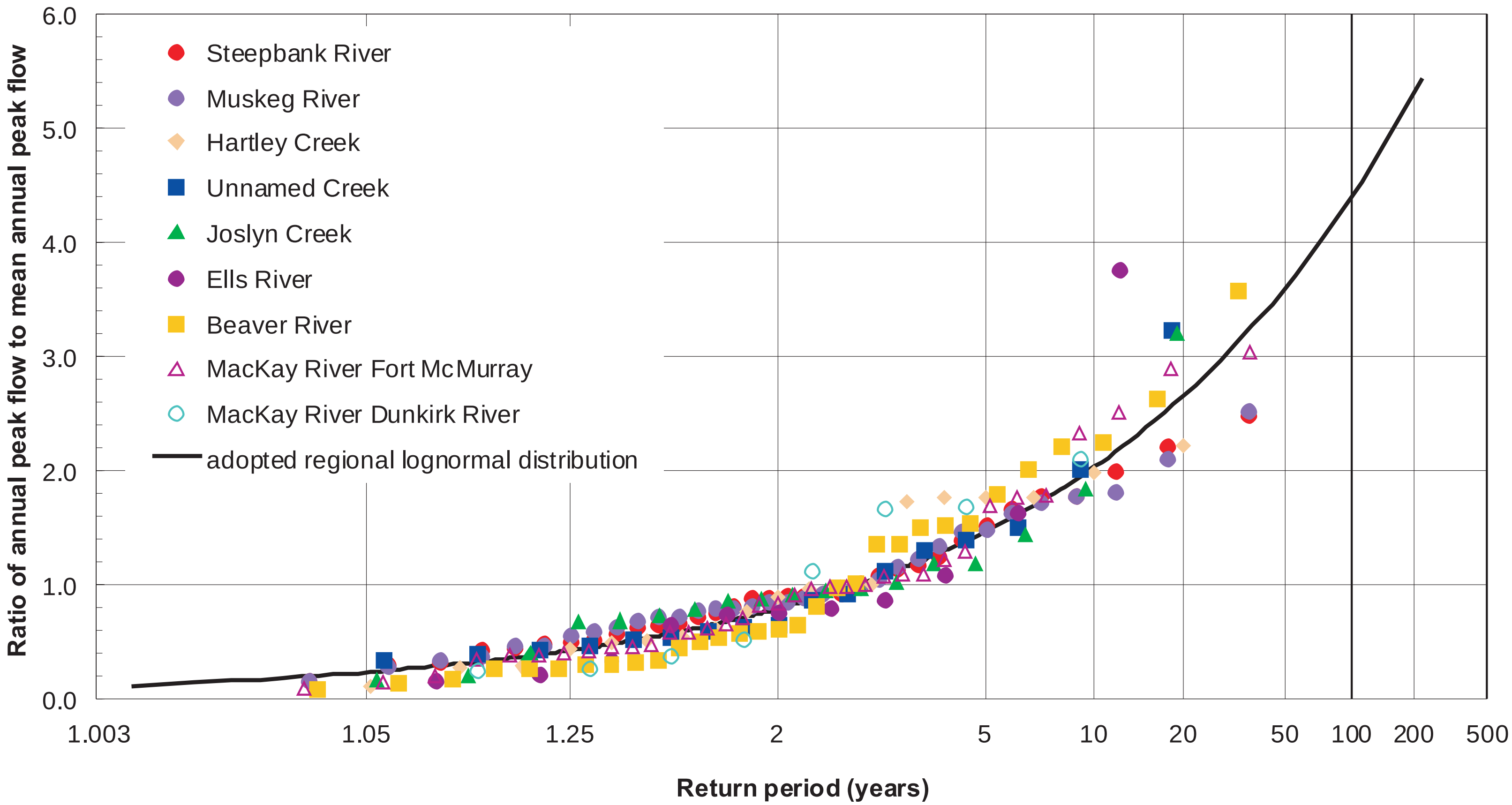
WEST ELLS SAGD PROJECT

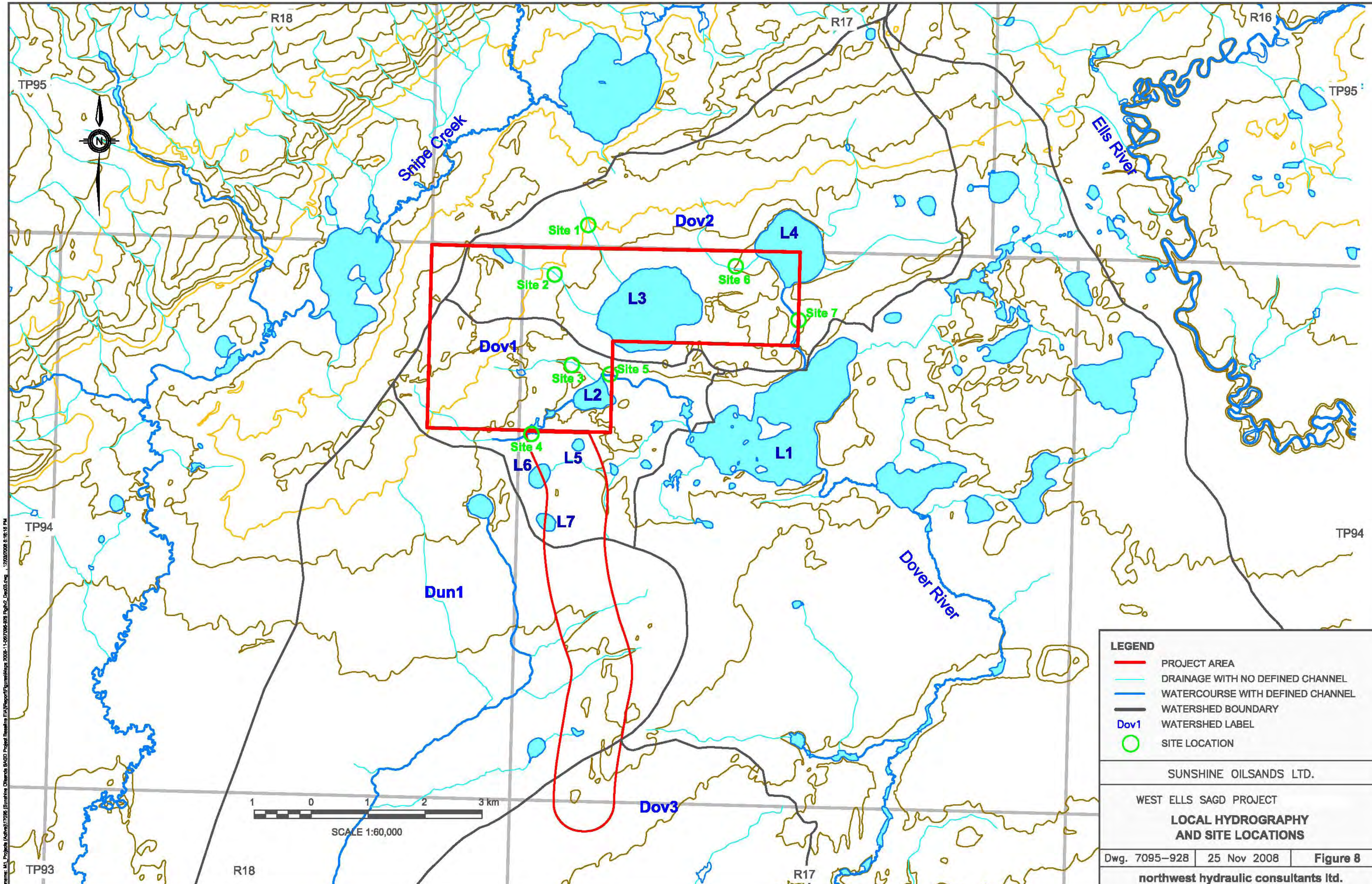
VARIATION OF DISCHARGE WITH DRAINAGE AREA

Project 1-7095	7 Nov 2008	**Figure 6**

northwest hydraulic consultants



SUNSHINE OILSANDS LTD.		
WEST ELLS SAGD PROJECT **REGIONAL FLOW FREQUENCY DISTRIBUTIONS**		
Project 1-7095	7 Nov 2008	**Figure 7**
northwest hydraulic consultants		

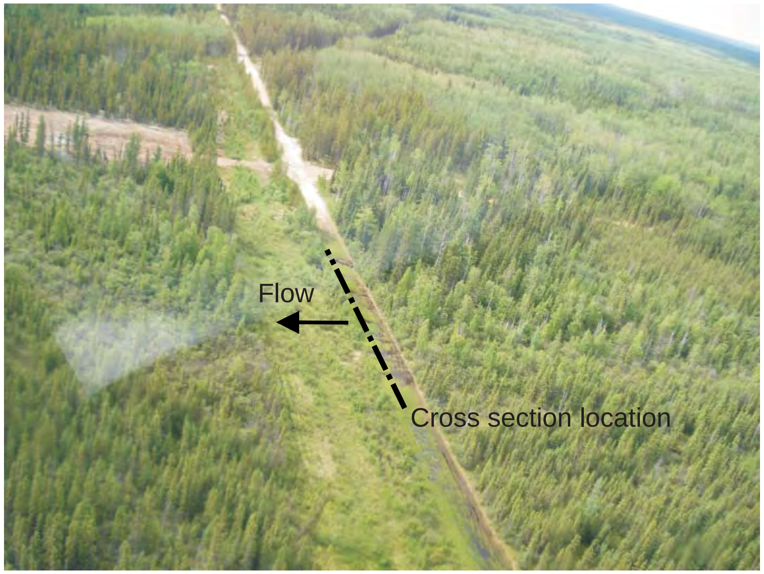

R18
R17
R16
TP95
TP95
Snipe Creek
Ells River
Site 1
Dov2
L4
Site 2
Site 6
L3
Site 7
Dov1
Site 3
Site 5
L2
Site 4
L6
L5
L1
L7
TP94
TP94
Dover River
Dun1
Dov3
1 0 1 2 3 km
SCALE 1:60,000
TP93
R18
R17
LEGEND
PROJECT AREA
DRAINAGE WITH NO DEFINED CHANNEL
WATERCOURSE WITH DEFINED CHANNEL
WATERSHED BOUNDARY
Dov1 WATERSHED LABEL
SITE LOCATION
SUNSHINE OILSANDS LTD.
WEST ELLS SAGD PROJECT
LOCAL HYDROGRAPHY AND SITE LOCATIONS
Dwg. 7095-928
25 Nov 2008
Figure 8
northwest hydraulic consultants ltd.

Aerial view of edge of Lake L3 near Site 1

Aerial view of Site 1 looking west

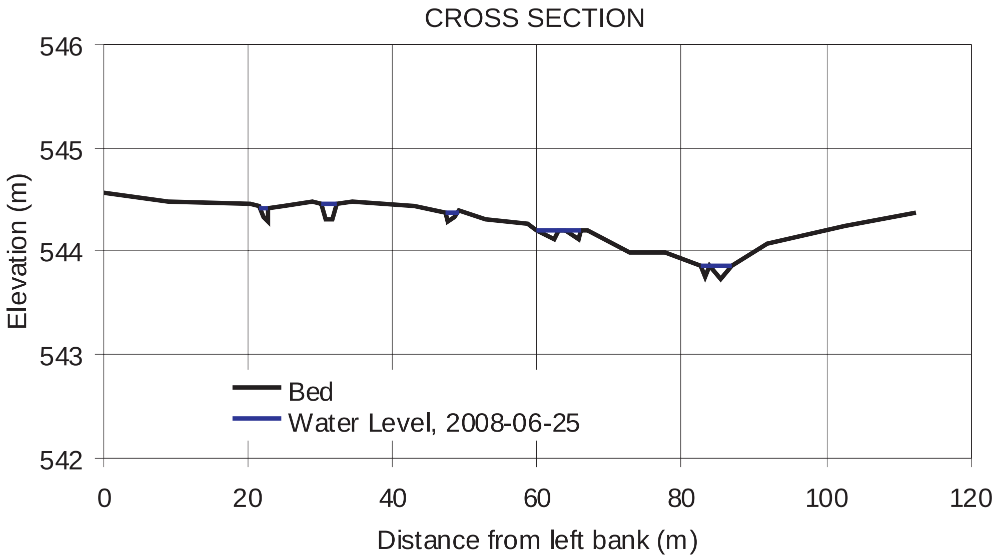
Aerial view of Site 1 looking east

SUNSHINE OILSANDS LTD.		
WEST ELLS SAGD PROJECT **CHANNEL CHARACTERISTICS AT SITE 1**		
Project 1-7095	7 Nov 2008	**Figure 9**
northwest hydraulic consultants		

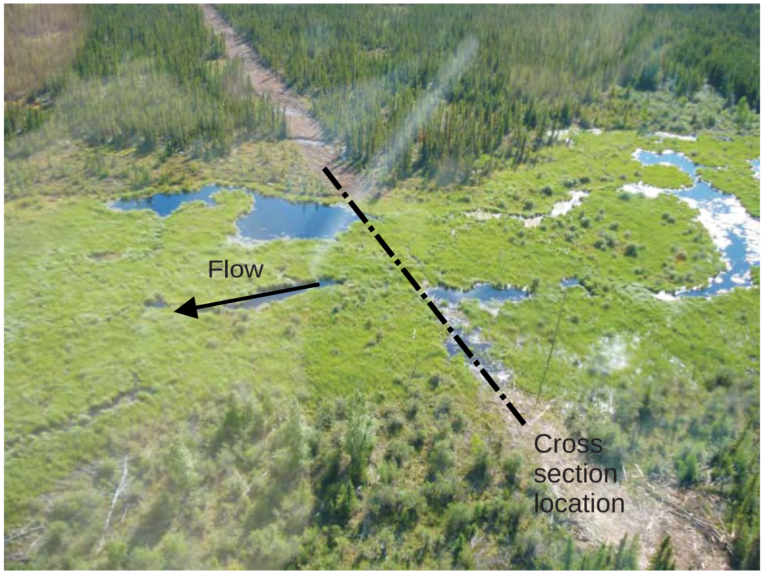


Aerial view of Site 2 looking south

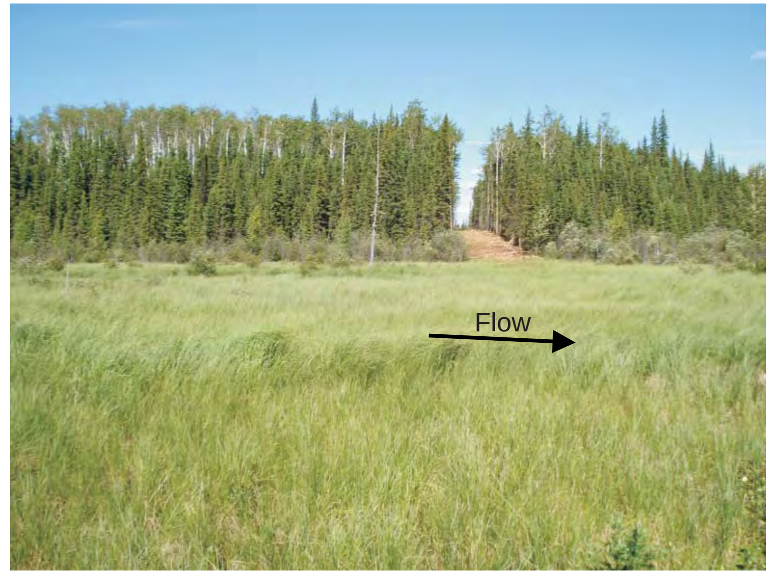
View of Site 2 looking east



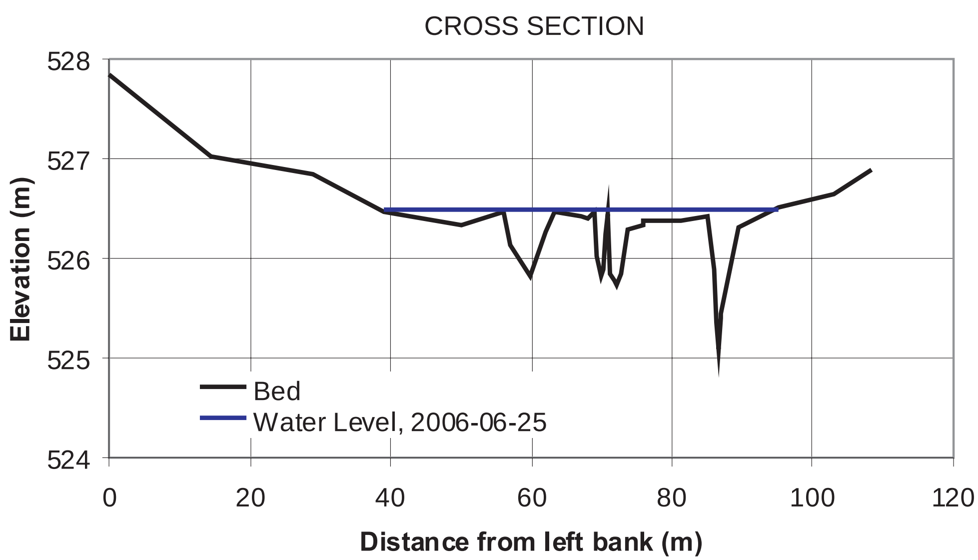
SUNSHINE OILSANDS LTD.		
WEST ELLS SAGD PROJECT **CHANNEL CHARACTERISTICS AT SITE 2**		
Project 1-7095	7 Nov 2008	**Figure 10**
northwest hydraulic consultants		



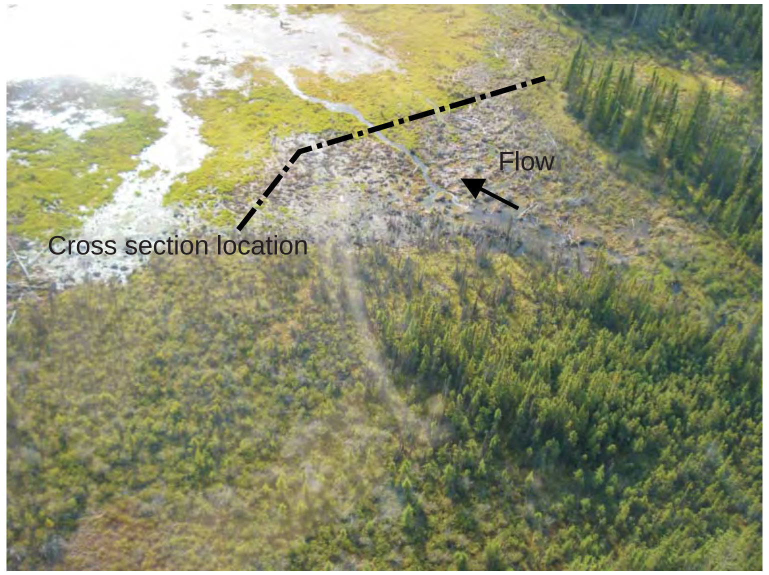
Aerial view of Site 3 looking south



View of Site 3 from right bank



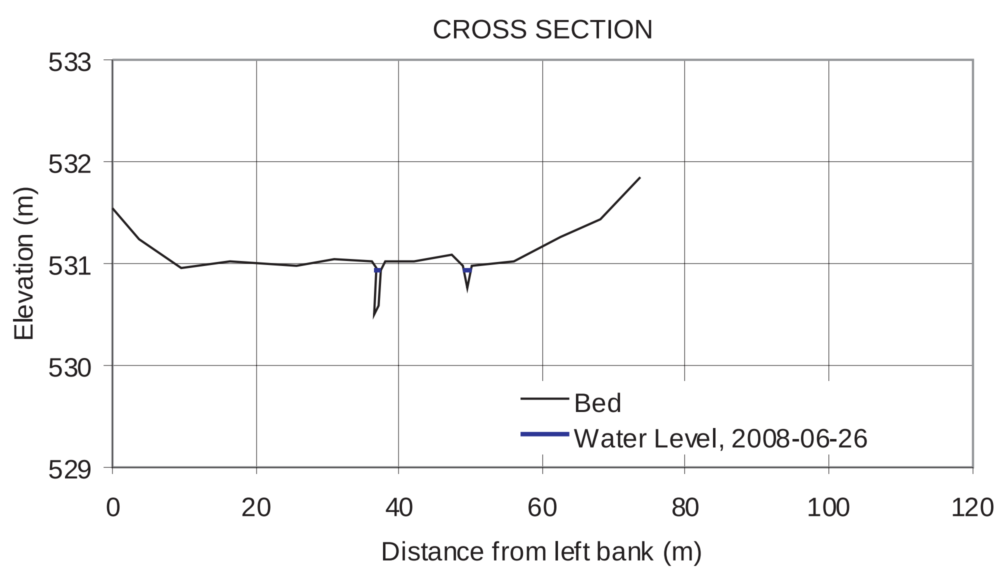
SUNSHINE OILSANDS LTD.		
WEST ELLS SAGD PROJECT		
CHANNEL CHARACTERISTICS AT SITE 3		
Project 1-7095	7 Nov 2008	**Figure 11**
northwest hydraulic consultants		

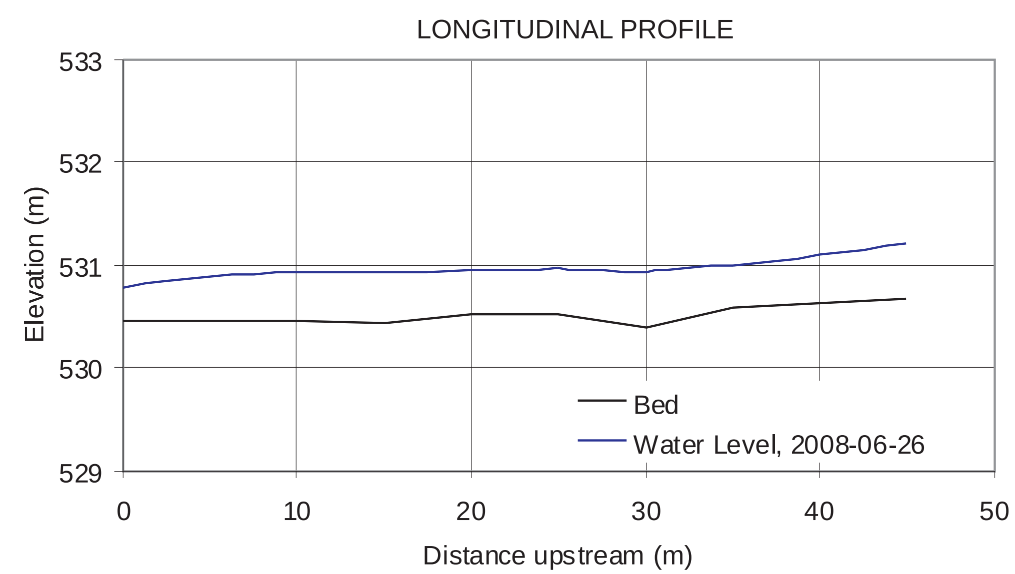


Aerial view of Site 4 looking southeast

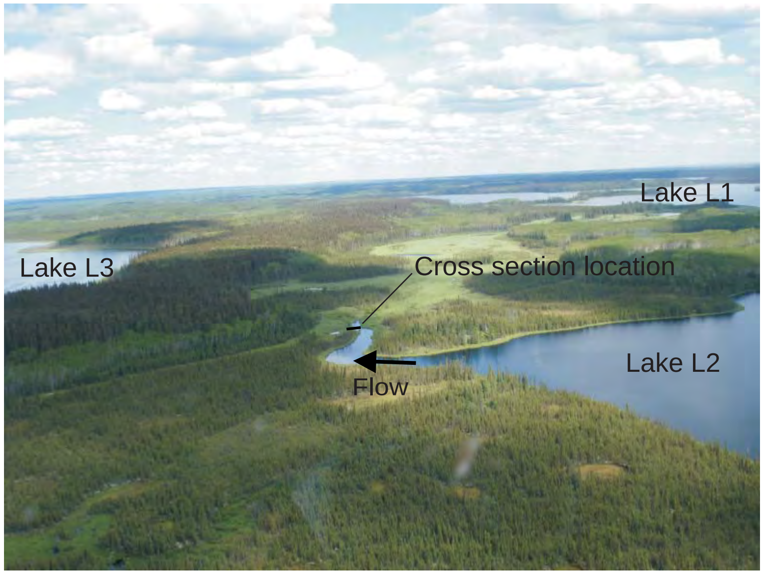

View downstream from Site 4


View upstream from Site 4

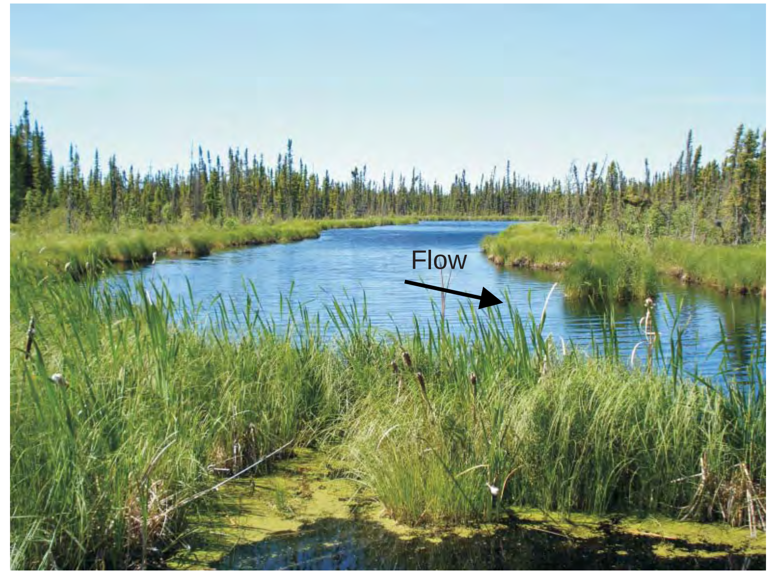




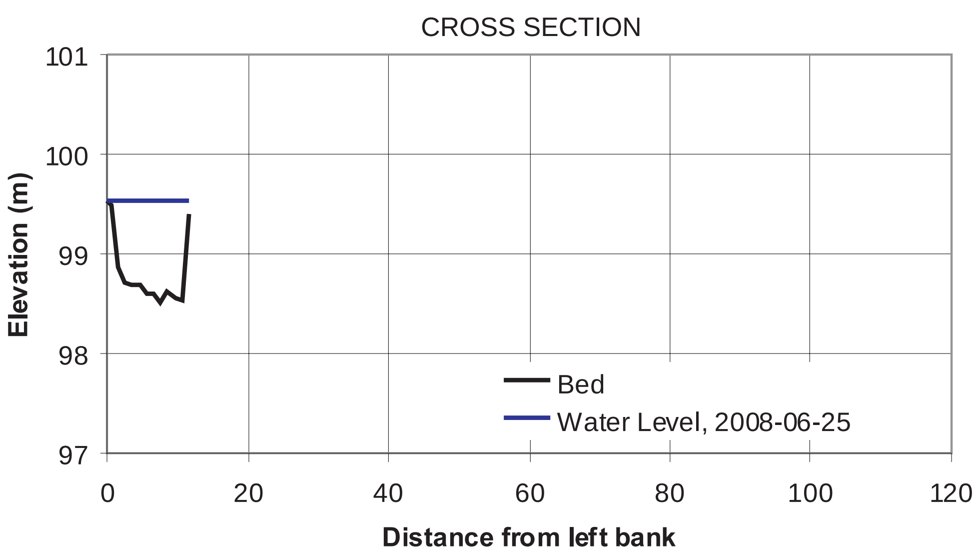
SUNSHINE OILSANDS LTD.		
WEST ELLS SAGD PROJECT **CHANNEL CHARACTERISTICS AT SITE 4**		
Project 1-7095	7 Nov 2008	**Figure 12**
northwest hydraulic consultants ltd.		



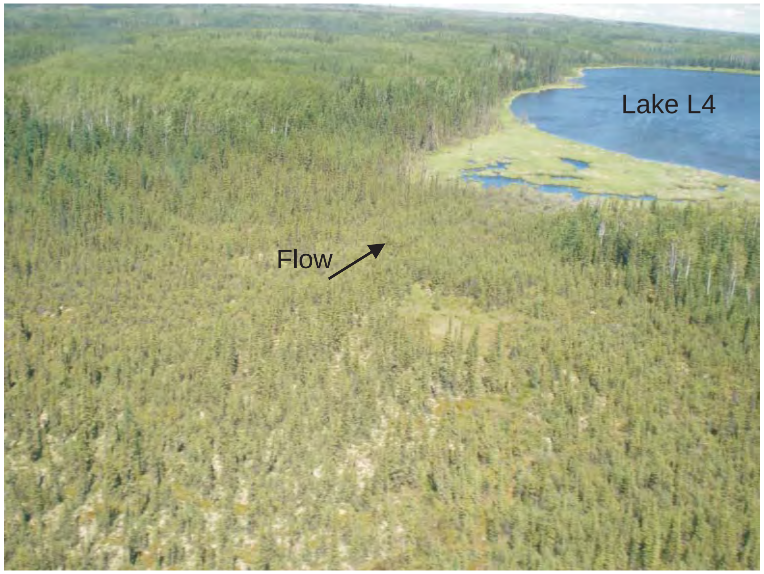
Aerial view of Site 5 looking east



View upstream of Site 5 from right bank



SUNSHINE OILSANDS LTD.		
WEST ELLS SAGD PROJECT		
CHANNEL CHARACTERISTICS AT SITE 5		
Project 1-7095	7 Nov 2008	**Figure 13**
northwest hydraulic consultants		

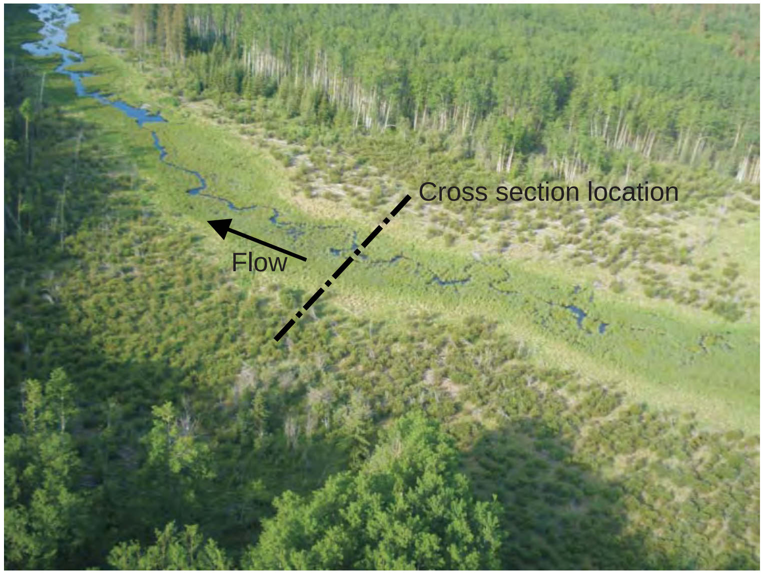


Aerial view of drainage into Lake L4 near Site 6 looking north

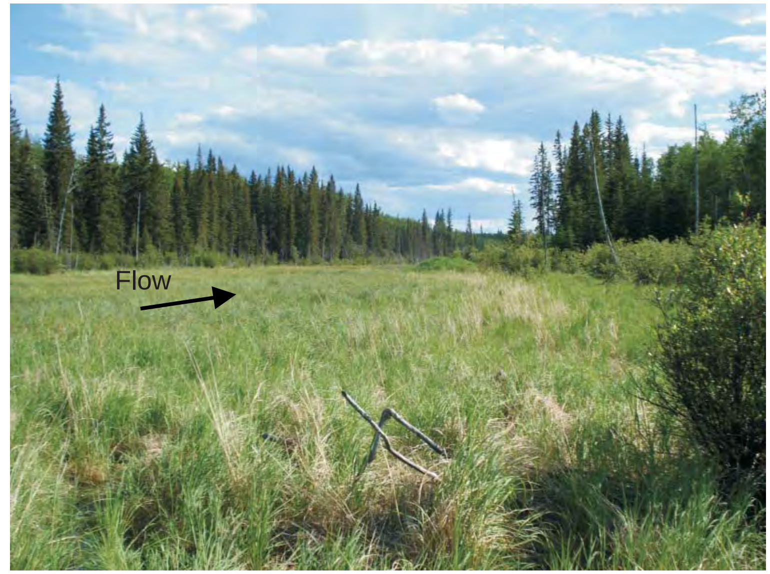
Aerial view of drainage into Lake L4 near Site 6 looking southwest

Aerial view of drainage near Site 6 looking west

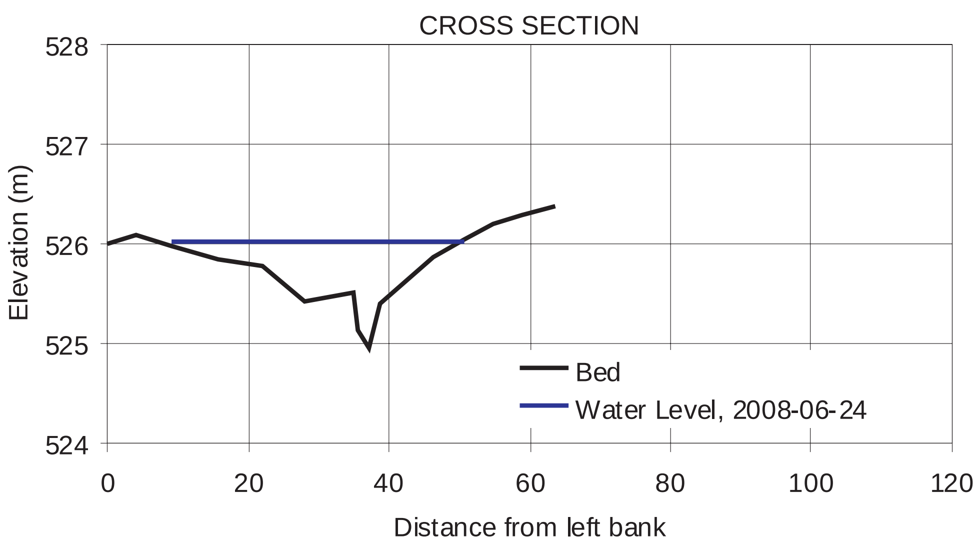
SUNSHINE OILSANDS LTD.		
WEST ELLS SAGD PROJECT		
CHANNEL CHARACTERISTICS AT SITE 6		
Project 1-7095	7 Nov 2008	**Figure 14**
northwest hydraulic consultants		



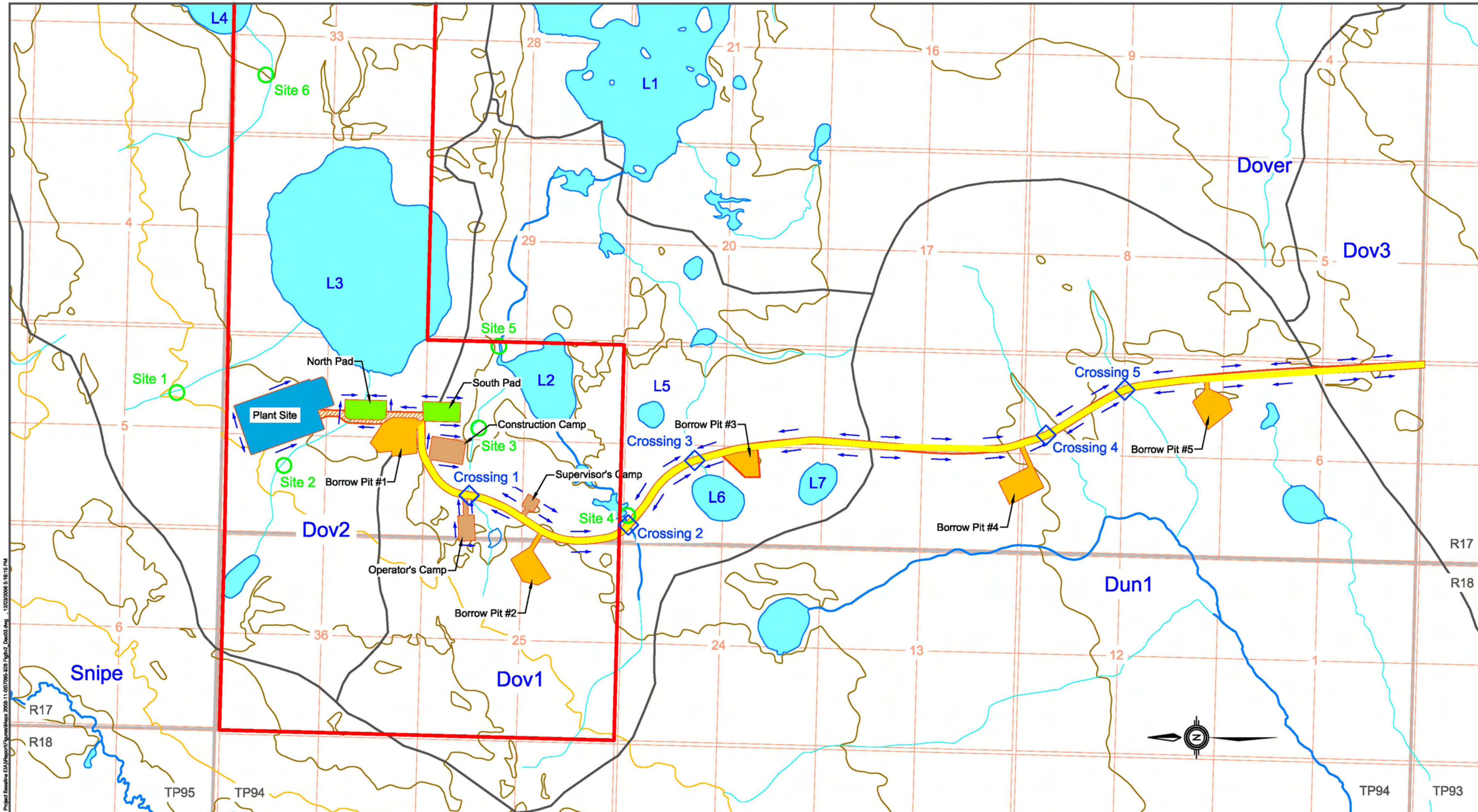
Aerial view of Site 7 looking north



View downstream of Site 7 from right bank



SUNSHINE OILSANDS LTD.		
WEST ELLS SAGD PROJECT		
CHANNEL CHARACTERISTICS AT SITE 7		
Project 1-7095	7 Nov 2008	**Figure 15**
northwest hydraulic consultants		



LEGEND

PROJECT AREA	SITE LOCATION	PLANT SITE	BORROW PIT
DRAINAGE WITH NO DEFINED CHANNEL	DRAINAGE DIRECTION	WELL PAD	UTILITY CORRIDOR
WATERCOURSE WITH DEFINED CHANNEL	CROSSING LOCATION	CAMP	ACCESS ROAD
WATERSHED BOUNDARY			
Dov1 WATERSHED LABEL			

500 0 500 1,000 m

SCALE 1:30,000

SUNSHINE OILSANDS LTD.

WEST ELLS SAGD PROJECT

PROJECT LAYOUT AND DRAINAGE

Dwg. 7095–928	25 Nov 2008	**Figure 16**

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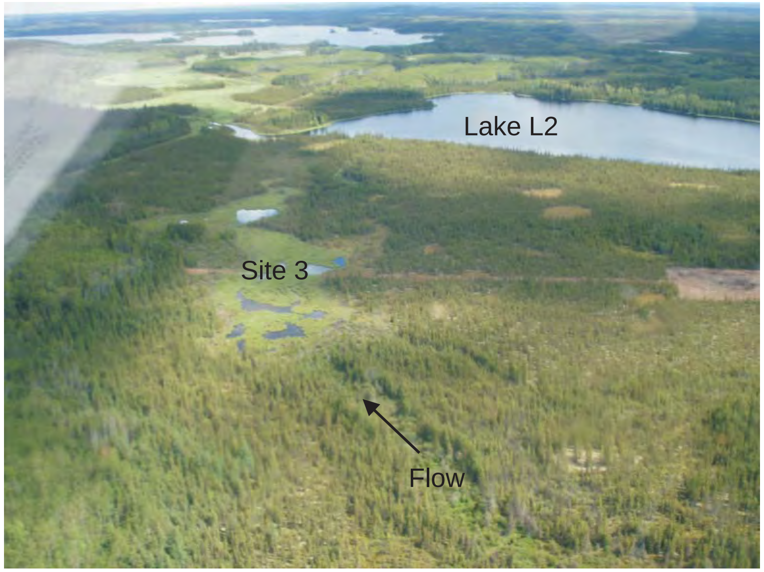
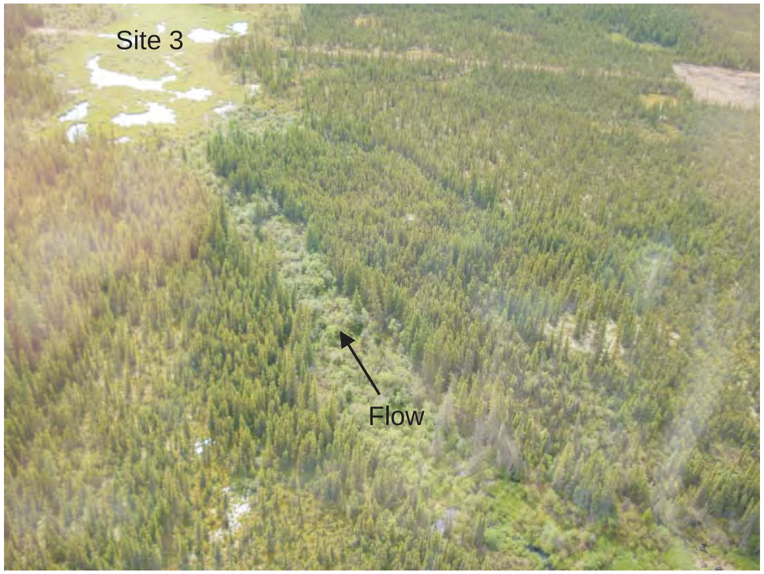
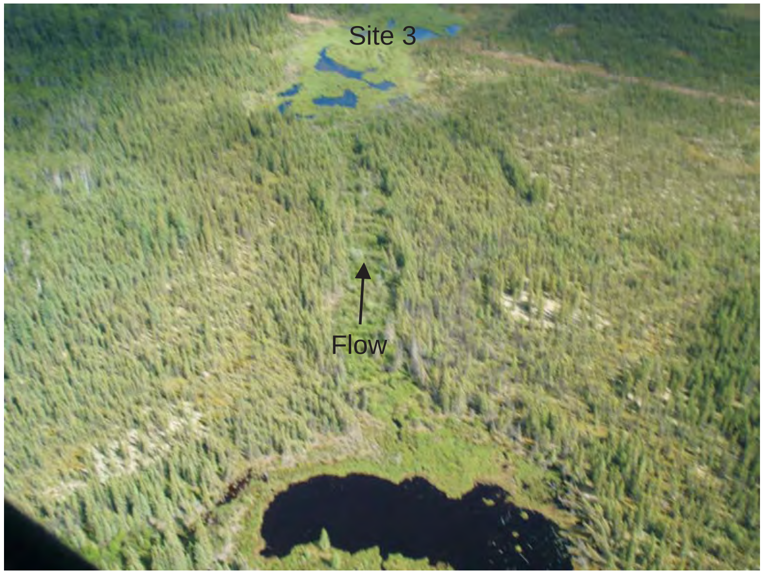


Aerial view of drainage east of Crossing 1 looking east



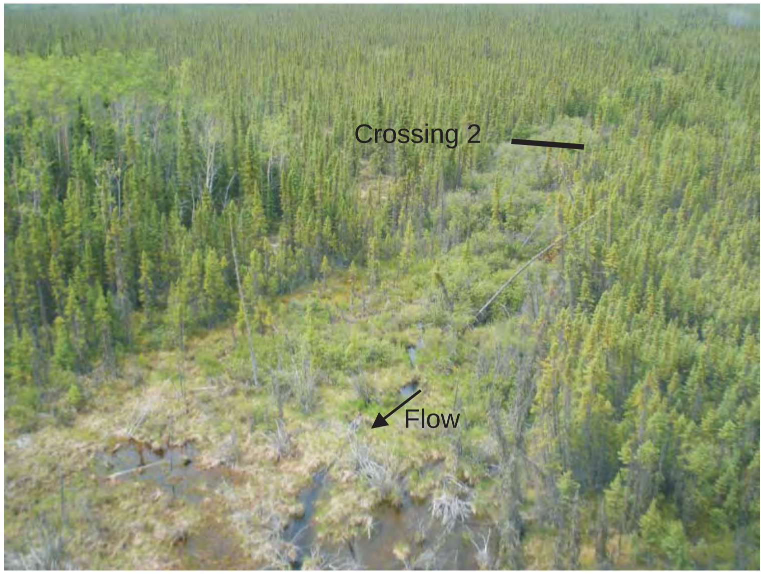
Aerial view of drainage east of Crossing 1 looking east



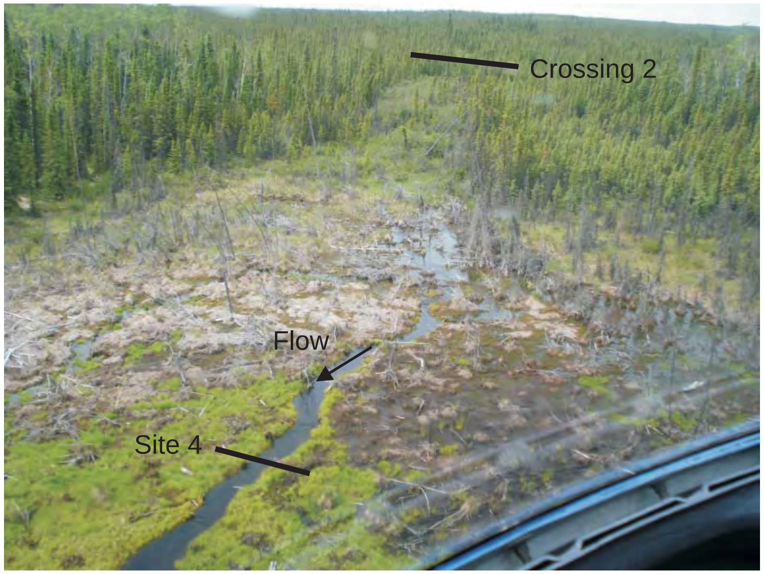
Aerial view of drainage east of Crossing 1 looking east

SUNSHINE OILSANDS LTD.		
WEST ELLS SAGD PROJECT 1 **PHOTOGRAPHS NEAR CROSSING 1**		
Project 1-7095	7 Nov 2008	**Figure 17**
northwest hydraulic consultants		

Aerial view near Crossing 2 looking southwest



Aerial view of drainage near Crossing 2 looking southwest



Aerial view of channel upstream of Site 4 looking southwest

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WEST ELLS SAGD PROJECT

PHOTOGRAPHS NEAR CROSSING 2

Project 1-7095	7 Nov 2008	**Figure 18**

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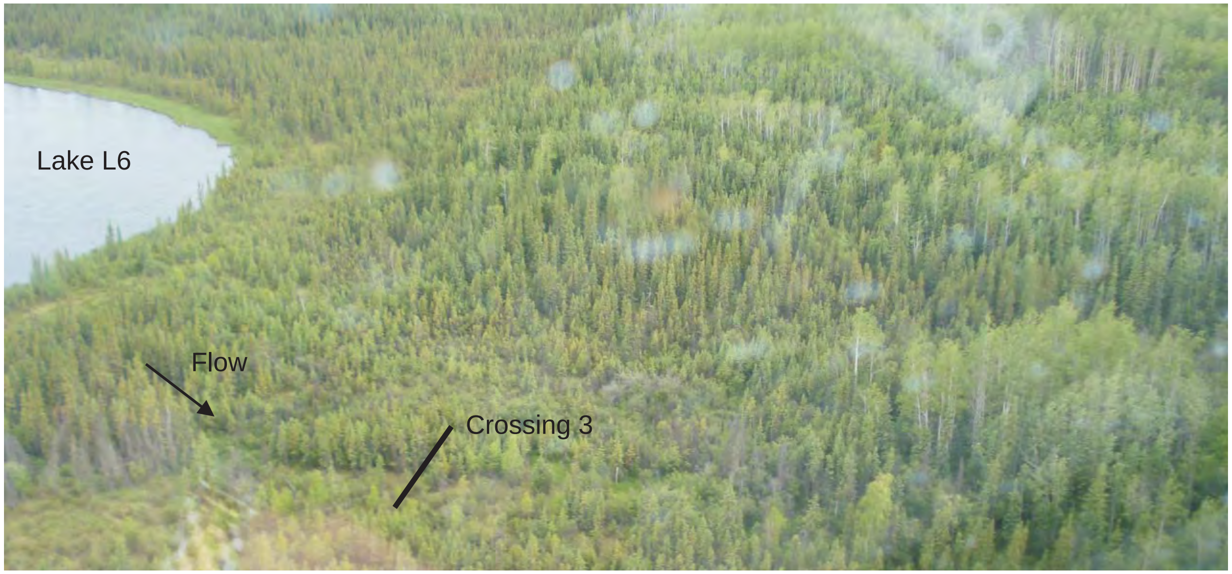
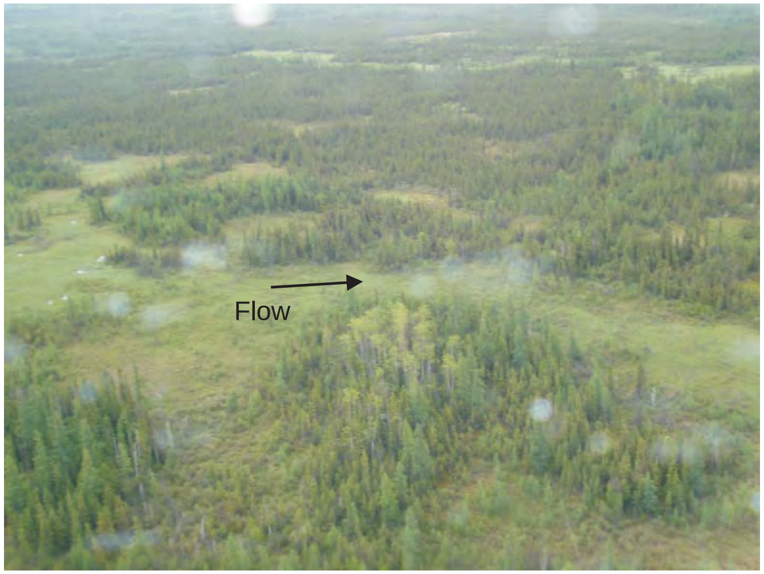


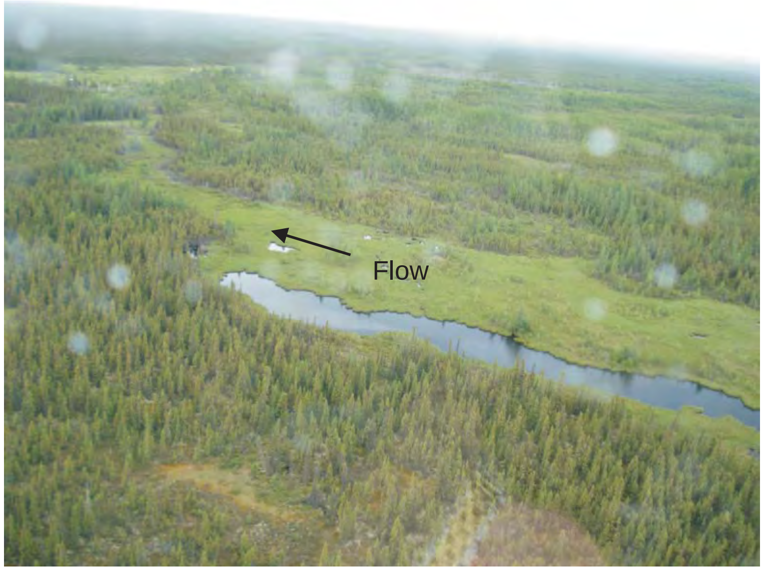
Aerial view of drainage near Crossing 3 looking northwest

Aerial view of drainage near Crossing 3 looking southwest

SUNSHINE OILSANDS LTD.		
WEST ELLS SAGD PROJECT **PHOTOGRAPHS NEAR CROSSING 3**		
Project 1-7095	7 Nov 2008	**Figure 19**
northwest hydraulic consultants		

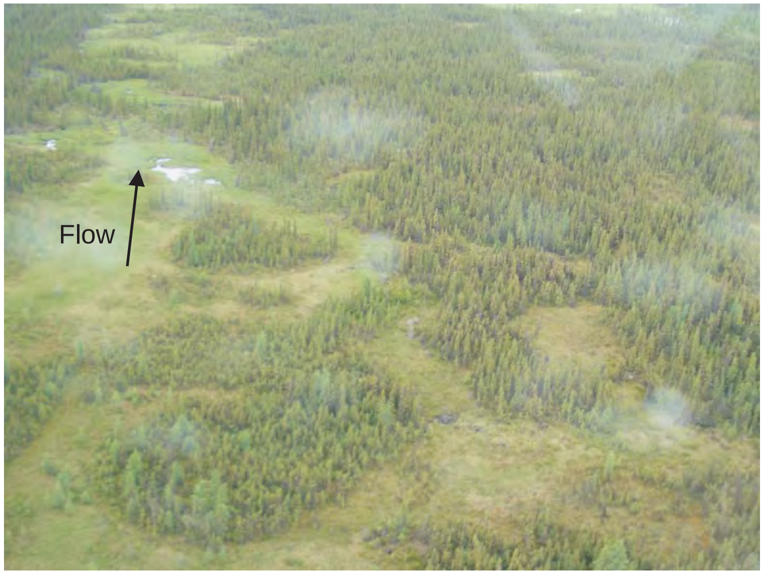


Aerial view of drainage near Crossing 4 looking southeast

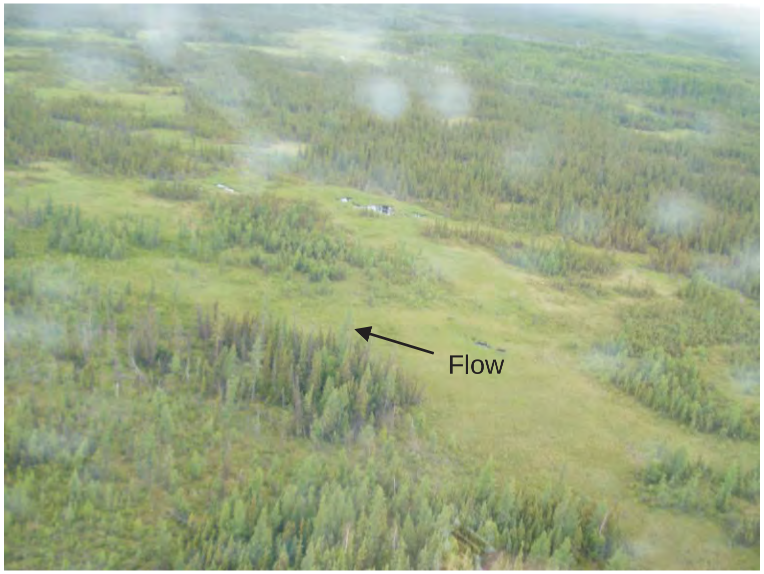


Aerial view of drainage near Crossing 4 looking northwest

SUNSHINE OILSANDS LTD.		
WEST ELLS SAGD PROJECT **PHOTOGRAPHS NEAR CROSSING 4**		
Project 1-7095	7 Nov 2008	**Figure 20**
northwest hydraulic consultants		



Aerial view of drainage near Crossing 5 looking west



Aerial view of drainage near Crossing 5 looking northwest

SUNSHINE OILSANDS LTD.		
WEST ELLS SAGD PROJECT **PHOTOGRAPHS NEAR CROSSING 5**		
Project 1-7095	7 Nov 2008	**Figure 21**
northwest hydraulic consultants		

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Phone: (780) 414-6373, Fax: (780) 414-6376
www.aciacoustical.com

Environmental Noise Impact Assessment
For

West Ells SAGD Project

Prepared for:
Sunshine Oilsands Ltd.

Prepared by:
S. Bilawchuk, M.Sc., P.Eng.
aci Acoustical Consultants Inc.
Edmonton, Alberta
APEGGA Permit to Practice #P7735

aci Project #: 08-064
November 09, 2009

Executive Summary

aci Acoustical Consultants Inc., of Edmonton AB, was retained by Sunshine Oilsands Ltd. to conduct an environmental noise impact assessment (NIA) for the West Ells SAGD Project (the Project). The purpose of the work was to generate a computer model of anticipated Project noise levels, and to compare the projected noise level results to the Alberta Energy Resources Conservation Board (ERCB) permissible sound level guidelines (ERCB Directive 038 on Noise Control).

The results of the noise modeling indicated projected noise levels below the ERCB's Directive 038 Permissible Sound Level of 40 dBA L_{eq}Night[1] for all receptors at 1.5 km from the CPF and well-pads. In addition, all noise levels from the facility equipment alone (i.e. no ambient sound level included) are projected to be close to 5 dBA below the Permissible Sound Level, providing an adequate factor of safety for potential sources of error in sound source determination, modeling error, and/or low frequency tonal components. No noise mitigation measures are required for normal operation of the Project.

Modeled Project Sound Levels

Receptor	Modeled L_{eq}Night (dBA)	ASL Night (dBA)	Modeled L_{eq}Night + ASL (dBA)	PSL-Night (dBA)	Compliant
R1	31.9	35.0	**36.7**	40.0	YES
R2	32.6	35.0	**37.0**	40.0	YES
R3	35.0	35.0	**38.0**	40.0	YES
R4	34.1	35.0	**37.6**	40.0	YES
R5	30.8	35.0	**36.4**	40.0	YES
R6	27.5	35.0	**35.7**	40.0	YES
R7	31.8	35.0	**36.7**	40.0	YES
R8	34.7	35.0	**37.9**	40.0	YES
R9	37.5	35.0	**39.4**	40.0	YES
R10	34.6	35.0	**37.8**	40.0	YES

[1] The term L_{eq} represents the energy equivalent sound level. This is a measure of the equivalent sound level for a specified period of time accounting for fluctuations. Night-time is defined from 22:00 – 07:00

Table of Contents

1.0 Introduction ... 1
2.0 Project Location and Study Area ... 1
3.0 Measurement & Modeling Methods ... 2
3.1. Environmental Noise Monitoring ... 2
3.2. Computer Noise Modeling (General) ... 2
3.3. Noise Sources ... 3
3.4. Modeling Confidence ... 4
4.0 Permissible Sound Levels ... 5
5.0 Results and Discussion ... 7
5.1. Modeling Results ... 7
5.2. Noise Mitigation Measures ... 7
5.2.1. Construction Noise ... 8
5.2.2. Transportation Noise ... 8
5.2.3. Drilling Noise ... 9
5.2.4. Upset Operations Potential Noise Sources ... 9
5.2.5. Effects of Climate Change ... 9
5.2.6. Traditional Ecological Knowledge / Traditional Land Use ... 9
6.0 Conclusion ... 10
7.0 References ... 11
Appendix I NOISE MODELING PARAMETERS ... 14
Appendix II THE ASSESSMENT OF ENVIRONMENTAL NOISE (GENERAL) ... 16
Appendix III SOUND LEVELS OF FAMILIAR NOISE SOURCES ... 28
Appendix IV NOISE IMPACT ASSESSMENT ... 30

List of Tables

Table 1. Basic Night-Time Sound Levels (as per ERCB Directive 038) ... 6
Table 2. Modeled Project Sound Levels ... 7

List of Figures

Figure 1. Project Study Area ... 12
Figure 2. Application Case Noise Modeling Results ... 13

1.0 Introduction

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2.0 Project Location and Study Area

The West Ells SAGD Project, as shown in Figure 1, is in Townships 94 and 95, and Ranges 17 & 18, West of the 4th Meridian. The Project will have a central processing facility (CPF) located in the northern half of Section 31-94-17-W4M. In addition, there will be two SAGD well-pad sites located at LSD SE31-94-17-W4M and NE30-94-17-W4M.

The ERCB's Directive 038 on Noise Control specifies that noise impact assessments are to be carried out to evaluate project impacts on the nearest dwelling. For the Project, however, there are no known permanent dwellings nearby. Directive 038 further specifies that, in the event the nearest dwelling is greater than a 1.5 km distance from the Project, new facilities must meet a permissible sound night time level of 40 dBA 1.5 km from the facility fence-line. Consequently, the study area for the noise impact assessment for the Project is identified as being an area that encompasses a 1.5 km radius from the CPF and the well-pads.

The closest major roadway nearby is Highway 63, which is more than 50 km from the Project. Thus, it is too far away to be of concern for the baseline noise climate. In addition, there are no other significant industrial facilities close enough to have any noise impact (i.e. well beyond at least 5 km away). Topographically the land in the study area is generally flat, covered with trees, bushes, field grasses, and lakes. As such, vegetative sound absorption is considered significant.

3.0 Measurement & Modeling Methods

3.1. Environmental Noise Monitoring

Given the remote location of the Project, the lack of permanent dwellings in close proximity to the Project, and the absence of nearby significant industrial noise sources, a baseline noise monitoring program was not conducted. This conforms with requirements of the ERCB Directive 038 on Noise Control.

3.2. Computer Noise Modeling (General)

The computer noise modeling was conducted using the CADNA/A (version 3.7.123) software package. CADNA/A allows for the modeling of various noise sources such as road, rail, and stationary sources. Topographical features such as land contours, vegetation, and bodies of water and meteorological conditions such as temperature, relative humidity, wind-speed and wind-direction are considered in the assessment. The modeling methods used met or exceeded the requirements of the ERCB Directive 038 on Noise Control.

The calculation method used for noise propagation follows the International Standards Organization (ISO) 9613-2. All receiver locations were assumed as being downwind from the source(s). In particular, as stated in Section 5 of the ISO 9613-2 document:

> "*Downwind propagation conditions for the method specified in this part of IS0 9613 are as specified in 5.4.3.3 of IS0 1996-2:1987, namely*
>
> - *wind direction within an angle of ± 45^0 of the direction connecting the centre of the dominant sound source and the centre of the specified receiver region, with the wind blowing from source to receiver, and*
> - *wind speed between approximately 1 m/s and 5 m/s, measured at a height of 3 m to 11 m above the ground.*
>
> *The equations for calculating the average downwind sound pressure level LAT(DW) in this part of IS0 9613, including the equations for attenuation given in clause 7, are the average for meteorological conditions within these limits. The term average here means the average over a short time interval, as defined in 3.1.*
>
> *These equations also hold, equivalently, for average propagation under a well-developed moderate ground-based temperature inversion, such as commonly occurs on clear, calm nights*".

Due to the large size of the study area and the density of vegetation within the study area, vegetative sound absorption was included in the model. A ground absorption coefficient of 0.6 was used along with a temperature of 10^{0}C and a relative humidity of 70%. As a result, all sound level propagation calculations are considered representative of summertime conditions for all surrounding receptors (as specified in Directive 038).

The computer noise modeling results were calculated in two ways. First, sound levels were calculated at specific receiver locations (i.e. receptors located at a 1500 m perimeter from the CPF and well-pads). Second, sound level conditions were calculated using a 5 m x 5 m receptor grid pattern within the study area. This provided color noise contours for easier visualization and evaluation of the results.

3.3. Noise Sources

The noise sources for the equipment associated with the Project are provided in Appendix I. The data were obtained either from (i) noise assessments carried out for other projects using similar operating equipment or, (ii) aci in-house information and calculations using methods presented in various texts or, (iii) sound level information provided by the proponent. All sound power levels (SWLs) used in the modeling are considered conservative.

All noise sources (eg. stacks, vent fans, motors, air compressors, and other operating equipment) have been modeled as point sources at their appropriate heights. Large buildings and storage tanks were included in the modeling calculations because of their ability to provide shielding as well as reflection for noise. Equipment located within buildings was modeled using the Sound Power Levels (Appendix I) and reduction based on a typical construction of a metal clad, insulated building with minimal windows and some man-doors and overhead doors. This also assumes that the doors and windows remain closed at all times. The reduction used for the buildings is considered conservative.

Finally, Directive 038 requires the assessment to include background ambient noise levels in the model. As specified in Directive 038, in most rural areas of Alberta where there is an absence of industrial noise sources, the average night-time ambient noise level is approximately 35 dBA. This is known as the average ambient sound level (ASL). This value was used as the baseline condition in the modeling with the various CPF and well-pad noise sources added.

3.4. Modeling Confidence

As mentioned previously, the algorithms used for the noise modeling follow the ISO 9613 standard. The published accuracy for this standard is ±3 dBA between 100 m – 1000 m. Accuracy levels beyond 1000m are not published. Experience based on similar noise models conducted over large distances shows that, as expected, as the distance increases, the associated accuracy in prediction decreases. Experience has shown that environmental factors such as wind, temperature inversions, topography and ground cover all have increasing effects over distances greater than approximately 1500 m. As such, for all receptors within approximately 1500 m of the various noise sources, the prediction confidence is considered high, while for all receptors beyond 1500 m, the prediction confidence is considered moderate. It is important to note that, the noise levels calculated in the model must meet the PSLs at 1500 m. Thus, for receptors located further away, noise levels are expected to be actually lower than that projected by the model. Therefore, the decreasing accuracy associated with model results beyond 1500 m is not considered to be significant.

4.0 Permissible Sound Levels

Environmental noise levels from industrial noise sources are commonly described in terms of equivalent sound levels or L_{eq}. This is the level of a steady sound having the same acoustic energy, over a given time period, as the fluctuating sound. In addition, this energy averaged level is A–weighted to account for the reduced sensitivity of average human hearing to low frequency sounds. These L_{eq} in dBA, which are the most common environmental noise measure, are often given for day-time (07:00 to 22:00) L_{eq}Day and night-time (22:00 to 07:00) L_{eq}Night while other criteria use the entire 24-hour period as L_{eq}24. Refer to Appendix II for a detailed description of the acoustical terms used and Appendix III for a list of common noise sources.

The document which most directly relates to the Permissible Sound Levels (PSLs) for this NIA is the ERCB Directive 038 on Noise Control (2007). This guideline sets the PSL at the receiver location based on population density and relative distances to heavily traveled road and rail as shown in Table 1. In all instances, there is a Basic Sound Level (BSL) of 40 dBA for the night-time (night-time hours are 22:00 – 07:00) and 50 dBA for the day-time (day-time hours are 07:00 – 22:00). Note that for this location, none of the adjustments to the BSL (discussed in the guideline) apply. In addition, Directive 038 specifies that new facilities must meet a PSL-Night of 40 dBA at 1.5 km from the facility fence-line if there are no closer dwellings. It is further recommended in Directive 038 that the design noise levels be approximately 5 dBA lower than the PSL to provide a suitable margin of safety. As such, the PSL at the 1.5 km boundary is an **L_{eq}Night of 40 dBA and an L_{eq}Day of 50 dBA with a recommendation that the resultant sound levels be close to 5 dBA lower than the PSL.**

The PSLs provided are related to noise associated with activities and processes at the Project and are not related to vehicle traffic on nearby highways (or access roads) or rail traffic. Noises from Project related traffic sources are not covered by any regulations or guidelines at the municipal, provincial, or federal levels. As such, an assessment of the noises related to vehicle and rail traffic was not conducted. However, recommendations for mitigation of Project vehicle traffic noise are provided in Section 5.2.2. In addition, construction noise is not specifically regulated by Directive 038. Construction noise mitigation recommendations are provided in Section 5.2.1.

Table 1. Basic Night-Time Sound Levels (as per ERCB Directive 038)

	Dwelling Density per Quarter Section of Land		
Proximity to Transportation	**1-8 Dwellings**	**9-160 Dwellings**	**>160 Dwellings**
Category 1	40	43	46
Category 2	45	48	51
Category 3	50	53	56

Category 1 Dwelling units more than 500m from heavily travelled roads and/or rail lines and not subject to frequent aircraft flyovers

Category 2 Dwelling units more than 30m but less than 500m from heavily travelled roads and/or rail lines and not subject to frequent aircraft flyovers

Category 3 Dwelling units less than 30m from heavily travelled roads and/or rail lines and not subject to frequent aircraft flyovers

5.0 Results and Discussion

5.1. Modeling Results

The results of the noise modeling are presented in Table 2 and illustrated in Figure 2. The results are provided as day/night since the noise levels will be essentially continuous. It can be seen that the projected noise levels at the 1.5 km boundary (from the CPF and well-pads) are below the PSL-Night of 40 dBA L_{eq}Night. The contribution from the Project equipment alone (without the ASL of 35 dBA) was generally well under 40 dBA which provides a factor of safety for any potential errors in the noise source determination and modeling error. It also provides a factor of safety for the potential of any low frequency tonal components often associated with boilers and heaters. Again, the results are considered conservative and it is likely that the actual noise levels will be lower.

Table 2. Modeled Project Sound Levels

Receptor	Modeled L_{eq}Night (dBA)	ASL Night (dBA)	Modeled L_{eq}Night + ASL (dBA)	PSL-Night (dBA)	Compliant
R1	31.9	35.0	**36.7**	40.0	YES
R2	32.6	35.0	**37.0**	40.0	YES
R3	35.0	35.0	**38.0**	40.0	YES
R4	34.1	35.0	**37.6**	40.0	YES
R5	30.8	35.0	**36.4**	40.0	YES
R6	27.5	35.0	**35.7**	40.0	YES
R7	31.8	35.0	**36.7**	40.0	YES
R8	34.7	35.0	**37.9**	40.0	YES
R9	37.5	35.0	**39.4**	40.0	YES
R10	34.6	35.0	**37.8**	40.0	YES

5.2. Noise Mitigation Measures

The results of the noise modeling indicate that noise mitigation is not required for normal operation of the Project.

5.2.1. Construction Noise

Although there are no specific construction noise level limits detailed by Directive 038, there are general recommendations for construction noise mitigation. The document states:

> "*While Directive 038 is not applicable to construction noise, licensees should attempt to take the following reasonable mitigating measures to reduce the impact on nearby dwellings of construction noise from new facilities or modifications to existing facilities. Licensees should:*
>
> - *Limit construction activity to the hours of between 07:00 and 22:00 to reduce the potential impact of construction noise.*
> - *Advise nearby residents of significant noise-causing activities and schedule these to create the least disruption to neighbours.*
> - *Ensure all internal combustion engines are fitted with appropriate muffler systems.*
> - *Take advantage of acoustical screening from existing on-site buildings to shield residential locations from construction equipment noise.*
> - *Where possible, schedule steam blow downs and venting to the daytime period of between 07:00 and 22:00 hours*
>
> *Should a complaint be made during construction, the licensee will be expected to respond expeditiously and take appropriate action to ensure that the issue has been managed responsibly.*"

Further to the information listed above, if construction activities are scheduled between the hours of 20:00 – 07:00, they should be limited as much as possible to "quiet" operations.

5.2.2. Transportation Noise

During construction and regular operation activities at the Project, most material deliveries should be made during the hours of 07:00 – 20:00. While the movement of heavy loads at night-time will increase the night-time sound levels, the duration will be short and frequency relatively low. During construction, large dimensional heavy loads requiring specific traffic control measures will likely be limited to night-time (01:00 – 5:00) and will be announced to those communities that are located en route along the nearby roads. The noise associated with this activity is typically not a source for complaints.

5.2.3. Drilling Noise

Drilling activities will likely be conducted at all hours of the day and night. Noise during drilling has the potential to affect any receptors near the Project (although likely to be well below the ERCB PSL of 40 dBA L_{eq}Night). It is recommended that the licensee consult with any concerned stakeholders as drilling operations commence and to work with stakeholders on an individual basis to address any identified issues with drilling related noise.

5.2.4. Upset Operations Potential Noise Sources

Upset operational noise could occur during operational upset/emergency conditions. The following upset conditions with the potential to create noise have been identified:

- Conditions that require steam blow downs.
- Conditions that require flaring at the CPF.
- During an emergency situation, the first priorities will always be to safeguard life and property. In the event that an emergency situation also results in excessive short term noise levels, it is recommended that the licensee will consult with any affected parties, on a case by case basis.

5.2.5. Effects of Climate Change

The effect of climate change on noise propagation is completely negligible. Any small changes in temperature and the resultant even smaller wind gradients, as well as the small changes in precipitation and relative humidity, over the span of several years will be significantly smaller than the typical day-to-day fluctuations. In addition, sound propagation is only weakly dependent on temperature. There will be no observable impact on the noise climate.

5.2.6. Traditional Ecological Knowledge / Traditional Land Use

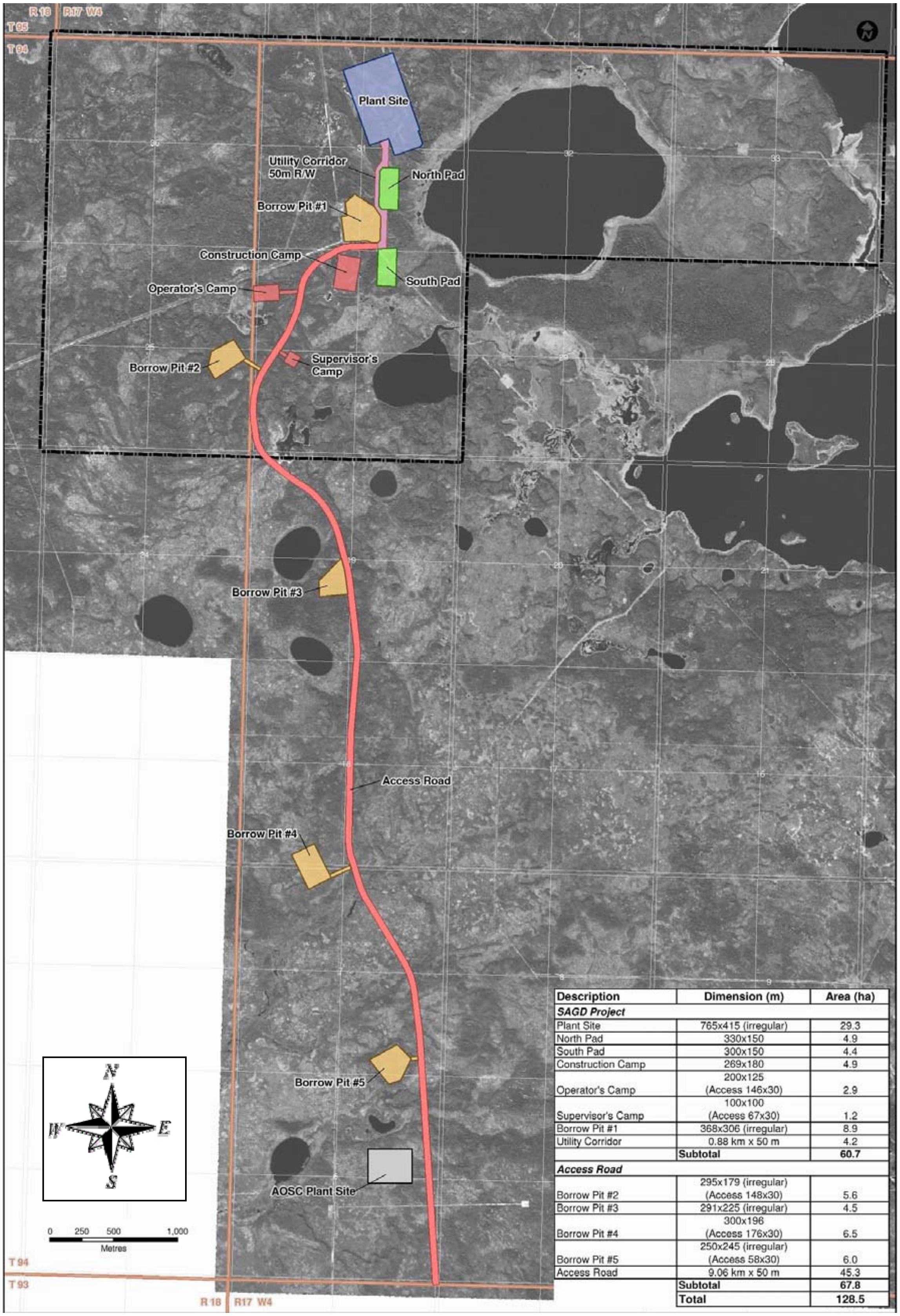
The noise levels generated as part of the Project are projected to be under the ERCB Directive 038 criteria at a distance of 1.5 km from all Project noise sources. As such, the relative noise impact on Traditional Land Use (TLU) areas, although not necessarily completely inaudible, is minimal.

6.0 Conclusion

The results of the noise modeling indicated projected noise levels below the ERCB's Directive 038 Permissible Sound Level of 40 dBA L_{eq}Night for all receptors at 1.5 km from the CPF and well-pads. In addition, all noise levels from the facility equipment alone (i.e. no ambient sound level included) are projected to be close to 5 dBA below the Permissible Sound Level, providing an adequate factor of safety for potential sources of error in sound source determination, modeling error, and/or low frequency tonal components. No noise mitigation measures are required for normal operation of the Project. A short form (ERCB form) noise impact assessment is presented in Appendix IV.

7.0 References

- Alberta Energy and Utilities Board (ERCB), *Directive 038 on Noise Control, 2007*, Calgary, Alberta
- International Organization for Standardization (ISO), *Standard 1996-1, Acoustics – Description, measurement and assessment of environmental noise – Part 1: Basic quantities and assessment procedures, 2003*, Geneva Switzerland.
- International Organization for Standardization (ISO), *Standard 9613-1, Acoustics – Attenuation of sound during propagation outdoors – Part 1: Calculation of absorption of sound by the atmosphere, 1993*, Geneva Switzerland.
- International Organization for Standardization (ISO), *Standard 9613-2, Acoustics – Attenuation of sound during propagation outdoors – Part 2: General method of calculation, 1996*, Geneva Switzerland.
- *Power Plant Construction Noise Emissions*. Allan M. Teplitzky & Eric W. Wood, Internoise '78 Conference Proceedings, pp 279 – 284.
- *Environmental Codes of Practice for Steam Electric Power Generation – Construction Phase*. Report EPS 1/PG/3, Environment Canada, 1989.



Description	Dimension (m)	Area (ha)
SAGD Project		
Plant Site	765x415 (irregular)	29.3
North Pad	330x150	4.9
South Pad	300x150	4.4
Construction Camp	269x180	4.9
Operator's Camp	200x125 (Access 146x30)	2.9
Supervisor's Camp	100x100 (Access 67x30)	1.2
Borrow Pit #1	368x306 (irregular)	8.9
Utility Corridor	0.88 km x 50 m	4.2
	Subtotal	**60.7**
Access Road		
Borrow Pit #2	295x179 (irregular) (Access 148x30)	5.6
Borrow Pit #3	291x225 (irregular)	4.5
Borrow Pit #4	300x196 (Access 176x30)	6.5
Borrow Pit #5	250x245 (irregular) (Access 58x30)	6.0
Access Road	9.06 km x 50 m	45.3
	Subtotal	**67.8**
	Total	**128.5**

Figure 1. Project Study Area

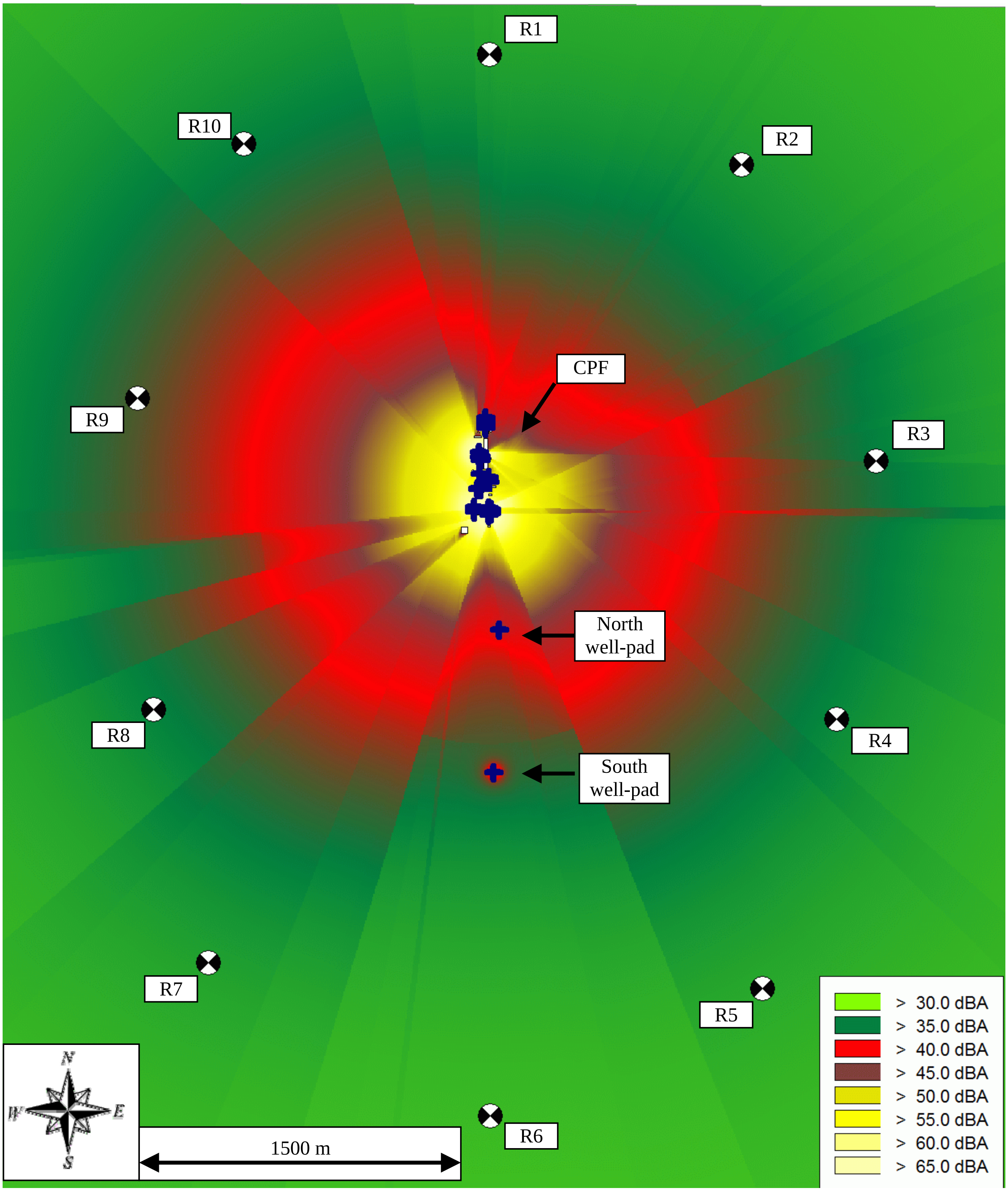


Figure 2. Application Case Noise Modeling Results

Appendix I

NOISE MODELING PARAMETERS

Tag	Description	Location	Height (m)	Model/Type	Rating (kW)	# Units	Equipment Sound Power Level (dBA)	Building Attenuation (dBA)	Overall Sound Power Level (dBA)
N/A	CoGen Inlet	CoGen Building	3	Gas Turbine	12797	1	105.5	0	**105.5**
N/A	CoGen Casing	CoGen Building	3	Gas Turbine	12797	1	128.7	28	**100.7**
N/A	CoGen Exhaust	CoGen Building	20	Gas Turbine	12797	1	107.2	0	**107.2**
N/A	CoGen Lube Oil Cooler	CoGen Building	5	Axial Fan	N/A	1	103.0	0	**103.0**
H-604	Steam Boiler Stack	Steam Generator Building	30	Heater	80000	1	99.5	0	**99.5**
H-604	Steam Boiler Casing	Steam Generator Building	3	Heater	80000	1	99.5	20	**79.5**
K-604	Steam Boiler Draft Fan	Steam Generator Building	3	Axial Fan	450	1	113.5	0	**113.5**
H-605	Steam Boiler Stack	Steam Generator Building	30	Heater	80000	1	99.5	0	**99.5**
H-605	Steam Boiler Casing	Steam Generator Building	3	Heater	80000	1	99.5	20	**79.5**
K-605	Steam Boiler Draft Fan	Steam Generator Building	3	Axial Fan	450	1	113.5	0	**113.5**
H-807	Utility Boiler Stack	Glycol Building	8.6	Heater	3690	1	79.5	0	**79.5**
K-807	Utility Boiler Draft Fan	Glycol Building	3	Axial Fan	5	1	94.0	0	**94.0**
H-610	Glycol Heater Stack	Glycol Building	8.2	Heater	4620	1	81.0	0	**81.0**
K-610	Glycol Heater Draft Fan	Glycol Building	3	Axial Fan	10	1	97.0	0	**97.0**
P553A/B	Cooling Glycol Circulation Pump	Glycol Building	1	Centrifugal	115	2	107.2	24	**83.2**
P554A/B	Heating Glycol Circulation Pump	Glycol Building	1	Centrifugal	45	1	103.0	24	**79.0**
E-421	Glycol Cooler	Glycol Building	5	Axial Fan	30	8	110.8	0	**110.8**
P-537A/B	LP Boiler Feedwater Pump	Source Water Building	1	Centrifugal	95	2	106.9	24	**82.9**
P-541A/B	HP Boiler Feedwater Pump	BFW Pump Building	1	Centrifugal	340	2	108.6	24	**84.6**
P-581	1st Stage Distillate Pump	Evaporator Building	1	Centrifugal	56	1	103.2	24	**79.2**
P-582	1st Evap Recirc Pump	Evaporator Building	1	Centrifugal	600	1	106.3	24	**82.3**
P-590	2nd Stage Recirc Pump	Evaporator Building	1	Centrifugal	150	1	104.5	24	**80.5**
P-591	2nd Stage Evap Recirc Pump	Evaporator Building	1	Centrifugal	150	1	104.5	24	**80.5**
K-606	1st Stage Vapor Compressor	Evaporator Building	3	Reciprocating	2250	1	122.5	25	**97.5**
K-616	2nd Stage Vapor Compressor	Evaporator Building	3	Reciprocating	950	1	118.8	25	**93.8**

Tag	Description	Location	Height (m)	Model/Type	Rating (kW)	# Units	Equipment Sound Power Level (dBA)	Building Attenuation (dBA)	Overall Sound Power Level (dBA)
P-524A/B	Oil removal Filter Feed pump	Tank Building	1	Centrifugal	50	2	106.1	24	**82.1**
P-525A/B	De-Oiled Water Pump	Tank Building	1	Centrifugal	45	1	103.0	24	**79.0**
K-600	VRU Compressor	Tank Building	1	Reciprocating	95	1	108.8	25	**83.8**
K-601	VRU Compressor	Tank Building	1	Reciprocating	95	1	108.8	25	**83.8**
K-608	Rotary Screw Air Compressor	Intsrument Air Building	1	Reciprocating	50	1	106.0	25	**81.0**
K-609	Rotary Screw Air Compressor	Intsrument Air Building	1	Reciprocating	50	1	106.0	25	**81.0**
WP-101	Emulsion Pump	Vessel Building	1	Centrifugal	75	2	106.6	24	**82.6**
WP-102	Emulsion Pump	Vessel Building	1	Centrifugal	75	2	106.6	24	**82.6**

Appendix II

THE ASSESSMENT OF ENVIRONMENTAL NOISE (GENERAL)

Sound Pressure Level

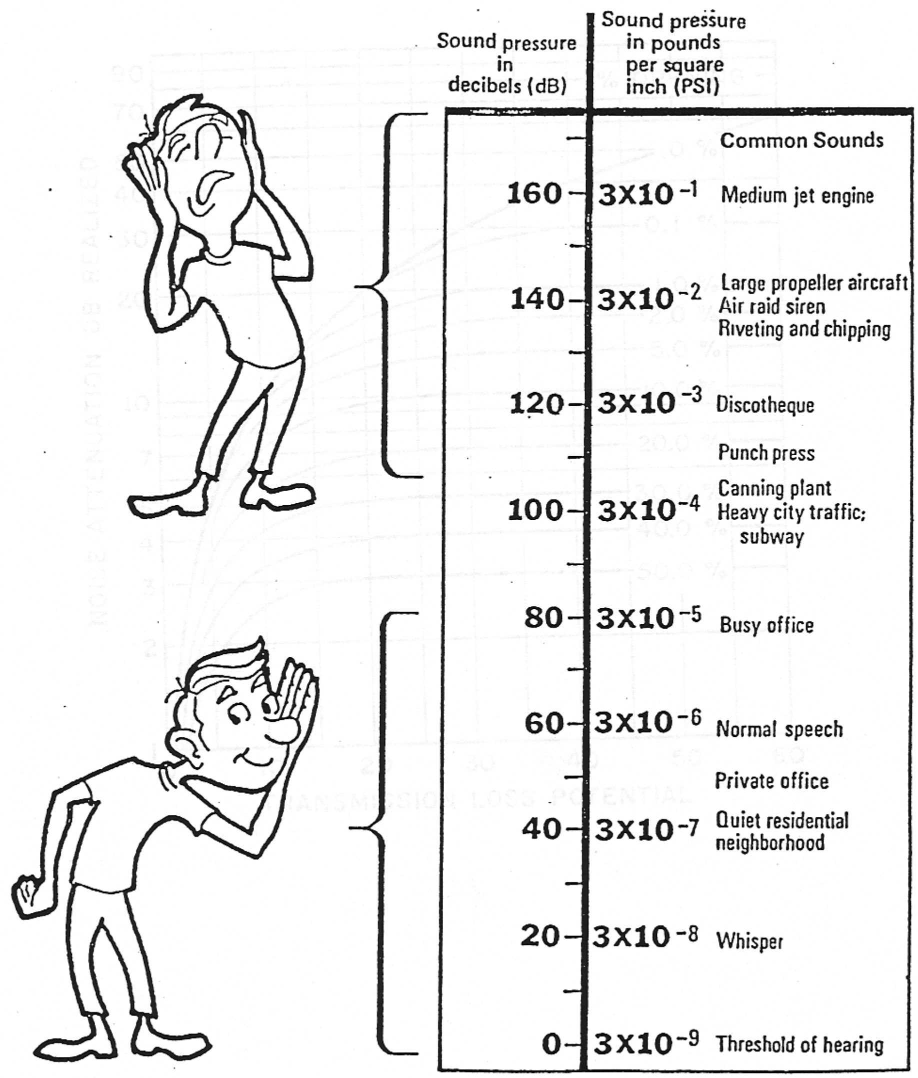
Sound pressure is initially measured in Pascal's (Pa). Humans can hear several orders of magnitude in sound pressure levels, so a more convenient scale is used. This scale is known as the decibel (dB) scale, named after Alexander Graham Bell (telephone guy). It is a base 10 logarithmic scale. When we measure pressure we typically measure the RMS sound pressure.

$$SPL = 10\log_{10}\left[\frac{P_{RMS}^{2}}{P_{ref}^{2}}\right] = 20\log_{10}\left[\frac{P_{RMS}}{P_{ref}}\right]$$

Where: SPL = Sound Pressure Level in dB
P_{RMS} = Root Mean Square measured pressure (Pa)
P_{ref} = Reference sound pressure level ($P_{ref} = 2\text{x}10^{-5}$ Pa = 20 μPa)

This reference sound pressure level is an internationally agreed upon value. It represents the threshold of human hearing for "typical" people based on numerous testing. It is possible to have a threshold which is lower than 20 μPa which will result in negative dB levels. As such, zero dB does not mean there is no sound!

In general, a difference of 1 – 2 dB is the threshold for humans to notice that there has been a change in sound level. A difference of 3 dB (factor of 2 in acoustical energy) is perceptible and a change of 5 dB is strongly perceptible. A change of 10 dB is typically considered a factor of 2. This is quite remarkable when considering that 10 dB is 10-times the acoustical energy!


Sound pressure in decibels (dB)
Sound pressure in pounds per square inch (PSI)
Common Sounds
160 3X10-1 Medium jet engine
140 3X10-2 Large propeller aircraft
Air raid siren
Riveting and chipping
120 3X10-3 Discotheque
Punch press
Canning plant
100 3X10-4 Heavy city traffic; subway
80 3X10-5 Busy office
60 3X10-6 Normal speech
Private office
40 3X10-7 Quiet residential neighborhood
20 3X10-8 Whisper
0 3X10-9 Threshold of hearing

Frequency

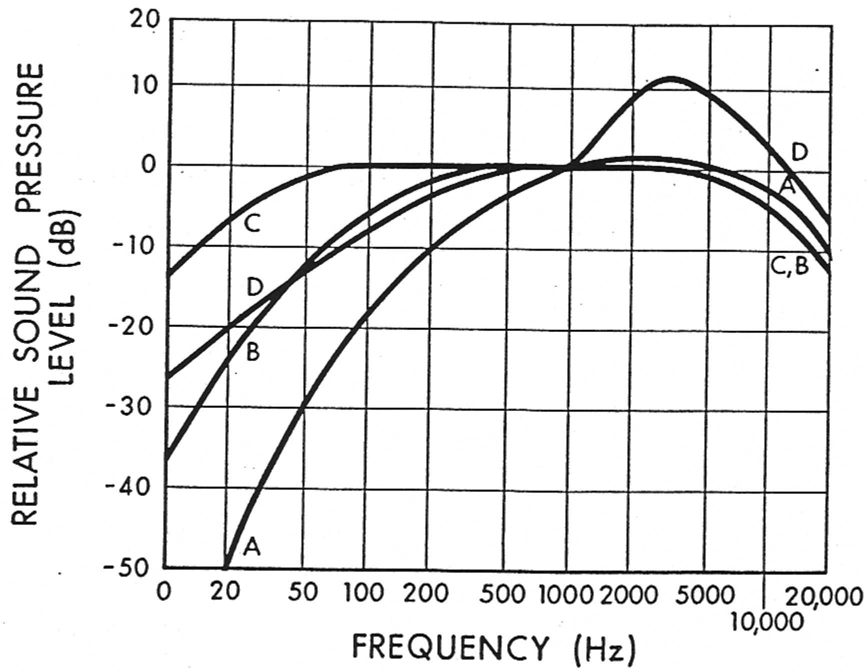
The range of frequencies audible to the human ear ranges from approximately 20 Hz to 20 kHz. Within this range, the human ear does not hear equally at all frequencies. It is not very sensitive to low frequency sounds, is very sensitive to mid frequency sounds and is slightly less sensitive to high frequency sounds. Due to the large frequency range of human hearing, the entire spectrum is often divided into 31 bands, each known as a 1/3 octave band.

The internationally agreed upon center frequencies and upper and lower band limits for the 1/1 (whole octave) and 1/3 octave bands are as follows:

Lower Band Limit	Whole Octave Center Frequency	Upper Band Limit
11	**16**	22
22	**31.5**	44
44	**63**	88
88	**125**	177
177	**250**	355
355	**500**	710
710	**1000**	1420
1420	**2000**	2840
2840	**4000**	5680
5680	**8000**	11360
11360	**16000**	22720

Lower Band Limit	1/3 Octave Center Frequency	Upper Band Limit
14.1	**16**	17.8
17.8	**20**	22.4
22.4	**25**	28.2
28.2	**31.5**	35.5
35.5	**40**	44.7
44.7	**50**	56.2
56.2	**63**	70.8
70.8	**80**	89.1
89.1	**100**	112
112	**125**	141
141	**160**	178
178	**200**	224
224	**250**	282
282	**315**	355
355	**400**	447
447	**500**	562
562	**630**	708
708	**800**	891
891	**1000**	1122
1122	**1250**	1413
1413	**1600**	1778
1778	**2000**	2239
2239	**2500**	2818
2818	**3150**	3548
3548	**4000**	4467
4467	**5000**	5623
5623	**6300**	7079
7079	**8000**	8913
8913	**10000**	11220
11220	**12500**	14130
14130	**16000**	17780
17780	**20000**	22390

Human hearing is most sensitive at approximately 3500 Hz which corresponds to the ¼ wavelength of the ear canal (approximately 2.5 cm). Because of this range of sensitivity to various frequencies, we typically apply various weighting networks to the broadband measured sound to more appropriately account for the way humans hear. By default, the most common weighting network used is the so-called "A-weighting". It can be seen in the figure that the low frequency sounds are reduced significantly with the A-weighting.



Combination of Sounds

When combining multiple sound sources the general equation is:

$$\Sigma SPL_n = 10\log_{10}\left[\sum_{i=1}^{n} 10^{\frac{SPL_i}{10}}\right]$$

Examples:

- Two sources of 50 dB each add together to result in 53 dB.
- Three sources of 50 dB each add together to result in 55 dB.
- Ten sources of 50 dB each add together to result in 60 dB.
- One source of 50 dB added to another source of 40 dB results in 50.4 dB

It can be seen that, if multiple similar sources exist, removing or reducing only one source will have little effect.

Sound Level Measurements

Over the years a number of methods for measuring and describing environmental noise have been developed. The most widely used and accepted is the concept of the Energy Equivalent Sound Level (L_{eq}) which was developed in the US (1970's) to characterize noise levels near US Air-force bases. This is the level of a steady state sound which, for a given period of time, would contain the same energy as the time varying sound. The concept is that the same amount of annoyance occurs from a sound having a high level for a short period of time as from a sound at a lower level for a longer period of time.
The L_{eq} is defined as:

$$L_{eq} = 10\log_{10}\left[\frac{1}{T}\int_0^T 10^{\frac{dB}{10}}\, dT\right] = 10\log_{10}\left[\frac{1}{T}\int_0^T \frac{P^2}{P_{ref}^2}\, dT\right]$$

We must specify the time period over which to measure the sound. i.e. 1-second, 10-seconds, 15-seconds, 1-minute, 1-day, etc. **An L_{eq} is meaningless if there is no time period associated**.

In general there a few very common L_{eq} sample durations which are used in describing environmental noise measurements. These include:

- L_{eq}24 - Measured over a 24-hour period
- L_{eq}Night - Measured over the night-time (typically 22:00 – 07:00)
- L_{eq}Day - Measured over the day-time (typically 07:00 – 22:00)
- L_{DN} - Same as L_{eq}24 with a 10 dB penalty added to the night-time

Statistical Descriptor

Another method of conveying long term noise levels utilizes statistical descriptors. These are calculated from a cumulative distribution of the sound levels over the entire measurement duration and then determining the sound level at xx % of the time.

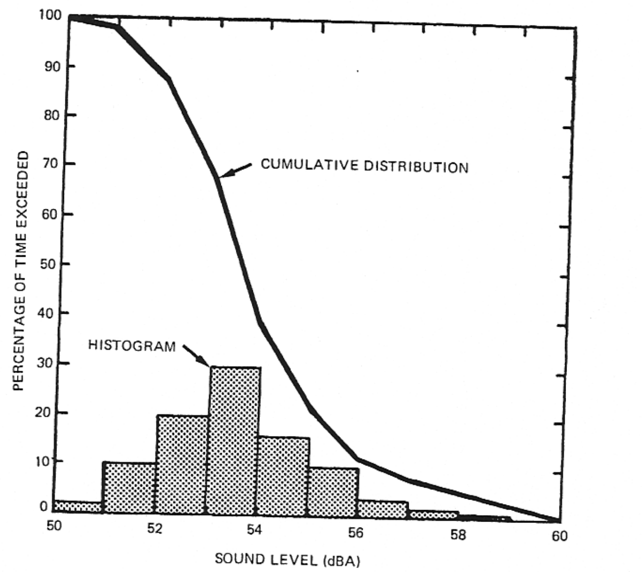


Figure 16.6 Statistically processed community noise showing histogram and cumulative distribution of A weighted sound levels.

Industrial Noise Control, Lewis Bell, Marcel Dekker, Inc. 1994

The most common statistical descriptors are:

L_{min} - minimum sound level measured
L_{01} - sound level that was exceeded only 1% of the time
L_{10} - sound level that was exceeded only 10% of the time.
- Good measure of intermittent or intrusive noise
- Good measure of Traffic Noise

L_{50} - sound level that was exceeded 50% of the time (arithmetic average)
- Good to compare to L_{eq} to determine steadiness of noise

L_{90} - sound level that was exceeded 90% of the time
- Good indicator of typical "ambient" noise levels

L_{99} - sound level that was exceeded 99% of the time
L_{max} - maximum sound level measured

These descriptors can be used to provide a more detailed analysis of the varying noise climate:

- If there is a large difference between the L_{eq} and the L_{50} (L_{eq} can never be any lower than the L_{50}) then it can be surmised that one or more short duration, high level sound(s) occurred during the time period.
- If the gap between the L_{10} and L_{90} is relatively small (less than 15 – 20 dBA) then it can be surmised that the noise climate was relatively steady.

Sound Propagation

In order to understand sound propagation, the nature of the source must first be discussed. In general, there are three types of sources. These are known as ‘point’, ‘line’, and ‘area’. This discussion will concentrate on point and line sources since area sources are much more complex and can usually be approximated by point sources at large distances.

Point Source

As sound radiates from a point source, it dissipates through geometric spreading. The basic relationship between the sound levels at two distances from a point source is:

$$\therefore SPL_1 - SPL_2 = 20\log_{10}\left(\frac{r_2}{r_1}\right)$$

Where: SPL_1 = sound pressure level at location 1, SPL_2 = sound pressure level at location 2
r_1 = distance from source to location 1, r_2 = distance from source to location 2

Thus, the reduction in sound pressure level for a point source radiating in a free field is **6 dB per doubling of distance**. This relationship is independent of reflectivity factors provided they are always present. Note that this only considers geometric spreading and does not take into account atmospheric effects. Point sources still have some physical dimension associated with them, and typically do not radiate sound equally in all directions in all frequencies. The directionality of a source is also highly dependent on frequency. As frequency increases, directionality increases.

Examples (note no atmospheric absorption):

- A point source measuring 50 dB at 100m will be 44 dB at 200m.
- A point source measuring 50 dB at 100m will be 40.5 dB at 300m.
- A point source measuring 50 dB at 100m will be 38 dB at 400m.
- A point source measuring 50 dB at 100m will be 30 dB at 1000m.

Line Source

A line source is similar to a point source in that it dissipates through geometric spreading. The difference is that a line source is equivalent to a long line of many point sources. The basic relationship between the sound levels at two distances from a line source is:

$$SPL_1 - SPL_2 = 10\log_{10}\left(\frac{r_2}{r_1}\right)$$

The difference from the point source is that the ‘20’ term in front of the ‘log’ is now only 10. Thus, the reduction in sound pressure level for a line source radiating in a free field is **3 dB per doubling of distance**.

Examples (note no atmospheric absorption):

- A line source measuring 50 dB at 100m will be 47 dB at 200m.
- A line source measuring 50 dB at 100m will be 45 dB at 300m.
- A line source measuring 50 dB at 100m will be 44 dB at 400m.
- A line source measuring 50 dB at 100m will be 40 dB at 1000m.

Atmospheric Absorption

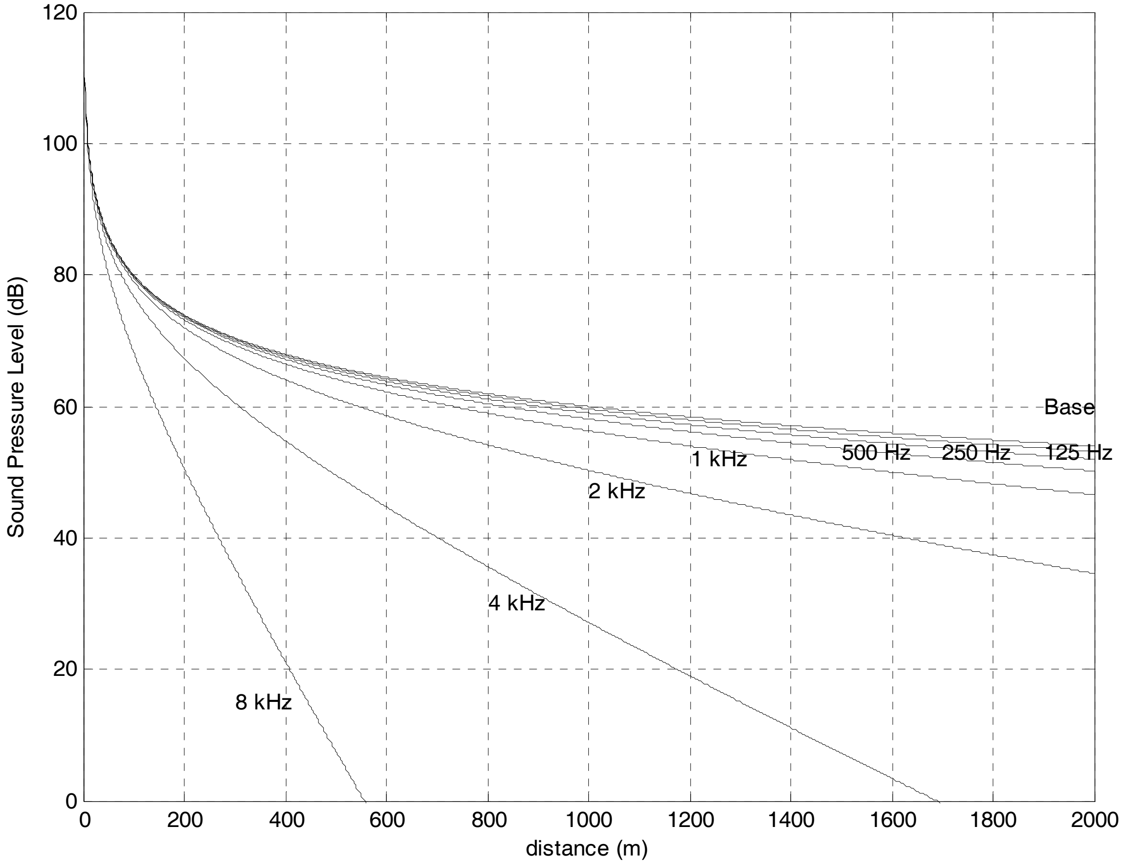
As sound transmits through a medium, there is an attenuation (or dissipation of acoustic energy) which can be attributed to three mechanisms:

1) **Viscous Effects** - Dissipation of acoustic energy due to fluid friction which results in thermodynamically irreversible propagation of sound.
2) **Heat Conduction Effects** - Heat transfer between high and low temperature regions in the wave which result in non-adiabatic propagation of the sound.
3) **Inter Molecular Energy Interchanges** - Molecular energy relaxation effects which result in a time lag between changes in translational kinetic energy and the energy associated with rotation and vibration of the molecules.

The following table illustrates the attenuation coefficient of sound at standard pressure (101.325 kPa) in units of dB/100m.

Temperature °C	Relative Humidity (%)	Frequency (Hz) 125	250	500	1000	2000	4000
30	20	0.06	0.18	0.37	0.64	1.40	4.40
	50	0.03	0.10	0.33	0.75	1.30	2.50
	90	0.02	0.06	0.24	0.70	1.50	2.60
20	20	0.07	0.15	0.27	0.62	1.90	6.70
	50	0.04	0.12	0.28	0.50	1.00	2.80
	90	0.02	0.08	0.26	0.56	0.99	2.10
10	20	0.06	0.11	0.29	0.94	3.20	9.00
	50	0.04	0.11	0.20	0.41	1.20	4.20
	90	0.03	0.10	0.21	0.38	0.81	2.50
0	20	0.05	0.15	0.50	1.60	3.70	5.70
	50	0.04	0.08	0.19	0.60	2.10	6.70
	90	0.03	0.08	0.15	0.36	1.10	4.10

- As frequency increases, absorption tends to increase
- As Relative Humidity increases, absorption tends to decrease
- There is no direct relationship between absorption and temperature
- **The net result of atmospheric absorption is to modify the sound propagation of a point source from 6 dB/doubling-of-distance to approximately 7 – 8 dB/doubling-of-distance (based on anecdotal experience)**



Atmospheric Absorption at 10°C and 70% RH

Meteorological Effects

There are many meteorological factors which can affect how sound propagates over large distances. These various phenomena must be considered when trying to determine the relative impact of a noise source either after installation or during the design stage.

Wind

- Can greatly alter the noise climate away from a source depending on direction
- Sound levels downwind from a source can be increased due to refraction of sound back down towards the surface. This is due to the generally higher velocities as altitude increases.
- Sound levels upwind from a source can be decreased due to a "bending" of the sound away from the earth's surface.
- Sound level differences of ±10dB are possible depending on severity of wind and distance from source.
- Sound levels crosswind are generally not disturbed by an appreciable amount
- Wind tends to generate its own noise, however, and can provide a high degree of masking relative to a noise source of particular interest.

Temperature

- Temperature effects can be similar to wind effects
- Typically, the temperature is warmer at ground level than it is at higher elevations.
- If there is a very large difference between the ground temperature (very warm) and the air aloft (only a few hundred meters) then the transmitted sound refracts upward due to the changing speed of sound.
- If the air aloft is warmer than the ground temperature (known as an *inversion*) the resulting higher speed of sound aloft tends to refract the transmitted sound back down towards the ground. This essentially works on Snell's law of reflection and refraction.
- Temperature inversions typically happen early in the morning and are most common over large bodies of water or across river valleys.
- Sound level differences of ±10dB are possible depending on gradient of temperature and distance from source.

Rain

- Rain does not affect sound propagation by an appreciable amount unless it is very heavy
- The larger concern is the noise generated by the rain itself. A heavy rain striking the ground can cause a significant amount of highly broadband noise. The amount of noise generated is difficult to predict.
- Rain can also affect the output of various noise sources such as vehicle traffic.

Summary

- In general, these wind and temperature effects are difficult to predict
- Empirical models (based on measured data) have been generated to attempt to account for these effects.
- Environmental noise measurements must be conducted with these effects in mind. Sometimes it is desired to have completely calm conditions, other times a "worst case" of downwind noise levels are desired.

Topographical Effects

Similar to the various atmospheric effects outlined in the previous section, the effect of various geographical and vegetative factors must also be considered when examining the propagation of noise over large distances.

Topography

- One of the most important factors in sound propagation.
- Can provide a natural barrier between source and receiver (i.e. if berm or hill in between).
- Can provide a natural amplifier between source and receiver (i.e. large valley in between or hard reflective surface in between).
- Must look at location of topographical features relative to source and receiver to determine importance (i.e. small berm 1km away from source and 1km away from receiver will make negligible impact).

Grass

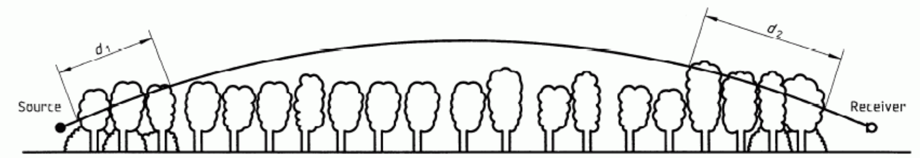
- Can be an effective absorber due to large area covered
- Only effective at low height above ground. Does not affect sound transmitted direct from source to receiver if there is line of sight.
- Typically less absorption than atmospheric absorption when there is line of sight.
- Approximate rule of thumb based on empirical data is:

$$A_g = 18\log_{10}(f) - 31 \qquad (dB/100m)$$

Where: A_g is the absorption amount

Trees

- Provide absorption due to foliage
- Deciduous trees are essentially ineffective in the winter
- Absorption depends heavily on density and height of trees
- No data found on absorption of various kinds of trees
- Large spans of trees are required to obtain even minor amounts of sound reduction
- In many cases, trees can provide an effective visual barrier, even if the noise attenuation is negligible.



NOTE — $d_f = d_1 + d_2$

For calculating d_1 and d_2, the curved path radius may be assumed to be 5 km.

Figure A.1 — Attenuation due to propagation through foliage increases linearly with propagation distance d_f through the foliage

Table A.1 — Attenuation of an octave band of noise due to propagation a distance d_f through dense foliage

Propagation distance d_f m	Nominal midband frequency Hz 63	125	250	500	1 000	2 000	4 000	8 000
$10 \le d_f \le 20$	Attenuation, dB: 0	0	1	1	1	1	2	3
$20 \le d_f \le 200$	Attenuation, dB/m: 0,02	0,03	0,04	0,05	0,06	0,08	0,09	0,12

Tree/Foliage attenuation from ISO 9613-2:1996

Bodies of Water

- Large bodies of water can provide the opposite effect to grass and trees.
- Reflections caused by small incidence angles (grazing) can result in larger sound levels at great distances (increased reflectivity, Q).
- Typically air temperatures are warmer high aloft since air temperatures near water surface tend to be more constant. Result is a high probability of temperature inversion.
- Sound levels can “carry” much further.

Snow

- Covers the ground for much of the year in northern climates.
- Can act as an absorber or reflector (and varying degrees in between).
- Freshly fallen snow can be quite absorptive.
- Snow which has been sitting for a while and hard packed due to wind can be quite reflective.
- Falling snow can be more absorptive than rain, but does not tend to produce its own noise.
- Snow can cover grass which might have provided some means of absorption.
- Typically sound propagates with less impedance in winter due to hard snow on ground and no foliage on trees/shrubs.

Appendix III

SOUND LEVELS OF FAMILIAR NOISE SOURCES

Used with Permission Obtained from ERCB Directive 038 (2007)

Source[1]	Sound Level (dBA)
Bedroom of a country home	30
Soft whisper at 1.5 m	30
Quiet office or living room	40
Moderate rainfall	50
Inside average urban home	50
Quiet street	50
Normal conversation at 1 m	60
Noisy office	60
Noisy restaurant	70
Highway traffic at 15 m	75
Loud singing at 1 m	75
Tractor at 15 m	78-95
Busy traffic intersection	80
Electric typewriter	80
Bus or heavy truck at 15 m	88-94
Jackhammer	88-98
Loud shout	90
Freight train at 15 m	95
Modified motorcycle	95
Jet taking off at 600 m	100
Amplified rock music	110
Jet taking off at 60 m	120
Air-raid siren	130

[1] Cottrell, Tom, 1980, *Noise in Alberta*, Table 1, p.8, ECA80 - 16/1B4 (Edmonton: Environment Council of Alberta).

SOUND LEVELS GENERATED BY COMMON APPLIANCES

Used with Permission Obtained from ERCB Directive 038 (2007)

Source[1]	Sound level at 3 feet (dBA)
Freezer	38-45
Refrigerator	34-53
Electric heater	47
Hair clipper	50
Electric toothbrush	48-57
Humidifier	41-54
Clothes dryer	51-65
Air conditioner	50-67
Electric shaver	47-68
Water faucet	62
Hair dryer	58-64
Clothes washer	48-73
Dishwasher	59-71
Electric can opener	60-70
Food mixer	59-75
Electric knife	65-75
Electric knife sharpener	72
Sewing machine	70-74
Vacuum cleaner	65-80
Food blender	65-85
Coffee mill	75-79
Food waste disposer	69-90
Edger and trimmer	81
Home shop tools	64-95
Hedge clippers	85
Electric lawn mower	80-90

[1] Reif, Z. F., and Vermeulen, P. J., 1979, "Noise from domestic appliances, construction, and industry," Table 1, p.166, in Jones, H. W., ed., *Noise in the Human Environment*, vol. 2, ECA79-SP/1 (Edmonton: Environment Council of Alberta).

Appendix IV

NOISE IMPACT ASSESSMENT

Licensee: **Sunshine Oilsands Ltd.**

Facility name: **West Ells SAGD Project** Type: **Steam Assisted Gravity Drain Oil Extraction**

Legal location: **LSD 11-31-99-18-W4M**

Contact: **Kim Young (Millennium EMS Solutions)** Telephone: **(780) 496-9048**

1. Permissible Sound Level (PSL) Determination (*Directive 038,* Section 2.1)

(Note that the PSL for a pre-1988 facility undergoing modifications may be the sound pressure level (SPL) that currently exists at the residence if no complaint exists and the current SPL exceeds the calculated PSL from Section 2.1.)

Complete the following for the nearest or most impacted residence(s):

Distance from facility	Direction from facility	BSL (dBA)	Daytime adjustment (dBA)	Class A adjustment (dBA)	Class B adjustment (dBA)	Nighttime PSL (dBA)	Daytime PSL(dBA)
1500m	All Directions	40	10	0	0	40	50

2. Sound Source Identification

For the new and existing equipment, identify major sources of noise from the facility, their associated sound power level (PWL) or sound pressure level (SPL), the distance (far or free field) at which it was calculated or measured, and whether the sound data are from vendors, field measurement, theoretical estimates, etc.

New Equipment	Predicted: X PWL (dBA) X SPL (dBA) OR Measured: X PWL (dBA) X SPL (dBA)	Data source	Distance calculated or measured (m)
Listed in Appendix I		**Measurements / Calculations**	

Existing Equipment/Facility	Predicted: X PWL (dBA) X SPL (dBA) OR Measured: X PWL (dBA) X SPL (dBA)	Data source	Distance calculated or measured (m)
None			

acoustical consultants inc

3. Operating Conditions

When using manufacturer's data for expected performance, it may be necessary to modify the data to account for actual operating conditions (for example, indicate conditions such as operating with window/doors open or closed). Describe any considerations and assumptions used in conducting engineering estimates:

Equipment assumed to be operating at all times at maximum capacity

4. Modelling Parameters

If modelling was conducted, identify the parameters used (see Section 3.5.1):

- **Ground absorption 0.6, Temperature 10^{0}C, Relative Humitidy 70%**
- **All receptors downwind, Following ISO 9613**
- **Included ambient sound level of 35 dBA in calculations**

5. Predicted Sound Level/Compliance Determination

Identify the predicted overall (cumulative) sound level at the nearest of most impacted residence. Typically, only the nighttime sound level is necessary, as levels do not often change from daytime to nighttime. However, if there are differences between day and night operations, both levels must be calculated.

Predicted sound level to the nearest or most impacted residence from new facility (including any existing facilities):

39.4 dBA (night) Permissible sound level: **40 dBA (night)**

If applicable: **39.4** dBA (day) Permissible sound level: **50 dBA (day)**

Is the predicted sound level less than the permissible sound level? **YES** If **YES**, go to number 7

6. Compliance Determination/Attenuation Measures

(a) If 5 is **NO**, identify the noise attenuation measures the licensee is committing to:
N/A

Predicted sound level to the nearest or most impacted residence from the facility (**with** noise attenuation measures):

N/A dBA (night); if applicable: **N/A dBA (day)**

Is the predicted sound level less than the permissible sound level? **YES** If **YES**, go to number 7
(b) If 6 (a) is **NO** or the licensee is not committing to any noise attenuation measures, the facility is not in compliance. If further attenuation measures are not practical, provide the reasons why the measures proposed to reduce the impacts are not practical.
Note: If 6 (a) is NO, the Noise Impact Assessment must be included with the application filed as non-routine.

7. Explain what measures have been taken to address construction noise.

Limiting construction to day-time hours only (07:00 – 22:00)

Advising nearby residents of significant noise sources and appropriately scheduling

Mufflers on all internal combustion engines

Taking advantage of acoustical screening

Limiting vehicle access during night-time

8. Analyst's Name : Steven Bilawchuk, M.Sc., P.Eng.

Company: **ACI Acoustical Consultants Inc.**

Title: **Director**

Telephone: **(780) 414-6373** Date: **November 30, 2008**

West Ells SAGD Project

Baseline Soil Survey and Terrain Assessment

Prepared for:

Sunshine Oilsands Ltd.

Prepared by:

Millennium EMS Solutions Ltd.
#208, 4207 – 98 Street
Edmonton, Alberta
T6E 5R7

November 2008

File # 08-015

Table of Contents

Page

Table of Contents ... i
List of Tables ... ii
List of Figures ... iii
List of Appendices ... iii

1.0 INTRODUCTION ... 1
2.0 STUDY AREA AND LOCAL SETTING ... 1
2.1 Study Areas ... 1
2.1.1 Proposed SAGD Footprint and SAGD LSA ... 2
2.1.2 Access Road Footprint and Access Road LSA ... 2
2.2 Local Setting ... 3
2.2.1 Landforms and Terrain ... 3
2.2.2 Site Physiography ... 3
3.0 BASELINE SOIL MAPPING ... 4
3.1 Soil Investigation Methods ... 4
3.1.1 Survey Design – Intensity Levels ... 4
3.1.2 Field Investigation Methods ... 4
3.1.2.1 Site Characteristics ... 5
3.1.2.2 Soil Profile Characteristics ... 5
3.1.3 Soil Sampling ... 5
3.1.4 Laboratory Methods ... 6
3.1.5 Data Analysis and Mapping Methods ... 6
3.2 Classification – Soil Series and Variants ... 7
3.3 Terrain Type Classification ... 12
3.4 The Soil Map Unit Symbol ... 12
3.5 Soil Map Units of the Project ... 14
3.6 Soil Map Unit Areas ... 16
4.0 BASELINE SOIL DATA, INTERPRETATIONS, AND RATINGS ... 18
4.1 Thickness of Soil Layers – Baseline Soil Evaluation ... 19
4.2 Forest Soil Capability Classification ... 20
4.2.1 Baseline Forest Soil Capability Classification ... 20
4.2.2 Reclaimed Forest Soil Capability Classification ... 24
4.3 Reclamation Suitability ... 26
4.4 Baseline Erosion Risk Assessment ... 29
5.0 POTENTIAL IMPACTS ... 30
5.1 Loss of Diversity ... 30

5.2 Admixing of Soil 30
5.3 Reclamation and Land Capability 31
5.4 Erosion of Reclaimed Soils 33

6.0 MITIGATION AND MONITORING 33

7.0 REFERENCES 35

List of Tables

Page

Table 1 Description of representative soil parent materials of the SAGD LSA and Access Road LSA 9
Table 2 Major soil series and variants in the SAGD LSA and Access Road LSA 10
Table 3 Summary of terrain type (landscape model) features in the SAGD LSA and Access Road LSA 12
Table 4 Descriptive summary of soil map units of the SGD LSA and Access Road LSA 14
Table 5 Soil map unit areas for the SAGD LSA and Phase 1 Footprint 17
Table 6 Soil map unit areas for the Access Road LSA and Access Road Footprint 18
Table 7 Surface litter, peat, topsoil, and subsoil thicknesses by Soil Model – SAGD LSA and Access Road LSA inclusive 20
Table 8 Baseline forest land capability ratings by Soil Model – SAGD LSA and Access Road LSA inclusive 22
Table 9 Extent of land capability in the SAGD LSA and Phase 1 Footprint 23
Table 10 Extent of land capability in the Access Road LSA and Access Road Footprint 23
Table 11 Predicted Reclaimed & Baseline Land Capability ratings for Soil Models of the SAGD LSA and Access Road LSA 25
Table 12 Reclamation suitability ratings for soil materials in the LSAs 28
Table 13 Comparison of the baseline and reclaimed forest land capability ratings for the Phase 1 Footprint 31
Table 14 Comparison of the baseline and reclaimed forest land capability ratings for the Access Road Footprint 32

List of Figures

Figure 1	Regional Location of the Project
Figure 2	Study Areas – SAGD LSA and Access Road LSA
Figure 3	Proposed SAGD and Access Road Footprints
Figure 4	Soil Inspection Locations within the SAGD LSA and Access Road LSA
Figures 5a–5c	Baseline Soil Map of the SAGD LSA and Access Road LSA
Figure 6	Soil Layer Thicknesses per Map Unit within the SAGD LSA and Access Road LSA
Figure 7	Forest Land Capability Ratings per Map Unit within the SAGD LSA and Access Road LSA
Figure 8a	Reclamation Suitability Ratings per Map Unit within the SAGD LSA and Access Road LSA – Topsoil
Figure 8b	Reclamation Suitability Ratings per Map Unit within the SAGD LSA and Access Road LSA – Upper Subsoil

List of Appendices

Appendix A	Figures and Maps
Appendix B	Soil Classification Methodology
Appendix C	Description of Soil Map Units
Appendix D	Soil Series/Variant Descriptions
Appendix E	Land Capability Classification and Reclamation Suitability Calculation Methodologies
Appendix F	Land Capability Classification Summary Tables – Baseline and Reclaimed

1.0 INTRODUCTION

Millennium EMS Solutions Ltd. (MEMS) was retained by Sunshine Oilsands Ltd. (Sunshine) to collect baseline soil and terrain information for the West Ells Steam Assisted Gravity Drainage (SAGD) Project ("the Project").

Objectives of the baseline soil survey were to:

- Produce a pre-disturbance soil inventory of the Project areas based on acceptable levels of soil survey data collection, i.e. Survey Intensity Level 2 (SIL 2) for the local study areas (LSA) and SIL 1 for the proposed disturbance areas, which are detailed in Section 2.1.
- Provide soil inventory information (i.e. baseline soil and topographic/landscape patterns) to determine current baseline conditions and assist with preparation of a conceptual reclamation plan for the Project.

This report details soil data collection, mapping, interpretation, and examines baseline soil conditions in relation to the following soils ratings and suitability documents:

- Forested land capability - Land Capability Classification System for Forest Ecosystems in the Oil Sands (Cumulative Environmental Management Association (CEMA) 2006);
- Reclamation suitability – Soil quality criteria relative to disturbance and reclamation (SQCWG 1987); and
- Soil erosion (wind and/or water) – water erosion potential of soils in Alberta (Tajek et al. 1985); wind erosion risk, Alberta (Coote and Pettapiece 1989); and soil series information for reclamation planning in Alberta (Pedocan 1993).

Based on the interpretation of the baseline data, an evaluation of the potential impacts to the soil resource as a result of the Project is discussed. General mitigation and monitoring activities to reduce the potential impacts are also outlined, and the potential effects to the soil resource are assessed after the implementation of site-specific mitigation. Detailed information regarding the soils handling, storage, reclamation and site mitigation and monitoring are provided in the Conservation and Reclamation Plan (C&R) (MEMS 2008).

2.0 STUDY AREA AND LOCAL SETTING

2.1 Study Areas

The Project is located in the West Ells area, approximately 60 km west of Fort McKay in north-eastern Alberta (Figure 1). Sunshine's bitumen resources in the West Ells area are located in Townships 94 and 95, Ranges 17 and 18 W4M approximately 90 km northwest of the Fort McMurray Urban Service Area in north-eastern Alberta. The investigation of the soil resource for the Project includes the assessment of two distinct study areas; the SAGD LSA and corresponding Access Road LSA. Details of the study areas and proposed footprints within each study area are detailed below.

2.1.1 Proposed SAGD Footprint and SAGD LSA

The proposed SAGD Project footprint ("SAGD footprint") includes all lands subject to direct disturbance from Phase 1 of the SAGD Project within Sections 30 and 31, Township 94, Range 17, West of the 4th Meridian. The footprint associated with Phase 1 of the SAGD development is approximately 60.7 ha and consists of the following components:

- Plant Site – 29.3 ha;
- North Pad – 4.9 ha;
- South Pad – 4.4 ha;
- Construction Camp – 4.9 ha;
- Operator's Camp – 2.9 ha;
- Supervisor's Camp 1.2 ha;
- Utility Corridor – 4.2 ha; and
- Borrow Pit #1 – 8.9 ha (Figure 3).

The SAGD LSA for the baseline assessment included 2,359 hectares (ha) of land surrounding the SAGD Phase 1 footprint. The SAGD LSA is located within the following Sections:

- 30, 31, 32 and 33, Township 94, Range 17, West of the 4th Meridian;
- 25 and 36, Township 94, Range 18, West of the 4th Meridian; and
- 3, 4 and 5, Township 95, Range 17 West of the 4th Meridian (Figure 2).

2.1.2 Access Road Footprint and Access Road LSA

The SAGD Project will require supporting infrastructure, which includes a proposed 9 km access road that will potentially impact an additional 67.8 ha and stretch south from Borrow Pit #1 and join the proposed Athabasca Oil sands Corporation (AOSC) Dover Project (Figure 3). The access road footprint is located in Sections 6, 7, 18, 19, and 30 Township 94, Range 17, West of the 4th Meridian. The access road includes the following components:

- Four Borrow Pits (pits # 2, 3, 4, and 5); and
- An access road Right of Way (RoW), approximately 9 km by 50 m.

The access road LSA is defined as a 500 m buffer surrounding the access road footprint, totalling 947.2 ha of land (Figure 2).

2.2 Local Setting

2.2.1 Landforms and Terrain

The SAGD and access road LSAs (the "study areas") are located in the north-eastern portion of the province on the LaBiche Formation, which is typically dark grey shale and silty shale; ironstone partings and concretions with silty fish-scale bearing beds in the lower parts; and is marine in nature (Hamilton et al. 1999).

The study areas are located on a variety of surficial parent material deposits. These include a Morainal-Horse River till; glaciofluvial outwash deposits of variable thickness (veneer to blanket) and textures overlying morainal till; and organic peat deposits located on nearly level terrain (Turchenek and Lindsay 1982a). Pockets of glaciolacustrine deposits are located throughout the study areas and are comprised of bedded silts and clays (Turchenek and Lindsay 1982a).

The topography in the study areas consists of gentle to moderate slopes (2-15%) on undulating to hummocky landforms. Areas of nearly level to level (0-2% slopes) terrain occur in drainage basins and adjacent to organic deposits. Hummocky to ridged landforms (10-15% slope) occur adjacent to the water bodies located in the study areas and are typically orientated east to west. Within the access road LSA, heading south, the landforms become more subdued with lower slopes and increased peat deposits.

The complexity of the morainal and undulating landforms lead to depressional and channelled transitional terrain where bog and fen organic communities occupy significant portions of the topography. Wetland areas are composed of shallow to moderately thick organic deposits (< 2.0 m) and are level to nearly level (slope gradients of 0-2%). Based on inspection site evidence, the peat is commonly underlain by glacial till although thin layers of glaciolacustrine clays, silty clays and/or medium to coarse textured glaciofluvial materials may overlie the till within the areas of organic landforms.

2.2.2 Site Physiography

The study areas straddle the Boreal Highland and the Peace River Lowland Ecoregions. The Boreal Highlands are dominated by rolling ground moraine and hummocky moraine on uplands, with organic deposits with steep sided hills and plateaus. While the Peace River Lowlands are dominated by fluvial landforms, including large deltas and limited areas of subdued till deposits. The access road LSA is located entirely in the Peace River Lowlands.

The Highlands consist of Gray Luvisols and Eutric/Dystric Brunisols while the Lowlands consist of mainly Gray Luvisols (ESWG 1995). Organic and wet transitional soils (Gleysols) soils do occur in the depressional areas and drain ways associated with hummocky and undulating terrain.

3.0 BASELINE SOIL MAPPING

This section provides information on the baseline soil survey of the LSAs, including:

- methods of soil investigation including field, laboratory, data analysis, and mapping;
- description of major soil series and variants – taxonomic entities that define the types of soils; and
- description and selection of soil map units.

The following discussions in Section 3 are inclusive of the SAGD LSA and access road LSA as all of the processes and methodologies implied to complete the baseline study are identical for both study areas.

3.1 Soil Investigation Methods

3.1.1 Survey Design – Intensity Levels

Initially, baseline soil data for the SAGD LSA was collected in June 2008. Site and soil data from 183 inspection sites were recorded and a total of 16 locations were sampled for analysis. The target survey intensity for the SAGD LSA was a Survey Intensity Level 2 (SIL 2). The acceptable range for an SIL 2 baseline soil survey is one inspection per 5 to 15 ha (MSWG 1981). The intensity achieved was approximately one inspection per 12.9 ha (183 sites over 2,359 ha), which is adequate for baseline soil mapping at a 1:15,000 production scale.

In October 2008 an additional 77 inspection sites and 11 sample locations were collected to attain an SIL 1 on the SAGD Phase 1 footprint and access road footprint. The acceptable range for an SIL 1 baseline soil survey is one inspection per 1 to 5 ha (MSWG 1981). Based on the June and October 2008 surveys, a total of 260 site inspections were completed in the area, of which 77 inspection sites were completed within the SAGD Phase 1 footprint and a total of 49 inspection sites along the access road footprint (i.e. 50 m wide RoW). This corresponds to an SIL of 1.0 and 1.4 inspections per ha for each footprint, respectively. This intensity level is sufficient for mapping at the 1:15,000 production scale. Figure 4 displays the inspection sites completed in the two study areas.

3.1.2 Field Investigation Methods

Site and soil characteristics were observed and recorded on field forms, following accepted guidelines and classification systems (Expert Committee on Soil Survey [ECSS] 1983, Soil Classification Working Group [SCWG] 1998).

3.1.2.1 Site Characteristics

Various site characteristics were documented at each inspection location to facilitate a better understanding of soil distribution, and corresponding landscape and vegetation relationships, throughout the study areas.

Site characteristics recorded at each inspection site included:

- surficial (parent) material type and grouping as per Agricultural Region of Alberta Soil Inventory Database, Version 3.0 (AGRASID 3.0, ASIC 2001);
- slope gradient, aspect, and position;
- surface stoniness;
- soil drainage and depth to apparent water table; and
- general vegetation including main tree and understory species.

Global positioning system (GPS) coordinates (UTM/NAD83) were captured by hand-held GPS units and transferred to the soil-site database.

3.1.2.2 Soil Profile Characteristics

At each inspection site the soil profile was investigated to a depth of approximately 100 cm for upland soils, while Organic soils were investigated to mineral contact or a maximum depth of 220 cm. A spade and 5-cm Dutch auger were used to investigate the soils to the appropriate depths.

Documented soil profile characteristics included:

- horizon types;
- horizon depths;
- soil texture by manual (field) tests;
- structure and consistence;
- colour (Munsell soil colour) for selected horizons/profiles;
- presence of mottles, including appropriate mottle descriptors, and in some cases colour;
- presence or lack of carbonates, using a 10% hydrochloric acid (HCl) solution; and
- other pertinent horizon or parent material features as required to aid in soil classification and/or description (i.e. unique soil attributes).

3.1.3 Soil Sampling

Soil horizons at 27 locations were analyzed, of which 16 were from the SAGD LSA and 14 from the access road LSA (three locations are in both study areas due to overlapping study areas). This number of samples provided good representation of most Organic, Brunisolic, Luvisolic and Gleysolic soils found in the LSAs and associated footprints.

Approximately 1 kg of soil from each horizon, excluding very thin (i.e. <2 cm thick) and discontinuous horizons, was collected in a labelled plastic bag, and then sealed for transport to the laboratory.

Laboratory results for all samples were used to characterize the soils of the study areas. Summary descriptions of the major soil series and variants found in the SAGD and access road LSAs, along with chemical and physical attributes amalgamated from sampled profiles, are provided in Appendix D. Data from the Alberta Soil Layer File ((AG30SLF), ASIC 2001), and the Alberta Oil Sands region (Turchenek and Lindsay 1982b) were also consulted for comparison of data sets and consistency. The amalgamated chemical and physical data were used to calculate the baseline forest capability ratings and reclamation suitability of the soils in the study areas.

3.1.4 Laboratory Methods

Soil samples were stored in coolers and delivered to an approved laboratory within a few days of sampling. Methods used were cross-referenced with acceptable analytical methods outlined in the *Land capability classification system for forest ecosystems in the Oil Sands* (CEMA 2006) and *Quality criteria relative to disturbance and reclamation* (SQCWG 1987). Results are summarized in Appendix D.

3.1.5 Data Analysis and Mapping Methods

All data was entered into an MS Access database designed for baseline soil surveys. The database was used to filter and query the soil data to establish trends and patterns. This was used as a tool to assist in determining soil map units and landscape models and baseline characteristics within the LSAs (i.e. soil horizon thickness).

In addition to the database, a variety of tools were used collectively to develop the soil map. These tools included:

- 1:40,000 satellite image of the study area, enlarged to 1:10,000;
- cursory Alberta Vegetation Inventory (AVI) data of the study areas;
- ecosite phase data provided by Geographic Dynamics Corporation as part of the West Ells baseline investigation (GDC 2008);
- Alberta Soil Name (AG30SNF) and Layer files (AG30SLF) from AGRASID (ASIC 2001, Brierley et al. 2006);
- PurVIEW™ softcopy mapping software coupled with a geographic information system (ArcView GIS™);

- the mappers' knowledge of soil patterns in the survey area and similar areas; and
- soil data available from other baseline soil surveys from within the region.

Enlarged laser prints of satellite imagery were used during the field portion of the survey to plan field survey activities, estimate the potential aerial extent of soils, and plot inspection sites during the survey. Mapping was conducted by using GIS applications to overlay ecosite phase data, AVI data, and soil inspection information onto an on-screen 3D image of the area of interest. Soil polygons were then drawn on the image based on similarities between landscapes, associated vegetation types, and soil profile data.

Based on the production scale, soil-landscape patterns (i.e. possible polygons) smaller than 1.5 ha in size that were not highly contrasting were not delineated.

3.2 Classification – Soil Series and Variants

Prior to creating soil map units, the soil population of the SAGD and access road LSAs was analyzed to understand the relationship between soil types and vegetation and terrain patterns and how each soil type (based on internal drainage, horizon orientation, and textures) fits into the landscape.

Soil classification to the series level (required for mapping) involved three steps:

- classification of each profile (inspection site) to the soil subgroup level (SCWG 1998) based on morphological features (e.g. types and arrangement of identified horizons, degree of gleying presence and/or thickness of organic layers, etc.);
- classification of soil parent materials according to mode of deposition plus textural characteristics (i.e. coarse textured material over medium textured till); and
- merging the two classifications to define soil series level taxa based on the AGRASID name file; (ASIC 2001, Brierley et al. 2006). Soil names were derived from Soil Correlation Area (SCA) 20, in which the LSAs occur.

Soil Subgroup Classification

All soil inspection sites were reviewed in the database and field level classification to the subgroup was either confirmed or updated based on the guidelines in the Canadian System of Soil Classification (SCWG 1998).

Soil Parent Material Classification

Assigning parent material groupings to soil inspection sites is required in order to classify a soil subgroup to the series level. A review of all inspection sites was conducted in order to evaluate layering (i.e. layered parent materials), thickness of layers, textures, coarse fragment content, and other morphological information. A set of general guidelines was followed in order to perform the assessment:

- Horizon sequence and textural data were scanned to determine if a significant parent material discontinuity (e.g. an overlay) occurred within the profile.
- If textural discontinuities were noted, thickness of the upper material became a factor in the assessment (the layer must be at 30 cm thick) (Note: for applying a group "L" code; refer to Appendix B, Table B-1).
- Textural variation resulting from soil development, e.g. finer textured illuvial (Bt) and coarser textured eluvial (Ae) horizons, were downgraded in the assessment process.

Chemical characteristics of parent materials, namely calcareousness and salinity, are also important to soil development, and hence to their taxonomy. Most parent materials within the study areas are moderately to slightly calcareous; and slightly to moderately alkaline. Table 1 briefly describes the most common parent materials within the area.

Table 1 Description of representative soil parent materials of the SAGD LSA and Access Road LSA

PM Group and Type	Physical Features	Chemical Features
C2 coarse textured, water-laid (fluvial or glaciofluvial)	Coarse textured (SL, LS, and S) material; typically <5% coarse fragments	Non - calcareous, non - saline material
C3 moderately coarse textured, water-laid (fluvial or glaciofluvial)	Moderately coarse textured (SL) material; typically <5% coarse fragments	Non - calcareous, non - saline material
F1/F3 fine textured water laid sediments, in some instances till like features	Fine textured (C, and SiC) materials, water laid, and in some cases displaying till like features (F3)	Non - to slightly calcareous, non - saline material
L2 coarse textured materials (non-till) overlying glacial till	Thin (30-99 cm), coarse textured (SL, LS, S) sediments overlying medium to moderately fine textured till	Non - calcareous, non - saline, material
L3 medium textured materials (non-till) overlying glacial till	Thin (30-99 cm), medium textured (L, SiL, SCL, CL) sediments overlying medium to moderately fine textured till	Non - to slightly calcareous, non - saline medium textured material over glacial till
L11 peat material (>40 cm) overlying coarse textured materials	Peat material (> 40 cm) overlying coarse textured (SL, LS, and S) textured mineral material	Peat over non - calcareous, non - saline material
L12 peat material (>40 cm) overlying medium textured materials	Peat material (> 40 cm) overlying medium textured (L, SiL, SCL, CL) textured mineral material	Peat over non - to slightly calcareous, non - saline material
L13 peat material (>40 cm) overlying fine textured materials	Peat material (> 40 cm) overlying medium textured (CL, SiCL, and C) textured mineral material	Peat over non - to slightly calcareous, non - saline material
M2/M3 medium to moderately fine textured, water-laid sediments	Medium textured (L, SiL, FSL) to Moderately fine textured (CL, SiCL, SCL) sediments; <1% coarse fragments	Weakly to moderately calcareous, non - saline
M4 glacial till (Predominantly Horse River till)	Medium (L) to moderately fine (CL-SCL) textured; typically 2-10% coarse fragments	Weakly to moderately calcareous, non - saline
P1 Peat material > 100 cm thick	Bog peat material	Non - calcareous, non - saline

Appendix B provides additional information regarding methodologies for soil classification to the series level in Alberta.

Soil Variants

Soil variants define soil entities that are sufficiently different from established soil series to warrant recognition, but do not justify a new soil name due to limited geographic extent.

Table B-2 in Appendix B lists all variants and their codes used in Alberta. Variants are applied as two lower case letters after the series name. In total, 24 soil series and variants were identified within the LSAs. Table 2 lists the 24 series/variants and associated parent materials.

Table 2 Major soil series and variants in the SAGD LSA and Access Road LSA

Soil Series/Variant (Code)	Subgroup	Classification Notes	Parent Material
Bitumont (BMT)	Orthic Gleysol	Peaty (pt) variants common	Glaciofluvial outwash material (C2)
Chateh (CHT)	Orthic Gleysol	Peaty (pt) variants common, limited to access road LSA	Fine textured water laid materials (F1/F3)
Dover (DOV)	Orthic Gray Luvisol	Occurrence limited to south portion of access road LSA	Fine textured till like material (F3)
Dover – gleyed (DOVgl)	Gleyed Gray Luvisol	Occurrence limited to south portion of access road LSA	Fine textured till like material (F3)
Horse River (HRR)	Orthic Gray Luvisol	Occurs in upland terrain	Medium textured slightly to moderately calcareous t till (M4)
Horse River – gleyed (HRRgl)	Gleyed Gray Luvisol	Gleyed profile displays evidence of gleyed conditions	Medium textured slightly to moderately calcareous t till (M4)
Livock (LVK)	Orthic Gray Luvisol	Occurs in upland terrain	Medium textured glaciofluvial deposits (>30 cm thick) over Horse River till (L3)
Livock – gleyed (LVKgl)	Gleyed Gray Luvisol	Gleyed profile displays evidence of gleyed conditions	Medium textured glaciofluvial deposits (>30 cm thick) over Horse River till (L3)
Mariana (MRN1)	Terric Mesisol	Often mapped with peaty Gleysols, and map unit is displayed as MRN1-G	40 – 100 cm of bog peat over: • coarser textured mineral material (MRN1c - L11), • medium textured mineral material (MRN1m - L12) and • fine textured mineral material (MRN1f - L13)
Mildred (MIL)	Eluviated Eutric Brunisol	Occurs in sandy deposits and glaciofluvial blankets in upland terrain	Sandy glaciofluvial outwash material (C2)
Mildred – gleyed (MILgl)	Gleyed Eluviated Dystric Brunisol	Gleyed profile displays evidence of gleyed conditions	Sandy glaciofluvial outwash material (C2)
Mildred – fine (MILfi)	Eluviated Eutric Brunisol	Gleyed variation also recorded	Moderately coarse glaciofluvial material (C3)
Mikwa (MKW)	Mesic/Fibric Organic Cryosol	Ice typically encountered with 100 cm, in some instance between 100-130 cm	Bog Peat material, depth to mineral typically not known due to frozen layer

Table 2 Major soil series and variants in the SAGD LSA and Access Road LSA

Soil Series/Variant (Code)	Subgroup	Classification Notes	Parent Material
McLelland1* (MLD1)	Terric Mesisol	Very poorly drained, occur in fen landscapes	40-100 cm of fen peat over: • coarser textured mineral material (MLD1c - L11), • medium textured mineral material (MLD1m - L12) and • fine textured mineral material (MLD1f - L13)
McLelland2* (MLD2)	Terric or Typic Mesisol	Very poorly drained, occur in fen landscapes	100-200 cm of fen peat over: • coarser textured mineral material (MLD2c - L11), • medium textured mineral material (MLD2m - L12) and • fine textured mineral material (MLD2f - L13)
McLelland3* (MLD3)	Typic Mesisol	Very poorly drained, occur in fen landscapes	>200 cm of dominantly fen peat (P2)
Moonshine (MNSaa)	Orthic Luvic Gleysol	**aa** – Home SCA is 17, poorly drained, often associated with peaty variants (pt)	Medium textured slightly to moderately calcareous t till (M4)
Muskeg2* (MUS2)	Terric/Typic Mesisol (modal)	Poorly to very poorly drained	100-200 cm of bog peat over: • coarser textured mineral material (MUS2c - L11), • medium textured mineral material (MUS2m - L12) and • fine textured mineral material (MUS2f - L13)
Muskeg3* (MUS3)	Typic Mesisol (modal)	Poorly to very poorly drained	>200 cm of dominantly bog peat (P1)
Peavine (PEA)	Orthic Gray Luvisol	Sporadic throughout the study areas	Medium textured water laid materials (M2/M3)
Peavine – gleyed (PEAgl)	Gleyed Gray Luvisol	Sporadic throughout the study areas	Medium textured water laid materials (M2/M3)
Sutherland (SUT)	Eluviated Eutric Brunisol	A result of a thick coarse glaciofluvial veneer over till	Coarse glaciofluvial material over medium textured till (M4), till occurs relatively deep in the profile (>70 cm)
Wanham (WHMaa)	Orthic Luvic Gleysol	Common in drainage locations	Medium textured water laid materials (M2/M3)
Wanham peaty (WHMaapt)	Orthic Luvic Gleysol	Peaty variant very common, often associated with shallow organics	Medium textured water laid materials (M2/Me)

*Numerical identifier and lower case letter used to differentiate organic soil types indicates overall depth of peat plus general texture of underlying substratum (refer to Section 3.4), and are **not** soil series or variants as specified in the Alberta Soil Names File (ASIC 2001, Brierley et al. 2006).

3.3 Terrain Type Classification

During the soil investigation, thirteen terrain types, or landscape models (LMs) were recognized as being large enough to map at the 1:15,000 scale. They are differentiated by surface expression and slope. The thirteen terrain types encountered in the LSAs are summarized in Table 3.

Table 3 Summary of terrain type (landscape model) features in the SAGD LSA and Access Road LSA

Terrain Type	LM Symbol	Description (with Slope Classes)
Hummocky	H1l H1m	l. low relief, slope class 4 (5-10% slopes) m. moderate relief, slope class 5 (10-15% slopes)
Undulating	U1l U1h	l. low relief, slope classes 1-2 (0-2% slopes) h. high relief, slope class 3 (2-5% slopes)
Organic (Bog & Fen)	O1 O2 O3 O5	Organic (peat land) landforms may be dominated by bog or fen peat, and have the following general surface features: O1 - level, flat, horizontal, or plateau; nearly level landscapes O2 - basin or bowl; slope classes 1-3 (0-5% slopes on the edges of the basins) O3 - channelled, along stream channels; slope classes 1-2 (0-2% slopes) O5 - level with small, elevated knolls or hummocks; slope classes 1-2 (0-2% slopes), hummocks may have slopes ranging from 3-5 (5-15% slopes). Hummocks considered to be frozen peat mounds found in Cryosol landscapes
Level	L1	A level plain with little to no relief, slope class 1 (0-0.5% slopes)
Water bodies	ZWA	Open water bodies (i.e. lakes, sloughs, and ponds)
Disturbed Lands	ZDL	Lands previously disturbed by human activity, not recorded in the access corridor.

3.4 The Soil Map Unit Symbol

The soil map unit symbols utilized for the baseline soil map are based on the AGRASID 3.0, which displays a unique soil descriptor as well as a landscape descriptor. The soil descriptor or Soil Model is the numerator and the terrain descriptor the denominator. The Soil Model (numerator) is created by using one or two soil series symbols (e.g. HRR and LVK is displayed as HRLV) that are considered dominant or co-dominant in that particular polygon. Additionally a numbering system is applied (i.e. HRLV**9**) that identifies recognizable patterns of soils within a polygon. Due to the differences in soil patterns observed between organic and upland soils, unique Soil Models have been created to describe each.

Soil Numerator – Upland soil patterns are depicted with Soil Model symbols that use one or two soil series/variant codes for naming, plus a Soil Model number. Soil Model numbers identify recognizable patterns involving the dominant (60%) or co-dominant (30-60%) and significant (10-30%) soil types. Soil Model numbers are used in situations where soil entities other than the named series/variants are significant in a polygon. The following Soil Model numbers were adapted from AGRASID (ASIC 2001) and used in the baseline mapping of the study areas:

- **2** soil map unit features significant[1] soils that are poorly drained (i.e. Gleysols, gleyed variants, Organics).
- **5** soil map unit features significant[1] soils (estimated 10-30% coverage) that have a finer textured profile in comparison to the dominant or co-dominant soils.
- **9** soil map unit features significant[1] poorly drained soils and significant[1] soils that contain coarser textured profiles than the dominant or co-dominant soils.
- **18** soil map unit features significant[1] finer textured soil than the dominant soils, and significant[1] poorly drained soils (Gleysolic, gleyed, and/or Organic)
- **20** soil map unit features significant[1] freely or imperfectly drained soils where the dominant or co-dominant soil types are poorly drained.
- **21** soil map unit features significant[1] Organic soils in landscapes where the dominant or co-dominant soils are Gleysolic.

Organic Soil Numerator – Organic soil map units were identified somewhat differently than those dominated by upland soils. To simplify the complexity of peat-dominated areas with respect to peat composition and thickness, the soil series used were restricted to Marianna (MRN), McLelland (MLD) or Muskeg (MUS). MLD was used with fen ecosite types; MRN was used for shallow bog vegetation and MUS with deeper bog vegetation. The numerical portion of the map unit symbol indicates depth of peat as follows:

- **1** Average peat depth 40-100 cm
- **2** Average peat depth 100-200 cm
- **3** Average peat depth >200 cm

The lower case symbols “c – coarse”,”m - medium”, “f - fine” were used in all organic map units where mineral soil was encountered to describe the texture of the underlying mineral strata. In the LSAs, medium textures dominate; hence the symbol “m” was used most frequently.

Map units dominated by Organic soils, but containing significant peaty Gleysolic soils, were identified with a “-G” postscript in the symbol (i.e. MRN1m-G).

[1] Estimated 10-30% coverage

Denominator – All soil map units contained a landscape denominator. The thirteen terrain types deemed large enough to map at the production scale are described in Table 3.

3.5 Soil Map Units of the Project

Table 4 lists soil map units within the LSAs and provides a brief summary of features. More in-depth descriptions are provided in Appendix C. Figures 5a, 5b and 5c display the baseline soil map of the SAGD LSA and access road LSA, respectively.

Table 4 Descriptive summary of soil map units of the SGD LSA and Access Road LSA

Map Unit	Soil Patterns	Parent Material and Terrain
BMT21 **L1**	Dom.: Bitumont (BMT & BMTpt) – Orthic Gleysol Signif.: Mariana (MRN1s-G) – Terric Mesisols over coarse textured material Signif.: Moonshine (MNSaa) & Wanham (WHMaa) – Orthic Luvic Gleysols	• Moderately coarse to coarse glaciofluvial parent material (C2) • L1 – nearly level terrain • Potential exists for medium textured Gleysols (MNSaa & WHMaa) to occur along edges of this map unit
DOV9 **U1l**	Dom.: Dover (DOV) – Orthic Gray Luvisol Signif.: Algar Lake (ALG) – Orthic Luvic Gleysol and Chateh (CHT) – Orthic Gleysol Signif.: Livock (LVK) – Orthic Gray Luvisol and Peavine (PEA) – Orthic Gray Luvisol	• Fine textured lacustrotill (F3) with areas of fine textured water laid materials • U1l – low-relief undulating (1-2 % slopes)
HRLVgl2 **U1l**	Co-dom.: Horse River – gleyed (HRRgl) & Livock – gleyed (LVKgl) – Gleyed Gray Luvisols Signif.: Moonshine (MNSaa) & Wanham (WHMaa) – Orthic Luvic Gleysols	• Horse river till to surface (M4) or a thin medium to moderately coarse water laid veneer over till (L3) • U1l & U1h – low and high relief undulating (0-5 % slopes)
HRLV9 **U1l** **U1h** **H1l** **H1m**	Co-dom.: Horse River - (HRR) & Livock – (LVK) – Orthic Gray Luvisols Signif.: Moonshine (MNSaa) & Wanham (WHMaa) – Orthic Luvic Gleysols Signif.: Mildred (MIL & Sutherland (SUT) – Eluviated Dystric Brunisols	• Horse river till to surface (M4) or a thin medium to moderately coarse water laid veneer over till (L3) • Significant thick veneer to blanket deposits of coarse glaciofluvial deposits (C2) • Terrain ranges from U1l to H1m (1-15% slopes)
LVPE2 **U1h**	Co-dom.: Livock (LVK) and Peavine (PEA) – Orthic Gray Luvisols Signif.: Moonshine (MNSaa) & Wanham (WHMaa) – Orthic Luvic Gleysols	• Thin medium to moderately coarse water laid veneer over till (L3) and in some areas a blanket of medium textured water laid material (M2/M3) • Significant poorly drained soils in drain ways ,swales and edges of map units • U1h – high relief undulating (2-5% slopes)

Table 4 Descriptive summary of soil map units of the SGD LSA and Access Road LSA

Map Unit	Soil Patterns	Parent Material and Terrain
MISU18 **U1l** **U1h**	Co-dom: Mildred (MIL) & Sutherland (SUT) -- Eluviated Dystric Brunisols Signif: Livock (LVK) & Horse River (HRR)– Orthic Gray Luvisol Signif.: Wanham (WHMaa) – Orthic Luvic Gleysol and Bitumont (BMT) – Orthic Gleysol	• Moderately coarse to coarse glaciofluvial parent material (C2) • Significant till and veneer over till outcrops within map unit, extent and locations variable • U1l & U1h – low and high relief undulating (0-5 % slopes)
MKW1 **O1** **O5**	Dom.: Mikwa (MKW) – Mesic and Fibric Organic Cryosol Signif.: Mariana (MRN1c, m, f) – Terric Mesisol/Fibrisol Signif.: Wanham (WHMaa) & Moonshine (MNSaa)– Orthic Luvic Gleysols and Bitumont (BMT) – Orthic Gleysol	• Bog peat (minimum 40 cm) over an ice contact • Variability in ice contact, as a result MRN, WHMaa and MNSaa were often recorded along the margins • Level to nearly level (0-2% slopes), horizontal, plateau, peat lands (O1) or peat lands with Cryosol mounds (hummocks) (O5)
MLD1m **O2** **O3**	Dom.: McLelland (MLD1m) – Terric Mesisol (may include Typic Fibrisol, Fibric Mesisol, and/or Mesic Fibrisol)	• Relatively shallow (40-100 cm) fen peat overlying medium textured materials • Peaty Gleysols were recorded along margins of this map unit • Bowl or basin (O2) or channelled organic landforms (O3) dominated
MLD2m **O2** **O3**	Dom.: McLelland (MLD) – Typic Mesisol (may include Typic Fibrisol, Fibric Mesisol, and/or Mesic Fibrisol)	• Moderately deep (100-200 cm) fen peat overlying medium (m) textured material • Bowl or basin (O2) or channelled organic landforms (O3) dominated
MLD3 **O3**	Dom.: McLelland (MLD3) – Typic Mesisol (may include Typic Fibrisol, Fibric Mesisol, and/or Mesic Fibrisol)	• Thick (>200 cm) fen peat • Channelled organic landforms (O3)
MNWH20 **U1l**	Co - dom.: Moonshine (MNSaa) & Wanham (WHMaa) – Orthic Luvic Gleysols, peaty variants common Signif.: Horse River – gl (HRRgl) & LVK – gl (LVKgl) – Gleyed Gray Luvisols Terric Mesisols, some fen peat areas recorded Signif.: Bitumont (BMT) – Orthic Gleysol and various gleyed coarse textured Brunisols (MILgl and SUTgl)	• Horse river till to surface (M4) or a thin medium to moderately coarse water laid veneer over till (L3) • Drier soils found on small ridges and upper slope positions of terraces, majority of the landscape has poor drainage and a shallow water table • Pockets of coarse textured Gleysols were typically recorded near drainage channels. • U1l – low relief undulating (0-2 % slopes)
MNWH21 **L1** **U1l**	Co - dom.: Moonshine (MNSaa) & Wanham (WHMaa) – Orthic Luvic Gleysols, peaty variants common Signif.: Mariana (MRN) – Terric Mesisol, with variable underlying texture.	• Horse river till to surface (M4) or a thin medium to moderately coarse water laid veneer over till (L3) • Shallow organics recorded throughout SLM, pockets of coarse textured mineral material common • U1l & L1 - low relief undulating (0-2 % slopes) and nearly level terrain (0-0.5% slopes)

Table 4 Descriptive summary of soil map units of the SGD LSA and Access Road LSA

Map Unit	Soil Patterns	Parent Material and Terrain
MRN1c,m,f-G **O1** **O2** **O3**	Dom.: Marianna (MRN) – Terric Mesisol (may include Terric Fibrisol and other organic intergrades) Signif.: Peaty Gleysols of variable texture and parent material: MNSaapt, WHMaapt, BMTpt Signif.: Mikwa (MKW) – Mesic/Fibric Organic Cryosol	• Shallow (40-100 cm) of bog peat over various textures (c, m, f), map units of all three are texture classes are present • Peaty Gleysols common throughout the map units, typically along margins • Level to nearly level (0-2% slopes), horizontal, plateau, peat lands (O1), bowl or basin landscapes (O2) or channelled organic landforms (O3)
MRN1m **O1** **O2** **O3**	Dom.: Mariana (MRN) - Terric Mesisol (may include Terric Fibrisol and other organic intergrades) Signif.: Mikwa (MKW) – Mesic/Fibric Organic Cryosol	• Shallow (40-100 cm) bog peat over medium textured (m) materials • Little evidence of peaty Gleysols within map units, however, MKW soils were recorded at various locations. • Level to nearly level (0-2% slopes), horizontal, plateau, peat lands (O1), bowl or basin landscapes (O2) or channelled organic landforms (O3)
MUS2m **O1** **O2** **O3**	Dom.: Muskeg (MUS) – Typic Mesisol (may include Typic Fibrisol, Fibric Mesisol, and/or Mesic Fibrisol) Signif.: Mikwa (MKW) – Mesic/Fibric Organic Cryosol	• Moderately deep (100-200 cm) bog peat over medium textured materials • MKW soils were recorded at various locations (ice at 50-150 cm) • Level to nearly level (0-2% slopes), horizontal, plateau, peat lands (O1), bowl or basin landscapes (O2) or channelled organic landforms (O3)
MUS3 **O1** **O3**	Dom.: Muskeg (MUS3s) – Typic Mesisol (may include Typic Fibrisol, Fibric Mesisol, and/or Mesic Fibrisol) Signif.: Mikwa (MKW) – Mesic/Fibric Organic Cryosol	• Deep (>200 cm) bog peat • MKW soils with variable levels of ice contact recorded (ice at 50-150 cm) • Level to nearly level (0-2% slopes), horizontal, plateau, peat lands (O1), or channelled organic landforms (O3)
ZDL	Disturbed Lands	• Well sites with study area
ZWA	Open water	• Not applicable

3.6 Soil Map Unit Areas

Soil patterns were mapped to a planned scale of 1:15,000 (Figure 5a, 5b and 5c). Map unit areas and polygon counts were calculated using ArcMap GIS software. Table 5 displays the Soil Models, associated areas, and percent coverage for the SAGD LSA and Phase 1 footprint, and Table 6 shows the same information for the access road LSA and footprint.

Table 5 Soil map unit areas for the SAGD LSA and Phase 1 Footprint

Soil Model	SAGD LSA		Phase 1 Footprint	
	LSA - Area	% of LSA	Footprint - Area	% of Footprint
UPLAND SOILS				
BMT21	21.8	0.9	6.8	11.2
HRLVgl2	71.2	3.0	1.8	3.0
HRLV9	559.3	21.8	16.4	27.1
LVPE2	5.1	0.2	--	--
MISU18	251.5	10.7	13.4	22.1
MNWH20	108.4	4.6	--	--
MNWH21	60.4	2.6	2.7	4.3
Totals	***1077.7***	***46***	***41.1***	***67.8***
ORGANIC SOILS				
MKW1	155.9	6.6	--	--
MLD1m	45.9	1.9	--	--
MLD2m	26.9	1.1	0.2	0.4
MLD3	3.0	0.1	--	--
MRNf1-G	18.6	0.8	--	--
MRN1m	369.5	15.7	9.5	15.5
MRN1m-G	144.4	6.1	9.9	16.3
MRN1c-G	64.0	2.7	--	--
MUS2m	101.0	4.3	--	--
MUS3	51.5	2.2	--	--
Organic Totals	***980.7***	***41.6***	***19.6***	***32.2***
NON-SOIL UNITS				
ZDL	**2.6**	**0.1**	--	--
ZWA	**297.9**	**12.6**	--	--
TOTALS*	**2359**	**100**	**61**	**100**

* Final totals are rounded.

Table 6 Soil map unit areas for the Access Road LSA and Access Road Footprint				
Soil Model	**Access Road LSA**		**Access Road Footprint**	
	LSA - Area	**% of LSA**	**Footprint - Area**	**% of Footprint**
UPLAND SOILS				
DOV9	24.1	2.5	6.6	9.8
HRLV9	178.8	18.8	21.6	32.0
HRLVgl2	18.2	1.9	--	--
LVPE2	49.2	5.2	10.4	15.3
MISU18	10.1	1.1	--	--
MNWH20	65.0	6.8	5.9	8.7
MNWH21	86.1	9.1	5.3	7.8
Totals	***431.5***	***45.4***	***49.8***	***73.6***
ORGANIC SOILS				
MKW1	105.4	11.1	3.3	4.8
MLD2m	51.1	5.4	0.6	0.8
MRN1m	66.4	7.0	3.2	4.8
MRN1m-G	90.2	9.5	4.6	6.8
MUS2m	86.8	9.1	1.5	2.2
MUS3	46.2	4.9	1.1	1.7
MRN1f-G	40.6	4.3	3.6	5.3
Organic Totals	***486.7***	***51.2***	***17.9***	***26.4***
NON-SOIL UNITS				
ZDL	1.1	0.1	--	--
ZWA	27.9	2.9	--	--
Totals	***29.0***	***3.0***	--	--
TOTALS*	**947**	**100**	**68**	**100**

* Final totals are rounded.

4.0 BASELINE SOIL DATA, INTERPRETATIONS, AND RATINGS

Baseline soil conditions were evaluated for the LSAs with respect to layer thickness, forest capability, reclamation suitability, and erosion potential utilizing the following information sources:

- 260 inspection sites were collected within the study areas of which:
  - 198 sites fell within the SAGD LSA, 77 of which are in the Phase 1 footprint; and
  - 77 sites fell within the access road LSA (15 of these sites are also in the SAGD LSA due to overlapping study areas), 49 of which are in the access road footprint.
- laboratory analysis of 27 sampled inspection sites in the LSAs;
- relevant soil series chemical and physical data from the Alberta Soil Names (AG30SNF) and Soil Layer (AG30SLF) files in AGRASID (ASIC 2001); and

- soils information from the AOSERP document (Turchenek and Lindsay 1982b).

Baseline interpretations for the LSAs were determined using all available data collected during the 2008 investigation. The data was not separated by study area, moreover, the large pool of data collected from both LSAs allows for a better representation of the soil and landscapes in the area as opposed to separate analysis and interpretations for each individual LSA.

4.1 Thickness of Soil Layers – Baseline Soil Evaluation

Average litter layer/surface peat, topsoil, and subsoil thickness data assists in determining suitable soil salvage and stockpiling requirements for reclamation purposes. Determination of surface litter/peat, peat deposits, topsoil, and subsoil layers were based on soil horizons as defined in The *Canadian system of soil classification guidelines* (SCWG 1998).

Soil layer depths were calculated by averaging all inspection points grouped by Soil Model (e.g. MNWH21) for the SAGD LSA and access road LSA combined. For example, all site locations within all MNWH21 occurring in the study areas were averaged for profile thickness. Determining profile thicknesses in this manner allows for a good representation of typical profile orientations based on the landscape in which these profiles were formed. Sites deemed to be inclusions within each Soil Model were excluded from the averaging calculation. Averages for litter layers <10 cm thick were not rounded; all other depth averages were rounded to the nearest 5 cm to account for variability between different soil polygons of the same map unit. Non-soil map units were not included in the determination of soil thickness (ZDL & ZWA). The results are listed in Table 7 and displayed spatially in Figure 6.

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Table 7 Surface litter, peat, topsoil, and subsoil thicknesses by Soil Model – SAGD LSA and Access Road LSA inclusive

Soil Model	Thickness (cm)*			
	Surface Litter/Peat	Peat (≥40)	Topsoil	Upper Subsoil
BMT21	35	--	20	30
DOV9	15	--	10	50
HRLVgl2	5	--	10	40
HRLV9	10	--	10	40
LVPE2	10	--	15	35
MISU18	8	--	15	50
MNWH20	15	--	10	40
MNWH21	30	--	5	35
MKW1	--	105	--	--
MLD1m	--	60	--	--
MLD2m	--	115	--	--
MLD3	--	200	--	--
MRN1f-G	--	40	--	55**
MRN1m	--	70	--	30**
MRN1m-G	--	50	--	30**
MRN1s-G	--	40	5	30**
MUS2m	--	120	--	--
MUS3	--	220	--	--

*Litter layers <10 cm thick were not rounded. All other depths were rounded to the nearest 5 cm.
**Subsoil layers comprised of mainly BCg layers.

4.2 Forest Soil Capability Classification

4.2.1 Baseline Forest Soil Capability Classification

Soil series and variants were used as the building blocks for rating soil landscapes according to the *Land Capability Classification System for Forest Ecosystems in the Oil Sands* (LCCS) (CEMA 2006). This classification system relies on a soil moisture regime index (SMR) and soil nutrient regime index (SNR) to obtain base ratings of forest soil capability. The base rating is adjusted by "limiting factors" as determined in the classification system. Limiting factors include reductions to soil capability based on adverse soil structure and consistence, pH, salinity, and/or sodicity (CEMA 2006). A more detailed description of the methodology and assumptions used to calculate forest soil capability is provided in Appendix E.

Forest soil capabilities were determined for Soil Models (HRLV9) through amalgamation of individual soil series ratings of soils estimated to occur in each Soil Model. The following outlines the steps carried out to obtain Soil Model ratings:

1. Land capability ratings were calculated for the main soil series and variants found in the LSAs, based on attributes amalgamated for each series/variant. Morphological and analytical data for sampled profiles within the area played a key role in determining basic index points. In addition, data from the Alberta Soil Layer File (AG30SLF; ASIC 2001) were also consulted.

2. Calculations for soil series and variants were facilitated by use of the "LCCS Calculator 2006" program, which is an MS Excel application designed to automatically calculate index points (rating), class, and subclasses based on inputted soil profile data.

3. Final land capability ratings for mapping units were then calculated by amalgamating ratings for each series/variant within Soil Models, weighted according to the proportion of each soil type within the Soil Model.

The baseline forest land capabilities for Soil Models of the LSAs are listed in Table 8. Distribution of final land capability classes are shown on Figure 6.

Table 8 Baseline forest land capability ratings by Soil Model – SAGD LSA and Access Road LSA inclusive

Map Unit (SLM)	Final Rating Index for SLM	Final Land Capability Rating
BMT21	23	**4W**
DOV9	62	**2**
HRLVgl2	57	**3W**
HRLV9	55	**3VD**
LVPE2	58	**3VD**
MISU18	43	**3X**
MNWH20	43	**3WF**
MNWH21	26	**4W**
MKW1	3	**5WF**
MLD1m	3	**5WF**
MLD2m	3	**5WF**
MLD3	2	**5WF**
MRNf1-G	10	**5WF**
MRN1m	0	**5WF**
MRN1m-G	10	**5WF**
MRN1s-G	9	**5WF**
MUS2m	0	**5WF**
MUS3	0	**5WF**

The distribution of land capability ratings are displayed for the SAGD LSA and Phase 1 footprint (Table 9) and access road LSA and footprint (Table 10).

Table 9 Extent of land capability in the SAGD LSA and Phase 1 Footprint

Land Capability Class	SAGD LSA		Phase 1 Footprint	
--	Area (ha)	% of LSA	Area (ha)	% of footprint
Class 1	--	--	--	--
Class 2	--	--	--	--
Class 3	995.5	42.2	32.6	53.7
Class 4	82.2	3.5	8.5	14.0
Class 5	980.7	41.6	19.6	32.3
Not Rated	300.5	12.7	--	--
Total	**2359**	**100**	**60.7**	**100**

Table 10 Extent of land capability in the Access Road LSA and Access Road Footprint

Land Capability Class	Access Road LSA		Access Road Footprint	
--	Area (ha)	% of LSA	Area (ha)	% of footprint
Class 1	--	--	--	--
Class 2	24.1	2.5	6.7	9.8
Class 3	321.3	33.9	38.0	56.0
Class 4	86.1	9.1	5.3	7.8
Class 5	486.7	51.4	17.9	26.4
Not Rated	29.0	3.1	--	--
Total	**947.2**	**100.0**	**67.8**	**100**

A majority of the Soil Models within the SAGD LSA were rated as either Class 3 (42.2%) or Class 5 (41.6%). Limitations to Class 3 Soil Models included slightly acidic pH (subclass V), firm consistence in the subsoil (subclass D), coarse textured soils (sandy soil profiles, subclass X) and poor drainage for certain significant soil types within the Soil Models (subclass W). Class 5 soils accounted for all of the Organics in the SAGD LSA. Approximately 300 ha of the SAGD LSA are covered by open water.

The SAGD Phase 1 footprint is covered by predominantly Class 3 (53.7%) and Class 5 soils (32.3%). Limitations to Class 3 soils within the SAGD Phase 1 footprint are similar to those of the surrounding LSA (pH, consistence and drainage). Class 4 soils cover approximately 14.0% of the Phase 1 footprint and are limited by poor drainage. Class 4 Soil Models represent transitional areas between the uplands (Class 2 and 3) and Organic soils (Class 5).

The access road LSA contains notable areas of Organics in comparison to the SAGD LSA. Within the access road LSA, Soil Models rated as Class 5 dominated the area (51.4%). These Class 5 organic Soil Models are limited by very poor drainage (subclass W). Class 2 and 3 soils accounted for 36.4% of the area. These Class 2 and 3 represent the driest Soil Models in the access road LSA and were limited by soil pH (subclass V), subsoil soil consistence (subclass D), and to a lesser extent coarse textured profiles (subclass X).

The access road footprint is predominantly Class 3 soils (56.0%) limited by soil pH (subclass V), subsoil soil consistence (subclass D) and to a lesser extent drainage issues (subclass W). Class 4 and 5 soils account for 34.2% of the access road footprint. This corresponds to organics and poorly drained transitional landscapes between the upland and Organic landscapes. Limitations area predominantly poor drainage (subclass W).

With respect to forest productivity, Class 3, 4 and 5 soils are defined below as listed in the LCCS manual (CEMA 2006):

- Class 3 – "Lands having limitations which, combined, are moderately severe for forest production….limitations will result in reduced productivity or benefits, or require increased inputs to the extent that the overall advantage to be gained from the use will be low".
- Class 4 – "Lands having severe limitations, some of which may be surmountable through management, but which cannot be feasible corrected with existing practice".
- Class 5 – "Lands having limitations that appear so severe as to preclude any possibility of successful forest production".

4.2.2 Reclaimed Forest Soil Capability Classification

In order to evaluate equivalent land capability post reclamation, the LCCS was utilized to predict the capability ratings of the reclaimed soils. Reclaimed forest soil capability was assessed using the same methodology as the baseline soils. Appendix E provides detail on the assessment method and general assumptions used to create the reclaimed profiles and predict reclaimed soil capability.

The reclaimed capability ratings were calculated based on assumptions about soil conditions after completion of site reclamation and implementation of appropriate mitigative measures (i.e. de-compaction activities). As soil processes evolve and profiles develop in the reclaimed soils, it is anticipated that over time the soil chemical and physical characteristics will support ecosystems similar to pre-disturbance conditions. Detailed soil salvage and reclamation methodologies/activities are discussed in the C&R Plan (MEMS 2008).

Table 11 displays the predicted reclaimed ratings for the SAGD LSA and access road LSA.

Table 11 Predicted Reclaimed & Baseline Land Capability ratings for Soil Models of the SAGD LSA and Access Road LSA

Map Unit (SLM)	Final Rating Index for SLM Reclaimed	Final Land Capability Rating Reclaimed	Final Rating Index for SLM Baseline	Final Land Capability Rating Baseline
BMT21	23	**4WF**	23	**4W**
DOV9	61	**2**	62	**2**
HRLVgl2	57	**3W**	57	**3W**
HRLV9	57	**3**	55	**3VD**
LVPE2	48	**3V**	58	**3VD**
MISU18	50	**3X**	43	**3X**
MNWH20	50	**3W**	43	**3WF**
MNWH21	36	**4W**	26	**4W**
MKW1	3	**5WF**	3	**5WF**
MLD1m	5	**5WF**	3	**5WF**
MLD2m	3	**5WF**	3	**5WF**
MLD3	2	**5WF**	2	**5WF**
MRNf1-G	15	**5WF**	10	**5WF**
MRN1m	0	**5WF**	0	**5WF**
MRN1m-G	14	**5WF**	10	**5WF**
MRN1s-G	9	**5WF**	9	**5WF**
MUS2m	0	**5WF**	0	**5WF**
MUS3	0	**5WF**	0	**5WF**

All Soil Models analyzed maintained the same final land capability rating, however there were subtle changes in the final index ratings assigned. In some cases the reclaimed soil models displayed slightly improved final index ratings. Detailed comparison of the baseline and reclaimed capability ratings of each LSA and associated footprint is discussed in Section 5.3 Reclamation and Land Capability.

4.3 Reclamation Suitability

Reclamation suitability was assessed utilizing the *Soil Quality Criteria Relative to Disturbance and Reclamation Guidelines* (SQCWG 1987). Criteria for the Northern Forest Region of Alberta for topsoil (upper lift) and subsoil (lower lift) material were followed. Topsoil is defined as the mixture of surface organic material and A horizon, typically to a depth of approximately 30 cm (SQCWG 1987). Subsoil is defined as being mineral soil material beneath the topsoil to a depth deemed appropriate based on site conditions (SQCWG 1987). For the purpose of this assessment, the subsoil (lower lift) includes all B horizons (BA, Bt, Btg, Bg, including those with gleyed modifiers) plus portions of the transitional BC horizon in instances where a B horizon is not present.

Rating the upper lift (UL - topsoil) and lower lift (LL – upper subsoil) of the Soil Models assists in site development and soil handling by determining which soils may present challenges during site construction and reclamation.

Map units dominated by Organic soils (i.e., soils with >40 cm of peat) were not included in the assessment as the guidelines are specific to mineral soils. The guidelines state that Organic soils should be salvaged and utilized as a soil conditioner (SQCWG 1987). More details on the application of the *Soil Quality Criteria Relative to Disturbance and Reclamation Guidelines* are provided in Appendix E. Ratings categories are defined as:

- **Good (G)** – no or slight limitations that affect use as a plant growth medium.
- **Fair (F)** – moderate limitations that affect use but can be overcome by proper planning and good management.
- **Poor (P)** – severe limitations that make use questionable. This does not mean the material cannot be used, but careful planning and very good management are required.
- **Unsuitable (U)** – chemical or physical properties are so severe that reclamation would not be economically feasible or in some cases impossible (i.e. special reclamation strategies must be implemented and land use may be severely restricted).

Reclamation suitability ratings by Soil Model in the SAGD and access road LSAs are presented in Table 12 and shown on Figure 7.

Reclamation suitability ratings for topsoil within the LSAs ranged from Fair–Good to Poor. Slightly acidic pH, determined to be the main limiting factor for a majority of the upland Soil Models, is characteristic of most soils in the LSAs and limited the ratings to Fair-Good. Coarse textured profiles limited certain Soil Models to a Poor rating with respect to the topsoil lift. Overall, topsoil in the LSAs is estimated to be Fair to Good as reclamation material; however, coarse textured landscapes are considered Poor due to the coarse textures associated. This includes the MISU18 and BMT21 Soil Models. Both of these Soil Models occur predominantly in the SAGD LSA and SAGD Phase 1 footprint. Approximately 6.8 ha of BMT21/L1 and 13.4 ha of MISU18/U1h are located within the SAGD Phase 1 footprint.

Subsoil ratings were similar to the topsoil ratings and ranged from Fair–Good to Poor. Subsoil materials were limited mainly by fine textured B horizons and elevated saturation percentage. Slightly acidic pH also limited some profiles. Coarse textured subsoil was the dominant factor in soils rated Poor. This included the MIL18 and BMT21 Soil Models, which occur only in the SAGD LSA.

Organic soils were not rated. However, a subsoil rating was estimated for the peaty variants and shallow Organic soil variants because the possibility for handling the mineral material underlying the shallow peat (<40 cm and 40-100 cm thick) does exist. Mineral material below the shallow peat layers rated Fair to Poor as reclamation media. Limitations included elevated saturation percentage firm consistence and/or fine or coarse textured subsoil material.

Table 12 Reclamation suitability ratings for soil materials in the LSAs

Soil Model	Topsoil		Subsoil		Comments
	Rating	Limitations	Rating	Limitations	
BMT21	P	Coarse textures	F-P	Coarse textured soils	LS to SL textured soils in dominant soil type
DOV9	F-G	Slightly acidic pH and coarse textured TS	F-P	Fine textured subsoil in some component soils	Coarse veneer over water laid materials
HRLVgl2	F	Slightly acidic pH	F-P	Fine textured subsoil in some component soils	Component soils have moderately coarse textures
HRLV9	F-G	Slightly acidic pH	F-P	Subsoil textures range from C to LS	
LVPE2	F	Slightly Acidic pH	F-G	Fine textured subsoil	
MISU18	P	Coarse textures	P	Coarse textured subsoil	LS to SL textured soils in dominant soil type
MNWH20	F	Slightly acidic pH and a range of coarse and medium textures in TS	F	Fine textured subsoil	Some component soils have coarse textured veneers
MNWH21	F	Slightly acidic pH	F	Fine textured subsoil	Organic soils account for 20% of Soil Model, Organics are not rated
MKW1	O	Organic soil, not rated	O	No mineral subsoil, frozen peat	Ice recorded at relatively shallow depths in the peat
MLD1m	O	Organic soil, not rated	O	Organic soil, not rated	Underlying mineral material encountered not considered upper subsoil (B horizon)
MLD2m	O	Organic soil, not rated	O	Organic soil, not rated	
MLD3	O	Organic soil, not rated	O	Organic soil, not rated	
MRNf1-G	O	Organic soil, not rated	P	Fine textured mineral material underlying peat	Limited upper subsoil material encountered
MRN1m	O	Organic soil, not rated	O	Organic soil, not rated	Underlying mineral material encountered not considered upper subsoil (B horizon)
MRN1m-G	O	Organic soil, not rated	F	Limited by saturation % and consistence	Limited upper subsoil material encountered
MRN1s-G	O	Organic soil, not rated	P	Coarse textured mineral material underlying peat	Limited upper subsoil material encountered
MUS2m	O	Organic soil, not rated	O	Organic soil, not rated	

Table 12 Reclamation suitability ratings for soil materials in the LSAs

Soil Model	Topsoil		Subsoil		Comments
	Rating	Limitations	Rating	Limitations	
MUS3	O	Organic soil, not rated	O	Organic soil, not rated	

4.4 Baseline Erosion Risk Assessment

Soil erosion by wind or water can affect soil profiles and distribution of soils in the landscape. Soil erosion is dependent on soil texture, slope gradient, length of slope, and vegetation type and cover. In areas where vegetation has been cleared and the soil surface disturbed, the risk of erosion generally increases. Bare soil has higher erosion potential than undisturbed profiles due to the lack of mechanisms that can reduce or minimize the erosive energy of wind or water.

Soil erosion by water is dependent on the type, extent, and distribution of precipitation. Within the study areas the risk of water erosion is typically low to moderate as the soil surface is currently well protected by tree and understory cover. An extensive litter/surface organic layer covers the majority of the soils within the LSAs. However, the coarse textured MISU18 Soil Model within the SAGD LSA (251.5 ha) is considered to have a moderate erosion risk by water during extreme precipitation events due to the thin vegetative litter layer and coarse textured surface soils.

Significant tree and understory cover and an extensive litter layer results in minimal exposure of surface soil material to wind throughout the study areas. A majority of the soil series in the region have a low potential for soil erosion via wind (Pedocan, 1993). Soils on crests of slopes and soils located in the MISU18 Soil Model have moderate potential for erosion by wind. However sufficient vegetative cover currently minimizes the potential for erosion of these coarse soils.

Undisturbed Organic soils recorded throughout the study areas have a low risk of erosion by water or wind as most peat landscapes have significant vegetative cover, occur in level or nearly level terrain, and may have water at surface for a portion of the year. This includes the BMT 21 Soil Model, which contains coarse textured mineral materials but is covered by a relatively thick layer of surface peat in a majority of the landscape, greatly reducing the risk of soil erosion. The BMT21 Soil Model (total extent of 21.8 ha) occurs only in the SAGD LSA, of which an estimated 6.8 ha are located in the SAGD Phase 1 footprint.

5.0 POTENTIAL IMPACTS

Disturbance of the soil resource will result in the removal of the natural soil profile and eventual replacement of salvaged materials at reclamation. The following discussions outline the potential impacts to the soil resource as a result of the development of the Project. The process of soil salvage, handling, and reclamation will be similar for both the Phase 1 and access road footprints with respect to soil salvage, storage and final reclamation. Therefore, the following sections discuss the two footprints inclusively where applicable.

5.1 Loss of Diversity

The majority of the SAGD Phase 1 footprint (approximately 57%) is located in low relief to high relief undulating to hummocky upland landscapes. Approximately 74% of the access road footprint is comprised of upland and transitional terrain. Upland areas in both footprints will be reclaimed to provide a level of moisture regime, landscape variability, and surface drainage patterns that resemble conditions in pre-disturbance landscapes, thus providing a similar degree of diversity. Over time, moisture regimes like those of the natural landscapes will return, allowing soil-forming processes associated with pre-disturbance soil types to re-establish. Post reclamation, organic landscapes that are to be padded over will maintain similar conditions to pre-disturbance. Transitional soils will be reclaimed, depending on the method of construction, to a moisture regime similar to pre-disturbance or slightly drier than the pre-disturbance conditions. No impacts to soil diversity are expected as a result of the Project.

5.2 Admixing of Soil

Soils within the footprints occur on a variety of landscapes, all with unique soil profile orientations. Soil profile thicknesses are variable and dependent on landscapes.

During construction of the Project and associated access road, soil salvage will consist of a single lift operation, which is also referred to as a “topsoil lift”. Topsoil is defined as “*the surface forest floor and all “A Horizon” soil (LFH, Ah, Ahe and Ae)*” (Alberta Government 2007). The topsoil lift is intended to include the topsoil plus leaf litter/shallow surface peat horizons located in the upland and transitional areas. Soil horizon (including the litter/surface peat layer) thicknesses are naturally variable and vary with slope position, aspect, and landform. Typically, the variability is sub metre, and ranges depending on the accompanying landform. The material depths presented in this report are averages (Table 7) and therefore depths are expected to be variable throughout the footprints. However, the averages presented in Table 7 provide a good guideline as to expected material depths in the different landscapes. On the plant site within the SAGD Phase 1 footprint, upper subsoil material will also be salvaged for use at reclamation. Thicknesses in the upper subsoil layers are expected to display variability similar to that of the surface layers.

Replacement of the topsoil lift will occur once site re-contouring and de-compaction are completed. Sunshine is committed to replace all salvaged topsoil material to ensure that the reclaimed landscape is returned to equivalent land capability (detailed calculations on soil volumes and replacement depths are provided in the C&R Plan (MEMS 2008). Overall, utilization of proper soil salvage, storage and replacement techniques throughout the life of the Project will minimize the loss of topsoil material.

5.3 Reclamation and Land Capability

The main goal for the reclamation program is to achieve land capability equivalent to pre-disturbance conditions. Tables 13 and 14 provide the forest land capability classification for both baseline and reclaimed Soil Models within the SAGD and access road footprints and a summary of predicted changes. The only changes associated with the post reclamation ratings are due to the creation of wetlands/shallow water bodies in the borrow pits.

Table 13 Comparison of the baseline and reclaimed forest land capability ratings for the Phase 1 Footprint

Capability Class	Baseline Capabilities		Reclaimed Capabilities		Difference (%)
	Area (ha)	Proportion (%)	Area (ha)	Proportion (%)	
Class 1	--	--	--	--	**0.0**
Class 2	--	---	--	---	**0.0**
Class 3	32.6	53.7	30.0	49.4	**-4.3**
Class 4	8.5	14.0	8.5	14.0	**0.0**
Class 5	19.6	32.3	19.6	32.3	**0.0**
Wetland*	**-**	**-**	**2.6**	**4.3**	**4.3**
TOTAL	**60.7**	**100**	**60.7**	**100**	**0.0**

* Wetlands created as a result of the development of the borrow pits.

Table 14 Comparison of the baseline and reclaimed forest land capability ratings for the Access Road Footprint

Capability Class	Baseline Capabilities		Reclaimed Capabilities		Difference (%)
	Area (ha)	Proportion (%)	Area (ha)	Proportion (%)	
Class 1	--	--	--	--	**0.0**
Class 2	6.7	9.9	4.5	6.6	**-3.3**
Class 3	38.0	56.0	34.0	50.2	**-5.8**
Class 4	5.3	7.8	5.3	7.8	**0.0**
Class 5	17.8	26.3	17.3	25.5	**-0.8**
Wetland*			**6.7**	**9.9**	**9.9**
TOTAL	**67.8**	**100**	**67.8**	**100**	**0.0**

* Wetlands created as a result of the development of the borrow pits.

There were no differences in overall land capability classes between baseline and reclaimed soil models for either footprint. There are, however, differences in subclasses and final calculated index point ratings between baseline and reclaimed soils. In some instances the reclaimed soil models rated slightly higher than the baseline conditions. These differences are a result of the following scenarios related to the LCCS system and amalgamation of soils:

- Predicted drier landscapes for various transitional soils (Peaty Gleysols) including the WHMaa and MNSaa. Baseline ratings were rated as hygric reduced, while reclaimed moisture regimes are predicted to be hygric aerated in some instances. Soil models that contain transitional soils or inclusion soils (i.e. MRN1m-G) as significant would potentially see an increase in the calculated index point ratings. This is dependent on the estimated occurrence of these soils within the Soil Model.
- In instances where the pH values of the litter and topsoil for baseline conditions were unique and slightly acidic, the resulting "blending" of the two horizons resulted in a pH subclass deduction of the reclaimed landscape greater than the baseline case. The reverse of this also occurred where the reclaimed pH values resulted in an improved rating. The deductions applied based on pH values for the LCCS are based on ranges of pH values. A difference of 0.3 pH can result in a deduction of between 15-40%.
- In some instances the blending of the litter layers with the nutrient deficient Ae horizons increased the SNR of various reclaimed profiles for the "topsoil" lift (0-20 cm in LCCS).

5.4 Erosion of Reclaimed Soils

Due to the variability of terrain in the SAGD Phase 1 and access road footprints, there is potential for soil erosion either by water and/or wind in the disturbed upland terrain. Erosion is of concern on all areas where bare mineral soil is exposed. This includes disturbed areas cleared of vegetation prior to soil salvage operations and areas where topsoil materials have been replaced but re-vegetation activities have not been completed.

The likelihood of soil erosion increases the longer soil is exposed to the agents of erosion. Implementation of mitigative measures such as timely re-vegetation of disturbed areas and establishing sediment traps (e.g. ditch blocks, silt fencing) will minimize erosional impacts. The access road footprint does not contain any areas of coarse soils. Various components of the SAGD Phase 1 footprint are located in areas that contain the MISU18 Soil Model. Upon disturbance, the coarse textured soils are considered to have a high potential for erosion via wind and/or water (Pedocan 1993). Through proper soil management techniques and timing of clearing, soil salvage and re-vegetation operations, the impact on soil erosion will be minimal.

6.0 MITIGATION AND MONITORING

In order to reduce the impact of the Project on soil resources, the following measures will be implemented.

- available topsoil and overlying litter/surface peat material (<0.4 m in thickness) within the SAGD Phase 1 and access road footprints will be salvaged for replacement at reclamation;
- within the plant site, a second-lift of upper subsoil to a maximum depth of 30 cm will be discretely salvaged to return a rooting zone similar to that which existed prior to the disturbance;
- soil storage stockpiles will be constructed appropriately (suitable slopes) and revegetated to prevent erosion. All soil stockpiles will be stored in locations that minimize the potential for impacts as a result of site activities and reduce the potential of wind and/or water erosion throughout the life of the Project;
- salvaged topsoil and subsoil materials will be replaced on areas that have been re-contoured to conditions similar to pre-disturbance and allow for appropriate surface drainage. Prior to replacement of coversoil, all compacted areas will be deep tilled to promote de-compaction of the overburden material;
- peat landscapes (> 40 cm of peat) will likely be padded over during construction. All peat landscapes padded over during construction will have geotextile and clay pads removed during reclamation. Efforts to de-compact and condition the peat material will be undertaken to allow for appropriate vegetation establishment and promote a

moisture regime similar to that of pre-disturbance conditions. Natural drainage patterns will be re-established through these peat landscapes;

- it is likely that other methods of site construction will also be implemented in peat landscapes, and could include partial or complete salvage of peat deposits. Peat landscapes disturbed as a result of the Project by methods other than padding will be reclaimed accordingly depending on the method of soil salvage, storage and intended final land use to ensure the desired land capability can be attained; and
- reclaimed areas will be appropriately revegetated following coversoil replacement operations in order to reduce erosion potential and promote vegetation establishment.

The Project contains adequate soil resources for reclamation. By utilizing acceptable soil salvage, soil handling and reclamation practices as outlined in C&R Plan, the impact to soil resources will be minimal (MEMS 2008).

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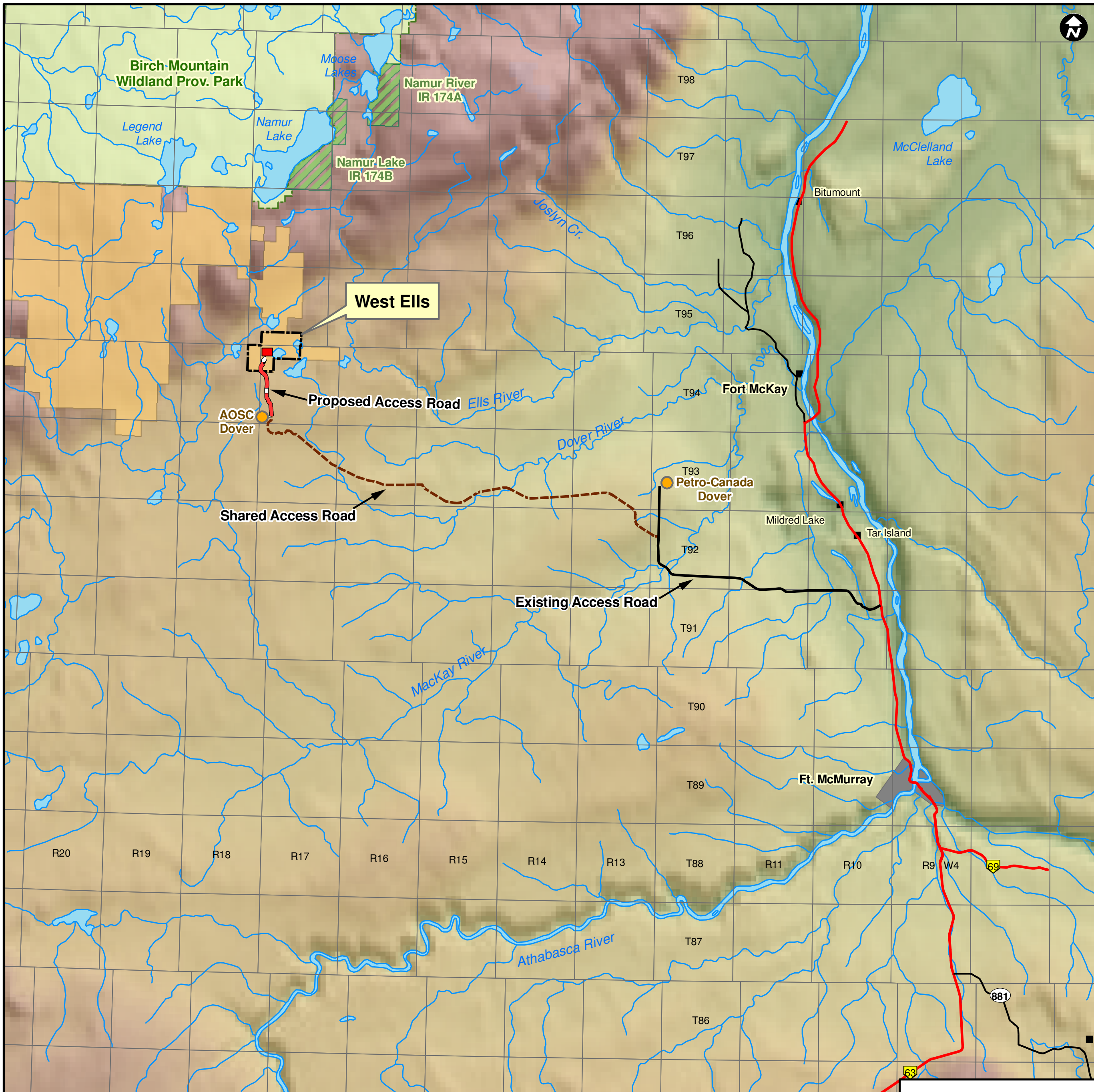
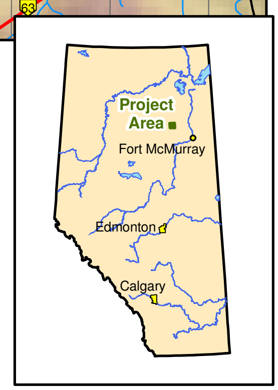
APPENDIX A: FIGURES AND MAPS





Legend

- West Ells SAGD Project Area
- Sunshine Oilsands Ltd. Lands
- Provincial Park
- First Nations

0 10 20
Kilometres

West Ells SAGD Project

Millennium EMS Solutions Ltd.

TITLE:

Project Location

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CHECKED:	RM
DATE:	Nov 24/08
PROJECT:	08-015

FIGURE: 1

REF: MEMS, 2008.

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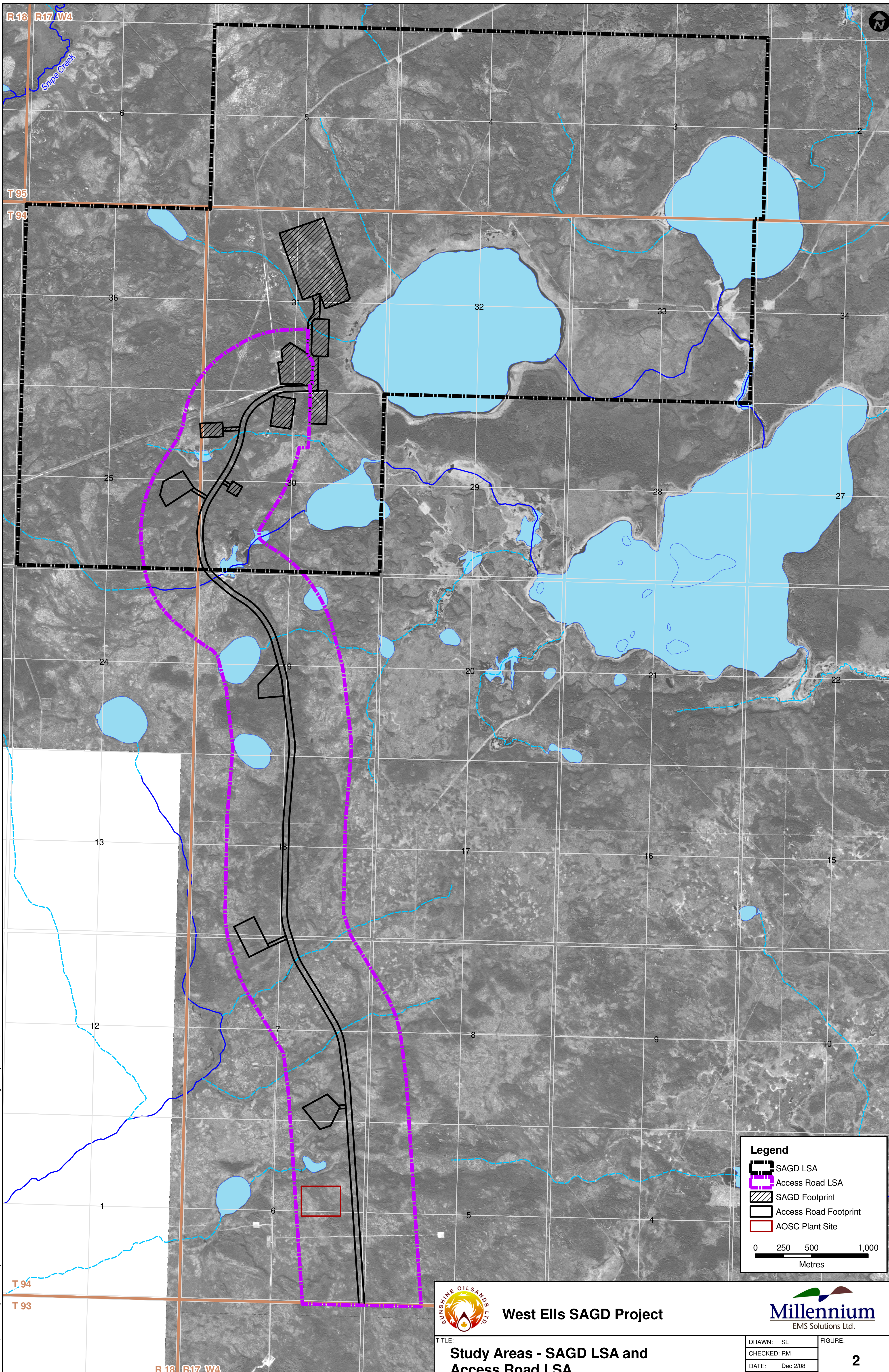

West Ells SAGD Project

TITLE:

Study Areas - SAGD LSA and Access Road LSA

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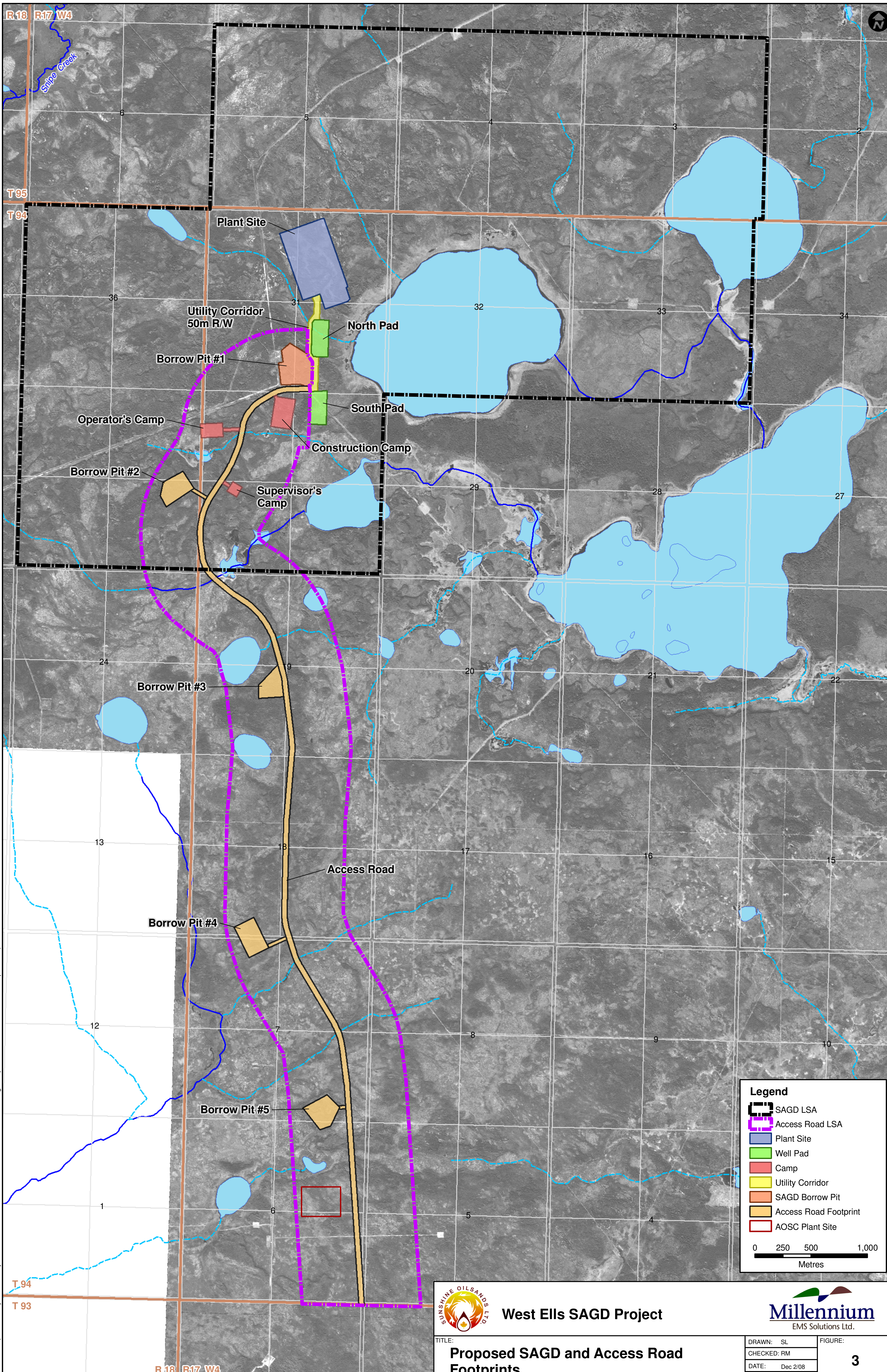
PROJECT: 08-015	

Map Document: (K:\Active Projects 2008\Projects 08-001 to 08-050\08-015 Sunshine SAGD\Final Docs\Soils\Fig 2 Study Areas.mxd) 02/12/2008 -- 12:36:25 PM



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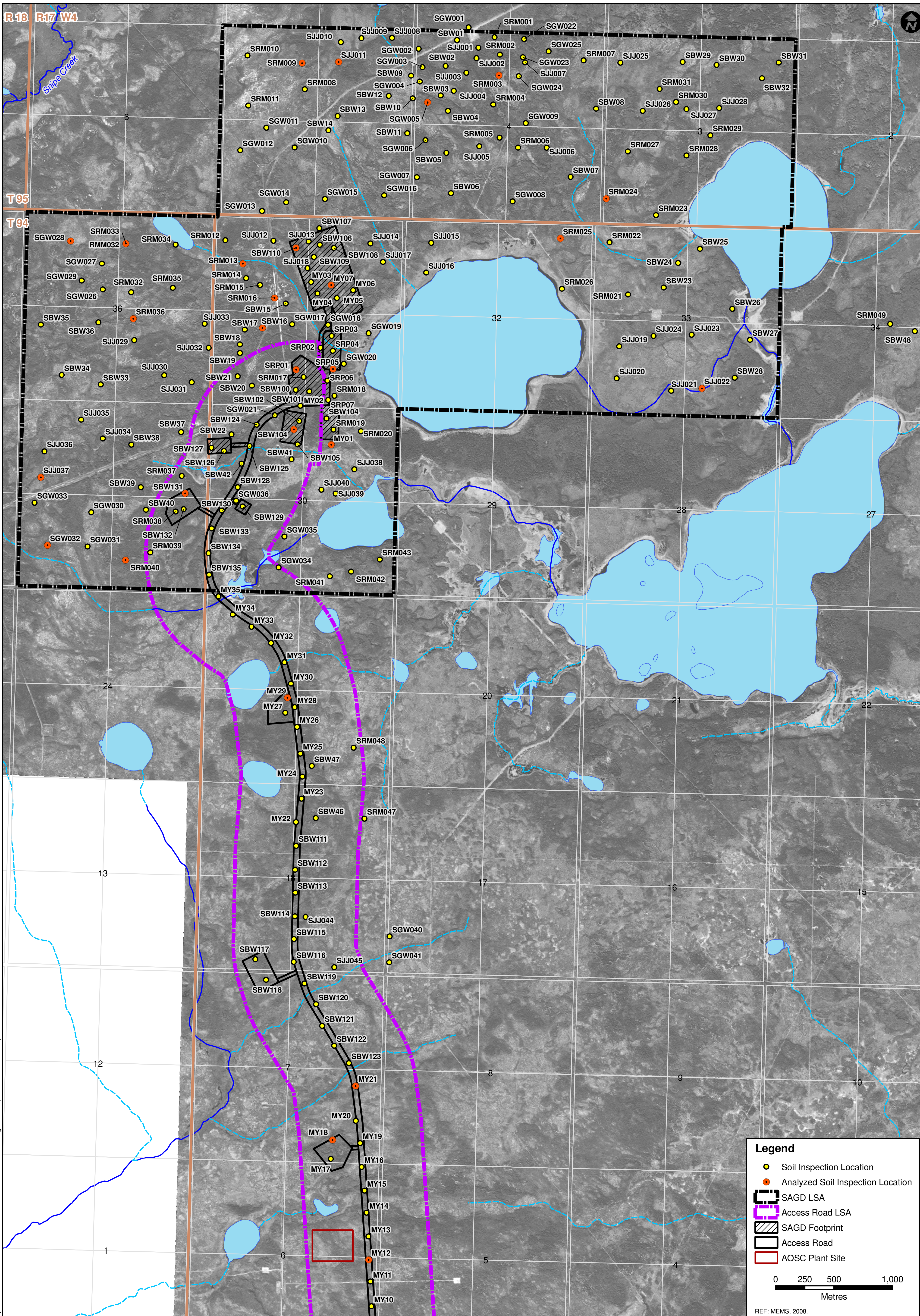

SUNSHINE OILSANDS LTD

West Ells SAGD Project

Millennium EMS Solutions Ltd.

TITLE:

Soil Inspection Locations within the SAGD LSA and Access Road LSA

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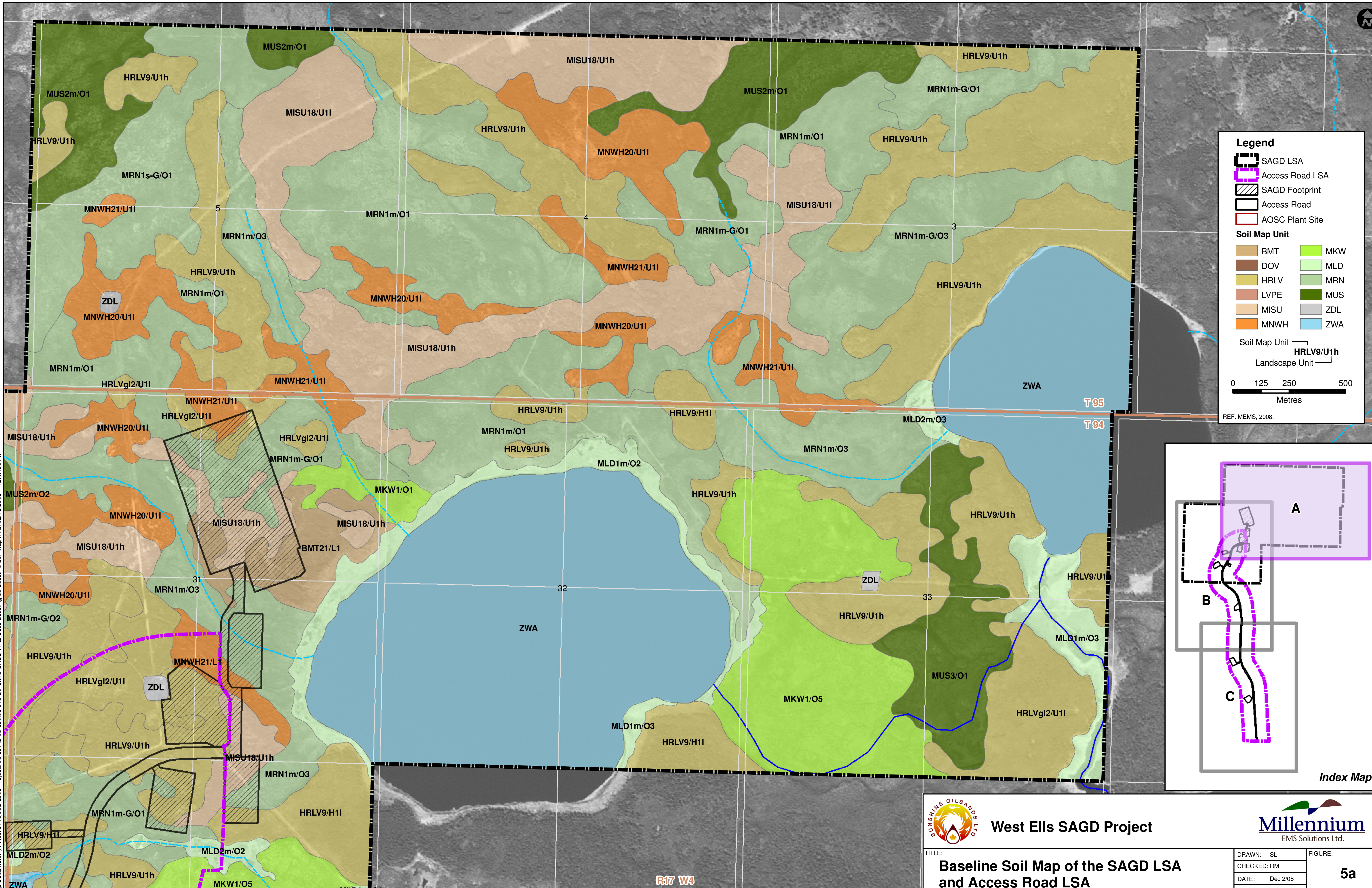
PROJECT: 08-015	



West Ells SAGD Project

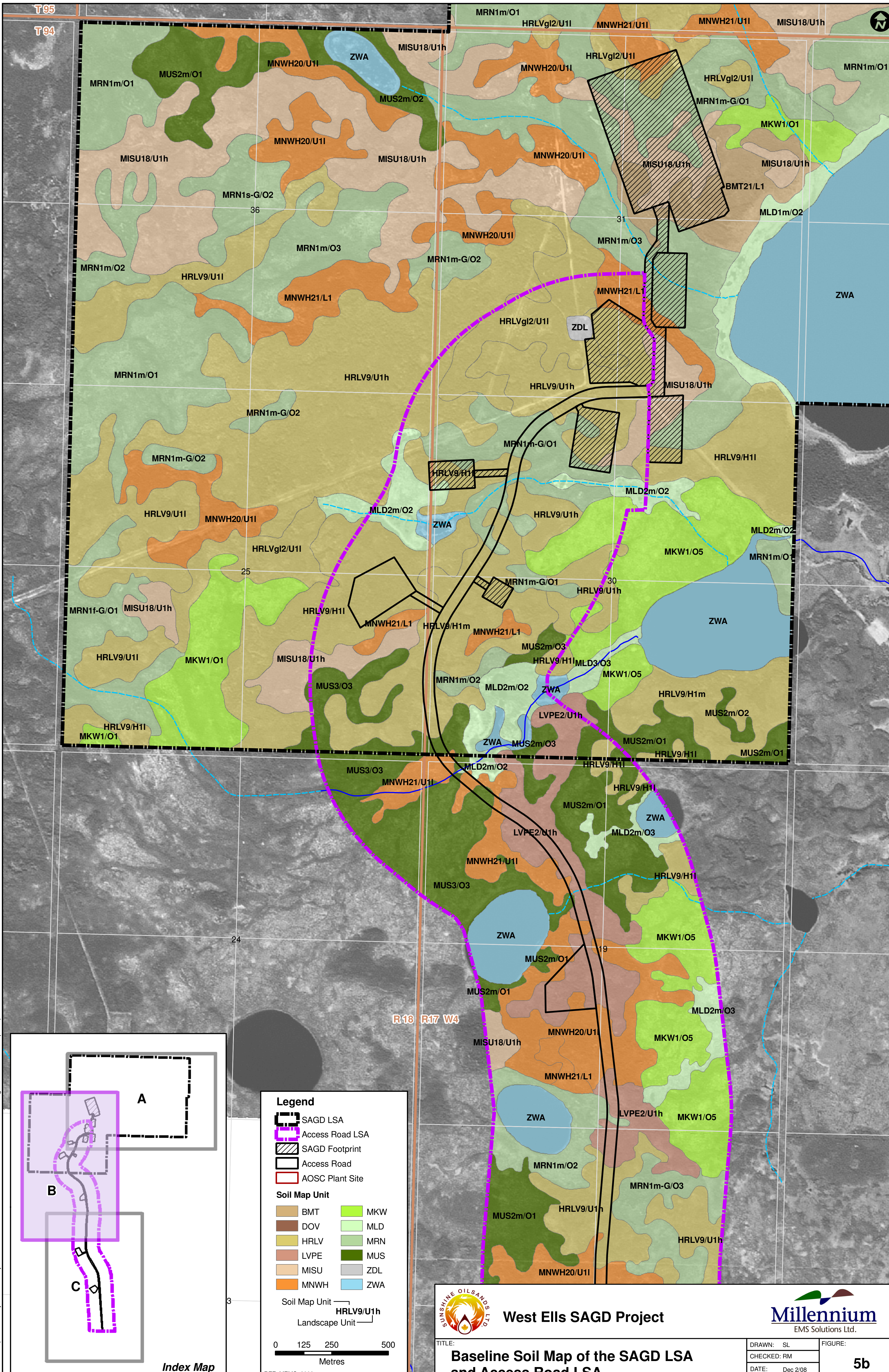
Millennium
EMS Solutions Ltd.

TITLE:
Baseline Soil Map of the SAGD LSA and Access Road LSA

DRAWN: SL
CHECKED: RM
DATE: Dec 2/08
PROJECT: 08-015

FIGURE: 5a

Map Document: (K:\Active Projects 2008\Projects 08-001 to 08-050\08-015 Sunshine SAGD\Final Docs\Soils\Fig 5a Baseline Soil Map.mxd) 02/12/2008 -- 12:47:36 PM



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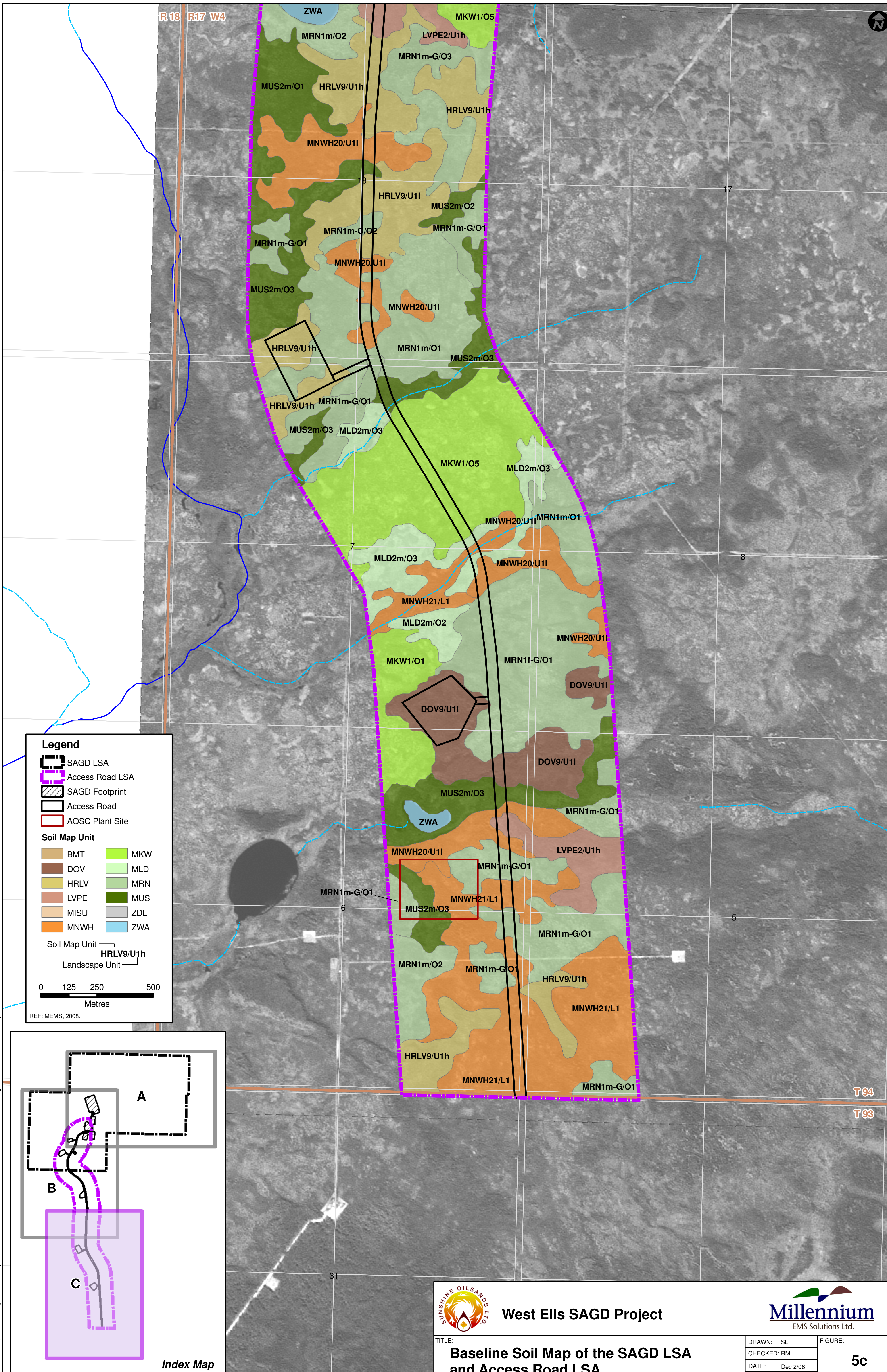

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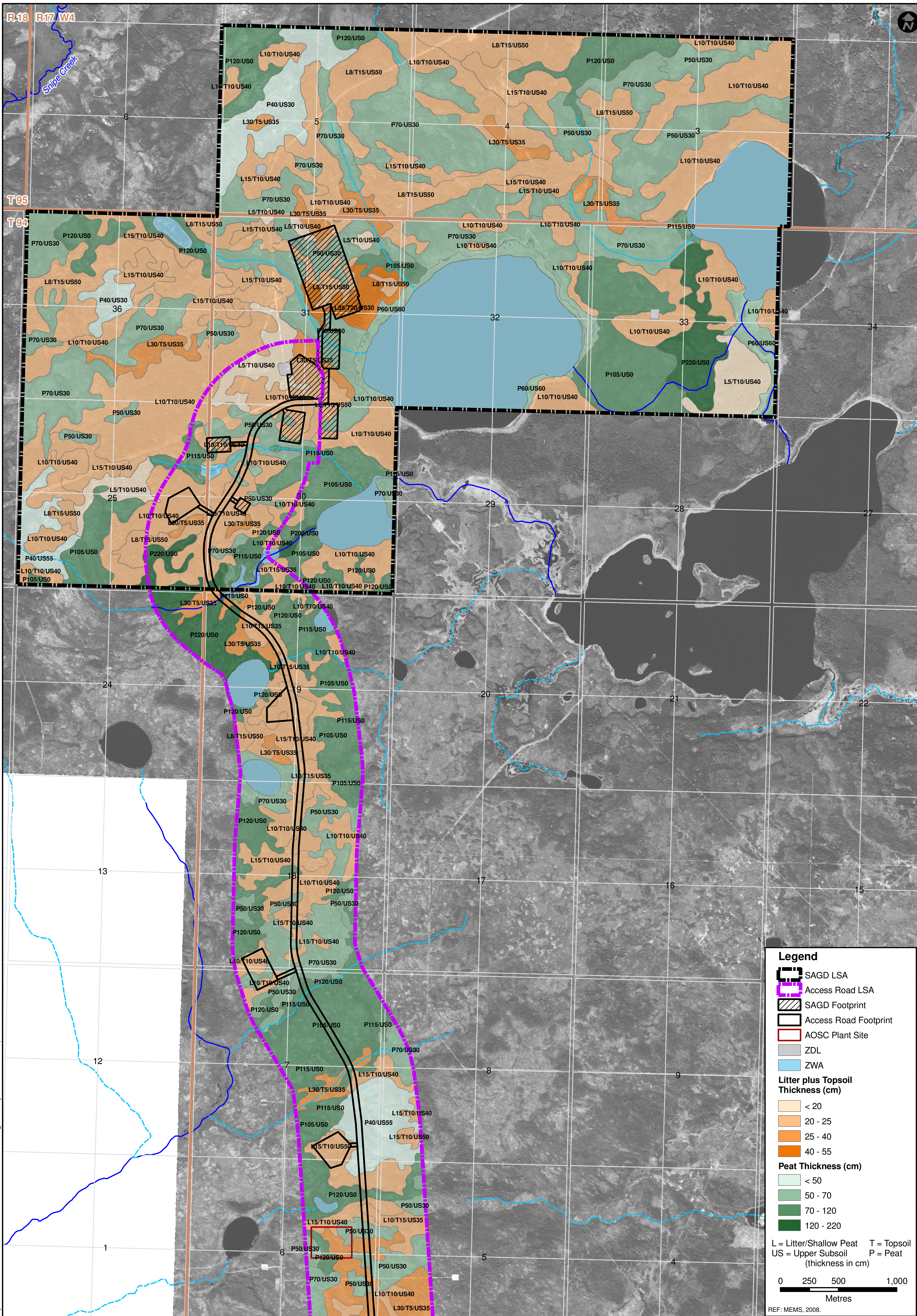

West Ells SAGD Project

Millennium EMS Solutions Ltd.

TITLE:
Soil Layer Thicknesses per Map Unit within the SAGD LSA and Access Road LSA

DRAWN: SL	FIGURE: 6
CHECKED: RM	
DATE: Dec 2/08	
PROJECT: 08-015	

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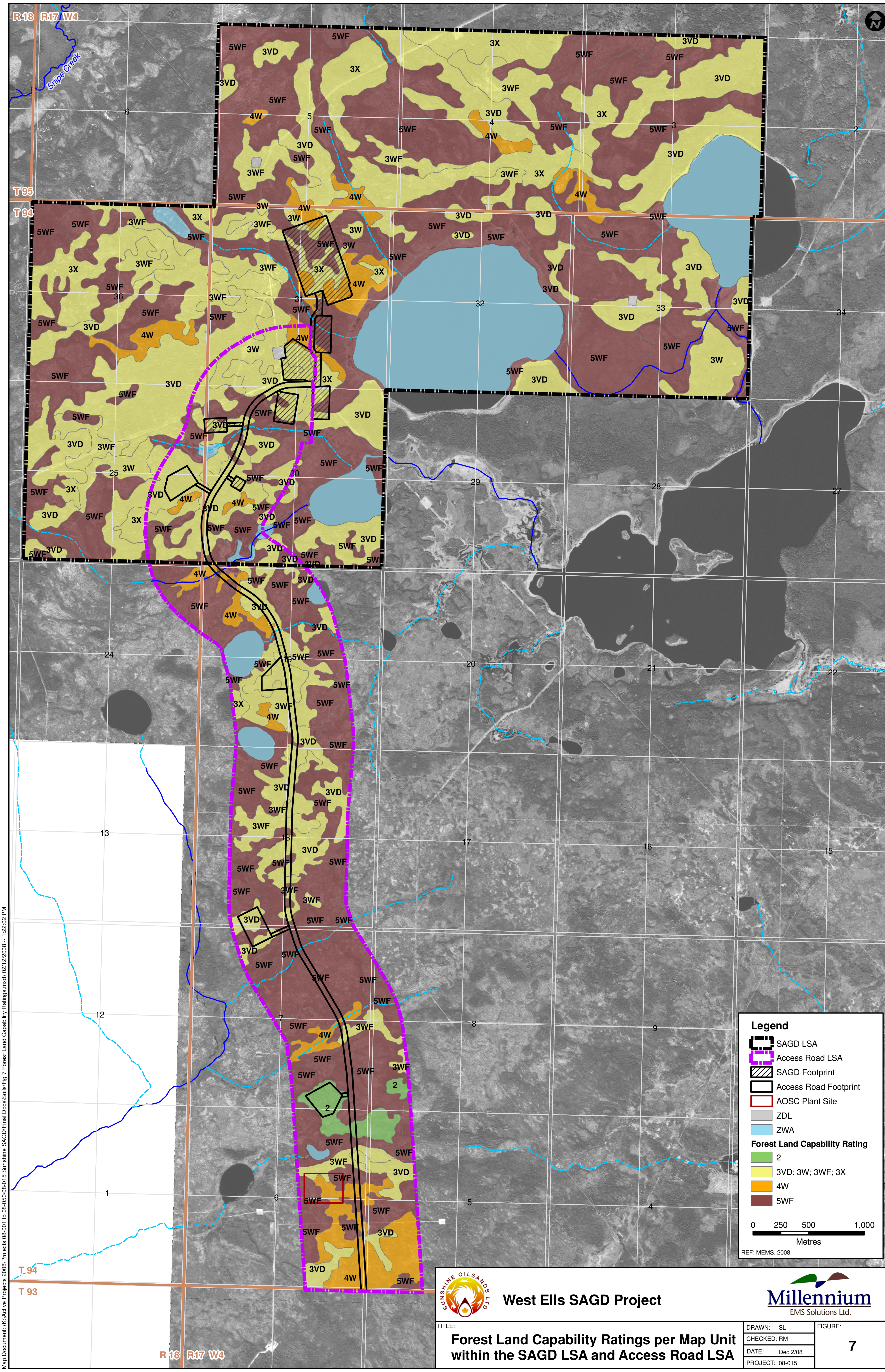

R 18
R 17
W4
Snipe Creek
T 95
T 94
T 93
Legend
SAGD LSA
Access Road LSA
SAGD Footprint
Access Road Footprint
AOSC Plant Site
ZDL
ZWA
Forest Land Capability Rating
2
3VD; 3W; 3WF; 3X
4W
5WF
0
250
500
1,000
Metres
REF: MEMS, 2008.
SUNSHINE OILSANDS LTD
West Ells SAGD Project
Millennium
EMS Solutions Ltd.
TITLE:
Forest Land Capability Ratings per Map Unit within the SAGD LSA and Access Road LSA
DRAWN: SL
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PROJECT: 08-015
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7
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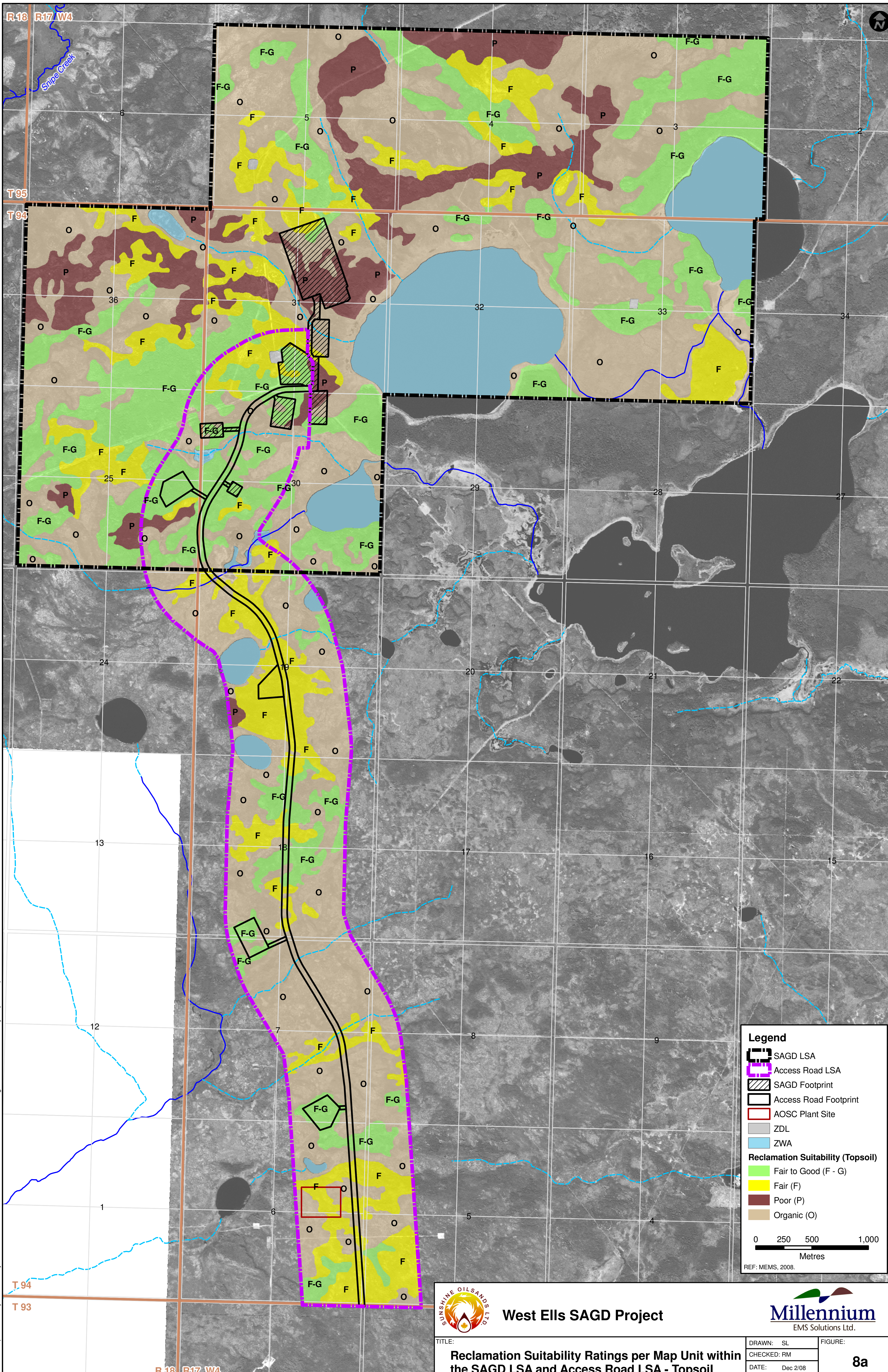

West Ells SAGD Project

TITLE:
Reclamation Suitability Ratings per Map Unit within the SAGD LSA and Access Road LSA - Topsoil

DRAWN: SL
CHECKED: RM
DATE: Dec 2/08
PROJECT: 08-015
FIGURE: 8a

Millennium EMS Solutions Ltd.

Map Document: (K:\Active Projects 2008\Projects 08-001 to 08-050\08-015 Sunshine SAGD\Final Docs\Soils\Fig 8a Reclamation Suitability - Topsoil.mxd) 02/12/2008 -- 1:24:21 PM

APPENDIX B: SOIL CLASSIFICATION METHODOLOGY

Introduction

Soil classification to the series level involves three major steps, as follows:

1. Classification of a profile to the soil subgroup level based on morphological features (e.g. types of A and B horizons, degree of gleying, etc.);
2. Classification of soil parent materials according to mode of deposition plus textural characteristics a described for AGRASID (ASIC 2001); and
3. Merging the two classifications to define soil series level taxa based on the AG30SNF (ASIC 2001), and selecting names from the appropriate Soil Correlation Area (SCA).

A more in-depth discussion of the tools used for classifying soils to the series level in Alberta – soil correlation areas, a revised parent material classification (grouping) system, and the use of soil variants is detailed below. Descriptions of the major and significant soil series and variants found in the study areas are provided in Appendix D.

Classifying Soils to the Subgroup Level

Classification to the subgroup level was based on the Canadian System of Soil Classification (SCWG 1998) and a review of other relevant soil surveys completed in the region. After entry in the soil database, all inspection sites were reviewed and classified to the subgroup level (i.e. Orthic Gray Luvisol) based on recorded horizon sequences, depth of horizons, soil structure, consistence, soil colour, and mottle description. Soil chemistry of sampled sites was also reviewed to refine subgroup level classification.

Classifying Soil Parent Materials

Classification of surficial parent materials is required for proper soil classification to the series level. The AG30SNF lists all established soil series in Alberta, and includes the corresponding parent material classification associated with each series. Parent material classification is based on textural groupings (i.e. dominant textures within the soil profile or control section). Four broad categories of parent material textural types are defined in this system: coarse, medium, fine, layered, and peat. Further differentiation into 47 textural groupings (i.e. codes listed in Table B-1) are based on general mode of deposition (i.e. glacial till, water-laid, wind deposited, or peat type) plus more detailed textural groupings. Table B-1 displays the parent material groupings adapted from AGRASID (ASIC 2001).

In order to ensure that the appropriate parent material classification was assigned to an inspection site, the following guidelines were observed:

- All inspections sites were reviewed in the database to determine the texture of the material in the top 1.0 m (up to 2.2 m for Organic soils).

- Sites without significant layering were classified according to the predominant texture and mode of deposition. Organic soils with relatively deep peat (>1.2 m) were defined as having either bog (P1) or fen (P2) parent materials.
- Significant textural changes were highlighted if the textural change occurred below **30 cm** from the mineral surface. This layering is defined as a textural discontinuity.

Classifying Soils to the Series Level

The parent material groupings and the subgroup classification of the soils were combined to assign soil series or variants to soil inspection sites. This was done by viewing the possible soils within the appropriate SCA (see below) and matching soil subgroups with the corresponding parent material grouping. A list of available soil series names taken from the AG30SNF (ASIC 2001) was used to determine the appropriate soil series. All inspection sites were classified to the series level using the subgroup classification and AG30SNF, based on the collected soil data.

Soil Correlation Area (SCA)

The Project occurs within SCA 20, defined as the Boreal Mixedwood Ecoregion of the Northern Alberta (ASSWG 1993). The latest edition of the Alberta Soil Names File (AG30SNF), distributed as part of AGRASID (ASIC 2001) lists 71 established soil series for this region

Table B1 Parent material textural groupings adapted from AGRASID (ASIC 2001)

Materials	Code	Description
Coarse textured materials:		
Undifferentiated	**C0**	Undifferentiated coarse textured (S, LS, SL) material
Gravels	**C1**	Gravels or gravelly (cobbly/stony) coarse textured material
Very coarse	**C2**	Very coarse (S, LS) sediments deposited by wind or water
Moderately coarse	**C3**	Moderately coarse (SL, FSL) sediments deposited by wind or water
Tills	**C4**	Very coarse textured till (*Till name*)
	C5	Moderately coarse textured till (*Till name*)
Bedrock	**C6**	Coarse textured (S, LS, SL) softrock
	C7	Coarse grained bedrock
Medium textured materials:		
Undifferentiated	**M0**	Undifferentiated medium textured (VFSL, L, SiL, SiCL, CL, SCL) materials
Gravelly	**M1**	Gravelly, medium textured, water-laid sediments (also cobbly and stony variations)
Medium	**M2**	Medium textured (L, SiL, VFSL) sediments deposited by wind and water
Moderately fine	**M3**	Moderately fine textured (CL, SCL, SiCL) sediments deposited by water
Till	**M4**	Medium textured (L to CL) till (*Till name*)
Bedrock	**M5**	Medium textured (L to CL) softrock
Gravelly till	**M6**	Gravelly, cobbly or stony, medium textured till
Fine textured materials:		
Undifferentiated	**F0**	Undifferentiated fine textured (C, SiC, HC) materials

Table B1 Parent material textural groupings adapted from AGRASID (ASIC 2001)

Materials	Code	Description
Fine	**F1**	Fine textured (C, SiC) water-laid sediments
Very fine	**F2**	Very fine textured (HC) water-laid sediments
Till-like	**F3**	Fine textured (C) water-laid sediments with till-like features
Till	**F4**	Fine textured (C) till (*Till name*)
Bedrock	**F5**	Fine textured (C, SiC) softrock
Layered materials (parent material change occurs between 30 and 100 cm):		
Gravelly coarse / till	**L1**	Gravel or gravelly (or cobbly/stony) coarse over medium or fine textured till
Coarse to medium / till	**L2**	Coarse textured (S, LS, SL) over medium or fine textured till
	L3	Medium textured (VFSL, L, sic, CL) over medium or fine textured till
Coarse to medium / gravel	**L4**	Coarse textured over gravel or gravelly coarse (includes cobbly and stony variations)
	L5	Medium textured over gravel or gravelly coarse (includes cobbly and stony variations)
Various depositional / softrock	**L6**	Till (Till name) over softrock
	L7	Coarse (not till) over softrock
	L8	Medium (not till) over softrock
Coarse to medium / Fine	**L9**	Coarse (not till) textured over fine or very fine (not till)
	L10	Medium (not till) textured over fine or very fine (not till)
Peat / various materials	**L11**	Peat (any) over coarse textured mineral materials
	L12	Peat (any) over medium textured mineral materials
	L13	Peat (any) over fine textured mineral materials
Fine / till	**L14**	Fine textured (not till) over medium to moderately fine textured till
	L15	Very fine textured (not till) over medium to moderately fine textured till
Fine / rock	**L16**	Fine to very fine textured (not till) over softrock
Gravelly medium / till	**L17**	Gravelly (or cobbly/stony) medium textured material over medium or fine textured till
Medium / coarse	**L18**	Medium textured material over coarse textured material
Gravelly medium / rock	**L19**	Gravelly medium textured material over softrock
Coarse / medium	**L20**	Coarse textured over medium or moderately fine (not till)
Gravelly coarse / medium	**L21**	Gravelly coarse textured over medium or moderately fine (not till)
Fine / medium	**L22**	Fine (not till) over medium (not till)
Peat Materials:		
Undifferentiated	**P0**	Undifferentiated peat
Bog	**P1**	Bog (*Sphagnum*) peat
Fen	**P2**	Fen peat
Forest	**P3**	Forest peat

Soil Variants

Soil variants are used to define soil entities that are sufficiently different from established soil series to warrant recognition, but do not justify a new soil name. Table B-2 lists all variants and their codes used in Alberta. Variants are indicated using the lower case letter codes after the series name.

Table B2 Soil variant codes (adapted from CAESA Soil Inventory Working Group 1997)

Code	Description	Code	Description
AA	Not modal SCA	*XM*	Medium material at 30-99 cm
AC	Acid	XP	Paralithic at 30-99 cm
CA	Calcareous	XS	Sand at 30-99 cm
CB	Cobbly	XT	Till at 30-99 cm
CO	Coarse	XU	Undifferentiated material at 30-99 cm
CR	Carbonated	XZ	Permafrost at 30-99 cm
CY	Cryic	YC	Clay at 100-200 cm
DA	Dark Ap (cultivated) horizon	YG	Gravel at 100-200 cm
DL	Disturbed	YL	Lithic at 100-200 cm
ER	Eroded	YM	Medium material at 100-200 cm
FI	Fine	YP	Paralithic at 100-200 cm
GL	Gleyed	YS	Sand at 100-200 cm
GM	Grumic	YT	Till at 100-200 cm
GR	Gravelly (entire profile)	YZ	Permafrost at 100-200 cm
OB	Overblown	ZB	Brunisolic
OW	Overwashed	ZE	Eluviated
NP	Non-Peaty	ZF	Fibric
PT	Peaty	ZG	Gleyed Rego
SA	Saline	ZH	Humic
SC	Saline subsoil	ZL	Luvisolic
ST	Stony	ZM	Mesic
TA	Thin A horizon	ZO	Orthic
TK	Thick A horizon	ZR	Rego
XC	Clay at 30-99 cm	ZS	Solodic
XG	Gravel at 30-99 cm	ZT	Solonetzic
XL	Lithic at 30-99 cm	ZZ	Atypical subgroup

APPENDIX C: DESCRIPTIONS OF SOIL MAP UNITS

Introduction – Soil Landscape Model

Below are a brief description of all soil models and SLM descriptions recorded in the LSA and access corridor including all baseline interpretations as detailed in the baseline assessment.

Soil Model (SM) and Soil Landscape Model (SLM) Descriptions

BMT21 Soil Model

Extent (ha / % of SAGD LSA):	21.8 ha / 0.9 %
Extent (ha / % of Access road LSA):	Not mapped
Dominant Soils (>60%):	Bitumont (BMT) – Orthic Gleysol
Significant Soils (10-30% ea.):	Mariana (MRN1c) - Terric Mesisols – sandy
Surficial (Parent) Materials:	Coarse to moderately coarse water laid veneer overlying medium textured till, in some areas the veneer is relatively thick (up to 1.0 m thick)
Surface Stoniness:	Non-stony
Land Use:	Forested

Baseline interpretations and layer thicknesses:

- Amalgamated forest capability rating – **4W**
- Reclamation Suitability – topsoil **P**, upper subsoil **F-P**
- Surface litter/peat thickness (average cm) – 35
- Topsoil thickness (average cm) – **20**
- Upper subsoil thickness (average cm) – **30**

BMT21 Soil Landscape Models (SLMs):

BMT21/L1	Extent – SAGD –21.8 ha of the LSA **L1** LM – nearly level terrain (0-2% slopes).

DOV9 Soil Model

Extent (ha / % of SAGD LSA):	Not mapped
Extent (ha / % of Access road LSA):	24.1 ha / 2.5 %
Dominant Soils (>60%):	Dover (DOV) – Orthic Gray Luvisol
Significant Soils (10-30% ea.):	Algar Lake (ALG) - Orthic Luvic Gleysol and Chateh (CHT) –- Orthic Gleysol
Surficial (Parent) Materials:	Fine textured lacustrotill (F3) with areas of fine textured water laid materials.
Surface Stoniness:	Non-stony
Land Use:	Forested

Baseline interpretations and layer thicknesses:

- Amalgamated forest capability rating – **2**
- Reclamation Suitability – topsoil **F-G**, upper subsoil **F-P**,
- Surface litter/peat thickness (average cm) – **15**
- Topsoil thickness (average cm) – **10**
- Upper subsoil thickness (average cm) – **50**

DOV9 Soil Landscape Models (SLMs):

DOV9/U1l	Extent – A/R – 24.1 ha of the LSA **U1l** LM – low relief undulating (0-2% slopes) topography

<u>HRLVgl2 Soil Model</u>

Extent (ha / % of SAGD LSA):	71.2 ha / 3.0%
Extent (ha / % of Access road LSA):	18.2 ha / 1.9%
Dominant Soils (>60%):	Horse River gleyed (HRRgl) and Livock gleyed (LVKgl) – Gleyed Gray Luvisols
Significant Soils (10-30% ea.):	Moonshine (MNSaa) and Wanham (WHMaa) – Orthic Luvic Gleysols
Surficial (Parent) Materials:	Horse River till to surface (M4) or a thin medium to moderately coarse water laid veneer over till (L3)
Surface Stoniness:	Non-stony
Land Use:	Forested

Baseline interpretations and layer thicknesses:

- Amalgamated forest capability rating – **3W**
- Reclamation Suitability – topsoil **F**, upper subsoil **F-P**
- Surface litter/peat thickness (average cm) – **5**
- Topsoil thickness (average cm) – **10**
- Upper subsoil thickness (average cm) – **40**

HRLVgl2 Soil Landscape Models (SLMs):

HRLVgl2 / U1l	Extent – SAGD – 71.2 ha of the LSA Extent – A/R – 18.2 ha of the LSA **U1l** LM – low relief undulating (0-2% slopes) topography.

HRLV9 Soil Model

Extent (ha / % of SAGD LSA):	559.3 ha / 24.8
Extent (ha / % of Access road LSA):	178.8 ha / 18.8 %
Dominant Soils (>60%):	Horse River (HRR) and Livock (LVK) – Orthic Gray Luvisols
Significant Soils (10-30% ea.):	Moonshine (MNSaa) and Wanham (WHMaa) – Orthic Luvic Gleysols, Mildred (MIL) and Sutherland (SUT) – Eluviated Dystric Brunisols
Surficial (Parent) Materials:	Horse river till to surface (M4) or a thin medium to moderately coarse water laid veneer over till (L3), significant thick veneer to blanket deposits of coarse glaciofluvial deposits (C2)
Surface Stoniness:	Non-stony
Land Use:	Forested

Baseline interpretations and layer thicknesses:

- Amalgamated forest capability rating – **3VD**
- Reclamation Suitability – topsoil **F-G**, upper subsoil **F-P**
- Surface litter/peat thickness (average cm) – **10**
- Topsoil thickness (average cm) – **10**
- Upper subsoil thickness (average cm) – **40**

HRLV9 Soil Landscape Models (SLMs):

HRLV9 / U1l	Extent – SAGD – 46.2 ha of the LSA Extent – A/R – 17.0 ha of the LSA **U1l** LM – low relief undulating (0-2% slopes) topography.
HRLV9 / U1h	Extent – SAGD – 313.6 ha of the LSA Extent – A/R – 88.5 ha of the LSA **U1h** LM – high relief undulating (2-5% slopes) topography.
HRLV9 / H1l	Extent – SAGD – 96.2 ha of the LSA Extent – A/R – 36.8 ha of the LSA **H1l** LM – low relief hummocky (5-10% slopes) topography.
HRLV9 / H1m	Extent – SAGD – 57.2 ha of the LSA Extent – A/R – 37.6 ha of the LSA **H1m** LM – high relief hummocky (10-15% slopes) topography.

LVPE2 Soil Model

Extent (ha / % of SAGD LSA):	5.1 ha / 0.2 %
Extent (ha / % of Access road LSA):	49.2 ha / 5.2 %
Dominant Soils (>60%):	Livock (LVK) and Peavine (PEA) – Orthic Gray Luvisols
Significant Soils (10-30% ea.):	Moonshine (MNSaa) and Wanham (WHMaa) – Orthic Luvic Gleysols
Surficial (Parent) Materials:	Thin medium to moderately coarse water laid veneer over till (L3) and in some areas a blanket of medium textured water laid material (M2/M3)
Surface Stoniness:	Non-stony
Land Use:	Forested

Baseline interpretations and layer thicknesses:

- Amalgamated forest capability rating – **3VD**
- Reclamation Suitability – topsoil **F**, Upper subsoil **F-G**
- Surface litter/peat thickness (average cm) – **10**
- Topsoil thickness (average cm) – **15**
- Upper subsoil thickness (average cm) – **35**

LVPE2 Soil Landscape Models (SLMs):

LVPE2 / U1h Extent – SAGD – 5.1 ha of the LSA
Extent – A/R – 49.2 ha of the LSA
U1lh LM – high relief undulating (2-5% slopes) topography.

MISU18 Soil Model

Extent (ha / % of SAGD LSA):	251.5 ha / 10.7 %
Extent (ha / % of Access road LSA):	10.1 ha / 1.1 %
Dominant Soils (>60%):	Mildred (MIL) and Sutherland (SUT) – Eluviated Dystric Brunisols
Significant Soils (10-30% ea.):	Horse River (HRR) and Livock (LVK) – Orthic Gray Luvisols, Wanham (WHMaa) – Orthic Luvic Gleysol and Bitumont (BMT) – Orthic Gleysol
Surficial (Parent) Materials:	Moderately coarse to coarse glaciofluvial parent material (C2), significant till and veneer over till outcrops within map unit, extent and locations variable
Surface Stoniness:	Non-stony
Land Use:	Forested

Baseline interpretations and layer thicknesses:

- Amalgamated forest capability rating – **3X**
- Reclamation Suitability – topsoil **P**, upper subsoil **P**
- Surface litter/peat thickness (average cm) – **8**
- Topsoil thickness (average cm) – **15**
- Upper subsoil thickness (average cm) – **50**

MISU18 Soil Landscape Models (SLMs):

MISU18 / U1l	Extent – SAGD – 45.1 ha of the LSA **U1l** LM – low relief undulating (0-2% slopes) topography.
MISU18 / U1h	Extent – SAGD – 206.4 ha of the LSA Extent – A/R – 10.1 ha of the LSA **U1lh** LM – high relief undulating (2-5% slopes) topography.

<u>MKW1 Soil Model</u>

Extent (ha / % of SAGD LSA):	155.9 ha / 6.6 %
Extent (ha / % of Access road LSA):	105.4 ha / 11.1 %
Dominant Soils (>60%):	Mikwa (MKW) – Mesic and Fibric Organic Cryosols
Significant Soils (10-30% ea.):	Mariana (MRN1f, m, c) – Terric Mesisol/Fibrisol, Moonshine (MNSaa) and Wanham (WHMaa) – Orthic Luvic Gleysols and Bitumont (BMT) – Orthic Gleysol
Surficial (Parent) Materials:	Bog peat (minimum 40 cm) over ice contact, variability in ice contact, as a result MRN, WHMaa and MNSaa were often recorded along the margins
Surface Stoniness:	Non-stony
Land Use:	Forested

Baseline interpretations and layer thicknesses:

- Amalgamated forest capability rating – **5WF**
- Reclamation Suitability – topsoil **O**, Upper subsoil **O**
- Surface litter/peat thickness (average cm) – **105**

MKW1 Soil Landscape Models (SLMs):

MKW1 / O1	Extent – SAGD – 34.3 ha of the LSA Extent – A/R – 13.8 ha of the LSA **O1** LM – level, flat, horizontal, or plateau; slope classes 1-2.
MKW1 / O5	Extent – SAGD – 120.9 ha of the LSA Extent – A/R – 92.6 ha of the LSA **O5** LM – level with small, elevated knolls or hummocks; slope classes 1-2 (0-2% slopes), hummocks may have slopes ranging from 3-5 (5-15% slopes). Hummocks considered frozen peat mounds found in Cryosol landscapes.

MLD1m Soil Model

Extent (ha / % of SAGD LSA):	45.9 ha / 4.9 %
Extent (ha / % of Access road LSA):	Not mapped
Dominant Soils (>60%):	McLelland (MLD2) – Typic Mesisol (may include Typic Fibrisol, Fibric Mesisol, and/or Mesic Fibrisol)
Significant Soils (10-30% ea.):	N/A
Surficial (Parent) Materials:	Relatively shallow (40-100 cm) fen peat overlying medium textured materials, peaty Gleysols were recorded along margins of this map unit
Surface Stoniness:	Non-stony
Land Use:	Forested

Baseline interpretations and layer thicknesses:

- Amalgamated forest capability rating – **5WF**
- Reclamation Suitability – topsoil **O**, Upper subsoil **O**
- Surface litter/peat thickness (average cm) – **60**

MLD1m Soil Landscape Models (SLMs):

MLD1m / O2	Extent – SAGD – 24.2 ha of the LSA **O2** LM – basin or bowl; slope classes 1-2.
MLD1m / O3	Extent – SAGD – 21.8 ha of the LSA **O3** LM – channelled, as along stream channels; slope classes 1-2.

MLD2m Soil Model

Extent (ha / % of SAGD LSA):	26.9 ha / 1.1 %
Extent (ha / % of Access road LSA):	51.1 ha / 5.4 %
Dominant Soils (>60%):	McLelland (MLD2m) – Typic Mesisol (may include Typic Fibrisol, Fibric Mesisol, and/or Mesic Fibrisol)
Significant Soils (10-30% ea.):	N/A
Surficial (Parent) Materials:	Moderately deep (100-200 cm) fen peat overlying coarse textured materials
Surface Stoniness:	Non-stony
Land Use:	Forested

Baseline interpretations and layer thicknesses:

- Amalgamated forest capability rating – 5WF
- Reclamation Suitability – topsoil O, upper subsoil O
- Surface litter/peat thickness (average cm) – 115

MLD2m Soil Landscape Models (SLMs):

MLD2m / O2 Extent – SAGD – 23.7 ha of the LSA
Extent – A/R – 23.5 ha of the LSA
O2 LM – basin or bowl; slope classes 1-2.

MLD2m / O3 Extent – SAGD – 3.2 ha of the LSA
Extent – A/R – 27.6 ha of the LSA
O3 LM – channelled, as along stream channels; slope classes 1-2.

MLD3 Soil Model

Extent (ha / % of SAGD LSA):	3.0 ha / 0.1 %
Extent (ha / % of Access road LSA):	Not mapped
Dominant Soils (>60%):	McLelland (MLD3) – Typic Mesisol (may include Typic Fibrisol, Fibric Mesisol, and/or Mesic Fibrisol)
Significant Soils (10-30% ea.):	N/A
Surficial (Parent) Materials:	Deep (>200 cm) fen peat
Surface Stoniness:	Non-stony
Land Use:	Forested

Baseline interpretations and layer thicknesses:

- Amalgamated forest capability rating – **5WF**
- Reclamation Suitability – topsoil **O**, upper subsoil **O**
- Surface litter/peat thickness (average cm) – **>200**

MLD3 Soil Landscape Models (SLMs):

MLD3 / O3	Extent – SAGD – 3.0 ha of the LSA **O3** LM – channelled, as along stream channels; slope classes 1-2.

<u>MNWH20 Soil Model</u>

Extent (ha / % of SAGD LSA):	108.4 ha / 4.6 %
Extent (ha / % of Access road LSA):	65.0 ha / 6.5 %
Dominant Soils (>60%):	Moonshine (MNSaa) and Wanham (WHMaa) – Orthic Luvic Gleysols, peaty variants common
Significant Soils (10-30% ea.):	Horse River gleyed (HRRgl) and Livock gleyed (LVKgl) – Gleyed Gray Luvisols, Bitumont (BMT) – Orthic Gleysols and Mildred gleyed (MILgl) and Sutherland gleyed (SUTgl) – Gleyed Eluviated Dystric Brunisols
Surficial (Parent) Materials:	Horse River till to surface (M4) or a thin medium to moderately coarse water laid veneer over till (L3)
Surface Stoniness:	Non-stony
Land Use:	Forested

Baseline interpretations and layer thicknesses:

- Amalgamated forest capability rating – 3WF
- Reclamation Suitability – topsoil F, upper subsoil F
- Surface litter/peat thickness (average cm) – 15
- Topsoil thickness (average cm) – 10
- Upper subsoil thickness (average cm) – 40

MNWH20 Soil Landscape Models (SLMs):

MNWH20 / U1l	Extent – SAGD – 108.4ha of the LSA Extent – A/R – 65.0 ha of the LSA **U1l** LM – low relief undulating (0-2% slopes) topography.

MNWH21 Soil Model

Extent (ha / % of SAGD LSA):	60.4 ha / 2.6 %
Extent (ha / % of Access road LSA):	86.1 ha / 9.1 %
Dominant Soils (>60%):	Moonshine (MNSaa) and Wanham (WHMaa) – Orthic Luvic Gleysols, peaty variants common
Significant Soils (10-30% ea.):	Mariana (MRN1f, m, c) – Terric Mesisol/Fibrisol
Surficial (Parent) Materials:	Horse River till to surface (M4) or a thin medium to moderately coarse water laid veneer over till (L3)
Surface Stoniness:	Non-stony
Land Use:	Forested

Baseline interpretations and layer thicknesses:

- Amalgamated forest capability rating – **4W**
- Reclamation Suitability – topsoil **F**, upper subsoil **F**
- Surface litter/peat thickness (average cm) – **30**
- Topsoil thickness (average cm) – **5**
- Upper subsoil thickness (average cm) – **35**

MNWH21 Soil Landscape Models (SLMs):

MNWH21/L1	Extent – SAGD –25.9 ha of the LSA Extent – A/R – 72.9 ha of the LSA **L1** LM – nearly level terrain (0-2% slopes).
MNWH21 / U1l	Extent – SAGD – 34.6ha of the LSA Extent – A/R – 13.6 ha of the LSA **U1l** LM – low relief undulating (0-2% slopes) topography.

MRN1c, m, f-G Soil Model

Extent (ha / % of SAGD LSA):	227.0 ha / 7.6 %
Extent (ha / % of Access road LSA):	130.8 ha / 13.8 %
Dominant Soils (>60%):	Mariana (MRN) – Terric Mesisol (may include Terric Fibrisol and other organic intergrades)
Significant Soils (10-30% ea.):	Moonshine peaty (MNSaapt), Wanham peaty (WHMaapt) and Bitumont peaty (BMTpt) – peaty gleysols of variable parent material
Surficial (Parent) Materials:	Shallow (40-100 cm) fen peat over various textures (c, m, f), map units of all three texture classes are present
Surface Stoniness:	Non-stony
Land Use:	Forested

Baseline interpretations and layer thicknesses:

- Amalgamated forest capability rating – **5WF**
- Reclamation Suitability – topsoil **O**, upper subsoil **P**

MRN1c-G

- Surface litter/peat thickness (average cm) – **40**

MRN1m-G

- Surface litter/peat thickness (average cm) – **50**

MRN1f-G

- Surface litter/peat thickness (average cm) – **40**

MRN1c, m, f-G Soil Landscape Models (SLMs):

MRN1c-G / O1	Extent – SAGD – 51.6 ha of the LSA **O1** LM – level, flat, horizontal, or plateau; slope classes 1-2.
MRN1c -G / O2	Extent – SAGD – 12.4 ha of the LSA **O2** LM – basin or bowl; slope classes 1-2.
MRN1m-G / O1	Extent – SAGD – 80.6 ha of the LSA Extent – A/R – 75.0 ha of the LSA **O1** LM – level, flat, horizontal, or plateau; slope classes 1-2.
MRN1m-G / O2	Extent – SAGD – 10.4 ha of the LSA Extent – A/R – 2.0 ha of the LSA **O2** LM – basin or bowl; slope classes 1-2.
MRN1m-G / O3	Extent – SAGD – 53.3 ha of the LSA Extent – A/R – 14.1 ha of the LSA **O3** LM – channelled, as along stream channels; slope classes 1-2.
MRN1f-G / O1	Extent – SAGD – 18.6 ha of the LSA Extent – A/R – 40.6 ha of the LSA **O1** LM – level, flat, horizontal, or plateau; slope classes 1-2.

MRN1m Soil Model

Extent (ha / % of SAGD LSA):	369.5 ha / 15.7%
Extent (ha / % of Access road LSA):	66.4 ha / 7.0 %
Dominant Soils (>60%):	Mariana (MRN) – Terric Mesisol (may include Terric Fibrisol and other organic intergrades)and Moonshine (MNSaa)
Significant Soils (10-30% ea.):	Mikwa (MKW) – Mesic/Fibric Organic Cryosols
Surficial (Parent) Materials:	Shallow (40-100 cm) fen peat over medium textured (m) materials
Surface Stoniness:	Non-stony
Land Use:	Forested

Baseline interpretations and layer thicknesses:

- Amalgamated forest capability rating – 5WF
- Reclamation Suitability – topsoil O, upper subsoil 0
- Surface litter/peat thickness (average cm) – 70

MRN1m Soil Landscape Models (SLMs):

MRN1m / O1	Extent – SAGD – 237.1 ha of the LSA Extent – A/R – 44.3 ha of the LSA **O1** LM – level, flat, horizontal, or plateau; slope classes 1-2.
MRN1m / O2	Extent – SAGD – 11.5 ha of the LSA Extent – A/R – 22.0 ha of the LSA **O2** LM – basin or bowl; slope classes 1-2.
MRN1m / O3	Extent – SAGD – 120.8 ha of the LSA Extent – A/R – 0.1 ha of the LSA **O3** LM – channelled, as along stream channels; slope classes 1-2.

MUS2m Soil Model

Extent (ha / % of SAGD LSA):	101.0 ha / 4.3 %
Extent (ha / % of Access road LSA):	86.8 ha / 9.1 %
Dominant Soils (>60%):	Muskeg (MUS) – Typic Mesisol (may include Typic Fibrisol, Fibric Mesisol, and/or Mesic Fibrisol)
Significant Soils (10-30% ea.):	Mikwa (MKW) – Mesic/Fibric Organic Cryosols
Surficial (Parent) Materials:	Moderately deep (100-200 cm) bog peat over medium textured materials
Surface Stoniness:	Non-stony

Land Use: Wetland

Baseline interpretations and layer thicknesses:

- Amalgamated forest capability rating – 5WF
- Reclamation Suitability – topsoil O, Upper subsoil O
- Surface litter/peat thickness (average cm) – 120

MUS2m Soil Landscape Models (SLMs):

MUS2m / O1 Extent – SAGD – 88.4 ha of the LSA
Extent – A/R – 35.4 ha of the LSA
O1 LM – level, flat, horizontal, or plateau; slope classes 1-2.

MUS2m / O2 Extent – SAGD – 9.5 ha of the LSA
Extent – A/R – 2.0 ha of the LSA
O2 LM – basin or bowl; slope classes 1-2.

MUS2m / O3 Extent – SAGD – 3.1 ha of the LSA
Extent – A/R – 49.9 ha of the LSA
O3 LM – channelled, as along stream channels; slope classes 1-2.

MUS3 Soil Model

Extent (ha / % of SAGD LSA):	51.5 ha / 2.2 %
Extent (ha / % of Access road LSA):	46.2 ha / 4.9 %
Dominant Soils (>60%):	Muskeg (MUS) – Typic Mesisol (may include Typic Fibrisol, Fibric Mesisol, and/or Mesic Fibrisol)
Significant Soils (10-30% ea.):	Mikwa (MKW) – Mesic/Fibric Organic Cryosols
Surficial (Parent) Materials:	Deep (>220 cm) bog peat over organic or deeper mineral materials.
Surface Stoniness:	Non-stony
Land Use:	Wetland

Baseline interpretations and layer thicknesses:

- Amalgamated forest capability rating – **5WF**
- Reclamation Suitability – topsoil **O**, Upper subsoil **O**
- Surface litter/peat thickness (average cm) – **>220**

MUS3 Soil Landscape Models (SLMs):

MUS3 / O1	Extent – SAGD – 38.7 ha of the LSA **O1** LM – level, flat, horizontal, or plateau; slope classes 1-2.
MUS3 / O3	Extent – SAGD – 12.9 ha of the LSA Extent – A/R – 46.2 ha of the LSA **O3** LM – channelled, as along stream channels; slope classes 1-2.

ZDL Soil Model

Extent (ha / % of SAGD LSA):	2.6 ha / 0.1 %
Extent (ha / % of Access road LSA):	Not mapped
Dominant Soils (>60%):	N/A
Significant Soils (10-30% ea.):	N/A
Surficial (Parent) Materials:	N/A
Surface Stoniness:	N/A
Land Use:	Disturbed Lands, well sites within study area

Soil Landscape Models (SLMs): **None (Not applicable)**

ZWA Soil Model

Extent (ha / % of SAGD LSA):	297.9 ha / 12.6 %
Extent (ha / % of Access road LSA):	23.0 ha / 3.0 %
Dominant Soils (>60%):	Non-soil – Water
Significant Soils (10-30% ea.):	N/A
Surficial (Parent) Materials:	N/A
Surface Stoniness:	N/A
Land Use:	Wetland (water bodies)

Soil Landscape Models (SLMs): **None (Not applicable)**

APPENDIX D: SOIL SERIES/VARIANT DESCRIPTIONS

Introduction

Brief tabular descriptions of the major and significant soil series and variants found in the LSA and associated access corridor are provided below. Soil and site data, including laboratory results, collected from within for the assessment were used to characterize and describe the soils. The project area occurs within SCA 20, and the soils were found to have relatively similar characteristics throughout the area. A subtle change in soil makeup was noticed near the south portion of the access corridor, soils unique to this area are identified. The summary descriptions below include chemical and physical attributes amalgamated from inspection sites and sampled profiles in the lease area, the Alberta Soil Layer File (AG30SLF, ASIC 2001), and the Alberta Oil Sands region (Turchenek et al. 1982b). These amalgamated attributes were used to calculate the baseline forest capability ratings and reclamation suitability of the soils in the LSA. The origin of the laboratory values is given for each series in the table heading as such:

- ASLF – Alberta Soil Layer File; or
- OSERP – Alberta Oil Sands Environmental Research Program;
- 2008 assessment – Site location displayed or;
- Referenced from previous Soil survey work completed in the region.

Bitumont (BMT) Series

BMT is an Orthic Gleysol formed on coarse textured water laid materials. Some important features of BMT include:

- Subgroup – Orthic Gleysol, a majority of the site found during the investigation were peaty variants (15-40 cm of peat over mineral).
- Parent material – coarse textured water-laid materials (C2).
- Drainage – Imperfect to poor.
- Distribution in study areas – recorded throughout the SAGD LSA and access road LSA, predominantly in proximity to the large lakes.

Table D1: General description of BMTpt series, Profile from OSERP-M79-6

Horizon	Depth (cm)	Field Texture	Coarse Fragments (%)	Structure	Consistence
Of	24-0	Organic	--	--	--
Aeg	0-15	LS	--	Granular	Non-plastic
Btg	15-51	LS	--	Weak sub-angular blocky	Non-plastic
BCg	51-100	S	--	Loose	Non-plastic

Table D2: Selected chemical and physical attributes of BMTpt series – OSERP- M79-6.

Horizon	Depth (cm)	pH	EC	OC	$CaCO_3$ Equiv.	TN	PSA (%)			Texture Class	DB	SAR
							Sand	Silt	Clay			
Of	24-0	4.3	-	45.8	-	1.08	-	-	-	Organic	0.12	
Aeg	0-15	6.6	-	0.86	-	0.18	88	10	2	LS	1.45	
Btg	15-51	7.1	-	0.2	-	0.08	80	17	3	LS	1.45	
BCg	51-100	6.6	-	-	-	-	90	6	4	S	1.5	

pH – measured in saturated paste or water EC – electrical conductivity (dS/m) OC – total organic carbon (%)
CaCO3 Equiv. – calcium carbonate equivalent (%) TN – total nitrogen (%), Kjeldahl method
PSA – particle size analysis (% sand, silt, and clay separates) by the hydrometer method, with texture class
DB – Bulk density (g/cm^3) SAR – sodium adsorption ratio

Chateh (CHT) Series

CHT is an Orthic Gleysol formed on fine textured water laid materials or fine textured lacustrotill. Some important features of CHT include:

- Subgroup – Orthic Gleysol all site found during the investigation were peaty variants (15-40 cm of peat over mineral).
- Parent material – fine textured, mainly water-laid or glacial materials (F1 or F3).
- Drainage – Imperfect to poor.
- Distribution in study areas – isolated to the southern portion of the access road LSA.

Table D3: General description of CHTpt series, from DCEL* - CHT Pedon.

Horizon	Depth (cm)	Field Texture	Coarse Fragments (%)	Structure	Consistence
Om	35-0	Organic	--	--	--
Bg	0-52	SiC	<1%	Massive	Sticky
BCg	52-100	SiC	<1%	Massive	Firm

Table D4: Selected chemical and physical attributes of CHTpt series - DCEL* - CHT Pedon.

Horizon	Depth (cm)	pH	EC	OC	$CaCO_3$ Equiv.	TN	PSA (%)			Texture Class	DB	SAR
							Sand	Silt	Clay			
Om	35-0	5.8	-	14.6	-	0.94	-	-	-	Organic	0.12	-
Bg	0-52	5.4	-	2.0	-	0.16	11	44	45	SiC	1.35	-
BCg	52-100	7.3	0.40	-	-	-	11	44	43	SiC	1.35	1.4

* Deer Creek Energy Limited, Joslyn SAGD Project, Phase IIIA-Soil Survey with Impact Assessment, Chateh pedon description and characteristics.
pH – measured in saturated paste or water EC – electrical conductivity (dS/m) OC – total organic carbon (%)
CaCO3 Equiv. – calcium carbonate equivalent (%) TN – total nitrogen (%), Kjeldahl method
PSA – particle size analysis (% sand, silt, and clay separates) by the hydrometer method, with texture class
DB – Bulk density (g/cm^3) SAR – sodium adsorption ratio

Dover (DOV & DOVgl) Series

DOV is an Orthic Gray Luvisol formed on fine textured water laid materials and/or fine textured Dover till. Some important features of DOV include:

- Subgroup – Orthic Gray Luvisol, gleyed profiles were also recorded.
- Parent material – fine glaciolacustrine material, calcareous (F1 or F3).

- Drainage –moderately well to imperfect.
- Distribution in study areas – recorded mainly in the southern portion of the access road LSA.

Table D5: General description of DOV series, Profile MY18.

Horizon	Depth (cm)	Field Texture	Coarse Fragments (%)	Structure	Consistence
LFH	9-0	Litter	--	--	--
Ae	0-14	SiL	--	Platy	Friable
Bt	14-66	Clay	--	Sub-angular blocky	V. firm
BC	66-100	Clay	--	Massive	V. firm

Table D6: Selected chemical and physical attributes of DOV series –MY18

Horizon	Depth (cm)	pH	EC	OC	$CaCO_3$ Equiv.	TN	PSA (%)			Texture Class	DB	SAR
							Sand	Silt	Clay			
LFH	9-0	6.4	--	41.6	--	0.52	--	--	--	Litter		
Ae	0-14	5.7	0.2	0.59	--	0.05	30	51	19	SiL	1.51	0.4
Bt	14-66	6.5	0.24	0.92	--	<0.02	14	33	53	C	1.38	0.7
BC	66-100	7.6	0.5	--	--	--	23	23	54	C	--	1.3

pH – measured in saturated paste or water EC – electrical conductivity (dS/m) OC – total organic carbon (%)
CaCO3 Equiv. – calcium carbonate equivalent (%) TN – total nitrogen (%), Kjeldahl method
PSA – particle size analysis (% sand, silt, and clay separates) by the hydrometer method, with texture class
DB – Bulk density (g/cm^3) SAR – sodium adsorption ratio

Horse River (HRR &HRRgl) Series

HRR is an Orthic Gray Luvisol formed on medium textured slightly to moderately calcareous and moderately stony Horse River till. Some important features of HRR include:

- Subgroup – Orthic Gray Luvisol & Gleyed Gray Luvisol (variant).
- Parent material – Horse River till (M4).
- Drainage – mainly moderately well drained to imperfect (gleyed variant).
- Distribution in study areas – dominant in upland terrain throughout the SAGD LSA, occurrence decrease moving south along the access road LSA.

Table D7: General description of HRR series, Profile SBW131

Horizon	Depth (cm)	Field Texture	Coarse Fragments (%)	Structure	Consistence
LFH	8-0	Litter	--	--	--
Ae	0-11	Loam	2-	Platy	Friable
Bt	11-54	Clay Loam	2-5	Subangular blocky	Firm
BC	54-90	Clay Loam	2-5	Massive	V. firm
Ck	90-100	Clay	10	Massive	V. firm

Table D8: Selected chemical and physical attributes of HRR series, Profile SBW131

Horizon	Depth (cm)	pH	EC	OC	$CaCO_3$ Equiv.	TN	PSA (%)			Texture Class	DB	SAR
							Sand	Silt	Clay			
LFH	8-0	5.3	--	26.5	--	0.47	--	--	--	Litter	0.1	
Ae	0-11	5.0	--	0.58	--	0.04	42	44	14	L	1.43	
Bt	11-54	4.9	0.10	--	--	--	38	26	36	CL	1.4	0.6
BC	54-90	5.9	0.39	--	--	--	39	26	35	CL	1.35	0.5
Ck	90-100	7.3	0.53	--	2	--	33	26	41	C	1.35	

pH – measured in saturated paste or water EC – electrical conductivity (dS/m) OC – total organic carbon (%)
CaCO3 Equiv. – calcium carbonate equivalent (%) TN – total nitrogen (%), Kjeldahl method
PSA – particle size analysis (% sand, silt, and clay separates) by the hydrometer method, with texture class
DB – Bulk density (g/cm^3) SAR – sodium adsorption ratio

Livock (LVK & LVKgl) Series

LVK is an Orthic Gray Luvisol formed on medium textured water laid veneer (minimum 30 cm thick) over Horse River till. Some important features of LVK include:

- Subgroup – Orthic Gray Luvisol & Gleyed Gray Luvisol (variant).
- Parent material –water laid veneer over till (L3).
- Drainage – mainly moderately well drained to imperfect (gleyed variant).
- Distribution in study areas – co-dominant to significant in upland terrain throughout the SAGD LSA, occurs with Peavine soils moving south along the access road LSA.

Table D9: General description of LVK series, Profile SRM025.

Horizon	Depth (cm)	Field Texture	Coarse Fragments (%)	Structure	Consistence
LFH	6-0	Litter	--	--	--
Ae	0-10	Loamy sand	--	Platy	Friable
AB	10-21	Sandy loam	--	Weak Subangular blocky	Friable
Bt	21-43	Loam	--	Subangular blocky	Firm
BC	43-75	Clay loam	1-2	Subangular blocky	Firm
Ck	75-100	Clay loam	2	Massive	Firm

Table D10: Selected chemical and physical attributes of LVK series, Profile SRM025.

Horizon	Depth (cm)	pH	EC	OC	$CaCO_3$ Equiv.	TN	PSA (%)			Texture Class	DB	SAR
							Sand	Silt	Clay			
LFH	6-0	6.4	--	30.4	1.5	1.14	--	--	--	Litter	0.1	--
Ae	0-10	6.5	0.5	<0.1	<0.7	0.03	83	11	6	LS	1.35	0.6
AB	10-21	5.1	0.2	0.2	<0.7	0.04	63	20	16	SL	1.45	1.5
Bt	21-43	5.1	0.2	--	--	--	39	35	26	L	1.5	1.5
BC	43-75	6.3	0.3	--	--	--	39	29	32	CL	1.45	1.4
Ck	75-100	7.5	0.5	--	--	--	38	30	32	CL	1.35	0.9

pH – measured in saturated paste or water EC – electrical conductivity (dS/m) OC – total organic carbon (%)
CaCO3 Equiv. – calcium carbonate equivalent (%) TN – total nitrogen (%), Kjeldahl method
PSA – particle size analysis (% sand, silt, and clay separates) by the hydrometer method, with texture class
DB – Bulk density (g/cm^3) SAR – sodium adsorption ratio
*Horizon to thin to sample.

Mariana (MRN) Series

MRN is a Terric Mesisol, which has a shallow bog peat layer over mainly medium textured material, however MRN soils were recorded over coarse (sandy – s) and fine textured materials (fine – f). Some important features of MRN:

- Subgroup – Terric Mesisol/Fibrisol with bog peat material (occurs in bog landscapes).
- Parent material – 40-100 cm of peat over various textured mineral materials, synonymous with MRN1m, MRN1s, and MRN1f.
- The MRN series is also mapped with significant peaty Gleysols, hence the soil map unit name MRN1m – G. The peaty Gleysols were typically MNSaa or WHMaa, in instance of MRN1s, the coarse textured BMT series was recorded.
- Drainage – poorly to very poorly drained.
- Distribution in study areas – located throughout the study areas in depressional drainways and open bog landscapes.

Table D11: General description of MRN1m series, Profile SJJ037.

Horizon	Depth (cm)	Field Texture	Coarse Fragments (%)	Structure	Consistence
Of	0-25	Organic	--	--	--
Om	25-77	Organic	--	--	--
BCg/Cg	77-120	Loam	--	Amorphous (Massive)	Slightly Plastic

Table D12: Selected chemical and physical attributes of MRN1m series, Profile SJJ037.

Horizon	Depth (cm)	pH	EC	OC	$CaCO_3$ Equiv.	TN	PSA (%)			Texture Class	DB	SAR
							Sand	Silt	Clay			
Of	0-25	4.4	0.6	33.9	2.4	1.09	--	--	--	O	0.06	1.9
Om	25-77	5.1	--	40.3	1.8	1.07	--	--	--	O	0.12	--
BCg/Cg	77-120	6.4	0.3	--	--	--	39	43	18	L	1.5	1.3

pH – measured in saturated paste or water EC – electrical conductivity (dS/m) OC – total organic carbon (%)
CaCO3 Equiv. – calcium carbonate equivalent (%) TN – total nitrogen (%), Kjeldahl method
PSA – particle size analysis (% sand, silt, and clay separates) by the hydrometer method, with texture class
DB – Bulk density (g/cm^3) SAR – sodium adsorption ratio

Mildred (MIL & MILgl & MILfi) Series

MIL is an Eluviated Dystric Brunisol formed on coarse textured fluvial outwash material. Some important features of MIL:

- Subgroup – Eluviated Dystric Brunisol & Gleyed Eluviated Dystric Brunisol (variant). Other notable variants included a finer textured version of a typical MIL, MILfi. Textures were sandy loam to loamy sand.
- Parent material – very coarse sediments deposited by wind or water, acidic – pH <5.5, glaciofluvial outwash material (C2).
- Drainage –rapidly drained, low relief sites (gleyed variant) can be imperfectly drained
- Distribution in study areas – Series occur throughout the study areas, map units typically occur on ridges within the north portion of the SAGD LSA.

Table D13: General description of MIL series, Profile SRP06.

Horizon	Depth (cm)	Field Texture	Coarse Fragments (%)	Structure	Consistence
LFH	6-0	Litter	--	--	--
Ae	0-16	LS	<1	Weak platy	Friable
Bm1	16-75	SL	<1	Single grain	Loose
Bm2/BC	75-100	SL	<1	Single grain	Loose

Table D14: Selected chemical and physical attributes of MIL series, Profile SRP06.

Horizon	Depth (cm)	pH	EC	OC	$CaCO_3$ Equiv.	TN	PSA (%)			Texture Class	DB	SAR
							Sand	Silt	Clay			
LFH	6-0	5.0	--	43.2	1.6	0.08	--	--	--	Litter	0.1	--
Ae	0-16	4.8	<0.1	<0.1	<0.7	0.03	85	12	2	LS	1.45	1.1
Bm1	16-75	5.3	0.1	0.8	<0.7	0.05	59	29	12	SL	1.5	0.7
Bm2/BC	75-100	5.4	0.2	--	--	--	59	29	12	SL	1.5	1.9

pH – measured in saturated paste or water EC – electrical conductivity (dS/m) OC – total organic carbon (%)
CaCO3 Equiv. – calcium carbonate equivalent (%) TN – total nitrogen (%), Kjeldahl method
PSA – particle size analysis (% sand, silt, and clay separates) by the hydrometer method, with texture class
DB – Bulk density (g/cm^3) SAR – sodium adsorption ratio

Mikkwa (MKW1) Series

MKW is an Organic Cryosol soil located on sphagnum peat. Typically the composition of the underlying mineral stratum is not known due to the presence of ice in the peat material at shallow depths. Some important features of MKW1:

- Subgroup – Mesic and Fibric Organic Cryosol.
- Parent material – organic material frozen within 1.0 m of surface, the thickness of the organic material and underlying mineral material is often not known due to the ice contact, therefore a P1 parent material code is applied. A P1 code is usually used to describe deep peat deposits (> 2.0 m thick).

- Drainage – poorly to very poorly drained.
- Distribution in study areas – occurrences variable throughout the study areas. MKW map units are more common in the south portion of the SAGD LSA and along the access road LSA.

Table D15: General description of a MKW1 series, Profile SGW028.

Horizon	Depth (cm)	Field Texture	Coarse Fragments (%)	Structure	Consistence
Of	0-44	--	--	--	--
Omz	44-77	--	--	--	Frozen

Table D16: Selected chemical and physical attributes of a MKW1 series, Profile SGW028.

Horizon	Depth (cm)	pH	EC	OC	$CaCO_3$ Equiv.	TN	PSA (%)			Texture Class	DB	SAR
							Sand	Silt	Clay			
Of	0-44	4.1	0.6	45.3	4.6	0.85	--	--	--	--	0.06	<0.4
Omz	44-77	4.9	--	46.5	2.9	--	--	--	--	--	0.12	--

pH – measured in saturated paste or water EC – electrical conductivity (dS/m) OC – total organic carbon (%)
CaCO3 Equiv. – calcium carbonate equivalent (%) TN – total nitrogen (%), Kjeldahl method
PSA – particle size analysis (% sand, silt, and clay separates) by the hydrometer method, with texture class
DB – Bulk density (g/cm^3) SAR – sodium adsorption ratio

McLelland (MLD1) Series

MLD is a Terric Mesisol, which has a shallow fen peat layer over mainly medium textured material, however MLD soils were recorded over coarse (sandy – s) and fine textured materials (fine – f). Some important features of MLD:

- Subgroup – Terric/Fibric Mesisol with fen peat material (occurs in fen landscapes).
- Parent material – 40-100 cm of peat over various textured mineral materials.
- Synonymous with MLD1m, MLD1c, and MLD1f (L11, L12 and L13).
- The MLD series is also mapped with significant peaty Gleysols, hence the soil map unit name MLD1m – G. The peaty Gleysols were typically MNSaa or WHMaa, in instance of MRN1s-G, the coarse textured BMT series was recorded and the fine textured CHT series in cases of MRN1f-G.
- Drainage – poorly to very poorly drained.
- Distribution in study areas – located throughout the study areas in depressional drainways and fen landscapes.

Table D17: General description of MLD1m variant, Profile SRM026.

Horizon	Depth (cm)	Field Texture	Coarse Fragments (%)	Structure	Consistence
Of	0-25	--	--	--	--
Om	25-54	--	--	--	--
BCg/Cg	54-120	Loam	--	Amorphous	Slightly Plastic

Table D18: Selected chemical and physical attributes of MLD1m variant, Profile SRM026.

Horizon	Depth (cm)	pH	EC	OC	$CaCO_3$ Equiv.	TN	PSA (%)			Texture Class	DB	SAR
							Sand	Silt	Clay			
Of	0-25	4.4	0.6	33.9	2.4	1.09	--	--	--	--	0.06	--
Om	25-54	5.1	--	40.3	1.8	1.07	--	--	--	--	0.12	--
BCg/Cg	54-120	6.4	0.30	--	--	--	39	43	18	L	1.5	0.6

pH – measured in saturated paste or water EC – electrical conductivity (dS/m) OC – total organic carbon (%)
CaCO3 Equiv. – calcium carbonate equivalent (%) TN – total nitrogen (%), Kjeldahl method
PSA – particle size analysis (% sand, silt, and clay separates) by the hydrometer method, with texture class
DB – Bulk density (g/cm^3) SAR – sodium adsorption ratio

McLelland-2 (MLD2) Series

MLD2m is a Terric/Typic Mesisol, where fen peat is between 100 – 200 cm thick over laying medium textured parent material, however MLD2 soils were recorded over coarse (sandy – s) and fine textured materials (fine – f). Some important features of MLD2:

- Subgroup – Terric or Typic Mesisol (soils with >120 cm of peat are considered Typic Mesisols).
- Parent material – fen peat over various textured mineral materials, synonymous with MLD2m, MLD2s, and MLD2f (L11, L12 and L13).
- Drainage – very poorly drained
- Distribution in study areas – dominant in various map units throughout the study areas and significant in various map units dominated by Terric Mesisols (i.e. MLD1m).

Table D19: General description of MLD2m variant (Fibric version), Profile SBW123.

Horizon	Depth (cm)	Field Texture	Coarse Fragments (%)	Structure	Consistence
Of/Om	0-124	--	--	--	--
Cg	124+	L	--	Amorphous	Plastic

Table D20: Selected chemical and physical attributes of MLD2m variant (Fibric version), Profile SBW123.

Horizon	Depth (cm)	pH	EC	OC	$CaCO_3$ Equiv.	TN	PSA (%)			Texture Class	DB	SAR
							Sand	Silt	Clay			
Of/Om	0-124	5.1	-	40.3	1.8	1.07	--	--	--	O	0.12	--
Cg	124+	6.4	0.3	--	--	--	39	43	18	L	1.5	1.3

pH – measured in saturated paste or water EC – electrical conductivity (dS/m) OC – total organic carbon (%)
CaCO3 Equiv. – calcium carbonate equivalent (%) TN – total nitrogen (%), Kjeldahl method
PSA – particle size analysis (% sand, silt, and clay separates) by the hydrometer method, with texture class
DB – Bulk density (g/cm^3) SAR – sodium adsorption ratio

Moonshine (MNSaa & MNSaapt) Series

MNSaa is an Orthic Luvic Gleysol formed on medium textured Horse River till. Some important features of MNSaa:

- Subgroup – Orthic Luvic Gleysol – home SCA is 17, hence the "aa" variant code, peaty variant common.
- Parent material – medium textured till (M4).
- Drainage – poorly drained.
- Distribution in study areas – Co-dominant in one map unit and significant in various map units dominated by shallow organics and other map units with till outcrops.

Table D23: General description of a MNSaa variant, Profile SRM003.

Horizon	Depth (cm)	Field Texture	Coarse Fragments (%)	Structure	Consistence
LFH	10-0	Litter	--	--	--
Ae	0-14	L	1-2	Platy	Friable
Btg	14-45	CL	1-2	Weak subangular blocky	Friable
BCg	45-70	CL	1-2	Massive	Firm
Ckg	70-100	CL	2-5	Massive	Firm

Table D24: Selected chemical and physical attributes of a MNSaa variant, Profile SRM003.

Horizon	Depth (cm)	pH	EC	OC	$CaCO_3$ Equiv.	TN	PSA (%)			Texture Class	DB	SAR
							Sand	Silt	Clay			
LFH	10-0	4.5	0.9	44.1	1.4	1.71	--	--	--	Litter	0.1	0.2
Ae	0-14	6.7	0.8	0.5	1.6	0.03	35	38	27	L	1.35	0.4
Btg	14-45	5.9	0.3	--	1.2	--	41	26	33	CL	1.45	1.5
BCg	45-70	6.9	3.6	--	<0.7	--	39	27	33	CL	1.45	2.4
Ckg	70-100	6.9	3.6	--	<0.7	--	39	27	33	CL	1.45	2.4

pH – measured in saturated paste or water EC – electrical conductivity (dS/m) OC – total organic carbon (%)
CaCO3 Equiv. – calcium carbonate equivalent (%) TN – total nitrogen (%), Kjeldahl method
PSA – particle size analysis (% sand, silt, and clay separates) by the hydrometer method, with texture class
DB – Bulk density (g/cm^3) SAR – sodium adsorption ratio

Muskeg-2 (MUS2) Series

MUS2 is a Terric/Typic Mesisol, where bog peat is between 100 – 200 cm thick over laying predominantly medium textured parent material, however MUS2 soils were recorded over coarse (sandy – s) and fine textured materials (fine – f). Some important features of MUS2m:

- Subgroup – Typic Mesisol, some occurrences of Terric Mesisols were recorded.
- Parent material – bog peat over various textured mineral materials, synonymous with MUS2m, MUS2s, and MUS2f (L11, L12 and L13).
- Drainage – poorly to very poorly drained.
- Distribution in study areas – dominant in a few map units and significant in various map units dominated by shallow organics (MRN1).

Table D25: General description of MUS2m variant, Profile SGW038

Horizon	Depth (cm)	Field Texture	Coarse Fragments (%)	Structure	Consistence
Of	0-76	--	--	--	--
Om	76-148	--	--	--	--
Cg	148+	L	--	Amorphous (Massive)	Slightly sticky

Table D26: Selected chemical and physical attributes of MUS2m variant.

Horizon	Depth (cm)	pH	EC	OC	$CaCO_3$ Equiv.	TN	PSA (%)			Texture Class	DB	SAR
							Sand	Silt	Clay			
Of	0-76	3.8	0.1	41.6	4.1	0.91	--	--	--	O	0.06	0.9
Om	76-148	3.9	--	47.8	2.5	1.84	--	--	--	O	0.12	--
Cg	148+	6.4	0.3	--	<0.7	--	39	43	18	L	1.5	1.3

pH – measured in saturated paste or water EC – electrical conductivity (dS/m) OC – total organic carbon (%)
CaCO3 Equiv. – calcium carbonate equivalent (%) TN – total nitrogen (%), Kjeldahl method
PSA – particle size analysis (% sand, silt, and clay separates) by the hydrometer method, with texture class
DB – Bulk density (g/cm^3) SAR – sodium adsorption ratio

Muskeg-3 (MUS3) Series

MUS1s is a Typic Mesisol, >200 cm of dominantly bog peat. Some important features of MUS3:

- Subgroup – Typic Mesisol.
- Parent material – bog peat (P1).
- Drainage – poorly to very poorly drained.
- Distribution in study areas – dominant in one map unit and significant in various map units dominated by moderately thick organics (MUS2).

Table D27: General description of MUS3 variant, Profile SJJ022

Horizon	Depth (cm)	Field Texture	Coarse Fragments (%)	Structure	Consistence
Of	0-138	Organic	--	--	--
Om	138-220	Organic	--	--	--

Table D28: Selected chemical and physical attributes of MUS3 variant, Profile SJJ022.

Horizon	Depth (cm)	pH	EC	OC	$CaCO_3$ Equiv.	TN	PSA (%)			Texture Class	DB	SAR
							Sand	Silt	Clay			
Of	0-138	3.8	0.1	41.6	4.1	0.91	--	--	--	O	0.06	0.9
Om	138-220	3.9	--	47.8	2.5	1.84	--	--	--	O	0.12	--

pH – measured in saturated paste or water EC – electrical conductivity (dS/m) OC – total organic carbon (%)
CaCO3 Equiv. – calcium carbonate equivalent (%) TN – total nitrogen (%), Kjeldahl method
PSA – particle size analysis (% sand, silt, and clay separates) by the hydrometer method, with texture class
DB – Bulk density (g/cm^3) SAR – sodium adsorption ratio

Peavine (PEA & PEAgl) Series

PEA is an Orthic Gray Luvisol that is formed on medium textured water laid materials. Some important features of PEA:

- Subgroup – Orthic Gray Luvisol & Gleyed Gray Luvisol (variant).
- Parent material – medium textured water laid materials ranging from fine sandy loam to loam to clay loam (M2 and M3).
- Drainage –moderately well to imperfectly drained (Gleysols).
- Distribution in study areas – significant in various map units and dominant in one map unit. More prevalent in the south portion of the access road LSA.

Table D29: General description of PEAgl variant, Profile, SGW032.

Horizon	Depth (cm)	Field Texture	Coarse Fragments (%)	Structure	Consistence
LFH	8-0	Litter	--	--	--
Ae	0-12	Sandy loam	--	Weak platy	Friable
AB	12-20	Sandy loam	--	Weak platy	Friable
Bt	20-48	Loam	--	Sub-angular blocky	Firm
BC	48-73	Loam	--	Massive	Firm
Ck	73-100	Clay loam	--	Massive	Firm

Table D30: Selected chemical and physical attributes of PEAgl variant, Profile SGW032.

Horizon	Depth (cm)	pH	EC	OC	$CaCO_3$ Equiv.	TN	PSA (%)			Texture Class	DB	SAR
							Sand	Silt	Clay			
LFH	8-0	4.9	--	25.9	1.1	0.62	--	--	--	Litter	0.1	--
Ae	0-12	4.7	0.3	1.8	0.7	0.06	50	44	6	SL	1.55	1.6
AB	12-20	4.7	0.3	1.8	0.7	0.06	50	44	6	SL	1.55	1.6
Bt	20-48	5	0.1	--	--	--	33	41	26	L	1.45	1.7
BC	48-73	5.1	0.1	--	--	--	33	41	26	L	1.45	2.5
Ck	73-100	6.4	0.8	--	<0.7	--	26	44	30	CL	1.45	0.4

pH – measured in saturated paste or water EC – electrical conductivity (dS/m) OC – total organic carbon (%)
CaCO3 Equiv. – calcium carbonate equivalent (%) TN – total nitrogen (%), Kjeldahl method
PSA – particle size analysis (% sand, silt, and clay separates) by the hydrometer method, with texture class
DB – Bulk density (g/cm^3) SAR – sodium adsorption ratio
* Profile not sampled.

Sutherland (SUT & SUTgl) Series

SUT is an Eluviated Dystric Brunisol that is formed on coarse textured fluvial outwash material overlying a till outcrop (till within 1.0 m of the surface). Some important features of SUT:

- Subgroup – Eluviated Dystric Brunisol.
- Parent material – very coarse sediments deposited by wind or water, acidic, GLFL outwash material overlying medium to moderately fine textured till (L2 parent material code).
- Drainage – mainly well to moderately well.
- Distribution in study areas – significant in various map units, typically occurs with the MIL series along side slopes or crests of upland topography.

Table D31: General description of SUT variant, Profile SGW005.

Horizon	Depth (cm)	Field Texture	Coarse Fragments (%)	Structure	Consistence
LFH	9-0	Litter	--	--	--
Ae	0-11	LS	--	Single grain	Loose
Bm	11-64	S	--	Single grain	Loose
BC	64-94	SCL	2-5	Massive	Firm
Ck	94-100	CL	2-5	Massive	V. firm

Table D32: Selected chemical and physical attributes of SUT variant, Profile SGW005.

Horizon	Depth (cm)	pH	EC	OC	$CaCO_3$ Equiv.	TN	PSA (%)			Texture Class	DB	SAR
							Sand	Silt	Clay			
LFH	9-0	6.1	0.7	39.2	1.9	1.63	--	--	--	Litter	0.1	0.2
Ae	0-11	4.7	0.2	0.2	<0.7	0.02	81	15	4	LS	1.45	0.7
Bm	11-64	6.2	0.2	--	--	--	91	3	5	S	1.5	0.5
BC	64-94	4.9	0.5	--	<0.7	--	48	23	30	SCL	1.5	0.9
Ck	94-100	6.9	0.6	--	0.7	--	44	26	30	CL	1.45	0.8

pH – measured in saturated paste or water EC – electrical conductivity (dS/m) OC – total organic carbon (%)
CaCO3 Equiv. – calcium carbonate equivalent (%) TN – total nitrogen (%), Kjeldahl method
PSA – particle size analysis (% sand, silt, and clay separates) by the hydrometer method, with texture class
DB – Bulk density (g/cm^3) SAR – sodium adsorption ratio

Wanham (WHMaa & WHMaapt) Series

WHMaa variant is an Orthic Luvic Gleysol formed on medium to moderately coarse textured water laid materials. Some important features of WHMaa:

- Subgroup – Orthic Luvic Gleysol, home SCA is 17, hence the “aa” variant code & the peaty variant is dominant in the study area.
- Parent material – medium textured sediments deposited by water (M2 and M3).
- Drainage – poorly drained.
- Distribution in study areas – dominant in one map unit and significant in various map units dominated by shallow organics and recorded in low areas within upland areas.

Table D33: General description of WHMaa series, Profile SRM040.

Horizon	Depth (cm)	Field Texture	Coarse Fragments (%)	Structure	Consistence
LFH	10-0	Litter	--	--	--
Aeg	0-8	Loam	--	Platy	Friable
ABg	8-16	Loam	--	Medium angular blocky	Friable
Btg	16-60	Clay loam	--	Sub-angular blocky	Friable
BCg/Ck	60-100	Loam	--	Massive	Very plastic

Table D34: Selected chemical and physical attributes of WHMaa series, Profile SRM040.

Horizon	Depth (cm)	pH	EC	OC	$CaCO_3$ Equiv.	TN	PSA (%) Sand	Silt	Clay	Texture Class	DB	SAR
LFH	10-0	4.5	0.90	44.1	1.4	1.71	--	--	--	Litter	0.1	0.2
Aeg	0-8	6.2	0.3	0.9	0.7	0.07	35	40	25	L	1.35	0.3
ABg	8-16	6.3	0.3	0.5	0.8	0.06	38	38	25	L	1.35	0.6
Btg	16-60	6.4	0.2	--	--	--	27	33	40	CL	1.45	1.2
BCg/Ck	60-100	7	0.2	--	--	--	38	39	23	L	1.45	1.2

pH – measured in saturated paste or water EC – electrical conductivity (dS/m) OC – total organic carbon (%)
CaCO3 Equiv. – calcium carbonate equivalent (%) TN – total nitrogen (%), Kjeldahl method
PSA – particle size analysis (% sand, silt, and clay separates) by the hydrometer method, with texture class
DB – Bulk density (g/cm^3) SAR – sodium adsorption ratio

APPENDIX E: LAND CAPABILITY CLASSIFICATION AND RECLAMATION SUITABILITY CALCULATION METHODOLOGIES

Land Capability Classification System for Forest Ecosystems in the Oil Sands – Detailed Methodology and Assumptions for Baseline Calculations

Forest soil capability was determined using the Land Capability Classification System (LCCS) for Forest Ecosystems in the Oil Sands (CEMA 2006). The classification system relies on a soil moisture regime index (SMR) and a soil nutrient regime index (SNR) to obtain a base rating of the soil capability. The base rating is adjusted by "limiting factors" as determined by the classification system. Limiting factors are ratings that create reductions to the soil capability dependent on soil structure and consistence, pH, salinity, and sodicity (CEMA 2006).

Soil Moisture Regime - The SMR is dependent on the available water holding capacity (AWHC) in relation to the estimated depth of the water table. If the water table is estimated to be >100 cm below surface an inferred AWHC is determined based on the soil textures of the profile, and each unique texture is weighted by horizon thickness and the AWHC multiplier to obtain the SMR. Modifiers such as coarse fragments, impermeable layers, textural layering and landscape are also considered in the calculation. For soils with an estimated water table depth <100 cm, the SMR is determined by categories in a table which take into consideration the presence and abundance of gleying and mottling, surface organic horizons, slope position, depth to water table, and common textures (CEMA 2006).

Soil Nutrient Regime - The SNR is calculated using soil organic carbon (c), total nitrogen (N) and the C:N ratio of the 0-20 cm layer of the soil, this includes all horizons starting in the top 20 cm of the profile (CEMA 2006). For organic soils, the top 20 cm of organic material is utilized for the SNR calculations.

The base rating of the soil is the total of the SMR and the SNR. Deductions from the base rating are then made based on the soil chemical and physical properties recorded in the top 1.0 m of the sampled horizon. The impacts of limiting factors are adjusted accordingly to display incremental decreases in potential impacts with depth. The final land rating is the difference between the base rating and limiting factors in the topsoil, upper subsoil and lower subsoil.

Limiting Factors - A brief description of the limiting factors utilized in the land capability classification of the Project includes:

Soil structure (**Subclass D**) – Deductions are based on the structure and consistence of the soil in the 0-20, 20-50 and 50-100 cm ranges. Deductions to the overall rating are impacted by firm to hard consistence and large to massive soil structure.

Soil Reaction – pH (**Subclass V**) – Soil pH values outside of the optimal range (5.0-7.0 for this application) trigger capability deductions in the 0-20, 20-50 and 50-100 cm ranges.

Soil salinity – Electrical Conductivity (EC) (**Subclass N**) – Deductions are implemented once the EC value is >2 dS/m in the 0-20, 20-50 and 50-100 cm ranges. An equation is given in which to determine the appropriate percent deduction. Above an EC of 8 dS/m a 100% deduction is applied.

Soil sodicity – Sodium (SAR) (**Subclass Y**) – deductions are based on a linear relationship between SAR values and percent deductions. SAR deductions are applied once the SAR value is >4 in the 0-20, 20-50 and 50-100 cm ranges. SAR values for sandy textured soils (sandy loam or coarser) are not deducted against the capability rating due to the low percentage of clay present.

Soil Fertility – Total Organic Carbon (TOC) and Total Nitrogen (TN) (**Subclass F**) – deductions are based on a cumulative rating that considers TOC, TN, carbon to nitrogen ratio (C:N ratio) and nutrient retention (based on textures). Cumulative ratings that are <5 result in the application of the "F" as a subclass to the final index rating.

Xeric or Wet - Available water holding capacities (**Subclass X or W)** – deductions are not based on the SNR, but on the SMR. Soils with rapid drainage due to the composition of the profile (i.e. sandy soils) may be limited by a subclass "X". Soils with very poor drainage due to depth of estimated water table may have a subclass "W".

A final land capability rating is then placed into a land capability class based on rating ranges as described in LCCS (CEMA 2006) which have been summarized in Table E1.

Table E1: Final Land Capability Classes and Rating Ranges as per the Land Capability Classification System for Forest Ecosystems in the Oil Sands (CEMA 2006)

Land Capability Ratings Range*	Land Capability Class*	Description*
81-100	**Class 1**	No significant limitations to supporting productive forestry.
61-80	**Class 2**	Some limitations that are moderately limiting for forest production, increased inputs are required in order to make feasible.
41-60	**Class 3**	Limitations are moderately severe for forest production, not likely that increased inputs will offset limitations.
21-40	**Class 4**	Limitations are severe, and cannot be feasibly corrected with existing practice.
0-20	**Class 5**	Limitations are so severe that forest production is not possible.

*All data extracted from the Land Capability Classification System for Forest Ecosystems in the Oil Sands (CEMA 2006).

Land Capability Classification System for Forest Ecosystems in the Oil Sands – Reclaimed Forest Capability Calculations

The same methodology outlined above was used to calculate the capability of reclaimed soils. However, several assumptions were required in order to estimate the post disturbance soil physical and chemical regimes. The assumptions include:

Mineral soils

- Salvaged soil will consist of a mixture of mineral A horizon and overlying litter/surface peat material, referred to as “topsoil lift”. It is anticipated that the replaced topsoil will have blended chemical characteristics from the pre-disturbance litter/shallow surface peat and A horizon(s) amalgamated proportionately depending on the thickness of the layers. A slight decrease in overall organic material content due to admixing of the litter layer with the mineral A horizon is expected (approximately 10%).
- It is estimated that overall topography of the reclaimed landscape will have gentler slopes then presently found (natural conditions). Generally, the moisture regime of reclaimed upland mineral landscapes is anticipated to return to mesic or sub mesic (depending on soil model) conditions since relief and drainage variability will not be as pronounced as found in the natural state.
- Contouring of slopes in the proposed disturbance areas will increase admixing of upper and lower subsoil materials. Chemical and physical characteristics of the upper and lower subsoil were blended in interpretative calculations to simulate soil salvage and placement activities during construction. This included the altering of consistence and structure of the reclaimed subsoil to reflect ripped profiles.
- Material deemed to be upper subsoil will be ripped to minimize compaction and improve structure.
- Areas that sustain high traffic throughout the life of the Project will be ripped and contoured to alleviate potential compaction issues. However, the resultant subsoil profiles will remain slightly firmer and contain larger soil peds (structural units) than undisturbed profiles.

Gleysolic Soils

- Due to the variability in peat and mineral horizons in map units dominated by Gleysolic soils, some attribute values were blended for ratings data.
- Reclamation of low-lying areas includes preparation of the subsoil material (contouring and de-compaction) and even replacement of the topsoil lift material.
- It is assumed that upper (and potentially lower) subsoil material will be used for contouring of the area; therefore soil attributes of the upper and lower subsoil were blended appropriately.

- It is anticipated that the transitional landscapes that have the soil material salvaged will be reclaimed with a slightly drier moisture regime than predisturbance conditions. Areas deemed to be hygric reduced prior to disturbance were evaluated assuming hygric aerated conditions post reclamation.

Shallow Organic Soils – Peat 40 -100 cm thick

- For level wetland areas with shallow Organic soils, it is believed that the landscape will in most cases be reclaimed to support moisture regimes (hygric to subhydric) similar to that of pre-disturbance conditions. However, final contouring is some areas in order to blend low-lying terrain with neighbouring upland terrain may result in some drier reclaimed Organic profiles along the fringes of these landscapes.
- All organic/peat material 40 cm and thinner will be salvaged from these landscapes. As discussed in CR#2 Conservation and Reclamation Plan there are various options with respect to salvage, utilization and construction in landscapes with > 40 cm of peat. The reclaimed LCCS calculations for relatively shallow organic soil models (,MRN1m-G, MLD1m-G, etc.) were based on the premise that all organic materials thicker than 40 cm will be padded over for construction and the pad will be removed at reclamation. However, it is possible that other methods are used (see CR#2) and decisions on the methods to be applied are expected to be made at the field level.

Deep Organic Soils – Peat > 100 cm thick

- Reclaimed LCCS calculations for deep peat soil models were based on the following soil salvage, construction, and reclamation activities in areas of deep Organic soils:
  - Any peat deposits (>0.4 m) in thickness are to be left in place throughout the life of the Project.
  - Geotextile will be placed over the surface of the peat and padded with subsoil material from a suitable borrow location.
  - At the time of site reclamation, the subsoil pads and geotextile membrane will be removed and the peat material will be conditioned (i.e. ripped and tilled to reduce compaction) to promote vegetation re-establishment and appropriate surface and sub-surface water flow.
- As discussed for the shallow organics it is possible that deep peat deposits may be salvaged or a portion of the peat material salvaged for reclamation. At this time the areas or locations in which alternate soil handling may take place is not known, therefore the reclaimed LCCS calculations are based on the conventional method of construction activities in deep peat landscapes.

Soil Quality Criteria Relative to Disturbance and Reclamation – Detailed Methodology and Assumptions for Baseline Calculations

This assessment followed the Soil Quality Criteria Relative to Disturbance and Reclamation Guidelines as specified for the northern forest region of Alberta (SQCWG 1987). The A and B horizons as defined in Section 4.1 of this report (topsoil and upper subsoil) were assessed for all applicable map units of the study areas. Organic soil map units or map units dominated by soils with >40 cm of peat (peaty Gleysols) were not included in the assessment as the guidelines are specific to mineral soils. Ratings categories of mineral soils included:

Good (G) -no or slight limitations that affect use as a plant growth medium;

Fair (F) -moderate limitations that affect use but can be overcome by proper planning and good management;

Poor (P) -severe limitations that make use questionable. This does not mean the material cannot be used, but rather careful planning and very good management is required; and

Unsuitable (U) -chemical or physical properties are so severe reclamation would not be economically feasible or in some cases impossible (i.e. special reclamation strategies must be implemented and land use may be severely restricted).

Each particular soil map unit within the SAGD and access road LSA's was rated based on typical soil series and variants found within each map unit. Ratings were determined based on the following process:

1. Each series/variant within a map unit was rated using the aforementioned information sources and the proportion of occurrence in the map unit accounted for (co-dominant vs. significant).
2. The most limiting parameter for each soil series/variant identified the overall rating for that soil entity.
3. Map unit ratings were determined by selecting the dominant ratings class for all series/variants within each map unit. If two ratings classes appeared co-dominant, the overall rating for the map unit was displayed as a range of the two co-dominant ratings (i.e. F-P).

The rating criteria used in this assessment is presented in Table E2 (topsoil) and Table E3 (subsoil).

Table E2: Criteria for evaluating suitability of surface material (topsoil) for revegetation in the northern forest region

Rating Parameter	Good (G)	Fair (F)	Poor (P)	Unsuitable (U)
Reaction (pH)[1]	5.0-6.5	4.0-5.0 & 6.5-7.5	3.5-4.0 & 7.5-9.0	<3.5 and >9.0
Salinity (E.C.)[2] (dS/m)	<2	2-4	4-8	>8
Sodicity (SAR)[2]	<4	4-8	8-12	>12[3]
Saturation %[3]	30-60	20-30, 60-80	15-20, 80-120	<15 and >120
Stoniness/Rockiness[4] (% Area)	<30/<20	30-50/20-40	50-80/40-70	>80/>70
Texture	SL, FSL, VFSL, L, SiL	CL, SCL, SiCL	S, LS, SiC, C, HC	
Moist Consistence	Very friable, Friable	Loose, Firm	Very firm	Extremely firm
$CaCO_3$ Equivalent (%)	<2	2-20	20-70	>70

Table adapted from *Soil quality criteria relative to disturbance and reclamation guidelines* as specified for the northern forest region of Alberta (SQCWG 1987).

1. pH values presented are most appropriate for trees, primarily conifers. Where reclamation objective is for other end land uses, such as erosion control, and where other plant species may be more important refer to the topsoil table of the Plains region.
2. Limits may vary depending on plant species to be used.
3. Materials characterized by a SAR of 12 to 20 may be rated as poor if texture is sandy loam or coarser and saturation % is less than 100.
4. <25 cm diameter stones/rocks intercepting surface.

Table E3: Criteria for Evaluating the Suitability of Subsurface Material (Subsoil) for Revegetation in the Northern Forest Region

Rating Parameter	Good (G)	Fair (F)	Poor (P)	Unsuitable (U)
Reaction (pH)[1]	5.0-7.0[2]	4.0-5.0 & 7.0-8.0[2]	3.5-4.0 & 8.0-9.0	<3.5 and >9.0
Salinity (E.C.)[3] (dS/m)	<3	3-5	5-8	>8
Sodicity (SAR)	<4	4-8	8-12	>12[4]
Saturation (%)	30-60	20-30, 60-80	15-20, 80-100	<15 and >100
Coarse Fragments (% / Vol)	<30[5] / <15[6]	30-50[5] / 15-30[6]	50-70[5] / 30-50[6]	>70[5] / >50[6]
Texture	FS, SL, VFSL, L, SiL	CL, SiC, SiCL	S, LS, SiC, C, HC	Bedrock
Moist Consistence	Very friable, Friable, Firm	Loose, Very firm	Extremely firm	Hard rock
$CaCO_3$ Equivalent (%)	<5	5-20	20-70	>70

Table adapted from the *Soil Quality Criteria Relative to Disturbance and Reclamation Guidelines* as specified for the northern forest region of Alberta (SQCWG 1987).

1 pH values presented are most appropriate for trees, primarily conifers. Where reclamation objective is for other end land uses, such as erosion control, and where other plant species may be more important refer to the topsoil table of the Plains region.
2 Higher value takes into consideration that in the lower lift the pH values of the soils are generally higher. Normally the pH rating should not be different than subsoil from other regions.
3 Limit may vary depending on plant species to be used.
4 Materials characterized by an SAR of 12 to 20 may be rated as Poor if texture is sandy loam or coarser and saturation % is less than 100.
5 Matrix texture (modal) finer than sandy loam.
6 Matrix texture (modal) sandy loam and coarse

APPENDIX F: LAND CAPABILITY CLASSIFICATION SUMMARY TABLES – BASELINE AND RECLAIMED

Vegetation and Wetlands Resource Assessment and Rare Plant Survey Report for the Sunshine Oilsands Ltd.

West Ells SAGD Project

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EXECUTIVE SUMMARY

This report was prepared on behalf of Sunshine Oilsands Ltd., proponents of the West Ells Steam Assisted Gravity Drainage Project, by Geographic Dynamics Corp. (GDC). Sunshine Oilsands Ltd. is proposing to build a steam assisted gravity drainage (SAGD) project on their oil sands leases located northwest of Fort McMurray, Alberta in Township 94 – Range 17 west of the 4th Meridian.

A rare plant survey was performed in the spring of 2008 in the area of the proposed West Ells SAGD development (Project). Seven rare plant species, including two vascular plants, two bryophytes and three lichens have been confirmed in the local study area (LSA), which encompasses Sections 30, 31, 32, 33 Township 94 – Range 17, Sections 25 and 36 – Township 94 – Range 18, and Sections 3, 4, and 5 – Township 95 – Range 17, all west of the 4th Meridian. One rare lichen, *Cladina stygia* was found within 35 m of the Phase 1 development footprint, at the edge of a borrow pit. No mitigation is recommended for this species, which was found 16 times in the study area.

Two provincially listed nuisance and noxious weed species were found in the LSA, outside the Project footprint. A management plan, with monitoring, is recommended to control the spread and establishment of non-native and invasive species.

The ecosite phase classification map shows that the LSA is dominated by ecosite phases d2 (low bush cranberry Aw-Sw) in the uplands and i1 (shrubby bog) in the lowlands. Twenty-three different ecosite phases were found in the LSA, including:

- lichen jack pine (a1);
- blueberry jack pine-aspen(b1);
- blueberry aspen-paper birch (b2);
- blueberry aspen-white spruce (b3);
- Labrador tea–mesic jack pine-black spruce (c1);
- low-bush cranberry aspen (d1);
- low-bush cranberry aspen-white spruce (d2)
- low-bush cranberry white spruce (d3);
- dogwood balsam poplar-aspen (e1);
- dogwood balsam poplar-white spruce (e2);
- horsetail balsam poplar-aspen (f1);
- horsetail balsam poplar-white spruce (f2);
- horsetail white spruce (f3);

- Labrador tea-subhygric black spruce-jack pine (g1);
- Labrador tea horsetail white spruce-black spruce (h1);
- treed bog (i1);
- shrubby bog (i2);
- treed poor fen (j1);
- shrubby poor fen (j2);
- treed rich fen (k1);
- shrubby rich fen (k2);
- graminoid rich fen (k3); and
- marsh (l1).

Clearing and construction for Phase 1 of the SAGD Project will impact 60.7 ha of area (2.6% of the LSA); of which 26.8 ha (44.2 % of the Phase 1 footprint) are upland and 33.9 ha (55.8 % of the Phase 1 footprint) are lowland ecosites. There are no ecosites of restricted distribution within the Phase 1 footprint, and all ecosites that will be potentially impacted are regionally common. The impact of Phase 1 of the Sunshine SAGD Project on vegetation resources is insignificant with mitigation. Proper construction, reclamation and revegetation techniques will effectively mitigate anticipated Project effects. The SAGD Project will require supporting infrastructure including a 9 km access road which could disturb an additional 67.8 ha.

Wetland classifications (Alberta Wetland Inventory Standards) were performed using a combination of aerial photo interpretation and ground survey plots. Phase 1 of the proposed Project will have little effect on wetlands in the LSA. Clearing and construction will impact 29 ha of wetlands (1.2% of the LSA). Marshes and treed swamps had the only restricted distributions (< 1% of the LSA), but none occur in or near the Phase 1 footprint. Therefore, no additional mitigation (beyond reclamation at Project closure) is required for wetlands.

Mitigation measures recommended for the Project include:

- marking of locations of rare plants to minimise accidental disturbance;
- minimizing overall Project and access road footprint where possible;
- utilizing a non-invasive seed mix for reclamation; and
- developing a management plan to control non-native and invasive species.

TABLE OF CONTENTS

EXECUTIVE SUMMARY iii
1.0 INTRODUCTION 1
1.1 Study Area 1
1.2 Report Objectives 2
1.3 Site Description 2
2.0 RARE PLANTS AND RARE PLANT COMMUNITIES 3
2.1 Introduction 3
2.1.1 Study Objectives 4
2.2 Methods 4
2.2.1 Pre-field Data Processing and Stratification 4
2.2.2 Data Collection 5
2.2.3 Post-survey Methods 6
2.2.4 Quality Assurance and Quality Control 7
2.3 Results 7
2.3.1 Rare Plants 7
2.3.2 Rare Vascular Plant Descriptions 8
2.3.3 Rare Bryophyte Descriptions 9
2.3.4 Rare Lichen Descriptions 10
2.3.5 Rare and Special Plant Communities 11
2.3.6 Non-native and Invasive Plants 11
2.4 Project Effects and Mitigation Efforts 11
2.4.1 Rare plants within the Phase 1 Project footprint 11
2.4.2 Non-native and Invasive Plants 12
3.0 ECOSITE CLASSIFICATION AND MAPPING 12
3.1 Study Objectives 12
3.2 Methods 12
3.2.1 Ecological Classification 12
3.2.2 Classification 13
3.2.3 Quality Assurance and Quality Control 15
3.2.4 Data Analysis 15
3.3 Results 16
3.3.1 Species Distribution and Abundance 16
3.3.2 Ecosites and Ecosite phases in the LSA 17
3.3.2.1 Distribution of Ecosite Phases within the LSA 19
3.3.2.2 Ecosite Phase Descriptions 20
3.3.2.3 Ecosite Phases within the Access Road and Buffer 27
3.4 Old growth forests 28
3.4.1 Study Objectives 28
3.4.2 Methods 28
3.4.3 Results 28
3.5 Effects and Mitigation Efforts 29
3.5.1 Project 29
3.5.2 Access Road 29
4.0 WETLAND CLASSIFICATION AND MAPPING 29
4.1 Introduction 29

4.1.1 Study Objectives 30
4.2 Methods 30
4.2.1 Field Survey Methods 30
4.2.2 Post-Survey Methods 30
4.2.2.1 Alberta Wetland Inventory Standards 30
4.3 Results 32
4.3.1 Project 32
4.3.2 Access Road 33
4.4 Effects and Mitigation Efforts 34
4.4.1 Project 34
4.4.2 Access Road 34
5.0 Mitigation and Monitoring 34
5.1 Mitigation 35
5.2 Monitoring 35

LIST OF TABLES

Table 2.1 Data collection form for rare plant and rare plant community survey. 6
Table 2.2 Rare plants within the Sunshine SAGD LSA. 8
Table 3.1 AVI characteristics used in ecosite phase mapping. 14
Table 3.2 Species richness, diversity and evenness of ecosites. 17
Table 3.3 Species richness, diversity and evenness of ecosite phases. 18
Table 3.4 Areas of ecosite phases within the LSA and Phase 1 footprint. 19
Table 3.5 Areas of ecosite phases within the access road and buffer. 27
Table 3.6 Areas and percent cover for old growth forests in the LSA. 29
Table 4.1 Alberta Wetland Inventory Standards (AWIS) classification (*From Halsey et al. 1996, 2003).* 31
Table 4.2 Wetland types identified in the LSA. 32
Table 4.3 Wetlands within the LSA and Phase 1 footprint. 33
Table 4.4 Wetlands within the access road and buffer. 33

LIST OF FIGURES

Figure 1a Sunshine West-Ells SAGD LSAs. Overview map (Map)
Figure 1b. Sunshine West-Ells SAGD. Plot Locations within the LSA
Figure 2 Rare plant locations. (Map)
Figure 3 Edatope (moisture/nutrient grid) showing the location of ecosites for the Boreal Mixedwood ecological area (Beckingham and Archibald 1996).
Figure 4 Example of an ecological unit identification code for the hierarchical ecological classification system (Beckingham and Archibald 1996).
Figure 5a Dominant Ecosite phase. Sunshine West-Ells Project. (Map)
Figure 5b Dominant Ecosite Phase. Sunshine West-Ells access road. (Map)
Figure 6 Old Growth Forests. Sunshine West-Ells Project. (Map)
Figure 7a Dominant Wetland Types. Sunshine West-Ells Project. (Map)
Figure 7b Dominant Wetland Types. Sunshine West-Ells access road. (Map)

LIST OF APPENDICES

Appendix 1: Rare plant locations within the LSA 39
Appendix 2: Ecosite descriptions 41
Appendix 3: Moisture regime descriptions from Beckingham and Archibald (1996) 44
Appendix 4: Nutrient regime descriptions from Beckingham and Archibald (1996) 45
Appendix 5: Flora of the Sunshine Oilsands Ltd. West-Ells SAGD Project 2008...46
Appendix 6: Plot Information Sunshine Oilsands Ltd. West-Ells SAGD Project 2008...52

1.0 INTRODUCTION

Sunshine Oilsands Ltd. (Sunshine) retained Geographic Dynamics Corp. (GDC) to conduct vegetation and wetland assessments for Sunshine's proposed West-Ells Steam Assisted Gravity Drainage (SAGD) Project area located about 90 km northwest of Fort McMurray in northern Alberta.

The following is a report of the vegetation and wetland resources in the vicinity of the proposed West-Ells SAGD Project (the Project). It outlines studies that were done to classify, map and describe vegetation found in terrestrial and wetland settings in the study area. This report also includes a preliminary assessment of a proposed 9 km long access road located south of the study area.

This vegetation assessment included:

- rare plant and rare plant community survey (Project);
- plant diversity survey (Project);
- ecosite classification and mapping (Project and Access Road);
- old growth forest assessment (Project and Access Road); and,
- wetland classification and mapping (Project and Access Road).

This report presents results from the spring 2008 field survey. A wetland classification as well as an ecosystem classification map of the Project study area was prepared based on the field survey and the interpretation of aerial photographs. The final location of the plant site, facilities, pads, borrows pits and the access road were not available before the spring survey was conducted (a preliminary location was used to locate sample sites). Therefore, an additional rare plant survey will be conducted in the Project footprint and access road in 2010.

1.1 Study Area

Effects on vegetation will be primarily from roads, well pads, and associated facilities and staging areas that must be cleared and leveled for construction. The vegetation and wetland resources local study area (LSA) encompassed approximately 2358 ha situated in Sections 30, 31, 32, 33 – Township 94 – Range 17, Sections 25 and 36 – Township 94 – Range 18, and Sections 3, 4, 5 – Township 95 – Range 17, all west of the 4th Meridian. The Project footprint includes all lands subject to direct disturbance from Phase 1 of the SAGD Project and will result in the disturbance of approximately 60.7 ha (Figure 1a). The local study area (LSA) was defined to accommodate potential environmental effects to the vegetation and wetland resources outside the Project footprint resulting from project activities. The SAGD Project will require supporting infrastructure which includes a 9 km access road. The proposed 9 km long access road will potentially impact an additional 67.8 ha (Figure 1a).

The following sections of this report describe the methods and results of the vegetation assessment. Project effects on the vegetation and wetland resources are discussed separately for Phase 1 of the Project (includes plant site, well pads, camps, one borrow pit, and utility corridor connecting well pads to plant site), and the access road (includes 50 m wide road, and four borrow pits). Potential Project effects are assessed after appropriate mitigation measures have been considered.

1.2 Report Objectives

The objectives of this report are to:

- Inventory and map rare plant and rare plant communities;
- Classify and map ecosystems to the ecosite phase level;
- Classify and map wetland areas according to Alberta Wetland Inventory Standards;
- Determine biodiversity indicators for vegetation in the LSA including: species richness, diversity and evenness within the designated ecosites;
- Identify the types of old growth forests in the LSA and determine the amount by area; and
- Assess project effects on the vegetation resource after considering appropriate mitigation measures to minimize Project impacts.

1.3 Site Description

The Project is located in the Central Mixedwood Natural Subregion of the Boreal Forest Natural Region. Beckingham and Archibald (1996) classify this area within the Boreal Mixedwood Ecological Area (BM). The BM is characterized by a variety of mixed stand types including aspen, balsam poplar, paper birch, white spruce, jack pine and balsam fir stands. Medium to tall, closed stands of trembling aspen and balsam poplar with white spruce, black spruce, and balsam fir, occurring in late succession stages, is most abundant. Understorey vegetation is primarily shrubs and forbs such as prickly rose, low-bush cranberry, bunchberry, wild sarsaparilla and dewberry. Cold and poorly-drained fens and bogs are covered with tamarack and black spruce. Formed on Mesozoic and Paleozoic sediments, the surface of this region is predominantly a gently undulating lowland plain covered with thick, loamy glacial till, clayey lacustrine, sandy fluvioglacial, and organic deposits. This low-relief plain is rather poorly drained, and organic materials cover about 50% of the area. The dominant soil types in the region are Organic, Gray Luvisols, Brunisols, and Gleysols, with some Cryosols (Beckingham and Archibald 1996). The whole region slopes gently and drains northward toward the Athabasca and Wabasca rivers within the region. Characteristic wildlife includes moose, black bear, wolf, lynx, snowshoe hare, waterfowl, ruffed grouse, and other birds.

Climate within the LSA is characterized by cool summers and long, cold winters (Natural Regions Committee 2006). The mean annual precipitation ranges from 350 to 500 mm. The average summer temperature for the Boreal forest region is 13.5°C and the average winter temperature is -13.5°C (Strong and Leggat 1992). Records indicate that the frost-free period for this area is approximately 90 days and the annual total precipitation is

400-460 mm (Alberta Agriculture and Rural Development 2008). Typically most precipitation is received in the month of July.

2.0 RARE PLANTS AND RARE PLANT COMMUNITIES

2.1 Introduction

A rare plant is defined by the Alberta Native Plant Council (ANPC) as “any native vascular or non-vascular (mosses, hornworts, liverworts) plant that, because of its biological characteristics or for some other reason, exists in low numbers or in very restricted areas in Alberta” (ANPC 2000a). This definition also applies to lichens and fungi. Although too little information exists on fungal distributions for them to be included in rare plant surveys, lichens are included.

A rare plant community is any community (a distinct assemblage of plant species that is found to recur under the same environmental conditions) that is uncommon, of limited extent, or locally significant (ANHIC 2006a). In addition, a special community is one that is not considered rare, but is unusual, either locally or regionally. The Alberta Natural Heritage Information Center (ANHIC) ranks, maps, and tracks rare plant species and communities (each one called a tracking element) in Alberta. Their ranking method is based on a system developed by the Nature Conservancy that is used throughout North America and is as follows (S = Alberta, G = global):

- S1/G1 – Five or fewer recorded occurrences, or with few individuals remaining
- S2/G2 – Six to 20 occurrences or many individuals in fewer occurrences
- S3/G3 – From 21 to 100 occurrences; might be rare and local throughout its range, or its range might be restricted (may be abundant at some locations or may be vulnerable to extirpation because of some biological factor)
- S4/G4 – Secure under present conditions, typically with more than 100 occurrences; or, fewer with many large populations (may be rare in parts of its range, especially at the periphery)
- S5/G5 – Secure under present conditions with more than 100 occurrences; may be rare in part of its range, especially the periphery
- SNR – Status not yet ranked
- SU/GU – Status uncertain, often because of low search effort or cryptic nature of the element; possibly in peril, not rankable, more information needed
- S?/G? – Rank questionable

The ranking of a plant species or community as rare for the purposes of this study follows ANHIC’s definition; that is, all S1, S2, and the tracked S3 species are considered rare. A combined rank (*e.g.* S1/S2) is given for species whose status is uncertain; the first rank indicates the rarity status given current documentation, and the second rank indicates the rarity status that will most likely be assigned after all historical data and likely habitats have been checked. In addition, all elements not previously reported from Alberta are considered rare.

Elements with S1 to S2/S3 ranks are recorded on ANHIC's tracking lists because they are species of high priority or conservation concern; species with ranks of S3 or S3/S4 are placed on watch lists. Species on watch lists are usually those that have restricted distributions but are common within their range. Elements on the tracking and watch lists are evaluated annually, and they may move from one list to another depending on whether their populations, or ANHIC's awareness of their populations, increase or decrease (Gould 2006). Species are also ranked globally according to their worldwide distribution and population sizes (NatureServe 2008).

2.1.1 Study Objectives

The objective of the rare plant and rare plant community survey was to inventory and map rare plants and rare plant communities within the Project footprint. Where appropriate, mitigation measures are provided. As well, non-native and invasive plant species were documented. The final location of the Project footprint and access road were not available before the spring survey was conducted, and only three rare plant plots fall within these areas. Therefore, an additional rare plant survey will be conducted in the Project footprint and access road in 2010.

2.2 Methods

2.2.1 Pre-field Data Processing and Stratification

Prior to the field survey, a list of potential rare plants and rare plant communities that could be found in the LSA and surrounding area was acquired from Alberta's Conservation Data Center – the Alberta Natural Heritage Information Centre (ANHIC 2006b, 2006c, 2006d).

Maps were created based on aerial photos and the Alberta Vegetation Inventory (AVI) database to identify areas that were most likely to support rare plant species or communities. Sample plots were then selected to incorporate the broadest range of habitats within the Phase 1 footprint (Figure 1b). The goal was to include representative samples of each habitat type (ecosite phase and wetland type) as well as unique landforms and other important features in the landscape to comply with Alberta Native Plant Council (APNC) rare plant survey guidelines (ANPC 2000a). Along the 9 km access road, the rare plant survey will be focused to within 50 m of the proposed route to ensure coverage of areas most likely to be impacted by construction.

Within the LSA, the rare plant survey was restricted to the Phase 1 footprint to ensure coverage of areas most likely to be impacted by construction. The purpose of the survey outside the footprint was to determine the distribution and abundance of ecosite phases within the LSA (Section 3.0) to collect information to measure biodiversity. Rare plant surveys were not performed at locations outside the Phase 1 footprint. However, any rare plants observed outside the footprint but still within the LSA (ecosite phase surveys) were also documented and are included in this assessment.

2.2.2 Data Collection

The rare plant and rare plant community survey was performed in accordance with ANPC guidelines (2000a). The data collection protocols used for this survey followed those outlined in the *Ecological Land Survey Site Description Manual* (Alberta Environmental Protection 1994). All rare plant plots were marked at the center with flagging tape denoting the plot number, date, and surveyor initials. Plot location was recorded at plot center with a GPS unit and one photograph of a representative area of the site was taken.

Plots were investigated using a floristic survey method with meander searches. A meander search is when the surveyor walks in a spiral pattern, starting at plot centre, in order to cover a greater area more thoroughly. The surveyor searches until no more new species are found. Unique or special landscape features such as microhabitats, ephemeral habitats, wet areas or transition zones are given special attention. These areas are important habitats for rare plants. Surveyors look for any special, unique or rare plant communities while performing the rare plant survey and while travelling between plots. Rare plants and rare plant communities are usually closely linked with soil moisture, nutrient levels, and substrate type.

Investigations focused on visiting a representative sample set for each habitat type, ecosite phase, plant community type, wetland type, and unique features within the Phase 1 footprint. While moving from one plot to another, surveyors scanned the area for rare or unique plants and communities. If a plant could not be identified in the field, a sample (voucher) was collected as specified in the *Native Plant Collection and Use Guidelines* (ANPC 2006). Samples were later identified in the laboratory. Rare plant vouchers were collected only if its removal would not lead to an immediate population loss greater than 4%. This was done to ensure that the potential for future plant propagation was not compromised. Vouchers collected included the minimum amount of material (leaf, seeds, twigs) needed to ensure proper identification. Whole plants were collected only if the population was large enough. For each rare plant population recorded, an ANHIC native plant report was filled out.

In total, 32 plots were surveyed for rare plant and/or community occurrences in the LSA. However, as the location of the Project footprint and road were not available at the time of the survey, only one plot is within the Phase 1 footprint (Figure 1b) and one along the access road (Figure 1b). At each rare plant sample plot, a full ecosite phase classification (see Section 3.0 for classification details) was compiled providing biodiversity information regarding plant community type, soil, slope, moisture and nutrient regime (Table 2.1). As well, a comprehensive plant list was completed for the plot area. Photographs of the habitat and close-up photos of (identified) rare plants were taken at each plot and a GPS waypoint was taken. Sampling occurred in the spring of 2008 (June 20-24, 2008). Additional plots will be placed in the Project footprint and along the access road.

Table 2.1 Data collection form for rare plant and rare plant community survey.	
Site Data	Plot number Date Plot type Surveyor Photo number(s) GPS coordinates Field AVI type Natural subregion Ecosite, ecosite phase and community type Ecosite fit Surface shape and expression Moisture regime Nutrient regime Aspect Slope, slope position, and slope length Site comments Landscape profile diagram
Vegetation Data	Strata Plant species name Percent cover*
Soil Data**	Soil texture Soil moisture regime Soil comments

* only in diversity survey

** soil data collected only to confirm ecosite classification

2.2.3 Post-survey Methods

Potential and confirmed rare plant species were mapped using the UTM coordinates from the GPS waypoints. The vascular plant samples that were collected were identified by GDC staff (Michael Schulz, M.Sc.). Moss, liverwort, and lichen species were sent for taxonomic validation by outside professional taxonomists (Marcie Plishka, M.Sc., Trevor Goward, Lichenologist). All plant names in this report follow NatureServe (2008).

Plot data was entered into a digital database, and queries were done to determine which plant species were rare. Potential and confirmed rare plant species within the Project area were then mapped using the UTM coordinates from the GPS waypoints taken at each rare plant survey location. Plot data is summarized in Appendix 6.

A query was also done to detect the presence of invasive plants and or weed species. The definition of a weed included all species identified in the Alberta Weed Control Act (Government of Alberta 2001).

2.2.4 Quality Assurance and Quality Control

Quality assurance and control methods used in the collection of field data included:

- Compilation of a list of potential rare plant species and communities and their habitats before field surveys, as well as obtaining the official ANHIC lists;
- Selection of sites in unique habitats and/or ecotones to ensure sites likely to contain rare plants were visited;
- Utilization of accepted protocols (*e.g.* ANPC collection guidelines) when a rare plant was encountered;
- Reviewing of data sheets to make certain they were complete, legible, and accurate; and
- Reviewing of plant specimens collected to ensure proper labelling and identification.

Quality assurance and control methods used in the office for data processing included:

- Ensuring that field data were entered properly into the database through quality checks and queries;
- Sending of plant specimens that were thought to be rare and/or difficult to identify to other qualified plant taxonomists outside GDC; and
- Ensuring that plant names were the most up-to-date and accurate.

2.3 Results

2.3.1 Rare Plants

Voucher specimens of non-vascular species that were not field identifiable were sent to outside taxonomists for identification and confirmation of any rare species. At the time of preparing this report, identification of only the vascular species was complete. The following is a description of rare species that have been confirmed to date, and the complete results of the 2008 rare plant survey will be available once taxonomic validation is finished.

Seven plant species identified in the LSA were on the Alberta Rare Plant Tracking and Watch Lists (Gould 2006), with eighteen occurrences. Two rare vascular plants were found with four occurrences, two rare bryophytes were found with a total of two occurrences, and three rare lichen species with 24 occurrences were found during the field survey (Figure 2). Table 2.2 lists the species and their rarity rankings within Alberta, adjacent jurisdictions, and globally.

Table 2.2 Rare plants within the Sunshine SAGD LSA.

Species	Plant Com-munity	Alberta Provin-cial Rank	Adjacent Jurisdictions Rank					Global Rank
			B.C.	Sask.	N.W.T.	Montana	Idaho	
Vascular Plants								
Chrysosplenium iowense	f3.2	S3	S2S3	S1?	SNR			G3
Chrysosplenium tetrandrum	k2.3, f1.1, k2.3	S3	S5	S5	SNR	S3	S1	G5
Bryophytes								
Conocephalum conicum	k1.1	S2						G5
Splachnum luteum	h1.2	S3	S2S3	S3?	SNR			G3
Lichens								
Cladina stygia	i1.1, c1.1, c1.3, d1.6, j1.1, g1.1, b3.3, h1.1, a1.1, b2.3	S1		SNR				G5
Omphalina umbellifera	h1.1, k1.1, j1.1, i1.1, f3.1	S1		SNR				GNR
Ramalina dilacerata	f3.1, d2.4	S2		S3S5				G3G5

A list of each rare plant occurrence in the LSA and the associated GPS coordinates can be found in Appendix 1.

2.3.2 Rare Vascular Plant Descriptions

Chrysosplenium iowense – Golden saxifrage

Chrysosplenium iowense is a small perennial herb with a stoloniferous habit, golden-yellow sepals with a wider outer pair which appear from May-July, and conspicuously veined leaves (Johnson *et al*. 1995). Golden saxifrage is found in moist, shady areas, often with rich soil, such as along stream banks, and within wetlands, in Canada (Johnson *et al*. 1995, Moss 1983). In the United States, it grows on north-facing talus slopes above streams, with occurrences often near cold groundwater seeps or ice caves (Roosa and Eilers 1978). Population sizes are not big, with a couple hundred individuals at most (NatureServe 2008). This may be due to several reproductive factors of golden saxifrage. This species does not develop flowering stems until the second season (Rosendahl 1947); flowering is temperature dependent, maximum production occurring at 11-12 ^{o}C (Smith 1981); plants are not self-compatible and require insect pollination (Weber 1979); and, dispersal of seeds is accomplished by drops of rain falling into the cup-shaped capsules containing the seeds, essentially splashing them out, but rarely more than 15 cm from the cup (Johnson *et al*. 1995). *C. iowense* is primarily a Canadian species, occurring from the Northwest Territories south into British Columbia, Alberta, Saskatchewan, and Manitoba, with a few disjunct populations (most likely relics from the Pleistocene ice age) occurring in Iowa and Minnesota (NatureServe 2008). Golden saxifrage is given the status of S3 (vulnerable) in Alberta, as it is fairly common, and its status is S2S3 (likely vulnerable) in British Columbia, S1? (probably critically imperilled) in Saskatchewan, and SNR (not ranked) in the Northwest Territories (NatureServe 2008). Globally, it is ranked as G3? (probably vulnerable), suggesting it may be locally abundant in some areas and rare in others, and its range may be restricted (Gould 2006). *C. iowense* was found once in the LSA, outside the Phase 1 footprint, in a horsetail white spruce (f3) ecosite phase.

Chrysosplenium tetrandrum **– Green saxifrage**

Chrysosplenium tetrandrum is a small yellowish-green perennial herb with a stoloniferous habit and small, apetalous flowers which appear from June-August (Moss 1983, NatureServe 2008). Its seeds are held in tiny cup-shaped capsules. Green saxifrage is found on moist, shady sites, often with rich soil, such as along stream banks and ledges, and in wetlands (Johnson *et al*. 1995, Moss 1983). *C. tetrandrum* is a circumpolar species, found across the northern boreal forest and the Arctic (Johnson *et al*. 1995). In North America, it is found from Alaska to northern Quebec and south into the northern United States (Moss 1983). *C. tetrandrum* is given the status of S3 in Alberta and Montana, S5 in Saskatchewan and British Columbia, SNR in the Northwest Territories, and S1 in Idaho (ANHIC 2008, NatureServe 2008). Globally, green saxifrage is secure with a rank of G5 (NatureServe 2008). This species was found three times in the survey, all outside the Phase 1 footprint, once in a horsetail poplar-aspen stand (f1), and twice in shrubby rich fens (k2).

2.3.3 Rare Bryophyte Descriptions

Conocephalum conicum **– Snake liverwort**

Conocephalum conicum is a shiny, thalloid (*i.e.* non-leafy) liverwort that resembles the more common *Marchantia polymorpha*, but never has gemmae cups, lacks marginal scales on the thallus undersides, has large, angular-patterned cells, and has an aromatic odour when crushed (Paton 1999, Schuster 1953). It also differs in having the antheridia (male reproductive organ) as a small wart-like structure, as opposed to the umbrella-like antheridia of *M. polymorpha*. *C. conicum* forms yellowish-green to grey-green mats with lobes that are 4-17 mm wide and plants that are at least 12 cm long. It occurs in moist habitats on soil, rocks, peat, and wood. *C. conicum* is ranked S2 (imperilled) in Alberta, but is ranked G5 (abundant, widespread, and secure) globally and SNR (not ranked) in Manitoba (ANHIC 2006, NatureServe 2008). This species was found outside the Phase 1 footprint, in a treed rich fen (k1) ecosite phase.

Splachnum luteum **– Yellow collar moss**

Splachnum luteum is a unique moss with serrated leaves and sporophytes shaped like small yellow umbrellas (Johnson *et al*. 1995). The umbrellas are composed of thick, spongy tissue that give off a sour odor to attract flies, which in turn land on the umbrella, pick up the sticky spores and distribute them to the next patch of moss (Johnson *et al*.

1995, Vitt *et al*. 1988). Yellow collar moss grows on moose (and occasionally, other herbivore) dung, which is why it has adapted to using flies to disperse its spores (Johnson *et al*. 1995). It is scattered across North America, occurring from Alaska to New Brunswick, and south into British Columbia, Alberta, and Saskatchewan (NatureServe 2008). It also occurs in northern Europe and Asia (NatureServe 2008). *S. lutuem* is given the ranking of S3 (vulnerable) in Alberta but it is on ANHIC's tracking list (ANHIC 2006). It is ranked S2S3 (likely vulnerable) in British Columbia, S3? (probably vulnerable) in Saskatchewan, and SNR (not ranked) in the Northwest Territories (Gould 2006, NatureServe 2008). Globally, it is ranked G3 (vulnerable) (Gould 2006). *S. luteum* was found outside the Phase 1 footprint, in a Labrador tea/horsetail white spruce-black spruce (h1) ecosite phase.

2.3.4 Rare Lichen Descriptions

Cladina stygia **– Black-footed reindeer lichen**

Cladina stygia is a highly branched fruticose shrub lichen in the Cladoniaceae family. It closely resembles the common *Cladina rangifera* (Gray reindeer lichen) in being grayish in colour, having slightly side-swept branches, and in having pycnidia (small black fungal fruiting bodies immersed in the lichen) (Brodo *et al*. 2001). However, *C. stygia* is more sparsely branched, is dark brown to blackish near the base, and has pinkish (rather than clear) jelly in its pycnidia. *C. stygia* grows in open, wet to boggy sites (Brodo *et al*. 2001) and is known from Alaska south and east throughout Canada, the northeastern states, and New England (Brodo *et al*. 2001, NatureServe 2008). Other populations are known in the southern Appalachians and north of the Columbia Basin region. It is rated S1 in Alberta, and SNR in Wisconsin, Saskatchewan, Ontario, and Quebec (Gould 2006, NatureServe 2008). It is globally secure at G5 (Gould 2006). *C. stygia* was found sixteen times in the LSA in a variety of ecosite phases (Table 2.2), with one possible occurrence in the Phase 1 footprint (see Section 2.4.1).

Omphalina umbellifera – **Green pea mushroom lichen**

Unlike most lichens, in which the fungal component of the lichen is an ascomycete (phylum Ascomycota), in *Omphalina umbellifera* the fungal component is a mushroom-forming basidiomycete (phylum Basidiomycota). *O. umbellifera* generally exists as a dark green globular crust on peat and rotting wood, but seasonally small, yellow to yellow-orange mushrooms are produced. Although these mushrooms are similar to many other Alberta mushrooms, this is the only species that forms a lichen (*i.e.* is associated in a lichenicolous relationship with algae). According to ANHIC, *O. umbellifera* is ranked S1 (critically imperilled) in Alberta (ANHIC 2006); however most references consider it common in the Pacific Northwest (Arora 1986, Phillips 1991), including Alberta (Schalkwijk-Barendsen 1991). It is likely under-reported because mushrooms are seasonal and not included as part of most surveys, and the green crust is fairly cryptic and not easily recognizable as a lichen. *O. umbellifera* is ranked SNR (not ranked) in Saskatchewan and GNR (not ranked) globally (NatureServe 2008). This species was found five times in the LSA, outside the Phase 1 footprint, in a variety of ecosite phases (Table 2.2).

Ramalina dilacerata **– Punctured ramalina**

Ramalina dilacerata, also called *R. minuscula*, is a greenish-yellow tufted shrub lichen with hollow, perforated branches that lack soredia (Johnson *et al*. 1995, Vitt *et al*. 1988). It is relatively small, with branches mostly 1-2 cm long, and fairly large, pale yellow apothecia are usually present. This species grows on stumps, trunks and branches of deciduous and coniferous trees and shrubs, most often in riparian areas (McCune and Geiser 1997, Johnson *et al*. 1995). Punctured gristle is found from Alaska to California and east into western Montana, in places with a strong oceanic influence (McCune and Geiser 1997). In Alberta, it is ranked as S2 (imperilled), and in Saskatchewan, as S3S5 (likely abundant, widespread, and secure) (NatureServe 2008). Globally, its status is G3G5 (Gould 2006). *R. dilacerata* was observed twice in the LSA, outside the Phase 1 footprint, in low-bush cranberry aspen-white spruce (d2) and horsetail white spruce (f3) ecosite phases.

2.3.5 Rare and Special Plant Communities

There were no rare or special plant communities found in the LSA.

2.3.6 Non-native and Invasive Plants

All vegetation data were entered into a Microsoft Access database and queries were conducted to identify non-native and invasive plant species within the LSA. The baseline field surveys identified only two species (1 occurrence each) of non-native and invasive species (Government of Alberta 2001) within the LSA. These occurrences comprised the following species and their designations:

1. **Noxious weeds**: *Ranunculus acris.*

2. **Nuisance weeds**: *Taraxacum officinale.*

2.4 Project Effects and Mitigation Efforts

2.4.1 Rare plants within the Phase 1 Project footprint

Cladina stygia was found once at the north end of a borrow pit at E395489, N6340491 (Figure 2). The plot center is outside the Phase 1 footprint, but within 35 m of the borrow pit, and because of the wandering nature of rare plant surveys, it is possible that *C. stygia* may fall inside the Project footprint. It is ranked S1 (critically imperilled) in Alberta and G5 (secure) globally. However, *C. stygia* was found 16 other times, outside the Phase 1 footprint, in a variety of ecosite phases (Table 2.2), and no mitigation is recommended for this species.

An assessment of Project effects and any mitigation requirements for additional rare plants in the Project footprint will be completed once the 2010 survey has been concluded.

While mitigation will not be recommended for rare plants found within the LSA but outside the Project footprint, efforts should be made to prevent accidental disturbance to these rare plant locations during construction and operation of the Project, future activities, or indirectly by changing drainage patterns outside the Project footprint. A list of each rare plant occurrence in the LSA and the associated GPS coordinates can be found in Appendix 1.

2.4.2 Non-native and Invasive Plants

Only two non-native and invasive plants were observed in the LSA. However, the removal of litter and increased bare ground can enhance the spread and establishment of invasive annual forbs and non-native species from adjacent areas (Hayes and Holl 2003). A vegetation monitoring and control program to address non-native and invasive species and their control is recommended for the construction, operation, and closure phases of the Project.

3.0 ECOSITE CLASSIFICATION AND MAPPING

3.1 Study Objectives

The purpose of the ecosite classification and mapping was to determine the distribution and abundance of ecosystems in the LSA (Figure 5a) and along the access road (Figure 5b). Ecosite classification provides a general description of the moisture and nutrient regime of a site and associated information about what species are dominant and the ability of the site to sustain certain species. Ecosite classification maps were used in conjunction with a map of existing and proposed disturbances (seismic lines, roads, well sites, etc.) in the area to help distinguish what ecosites will be influenced the most by the proposed new development. The main objectives were to:

- Determine the distribution and abundance of ecosite phases within the LSA and within a 500-m buffer around the access road;
- Identify and document main species composition;
- Identify and document plant community types;
- Calculate the area and percentage within the LSA, Phase 1 footprint, and the proposed access road and associated buffer that each ecosite phase occupies;
- Calculate species richness and diversity;
- Identify the types of old growth forests in the LSA and along the access road; and
- Determine the amount of area within the LSA and access road that is occupied by the identified old growth forest types.

3.2 Methods

3.2.1 Ecological Classification

The ecological classification system used for this Project was that of Beckingham and Archibald (1996) (Appendix 2). It incorporates vegetation, soil, site, and productivity information to classify ecosystems to ecosite phase. Under this system ecosites are defined relative to the modal or reference site within a particular natural subregion. In this construct, the modal or reference site refers to a site that is more strongly influenced by the regional climate than by edaphic (soil) or landscape features, and as a result is typified by moderate soil moisture and nutrient conditions. This system of ecosite classification is hierarchical as follows (from largest to smallest):

- Natural region and subregion-Ecological area (mapped at 1:1,000,000 scale)
- Ecosite (mapped at 1:20,000 scale)
- Ecosite phase (mapped at 1:15,000 scale)
- Plant community type (mapped at 1:5000 scale)

The Natural Regions and Subregions of Alberta form the base of the system and represent distinct landscapes that are delimited and classified on the basis of unique climatic, geomorphological, physiographical, and ecological characteristics. Ecosystem classification within this framework is used to further distinguish and classify ecosystems and associated plant communities as follows:

- Ecosite, which forms the functional unit, is defined on the edatopic grid by nutrient and moisture regimes in an area with similar climatic and environmental conditions (Figure 3). Ecosite is identified by a letter increasing from "*a*" to the last letter used; in the case of the Boreal Mixedwood ecological area, letters go from "*a*" to "*l*";

- Ecosite phase, which is based on the dominant tree species, or tallest physiognomic vegetation layer if trees are not present (*e.g*., shrubs), represents the smallest mappable unit. Ecosite phase correlates well with traditional forest cover maps and is identified with a letter number combination, with the letter representing the ecosite and the number representing the phase within that ecosite (e.g., c1, d1, d2); and

- Plant community type, which is characterized by the dominant understorey plant species, but also includes the overall plant community. Plant community type is identified by a number that follows the ecosite phase (e.g., c1.1, d1.2, d2.2) (Figure 4).

3.2.2 Classification

In preparation for the field-level vegetation assessment, preliminary maps were created depicting ecosite phase, based on interpretation of an orthophotograph and aerial photographs of the area, as well as Alberta Vegetation Inventory (AVI) maps and database. The aerial photos were at a scale of 1:15,000. The canopy closure, stand height, most prevalent tree species, moisture regime, and non-forested land descriptions (industrial) were used from the AVI database to give each polygon a label (see Table 3.1).

The AVI database polygons were then edited to define ecosite phase boundaries. AVI data does not effectively delineate bogs and fens or consider changes in elevation. AVI polygon boundaries were modified through interpretation of the orthophoto and aerial photos. When classifying polygons containing multiple ecosite phases, only the two dominant ecosite phases were included. Polygons were not classified to the plant community type level because understorey plant species could not be identified through the use of aerial photos alone.

The interpreted maps were then used to locate and stratify sample sites for detailed ecosite phase classification in the field (for ground-truthing of preliminary polygons), as well as for conducting the rare plant and rare plant community surveys within the Phase 1 footprint as discussed in Section 2.0. In the field, ecosite classifications were completed to the plant community type level (Beckingham and Archibald 1996) at all rare plant plots, as well as at “ecocall” site locations performed while in transit between plots. Field classifications were based on an evaluation of indicator plant species and topography features. Full soil profile descriptions were completed to determine basic soil properties and the moisture and nutrient regime of the site. This data was utilized to aid in ground-truthing photo interpretations

After the field survey, the AVI database polygons were again edited using field data and 1:15,000 scale aerial photos to more clearly define ecosites and ecosite phase boundaries. The ecosites are described in Appendix 2. Ecosite phases are described in Section 3.3.2.

Table 3.1 AVI characteristics used in ecosite phase mapping.

Characteristic	Value	Value Description
Crown class values	A	6 – 30% cover
	B	30 – 50% cover
	C	50 – 80% cover
	D	80%+ cover
Height values	1 thru 35	Height of canopy in 1-m increments
Species	sp 1 - sp 5	Name of species in order of most dominant to least Dominant
	per 1 - per 5	Percentage of species listed in intervals of 10%
Non-forested vegetated land	Sc	Closed shrub
	So	Open shrub
	Hg	Herbaceous grassland
	Br	Bryophyte – moss
Non-forested land (Industrial)	AIH	Permanent right-of-ways, highways, railroads, etc
	AIG	Gravel pits, borrow pits
	AII	Industrial sites, plant sites
	CIP	Pipelines, transmission lines, forestry look out towers
	CIW	Geophysical-well sites that have been seeded
	CIU	Unknown clearings

3.2.3 Quality Assurance and Quality Control

Quality assurance and control methods used in the collection of field data included:

- Selection of sites across the whole LSA to ensure equal representation of different types of ecosites;
- Selection of sites in homogenous vegetation to ensure accurate ecosite phase and plant community type classification;
- Selection of sites that were difficult to distinguish ecosite phase from remote data sources that were available; and
- Daily review and correction of data sheets to ensure they were complete, legible, and accurate.

Quality assurance and control methods used in the office for mapping and classification included:

- Utilization of accurate aerial photos with a scale of 1:15,000
- Utilization of AVI database and LIDAR imagery to clarify ecosite phase classifications

3.2.4 Data Analysis

Field data from sample plots were entered into a Microsoft Access database for summary and analysis. The database was subsequently queried to isolate relevant information for further analyses. Preliminary maps were revised to show vegetation and wetland resources.

To determine biodiversity, sample plots located within each identified ecosite and ecosite phase were treated as replicates and assumed to reflect the average and range in species richness and abundance for the whole ecosite or ecosite phase within the LSA. Only ecosite plots with abundance (percent cover) of each species were used to calculate biodiversity parameters, as only these plots represented discrete sample locations (the area covered in a rare plant wander can vary from plot to plot). This provided the required data for calculation of species richness, diversity and evenness.

The data were subjected to queries (Microsoft Access) and analysis (SAS) to obtain the diversity parameters of species richness, evenness, and Shannon diversity index for ecosites and ecosite phases within the LSA. As well, the area of each ecosite phase within the LSA and access road buffer was determined, and a map was produced showing the distribution of each dominant ecosite phase.

The total species richness is simply a count of all of the species found within that ecosite (based on total species recorded for all plots in that ecosite), whereas the mean species richness gives the average number of species found within a certain ecosite. The mean evenness measures, on average, how equal each species is in relative abundance within that ecosite and/or ecosite phase (Equation 1, Pielou 1966).

$$E = H/ln(S)$$

Where:

E = evenness;

H = Shannon diversity index; and

ln(S) = natural logarithm of species richness

Evenness is measured on a scale from 0 to 1. For example, an ecosite with a value of 1 indicates that each species within that ecosite is equally abundant. Therefore, the closer the evenness value is to 1, the more equitable the plant community is. A community with a low evenness value is typically dominated by one or a few species.

Diversity indices were also used in this study to account for both abundance and evenness, as both parameters are useful for ascertaining true diversity. The higher the value of the index, the more diverse the community. The Shannon diversity index is one such index, in which the proportion of all individuals belonging to species *i* relative to the total number of individuals of all species is calculated and then multiplied by the natural logarithm of this proportion. The resulting product is then summed across all species and multiplied by -1 to obtain the log of the number of species of equal abundance (MacArthur and MacArthur 1961) (Equation 2). The average Shannon diversity index is reported for each ecosite and ecosite phase.

$$H = - sum(P_i * ln(P_i))$$

Where:

H = Shannon diversity index;

P_i = proportion of individuals of species *i* relative to the total number of individuals of all species; and

$ln(P_i)$ = the natural logarithm of P_i.

Biodiversity measures of species richness, diversity and evenness were calculated using the Statistical Analysis Software (SAS 9.1, 1990). Species richness (S) was calculated as a count of the species encountered in each plot. Where a single species occurred in more than one strata within the same plot (trees and shrubs), abundance data (percent cover) were combined for the calculations of species richness and proportion. The results of the analysis are presented in Section 3.3 and in Table 3.2 (Ecosite) and Table 3.3 (Ecosite phase).

3.3 Results

3.3.1 Species Distribution and Abundance

A total of 302 plant species were found in the LSA. Of these, 151 were vascular plants, 62 were mosses and liverworts and 89 were lichens. For a complete list of the flora identified in the LSA, refer to Appendix 5.

The most prevalent tree species were black spruce, aspen and white spruce, with small amounts of balsam poplar, paper birch, jack pine, and tamarack.

3.3.2 Ecosites and Ecosite phases in the LSA

Twelve ecosites were identified in the LSA. Table 3.2 presents, for each ecosite, the number of sites sampled, the total number of species found in each ecosite, and diversity parameters (mean richness, mean Shannon diversity index, mean Shannon evenness). Standard deviations around each mean are also shown.

Biodiversity analysis found considerable differences between the ecosites in the LSA. Although a minimum of five sample plots per ecosite was targeted, establishment of plots was limited to the presence of enough ecosite types to reach this goal. Also, in stratifying the LSA for maximum sample plot coverage, several ecosite types were more common and were therefore sampled more frequently than others. Ecosites a (lichen), b (blueberry), c (Labrador tea-mesic), e (dogwood), and l (marsh) were sampled fewer than five times, while ecosites d (low-bush cranberry) and k (rich fen) were sampled 20 and 12 times, respectively. For this reason, and especially when applied to ecosite phase, diversity parameters may not reflect actual variation in these communities.

Ecosite e (dogwood) was highest in species richness (34.5) and Shannon diversity (2. 7) and evenness (0.8), while the l ecosite (marsh) had the lowest mean species richness (6.3), and Shannon diversity (0.73) and evenness (0.4).

Table 3.2 Species richness, diversity and evenness of ecosites.

Ecosite	# of sites (n)	Richness		Diversity		Evenness	
		Mean	StDev	Mean	StDev	Mean	StDev
a	1	28.0	-	1.8	-	0.5	-
b	4	27.0	6.4	2.1	0.4	0.7	0.07
c	3	26.0	3.5	2.0	0.08	0.6	0.01
d	20	23.6	6.7	2.2	0.4	0.7	0.1
e	2	34.5	7.8	2.7	0.08	0.8	0.07
f	6	27.5	8.1	2.2	0.6	0.7	0.1
g	5	16.6	10.6	1.6	0.8	0.6	0.1
h	8	28.9	9.6	2.1	0.8	0.6	0.2
i	10	19.3	5.2	1.8	0.1	0.6	0.06
j	9	28.0	11.5	2.2	0.3	0.7	0.06
k	12	21.4	10.2	1.7	0.6	0.6	0.1
l	4	6.3	2.9	0.7	0.6	0.4	0.3

Table 3.3 presents data for ecosite phases. The highest species richness was found in the lowland ecosite phase j1 (treed poor fen; 34.6), and the lowest was found in the l1 (marsh; 6.3). Shannon diversity was highest in the e2 ecosite phase (2.67), and lowest in the l1 ecosite phase (0.7). The highest evenness (mean=0.8) was in e2 and d2 (low-

bush cranberry aspen-white spruce) ecosite phases and lowest again in the l1 ecosite phase (0.37).

Table 3.3 Species richness, diversity and evenness of ecosite phases.

Ecosite phase	# of sites (n)	Richness		Diversity		Evenness	
		Mean	StDev	Mean	StDev	Mean	StDev
a1	1	28.0	-	1.8	-	0.5	-
b1	1	18.0	-	1.6	-	0.6	-
b2	2	29.5	3.5	2.3	0.2	0.7	0.05
b3	1	31.0	-	2.3	-	0.7	-
c1	3	26.0	3.5	2.0	0.08	0.6	0.01
d1	8	24.3	8.8	2.3	0.4	0.7	0.09
d2	8	23.8	6.2	2.4	0.3	0.8	0.07
d3	4	21.8	2.9	1.8	0.4	0.6	0.1
e1	0[1]	-	-	-	-	-	-
e2	2	34.5	7.8	2.7	0.08	0.8	0.07
f1	2	30.5	6.4	2.6	0.4	0.8	0.06
f2	1	13.0	-	1.1	-	0.4	-
f3	3	30.3	4.0	2.4	0.09	0.7	0.05
g1	5	16.6	10.6	1.6	0.8	0.6	0.1
h1	8	28.9	9.6	2.1	0.8	0.6	0.2
i1	6	20.7	5.7	1.8	0.1	0.6	0.06
i2	4	17.3	4.4	1.8	0.08	0.7	0.06
j1	5	34.6	10.6	2.4	0.3	0.7	0.04
j2	4	19.8	6.3	2.0	0.2	0.7	0.08
k1	2	24.0	4.2	2.0	0.3	0.6	0.06
k2	5	31.0	4.3	2.2	0.4	0.6	0.1
k3	5	10.8	2.3	1.0	0.2	0.4	0.07
l1	4	6.3	2.9	0.7	0.6	0.4	0.3

[1] – Ecosite phase e1 was not observed in the field survey however is present in the LSA based on aerial photo interpretation.

3.3.2.1 Distribution of Ecosite Phases within the LSA

The existing boundaries of the AVI polygons were modified to depict different ecosite phases by looking for obvious visual differences using aerial photos and orthophoto images. The final map resulted in 557 ecosite phase polygons in the LSA. In the field, 91 classification points were visited in the LSA and assigned to a plant community type (Beckingham and Archibald 1996). The ecosite phases found within the LSA were: a1, b1, b2, b3, c1, d1, d2, d3, e1, e2, f1, f2, f3, g1, h1, i1, i2, j1, j2, k1, k2, k3 and l1 (Table 3.4). In addition 2 natural cover types and 2 anthropogenic type polygons were identified (AVI codes). Figure 5a shows the ecosites that were mapped in the LSA.

Table 3.4 Areas of ecosite phases within the LSA and Phase 1 footprint.

Ecosite phase/ AVI code	**Total area in LSA (ha)**	**Percent of LSA (%)**	**Total area in** Phase 1 footprint **(ha)**	**Percent relative to LSA (%)**[1]
a1-lichen Pj	0.3	0.01	-	-
b1-blueberry Pj-Aw	-[2]	-	-	-
b2-blueberry Aw(Bw)	1.4	0.06	-	-
b3-blueberry Aw-Sw	2.6	0.1	-	-
c1-Labrador tea-mesic Pj-Sb	60.1	2.5	-	-
d1-low-bush cranberry Aw	321.4	13.6	20.2	0.9
d2-low bush cranberry Aw-Sw	347.4	14.7	6.6	0.3
d3-low bush cranberry Sw	26.3	1.1	-	-
e1-dogwood Pb-Aw	7.1	0.3	-	-
e2-dogwood Pb-Sw	0.8	0.03	-	-
f1- horsetail Pb-Aw	7.8	0.3	-	-
f2-horsetail Pb-Sw	8.6	0.4	-	-
f3-horsetail Sw	2.7	0.1	-	-
g1-Labrador tea –subhygric Sb-Pj	75.7	3.2	-	-
h1-Labrador tea/horsetail Sw-Sb	123.6	5.2	4.9	0.2
i1-treed bog	427.9	18.1	3.1	0.1
i2-shrubby bog	263.1	11.2	0.5	0.02
j1-treed poor fen	158.3	6.7	10.1	0.4
j2-shrubby poor fen	104.8	4.4	9.2	0.4
k1-treed rich fen	21.9	0.9	5.8	0.2
k2-shrubby rich fen	23.1	1.0	0.3	0.01
k3-graminoid rich fen	55.2	2.3	-	-
l1-marsh	10.1	0.4	-	-
CIP - Pipelines, transmission lines	12.6	0.5	-	-
CIW - Seeded well sites	2.9	0.1	0.01	0.0004
NWR-river	1.3	0.05	-	-
NWL - lake, pond	291.5	12.4	-	-
Total	2358.3	100.0	60.7	2.6

[1] – % area calculated as (Area in Phase 1 footprint/Area in LSA) x 100%.
[2] – Classification from field survey observations, area too small for classification from air photo interpretation.

The LSA covers a total area of 2358 ha (Table 3.4) of which 787 ha (33%) are upland areas and 1264 ha (54%) are lowland areas (ecosites g through l). Existing disturbances, including clearings, pipelines, transmission lines, and well sites, cover approximately 16 ha (0.7%) of the LSA, and water (lakes, ponds, and rivers) occupies 293 ha (13%).

Treed bogs (i1) and shrubby bogs (i2) are the dominant lowland areas comprising 428 ha (18%) and 263 ha (11%) respectively. Though classified as shrubby, small black spruce are well represented in much of the i2 ecosite phase, and over time this area will likely transition into treed bogs. Upland areas are dominated by the low-bush cranberry (d1 and d2) ecosite phases, occupying 321 ha (14%) and 347 ha (15%), respectively (Table 3.4).

Fens occupy 15% (363 ha) of the LSA. Of the fens, 263 ha (11%) are poor fens while 100 ha (4%) are rich fens. Marshes comprise 10.1 ha (0.4 %) of the LSA.

Ecosite phases of restricted distribution (< 1% of the LSA) were a1, b1, b2, b3, e1,e2, f1, f2, and f3 in upland areas and k1 and l1-marsh in the lowlands (Table 3.4).

Clearing and construction within the LSA will impact 60.7 ha (2.6%) of area (Phase 1 footprint). Of the ecosite phases found in the Phase 1 footprint, only the treed rich fen (k1) is of restricted distribution.

3.3.2.2 Ecosite Phase Descriptions

Ecosite phases observed in the LSA are described below. Only ecosite phases that were present in the LSA will be presented here. The descriptions for ecosites as well as descriptions of the different moisture regimes and nutrient regimes are provided in Appendix 2, 3 and Appendix 4, respectively.

a1 lichen jack pine

Ecosite phase a1 (lichen jack pine) occupies 0.3 ha (0.01%) of the LSA. This ecosite phase is dominated by jack pine, with typical understorey species consisting of blueberry, bearberry, bog cranberry, and various lichens, especially reindeer lichen. The moisture regime ranges from xeric to submesic, and the nutrient regime is very poor to poor. Typically, this ecosite is found on crests or upper slopes within the landscape. Soil texture is sand, resulting in a rapidly to well drained drainage regime. Species richness in this phase is 28, Shannon diversity index is 1.8, and evenness is 0.5. One community type was found in this ecosite phase in the LSA:

a1.1 lichen jack pine - bearberry

b1 blueberry jack pine-aspen

The b1 (blueberry jack pine-aspen) ecosite phase was encountered during the field survey, but was too small to be captured as a distinct polygon in the map coverage and therefore the area is not reported. This phase has a canopy of jack pine and aspen, with an understorey dominated by bog cranberry, blueberry, green alder, bearberry, and Labrador tea. Typical ground cover includes Schreber's and stair step moss, as well as reindeer lichen. The moisture regime is subxeric to mesic, with a poor to medium nutrient regime. Soil texture varies from sand to loamy sand to sandy loam and sandy clay loam, resulting in a drainage regime of rapid to moderately well. Organic thickness typically does not exceed 15 cm. Diversity in this phase is low: species richness is 18; the diversity index is 1.6, and evenness is 0.6. One b1 community type was found in the LSA.

b1.1 blueberry jack pine-aspen – bearberry

b2 blueberry aspen-paper birch

The blueberry aspen-paper birch ecosite phase occupies 1.4 ha (0.06%) of the LSA. This phase is dominated by aspen and paper birch with some white spruce in the canopy, and blueberry, bearberry and Labrador tea in the understorey. The moisture regime ranges between subxeric to submesic with a nutrient regime ranging from poor to rich. The soil texture varies between sand and clay in the form of sandy loam, loamy sand, and sandy clay. Mean species richness is 29.5, Shannon diversity is 2.3, and evenness is 0.7.

b2.1 blueberry jack pine-aspen - bearberry

b2.3 blueberry jack pine-aspen – Labrador tea

b3 blueberry aspen-white spruce

The blueberry aspen-white spruce ecosite phase occupies 2.6 ha (0.1%) of the LSA. This phase is dominated by aspen and white spruce in the canopy, and blueberry, bearberry and bog cranberry and prickly rose in the understorey. The moisture regime ranges between subxeric to mesic with a nutrient regime ranging from poor to medium. The soil texture varies between loamy sand and sand. Mean species richness is 31, the diversity index is 2.3, and the evenness is 0.7. One community type was found in the survey.

b3.3 blueberry aspen-white spruce – Labrador tea

c1 Labrador tea–mesic jack pine-black spruce

Ecosite phase c1 occupies 60.1 ha (2.5%) of the LSA. It is dominated by a typically two-tiered canopy of jack pine and black spruce. The understorey is dominated by Labrador tea and bog cranberry. The soil texture varies by location between sand, sandy loam, loamy sand, loam, sandy clay loam, clay loam or clay. The humus form is mor and peaty mor. Mean species richness is 26, Shannon diversity index is 2, and evenness is 0.6. There were two community types found within the LSA.

c1.1 Labrador tea–mesic jack pine-black spruce – feather moss

c1.3 Labrador tea–mesic jack pine-black spruce – feather moss

d1 low-bush cranberry aspen

Ecosite phase d1 occupies 321.4 ha (13.6%) of the LSA, and is dominated by aspen, with some balsam poplar, paper birch and white spruce present. The understorey is dominated by prickly rose and low-bush cranberry. The moisture regime ranges from submesic to subhygric, but is usually mesic. The nutrient regime is medium to rich. The soil texture is finer than the previous ecosites consisting of silty loam, sandy loam, sand, loam, clay, silty clay, clay loams, sandy clay loams or silty clay loams. Mean species richness is 24.3, Shannon diversity index is 2.3, and evenness is 0.7. Four of the nine different community types within this ecosite phase were found in the LSA.

d1.3 low-bush cranberry aspen – beaked hazelnut

d1.5 low-bush cranberry aspen – low-bush cranberry

d1.6 low-bush cranberry aspen - rose

d1.7 low-bush cranberry aspen – beaked willow

d2 low-bush cranberry aspen-white spruce

Ecosite phase d2 occupies 347.4 ha (14.7%) of the LSA and is dominated by aspen and white spruce; however, balsam poplar, paper birch, balsam fir and some black spruce may be present. The understorey is dominated by low-bush cranberry and prickly rose. The nutrient regime ranges from poor to rich and the moisture regime is similar to ecosite phase d1. Soil texture ranges from sand to clay through different locations including (but not limited to) loam, silty loam, silty clay, silty clay loam, sand or sandy loam. Mean species richness is 23.8, Shannon diversity index is 2.3, and evenness is 0.8. Five of the nine community types were found in the LSA.

d2.1 low-bush cranberry aspen-white spruce – Canada buffalo-berry

d2.3 low-bush cranberry aspen-white spruce – beaked hazelnut

d2.4 low-bush cranberry aspen-white spruce – green alder

d2.7 low-bush cranberry aspen-white spruce – beaked willow

d2.9 low-bush cranberry aspen-white spruce – balsam fir

d3 low-bush cranberry white spruce

Ecosite phase d3 occupies 26.3 ha (1.1%) of the LSA. It is dominated by white spruce, but may also have some balsam fir, aspen, paper birch, balsam poplar, or black spruce present. The understorey is dominated by twinflower and low-bush cranberry. Stair-step moss is a significant ground cover. The moisture regime is mesic to subhygric and the nutrient regime ranges from poor to rich, though most locations are medium. Soil texture range is broad, ranging between clay and sandy loam with some silty loam. Mean species richness is 21.8, Shannon diversity index is 1.8, and evenness is 0.6. There were two of the five plant community types found within the LSA.

d3.3 low-bush cranberry white spruce – green alder

d3.5 low-bush cranberry white spruce – feather moss

e1 dogwood balsam poplar-aspen

Ecosite phase e1 occupies 7.1 ha (0.3%) of the LSA. It is dominated by balsam poplar and aspen, however white spruce and paper birch may also be present. The understorey is dominated by dogwood, low-bush cranberry and prickly rose. Wild sarsaparilla, dewberry, and fireweed constitute the common forb species, and marsh reed grass is also often present. The nutrient regime ranges from medium to rich and the moisture regime is mesic to subhygric. Soil texture ranges from sand to clay including clay, clay loam, silty loam, silty clay, silty clay loam, sand or sandy loam. No plots were completed in the e1 ecosite phase.

e2 dogwood balsam poplar-white spruce

Ecosite phase e2 occupies 0.8 ha (0.03%) of the LSA. It has a canopy dominated by balsam poplar and white spruce, and may contain lesser amounts of aspen, white birch, and balsam fir. The shrub layer may be diverse, with dogwood, low-bush cranberry, rose and bracted honeysuckle common. Wild sarsaparilla, dewberry, bunchberry, and bishop's cap are common forbs, and marsh reed grass and feather mosses are also present. Soil texture ranges between clay, silty clay loam, clay loam, sandy clay loam, or sand. The moisture regime can be mesic to subhygric, and the nutrient regime may vary between medium and rich. Mean species richness is 34.5, Shannon diversity index is 2.7, and evenness was 0.8. Two of five community types were found in the LSA.

e2.1 dogwood balsam poplar-white spruce – dogwood/fern

e2.3 dogwood balsam poplar-white spruce – river alder-green alder/fern

f1 horsetail balsam poplar-aspen

Ecosite phase f1 occupies 7.8 ha (0.3%) of the LSA. The canopy of is dominated by balsam poplar and aspen, with lesser amounts of paper birch and white spruce. Willow, prickly rose, green/river alder, meadow horsetail, common horsetail, and marsh reed grass are found in this ecosite phase. Little to no moss is present in this ecosite phase. It has a hygric moisture regime and a medium to rich nutrient regime. Soil texture is generally silt, clay, silty clay, or loam. Mean species richness is 30.5, Shannon diversity index is 2.6, and evenness is 0.8. There is only one community type in this phase, and it was found in the LSA.

f1.1 horsetail balsam poplar-aspen

f2 horsetail balsam poplar-white spruce

Ecosite phase f2 occupies 8.6 ha (0.4%) of the LSA and has a canopy dominated by balsam poplar and white spruce with paper birch, aspen and balsam fir also potentially present. Low-bush cranberry, willow species, prickly rose, and dogwood are common shrub species in this phase. Meadow and common horsetail, wild sarsaparilla, bishop's cap, bunchberry, marsh reed grass, and feather mosses are commonly found in the understorey. Soil texture ranges from sand to clay including clay loam, silt, silty loam, silty clay, sandy clay loam, or sandy loam. The moisture regime ranges between hygric and mesic, but is most commonly subhygric. The nutrient regime is medium to rich.

Mean species richness is 13, Shannon diversity index is 1.1, and evenness is 0.4. The one community type in this ecosite phase was found in the LSA.

f2.1 horsetail balsam poplar-white spruce

f3 horsetail white spruce

Ecosite phase f2 occupies 2.7 ha (0.1%) of the LSA. The canopy is dominated by white spruce, often with small amounts of balsam fir, aspen, balsam poplar, and white birch. Twin flower, prickly rose, low-bush cranberry, and currant make up the shrub layer, and meadow and common horsetail, bunchberry, and dewberry are the prominent forbs. Marsh reedgrass and sometimes sedges may also be present with feather mosses. Soils are generally silty clay or clay, and the moisture regime can be mesic to hygric. Mean species richness is 30.3, Shannon diversity index is 2.4, and evenness is .07. Two of the community types were observed in the LSA.

f3.1 horsetail white spruce

f3.2 horsetail white spruce – feather moss

g1 Labrador tea-subhygric black spruce-jack pine

Ecosite phase g1 occupies 75.7 ha (3.2%) of the LSA and is dominated by black spruce and jack pine. The dominant understorey is Labrador tea and black spruce, with a ground cover of mosses including Schreber’s moss and stair-step moss. Organic layer thickness is usually in the 6-15 cm range, but has been found as deep as 80 cm or more. The humus form is mor or raw moder. Soil texture varies greatly by site including, but not limited to, sandy loam, silt, sandy clay loam, silty loam, sand, loamy sand or organic-fibric. Mean species richness is 16.6, Shannon diversity index is 1.6, and evenness is 0.6. Both plant community types of this ecosite phase were found within the LSA.

g1.1 Labrador tea-subhygric black spruce-jack pine – Labrador tea feather moss

g1.2 Labrador tea-subhygric black spruce-jack pine – feather moss

h1 Labrador tea horsetail white spruce-black spruce

Ecosite phase h1 occupies 123.6 ha (5.2%) of the LSA, and is dominated by white spruce and black spruce with some paper birch. The dominant shrubs, forbs and mosses are Labrador tea, bog cranberry, common and meadow horsetail, stair-step moss and Schreber’s moss. The humus form ranges from peatymor to mor, and mottles are usually visible in the top 25 cm of the soil profile. Soils range from silty loam to clay and organic (mesic and humic) soils. The ground is largely covered in feather moss, Labrador tea and horsetail. Mean species richness is 28.9, Shannon diversity index 2.1, and evenness is 0.6. One h1 plant community type was found in the LSA.

h1.1 Labrador tea horsetail white spruce-black spruce

i1 treed bog

Ecosite phase i1 occupies 427.9 ha (18.1 %) of the LSA, and is the most common ecosite phase in the LSA. Dominated by stunted black spruce, it has an understorey of Labrador tea, bog cranberry, black spruce and small bog cranberry. There are some forbs present, but ground cover is largely mosses: predominantly peat mosses and Schreber's moss. Mean species richness is 20.7, Shannon diversity index is 1.8, and evenness is 0.6. There is only one community type in this ecosite phase.

i1.1 black spruce Labrador tea – cloudberry peat moss

i2 shrubby bog

Ecosite phase i2 occupies 263.1 ha (11.2 %) and is the second most common phase in the LSA. It is typically dominated by shrubs like Labrador tea, black spruce (less than 5 m tall), bog cranberry, leather leaf, small bog cranberry; the forb indicator species cloudberry may also be dominant. Ground cover is predominantly peat moss with some Schreber's moss and/or slender hair-cap moss. Organic thickness is usually greater than 80 cm, but can be in the 60-70 cm range. The humus form is peatymor. Parent material is organic matter and some organic and glaciolacustrine deposits. Mean species richness is 17.3, Shannon diversity index is 1.8, and evenness 0.7. There is only one community type in this ecosite phase.

i2.1 black spruce-Labrador tea – cloudberry peat moss

j1 treed poor fen

Ecosite phase j1 occupies 158.3 ha (6.7%) of the LSA and is dominated by stunted black spruce and tamarack. Both are usually considered unmerchantable. The dominant understorey shrubs are Labrador tea, black spruce, bog cranberry, and willow. There are a few more forbs than in the i ecosite, including common horsetail, three-leaved Solomon's seal and cloudberry. The ground cover is mostly peat moss with some golden moss and other mosses. There are some grasses and lichens present. Mean species richness is 34.6, Shannon diversity index is 2.4, and evenness 0.7. There is only one community type in this ecosite phase.

j1.1 black spruce-tamarack – dwarf birch sedge peat moss

j2 shrubby poor fen

Ecosite phase j2 occupies 104.8 ha (4.4%) of the LSA, and is dominated by Labrador tea, black spruce and dwarf birch. There are some forbs, grasses, and lichens. Ground cover is mostly peat moss with some golden moss, tufted moss and slender hair-cap moss. Organic thickness is sometimes less than 80 cm and can range in the 26-39 cm or 60-79 cm range. Soil texture is fibric, mesic, loamy sand, clay, or humic. Occasionally mottles are present in the top 25 cm. Parent material is typically organic. Mean species richness is 19.8, Shannon diversity index is 2, and evenness is 0.7. There is only one community type in this ecosite phase.

j2.1 black spruce – tamarack dwarf birch sedge peat moss

k1 treed rich fen

Ecosite phase k1 occupies 21.9 ha (0.9 %) of the LSA. This phase is dominated by tamarack with some black spruce. The understorey shrub layer is dominated by dwarf birch, tamarack and willow. The understorey forb layer is dominated by three-leaved Solomon's seal, buckbean and marsh cinquefoil. There are some grasses and the ground cover is mossy with species like tufted moss, golden moss and peat moss. Organic thickness is greater than 80 cm, the humus form is peatymor, and the soil texture is fibric or mesic. Mean species richness is 24, Shannon diversity index is 2, and evenness 0.6. There is only one community type in this ecosite phase.

k1.1 tamarack – dwarf birch sedge golden moss

k2 shrubby rich fen

Ecosite phase k2 occupies 23.1 ha (1%) of the LSA, and is dominated by willow species, with some dwarf birch, river alder and tamarack. Typical dominant forbs and grasses are marsh marigold, sweet gale, buckbean, sedges and marsh reed grass. Some mosses are present, specifically brown moss, tufted moss and golden moss. Organic thickness can vary from greater than 80 cm to 0-25 cm. Humus form is peatymor, and soil texture ranges between fibric, mesic, clay, silty loam, humic, heavy clay, and silty clay. Where the organic matter does not exceed 25 cm, mottles may be visible. Parent material is organic, glaciolacustrine or lacustrine. Mean species richness 31, Shannon diversity index is 2.2, and evenness 0.6. Two plant community types were found in the LSA.

k2.2 willow sedge brown moss

k2.3 willow marsh reed grass

k3 graminoid rich fen

Ecosite phase k3 occupies 55.2 ha (2.3%) of the LSA and is dominated by sedges, marsh reed grass, and northern reed grass. Forbs and mosses present are marsh cinquefoil, buckbean, marsh skullcap, ragged moss and brown moss. Organic thickness can range between 6-59 cm or greater than 80 cm. The humus form is peatymor with a soil texture varying between fibric, heavy clay, mesic, and clay. Mottles can be seen in the top 0-25 cm of the soil profile when organic matter is not present. Parent material is organic, lacustrine, and organic/glaciolacustrine. Mean species richness is 10.8, Shannon diversity index 1, and evenness is 0.4. Both plant community types were found in the LSA.

k3.1 sedge fen

k3.2 marsh reed grass fen

l1 marsh

Ecosite phase l1 occupies 10.1 ha (0.4 %) of the LSA and is dominated by forbs and grasses such as: cattails, northern willow herb, wild mint, sedge, reed grass, marsh reed grass, creeping spike rush, bulrush and rush. There is some brown moss present. Mean species richness is 6.3, Shannon diversity index is 0.7, and evenness is 0.4. One community type was found in the LSA.

l1.1 cattail marsh

3.3.2.3 Ecosite Phases within the Access Road and Buffer

The proposed access road has been mapped to include a 500 m buffer (250 m on each side of the center line). The total area of this buffer is 947 ha (Table 3.5) of which 214 ha (22.6%) are upland areas and 705 ha (74.4%) are lowland areas. In addition, 28.4 ha (3%) is water (lakes and ponds). Treed bogs (i1) and shrubby bogs (i2) are the dominant lowland areas comprising 179 ha (18.9 %) and 330 ha (34.8%), respectively. Upland areas are dominated by the low-bush cranberry (d1 and d2) ecosite phases dominated by aspen and white spruce.

Fens comprised 102 ha (10.9%) of the access road and buffer. Of the fens, 44 ha (4.6%) are poor fens while 59 ha (6.2%) is made up of rich fens.

Table 3.5 Areas of ecosite phases within the access road and buffer.

Ecosite phase/ AVI code	Area of Buffer (ha)	Percent of Buffer (%)	Area of Access Road (ha)	Percent relative to Buffer (%)[1]
a1-lichen Pj	0[1]	-	-	-
b1-blueberry Pj-Aw	0.1	0.0	-	-
c1-Labrador tea-mesic Pj-Sb	43.7	4.6	3.4	0.4
d1-low-bush cranberry Aw	84.2	8.9	13.5	1.4
d2-low bush cranberry Aw-Sw	85.6	9.0	14.9	1.6
g1-Labrador tea –subhygric Sb-Pj	71.4	7.5	7.1	0.8
h1-Labrador tea/horsetail Sw-Sb	21.9	2.3	2.0	0.2
i1-treed bog	179.1	18.9	8.9	0.9
i2-shrubby bog	329.9	34.8	13.9	1.5
j1-treed poor fen	27.0	2.8	1.5	0.2
j2-shrubby poor fen	17.0	1.8	0.8	0.09
k1-treed rich fen	12.2	1.3	0.8	0.09
k2-shrubby rich fen	36.2	3.8	1.0	0.1
k3-graminoid rich fen	10.4	1.1	0.02	0.002
NWL - lake, pond	28.4	3.0	-	-
Total	947.2	100	67.8	7.16

[1] – Negligible.

3.4 Old growth forests

Old growth forests differ from younger stands in both structure and function. The canopy is composed primarily of old trees, although there is considerable heterogeneity within the stand. Other unique characteristics of old growth stands include an accumulation of snags and downed woody material, which provide habitat for a broad range of wildlife, and increased species and genetic diversity. Old growth forests also serve as important sources of propagules for forest regeneration and as refugia for plants and wildlife.

3.4.1 Study Objectives

The purpose of the old growth forest analysis is to determine what types of old growth forests are in the area and which ones will be affected by the proposed development. The specific objectives of this study are to:

- Identify the types of old growth forests in the LSA and along the access road; and
- Determine the amount of area within the LSA and along the access road that are occupied by the identified old growth forest types.

3.4.2 Methods

The definition of what constitutes an old growth forest varies depending on the reference used, and can be defined by criteria involving age and/or stand structural characteristics. The approach used here follows the age-based definition proposed by Schneider (2002), because age-based definitions can be easily applied using Alberta Vegetation Inventory (AVI) data. Old growth is defined according to tree species, using the following criteria:

- White spruce, black spruce, and tamarack forests: 140 years or older
- Pine forests and mixed pine-spruce/tamarack forests: 120 years or older
- Deciduous and mixed coniferous-deciduous forests: 100 years or older

Mixed stands are defined as those with less than 80% cover of the dominant tree species, or those with 20% or more of the tree type that would otherwise give a younger old growth criterion. For example, a stand with 60% black spruce, 20% tamarack, and 20% birch would be considered old growth at 140 years or older, but one with 50% black spruce, 20% tamarack, and 30% birch would be considered old growth at 100 years or older. Stand origin from the AVI data was used to determine ages, and was rounded to the nearest decade.

3.4.3 Results

The LSA contained scattered stands of old growth forests (Figure 6) that totalled 18.9 ha, comprising 0.8% of the LSA. Mixed aspen forests occupied the largest amount of area of old growth forest, while pure aspen forests occupied the least. Table 3.6 lists the types of old growth forests and their area and proportion within the LSA. There are no old growth stands within the Phase 1 footprint or along the access road.

Table 3.6 Areas and percent cover for old growth forests in the LSA.				
Forest Type	**Age (years)**	**Number of polygons**	**Total Area in the LSA(ha)**	**Percent of the LSA(%)**
Aspen pure	100-140	1	0.3	0.01
Aspen mixed	100	3	13.1	0.6
White spruce pure	140	6	3.4	0.1
White spruce/deciduous mixed	100-140	1	2.1	0.09
Total	-	11	**18.9**	**0.8**

3.5 Effects and Mitigation Efforts

3.5.1 Project

Clearing and construction within the Phase 1 footprint will impact 60.7 ha of area (2.6% of the LSA), of which 1.2% are upland and 1.4% are lowland ecosites. Of the ecosites of restricted distribution that occur in the LSA, 5.84 ha of treed rich fen (k1) will be removed from the Phase 1 footprint. However, given the small area to be disturbed, and because all ecosites that will be potentially affected are regionally common (including k1), no additional mitigation (beyond reclamation and revegetation at Project closure) is required for ecosites phases.

No old growth stands fall within the Phase 1 footprint or along the access road and therefore mitigation is not required for old growth.

3.5.2 Access Road

The clearing and construction of the access road will remove 67.8 ha of area, of which 32 ha are upland and 36 ha are lowland ecosites. Note that the access road and LSA overlap (Figure 1a). The road footprint is relatively small (50 m) and does not significantly impact any ecosite of restricted distribution. Therefore no additional mitigation (beyond reclamation and revegetation at Project closure) is required for ecosites phases along the access road.

4.0 WETLAND CLASSIFICATION AND MAPPING

4.1 Introduction

Wetlands are defined by the National Wetlands Working Group (NWWG) (1988) as “land that is saturated with water long enough to promote wetland or aquatic processes as indicated by poorly drained soils, hydrophytic vegetation and various kinds of biological activity which are adapted to a wet environment.” Wetlands are categorized into two groups: peatlands and non-peat forming wetlands (Halsey *et al*. 1996). Peatlands, usually having greater than 40 cm of accumulated organic matter, are subdivided into bogs, fens and some swamps. Non-peat forming wetlands, usually having less than 40 cm of accumulated organic matter, are sub-divided into three groups: shallow open water, marsh, and swamps. Each of these wetlands is formed by a combination of geomorphic, hydrologic, edaphic, climatic or biological factors.

Alberta has used these wetland subdivisions to build the Alberta Wetland Inventory Classification Standards. In Alberta, 21% of the land is covered by wetlands. Of that 21%, 93% are peatlands (Alberta Environment 2003). Nationally, 11% of Canada's wetlands are located in Alberta, making Alberta's wetlands an important resource both provincially and federally (Alberta Water Resources Commission 1993).

4.1.1 Study Objectives

The purpose of the wetland assessment was to acquire baseline data on all wetlands, peatlands, and riparian plant communities, as well as to map and describe wetlands following the Alberta Wetland Inventory Standards (Halsey and Vitt 1996). The specific objectives required to accomplish this were as follows:

- Describe wetland community distribution, structure, and diversity using ecosite phases (after Beckingham and Archibald 1996);
- Characterize all riparian/wetland communities according to the appropriate classification guides (Alberta Wetlands Inventory Standards); and
- Establish a detailed mitigation and reclamation strategy to minimize Project effects.

These objectives applied to both the LSA and access road.

4.2 Methods

4.2.1 Field Survey Methods

Wetland sampling was incorporated into the general vegetative resources survey and therefore done at the same time as upland sampling. Field survey methods followed the methods outlined in Section 3.2.2. All plots within wetlands were classified using the Beckingham ecosite system (Beckingham and Archibald 1996) and all wetland plots were classified using the Alberta Wetlands Inventory Standards classification system in the field. The Beckingham system recognizes four wetland ecosites – bog, poor fen, rich fen, and marsh (i, j, k and l ecosites, respectively). These are discussed in Section 3.3.

4.2.2 Post-Survey Methods

4.2.2.1 Alberta Wetland Inventory Standards

The *Alberta Wetland Inventory Standards* (Halsey *et al*. 1996, 2003) classifies wetlands by incorporating the NWWG standards (1988) into a slightly more simplified design

(Halsey *et al*. 1996, 2003). The *Alberta Wetland Inventory Standards* (AWIS) includes four levels:

- Wetland class (NWWG 1988);
- Vegetation modifier (*i.e.* forested, wooded, open);
- Wetland complex landform modifier (permafrost, patterning); and
- Local landform/vegetation modifier.

Classes and modifiers are denoted with a single letter, providing a four-letter code for each wetland type (Table 4.1). This system is designed for easy classification based on aerial photo interpretation and does not consider many edaphic or geomorphologic characteristics. A total of 15 types of wetlands are common to Alberta based on the above criteria (Halsey *et al*. 1996, 2003).

Table 4.1 Alberta Wetland Inventory Standards (AWIS) classification (*From Halsey et al. 1996, 2003*).

Level	Criteria	Code
Wetland Class	Bog	B
	Fen	F
	Swamp	S
	Marsh	M
	Shallow Open Water	W
	Non-wetland	MINL
Vegetation Modifier	Forested: closed canopy >70% tree coverage	F
	Wooded: open canopy >6-70% tree coverage	T
	Open: shrubs, sedges, graminoids, herbs, etc. <6% tree cover	O
Wetland Complex Landform Modifier	Permafrost is present	X
	Patterning is present	P
	Permafrost or patterning is not present	N
Local Landform Modifier	Collapse scar	C
	Internal lawn with islands of forested peat plateau	R
	Internal lawns	I
	No internal lawns are present	N
	Shrub cover >25% when tree cover ≤6%	S
	Graminoid dominated with shrub cover ≤25% and tree cover ≤6%	G

The ecosite map was used to produce the map of AWIS wetlands. Any polygon that had an i, j, k, or l ecosite phase as part of its classification, even if it was not the dominant phase, was classified using AWIS. In some cases, some polygons that have a g1 or h1 ecosite phase according to the Beckingham system can also be classified using the Alberta Wetland Inventory Standards. This is because some sites classified as g1 and h1 could be classified as wetlands based on their moisture regime (using the Beckingham system, a moisture regime of hygric-hydric, or 7-9), and/or hydrophytic vegetation. None of the g1 or h1 ecosite phases in the LSA or along the access road have been classified as wetlands.

The ecosite level in the hierarchical ecological classification system provided information to determine Wetland Class. Ecosite phases were used to determine the Vegetation Modifier, and aerial photos were used to determine Wetland Complex Landform Modifier and the Local Landform Modifier.

4.3 Results

4.3.1 Project

The Alberta Wetland Inventory Standards do not classify any non-wetland or anthropogenic features; these were classified on the ecosite phase map (Figures 5a and 5b). Figure 7a and 7b are maps of the dominant wetland type for each polygon. Within each polygon other wetland types are present but represented only small portions of the polygon or were dispersed and too small to map at the scale used.

Within the LSA, five different wetland types were identified (Table 4.3) covering a total of 1064 ha (45% of the LSA). The most common wetland types identified were bogs (691 ha). Other wetland classes identified were fens (363 ha), and marshes (10 ha). Several lakes and ponds were found within the LSA. These are not classified by either the Beckingham and Archibald (1996) classification system or the AWIS system (given AVI code NWL or NWR); however, wetland vegetation along shores and banks was classified. Detailed descriptions of the wetland classes found in the LSA are listed in Table 4.2. A map of the dominant wetlands (*i.e*. those that occupy the majority of their respective polygons) of the LSA is given in Figure 7a.

The marsh type of wetland (MONG) is the only wetland of restricted distribution within the LSA (<1%).

Table 4.2 Wetland types identified in the LSA.

Alberta Wetland Inventory Standards (Halsey *et al*. 1996, 2003)	
AWIS Classification	**Description**
BTNN	Bog, treed, no patterning or permafrost, no internal lawns present
FONG	Fen, open, no patterning or permafrost, graminoid dominated with shrub cover
FONS	Fen, open, no patterning or permafrost, shrub cover
FTNN	Fen, treed, no patterning or permafrost, no internal lawns present
MONG	Marsh, open, no patterning or permafrost, graminoid cover

Table 4.3 Wetlands within the LSA and Phase 1 footprint.					
AWIS Classification	**Area in LSA (ha)**	**Percent of LSA (%)**	**Area in Phase 1 footprint (ha)**	**Percent of Wetland Type (%)[1]**	**Percent relative to LSA (%)[2]**
BTNN	690.9	29.3	3.5	0.5	0.1
FONG	55.2	2.3	-	-	-
FONS	23.1	1.0	0.3	1.3	0.01
FTNN	284.9	12.1	25.2	8.8	1.1
MONG	10.1	0.4	-	-	-
Total	**1064.2**	**45.1**	**29**	**10.6**	**1.2**

[1] – % of wetland type calculated as: (Amount of wetland type in Phase 1 footprint/Amount same type in LSA) x 100%.
[2] – % area calculated as: (Area in Phase 1 footprint/Total Area in LSA) x 100%.

4.3.2 Access Road

Within the access road and buffer, 1208 ha of wetlands were found (Table 4.4). Treed bog (BTNN) was the most common followed by treed fen (FTNN). No shallow open water areas were found. A map of the dominant wetlands (*i.e.* those that occupy the majority of their respective polygons) along the access road is given in Figure 7b.

The buffer around the access road covers 502 ha of bog and 107 ha of fen. No marshes were found. There are no wetland types of restricted distribution found within the access road buffer. Additionally, there were 93 ha that according to the Beckingham system had the potential to be wetland (g1 and h1 ecosite phases).

Table 4.4 Wetlands within the access road and buffer.					
AWIS Classification	**Area in buffer (ha)**	**Percent of buffer (%)**	**Area in access road (ha)**	**Percent of Wetland Type (%)[1]**	**Percent relative to buffer (%)[2]**
BTNN	502.9	53.1	22.6	4.5	2.4
FONG	10.4	1.1	0.02	0.2	0.002
FONS	36.2	3.8	1.0	2.7	0.1
FTNN	60.8	6.4	3.1	5.1	0.3
MONG	-	-	-	-	-
Wetland	**610.4**	**64.4**	**26.7**	**12.5**	**2.8**

[1] – % of wetland type calculated as: (Amount of wetland type in footprint/Amount same type in LSA) x 100%.
[2] – % area calculated as: (Area in footprint/Total Area in LSA) x 100%.

4.4 Effects and Mitigation Efforts

4.4.1 Project

The Project will have an effect on wetlands in the Phase 1 footprint in that they will be cleared and/or filled during construction and operation. Phase 1 of the Project will remove 29 ha of wetlands (1.2% of the total area of LSA). However, this effect is expected to be minimal as the amount of wetland to be affected constitutes only 1.2% of the total wetland area in the LSA, and all are locally and regionally common. Marshes (MONG) had the only restricted distributions (< 1% of the LSA), but none occur in or near the Phase 1 footprint. Therefore, no additional mitigation (beyond reclamation at Project closure) is required for wetlands in the LSA.

4.4.2 Access Road

The Project will have an effect on wetlands along the access road in that they will be cleared and/or filled during construction and operation. The Project will remove 27 ha of wetlands (2.8 % of the access buffer) along the access road. However, this effect is expected to be minimal as the amount of wetland to be affected constitutes only 2.4% of the total wetland area in the access road buffer, and all are locally and regionally common. There are no wetlands of restricted distribution along the access road. Therefore, no additional mitigation (beyond reclamation at Project closure) is required for wetlands in the LSA.

5.0 MITIGATION AND MONITORING

Seven rare plant species, including two vascular plants, two bryophytes and three lichens have been confirmed in the LSA. *Cladina stygia* was found once at the north end of a borrow pit at E395489, N6340491 (Figure 2). The plot center is outside the Phase 1 footprint, but within 35 m of the gravel pit, and because of the wandering nature of rare plant surveys, it is possible that *C. stygia* may fall inside the Phase 1 footprint. It is ranked S1 (critically imperilled) in Alberta and G5 (secure) globally. However, *C. stygia* was found 16 other times, outside the Phase 1 footprint, in a variety of ecosite phases (Table 2.2).

An assessment of Project effects and any mitigation requirements for additional rare plants in the Project footprint will be completed once the 2010 survey has been concluded.

Clearing and construction within the LSA will impact 60.7 ha of area (2.6% of the LSA), of which 1.2% are upland and 1.4% are lowland ecosites. Of the ecosites of restricted distribution that occur in the LSA, 5.84 ha of treed rich fen (k1) will be removed from the Phase 1 footprint. However, given the small area to be disturbed, and because all ecosites that will be potentially affected are regionally common (including k1), no additional mitigation (beyond reclamation and revegetation at Project closure) is required for ecosites phases.

The clearing and construction of the access road will remove 67.8 ha of area, of which 32 ha are upland and 36 ha are lowland ecosites. The road footprint is relatively small (50 m) and does not significantly impact any ecosite of restricted distribution.

The Project will have an effect on wetlands in the Phase 1 footprint in that they will be cleared and/or filled during construction and operation. Phase 1 of the Project will remove 29 ha of wetlands (1.2% of the LSA). However, this effect is expected to be minimal as the amount of wetland to be affected constitutes only 2.7% of the total wetland area in the LSA, and all are locally and regionally common. Marshes (MONG) had the only restricted distributions (< 1% of the LSA), but none occurs in or near the Phase 1 footprint.

The Project will have an effect on wetlands along the access road in that they will be cleared and/or filled during construction and operation. The Project will remove 27 ha of wetlands along the access road. However, this effect is expected to be minimal as the amount of wetland to be affected constitutes only 2.8% of the total wetland area in the access road buffer, and all are locally and regionally common. There are no wetlands of restricted distribution along the access road.

Proper construction, reclamation and revegetation techniques will effectively mitigate anticipated Project effects. The impact of the Project on vegetation and wetland resources is insignificant with mitigation.

5.1 Mitigation

Mitigation measures that will be implemented include:

- marking of locations of rare plants near or inside the Project footprint to minimise accidental disturbance;
- preserving adjacent suitable habitat for rare species identified;
- minimizing overall disturbance footprint where possible;
- utilizing a non-invasive seed mix for reclamation; and
- developing a management plan to control non-native and invasive species.

5.2 Monitoring

Monitoring will include:

- conducting a rare plant survey on any new development areas;
- checking the success of revegetation activities; and
- checking the success of weed control activities.

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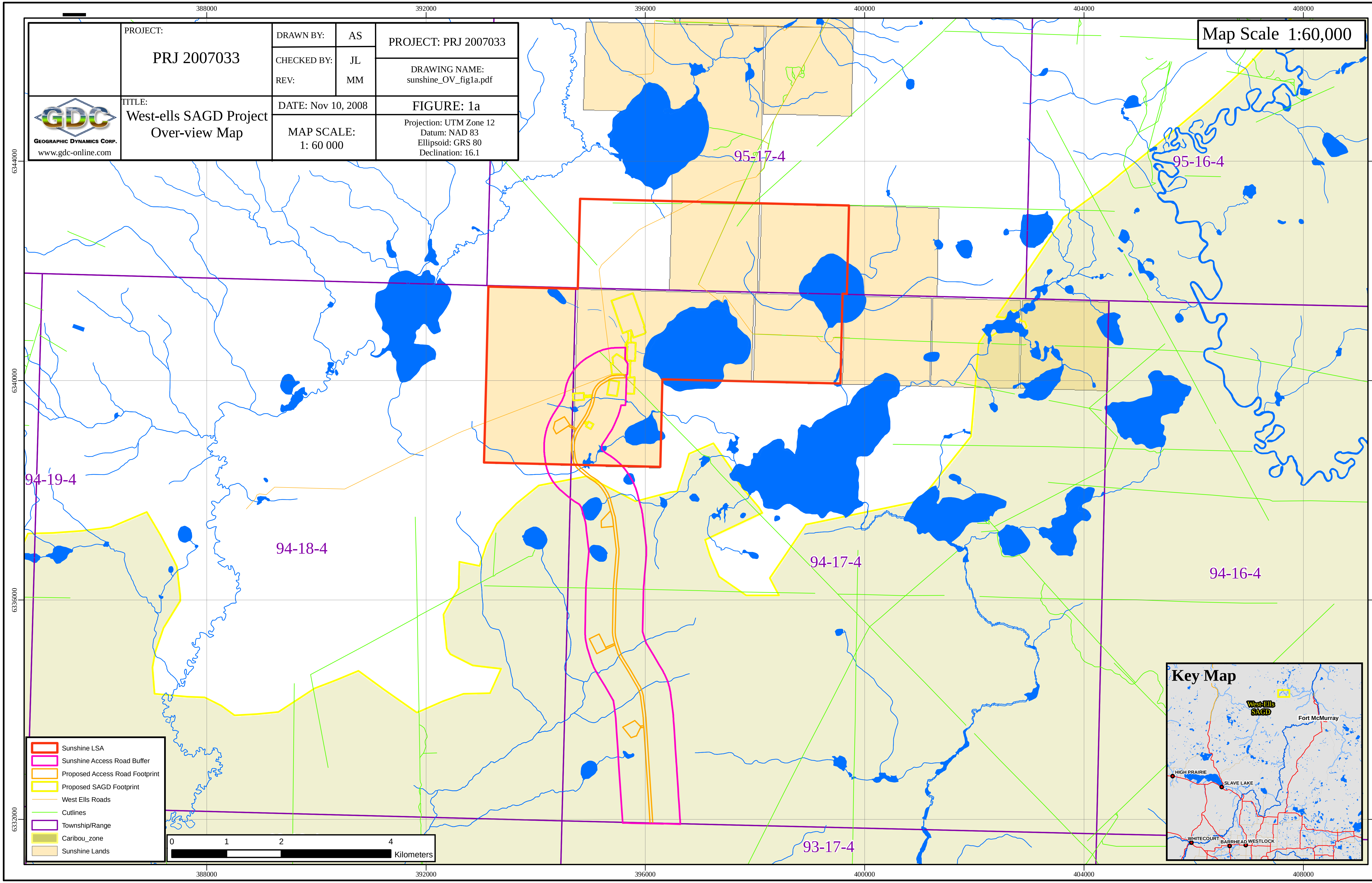

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94-16-4
93-17-4
Sunshine LSA
Sunshine Access Road Buffer
Proposed Access Road Footprint
Proposed SAGD Footprint
West Ells Roads
Cutlines
Township/Range
Caribou_zone
Sunshine Lands
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1
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Kilometers
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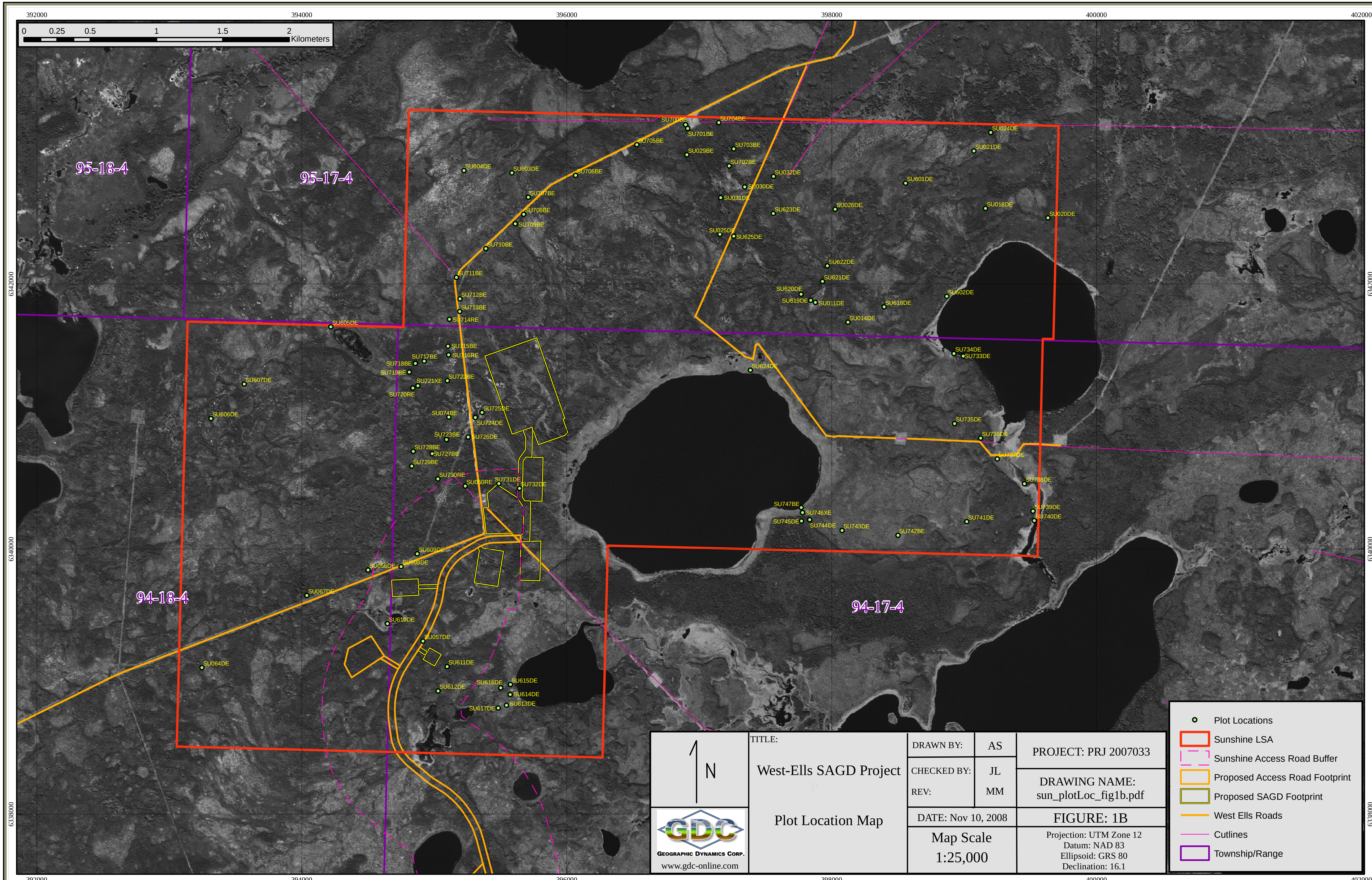
HIGH PRAIRIE
SLAVE LAKE
WHITECOURT
BARRHEAD
WESTLOCK



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94-17-4
Plot Locations
Sunshine LSA
Sunshine Access Road Buffer
Proposed Access Road Footprint
Proposed SAGD Footprint
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Cutlines
Township/Range
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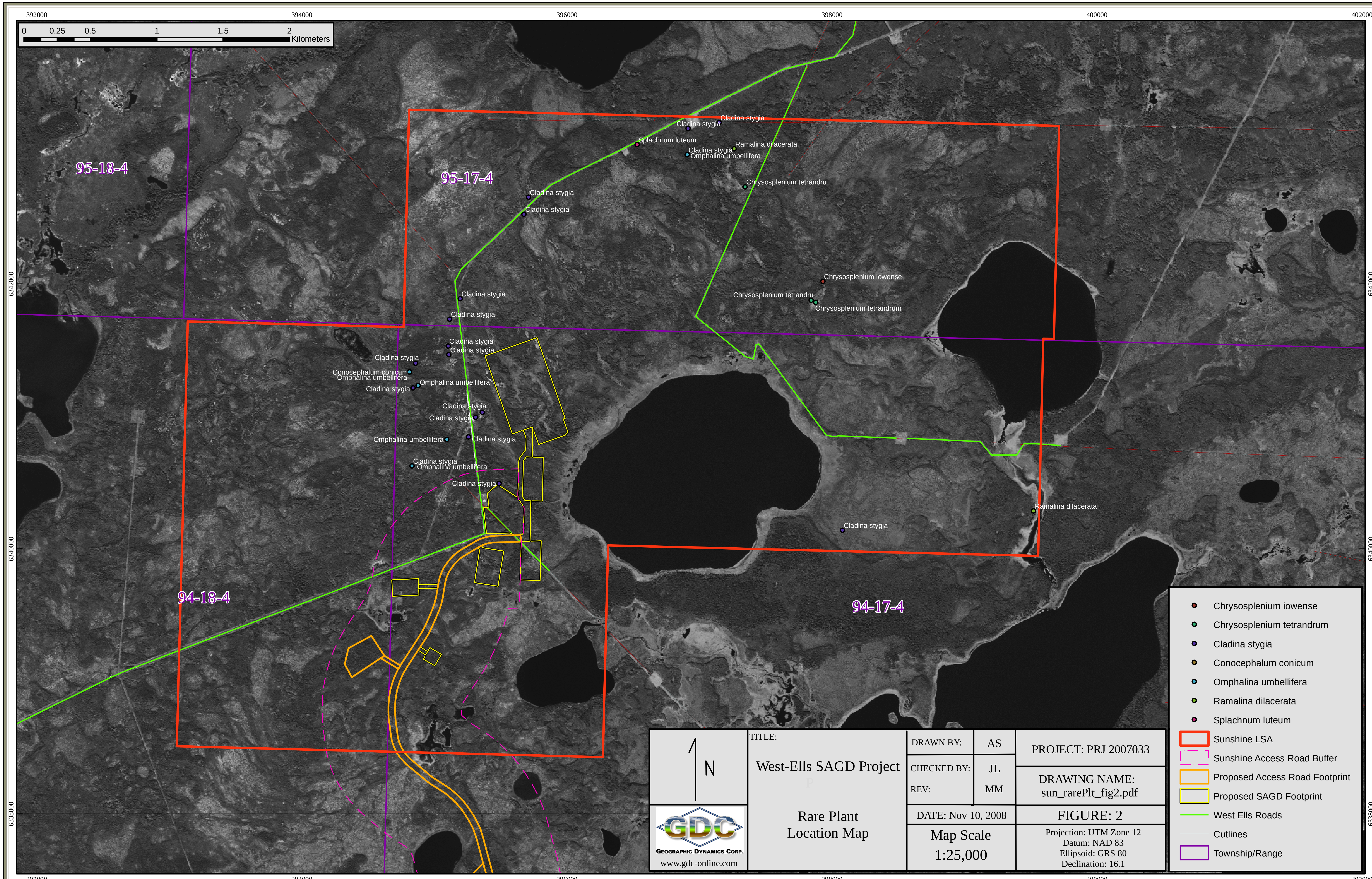

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94-18-4
94-17-4
Cladina stygia
Splachnum luteum
Ramalina dilacerata
Omphalina umbellifera
Chrysosplenium tetrandru
Chrysosplenium iowense
Chrysosplenium tetrandrum
Conocephalum conicum
N
Chrysosplenium iowense
Chrysosplenium tetrandrum
Cladina stygia
Conocephalum conicum
Omphalina umbellifera
Ramalina dilacerata
Splachnum luteum
Sunshine LSA
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Proposed Access Road Footprint
Proposed SAGD Footprint
West Ells Roads
Cutlines
Township/Range
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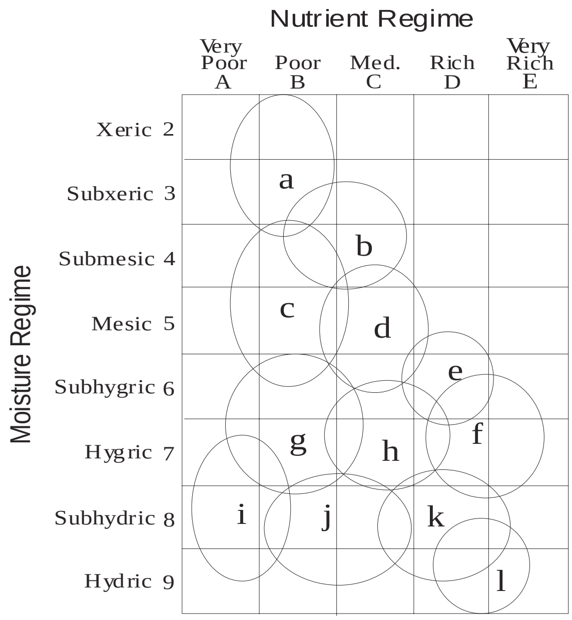


Ecosites:

a = lichen
subxeric/poor

b = blueberry
submesic/medium

c = Labrador tea–mesic
mesic/poor

d = low-bush cranberry
mesic/medium

e = dogwood
subhygric/rich

f = horsetail
hygric/rich

g = Labrador tea–subhygric
subhygric/poor

h = Labrador tea/horsetail
hygric/medium

i = bog
subhydric/very poor

j = poor fen
subhydric/medium

k = rich fen
subhydric/rich

l = marsh
hydric/rich

Figure 3 Edatope (moisture/nutrient grid) showing the location of ecosites for the Boreal Mixedwood ecological area (Beckingham and Archibald 1996).

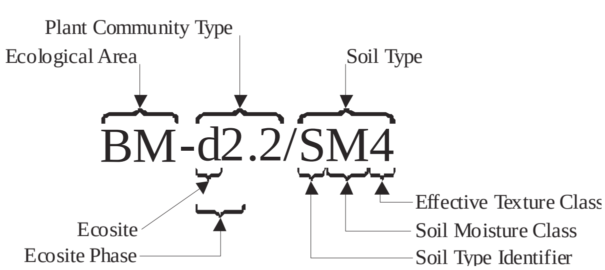
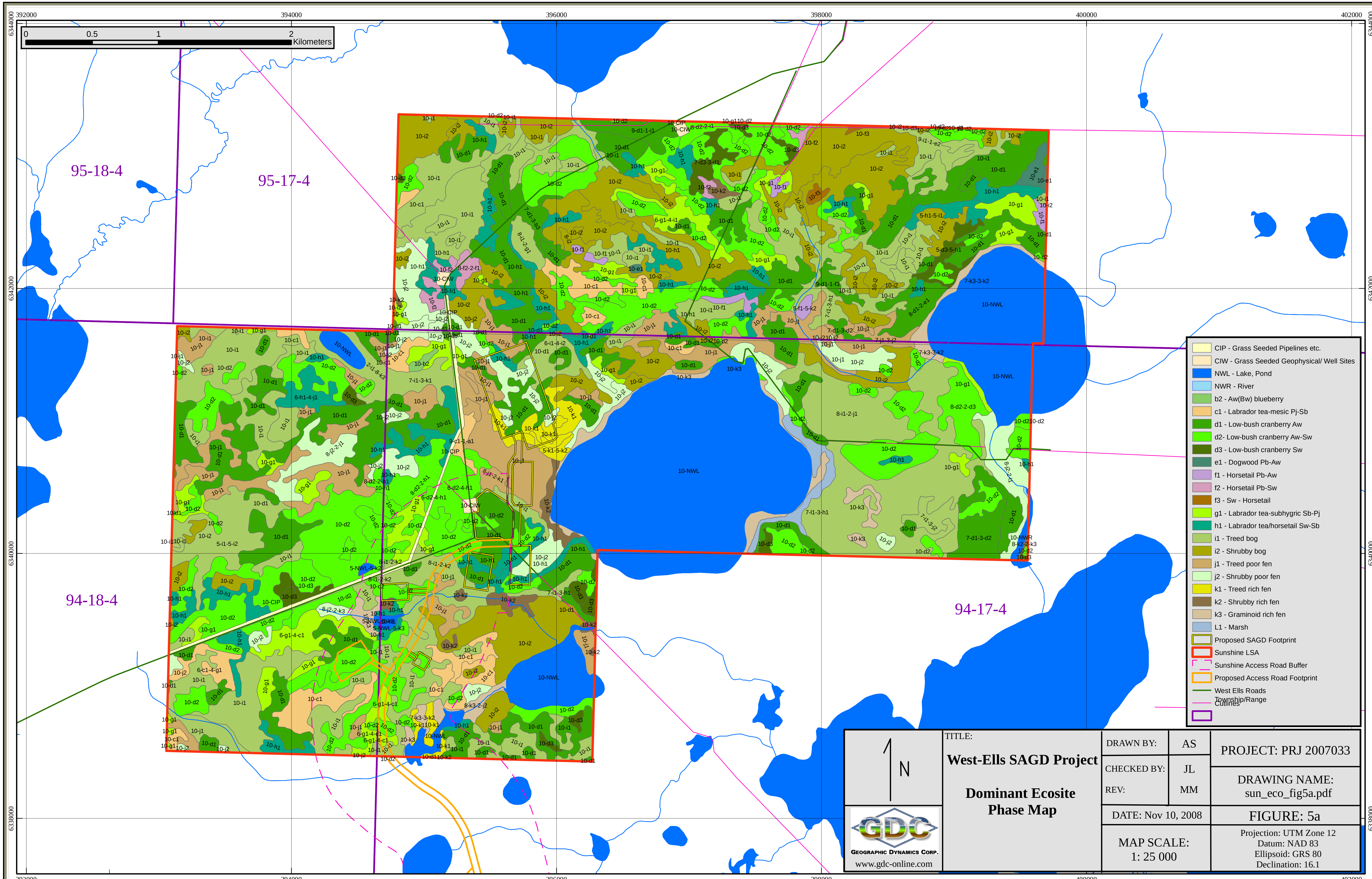


Figure 4 Example of an ecological unit identification code for the hierarchical ecological classification system (Beckingham and Archibald 1996).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95-17-4
94-18-4
94-17-4
CIP - Grass Seeded Pipelines etc.
CIW - Grass Seeded Geophysical/ Well Sites
NWL - Lake, Pond
NWR - River
b2 - Aw(Bw) blueberry
c1 - Labrador tea-mesic Pj-Sb
d1 - Low-bush cranberry Aw
d2- Low-bush cranberry Aw-Sw
d3 - Low-bush cranberry Sw
e1 - Dogwood Pb-Aw
f1 - Horsetail Pb-Aw
f2 - Horsetail Pb-Sw
f3 - Sw - Horsetail
g1 - Labrador tea-subhygric Sb-Pj
h1 - Labrador tea/horsetail Sw-Sb
i1 - Treed bog
i2 - Shrubby bog
j1 - Treed poor fen
j2 - Shrubby poor fen
k1 - Treed rich fen
k2 - Shrubby rich fen
k3 - Graminoid rich fen
L1 - Marsh
Proposed SAGD Footprint
Sunshine LSA
Sunshine Access Road Buffer
Proposed Access Road Footprint
West Ells Roads
Cutlines
Township/Range
N
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West-Ells SAGD Project
Dominant Ecosite Phase Map
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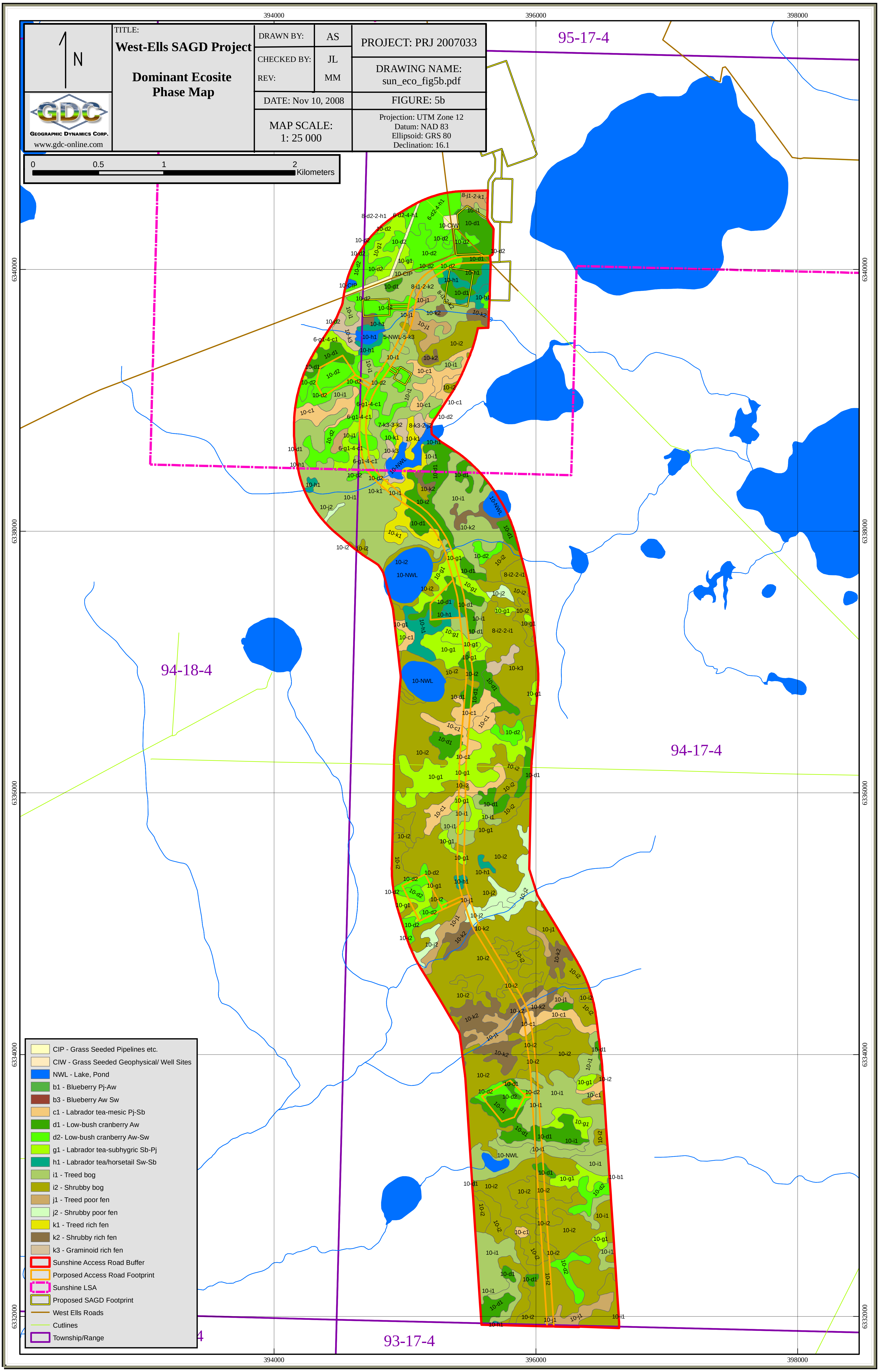
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6334000
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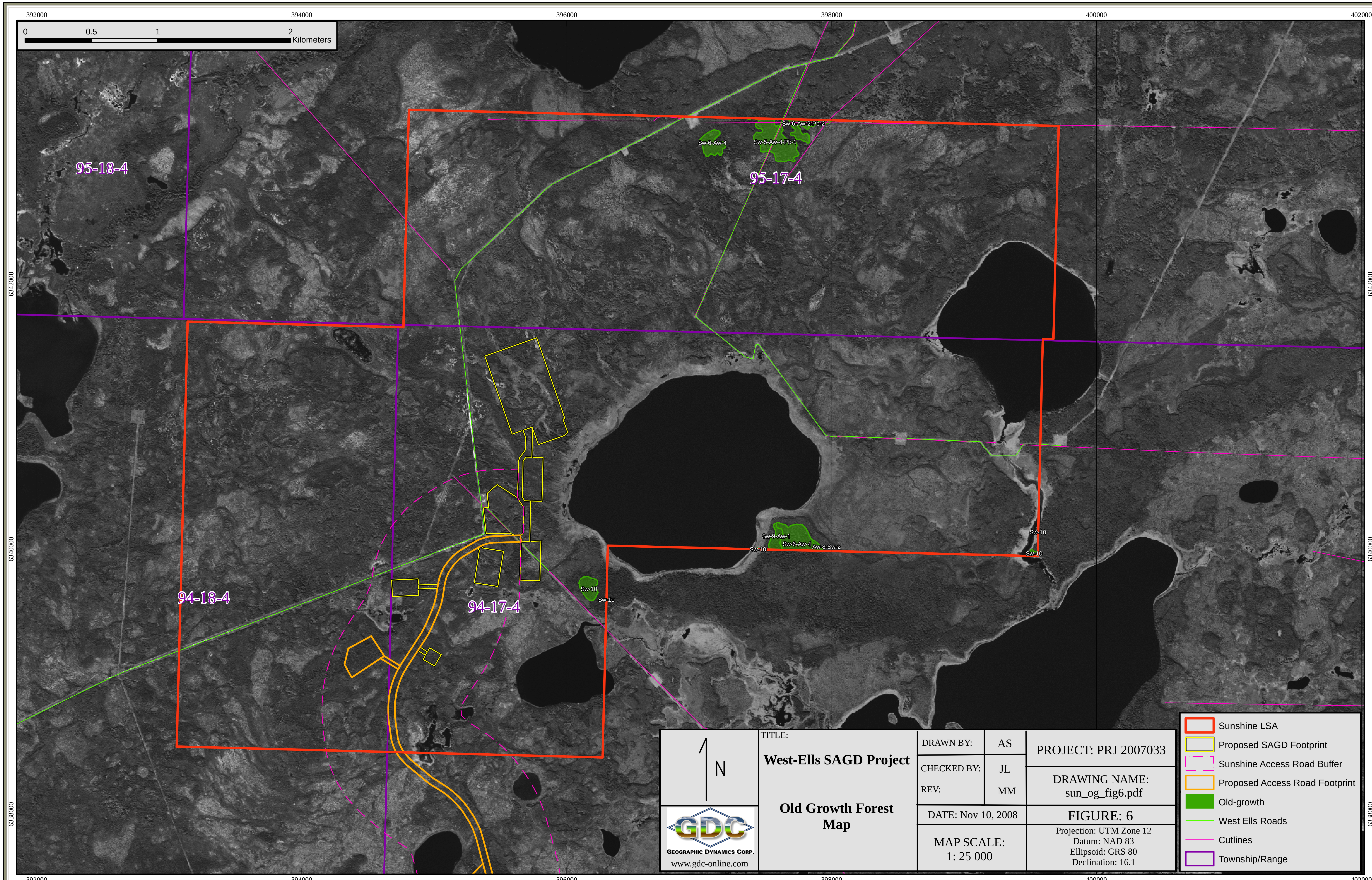
95-17-4
94-18-4
94-17-4
93-17-4
CIP - Grass Seeded Pipelines etc.
CIW - Grass Seeded Geophysical/ Well Sites
NWL - Lake, Pond
b1 - Blueberry Pj-Aw
b3 - Blueberry Aw Sw
c1 - Labrador tea-mesic Pj-Sb
d1 - Low-bush cranberry Aw
d2- Low-bush cranberry Aw-Sw
g1 - Labrador tea-subhygric Sb-Pj
h1 - Labrador tea/horsetail Sw-Sb
i1 - Treed bog
i2 - Shrubby bog
j1 - Treed poor fen
j2 - Shrubby poor fen
k1 - Treed rich fen
k2 - Shrubby rich fen
k3 - Graminoid rich fen
Sunshine Access Road Buffer
Porposed Access Road Footprint
Sunshine LSA
Proposed SAGD Footprint
West Ells Roads
Cutlines
Township/Range



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Sw-6-Aw-4
Sw-5-Aw-4-Pb-1
Sw-9-Aw-1
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West-Ells SAGD Project
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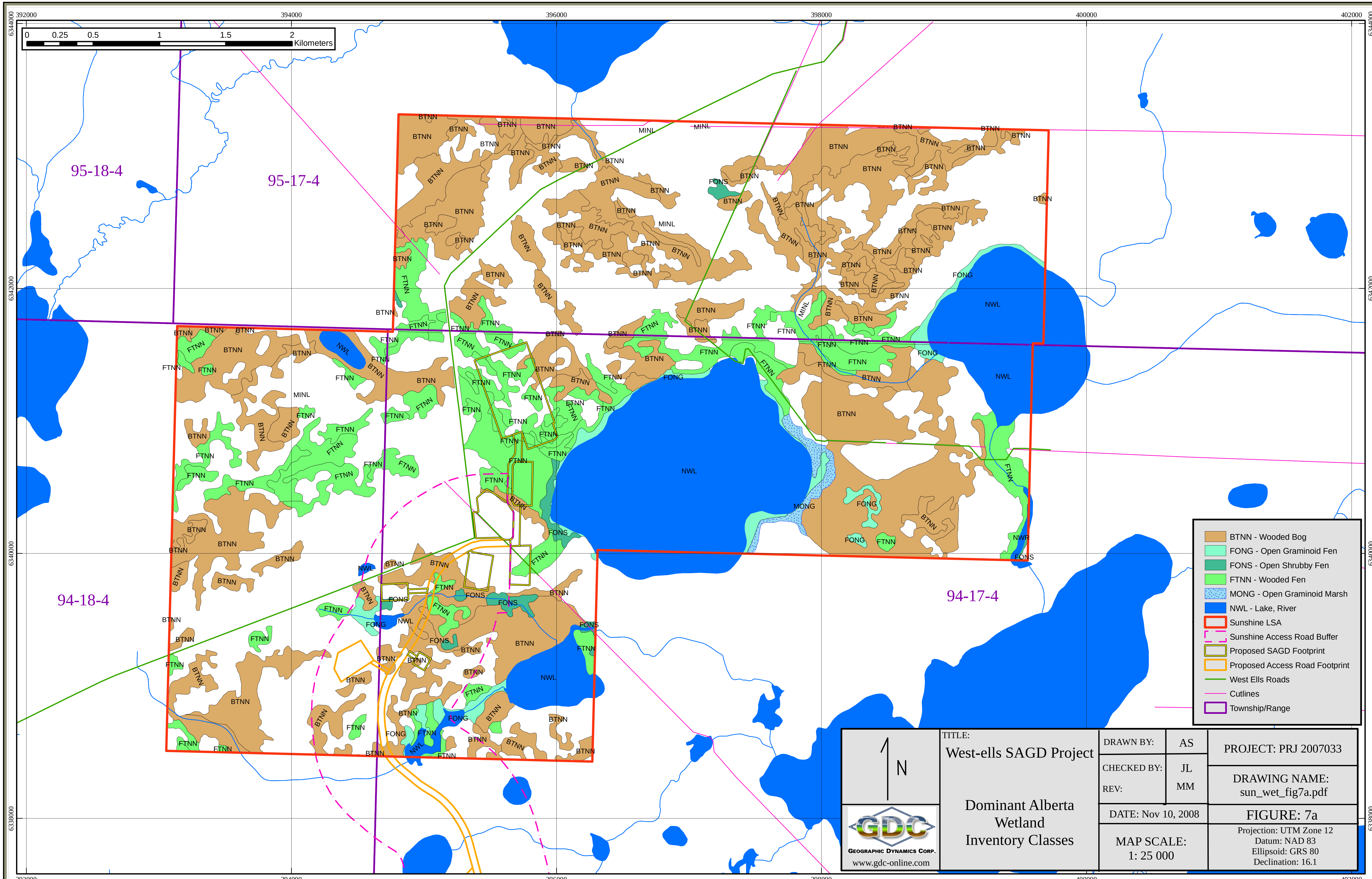
Proposed SAGD Footprint
Sunshine Access Road Buffer
Proposed Access Road Footprint
Old-growth
West Ells Roads
Cutlines
Township/Range



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95-17-4
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94-17-4
BTNN - Wooded Bog
FONG - Open Graminoid Fen
FONS - Open Shrubby Fen
FTNN - Wooded Fen
MONG - Open Graminoid Marsh
NWL - Lake, River
Sunshine LSA
Sunshine Access Road Buffer
Proposed SAGD Footprint
Proposed Access Road Footprint
West Ells Roads
Cutlines
Township/Range
N
GDC
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TITLE:
West-ells SAGD Project
Dominant Alberta Wetland Inventory Classes
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REV: MM
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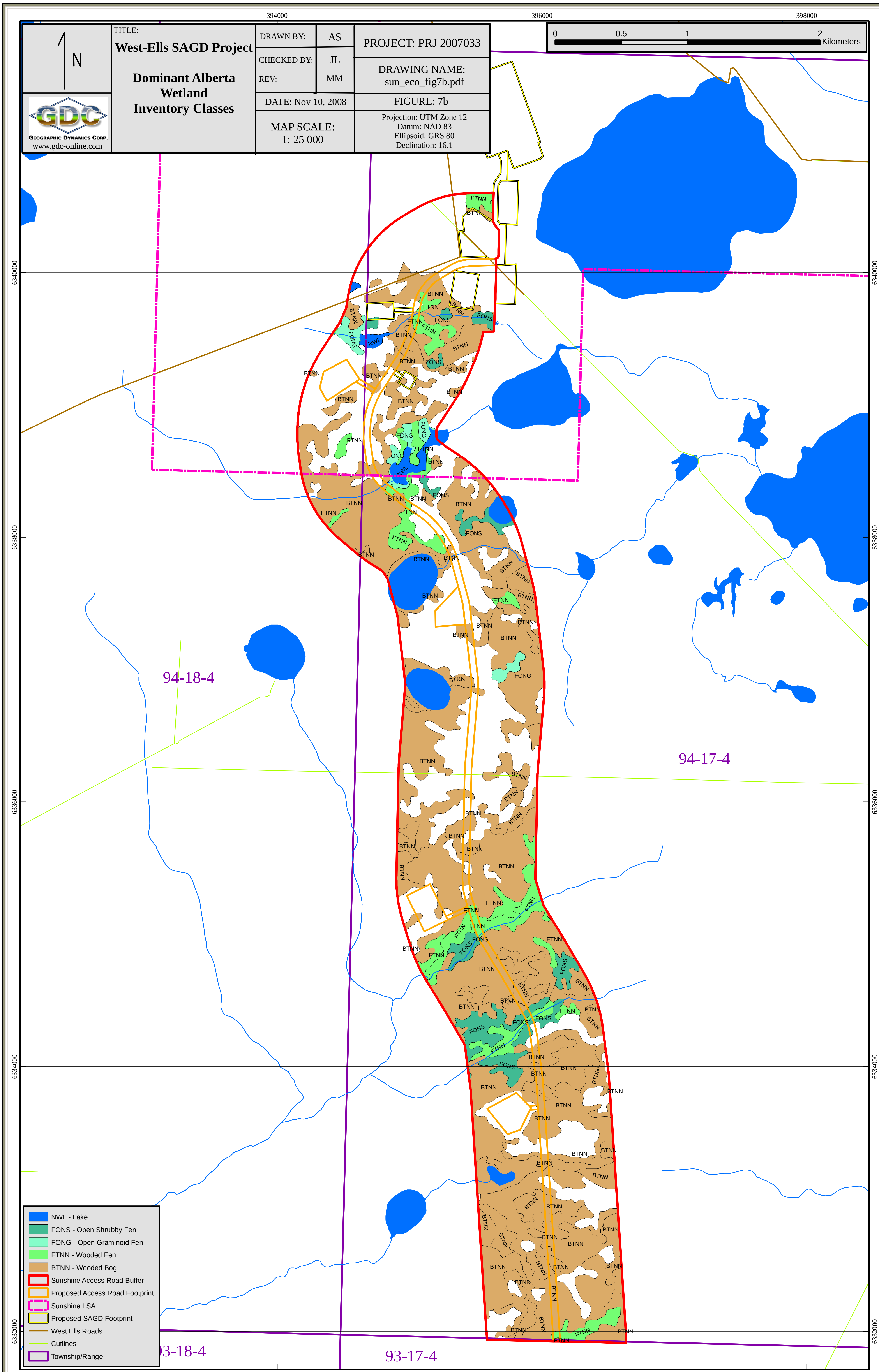

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Dominant Alberta Wetland Inventory Classes
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CHECKED BY: JL
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DATE: Nov 10, 2008
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94-17-4
93-18-4
93-17-4
NWL
FONS
FONG
FTNN
BTNN
NWL - Lake
FONS - Open Shrubby Fen
FONG - Open Graminoid Fen
FTNN - Wooded Fen
BTNN - Wooded Bog
Sunshine Access Road Buffer
Proposed Access Road Footprint
Sunshine LSA
Proposed SAGD Footprint
West Ells Roads
Cutlines
Township/Range

Appendix 1: Rare plant locations within the LSA

Plot	Easting	Northing	Species	Common Names	Provincial Rank	Global Rank	Ecosite	Phase	Community
SU621DE	397932	6342017	Chrysosplenium iowense	golden saxifrage	S3	G3	F	3	2
SU619DE	397843	6341874	Chrysosplenium tetrandrum	green saxifrage	S3	G5	F	1	1
SU030DE	397345	6342731	Chrysosplenium tetrandrum	green saxifrage	S3	G5	K	2	3
SU011DE	397878	6341858	Chrysosplenium tetrandrum	green saxifrage	S3	G5	K	2	3
SU719BE	394813	6341334	Conocephalum conicum	snake liverwort	S2	G5	K	1	1
SU705BE	396530	6343050	Splachnum luteum	yellow collar moss	S3	G3	H	1	2
SU720RE	394840	6341212	Cladina stygia	(black-based) reindeer lichen	S1	G5	D	1	6
SU743DE	398080	6340137	Cladina stygia	(black-based) reindeer lichen	S1	G5	I	1	1
SU724DE	395311	6340990	Cladina stygia	(black-based) reindeer lichen	S1	G5	A	1	1
SU725DE	395362	6341029	Cladina stygia	(black-based) reindeer lichen	S1	G5	C	1	1
SU726DE	395257	6340843	Cladina stygia	(black-based) reindeer lichen	S1	G5	C	1	3
SU704BE	397150	6343216	Cladina stygia	(black-based) reindeer lichen	S1	G5	I	1	1
SU707BE	395711	6342653	Cladina stygia	(black-based) reindeer lichen	S1	G5	B	3	3
SU708BE	395676	6342524	Cladina stygia	(black-based) reindeer lichen	S1	G5	G	1	1
SU701BE	396914	6343171	Cladina stygia	(black-based) reindeer lichen	S1	G5	I	1	1
SU712BE	395195	6341885	Cladina stygia	(black-based) reindeer lichen	S1	G5	J	1	1
SU714RE	395116	6341732	Cladina stygia	(black-based) reindeer lichen	S1	G5	I	1	1
SU715BE	395104	6341528	Cladina stygia	(black-based) reindeer lichen	S1	G5	B	2	3
SU716RE	395110	6341463	Cladina stygia	(black-based) reindeer lichen	S1	G5	G	1	1
SU718BE	394859	6341398	Cladina stygia	(black-based) reindeer lichen	S1	G5	C	1	3
SU729BE	394831	6340624	Cladina stygia	(black-based) reindeer lichen	S1	G5	J	1	1
SU029BE	396908	6342973	Cladina stygia	(black-based) reindeer lichen	S1	G5	H	1	1
SU731DE	395489	6340491	Cladina stygia	(black-based) reindeer lichen	S1	G5	J	1	1
SU719BE	394813	6341334	Omphalina umbellifera	green-pea mushroom lichen	S1	GNR	K	1	1
SU721XE	394877	6341230	Omphalina umbellifera	green-pea mushroom lichen	S1	GNR	I	1	1
SU723BE	395093	6340824	Omphalina umbellifera	green-pea mushroom lichen	S1	GNR	F	3	1
SU729BE	394831	6340624	Omphalina umbellifera	green-pea mushroom lichen	S1	GNR	J	1	1

Plot	Easting	Northing	Species	Common Names	Provincial Rank	Global Rank	Ecosite	Phase	Community
SU029BE	396908	6342973	Omphalina umbellifera	green-pea mushroom lichen	S1	GNR	H	1	1
SU739DE	399522	6340283	Ramalina dilacerata	punctured gristle	S2	G3G5	F	3	1
SU703BE	397262	6343018	Ramalina dilacerata	punctured gristle	S2	G3G5	D	2	4

Appendix 2: Ecosite descriptions

Ecosites are described below as defined in Beckingham and Archibald (1996). Only ecosites that were found in the study area are described here. Descriptions of the different moisture regimes are provided in Appendix 3.

Ecosite a (lichen) is the driest ecosite with rapidly drained acidic soils leading to a poor nutrient status. Parent materials are coarse textured and can be eolian, fluvial-eolian, or glaciofluvial in nature. The organic layer is very thin, usually less than 5 cm thick. Species indicative of nutrient poor conditions are found in this ecosite, such as bearberry, lichen, and bog cranberry. Jack pine is the dominant tree species, and often forms a fire edaphic climax community because the fire return interval is faster than the rate of succession towards a black spruce dominated canopy. There is only one ecosite phase within this ecosite.

Ecosite b (blueberry) is dry and has a poor to medium nutrient regime. Parent material tends to be coarse-textured glaciofluvial resulting in sand and loamy sand soil textures. This ecosite is intermediate in both moisture and nutrient regime between the lichen ecosite (a) and the low-bush cranberry ecosite (d). Thus, species typical of both of these ecosites occur within the b ecosite, such as jack pine, blueberry, bearberry, bog cranberry, and Labrador tea from the lichen ecosite, and aspen, white spruce, bunchberry, and hairy wild rye from the low-bush cranberry ecosite. Successionally, the pine, aspen, and birch dominated ecosite phases may succeed to white spruce, but the process is slow due to the dry nature of these sites. There are four ecosite phases within this ecosite.

Labrador tea-mesic ecosite (c)

Ecosite c has nutrient poor and relatively acidic surface soils. The moisture regime ranges from subxeric to subhygric. It is often dominated by Labrador tea or bog cranberry in the understorey. The parent material is dominantly morainal or glaciofluvial. The area is upland, located typically on mid to upper slopes. The canopy usually consists of two dominant species: jack pine and black spruce. Jack pine, the faster growing species, typically comprises the higher layer, while black spruce, the slower species, often forms a secondary canopy beneath the pine. This ecosite is considered mesic, with no mottles in the top 25 cm of the soil profile. The organic layer is usually between 6-15 cm deep, although there can be less than 6 cm of organic matter. There is only one phase associated with this ecosite.

Low-bush cranberry ecosite (d)

Ecosite d is considered the reference site of the Boreal Mixedwood because of its mesic moisture regime and medium nutrient regime. Parent material is usually moderately fine to fine-textured till or glaciolacustrine. Drainage is moderately well to imperfect. The ecosite starts as a deciduous stand of aspen, balsam poplar and/or paper birch. Over time these stands succeed to white spruce and balsam fir with reduced understorey structure and diversity. The organic layer is usually 6-15 cm thick, but can be less than 6 cm in thickness. There are three ecosite phases associated with this ecosite

Dogwood ecosite (e)

Ecosite e is subhygric and nutrient rich and is common on mid to lower slope positions, or adjacent to water courses where they will receive nutrient rich seepage water for part of the growing season. Parent material is usually fine glaciolacustrine or till deposits. Drainage is generally well to imperfect. This ecosite tends to be the most productive in the Boreal Mixedwood, and plant communities tend to be high in species richness, diversity and cover. Succession in the dogwood ecosite is slow initially, due to the high grass, forb and shrub cover, however once white spruce becomes established, growth rates are generally quite high. There are three phases in this ecosite.

Horsetail ecosite (f)

Ecosite f is nutrient rich and has a subhygric to hygric moisture regime. This ecosite is found on level sites or lower slopes in areas where water and nutrients are replenished by flooding or seepage. These sites usually have fluvial parent materials, gleysolic soils, and organic matter accumulation. Horsetails commonly form a blanket over the forest floor. Succession in f ecosites is controlled by high water content in soils, with white spruce forming the canopy in the last successional stage. Once trees are removed from this ecosite, rising water tables may make tree establishment difficult. There are three phases associated with this ecosite.

Labrador tea – subhygric ecosite (g)

Ecosite g is nutrient poor with poorly drained soils. The soils are quite acidic, which is indicated by bog cranberry and Labrador tea. This site occurs on a number of soil types such as fine-textured till or glaciolacustrine deposits, coarse-textured glaciofluvial material, or on organic matter where Gleysolic soils are present. This ecosite is similar to the c ecosite; however, g occurs on lower topographic sites and its soils have mottles within the top 25 cm. The site is often dominated by black spruce rather than pine. There is only one ecosite phase in this ecosite.

Labrador tea / horsetail ecosite (h)

Ecosite h is wet and has a medium to rich nutrient regime. It is often found on lower slopes or level areas. Parent material is commonly glaciolacustrine or till. Soils tend to be Gleysolic with an accumulation of organic matter ranging in thickness from 6-59 cm deep. This is an intermediate community between ecosites f and g. The forest floor is often covered by a blanket of horsetail and Labrador tea. When trees are removed, the water table rises and makes it difficult for trees to re-establish. After disturbance, areas are often colonized by hydrophytic species like willow, marsh reed grass and sedges. There is only one ecosite phase associated with this ecosite.

Bog ecosite (i)

Ecosite i has mostly organic soil with slowly decomposing peat moss. The sites are poorly drained and have a very poor to poor nutrient regime. Bogs occupy depressions or level ground where water is stagnant or where there is a high water table impeding drainage and allowing for organic matter accumulation. This ecosite is an “edaphic climax” that is maintained by the water tables. Soil texture is fibric, mesic or humic. The organic layer is usually greater than 80 cm thick with humus forms that are peatymor or, occasionally, mor. Parent material is organic matter, and the moisture regime is subhydric, hydric or hygric. There are two phases associated with this ecosite.

Poor fen ecosite (j)

Ecosite j is wet like a bog, but has more nutrients. The poor fen has an intermediate nutrient regime, between the bog and the rich fen. Drainage is poor, but there is some movement of water. Similar to the bog, this ecosite occupies depressions or level areas where organic matter accumulates. The organic matter accumulating in the poor fen consists of bog species and some rich fen species. Organic matter thickness is usually over 80 cm, but occasionally is between 26-59 cm. Soil texture is fibric or mesic, and succession is very slow. The system relies on water flow; impeding the flow could reduce or eliminate tree cover and change species composition of the different layers. There are two ecosite phases in this ecosite.

Rich fen ecosite (k)

Ecosite k is an alkaline nutrient rich fen with flowing water where nutrients can flow through the system. The topographic position is usually in depressions or level ground where the water table is near the surface for a large part of the growing season. Organic matter is composed of decomposing sedges as well as golden, tufted and brown mosses. Organic thickness is usually greater than 80 cm, but can range from 0-16 cm in a few locations. Humus form is peatymor. Soil texture is mesic, fibric, clay or heavy clay. Mottles can be found in the top 25 cm in areas without deep organic matter. Succession is slow resulting in slow recovery after disturbance. There are three ecosite phases in this ecosite.

Marsh ecosite (l)

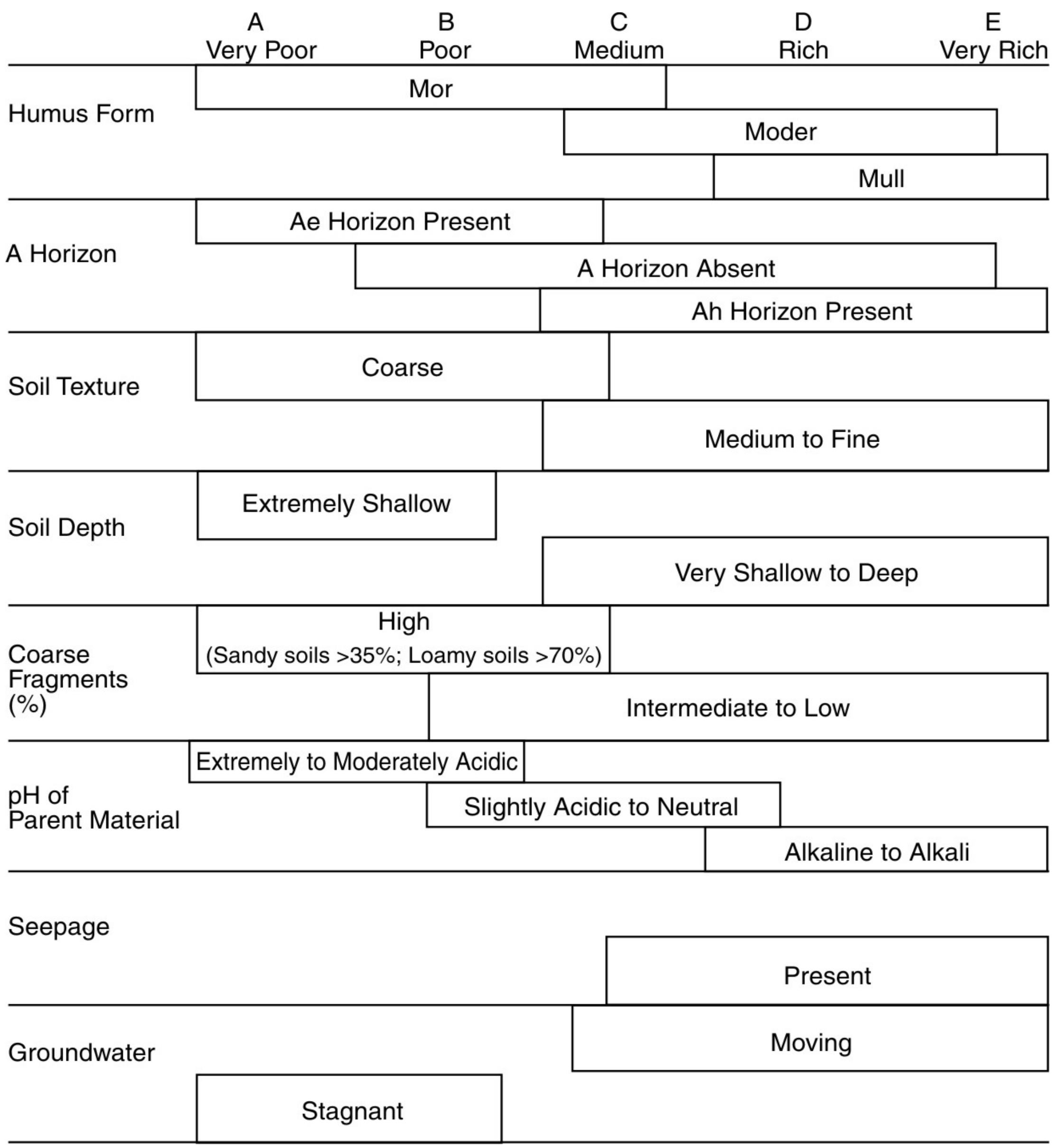
Ecosite l (marsh) is very wet (hydric) and rich to very rich in nutrients. Marshes are found in level or depressed areas and around the shorelines of water bodies and riparian zones. The water is above the rooting zone for part of the growing season. This ecosite is considered a stable community where any changes are determined by disturbance. Organic thickness varies with ranges between 0-5 cm, 6-15 cm or greater than 80 cm deep. Humus forms are non-existent, peatymor, or mor. Soil texture varies between sand, organic (fibric), and silty sand. Mottles can be seen at depths of 0-25 cm, or as deep as 100 cm. Parent material is lacustrine, fluvial, organic, or organic/lacustrine. There is only one ecosite phase associated with this ecosite.

Appendix 3: Moisture regime descriptions from Beckingham and Archibald (1996)

Moisture regime	Description
Very xeric (1)	Water removed extremely rapidly in relation to supply; soil is moist for a negligible time after precipitation
Xeric (2)	Water removed very rapidly in relation to supply; soil is moist for brief periods following precipitation
Subxeric (3)	Water removed rapidly in relation to supply; soil is moist for short periods following precipitation
Submesic (4)	Water removed readily in relation to supply; water available for moderately short periods following precipitation
Mesic (5)	Water removed somewhat slowly in relation to supply; soil may remain moist for significant but sometimes short periods of the year; available soil water reflects climatic input
Subhygric (6)	Water removed slowly enough to keep the soil wet for a significant part of the growing season; some temporary seepage and possible mottling below 20 cm
Hygric (7)	Water removed slowly enough to keep the soil wet for most of the growing season; permanent seepage and mottling present; possibly weak gleying
Subhydric (8)	Water removed slowly enough to keep the water table at or neat the surface for most of the year; organic and gleyed mineral soils; permanent seepage less than 30 cm below the surface.
Hydric (9)	Water removed so slowly that the water table is at or above the surface all year; organic and gleying mineral soils

Appendix 4: Nutrient regime descriptions from Beckingham and Archibald (1996)

Nutrient regime is an index of the relative amount of essential nutrients that are available for plant growth. The determination of nutrient regime requires the integration of many environmental and biotic parameters. Soil nutrient regime occurs on a relative scale ranging from very poor (A) to very rich (E). Nutrient regime can be determined in the field with assistance of an ecosite classification field guide (*e.g.* Beckingham and Archibald, 1996) or the *Ecological Land Survey Site Description Manual* (Alberta Environmental Protection, 1996).



Nutrient regime characteristics (From Beckingham *et al*. 1996).

Appendix 5: Flora of the Sunshine Oilsands Ltd. West-Ells SAGD Project 2008

VegCode	Species	Common name
ABIEABI	Abietinella abietina	wiry fern moss
ACHIMIL	Achillea millefolium	common yarrow
ACTARUB	Actaea rubra	red and white baneberry
ALNUINT	Alnus incana ssp tenuifolia	river alder
ALNUVIR	Alnus viridis	green alder
AMELALN	Amelanchier alnifolia	saskatoon
ANDRPOL	Andromeda polifolia	bog rosemary
ARALNUD	Aralia nudicaulis	wild sarsaparilla
ARCTRUB	Arctostaphylos rubra	alpine bearberry
ARCTUVA	Arctostaphylos uva-ursi	common bearberry
ARNICOR	Arnica cordifolia	heart-leaved arnica
ASTEBOR	Aster borealis	marsh aster
ASTECIL	Aster ciliolatus	Lindley's aster
ASTECON	Aster conspicuus	showy aster
ASTEPUN	Aster puniceus	purple-stemmed aster
ASTRAME	Astragalus americanus	American milkvetch
ASTRCAN	Astragalus canadensis	Canadian milkvetch
AULAPAL	Aulacomnium palustre	tufted moss/glow moss
BETUGLA	Betula glandulosa	bog birch
BETUOCC	Betula occidentalis	water birch
BETUPAP	Betula papyrifera	white birch
BETUPUM	Betula pumila	dwarf birch
BRACSAL	Brachythecium salebrosum	golden ragged moss
BROMPUM	Bromus inermis ssp pumpellianus	
BRYOLAN	Bryoria lanestris	brittle horsehair
BRYUPSE	Bryum pseudotriquetrum	tall clustered thread moss
CALACAN	Calamagrostis canadensis	bluejoint
CALLGIG	Calliergon giganteum	giant water moss
CALOCER	Caloplaca cerina	crusted orange lichen
CALOHOL	Caloplaca holocarpa	
CALTPAL	Caltha palustris	marsh-marigold
CANDVIT	Candelariella vitellina	
CARDPEN	Cardamine pensylvanica	bitter cress
CAREAQU	Carex aquatilis	water sedge
CAREATH	Carex atherodes	awned sedge
CARECAN	Carex canescens	short sedge
CARECON	Carex concinna	beautiful sedge
CAREDIS	Carex disperma	two-seeded sedge
CAREGYN	Carex gynocrates	northern bog sedge
CARELIM	Carex limosa	mud sedge
CARENOR	Carex norvegica	Norway sedge
CAREPAP	Carex paupercula	

VegCode	Species	Common name
CARESAR	Carex sartwellii	Sartwell's sedge
CARESIC	Carex siccata	hay sedge
CAREUTR	Carex utriculata	small bottle sedge
CAREVAG	Carex vaginata	sheathed sedge
CERAPUR	Ceratodon purpureus	purple horn-toothed moss/fire moss
CHAMCAL	Chamaedaphne calyculata	leatherleaf
CHRYIOW	Chrysosplenium iowense	golden saxifrage
CHRYTET	Chrysosplenium tetrandrum	green saxifrage
CICUBUL	Cicuta bulbifera	bulb-bearing water-hemlock
CICUMAC	Cicuta maculata	water-hemlock
CLADMIT	Cladina mitis	green/yellow reindeer lichen
CLADRAN	Cladina rangiferina	grey reindeer lichen
CLADSTE	Cladina stellaris	northern/star reindeer lichen
CLADSTY	Cladina stygia	(black-based) reindeer lichen
CLADAMA	Cladonia amaurocraea	(cup-forming prickle cladonia)
CLADBOR	Cladonia borealis	red/boreal pixie-cup
CLADBOT	Cladonia botrytes	stump cladonia
CLADCEN	Cladonia cenotea	powdered funnel cladonia
CLADCER	Cladonia cervicornis	whorled cup lichen
CLADCHL	Cladonia chlorophaea	false pixie-cup
CLADCON	Cladonia coniocraea	tiny toothpick cladonia
CLADCOR	Cladonia cornuta	horn cladonia
CLADCRI	Cladonia crispata	shrub funnel cladonia
CLADCRS	Cladonia cristatella	(skinny) British soldiers
CLADDEF	Cladonia deformis	deformed cup
CLADFIM	Cladonia fimbriata	(tall false pixie-cup)
CLADGRT	Cladonia gracilis ssp turbinata	brown-foot cladonia
CLADMAC	Cladonia macilenta	scarlet toothpick cladonia
CLADMUL	Cladonia multiformis	seive cladonia
CLADPHY	Cladonia phyllophora	black-foot cladonia
CLADSOB	Cladonia sobolescens	
CLADSUB	Cladonia subulata	tall toothpick cladonia
CLADSUL	Cladonia sulphurina	sulphur cup
CLADUNC	Cladonia uncialis	prickle cladonia
CLIMDEN	Climacium dendroides	common tree moss
CONOCON	Conocephalum conicum	snake liverwort
CORAMAC	Corallorhiza maculata	spotted coralroot
CORATRI	Corallorhiza trifida	pale coralroot
CORNCAN	Cornus canadensis	bunchberry
DELPGLA	Delphinium glaucum	tall larkspur
DICRSCH	Dicranella schreberiana	Schreberian fork moss
DICRFUS	Dicranum fuscescens	curly heron's bill moss
DICRPOL	Dicranum polysetum	electric eels
DICRSCO	Dicranum scoparium	broom moss
DICRUND	Dicranum undulatum	wavy dicranum

VegCode	Species	Common name
DIPHCOM	Diphasiastrum complanatum	ground-cedar
DROSROT	Drosera rotundifolia	round-leaved sundew
DRYOCAR	Dryopteris carthusiana	narrow spinulose shield fern
EMPENIG	Empetrum nigrum	crowberry
EPILANG	Epilobium angustifolium	common fireweed
EPILPAL	Epilobium palustre	marsh willowherb
EQUIARV	Equisetum arvense	common horsetail
EQUIFLU	Equisetum fluviatile	swamp horsetail
EQUIPRA	Equisetum pratense	meadow horsetail
EQUISCI	Equisetum scirpoides	dwarf scouring-rush
EQUISYL	Equisetum sylvaticum	woodland horsetail
ERIOVAG	Eriophorum vaginatum	sheathed cottongrass
EURHPUL	Eurhynchium pulchellum	common beaked moss
EVERMES	Evernia mesomorpha	spuce moss/northern perfume
FRAGVIR	Fragaria virginiana	wild strawberry
GALIBOR	Galium boreale	northern bedstraw
GALITRF	Galium trifidum	small bedstraw
GALITRI	Galium triflorum	sweet-scented bedstraw
GEOCLIV	Geocaulon lividum	northern bastard toadflax
GEUMTRI	Geum triflorum	three-flowered avens
GYMNDRY	Gymnocarpium dryopteris	oak fern
HELOBLA	Helodium blandowii	Blandow's feather moss
HYLOSPL	Hylocomium splendens	stair-step moss
HYPOPHY	Hypogymnia physodes	monk's hood lichen/hooded tube
ICMAERI	Icmadophila ericetorum	fairy puke/spraypaint
IMSHALE	Imshaugia aleurites	floury starburst
KALMPOL	Kalmia polifolia	northern laurel
LARILAR	Larix laricina	tamarack
LATHOCH	Lathyrus ochroleucus	cream-colored vetchling
LATHVEN	Lathyrus venosus	purple peavine
LEDUGRO	Ledum groenlandicum	common Labrador tea
LEDUPAL	Ledum palustre	northern Labrador tea
LEMNMIN	Lemna minor	common duckweed
LEYMINN	Leymus innovatus	hairy wildrye
LINNBOR	Linnaea borealis	twinflower
LONICAE	Lonicera caerulea	fly honeysuckle
LONIDIO	Lonicera dioica	twining honeysuckle
LYCOANN	Lycopodium annotinum	stiff club-moss
LYCOCLA	Lycopodium clavatum	running club-moss
LYSITHY	Lysimachia thyrsiflora	tufted loosestrife
MAIACAN	Maianthemum canadense	wild lily-of-the-valley
MARCPOL	Marchantia polymorpha	green-tongue liverwort
MELASEP	Melanelia septentrionalis	northern brown lichen
MERTPAN	Mertensia paniculata	tall lungwort
MITENUD	Mitella nuda	bishop's-cap

VegCode	Species	Common name
MNIUSPI	Mnium spinulosum	red-mouthed mnium
MOEHLAT	Moehringia lateriflora	blunt-leaved sandwort
MYLIANO	Mylia anomala	hard scale (common sphagnum) liverwort
MYRIGAL	Myrica gale	sweet gale
NUPHLUV	Nuphar lutea ssp variegata	yellow pond-lily
OMPHUMB	Omphalina umbellifera	green-pea mushroom lichen
ORTHSEC	Orthilia secunda	one-sided wintergreen
OXYCMIC	Oxycoccus microcarpus	small bog cranberry
PARMSUL	Parmelia sulcata	waxpaper lichen/powdered shield
PARMAMB	Parmeliopsis ambigua	green starburst
PARMHYP	Parmeliopsis hyperopta	grey starburst
PEDILAB	Pedicularis labradorica	Labrador lousewort
PEDIPAR	Pedicularis parviflora	swamp lousewort
PELTAPH	Peltigera aphthosa	freckle pelt/studded leather lichen
PELTCAN	Peltigera canina	dog pelt/dog lichen
PELTDID	Peltigera didactyla	temporary pelt/small felt lichen
PELTLEU	Peltigera leucophlebia	(veined freckle pelt)
PELTNEC	Peltigera neckeri	(shiny powdered pelt)
PELTNEO	Peltigera neopolydactyla	frog pelt/finger felt lichen
PELTRUF	Peltigera rufescens	felt pelt
PELTSCA	Peltigera scabrosa	rough pelt
PETAFRI	Petasites frigidus	arctic sweet coltsfoot
PETAFRF	Petasites frigidus var frigidus	sweet coltsfoot
PETAPAL	Petasites frigidus var palmatus	palmate-leaved coltsfoot
PETASAG	Petasites frigidus var sagittatus	arrow-leaved coltsfoot
PHYSADS	Physcia adscendens	hooded rosette
PHYSAIP	Physcia aipolia	grey-eyed rosette
PHYSSTE	Physcia stellaris	star rosette
PICEGLA	Picea glauca	white spruce
PICEMAR	Picea mariana	black spruce
PINUBAN	Pinus banksiana	jack pine
PLAGCUS	Plagiomnium cuspidatum	woodsy leafy moss
PLAGELL	Plagiomnium ellipticum	marsh magnificent moss
PLATHYP	Platanthera hyperborea	northern green bog orchid
PLATOBT	Platanthera obtusata	blunt-leaved bog orchid
PLATORB	Platanthera orbiculata	round-leaved bog orchid
PLATREP	Platygyrium repens	
PLEUSCH	Pleurozium schreberi	big red stem/Schreber's moss
POAPALU	Poa palustris	fowl bluegrass
POAPRAT	Poa pratensis	Kentucky bluegrass
POLEACU	Polemonium acutiflorum	tall Jacob's-ladder
POLYAMP	Polygonum amphibium	water smartweed
POLYCOC	Polygonum coccineum	water smartweed
POLYJUN	Polytrichum juniperinum	juniper hair-cap
POLYSTR	Polytrichum strictum	slender hair-cap

VegCode	Species	Common name
POPUBAL	Populus balsamifera	balsam poplar
POPUTRE	Populus tremuloides	aspen
POTEPAL	Potentilla palustris	marsh cinquefoil
POTETRI	Potentilla tridentata	three-toothed cinquefoil
PTILCIL	Ptilidium ciliare	northern (rock) naugehyde liverwort
PTILPUL	Ptilidium pulcherrimum	(small wood) naugehyde liverwort
PTILCRI	Ptilium crista-castrensis	knight's plume moss
PYLAPOL	Pylaisiella polyantha	stocking (aspen) moss
PYROASA	Pyrola asarifolia	common pink wintergreen
PYROCHL	Pyrola chlorantha	greenish-flowered wintergreen
RAMADIL	Ramalina dilacerata	punctured gristle
RANUACR	Ranunculus acris	tall buttercup
RANUAQU	Ranunculus aquatilis	large-leaved white water-crowfoot
RANUGME	Ranunculus gmelinii	yellow water-crowfoot
RANULAP	Ranunculus lapponicus	Lapland buttercup
RANUMAC	Ranunculus macounii	Macoun's buttercup
RIBEAME	Ribes americanum	wild black currant
RIBEGLA	Ribes glandulosum	skunk currant
RIBEHUD	Ribes hudsonianum	northern blackcurrant
RIBELAC	Ribes lacustre	bristly black currant
RIBEOXY	Ribes oxyacanthoides	northern gooseberry
RIBETRI	Ribes triste	wild redcurrant
ROSAACI	Rosa acicularis	prickly rose
RUBUARC	Rubus arcticus	dwarf raspberry
RUBUCHA	Rubus chamaemorus	cloudberry
RUBUIDA	Rubus idaeus	wild red raspberry
RUBUPED	Rubus pedatus	dwarf bramble
RUBUPUB	Rubus pubescens	dewberry
RUMEOCC	Rumex occidentalis	western dock
SALIATH	Salix athabascensis	Athabasca willow
SALIBEB	Salix bebbiana	beaked willow
SALIDIS	Salix discolor	pussy willow
SALIGLA	Salix glauca	smooth willow
SALIMAC	Salix maccalliana	velvet-fruited willow
SALIMYR	Salix myrtillifolia	myrtle-leaved willow
SALIPED	Salix pedicellaris	bog willow
SALIPLA	Salix planifolia	flat-leaved willow
SALIPSE	Salix pseudomonticola	FALSE mountain willow
SALIPYR	Salix pyrifolia	balsam willow
SALISCO	Salix scouleriana	Scouler's willow
SALISER	Salix serissima	autumn willow
SANIUNC	Sanionia uncinata	sickle moss/hook moss
SCHEPAL	Scheuchzeria palustris	scheuchzeria
SCUTGAL	Scutellaria galericulata	marsh skullcap
SENEPAU	Senecio pauciflorus	few-flowered ragwort

VegCode	Species	Common name
SHEPCAN	Shepherdia canadensis	Canada buffaloberry
SMILTRI	Smilacina trifolia	three-leaved Solomon's-seal
SOLIMUL	Solidago multiradiata	alpine goldenrod
SOLISIS	Solidago simplex ssp simplex	mountain goldenrod
SPHAANG	Sphagnum angustifolium	poor fen peat moss
SPHACAP	Sphagnum capillifolium	acute-leaved peat moss
SPHAFUS	Sphagnum fuscum	rusty peat moss
SPHAJEN	Sphagnum jensenii	pendant branch peat moss
SPHAMAG	Sphagnum magellanicum	midway peat moss
SPHARIP	Sphagnum riparium	shore-growing peat moss
SPHASQU	Sphagnum squarrosum	squarrose peat moss/shaggy sphagnum
SPHAWAR	Sphagnum warnstorfii	Warnstorf's peat moss
SPLALUT	Splachnum luteum	yellow collar moss
STELLON	Stellaria longifolia	long-leaved chickweed
STELLOG	Stellaria longipes	long-stalked chickweed
STERTOM	Stereocaulon tomentosum	woolly coral
SYMPOCC	Symphoricarpos occidentalis	buckbrush
TARAOFF	Taraxacum officinale	common dandelion
THALDAS	Thalictrum dasycarpum	tall meadowrue
THALSPA	Thalictrum sparsiflorum	flat-fruited meadowrue
THUIREC	Thuidium recognitum	hook-leaf fern moss
TOMENIT	Tomentypnum nitens	golden fuzzy fen moss
TRIEBOR	Trientalis borealis	northern starflower
TRIEEUR	Trientalis europaea	Arctic starflower
TUCKAME	Tuckermannopsis americana	fringed ruffle
TYPHLAT	Typha latifolia	common cattail
URTIDIO	Urtica dioica	common nettle
USNELAP	Usnea lapponica	powdery old man's beard
VACCCAE	Vaccinium caespitosum	dwarf bilberry
VACCMYR	Vaccinium myrtilloides	common blueberry
VACCSCO	Vaccinium scoparium	grouseberry
VACCVIT	Vaccinium vitis-idaea	bog cranberry
VIBUEDU	Viburnum edule	low-bush cranberry
VICIAME	Vicia americana	wild vetch
VIOLADU	Viola adunca	early blue violet
VIOLPAL	Viola palustris	marsh violet
VIOLREN	Viola renifolia	kidney-leaved violet

Appendix 6: Plot Information Sunshine Oilsands Ltd. West-Ells SAGD Project 2008

Plot	Date	PlotTiming	PltType	Zone	Easting	Northing	Ecosite	Phase	Com	AWIS Type
SU011DE	6/24/2008	EARLY	DIVERSITY	12	397878	6341858	K	2	3	FONS
SU014DE	6/24/2008	EARLY	DIVERSITY	12	398124	6341709	D	1	7	
SU018DE	6/20/2008	EARLY	DIVERSITY	12	399163	6342568	H	1	1	
SU020DE	6/20/2008	EARLY	DIVERSITY	12	399634	6342497	G	1	1	
SU021DE	6/20/2008	EARLY	DIVERSITY	12	399075	6343002	E	2	3	
SU056DE	6/22/2008	EARLY	DIVERSITY	12	394501	6339840	D	2	1	
SU057DE	6/23/2008	EARLY	DIVERSITY	12	394916	6339303	D	2	9	
SU064DE	6/22/2008	EARLY	DIVERSITY	12	393248	6339102	J	2	1	FTNN
SU067DE	6/22/2008	EARLY	DIVERSITY	12	394040	6339647	D	3	5	
SU074BE	6/22/2008	EARLY	BOTH	12	395111	6340994	D	1	6	
SU601DE	6/21/2008	EARLY	DIVERSITY	12	398559	6342759	D	1	6	
SU602DE	6/21/2008	EARLY	DIVERSITY	12	398870	6341905	E	2	1	
SU603DE	6/22/2008	EARLY	DIVERSITY	12	395588	6342836	D	1	5	
SU604DE	6/22/2008	EARLY	DIVERSITY	12	395225	6342855	I	1	1	BTNN
SU605DE	6/22/2008	EARLY	DIVERSITY	12	394220	6341675	K	3	1	FONG
SU606DE	6/22/2008	EARLY	DIVERSITY	12	393315	6340983	B	1	1	
SU607DE	6/22/2008	EARLY	DIVERSITY	12	393567	6341243	I	1	1	BTNN
SU740DE	6/24/2008	EARLY	DIVERSITY	12	399531	6340212	L	1	2	MONG
SU741DE	6/24/2008	EARLY	DIVERSITY	12	399021	6340204	J	2	1	
SU742BE	6/24/2008	EARLY	BOTH	12	398503	6340101	I	2	1	BTNN
SU743DE	6/24/2008	EARLY	DIVERSITY	12	398080	6340137	I	1	1	BTNN
SU744DE	6/24/2008	EARLY	DIVERSITY	12	397836	6340218	H	1	1	
SU745DE	6/24/2008	EARLY	DIVERSITY	12	397774	6340209	D	1	5	
SU720RE	6/22/2008	EARLY	RARE	12	394840	6341212	D	1	6	

Plot	Date	PlotTiming	PltType	Zone	Easting	Northing	Ecosite	Phase	Com	AWIS Type
SU721XE	6/22/2008	EARLY	X	12	394877	6341230	I	1	1	BTNN
SU722BE	6/22/2008	EARLY	BOTH	12	395100	6341268	K	2	2	FONS
SU723BE	6/22/2008	EARLY	BOTH	12	395093	6340824	F	3	1	
SU724DE	6/23/2008	EARLY	DIVERSITY	12	395311	6340990	A	1	1	
SU725DE	6/23/2008	EARLY	DIVERSITY	12	395362	6341029	C	1	1	
SU746XE	6/23/2008	EARLY	X	12	397781	6340273	J	1	1	FTNN
SU608DE	6/22/2008	EARLY	DIVERSITY	12	394751	6339865	K	3	2	FTNN
SU609DE	6/22/2008	EARLY	DIVERSITY	12	394873	6339962	G	1	2	
SU610DE	6/23/2008	EARLY	DIVERSITY	12	394648	6339434	K	3	2	FONS
SU611DE	6/23/2008	EARLY	DIVERSITY	12	395099	6339111	D	3	5	
SU612DE	6/23/2008	EARLY	DIVERSITY	12	395030	6338927	K	2	3	FONS
SU613DE	6/23/2008	EARLY	DIVERSITY	12	395546	6338818	I	2	1	BTNN
SU726DE	6/23/2008	EARLY	DIVERSITY	12	395257	6340843	C	1	3	
SU727BE	6/23/2008	EARLY	BOTH	12	394986	6340717	H	1	1	
SU728BE	6/23/2008	EARLY	BOTH	12	394843	6340735	J	1	1	FTNN
SU729BE	6/23/2008	EARLY	BOTH	12	394831	6340624	J	1	1	
SU730RE	6/23/2008	EARLY	RARE	12	395028	6340527	D	2	7	
SU731DE	6/23/2008	EARLY	DIVERSITY	12	395489	6340491	J	1	1	FTNN
SU618DE	6/24/2008	EARLY	DIVERSITY	12	398397	6341826	J	1	1	FTNN
SU619DE	6/24/2008	EARLY	DIVERSITY	12	397843	6341874	F	1	1	
SU620DE	6/24/2008	EARLY	DIVERSITY	12	397770	6341921	D	2	1	
SU621DE	6/24/2008	EARLY	DIVERSITY	12	397932	6342017	F	3	2	
SU622DE	6/24/2008	EARLY	DIVERSITY	12	397969	6342135	H	1	2	
SU623DE	6/24/2008	EARLY	DIVERSITY	12	397561	6342530	D	2	1	
SU024DE	6/20/2008	EARLY	DIVERSITY	12	399202	6343141	D	2	3	
SU025DE	6/21/2008	EARLY	DIVERSITY	12	397158	6342373	I	1	1	BTNN
SU026DE	6/21/2008	EARLY	DIVERSITY	12	398028	6342562	D	2	4	
SU029BE	6/20/2008	EARLY	BOTH	12	396908	6342973	H	1	1	

Plot	Date	PlotTiming	PltType	Zone	Easting	Northing	Ecosite	Phase	Com	AWIS Type
SU030DE	6/21/2008	EARLY	DIVERSITY	12	397345	6342731	K	2	3	FTNN
SU031DE	6/21/2008	EARLY	DIVERSITY	12	397164	6342650	H	1	1	
SU614DE	6/23/2008	EARLY	DIVERSITY	12	395574	6338899	I	2	1	BTNN
SU615DE	6/23/2008	EARLY	DIVERSITY	12	395577	6338975	J	2	1	FTNN
SU616DE	6/23/2008	EARLY	DIVERSITY	12	395504	6338950	K	3	1	FTNN
SU617DE	6/23/2008	EARLY	DIVERSITY	12	395484	6338797	I	2	1	BTNN
SU624DE	6/24/2008	EARLY	DIVERSITY	12	397388	6341347	D	3	5	
SU625DE	6/24/2008	EARLY	DIVERSITY	12	397262	6342359	H	1	2	
SU032DE	6/21/2008	EARLY	DIVERSITY	12	397562	6342809	G	1	1	
SU050RE	6/23/2008	EARLY	RARE	12	395235	6340473	D	2	9	
SU700BE	6/20/2008	EARLY	BOTH	12	396899	6343201	D	1	3	
SU701BE	6/20/2008	EARLY	BOTH	12	396914	6343171	I	1	1	BTNN
SU747BE	6/24/2008	EARLY	BOTH	12	397772	6340311	K	3	1	
SU702BE	6/20/2008	EARLY	BOTH	12	397228	6342889	F	2	1	
SU703BE	6/20/2008	EARLY	BOTH	12	397262	6343018	D	2	4	
SU704BE	6/20/2008	EARLY	BOTH	12	397150	6343216	I	1	1	BTNN
SU705BE	6/21/2008	EARLY	BOTH	12	396530	6343050	H	1	2	
SU706BE	6/21/2008	EARLY	BOTH	12	396068	6342817	D	2	1	
SU707BE	6/21/2008	EARLY	BOTH	12	395711	6342653	B	3	3	
SU708BE	6/21/2008	EARLY	BOTH	12	395676	6342524	G	1	1	
SU709BE	6/20/2008	EARLY	BOTH	12	395613	6342452	D	1	5	
SU710BE	6/21/2008	EARLY	BOTH	12	395390	6342265	F	1	1	
SU711BE	6/21/2008	EARLY	BOTH	12	395168	6342048	L	1	2	MONG
SU712BE	6/12/2008	EARLY	BOTH	12	395195	6341885	J	1	1	FTNN
SU713BE	6/21/2008	EARLY	BOTH	12	395193	6341791	K	2	2	FTNN
SU714RE	6/22/2008	EARLY	RARE	12	395116	6341732	I	1	1	BTNN
SU715BE	6/22/2008	EARLY	BOTH	12	395104	6341528	B	2	3	
SU716RE	6/22/2008	EARLY	RARE	12	395110	6341463	G	1	1	

Plot	Date	PlotTiming	PltType	Zone	Easting	Northing	Ecosite	Phase	Com	AWIS Type
SU717BE	6/22/2008	EARLY	BOTH	12	394925	6341415	B	2	1	
SU718BE	6/22/2008	EARLY	BOTH	12	394859	6341398	C	1	3	
SU719BE	6/22/2008	EARLY	BOTH	12	394813	6341334	K	1	1	FTNN
SU732DE	6/23/2008	EARLY	DIVERSITY	12	395644	6340455	K	1	1	
SU733DE	6/24/2008	EARLY	DIVERSITY	12	398994	6341454	G	1	2	
SU734DE	6/24/2008	EARLY	DIVERSITY	12	398925	6341473	L	1	2	
SU735DE	6/24/2008	EARLY	DIVERSITY	12	398929	6340945	D	1	5	
SU736DE	6/23/2008	EARLY	DIVERSITY	12	399126	6340834	D	3	3	
SU737DE	6/24/2008	EARLY	DIVERSITY	12	399251	6340678	J	2	1	
SU738DE	6/24/2008	EARLY	DIVERSITY	12	399456	6340490	L	1	2	MONG
SU739DE	6/24/2008	EARLY	DIVERSITY	12	399522	6340283	F	3	1	

WEST ELLS SAGD PROJECT WILDLIFE ASSESSMENT

Sunshine Oilsands Ltd.
Millennium EMS Solutions Ltd.

Westworth Associates Environmental Ltd.
Edmonton, Alberta

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EXECUTIVE SUMMARY

Sunshine Oilsands Ltd. is proposing to construct a 10,000 barrel /day steam-assisted gravity drainage project in the area west of the Ells River. To complete their application, Westworth Associates Environmental Ltd. conducted baseline wildlife surveys and an assessment of the effects of the West Ells SAGD Project – Phase 1 on wildlife. The Project Area provides habitat for a broad range of mammals, birds and amphibians, and is of particular importance because of its proximity to the Wabasca-Dunkirk Caribou Management Zone. The Lease Study Area had a number of relatively large waterbodies that provide key breeding and migratory habitats for numerous species of waterbirds. Five Valued Ecosystem Components were selected on which to assess potential impacts of the Project including Canadian toad, waterbirds, beaver, moose and woodland caribou. Project impacts on Canadian toad, waterbirds and beaver are expected to be minimal following mitigation. The Phase 1 of the Project is not expected to have a significant effect on regional populations of moose or caribou, although increasing regional activities may have some impact on caribou.

Table of Contents

ACKNOWLEDGEMENTS ..... **I**

EXECUTIVE SUMMARY ..... **III**

TABLE OF CONTENTS ..... **V**

LIST OF TABLES ..... **VII**

LIST OF FIGURES ..... **X**

1.0 INTRODUCTION **1**

2.0 STUDY AREA AND METHODS **3**

2.1 STUDY AREA 3
2.2 METHODS 3
2.2.1 Review of Existing Information *3*
2.2.2 Field Surveys *4*
2.2.3 Special Status Species *11*

3.0 WILDLIFE HABITAT **15**

3.1 OVERVIEW 15
3.1.1 SAGD Project Study Area *15*
3.1.2 Access Road Study Area *16*

4.0 WILDIFE USE **19**

4.1 EXISTING INFORMATION 19
4.2 FIELD SURVEYS 19
4.2.1 Winter Tracking Survey *19*
4.2.2 Aerial Ungulate Survey *23*
4.2.3 Aerial Access Road Survey *24*
4.2.4 Owl Survey *24*
4.2.5 Raptor Survey *26*
4.2.6 Amphibian and Yellow Rail Surveys *27*
4.2.7 Songbird Surveys *28*
4.2.8 Waterbird Surveys *31*
4.2.9 Beaver Surveys *32*
4.3 SPECIAL STATUS WILDLIFE SPECIES 33

5.0 WILDLIFE ASSESSMENT 35

5.1 POTENTIAL PROJECT EFFECTS ON VECS 35

5.1.1 Canadian Toad 35

5.1.2 Waterbirds 36

5.1.3 Beaver 37

5.1.4 Moose 38

5.1.5 Woodland Caribou 39

5.2 SAGD PROJECT STUDY AREA ASSESSMENT 40

5.2.1 Overview 40

5.2.2 Canadian Toad 41

5.2.3 Waterbirds 42

5.2.4 Beaver 43

5.2.5 Moose 44

5.2.6 Woodland Caribou 46

5.3 ACCESS ROAD STUDY AREA ASSESSMENT 48

5.3.1 Overview 48

5.3.2 Canadian Toad 49

5.3.3 Waterbirds 50

5.3.4 Beaver 52

5.3.5 Moose 53

5.3.6 Woodland Caribou 54

6.0 WILDLIFE PROTECTION MEASURES 57

6.1 HABITAT LOSS 57

6.2 MORTALITY 57

6.3 HABITAT FRAGMENTATION AND CONNECTIVITY 58

6.4 MONITORING 58

7.0 LITERATURE CITED 59

8.0 PERSONAL COMMUNICATIONS 67

9.0 CLOSURE 69

List of Tables

Table 1. Summary of major infrastructure features of the West Ells SAGD Project. 1

Table 2. Definitions of general status categories for wildlife in Alberta (Source: ASRD 2005). . 12

Table 3. Definitions of federal status rankings for wildlife in Canada (Source: COSEWIC 2008). 12

Table 4. The CEMA ranking of priority wildlife species and wildlife species groups in the Athabasca oil sands region (Source: CEMA 2001). 13

Table 5. Structural stage definitions used to describe stand age for habitats in the West Ells SAGD Study Area. 15

Table 6. Areal extent of habitat types in the West Ells SAGD Project Study Area. 16

Table 7. Areal extent of habitat types in the Access Road Study Area. 17

Table 8. Winter tracking survey effort and total wildlife track frequency by habitat type in the SAGD Project Study Area, March 2008. 20

Table 9. Track densities of carnivores recorded during winter track surveys in the SAGD Project Study Area, March 2008. 20

Table 10. Rodents and snowshoe hare track densities recorded during winter track surveys conducted in the SAGD Project Study Area, March 2008. 22

Table 11. Track densities of moose and grouse recorded during winter track surveys conducted in the SAGD Project Study Area, March 2008. 24

Table 12. Area assessed by habitat type relative to total available habitat during owl surveys conducted in the SAGD Project Study Area, April 2008. 25

Table 13. Owls observed during the nocturnal owl surveys in the SAGD Project Study Area, April 2008. 25

Table 14. Area assessed by habitat type relative to total available habitat during raptor surveys conducted in the SAGD Project Study Area, May 2008. 26

Table 15. Area assessed during amphibian and yellow rail surveys conducted in the SAGD Project Study Area, May 2008. 27

Table 16. List of bird species recorded during the songbird survey in the SAGD Project Study Area, June 2008. 29

Table 17. Songbird densities in the SAGD Project Study Area, June 2008. 30

Table 18. Density and species richness of songbirds by habitat type in the SAGD Project Study Area, June 2008. 30

Table 19. Waterbirds recorded during surveys conducted in the SAGD Project Study Area, October 2008. 32

Table 20. Density of waterfowl, waterbirds and shorebirds recorded during surveys conducted in the SAGD Project Study Area, June and October 2008. 32

Table 21. Results of aerial beaver surveys conducted in the SAGD Project Study Area, October 2008. 33

Table 22. Wildlife special status species that may occur in the West Ells SAGD Project Area. 34

Table 23. Extent of wildlife habitat in the SAGD Project Study Area that will be lost during construction of the West Ells SAGD Project footprint. 41

Table 24. Potential waterbird breeding habitat at baseline and with the project in the SAGD Project Study Area. 42

Table 25. Distance from each major waterbody in the SAGD Project Study Area to the closest Project infrastructure. 43

Table 26. Deciduous habitat within 200 m of waterbodies affected by Project development in the SAGD Project Study Area. 44

Table 27. Change in moose habitat availability associated with Project development, based on 100-300 m ZOIs around infrastructure locations in the SAGD Project Study Area. 45

Table 28. Change in woodland caribou habitat availability associated with Project development, based on 100-1,000 m ZOIs around infrastructure locations in the SAGD Project Study Area. 47

Table 29. Habitat losses associated with road construction in the Access Road Study Area. 49

Table 30. Potential waterbird breeding habitat at baseline and with Project development in the Access Road Study Area. 50

Table 31. Distance from major waterbodies in the Access Road Study Area to the closest Project infrastructure. 51

Table 32. Deciduous habitat within 200 m of waterbodies affected by the Project in the Access Road Study Area. 52

Table 33. Change in moose habitat availability associated with Project development, based on 100-300 m ZOIs around infrastructure locations in the Access Road Study Area. 53

Table 34. Guideline or threshold values for cumulative effects indicators for woodland caribou. 55

List of Figures

Figure 1. Location of the Project in northeastern Alberta. 71

Figure 2. Wildlife habitat types in the West Ells Study Areas.. 73

Figure 3. Observations from the Fish and Wildlife Information Management System (FWMIS). 75

Figure 4. Winter track transects in the West Ells SAGD Project Study Area, March 2008. 77

Figure 5. Aerial survey results in the West Ells Study Areas, March 2008. 79

Figure 6. Wildlife trails and lichen areas identified in the Access Road Study Area. 81

Figure 7. Owl survey stations and observations in West Ells SAGD Project Study Area, April 2008.. 83

Figure 8. Raptor survey stations in the West Ells SAGD Project Study Area, May 2008. 85

Figure 9. Amphibian survey stations in West Ells SAGD Project Study Area, May 2008. 87

Figure 10. Songbird survey stations in the West Ells SAGD Project Study Area, June 2008. .. 89

Figure 11. Waterbird survey lakes in the West Ells SAGD Project Study Area, June and October 2008. 91

Figure 12. Beaver observations in the West Ells SAGD Project Study Area, October 2008. ... 93

Figure 13. Potential moose movement pathways in the West Ells SAGD Project Study Area. 95

Figure 14. Potential moose movement pathways in the West Ells Access Road Study Area. . 97

1

1.0 INTRODUCTION

Sunshine Oilsands Ltd. is proposing to construct a 10,000 barrel / day steam-assisted gravity drainage (SAGD) project in the area west of the Ells River (hereinafter referred to as the West Ells SAGD Project Area). Phase 1 of the Project is composed of a plant, two well pads, five borrow pits, three camps, an access road and a utility corridor (Table 1). A 50 m wide, approximately 9 km long access road is proposed to extend into the southern portion of the Project Area. The total footprint of Phase 1 of the West Ells SAGD Project, including access road will be 128.5 ha in area.

Table 1. Summary of major infrastructure features of the West Ells SAGD Project.

Project Feature	No.	Total Area (ha)
SAGD Project – Phase 1:		
Plant site	1	29.3
Pads	2	9.3
Camps	3	9.0
Borrow pit	1	8.9
Utility corridor	1	4.2
Subtotal		*60.7*
Access Road:		
Borrow pits	4	22.6
Access road	1	45.3
Subtotal		*67.8*
Total		**128.5**

2

2.0 STUDY AREA AND METHODS

2.1 Study Area

The West Ells SAGD Project Area is located approximately 85 km north of Fort McMurray in northeastern Alberta (Figure 1) and is comprised of two study areas. The SAGD Project Study Area includes Sections 3 – 5 of Range 17, Township 95, Sections 25 and 36 of Range 18, Township 94, and Sections 30 – 33 of Range 17, Townships 94, west of the 4th meridian. The south access road, which passes through Sections 6, 7, 18, 19 and 30 of Range 17, Township 94, west of the 4th meridian, comprise the Access Road Study Area. The SAGD Project Study Area occupies 2,359 ha while the Access Road Study Area includes habitats within 500 m of either side of the road centerline.

The West Ells SAGD Project Area falls within the Central Mixedwood Subregion and the Boreal Highlands Subregion of the Boreal Forest Natural Region. However, most of the Project Area is located in the Central Mixedwood Subregion, which is characterized by a mix of black spruce bog, aspen and white spruce forest. The SAGD Project Study Area and the Access Road Study Area are dominated by black spruce lowland forest, which is important for several sensitive, rare and endangered wildlife species, including woodland caribou. The Boreal Highlands Subregion is higher in elevation and has more diverse forests than the Central Mixedwood Subregion. In addition to aspen and white spruce forests in the upland areas, balsam poplar and white birch forests frequently occur in wet areas.

2.2 Methods

2.2.1 Review of Existing Information

A thorough review of relevant wildlife information was conducted. Relevant wildlife survey data was reviewed from other recently completed oil sands applications in northeastern Alberta including the Fort Hills Oil Sands Project (True North Energy Inc.), the Jackpine Mine Expansion and Pierre River Mine Projects (Shell Canada), Jackpine Mine Phase 1 (Shell Canada), the Kearl Oil Sands Project (Imperial Oil Resources Ventures Ltd), and the Joslyn SAGD Project Phase IIIA (Deer Creek Energy Ltd.). In addition, the following agencies and databases were contacted or searched to obtain background information on the wildlife resources present in the West Ells SAGD Project Area including:

- Alberta Sustainable Resource Development (ASRD);
- Fish and Wildlife Management Information System (FWMIS)
- Alberta Natural Heritage Information System (ANHIC);
- Alberta Caribou Committee (ACC); and
- Cumulative Environmental Management Association (CEMA).

Several regional biologists and local residents were contacted and asked to provide background information on wildlife occurrence, abundance and management practices in the area. Todd Powell (ASRD) and Marge Meijer (ANHIC) provided information regarding the occurrence and management of woodland caribou in the region and on the possible occurrence of species of conservation concern and rare natural elements (wildlife habitats or species), respectively.

2.2.2 Field Surveys

Field surveys to determine wildlife use of the Study Areas were conducted between March and October 2008. Field work was not conducted in Section 5, Range 17, Township 95 because this section was added after most surveys had been completed. However, because of the proximity of the new land base to the existing SAGD Project Study Area, survey results were extrapolated to the new area. In addition, surveys in the Access Road Study Area were limited to a reconnaissance helicopter overflight to identify wildlife trails and important features for wildlife. Instead, information collected as part of the wildlife survey program in the SAGD Project Study Area was extrapolated to the Access Road Study Area.

In general, field surveys were designed to sample habitats proportionally to their availability in the SAGD Project Study Area, and to ensure that important habitats (e.g., waterbodies for amphibians, and mature forest for raptors) were adequately sampled. Nevertheless, there were some constraints that affected the field surveys including lack of access, remoteness of the Project, and safety concerns (bear encounters).

2.2.2.1 Winter Tracking Survey

Winter track surveys were conducted in March 2008 to obtain information on habitat use and winter distribution of furbearing mammals and ungulates in the SAGD Project Study Area. Transects were selected to ensure they were distributed throughout the study area and included all dominant habitat types. Each transect began at an access road, trail or seismic line and ranged from approximately 250 to 300 m in length. Wildlife tracks that were intersected along each transect were identified to species (where possible) and recorded at 25 m intervals. Attempts were made to estimate the number of animals travelling on a wildlife trail, but the exact number of tracks of snowshoe hare and red squirrel often could not be determined. In these cases, it was assumed that snowshoe hare runs contained five individual tracks and red squirrel runs contained three individual tracks.

Track frequencies (tracks/km/day) based on habitat types sampled were calculated based on the time between a fresh snowfall of more than 2 cm and the time of the track survey was conducted and track transect length. To account for track accumulation and variable transect length, the data were converted to a standardized measure as follows:

$$\text{Relative Track Density} = \frac{\text{Number of tracks recorded on a transect}}{\text{Transect length (m)} \times \text{Days since snowfall}}$$

Track frequencies by habitat type were calculated by summing the relative track densities in each 25 m segment and taking the average density across all segments in each habitat type. This method accounted for transects which bisected several different habitat types. A Kruskall-Wallis test was used to determine whether track density differed significantly among habitat types. For species for which significant differences were detected, a Mann-Whitney U test (corrected for ties) was used to determine which habitat types differed from one another. All statistical tests used an α value of 0.95 and were conducted using SPSS 16.0 for Windows (SPSS 2007).

2.2.2.2 Winter Aerial Ungulate Survey

Information on ungulate distribution, habitat use and population size and structure was collected during a winter aerial survey of the SAGD Project Study Area conducted in March 2008. A Bell 206B Jet Ranger helicopter was used for the aerial survey, flying approximately 100 m above ground at an air speed varying from 90 to 110 km/hr. Parallel transects were established at 800 m intervals in an east-west direction. Observers included a navigator-observer in the front left seat and two observers, seated on each side of the rear of the aircraft. Observers were able to detect ungulates within 200 m of either side of the helicopter, resulting in approximately 50% coverage of the SAGD Project Study Area.

When animals were located, the helicopter slowly circled the animal(s) and the species, number of individuals, age and sex of observed animals, habitat in which the animals were observed, GPS location and time of observation were recorded. The sex and age of moose can be determined using a combination of physical characteristics (Mitchell 1970) including relative body size, presence or absence of a vulva patch, nose colour and presence of antler scars. Sex and age classification of white-tailed deer were not attempted, as these characteristics are difficult to determine during mid-winter aerial surveys.

Winter aerial ungulate survey data is designed to estimate the abundance or density (no. of animals/km^2) of ungulate species in an area. Aerial surveys tend to underestimate ungulate populations because observers are unlikely to see all the animals present in a given area (Caughley and Goddard 1972). Under estimation of ungulate populations can result from a number of factors including dense forest cover, poor snow conditions, poor lighting and observer fatigue (Caughley 1974, LaResche and Rausch 1974). While survey and snow conditions were excellent during the aerial ungulate survey, some portions of the SAGD Project Study Area contained dense forest cover, resulting in potential underestimates of ungulate populations. To compensate for this, a sightability correction factor of 1.1 was applied to the moose and deer counts for surveys with low observability (Gasaway et al. 1986). This value is similar to other sightability correction factors previously adopted for moose surveys in northern Alberta (Horejsi and Hornbeck 1985, Brusnyk and Westworth 1986).

2.2.2.3 Aerial Access Road Survey

Wildlife movement throughout the region is a conservation concern, particularly since the proposed access road is located within the Wabasca-Dunkirk caribou management zone. Woodland caribou have been reported to avoid linear features including roads, seismic lines, and pipelines (Cameron et al. 1992, Dyer 1999, Oberg 2001). Caribou typically show reluctance to cross linear features (Dyer et al. 2002, Smith and Cameron 1983), especially when several features occur in parallel (e.g., road and pipeline; Curatolo and Murphy 1986). Moose are also expected to move throughout the region, likely following drainages and riparian areas (Penner 1976). Impediment of wildlife movement could result in reduced access to high quality forage, increased stress levels, and increased levels of predation.

Effects of linear disturbances on wildlife can be mitigated in several ways, including wildlife crossings, road signage and engineering considerations. However, these mitigations are most effective when wildlife trails and movement corridors have been identified prior to disturbance. Therefore, an aerial survey along the proposed access road was used to identify wildlife trails and other important habitat features. A Bell 206B Jet Ranger helicopter was used for the aerial survey, flying approximately 100 m above ground at an air speed varying from 90 to 110 km/hr. An observer-navigator sat in the front of the helicopter, while a second observer was seated in the rear on the opposite side. Observers used a GPS unit to mark the location of wildlife trails and other important habitat features such as mature coniferous forests and riparian corridors.

2.2.2.4 Owl Survey

Owls are primarily nocturnal (i.e., active at night) and most species respond to playbacks of recorded owl calls (Mosher et al. 1990, Resource Inventory Committee 2001). Call playback broadcasts were used to detect breeding nocturnal owls within the SAGD Project Study Area in April 2008. Broadcast surveys were considered to be an appropriate survey method for most species likely to inhabit the area (Takats and Holroyd 1997). The surveys were focused on detecting the boreal owl, northern saw-whet owl, great gray owl, long-eared owl, barred owl, and the great horned owl which were expected to occur in the study area and are known to respond to broadcast calls. Other species that may inhabit the study area but are not likely to respond to broadcast surveys include the short-eared owl and the northern hawk owl. These species may be observed incidentally during other surveys conducted in the area.

Predetermined broadcast stations were established along accessible portions of the SAGD Project Study Area approximately 1,600 m apart, resulting in an 800 m listening radius for each station. This spacing allows for maximum coverage and distribution of points while minimizing the possibility of eliciting responses from the same individual at more than one broadcast station (Takats and Holroyd 1997). Broadcast stations were selected to maximize coverage of mature forest, where many owl species of interest (e.g., great-gray owl and barred owl; Johnsgard 1988) are expected to nest. Surveys began one half-hour after sunset and concluded by approximately 0100 hr each morning. Each broadcast station began with a two min period of silence to allow for disturbance effects from travel to subside. Twenty sec owl calls were then played followed by another period of silence after each call. Pre-recorded owl calls were broadcast on a Sony PSYC or similar compact disc (CD) player. Smaller owl species were broadcast first to avoid creating an aversion of small species towards the calls of larger owl species and to avoid potential predation of smaller owls by larger species. The order of the broadcast was 1) northern saw-whet owl, 2) boreal owl, 3) long-eared owl, 4) barred owl, 5) great gray owl, and 6) great horned owl.

The approximate locations of the owls were calculated from the UTM coordinates of the survey station, the compass bearing and estimated distance of the owl from the station. This yielded an approximate location only, and did not allow for determination of a potential habitat association. Owls generally respond to the broadcast calls by calling and moving towards the survey station, and therefore the location at which the owl was heard calling is not necessarily the habitat in which it was prior to the broadcast call. Therefore, it was not considered necessary to precisely locate each responding owl. Densities of raptors were not estimated due to low sample size and the potential for bias when inciting responses of raptors through call broadcasting.

2.2.2.5 Amphibian and Yellow Rail Surveys

Amphibian and yellow rail surveys were conducted in the SAGD Project Study Area in late May 2008. Amphibians breed during spring in suitable wetlands adjacent to preferred terrestrial habitat. Male frogs and toads call loudly from these wetlands during the breeding season. Their calls are unique to each species and can be heard from a considerable distance. Canadian toad breeding calls can be heard by observers up to 1,000 m away (AXYS 1999, 2001a, 2001b).

The timing of the survey was designed to coincide with peak calling periods for Canadian toads and yellow rails. Details of yellow rail breeding habits are poorly understood and surveys for this species in the Northwest Territories have been conducted in mid- to late June; however, yellow rails may start calling as early as mid- to late May (R. Bazin, Canadian Wildlife Service, personal communication).

Amphibian surveys were conducted at a series of predetermined listening points approximately 1,000 m apart. Surveys began 30 min after sunset and typically ended at 0100 hrs the following morning. At each listening point, an observer listened for five min and recorded all calling amphibians. The relative abundance of amphibians was coded by species using the following call categories:

0 = no amphibians heard;
1 = individuals can be counted (no overlapping calls);
2 = calls of individuals are distinguishable, but some calls overlap; and
3 = full chorus, or continuous calls, where individuals cannot be distinguished.

Following the five min listening period for amphibians, observers used a call-playback method to elicit responses from yellow rails. At each pre-determined nocturnal listening station, vocalizations of yellow rails were played for approximately 30 sec, followed by 30 sec of listening, and repeated five times (Bazin and Baldwin 2007). Results of the amphibian and yellow rail surveys were reported as presence or absence only due to low sample size for yellow rails and the inability to determine total number of amphibians due to high densities and call overlap.

2.2.2.6 Forest Raptor Survey

Forest raptors that may occur in the West Ells Area include the northern goshawk, broad-winged hawk, Cooper's hawk, and the sharp-shinned hawk. Forest raptors typically live in closed canopy forests, build nests below the forest canopy and are difficult to detect. An effective method for surveying forest raptors is to use broadcast calls to elicit a vocal or visual response, similar to the method used for owls (Rosenfeld et al. 1985, Kennedy and Stahlecker 1993, Resources Inventory Committee 1996).

Forest raptor surveys were conducted in the SAGD Project Study Area in May 2008. Pre-determined broadcast stations were established where most of the suitable habitat for forest raptors exists in the SAGD Project Study Area (i.e., mature upland stands). Each station was approximately 1,000 m apart and was surveyed during daylight hours, when forest raptors are active. Each station surveyed an area of approximately 500 m radius; therefore this distribution of points allowed for some overlap of survey area which maximized coverage of the SAGD Project Study Area.

At each station, a two min period of silence was observed before beginning the broadcasts to allow for the effects of the observer to subside. After the quiet period, a recording was played that consisted of a sequence of 30 sec of calling followed by 30 sec of silence, 10 sec of calling, 30 sec of silence, 10 sec of calling, and 30 sec of silence for each species in the following order: 1) sharp-shinned hawk, 2) Cooper's hawk, 3) broad-winged hawk, 4) northern goshawk, and 5) great horned owl. Forest hawks respond to the territorial call of the great horned owl (Mosher and Fuller 1996), so this call was also incorporated at the end of the calling sequence. At each 10 sec calling interval, the portable CD player was rotated 120^{o} to maximize broadcast effectiveness and survey the broadcast radius in all directions.

The exact location of calling raptors was determined where possible; however, raptors often call from a distance and triangulation is required to accurately estimate the location. Raptor survey data were summarized on the basis of species presence or absence (not detected) by habitat type. Densities of raptors were not estimated due to low sample size and the potential for bias when eliciting responses of raptors through call broadcasting.

2.2.2.7 Breeding Bird Survey

Early morning point counts for songbirds were conducted in June 2008. June is the peak breeding season for songbirds in northern Alberta, and is considered to be the ideal time for conducting breeding bird surveys. The songbird surveys were used to determine both the diversity and abundance of songbirds across each habitat type present in the SAGD Project Study Area. Particular emphasis was placed on detecting rare, sensitive or endangered species, such as the black-throated green warbler, Cape May warbler, and blackburnian warbler.

A modified fixed-radius point-count sampling procedure as described by Bibby et al. (1993) was used for the breeding bird survey. This survey method includes a stationary observation point, where all birds are recorded by sight or sound within 50 m of the observer. Circular census plots with a 50 m radius were established within a single ecosite phase wherever possible. For this reason, points were chosen in polygons that were approximately 150 m in diameter to accommodate the 50 m radius census point and a 25 m buffer from the edge of the polygon. Survey points were accessed by helicopter and on foot.

Songbirds are active and vocal during the early morning; therefore, bird surveys were initiated no earlier than one-half hr before sunrise and continued until approximately 1030 hrs. As climatic and temporal conditions can greatly influence the behaviour of birds, and therefore the outcome of bird surveys, efforts were made to survey during conditions when birds would be the most active (i.e., when winds were below Beaufort Wind Scale 3 [12 km/hr], no precipitation).

Once at a survey point, observers waited two min before proceeding with the point-count to allow for birds to adjust to observer presence. Following this two min period, bird observations, both visual and vocal, were recorded over a five min listening period. The distance and direction to each bird was recorded, along with the sex of the bird, if possible. General habitat characteristics and other incidental observations were also recorded. Territorial males were considered representative of breeding pairs. Birds observed outside of the 50 m point-count radius, or birds observed during travel between point-count stations were recorded as incidental observations and were excluded from relative density and diversity calculations. However, these observations were included in discussions of detection or non-detection and distribution of birds in the SAGD Project Study Area.

Analysis of the breeding bird survey information included determining the relative density of songbirds among habitat types. The density of songbirds, species richness and diversity index value were calculated for each habitat type. Density is calculated as the number of total and individual species breeding pairs (represented by territorial males) per 40 ha, an area typically used by breeding bird researchers (Fanzreb 1981). Species richness was simply the number of species observed within each habitat type. Diversity of birds is determined using the Shannon Diversity Index (*H*), which is a measure of both the diversity and abundance of birds within each habitat type and is calculated as:

$$H = -\sum_{i=1}^{N} p_i \ln p_i$$

Where: H = Shannon Diversity Index
pi= proportion of species *i* relative to the total number of species

The Shannon Diversity Index is a measure of diversity in a community with N species, with *pi* being the relative abundance of the *i*th species in a given community (measured between 0 and 1). In the calculation, the relative weight given to species with fewer observations is less than that for species with more observations. Hence, species encountered infrequently are given slightly less value in the estimation of diversity than species encountered more regularly.

2.2.2.8 Waterbird Surveys

Aerial waterbird surveys of all waterbodies (e.g., lakes, ponds and watercourses) were conducted in June and October 2008 to detect breeding and migrating waterbirds within the

SAGD Project Study Area. There are a number of lakes, ponds and wetlands within the study area that may provide habitat for waterbirds in both the spring and fall.

Aerial waterbird surveys were conducted using a Bell 206B Jet Ranger helicopter. A primary navigator-observer was seated in the front left and one observer-recorder was seated in the rear right of the aircraft. Watercourses and waterbodies were flown such that the open water channel or body was positioned mainly on the left side of the aircraft for most effective viewing by the navigator and the rear seat secondary observer. Total coverage of the surveyed wetland was attained by flying in a counter-clockwise direction along the shoreline of open-water ponds.

The helicopter flew at an altitude between approximately 20 and 60 m above the ground, along the shoreline and over open water. Survey speeds varied from a hover to 60 km/hr to ensure accurate species identification. Survey speed and flight path were influenced by prevailing winds. Incidental wildlife observations, such as ungulates or raptor nests were also recorded.

2.2.2.9 Beaver Survey

American beaver is listed as a Priority 2 species by CEMA, and is considered a keystone species in Alberta because of its' close relationship with riparian areas and waterbodies. Beaver is also important from a socio-economic perspective and is a key traditional use species. Because of these factors, beaver surveys were conducted in the fall of 2008 while assessing waterfowl abundance in the SAGD Project Study Area. A UTM coordinate was recorded at each beaver lodge and cache, and a description of the feature recorded. These data were later used to map the location of each beaver lodge and cache in the surveyed waterbodies.

2.2.2.10 Incidental Wildlife Observations

Incidental observations of all wildlife were recorded during all baseline surveys conducted in the Study Area. Survey crews recorded all target and non-target wildlife species not detected by standard wildlife survey protocols at the time. Incidental wildlife were most often documented within survey plots for other species or species groups and while traveling between survey points for both target and non-target species groups.

2.2.3 Special Status Species

2.2.3.1 Provincial Status

The provincial status of all wildlife occurring in Alberta is ranked by ASRD. The provincial ranking system functions as an important first step in determining which species may be sensitive to development and which may already be declining. Once a species has been classified as "May be at Risk" of extirpation, it may be considered for legal designation under the provincial *Wildlife Act*. It is then also often considered for federal status by the Committee on the Status of Endangered Species in Canada (COSEWIC). Table 2 summarizes the general status categories used to rank all wildlife species in Alberta. The rank is based on a number of criteria, including abundance and distribution, population trend, and threats to both the species and associated habitats.

Table 2. Definitions of general status categories for wildlife in Alberta (Source: ASRD 2005).

Rank	Definition
At Risk	Any species known to be 'At Risk' after a formal detailed status assessment.
May Be At Risk	Any species that 'May Be At Risk' of extinction or extirpation, and is therefore a candidate for detailed risk assessment
Sensitive	Any species that is not at risk of extinction or extermination but might require species attention or protection to prevent it from becoming at risk.
Secure	A species that is not 'At Risk', 'May Be At Risk' or 'Sensitive'
Undetermined	Any species for which insufficient information, knowledge or data is available to reliably evaluate its general status.
Not Assessed	Any species that has not be examined for The General Status of Alberta Wild Species 2000 report.
Exotic / Alien	Any species that has been introduced because of human activities.
Extirpated / Extinct	Any species not longer thought to be present in Alberta ('Extirpated') or no longer believed to be present anywhere in Alberta ('Extinct').
Accidental / Vagrant	Any species occurring infrequently and unpredictably in Alberta, i.e. outside its usual range.

2.2.3.2 Federal Status

Federally, COSEWIC was established within the *Species at Risk Act* (SARA) as an independent body of experts responsible for identifying and assessing the population status of wild species in Canada. Priority is given to species that might be at risk of extirpation or extinction throughout Canada. Species ranked by COSEWIC (Table 3) are then eligible for federal protection by the government.

Table 3. Definitions of federal status rankings for wildlife in Canada (Source: COSEWIC 2008).

Rank	Definition
Extinct	A wildlife species that no longer exists.
Exterminated	A wildlife species no longer existing in the wild in Canada, but occurring elsewhere.
Endangered	A wildlife species facing imminent extinction or extirpation.
Threatened	A wildlife species likely to become endangered if limiting factors are not reversed.
Special Concern	A wildlife species that might become 'Threatened' or an 'Endangered' species because of a combination of biological characteristics and identified threats.

Data Deficient	A wildlife species for which there is inadequate information to make a direct or indirect assessment of its risk of extinction.
Not at Risk	A wildlife species that has been evaluated and found to be not at risk of extinction given current circumstances.

2.2.3.3 Cumulative Environmental Management Association Ranking

The CEMA is a multi-stakeholder, consensus-based forum that provides a framework and information network for the cumulative effects assessment of projects in the Athabasca oil sands region of northeastern Alberta. The CEMA has identified a number of species of concern in Alberta that have been assigned to 1 of 3 ranks: Priority 1, Priority 2 and Priority 3 (Table 4). Priority 1 species are considered most important for future monitoring initiatives, whereas Priority 3 species require attention but are not as critical.

Table 4. The CEMA ranking of priority wildlife species and wildlife species groups in the Athabasca oil sands region (Source: CEMA 2001).

Priority 1 Species	Priority 2 Species	Priority 3 Species
Canadian toad	Black bear	Wood frog
Moose	American beaver	Gray wolf
Woodland caribou	River otter	Bald eagle
Muskrat	Ducks and geese	Common loon
Fisher/red-backed vole	Ruffed grouse	Deciduous forest bird community
Canada lynx / snowshoe hare	Mixedwood forest bird community	Wetlands forest bird community
Old-growth bird community	Pileated woodpecker	Pine forest bird community
	Boreal owl	Early successional bird community
		Northern goshawk
		Broad-winged hawk

3

3.0 WILDLIFE HABITAT

3.1 Overview

Wildlife data were summarized and presented according to general wildlife habitat classes, which were based either on 1) ecosite phases (GDC 2008), or 2) field observations during wildlife surveys. In the first case, ecosite phases were grouped into habitat classes based on similarities in vegetation species composition, moisture regime, topographic position, and general value to wildlife. When field observations were used to categorize habitats, observers described the vegetation community and took photographs, which were then used to place the habitat into one of the general wildlife habitat classes. Habitat classification followed previous groupings proposed by Komex (2005) and AXYS (2001b). When describing wildlife observations, the structural stage of a stand was also sometimes noted (Table 5).

Table 5. Structural stage definitions used to describe stand age for habitats in the West Ells SAGD Study Area.

Structural Stages	Definition
1	Non-vegetated (bare ground/rock)
2	Herbaceous (graminoid or shrub < 20 cm)
3a	Low shrub (20 cm - 1.5 m)
3b	Tall shrub (1.5 m - 5 m)
4	Pole sapling (single canopy)
5	Young forest (single or diverse canopy)
6	Mature forest (primary/secondary canopies)
7	Old growth forest (diverse canopies, snags)

3.1.1 SAGD Project Study Area

The SAGD Project Study Area is composed of a mosaic of habitat types, the most dominant being lowland treed and shrub, mixedwood and deciduous stands (Table 6; Figure 2). Lowland habitats are expected to have relatively high value for woodland caribou, an “At Risk” species in Alberta. Deciduous and deciduous-dominated mixedwood stands support a diversity of species ranging from warblers to moose. Waterbodies, which comprise 12.5% of the area, provides habitat for breeding and migrating waterfowl and shorebirds. Although white spruce represents a relatively small proportion of the total area, it provides habitat for listed warblers such as the

Cape May warbler. Sedge meadows and marshes are important habitats that collectively account for 2.5% of the SAGD Project Study Area. Existing disturbance currently accounts for just 15.5 ha, or 0.7% of the area (Table 6).

Table 6. Areal extent of habitat types in the West Ells SAGD Project Study Area.

Habitat Types	Ecosite Phases	Area (ha)	Cover (%)	Description
Lowland treed	i1, j1, k1	638.1	27.1	Treed bogs/fens, black spruce/tamarack dominated, with Labrador tea, dwarf birch, and bog cranberry
Lowland shrub	i2, j2, k2	362.2	15.4	Shrubby bogs and fens with Labrador tea, black spruce, dwarf birch and willow
Deciduous-dominated mixedwood	d2	353.6	15.0	Aspen-dominated mixedwood with white spruce and minor components of birch/balsam poplar; high shrub diversity
Deciduous	b2, d1, e1, f1	345.9	14.7	Aspen dominated with some balsam poplar, shrubs include prickly rose, willow, cranberry, and dogwood
Waterbody	NWL, NWR	293.9	12.5	Open water
White spruce	d3, e3, f3, h1	141.7	6.0	White spruce dominated with balsam fir/deciduous component; understory includes prickly rose and twin-flower
Mixed coniferous	c1, g1	138.7	5.9	Black spruce and jack pine with Labrador tea and bog cranberry
Sedge meadow	k3	49.8	2.1	Graminoid fens with sedges, reed grass and moss
Disturbance	CIP, CIU, CIW	15.5	0.7	Well pads, pipelines, cutblocks and other cleared areas
Coniferous-dominated mixedwood	f2	9.3	0.4	White spruce –dominated mixedwood with white birch and minor components of aspen and poplar
Marsh	l1	10.0	0.4	Cattails, sedges and reed grasses.
Totals		**2,358.8**	**100.0**	

3.1.2 Access Road Study Area

Although the Access Road Study Area also has a range of habitat types, this Study Area is primarily dominated by lowland shrub, and to a lesser extent lowland treed, habitat (Table 7; Figure 2). As such, the access road passes through prime caribou habitat and does in fact bisect the Wabasca-Dunkirk Caribou Management Zone. Deciduous stands are relatively uncommon in this study area. There are several lakes that may provide both breeding and migratory habitat for waterbirds, not to mention living habitat for beaver. As with the SAGD Project Study Area, existing disturbance is a minor component of the baseline habitat available to wildlife.

Table 7. Areal extent of habitat types in the Access Road Study Area.

Habitat Types	Ecosite Phases	Area (ha)	Cover (%)	Description
Lowland shrub	i2, j2, k2	383.4	40.3	Shrubby bogs and fens with Labrador tea, black spruce, dwarf birch and willow
Lowland treed	i1, j1, k1	217.1	22.8	Treed bogs/fens, black spruce/tamarack dominated, with Labrador tea, dwarf birch, and bog cranberry
Mixed coniferous	c1, g1	115.2	12.1	Black spruce and jack pine with Labrador tea and bog cranberry
Deciduous-dominated mixedwood	d2	89.6	9.4	Aspen-dominated mixedwood with white spruce and minor components of birch/balsam poplar; high shrub diversity
Deciduous	b2, d1, e1, f1	84.2	8.9	Aspen dominated with some balsam poplar, shrubs include prickly rose, willow, cranberry, and dogwood
Waterbody	NWL, NWR	29.5	3.1	Open water
White spruce	d3, e3, f3, h1	18.0	1.9	White spruce dominated with balsam fir/deciduous component; understory includes prickly rose and twin-flower
Sedge meadow	k3	10.3	1.1	Graminoid fens with sedges, reed grass and moss
Disturbance	CIP, CIU, CIW	3.9	0.4	Wellpads, pipelines, cutblocks and other cleared areas
Coniferous-dominated mixedwood	f2	0.1	<0.1	White spruce –dominated mixedwood with white birch and minor components of aspen and poplar
Marsh	l1	0	0	Cattails, sedges and reedgrasses.
Totals		**951.1**	**100.0**	

4

4.0 WILDIFE USE

4.1 Existing Information

A search of the ANHIC database did not reveal any records of listed species for an area within 20 km of the West Ells SAGD Project (M. Meijer, ANHIC, personal communication). However, it should be noted that a lack of records in the region does not necessarily mean species of conservation concern do not occur in the area, but may simply reflect a paucity of data.

The FWMIS was also searched for "Sensitive", "May Be at Risk" and "At Risk" species within the Project Study Areas and surrounding region. The search revealed that American white pelican nesting colonies are located at a small unnamed lake and at Namur Lake, approximately 200 m and 19 km north of the West Ells SAGD Project, respectively (Figure 3). Woodland caribou have also been observed within 10 – 20 km of the Project Study Areas, primarily south where the Wabasca-Dunkirk caribou management zone is located. The slopes of the Namur Plateau support moose along the drainages and many species of furbearers, including wolverine, wolf, lynx, fisher and otter (F. Kunnas, ASRD, personal communication).

4.2 Field Surveys

4.2.1 Winter Tracking Survey

Winter track surveys were conducted on March 19, 2008. Twenty-eight transects varying in length from 250 – 300 m were established in different habitat types throughout the SAGD Project Study Area (Table 8; Figure 4) for a total sampling effort of 7.7 km. Effort was made to survey habitat types in a similar proportion as they occurred in the SAGD Project Study Area. Overall, total wildlife track frequency was highest in white spruce, followed by mixed coniferous, deciduous-dominated mixedwood and deciduous forest (Table 8). Track frequency was significantly higher in these three habitats than in lowland shrub (p=0.00), lowland treed (p=0.00) and disturbance (p=0.00). Lowland treed habitat also had significantly greater track frequency than lowland shrub (p=0.00) and disturbance (p=0.01).

Table 8. Winter tracking survey effort and total wildlife track frequency by habitat type in the SAGD Project Study Area, March 2008.

Habitat Type	Length (m)	Track Frequency (tracks/km/day)
Lowland treed	2,275	38.7
Lowland shrub	1,750	23.0
Deciduous-dominated mixedwood	1,400	77.6
Mixed coniferous	825	97.4
Deciduous	800	76.3
White spruce	525	101.0
Disturbance	50	0.0
Sedge meadow	25	0.0
Coniferous-dominated mixedwood	0	0.0
Total	**7,650**	**56.4**

4.2.1.1 Carnivores

Six different carnivore species were recorded during winter track surveys conducted in the SAGD Project Study Area (Table 9). Two of these species (fisher and Canada lynx) are considered "Sensitive" in Alberta and are also identified as Priority 1 CEMA species.

Table 9. Track densities of carnivores recorded during winter track surveys in the SAGD Project Study Area, March 2008.

Habitat Type	Track Density (SD[1])					
	American Marten	Ermine	Fisher	Least Weasel	Coyote	Canada Lynx
Deciduous	0.8 (3.3)	0.4 (2.4)	0.8 (3.3)	0	0.4 (2.4)	0
Disturbance	0	0	0	0	0	0
Lowland shrub	0.2 (1.6)	0.8 (3.8)	0	0	0	0.2 (1.6)
Lowland treed	4.5 (8.7)	0.7 (3.1)	0	0.2 (1.4)	0	0
Mixed coniferous	2.0 (5.9)	0.4 (2.3)	0	0	0	0.4 (2.3)
Deciduous-dominated mixedwood	1.4 (4.2)	0.7 (3.0)	0.2 (1.8)	0.2 (1.8)	0	0.2 (1.8)
Sedge meadow	0	0	0	0	0	0
White spruce	3.8 (8.6)	1.3 (5.8)	0	0	0	0
Total	**2.2 (6.2)**	**0.7 (3.3)**	**0.1 (1.3)**	**0.1 (1.1)**	**0.04 (0.8)**	**0.1 (1.3)**
Significance (p value)	*0.00*[2]	*1.00*	*0.11*	*0.93*	*0.29*	*0.85*

[1] Standard deviation.
[2] Denotes statistical significance at $p<0.05$.

<u>*American Marten*</u>

American marten was the most commonly detected carnivore and mustelid species during the winter track surveys (Table 9). The mean track frequency was 2.2 tracks/km/day across all habitat types. Track frequency was significantly higher in lowland treed habitat compared to lowland shrub (p=0.00), deciduous (p=0.02), and deciduous-dominated mixedwood (p=0.02) habitats. Marten typically prefer coniferous habitats over deciduous and shrubby areas because of lower snow depths (Pattie and Fisher 1999), and avoid those with no overstory or shrubs (Buskirk and Powell 1994).

Ermine

Ermine, or short-tailed weasel, had a mean track frequency of 0.7 tracks/km/day (Table 9). Ermine were most frequently recorded in white spruce stands, although this was not statistically significant. This species was also relatively common in lowland habitats and deciduous-dominated mixedwood. Overall, however, there was not a strong preference for certain habitat types. The ermine is usually most abundant in coniferous or mixedwood forests (Pattie and Fisher 1999).

Fisher

Fisher, a "Sensitive" species in Alberta, was detected in only deciduous and deciduous-dominated mixedwood forests (Table 9). Fisher appears to prefer habitats with a moderate deciduous component (Thomasma et al. 1994), and in some cases select pure deciduous stands (Tully 2006). In general, fisher select dense forests with abundant coarse woody debris which provide habitat for small mammal prey (Olsen et al. 1999). Overall, the fisher is relatively uncommon in the SAGD Project Study Area.

Least Weasel

Least weasel was detected in only lowland treed and deciduous-dominated mixedwood stands (Table 9). Habitat use appears to depend more on prey abundance than vegetation characteristics of any given habitat type (Pattie and Fisher 1999). Typical prey includes voles, mice, insects, amphibians, birds and eggs.

Coyote

Coyote tracks were observed only in deciduous habitat, at a frequency of 0.4 tracks/km/day (Table 9). Deciduous habitat with shrubby understory is likely to provide high quality habitat for snowshoe hare, one of the primary prey species of coyote in this area.

Canada Lynx

Although lynx are typically less common than coyotes, this felid species was detected relatively frequently in the SAGD Project Study Area (Table 9). Lynx tracks were recorded most often in mixed coniferous habitat, followed by lowland shrub and deciduous-dominated mixedwood. Lynx rely on snowshoe hare as their primary prey species, which typically occur in the same habitats.

4.2.1.2 Rodents and Snowshoe Hare

Two rodents, red squirrel and beaver, were noted during the winter track surveys (Table 10). Although snowshoe hare was the only lagomorph recorded, it was extremely common and widespread throughout the SAGD Project Study Area. None of these species are considered "Sensitive" in Alberta, although beaver is a Priority 2 CEMA-listed species and snowshoe hare is listed as Priority 1 because of its' importance as a prey species.

Table 10. Rodents and snowshoe hare track densities recorded during winter track surveys conducted in the SAGD Project Study Area, March 2008.

Habitat Type	Track Density (SD[1])		
	Snowshoe Hare	**Red Squirrel**	**Beaver**
Deciduous	37.9 (36.2)	35.0 (50.7)	0
Disturbance	0	0	0
Lowland shrub	9.1 (20.9)	7.8 (16.4)	0.2 (1.6)
Lowland treed	25.5 (35.5)	6.7 (14.1)	0
Mixed coniferous	57.4 (64.1)	36.4 (43.5)	0
Deciduous-dominated mixedwood	45.2 (37.3)	26.2 (27.0)	0
Sedge meadow	0	0	0
White spruce	55.2 (47.6)	40.0 (47.3)	0
Total	**31.9 (41.5)**	**18.9 (32.2)**	**0.1 (1.3)**
Significance (p-value)	*0.00[2]*	*0.00[2]*	*0.85*

[1] Standard deviation.
[2] Denotes statistical significance at $p<0.05$.

Snowshoe Hare

Snowshoe hare tracks were observed at a density of 31.9 tracks/km/day in the SAGD Project Study Area (Table 10). This species was significantly more abundant in mixed coniferous compared to disturbance (p=0.03), lowland shrub (p=0.00) and lowland treed (p=0.00) habitats, while white spruce had a significantly higher track density than lowland shrub (p=0.00) and lowland treed (p=0.00) stands. Snowshoe hare are typically found in dense shrub thickets (e.g., willow, alder, rose, saskatoon and conifer) of the forest understory (Pattie and Fisher 1999).

Red Squirrel

Red squirrel was the second most frequently recorded species during the winter track surveys (Table 10). This species is important because of its role as a prey item for many carnivores in the SAGD Project Study Area. Red squirrel tracks were significantly more abundant in white spruce, mixed coniferous and deciduous stands compared to lowland shrub (p=0.00) and lowland treed (p=0.00) habitats. Red squirrels are typically most abundant in coniferous forests, where there are plentiful cones to forage upon.

Beaver

Beaver tracks were observed only once in lowland shrub habitat (Table 10). Beaver are expected to occur in similar riparian habitats throughout the Project Study Areas. This species is considered a "keystone species" because of its importance in modifying waterbodies and riparian zones. Beaver are typically most common around ponds and slow streams, especially when deciduous habitat occurs within 200 m of the waterbodies.

4.2.1.3 Ungulates

A single ungulate species (moose) was detected during the winter track surveys. Other potential ungulates that could occur in the Project Study Areas include deer and woodland caribou, given the proximity of the Wabasca-Dunkirk caribou management zone. Movement of ungulates smaller than moose may have been affected by the deep snow conditions that were encountered during the winter track survey, which may have resulted in the lack of field observations.

Moose were recorded in three habitats including deciduous, lowland shrub and lowland treed habitats (Table 11). These habitats tend to have high availability of preferred forage species, including willow, red-osier dogwood, cranberry and other shrubs (Romito et al. 1999). Moose occurred at significantly higher frequency in lowland shrub ($p=0.00$), which typically has an abundance of suitable winter forage.

4.2.1.4 Grouse

Grouse tracks were recorded in five habitat types ranging from deciduous forest to lowland treed types, although there was no significant difference in track frequency among habitats (Table 11). A number of grouse species may occur in the SAGD Project Study Area, including ruffed grouse, spruce grouse, sharp-tailed grouse and willow ptarmigan. Ruffed grouse are typically found in mixedwood and poplar forests, while spruce grouse are most abundant in coniferous woodlands (Fisher and Acorn 1998). Sharp-tailed grouse prefer more open habitats, such as sedge meadows or grasslands. Willow ptarmigan are considered very rare in Alberta but may occur in winter in open forests.

4.2.2 Aerial Ungulate Survey

An aerial ungulate survey was conducted over the Project Study Areas on March 7, 2008. Conditions were considered good, with 10% cloud cover and temperatures of -4 °C. Despite the good survey conditions, no moose were observed in the SAGD Project Study Area, but two cow moose were observed 1.7 km outside of the SAGD Project Study Area (Figure 5). A bull moose was also recorded during the fall waterfowl survey along the shores of the largest lake (Lake 2) in the study area. Surveys conducted in Wildlife Management Unit 531, which includes the West Ells SAGD Project area, indicate that moose densities range from 0.06 moose/km^2 to 0.37 moose/km^2, with most observations <0.22 moose/km^2 (Westworth Associates Environmental Ltd. 2002).

Table 11. Track densities of moose and grouse recorded during winter track surveys conducted in the SAGD Project Study Area, March 2008.

Habitat Type	Track Density (SD[1])	
	Moose	**Grouse**
Deciduous	0.4 (2.4)	0.4 (2.4)
Disturbance	0	0
Lowland shrub	3.8 (8.8)	0.4 (2.2)
Lowland treed	0.4 (2.4)	0.6 (2.7)
Mixed coniferous	0	0.8 (3.2)
Deciduous-dominated mixedwood	0	3.3 (1.7)
Sedge meadow	0	0
White spruce	0	0
Total	**1.0 (4.7)**	**1.0 (5.6)**
Significance (p-value)	*0.00*[2]	*0.71*

[1] Standard deviation.

[2] Denotes statistical significance at $p<0.05$.

4.2.3 Aerial Access Road Survey

An aerial survey of the access road was conducted on October 5, 2008. Fifteen wildlife trails were recorded intersecting the access road (Figure 6). Eight of these trails were classified as moose trails, while the other seven may have been used by other species such caribou and deer. One trail passed through an area with abundant lichen, and may have been used by caribou. Several trails were also located near proposed Project facilities. Most of the access road passes through mature, tall forest with little open bog so the number of trails may have been underestimated. However, seven areas containing terrestrial lichen, a high quality forage for caribou, were identified. This information can be used to guide mitigation of road impacts on wildlife, particularly caribou and moose whose movements are affected by linear features. Areas with high potential for caribou, such as open bogs with abundant lichen, should be the focus of mitigation measures to avoid disruption of caribou movement through the region.

4.2.4 Owl Survey

Nocturnal owl surveys took place on April 16, 2008, at 10 stations throughout the SAGD Project Study Area (Figure 7). Each listening station encompassed a 201 ha area resulting in a survey effort of 1,412.1 ha. Each habitat type in the study area was surveyed, such that survey effort increased with increasing prevalence of each habitat type (Table 12). Overall, 60% of the SAGD Project Study Area was surveyed for owls, with between 24.0% and 89.0% of each habitat type surveyed. The most important habitats for owls were expected to be the forested types, although the nature of the call-playback surveys did not permit habitat associations for the recorded owls.

Table 12. Area assessed by habitat type relative to total available habitat during owl surveys conducted in the SAGD Project Study Area, April 2008.

Habitat Types	Area Surveyed (ha)	Area Available in the SAGD Project Study Area (ha)	% Total Available Area Surveyed
Lowland treed	426.7	638.1	66.9
Deciduous-dominated mixedwood	283.3	353.6	80.1
Lowland shrub	201.9	362.2	55.7
Deciduous	190.7	345.9	55.1
Waterbody	93.3	294.0	31.7
White spruce	89.6	141.7	63.2
Mixed coniferous	84.9	138.7	61.2
Sedge meadow	17.3	49.8	34.7
Disturbance	13.8	15.5	89.0
Marsh	8.4	10.0	84.3
Coniferous-dominated mixedwood	2.2	9.3	24.0
Total	**1,412.1**	**2,358.8**	**59.9**

Eight owls were recorded during the nocturnal owl surveys, with the most common being the boreal owl (Table 13). The boreal owl is a Priority 2 CEMA-listed species. Five observations of boreal owls resulted in a density of 0.14 owls/40 ha in the SAGD Project Study Area. Typical habitat for this species in Canada is boreal forest with spruce, aspen, poplar, white birch and balsam fir (Bondrup-Nielsen 1978; Meehan and Ritchie 1982). This species appears to often select aspen in which to nest (Bondrup-Nielsen 1978), suggesting that forest stands with a deciduous component, such as deciduous-dominated mixedwood, are important.

Table 13. Owls observed during the nocturnal owl surveys in the SAGD Project Study Area, April 2008.

Species	No.	Density (No./40 ha)
Great-horned owl	2	0.06
Boreal owl	5	0.14
Barred owl	1	0.03

Two great-horned owls responded to the call play-back during the owl surveys (0.06 owls/40 ha; Table 13), while an additional individual was noted while surveyors walked between survey stations. Great-horned owls use a variety of habitats, nesting in both deciduous and coniferous woodlands (Semenchuk 1992). This species seems to prefer open or second-growth habitats, and is often found in agricultural or even urban areas (Houston et al. 1998).

A single barred owl was recorded for a density of 0.03 owls/40 ha (Table 13). The barred owl is considered "Sensitive" in Alberta due to the loss of contiguous, mature forest upon which it depends. Barred owls prefer dense mixedwood forest, particularly with balsam poplar, often near riparian areas (Takats 1998). Nesting typically occurs in natural cavities in large trees, often fairly close to the ground (Semenchuk 1992).

4.2.5 Raptor Survey

Seven stations were surveyed for raptors in May 2008 using the broadcast method. Each station was assumed to broadcast up to 500 m, resulting in a total survey area of 510.0 ha (Table 14; Figure 8). As with the owl surveys, effort was made to survey habitat both in proportion to availability in the SAGD Project Study Area and according to the potential for raptors to occur in that habitat. Surveys were limited by ground accessibility and safety constraints. All habitat types except coniferous-dominated mixedwood, which represents only 0.4% of the SAGD Project Study Area, were surveyed.

Table 14. Area assessed by habitat type relative to total available habitat during raptor surveys conducted in the SAGD Project Study Area, May 2008.

Habitat Types	Area Surveyed (ha)	Area Available in the SAGD Project Study Area (ha)	% Total Available Area Surveyed
Lowland treed	149.0	638.1	23.3
Lowland shrub	84.3	362.2	23.3
Deciduous-dominated mixedwood	77.8	353.6	22.0
Waterbody	64.5	294.0	21.9
Deciduous	63.9	345.9	18.5
White spruce	32.8	141.7	23.1
Sedge meadow	18.8	49.8	37.7
Mixed coniferous	8.2	138.7	5.9
Marsh	6.7	10.0	67.3
Disturbance	4.1	15.5	26.7
Coniferous-dominated mixedwood	0.0	9.3	0.0
Total	**510.0**	**2,358.8**	**21.6**

Two raptors responded to the call-playback during the raptor surveys. A red-tailed hawk responded to the sharp-shinned hawk call, while a sharp-shinned hawk responded to the broadcast of the Cooper's hawk. Red-tailed hawks prefer relatively open woodland near open areas, such as waterbodies or meadows (Semenchuk 1992, Preston and Beane 1997). In contrast, the sharp-shinned hawk is usually found in thick deciduous and mixedwood forests (Semenchuk 1992). Approximately 30% (704 ha) of the SAGD Project Study Area is comprised of these two habitat types.

4.2.6 Amphibian and Yellow Rail Surveys

Amphibian and yellow rail surveys took place immediately following the raptor surveys in May 2008. These nocturnal surveys encompassed an area of up to 800 m from the listening station, resulting in 472.4 ha of habitat surveyed (Table 15). Most of the habitats surveyed were the waterbody, lowland treed, and shrub types. Crew safety (bear in area) limited the number of listening stations surveyed in the SAGD Project Study Area. However, crew members listened for amphibians and yellow rails as they travelled through the SAGD Project Study Area at night, which provided additional information on use of the area by these species.

Table 15. Area assessed during amphibian and yellow rail surveys conducted in the SAGD Project Study Area, May 2008.

Habitat Types	Area Surveyed (ha)	Area Available in the SAGD Project Study Area (ha)	% Total Area Available Surveyed
Waterbody	115.4	294.0	39.2
Lowland treed	106.6	638.1	16.7
Lowland shrub	93.2	362.2	25.7
Deciduous-dominated mixedwood	50.9	353.6	14.4
Deciduous	42.6	345.9	12.3
White spruce	25.7	141.7	18.1
Sedge meadow	18.9	49.8	38.0
Mixed coniferous	10.0	138.7	7.2
Marsh	9.2	10.0	91.5
Coniferous-dominated mixedwood	0.0	9.3	0.0
Disturbance	0.0	15.5	0.0
Total	**472.4**	**2,359.1**	**20.0**

Amphibians were detected at all three listening stations (Figure 9). Boreal chorus frogs were heard at all stations, with between 11 and 20 individuals detected (calls were overlapping, but some individuals could still be distinguished). Boreal chorus frogs are usually found within a short distance of waterbodies, such as flooded meadows, lake margins, and quiet backwaters of rivers and streams (Alberta Conservation Association No Date). Wood frogs were heard at the two westerly stations where between one and 10 individuals were detected (individual calls could be counted). Wood frogs are typically found in mixed forest habitats or grassy areas near ponds, marshes, lake margins and quiet backwaters of rivers and streams. Both chorus frogs and wood frogs were heard along the edges of major waterbodies as surveyors traversed the SAGD Project Study Area. No Canadian or western toads were recorded. Toads use wetland and waterbodies during the breeding season, and upland sites for hibernation. The western toad can be found in a wide range of habitats (forest to meadows) but are usually found near waterbodies. Canadian toads are typically found at permanent waterbodies in close proximity to sandy or loose soils.

No yellow rails were detected during the surveys. This species requires sedge meadows and was expected to occur adjacent to the lakes in the SAGD Project Study Area. Call playback was used at the amphibian survey stations, and observers also listened for rails while traversing through the area. Rails can be detected from up to 800 m away, and therefore surveys were considered sufficient to cover most of the SAGD Project Study Area. Surveyors were unable to access Lake 1, located at the eastern edge of the SAGD Project Study Area.

4.2.7 Songbird Surveys

Songbird surveys were conducted in mid-June 2008, under ideal conditions with calm winds and clear skies. Thirty-five stations throughout the SAGD Project Study Area were surveyed in eight habitat types including coniferous-dominated mixedwood (6), deciduous (3), sedge meadow (2), white spruce (6), lowland shrub (2), lowland treed (6), mixed coniferous (1) and deciduous-dominated mixedwood (9). Disturbance, marsh and waterbody types were not sampled; however, the latter two types were surveyed during the spring and fall waterbird surveys. Forty species of birds were observed during the songbird surveys (Table 16), including waterbirds and shorebirds recorded on waterbodies adjacent to survey stations, and while traversing between stations. Among the 40 species observed were six "Sensitive" species: bay-breasted warbler, broad-winged hawk, Cape May warbler, pileated woodpecker, sora and western tanager.

The most common songbird species were Tennessee warbler, yellow-rumped warbler and chipping sparrow (Table 17). Similar results were recorded in other studies conducted in the region. At the Joslyn Deer Creek SAGD Project area located east of the West Ells SAGD Project area, Tennessee warblers were also the most common species (60 territories/40 ha), followed by chipping sparrows (24 territories/40 ha), palm warblers and ovenbirds (Komex International Ltd. 2005). In the ESSO Kearl Oil Sands Project Area, Tennessee warblers were also the most common species at 33.7 territories/40 ha, followed by chipping sparrows (15.8 territories/40 ha), ovenbird (13.6 territories/40 ha) and yellow-rumped warbler (12.2 territories/40 ha) (IORVL 2005). At the Shell Jackpine Mine site, Tennessee warbler, gray jay and yellow-rumped warbler were the three most frequently detected species at the 89 stations surveyed (Golder 2002). Similarly, chipping sparrows and Tennessee warblers were the most common species at the Jackpine Mine expansion Project study area (Shell Canada 2007).

Several "Sensitive" species were relatively common in the SAGD Project Study Area including the bay-breasted warbler and Cape May warbler. One other "Sensitive" species, the western tanager, was also observed during the breeding bird surveys. Bay-breasted warblers were not detected at the ESSO Kearl Oil Sands Project Area (IORVL 2005), and were detected infrequently at Jackpine mine (Golder 2002) and Joslyn Deer Creek (Komex International Ltd. 2005). Bay-breasted warblers typically occur in mature coniferous forests (Fisher and Acorn 1998; Semenchuk 1992), and in the SAGD Project Study Area, were detected most commonly in coniferous-dominated mixedwood (4) and white spruce (3) stands, with one detection in each of deciduous-dominated mixedwood and mixed coniferous habitat types. Cape May warblers were detected at low frequency in most project areas in the region, and in Alberta are usually found in mature, dense white spruce stands in coniferous and mixedwood forests (Semenchuk 1992). Habitat use of the SAGD Project Study Area was variable, including coniferous-dominated mixedwood (2), white spruce (2) and deciduous-dominated mixedwood (1). Western tanagers, which tend to use mature open coniferous and mixedwood forests (Semenchuk 1992), and occasionally deciduous types, were recorded in deciduous-dominated mixedwood stands in the SAGD Project Study Area.

Table 16. List of bird species recorded during the songbird survey in the SAGD Project Study Area, June 2008.

Common Name	Scientific Name	Common Name	Scientific Name
Alder flycatcher	*Empidonax alnorum*	Magnolia warbler	*Dendroica magnolia*
American wigeon	*Anas americana*	Marsh wren	*Cistothorus palustris*
Black-and-white warbler	*Mniotilta varia*	Northern flicker	*Colaptes auratus*
Bay-breasted warbler[1]	*Dendroica castanea*	Ovenbird	*Seiurus noveboracensis*
Black-capped chickadee	*Poecile atricapilla*	Palm warbler	*Dendroica palmarum*
Blue-headed vireo	*Vireo solitarius*	Pine siskin	*Carduelis pinus*
Boreal chickadee	*Poecile hudsonica*	Pileated woodpecker[1]	*Dryocopus pileatus*
Broad-winged hawk[1]	*Buteo platypterus*	Red-breasted nuthatch	*Sitta canadensis*
Chipping sparrow	*Spizella passerina*	Ruby-crowned kinglet	*Regulus calendula*
Cape May warbler[1]	*Dendroica tigrina*	Red-eyed vireo	*Vireo olivaceus*
Common loon	*Gavia immer*	Red-winged blackbird	*Agelaius phoeniceus*
Common raven	*Corvus corax*	Sora[1]	*Porzana carolina*
Connecticut warbler	*Oporornis agilis*	Solitary sandpiper	*Tringa solitaria*
Dark-eyed junco	*Junco hyemalis*	Swainson's thrush	*Catharus ustulatus*
Golden-crowned kinglet	*Regulus satrapa*	Tennessee warbler	*Vermivora peregrina*
Gray jay	*Periosoreus canadensis*	Western tanager[1]	*Piranga ludoviciana*
Hermit thrush	*Catharus guttatus*	Wilson's snipe	*Gallinago delicata*
Le Conte's sparrow	*Ammodramus leconteii*	White-throated sparrow	*Zonotrichia albicollis*
Lesser scaup	*Aythya affinis*	Yellow-bellied sapsucker	*Sphyrapicus varius*
Lincoln's sparrow	*Melospiza lincolnii*	Yellow-rumped warbler	*Dendroica coronata*

[1] Sensitive species in Alberta (ASRD 2005).

Species richness was strongly correlated (Spearman Rank two-tailed test for correlation) with the number of stations surveyed/habitat type (R=0.926; p=0.001), as was the diversity index (R=0.786; p=0.021). This suggests that high diversity or species richness in a given habitat type does not necessarily indicate that this habitat is capable of supporting a wide diversity of species. The density of songbirds, defined as the number of territories/40 ha, was not strongly correlated with the number of stations surveyed, and was therefore considered a more reliable indication of habitat quality. Habitats with a high density of species were assumed to be capable of supporting a large number of breeding songbird pairs.

Lowland treed habitat had the highest density of songbirds, closely followed by the coniferous–dominated and deciduous-dominated mixedwood types (Table 18). Sensitive species including bay-breasted warbler, Cape May warbler and western tanager were all found in mixedwood stands; however, none were recorded in lowland treed. Deciduous, sedge meadow and white spruce habitats had moderate bird densities, although the latter habitat type appeared to be important for bay-breasted and Cape May warblers. Lowland shrub (shrubby bogs and willow-dominated fens) and mixed coniferous habitat types had the lowest songbird density.

Table 17. Songbird densities in the SAGD Project Study Area, June 2008.

Common Name	Density (Territories/40 ha)	Common Name	Density (Territories/40 ha)
Tennessee warbler	50.96	Ruby-crowned kinglet	4.37
Yellow-rumped warbler	32.03	Black-and-white warbler	2.91
Chipping sparrow	23.29	Black-capped chickadee	2.91
Bay-breasted warbler	13.10	Red-winged blackbird	2.91
Dark-eyed junco	11.65	Western tanager	2.91
Ovenbird	8.74	Alder flycatcher	1.46
Cape May warbler	7.28	Golden-crowned kinglet	1.46
Magnolia warbler	5.82	Hermit thrush	1.46
Palm warbler	5.82	Le Conte's sparrow	1.46
Red-breasted nuthatch	5.82	Lincoln's sparrow	1.46
Swainson's thrush	5.82	Marsh wren	1.46
Boreal chickadee	4.37	White-throated sparrow	1.46
Gray jay	4.37	Northern flicker	1.46
Pine siskin	4.37		

The overall density of songbird territories was 211.1 territories/40 ha, which is higher than the 202 breeding territories/40 ha recorded by IORVL 2005 and the 191 territories/40 ha at the Shell Jackpine Mine site (Golder 2002), but within the range of breeding territories (204 – 561 territories/40 ha) at Deer Creek's Joslyn SAGD Project (Komex International Ltd. 2005).

In summary, the mixedwood habitat supported relatively high densities of breeding songbirds, and was also important for several "Sensitive" species. White spruce stands were also used by "Sensitive" warblers, although overall density of songbirds was only moderate in this type. Lowland shrub, sedge meadow and mixed coniferous habitats appeared to have low songbird densities, although the small sample sizes should be considered when drawing conclusions.

Table 18. Density and species richness of songbirds by habitat type in the SAGD Project Study Area, June 2008.

Habitat	No. of Sites Surveyed	Species Richness	Density (Territories/40 ha)	Diversity Index
Deciduous-dominated mixedwood	9	14	226.3	0.945
Coniferous-dominated mixedwood	6	9	229.3	0.837
Lowland treed	6	10	263.3	0.927
White spruce	6	9	186.8	0.829
Deciduous	3	9	186.4	0.932
Lowland shrub	2	3	101.9	0.452
Sedge meadow	2	6	203.8	0.753
Mixed coniferous	1	3	152.9	0.477
Total	**35**	**27**	**211.1**	**1.170**

4.2.8 Waterbird Surveys

Aerial waterbird surveys were conducted in mid-June and early October at eight lakes or wetlands throughout the SAGD Project Study Area (Figure 11). Twelve species were confirmed to be using the area, with four of these considered "Sensitive" in Alberta (Table 19). It is likely that the unidentified scaup were actually lesser scaup, and the scoter species was actually white-winged scoter, but this could not be confirmed in the field. In spring, the most common species were bufflehead, lesser scaup and ruddy duck. Similarly, bufflehead and scaup were also the most frequently recorded species in fall along with canvasback and common merganser. In general, fall waterfowl numbers far exceeded those in the spring surveys, indicating that the lakes in the SAGD Project Study Area are important during the migratory period.

Size of lakes and wetlands ranged from 1.1 ha (Lake 4) to 192.6 ha (Lake 2), with waterbodies accounting for over 12% of the SAGD Project Study Area. Waterbird density was calculated for each lake in spring and fall (Table 20). In spring, Lake 4 had the highest density of birds, followed by Lakes 3 and 8. The largest lakes were used by relatively few waterbirds in the spring. The reverse was true during the fall surveys, with the large lakes supporting relatively high densities of waterfowl. Lake 7 had a high number of waterfowl for its size, suggesting that this lake is of particular importance during migration. Lake 1A was surveyed only in the fall, and had four surf scoters. These data support the conclusion that lakes in the SAGD Project Study Area are important for waterfowl and other waterbirds, especially during the fall migratory period.

A number of additional species were recorded during songbird surveys conducted in mid-June. These species included sora, common loon, American wigeon, solitary sandpiper and Wilson's snipe. The sora is the only species considered "Sensitive" in Alberta.

Table 19. Waterbirds recorded during surveys conducted in the SAGD Project Study Area, October 2008.

Common Name	Scientific Name	Counts		Alberta Status	COSEWIC Status
		Spring	Fall		
American coot	*Fulica americana*	0	6	Secure	Not listed
American wigeon	*Anas americana*	3	0	Secure	Not listed
Bufflehead	*Bucephala albeola*	58	267	Secure	Not listed
Blue-winged teal	*Anas discors*	1	0	Secure	Not listed
Canvasback	*Aythya valisineria*	0	46	Secure	Not listed
Common goldeneye	*Bucephala clangula*	0	20	Secure	Not listed
Common loon	*Gavia immer*	9	0	Secure	Not at Risk
Common merganser	*Mergus merganser*	0	42	Secure	Not listed
Gadwall	*Anas strepera*	1	0	Secure	Not listed
Great blue heron	*Ardea herodias*	1	0	Sensitive	Not listed
Green-winged teal	*Anas crecca*	3	0	Sensitive	Not listed
Lesser scaup	*Aythya affinis*	55	65	Sensitive	Not listed
Scaup spp.	*Aythya spp.*	15	100	-	-
Mallard	*Anas platyrhynchos*	23	37	Secure	Not listed
Red-necked grebe	*Podiceps grisegena*	2	2	Secure	Not at Risk
Ruddy duck	*Oxyura jamaicensis*	54	0	Secure	Not listed
Surf scoter	*Melanitta perspicillata*	0	4	Secure	Not listed
White-winged scoter	*Melanitta fusca*	8	0	Sensitive	Not listed
Scoter spp.	*Melanitta spp.*	9	0	-	-

Table 20. Density of waterfowl, waterbirds and shorebirds recorded during surveys conducted in the SAGD Project Study Area, June and October 2008.

Lake	Area (ha)	Spring		Fall	
		Count	Density	Count	Density
1	108.7	33	0.30	289	2.66
1a	1.3	NS[1]	-	4	3.08
2	192.6	114	0.59	222	1.15
3	5.2	30	5.74	5	0.96
4	1.1	8	7.47	0	0
5/6	4.0	4	1.00	0	0
7	26.8	28	1.05	69	2.58
8	4.7	25	5.29	0	0

[1] NS = Not surveyed.

4.2.9 Beaver Surveys

Aerial surveys of waterbodies in the SAGD Project Study Area revealed a widespread occurrence of beaver. Eighteen lodges, including five older, disused lodges, were identified on five lakes (Table 21; Figure 12). Two of the lodges were located just outside of the study area, but beaver living in these lodges are expected to use the entire lake and adjacent riparian area. There were also three food caches noted on Lake 1. All of the beaver activity on Lake 1 was focused around the inlet at the southern end of the lake, while beaver lodges were scattered around the edge of the larger Lake 2.

Table 21. Results of aerial beaver surveys conducted in the SAGD Project Study Area, October 2008.

Lake	Lodges	Food Caches
1A	0	0
1	6	3
2	8	0
3	0	0
4	1	0
5-6	0	0
7	2	0
8	1	0
Total	**18**	**3**

4.3 Special Status Wildlife Species

Special status wildlife species that may occur in the West Ells SAGD Project Study Areas were identified based on various information sources including the General Status of Alberta Wild Species (ASRD 2005), the Cumulative Environmental Management Association (CEMA 2001), and the Committee on the Status of Endangered Wildlife in Canada (COSEWIC 2008). Based on these information sources, 50 special status wildlife species may occur, including Canadian toad, pileated woodpecker and woodland caribou (Table 22). Eight of these species have been recorded within the SAGD Project Study Area either as tracks, scat, auditory or visual observations.

The SAGD Project Study Area is located just 45 m north of the Wabasca-Dunkirk caribou management zone, and therefore the potential for occurrence of caribou in the Study Area is high. The Access Road Study Area passes directly through the caribou management zone. Caribou from the West Side of the Athabasca River herd (WSAR) may occur in this region. The WSAR herd was most recently estimated to have 200 individuals, and have a slightly decreasing rate of growth (ACC 2008). The location of the Study Area relative to the caribou zone means that caribou need to be carefully considered when planning and executing the Project.

Table 22. Wildlife special status species that may occur in the West Ells SAGD Project Area.

Common Name	Scientific Name	Alberta Status	COSEWIC Status
Amphibians and Reptiles:			
Canadian Toad	*Bufo hemiophrys*	May Be at Risk	Not at Risk
Red-sided Garter Snake	*Thamnophis sirtalis*	Sensitive	-
Birds:			
Pied-billed Grebe	*Podilymbus podiceps*	Sensitive	-
Horned Grebe	*Podiceps auritus*	Sensitive	-
Western Grebe	*Aechmophorus occidentalis*	Sensitive	-
American White Pelican	*Pelecanus erythrorhynchos*	Sensitive	Not at Risk
American Bittern	*Botaurus lentiginosus*	Sensitive	-
Great Blue Heron	*Ardea herodias*	Sensitive	-
Green-winged Teal	*Anas crecca*	Sensitive	-
Northern Pintail	*Anas acuta*	Sensitive	-
Lesser Scaup	*Aythya affinis*	Sensitive	-
White-winged Scoter	*Melanitta fusca*	Sensitive	-
Osprey	*Pandion haliaetus*	Sensitive	-
Bald Eagle	*Haliaeetus leucocephalus*	Sensitive	Not at Risk
Northern Harrier	*Circus cyaneus*	Sensitive	Not at Risk
Northern Goshawk	*Accipiter gentilis*	Sensitive	Not at Risk
Broad-winged Hawk	***Buteo platypterus***	***Sensitive***	***Not at Risk***
Sharp-tailed Grouse	*Tympanuchus phasianellus*	Sensitive	-
Yellow Rail	*Coturnicops noveboracensis*	Undetermined	Special Concern
Sora	***Porzana carolina***	***Sensitive***	***-***
Sandhill Crane	*Grus canadensis*	Sensitive	-
Upland Sandpiper	*Bartramia longicauda*	Sensitive	-
Black Tern	*Chlidonias niger*	Sensitive	Not at Risk
Northern Hawk Owl	*Surnia ulula*	Sensitive	Not at Risk
Barred Owl	*Strix varia*	Sensitive	-
Great Gray Owl	*Strix nebulosa*	Sensitive	Not at Risk
Short-eared Owl	*Asio flammeus*	May Be at Risk	Special Concern
Common Nighthawk	*Chordeiles minor*	Sensitive	Threatened
Black-backed Woodpecker	*Picoides arcticus*	Sensitive	-
Pileated Woodpecker	***Dryocopus pileatus***	***Sensitive***	***-***
Olive-sided flycatcher	*Contopus cooperi*	Secure	Threatened
Least Flycatcher	*Empidonax minimus*	Sensitive	-
Eastern Phoebe	*Sayornis phoebe*	Sensitive	-
Barn Swallow	*Hirundo rustica*	Sensitive	-
Brown Creeper	*Certhia americana*	Sensitive	-
Cape May Warbler	***Dendroica tigrina***	***Sensitive***	***-***
Black-throated Green Warbler	*Dendroica virens*	Sensitive	-
Blackburnian Warbler	*Dendroica fusca*	Sensitive	-
Bay-breasted Warbler	***Dendroica castanea***	***Sensitive***	***-***
Common Yellowthroat	*Geothlypis trichas*	Sensitive	-
Canada Warbler	*Wilsonia canadensis*	Sensitive	Threatened
Western Tanager	***Piranga ludoviciana***	***Sensitive***	***-***
Rusty Blackbird	*Euphagus carolinus*	Sensitive	Special Concern
Mammals:			
Northern Long-eared Bat	*Myotis septentrionalis*	May Be at Risk	-
Silver-haired Bat	*Lasionycteris noctivagans*	Sensitive	-
Hoary Bat	*Lasiurus cinereus*	Sensitive	-
Fisher	***Martes pennanti***	***Sensitive***	***-***
Wolverine	*Gulo gulo*	May Be at Risk	Special Concern
Canada Lynx	***Lynx canadensis***	***Sensitive***	***Not at Risk***
Woodland Caribou	*Rangifer tarandus caribou*	At Risk	Threatened

[1] Bolded and italicized species indicate that the species have been observed in the project study areas.

5

5.0 WILDLIFE ASSESSMENT

Effects of the West Ells SAGD Project on wildlife may be categorized as habitat loss, mortality or habitat fragmentation and loss of connectivity. Each of these factors is discussed in relation to five Valued Ecosystem Components (VECs), which include Canadian toad, waterbirds, beaver, moose and woodland caribou. These species were selected based on several criteria including: 1) representation of a suite of species inhabiting common habitats; 2) indicator of environmental change; 3) economic and/or social importance, or; 4) classification as a species of concern by provincial or federal agencies. Project effects were discussed and assessed separately for the SAGD Project Study Area and the Access Road Study Area.

5.1 Potential Project Effects on VECs

5.1.1 Canadian Toad

Habitat requirements for Canadian toads vary seasonally. During the breeding season, activity is focussed on large permanent waterbodies, particularly lakes and ponds (Garcia et al. 2004), but also streams and artificial waterbodies such as borrow pits (Roberts et al. 1979, Roberts and Lewin 1979). Hibernacula are usually in sandy soils of upland sites, such as those found in jack pine or aspen stands, often along stream banks (Garcia et al. 2004). The hibernacula found by Garcia et al. (2004) in northeastern Alberta were typically “islands” of upland forest (aspen or jack pine) with sandy soil, surrounded by black spruce bog. Toads can travel up to 1,100 m from breeding habitat to hibernacula.

The Project has the potential to affect Canadian toads in several ways including habitat loss, mortality and fragmentation of habitat. Wetland loss and alteration has been identified as one of the primary threats to Canadian toads, particularly in southern Alberta where agriculture is prevalent (Hamilton et al. 1998). Alteration of drainage patterns or removal of waterbodies as a result of the Project would negatively affect Canadian toads during the breeding season.

There are also several mechanisms associated with the Project which could increase mortality rates. The first is associated with disturbance of hibernacula with clearing and construction activities. Canadian toads generally burrow below the frost line to avoid freezing during the winter, typically to at least 1.25 m in northeastern Alberta (Garcia et al. 2004). Exposure of hibernacula to frigid temperatures would result in the death of any hibernating toads, which are unable to withstand such conditions (Hamilton et al. 1998). Destruction of hibernacula can result in the loss of many individuals or even entire populations (Hamilton et al. 1998). Secondly, clearing and construction could result in direct mortality of individuals who were unable to move out of the way of machines and vehicles (Fahrig et al. 1995). The third potential source of mortality is pollution of waterbodies with deleterious substances associated with the Project, such as accidental spills of vehicle fuel and oil, other chemicals or even excessive amounts of dust. Amphibians are particularly vulnerable to contamination because of their thin skin that easily absorbs contaminants (ASRD 2002).

Construction of Project-related infrastructure also has the potential to fragment Canadian toad habitat and prevent individuals from accessing either breeding or hibernating habitat. In northeastern Alberta, toads make large-scale upslope movements of up to over 3 km cumulatively, between June and August (Garcia et al. 2004). Roads and other facilities may impede movement, potentially resulting in mortality when attempting to cross roads, longer journeys from going around infrastructure, and reduced reproductive rates if individuals are unable to reach breeding habitat.

5.1.2 Waterbirds

Waterbirds were selected as a VEC because of the importance of the area as migratory, and to a lesser extent, breeding habitats. The aerial waterfowl surveys conducted over the SAGD Project Study Area revealed high numbers of ducks and other waterbirds during the fall migratory period. Migratory waterfowl often return to the same lakes annually to rest and forage (DUC 2008), and alterations to waterbodies in the area may discourage birds from stopping. Both breeding and migratory habitats are considered important in the area, and therefore both were assessed. Although the specific nesting habitat requirements vary among species, it is generally assumed that non-forested habitat (i.e., marsh, graminoid or shrubby meadows) within 250 m of waterbodies provides potential nesting habitat (Westworth, Brusnyk and Associates 1996).

Waterbirds may be affected by the Project via habitat loss, sensory disturbance, or mortality. As previously mentioned, alteration to waterbodies could result in avoidance of this migratory stopover habitat. Consequences of this could include overuse of adjacent lakes, exhaustion and poor health in birds unable to stop in traditional areas, and altered migration patterns. Reproductive success could also be affected if nesting cover is removed and waterbodies altered such that forage availability declines. Sensory disturbance of waterbirds is expected to result in the indirect loss of otherwise suitable habitat. Ruddock and Whitfield (2007) conducted a review of disturbance distances for a number of bird species in the U.K. Common goldeneye tended to respond to human disturbance from a distance of up to 300 m during chick rearing, while experts suggested that black scoters responded from up to 500 m (Ruddock and Whitfield 2007). Black-throated divers, a species similar to the common loon in North America, had a mean disturbance distance of 368 m for static disturbances during incubation, and 343 m during chick-rearing (Ruddock and Whitfield 2007). In general, waterbirds seem to be more sensitive to disturbance when they have broods, and respond at a distance of approximately 300 m. Vehicles tend to produce less of an effect than human presence (Ruddock and Whitfield 2007).

Mortality could arise from several sources. Vegetation clearing during the breeding season has the potential to destroy nests or even birds. Ducks and geese attempting to cross roads could be struck by passing vehicles, while improved access to the area may result in increased hunting pressure. Also, lights on Project infrastructure could confuse birds, resulting in collisions with buildings and towers. Poor health and even mortality could result from contamination of waterbodies in the SAGD Project Study Area. There will be, however, measures in place to prevent the release of contaminated water with the SAGD process, and any accidental spills of vehicle fluids will be immediately cleaned up. In general, therefore, mortality is not considered the primary Project-related threat to waterbirds.

5.1.3 Beaver

American beaver is a semi-aquatic furbearer associated with streams, lakes, ponds and marshes in forested areas (Muller-Schwarze and Sun 2003). Waterbodies of at least 1.5 m depth are preferred, and stable shorelines are required for dam and lodge construction. Areas with abundant deciduous vegetation, including aspen, poplar, willow and alder, within 200 m of the waterbody are considered high quality habitat for beaver (Skinner 1984; Nietfeld et al. 1985). Typically, densities greater than one lodge/km of stream channel indicates a population in prime habitat (Muller-Schwarze and Sun 2003). In the SAGD Project Study Area, lodges often occurred in clusters on lakeshores. For example, on Lake 1, three lodges were located for a density of 0.7 lodges/km of shoreline. In contrast, Lake 2 had a density of 1.5 lodges/km of shoreline. This indicates that Lake 2 provides higher quality beaver habitat than Lake 1.

Beavers could be affected by the Project primarily through habitat loss or alteration and mortality. Direct loss of waterbodies and/or shoreline habitat would have a negative effect on beaver through the removal of forage and cover. Although beavers have the ability to create their own cover by modifying waterways, woody vegetation is required for dam material and forage. If this is not available, beavers will abandon the area for more favourable habitat. Sensory disturbance and proximity to anthropogenic features is not expected to affect beaver, as this species is frequently recorded adjacent to roads and other infrastructure.

Risk of mortality may increase with the Project due to increased human activity and access to the areas. Beaver may be subject to collisions with vehicles travelling through the area, particularly during construction when traffic levels will be highest. In addition, trapping and hunting could potentially increase with the improved access to the area.

5.1.4 Moose

Moose occur in various habitats often in close association with deciduous, shrub, riparian and especially with wetland habitats (Banfield 1974). Moose typically respond more to food availability than cover when compared to other ungulates (Kearney and Gilbert 1976). They require large amounts of woody browse (e.g., balsam fir, poplar, red osier dogwood, birch, willow) found in shrubby habitats that are characteristic of early seral stages of forest succession (initiated by fire or forest harvesting) and wetland (e.g., thicket swamp) habitats. Moose abundance increases with higher densities of small aspen, willow, shrub/saplings, snags and overall proportion of deciduous vegetation in forested habitats (Dussault et al. 2005). Wetlands have a disproportionate value for moose as they are an important source of forage, are used to escape predators and are also used during the summer to moderate their body temperature.

Although moose will be affected by habitat loss associated with the Project, regrowth in cleared areas may attract moose once sensory disturbance and human activity has decreased. Moose tend to avoid habitat around developments due to sensory disturbance (Westworth Brusnyk and Associates 1991), altered vegetation (Yost and Wright 2001), increased risk of vehicular collisions (Dussault et al. 2006), and increased access for predators and hunters. In eastern Alberta, moose avoided a heavy oil extraction facility in Cold Lake by at least 300 m (Westworth Brusnyk and Associates 1991). Avoidance is expected to decrease around quiet linear features such as winter roads and transmission lines.

Avoidance of Project-related infrastructure and disturbance may result in habitat fragmentation and disruption of movement patterns through the SAGD Project Study Area and the surrounding region. In addition to daily movements, moose also make seasonal movements from upland habitats in summer to lowland habitats in early and late winter (Hauge and Keith 1980, 1981). As of 2002 (Westworth Associates Environmental Ltd. 2002), no distinct travel routes had been identified in the Regional Sustainable Development Strategy (RSDS) study area in northeastern Alberta, although moose likely make use of riparian areas as movement corridors (Penner 1976) as well as sources of forage (Romito et al. 1999) and security cover (Timmerman and McNichol 1988). Placement of roads and Project facilities has the potential to disrupt traditional movement through the region.

Improved access into the area may also increase hunting pressure on moose. Moose populations are monitored by ASRD, but it is unclear at this point how much hunting pressure will increase and how moose will respond. Mortality may also increase due to collisions with vehicles associated with the Project, particularly during the construction phase.

5.1.5 Woodland Caribou

Woodland caribou in northern Alberta range over 500 km^2 annually, with the females using smaller home ranges than males during the summer (Stuart-Smith et al. 1997). Caribou require large, contiguous tracts of their preferred habitat (i.e., forested peatland) so that they can maintain low population densities across their range (Alberta Woodland Caribou Recovery Team 2005). This behaviour, called hyperdispersion, is an important anti-predator strategy, as predators usually hunt in areas with high prey density or predictability. These large home ranges may also reflect the relatively low and patchy availability of forage. The WSAR caribou herd, whose range overlaps the Access Road Study Area, is a declining population with a calf recruitment rate of 17.6 calves/100 cows and a cow survival rate of 83.1% (Alberta Caribou Committee 2008).

Woodland caribou rely primarily on lichen to meet their forage requirements during the winter (Thomas et al. 1996; Dzus 2001). Although lichens contain little protein, they provide a reliable source of digestible energy (Dunford 2003). In northeastern Alberta, lichens occur primarily in mature black spruce forest, although recent work suggests that early seral peatlands may also be a source of lichen (Dunford 2003). Woodland caribou showed avoidance of young and upland habitats, and a preference for old peatland habitat (Dunford 2003). Although caribou have been found to use recently burned areas in spring and summer (i.e., source of nutritious herbaceous vegetation; Nagy et al. 2003), burns provide little forage and habitat for caribou during the winter.

Loss of suitable habitat associated with Project-related vegetation clearing is a concern, but less so than habitat avoidance due to sensory disturbance. Caribou are highly sensitive to disturbance (Alberta Woodland Caribou Recovery Team 2005), particularly during the calving season (April to June). Calf mortality is highest in the first 30 days after birth (Dzus 2001), and every day that calves are allowed to develop undisturbed by humans and predators increases their chances of survival to 1 year of age (Boreal Caribou Committee 2005). At all times of the year, caribou tend to show strong avoidance of anthropogenic disturbance, particularly when levels of human activity are high (Dyer et al. 1999). Research conducted in northeastern Alberta found that caribou avoid roads by 100 – 250 m, old well sites by 250 – 500 m, new well sites by 250 - 1000 m, and conventional seismic lines by 100 – 250 m, depending on season and sex of caribou (Dyer et al. 1999). It is important to note that there was still caribou use of the areas within the avoidance zones, although use was significantly reduced compared to areas further from development.

Avoidance of development and human activity by caribou is a mechanism by which sensory disturbance, increased predation and hunting, and other sources of mortality are reduced. Improved access within the area including roads, seismic lines and utility lines, may lead to increased rates of predation by wolves, which are thought to travel along these linear features (James and Stuart-Smith 2000). Accessibility by predators is expected to be even higher on linear features used by humans, where the snow has been compacted and travel easy. Direct mortality associated with human access including poaching and vehicular collisions, is also a potential effect of the Project on caribou.

Project infrastructure has the potential to disrupt caribou movement through the region (i.e., connectivity). Dyer et al. (2002) found that although seismic lines were not barriers to caribou movement, roads with moderate traffic levels functioned as semi-permeable barriers. Caribou typically show reluctance to cross linear features (Dyer et al. 2002, Smith and Cameron 1983), especially when several features occur in parallel (e.g., road and pipeline; Curatolo and Murphy 1986). If caribou are unable to move freely across the landscape, the strategy of hyperdispersion may be compromised (Schaefer et al. 2001), resulting in higher predation rates.

5.2 SAGD Project Study Area Assessment

5.2.1 Overview

The most immediate effect of the Project in the SAGD Project Study Area will be the direct loss of wildlife habitat. A total of 60.7 ha are expected to be lost from clearing activities associated with the Phase 1 construction (Table 23). Most of the habitat lost will be deciduous and treed lowland forests, representing 5.8% and 3.1% of the total habitat available, respectively, in the SAGD Project Study Area at baseline. Treed lowland habitat supports a high density of breeding songbirds, and also appeared to provide good habitat for American marten and least weasel. Although no woodland caribou were observed in the SAGD Project Study Area, treed lowland habitat with black spruce and lichen is expected to provide high quality habitat for this species. Deciduous stands had moderate to low songbird densities, but relatively high diversity, and supported fisher, a "Sensitive" species in Alberta. Deciduous forest is also expected to provide forage and building materials for beaver, a species of social, economic and ecological importance in the area.

Smaller amounts of lowland shrub, deciduous-dominated mixedwood and white spruce habitats will also be lost as a result of the Phase 1 development (Table 23). Mixedwood and white spruce habitats are of particular importance for bay-breasted warbler, Cape May warbler and western tanager, and provides habitat for forest raptors and owls. Coniferous-dominated mixedwood forest appeared to be important for breeding songbirds, including "Sensitive" warblers, while the waterbodies supported high numbers of migrating and breeding waterfowl. Both of these habitats are not expected to be affected by Phase 1 of the Project.

Table 23. Extent of wildlife habitat in the SAGD Project Study Area that will be lost during construction of Phase 1 of the West Ells SAGD Project.

Habitat	Habitat Loss (ha)	% of Total Lost	% of Total Available in SAGD Project Study Area
Deciduous	20.2	33.3	5.8
Lowland treed	19.6	32.3	3.1
Lowland shrub	9.4	15.5	2.6
Deciduous-dominated mixedwood	6.6	10.9	1.9
White spruce	4.9	8.1	3.5
Disturbance	<0.1	<0.1	<0.1
Coniferous-dominated mixedwood	0	0	0
Marsh	0	0	0
Mixed coniferous	0	0	0
Sedge meadow	0	0	0
Waterbody	0	0	0
Total	**60.7**	**100.0**	**2.6**

5.2.2 Canadian Toad

5.2.2.1 Habitat Loss

At baseline, 304 ha of potential breeding habitat (waterbodies and marshes) are present in the SAGD Project Study Area. None of this habitat will be directly affected by construction or operation of Phase 1. Suitable hibernating habitat was considered to be ecosite phases with well-drained sandy soils and upland species and included b1, b2, c1, d1 and d2. These ecosite phases, however, are only suitable to toads for over-wintering if they occur within 1 km of waterbodies. Under baseline conditions, 559.3 ha of suitable hibernating habitat are present in the SAGD Project Study Area of which 26.8 ha will be affected by the Phase 1 development. This represents an approximate 4.8% loss of potential over-wintering habitat for Canadian toads.

Since breeding habitat is not limiting, and potential hibernating habitat will still be available in the SAGD Project Study Area, effects of direct habitat loss on Canadian toads are expected to be minimal. There is little evidence of sensory disturbance resulting in habitat avoidance by Canadian toads; rather, physical disturbance of hibernacula is a much greater threat to this species (Hamilton et al. 1998).

5.2.2.2 Mortality

The probability of increased mortality rates for toads occurring as a result of the Phase 1 development in the SAGD Project Study Area is considered to be relatively low. Less than 5% of the potential hibernating habitat in the SAGD Project Study Area will be disturbed during Phase 1, and therefore the probability of disturbing over-wintering toads is low. Canadian toads were not detected during spring amphibian surveys, and although this does not necessarily mean this species does not occur in the study area, it is most likely uncommon to rare. Risk can be further reduced by avoiding infrastructure placement in upland habitats as much as possible. Since few roads are present in the SAGD Project Study Area (other than access roads to the plant site and well pads), the risk of mortality due to vehicles is considered negligible.

5.2.2.3 Habitat Fragmentation and Connectivity

Although Project infrastructure will fragment Canadian toad hibernating habitat and reduce connectivity to a small extent, effects on toads are expected to be minimal. There is sufficient alternate habitat within the SAGD Project Study Area distant from the Phase 1 development that movement of Canadian toads is unlikely to be affected.

5.2.3 Waterbirds

5.2.3.1 Habitat Loss

Assuming that untreed habitats within 250 m of waterbodies function as potential nesting habitat for waterbirds, there was a total of 127.6 ha available at baseline (Table 24). This value changes very little with Phase 1 development, with the loss of only 0.2 ha of lowland shrub habitat. Similarly, the Phase 1 development does not affect any waterbodies in the SAGD Project Study Area, and therefore, direct loss of breeding or migratory habitat for waterbirds and waterfowl is negligible.

Table 24. Potential waterbird breeding habitat at baseline and with the Phase 1 development in the SAGD Project Study Area.

Potential Breeding Habitat	Baseline Case (ha)	Project Case (ha)	Difference (ha)	% Change
Lowland shrub	71.8	71.6	-0.2	0.1
Marsh	10.0	10.0	0.0	0.0
Sedge meadow	45.8	45.8	0.0	0.0
Total	**127.6**	**127.4**	**-0.1**	**<0.1**

Indirect loss of habitat due to sensory disturbance is a potential impact on waterbirds and waterfowl, particularly during the migration and brooding periods. Table 25 summarizes the distance from each waterbody to the closest Phase 1 infrastructure. Compared to the average disturbance distance of 300 m (Ruddock and Whitfield 2007), most waterbodies are far enough from the Phase 1 development that waterbirds are unlikely to be affected by Project-related activities.

Table 25. Distance from each major waterbody in the SAGD Project Study Area to the closest Phase 1 development infrastructure.

Waterbody	Distance to Closest Infrastructure (m)
1	2,912.9
1A	3,547.7
2	209.7
3	823.1
4	102.6
7	499.0
8	368.5
n/a	127.3
Average	**1,073.9**

5.2.3.2 Mortality

Since very little potential waterbird habitat will be affected by the Phase 1 development in the SAGD Project Study Area, mortality due to destruction of nests or vehicular collisions is also expected to be negligible. Potential increases in hunting can be minimized by controlling access to the SAGD Project Study Area and preventing employees from hunting on-site. Contamination of waterbodies from accidental spills of deleterious substances is also not expected to be an issue, and the immediate clean-up of any accidental spills of vehicle fluids and other chemicals will prevent pollution of waterbird habitat. Therefore, Phase 1 Project-related mortality is unlikely to affect waterbirds and waterfowl in the SAGD Project Study Area.

5.2.3.3 Habitat Fragmentation and Connectivity

The Phase 1 development is also not expected to have any effects on fragmentation and connectivity of waterbird habitat because most facilities will not be located close to waterbodies.

5.2.4 Beaver

5.2.4.1 Habitat Loss

No waterbodies will be directly affected by the Phase 1 development in the SAGD Project Study Area, and therefore there should be no impacts on beaver cover habitat. Forage habitat, considered to be deciduous or deciduous-dominated mixedwood stands within 200 m of waterbodies, will also be minimally affected by the Phase 1 footprint (Table 26). Availability of deciduous forest will remain unchanged with Phase 1 development, while deciduous-dominated mixedwood will decrease by 2.2 ha, or 4% of baseline. Overall, there should be only a 2% decrease in beaver forage habitat availability in the SAGD Project Study Area. This is not expected to affect beaver, which are also unlikely to be affected by sensory disturbance associated with the Phase 1 development.

Table 26. Deciduous habitat within 200 m of waterbodies affected by Phase 1 development in the SAGD Project Study Area.

Habitat Type	Baseline Case (ha)	Project Case (ha)	Difference (ha)	% Change
Deciduous	49.6	49.6	0.0	0.0
Deciduous-dominated mixedwood	54.2	52.0	-2.2	4.0
Total	**103.8**	**101.6**	**-2.2**	**2.0**

5.2.4.2 Mortality

Mortality due to vehicular collisions will not be discussed in detail for the SAGD Project Study Area, because the access road is assessed separately. The likelihood of beaver being struck by vehicles on the short access routes to Project infrastructure, such as borrow pits and well pads, is expected to be negligible. Trapping may increase with improved access into the SAGD Project Study Area, but can be controlled by regulating access. Overall, increases in mortality risk for beaver associated with Phase 1 development are expected to be negligible in the SAGD Project Study Area.

5.2.4.3 Habitat Fragmentation and Connectivity

Habitat fragmentation and connectivity is not expected to affect beaver in the SAGD Project Study Area. There is very little impact to beaver habitat, both waterbodies and adjacent forage, and therefore connectivity and fragmentation is not likely to be an issue.

5.2.5 Moose

5.2.5.1 Habitat Loss

Approximately 36.2 ha of moose habitat (deciduous, deciduous-dominated mixedwood, lowland shrub, marsh and sedge meadow; Table 23) in the SAGD Project Study Area will be directly affected by the Phase 1 development. This represents approximately 3% of the total moose habitat available in the study area at baseline, which is a relatively minor amount for moose. However, there is also expected to be some indirect loss of habitat within 300 m of noisy developments (e.g., plant site, borrow pits, roads) and 100 m of quiet, infrequently used features (e.g., utility corridor). Habitat within these Zones of Influence (ZOIs) is expected to receive less use than similar habitat further from disturbance. Thus, while habitat within these ZOIs is not completely unavailable for moose, it is considered to be of lower quality than comparable habitat elsewhere. The ZOIs are expected to decrease in size after construction is completed, and will likely be lower during the operations phase, depending on the level of activity. For this assessment, construction ZOIs were considered as the “worst-case scenario”.

Without considering ZOIs, there are approximately 1,122 ha of potential moose habitat in the SAGD Project Study Area (Table 27). Moose may also use other habitat types, but the five habitats identified in Table 27 were considered the highest quality for this species. When ZOIs were incorporated into the baseline case, availability of high quality moose habitat decreased by 56.5 ha, for a total of 1,065 ha outside the ZOIs. In the Project case (Phase 1 development), total habitat availability outside the ZOIs decreased by 12.7% relative to baseline. A total of 156.4 ha of potential high quality moose habitat fell within ZOIs around the Phase 1 development and existing disturbances, representing 14% of that available at baseline (without ZOIs). Once the busy construction period is over, however, and ZOIs have decreased around the Project, this habitat will become once again relatively high quality for moose. Therefore, impacts on moose habitat availability are considered moderate during construction, but minor for the remainder of the Project. On a regional scale, the Phase 1 development is not expected to affect moose populations because of habitat availability in adjacent regions.

Table 27. Change in moose habitat availability associated with Project development, based on 100-300 m ZOIs around Phase 1 infrastructure locations in the SAGD Project Study Area.

Habitat Type	Baseline Case (ha)	Baseline Habitat Availability		Project Habitat Availability		% Change with Project
		ZOI Habitat (ha)	Total Available (ha)	ZOI Habitat (ha)	Total Available (ha)	
Deciduous-dominated mixedwood	353.6	41.0	312.6	73.0	274.0	12.4
Deciduous	345.9	7.9	338.0	27.1	298.7	11.6
Lowland shrub	362.2	7.5	354.7	44.5	308.3	13.1
Marsh	10	0.0	10.0	0.0	10.0	0.1
Sedge meadow	49.8	0.0	49.8	11.8	38.0	23.7
Total Moose Habitat	**1,121.6**	**56.4**	**1,065.1**	**156.4**	**928.9**	**12.7**

5.2.5.2 Mortality

Hunting pressure on moose may increase with improved access to the SAGD Project Study Area. While it is not possible to quantify these changes at present, certain measures can be used to minimize the effects of hunting on moose. An access management plan can be used to control access into the SAGD Project Study Area, and minimize employee recreational activities in the study area. Unused cutlines and other potential access routes can be rolled back or blocked off to prevent access by hunters. With these mitigation measures, hunting-related mortality is not expected to have a significant effect on moose in the Project Study Areas.

Predation may also increase with improved access since wolves and other predators tend to travel along cutlines and other such features that provide easy access. Predator access is harder to control than human access, but mitigation such as slash piles across unused rights-of-way and preventing human access to cutlines (i.e., snowmobile trails) may be effective.

Wildlife-vehicle collisions are addressed in more detail as part of the Access Road Study Area assessment. Since vehicle speeds within the SAGD Project Study Area will be strictly controlled, the effects of wildlife-vehicle collisions on wildlife are expected to be negligible.

5.2.5.3 Habitat Fragmentation and Connectivity

The Phase 1 footprint does not appear to fragment high quality moose habitat in the SAGD Project Study Area since suitable moose habitat is already patchy and broadly distributed within the study area. The Phase 1 footprint itself is relatively small (60.7 ha) and not expected to significantly alter landscape metrics. However, the Phase 1 footprint may have an impact on moose movements through the SAGD Project Study Area and beyond. Although moose do not seem to use traditional trails in the same way as woodland caribou, they do tend to follow drainages and riparian corridors. Based on the occurrence of drainages and riparian corridors in the SAGD Project Study Area, several potential corridors for moose exist which may be affected by the Phase 1 development (Figure 13). Use of these corridors by moose can be confirmed with further field assessments. Once movement pathways have been confirmed, mitigation measures such as adjusting infrastructure placement where possible, wildlife crossings/ramps, and road signage can be used to reduce effects of the Project on moose movements.

5.2.6 Woodland Caribou

5.2.6.1 Habitat Loss

Phase 1 development will result in the direct loss of 29 ha of lowland treed (19.6 ha) and lowland shrub (9.4) habitats (see Table 23), which are considered relatively high quality for woodland caribou. This represents just 1.2% of the total habitat available in the SAGD Project Study Area (2,358.8 ha), and 2.9% of the available high quality habitat (1,000.3 ha). Direct habitat loss is not expected to have a significant effect on woodland caribou at the scale of the SAGD Project Study Area or region.

Indirect loss of habitat due to avoidance of disturbance is typically a larger issue for caribou than direct habitat loss. ZOIs were based on Dyer's (1999) work in northeastern Alberta, and included the following distances for various features: roads, camps, borrow pits = 250 m; plant and pads = 1000 m; old well pads = 500 m; other (utility lines etc) = 100 m. These ZOIs are applicable to female caribou during the calving season, when caribou are thought to be most sensitive to disturbance. Project ZOIs were assumed to be 1,000 m during construction, as noise and human activity will be greatest during this phase. As with moose, habitats within ZOIs were assumed to receive lower use than similar habitats further from disturbance.

Table 28. Change in woodland caribou habitat availability associated with Project development, based on 100-1,000 m ZOIs around Phase 1 infrastructure locations in the SAGD Project Study Area.

Habitat Type	Baseline Case (ha)	Baseline Habitat Availability		Project Habitat Availability		% Change with Project
		ZOI Habitat (ha)	Total Available (ha)	ZOI Habitat (ha)	Total Available (ha)	
Lowland shrub	362.2	47.7	314.5	149.5	212.7	32.3
Lowland treed	638.1	79.8	558.3	216.4	421.7	24.5
Total Caribou Habitat	**1,000.3**	**127.5**	**918.2**	**365.8**	**634.5**	**30.9**

At baseline, 1,000.3 ha of relatively high quality caribou habitat occurs within the SAGD Project Study Area (Table 28). When existing disturbance features are buffered by the ZOIs, the amount of caribou habitat in the SAGD Project Study Area is reduced to 918.2 ha. Most of this habitat is lowland treed, which is considered high quality habitat for caribou. However, with the addition of the Phase 1 development, 365.8 ha of lower quality habitat will be created in the SAGD Project Study Area because of the ZOIs associated with Phase 1 infrastructure. This represents an approximate 31% decrease in caribou habitat availability in the SAGD Project Study Area with Phase 1 development (Table 28). However, it should be noted that this does not indicate that caribou will avoid use of habitat located in Project ZOIs but rather caribou will likely use these areas at lower levels. Caribou use of the ZOIs may also increase slightly after Project construction is completed although caribou are typically sensitive to any human activity.

Based on the analysis of habitat ZOIs, effects of the Phase 1 development on caribou are considered to be moderate, and particularly during construction, since caribou may be deflected around the SAGD Project Study Area into other, more unsuitable habitats. The amount of caribou habitat that will be affected indirectly by the Phase 1 development is significant at the local level (e.g., SAGD Project Study Area), but given the widespread availability of suitable habitat in adjacent areas, these effects are not considered significant at the regional scale. Further, habitat within the ZOIs will be unaffected by the Phase 1 development and will still be available to caribou once construction activity has been completed. Use of construction timing windows, particularly during the sensitive calving season (March – July), will assist in further minimizing the effects of the Project on caribou.

5.2.6.2 Mortality

Improved access via the access road may result in higher rates of predation and more opportunities for poaching of caribou in the SAGD Project Study Area. Although predation is difficult to control, human access can be controlled with an Access Management Plan. An effective plan will minimize human travel along corridors, preventing the creation of hard-packed trails along which wolves and other predators can easily travel. With mitigation, only a minor increase in caribou mortality rates is expected within the SAGD Project Study Area.

5.2.6.3 Habitat Fragmentation and Connectivity

The north pad and utility corridor are located within a large area of lowland treed habitat (see Figure 2) which will not only result in the loss of effective caribou habitat but will also result in some fragmentation of remaining habitat. Similarly, Phase 1 development has the potential to affect caribou movement patterns in the SAGD Project Study Area. Caribou moving east-west across the study area may be deflected by Project infrastructure into low quality habitats with higher predator densities. However, effects on caribou movement cannot be fully assessed without knowledge of trail systems and movement patterns in the SAGD Project Study Area. These data can be collected with further surveys. Consequently, the Phase 1 development has the potential to affect caribou movement and habitat connectivity in the SAGD Project Study Area. Mitigation measures can be implemented to reduce this effect.

5.3 Access Road Study Area Assessment

5.3.1 Overview

The most direct effect of the Project in the Access Road Study Area will be habitat loss associated with road construction. It is expected that 67.8 ha of wildlife habitat will be lost (Table 29). Most of the habitat lost will be lowland shrub, deciduous-dominated mixedwood and deciduous, respectively representing 4.0%, 16.7% and 16.1% of the total habitat available in the Access Road Study Area at baseline. Lowland shrub had lower habitat suitability for breeding songbirds, but provided good habitat for moose and beaver. Depending on the location, lowland shrub may also provide suitable nesting habitat for waterbirds and waterfowl. Deciduous-dominated mixedwood had relatively high songbird densities, and provided habitat for Cape May warbler and western tanager, two “Sensitive” species. In addition, fisher and grouse were most abundant in this mixedwood type. Deciduous stands had moderate to low songbird densities, but relatively high diversity, and supported fisher, a “Sensitive” species in Alberta. Deciduous forest is also expected to provide forage and building materials for beaver, a species of social and ecological importance in the area.

Smaller amounts of lowland treed, mixed coniferous and white spruce will also be lost during Project development (Table 29). Lowland treed habitat had particularly high songbird density, while white spruce stands supported "Sensitive" species such as the bay-breasted warbler. Coniferous-dominated mixedwood, marsh, mixed coniferous, sedge meadow and waterbody types in the Access Road Study Area will not be affected by road construction. Coniferous-dominated mixedwood forest appeared to be important for breeding songbirds, including "Sensitive" warblers, while the waterbodies supported high numbers of migrating and breeding waterfowl.

Table 29. Habitat losses associated with road construction in the Access Road Study Area.

Habitat	Habitat Loss (ha)	% of Total Lost	% of Total Available in Access Road Study Area
Lowland shrub	15.4	22.7	4.0
Deciduous-dominated mixedwood	14.9	22.0	16.7
Deciduous	13.5	20.0	16.1
Lowland treed	11.5	16.9	5.3
Mixed coniferous	10.5	15.5	9.1
White spruce	1.9	2.9	10.8
Sedge meadow	0.1	0.1	0.2
Coniferous-dominated mixedwood	0.0	0.0	0.0
Disturbance	0.0	0.0	0.0
Marsh	0.0	0.0	0.0
Waterbody	0.0	0.0	0.0
Total	**67.8**	**100.0**	**7.1**

5.3.2 Canadian Toad

5.3.2.1 Habitat Loss

At baseline, 29.5 ha of potential breeding habitat (waterbodies and marshes) is available for Canadian toads in the Access Road Study Area. However, none of this breeding habitat will be directly affected by construction or operation of the Project. In the case of hibernating or over-wintering habitat, ecosite phases with well-drained sandy soils and upland vegetation species were considered suitable for toads including b1, b2, c1, d1 and d2. These ecosite phases, however, are only suitable for Canadian toads if they are located within approximately 1 km of waterbodies. Based on this criterion, 194.0 ha of potential hibernating habitat exist within the Access Road Study Area at baseline but decreases by 27.1 ha to 166.9 ha under the Project case. This represents an approximate 14.0% loss of potential over-wintering habitat for toads.

Most of the Access Road Study Area is composed of habitat unsuitable for hibernation by toads, and therefore the loss of 14.0% of potential hibernation habitat may appear to be significant. However, the Access Road Study Area is only 1 km wide, centred on the proposed road, and does not consider habitat available to toads outside the area but within 1 km of waterbodies. Based on satellite imagery classified into vegetation types by the Earth Observatory for Sustainable Development of Forests (http://cfs.nrcan.gc.ca/subsite/eosd), it was determined that most of the habitat around the Access Road Study Area is lowland shrub or treed bog, and therefore unsuitable as over-wintering habitat. These data suggest that toads are uncommon in the area but this should be confirmed by conducting surveys in the Access Road Study Area. In summary, the Project has the potential to affect over-wintering habitat for Canadian toads within the Access Road Study Area, but this effect is unlikely to be significant at a regional level.

5.3.2.2 Mortality

The probability of increased mortality of Canadian toads occurring in the Access Road Study Area as a result of Project development is considered to be relatively low. Only a small amount of potential hibernating habitat will be disturbed by clearing, and the likelihood of disturbing toads is considered to be low. Risk can be further reduced by avoiding upland habitat with sandy soils as much as possible. There is also potential for toads to be run over by vehicles on the access road, as they move to and from upland habitats. This risk can be minimized through the appropriate use of culverts and bridges to maintain connectivity of aquatic habitat. These structures also act as “underpasses” for migrating Canadian toads. Overall, Project-related mortality of Canadian toads in the Access Road Study Area is expected to be negligible.

5.3.2.3 Habitat Fragmentation and Connectivity

As discussed above, the access road may affect connectivity of Canadian toad habitat. With mitigation, however, significant Project-related effects are not expected to occur.

5.3.3 Waterbirds

5.3.3.1 Habitat Loss

Based on the assumption that unforested habitat within 250 m of waterbodies provides potential nesting habitat for waterbirds, 52.4 ha of suitable nesting habitat occurs within the Access Road Study Area at baseline (Table 30). Availability of suitable waterbird nesting habitat changes very little with Project development, with the loss of only 1.1 ha of lowland shrub habitat and less than 0.1 ha of sedge meadow habitat. Similarly, the Project does not affect any waterbodies in the Access Road Study Area, and therefore, direct loss of breeding or migratory habitat for waterbirds and waterfowl is negligible.

Table 30. Potential waterbird breeding habitat at baseline and with Project development in the Access Road Study Area.

Potential Breeding Habitat	Baseline Case (ha)	Project Case (ha)	Difference (ha)	% Change

Lowland shrub	44.2	43.1	-1.0	2.3
Marsh	0.0	0.0	0.0	0.0
Sedge meadow	8.2	8.1	0.1	0.3
Total	**52.4**	**51.2**	**-1.1**	**2.1**

Indirect loss of habitat due to sensory disturbance can affect waterbirds and waterfowl, particularly during migration and brooding. Most of the waterbodies in the Access Road Study Area are within the average disturbance distance of 300 m (Ruddock and Whitfield 2007) (Table 31) and therefore, sensory disturbance is a potential issue. Sensory disturbance is most likely to occur during Project construction, while disturbance associated with operations and maintenance activities being limited mostly to vehicular traffic along the access road. Since disturbance distances are typically lower with vehicles than human disturbance, it is expected that sensory disturbance will be negligible following Project construction.

Table 31. Distance from major waterbodies in the Access Road Study Area to the closest Project infrastructure.

Waterbody	Distance to Closest Infrastructure (m)
1	417.0
2	354.4
3	205.6
4	153.3
5	117.3
6	116.2
7	47.5
Average	**201.6**

5.3.3.2 Mortality

Since very little potential waterbird habitat will be affected by the Project in the Access Road Study Area, mortality due to destruction of nests or vehicular collisions is expected to be negligible. Potential increases in hunting can be minimized by controlling access to the Access Road Study Area and preventing employees from hunting on-site. Contamination of waterbodies from accidental spills of deleterious substances is also not expected to be an issue, and the immediate clean-up of any accidental spills of vehicle fluids and other chemicals will prevent pollution of waterbird habitat. Therefore, Project-related mortality is unlikely affect waterbirds and waterfowl in the Access Road Study Area.

5.3.3.3 Habitat Fragmentation and Connectivity

The Project is also not expected to have any impacts on fragmentation and connectivity of waterbird habitat because the access road will not be located close to most waterbodies.

5.3.4 Beaver

5.3.4.1 Habitat Loss

No waterbodies will be directly affected by Project development in the Access Road Study Area, and there should be no impacts on beaver cover habitat. However, forage habitat, considered to be deciduous or deciduous-dominated mixedwood stands within 200 m of waterbodies, will be affected construction of the access road (Table 32). Availability of deciduous forest is expected to decrease by almost 20% (3.7 ha) following road construction, while deciduous-dominated mixedwood will decrease by only 0.5 ha, or 4% of baseline. Overall, forage habitat availability for beaver in the Access Road Study Area will decrease by 4.2 ha or 13.2% (Table 32). While this may seem significant at the local level (because of the small size of the study area), effects of the Project on beaver foraging habitat is expected to be negligible at the regional level.

Table 32. Deciduous habitat within 200 m of waterbodies affected by the Project in the Access Road Study Area.

Habitat Type	Baseline Case (ha)	Project Case (ha)	Difference (ha)	% Change
Deciduous	18.8	15.1	-3.7	19.7
Deciduous-dominated mixedwood	13.0	12.5	-0.5	3.8
Total	**31.8**	**27.6**	**-4.2**	**13.2**

5.3.4.2 Mortality

The road will provide improved, all-season access into the area, which could potentially increase the trapping-related mortality for beaver. However, the effects of trapping mortality can be minimized with the implementation of an Access Management Plan that controls public access into the area. Wildlife-vehicle collisions may also result in some beaver mortality but is not expected to be a concern. Overall, Project-related effects on beaver mortality in the Access Road Study Area are expected to be negligible.

5.3.4.3 Habitat Fragmentation and Connectivity

While waterbodies in the Access Road Study Area will not be affected road construction, there will be some fragmentation of deciduous and deciduous-dominated mixedwood habitats. However, most waterbodies are far enough from the road that beavers will still be able to access forage without having to cross roads. Overall, Project-related effects related to habitat fragmentation and connectivity are not expected to affect beaver at the local or regional levels.

5.3.5 Moose

5.3.5.1 Habitat Loss

Approximately 44 ha of relatively high quality moose habitat (i.e., deciduous, deciduous-dominated mixedwood, and lowland shrub; see Table 29) will be cleared during construction of the access road. This represents a loss of 7.7% of the potential moose habitat available in the Access Road Study Area, which is a considered to be a relatively minor loss for moose. At baseline, 567.5 ha of potential high quality moose habitat are present in the Access Road Study Area, 68% of which is comprised of lowland shrub (Table 33). When ZOIs (100-300 m) are buffered around existing disturbances in the Access Road Study Area, potential moose habitat availability is reduced by only 10.8 ha. With Project development, however, moose habitat availability (based on ZOIs of 100–300 m) in the Access Road Study Area will be reduced by about 216 ha (or 61.3% (Table 33). While this suggests that moose habitat suitability near the access road will be reduced by sensory disturbances associated with road construction, moose are expected to use these habitats once construction has been completed. Overall, a temporary reduction in moose habitat suitability is expected during construction of the access road, but this disturbance effect is not expected to affect local or regional moose populations.

Table 33. Change in moose habitat availability associated with Project development, based on 100-300 m ZOIs around infrastructure locations in the Access Road Study Area.

Habitat Type	Baseline Case (ha)	Baseline Habitat Availability		Project Habitat Availability		% Change with Project
		ZOI Habitat (ha)	Total Available (ha)	ZOI Habitat (ha)	Total Available (ha)	
Deciduous-dominated mixedwood	89.6	9.9	79.7	58.5	31.1	61.0
Deciduous	84.2	0.9	83.3	5.1	29.1	65.0
Lowland shrub	383.4	0.0	383.4	230.8	152.6	60.2
Marsh	0.0	0.0	0.0	0.0	0.0	0.0
Sedge meadow	10.3	0.0	10.3	7.5	2.8	73.2
Total Moose Habitat	**567.5**	**10.8**	**556.7**	**351.9**	**215.6**	**61.3**

5.3.5.2 Mortality

Hunting pressure on moose may increase with improved access to the Access Road Study Area. While it is not possible to quantify these changes at present, certain measures can be used to minimize the effects of hunting on moose. An access management plan can be used to control access into the Access Road Study Area, and to minimize employee recreational activities in the study area. Unused cutlines and other potential access routes can be rolled back or blocked off to prevent access by hunters. With these mitigation measures, hunting-related mortality is not expected to have a significant effect on moose in the Access Road Study Area.

Predation may also increase with improved access since wolves and other predators tend to travel along cutlines and other such features that provide easy access. However, predators may avoid travelling along the access road due to high levels of traffic, particularly during construction, and therefore predation is not likely to increase greatly with the Project.

Vehicular collisions are a potential threat to moose attempting to cross the access road or travelling along it, particularly at night. Impacts can be mitigated by placing signage at potential crossing areas along the road, and enforcing low speed limits. With these measures, mortality due to vehicular collisions is expected to be minor for moose.

5.3.5.3 Habitat Fragmentation and Connectivity

The access road is expected to reduce connectivity of habitat and have low to moderate effects on movement of moose throughout the Access Road Study Area. Although moose do not seem to use traditional trails in the same way as woodland caribou, they do tend to follow drainages and riparian corridors. As with the SAGD Project Study Area, there are a number of potential movement pathways across the Access Road Study Area (Figure 14). Based on the occurrence of trails in the Road Access Study Area, several potential corridors for moose exist which may be affected by access road construction. This may disrupt movement of moose in the Access Road Study Area and into the surrounding region, which could result in moose mortality from vehicular collisions or moose travelling through lower quality habitat. Use of these corridors by moose can be confirmed with further surveys. Once movement corridors have been confirmed, mitigation measures such wildlife crossing signage and reduced speed limits can be used to reduce effects of the access road on moose movements.

5.3.6 Woodland Caribou

5.3.6.1 Habitat Loss

Project development will result in the direct loss of 26.9 ha of lowland treed and lowland shrub habitats (Table 29), which are considered relatively high quality for woodland caribou. This represents just 4.5% of the total habitat available in the Access Road Study Area. Direct habitat loss is not expected to have a significant effect on woodland caribou at the scale of the Access Road Study Area or in the region.

It was assumed that caribou will avoid the access road footprint by 1 km during construction, the most intense period of human activity and disturbance. This value was based on Dyer's (1999) work in northeastern Alberta, and assumed that construction was similar in disturbance value to new well pads. Since the Access Road Study Area is only 1 km wide, centered on the access road, caribou are expected to avoid the Access Road Study Area during construction, plus an additional 500 m into the Wabasca-Dunkirk caribou management zone. Although this complete avoidance may not occur, construction of the access road will affect woodland caribou at the local level.

Caribou may be forced out of the Access Road Study Area and into adjacent areas, including the Wabasca-Dunkirk caribou management zone, which is 1.5 million ha in size. Because of the large size of the caribou zone and relative lack of development in this region, construction of the access road is unlikely to affect caribou populations at the regional level. While the access road alone is unlikely to affect caribou in the Wabasca-Dunkirk management zone, increasing regional activity may have some impact on caribou. Sorensen et al. (2007) used a regression model to demonstrate that caribou populations in northern Alberta are sustainable in areas with up to 66% of the habitat burned or up to 61% of the habitat within 250 m of development. In addition, a number of studies have identified threshold values for cumulative effects indicators for caribou (Table 34). The proposed West Ells SAGD access road will contribute to cumulative effects in the Wabasca-Dunkirk caribou management zone by increasing the density of linear features in the caribou management zone. However, at the present time, the presence of the West Ells SAGD Project access road is not considered significant, but increasing regional development may have some impact on caribou.

Table 34. Guideline or threshold values for cumulative effects indicators for woodland caribou.

Indicator	Guideline or Threshold	Comments
Total Corridor Density (>3 m wide)	>1.8 km/km^2 (Francis et al. 2002)	Boreal caribou populations decline above threshold.
	>3 km/km^2 (Stelfox *in* Salmo Consulting 2004)	Boreal caribou populations do not persist above threshold.
	2.04 km/km^2 (Dzus 2001)	Linear corridor density associated with declining caribou populations in ESAR caribou range.
	>1.2 km/km^2 (Weclaw and Hudson 2004)	Caribou extirpated from northern Alberta in 40 years if linear densities exceed threshold.
Road Density	1.0 – 1.3 km/km^2 (Dyer et al. 2002)	Density in caribou seasonal home ranges in Alberta.
	<0.6 km/km^2 (Salmo Consulting 2004)	Road densities in mountain ecotype caribou range.

5.3.6.2 Mortality

Improved access via the access road may result in higher rates of predation and more opportunities for poaching of woodland caribou in the Access Road Study Area. Access by humans can be limited by implementing an Access Management Plan and employee education programs. Predators are expected to avoid travelling along the access road because of the expected traffic levels, particularly during construction, and therefore predation of caribou is not likely to increase greatly with construction of the access road.

Vehicular collisions are a potential threat to caribou attempting to cross the access road or travelling along it, particularly at night. Impacts can be mitigated by placing sign postage at the intersection of caribou trails along the road (Figure 6), and enforcing low speed limits. With these and other measures, mortality due to vehicular collisions is expected to be minor for woodland caribou.

5.3.6.3 Habitat Fragmentation and Connectivity

The access road will contribute to habitat fragmentation and connectivity of caribou habitat within the Access Road Study Area. As previously discussed, caribou tend to follow traditional trails and if these trails are bisected by a busy access road, are reluctant to cross. An aerial survey conducted in October 2008 identified a number of trails that may be important in maintaining caribou movement through the Access Road Study Area and surrounding region. Use of these corridors by caribou can be confirmed by conducting additional surveys. Once movement corridors have been confirmed, mitigation measures such wildlife crossing signage and reduced speed limits can be used to reduce effects of the access road on caribou movements. However, even with these mitigation measures, the presence of the access road is still expected to affect caribou habitat connectivity within the Access Road Study Area.

As previously discussed, the effects of the access road on regional caribou populations, such as those within the Wabasca-Dunkirk caribou management zone, are not expected to be significant. At present, there is relatively little development in this region and cumulative effects are fairly minor. The access road itself represents the addition of only a 6.8 km linear feature into the north end of the caribou management zone, and it is likely that caribou can avoid the area without being affected by the road. However, the contribution of future projects within the caribou management zone may result in the exceedance of cumulative effects thresholds (Table 34) which may exacerbate caribou population declines in the region.

6

6.0 WILDLIFE PROTECTION MEASURES

As discussed above, potential effects of Phase 1 of the West Ells SAGD Project and access road include direct and indirect habitat loss, increased mortality, and habitat fragmentation with the introduction of corridors and facilities. To minimize the effects of the proposed SAGD project and associated infrastructure on wildlife, the following additional protection measures should also be implemented in the SAGD Project and/or Access Road Study Areas as appropriate.

6.1 Habitat Loss

- Final location and size of plant, well pads, roads and borrow pits should be designed to reduce the impact to old-growth forests, riparian areas and other unique habitats.
- Vegetation clearing should be conducted during the winter months to avoid sensory disturbance of breeding birds and calving woodland caribou. An "early-in, early-out" policy should be employed with regards to caribou (i.e., start activities 15 October and be out of the area by 15 February, whenever possible).
- The reclamation plan should include measures such as progressive reclamation of unused features (e.g., temporary road widening to facilitate construction vehicles), conversion of borrow pits into wetlands for amphibians and waterbirds, and use of native species for all reclamation. The access road should be promptly rolled back and reclaimed immediately following Project closure.
- Hydrological flow should be maintained through the use of culverts, bridges and other devices as necessary.

6.2 Mortality

- If vegetation clearing cannot be accomplished during the fall and winter months, nest searches should be conducted prior to clearing between May and August. This will reduce the probability of destroying raptor, songbird and waterfowl/waterbird nests.
- An Access and Recreation Management Plan should be designed and implemented to minimize recreational use of the area once the road has been constructed. This will include, but will not be limited to the following:
    - Restriction of the recreational use of snowmobiles and ATV's along the access road and utility corridors by Project employees.

  - o New linear features (cutlines) that are connected to the main access road should be blocked to minimize recreational use.
  - o Project employees should be prohibited from hunting along the access road and in the SAGD Project Study Area.
  - o Access should be coordinated with neighbouring operators.
  - o Low speed limits should be enforced along all access roads and signs should be posted at wildlife crossings or important wildlife habitat areas to minimize mortality risk.
  - o A policy should be implemented concerning no-littering and no feeding or harassment of wildlife by on-site workers.
  - o All wildlife mortalities resulting from collisions with vehicles should be promptly reported to ASRD personnel.
- Creation of a Spill Management Plan, including measures such as refueling vehicles away from waterbodies, carrying spill kits in all vehicles, and prompt reporting and cleaning up of accidental spills.
- To minimize interactions with bears and other scavenging wildlife, all garbage should be stored in bear-proof containers until such time as it is transported to off-site waste treatment facilities.

6.3 Habitat Fragmentation and Connectivity

Pre-disturbance surveys should be carried out to confirm the occurrence of wildlife trails within the SAGD Project Study Area and Access Road Study. These surveys may involve a combination of ground surveys and remote cameras, and aerial surveys in areas not previously surveyed. Data from these surveys could be used to determine placement of road signage to limit vehicle speeds in areas identified as wildlife crossings, place wildlife crossing structures where appropriate (necessary only if aboveground pipeline is adjacent to the road) and to monitor changes in wildlife use in the area.

6.4 Monitoring

A wildlife monitoring program should be put in place during the operations and decommissioning phases of the Project. The goals of the wildlife monitoring program should be to evaluate the effectiveness of wildlife mitigation and reclamation procedures. Sunshine Oilsands Ltd. should work with ASRD to develop the details of such a monitoring program.

7

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8

8.0 PERSONAL COMMUNICATIONS

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9

9.0 CLOSURE

This report was prepared by Westworth Associates Environmental Ltd. for Sunshine Oilsands Ltd. and Millennium EMS Solutions Ltd. The material in it reflects Westworth Associates Environmental Ltd.'s best judgement in light of the information available to it at the time of preparation. Any use which a third party makes of this report, or any reliance on or decisions made based on it, are the responsibilities of such third parties. Westworth Associates Environmental Ltd. accepts no responsibility for damages, if any, suffered by any third party as a result of decisions made or actions based on this report.

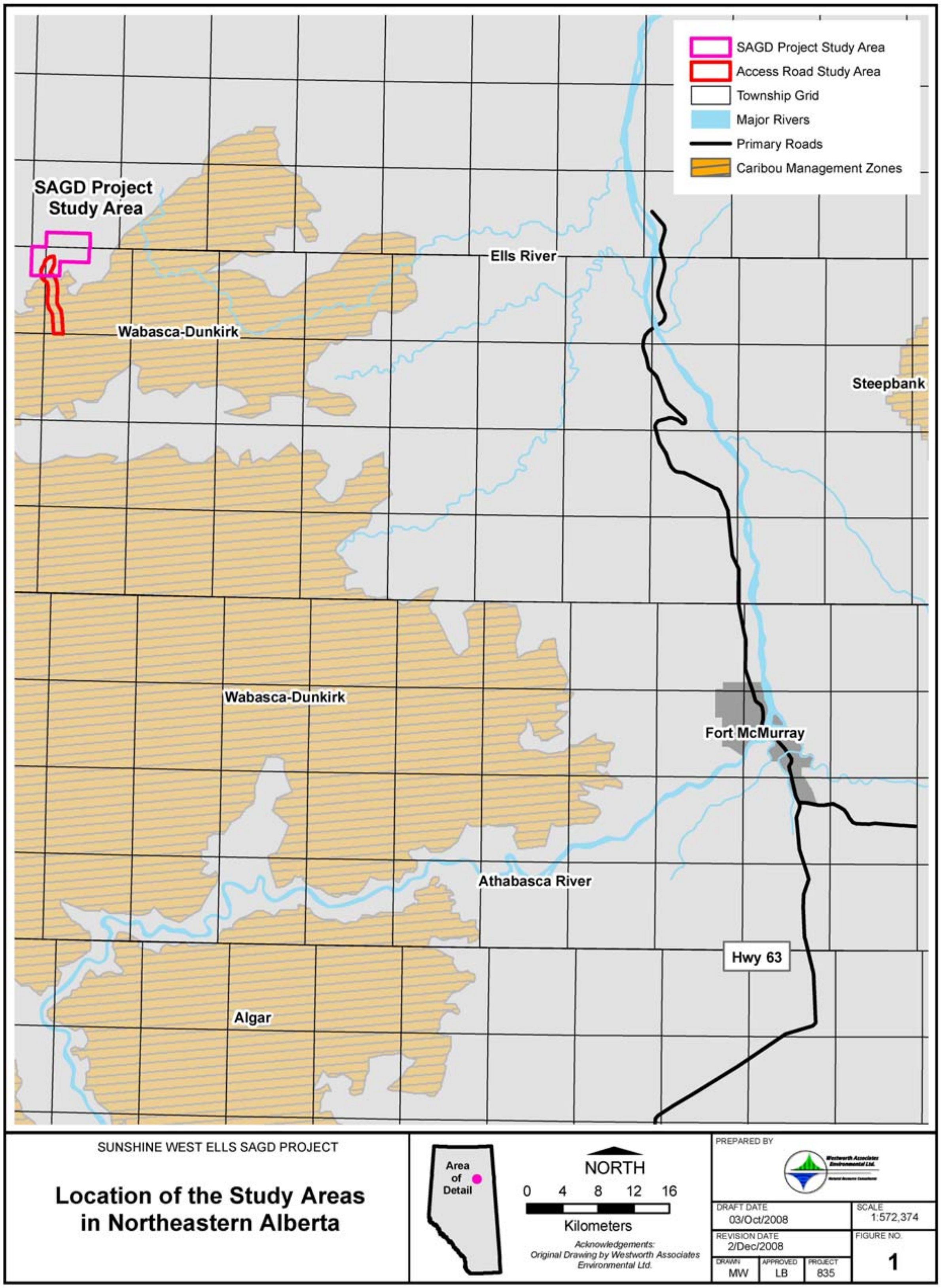

Figure 1. Location of the Project in northeastern Alberta.

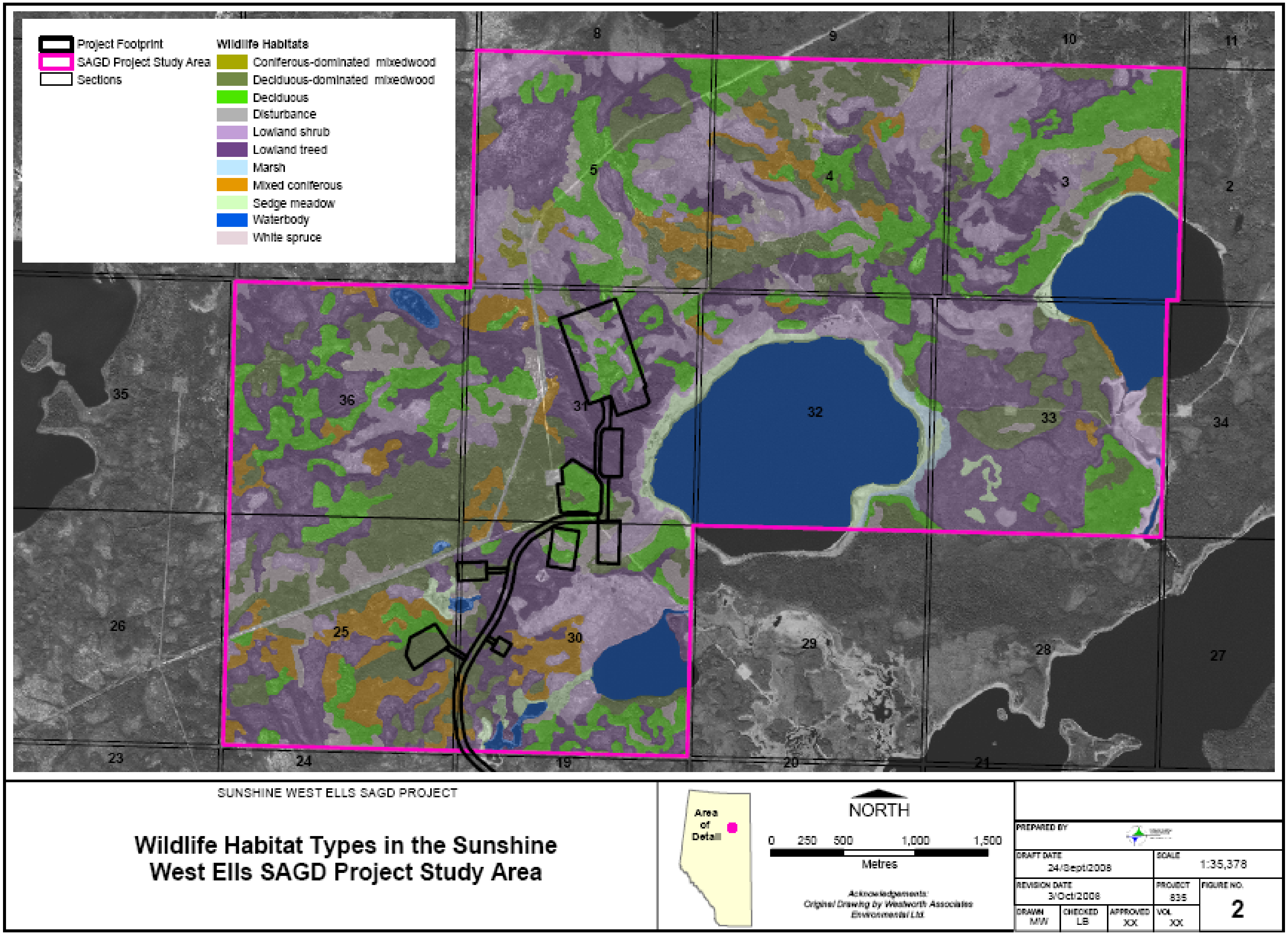

Figure 2. Wildlife habitat types in the West Ells Study Areas.

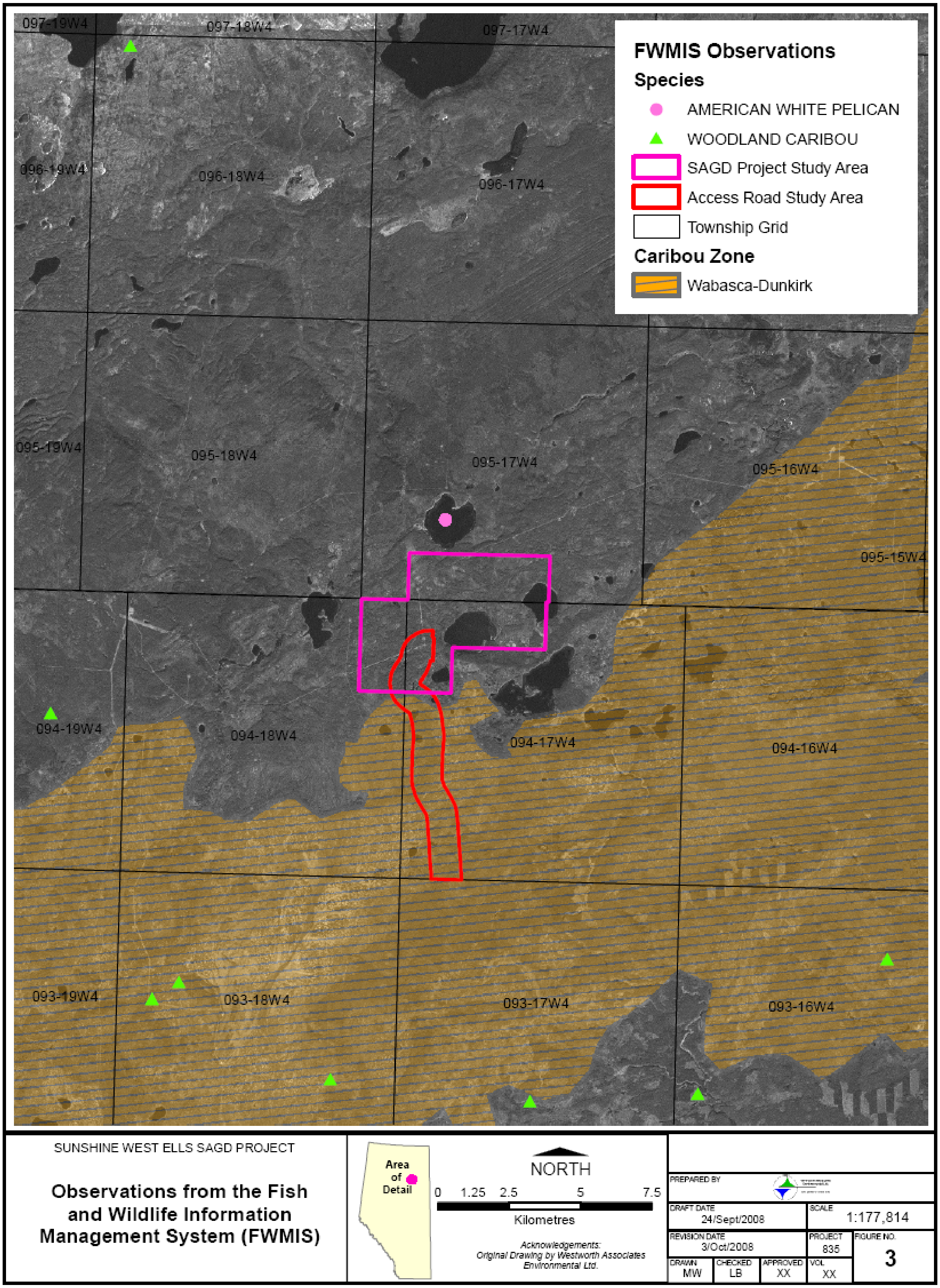

Figure 3. Observations from the Fish and Wildlife Information Management System (FWMIS).

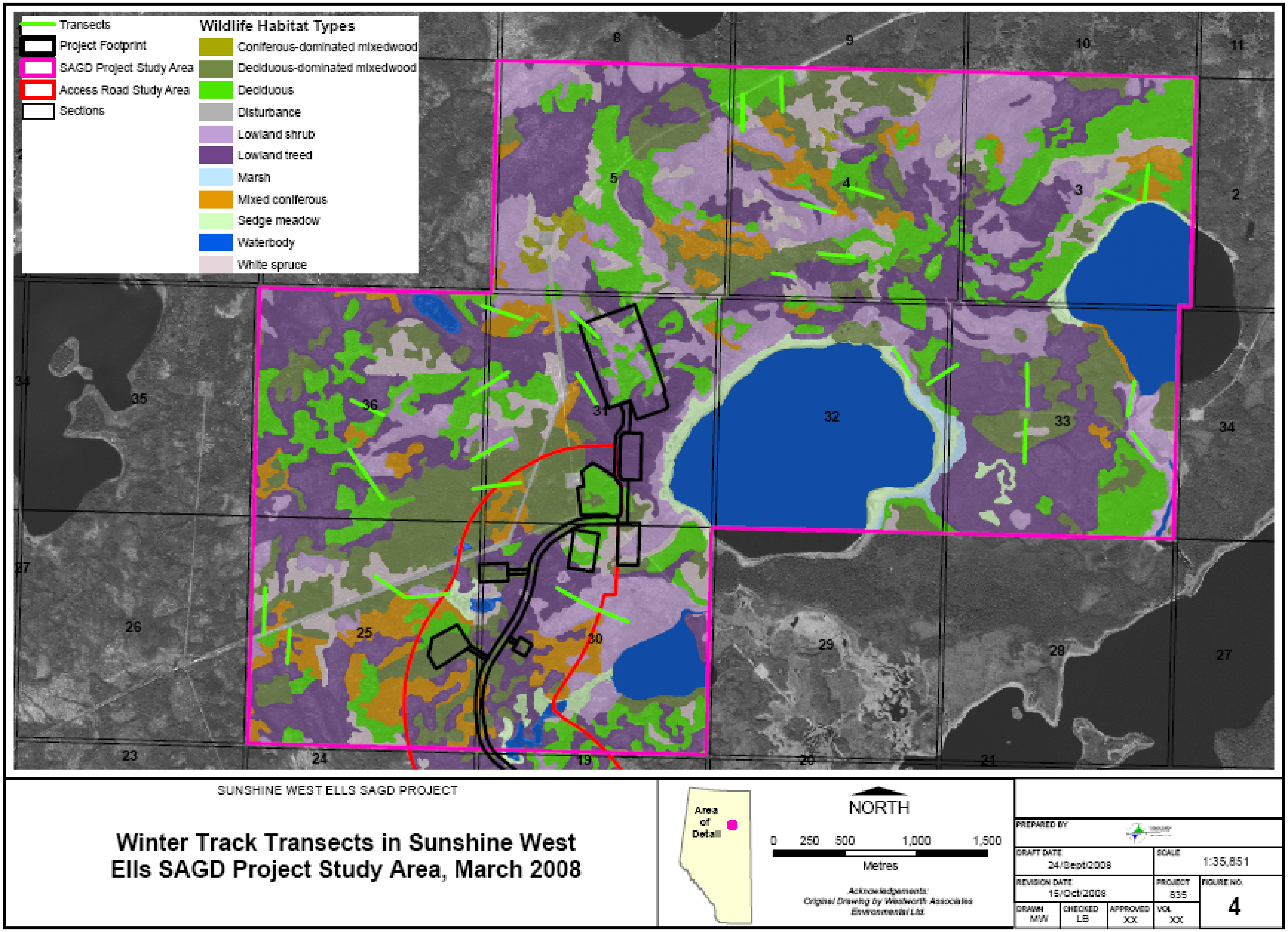

Figure 4. Winter track transects in the West Ells SAGD Project Study Area, March 2008.

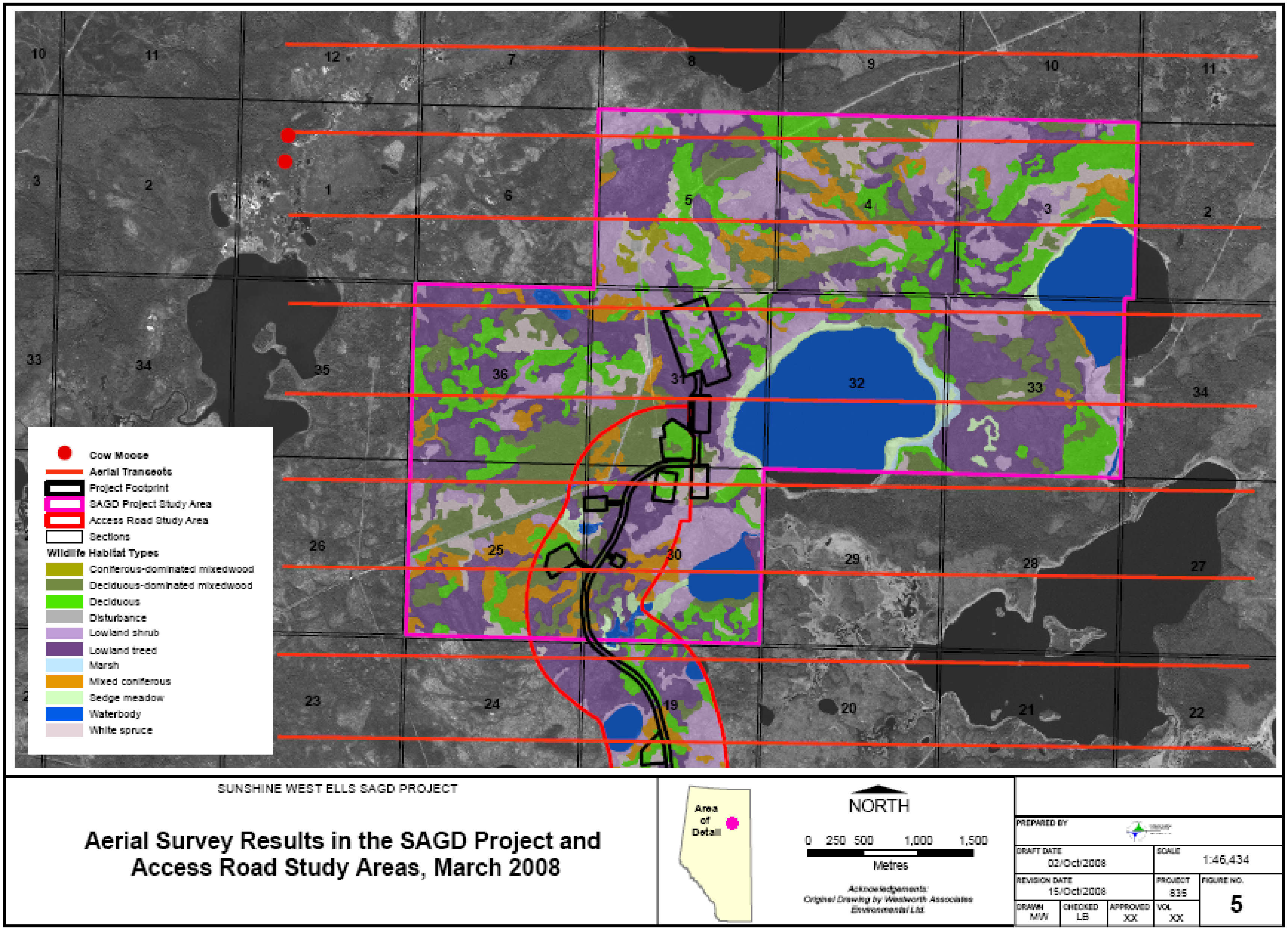

Figure 5. Aerial survey results in the West Ells Study Areas, March 2008.

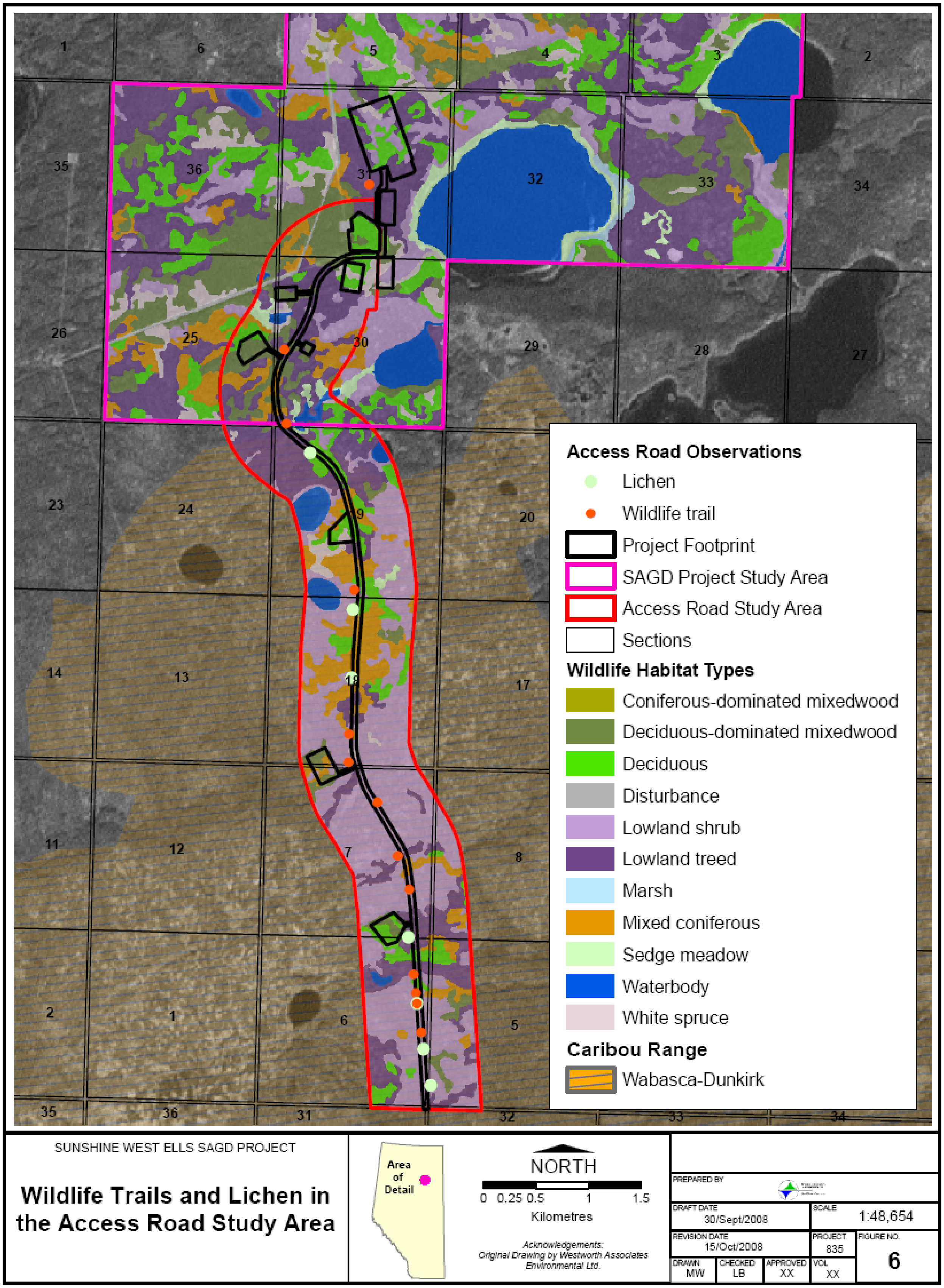

Figure 6. Wildlife trails and lichen areas identified in the Access Road Study Area.

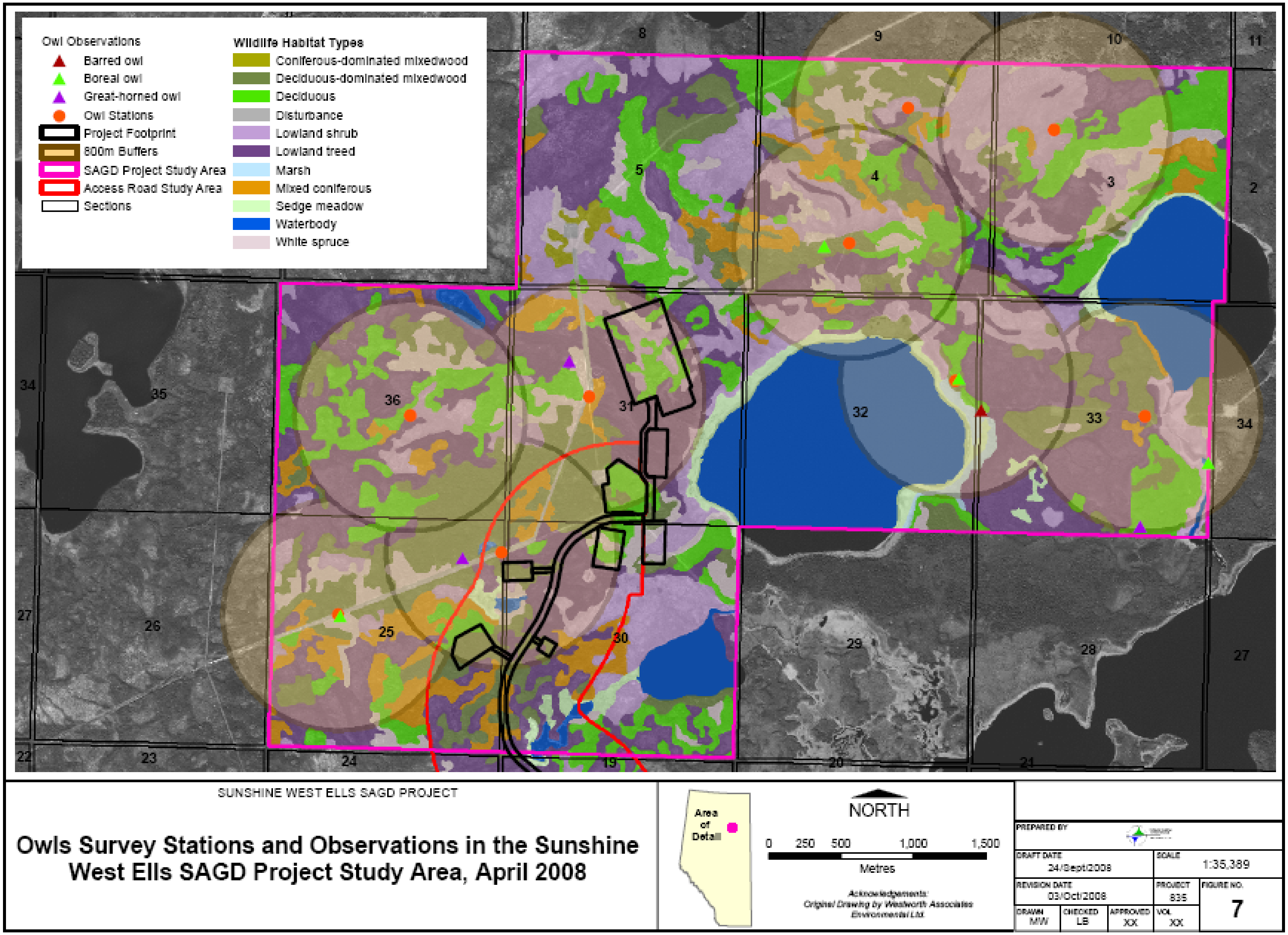

Figure 7. Owl survey stations and observations in West Ells SAGD Project Study Area, April 2008.

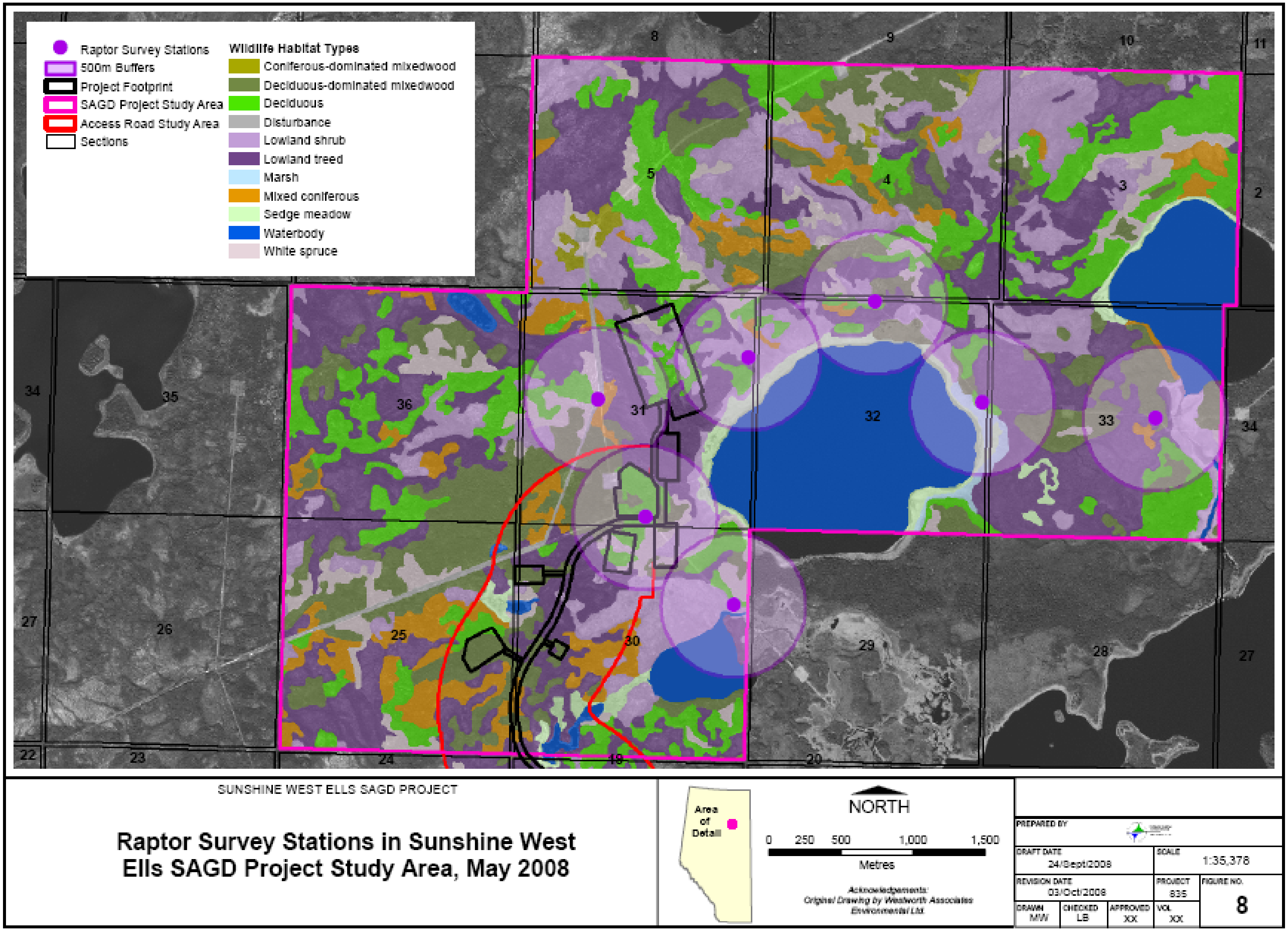

Figure 8. Raptor survey stations in the West Ells SAGD Project Study Area, May 2008.

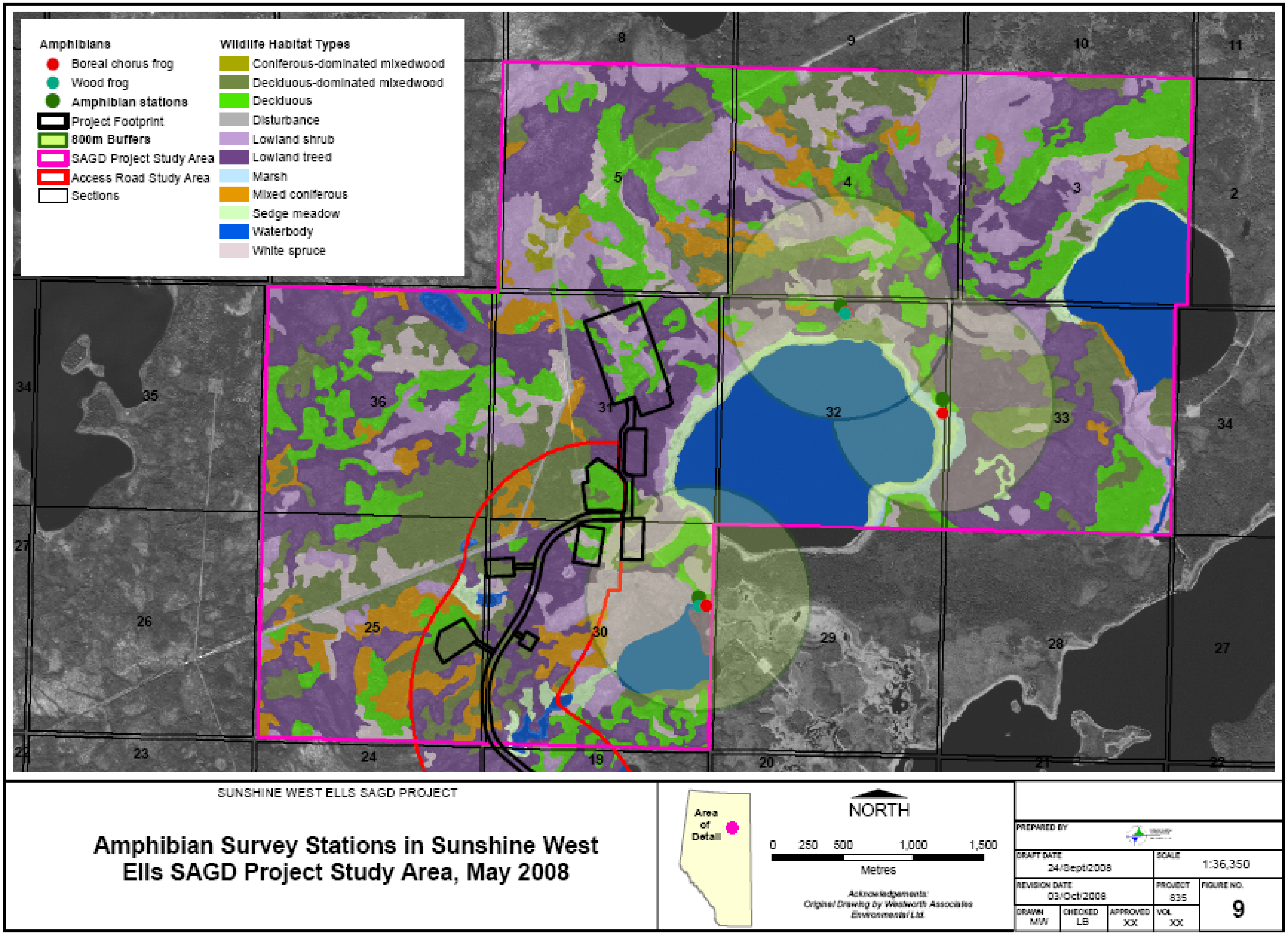

Figure 9. Amphibian survey stations in West Ells SAGD Project Study Area, May 2008.

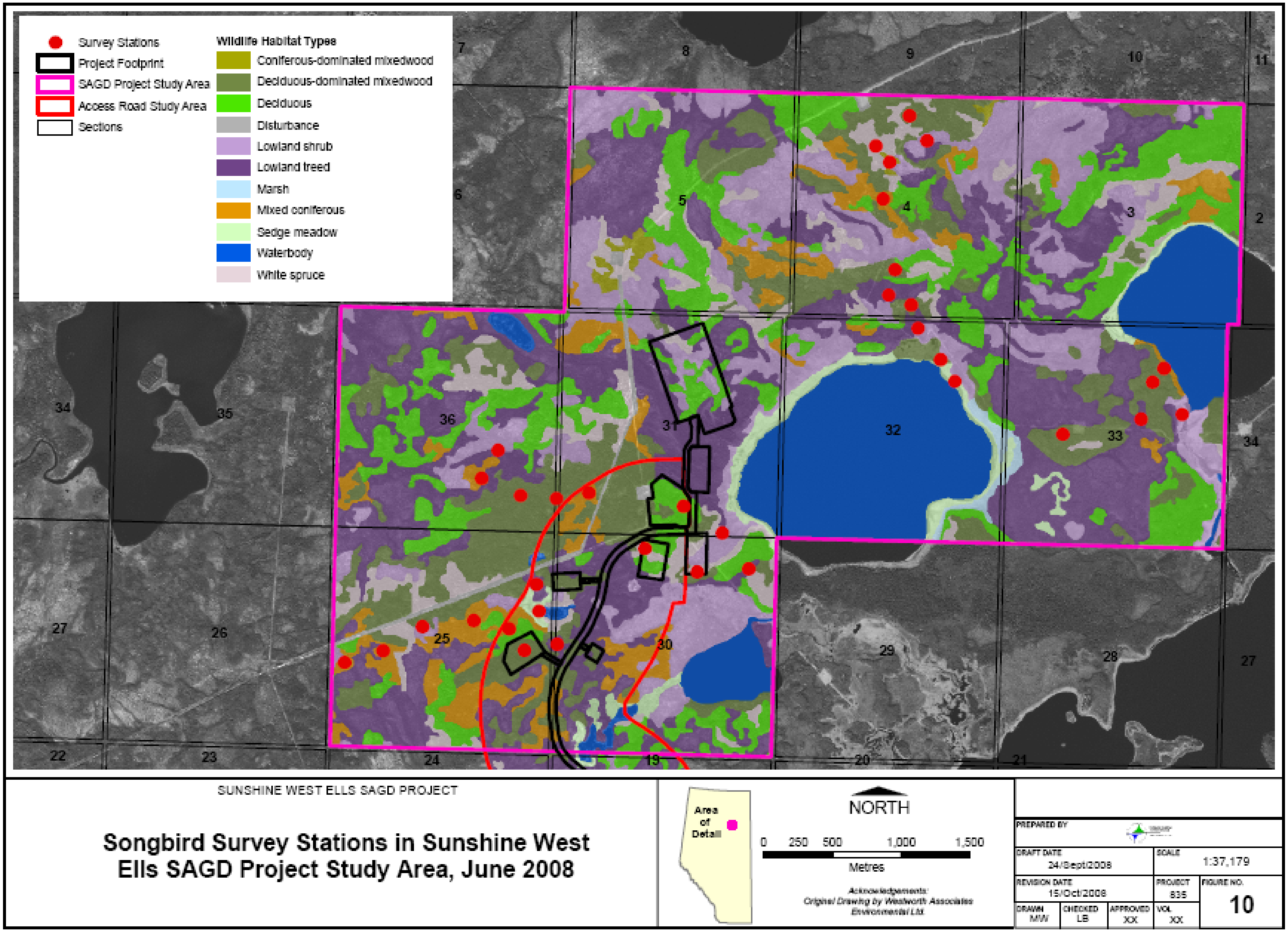

Figure 10. Songbird survey stations in the West Ells SAGD Project Study Area, June 2008.

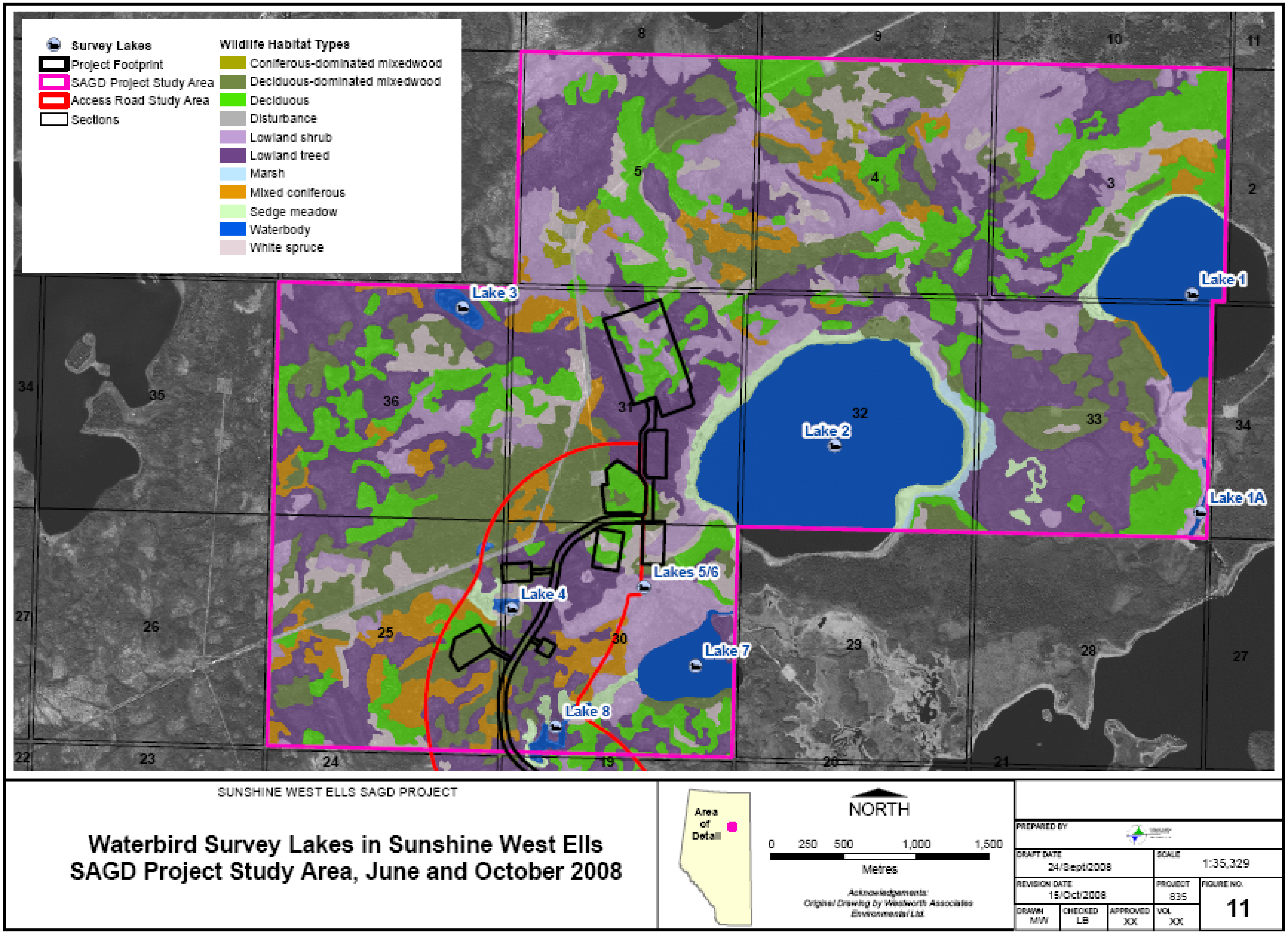

Figure 11. Waterbird survey lakes in the West Ells SAGD Project Study Area, June and October 2008.

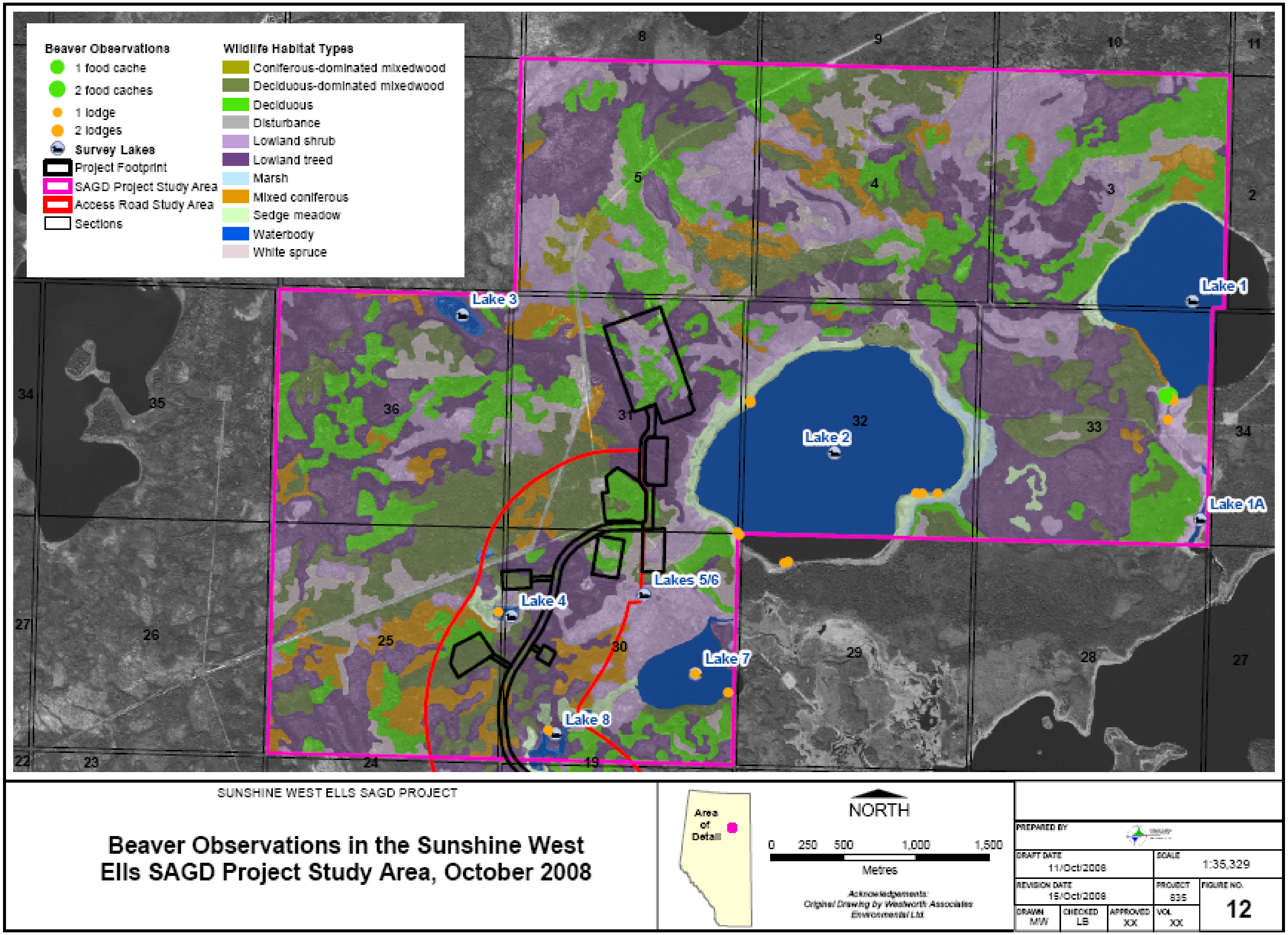

Figure 12. Beaver observations in the West Ells SAGD Project Study Area, October 2008.

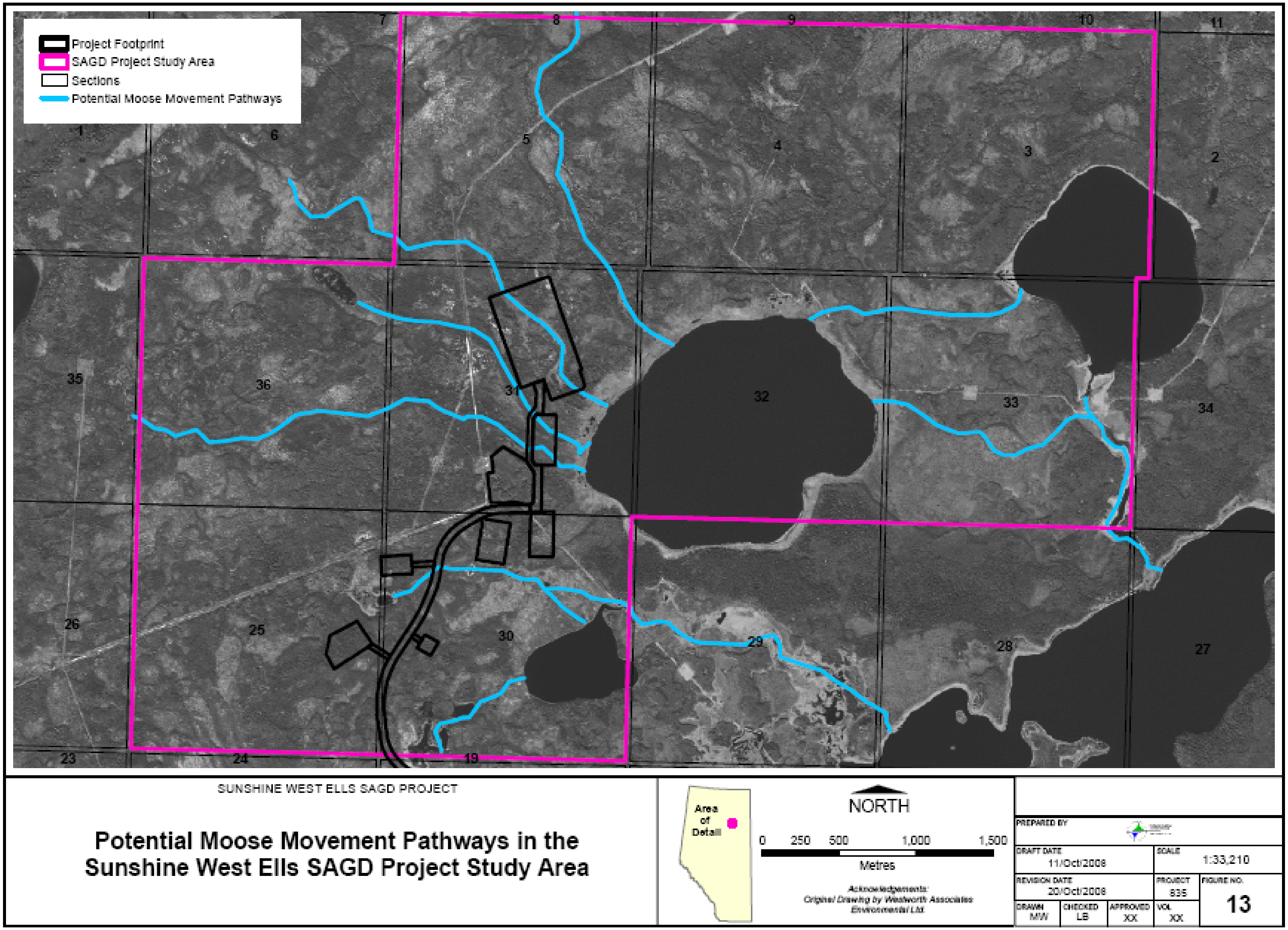

Figure 13. Potential moose movement pathways in the West Ells SAGD Project Study Area.

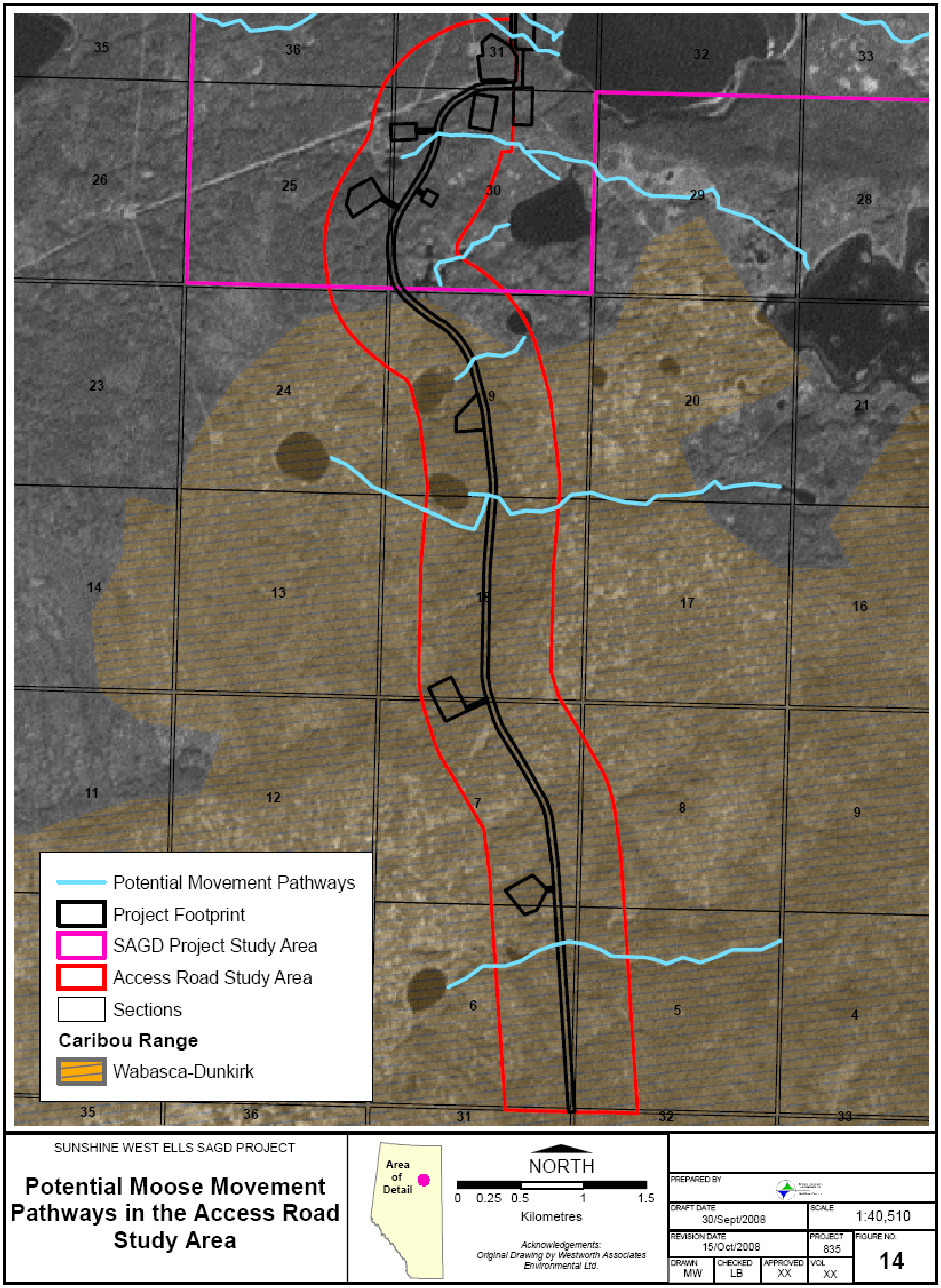

Figure 14. Potential moose movement pathways in the West Ells Access Road Study Area.