

Appendix 12-A

Murray River Coal Project: Wetland Ecosystem Baseline Report

MURRAY RIVER COAL PROJECT

Application for an Environmental Assessment Certificate / Environmental Impact Statement

HD Mining International Ltd.

MURRAY RIVER COAL PROJECT Wetland Ecosystem Baseline Report



Rescan™ Environmental Services Ltd.
Rescan Building, Sixth Floor - 1111 West Hastings Street
Vancouver, BC Canada V6E 2J3
Tel: (604) 689-9460 Fax: (604) 687-4277

August 2013

MURRAY RIVER COAL PROJECT WETLAND ECOSYSTEM BASELINE REPORT

August 2013
Project #0194106-0005-0609

Citation:

Rescan. 2013. *Murray River Coal Project: Wetland Ecosystem Baseline Report*. Prepared for HD Mining International Ltd. by Rescan Environmental Services Ltd.: Vancouver, British Columbia.

Prepared for:



HD Mining International Ltd.

Prepared by:



Engineers and Scientists

Rescan™ Environmental Services Ltd.
Vancouver, British Columbia

Executive Summary

Executive Summary

HD Mining International Ltd. (HD Mining) proposes to develop the Murray River Coal Project (the Project) as a 6 million tonne per annum (6 Mtpa) underground metallurgical coal mine. The property is located approximately 12.5 km south of Tumbler Ridge, British Columbia. The Project is located within the Peace River Coalfield (PRC), an area with a long history of metallurgical grade coal mining, mainly from open pit mining. HD Mining is proposing to access deeper zones of the coal field (600 to 1,000 m below surface) through underground mining techniques.

To support HD Mining's planning and development of the Project, and to contribute to the environmental assessment process, environmental and socio-economic baseline studies were initiated by Rescan Environmental Services Ltd. (Rescan). Project-specific studies began in 2010 and have continued through 2012. As appropriate and available, historical data from government sources and neighbouring projects, as well as traditional use/knowledge information, have been compiled and incorporated into analysis.

This report presents a cumulative summary of all Wetland Ecosystem information compiled for the Project to date.

Identification and quantification of wetland ecosystem extent and function within the Project area are necessary to facilitate a sound assessment of Project effects on the environment, as well as provide for information necessary to develop appropriate avoidance and mitigation measures as well as potential monitoring and compensation plans.

The main objectives of the Wetland baseline program were to:

- Identify the spatial location and area of wetland ecosystems in the Project area, with a focus on the LSA;
- Classify wetland ecosystems in accordance with the *The Canadian Wetland Classification System* (Warner and Rubec 1997), and class and vegetation associations per MacKenzie and Moran 2004);
- Identify rare or sensitive wetland ecosystems as recorded by the BC Conservation Data Centre (BC CDC; MOE 2007);
- Record biophysical data on vegetation, soils, hydrology, and incidental wildlife to characterize functional components of wetland ecosystems in the Project area;
- collect ecosystem, vegetation, aquatic biology, and hydrology data from a sample of wetlands in the wetland study area; and
- establish wetland values through consultation with fisheries, wildlife, and socio-economic scientists.

A total of 32 field surveys were completed resulting in the classification of 27 wetland ecosystems. 49 wetlands were identified and mapped in the study area (Including TRIM and TEM wetland ecosystem identification). Wetlands were found to cover 136 ha. All five wetland classes (bog, fen, marsh, swamp, and shallow open water) were observed in the wetland study area. Nine wetland associations were identified including four bog, one fen, one marsh, and three swamp associations. Marshes and

WETLAND ECOSYSTEM BASELINE REPORT

swamps accounted for the majority of all wetland observations, with swamp wetland ecosystems accounting for the largest wetland area.

Based on field observations the inferred primary hydrological functions of wetland ecosystems in the study area are groundwater recharge and water storage. The inferred primary biochemical functions are nutrient and organic export, carbon storage, and water quality improvements. The inferred primary ecological functions are the presence of listed/sensitive ecosystems and wetland complexes. Two listed wetland associations (Wb09 and Wb06) were identified in the wetland study area as components of wetland ecosystems at survey sites MW26, MW29, 404, 407, 494, and 505. Wetlands were also observed to provide valuable aquatic, semi-aquatic, and terrestrial habitat for a variety of wildlife species.

Acknowledgements

Acknowledgements

This report was prepared for HD Mining International Ltd. (HD Mining) by Rescan Environmental Services Ltd. (Rescan). The work was managed by Andrea Daezli (M.Env., R.P.Bio.) and Stephen Monninger (M.S.) and directed by Clem Pelletier (B.Sc.). The wetland study was designed and coordinated by Wade Brunham (M.Sc., PWS, EP). The report was written by Wade Brunham and updated in 2013 by Reed Hentze (B.Sc., PWS, P.Biol., EP). Mike Stead (B.Sc.) and Kevin Lesk-Winfield (B.App., Tech.GIS) completed the Wetland GIS. Field work was conducted by Wade Brunham, with assistance from Eric Bai.

Table of Contents

MURRAY RIVER COAL PROJECT

WETLAND ECOSYSTEM BASELINE REPORT

Table of Contents

Executive Summary	i
Acknowledgements.....	iii
Table of Contents	v
List of Figures	vi
List of Tables	vii
List of Plates	vii
List of Appendices	viii
Glossary and Abbreviations	ix
1. Introduction	1-1
2. Background Information.....	2-1
2.1 Applicable Legislation (Federal and Provincial)	2-1
2.2 Literature Review	2-1
3. Wetland Setting and Wetland Study Area	3-1
3.1 Wetland Study Area	3-1
4. Methodology.....	4-1
4.1 Wetland Ecosystem Survey and Mapping	4-1
4.1.1 Wetland Ecosystem Survey	4-1
4.1.2 Wetland Classification	4-3
4.1.3 Wetland Mapping	4-4
4.1.4 Wetland Function.....	4-4
4.1.4.1 Wetland Hydrological Function.....	4-6
4.1.4.2 Wetland Biochemical Function	4-6
4.1.4.3 Wetland Ecological Function.....	4-11
4.1.4.4 Wetland Habitat Function	4-12
5. Results.....	5-1
5.1 Wetland Ecosystem Classification	5-1
5.1.1 Bog Wetlands.....	5-1
5.1.2 Fen Wetlands.....	5-6
5.1.3 Marsh Wetlands	5-7
5.1.4 Swamp Wetlands.....	5-8

5.1.5	Shallow Open Water Wetlands	5-11
5.2	Wetland Ecosystem Extent and Mapping	5-13
5.3	Wetland Ecosystem Function	5-14
5.3.1	Hydrological Function	5-14
5.3.2	Biochemical Function	5-14
5.3.2.1	Summary of Wetland Sediment and Water Quality Data.....	5-31
5.3.2.2	Summary of Wetland Vegetation Data	5-31
5.3.3	Ecological Function	5-33
5.3.4	Habitat Function.....	5-33
6.	Summary	6-1
	References.....	R-1

List of Figures

FIGURE	PAGE
Figure 1-1. Project Location.....	1-3
Figure 1-2. Project Study Boundaries	1-4
Figure 1-3. Preliminary Site Layout	1-5
Figure 3.1-1. Wetland Study Area and Wetland Survey Sites 2010-2012	3-2
Figure 4.1-1. Wetland Classes and their Edatopic Position	4-5
Figure 4.1-2. Wetland Vegetation Tissue, Water, Sediment, and Chlorophyll <i>a</i> Sample Locations.....	4-8
Figure 5.1-1. Proportion of Wetland Class/Site Associations Observed in the Murray River Wetland Study Area	5-2
Figure 5.2-1. Mapped Wetland Extent - Map 1	5-15
Figure 5.2-2. Mapped Wetland Extent - Map 2	5-17
Figure 5.2-3. Mapped Wetland Extent - Map 3	5-19
Figure 5.2-4. Mapped Wetland Extent - Map 4	5-21
Figure 5.2-5. Mapped Wetland Extent - Map 5	5-23
Figure 5.2-6. Mapped Wetland Extent - Map 6	5-25
Figure 5.2-7. Mapped Wetland Extent - Map 7	5-27
Figure 5.3-1. Histogram of Observed Wetland Sizes	5-29
Figure 5.3-2. Box Plots of Vegetation Tissue Metal Concentrations	5-32
Figure 5.3-3. Map of Sensitive Wetland Ecosystems.....	5-34

List of Tables

TABLE	PAGE
Table 4.1-1. Wetland HDI, SMR, and SNR Field Codes	4-2
Table 4.1-2. Wetland Function and Associated Fieldwork Component	4-6
Table 4.1-3. Wetland Hydrogeomorphic Position	4-6
Table 4.1-4. Plant Tissue Sample Locations	4-7
Table 4.1-5. Metal Analysis and Associated Detection Limits for Plant Tissue Samples	4-9
Table 4.1-6. Soil Nutrient Regime Descriptions	4-11
Table 5.1-1. Wetland Associations Observed in the Murray River Wetland Study Area	5-1
Table 5.2-1. Area of Wetland Associations in the Murray River Wetland Study Area.....	5-13
Table 5.3-1. Samples Sites with Results beyond the 90% Confidence Interval	5-31
Table 5.3-2. Potentially Occurring Red- and Blue-listed Ecosystems	5-33
Table 5.3-3. Wetland Survey: Incidental Wildlife Observations.....	5-35

List of Plates

PLATE	PAGE
Plate 4.1-1. Soil core from wetland site MW01.	4-3
Plate 4.1-2. Submerged macrophytes at site MW01.....	4-9
Plate 4.1-3. Aquatic sampling at reference wetland.....	4-10
Plate 4.1-4. Sampling at site LW11.....	4-10
Plate 4.1-5. RW3 sedges and open water.	4-11
Plate 5.1-1. Wb05 bog at site MW07.	5-3
Plate 5.1-2. Wb06 bog at site 404.	5-4
Plate 5.1-3. Wb08 bog at site MW15.	5-5
Plate 5.1-4. Wb09 bog at site MW26.	5-6
Plate 5.1-5. Wf04 fen at site MW12.	5-7
Plate 5.1-6. Wm01 marsh at site MW19.	5-8
Plate 5.1-7. Ws07 swamp at site MW05.....	5-9
Plate 5.1-8. Willow swamp association at site MW20.	5-10
Plate 5.1-9. Willow-sedge swamp association at site MW25.....	5-11

WETLAND ECOSYSTEM BASELINE REPORT

Plate 5.1-10. Submergent community at site MW01.	5-12
Plate 5.1-11. Deep un-vegetated stream/pools in bog community at site MW26.....	5-12
Plate 5.1-12. Flooded land at site MW04.....	5-13
Plate 5.3-1. View of wetland (MW01), showing stream flowing from pond 2 to beaver dam at the outlet along the Murray River Forest Service Road, June 30, 2010.	5-30
Plate 5.3-2. View of wetland (MW01) showing outlet channel with beaver dam along Murray River Forest Service Road, June 30, 2010.....	5-30
Plate 5.3-3. View of wetland (MM01) showing westernmost pond, June 30, 2010.....	5-31
Plate 5.3-4. Moose rub and antler shed adjacent to wetland MW17.	5-35
Plate 5.3-5. Wood frog observed in aquatic feature adjacent to Mast Forest Service Road.	5-35

List of Appendices

Appendix 1. Wetland Ecosystem and Classification Data
Appendix 2. Wetland Habitat Information Form
Appendix 3. Wetland Ecosystem Vegetation Species List
Appendix 4. Wetland Vegetation Tissue Metal Concentration Data
Appendix 5a. Wetland Water Data
Appendix 5b. Sediment Data
Appendix 5c. Chlorophyll <i>a</i> Data

Glossary and Abbreviations

Glossary and Abbreviations

Terminology used in this document is defined where it is first used. The following list will assist readers who may choose to review only portions of the document.

BC	British Columbia
BC CDC	British Columbia Conservation Data Centre
BEC	Biogeoclimatic Ecosystem Classification
BWBS	Boreal White Black Spruce BEC Zone
COSEWIC	Committee on the Status of Endangered Wildlife in Canada
Dy	Dynamic Hydrodynamic Index
ESSF	Engelmann Spruce Sub-alpine Fir BEC Zone
GIS	Geographic Information System
HD Mining	HD Mining International Ltd
HDI	Hydrodynamic index
LSA	Local Study Area
MEM	Ministry of Energy and Mines (British Columbia)
Mo	Mobile Hydrodynamic Index
MOE	Ministry of Environment (British Columbia)
MOELP	Ministry of Environment, Land and Parks (British Columbia; currently known as the Ministry of Environment)
MOF	Ministry of Forests (British Columbia)
MSDA	Mine Surface Development Area
NAD	North American Datum
Rescan	Rescan Environmental Services Ltd.
RISC	Resources Information Standards Committee
RSA	Regional Study Area
SARA	<i>Species at Risk Act</i>
SBS	Sub-boreal Spruce BEC Zone
SI	Sluggish Hydrodynamic Index
SMR	Soil Moisture Regime
SNR	Soil Nutrient Regime

WETLAND ECOSYSTEM BASELINE REPORT

St	Stagnant Hydrodynamic Index
TEM	Terrestrial Ecosystem Mapping
TRIM	Terrestrial Resource Information Management
UTM	Universal Transverse Mercator
VM	Very Moist SNR
VW	Very Wet SNR
W	Wet SNR

1. Introduction

1. Introduction

HD Mining International Ltd. (HD Mining) proposes to develop the Murray River Coal Project (the Project) as a 6 million tonne per annum (6 Mtpa) underground metallurgical coal mine. The property is located approximately 12.5 km south of Tumbler Ridge, British Columbia (Figure 1-1), and consists of 57 coal licences covering an area of 16,024 hectares. The Project is located within the Peace River Coalfield (PRC), an area with a long history of metallurgical grade coal mining, mainly from open pit mining. HD Mining is proposing to access deeper zones of the coal field (600 to 1,000 m below surface) through underground mining techniques.

In October 2011, HD Mining submitted an application to the BC Ministry of Energy and Mines and Ministry of Environment seeking permission to complete a bulk sampling program as part of exploration of the property. In March 2012, HD Mining received approval to conduct a 100,000 tonne bulk sample for the purpose of conducting testing to assist in developing markets for the coal.

Beyond the bulk sample program, in order to develop a full mine at the proposed 6 Mtpa, the Project is subject to both the BC and Canadian environmental assessment processes. Development of any infrastructure for the full mine is not permitted before the requirements of these processes are met.

To support HD Mining's planning and development of the Project, and to contribute to the environmental assessment process, environmental and socio-economic baseline studies were initiated by Rescan Environmental Services Ltd. (Rescan). Project-specific studies began in 2010 and have continued through 2012. As appropriate and available, historical data from government sources and neighbouring projects, as well as traditional use/knowledge information, have been compiled and incorporated into analysis.

In order to help guide the scope of baseline studies, regional and local study areas (RSA and LSA, respectively) have been developed (Figures 1-2 and 1-3). The RSA is intended to encompass an area beyond which effects of the Project would not be expected. It is also intended to be ecologically relevant based on the home range of key wildlife species known to inhabit the region. The LSA encompasses an area surrounding the proposed Project infrastructure within which direct effects from the Project may be anticipated. Its boundary has also been developed following natural terrain and drainage boundaries in order to be ecologically relevant. For consistency, the same RSA and LSA are used for all environmental studies.

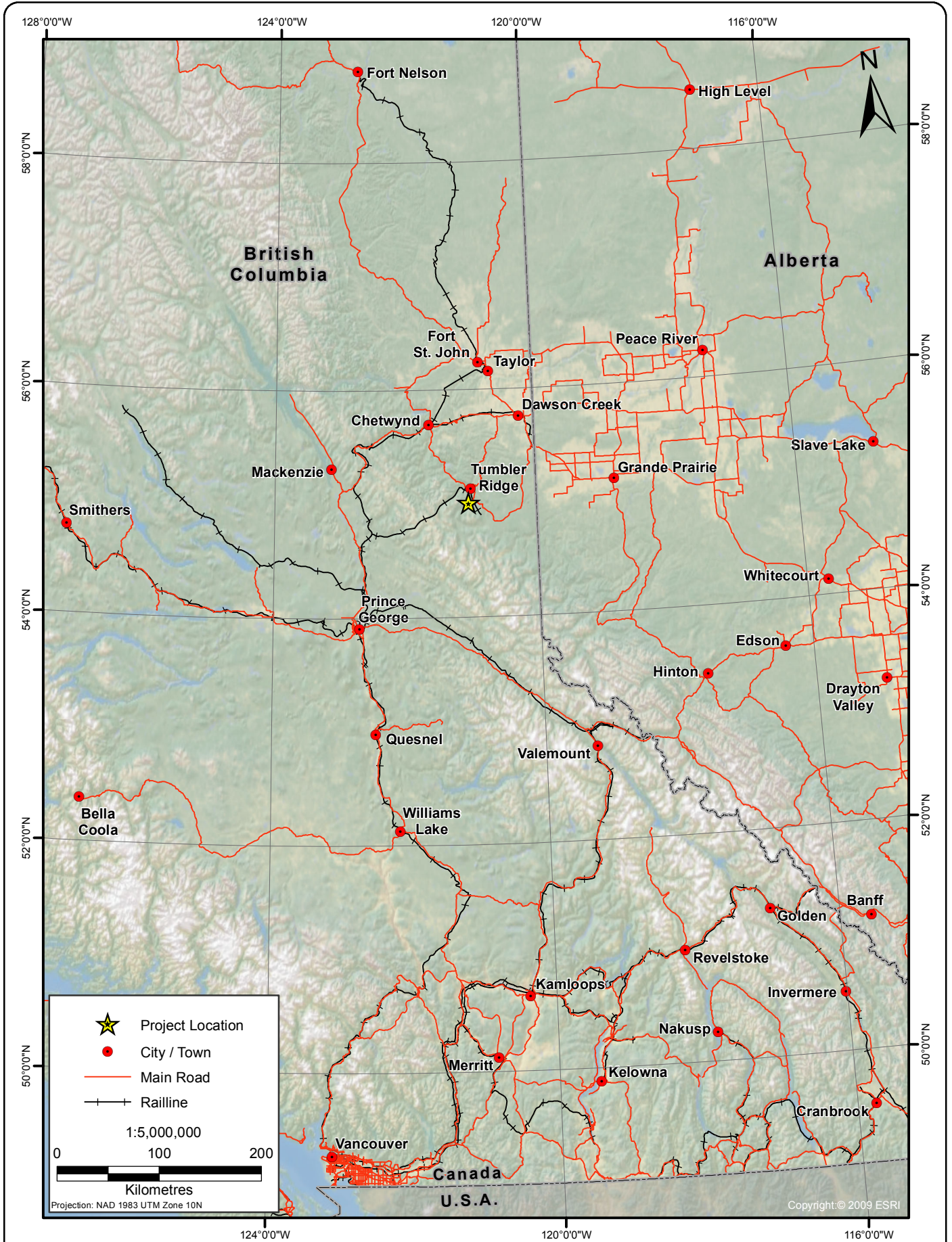
This report presents a cumulative summary of all wetland ecosystem information compiled for the Project to date. The objectives of the wetland baseline studies were to:

- Identify the spatial location and area of wetland ecosystems in the Project area, with a focus on the LSA;
- Classify wetland ecosystems in accordance with the *The Canadian Wetland Classification System* (Warner and Rubec 1997), and class and vegetation associations per MacKenzie and Moran 2004);
- Identify rare or sensitive wetland ecosystems as recorded by the BC Conservation Data Centre (BC CDC; MOE 2007);
- Record biophysical data on vegetation, soils, hydrology, and incidental wildlife to characterize functional components of wetland ecosystems in the Project area;

WETLAND ECOSYSTEM BASELINE REPORT

- collect ecosystem, vegetation, aquatic biology, and hydrology data from a sample of wetlands in the wetland study area; and
- establish wetland values through consultation with fisheries, wildlife, and socio-economic scientists.
- produce a baseline report describing wetland ecosystems in the wetland study area.

In 2010, ecosystem, hydrology and biological data were collected from a subset of wetlands in the wetland study area. Terrestrial Resource Information Management (TRIM) data were gathered to determine wetland abundance and extent. Fieldwork conducted during June 2011 and September 2012 was used to classify wetlands according to the *Wetlands of British Columbia* (MacKenzie and Moran 2004) identification guide and develop descriptions of wetland function.



MURRAY RIVER COAL PROJECT

Project Location

Figure 1-1



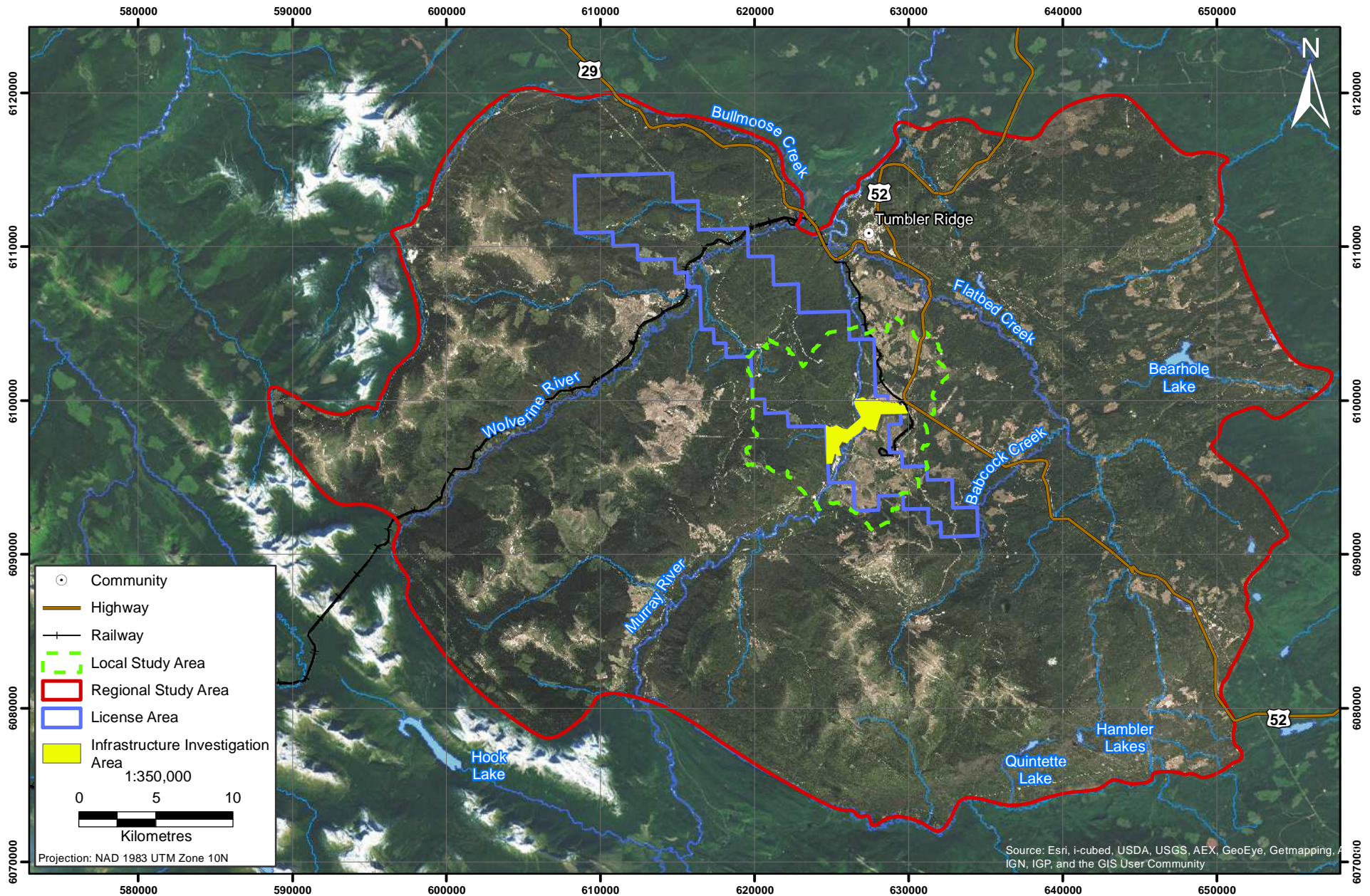


Figure 1-2



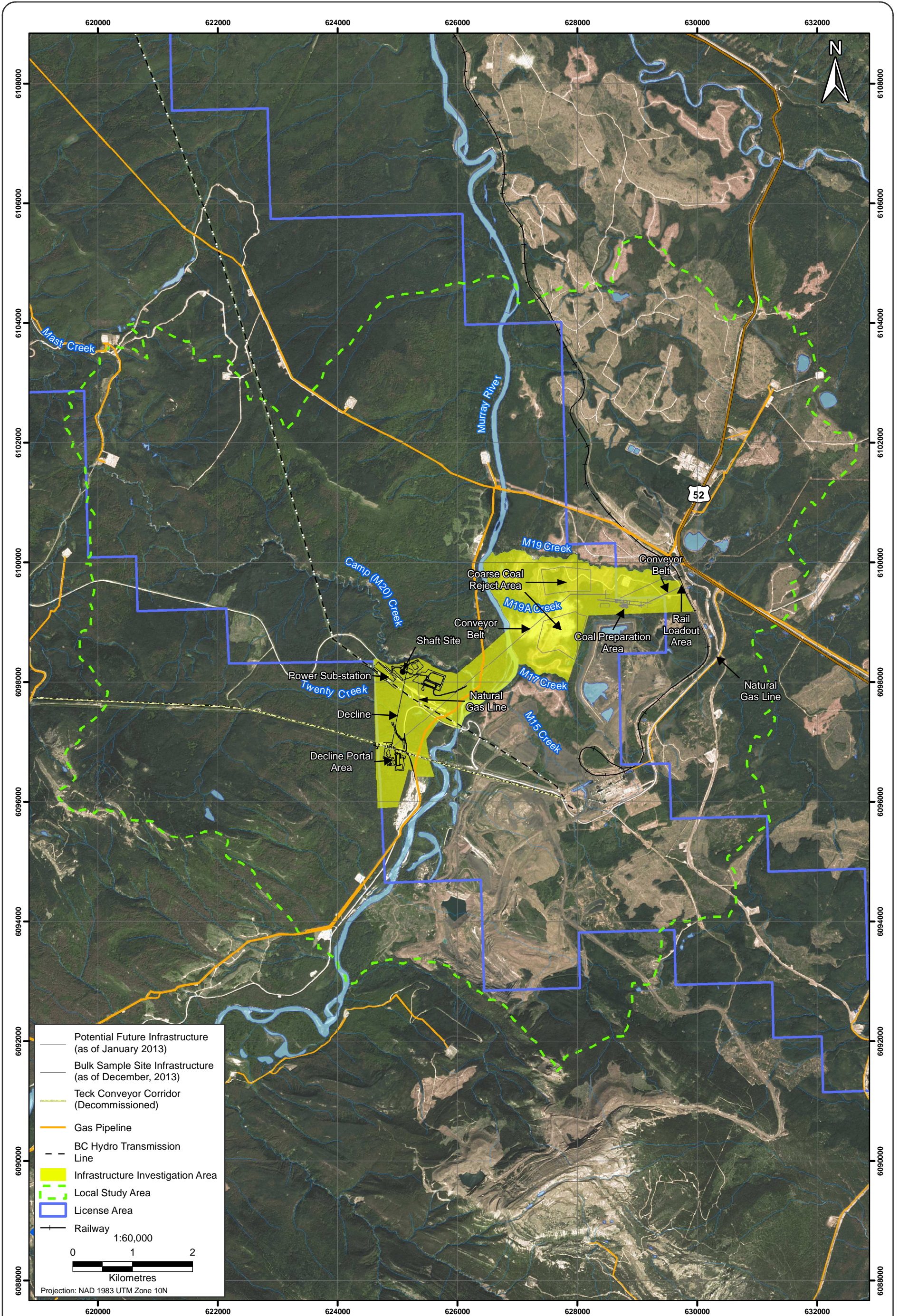
MURRAY RIVER COAL PROJECT

Project Study Boundaries

Figure 1-2



Source: Esri, i-cubed, USDA, USGS, AEX, GeoEye, Getmapping, IGN, IGP, and the GIS User Community



2. Background Information

2. Background Information

2.1 APPLICABLE LEGISLATION (FEDERAL AND PROVINCIAL)

Wetland ecosystems need to be surveyed and mapped according to provincial standards to receive appropriate permits for mine plan approval. Wetlands in the proposed mine site area must be mapped to a 1:5000 scale, and vegetation must be sampled and analyzed to establish baseline metal levels and trace element uptake (MEM 1998). In addition, the BC MOE standards for environmental baseline programs identify wetlands as a component of aquatic ecosystems that need to be studied (MOE 2009).

Wetlands in Canada are managed and conserved through the Federal Policy of Wetland Conservation, which states that there will be “no net loss of wetland functions on all federal lands and waters.” The Policy also states that the functions and values derived from wetlands will be maintained, and wetlands will be enhanced and rehabilitated in areas of continuing loss and degradation (Milko 1998).

2.2 LITERATURE REVIEW

A review of reports and literature relevant to wetlands focused on the following:

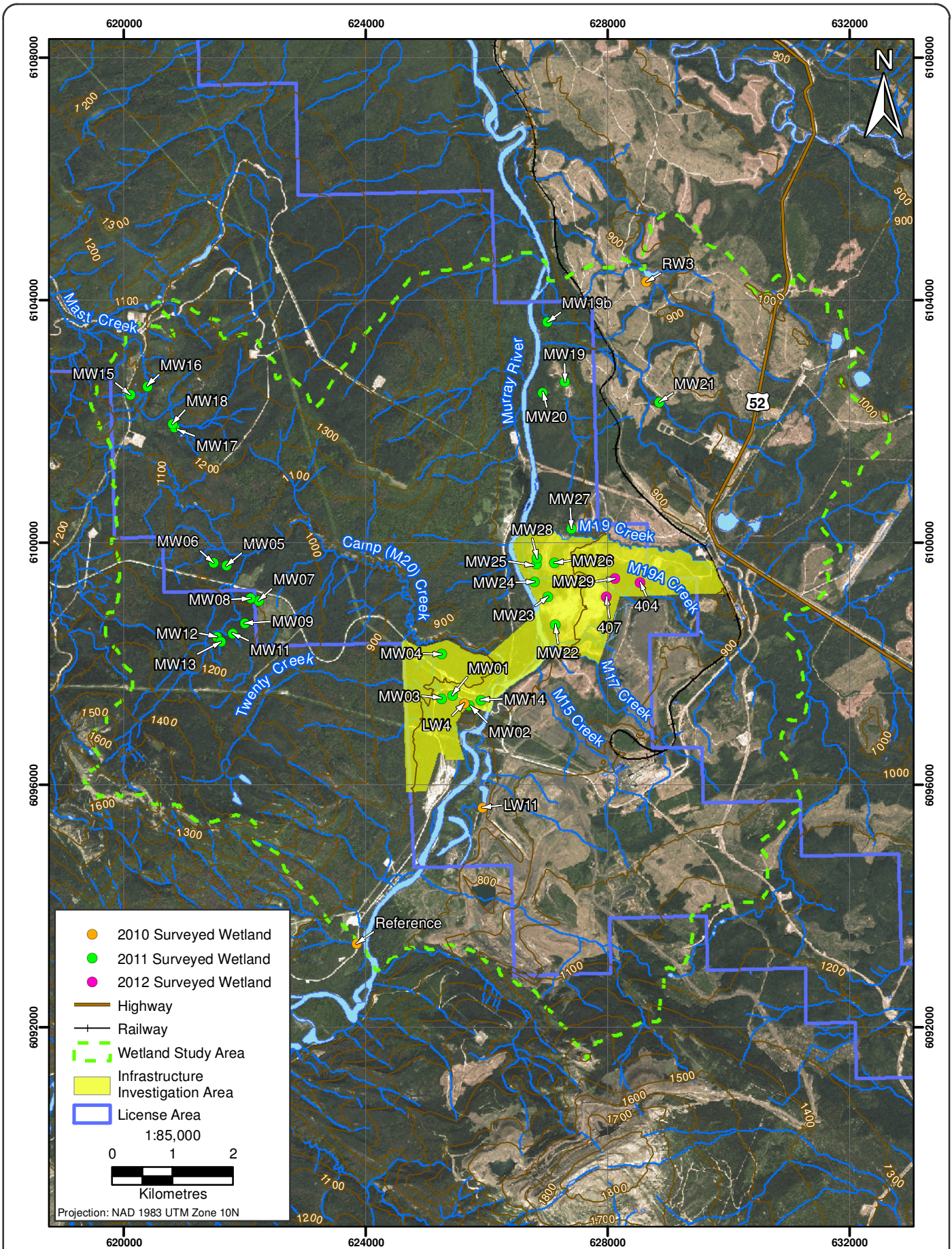
- Terrestrial Resource Information Management (RISC 1998), a BC ecosystem mapping standard and associated ecosystem information database;
- *Wetlands of British Columbia: a Guide to Identification* (MacKenzie and Moran 2004), a classification and interpretive guide;
- *The Canadian Wetland Classification System* (Warner and Rubec 1997), a guide to wetland classification created by the National Wetlands Working Group;
- *Wetlands Environmental Assessment Guideline* (Milko 1998), a guide to wetlands assessment consistent with federal wetlands policy; and
- *Wetland Ecological Functions Assessment: An Overview of Approaches* (Hanson et al. 2008), an overview of methodology for the valuation of wetlands and assessment of their functions.

3. Wetland Setting and Wetland Study Area

3. Wetland Setting and Wetland Study Area

3.1 WETLAND STUDY AREA

The wetland study area (Figure 3.1-1) includes all potential infrastructure areas for the Project. The area was developed in collaboration with terrestrial ecologists and wildlife biologists to ensure a biologically relevant area was selected for the study of wetland ecosystems. The wetland study area boundary incorporates, heights-of-land, the Project licence area, water courses, and existing infrastructure, covering an area of 12,097 ha.



- 2010 Surveyed Wetland
- 2011 Surveyed Wetland
- 2012 Surveyed Wetland
- Highway
- Railway
- Wetland Study Area
- Investigation Area
- License Area

1:85,000

0 1 2
Kilometres

Projection: NAD 1983 UTM Zone 10N



MURRAY RIVER COAL PROJECT

Wetland Study Area and Wetland Survey Sites 2010-2012

Figure 3.1-1



4. Methodology

4. Methodology

4.1 WETLAND ECOSYSTEM SURVEY AND MAPPING

Wetlands were surveyed and mapped to establish their extent, type, size, and distribution. Ecosystem components such as vegetation, soil, and hydrologic information were collected and used to establish wetland type and provide supporting information for wetland function descriptions. The following section presents the methodology for the wetland ecosystem survey, wetland classification, wetland mapping, and wetland function studies.

4.1.1 Wetland Ecosystem Survey

Wetlands were surveyed in August 2010, June 2011 and September 2012; 32 wetland survey plots were established. Survey methods followed *Field Description of Wetland and Related Ecosystems in the Field* (MacKenzie 1999) and *Wetlands of British Columbia: A Guide to Identification* (MacKenzie and Moran 2004). Data collected during these field surveys were used to classify wetland ecosystems following the Canadian Wetland Classification System (class level; Warner and Rubec 1997) and the provincial classification system (association level; MacKenzie and Moran 2004). Wetland survey locations are displayed in Figure 3.1-1; wetland field data are available in Appendix 1.

Prior to field surveys, equipment and field clothing were cleaned using a 1% Virkon solution to prevent the spread of *Batrachochytrium dendrobatidis* between wetland sites. *B. dendrobatidis* is a pathogen for amphibians.

Wetland surveys were planned at all TRIM identified wetlands and at areas of interest identified through aerial photograph interpretation. Areas of interest include level or slightly sloping areas near mapped surface water features such as streams, rivers, and lakes. A plot was established at each survey site. Plots were 20 by 20 m and were established in large uniform wetlands or at the centre of wetlands smaller than 400 m². The edges of wetlands smaller than 400 m² were used as the survey plot boundary. A series of soil cores were established throughout each plot. At the centre of the plot, a GPS coordinate was recorded and photographs of the soil surface and of other significant features such as landforms, unique vegetation, and wildlife were taken in each cardinal direction.

Wetland Habitat Information Forms (Appendix 2) were completed at each sample site. These forms, developed by Rescan, are based on the provincial Ground Inspection Forms but were adapted for use in wetland studies. Information recorded on the field forms includes:

- Plot number;
- Project ID;
- Surveyor;
- Date;
- Photograph numbers;
- GPS coordinates in Universal Transverse Mercator (UTM);
- Aspect (slope direction);
- Slope;

WETLAND ECOSYSTEM BASELINE REPORT

- Meso slope position (site position in the overall landscape);
- Soil Moisture Regime (SMR; Table 4.1-1);
- Hydrodynamic index (HDI; Table 4.1-1);
- Soil Nutrient Regime (SNR; Table 4.1-1);
- Hydrogeomorphic position;
- Drainage mineral soils;
- Moisture subclasses - organic soils;
- Mineral soil texture;
- Organic soil texture and von Post scale of decomposition;
- Surface organic horizon thickness;
- Humus form (decomposition of surface layer);
- Root restricting layer;
- Coarse fragment content;
- List of vegetation (dominant or indicator plant species and percent cover);
- Water colour and basic water chemistry (pH and conductivity);
- Soil profile diagram;
- Wildlife observations; and
- Site diagram.

Table 4.1-1. Wetland HDI, SMR, and SNR Field Codes

HDI Code	Soil Moisture Code	Soil Nutrient Code
St - Stagnant	VM - Very Moist	A - Very Poor
Sl - Sluggish	W - Wet	B - Poor
Mo - Mobile	VW - Very Wet	C - Medium
Dy - Dynamic		D - Rich
VD - Very Dynamic		E - Very Rich
		F - Hyper

The soil survey methodologies for wetland ecosystem classification incorporated aspects from *The Canadian System of Soil Classification* (Canada Soil Survey Committee 1987), *Towards a Taxonomic Classification of Humus Forms* (Green, Trowbridge, and Klinka. 1993), *Describing Ecosystems in the Field* (Luttmerding et al. 1990), and *Field Description of Wetland and Related Ecosystems in the Field* (MacKenzie 1999). These methods require soil identification to a depth of 160 cm or lithic contact. Super-saturated soils made deep sampling impossible at numerous sites. Soil pits were dug to a minimum depth of 40 cm, or when significant contact with the water table or lithic/parent material was made. Plate 4.1-1 shows a typical soil core.



Plate 4.1-1. Soil core from wetland site MW01.

A list of vegetation species and the relative percent cover of plant classes (forb, shrubs) was recorded at each plot. Special focus was placed on the identification of wetland association indicator species such as *Carex spp.* (sedge) and *Salix spp.* (willow). Vegetation identification references included: *Plants of Coastal British Columbia* (Pojar and MacKinnon 1994), *Plants of Northern British Columbia* (MacKinnon, Coupe, and Pojar 1999), and *Plants of the Western Boreal Forest and Aspen Parkland* (Johnson et al. 1995). Species not identified in the field were collected and identified using *The Illustrated Flora of British Columbia* (Douglas, Meidinger, and Pojar 2001). Vegetation data are available in Appendix 3.

4.1.2 Wetland Classification

Wetland classification is the process by which ecologically important factors are interpreted so that commonalities among sites are placed into recognizable groups (MacKenzie and Moran 2004). The classification process, in BC, integrates several classification models into a single hierarchical framework. The “class” concept, as described in *The Canadian Wetland Classification System* (Warner and Rubec 1997), is used as the broad description of a site. The “site association” concept is used as a more precise description of individual sites, and incorporates vegetation assemblages. Each wetland class (bog, fen, marsh, swamp, shallow open water) is composed of a number of site associations, which are defined as sites capable of supporting a similar community at climax (MacKenzie and Moran 2004).

Currently, limited information is available detailing wetland classification at the site level in BC, with the principal data source being the TRIM database. TRIM data are useful for identifying the locations of wetlands larger than 2 ha. However, these data do not provide detailed ecosystem information, and wetland areas are often inaccurately mapped or classified. Wetlands in TRIM are classified as marsh or swamp. These two wetland classes are recognized as two of the five federal wetland classes (Warner and Rubec 1997). Bogs, fens, and shallow open water wetlands (the remaining three federal wetland classes) are not differentiated by TRIM. These three remaining classes are either included in the marsh

or swamp TRIM classes or not mapped as wetlands altogether. The definitions for marsh and swamp supplied by TRIM (MOELP 1991) are:

1. **Marsh** - a water-saturated, poorly drained, treeless area intermittently or permanently water covered, having cattail, rushes or grass-like vegetation.
2. **Swamp** - a water-saturated area, intermittently or permanently covered with water, having shrubs.

It is likely that some shallow open water, fens, and tree-less bogs are included in the TRIM marsh class. The TRIM swamp class does not include treed swamps, which can represent a major percentage of wetlands in northern BC (MacKenzie and Moran 2004). Bogs and shallow open water wetlands are not included in either TRIM class; however, shallow open water wetlands may appear as small “indefinite” and/or “intermittent” lakes in the TRIM data set. Although there are some problems associated with the classification of TRIM wetlands, the data set provides a provincially-consistent form of wetland mapping. For this study TRIM wetlands were incorporated into the wetland Geographic Information System (GIS) and used to support wetland mapping, but they were not relied upon to support wetland classification.

Through the process of classification wetlands were assigned a federal wetland class using soil matrix, soil nutrient, and vegetation indicators. Wetland ecosystems were then assigned to a site association following the wetland edatopic grids (Figure 4.1-1). Wetland classification was typically done in the field at the time of the wetland survey; however, wetland classification was checked for accuracy against standard literature once field studies were complete. Wetland classification data were recorded in the wetland database (Appendix 1).

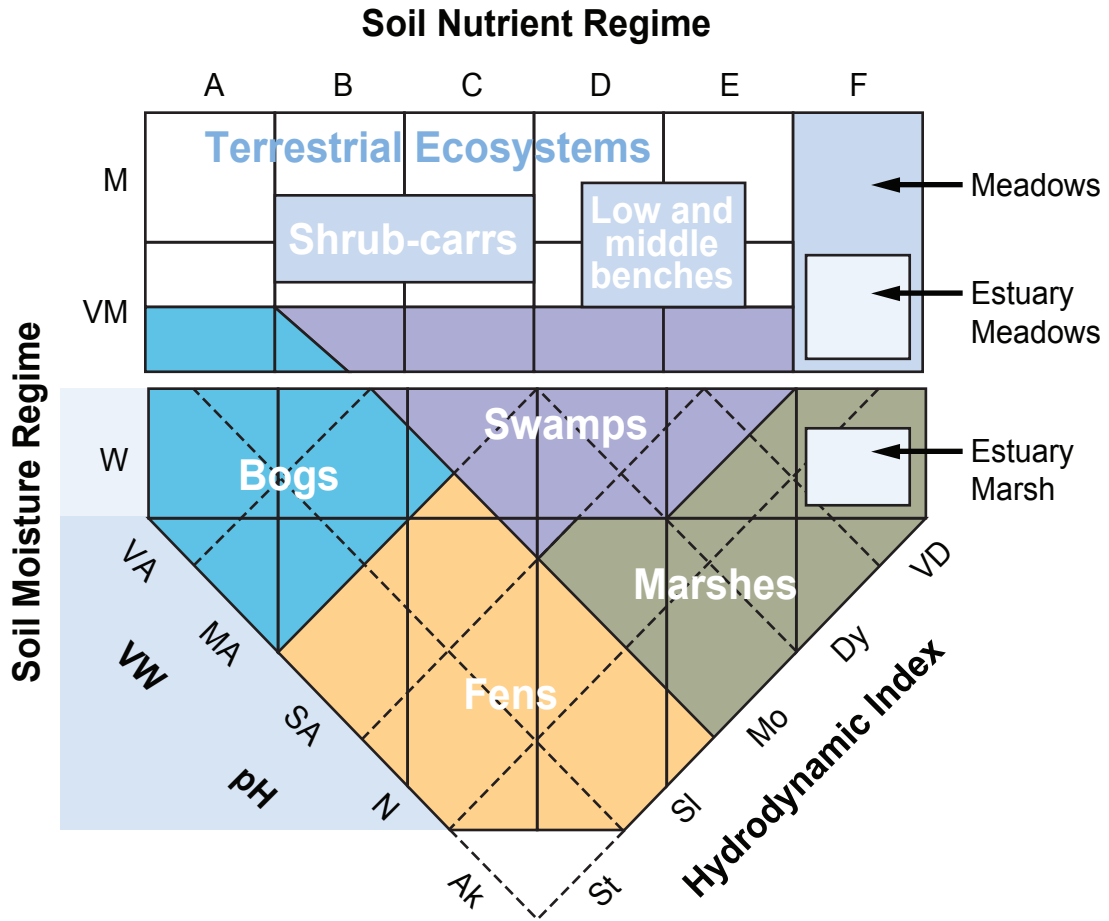
4.1.3 Wetland Mapping

Wetlands at each survey location were delineated in the field using a 2005 1:30,000 colour aerial photograph; these delineations were digitized using ArcView 10. When supported by field observations TRIM boundaries were incorporated into the final GIS product. In addition 3 wetland ecosystem polygons were added from Terrestrial Ecosystem Mapping (TEM) completed by Rescan in 2011. All of the above delineations were recorded into a comprehensive wetland GIS data product. The areas associated with each wetland polygon were calculated and added to the wetland field plot and classification data (Appendix 2).

4.1.4 Wetland Function

Wetland function is defined as a process or series of processes that a given wetland carries out, such as a wetland’s ability to store and filter water. There are four primary functions (Milko 1998) that should be included in an environmental assessment (Hanson et al. 2008): hydrological, biochemical, ecological, and habitat. Wetland functions include a series of complicated interactions between various wetland components such as water, soil, and vegetation. Aspects of wetland function were studied during baseline studies to establish baseline condition so that environmental monitoring during pre-construction, operations, and post-closure will have a point of reference. Table 4.1-2 shows which aspects of wetland functions are described by field data.

The principle wetland functions for each wetland class were determined through integrating data collected in support of the functional component of the baseline study (Table 4.1-1), individual wetland class and landscape position, and scientific literature (principally Jacques Whitford Environmental Limited 2007; Hanson et al. 2008).



Source: MacKenzie and Moran 2004

Table 4.1-2. Wetland Function and Associated Fieldwork Component

Wetland Function	Fieldwork Component
Hydrological Function	Hydrology survey
	Ecosystem survey (hydrodynamics)
	Ecosystem survey (hydrogeomorphic position)
Biochemical Function	Wetland classification (wetland class)
	Vegetation tissue metal Concentrations
	Wetland sediment metal concentrations
	Ecosystem survey (soil water pH and conductivity measurements)
Ecological Function	Wetland classification (rare or unique wetlands)
	Wetland classification (wetland complexes)
Habitat Function	Wetland classification (wetland class)
	Ecosystem survey (wildlife observations)

4.1.4.1 Wetland Hydrological Function

Wetland hydrologic function is defined as a wetlands contribution to ground and surface water resources. A wetland hydrology reconnaissance was carried out on foot at site MW01. This site was selected given its size and proximity to the project. The perimeter of the wetland was traversed and the margins were surveyed for in and out flow locations. The areas of open water and water control structures (i.e., beaver dams) were also recorded, as was the direction of flow through the wetland.

Wetland hydrodynamics (Table 4.1-1) were recorded at each site. Hydrodynamics are the vertical and lateral water flow in a given wetland and relate to the speed and frequency of water flow. For example, an isolated bog wetland, receiving the majority of its water from precipitation, may be described as stagnate to sluggish; whereas a riparian swamp, receiving seasonal water fluctuations associated with the surface water network, may be described as mobile or dynamic.

The hydrogeomorphic position (Table 4.1-3) was recorded at each site. The hydrogeomorphic position describes the topographic position and hydrology of a wetland (MacKenzie and Moran 2004).

Table 4.1-3. Wetland Hydrogeomorphic Position

Hydrogeomorphic Position	Definition
Fluvial System	Site associated with flowing water and subject to flooding, erosion, and sedimentation.
Lacustrine System	Sites at lakesides, directly affected by lake hydrological processes
Palustrine Basins and Hollows System	Sites in depressions and other topographic low points with the watertable near or at the surface; receive water mainly from groundwater and precipitation
Palustrine Ponds and Potholes System	Sites associated with small waterbodies
Palustrine Seepage Slope System	Sloping sites with near-surface ground-water seepage

Note: adapted from MacKenzie and Moran (2004).

4.1.4.2 Wetland Biochemical Function

The wetland biochemical function is defined as a wetland’s contribution to the quality of surface and groundwater of an area. Water, sediment, and vegetation components of a wetland influence its biochemical function. Completely describing biochemical function is not possible given site specific interactions between wetland components (water, soil, and vegetation), landscape position, and environmental factors such as salinity, precipitation, and climate (Almas and Singh 2001; Brunham 2009;

Brunham and Bendell 2010). However, aspects of biochemical function can be studied and these data, in conjunction with ecosystem classification data, can be used to infer high level biochemical process likely present in the area's wetlands. The aspects of biochemical function studied for this baseline include vegetation tissue metal concentrations, sediment metal concentrations, wetland soil nutrients, and pH.

Vegetation Tissue Sampling

Plant tissue samples from large leafed *Carex sp.* (beaked and water sedge) were collected in triplicate at eight randomly selected sites (Table 4.1-4; Figure 4.1-2). The samples were analyzed for tissue metal concentrations to establish baseline metal concentrations in wetland vegetation. Samples were shipped to ALS Environmental for analysis. Metals and associated detection limits are presented in Table 4.1-5, and raw data are available in Appendix 4.

Table 4.1-4. Plant Tissue Sample Locations

Site	Sample Year	Easting	Northing
Reference	2010	623849	6093375
LW11	2010	624931	6095621
RW3	2010	628641	6104302
MW01	2010/2011	625361	6097346
MW07	2011	622232	6099040
MW12	2011	621537	6098447
MW14	2011	625902	6097403
MW22	2011	627136	6098646

Note: all coordinates are in UTM 10 N NAD 83.

Metals for which greater than 50% of the samples had a concentration below the detection limit were excluded from further analysis. General descriptive statistics of the remaining metals were calculated; for individual samples with a result below the detection limit, half the detection limit value was used in the analysis.

Water, Sediment, and Chlorophyll a Sampling

Water, sediment, and chlorophyll a samples were collected from four sites in 2010. For complete sample methodology refer to the Rescan (2011b) *Murray River Project Aquatic Biology Baseline*. Water samples and chlorophyll a samples were collected at site MW01; however, sediment samples could not be collected because the sediments were covered by submerged macrophytes (Plate 4.1-2). Water, sediment, and chlorophyll a samples were collected at the reference site (Plate 4.1-3), LW11 (Plate 4.1-4), and RW3 (Plate 4.1-5). The water quality, sediment quality, and chlorophyll a samples were shipped to ALS Environmental for analysis. Raw data are available in Appendix 5.

Soil Nutrients and pH

Soil nutrients and pH were recorded at each site. Nutrients are an aspect of biochemical function because wetlands either act as a net sink or net producer of nutrients, thus affecting surface and groundwater quality. Soil nutrients were recorded according to MacKenzie and Moran (2004), who categorize available nutrients according to observational data such as colour, level of decomposition, texture, and water availability (Table 4.1-6). Wetland pH is an aspect of biochemical function because the rate of decomposition is influenced, in part, by pH. The pH also influences the uptake kinetics of metals (Almas and Singh 2001). The pH was measured using an Okton pH sonde.

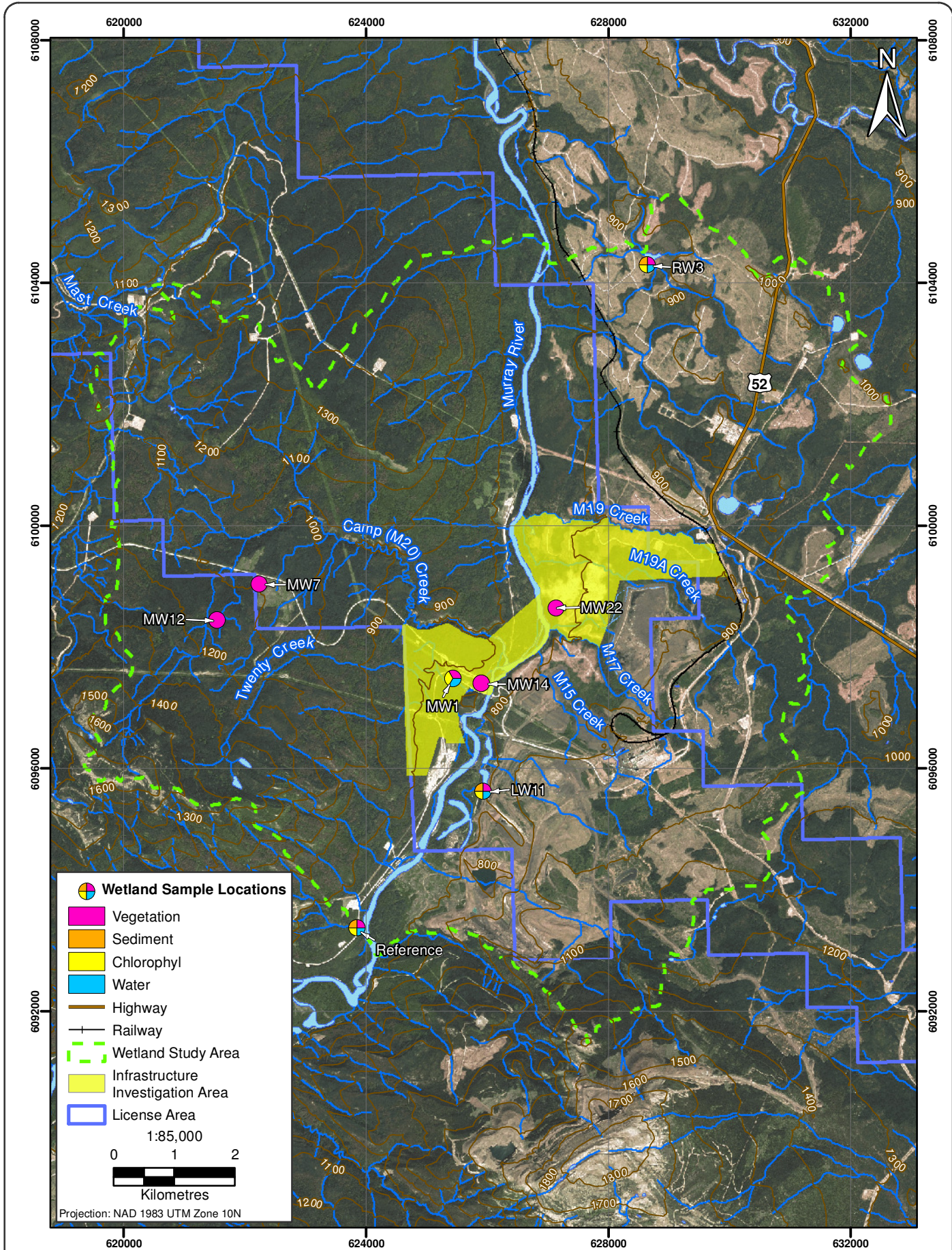


Table 4.1-5. Metal Analysis and Associated Detection Limits for Plant Tissue Samples

Metal	Abbreviation	Dry Weight Detection Limit (mg/kg)	Average Wet Weight Detection Limit (mg/Wkg)
Aluminum	Al	10	2.7
Antimony	Sb	0.05	0.0135
Arsenic	As	0.05	0.0135
Barium	Ba	0.05	0.0135
Beryllium	Be	0.3	0.135
Bismuth	Bi	0.3	0.0405
Cadmium	Cd	0.03	0.00675
Calcium	Ca	10	2.7
Chromium	Cr	0.5	0.135
Cobalt	Co	0.1	0.027
Copper	Cu	0.05	0.0135
Lead	Pb	0.1	0.027
Lithium	Li	0.5	0.135
Magnesium	Mg	3	1.35
Manganese	Mn	0.05	0.0135
Mercury	Hg	0.005	0.001
Molybdenum	Mo	0.05	0.0135
Nickel	Ni	0.5	0.135
Selenium	Se	1	0.27
Strontium	Sr	0.05	0.0135
Thallium	Tl	0.03	0.0135
Tin	Sn	0.2	0.0675
Uranium	U	0.01	0.0027
Vanadium	V	0.5	0.135
Zinc	Zn	0.5	0.135



Plate 4.1-2. Submerged macrophytes at site MW01.



Plate 4.1-3. Aquatic sampling at reference wetland.



Plate 4.1-4. Sampling at site LW11.



Plate 4.1-5. RW3 sedges and open water.

Table 4.1-6. Soil Nutrient Regime Descriptions

SNR	Code	Indicators
Very Poor	A	Stagnant hydrodynamics, von Post 1-3, tea coloured or yellowish water, pH < 5
Poor	B	Stagnant to sluggish hydrodynamics; von Post 3-6; tea coloured or yellowish water, possibly green-brown or clear; pH 4.5-6
Medium	C	Sluggish to mobile hydrodynamics; von Post 4-7; tea coloured, yellowish, green-brown, or clear water; pH 5-6.5
Rich	D	Sluggish to dynamic hydrodynamics, von Post 7-10, green-brown and turbid water, pH 6-7.4
Very Rich	E	Mobile to dynamic hydrodynamics, von Post 8-10, green-brown and turbid water, pH 6.5-8
Hyper	F	Excess salt accumulation, pH > 8, high conductivity

4.1.4.3 Wetland Ecological Function

Wetland ecological function is the relationship between a wetland and surrounding ecosystems. Aspects of the wetland ecosystem function include rare or unique wetlands and wetland complexes.

Rare Wetland Ecosystems

The site classification information (Appendix 1) is used to determine rare and sensitive ecosystems. Riparian area wetlands are considered a sensitive habitat as recorded by the Sensitive Habitat Inventory Mapping Project (Mason and Knight 2001). The BC Conservation Data Centre (BC CDC; MOE 2007) identifies certain wetlands as:

- **red-list** - includes any ecological community that is extirpated, endangered, or threatened in BC; or
- **blue-list** - includes any ecological community, considered to be of special concern (formerly vulnerable) in BC.

Wetlands in each Biogeoclimatic Ecosystem Classification (BEC) subzone were grouped according to wetland association. The wetland associations were compared against the BC CDC list of wetland associations in similar BEC subzones within the regional forest district. Wetland associations matching those in the BC CDC list would be determined to be listed as red or blue and therefore require special management consideration.

Wetland Complexes

Wetlands complexes (a number of wetland classes or site associations within a wetland ecosystem) were described in terms of the dominate community with a maximum of two sub-communities. The percentage of each of the observed communities in the wetland complex was estimated and recorded as a decile. Up to three deciles were recorded and described at each site. Wetland area was calculated for each wetland class and association in each decile. This methodology is consistent with Terrestrial Ecosystem Mapping (TEM) methodologies (RISC 1998) and was used to estimate the area of each community type once mapping was complete.

4.1.4.4 Wetland Habitat Function

Wetland habitat function includes both terrestrial and aquatic habitat components and is defined as a wetland's contribution to the wildlife habitat within a given region. The ability of wetlands to maintain local and regional biodiversity by providing a wide range of aquatic and terrestrial habitat types was studied by recording wildlife observation during the wetland field survey. These wildlife observations were also checked against the Committee on the Status of Endangered Wildlife in Canada (COSEWIC) and *Species at Risk Act* (SARA; 2002b) listed species to determine if species requiring special management considerations were identified during wetland studies.

5. Results

5. Results

5.1 WETLAND ECOSYSTEM CLASSIFICATION

A total of 32 wetland surveys were completed in 2010, 2011 and 2012, which resulted in the classification and mapping of 24 wetland ecosystems. Through GIS interpretation and analysis a further 25 (22 TRIM and 3 TEM) wetland features were identified. This section summarizes the wetland classes and associations observed in the wetland study area.

All five wetland classes were observed in the wetland study area (Figure 5.1-1) and classified to a wetland association. Shallow open water communities were not encountered as a simple wetland community but were observed numerous times as a component of larger wetland complexes.

A total of nine wetland associations were identified as a result of wetland classification. These associations include four bog, one fen, one marsh, and three swamp associations. The wetland classification results are presented in Table 5.1-1, and descriptions of individual wetland associations are provided below.

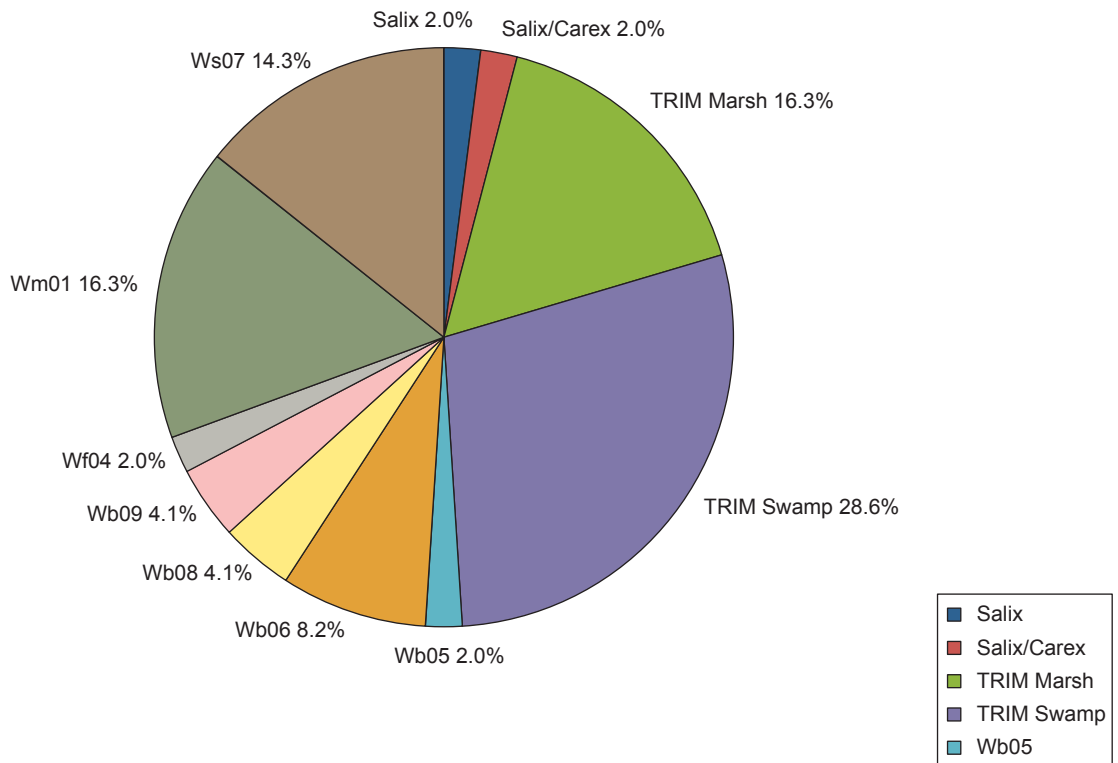
Table 5.1-1. Wetland Associations Observed in the Murray River Wetland Study Area

Wetland Associations	Wetland Class				Total
	Bog	Fen	Marsh	Swamp	
Wb05	1				1
Wb06	4				4
Wb08	2				2
Wb09	2				2
Wf04		1			1
Wm01			8		8
TRIM Marsh			8		8
Ws07				7	7
Salix				1	1
Salix/Carex				1	1
TRIM Swamp				14	14
Total	9	1	16	23	49

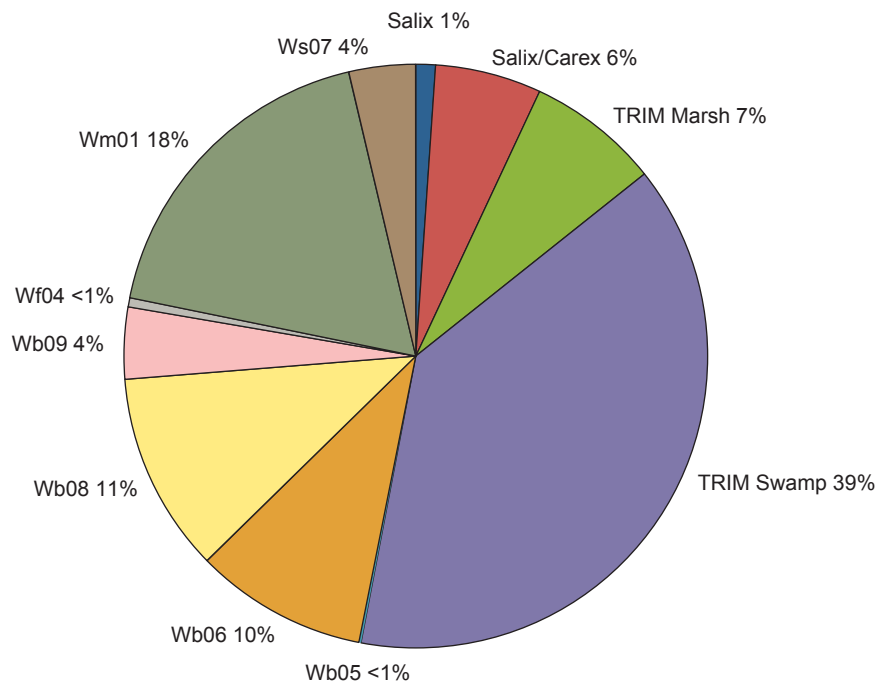
5.1.1 Bog Wetlands

A bog is a nutrient-poor, *Sphagnum*-dominated peatland ecosystem in which the rooting zone is isolated from mineral-enriched groundwater, soils are acidic, and few minerotrophic plant species occur (MacKenzie and Moran 2004). Bogs may be treed or tree-less and are usually covered with *Sphagnum spp.* and ericaceous shrubs. Precipitation, fog, and snowmelt are the primary water sources. Precipitation does not usually contain dissolved minerals and is mildly acidic; subsequently bog waters are low in dissolved minerals and are acidic in nature. Bog water acidity is enhanced because of organic acids formed during the decomposition of peat (Warner and Rubec 1997). Four bog associations (Wb05, Wb06, Wb08, and Wb09) were identified and represented approximately 18.4% of all observed wetlands ecosystems by count and 24.7% by area (including TRIM and TEM Bog dominated ecosystems).

Observed Count



Calculated Area



- Salix
- Salix/Carex
- TRIM Marsh
- TRIM Swamp
- Wb05
- Wb06
- Wb08
- Wb09
- Wf04
- Wm01
- Ws07

Wb05 Site Description:

Site Association Code: Wb05

Wetland Class: Bog

Site Name: Black spruce - water sedge - peat-moss

Wetland Area: 0.16 ha

These bogs are common throughout the sub-boreal and central interior below 1,300 m. They occur as components of larger peatlands or in small, closed basins where there is little lateral and groundwater movement (MacKenzie and Moran 2004).

Within the wetland study area this type of bog was observed at sites MW07 and MW21. The vegetation was dominated by *Carex aquatilis*, *Ledum groenlandicum*, and *Picea* sp. (Plate 5.1-1). The moss layer was dominated by *Sphagnum* sp., *Aulacomnium* sp., and *Polytrichum* sp. The soil was humic or mesic sphagnum peat and the soil nutrient regime was poor to rich. The HDI was stagnant or sluggish, and soil water pH was 4.1 in the poorer nutrient site and 7.5 in the richer site. The richer Wb05 community (MW21) was a component of a larger peatland, whereas the poor bog (MW07) community was in a closed basin. Generally, bog communities are not nutrient rich sites; however, the vegetation and hydrodynamics of this site are consistent with a bog and thus the site was classified as a bog.



Plate 5.1-1. Wb05 bog at site MW07.

Wb06 Site Description:

Site Association Code: Wb06

Wetland Class: Bog

Site Name: Tamarack - Water sedge - Fen moss

Wetland Area: 12.96 ha

Within the wetland study area this type of bog was observed at sites 404, 494, 530, and MW29. These bogs are common throughout the eastern BWBS. Sites are hummocky and dominated by *Larix laricina*, *Picea* sp., *Carex aquatilis*, *Ledum groenlandicum*, and *Betula nana* (Plate 5.1-2.). The trees grow on elevated micro sites with the sedge growing in wetted depression (MacKenzie and Moran 2004). The moss layer is dominated by *Tomentypnum nitens*, *Sphagnum fuscum*, and *Sphagnum girgensohnii*. On sites that were tested, the organic soil is made of mesic, sphagnum derived peat (>1.3m) and the soil nutrient regime was very poor with a pH of 6 at site 404.



Plate 5.1-2. Wb06 bog at site 404.

Wb08 Site Description

Site Association Code: Wb08

Wetland Class: Bog

Site Name: Black spruce - soft-leaved sedge - peat-moss

Wetland Area: 15.03 ha

These bogs/poor swamps are uncommon throughout the interior, but when found, they usually occupy palustrine basins and hollows below 1,300 m. These sites are strongly hummocky and are often fed by slow moving groundwater (MacKenzie and Moran 2004).

Within the wetland study area this type of bog was observed at sites MW15 and MW22. The vegetation was dominated by *Carex disperma* and *Picea sp.* (Plate 5.1-3). The moss layer was dominated by *Sphagnum sp.* and *Aulacomnium sp.* The soil was mesic and humic sphagnum peat, and the soil nutrient regime was moderate to rich. The HDI was stagnant or sluggish; soil water pH was generally neutral ranging from 6.9 to 7.4. Similar to the Wb05 bog community nutrient rich sites are not common. The vegetation and hydrodynamics of this site are consistent with a bog and thus the site was classified as a bog.



Plate 5.1-3. Wb08 bog at site MW15.

Wb09 Site Description:

Site Association Code: Wb09

Wetland Class: Bog

Site Name: Black spruce - common horsetail - peat-moss

Wetland Area: 5.41 ha

These bogs are uncommon throughout the interior, but when found, they usually occupy palustrine basins and hollows; they also form components of larger peatlands. These sites are transitional to forested swamps but have bog affiliated species, poor tree growth, and more stagnant hydrology (MacKenzie and Moran 2004).

Within the wetland study area this type of bog was observed at site MW26 and site 407. The vegetation was dominated by *Ledum groenlandicum*, *Equisetum arvense*, *Carex disperma*, and *Picea sp.* (Plate 5.1-4). The moss layer was dominated by *Pleurozium schreberi*, *Tomenthypnum nitens*, *Aulacomnium sp.*, *Sphagnum sp.*, and *Aulacomnium sp.* The soil on site MW26 was a humic organisol over a silty mineral layer and the soil nutrient regime was rich. In contrast, the soil on site 407 was mesic with mostly sphagnum derived peat (>130cm) and the soil nutrient regime was very poor. The HDI was stagnant, and soil water pH for site MW26 was 7.5. The bog community of site MW26 also exceeded the normal parameters for nutrients but the vegetation and hydrodynamics were consistent with bogs and thus the site was classified as a bog.



Plate 5.1-4. Wb09 bog at site MW26.

5.1.2 Fen Wetlands

A fen is a nutrient-medium peatland ecosystem, dominated by sedges and brown mosses, where mineral-bearing groundwater is within the rooting zone and minerotrophic plant species are common (MacKenzie and Moran 2004; Plate 5.1-4). Fens can have fluctuating water tables and are often rich in dissolved minerals. Surface water flow can be direct, through channels, pools, and other open features that can often form characteristic surface patterns. The vegetation in fens is closely related to the depth and chemistry of

groundwater. Shrubs occupy drier sites and minerotrophic graminoid vegetation (grass) is typically found in wetter sites (Warner and Rubec 1997). One fen association was identified in the wetland study area and accounted for 2.0% of the wetlands observed by count and 0.5% of the wetland ecosystems by area.

Wf04 Site Description:

Site Association Code: Wf04

Wetland Class: Fen

Site Name: Barclay's willow - water sedge - glow moss

Wetland Area: 0.70 ha

These fens are common in the subalpine elevations and often occur on seepage slopes, glacier-fed creeks, and in frost-prone basins (MacKenzie and Moran 2004; Plate 5.1-4).

One Wf04 fen association was observed within the wetland study area. This site was surveyed at MW12 (Plate 5.1-5). The SMR was wet, the HDI was stagnant, and the SNR was C; the ecosystem was found in a basin and hollows hydrogeomorphic position. The shrub layer was predominant at this site and was generally composed of *Salix barclayi*. There were a number of non-swamp indicator species such as *Picea sp.*, *Oxycoccus oxycoccus*, and *Ledum groenlandicum*, indicating that this site may be transitioning to a bog or *Picea*-dominated swamp.



Plate 5.1-5. Wf04 fen at site MW12.

5.1.3 Marsh Wetlands

A marsh is a permanently to seasonally flooded non-tidal mineral wetland dominated by emergent grass-like vegetation (MacKenzie and Moran 2004; e.g., Plate 5.1-5). Marshes are the most heavily used wetland type for most wetland-using wildlife species. They are typically eutrophic and support large standing crops of palatable vegetation, plankton, and aquatic invertebrates. They are the favoured wetland class for most waterfowl, amphibians, and semi-aquatic mammals because they provide good cover, open

water, and food. Soils are typically mineral but can also have a well-decomposed organic surface tier (Warner and Rubec 1997; MacKenzie and Moran 2004). Marsh communities accounted for the majority of the wetland area and often existed in a complex with shallow open water and shrub and treed wetland and riparian areas. Approximately 16.3% of all wetland observations by count were marsh class wetlands with TRIM marshes accounting for an additional 16.3% (by count). Marsh wetland ecosystems accounted for 18.1% of wetland association by area with an additional 7.3% (9.9 hectare) of TRIM marsh also identified. All observed marshes were the Wm01 association.

Wm01 Site Description:

Site Association Code: Wm01

Wetland Class: Marsh

Site Name: Beaked sedge - water sedge

Wetland Area: 24.58 ha

This association is the most widespread and common marsh association in the province. They are found on sites inundated by shallow low energy flood waters, and the margins of beaver ponds, lakes, and palustrine basins (MacKenzie and Moran 2004).

Within the wetland study area this community was observed at sites MW01, MW14, MW16, MW18, MW19, MW23, MW24, and MW27 (Plate 5.1-6). Species diversity at these sites was low; vegetation was dominated by *Carex utriculata* or *C. aquatilis*. Some sites had shrubs and wetland adapted forbs, such as *Equisetum arvense* and *Scirpus microcarpus*, occurring on margins and in transitional areas. All sites had an organic veneer over a poorly to imperfectly drained mineral soil. Organic soil types comprised fibric or mesic peat, with SMRs of W to VW and SNRs of B to D; the soil water pH was 7 to 8.



Plate 5.1-6. Wm01 marsh at site MW19.

5.1.4 Swamp Wetlands

A swamp is a nutrient-rich wetland ecosystem with significant groundwater inflow, periodic surface aeration, and elevated microsites supporting the growth of trees and tall shrubs (MacKenzie and Moran 2004; plates 5.1-6 to and 5.1-8). Swamps generally have more than 30% tree or tall shrub cover. Soils

are often gleyed mineral soils with a surface layer of anaerobically decomposed woody peat. In general, there are three physically different swamp communities: (1) shrub-thicket, (2) coniferous forest, and (3) hardwood (deciduous) swamps (Warner and Rubec 1997). Swamps have a more vertical structure than other wetland classes and support more diverse avifaunal assemblages (MacKenzie and Moran 2004). Furthermore, forested swamps typically have an open canopy that appears to be favoured by many bird and bat species (MacKenzie and Moran 2004; Lausen 2006). Three swamp associations were observed in the wetland study area: Ws07, willow, and willow - sedge). Approximately 18.4% of all wetland ecosystem observations by count were the swamp association, with TRIM swamps accounting for an additional 28.6% (by count). Swamp associations accounted for 10.7% of wetland association by area with an additional 38.7% by area (56.1 hectare), of TRIM swamp also identified.

Ws07 Site Description:

Site Association Code: Ws07

Wetland Class: Swamp

Site Name: Spruce - common horsetail - leafy moss

Wetland Area: 5.02 ha

These swamps are common in the northern boreal mountains and central and sub-boreal interior from low to subalpine elevations. They occur on lower and toe slopes and margins of wetlands where there is significant flow of mineral-rich groundwater. These can be moderately productive sites with spruce, up to 25 m tall rooting on elevated mounds (MacKenzie and Moran 2004).

Within the wetland study area the Ws07 was observed at sites MW05, MW06, MW08, MW09, MW11, MW13, and TEM Polygon 575. The vegetation was diverse with an open overstorey canopy of *Picea sp.*, *Alnus crispa*, dominant in the shrub layer; and a variety of species in the understorey (Plate 5.1-7). Soils were largely deep mesic or humic soils. The HDI varied from stagnant to mobile, soil water pH ranged from 6.1 to 7.5, and the SMR was wet.



Plate 5.1-7. Ws07 swamp at site MW05

Willow Site Description

Site Association Code: Willow

Wetland Class: Swamp

Site Name: Willow

Wetland Area: 1.47 ha

Differences in climatic regimes, site conditions, and hydrological characteristics, as well as the stochastic establishment capacity of *Salix spp.*, allow for a wide range of willow associations (MacKenzie and Moran 2004). The general willow association was created as a classification for sites that do not fit in the more specific swamp associations listed above and in Mackenzie and Moran (2004).

Within the wetland study area one site (MW20) was classified as a willow association. MW20 (Plate 5.1-8) supported a diversity of willow species. This site was characterized by poorly drained mineral soils with little organic material, the SMR was VW, the HDI was mobile, and soil water pH was 7.4.



Plate 5.1-8. Willow swamp association at site MW20.

Willow Sedge Site Description:

Site Association Code: Willow - sedge

Wetland Class: Swamp

Site Name: Willow - sedge

Wetland Area: 8.00 ha

Similar to the general willow association differences in climatic regimes, site conditions, and hydrological changes, allow for a wide range of willow-sedge associations (MacKenzie and Moran 2004). The general willow-sedge association was created as a classification for sites that do not fit in the more specific willow-sedge associations listed above and in Mackenzie and Moran (2004).

Within the wetland study area one site (MW25) was classified as a willow-sedge association. MW25 (Plate 5.1-9) supported a diversity of willow species and other shrubs. *Carex aquatilis*, *Equisetum fluvitile*, and *Calamagrostis canadensis* were the dominant forbs/graminoids at this site. This site was characterized by poorly drained mineral soils with little organic material, the SMR was W, the HDI was mobile, and soil water pH was 8.0.



Plate 5.1-9. Willow-sedge swamp association at site MW25.

5.1.5 Shallow Open Water Wetlands

Shallow open water wetlands are ecosystems that are permanently flooded by still or slow-moving water and dominated by rooted and floating aquatic plants. Shallow open water wetlands are often the transition from bogs, fens, marshes, and swamps to permanent deep water bodies (i.e., sluggish streams and lakes; Warner and Rubec 1997; MacKenzie and Moran 2004). They are among the most important habitat for wildlife and fish because of vegetative cover and high prey densities (MacKenzie and Moran 2004).. A variety of shallow open water ecosystems were observed throughout the wetland study area, including a submergent community at MW01 (Plate 5.1-10), deep un-vegetated bog stream/pools (Plate 5.1-11), and flooded land (Plate 5.1-12). The areas associated with these wetland

classes has been incorporated into the other classes as they always occurred as a small component of larger systems.



Plate 5.1-10. Submergent community at site MW01.



Plate 5.1-11. Deep un-vegetated stream/pools in bog community at site MW26.



Plate 5.1-12. Flooded land at site MW04.

5.2 WETLAND ECOSYSTEM EXTENT AND MAPPING

A total of 139.38 ha of wetlands were mapped in the wetland study area; 62.70 ha were delineated through wetland surveys, 10.63 ha were incorporated from TEM, and 62.54 ha were incorporated from TRIM. The area of each wetland association described in Section 5.1 is presented in Table 5.2-1 as are the areas for TRIM Marsh and TRIM Swamp. Maps of wetland ecosystems in the wetland study area are presented in Figures 5.2-1 through 5.2-7.

Table 5.2-1. Area of Wetland Associations in the Murray River Wetland Study Area

Wetland Association	Bog	Fen	Marsh	Swamp	TRIM Marsh	TRIM Swamp	Total
Wb05	0.16	-	-	-	-	-	0.16
Wb06	12.96	-	-	-	-	-	12.96
Wb08	15.03	-	-	-	-	-	15.03
Wb09	5.41	-	-	-	-	-	5.41
Wf04	-	0.70	-	-	-	-	0.70
Wm01	-	-	24.58	-	-	-	24.58
TRIM Marsh	-	-	-	-	9.95	-	9.95
Ws07	-	-	-	5.02	-	-	5.02
Salix	-	-	-	1.47	-	-	1.47
Salix/Carex	-	-	-	8.00	-	-	8.00
TRIM Swamp	-	-	-	-	-	52.59	52.59
Total	33.56	0.70	24.58	14.49	9.95	52.59	135.87

5.3 WETLAND ECOSYSTEM FUNCTION

The following is a description of the primary wetland functions identified in the wetland study area.

5.3.1 Hydrological Function

Wetland hydrologic function is defined as a wetlands contribution to ground and surface water resources. The hydrologic function of wetlands in the wetland study area can be inferred from the wetland classes and identified associations, as well as from their HDI and landscape, or hydrogeomorphic, position. The majority of wetlands, both in terms of individual ecosystems and overall area, were swamps and marshes. Both of these wetland classes have a strong mineral soil component that displays hydromorphic characteristics. Thus the hydrology of marshes and swamps tends to be more mobile or dynamic when compared to other wetland classes. The HDI recorded at the survey sites confirms this; only marsh and swamp classes were observed to have a mobile hydrology (Appendix 1). Additionally, landscape or hydrogeomorphic position reflects site hydrology.

Marshes and swamps can exist in varied hydrogeomorphic positions giving them a variety of hydrological functions. For instance, a treed swamp found in a palustrine seepage slope position may recharge groundwater reserves, whereas a willow swamp associated with a fluvial or lacustrine system will have a flood control or erosion protection hydrological function. The majority of observed sites were in the palustrine basin and hollows hydrogeomorphic category. The hydrological function typically associated with this landscape position is groundwater recharge and water storage. Wetlands in the palustrine basin and hollows hydrogeomorphic category are typically small, less than 1 ha, where topography limits the depth to water within the basin and hollow.

Small wetlands have a greater perimeter to volume ratio than larger wetlands and therefore better support groundwater recharge (Weller 1994). Approximately 37% of all mapped wetlands were smaller than 1 ha (Figure 5.3-1), with 20% of these wetland ecosystems smaller than 0.5 ha. This is a strong indication that one of the primary hydrological functions of wetlands in the wetland study area is groundwater recharge.

Another primary hydrological function within the wetland study area is water storage. Most surveyed wetlands had an open water component (plates 5.3-1 to 5.3-3). These complexes hold water in ponds and small channels. Water storage is important, as it prevents downstream areas from flooding during spring freshet or in high precipitation events.

5.3.2 Biochemical Function

Wetland biochemical function is defined as a wetland's contribution to the quality of surface and groundwater of an area. Water, sediment, and vegetation components of a wetland influence its biological function. Aspects of the biochemical function of aquatic ecosystems were sampled to provide baseline data on water, sediment and vegetation; raw data are available in appendices 4 and 5.

Hanson et al. (2008) present a number of wetland functions associated with the different wetland classes. As the majority of wetlands in the wetland study area are marsh and swamp wetlands, it is likely that the primary wetland biochemical functions are:

- nutrient and organic export (marsh and swamp);
- carbon sequestration and storage (marsh and swamp); and
- water quality improvements (swamp; Hanson et al. 2008).

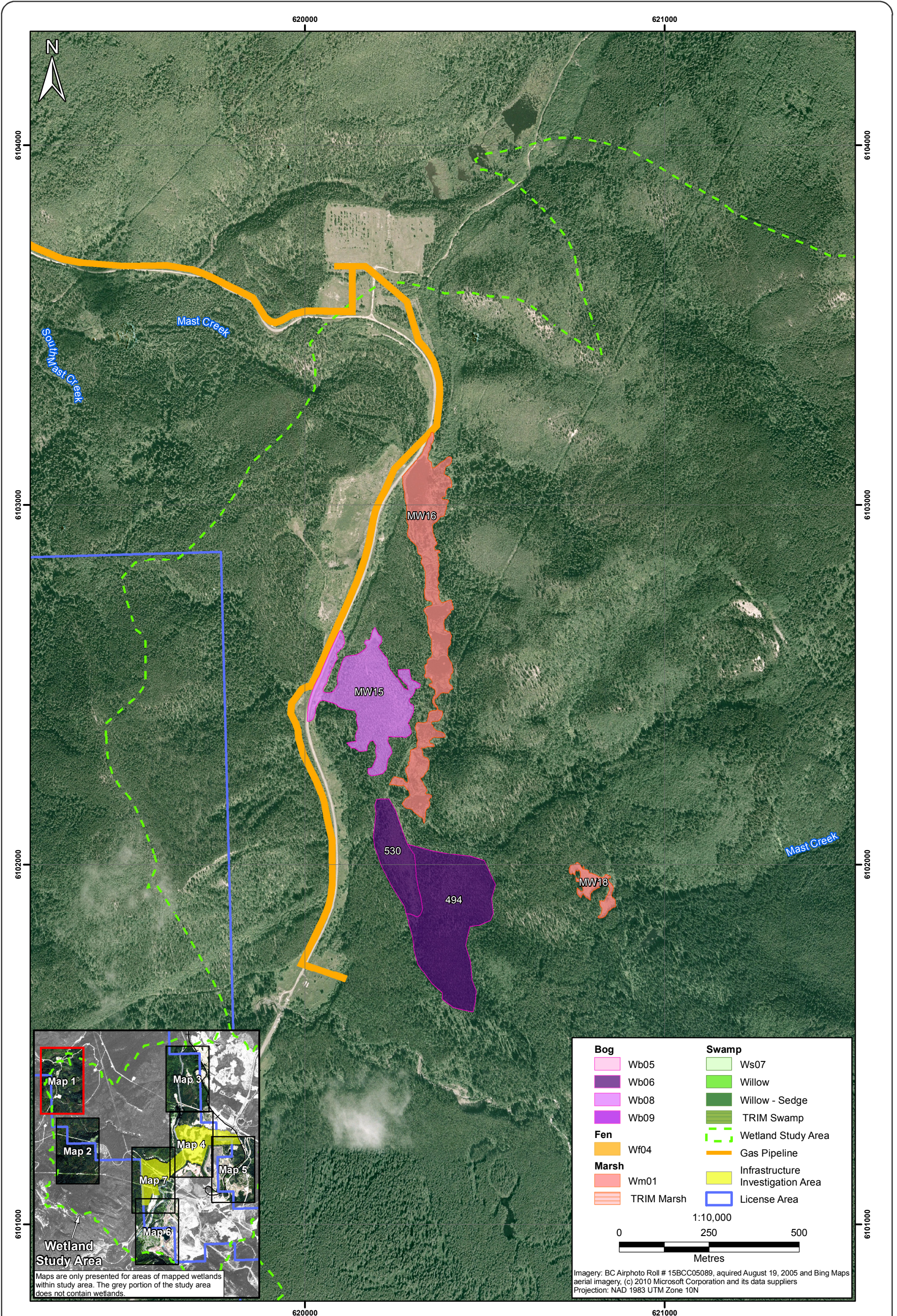


Figure 5.2-1

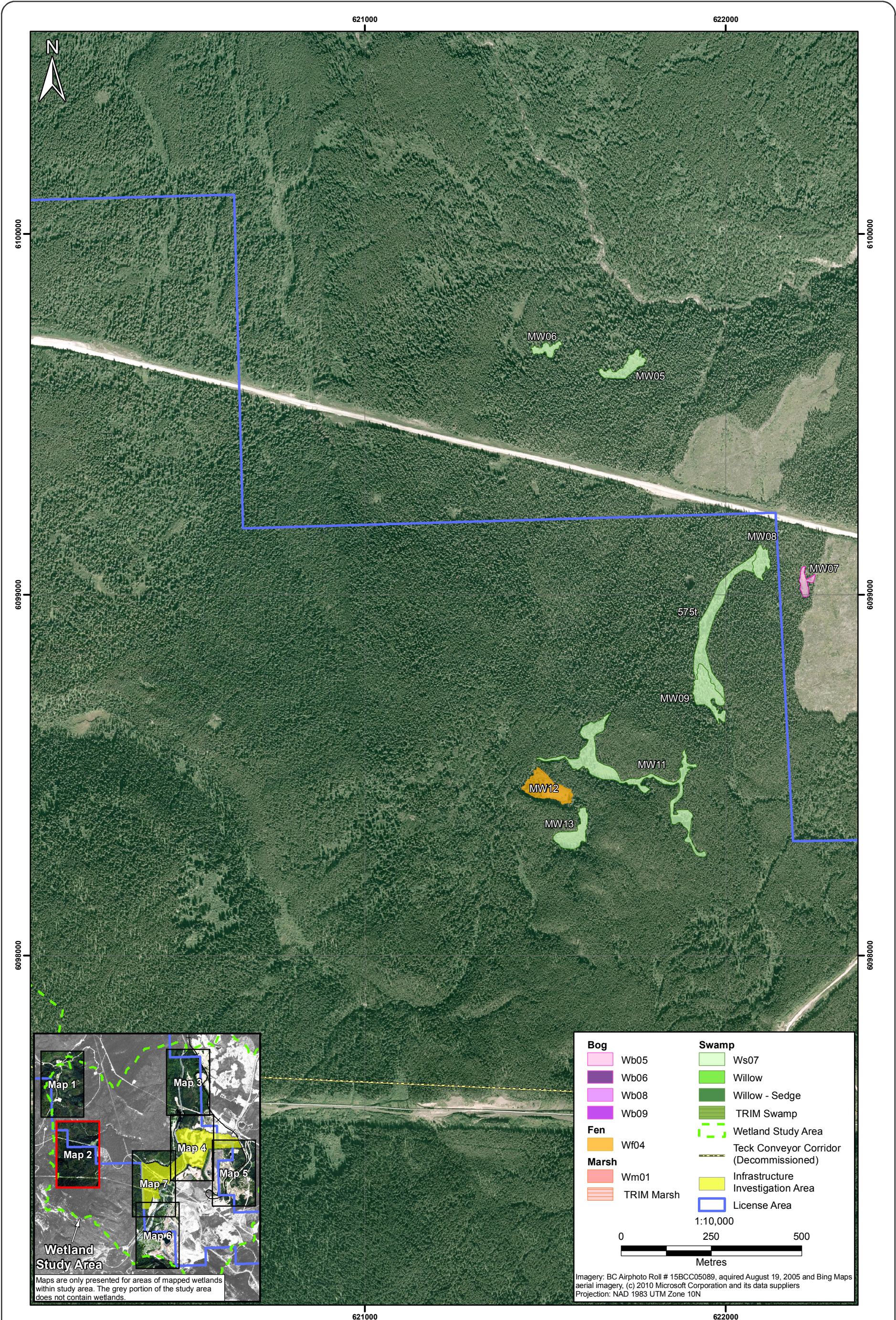


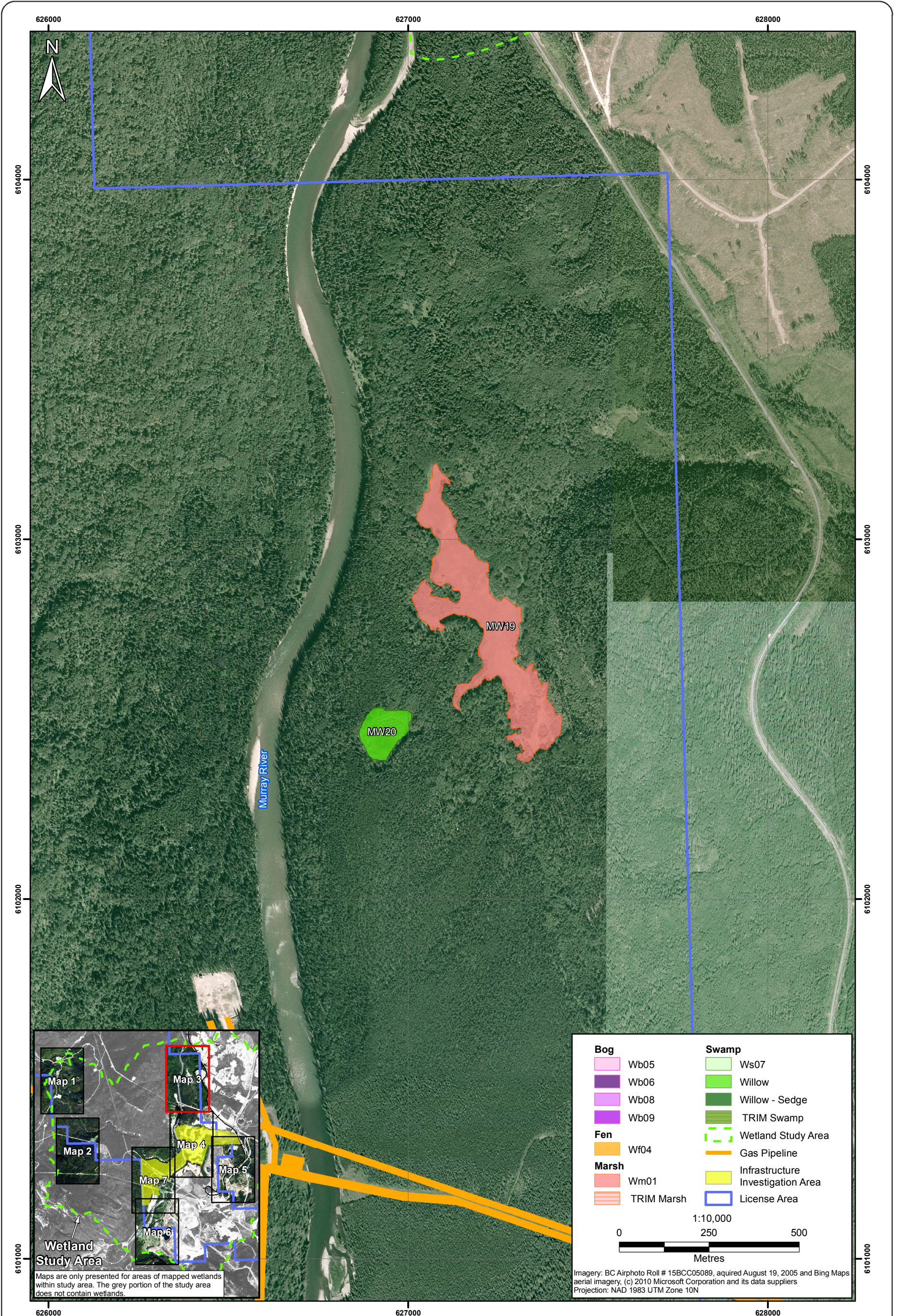
MURRAY RIVER COAL PROJECT

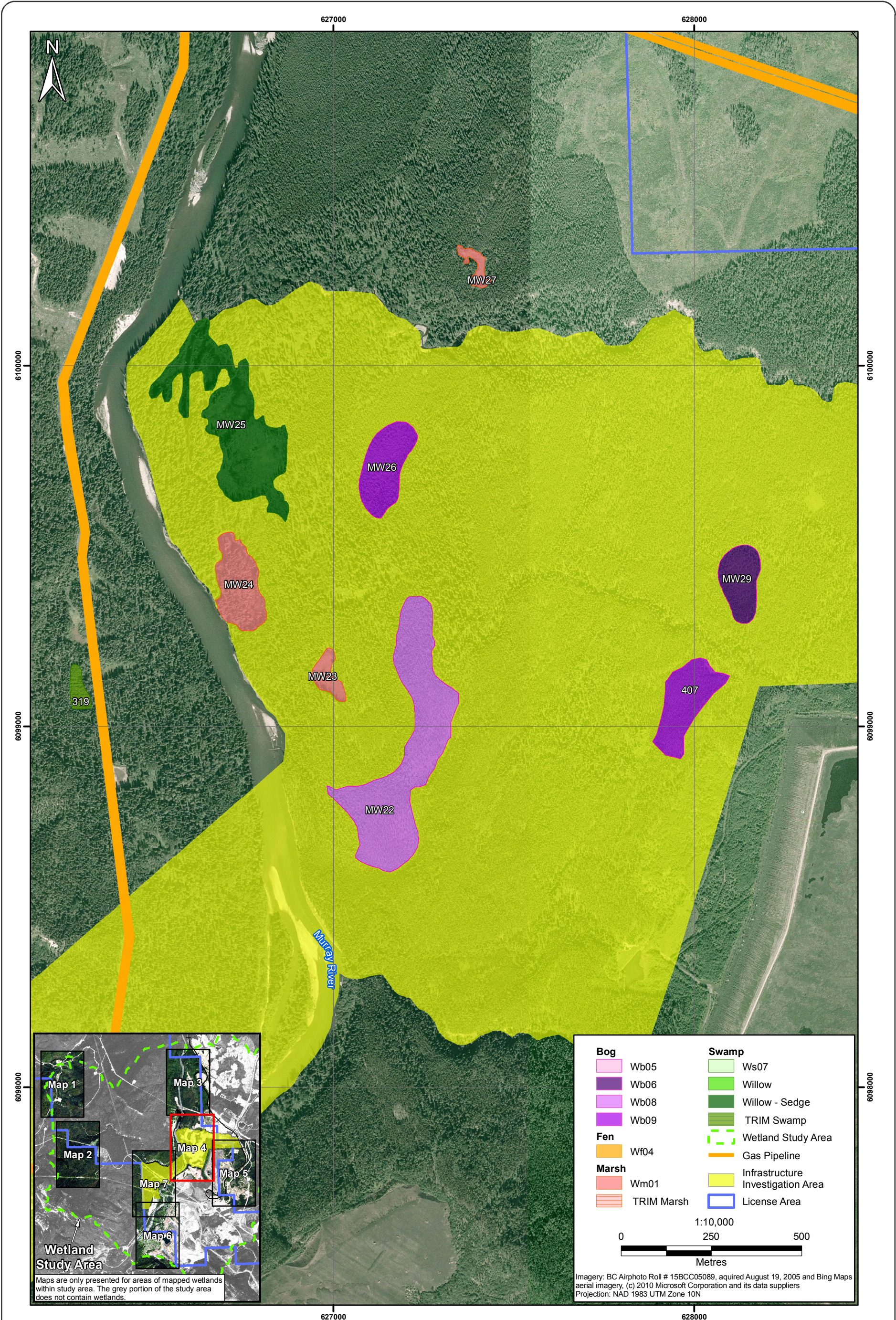
Mapped Wetland Extent Map 1

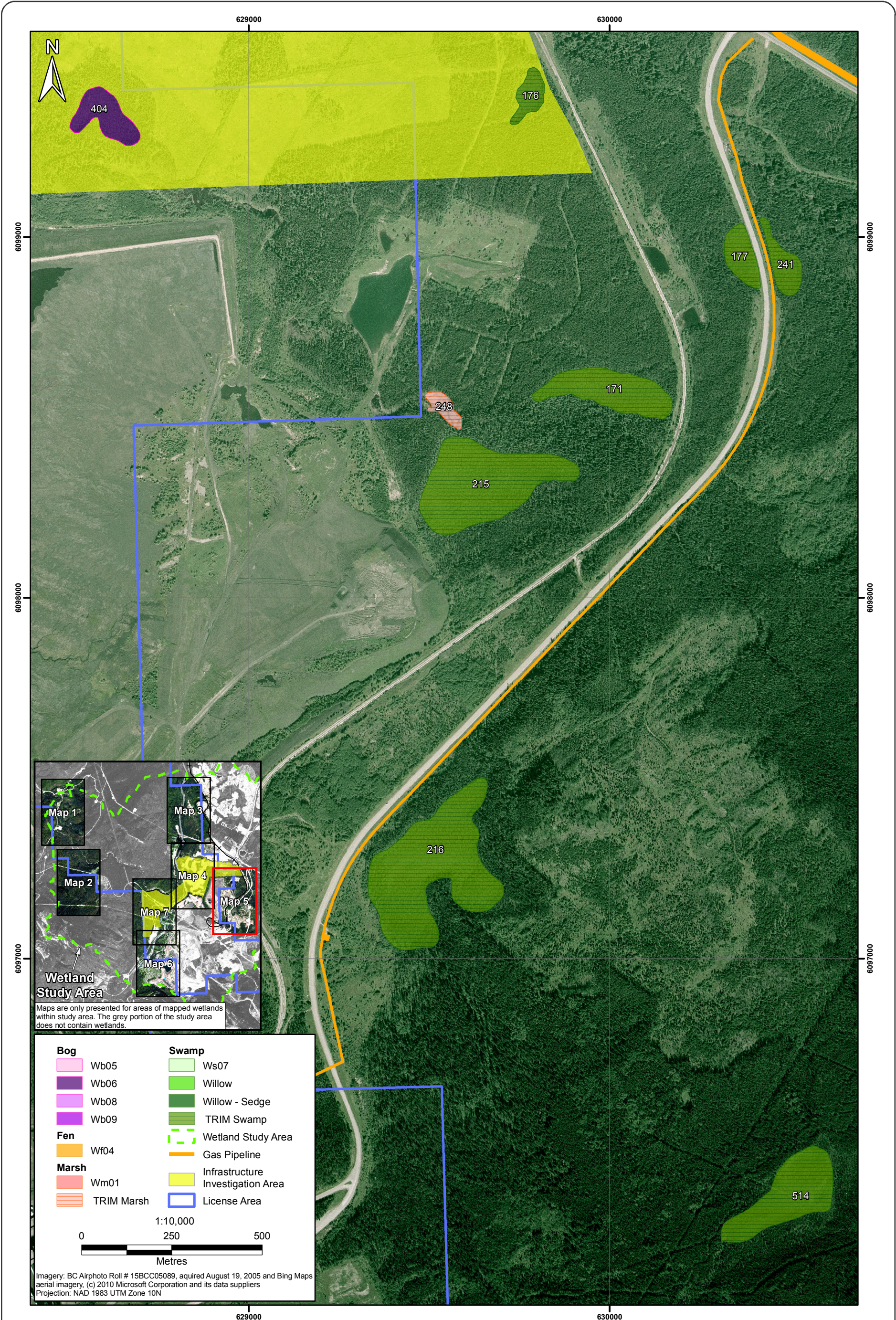
Figure 5.2-1



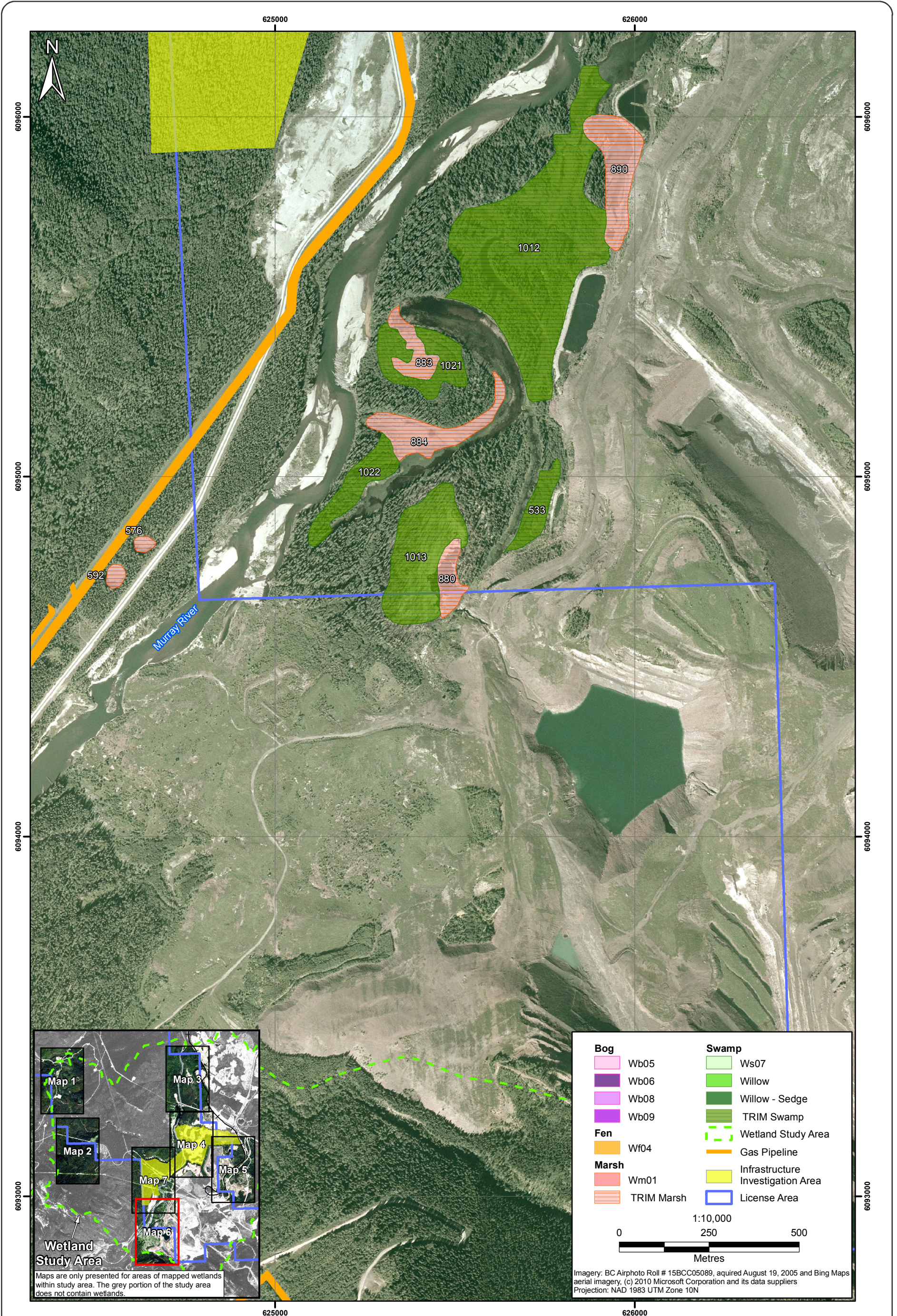


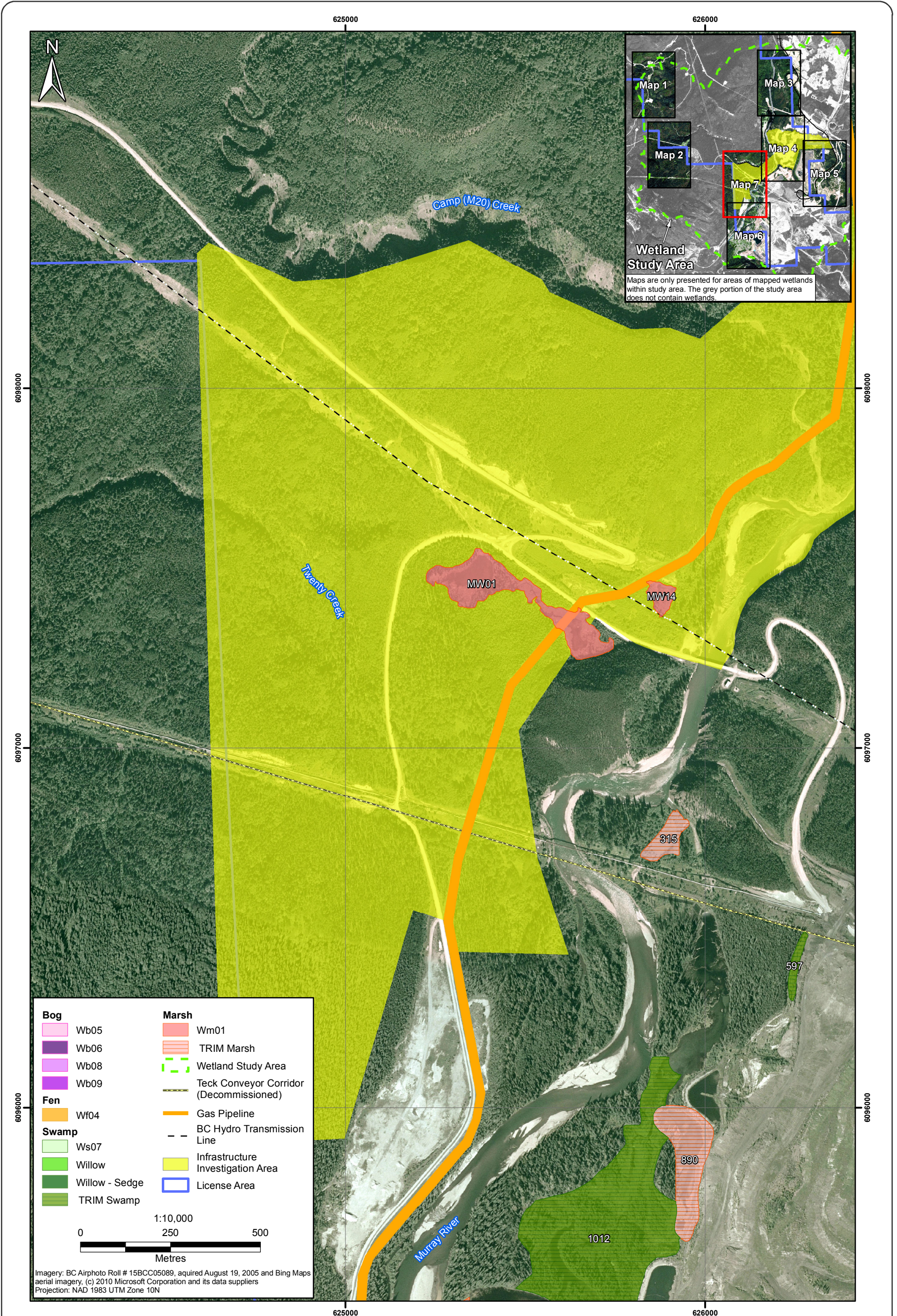






Imagery: BC Airphoto Roll # 15BCC05089, acquired August 19, 2005 and Bing Maps aerial imagery, (c) 2010 Microsoft Corporation and its data suppliers
 Projection: NAD 1983 UTM Zone 10N





Wetland Study Area

Maps are only presented for areas of mapped wetlands within study area. The grey portion of the study area does not contain wetlands.

Bog	Wb05	Marsh	Wm01
Wb06	Wb08	TRIM Marsh	Wetland Study Area
Wb09	Wf04	Teck Conveyor Corridor (Decommissioned)	Gas Pipeline
Fen	Ws07	BC Hydro Transmission Line	Infrastructure Investigation Area
Willow	Willow - Sedge	License Area	
TRIM Swamp			

1:10,000

0 250 500

Metres

Imagery: BC Airphoto Roll # 15BCC05089, acquired August 19, 2005 and Bing Maps aerial imagery, (c) 2010 Microsoft Corporation and its data suppliers
Projection: NAD 1983 UTM Zone 10N

Figure 5.2-7



MURRAY RIVER COAL PROJECT

Mapped Wetland Extent Map 7

Figure 5.2-7



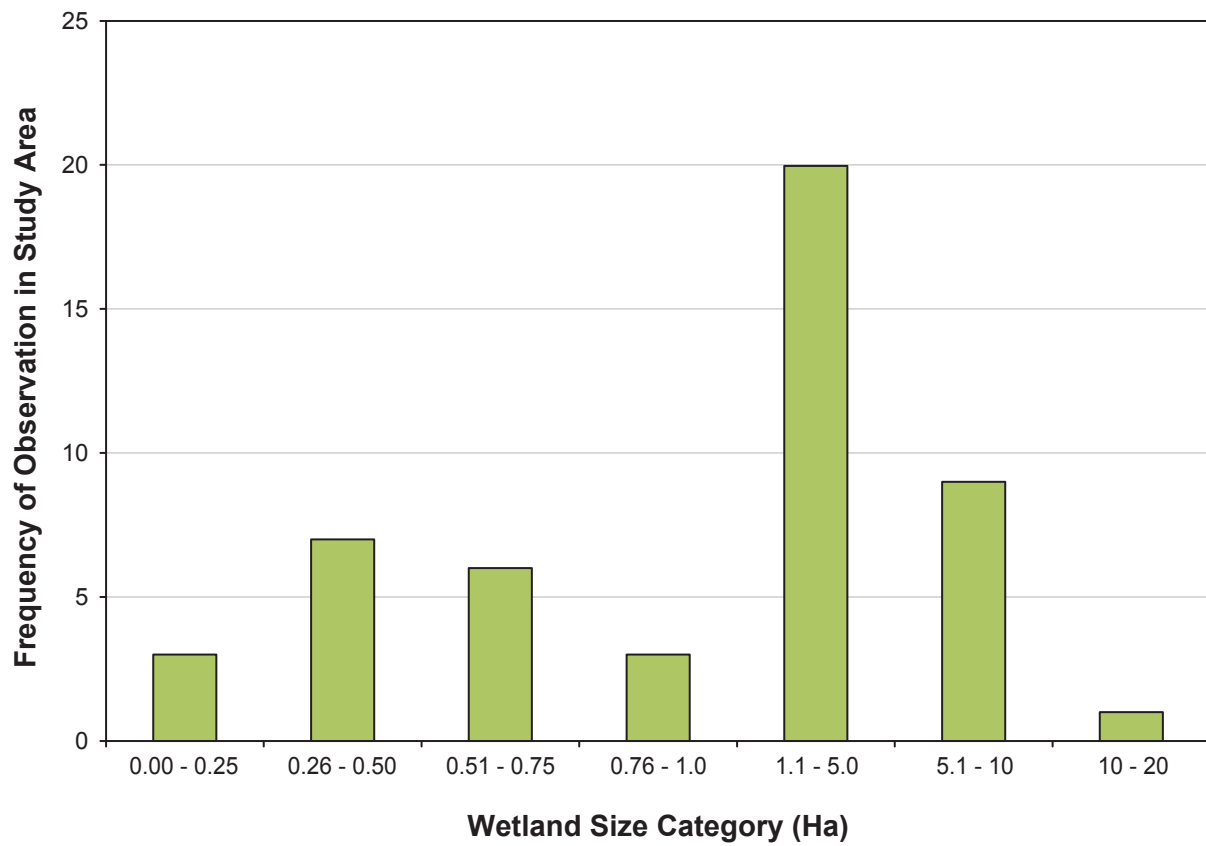




Plate 5.3-1. View of wetland (MW01), showing stream flowing from pond 2 to beaver dam at the outlet along the Murray River Forest Service Road, June 30, 2010.



Plate 5.3-2. View of wetland (MW01) showing outlet channel with beaver dam along Murray River Forest Service Road, June 30, 2010.



Plate 5.3-3. View of wetland (MM01) showing westernmost pond, June 30, 2010.

5.3.2.1 Summary of Wetland Sediment and Water Quality Data

The samples collected for wetland sediment and water quality are varied and generally do not have any discernible pattern. Raw data are available in Appendix 5.

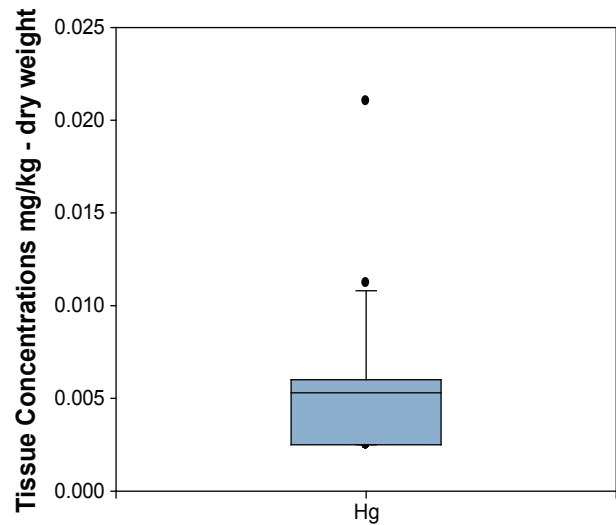
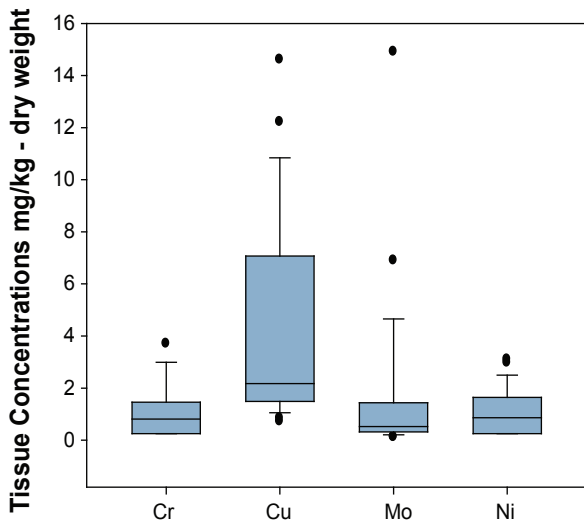
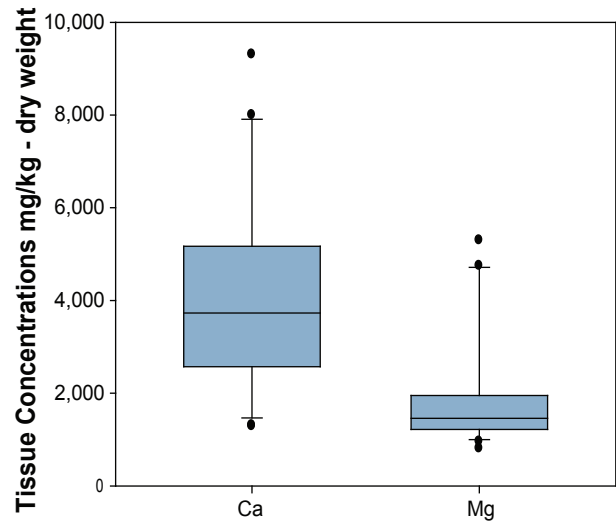
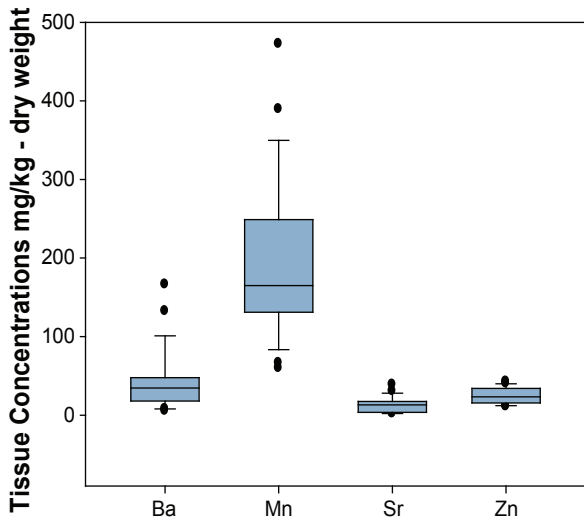
5.3.2.2 Summary of Wetland Vegetation Data

A total of 27 plant (*Carex aquatilis*) tissue samples were collected at nine sites and were analyzed for metal concentration. The raw data are presented in Appendix 4. Guidelines for plant tissue metal concentrations do not currently exist. These data are collected to serve as a baseline for comparison.

Sample results were below the detection limit in more than 50% of samples for Al, Sb, As, Be, Bi, Cd, Co, Pb, Li, Se, Ti, Sn, U, and V; results for these parameters will not be discussed. Box plots for parameters where more than 50% of the results were above the detection limit were prepared to depict the distribution of the data (Figure 5.3-2). This was done to identify sites that are consistently low or consistently high in metal concentrations (Table 5.3-1).

Table 5.3-1. Samples Sites with Results beyond the 90% Confidence Interval

Parameter	Sites Below 5th Percentile	Sites Above 95th Percentile
Ba	MW07 and LW11	MW01
Ca	MW07	RW3 and MW01
Cu	MW12	Reference and MW14
Cr	-	MW01
Hg	-	MW07
Mg	MW12	RW3
Mn	LW11	MW01 and MW07
Mo	RW3	MW07
Ni	-	MW07
Sr	MW07	LW11 and RW3
Zn	Reference	MW07



Sites MW01 and MW07 tended to have metal concentrations that were higher than other sites. The cause for this is not known, but it may be related to some historical industrial activity or proximity to a road. Both sites are not far from the Murray River and Mast Forest Service roads. Regardless of the cause of these elevated metal concentrations, it is important to keep in mind that some sites have plant tissue metal concentrations that exceed other sites and thus may not be suitable as a point of reference for future monitoring.

5.3.3 Ecological Function

Wetland ecology is defined as the relationship between a wetland and surrounding ecosystems. Aspects of the wetland ecosystem function include rare or unique wetlands and wetland complexes.

Four BEC subzones were identified in the wetland study area (Table 5.3-2; Rescan 2011a), situated in the Peace Forest District. A rare ecosystem search was conducted to identify wetland communities in these BEC subzones of the Peace Forest District that are red- or blue- listed (MOE 2007). A total of six wetland associations were identified during the search. Of these associations two were found in the wetland study area. The Wb09 association was identified at site MW26 and 407 and the Wb06 association was found at TEM (2010) sites 91 and 92 and polygons 404, 494, 530 and MW29. These sites are considered sensitive ecosystems and should be avoided by the Project (Figure 5.3-3). Although the other listed wetland associations were not observed during field studies this does not preclude the possibility of their presence within the wetland study area.

Table 5.3-2. Potentially Occurring Red- and Blue-listed Ecosystems

Subzones in the Wetland Study Area	BWBS mw	BWBS wk1	ESSF mv2	SBS wk2
Red- and Blue- listed Wetland Associations	Wf02	Wb06	Wf02	Wf02
	Wb06	Wb09		Wf13
	Wb09			Wb06
	arctic rush- Nuttall's alkaligrass- seablite			
	mat muhly-artic rush-neveda bluegrass			

Wetland complexes are a manifestation of ecological function as they support structurally different ecosystems which provide a diversity of habitat types within a given area. The majority of surveyed wetlands were found to exist as simple wetlands. However, complexes accounted for the largest area of mapped wetlands. These complexes tended to be a marsh and shallow open water communities such as those identified in Section 5.1.5. It is also likely that large TRIM wetlands that were not visited are also wetland complexes. Wetland complexes should be considered sensitive ecosystems and should be managed accordingly (Figure 5.3-3).

5.3.4 Habitat Function

Wetland habitat function includes both terrestrial and aquatic habitat components and is defined as a wetland's contribution to the wildlife habitat within a given region. Wetlands maintain local and regional biodiversity by providing a wide range of aquatic and terrestrial habitat types, as confirmed by the variety of wildlife observed during the wetland field survey (Table 5.3-3). Wildlife observations included a number of mammalian, avian, and herptofauna species, although approximately 50% of all wildlife observations were of moose (*Alces alces*; Plate 5.3-4).

No COSEWIC/SARA listed species were directly observed during wetland field studies. However, a number of herptofauna were observed during wetland field surveys (Plate 5.3-5).

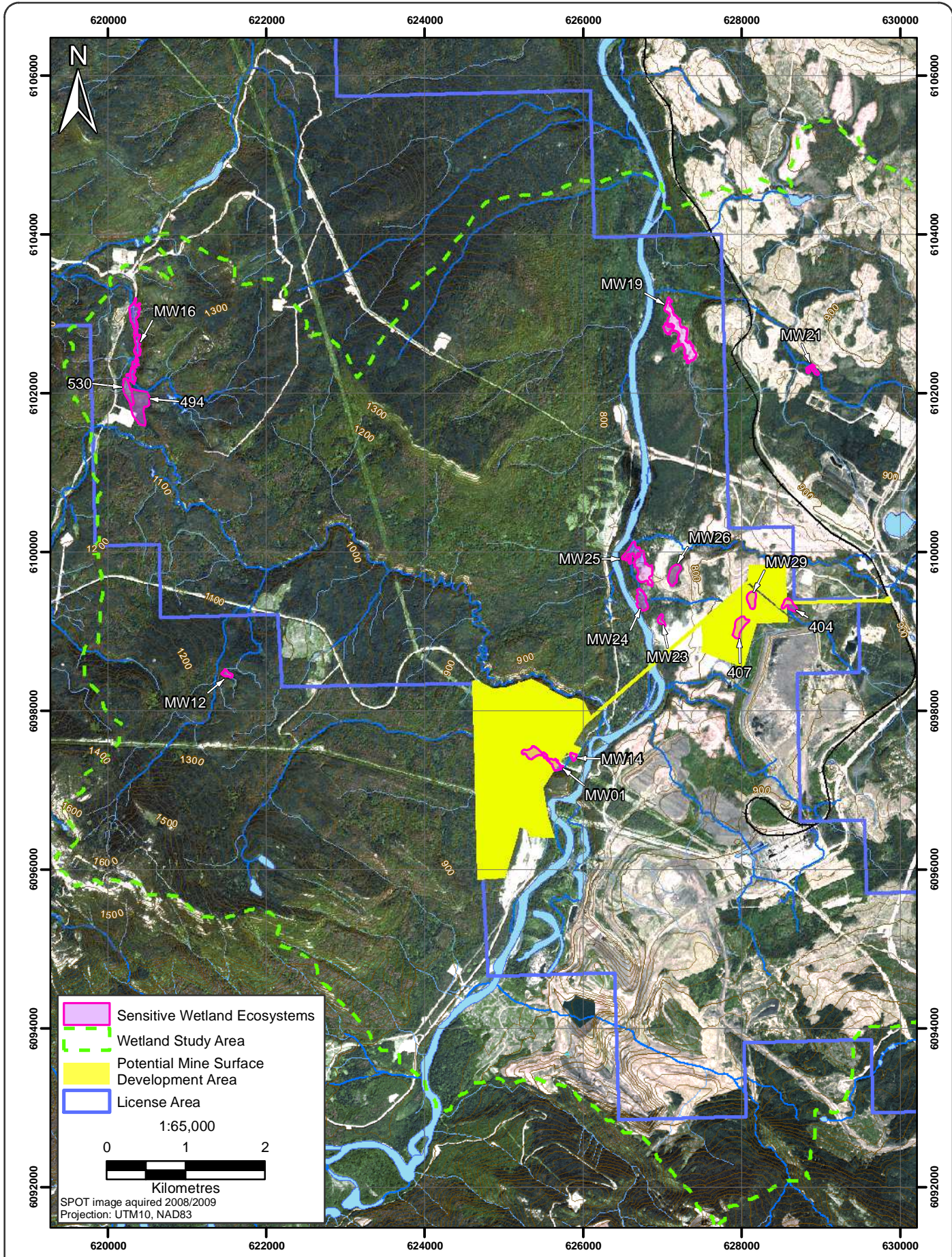


Table 5.3-3. Wetland Survey: Incidental Wildlife Observations

Plot	Genus	Species	Common Name	Observation
MW2	<i>Castor</i>	<i>canadensis</i>	beaver	lodge, tracks, individual
MW3	<i>Castor</i>	<i>canadensis</i>	beaver	dam
MW7	<i>Alces</i>	<i>alces</i>	moose	tracks, scat
MW9	<i>Alces</i>	<i>alces</i>	moose	scat, dead moose
MW11	<i>Alces</i>	<i>alces</i>	moose	scat
MW16	<i>Castor</i>	<i>canadensis</i>	beaver	dam, lodge
MW16	<i>Alces</i>	<i>alces</i>	moose	tracks
MW17	<i>Castor</i>	<i>canadensis</i>	beaver	dam
MW17	<i>Alces</i>	<i>alces</i>	moose	antler shed
MW19	<i>Alces</i>	<i>alces</i>	moose	skull
MW19	<i>Lithobates</i>	<i>sylvaticus</i>	wood frog	individual
MW20	<i>Alces</i>	<i>alces</i>	moose	tracks
MW20	<i>Lithobates</i>	<i>sylvaticus</i>	wood frog	individual
MW21	<i>Alces</i>	<i>alces</i>	moose	tracks
MW23	<i>Lithobates</i>	<i>sylvaticus</i>	wood frog	individual
MW24	<i>Alces</i>	<i>alces</i>	moose	tracks
MW25	<i>Lithobates</i>	<i>sylvaticus</i>	wood frog	individual
MW25	<i>Castor</i>	<i>canadensis</i>	beaver	gnawing



Plate 5.3-4. Moose rub and antler shed adjacent to wetland MW17.



Plate 5.3-5. Wood frog observed in aquatic feature adjacent to Mast Forest Service Road.

6. Summary

6. Summary

A total of 31 field surveys were completed resulting in the classification of 27 wetland ecosystems and the mapping of 24 wetland complex polygons. Through a GIS analysis an additional 25 wetland polygons were identified and mapped in the study area (including TRIM and TEM wetland ecosystem identification). These 49 wetlands were mapped and included in the final GIS product.

A total of 135.87 ha of wetlands were mapped; 62.7 ha were delineated through wetland surveys, and 73.2 ha were incorporated from TRIM and TEM mapping products. The largest mapped wetland features were TRIM Swamp, accounting for 38.7 % of all mapped wetlands.

All five wetland classes (bog, fen, marsh, swamp, and shallow open water) were observed. Shallow open water communities were not encountered as a simple wetland community but were observed numerous times as a component of larger wetland complexes. Nine wetland associations were identified including four bog, one fen, one marsh, and three swamp associations. Marshes and swamps account for 79.6% of all wetland observations by count and 74.8 % by delineated area.

Wetland classification and extent of data were, in combination with biochemical sample results, used to describe wetland functions. Wetland functions are the processes a wetland carries out and are of a hydrological, biochemical, ecological, or habitat nature.

Based on field observations the inferred primary hydrological functions of wetland ecosystems in the study area are groundwater recharge and water storage. These were identified as the primary functions because of the wetland sizes and classes identified in the wetland study area. The inferred primary biochemical functions are nutrient and organic export, carbon storage, and water quality improvements as determined through a comparison of wetland classes to know wetland functions (Hanson et al. 2008). The inferred primary ecological functions are the presence of listed/sensitive ecosystems and wetland complexes. Two listed wetlands (Wb09 and Wb06) were identified in the wetland study area. The site association Wb09 was identified at MW26 and 407, and the site association Wb06 was identified at TEM sites 91 and 92 and polygons 404, 494, 530 and MW29. These sites should be avoided so that it will not be affected by the Project. Additionally, nine wetland complexes were identified. These wetlands should be given specific reserve and management buffers, consistent with the Riparian Area Management Guidebook (MOF 1995). Wetlands also provide valuable aquatic, semi-aquatic, and terrestrial habitat for a variety of floral and faunal species.

References

References

Definitions of the acronyms and abbreviations used in this reference list can be found in the Glossary and Abbreviations section.

2002a. *Environmental Assessment Act*, SBC. C. 43.

2002b. *Species at Risk Act*, SC. C. 29.

Almas, A. R. and B. R. Singh. 2001. Plant Uptake of Cadmium-109 and Zinc-65 at Different Temperature and Organic Matter Levels. *Journal of Environmental Quality* (30): 869-77.

Brunham, W. G. 2009. The Effect of Temperature on Metal Accumulation in *Typha latifolia* and *Scirpus acutus*. Master of Science Thesis diss., Simon Fraser University.

Brunham, W. G. and L. Bendell. 2010. The Effect of Temperature on the Accumulation of Cadmium, Copper, Zinc, and Lead by *Scirpus acutus* and *Typha latifolia*: A Comparative Analysis. *Water, Air, & Soil Pollution* 219 (1-4): 417-28.

Canada Soil Survey Committee. 1987. *The Canadian System of Soil Classification*. 2 ed. Ottawa, ON: Agriculture Canada Publication 1646.

Douglas, G. W., D. Meidinger, and J. Pojar. 2001. *Illustrated Flora of British Columbia*. Vols 1-6. Victoria, BC: Ministry of Environment Lands and Parks.

Green, R. N., R. L. Trowbridge, and K. Klinka. 1993. Towards a Taxonomic Classification of Humus Forms. *Forest Science*, Supp. No. Monograph 29

Hanson, A., L. Swanson, D. Ewing, G. Graba, S. Meyer, L. Ross, W. M., and J. Kirby. 2008. *Wetland Ecological Functions Assessment and Overview of Approaches*. Environment Canada Technical Report Series No. 497: Atlantic Region.

Jacques Whitford Environmental Limited. 2007. *Final Report: Wetland Valuation in Atlantic Canada*. Project No. 1022659. Jacques Whitford Environmental Limited: Halifax, NS.

Johnson, D., L. Kershaw, A. MacKinnon, and J. Pojar. 1995. *Plants of the Western Boreal Forest and Aspen Parkland*. Vancouver, BC: Lone Pine Publishing and the Canadian Forest Service.

Lausen, C. 2006. *Bat Survey of Nahanni National Park Reserve and Surrounding Areas, Northwest Territories*. Prepared for Parks Canada and Canadian Parks and Wilderness Society: n.p.

Luttmerding, H. A., D. A. Demarchi, E. C. Lea, D. V. Meidinger, and T. Vold, eds. 1990. *Describing ecosystems in the field*. Victoria, BC: 2nd Ed. MOE Manual 11. BC Ministry of Environment, Lands and Parks and BC Ministry of Forests.

MacKenzie, W. H. 1999. *Field Description of Wetlands and Related Ecosystems in British Columbia*. Ministry of Forests Research Program: Victoria, BC.

MacKenzie, W. H. and J. R. Moran. 2004. *Wetlands of British Columbia: A Guide to Identification*. Land Management Handbook 52. Ministry of Forests Research Program: Victoria, BC.

MacKinnon, A., R. Coupe, and J. Pojar. 1999. *Plants of Northern British Columbia*. Expanded 2nd Ed. ed. Vancouver, BC: Lone Pine Publishing and BC Ministry of Forests.

Mason, B. and R. Knight. 2001. *Sensitive Habitat Inventory and Mapping*. Community Mapping Network, 315pp + viii. M. Johannes, Editor: Vancouver, BC.

- MEM. 1998. *Application Requirements for a Permit Approving the Mine Plan and Reclamation Program Pursuant to the Mines Act R.S.B.C. 1996, C.293*.
<http://www.empr.gov.bc.ca/Mining/Permitting-Reclamation/Guidance/PermitAppReqs/Pages/default.aspx>. (accessed October 2011).
- Milko, R. 1998. *Wetlands environmental assessment guideline*. Minister of Public Works and Government Services Canada: n.p.
- MOE. 2007. *BC Species and Ecosystems Explorer*. Government of British Columbia: n.p.
- MOE. 2009. *Water and Air Resource Protection Guidelines for Mine Proponents and Operators: Baseline Monitoring. Draft*. British Columbia Ministry of Environment: BC.
- MOELP. 1991. *British Columbia Specifications and Guidelines for Geomatics*. Content Series Vol. 4. Release 2.0. Province of British Columbia: BC.
- MOF. 1995. *Riparian Management Area Guidebook*. Forest Practices Code of British Columbia Act, Government of British Columbia: BC.
- Pojar, J. and A. MacKinnon. 1994. *Plants of Coastal British Columbia: Including Washington, Oregon and Alaska*. Vancouver, BC: Lone Pine Publishing and BC Ministry of Forests.
- Rescan. 2011a. *Murray River Project 2010-2011 Vegetation and Ecosystems Baseline Study*. Prepared for HD Mining International Ltd. by Rescan Environmental Services Ltd.: Vancouver, BC.
- Rescan. 2011b. *Murray River Project Aquatic Biology Baseline*. Prepared for HD Mining International Ltd. by Rescan Environmental Services Ltd.: Vancouver, BC.
- RISC. 1998. *Standard for Digital Terrestrial Ecosystem Mapping (TEM) Data Capture in British Columbia Ecosystem Technical Standards and Database Manual*. Resources Information Standards Committee, Province of British Columbia: BC.
- Warner, B. G. and C. D. A. Rubec, eds. 1997. *The Canadian wetland classification system: The national wetlands working group*. Waterloo, ON: Wetlands Research Centre, University of Waterloo.
- Weller, M. 1994. *Freshwater Marshes: Ecology and Wildlife Management*. 3 ed. Minneapolis, MN: The University of Minnesota.

Appendix 1

Wetland Ecosystem and Classification Data

Appendix 1. Wetland Ecosystem and Classification Data

Project_ID	Plot	Surveyor	Date	Easting	Northing	Elevation	Soil_Mois	Hydrodynam	Soil_Nutr	Meso_Slop	Hydrogeomo	Drainage__	Soil_Type	Mineral__S	Moisture__	Organic__S	Organic__H	Coarse__Fr	Water__Col	pH	Conductivi
0791-002-03-12	MW18	WB	6/16/2011	620801	6101957	1151	W	St	B	Depression	Basins and Hollows	Imperfectly	Clayey	SiCL	-	-	0	20-35%	-	0.0	-
0791-002-03-12	MW16	WB	6/16/2011	620384	6102586	1121	W	Mo	D	Depression	Basins and Hollows	Poorly	Clayey	CL	-	Mesic	35	<20%	Tea Coloured	7.4	150
0791-002-03-12	MW06	WB	6/15/2011	621483	6099672	1061	W	St	C	Depression	Basins and Hollows	Poorly	Clayey	SC	Aquic	Mesic	101	<20%	Green-Brown Clear	7.1	160
0791-002-03-12	MW05	WB	6/15/2011	621699	6099617	1072	W	Mo	D	Depression	Basins and Hollows	Poorly	Silty	Si	Aquic	Humic	35	<20%	Green-Brown Clear	7.5	150
0791-002-03-12	MW07	WB	6/15/2011	622232	6099041	1076	W	St	B	-	Basins and Hollows	Poorly	Clayey	SiC	Aquic	Mesic	110	<20%	Green-Brown Clear	4.1	30
0791-002-03-12	MW08	WB	6/15/2011	622090	6099078	1104	W	St	D	Depression	Basins and Hollows	Poorly	Clayey	SC	Aquic	Humic	50	<20%	Tea Coloured	6.2	120
0791-002-03-12	MW12	WB	6/15/2011	621538	6098447	1126	W	St	C	Depression	Basins and Hollows	-	-	-	Aquic	Mesic	120	-	-	6.7	130
0791-002-03-12	MW13	WB	6/15/2011	621604	6098358	1138	W	St	C	Depression	Basins and Hollows	-	-	-	Aquic	Mesic	120	<20%	-	6.9	120
0791-002-03-12	MW09	WB	6/15/2011	621997	6098670	1120	W	St	D	Depression	Basins and Hollows	-	-	-	Aquic	Humic	120	<20%	Tea Coloured	6.9	230
0791-002-03-12	MW14	WB	6/16/2011	625902	6097403	772	VW	Sl	D	Depression	Basins and Hollows	Poorly	Silty	-	Aquic	Fibric	20	<20%	-	7.3	490
0791-002-03-12	MW01	WB	6/14/2011	625362	6097346	1055	W	Sl	D	Depression	Basins and Hollows	Very Poorly	Silty	Si	Aquic	Mesic	84	<20%	Green-Brown Clear	7.0	440
0791-002-03-12	MW11	WB	6/15/2011	621794	6098499	1107	W	St	C	Depression	Basins and Hollows	-	-	-	-	Humic	120	<20%	Tea Coloured	6.1	-
0791-002-03-12	MW19	WB	6/17/2011	627299	6102654	781	W	St	B	Level	Fluvial	Poorly	Clayey	-	-	-	0	<20%	Green-Brown Clear	7.1	340
0791-002-03-12	MW20	WB	6/17/2011	626932	6102487	784	VW	Mo	-	Depression	Basins and Hollows	Poorly	-	-	-	-	0	-	Tea Coloured	7.4	280
0791-002-03-12	MW27	WB	6/18/2011	627402	6100228	791	W	St	B	Depression	Ponds and Potholes	Imperfectly	Sandy	S	-	-	0	>70%	Tea Coloured	8.0	160
0791-002-03-12	MW25	WB	6/18/2011	626831	6099643	765	W	Mo	C	Depression	Basins and Hollows	Poorly	Silty	-	-	-	0	<20%	Green-Brown Clear	8.0	-
0791-002-03-12	MW24	WB	6/18/2011	626794	6099355	766	W	Sl	D	Depression	Ponds and Potholes	Very Poorly	Clayey	C	Aquic	Mesic	27	<20%	Green-Brown Clear	7.6	520
0791-002-03-12	MW23	WB	6/18/2011	627017	6099110	772	W	Sl	D	Depression	Ponds and Potholes	Poorly	Sandy	LS	Peraquic	Humic	40	20-35%	-	7.4	580
0791-002-03-12	MW15	WB	6/16/2011	620103	6102444	1105	VM	St	C	Depression	Basins and Hollows	-	-	-	Aquic	Humic	120	<20%	-	6.9	170
0791-002-03-12	MW26	WB	6/18/2011	627126	6099666	772	VM	St	D	Depression	Basins and Hollows	Imperfectly	Silty	-	Subaquic	Humic	90	<20%	-	7.5	310
0791-002-03-12	MW22	WB	6/18/2011	627136	6098646	767	W	St	D	Depression	Basins and Hollows	-	-	-	Subaquic	Mesic	120	<20%	Green-Brown Clear	7.4	340
0791-002-03-12	171	TRIM	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
0791-002-03-12	176	TRIM	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
0791-002-03-12	215	TRIM	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
0791-002-03-12	248	TRIM	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
0791-002-03-12	315	TRIM	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
0791-002-03-12	319	TRIM	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
0791-002-03-12	533	TRIM	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
0791-002-03-12	177	TRIM	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
0791-002-03-12	241	TRIM	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
0791-002-03-12	216	TRIM	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
0791-002-03-12	514	TRIM	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
0791-002-03-12	576	TRIM	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
0791-002-03-12	592	TRIM	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
0791-002-03-12	597	TRIM	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
0791-002-03-12	880	TRIM	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
0791-002-03-12	883	TRIM	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
0791-002-03-12	884	TRIM	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
0791-002-03-12	890	TRIM	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
0791-002-03-12	1012	TRIM	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
0791-002-03-12	1013	TRIM	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
0791-002-03-12	1021	TRIM	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
0791-002-03-12	1022	TRIM	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
0791-002-03-12	530t	TEM	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
0791-002-03-12	494t	TEM	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
0791-002-03-12	575t	TEM	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
0791-002-03-12	MW29	TG	41226	628127	6099408	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
0791-002-03-12	404	TG	41226	628542	6099347	1002	VW	-	A	Depression	-	Very Poorly	-	-	-	Mesic	>130	<20%	-	6	-
0791-002-03-12	407	TG	41227	627980	6099108	819	VW	-	A	Depression	-	Very Poorly	-	-	-	Mesic	>130	<20%	-	-	-

Appendix 1. Wetland Ecosystem and Classification Data

Project_ID	Wetland_C	Wetland_A	WL1__	WL1_Class	WL1_Associ	WL2__	WL2_Class	WL2_Associ	WL3__	WL3_Class	WL3_Associ	Tall_tree	Tree_Shrub	Forb__cov	Bryophyte	Notes	Area_ha	In_LSA
0791-002-03-12	Marsh	Wm01	100	Marsh	Wm01	-	-	-	-	-	-	0	5	95	35	Data is a compilation of survey sites MW17, and MW18	0.66	Yes
0791-002-03-12	Marsh	Wm01	100	Marsh	Wm01	-	-	-	-	-	-	0	0	85	0	Beaver controlled	6.17	Yes
0791-002-03-12	Swamp	Ws07	100	Swamp	Ws07	-	-	-	-	-	-	10	25	70	85	close to a cutblock	0.19	Yes
0791-002-03-12	Swamp	Ws07	100	Swamp	Ws07	-	-	-	-	-	-	20	70	20	85	-	0.40	Yes
0791-002-03-12	Bog	Wb05	100	Bog	Wb05	-	-	-	-	-	-	5	15	30	99	close to a cutblock	0.16	Yes
0791-002-03-12	Swamp	Ws07	100	Swamp	Ws07	-	-	-	-	-	-	15	50	25	90	-	0.30	Yes
0791-002-03-12	Fen	Wf04	60	Fen	Wf04	40	Fen	Wf03	-	-	-	0	15	60	100	-	0.70	Yes
0791-002-03-12	Swamp	Ws07	100	Swamp	Ws07	-	-	-	-	-	-	2	40	40	40	-	0.49	Yes
0791-002-03-12	Swamp	Ws07	100	Swamp	Ws07	-	-	-	-	-	-	27	30	15	85	-	0.69	Yes
0791-002-03-12	Marsh	Wm01	100	Marsh	Wm01	-	-	-	-	-	-	0	25	8	0	-	0.49	Yes
0791-002-03-12	Marsh	Wm01	60	Marsh	Wm01	25	SOW	SOW	15	Swamp	Ws07	6	32	73	65	Data is a compilation of survey sites MW01, MW02, and MW03	3.97	Yes
0791-002-03-12	Swamp	Ws07	100	Swamp	Ws07	-	-	-	-	-	-	5	40	25	15	-	1.78	Yes
0791-002-03-12	Marsh	Wm01	100	Marsh	Wm01	-	-	-	-	-	-	0	0	0	0	Open meadow with lots of invasive species present	9.50	Yes
0791-002-03-12	Swamp	Salix	100	Swamp	Salix	-	-	-	-	-	-	0	0	0	0	Site flooded	1.47	Yes
0791-002-03-12	Marsh	Wm01	100	Marsh	Wm01	-	-	-	-	-	-	0	25	65	0	-	0.42	Yes
0791-002-03-12	Swamp	Salix/Carex	60	Swamp	Salix/Carex	40	Marsh	Wm01	-	-	-	0	15	75	10	Data is a compilation of survey sites MW25 and MW28	8.00	Yes
0791-002-03-12	Marsh	Wm01	80	Marsh	Wm01	20	SOW	SOW	-	-	-	0	15	60	30	Beaver controlled	2.67	Yes
0791-002-03-12	Marsh	Wm01	90	Marsh	Wm01	10	SOW	SOW	-	-	-	0	5	65	15	-	0.71	Yes
0791-002-03-12	Bog	Wb08	100	Bog	Wb08	-	-	-	-	-	-	0	25	15	100	-	5.55	Yes
0791-002-03-12	Bog	Wb09	100	Bog	Wb09	-	-	-	-	-	-	20	25	10	99	close to a cutblock	2.62	Yes
0791-002-03-12	Bog	Wb08	100	Bog	Wb08	-	-	-	-	-	-	25	15	5	100	-	9.48	Yes
0791-002-03-12	TRIM Swamp	TRIM Swamp	-	-	-	-	-	-	-	-	-	-	-	-	-	-	3.18	Yes
0791-002-03-12	TRIM Swamp	TRIM Swamp	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.82	Yes
0791-002-03-12	TRIM Swamp	TRIM Swamp	-	-	-	-	-	-	-	-	-	-	-	-	-	-	6.86	Yes
0791-002-03-12	TRIM Marsh	TRIM Marsh	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.52	Yes
0791-002-03-12	TRIM Marsh	TRIM Marsh	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.91	Yes
0791-002-03-12	TRIM Swamp	TRIM Swamp	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.82	Yes
0791-002-03-12	TRIM Swamp	TRIM Swamp	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1.63	Yes
0791-002-03-12	TRIM Swamp	TRIM Swamp	-	-	-	-	-	-	-	-	-	-	-	-	-	-	6.86	Yes
0791-002-03-12	TRIM Swamp	TRIM Swamp	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1.87	Yes
0791-002-03-12	TRIM Swamp	TRIM Swamp	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.50	Yes
0791-002-03-12	TRIM Swamp	TRIM Swamp	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1.34	Yes
0791-002-03-12	TRIM Marsh	TRIM Marsh	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.20	Yes
0791-002-03-12	TRIM Marsh	TRIM Marsh	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.28	Yes
0791-002-03-12	TRIM Swamp	TRIM Swamp	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.38	Yes
0791-002-03-12	TRIM Marsh	TRIM Marsh	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1.09	Yes
0791-002-03-12	TRIM Marsh	TRIM Marsh	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1.23	Yes
0791-002-03-12	TRIM Marsh	TRIM Marsh	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2.54	Yes
0791-002-03-12	TRIM Marsh	TRIM Marsh	-	-	-	-	-	-	-	-	-	-	-	-	-	-	3.18	Yes
0791-002-03-12	TRIM Swamp	TRIM Swamp	-	-	-	-	-	-	-	-	-	-	-	-	-	-	18.02	Yes
0791-002-03-12	TRIM Swamp	TRIM Swamp	-	-	-	-	-	-	-	-	-	-	-	-	-	-	5.49	Yes
0791-002-03-12	TRIM Swamp	TRIM Swamp	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2.67	Yes
0791-002-03-12	TRIM Swamp	TRIM Swamp	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2.16	Yes
0791-002-03-12	Bog	Wb06	100	Bog	Wb06	-	-	-	-	-	-	-	-	-	-	From TEM	2.36	Yes
0791-002-03-12	Bog	Wb06	100	Bog	Wb06	-	-	-	-	-	-	-	-	-	-	From TEM	7.10	Yes
0791-002-03-12	Swamp	Ws07	100	Swamp	Ws07	-	-	-	-	-	-	-	-	-	-	From TEM	1.17	Yes
0791-002-03-12	Bog	Wb06	100	Bog	Wb06	-	-	-	-	-	-	-	-	-	-	-	1.87	Yes
0791-002-03-12	Bog	Wb06	100	Bog	Wb06	-	-	-	-	-	-	0	46	10	45	Water table at 40cm	1.63	Yes
0791-002-03-12	Bog	Wb09	100	Bog	Wb09	-	-	-	-	-	-	8	45	20	41	Water table > 100cm therefore no sampling	2.78	Yes
																	135.87	

Appendix 2

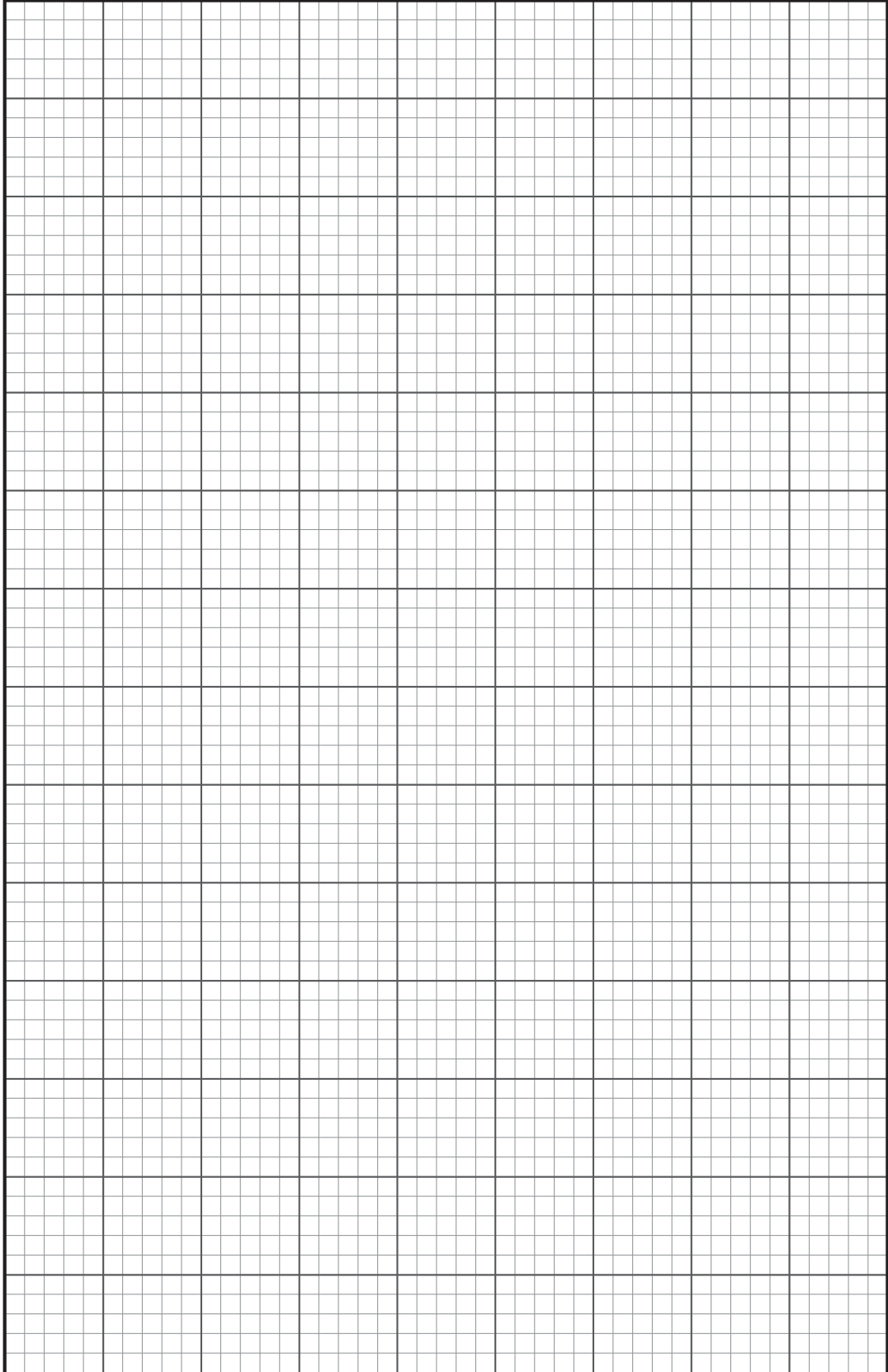
Wetland Habitat Information Form



WETLAND HABITAT INFORMATION FORM

<input type="checkbox"/> W	<input type="checkbox"/> T	PHOTO	X:	Y:	DATE
PROJECT ID			SURV.		
MAPSHEET			PLOT #		
UTM ZONE		NORTH		EAST	
ASPECT			ELEVATION		
SLOPE		%	SMR	HDI	SNR
MESO SLOPE POSITION	<input type="checkbox"/> Crest	<input type="checkbox"/> Upper slope	<input type="checkbox"/> Mid slope	<input type="checkbox"/> Lower slope	<input type="checkbox"/> Toe
			<input type="checkbox"/> Depression	<input type="checkbox"/> Level	
HYDROGEO-MORPHIC POSITION	<input type="checkbox"/> Estuarine	<input type="checkbox"/> Fluvial	<input type="checkbox"/> Lacustrine	<input type="checkbox"/> Ponds & Potholes	<input type="checkbox"/> Basins & Hollows
			<input type="checkbox"/> Seepage Slopes		
DRAINAGE - MINERAL SOILS	<input type="checkbox"/> Very rapidly	<input type="checkbox"/> Rapidly	<input type="checkbox"/> Well	<input type="checkbox"/> Mod. well	<input type="checkbox"/> Imperfectly
			<input type="checkbox"/> Poorly	<input type="checkbox"/> Very poorly	
MINERAL SOIL TEXTURE	<input type="checkbox"/> Sandy (LS,S)		<input type="checkbox"/> Silty (SiL,Si)		
	<input type="checkbox"/> Loamy (SL,L,SCL,FSL)		<input type="checkbox"/> Clayey (SiCL,CL,SC,SiC,C)		
MOISTURE SUBCLASSES ORGANIC SOIL	<input type="checkbox"/> Aqueous	<input type="checkbox"/> Peraquic	<input type="checkbox"/> Aquic	<input type="checkbox"/> Subaquic	<input type="checkbox"/> Perhumid
			<input type="checkbox"/> Humid		
ORGANIC SOIL TEXTURE			SURF. ORGANIC HORIZON THICKNESS		
<input type="checkbox"/> Fibric	<input type="checkbox"/> Mesic	<input type="checkbox"/> Humic	_____ cm		
HUMUS FORM			ROOTING DEPTH		
<input type="checkbox"/> Mor	<input type="checkbox"/> Moder	<input type="checkbox"/> Mull	Depth _____ cm Type _____		
VON POST					
1	2	3	4	5	6
7	8	9	10		
COARSE FRAGMENT CONTENT					
<input type="checkbox"/> < 20%		<input type="checkbox"/> 20-35%		<input type="checkbox"/> 35-70%	
<input type="checkbox"/> > 70%					
ECOSYSTEM			COMPONENT: <input type="checkbox"/> WL1 <input type="checkbox"/> WL2 <input type="checkbox"/> WL3		
BGC UNIT			WETLAND CLASS		
SITE SERIES			ASSOCIATION		
STRUCTURAL STAGE			MODIFIER		
WETLAND POLYGON SUMMARY					
	%	CLASS		ASSOCIATION	
WL1					
WL2					
WL3					

WETLAND MAP



Features to include: North arrow, wildlife features, open water, slope, vegetation communities, wetland boundary, direction of water flow, soil core locations.

NOTES

Appendix 3

Wetland Ecosystem Vegetation Species List

Appendix 3. Wetland Ecosystem Vegetation Species List

Plot	Genus	Species	Layer	Plot	Genus	Species	Layer
MW1	<i>Larix</i>	<i>sp</i>	tree/shrub	MW5	<i>Cicuta</i>	<i>maculata</i>	forb
MW1	<i>Picea</i>	<i>sp</i>	tree/shrub	MW5	<i>Viola</i>	<i>sp</i>	forb
MW1	<i>Alnus</i>	<i>sp</i>	tree/shrub	MW5	<i>Ranunculus</i>	<i>sp</i>	forb
MW1	<i>Equisetum</i>	<i>fluviatile</i>	forb	MW5	<i>Geum</i>	<i>macrophyllum</i>	forb
MW1	<i>Carex</i>	<i>aquatilis</i>	forb	MW5	<i>Calamagrostis</i>	<i>canadensis</i>	forb
MW1	<i>Ledum</i>	<i>groenlandicum</i>	forb	MW5	<i>Sphagnum</i>	<i>sp</i>	bryop
MW1	<i>Erigeron</i>	<i>sp</i>	forb	MW5	<i>Mnium</i>	<i>sp</i>	bryop
MW1	<i>Carex</i>	<i>disperma</i>	forb	MW5	<i>Lycopodium</i>	<i>sp</i>	bryop
MW1	<i>Smilacina</i>	<i>trifolium</i>	forb	MW6	<i>Viburnum</i>	<i>edule</i>	tree/shrub
MW1	<i>Taraxacum</i>	<i>officinale</i>	forb	MW6	<i>Salix</i>	<i>barclayi</i>	tree/shrub
MW1	<i>Arctostaphylos</i>	<i>uva-ursi</i>	forb	MW6	<i>Picea</i>	<i>sp</i>	tree/shrub
MW1	<i>Carex</i>	<i>sp</i>	forb	MW6	<i>Alnus</i>	<i>sp</i>	tree/shrub
MW1	<i>Mnium</i>	<i>sp</i>	forb	MW6	<i>Lonicera</i>	<i>involuta</i>	tree/shrub
MW1	<i>Pleurozium</i>	<i>sp</i>	forb	MW6	<i>Ledum</i>	<i>groenlandicum</i>	tree/shrub
MW2	<i>Salix</i>	<i>sp</i>	tree/shrub	MW6	<i>Rosa</i>	<i>sp</i>	tree/shrub
MW2	<i>Betula</i>	<i>nana</i>	tree/shrub	MW6	<i>Cornus</i>	<i>canadensis</i>	tree/shrub
MW2	<i>Lonicera</i>	<i>involuta</i>	tree/shrub	MW6	<i>Calamagrostis</i>	<i>canadensis</i>	forb
MW2	<i>Alnus</i>	<i>sp</i>	tree/shrub	MW6	<i>Equisetum</i>	<i>fluviatile</i>	forb
MW2	<i>Picea</i>	<i>sp</i>	tree/shrub	MW6	<i>Viola</i>	<i>spp</i>	forb
MW2	<i>Larix</i>	<i>sp</i>	tree/shrub	MW6	<i>Athyrium</i>	<i>filix-femina</i>	forb
MW2	<i>Carex</i>	<i>aquatilis</i>	forb	MW6	<i>Cicuta</i>	<i>maculata</i>	forb
MW2	<i>Carex</i>	<i>utriculata</i>	forb	MW6	<i>Geum</i>	<i>macrophyllum</i>	forb
MW2	<i>Typha</i>	<i>latifolia</i>	forb	MW6	<i>Epilobium</i>	<i>angustifolium</i>	forb
MW2	<i>Potamogeton</i>	<i>sp</i>	forb	MW6	<i>Heracleum</i>	<i>lanatum</i>	forb
MW2	<i>Ribes</i>	<i>sp</i>	forb	MW6	<i>Veratrum</i>	<i>viride</i>	forb
MW2	<i>Phalaris</i>	<i>arundinacea</i>	forb	MW6	<i>Rubus</i>	<i>articus</i>	forb
MW2	<i>Rubus</i>	<i>arcticus</i>	forb	MW6	<i>Pyrola</i>	<i>asarifolia</i>	forb
MW2	<i>Comarum</i>	<i>palustre</i>	forb	MW6	<i>Mnium</i>	<i>sp</i>	bryop
MW2	<i>Calliergon</i>	<i>sp</i>	bryop	MW6	<i>Aulacomnium</i>	<i>sp</i>	bryop
MW2	<i>Carex</i>	<i>sp</i>	forb	MW6	<i>Lycopodium</i>	<i>sp</i>	bryop
MW2	<i>Equisetum</i>	<i>fluviatile</i>	forb	MW6	<i>Sphagnum</i>	<i>sp</i>	bryop
MW2	<i>Mnium</i>	<i>sp</i>	bryop	MW7	<i>Ledum</i>	<i>groenlandicum</i>	tree/shrub
MW2	<i>Sphagnum</i>	<i>sp</i>	bryop	MW7	<i>Picea</i>	<i>sp</i>	tree/shrub
MW3	<i>Picea</i>	<i>sp</i>	tree/shrub	MW7	<i>Oxycoccus</i>	<i>oxycoccus</i>	tree/shrub
MW3	<i>Alnus</i>	<i>sp</i>	tree/shrub	MW7	<i>Vaccinium</i>	<i>vitis-idaea</i>	tree/shrub
MW3	<i>Ledum</i>	<i>groenlandicum</i>	tree/shrub	MW7	<i>Pinus</i>	<i>contortata</i>	tree/shrub
MW3	<i>Salix</i>	<i>sp</i>	tree/shrub	MW7	<i>Vaccinium</i>	<i>membranaceum</i>	tree/shrub
MW3	<i>Vaccinium</i>	<i>vitis-idaea</i>	tree/shrub	MW7	<i>Carex</i>	<i>aquatilis</i>	forb
MW3	<i>Linnaea</i>	<i>borealis</i>	tree/shrub	MW7	<i>Equisetum</i>	<i>fluviatile</i>	forb
MW3	<i>Rosa</i>	<i>sp</i>	tree/shrub	MW7	<i>Sphagnum</i>	<i>sp</i>	bryop
MW3	<i>Picea</i>	<i>sp</i>	tree/shrub	MW7	<i>Polytrichum</i>	<i>sp</i>	bryop
MW3	<i>Equisetum</i>	<i>fluviatile</i>	forb	MW8	<i>Salix</i>	<i>barclayi</i>	tree/shrub
MW3	<i>Calamagrostis</i>	<i>canadensis</i>	forb	MW8	<i>Alnus</i>	<i>incana</i>	tree/shrub
MW3	<i>Carex</i>	<i>sp</i>	forb	MW8	<i>Ledum</i>	<i>groenlandicum</i>	tree/shrub
MW3	<i>Cicuta</i>	<i>maculata</i>	forb	MW8	<i>Vaccinium</i>	<i>vitis-idaea</i>	tree/shrub
MW3	<i>Ribes</i>	<i>sp</i>	forb	MW8	<i>Oxycoccus</i>	<i>oxycoccus</i>	tree/shrub
MW4	<i>Populus</i>	<i>balsamifera</i>	tree/shrub	MW8	<i>Picea</i>	<i>sp</i>	tree/shrub
MW5	<i>Alnus</i>	<i>incana</i>	tree/shrub	MW8	<i>Larix</i>	<i>sp</i>	tree/shrub
MW5	<i>Ledum</i>	<i>groenlandicum</i>	tree/shrub	MW8	<i>Cornus</i>	<i>canadensis</i>	tree/shrub
MW5	<i>Viburnum</i>	<i>edule</i>	tree/shrub	MW8	<i>Abies</i>	<i>sp</i>	tree/shrub
MW5	<i>Salix</i>	<i>barclayi</i>	tree/shrub	MW8	<i>Linnaea</i>	<i>borealis</i>	tree/shrub
MW5	<i>Abies</i>	<i>sp</i>	tree/shrub	MW8	<i>Betula</i>	<i>nana</i>	tree/shrub
MW5	<i>Lonicera</i>	<i>involuta</i>	tree/shrub	MW8	<i>Equisetum</i>	<i>arvense</i>	forb
MW5	<i>Picea</i>	<i>sp</i>	tree/shrub	MW8	<i>Pyrola</i>	<i>asarifolia</i>	forb
MW5	<i>Rubus</i>	<i>arcticus</i>	tree/shrub	MW8	<i>Cicuta</i>	<i>maculata</i>	forb
MW5	<i>Cornus</i>	<i>canadensis</i>	tree/shrub	MW8	<i>Geum</i>	<i>macrophyllum</i>	forb
MW5	<i>Ribes</i>	<i>lacustre</i>	tree/shrub	MW8	<i>Heracleum</i>	<i>lanatum</i>	forb
MW5	<i>Equisetum</i>	<i>fluviatile</i>	forb	MW8	<i>Rubus</i>	<i>articus</i>	forb
MW5	<i>Trentalis</i>	<i>arctica</i>	forb	MW8	<i>Gymnocarpium</i>	<i>dryopteris</i>	forb

Appendix 3. Wetland Ecosystem Vegetation Species List

Plot	Genus	Species	Layer	Plot	Genus	Species	Layer
MW8	<i>Viburnum</i>	<i>edule</i>	forb	MW12	<i>Sphagnum</i>	<i>sp</i>	bryop
MW8	<i>Poa</i>	<i>sp</i>	forb	MW12	<i>Aulacomnium</i>	<i>palustre</i>	bryop
MW8	<i>Carex</i>	<i>disperma</i>	forb	MW13	<i>Salix</i>	<i>barclayi</i>	tree/shrub
MW8	<i>Mnium</i>	<i>sp</i>	bryop	MW13	<i>Alnus</i>	<i>incana</i>	tree/shrub
MW8	<i>Sphagnum</i>	<i>sp</i>	bryop	MW13	<i>Viburnum</i>	<i>edule</i>	tree/shrub
MW8	<i>Lycopodium</i>	<i>sp</i>	bryop	MW13	<i>Ribes</i>	<i>lacustre</i>	tree/shrub
MW9	<i>Alnus</i>	<i>incana</i>	tree/shrub	MW13	<i>Picea</i>	<i>sp</i>	tree/shrub
MW9	<i>Cornus</i>	<i>canadensis</i>	tree/shrub	MW13	<i>Cornus</i>	<i>canadensis</i>	tree/shrub
MW9	<i>Abies</i>	<i>sp</i>	tree/shrub	MW13	<i>Cicuta</i>	<i>maculata</i>	forb
MW9	<i>Picea</i>	<i>sp</i>	tree/shrub	MW13	<i>Calamagrostis</i>	<i>canadensis</i>	forb
MW9	<i>Viburnum</i>	<i>edule</i>	tree/shrub	MW13	<i>Equisetum</i>	<i>fluviatile</i>	forb
MW9	<i>Lonicera</i>	<i>involuta</i>	tree/shrub	MW13	<i>Pyrola</i>	<i>asarifolia</i>	forb
MW9	<i>Salix</i>	<i>barclayi</i>	tree/shrub	MW13	<i>Viola</i>	<i>sp</i>	forb
MW9	<i>Geum</i>	<i>macrophyllum</i>	forb	MW13	<i>Disporum</i>	<i>hookeri</i>	forb
MW9	<i>Gymnocarpium</i>	<i>dryopteris</i>	forb	MW13	<i>Athyrium</i>	<i>filix-femina</i>	forb
MW9	<i>Pyrola</i>	<i>asarifolia</i>	forb	MW13	<i>Geum</i>	<i>macrophyllum</i>	forb
MW9	<i>Disporum</i>	<i>hookeri</i>	forb	MW13	<i>Mnium</i>	<i>sp</i>	bryop
MW9	<i>Rubus</i>	<i>articus</i>	forb	MW14	<i>Ribes</i>	<i>lacustre</i>	tree/shrub
MW9	<i>Rubus</i>	<i>pedatus</i>	forb	MW14	<i>Cornus</i>	<i>stolonifera</i>	tree/shrub
MW9	<i>Carex</i>	<i>disperma</i>	forb	MW14	<i>Salix</i>	<i>bebbiana</i>	tree/shrub
MW9	<i>Equisetum</i>	<i>fluviatile</i>	forb	MW14	<i>Salix</i>	<i>scouleriana</i>	tree/shrub
MW9	<i>Athyrium</i>	<i>filix-femina</i>	forb	MW14	<i>Carex</i>	<i>aquatilis</i>	forb
MW9	<i>Cicuta</i>	<i>maculata</i>	forb	MW14	<i>Equisetum</i>	<i>arvense</i>	forb
MW9	<i>Viola</i>	<i>sp</i>	forb	MW14	<i>Geum</i>	<i>macrophyllum</i>	forb
MW9	<i>Calamagrostis</i>	<i>canadensis</i>	forb	MW15	<i>Ledum</i>	<i>groenlandicum</i>	tree/shrub
MW9	<i>Heracleum</i>	<i>lanatum</i>	forb	MW15	<i>Picea</i>	<i>sp</i>	tree/shrub
MW9	<i>Galium</i>	<i>trifolium</i>	forb	MW15	<i>Empetrum</i>	<i>nigrum</i>	tree/shrub
MW9	<i>Pleurozium</i>	<i>schreberi</i>	bryop	MW15	<i>Vaccinium</i>	<i>vitis-idaea</i>	tree/shrub
MW9	<i>Sphagnum</i>	<i>sp</i>	bryop	MW15	<i>Kalmia</i>	<i>microphylla</i>	tree/shrub
MW9	<i>Mnium</i>	<i>sp</i>	bryop	MW15	<i>Gaultheria</i>	<i>hispidula</i>	tree/shrub
MW11	<i>Alnus</i>	<i>incana</i>	tree/shrub	MW15	<i>Betula</i>	<i>nana</i>	tree/shrub
MW11	<i>Ledum</i>	<i>groenlandicum</i>	tree/shrub	MW15	<i>Larix</i>	<i>sp</i>	tree/shrub
MW11	<i>Abies</i>	<i>sp</i>	tree/shrub	MW15	<i>Equisetum</i>	<i>arvense</i>	forb
MW11	<i>Ribes</i>	<i>lacustre</i>	tree/shrub	MW15	<i>Mitella</i>	<i>nuda</i>	forb
MW11	<i>Pinus</i>	<i>contortata</i>	tree/shrub	MW15	<i>Carex</i>	<i>aquatilis</i>	forb
MW11	<i>Cornus</i>	<i>canadensis</i>	tree/shrub	MW15	<i>Oxycoccus</i>	<i>oxycoccus</i>	forb
MW11	<i>Salix</i>	<i>barclayi</i>	tree/shrub	MW15	<i>Viola</i>	<i>sp</i>	forb
MW11	<i>Cicuta</i>	<i>maculata</i>	forb	MW15	<i>Polytrichum</i>	<i>sp</i>	bryop
MW11	<i>Equisetum</i>	<i>fluviatile</i>	forb	MW15	<i>Pleurozium</i>	<i>sp</i>	bryop
MW11	<i>Calamagrostis</i>	<i>canadensis</i>	forb	MW15	<i>Sphagnum</i>	<i>sp</i>	bryop
MW11	<i>Pyrola</i>	<i>asarifolia</i>	forb	MW16	<i>Salix</i>	<i>planifolia</i>	tree/shrub
MW11	<i>Athyrium</i>	<i>filix-femina</i>	forb	MW16	<i>Alnus</i>	<i>sp</i>	tree/shrub
MW11	<i>Disporum</i>	<i>hookeri</i>	forb	MW16	<i>Carex</i>	<i>utriculata</i>	forb
MW11	<i>Rubus</i>	<i>pedatus</i>	forb	MW16	<i>Carex</i>	<i>aquatilis</i>	forb
MW11	<i>Gymnocarpium</i>	<i>dryopteris</i>	forb	MW16	<i>Heracleum</i>	<i>lanatum</i>	forb
MW11	<i>Lycopodium</i>	<i>annotinum</i>	bryop	MW16	<i>Geum</i>	<i>macrophyllum</i>	forb
MW11	<i>Pleurozium</i>	<i>schreberi</i>	bryop	MW16	<i>Epilobium</i>	<i>sp</i>	forb
MW12	<i>Salix</i>	<i>barclayi</i>	tree/shrub	MW16	<i>Equisetum</i>	<i>fluviatile</i>	forb
MW12	<i>Oxycoccus</i>	<i>oxycoccus</i>	tree/shrub	MW17	<i>Salix</i>	<i>barclayi</i>	tree/shrub
MW12	<i>Picea</i>	<i>sp</i>	tree/shrub	MW17	<i>Alnus</i>	<i>sp</i>	tree/shrub
MW12	<i>Pinus</i>	<i>contortata</i>	tree/shrub	MW17	<i>Carex</i>	<i>disperma</i>	forb
MW12	<i>Ledum</i>	<i>groenlandicum</i>	tree/shrub	MW17	<i>Carex</i>	<i>utriculata</i>	forb
MW12	<i>Carex</i>	<i>aquatilis</i>	forb	MW17	<i>Equisetum</i>	<i>fluviatile</i>	forb
MW12	<i>Pyrola</i>	<i>asarifolia</i>	forb	MW17	<i>Alopecurus</i>	<i>aequalis</i>	forb
MW12	<i>Cicuta</i>	<i>maculata</i>	forb	MW17	<i>Geum</i>	<i>macrophyllum</i>	forb
MW12	<i>Comarum</i>	<i>palustre</i>	forb	MW17	<i>Moss</i>	<i>spp</i>	bryop
MW12	<i>Carex</i>	<i>disperma</i>	forb	MW18	<i>Salix</i>	<i>sp</i>	tree/shrub
MW12	<i>Ranunculus</i>	<i>sp</i>	forb	MW18	<i>Pinus</i>	<i>contortata</i>	tree/shrub
MW12	<i>Potentilla</i>	<i>anserina</i>	forb	MW18	<i>Carex</i>	<i>utriculata</i>	forb

Appendix 3. Wetland Ecosystem Vegetation Species List

Plot	Genus	Species	Layer	Plot	Genus	Species	Layer
MW18	<i>Alopecurus</i>	<i>aequalis</i>	forb	MW25	<i>Moss</i>	<i>spp</i>	bryop
MW18	<i>Geum</i>	<i>macrophyllum</i>	forb	MW26	<i>Picea</i>	<i>sp</i>	tree/shrub
MW18	<i>Epilobium</i>	<i>sp</i>	forb	MW26	<i>Ledum</i>	<i>groenlandicum</i>	tree/shrub
MW18	<i>Viola</i>	<i>sp</i>	forb	MW26	<i>Larix</i>	<i>sp</i>	tree/shrub
MW18	<i>Taraxacum</i>	<i>officinale</i>	forb	MW26	<i>Gaultheria</i>	<i>hispidula</i>	tree/shrub
MW18	<i>Ranunculus</i>	<i>cymbalaria</i>	forb	MW26	<i>Oxycoccus</i>	<i>oxycoccus</i>	tree/shrub
MW18	<i>Fragaria</i>	<i>sp</i>	forb	MW26	<i>Cornus</i>	<i>canadensis</i>	tree/shrub
MW19	<i>Carex</i>	<i>aquatilis</i>	forb	MW26	<i>Alnus</i>	<i>incana</i>	tree/shrub
MW19	<i>Poa</i>	<i>palustris</i>	forb	MW26	<i>Rubus</i>	<i>pedatus</i>	tree/shrub
MW19	<i>Taraxacum</i>	<i>officinale</i>	forb	MW26	<i>Equisetum</i>	<i>fluviatile</i>	forb
MW19	<i>Geum</i>	<i>macrophyllum</i>	forb	MW26	<i>Maianthemum</i>	<i>canadensis</i>	forb
MW19	<i>Achillea</i>	<i>millefolium</i>	forb	MW26	<i>Calamagrostis</i>	<i>canadensis</i>	forb
MW19	<i>Carex</i>	<i>disperma</i>	forb	MW26	<i>Rubus</i>	<i>arcticus</i>	forb
MW20	<i>Salix</i>	<i>sp</i>	tree/shrub	MW26	<i>Ranunculus</i>	<i>sp</i>	forb
MW21	<i>Picea</i>	<i>sp</i>	tree/shrub	MW26	<i>Carex</i>	<i>disperma</i>	forb
MW21	<i>Larix</i>	<i>sp</i>	tree/shrub	MW26	<i>Sphagnum</i>	<i>sp</i>	bryop
MW21	<i>Betula</i>	<i>nana</i>	tree/shrub	MW26	<i>Mnium</i>	<i>sp</i>	bryop
MW21	<i>Ledum</i>	<i>groenlandicum</i>	tree/shrub	MW26	<i>Aulacomnium</i>	<i>palustre</i>	bryop
MW21	<i>Vaccinium</i>	<i>sp</i>	tree/shrub	MW27	<i>Salix</i>	<i>sp</i>	tree/shrub
MW21	<i>Rubus</i>	<i>arcticus</i>	tree/shrub	MW27	<i>Carex</i>	<i>utriculata</i>	forb
MW21	<i>Vaccinium</i>	<i>vitis-idaea</i>	tree/shrub	MW27	<i>Comarum</i>	<i>palustris</i>	forb
MW21	<i>Rosa</i>	<i>sp</i>	tree/shrub	MW27	<i>Equisetum</i>	<i>fluviatile</i>	forb
MW21	<i>Salix</i>	<i>barclayi</i>	tree/shrub	MW28	<i>Carex</i>	<i>utriculata</i>	forb
MW21	<i>Carex</i>	<i>aquatilis</i>	forb	MW28	<i>Moss</i>	<i>spp</i>	bryop
MW21	<i>Mitella</i>	<i>nuda</i>	forb				
MW21	<i>Smilacina</i>	<i>stellatum</i>	forb				
MW21	<i>Ranunculus</i>	<i>sp</i>	forb				
MW21	<i>Equisetum</i>	<i>fluviatile</i>	forb				
MW21	<i>Sphagnum</i>	<i>sp</i>	bryop				
MW21	<i>Aulacomnium</i>	<i>sp</i>	bryop				
MW22	<i>Picea</i>	<i>sp</i>	tree/shrub				
MW22	<i>Larix</i>	<i>sp</i>	tree/shrub				
MW22	<i>Ledum</i>	<i>groenlandicum</i>	tree/shrub				
MW22	<i>Betula</i>	<i>nana</i>	tree/shrub				
MW22	<i>Oxycoccus</i>	<i>oxycoccus</i>	tree/shrub				
MW22	<i>Gaultheria</i>	<i>hispidula</i>	tree/shrub				
MW22	<i>Carex</i>	<i>aquatilis</i>	forb				
MW22	<i>Maianthemum</i>	<i>canadense</i>	forb				
MW22	<i>Carex</i>	<i>disperma</i>	forb				
MW22	<i>Sphagnum</i>	<i>sp</i>	bryop				
MW22	<i>Aulacomnium</i>	<i>palustre</i>	bryop				
MW23	<i>Salix</i>	<i>sp</i>	tree/shrub				
MW23	<i>Equisetum</i>	<i>arvense</i>	forb				
MW23	<i>Equisetum</i>	<i>fluviatile</i>	forb				
MW23	<i>Carex</i>	<i>utriculata</i>	forb				
MW23	<i>Mnium</i>	<i>sp</i>	bryop				
MW23	<i>Calliergon</i>	<i>sp</i>	bryop				
MW24	<i>Salix</i>	<i>sp</i>	tree/shrub				
MW24	<i>Equisetum</i>	<i>fluviatile</i>	forb				
MW24	<i>Carex</i>	<i>utriculata</i>	forb				
MW24	<i>Calamagrostis</i>	<i>canadensis</i>	forb				
MW24	<i>Veronica</i>	<i>americana</i>	forb				
MW24	<i>Calliergon</i>	<i>sp</i>	bryop				
MW25	<i>Alnus</i>	<i>incana</i>	tree/shrub				
MW25	<i>Rubus</i>	<i>parviflorus</i>	tree/shrub				
MW25	<i>Salix</i>	<i>sp</i>	tree/shrub				
MW25	<i>Carex</i>	<i>aquatilis</i>	forb				
MW25	<i>Equisetum</i>	<i>fluviatile</i>	forb				
MW25	<i>Calamagrostis</i>	<i>canadensis</i>	forb				

Appendix 4

Wetland Vegetation Tissue Metal Concentration Data

Appendix 5a

Wetland Water Data

Appendix 5a. Wetland Water Data

ALS File No. L922661						
Sample ID	MW01	LW 11	RW3	Reference	TRAVEL BLANK	FIELD BLANK
Date Sampled	17-AUG-10	18-AUG-10	19-AUG-10	17-AUG-10		18-AUG-10
Time Sampled	00:00	00:00	00:00	00:00		00:00
ALS Sample ID	L922661-1	L922661-3	L922661-6	L922661-2	L922661-4	L922661-5
Matrix	Water	Water	Water	Water	Water	Water
Physical Tests						
Colour, True	25.6	13.1	31.7	18.1	<5.0	-
Conductivity	390	1660	381	483	<2.0	-
Hardness (as CaCO3)	205	827	196	263	-	<0.50
Physical Tests						
pH	8.05	8.06	8.13	8.10	5.87	-
Total Suspended Solids	94.8	6.7	4.3	6.8	<3.0	-
Total Dissolved Solids	225	1360	236	278	<10	-
Anions and Nutrients						
Acidity (as CaCO3)	4.9	6.1	3.8	4.9	2.7	-
Alkalinity, Bicarbonate (as CaCO3)	217	232	219	282	<2.0	-
Alkalinity, Carbonate (as CaCO3)	<2.0	<2.0	<2.0	<2.0	<2.0	-
Alkalinity, Hydroxide (as CaCO3)	<2.0	<2.0	<2.0	<2.0	<2.0	-
Alkalinity, Total (as CaCO3)	217	232	219	282	<2.0	-
Ammonia as N	0.0199	0.0253	0.167	0.0100	<0.0050	<0.0050
Bromide (Br)	<0.050	<0.050	<0.050	<0.050	<0.050	-
Chloride (Cl)	3.39	2.20	<0.50	<0.50	<0.50	-
Fluoride (F)	0.061	0.292	0.082	0.070	<0.020	-
Nitrate (as N)	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	-
Nitrite (as N)	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	-
Total Kjeldahl Nitrogen	3.09	0.360	0.640	0.230	<0.050	-
Total Nitrogen	3.09	0.360	0.640	0.230	<0.050	<0.050
Total Phosphate as P	0.171	0.0247	0.0285	0.0232	<0.0020	-
Sulfate (SO4)	0.68	798	2.80	<0.50	<0.50	-
Cyanides						
Cyanide, Weak Acid Diss	0.0011	<0.0010	0.0010	<0.0010	-	<0.0010
Cyanide, Total	0.0181	0.0053	0.0083	0.0052	-	<0.0010
Organic / Inorganic Carbon						
Total Organic Carbon	-	-	-	-	-	-
Total Organic Carbon	41.2	6.27	16.2	8.12	<0.50	1.71
Total Metals						
Aluminum (Al)-Total	0.178	0.129	0.0046	0.771	-	<0.0010
Antimony (Sb)-Total	<0.00010	0.00013	<0.00010	<0.00010	-	<0.00010
Arsenic (As)-Total	0.00052	0.00073	0.00017	0.00119	-	<0.00010
Barium (Ba)-Total	0.346	0.0484	0.136	0.265	-	<0.000050
Beryllium (Be)-Total	<0.00050	<0.00050	<0.00050	<0.00050	-	<0.00050
Bismuth (Bi)-Total	<0.00050	<0.00050	<0.00050	<0.00050	-	<0.00050
Boron (B)-Total	0.013	0.070	0.014	0.017	-	<0.010
Cadmium (Cd)-Total	0.000064	0.000039	<0.000010	0.000048	-	<0.000010
Calcium (Ca)-Total	58.0	139	52.6	70.6	-	<0.020
Chromium (Cr)-Total	0.00042	0.00025	<0.00010	0.00107	-	<0.00010
Cobalt (Co)-Total	0.00033	0.00084	<0.00010	0.00065	-	<0.00010
Copper (Cu)-Total	0.00100	0.00059	<0.00030	0.00164	-	<0.00010
Iron (Fe)-Total	3.73	0.554	0.171	1.77	-	<0.030
Lead (Pb)-Total	0.000471	0.000187	<0.000050	0.000720	-	<0.000050
Lithium (Li)-Total	0.0059	0.118	0.0061	0.0113	-	<0.0050
Magnesium (Mg)-Total	19.5	121	16.1	25.1	-	0.0056
Manganese (Mn)-Total	0.102	0.230	0.0473	0.132	-	<0.000050
Mercury (Hg)-Total	<0.000010	<0.000010	<0.000010	<0.000010	-	<0.000010
Molybdenum (Mo)-Total	0.000387	0.00246	0.000093	0.00110	-	<0.000050
Nickel (Ni)-Total	0.00177	0.00532	<0.00050	0.00290	-	<0.00050
Phosphorus (P)-Total	<0.30	<0.30	<0.30	<0.30	-	<0.30
Potassium (K)-Total	0.330	4.40	0.587	1.05	-	<0.050
Selenium (Se)-Total	0.00042	0.00036	<0.00010	0.00017	-	<0.00010

Appendix 5a. Wetland Water Data

ALS File No. L922661						
Sample ID	MW01	LW 11	RW3	Reference	TRAVEL BLANK	FIELD BLANK
Date Sampled	17-AUG-10	18-AUG-10	19-AUG-10	17-AUG-10		18-AUG-10
Time Sampled	00:00	00:00	00:00	00:00		00:00
ALS Sample ID	L922661-1	L922661-3	L922661-6	L922661-2	L922661-4	L922661-5
Matrix	Water	Water	Water	Water	Water	Water
Total Metals (continued)						
Silicon (Si)-Total	4.93	2.61	2.86	4.78	-	<0.050
Silver (Ag)-Total	<0.000010	<0.000010	<0.000010	<0.000010	-	<0.000010
Sodium (Na)-Total	2.9	86.4	6.5	6.3	-	<2.0
Strontium (Sr)-Total	0.150	1.52	0.146	0.314	-	<0.00010
Thallium (Tl)-Total	<0.00010	<0.00010	<0.00010	<0.00010	-	<0.00010
Tin (Sn)-Total	<0.00010	<0.00010	<0.00010	<0.00010	-	<0.00010
Titanium (Ti)-Total	<0.010	0.012	<0.010	0.015	-	<0.010
Uranium (U)-Total	0.000127	0.00374	0.000039	0.000261	-	<0.000010
Vanadium (V)-Total	<0.0010	<0.0010	<0.0010	0.0020	-	<0.0010
Zinc (Zn)-Total	0.0076	0.0040	<0.0010	0.0055	-	<0.0010
Dissolved Metals						
Aluminum (Al)-Dissolved	0.0011	<0.0010	<0.0010	0.0015	-	<0.0010
Antimony (Sb)-Dissolved	<0.00010	<0.00010	<0.00010	<0.00010	-	<0.00010
Arsenic (As)-Dissolved	0.00020	0.00061	0.00013	0.00066	-	<0.00010
Barium (Ba)-Dissolved	0.225	0.0404	0.133	0.223	-	<0.000050
Beryllium (Be)-Dissolved	<0.00050	<0.00050	<0.00050	<0.00050	-	<0.00050
Bismuth (Bi)-Dissolved	<0.00050	<0.00050	<0.00050	<0.00050	-	<0.00050
Boron (B)-Dissolved	<0.010	0.069	0.013	0.015	-	<0.010
Cadmium (Cd)-Dissolved	<0.000010	0.000011	<0.000010	<0.000010	-	<0.000010
Calcium (Ca)-Dissolved	51.2	137	52.0	66.8	-	<0.020
Chromium (Cr)-Dissolved	<0.00010	<0.00010	<0.00010	<0.00010	-	<0.00010
Cobalt (Co)-Dissolved	<0.00010	0.00017	<0.00010	<0.00010	-	<0.00010
Copper (Cu)-Dissolved	<0.00040	<0.00020	<0.00010	<0.00040	-	<0.00010
Iron (Fe)-Dissolved	<0.030	<0.030	0.036	<0.030	-	<0.030
Lead (Pb)-Dissolved	<0.000050	<0.000050	<0.000050	<0.000050	-	<0.000050
Lithium (Li)-Dissolved	0.0061	0.116	0.0060	0.0107	-	<0.0050
Magnesium (Mg)-Dissolved	18.7	118	16.0	23.4	-	<0.0050
Manganese (Mn)-Dissolved	0.000607	0.158	0.0274	0.0205	-	<0.000050
Mercury (Hg)-Dissolved	<0.000010	<0.000010	<0.000010	<0.000010	-	<0.000010
Molybdenum (Mo)-Dissolved	0.000202	0.00235	0.000086	0.00116	-	<0.000050
Nickel (Ni)-Dissolved	0.00110	0.00371	<0.00050	0.00152	-	<0.00050
Phosphorus (P)-Dissolved	<0.30	<0.30	<0.30	<0.30	-	<0.30
Potassium (K)-Dissolved	0.143	4.45	0.577	0.793	-	<0.050
Selenium (Se)-Dissolved	0.00011	0.00020	<0.00010	0.00012	-	<0.00010
Silicon (Si)-Dissolved	4.47	2.31	2.80	3.80	-	<0.050
Silver (Ag)-Dissolved	<0.000010	<0.000010	<0.000010	<0.000010	-	<0.000010
Sodium (Na)-Dissolved	2.8	87.3	6.4	6.4	-	<2.0
Strontium (Sr)-Dissolved	0.132	1.52	0.143	0.313	-	<0.00010
Thallium (Tl)-Dissolved	<0.00010	<0.00010	<0.00010	<0.00010	-	<0.00010
Tin (Sn)-Dissolved	<0.00010	<0.00010	<0.00010	<0.00010	-	<0.00010
Titanium (Ti)-Dissolved	<0.010	<0.010	<0.010	<0.010	-	<0.010
Uranium (U)-Dissolved	0.000057	0.00369	0.000040	0.000240	-	<0.000010
Vanadium (V)-Dissolved	<0.0010	<0.0010	<0.0010	<0.0010	-	<0.0010
Zinc (Zn)-Dissolved	0.0020	<0.0010	<0.0010	<0.0010	-	<0.0010

Appendix 5b

Sediment Data

Appendix 5b. Sediment Data

ALS File No. L922661									
Sample ID	REF ALT-SED 01	REF ALT-SED 02	REF ALT-SED 03	LW11- SED-01	LW11- SED-02	LW11- SED-03	RW3-ALT-SED- 01	RW3-ALT-SED- 02	RW3-ALT-SED- 03
Date Sampled	17-AUG-10	17-AUG-10	17-AUG-10	18-AUG-10	18-AUG-10	18-AUG-10	19-AUG-10	19-AUG-10	19-AUG-10
Time Sampled	00:00	00:00	00:00	00:00	00:00	00:00	00:00	00:00	00:00
ALS Sample ID	L922661-7	L922661-8	L922661-9	L922661-10	L922661-11	L922661-12	L922661-13	L922661-14	L922661-15
Matrix	Soil	Soil	Soil	Soil	Soil	Soil	Soil	Soil	Soil
Particle Size									
% Gravel (>2mm)	11.9	<0.10	3.14	<0.10	5.66	<0.10	-	-	-
% Sand (2.0mm - 0.063mm)	44.6	46.4	27.6	14.7	30.4	11.3	-	-	-
% Silt (0.063mm - 4um)	36.7	46.7	64.3	82.6	60.9	73.7	-	-	-
% Clay (<4um)	6.78	6.89	5.03	2.65	3.05	15.0	-	-	-
Leachable Anions & Nutrients									
Total Nitrogen by LECO	0.122	0.216	0.320	0.678	0.520	0.566	2.28	2.14	2.16
Organic / Inorganic Carbon									
Total Organic Carbon	2.30	4.18	6.63	8.96	7.35	8.01	39.3	39.0	37.5
Total Organic Carbon	-	-	-	-	-	-	-	-	-
Plant Available Nutrients									
Available Phosphate-P	<2.0	<2.0	<2.0	<8.0	<2.7	<2.0	59.2	32.9	<10
Available Sulfate-S	26.1	30.6	36.2	2220	3030	2900	522	334	372
Metals									
Aluminum (Al)	8900	9750	7650	5000	3530	3570	690	1400	1270
Antimony (Sb)	0.49	0.35	0.32	1.02	0.74	0.86	0.18	0.20	0.19
Arsenic (As)	8.88	6.57	5.38	3.88	2.97	2.82	1.12	1.22	1.03
Barium (Ba)	198	305	253	193	253	260	217	183	226
Beryllium (Be)	0.63	0.64	0.56	0.34	0.27	0.25	<0.10	<0.10	<0.10
Bismuth (Bi)	0.19	0.19	0.14	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10
Cadmium (Cd)	0.705	1.06	0.891	1.53	1.53	1.19	0.252	0.333	0.249
Calcium (Ca)	25400	22300	15600	181000	251000	217000	58100	34700	38800
Chromium (Cr)	16.8	17.6	14.6	9.4	6.8	6.5	1.6	2.8	3.6
Cobalt (Co)	10.7	9.88	7.92	25.9	23.0	23.1	1.36	1.57	1.26
Copper (Cu)	24.7	24.9	20.5	14.5	12.2	11.1	4.04	5.36	6.84
Iron (Fe)	27300	23600	19200	13100	11600	10000	7560	7550	7400
Lead (Pb)	17.2	13.7	11.2	6.37	5.19	4.81	2.93	2.51	2.97
Magnesium (Mg)	7390	6410	4880	9840	9210	8610	2940	2870	2830
Manganese (Mn)	432	637	326	938	1000	947	349	245	244
Mercury (Hg)	0.0499	0.0785	0.0726	0.0428	0.0344	0.0305	0.0694	0.0638	0.0610
Molybdenum (Mo)	1.34	0.76	0.73	9.48	4.41	6.63	1.30	1.37	0.99
Nickel (Ni)	30.9	31.0	26.3	66.9	50.5	61.6	5.35	6.40	6.01
Phosphorus (P)	734	852	730	736	644	573	1110	906	956
Potassium (K)	1140	1270	1020	1150	890	870	290	250	330
Selenium (Se)	0.59	1.06	0.94	6.57	5.89	5.41	1.31	1.77	1.16
Silver (Ag)	0.193	0.297	0.242	0.138	0.103	0.101	<0.050	0.055	0.053
Sodium (Na)	240	120	<100	1270	720	590	250	190	410
Strontium (Sr)	56.0	67.3	51.8	712	976	888	99.5	68.8	80.0
Sulfur (S)-Total	350	490	730	8700	8400	8500	20600	14100	12100
Thallium (Tl)	<0.10	<0.10	<0.10	0.27	0.22	0.21	<0.10	<0.10	<0.10
Tin (Sn)	0.39	0.26	0.22	<0.20	<0.20	<0.20	<0.20	<0.20	0.30
Titanium (Ti)	45.4	35.3	30.3	32.6	18.2	23.6	8.2	18.0	21.9
Uranium (U)	0.614	0.569	0.536	9.58	4.11	6.74	0.489	0.613	0.338
Vanadium (V)	30.5	30.1	25.7	18.9	14.0	14.3	2.7	4.5	3.9
Zinc (Zn)	91.8	96.3	83.4	119	118	96.5	32.6	40.4	32.7

Appendix 5c

Chlorophyll *a* Data

Appendix 5c. Chlorophyll a Data

ALS File No. L922661												
Sample ID	MW01-CA1	MW01-CA2	MW01-CA3	REF ALT-CA1	REF ALT-CA2	REF ALT-CA3	LW11-CA1	LW11-CA2	LW11-CA3	RW3 ALT-CA1	RW3 ALT-CA2	RW3 ALT-CA3
Plant Pigments												
Chlorophyll a	13.5	19.3	51.7	8.61	9.84	6.88	4.14	2.59	3.59	3.80	2.22	3.08