ENCANA EKWAN PIPELINE INC.

EKWAN PIPELINE PROJECT

ENVIRONMENTAL IMPACT ASSESSMENT AND MITIGATION PLAN

Prepared by:

AXYS Environmental Consulting Ltd.

In association with:

AMEC Earth and Environmental

FMA Heritage Resources Consultants

LGL Limited Environmental Research Associates

RWDI West Inc. Consulting Engineers

March 2003

POG1045

Table of Contents

List of Tables

List of Figures

Overview of Key Findings

The key findings of this environmental impact assessment (EIA) are presented in the tables below. Each table contains a summary of the predicted effects of the Ekwan Pipeline Project in the following discipline areas:

- air quality
- soils and terrain
- vegetation
- wildlife
- fisheries and aquatic resources and
- land and resource use

Within each table, project effects on the issues or measurable parameters examined are rated are characterized using the following impact descriptors:

- Magnitude/Extent – refers to the degree of change (or risk) at the local (i.e., 2 km-wide intensive study corridor) and regional scale.
- Duration – refers to the length of time over which the project-related effect is measurable
- Reversibility – refers to the potential for conditions to return to baseline conditions, in the absence of the project

While these broad definitions of the impact descriptors remain consistent for the different resource disciplines within the EIA, each discipline has developed slightly different categories within the descriptors to suit the resource issue in question. Each project effect is also assessed for its potential to measurably contribute to cumulative effects (CE). Notes in each table explain how these impact descriptors are applied to the discipline in question.

A detailed discussion of and rationale for these findings is presented in the results sections of each discipline-specific portion of this EIA.

Summary of Project Effects for Air Quality

Assessment Scenario	Issue/ Measurable Parameter	Magnitude/ Extent[1]	Duration[2]	Reversible/ Non-Reversible[3]	Potential for Measurable Contribution to Cumulative Effects[4]
Construction	NO_x	Low	Short-term	Reversible	No
Construction	CO	Low	Short-term	Reversible	No
Construction	PM	Low	Short-term	Reversible	No
Construction	HC	Low	Short-term	Reversible	No
Operations	HC, NO_x, CO, PM	Low	Medium term	Reversible	No

Notes: [1] **Magnitude/Extent**

Low – Change in measurable parameter will have no effect on associated ecological resources (e.g., soils, vegetation, wildlife)

Moderate – Change in measurable parameter will have possible local effect on associated ecological resources (i.e., within 2 km mapped corridor)

High – Change in measurable parameter will have possible measurable effect on associated ecological resources within Etsho Resource Management Zone

[2] **Duration** – refers to the length of time over which the project-related effect is measurable

Short term – less than one year

Medium term – greater than one year but not beyond life of project

Long term – beyond life of project

[3] **Reversibility** – refers to the potential for conditions to return to baseline conditions, in the absence of the project

Reversible – will likely revert to baseline conditions following end of project life or before

Non-reversible – unlikely to revert to baseline conditions following end of project life

[4] **Potential for Measurable Contribution to Cumulative Effects**

Yes – measurable contribution to CE within Etsho Resource Management Zone

No – no measurable contribution to CE within Etsho Resource Management Zone

Summary of Project Effects for Terrain and Soils

Assessment Scenario	Issue/Measurable Parameter	Magnitude/ Extent[1]	Duration[2]	Reversible/ Non-Reversible[3]	Potential for Measurable Contribution to Cumulative Effects[4]
Construction	Soil Capability	Low	Short to medium term	Reversible	No
	Surface and Shallow Subsurface Drainage	Moderate	Medium term	Reversible	No
	Permafrost Degradation	Moderate	Long-term	Non-reversible	No
Operations	Soil Capability	Low	Short to medium term	Reversible	No
	Surface and Shallow Subsurface Drainage	Moderate	Medium term	Reversible	No
	Permafrost Degradation	Moderate	Long-term	Non-reversible	No

Notes: [1] **Magnitude/Extent** – refers to the degree of change (or risk) to biodiversity

Low – change in measurable parameter will have no effect on associated ecological resources (e.g., vegetation, wildlife)

Moderate – change in measurable parameter will have possible local (within 1 km of project) effect on associated ecological resources

High – change in measurable parameter will have possible measurable effect on associated ecological resources within Etsho Resource Management Zone

[2] **Duration** – refers to the length of time over which the project-related effect is measurable

Short term – less than 1 year

Medium term – greater than 1 year but not beyond life of project

Long term – beyond life of project

[3] **Reversibility** – refers to the potential for conditions to return to baseline conditions, in the absence of the project

Reversible – will likely revert to baseline conditions following end of project life or before

Non-reversible – unlikely to revert to baseline conditions following end of project life

[4] **Potential for Measurable Contribution to Cumulative Effects**

Yes – measurable contribution to CE within Etsho Resource Management Zone

No – no measurable contribution to CE within Etsho Resource Management Zone

Summary of Project Effects for Vegetation

Assessment Scenario	Issue	Magnitude/ Extent[1]	Duration[2]	Reversible/ Non-Reversible[3]	Potential for Measurable Contribution to Cumulative Effects[4]
Construction	Community Diversity-effects from ROW preparation and drainage alteration	Low	N/A	N/A	No
	Structural Diversity-effects from ROW preparation	Low	N/A	N/A	No
	Species Diversity-effects from ROW preparation, altered drainage, and weed introductions	Moderate	Long-term	Non-reversible	No
Operations	Community Diversity-effects from ROW maintenance	Low	N/A	N/A	No
	Structural Diversity-effects from ROW maintenance	Low	N/A	N/A	No
	Species Diversity-effects from ROW maintenance, and weed introductions	Moderate	Long-term	Non-reversible	No

Notes: [1] **Magnitude/Extent**– refers to the degree of change (or risk) to biodiversity

Low – change in measurable parameter will have no effect on local community or species diversity (i.e., within 2 km mapped corridor)

Moderate – change in measurable parameter will have possible effect on local community or species diversity (i.e., within 2 km mapped corridor

High – change in measurable parameter will have possible measurable effect on community or species diversity within Etsho Resource Management Zone

[2] **Duration** – refers to the length of time over which a project-related effect is measurable

Short term – less than 1 year

Medium term – greater than 1 year but not beyond life of project

Long term – beyond life of project

[3] **Reversibility/Non-reversibility**

Reversible – will likely revert to baseline conditions following end of project life or before

Non-reversible – unlikely to revert to baseline conditions following end of project life

[4] **Potential for Measurable Contribution to Cumulative Effects**

Yes – measurable contribution to CE within Etsho Resource Management Zone

No – no measurable contribution to CE within Etsho Resource Management Zone

Summary of Project Effects for Wildlife

Wildlife Species	Assessment Scenario	Measurable Parameter	Magnitude/ Extent[1]	Duration[2]	Reversible/ Non-Reversible[3]	Potential for Measurable Contribution to Cumulative Effects[4]
Caribou	Construction	Habitat Availability	Low	Short-term	Reversible	No
		Habitat Diversity	Low	N/A	N/A	No
		Indirect Mortality Risk–new access potential	Low	Short-term	Reversible	No
		Direct Mortality Risk- vehicle strikes	Low	Short-term	Reversible	No
	Operations	Habitat Availability	Low	Long-term	Reversible	No
		Indirect Mortality Risk– new access potential	High	Medium term	Reversible	Yes
Moose	Construction	Habitat Availability	Low to Moderate	Short-term	Reversible	No
		Habitat Diversity	Low	N/A	N/A	No
		Indirect Mortality Risk– new access potential	Low	Short-term	Reversible	No
		Direct Mortality Risk – vehicle strikes	Low	Short-term	Reversible	No
	Operations	Habitat Availability	Low to Moderate	Long-term	Reversible	No
		Indirect Mortality Risk– new access potential	High	Medium term	Reversible	Yes*

Summary of Project Effects for Wildlife (cont'd)

Wildlife Species	Assessment Scenario	Measurable Parameter	Magnitude/ Extent[1]	Duration[2]	Reversible/ Non-Reversible[3]	Potential for Measurable Contribution to Cumulative Effects[4]
Grizzly Bear	Construction	Habitat Availability	Low to Moderate	Short-term	Reversible	No
		Habitat Diversity	Low	N/A	N/A	No
		Indirect Mortality Risk– new access potential	Low	N/A	N/A	No
		Direct Mortality Risk- winter den disruption	Low	Short-term	Reversible	No
	Operations	Habitat Availability	Low	Long-term	Reversible	No
		Indirect Mortality Risk– new access potential	Low	N/A	N/A	No
Marten	Construction	Habitat Availability	Low to Moderate	Short-term	Reversible	No
		Habitat Diversity	Low	N/A	N/A	No
		Indirect Mortality Risk–new fragmentation and blockage of cross-ROW movements	Low	Short-term	Reversible	No
		Direct Mortality Risk- den disruptions	Low	Short-term	Reversible	No
	Operations	Habitat Availability	Low to Moderate	Long-term	Reversible	No
		Indirect Mortality Risk– new fragmentation and blockage of cross-ROW movements	Low	Medium term	Reversible	No

Summary of Project Effects for Wildlife (cont'd)

Wildlife Species	Assessment Scenario	Measurable Parameter	Magnitude/ Extent[1]	Duration[2]	Reversible/ Non-Reversible[3]	Potential for Measurable Contribution to Cumulative Effects[4]
Beaver	Construction	Habitat Availability	Low	Short-term	Reversible	No
		Habitat Diversity	Low	N/A	N/A	No
		Indirect Mortality Risk–new fragmentation	Low	N/A	N/A	No
		Direct Mortality Risk-dam removals	Low	Short-term	Reversible	No
	Operations	Habitat Availability	Low	Long-term	Reversible	No
		Indirect Mortality Risk–new fragmentation	Low	N/A	N/A	No
Black-throated Green Warbler	Construction	Habitat Availability	Low	N/A	N/A	No
		Habitat Diversity	Low	N/A	N/A	No
		Indirect Mortality Risk–new fragmentation	Low	N/A	N/A	No
		Direct Mortality Risk-nest destruction	Low	N/A	N/A	No
	Operations	Habitat Availability	Low	Long-term	Reversible	No
		Indirect Mortality Risk–new fragmentation	Low	Medium term	Reversible	No

Summary of Project Effects for Wildlife (cont'd)

Wildlife Species	Assessment Scenario	Measurable Parameter	Magnitude/ Extent[1]	Duration[2]	Reversible/ Non-Reversible[3]	Potential for Measurable Contribution to Cumulative Effects[4]
Trumpeter Swan	Construction	Habitat Availability	Low	N/A	N/A	No
		Habitat Diversity	Low	N/A	N/A	No
		Indirect Mortality Risk–new fragmentation	Low	N/A	N/A	No
		Direct Mortality Risk-nest destruction	Low	N/A	N/A	No
	Operations	Habitat Availability	Low	Long-term	Reversible	No
		Indirect Mortality Risk–new fragmentation	Low	N/A	N/A	No

Notes: * For analytical purposes, caribou were considered the representative species for ungulates, including moose.

[1] **Magnitude/Extent** – refers to the degree of change (or risk) to biodiversity

Low – Change in measurable parameter will have no effect on local species abundance or diversity (i.e., within two km mapped corridor)

Moderate – Change in measurable parameter will have possible effect on local species abundance or diversity (i.e., within two km mapped corridor)

High – Change in measurable parameter will have possible measurable effect on species abundance or diversity within Etsho RMZ

[2] **Duration** – refers to the length of time over which the project-related effect is measurable

Short term – less than 1 year

Medium term – greater than 1 year but not beyond life of project

Long term – beyond life of project

[3] **Reversibility** – refers to the potential for conditions to return to baseline conditions, in the absence of the project

Reversible – Will likely revert to baseline conditions following end of project life or before

Non-reversible – unlikely to revert to baseline conditions following end of project life

[4] **Potential for Measurable Contribution to Cumulative Effects**

Yes – measurable contribution to CE within Etsho Resource Management Zone(generally requires high magnitude and medium to long-term impact on species)

No – no measurable contribution to CE within Etsho Resource Management Zone

Summary of Project Effects for Fisheries and Aquatic Resources

Assessment Scenario	Issue/Measurable Parameter	Magnitude/ Extent[1]	Duration[2]	Reversible/ Non-Reversible[3]	Potential for Measurable Contribution to Cumulative Effects[4]
Construction	Altered Instream Habitat	Low	Short-term	Reversible	no
	Sediment Introductions	Low	Short-term	Reversible	no
	Altered stream flows	Moderate	Short-term	Reversible	no
	New Access Potential	Low	Short-term	Reversible	no
Operations	Sediment Introductions	Low	Short-term	Reversible	no
	New Access Potential	Low	Long-term	Reversible	no

Notes: [1] **Magnitude/Extent** – refers to the degree of change (or risk) to biodiversity

Low – change in measurable parameter will have no effect on local species abundance and diversity (stream productive capacity) (i.e., within 2 km mapped corridor)

Moderate – change in measurable parameter will have possible effect on local species abundance and diversity (stream productive capacity) (i.e., within 2 km mapped corridor)

High – possible measurable effect on species abundance and diversity (stream productive capacity) within Etsho Resource Management Zone

[2] **Duration** – refers to the length of time over which the project-related effect is measurable

Short term – less than 1 year

Medium term – greater than 1 year but not beyond life of project

Long term – beyond life of project

[3] **Reversibility/Non-reversibility** – refers to the potential for conditions to return to baseline conditions, in the absence of the project

Reversible – will likely revert to baseline conditions following end of project life or before

Non-reversible – unlikely to revert to baseline conditions following end of project life

[4] **Potential for Measurable Contribution to Cumulative Effects**

Yes – measurable contribution to CE within Etsho Resource Management Zone(generally requires high magnitude and medium to long-term impact on species)

No – no measurable contribution to CE within Etsho Resource Management Zone

Summary of Project Effects for Land and Resource Use

Assessment Scenario	Issue	Magnitude/ Extent[1]	Duration[2]	Reversible/ Non-Reversible[3]	Potential for Measurable Contribution to Cumulative Effects[4]
Construction	Effects on furbearer habitat and mortality	Low	Short to long term	Reversible	No
	Effects on trapper harvest and income	Low	Short to long term	Reversible	No
	Effects on moose and caribou habitat and mortality	Low	Medium to long term	Reversible	No
	Effects on traditional hunting	Low	Medium to Long term	Reversible	No
	Effects on guide outfitting	Low	Medium to Long term	Reversible	No
	Effects on oilfield development activities	Low	Short to long term	Reversible	No
	Effects on merchantable timber	Moderate	Long term	Reversible	No
	Effects on consumptive and non consumptive recreation	Low	Medium to long term	Reversible	No
Operations	Effects on furbearer habitat and mortality	Low	Short to long term	Reversible	No
	Effects on trapper harvest and income	Low	Short to long term	Reversible	No
	Effects on moose and caribou habitat and mortality	Low	Medium to long term	Reversible	No
	Effects on traditional hunting	Low	Medium to Long term	Reversible	No
	Effects on guide outfitting	Low	Medium to Long term	Reversible	No
	Effects on oilfield development activities	Low	Short to long term	Reversible	No
	Effects on merchantable timber	Moderate	Long term	Reversible	No
	Effects on consumptive and non consumptive recreation	Low	Medium to long term	Reversible	No

Notes: [1] **Magnitude/Extent** – refers to the degree of change (or risk) to land use opportunities
Low or Moderate – possible effect on local (within two km) land use opportunities
High – possible effect on land use opportunities beyond 2 km-wide corridor

[2] **Duration** – refers to the length of time over which the project-related effect is measurable
Short term – less than one year
Medium term – greater than one year but not beyond life of project
Long term – beyond life of project

[3] **Reversibility** – refers to the potential for conditions to return to baseline conditions, in the absence of the project

Reversible – will likely revert to baseline conditions following end of project life or before

Non-reversible – unlikely to revert to baseline conditions following end of project life

[4] **Potential for Measurable Contribution to Cumulative Effects**

Yes – measurable contribution to CE within Regional Study Area

No – no measurable contribution to CE within the Regional Study Area

Abbreviations

°C	Degrees Celsius
AIA	Archaeological Impact Assessment
ALR	agricultural land reserve
ANHIC	Alberta National Heritage Information Centre
AS	Average Speed
AVI	Alberta Vegetation Inventory
AWI	Alberta Wetland Inventory
AXYS	AXYS Environmental Consulting Ltd.
BC CDC	British Columbia Conservation Data Centre
BEI	Broad Ecosystem Inventory
CSSA	Core Security Study Area
CEA	Cumulative Effects Assessment
CEAA	*Canadian Environmental Assessment Act*
CEM	Cumulative Effects Model
CLI	Canada Land Inventory
CMT	Culturally Modified Trees
CSH	Core Security Habitat
cm	centimetre
CO	carbon monoxide
DT	Duty of Unit
DTFN	Dene Tha' First Nation
EF	Emission Factor(s)

EIA	Environmental Impact Assessment
Ekwan	Ekwan Pipeline Inc.
ELC	Ecological Land Classification
EPN	Early Public Notification
EPP	Environmental Protection Plan
ER	Emission Rate
FHAP	Fish Habitat Assessment Procedure
FMA	Forest Management Agreement
FNFN	Fort Nelson First Nation
ha	hectares
HC	Hydrocarbon Compounds
HRIA	Historical Resources Impact Assessment
km	kilometre
km/h	kilometre per hour
KP	Kilometre Post
LDGT	Light-Duty Gasoline Trucks
LDGV	Light-Duty Gasoline Vehicles
LOC	License of Operation
LSA	Local Study Area
m	metre
m/h	miles per hour
m/s	metres per second
m^3	cubic metres
m^3/s	cubic metres per second

masl	metres above sea level
MF	Mass of Fuel
MoF	Ministry of Forestry
MSC	Meteorology Service of Canada
NEB	National Energy Board
NGTL	NOVA Gas Transmission Ltd.
NO_x	Nitrogen Oxides
PM	Particulate Matter
RMZ	Resource Management Zone
ROW	right-of-way
RSA	Regional Study Area
SYD	Sierra-Yoyo-Desan
t	tonne
TCPL	TransCanada PipeLines Limited
TEM	Terrestrial Ecosystem Mapping
TLUS	Traditional Land Use Survey
USEPA	United States Environmental Protection Agency
VOC	Volatile Organic Compounds

13 Environmental Impact Assessment and Mitigation Plan

13.1 Introduction

13.1.1 Project Background

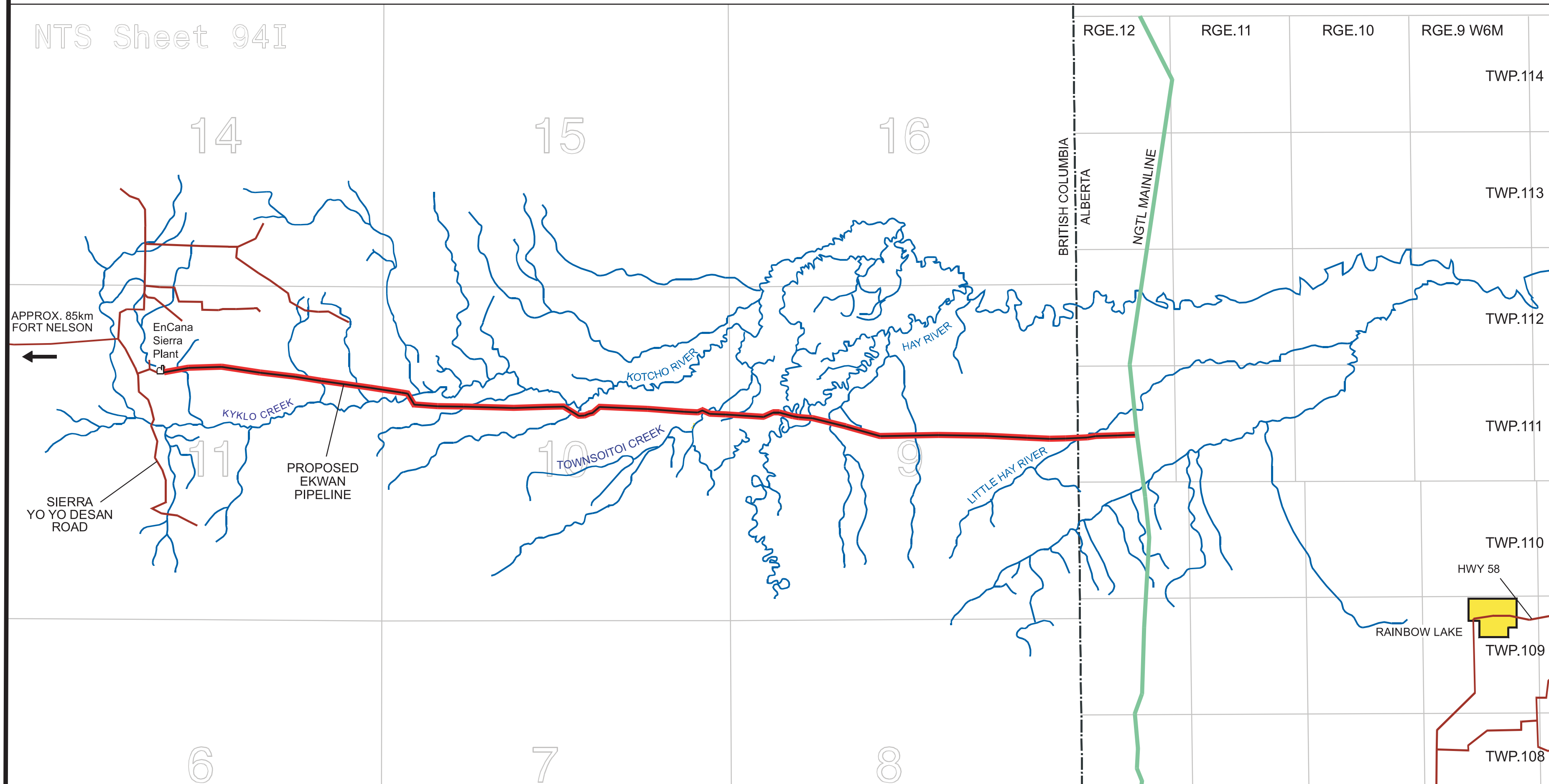
EnCana Ekwan Pipeline Inc. (EnCana Ekwan) is proposing to construct the Ekwan Pipeline (the Project) to carry sweet natural gas from EnCana's Sierra plant located in the Sierra/Kyklo gas field in northeastern British Columbia to the existing NOVA Gas Transmission Ltd. (NGTL) pipeline system west of Rainbow Lake, Alberta (see Figure 13.1-1). As part of its filing requirements to the National Energy Board (NEB) for an Application for the Pipeline, made pursuant to Section 52 of the *National Energy Board Act*, EnCana Ekwan has retained AXYS Environmental Consulting Ltd. (AXYS) to prepare this Environmental Impact Assessment (EIA) document to identify key biophysical resources in the Project area, the nature of anticipated project effects on these resources, and mitigation plans for minimizing such effects.

More details on the Project are provided in Section 13.2 of this EIA document and in Volume 1 of the Application.

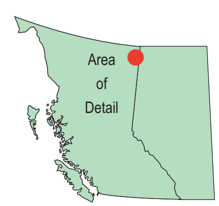
13.1.2 Regulatory Setting

This Pipeline is regulated under the *National Energy Board Act* (the Act) as it crosses a provincial border. Pursuant to the Act, EnCana Ekwan is required to submit environmental information pertaining to the Project as outlined in Part VII of the *Guidelines for Filing Requirements* (NEB 1995). In addition, the work required in and about navigable streams to construct the Pipeline will require approvals under the Section 108 of the *Navigable Waters Protection Act*.

The Project will be subjected to review under the *Canadian Environmental Assessment Act* (CEAA), with the NEB and Canadian Coast Guard serving as Responsible Authorities. Environment Canada and Fisheries and Oceans Canada are supporting Federal Authorities participating in the review of this Project.



EnCana Ekwan Pipeline



Acknowledgements:
Original drawing prepared by EnCana

ENCANA

AXYS Environmental Consulting Ltd

DRAFT DATE		SCALE	
March 5, 2003		N/A	
REVISION DATE		PROJECT	FIGURE NO.
March 5, 2003		POG1045	13.1-1
DRAWN	CHECKED	APPROVED	VOL
L.A.T.	A.K.		

13.1.3 Scope of Environmental Assessment

This Project will result in the development of approximately 62.5 km of new right-of-way (ROW), as defined by the Comprehensive Study List Regulations of CEAA. The remainder of the proposed Pipeline ROW will be parallel to and contiguous with existing operating pipeline and/or powerline ROWs (see Appendix 13A).

Under the Comprehensive Study List Regulations of CEAA, a pipeline project requiring less than 75 km of new ROW is to be reviewed as a Screening, rather than a Comprehensive Study. Therefore, the EIA for this Project will satisfy the information requirements set out in Section 16(1) of CEAA (see Appendix 13C).

The *Guidelines for Filing Requirements* (NEB 1995) provide additional guidance or 'terms of reference' on the information required in the EIA. Appendices 13B and 13C present concordance tables, cross-referencing sections of the EIA with the information requirements of Part VII of the NEB filing requirements and Section 16(1) of CEAA.

13.2 Project Description

13.2.1 Scope of Project

This Project will involve the construction and operation of approximately 83 km of 61 cm (51 miles of 24 inch) pipeline. No upstream modifications to the EnCana Sierra Gas Plant or downstream modifications to the NGTL Northwest Mainline pipeline system will be required to accommodate the new gas flow through the proposed Pipeline. Therefore, based on the 'principal project/accessory test' provided by the *Canadian Environmental Assessment Act* Training Compendium (Canadian Environmental Assessment Agency 1994), the 'scope of the project' from the perspective of the *Canadian Environmental Assessment Act* can be defined as the physical works associated with the construction and operation of the Pipeline only.

Project details are provided in Volume 1 of the Application document. The information presented in this Volume 2 represents a summary of relevant details that will assist the reader in better understanding the environmental implications of the Project.

13.2.2 Pipeline Details

13.2.2.1 Routing Alternatives

During the initial planning stages for this Project, three routing alternatives were considered for moving gas from the EnCana Sierra Gas Plant to the NGTL Northwest Mainline Pipeline. Since there were no obvious biophysical or land use constraints between the tie-in points, options were developed that maximized the use of existing linear corridors (e.g., seismic lines, roads and utility ROWs) and that offered acceptable crossing locations of major streams.

More detailed analysis was done for these three alternatives and public consultation (the North, Mid-route and South Alternatives). All three alternatives have a common alignment from the EnCana Sierra Gas Plant to the crossing of Kyklo Creek 20.6 km to the east. All follow an existing pipeline and dry-weather access road to the creek, and then require approximately 1.1 km of new ROW to cross the creek. The remaining segments of the alternatives are discussed in the following:

North Alternative. On the south side of the Kyklo Creek crossing, this alternative heads east along seismic lines to the Hay River area (a distance of approximately 32.2 km), shifting from seismic lines for 2 km to avoid stream meanders associated with Kotcho River and for an additional 2 km to improve crossing locations at Townsoitoi Creek and a tributary to Townsoitoi Creek. From the Hay River, the route travels southeast for approximately 7.7 km before rejoining an east-west trending seismic line. Immediately west of the Little Hay River, this routing encounters a relatively extensive Nexen oil field development for approximately 11 of the 20.9 km. Through much of this area, the route will require new

ROW to avoid conflicts with existing facilities. However, this ROW will be in very close proximity to these facilities

South Alternative. South of the Kyklo Creek crossing, this alternative travels south/southeast along a pipeline for 2.6 km, before angling southeast for an additional 8.8 km along existing seismic lines. The route then runs almost due east for 48.9 km, following seismic lines and pipelines for 29.9 km and 16.9 km, respectively for this distance. To avoid a crossing of Fire Creek, the route deviates to the northeast for the remainder of its length (approximately 4 km), requiring a new ROW through this area.

Mid-route. This alternative follows the same alignment as the North alternative from Kyklo Creek east to the Kotcho River meanders. From this point, the route travels to the southeast, following a portion of the proposed alignment for the Northern Link Road southeast to the Hay River for approximately 19.4 km. This segment represents new cut, as the road alignment has not been developed. The route joins the South alternative just east of the Hay River, and follows it for the remainder of its length.

The Northern Link Road is a proposed all-weather road that would connect Rainbow Lake, Alberta with Fort Nelson, British Columbia. While an alignment for the road has undergone a preliminary survey, funding for the road construction has not been acquired, and it is unlikely that the road will be built prior to Pipeline construction. Based on discussions with Forestry personnel in both provinces, there is no guarantee that the road will be constructed.

The only portion of the road alignment suitable for the Pipeline is that section from the Kotcho River that meanders southeast to the Hay River. The remainder of the road alignment deviates too far from the straight line distance between tie-in points for the Pipeline, and attempting to follow more of the road would add significantly to the construction costs of the Pipeline.

13.2.2.1.1 Route Selection Criteria

The three alternatives were evaluated based on the following criteria:

- **Land Use Compatibility**. The British Columbia portion of all of the proposed routing alternatives fall within the Etsho Resource Management Zone (RMZ) of the Fort Nelson Land and Resource Management Plan, and all cross the Petitot/Hay Rivers Corridors RMZ.

  To identify potential conflicts with existing land use practices and traditional activities, the three alternatives were presented to and discussed with representatives from British Columbia Ministry of Forests, British Columbia Oil and Gas Commission, British Columbia Ministry of Water, Land and Air Protection, and Alberta Lands and Forest Division, as well as representatives from Fort Nelson, Prophet River and Dene Tha' First Nations. Additional mail-outs introducing the Project and requesting comments on routing alternatives were also sent to municipal offices in Fort Nelson and Rainbow Lake, as well as trappers potentially affected by the Project. More details on the Early Public Notification and Public Consultation initiatives undertaken for this Project are presented in Sections 10 and 12 of the Application.

- **Construction Cost/Difficulty**. Pipeline length is a major contributing factor to the cost of this Project. Consequently, the lengths (and associated cost) of the routing alternatives were evaluated as part of the selection process.

  Wetland terrain features with high groundwater tables (i.e., fens) can pose construction difficulties and result in incremental construction costs for the Project. These areas often do not develop a thick frozen layer during winter because of the presence of moving subsurface groundwater. To develop a ROW capable of supporting heavy equipment in these areas, extensive frost packing, corduroy installation and on-going ROW repairs are frequently required during the construction period, with associated additional costs. The high groundwater levels associated with these areas will require extensive weighting of the pipe to keep it from surfacing during operations, adding additional costs to the Project. Consequently, a cursory identification of fens was undertaken and compared for the three alternatives to assist in the selection process.

- **Biophysical Sensitivities**. The Project area falls within the Boreal White and Black Spruce (BWBS mw) biogeoclimatic variant of British Columbia. The area is dominated by poorly drained glaciolacustrine and organic landforms, with some interspersed fluvial deposits along major stream channels. It supports a moderate diversity of wildlife species, as well as several larger drainage systems with relatively low aquatic diversity. The three routes have been evaluated for wildlife and fisheries potential in a qualitative fashion.

  Pipeline ROWs developed in forested terrain represent new access potential and incremental habitat fragmentation, particularly where no existing maintained linear corridors can be followed by the new development. Consequently, to assess the relative contribution of the alternatives to new access and fragmentation, the proportion of each alignment requiring new ROW was evaluated.

13.2.2.1.2 Evaluation of Alternatives

13.2.2.1.2.1 Land Use Compatibility

The Etsho RMZ that is encountered by the three alternatives is an Enhanced Resource Development area, where the management intent is ‘to provide for intensive development of resources such as timber, natural gas and minerals’ (Fort Nelson LRMP 1997). Resource development is also considered compatible in the Petitot/Hay Rivers Corridors RMZ, provided that access development is appropriately managed, and that riparian and cultural/traditional values are protected. Therefore, all three alternative routes are considered acceptable for pipeline development from a land use planning perspective.

None of the stakeholders contacted through meetings or mailouts expressed concerns or preferences for any of the routing alternatives presented for the Project. From a land use planning perspective, the proposed Northern Link Road is not viewed as a serious development corridor by provincial authorities, and to date there was no direction from provincial authorities to consider portions of the proposed road alignment for pipeline routing.

13.2.2.1.2.2 Construction Costs/Difficulty

Table 13.2-1 summarizes the cost implications of each alternative, based on their total length.

Table 13.2-1 Cost Comparisons of the Three Alternatives

Route Alterative	**Total Length** (km)	**Estimated Cost @ $342,000/km** (million $)
North	83.0	28.4
Mid	86.5	29.6
South	86.5	29.6

The North alternative offers an estimated cost savings of $1.2 million over the Mid-route and South alternative from a construction ‘lay price’ perspective.

Based on a preliminary evaluation of wetland types along the alternatives, the Mid-route likely encounters the least amount of problematic ‘fen’ terrain types, as it follows predominantly upland terrain from Kotcho Creek to the Hay River. The North alternative encounters the next lowest amount, with the majority of the fens occurring east of the Hay River crossing and relatively few large fens being encountered west of the crossing. The South alternative encounters extensive stretches of open tamarack fen on both sides of the Hay River, and is expected to present the greatest construction difficulties of the three alternatives.

13.2.2.1.2.3 Biophysical Sensitivities

In October 2002, an overflight of the three alternatives was undertaken by terrain/vegetation, wildlife and fisheries specialists to identify and compare resource conditions and sensitivities along the three options.

From a wildlife perspective, all three alternatives offer comparable habitat conditions. While the North and Mid-route alternatives encounter slightly more forested moraine and fluvial deposits, all three alternatives encounter extensive stretches of poorly drained fens and bogs with limited botanical and structural diversity. Fluvial deposits associated with the major drainages in the area (i.e., Kyklo Creek, Kotcho River, Townsoitoi Creek, Hay River, Little Hay River, Fire Creek) support the most mature and structurally diverse forested habitats, offer the best winter thermal cover in the Project area, and likely support the greatest diversity of wildlife. Each of the alternatives encounters four or five of these forest types on a localized basis only.

From a fisheries perspective, all of the alternatives encounter a comparable number of named stream crossings, including Kyklo Creek, Townsoitoi Creek, Timberwolf Creek, the Hay River and the Little Hay River, with similar crossing conditions. The North alternative crosses Timberwolf Creek in a muskeg-dominated portion of the drainage where no defined channel is present, while the Mid-route and South alternatives encounter a more defined channel of the creek. Similarly, the South alternative crosses Townsoitoi Creek where no channel is apparent, while the North and Mid-route alternatives encounter a more defined channel. All of the named crossings support low gradient, lentic habitat with low habitat diversity, suitable for mainly cyprinid and forage fish species.

Table 13.2-2 provides a comparison of the types of linear corridors followed by the three alternatives, as well the amount of new ROW required by each alternative.

Table 13.2-2 Linear Corridors Followed by Each Alternative

Alternative	**Length of Seismic Lines Followed** (km)	**Length of Roads/Utility Corridors Followed** (km)	**New ROW not Following Existing Corridor** (km)	**Total Length** (km)
North	42.8	20.5	19.4	82.7
Mid-route	40.8	20.6	25.1	86.5
South	39.2	40.1	7.2	86.5

Note: Approximate distances only, based on preliminary routing

The South alternative offers the least amount of ‘new cut’ ROW and associated new fragmentation of the three options, followed by the Mid-route. The South alternative also requires the least amount of new ROW, as defined by the Comprehensive Study List Regulations of CEAA, as it follows almost twice the length of existing utility corridors as the other options.

13.2.2.1.3 Summary

Overall, the North alternative is the preferred route for the Pipeline. The North route poses reduced construction costs and risks for the Project, and it encounters comparable fisheries, wildlife and land use values as the other options. The North alternative is compatible with the resource management objectives for the area, and no opposition to the route has been expressed by provincial resource management agencies or affected stakeholders.

Although the North alternative requires more new ROW than the Mid-route and South alternative (as defined by the Comprehensive Study List Regulations of CEAA), it follows existing disturbed corridors for 76 percent of its length, and presents little new access potential and associated habitat fragmentation for the area.

The subsequent material presented in the EIA deals with the preferred North alternative only from this point forward. It should be noted that, during the detailed legal survey of this preferred alignment, some minor adjustments were made to the route to avoid conflicts with new and proposed Nexen oil developments near the British Columbia/Alberta border. Consequently, the proportion of the line following existing disturbed corridors has changed somewhat from the preliminary figures presented in Table 13.2-2. The EIA reflects the new alignment.

13.2.2.2 Pipeline Details

Compression facilities at the EnCana Sierra Gas Plant will generate sufficient pressure to transport gas from the plant to the NGTL tie-in point, and no additional compressor stations will be required along the route. Similarly, no additional compression facilities will be required on the NGTL Northwest Mainline system to accommodate the new gas flow.

13.2.2.2.1 Buried Pipeline

The Ekwan Pipeline would extend from the EnCana Sierra Gas Plant in northeastern British Columbia (A-26-K/94-I-11, approximately 80 km east/southeast of Fort Nelson, British Columbia) to a tie-in point with the NGTL Northwest Mainline (27-110-12 W6M, approximately 35 km northwest of Rainbow Lake, Alberta). All but 4.1 km of the 83 km-long Pipeline is located in British Columbia.

The buried Pipeline would be constructed within a ROW with a maximum width of 25 m, with some additional temporary workspace being required for stream crossings, heavy grade areas, timber decking sites, side bends and facility/road crossings.

13.2.2.2.2 Pig Launching and Receiving Facilities

Pigging facilities (pig launcher) will also be developed near the beginning of the Pipeline and a pig receiver will be developed at the end of the Pipeline.

13.2.2.2.3 Block Valves

Block valves will be installed at approximately KP 30 and KP 55 along the Pipeline. These valves will be accommodated within the ROW, and no extra workspace will be required for their development. These sites will not require all-weather road access rather, they will be periodically accessed by helicopter for any necessary servicing.

13.2.2.2.4 Cathodic Protection

An impressed current cathodic protection system will supplement the external pipeline coating to provide corrosion protection for the entire Pipeline. The Pipeline will be electrically isolated from the upstream EnCana Sierra Gas Plant and the downstream meter station.

13.2.3 Other Facilities

13.2.3.1 NGTL Meter Station

A NGTL meter station will be installed either within or immediately adjacent to the tie-in point with the NGTL Northwest Mainline pipeline. Approximately 0.4 ha (60 m x 60 m) of aspen-dominated forest will be cleared, graded and graveled to accommodate site development.

13.2.4 Construction

13.2.4.1 Schedule and Sequencing

Assuming receipt of all regulatory approvals, construction of the Pipeline would commence in early-December 2003 with the clearing of the line. Frost packing on the workside of the ROW would be initiated in conjunction with clearing to provide a stable working surface for the mainline activities in wetter areas. Pipeline construction would be completed by late March 2004. Seeding of the ROW, where required, will be undertaken upon completion of construction.

It is possible that some ditch settlement and localized ditchline erosion may occur during the first summer after construction. If this occurs, remedial work would be undertaken in the January to March period of 2005, and any necessary seeding would be undertaken at the end of this activity.

13.2.4.2 Temporary Construction Facilities

13.2.4.2.1 Construction Camps

Two camps (approximately 200 man and 150 man) will be required to support construction activities for the December 2003 to March 2004 period. The camp contractor(s) will be responsible for obtaining the necessary provincial permits required for camp operations. Details on camp locations and operations will also be the responsibility of the contractor(s), and will not be finalized until fall 2003. Preliminary assessment points toward the camps being located around KP 20 and KP 70.

13.2.4.2.2 Pipe Stockpile Sites

Pipe for the Project would be delivered by rail to Fort Nelson and would be trucked to the site. The stockpile site for the pipe will likely be established in close proximity to the rail service in Fort Nelson, although some auxiliary sites may also be developed closer to the Project area. Final site selection will be determined considering pipe mill location.

13.2.4.3 Access Requirements

The all-weather Sierra-Yoyo-Desan (SYD) resource road currently provides access from Fort Nelson to the Sierra/Kyklo gas field. An existing 5.5 km-long all-weather road, in turn, links the EnCana Sierra Gas Plant to the SYD road. The SYD road, in combination with the plant road, will represent the primary route to access the western terminus of the Pipeline for both construction and operations. From the plant, the proposed Pipeline will parallel an existing pipeline and associated dry-weather truck trail for 20.6 km to the crossing of Kyklo Creek. This trail will provide the contractor with suitable access over this stretch of the Pipeline route during construction.

The remainder of the route is accessible by winter road only, and the contractor will be reliant on the workside of the new ROW as the primary access route for this portion of the line. However, each year, a winter road (28th baseline road) is developed between Rainbow Lake, Alberta and the SYD road to support resource activities. A good portion of this road parallels an east-west trending BC Hydro powerline ROW, approximately 9 to 11 km south of the proposed Pipeline alignment. A number of additional winter roads are developed north from the Rainbow Lake-SYD winter road each year to access gas exploration and development activities in the vicinity of the proposed Ekwan Pipeline, particularly near the Kyklo Creek crossing and the British Columbia-Alberta border. The contractor will also rely on these routes to some degree to access the central and eastern sections of the Pipeline. Depending on the traffic on these winter roads and where they cross the ROW it may be necessary to open additional temporary access. These would only be done along existing seismic lines or previously cleared lines but may entail additional clearing or removal of regrowth.

From an operational perspective, no permanent access (other than the existing EnCana Sierra Gas Plant road) will be required for the Project. All bridges installed along the ROW to facilitate construction will be removed at the end of the construction season, as will sections of corduroy used to stabilize wet sections of the ROW during construction. Routine maintenance of such Project facilities as block valves will be completed with helicopter support. If more substantial remediation work requiring equipment is needed, then the sites will be accessed via winter roads.

13.2.5 Operational Activities

Operational activities along the rest of the ROW will generally be limited to yearly aerial surveillance, and occasional helicopter maintenance checks of block valves. Given the cold, wet soil conditions and slow-growing nature of trees in the Project area, vegetation maintenance of the ROW is expected to be minimal (i.e., less than once every 10 years). If it does occur, the removal of larger trees and shrubs would be restricted to approximately an 8 m-wide corridor over the trenchline to facilitate aerial surveillance, and the rest of the ROW would be allowed to recolonize to native vegetation. Additional clearing would be required at block valve sites to accommodate helicopter landings. Vegetation management would be undertaken through mechanical, rather than chemical methods during the frozen winter period.

13.3 Assessment Methods

13.3.1 Issues Scoping

Issues scoping refers to the identification of key interactions between the project and environment that become the focus of the EIA. For this Project, these issues were identified through the Ekwan Early Public Notification (EPN) program, through Traditional Knowledge obtained from First Nation stakeholders, and from the collective professional knowledge of the EIA team.

13.3.1.1 Early Public Notification

The EPN program of EnCana Ekwan consisted of:

- meetings with provincial resource managers and federal resource agencies during early Project planning and routing evaluations
- meetings or written correspondence with directly affected First Nation communities and trappers
- routing fly-overs with trappers
- mail-outs of Project information to potentially-affected provincial, municipal and public stakeholders
- five open houses

Through these various processes, contacted parties were asked to comment on routing alternatives, and their concerns and interests regarding the Project. This information was synthesized, and used to help define the focus of the EIA. More detailed information on the nature and results of the EPN program are presented in Section 12 of the Application.

13.3.1.2 Traditional Knowledge

The traditional knowledge of First Nations communities with interests in the Project area was also used to define key issues for consideration in the EIA. This information was collected:

- from existing traditional land use studies available for the Project area
- during meetings and routing fly-overs with directly affected First Nations communities or trappers
- during winter geotechnical investigations at major stream crossings that were monitored by representatives of First Nations

13.3.1.3 Internal Scoping

AXYS Environmental Consulting Ltd. has extensive experience with the resource characteristics and management objectives of the area. In addition, the team is very familiar with the potential adverse interactions that can arise between pipeline developments and biophysical resources in the Project area, and the mitigation options that are available to reduce the implications of such interactions. The team used this collected expertise to further refine the focus of the EIA.

13.3.2 Defining Impact Parameters

The EIA is developed through the stand-alone resource or discipline-specific sections of Air, Terrain and Soils, Vegetation, Wildlife, Aquatic Resources, Historical Resources, Land and Resource Use and Traditional Land Use. Within each of these sections, the key resource issues identified through the scoping process are reviewed. Where quantitative assessments are to be undertaken, the measurable parameters used to assess the baseline conditions of these key resources and to track project-related effects to these key resources are also identified.

13.3.3 Study Areas

The discipline sections in this EIA discuss the study areas selected for the assessment. For the majority of the disciplines, regional information used to evaluate resource baseline conditions has generally been drawn from within the Etsho RMZ of the Fort Nelson Land and Resource Management Plan and the adjacent Upper Hay Forest planning region of Alberta. Most ground-based biophysical information developed specifically for the Project has been or will be collected within a 2 km-wide corridor centered on the preferred alignment for the Pipeline. Similarly, from an impact assessment perspective, Project contributions to resource change are largely presented within the context of this 2 km-wide corridor.

Where the Project is considered to contribute in a meaningful way to regional cumulative effects, larger regional study areas have been selected on a discipline-specific basis to conduct a broader cumulative effects assessment (CEA). These larger study areas are sized to allow a evaluation of Project contributions to regional cumulative effects for the resource in question.

13.3.4 Assessment Scenarios

Assessment scenarios refer to the ‘slices in time’ when resource conditions and associated Project-related changes to those conditions are assessed against some reference value (frequently baseline). For this Project, the assessment scenarios include:

- Baseline (early February, 2003)
- Construction (December 2003 to March 2004)

- Operations (2007 [5 years from baseline to allow for future predictions])
- Abandonment (2034 [qualitative discussion only because of highly speculative nature of impact predictions 30 years into the future])

Baseline conditions represent known activities as of early February, 2003. This date represents the end of EnCana Ekwan's public open house session, and was chosen to incorporate any information on land use activities that may have been collected during these sessions.

It must be recognized that, even in the absence of this Project, conditions within the assessment area will not remain stagnant, as other operators in the area are contributing to on-going land use change. This makes it meaningless to track only the effects of the Project, in isolation from other unrelated effects. Therefore, for each assessment period, the change in the resource in question from baseline is expressed with and without the effects of the Project, where appropriate, to enable the reader to identify the incremental Project contributions to cumulative change.

13.3.5 Identifying Mitigation Options

The pipeline industry has developed a number of 'best available practices' for minimizing impacts to the environment from either construction or operations, particularly with regards to route selection, topsoil handling issues, crossing techniques for fish-bearing streams, and reclamation. In addition, a number of project-specific mitigation measures will be implemented specifically for this Project to address regionally important issues and concerns (e.g., permafrost). For each discipline section in this EIA, mitigation measures to be implemented to reduce project effects on key resources are identified. These measures have been reviewed by EnCana Ekwan and adopted as an environmental commitment of the Project.

The mitigation measures developed by the various disciplines have been synthesized in the Environmental Protection Plan (EPP) for the Project (see Appendix 13D of this document). These measures are also spatially presented on the airphoto-based Environmental Alignment Sheets (see Appendix 13A). Both of these mitigation documents will be incorporated into the contract documents of the Pipeline contractor.

13.3.6 Quantifying Residual Project Effects

As discussed in Section 13.3.4 above, Project contributions to resource change are evaluated for each assessment period, factoring in on-going change from the overlapping effects of other land use activities. Project effects are evaluated <u>after</u> the implementation of proposed mitigation (i.e., residual project effects).

Following the direction of the Canadian Environmental Assessment Agency's Training Compendium (Canadian Environmental Assessment 1994), project effects are characterized for most key resources using the following impact descriptors:

- *Magnitude/Extent* – refers to the degree of change (or risk) to biodiversity at the local (i.e., 2 km-wide intensive study corridor) and regional (i.e., Etsho RMZ) scale.
- *Duration* – refers to the length of time over which the project-related effect is measurable
- *Reversibility* – refers to the potential for conditions to return to baseline conditions, in the absence of the project

While these broad definitions of the impact descriptors remain consistent for the different resource disciplines within the EIA, each discipline has developed slightly different categories within the descriptors to suit the resource issue in question.

The descriptor 'Impact Frequency' has not been included in this characterization as it adds little value for the assessment. Typically, most impacts from pipeline construction are one-time events that are concentrated into the year of construction. The impacts from operations (e.g., occasional surveillance, pigging, remedial digs and vegetation control) can be characterized as infrequent, short-term events with little consequence to the environment.

13.3.7 Cumulative Effects Implications

Two categories of cumulative effects can result from project development. These include:

- **Combined Project Effects** – This refers to the overlapping effects of different aspects of the project (e.g., vegetation damage from project emissions can combine with clearing activities to increase the overall cumulative effect of the project on vegetation). Consequently, for each discipline, the potential for overlapping effects is evaluated for key resources.
- **Project Contributions to Regional Cumulative Effects** – Typically, a pipeline development represents a highly localized impact on the biophysical environment. While it can be argued that any change to a resource, however small, can contribute to cumulative effects, it can also be argued that some project effects will be too trivial to represent a meaningful contribution to cumulative regional pressures on resource conditions and trends. Therefore, to maintain relevance in the EIA, some professional judgment has to be applied to identify those project effects that have the potential to contribute in a meaningful way to regional cumulative effects and resource concerns. For this EIA, the impact descriptors have been used as a vehicle for identifying project effects with regional cumulative implications. In general, those project effects considered to influence biophysical diversity at the regional planning level for medium to long-term durations are short-listed for a broader regional CEA.

Figure 13.3-1 presents the conceptual approach for selecting and pursuing CEA issues in this EIA.

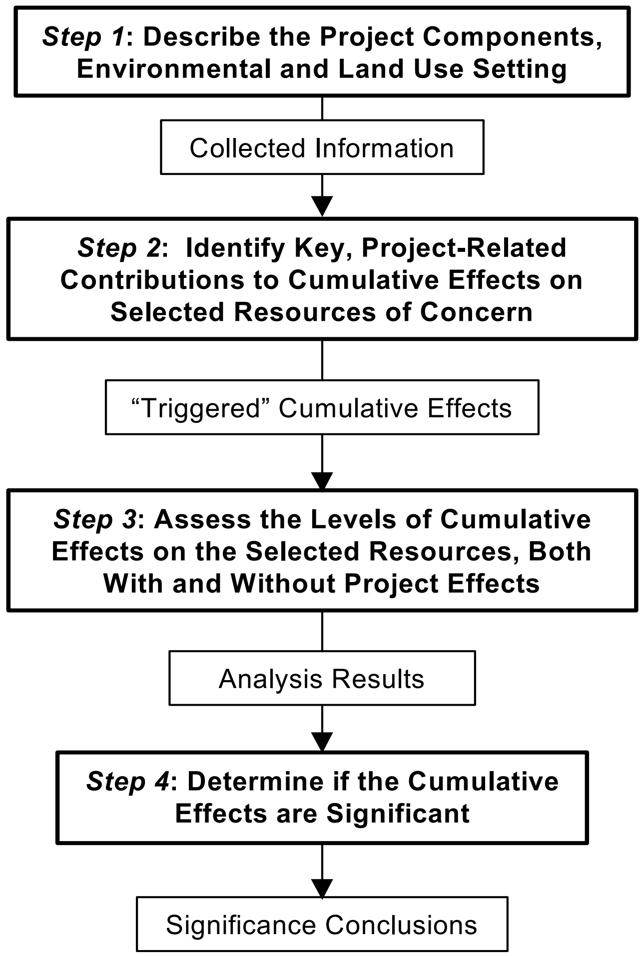


Figure 13.3-1 CEA Framework

In support of the CEAs undertaken for this EIA, a project inclusion list (see Table 13.3-1) was developed, identifying existing and future (up to 2007) known or proposed land use activities within 15 km of the proposed Pipeline alignment, whose impact on resources could overlap those of the Ekwan Project.

Table 13.3-1 Project Inclusion List

Baseline Scenario Land Use Activity (as of early February 2003)	Construction Scenario Land Use Activity	Operations Scenario Land Use Activity
Roads (all weather and winter) Borrow pits Sumps Log decks Seismic lines Wells Pipelines	Baseline land use activity EnCana Ekwan Pipeline NGTL meter station	Baseline land use activity EnCana Ekwan Pipeline Nexen Canada Inc. well sites, sumps, borrow pits, winter roads and gathering systems

Information collection on likely future projects was halted in early February to facilitate the completion of the EIA for the Ekwan application. At that time, provincial agencies had indicated that the future of the Northern Link Road was uncertain, and it was excluded from future likely projects. If the status of the road changes over the next several months, the appropriate re-analysis of cumulative effects, including the road, will be undertaken by EnCana and submitted as supplemental information to the Board.

13.3.8 Follow-up and Monitoring

Follow-up and monitoring programs are generally required where:

- the confidence of impact predictions are considered low
- the effectiveness of proposed mitigation is in question

Each discipline-specific section below identifies follow-up and monitoring needs for their particular resource issues.

13.4 Air

13.4.1 Baseline Setting

The Project area is located in northeast British Columbia, and is at elevations that range from 330 to 550 m ASL. There are two meteorological stations nearby: Fort Nelson Airport in British Columbia, which is located 70 km west of the EnCana Sierra Gas Plant; and Rainbow Lake Forestry Lookout in Alberta, which is located 30 km east of the tie-in point with NGTL's Northwest Mainline pipeline. The Rainbow Lake meteorological station only provides data from May to September and is located at a higher elevation than the Project area (i.e., 580 m ASL). The Fort Nelson Airport meteorological station provides year-round data and is located at a similar terrain elevation as the Project area (i.e., 382 m ASL).

Because of data completeness and elevation similarity, data from the Fort Nelson Airport station are used to characterize the climate for the study area. Meteorological data are compiled on an hourly basis and are available through the Meteorological Service of Canada (MSC). The following analysis of the meteorology is based on climate normals for the period 1971 to 2000 (MSC 2003).

13.4.1.1 Site Description

The terrain in the study area consists of mostly flat low-lying plateaus to the east and rolling hills towards the west (NRC 2003). There are gradual increases in elevation to the northwest and southeast. While terrain in the study area is relatively flat, the orientation of the shallow river valleys can influence local wind patterns. The western portion of the proposed Pipeline parallels Kotcho River which has a west to east orientation. Towards the east, the proposed Pipeline crosses the Hay River that has a south to north orientation.

The Fort Nelson Airport is located within the valley defined by the Fort Nelson River that has a south to north orientation. As a consequence the wind directions observed at the airport are likely to have north-south bias that may not necessarily occur in the study area. Other than the wind direction, the meteorological parameters observed at the airport are expected to be representative of those found in the Project study area.

13.4.1.2 Climate

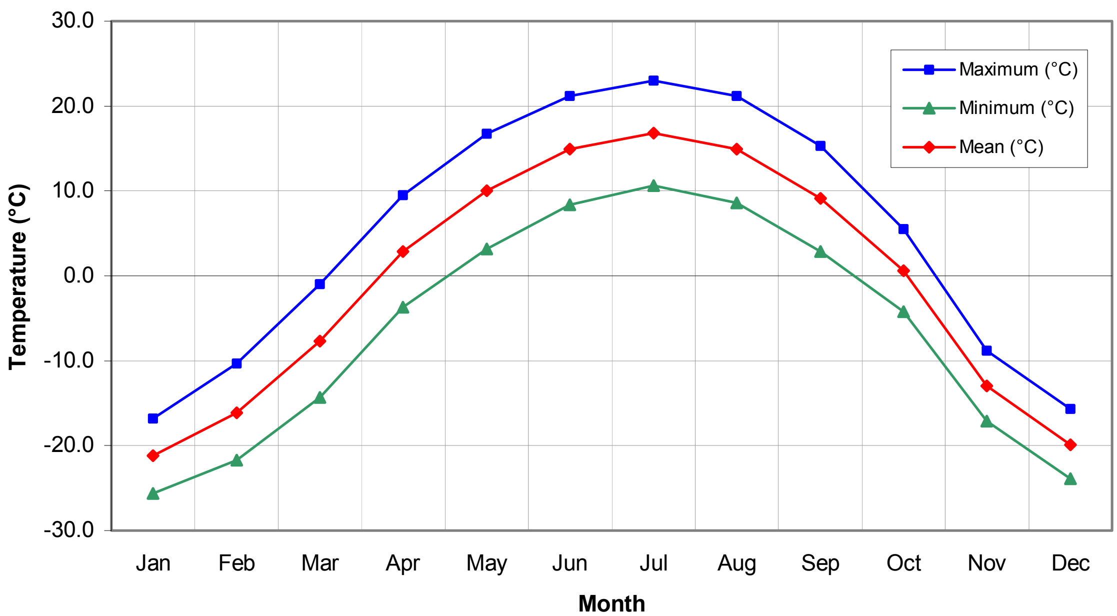
The Fort Nelson area is subject to a wide range of weather conditions, from warm summers to extremely cold winters. Continental climate causes the area to be very dry and below 0°C for five months of the year, on average. Precipitation levels are relatively low throughout the year and there is a large seasonal and diurnal temperature variation. The Koeppen Climate Classification scheme describes this region as having severe winters and temperate summers; the average temperatures of the coldest and warmest months are -21.2 and 16.8°C, respectively (MSC 2003).

The primary types of vegetation in this region are temperate deciduous and boreal coniferous forests. The growing season is very similar to temperate regions but lasts over a shorter duration and often starts and ends with periods of frost. It is also common to find patches of permafrost around the Fort Nelson area (Government of BC 2002).

13.4.1.2.1 Temperature

Figure 13.4-1 shows the mean daily, mean maximum, and mean minimum temperatures observed at the Fort Nelson Airport. The annual mean daily temperature, maximum temperature and minimum temperature are -0.7°C, 5.0°C and -6.4°C, respectively. Average maximum temperatures greater than 20°C occur in June, July, and August; average minimum values less than -20°C occur in December, January, and February.

The extreme maximum recorded temperature of 36.7°C occurred on July 01, 1942. The extreme minimum recorded temperature of -51.7°C occurred on January 30, 1947.

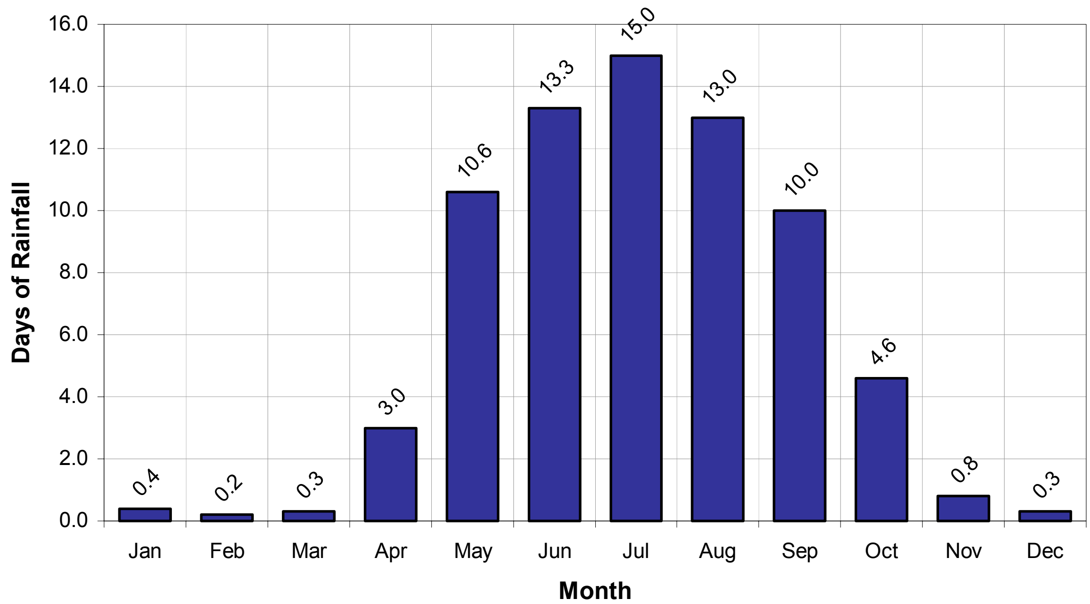


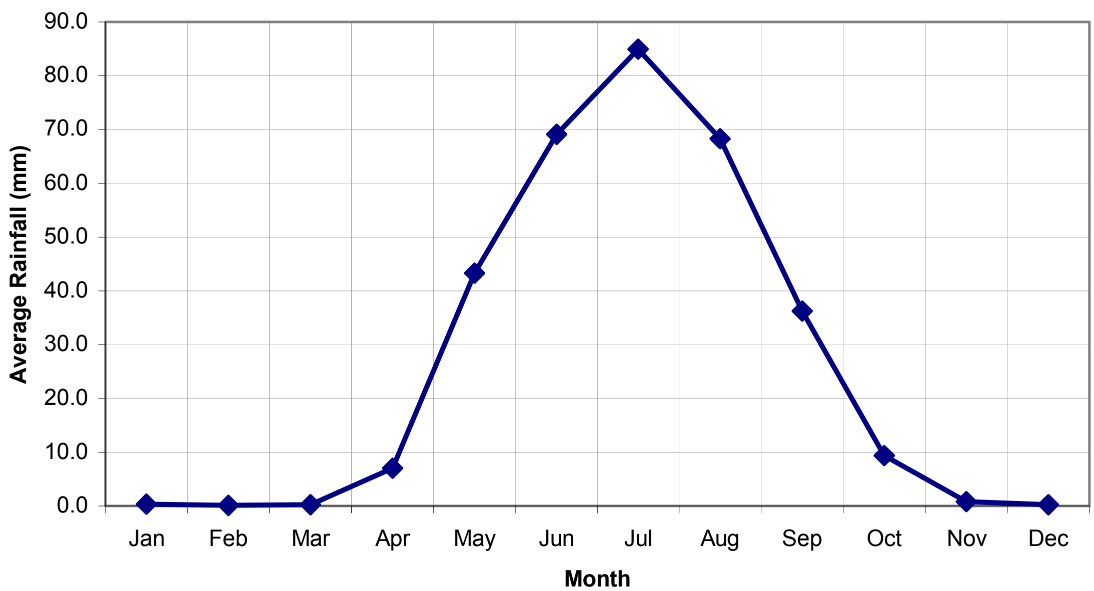
Source: MSC 2003

Figure 13.4-1 Temperature Normals Measured at the Fort Nelson Airport for the Period 1971 to 2000

13.4.1.3 Precipitation

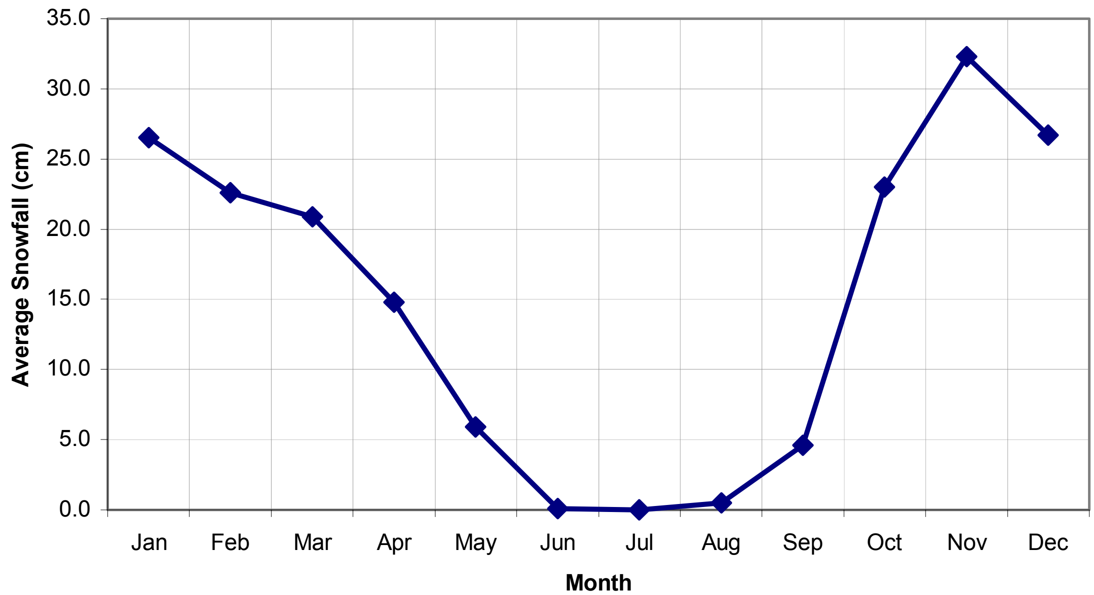
Figures 13.4-2, 13.4-3 and 13.4-4 show the mean rainfall, mean snowfall and mean total precipitation as well as the number of days of measurable precipitation. The mean annual rainfall, snowfall, and total precipitation are 319.8 mm, 177.8 cm and 451.7 mm, respectively. On average, there are 129.5 days each year when there is measurable precipitation (greater than 0.2 mm of water equivalent recorded).

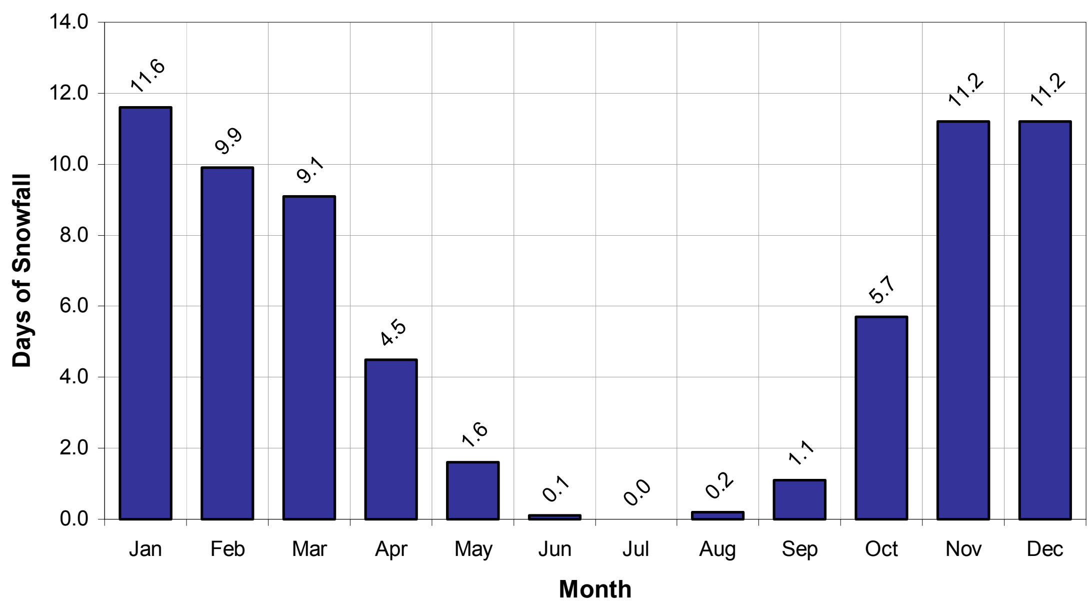




Source: MSC 2003

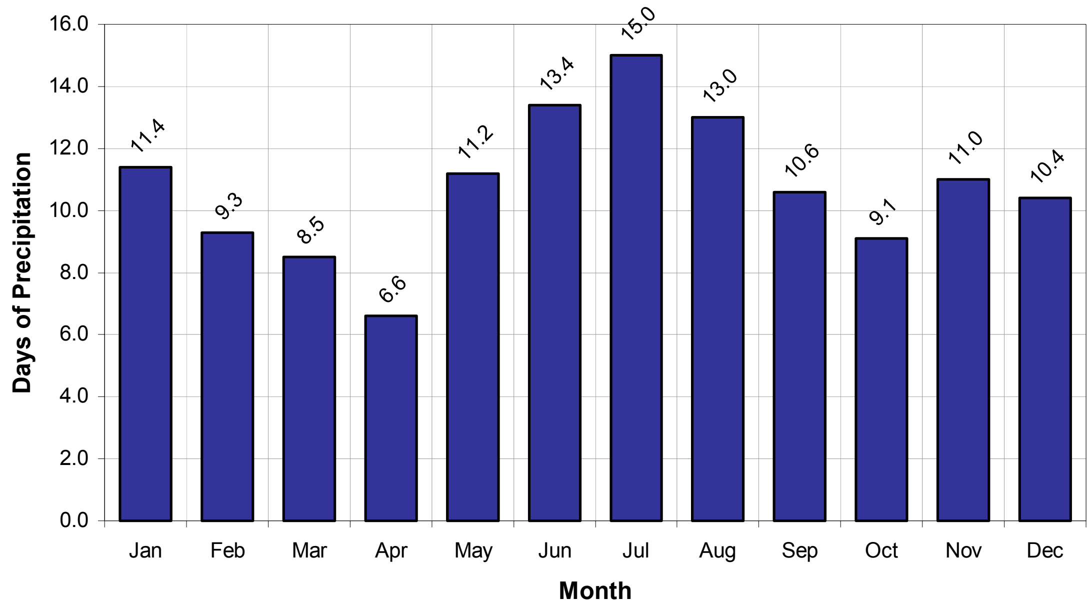
Figure 13.4-2 Mean Monthly Rainfall and Number of Days with Measurable Rainfall Observed at the Fort Nelson Airport for the Period 1971 to 2000

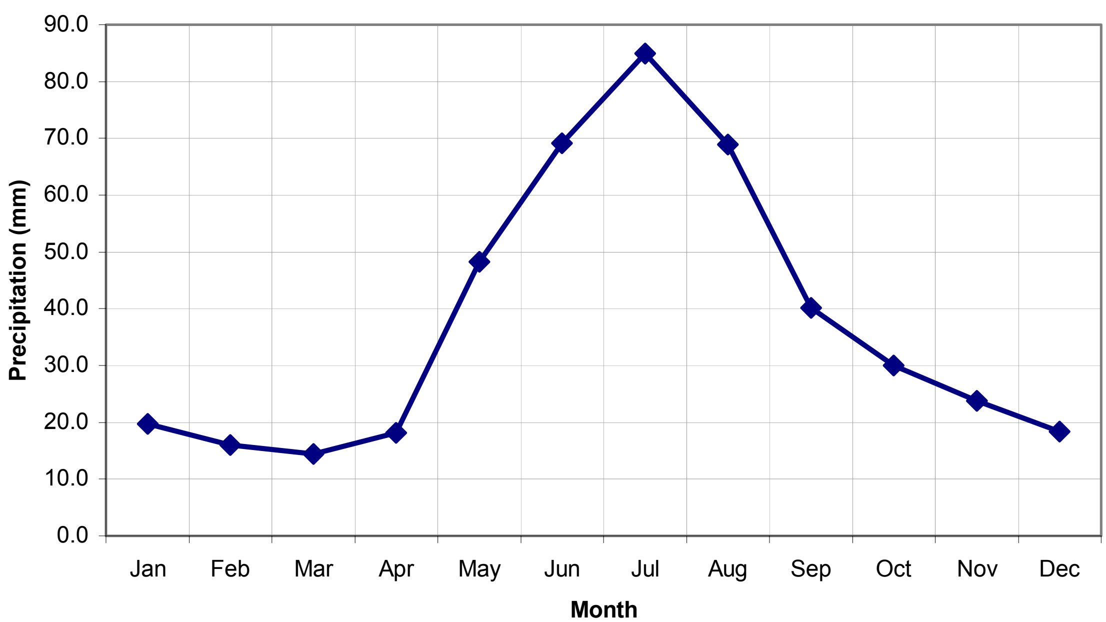




Source: MSC 2003

Figure 13.4-3 Mean Monthly Snowfall and Number of Days with Measurable Snowfall Observed at the Fort Nelson Airport for the Period 1971 to 2000





Source: MSC 2003

Figure 13.4-4 Mean Monthly Precipitation and Number of Days with Measurable Rainfall Observed at the Fort Nelson Airport for the Period 1971 to 2000

The recorded extreme rainfall in a 24-hour period was 80.5 mm and occurred on August 27, 1964. The recorded extreme snowfall event in a 24-hour period was 35.3 cm and occurred on October 15, 1964 and December 27, 1947. The recorded extreme total precipitation event in a 24-hour period is the same as the extreme rainfall event as there was no snowfall during that event (MSC 2003).

13.4.1.4 Wind

Fort Nelson is not an especially windy area; the average windspeed is 1.8 m/s and windspeeds are less than 3 m/s approximately 80 percent of the time (Figure 13.4-5). Figure 13.4-6, in the form of a wind rose, shows the distribution of wind direction measured at the Fort Nelson Airport using meteorological data collected from 1992 to 1996. The most frequent winds are from the east-southeast and the north-northeast, reflecting the terrain in the vicinity of the airport.

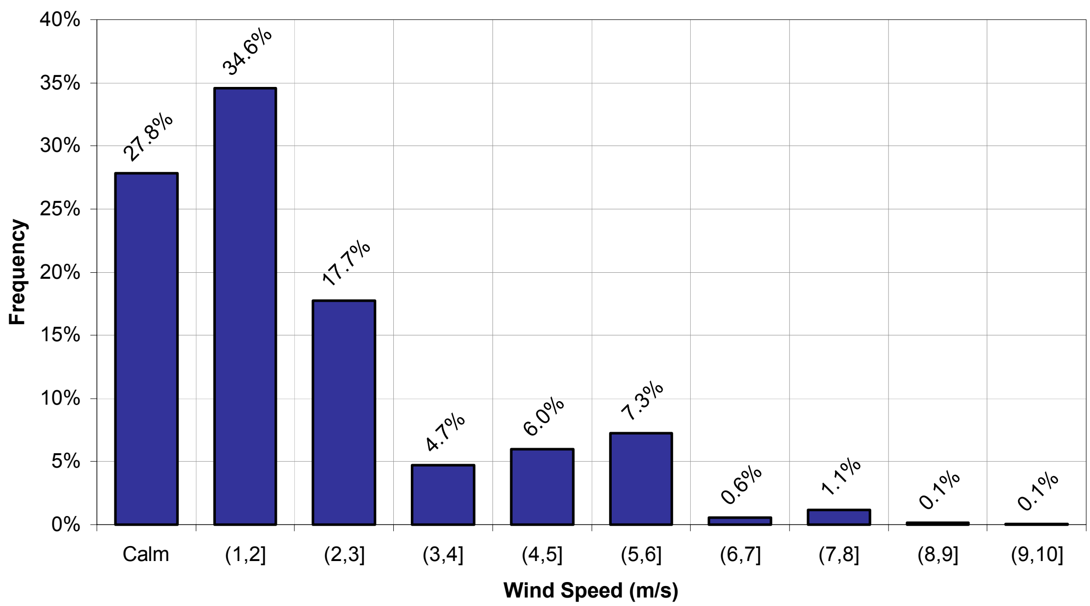


Figure 13.4-5 Windspeed Frequencies Measured at the Fort Nelson Airport for the Period 1992 to 1996

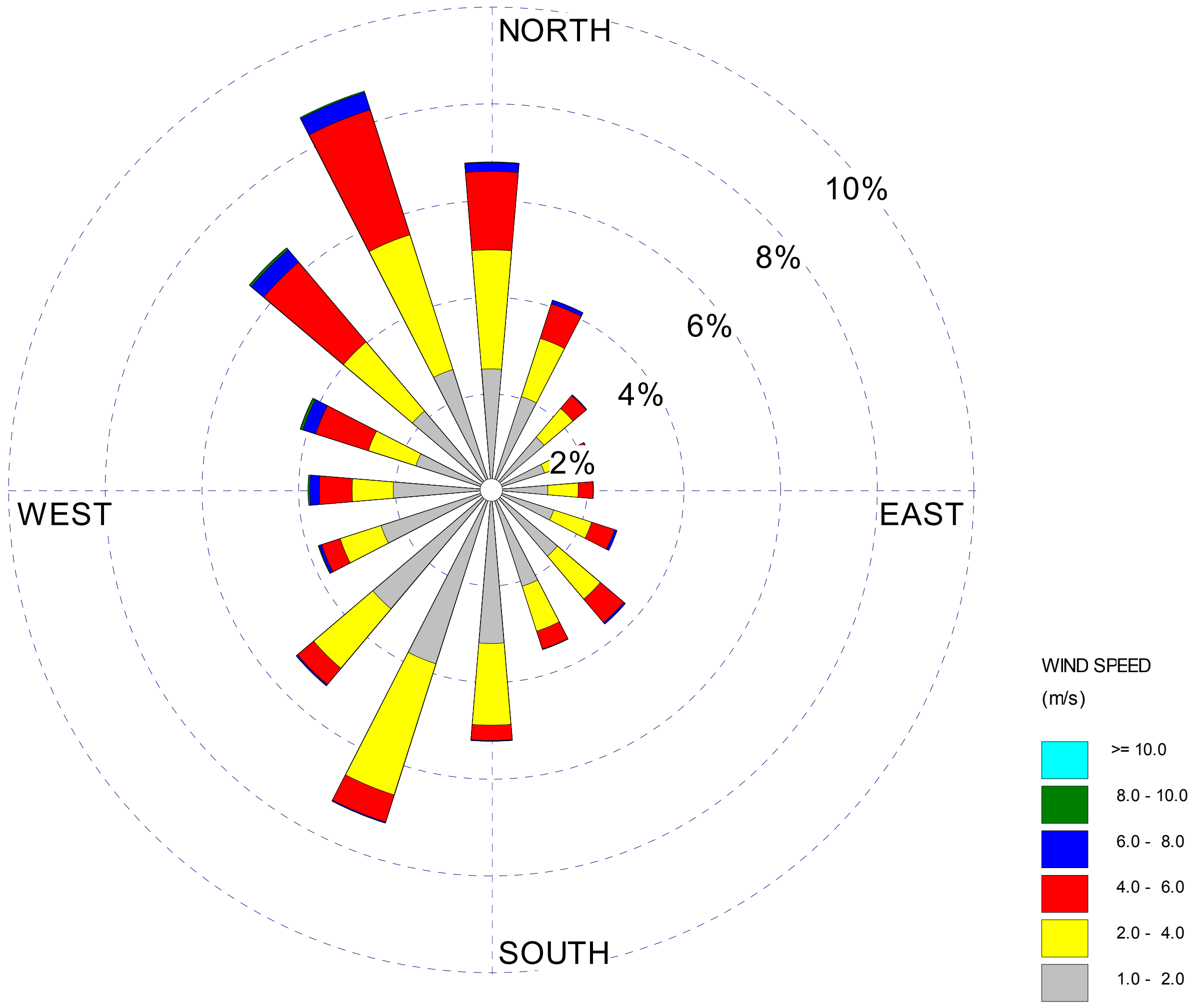


Figure 13.4-6 Wind Direction Distribution Measured at the Fort Nelson Airport for the Period 1992 to 1996

Figure 13.4-7 shows the seasonal wind direction distribution also using Fort Nelson Airport meteorological data collected from 1992 to 1996. Terrain effects appear to be the most pronounced during the winter and the least pronounced during the spring and summer.

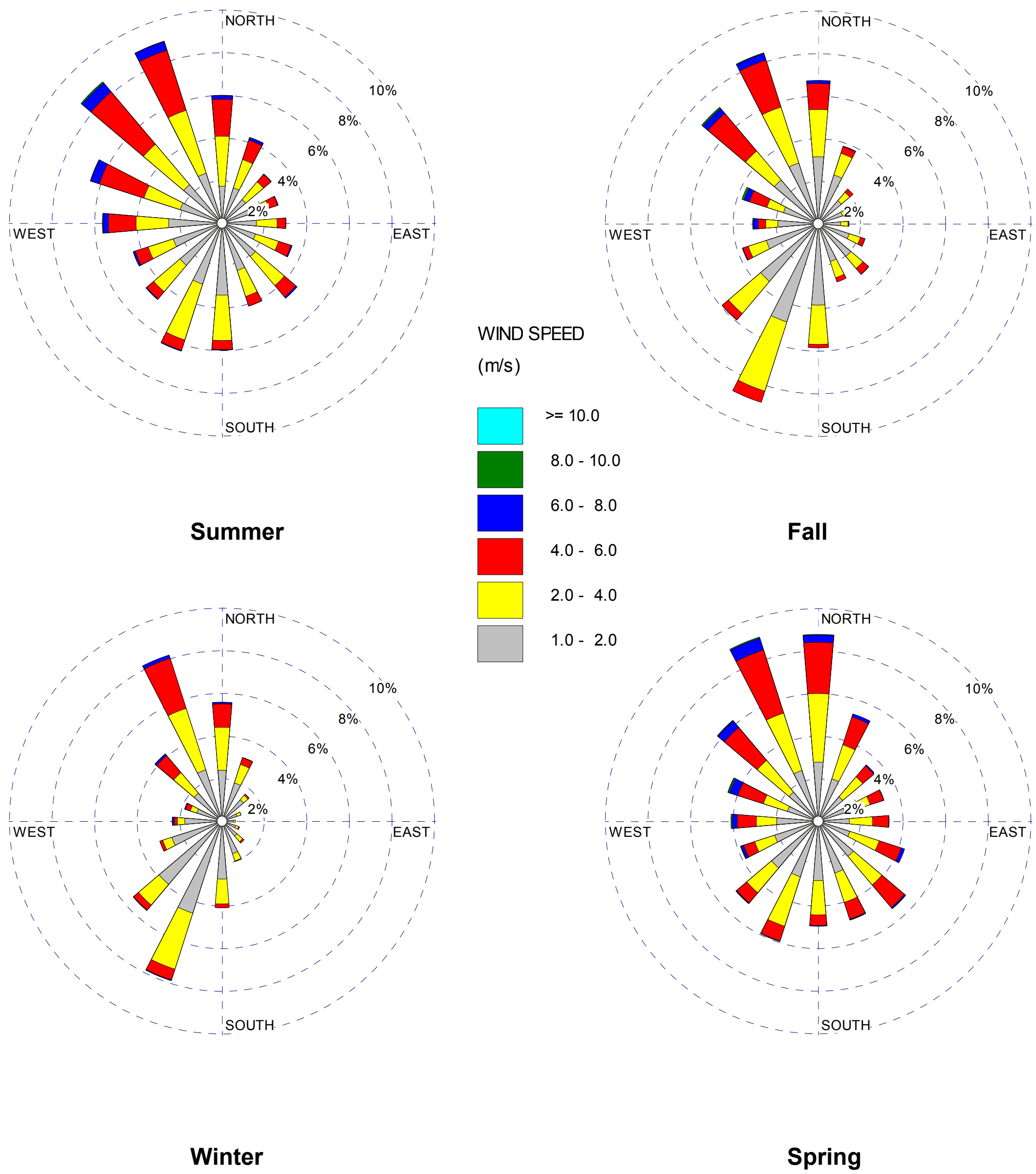


Figure 13.4-7 Seasonal Wind Direction Distribution Measured at the Fort Nelson Airport for the Period 1992 to 1996

13.4.1.5 Emission Sources

There are no continuous emission sources within 20 km of the Project other than EnCana's Sierra gas plant and Nexen Canada's Hay River Development. The EnCana Sierra Gas Plant is located at the western tie-in point of the proposed pipeline. This plant contains a flare stack, incinerator, generator, refrigeration unit and four compressor engines. The operation of these devices will result in combustion products and fugitive hydrocarbon vapour emissions to the atmosphere. About ten kilometres west of the east tie-in point, Nexen Canada operates the Hay River Development. This facility contains two turbine generators (9 MW total), two glycol boilers and one 200 Hp gas compressor. The emissions from the facilities have a localized effect in the vicinity of the facility but are not expected to contribute beyond a few hundred metres.

Construction activities and operations associated with oil and gas industry projects can be a source of gaseous and particle emissions on a short term or temporary basis. Other sources of emissions in the study area include motor vehicle exhaust, dust from gravel roads, and aircraft emissions. Due to the remoteness of the area, these emissions are expected to be minor.

Natural sources of gaseous and particulate emissions in the RSA are mainly associated with forest fires, which can severely impact the entire area. Although most of the region is dominated by lowland (wetland) terrain types, Kotcho Forest is within the northern portion of the study area and is the only major potential source of forest fire emissions in the area. Forest fires are intermittent and seasonal emission sources; in this region they are most common through late spring to early fall. Furthermore, forest fire emissions from well outside the study area could impact the local air quality.

The closest major towns are Fort Nelson, British Columbia and Rainbow Lake, Alberta. Emissions from these communities are not expected to have a significant effect in the Project area.

13.4.2 Results of Issues Scoping

13.4.2.1 Project Effects Analysis

During the construction phase of the Project, construction activities will occur along the entire 83 km length as opposed to a single point source of emissions. While these activities are expected to be of limited duration, they will produce emissions to the atmosphere. There are no significant sources of pollutants associated with the normal operation of the Pipeline.

13.4.2.1.1 Construction Phase

There are two major sources of emissions associated with the construction phase of the Project:

- The vehicles used for construction operations will emit combustion products, which contain trace amounts of nitrogen oxides (NO_x), carbon monoxide (CO), hydrocarbon compounds (HC), and particulate matter (PM) (USEPA 1996a). This assessment focuses on the emissions from combustion sources only. Construction emissions are most prevalent during the daytime as most of the operations are halted overnight.
- The burning of unusable vegetation that must be cleared to proceed with the Project include NO_x, CO, PM, and volatile organic compounds (VOC) (USEPA 1996b).

13.4.2.1.2 Operational Phase

There are no continuous emission sources proposed for the Project.

13.4.2.2 Key Impact Questions

Based on the above discussion, the key questions described in Table 13.4-1 will be the focus of the air quality component of the subsequent impact assessment.

Table 13.4-1 Key Impact Questions on Air Quality Assessment Approach

Key Impact Question	Assessment Approach
How will the construction of the Project affect local air quality?	Qualitative discussion on emissions from construction.
How will the operation of the Project affect local air quality?	Qualitative discussion on emissions while the Pipeline is in use.

13.4.2.2.1 How will the Construction of the Project Affect Local Air Quality?

Combustion emissions from construction vehicles and camps will have a short-term and local effect on the air quality. Non-merchantable timber and slash retrieved from the clearing process will be burned resulting in mainly particulate matter emissions. This will have a local and short-term effect on air quality.

13.4.2.2.2 How will the Operation of the Project Affect Local Air Quality?

There are no continuous emission sources proposed for the Project, therefore the effect on local air quality will be negligible.

13.4.3 Study Areas

The study area considered for this assessment is a corridor along the preferred Pipeline route. Emissions from construction activities will occur in the Pipeline right-of-way and adjacent areas.

13.4.4 Assessment Scenarios

Two scenarios were employed for the impact assessment on air quality. These are discussed in the following sections.

13.4.4.1 Construction Scenario

The construction scenario represents the predicted air quality conditions at the time of construction (i.e., December 2003 to March 2004).

13.4.4.2 Operations

The operations scenario represents the predicted air quality conditions after the Project has been completed and is operating (i.e., 2007).

13.4.5 Proposed Mitigation

The use of construction vehicles with appropriate emission controls will help reduce the combustion emissions during construction.

The following mitigation measures can promote more efficient combustion and reduce PM emissions during slash burning:

- minimizing the amount of fuel material burned by salvaging merchantable lumber
- minimizing the length of the smoldering phase by cleaning up piles immediately after the burn and restricting burn piles to waste wood
- burning large material with high-moisture content and burning fine material with low moisture content

13.4.6 Residual Project Effects

13.4.6.1 Analytical Procedures

There will be two construction camps. The west camp will be located at approximately KP 21 (Kyklo Creek) and will house 200 workers. The east camp will be located at approximately KP 70 and will house 150 workers. The two camps will release emissions from heating and cooking operations. The associated emissions were not estimated as they are expected to be significantly less than those associated with vehicle activity.

Each of the two construction spreads are expected to work in an east to west direction with the westerly spread starting in the middle and the easterly spread starting at the east end. The most intensive construction activities will occur over approximately 27 days. This 27 day period was assessed for this EIA. It is assumed that construction will occur over continuously moving 4 km sections and progress at a rate of 1.5 km per day. Essentially, the two teams combined would complete 3 km of pipeline each day. The average workday will begin at 8:00 am and end at 5:00 pm (9 h) but it is assumed that each vehicle unit will only be operating for half that time (4.5 h).

The construction equipment was grouped according to off-road construction equipment and smaller highway vehicles. The off-road vehicles and equipment generally do not have the same level of emission control as the smaller highway vehicles.

13.4.6.1.1 Approach for Off-road Construction Equipment

Table 13.4-2 lists the off-road construction units and their corresponding emission factors for the major pollutants of interest (SBC 1997). Construction vehicles can include several different vehicle types, each with differing emission factors. As the emission factors do not differ significantly, the average of seven vehicle types were used. Off-road trucks, on the other hand, are a specific unit and have emission factors assigned to them.

Table 13.4-2 Number of Units and Emission Factors for Heavy Equipment used in the Construction Phase

Unit Type	Number of Units	Emission Factors (g/hp×h)			
		NO_x	CO	PM	HC
Construction vehicles	86	11.0	3.0	0.8	0.8
Off-road trucks	14	11.0	2.3	0.5	0.4

Source: SBC 1997

Heavy construction equipment emissions are based on the horsepower of the unit and expressed in grams of pollutant emitted per horsepower hour (g/hp×h) of work (Table 13.4-2). If the duty of a unit is known, an emission rate can be determined since the emission factor is based on power input. Heavy construction vehicles are usually diesel powered and have high NO_x emissions. Emission estimates are based on 100 units: 86 construction vehicles (at 220 hp per vehicle) and 14 off-road trucks (at 300 hp per vehicle). The emission rate was estimated from:

ER =EF × DT

Where:

ER = Emission Rate (g/h)

EF = Emission Factor (g/hp×h)

DT = Duty of Unit (hp)

13.4.6.1.2 Approach for Smaller Highway Vehicles

Table 13.4-3 lists the smaller units and corresponding emission factors for the major pollutants of interest. Smaller vehicles, such as pick-up trucks, will be used throughout the construction site for various tasks. The emission factors for these units are based on the distance traveled and are expressed as grams of pollutant emitted per mile traveled (g/mi). The smaller vehicles are considered to be mobile road sources as described in EPA AP-42 Volume II (2000), which provides emission factors for these sources. They are divided into two categories (Table 13.4-3): Light-Duty Gasoline Trucks (LDGT) and Light-Duty Gasoline Vehicles (LDGV). Certain criteria are required to assign mobile emission factors such as model year, ambient temperature, and hot/cold start fractions. The following assumptions were made for all mobile road sources: model year is 2000, ambient temperature is 4°C, and equal hot/cold start fractions (USEPA 2000).

Table 13.4-3 Number of Units and Emission Factors for Smaller Vehicles used in the Construction Phase

Unit Type	Number of Units	Emission Factor (g/mi)			
		NO_x	CO	PM	HC
Pick-up trucks (LDGT)	50	3.2	141.7	4.3	12.7
Smaller miscellaneous vehicles (LDGV)	50	2.4	103.5	4.3	13.9

Source: USEPA 2000

The total emissions can be determined by assuming an average speed for the vehicles. For the purposes of this study, it is assumed that the vehicles are traveling at an average speed of 16 km/h. The following equation shows the method used for estimating the emission rate from smaller vehicles. The emission rate was estimated from:

$$\mathbf{ER = EF \times AS}$$

Where:

ER = Emission Rate (g/h)

EF = Emission Factor (g/mi)

AS = Average Speed (mi/h)

13.4.6.1.3 Slash Burning

Merchantable timber from the clearing process will be salvaged. Most of the remaining wood will be burned. Burning is a cost effective method of waste wood disposal. It can prevent wildfires near the Project and also further the succession of plant communities by an influx of nutrients to the soil. There is, however, a concern with this practice due to the air pollution produced (USEPA 1996b).

Wood waste will be placed in piles along the entire length of the Pipeline at intervals of 300 m. Each pile will be approximately 15 m^3 in volume. The mass of material in each pile is required to estimate the emissions from burning. The density of each pile is assumed to be 50 percent the density of the wood, which was taken as 400 kg/m^3 (Bodig and Jayne 1982). The 50 percent factor, which allows for open space within each pile, results in an estimated 3 t/pile. A total of 825 t of wood will be burned in approximately 28 events. Each event will consist of ten consecutive piles being burned.

The US EPA AP-42 document provides generic emission factors for spot burning (USEPA 1996b). Spot burning is described as a number of fires ignited along a line or a pattern, and was viewed as representing the proposed waste wood burning operations. For the purposes of this assessment, the EPA AP-42 emission factors were used to estimate the emission from each pile:

TE = EF × MF

Where:

TE = Emission (g)

EF = Emission Factor (g/kg)

MF = Mass of fuel (kg)

13.4.6.2 Results

13.4.6.2.1 Construction Equipment and Vehicle Emissions

Table 13.4-4 summarizes the emission rate estimates for all sources used in the construction phase. These emissions would typically be distributed along two four-km sections that are continuously moving. The emissions will occur only during the daytime when construction is in progress and will occur over a 27-consecutive day construction period.

The use of emission factors generally provides a first-order overview of the emissions on a conservative basis. Although the number of units and type of equipment are known, several assumptions were made to estimate emissions. These assumptions were made to provide a representative worst-case emission estimate.

Table 13.4-4 Total Emissions Estimate for Each Unit Type used in the Construction Phase

Unit Type	Number of Units	Emission Rate (t/d)			
		NO_x	CO	PM	HC
Construction vehicles	86	0.94	0.25	0.06	0.07
Off-road trucks	14	0.21	0.04	0.01	0.01
Pick-up trucks	50	0.01	0.32	0.01	0.03
Smaller miscellaneous vehicles	50	0.01	0.23	0.01	0.03
Total	**200**	**1.16**	**0.85**	**0.09**	**0.14**

Note: Columns may not equal totals due to rounding.

13.4.6.2.2 Slash Burning Emissions

Table 13.4-5 summarizes the estimated emissions from each pile, and for each event (i.e., 10 piles). The total emission per event represents ten piles burning at the same time consecutively in a row. The chemical species listed in Table 13.4-5 are the most common detectable pollutants from slash burning. Slash burning is temporary and is expected to last for a short duration. The pollutants emitted from the process will disperse in the surrounding area dependant primarily on the prevailing meteorological conditions at the time of the burn event.

Table 13.4-5 Estimated Emissions Per Pile and Per Event from Prescribed Burning Operations

Description	Wood Waste Mass (t)	Emissions (t)			
		NO_x	CO	PM	HC
Emission estimate per pile	3.0	0.01	0.43	0.05	0.02
Emission estimate per event	30.0	0.12	4.32	0.54	0.15

There will be 28 burning events along the length of the Pipeline. These estimates provide a "best guess" and can be used to assess the general outcome of the burning events. The emissions from prescribed burning are minimal and not expected to cause major long-term impacts in the study region.

13.4.6.2.3 Summary of Results

Given the winter construction period for the Project (i.e., dormant season) and the short-term, transient nature of emissions associated with pipeline construction, Project emissions are not expected to have measurable effects on other biophysical resources along the Pipeline corridor. Consequently, Project effects are rated as low short in duration, and reversible and offer no potential for measurable contribution to cumulative effects.

Table 13.4-6 summarizes the impact assessments above, using impact descriptors as defined in the table footnotes below.

Table 13.4-6 Summary of Project Effects for Air Quality

Assessment Scenario	Issue/ Measurable Parameter	Magnitude/ Extent[1]	Duration[2]	Reversible/ Non-Reversible[3]	Potential for Measurable Contribution to Cumulative Effects[4]
Construction	NO_x	Low	Short-term	Reversible	No
Construction	CO	Low	Short-term	Reversible	No
Construction	PM	Low	Short-term	Reversible	No
Construction	HC	Low	Short-term	Reversible	No
Operations	HC, NO_x, CO, PM	Low	Medium term	Reversible	No

__Notes__: [1] **Magnitude/Extent**

Low – Change in measurable parameter will have no effect on associated ecological resources (e.g., soils, vegetation, wildlife)

Moderate – Change in measurable parameter will have possible local effect on associated ecological resources (i.e., within 2 km mapped corridor)

High – Change in measurable parameter will have possible measurable effect on associated ecological resources within Etsho Resource Management Zone

[2] **Duration** – refers to the length of time over which the project-related effect is measurable

Short term – less than one year

Medium term – greater than one year but not beyond life of project

Long term – beyond life of project

[3] **Reversibility** – refers to the potential for conditions to return to baseline conditions, in the absence of the project

Reversible – will likely revert to baseline conditions following end of project life or before

Non-reversible – unlikely to revert to baseline conditions following end of project life

[4] **Potential for Measurable Contribution to Cumulative Effects**

Yes – measurable contribution to CE within Etsho Resource Management Zone

No – no measurable contribution to CE within Etsho Resource Management Zone

13.4.7 Cumulative Effects Implications

There are no continuous emission sources associated with the operation of the Pipeline. Construction emissions are short-term and will cease upon completion of the Project. Given the distance between communities (Fort Nelson and Rainbow Lake) and the small number of continuous emission sources (Sierra Gas Plant and Nexen Canada's Hay River Development), no significant cumulative effects are expected.

13.4.8 Follow-up and Monitoring

Given the transient nature of the construction emissions no ambient monitoring is recommended.

13.5 Terrain and Soils

13.5.1 Baseline Setting

13.5.1.1 Regional Overview

The proposed Project is located in the Hay River Lowland ecoregion, which is a broad, level lowland plain. The major drainages are the Fort Nelson, Liard and Hay Rivers (Marshall et al. 1999). Surficial material is dominantly peat blankets or veneers over glaciolacustrine deposits and glacial till. The topography is generally level or gently rolling with little relief. Soils are commonly classified as Organic Cryosols, Gleysols, Organic soils and Gray Luvisols (Valentine 1971; Agriculture and Agri-Food Canada 1994; Marshall et al. 1999).

13.5.1.2 Methods

Air photo interpretation and classification of terrain map units were undertaken within a 2 km-wide study corridor centered on the Pipeline alignment on 1:40,000 scale air photos using the methods described in Appendix 13E. Limited ground truthing was also carried out in the three major parent material types encountered along the route. Descriptions of the terrain and soil assessment sites are available in Appendix 13E.

Soil great groups or subgroups were extrapolated from the terrain map units, soil assessment sites and previously published literature. Sufficient information was available for some terrain units to warrant classification to the subgroup level, while others were more appropriately classified to the great group. Soil classification was based on the Canadian System of Soil Classification (Soil Classification Working Group 1998). Information on potential permafrost distribution was obtained from terrain mapping and available literature.

13.5.1.3 Bedrock Geology

The Project area is underlain by flat-lying concretionary, fish scale-bearing marine shales with minor siltstones and sandstones of Cretaceous age. In British Columbia, these bedrock strata are mapped as part of the Lower Cretaceous Fort St. John Group (Thompson 1977), while in Alberta they form part of the Shaftesbury Formation of Upper and Lower Cretaceous age (Hamilton et al. 1999).

No bedrock exposures were noted during the route reconnaissance, nor are they visible on air photos. This is consistent with the observation of Thompson (1977) that “outcrops are rare and occur, for the most part, along the major rivers and streams”. On this basis, it is not expected that bedrock will be encountered within trench depth along the Pipeline.

13.5.1.4 Landforms and Surficial Geology

Physiographically, the Pipeline is located in the Fort Nelson Lowlands physiographic section, which is within the Hay River Lowland ecoregion (Pettapiece 1986; Holland 1964; British Columbia Department of Environment 1964). The Fort Nelson Lowland lies within the drainage basins of the Fort Nelson, Hay and Petitot Rivers and the elevation ranges from 325 to 450 m. This area is characterized by level to very gently rolling topography. Slopes are generally between one to three percent for the majority of the route (Agriculture and Agri-Food Canada 1994). Terrain adjacent to major drainage channels may be slightly steeper, but still remaining below 25 percent slope. The lack of relief is partially attributed to flat lying shale bedrock over which glaciolacustrine or organic deposits are thick enough to mask any minor irregularities of the surface. The relative flatness of the region inhibits the establishment of a well-defined drainage system. Streams tend to meander across the landscape until reaching a primary or secondary river (Holland 1964).

A glaciolacustrine plain formed from a proglacial lake that extended into northeastern British Columbia from the retreating front of the Keewatin ice sheet forms the majority of the Project area (Holland 1964; Valentine 1971; Valentine et al. 1978). The glaciolacustrine deposits are fine textured with few stones and form a level to gently rolling landscape. Organic material commonly accumulates at the surface because of the flat landscape that prevents runoff and the fine textured mineral deposits that restrict water percolation. Deep organic deposits are associated with sporadic discontinuous permafrost along the Pipeline.

The Project is within the sporadic discontinuous permafrost zone (Bone 1992). Permafrost is defined as ground that remains at or below 0°C for at least two consecutive years (Permafrost Subcommittee 1988). Permafrost does not necessarily contain ice; rather it is based solely on temperature criteria of the mineral or organic parent material.

Areas of potential permafrost are associated with poorly drained, deep organic deposits with level to very gentle slopes. These conditions provide the proper thermodynamic balance between the ground surface (which is controlled by air temperature and incoming solar radiation) and the geothermal gradient to enable permafrost to exist (Williams and Smith 1989). The ground temperature remains low throughout the year under thick, poorly drained peat deposits because the dry surface of the peat in the summer (due to evaporation) has a low thermal conductivity which inhibits warming of the ground. However, once the peat is saturated in the fall the thermal conductivity is high and the ground can cool rapidly.

Terrain units with potential permafrost comprise 5.4 percent (931.6 ha) of the mapped corridor and 5.3 percent (11.2 ha) of the ROW (Table 13.5-1). These areas have been delineated based on the presence of dominant or subdominant terrain units with potential permafrost within a polygon. More detailed air photo interpretation has been conducted on the ROW to determine potential permafrost distribution at a scale that is more appropriate for the purposes of pipeline construction planning. The detailed air photo interpretation represents portions of polygons with potential permafrost along the ROW that are not large enough to be mapped as a dominant or subdominant terrain unit. The alignment sheets in Appendix 13A show the detailed locations and terrain polygons with potential permafrost along the Pipeline route. Fieldwork will be conducted in March 2003 to identify the distribution of permafrost along the ROW. The results of this work will be filed as a supplementary report.

13.5.1.4.1 Terrain Map Units

The western portion of the route is generally better drained with a greater concentration of moderately well or imperfectly drained glaciolacustrine deposits (Kmg, Kig). East of the Kyklo Creek crossing the route traverses a higher proportion of poorly drained organic deposits (Opg). East of the Hay River the route passes through virtually all poorly or very poorly drained organic deposits (Opg, Ovg). Significant moderately well drained fluvial deposits (Fmg) are associated with the major drainage valleys of the Kyklo Creek and Hay River with minor amounts adjacent to lesser streams. The landforms and surficial geology within the mapped corridor are shown on the alignment sheets in Appendix 13A.

The dominant terrain type within the mapped corridor exhibits poorly drained, organic parent material on a gently sloping landscape (Opg). This terrain type covers 39.6 percent (6886.1 ha) of the corridor (Table 13.5-1). Moderately well drained, glaciolacustrine parent material with gentle slopes (Kmg) is the second most common terrain type and covers 20.6 percent (3570.8 ha) of the corridor. A similar terrain type, but with imperfect drainage (Kig) comprises 13.1 percent (2282.9 ha) of the corridor. Moderately well drained fluvial deposits, very poorly drained organic deposits, and poorly drained organic deposits with potential permafrost are all present as minor components of the terrain in the corridor (Table 13.5-1). Definitions of all terrain map unit components are available in Appendix 13E.

13.5.1.4.2 Drainage

The regional topographic and parent material characteristics create a landscape with dominantly poor soil drainage. The lack of well established drainage channels and the abundance of organic deposits creates conditions where drainage is commonly in the form of shallow subsurface groundwater flow. This flow is not within a defined channel, but rather runs through porous peat deposits with high hydraulic conductivity in organic terrain. Terrain classified as very poorly drained has high potential to be part of an undefined drainage channel.

The Pipeline crosses several defined named drainage channels including (from west to east) Kyklo Creek, Townsoitoi Creek, Hay River and Little Hay River. The lack of slope in the region results in complex meandering channel forms consisting of fine-grained fluvial deposits as well as peat accumulations in areas of poor drainage, such as oxbows. These rivers and creeks are all part of the Hay River drainage basin, which drains into Great Slave Lake and ultimately reaches the Arctic Ocean via the Mackenzie River.

Table 13.5-1 Terrain Map Units and Soil Types within the 2 km-wide Mapped Corridor and ROW

Terrain Map Unit	Terrain Map Unit Characteristics	Soil Great Groups or Subgroups	Mapped Corridor		ROW	
			Area (ha)	Proportion of the Total (%)	Area (ha)	Proportion of the Total (%)
Mineral Terrain						
Fmg	Gently sloping, moderately well drained fluvial material.	Orthic Gray Luvisol, Cumulic Regosol, Orthic Regosol	1,135.6	6.5	7.6	3.6
Total Fluvial Terrain			1,135.6	6.5	7.6	3.6
Kig	Gently sloping, imperfectly drained glaciolacustrine material.	Gleyed Gray Luvisol, Gleysol	2,282.9	13.1	36.2	17.1
Kigp	Gently sloping, imperfectly drained glaciolacustrine material with evidence of permafrost.	Cryic phase - Gleyed Gray Luvisol, Gleysol	9.4	0.1	0.0	0.0
Kmg	Gently sloping, moderately well drained glaciolacustrine material.	Orthic Gray Luvisol	3,570.8	20.6	33.2	15.7
Total Glaciolacustrine Terrain			5,863.1	33.8	69.3	32.8
Organic Terrain						
Opg	Gently sloping, poorly drained organic material.	Peaty Gleysol, Typic/Terric Mesisol, Typic/Terric Fibrisol	6,886.1	39.6	73.8	35.0
Opgp	Gently sloping, poorly drained organic material with evidence of permafrost.	Mesic Organic Cryosol, Fibric Organic Cryosol	931.6	5.4	11.2	5.3
Ovg	Gently sloping, very poorly drained organic material.	Typic Mesisol	1,884.4	10.8	21.1	10.0
Total Organic Terrain			9,702.1	55.8	106.0	50.2
Hhg	Waterbodies	n/a	450.4	2.6	1.2	0.6
Fmga Kiga Kmga Opga	a – disturbed through anthropogenic means	Various	218.7	1.3	26.8	12.7
Total			17,370.0[1]	100.0	211.1	100.0

Notes: Columns may not equal totals due to rounding.
ha = hectare
1 Total corridor area is smaller, 16,500 ha (82.5 km x 2 km), as mapping units were extended past the 2 km buffer at the Hay and Kotcho rivers to avoid dissecting map polygons in these areas. See Appendix 13E for additional detail.

The mapped corridor contains 45.7 percent poorly drained, 27.5 percent moderately well drained, 13.3 percent imperfectly drained and 10.9 percent very poorly drained land (Table 13.5-2). The remainder of the study area is open water (2.6 percent).

Table 13.5-2 Dominant Drainage Classes in the 2 km-wide Mapped Corridor

Drainage Class	Area (ha)	Proportion of the Mapped Corridor (%)
Moderately well	4,774.1	27.5
Imperfect	2,309.4	13.3
Poor	7,945.3	45.7
Very poor	1,889.6	10.9
Waterbodies	451.6	2.6
Total	17,370.0[1]	100.0

Note: 1 Total corridor area is smaller, 16,500 ha (82.5 km x 2 km), as mapping units were extended past the 2 km buffer at the Hay and Kotcho rivers to avoid dissecting map polygons in these areas. See Appendix 13E for additional detail.

13.5.1.5 Soils

13.5.1.5.1 Soil Development

Soil development is dependent on climate, vegetation, topography, parent material and time (Jenny 1941). The regional soils reflect the dominant soil development conditions within the Project area. The Project is located in an area of long, cold winters and short, warm summers (Valentine et al. 1978). Precipitation levels are low to moderate with a summer maximum. Frost penetration is deep in the winter and some permafrost exists in well-insulated soils, such as deep peat deposits. Organic Cryosols occur where these conditions are present.

Topography is subdued by horizontally bedded shales and level glaciolacustrine deposits. Extensive areas of poor drainage occur because runoff is slow or absent due to the low relief. Where fine textured surficial deposits are present, poor drainage is also related to low hydraulic conductivity. The water table is generally within one metre of the surface for the majority of the Pipeline (Agriculture and Agri-Food Canada 1994). Excess moisture is limiting to soil development because development processes require the ability to transfer soil constituents within the profile and adequate aeration for microbial activities. These processes are inhibited by saturation with water for extended periods of the growing season. Profiles subjected to water saturation are associated with the development of Gleyed Gray Luvisols, Gleysols, or Organic soils depending on the length of time for which the profile is saturated. Slight topographic undulations or slopes near drainage channels create areas that are moderately well drained where the development of Orthic Gray Luvisols can occur.

Parent materials in the Project area are glaciolacustrine, organic and fluvial. The glaciolacustrine deposits are fine textured and soils formed in this material generally range between silty clay loam to silty clay (Agriculture and Agri-Food Canada 1994). Fluvial soils may contain slightly coarser textures of clay loam to silty clay loam. Fine textured soils contain abundant clay particles for translocation and the formation of Gray Luvisols. Organic matter is prone to accumulation within the study area because the cool climate and the high moisture conditions limit microbial decomposition. Peat accumulations create Organic soils, such as Terric and Typic Fibrisols and Mesisols or Gleysolic soils with a peaty surface horizon.

13.5.1.5.2 Soil Types

The dominant soil types within the mapped corridor are Typic/Terric Mesisols, Typic/Terric Fibrisols and peaty Gleysols. These soil types cover 39.6 percent (6886.1 ha) of the corridor (Table 13.5-1). These soils occur in a complex of organic deposits and are differentiated based on the thickness of peat and drainage variations. Peaty Gleysols may be classified as either Orthic Luvic Gleysols or Orthic Gleysols with a peaty surface horizon.

The second most common soil type is an Orthic Gray Luvisol formed on moderately well drained glaciolacustrine deposits. This soil type comprises 20.6 percent (3570.8 ha) of the corridor (Table 13.5-1). In more poorly drained areas, Gleyed Gray Luvisols and Gleysols formed on the same parent material cover 13.1 percent (2282.9 ha) of the corridor.

Orthic Gray Luvisols, Cumulic Regosols and Orthic Regosols formed on fluvial deposits cover 6.5 percent (1135.6 ha) of the corridor. Fibric and Mesic Organic Cryosols, where permafrost can potentially be found, comprise 5.4 percent (931.6 ha) of the corridor. Typical characteristics of the soil types found within the mapped corridor as well as landform relationships are described in Appendix 13F.

The regional soils around the Pipeline are dominantly mapped as Organic Cryosols in the available literature (Valentine 1971; Agriculture and Agri-Food Canada 1994; Marshall et al. 1999). However, these maps and information are at a much smaller scale with the most detailed map at a scale of 1:126,720. It is more likely that Organic Cryosols occur in discrete areas of sporadic permafrost within dominantly Organic soils. Additionally, the majority of the Pipeline route is located on previously disturbed ROWs, such as seismic lines or existing pipeline ROWs. These ROWs are not anticipated to contain permafrost because, if permafrost was originally present, it would have degraded due to surface clearing.

The primary reclamation concerns for the soils within the corridor are related to permafrost, compaction and construction in organic terrain. Organic Cryosols contain permafrost within one metre of the surface and therefore the permafrost table will be encountered within the trench depth if it has not previously been degraded. Reclamation difficulties may arise from permafrost melting which can cause wetter moisture regimes and ground subsidence. The corridor contains mainly fine-textured mineral and organic soils with high moisture contents; these characteristics are highly susceptible to compaction during pipeline construction.

Reclamation concerns arise for pipeline construction in organic terrain because these soils and ecosystems can easily be degraded if disturbed in unfrozen conditions.

13.5.1.5.3 Soil Capability

Land use along the Pipeline may include, but not be limited to, forestry, recreation, wetland communities, other vegetation communities and the associated wildlife habitats. Soil capability is defined for this Project as the ability of a soil to support a range of land use options.

The Pipeline does not encounter any agricultural land reserve (ALR). Soils within the mapped corridor are not suitable for agriculture because of heavy textures, excess moisture and peat deposits. Additionally, agriculture in the study area is limited by the cool climate and short summers.

The Canada Land Inventory (CLI) has a system that rates land on its inherent ability to produce commercial timber. This 'land capability for forestry' system has seven classes ranging from land with no limitations to the growth of commercial forests (Class 1), to land with severe limitations that preclude the growth of commercial forests (Class 7) (Table 13.5-3) (CLI 1967). The system also uses capability subclasses to identify major limitations to growth.

Insufficient information was available to calculate land capability, however classes were assigned qualitatively based on dominant soil and terrain characteristics and land capability classes available for the surrounding area (Valentine 1971). The mapped corridor was classified between Classes 3 to 7 within the CLI system (Table 13.5-4). The primary limitations to commercial forest growth in the Project area are excess soil moisture, rooting restrictions caused by dense, fine textured soil layers and low temperatures.

Land rated as Class 3 would be further limited for forestry because stand size is generally small. The Project area contains upland, moderately well drained soils (Orthic Gray Luvisols) that are frequently interspersed with depressional, poorly drained sites supporting Gleysolic or Organic soils.

The majority of the corridor is rated as Class 6 for land capability and comprises 45.0 percent of the total study area (Table 13.5-4). Land capability Class 3 and Classes 4 to 5 cover 27.1 percent and 13.2 percent of the corridor, respectively. Land that precludes the growth of commercial forests comprises 10.8 percent of the corridor.

Table 13.5-3 CLI Land Capability for Forestry Classes

Capability Class	Common Characteristics
Class 1 – Lands having no important limitations to the growth of commercial forests.	Soils are deep, permeable, of medium texture, moderately well-drained to imperfectly drained, have good water-holding capacity and are naturally high in fertility. Their topographic position is such that they frequently receive seepage and nutrients from adjacent areas.
Class 2 – Lands having slight limitations to the growth of commercial forests.	Soils are deep, well-drained to moderately well-drained, of medium to fine texture and have good water-holding capacity. The most common limitations (all of a relatively slight nature) are: adverse climate, soil moisture deficiency, restricted rooting depth, somewhat low fertility, and the cumulative effects of several minor soil characteristics.
Class 3 – Lands having moderate limitations to the growth of commercial forests.	Soils may be deep to somewhat shallow, well-drained to imperfectly drained, of medium to fine texture with moderate to good water-holding capacity. They may be slightly low in fertility or suffer from periodic moisture imbalances. The most common limitations are: adverse climate, moderate deficiency or excess of soil moisture, restricted rooting depth, somewhat low fertility, impeded soil drainage, exposure (in maritime areas) and occasional inundation.
Class 4 – Lands having moderately severe limitations to the growth of commercial forests.	Soils may vary from deep to moderately shallow, from excessive through imperfect to poor drainage, from coarse through fine texture, from good to poor water-holding capacity, from good to poor structure and from good to low natural fertility. The most common limitations are: adverse climate, deficiency or excess of soil moisture, restricted rooting depth, poor structure, excessive carbonates, low fertility and exposure.
Class 5 – Lands having severe limitations to the growth of commercial forests.	Soils are frequently shallow to bedrock, stony, excessively or poorly drained, of coarse or fine texture, may have poor water-holding capacity and be low in natural fertility. The most common limitations are: adverse regional or local climate, shallowness to bedrock, deficiency or excess of soil moisture, excessive stoniness, high levels of carbonates, low natural fertility and exposure particularly in maritime areas.
Class 6 – Lands having very severe limitations to the growth of commercial forests.	The mineral soils are frequently shallow, stony, excessively drained, of coarse texture and low in fertility. Most of the land in this class is composed of poorly drained organic soils. The most common limitations (frequently in combination) are: shallowness to bedrock, deficiency or excess of soil moisture, high levels of soluble salts, low natural fertility, exposure, inundation and stoniness.
Class 7 – Lands having severe limitations which preclude the growth of commercial forests.	Mineral soils are usually extremely shallow to bedrock, subject to regular flooding, or contain toxic levels of soluble salts. Actively eroding or extremely dry soils may also be placed in this class. Most of the land is very poorly drained organic soils. The most common limitations (frequently in combination) are: shallowness to bedrock, excessive soil moisture, frequent inundation, active erosion, toxic levels of soluble salts and extremes of climate or exposure.

Source: CLI 1967

Table 13.5-4 Land Capability Classes for Forestry in the 2 km-wide Mapped Corridor

Soil Types within the Mapped Corridor	Capability Class	Limitations to Growth	Mapped Corridor		ROW	
			Area (ha)	Proportion of the Total (%)	Area (ha)	Proportion of the Total (%)
Orthic Gray Luvisol, Cumulic Regosol, Orthic Regosol	Class 3	Low temperatures, physical rooting restrictions, inundation by streams	1,135.6	6.5	7.6	3.6
Gleyed Gray Luvisol, Gleysol, including cryic phases	Class 4 to 5	Low temperatures, physical rooting restrictions, excess soil moisture	2,292.3	13.2	36.2	17.1
Orthic Gray Luvisol	Class 3	Low temperatures, physical rooting restrictions	3,570.8	20.6	33.2	15.7
Peaty Gleysol, Typic/Terric Mesisol, Typic/Terric Fibrisol	Class 6	Low temperatures, excess soil moisture	6,886.1	39.6	73.8	35.0
Mesic Organic Cryosol, Fibric Organic Cryosol	Class 6	Low temperatures, excess soil moisture	931.6	5.4	11.2	5.3
Typic Mesisol	Class 7	Low temperatures, excess soil moisture	1,884.4	10.8	21.1	10.0
Waterbodies	n/a	n/a	450.4	2.6	1.2	0.6
Disturbed Land	n/a	n/a	218.7	1.3	26.8	12.7
Total			17,370.0[1]	100.0	211.1	100.0

Notes: 1 Total corridor area is smaller, 16,500 ha (82.5 km x 2 km), as mapping units were extended past the 2 km buffer at the Hay and Kotcho rivers to avoid dissecting map polygons in these areas. See Appendix 13E for additional detail.

13.5.2 Results of Issues Scoping

13.5.2.1 Project Effects Analysis

Pipeline developments represent long but narrow disturbances on the landscape. Therefore, pipelines, either singularly or collectively in a development field, have little potential to significantly alter terrain and soil characteristics at a regional, landscape level. Instead, their effects are generally restricted to the actual developed ROW or immediately adjacent lands (i.e., within 10–50 m). The following discussion summarizes the typical effects of pipelines on terrain and soils.

Soil Disturbance

To develop a safe, efficient work surface for the construction of a pipeline, a certain degree of surface grading will be required by the contractor to level local elevated terrain features and smooth surface irregularities encountered by the ROW. This activity has the potential to alter the physical and chemical properties of surface soil horizons. In addition, trenching operations to two metres in depth to accommodate the installation and burial of the Pipeline will bring subsurface materials to the surface, resulting in the mixing of soil horizons. Heavy equipment traffic on the work side of the ROW can also lead to soil compaction and reduced percolation rates.

The limited relief encountered along the ROW will minimize the degree of serious ROW grading. In addition, where extensive peat-accumulating wetlands are encountered along the route, the contractor will snow/frost pack the ROW with minimal grading to stabilize the ROW. Consequently, terrain and soil disturbance will likely be reduced for this Project, relative to other pipeline developments in areas of greater topographic relief.

Soil Erosion

Before the re-establishment of vegetation on the ROW, the soil left exposed by grading and ditching operations can be prone to wind and water erosion, leading to loss of topsoil material. Where the ROW is adjacent to streams, exposed soil can also contribute to an increased sediment load in the stream.

The risk of soil erosion on the Project is greatly reduced because of the limited topographic relief encountered by the ROW. Even approach slopes that have developed in fluvial deposits adjacent to major stream channels are gradual and short, with limited potential for runoff and erosion.

Ditchline Settlement

Where pipelines are developed in deep peat-accumulating wetlands, the backfill material available for burying the pipe is often limited to light organic material. This material can settle over time or be slowly removed from ditchline during spring snow-melt conditions, resulting in ditch subsidence over stretches of the Pipeline. This subsidence can, in turn, capture and re-direct surface and shallow subsurface water flows down ditchline, causing localized changes in drainage patterns. Representatives from BC MoF (Ministry of Forestry) raised this issue during initial regulatory meetings held for the Project.

Permafrost

The Project will be developed in an area characterized by pockets of sporadic discontinuous permafrost. ROW development removes the insulating effect of tree cover and surface organics that maintains subsurface permafrost. This can lead to localized permafrost degradation and subsequent terrain settlement on and adjacent to the ROW. Representatives from BC MoF raised this issue during initial regulatory meetings held for the Project.

Melting of permafrost can also cause localized changes to soil moisture regimes. Wetter conditions can impact soil development processes and the capability of the soil to support existing or reclaimed vegetation communities. Ditchline instability can be caused by melting of subsurface permafrost and jeopardize pipeline integrity through differential pipe settlement. This represents a potential effect of the environment on the Project.

13.5.2.2 Key Impact Questions

Based on the above discussion, the key questions described in Table 13.5-5 will be the focus of the terrain and soils component of the subsequent impact assessment.

Table 13.5-5 Key Impact Questions on Terrain and Soils and Assessment Approach

Key Impact Question	Assessment Approach
How will the Project affect soil capability?	Qualitative discussion on baseline soil characteristics, and effects of surface disturbance on capability.
How will the Project affect soil erosion?	Qualitative discussion on baseline soil and terrain characteristics, existing erosion potential and effects of surface disturbance on erosion potential.
How will the Project affect local drainage patterns?	Qualitative discussion of baseline surface and shallow subsurface drainage patterns encountered by the ROW, likely areas of backfill loss/settlement and effects of settlement on this drainage.
How will the Project affect local permafrost patterns?	Qualitative discussion of permafrost potential along the route (based on terrain features), and effects of ROW on permafrost
How will permafrost affect the Pipeline?	Qualitative discussion of the effects of permafrost degradation on ditchline and Pipeline integrity.

13.5.2.2.1 How Will the Project Affect Soil Capability?

Construction and reclamation activities associated with the Project have the potential to alter the physical and chemical characteristics of natural soils within the ROW. Changes to soil characteristics can in turn impact soil capability. Impacts to soil capability are related to surface clearing, grading, stripping, trenching and ROW traffic. The primary issues for soil capability that arise from these activities are mixing, compaction, contamination and terrain alterations.

Mixing of topsoil and subsoil can occur during stripping of surface material, trenching, and from rutting caused by vehicle and machinery traffic on the ROW. Mixing can negatively impact soil capability by diluting the organic matter content of the surface horizons through the incorporation of subsoil.

Texture changes, resulting from mixing topsoil and low quality subsoil can also negatively impact the quality of the root zone and soil capability. The subsoil and parent material of mineral soils in the study area are generally heavy textured. Clay particles that are brought to the surface have the potential to create a rooting medium with little structure or porosity. A root zone with these characteristics is associated with problems such as rooting impedances, reduced permeability and difficult seed establishment.

Soil compaction can occur through heavy machinery traffic on the Pipeline ROW. Compaction is also related to the movement and replacement of soils during construction and reclamation. These actions can destroy soil structure and decrease porosity. Compaction can also cause a decrease to the infiltration capacity, which can lead to both water ponding and increased runoff, causing increased erosion potential.

Moist, fine-textured soils, present in approximately 36.4 percent of the ROW, are highly susceptible to compaction (Table 13.5-1). High soil moisture content provides less friction between particles and facilitates reorganization into a more compact structure. Peat deposits, which comprise approximately 50.2 percent of the ROW are at risk of compaction because they have a low bulk density and are highly compressible. Compaction of organic material can reduce its insulating capacity leading to permafrost degradation in permafrost-affected areas (Williams and Smith 1989). However, the winter construction proposed for this Project will greatly reduce the potential for soil compaction and associated degradation.

Soil contamination can potentially occur during pipeline construction and operations. Contamination can originate from sources such as minor leaks from construction equipment or accidental spills during refueling. Release of contaminants into the soil can potentially affect nutrient cycling, kill soil organisms and affect the ability of the soil to support existing or reclaimed vegetation.

Terrain alterations can occur during pipeline construction and reclamation from removal and redistribution of surface materials during grading. Grading levels the topography and therefore has the potential to alter soil capability, since soil development is highly dependent on landscape position. However, extensive grading will not be required for the Project due to the relatively flat landscape.

13.5.2.2.2 How Will the Project Affect Soil Erosion?

Construction of the Project will require the removal of vegetation cover and some soil disturbance over the ROW. Once the protection and stabilization provided by vegetation is removed, the soil is exposed to erosive forces. Surface disturbance will also loosen the soil and leave it more susceptible to movement by water and wind. The fine textures present in the mapped corridor are susceptible to water erosion, but detachment and transport of these particles is limited by the lack of significant slopes.

Erosion can lead to decreased soil productivity because it removes fine particles from the surface soil layers where organic matter is concentrated. Fine soil particles provide abundant nutrient retention capacity and when these particles are removed, along with organic matter, the root zone becomes nutrient depleted.

13.5.2.2.3 How Will the Project Affect Local Drainage Patterns?

Four major drainage channels will be crossed using directional drilling and four minor channels will be crossed using open cuts. However, the Project area contains many undefined drainage pathways that occur as surface or shallow subsurface flow through organic deposits. The mapped corridor is characterized by a lack of relief and drainage patterns that are not well established. Therefore, slight changes to the landscape, such as a linear depression created through trench subsidence, could theoretically redirect drainage patterns. In organic terrain there is also the potential for shallow subsurface flow across the trench to be impeded by compacted backfill material. This is not anticipated to occur for the Project because backfill will be comprised of the organic material removed for trenching; alternate borrow sources will not be used.

13.5.2.2.4 How Will the Project Affect Local Permafrost Patterns?

The pipeline is within the zone of sporadic discontinuous permafrost (Bone 1992). Pipeline development in permafrost areas is associated with several issues relating to soils and terrain. These issues are changes to the thermal regime of the ground leading to permafrost degradation, thermokarst subsidence and changes to moisture regimes.

A change in the thermal regime of the ground is the primary way that the Project may impact permafrost patterns. There is frequently a delicate balance between the permafrost table and the active layer, especially in zones of sporadic permafrost. Minor changes to the thermal regime of the ground can induce permafrost melting. There are several mechanisms through which the thermal regime may be impacted. These include surface clearing, ground disturbance, and pipeline temperature.

Surface clearing of vegetation cover occurs during the construction phase of pipeline development over the entire ROW. With surface vegetation removed, the ground temperature is raised because shade is no longer present. Vegetation also has a higher reflective power than bare ground, which means that a greater amount of incoming radiation is reflected rather than absorbed (Williams and Smith 1989). Dark coloured bare ground will experience increased radiation absorption causing increased temperatures. Increased ground temperatures may create a deeper active layer and an associated degradation of permafrost. Vegetation also helps to maintain the moisture balance in the active layer because plants remove moisture from the soil. When vegetation is cleared for pipeline construction a greater proportion of soil moisture remains in the profile causing excess wetness and restrictions to soil development processes.

Ground disturbance can affect the thermal regime of the ground by the removal or compaction of the surficial material. Once any soil or subsoil is removed or compacted during pipeline construction, the depth of the insulating layer over permafrost is reduced resulting in a change to the thermal regime of the ground (Williams and Smith 1989). Increased ground temperatures may create a deeper active layer and an associated degradation of permafrost.

The temperature of the pipe can also influence ground temperatures, once it has been placed in the ground and is operational. When a pipeline is located in a permafrost zone and the temperature of the pipe is higher than the surrounding ground, thawing can occur.

Permafrost degradation is associated with two main impacts to terrain and soils: a wetter moisture regime and thermokarst (discussed in Section 13.5.2.2.5). When the permafrost table is lowered the result will be increased moisture within the active layer. The permafrost table may still be present to act as an impermeable barrier to water drainage resulting in waterlogged conditions in the upper part of the profile. This can create ponding at the surface, which can adversely affect soil development processes dependant on aeration and will also affect vegetation composition.

13.5.2.2.5 How Will Permafrost Affect the Pipeline?

Permafrost can potentially affect pipeline stability through the actions of thermokarst. Thermokarst is associated with permafrost degradation. Thermokarst occurs when permafrost that contains excess ice thaws and the ground subsides in proportion to the volume of excess ice (Williams and Smith 1989). Pipeline integrity can then be jeopardized through differential pipe settlement.

13.5.3 Study Area Boundary

The study area used for the purposes of assessing Project effects on terrain and soils is defined as a 2 km-wide corridor centered on the preferred alignment. While Project impacts will occur on a local scale and will be largely constrained to a 25 m-wide pipeline ROW and immediately adjacent area, these impacts must be assessed within the context of broader regional conditions. The 2 km-wide corridor provides a suitable area to characterize terrain and soil conditions and diversity on a more regional basis. It also allows for a more meaningful interpretation of the effects of the Project on land capability in the Project area. The total area of the 2 km-wide mapped corridor is 17,370 ha.

13.5.4 Assessment Scenarios

13.5.4.1 Baseline

Baseline represents the soil and terrain conditions in the mapped corridor prior to the Pipeline development, including the cumulative effects of past and existing disturbances. Baseline conditions are defined as those present in early February 2002.

13.5.4.2 Construction Scenario

The construction scenario represents the predicted condition of the land base at the time of construction (i.e., December 2003 to March 2004). By comparing construction to baseline conditions, the effects of construction activities from the Project on terrain and soils can be determined.

13.5.4.3 Operations

The operations scenario represents the predicted terrain and soils conditions after reclamation has been completed, five years into the future from Baseline during Operations (i.e., 2007). By comparing operations to baseline conditions, the success of reclamation, effects of operational activities on terrain and soils, and the effects of other new (i.e., since baseline) unrelated activities within the mapped corridor, can be determined.

13.5.5 Proposed Mitigation

Ekwan will incorporate several design features and mitigation measures to help minimize Project impacts to soils and terrain.

13.5.5.1 Soil Handling and Salvage

Proper soil handling and reclamation techniques should mitigate many of the potential impacts to soil and terrain. Please refer to the EPP in Appendix 13D for a full description of the mitigation measures. Soil handling has been designed with the goal of minimum surface disturbance; therefore, grading and grubbing will be minimized wherever feasible.

13.5.5.1.1 Mineral Terrain

Where grading is required Green Area Grubbing techniques will be implemented (see Figure 19 in Appendix 13D.A). The location and extent of grading along the ROW is based on slope and surface roughness and will largely be determined during construction by the contractor. Soil handling will involve stripping of all surface organic material, which includes woody debris and litter (LFH horizons) along with 15 to 20 cm of the underlying mineral soil. Stripping will be performed in one lift, resulting in mixing of the organic and mineral material. The inclusion of mineral material with the surface organics is necessary to provide a medium suitable for seed germination and plant growth after reclamation.

This stripped material will be stored on both sides of the ROW to ensure sufficient material is available for surface coverage during reclamation. The stockpiled organic-mineral mixture will be stored separately from the spoil removed from the trench for pipe placement. The stripped surface will then be graded to the minimum degree necessary to enable construction and pipe placement. The stored organic-mineral mixture will be spread evenly over the ROW as part of final clean-up in late March. It will provide both a suitable soil medium for reclamation, as well as a seed bank of native species to encourage natural recolonization.

Mineral soils with a peaty surface horizon less than 40 cm thick (peaty Gleysols) are categorized as mineral terrain and will be treated as described above.

13.5.5.1.2 Organic Terrain

Soil will not be salvaged in organic terrain where the peat depth exceeds 40 cm. Grading will generally be minimized in flat organic terrain to protect surface stability.

Permafrost may be associated with deep organic terrain within the study area. Where permafrost is present, minimal grading or grubbing will be performed and specific measures will be implemented to minimize permafrost degradation (see Section 13.5.5.6 and Volume 1, Section 5, Permafrost Protection Plan).

13.5.5.2 Compaction and Mixing

Construction will commence during the winter under frozen soil conditions. The risk of compaction and surface disturbance is significantly reduced when soils are frozen as they have a greater load bearing capacity. The probability that rutting will cause mixing of topsoil and subsoil is also reduced when the soil is frozen.

However, if thaw conditions are encountered an appropriate contingency plan is in place (see EPP, Appendix 13D). This may involve the use of temporary measures, such as restricted traffic lanes, low ground pressure vehicles, swamp mats or other methods of surface stabilization to reduce impacts on soils. If necessary, construction will be constrained to night time or temporarily halted to minimize compaction and mixing wherever possible.

In the event of compaction problems, mineral subsoil will be ripped prior to surface soil replacement to prevent problems such as a perched water table or rooting impediments.

13.5.5.3 Erosion

While erosion concerns are minor for the Project because of the relatively flat terrain, mitigation measures are in place in the event that erosion occurs. Ekwan will use directional drilling techniques on major drainage crossings, which will reduce the amount of surface disturbance and protect the slopes associated with river valleys from erosion. The ROW will be monitored for signs of erosion both during construction and after reclamation. If problems are identified, mitigation measures will be implemented. Erosion may be reduced during and following construction through several methods such as:

- silt fences
- rollback and incorporation of non-merchantable timber and slash into the surface materials of erosion-prone slopes

13.5.5.4 Contamination

The best mitigation against soil contamination is to implement an appropriate plan for the prevention and containment of spills and leaks. Ekwan will require that contractors hired for pipeline construction have a comprehensive spill and containment plan and personnel trained to implement this plan. If soil contamination occurs, it will be dealt with according to the spill contingency plans provided in the Environmental Protection Plan (Appendix 13D).

13.5.5.5 Drainage Issues

Ditchline subsidence in deep organic terrain is a common residual effect of pipelines in such terrain features. To minimize this subsidence, spoil will be mounded over the trenchline during backfilling operations to allow for subsidence. This will also minimize the potential for the interception and diversion of localized drainage down ditchline after spring thaw. Gaps in this elevated roach over ditchline will be left at natural drainage crossings and at standard 100 m intervals in wetland terrain to ensure that the roach itself does not become an additional impediment to natural drainage patterns.

During the summer after construction, the ROW will be flown as part of post construction audit procedures, and sections of sunken ditch and associated flow diversions will be noted. Where required, winter remediation programs will be undertaken to correct major sections of sunken ditch. Competent material, if available, will be stripped from the ROW adjacent to ditchline, and windrowed over the subsided sections. If this is not possible, then competent mineral subsoil will be acquired from approved borrow sites close to the remediation area, and will be used to construct stub berms across the sunken ditch at strategic locations. These stub berms serve to redirect flows out of the ditch and into suitable adjacent vegetated areas to stabilize the ditchline and ensure pipeline integrity.

13.5.5.6 Permafrost

Pipeline routing has been planned to avoid permafrost when possible. Of the three alternative routes, the preferred route encounters the least amount of deep organic terrain with potential for permafrost. Additionally, existing disturbances such as seismic lines, winter roads, transmission corridors and pipeline ROWs are followed whenever possible. Permafrost degradation has likely already occurred along existing disturbances due to surface clearing in areas where permafrost was initially present. The pipeline trench will be located on the cleared area when possible so ditching operations have a low likelihood of encountering permafrost.

Where the Pipeline route does not follow an existing disturbance there is potential for permafrost degradation. Where permafrost has been specifically identified prior to pipeline construction minimum surface disturbance techniques, such as no stripping or grading will be implemented when possible. Rollback will be placed on the cleared ROW to insulate the surface from changes in ground temperature in areas identified as having permafrost.

13.5.6 Residual Project Effects

The following assessment sections are based on the assumption that the mitigation measures discussed above are implemented and are effective. Where there is some doubt as to the effectiveness of mitigation, follow-up or monitoring requirements are discussed in Section 13.5.8.

13.5.6.1 Analytical Procedures

A qualitative assessment has been used to evaluate the level of Project effects on terrain and soils, based on the author's knowledge of biophysical conditions in the Project area, standard pipeline practices, and the general effectiveness of proposed mitigation. Project effects have been characterized in terms of their magnitude/extent, duration, reversibility and potential for contributing a measurable impact to cumulative effects, as defined in Table 13.5-7.

13.5.6.2 Results

Surface disturbance in the mapped corridor will increase throughout the life of the Project. At baseline 1.3 percent (218.7 ha) of the corridor is classified as disturbed (Table 13.5-6). During the construction scenario the Project will disturb 184.3 ha, increasing the amount of disturbance to 2.3 percent (403.0 ha) of the corridor. During the operations scenario the amount of disturbance will be further increased to 2.5 percent (438.2 ha) of the corridor. This increase is related to future developments by other operators in the mapped corridor. All disturbance related to the Project will occur during the construction scenario. The total Project-specific disturbance comprises 1.1 percent of the mapped corridor.

No terrain unit is disproportionately impacted by the development of the Project. Therefore, the Project will not affect terrain or soil diversity within the 2 km-wide study corridor or beyond. The amount of disturbance and potential Project effects for each terrain unit and soil type in the mapped corridor are summarized in Table 13.5-6.

13.5.6.2.1 Soil Capability

The Project will result in some mixing of soil profiles and compaction of mineral and organic soils. Winter construction and other mitigation measures described in Section 13.5.5.2 will reduce the impacts on soil capability associated with mixing and compaction. Mixing and compaction impacts are primarily associated with the construction scenario.

Mixing will occur within the Pipeline trench in organic soils and peaty Gleysols. However, the effects of mixing on soil capability discussed previously (organic matter dilution and texture changes) are not as applicable to organic soils and decreases to soil capability are not predicted. In some cases soil capability may be increased in areas of shallow peat deposits over mineral substrates. The incorporation of some mineral material with peat into the final surface materials on the reclaimed ROW will provide a better rooting medium for certain vegetation types.

Grading will alter terrain within the ROW during the construction scenario, but it will be on a minor scale. Grading will not be required extensively for the Project because of the absence of strong topography throughout the route. Implementation of the soil handling procedures outlined in Section 13.5.5.1 will minimize impacts to soil capability associated with minor terrain alterations.

Contamination risks will be minimized by the implementation of comprehensive prevention and containment plans during both the construction and operations scenarios.

Table 13.5-6 Area and Potential Project Effects for Terrain Units and Soils within the 2 km-wide Mapped Corridor in the Baseline, Construction and Operations Scenarios

Terrain Unit	Soil Great Group and Subgroup	Potential Project Effects	Baseline	Construction*		Operations			
			Area of Terrain Unit (ha) and Proportion of Mapped Corridor (%)	Area of Terrain Unit (ha) and Proportion of Mapped Corridor (%)	Percent Change Relative to Baseline (%)	Area of Terrain Unit (ha) and Proportion of Mapped Corridor (%)	Project Contribution to Percent Change Relative to Baseline (%)	Contribution of Future Developments to Percent Change Relative to Baseline (%)	Total Percent Change Relative to Baseline (%)
Fmg	Orthic Gray Luvisol, Cumulic Regosol, Orthic Regosol	Mixing, compaction due to fine texture, contamination.	1,135.6 ha 6.5%	1,128.0 ha 6.5%	-0.7	1,128.0 ha 6.5%	-0.7	0.0	-0.7
Kig Kigp	Gleyed Gray Luvisol, Gleysol, including cryic phases	Mixing, compaction due to fine texture and imperfect drainage, frost heaving, contamination.	2,292.3 ha 13.2%	2,256.1 ha 13.0%	-1.6	2,251.9 ha 13.0%	-1.6	-0.2	-1.8
Kmg	Orthic Gray Luvisol	Mixing, compaction due to fine texture, contamination.	3,570.8 ha 20.6%	3,537.7 ha 20.4%	-0.9	3,531.3 ha 20.3%	-0.9	-0.2	-1.1
Opg	Peaty Gleysol, Typic/Terric Mesisol, Typic/Terric Fibrisol	Compaction, changes to drainage patterns, contamination.	6,886.1 ha 39.6%	6,812.4 ha 39.2%	-1.1	6,800.7 ha 39.2%	-1.1	-0.1	-1.2

Table 13.5-6 Area and Potential Project Effects for Terrain Units and Soils within the 2 km-wide Mapped Corridor in the Baseline, Construction and Operations Scenarios (cont'd)

Terrain Unit	Soil Great Group and Subgroup	Potential Project Effects	Baseline	Construction*		Operations			
			Area of Terrain Unit (ha) and Proportion of Mapped Corridor (%)	Area of Terrain Unit (ha) and Proportion of Mapped Corridor (%)	Percent Change Relative to Baseline (%)	Area of Terrain Unit (ha) and Proportion of Mapped Corridor (%)	Project Contribution to Percent Change Relative to Baseline (%)	Contribution of Future Developments to Percent Change Relative to Baseline (%)	Total Percent Change Relative to Baseline (%)
Opgp	Mesic Organic Cryosol, Fibric Organic Cryosol	Permafrost degradation, compaction, changes to drainage patterns, contamination.	931.6 ha 5.4%	920.3 ha 5.3%	-1.2	908.7 ha 5.2%	-1.2	-1.3	-2.5
Ovg	Typic Mesisol	Compaction, changes to drainage patterns, contamination.	1,884.4 ha 10.8%	1,863.3 ha 10.7%	-1.1	1,862.0 ha 10.7%	-1.1	-0.1	-1.2
Hhg	Waterbodies	n/a	450.4 ha 2.6%	449.2 ha 2.6%	-0.3	449.2 ha 2.6%	-0.3	0.0	-0.3
Disturbed Land	Various	n/a	218.7 ha 1.3%	403.0 ha 2.3%	+84.3	438.2 ha 2.5%	+84.3	+16.1	+100.4
Total			17,370.0 ha[1] 100.0%	17,370.0 ha[1] 100.0%	n/a	17,370.0 ha[1] 100.0%	n/a	n/a	n/a

Notes: Columns may not equal totals due to rounding.
* No development will occur during the Construction scenario except the Project.
1 Total corridor area is smaller, 16,500 ha (82.5 km x 2 km), as mapping units were extended past the 2 km buffer at the Hay and Kotcho rivers to avoid dissecting map polygons in these areas. See Appendix 13E for additional detail.

The capability of the land in the Project area to produce commercial timber is low due to limitations such as soil moisture, rooting restrictions caused by dense, fine textured soil layers and low temperatures. The most productive area within the mapped corridor is rated as Class 3, which is described as land having moderate limitations to the growth of commercial forests. Land rated as Class 3 would be further limited for forestry because stand size is generally small. The Project will result in the disturbance of 40.8 ha of Class 3 land for forestry on the ROW. However, with implementation of the mitigative measures described previously for mineral soils, the capability of the land to produce commercial timber is not predicted to decrease. As discussed above, in shallow organic soils, the incorporation of some mineral material with peat into the final surface materials on the reclaimed ROW may provide a better rooting medium for certain vegetation types, including commercial tree species.

Once reclamation is complete and all mitigative measures have been implemented, the potential impacts on soil capability during the construction and operations scenarios are predicted to be of a low magnitude, short to medium term in length, reversible, and will not produce a measurable contribution to cumulative effects within the Etsho RMZ (Table 13.5-7).

13.5.6.2.2 Erosion

The fine-textured soils in the mapped corridor are susceptible to water erosion once vegetation has been cleared, but the presence of gentle terrain negates the risk of erosion. Additionally, organic terrain, which has a negligible risk of water erosion under normal conditions, is present in 55.8 percent of the mapped corridor. If erosion does occur during either the construction or operations scenarios, the erosion control measures outlined in Section 13.5.5.3 will mitigate the problem.

The potential and residual impacts of erosion from the Project are predicted to be negligible and therefore, this issue was not carried forward in the assessment.

13.5.6.2.3 Drainage

There is strong potential for sections of the ROW encountering flat lying organic terrain to experience some subsidence after reclamation. In the event that this occurs, surface and shallow subsurface drainage have the potential to be redirected down the Pipeline trench. Mitigation measures, such as remedial backfilling or stub berm installation, will be used as necessary to correct the problem.

Once reclamation is complete and all mitigative measures have been implemented, the potential impacts on drainage patterns within the mapped corridor during the construction and operations scenarios are predicted to be of a moderate magnitude, medium term in duration, reversible, and will not produce a measurable contribution to cumulative effects within the Etsho RMZ (Table 13.5-7).

13.5.6.2.4 Permafrost

The Project will impact permafrost patterns where permafrost is present along undisturbed portions of the route. Permafrost degradation may be induced in these areas. The amount of permafrost encountered in undisturbed areas is predicted to be low, but the actual distribution is not known due to the sporadic nature of the permafrost.

Mitigation to limit permafrost degradation where it is encountered will be implemented. Measures may include minimum grading techniques and slash rollback to insulate the surface (Section 13.5.5.6). Potential impacts to permafrost patterns would initiate during the construction scenario and continue throughout the operations scenario.

Once reclamation is complete and all mitigative measures have been implemented, the potential impacts on permafrost patterns within the mapped corridor during the construction and operations scenarios are predicted to be of a moderate magnitude, long-term in duration, and non-reversible. Overlapping Project effects can potentially cause magnified changes to permafrost distribution, but these impacts will not produce a measurable contribution to cumulative effects within the Etsho RMZ (Table 13.5-7) because of the highly localized nature of permafrost encountered by the route.

13.5.6.2.5 Summary

Table 13.5-7 provides a summary of the predicted levels of effects from the Project.

13.5.7 Cumulative Effects Implications

13.5.7.1 Combined Project Effects

The residual Project effects discussed above for soil capability, drainage and permafrost were evaluated for their impacts on soil and terrain. Interaction of the residual effects of each of these issues to produce a significant effect on soil and terrain must be considered.

13.5.7.2 Project Contributions to Regional Cumulative Effects

The impacts to soil capability and drainage are predicted to be reversible over the short to medium term. Therefore, there is little potential for these impacts to combine and create a significant impact on soil and terrain. In areas of permafrost, degradation can potentially be magnified where drainage problems also occur. Water has a high latent heat capacity and has the potential to alter the thermal regime of the ground by insulating the ground from freezing. This can potentially result in further degradation than would be attributed to surface clearing and disturbance.

The Project will not represent a measurable contribution to cumulative effects within the Etsho RMZ (Table 13.5-7). Predicted combined Project effects are largely restricted to the

Project footprint and immediately adjacent areas, and will not significantly affect land capability within the 2 km-wide study corridor.

Table 13.5-7 Summary of Project Effects for Terrain and Soils

Assessment Scenario	Issue/Measurable Parameter	Magnitude/ Extent[1]	Duration[2]	Reversible/ Non-Reversible[3]	Potential for Measurable Contribution to Cumulative Effects[4]
Construction	Soil Capability	Low	Short to medium term	Reversible	No
	Surface and Shallow Subsurface Drainage	Moderate	Medium term	Reversible	No
	Permafrost Degradation	Moderate	Long-term	Non-reversible	No
Operations	Soil Capability	Low	Short to medium term	Reversible	No
	Surface and Shallow Subsurface Drainage	Moderate	Medium term	Reversible	No
	Permafrost Degradation	Moderate	Long-term	Non-reversible	No

Notes: [1] **Magnitude/Extent** – refers to the degree of change (or risk) to biodiversity

Low – change in measurable parameter will have no effect on associated ecological resources (e.g., vegetation, wildlife)

Moderate – change in measurable parameter will have possible local (within 1 km of project) effect on associated ecological resources

High – change in measurable parameter will have possible measurable effect on associated ecological resources within Etsho Resource Management Zone

[2] **Duration** – refers to the length of time over which the project-related effect is measurable

Short term – less than 1 year

Medium term – greater than 1 year but not beyond life of project

Long term – beyond life of project

[3] **Reversibility** – refers to the potential for conditions to return to baseline conditions, in the absence of the project

Reversible – will likely revert to baseline conditions following end of project life or before

Non-reversible – unlikely to revert to baseline conditions following end of project life

[4] **Potential for Measurable Contribution to Cumulative Effects**

Yes – measurable contribution to CE within Etsho Resource Management Zone

No – no measurable contribution to CE within Etsho Resource Management Zone

13.5.8 Follow-up and Monitoring

13.5.8.1 Monitoring for Reclamation Success

Monitoring will be conducted to ensure the success of the approved reclamation plans. A post-construction monitoring program will be performed at the end of the first complete growing season following construction. Soil and terrain characteristics within the reclaimed ROW will be observed to ensure that no impediments to soil processes or the establishment of vegetation exist. Reclaimed areas will be inspected for:

- drainage impediments
- trench subsidence
- consistency of drainage patterns with original patterns and directions
- contours and roughness that have been blended in with adjacent terrain
- surfaces that are stable and not subject to gully or rill erosion, slope movement, slumping or subsidence

Depending on the findings of this first survey, a second year of monitoring may be required to continue to track outstanding issues.

13.5.8.1.1 Reporting

EnCana will produce a report of the post-construction monitoring program at the end of the first complete growing seasons (2004) following construction. This report will be submitted to the NEB.

13.6 Vegetation

13.6.1 Baseline Setting

This baseline assessment provides an overview of current vegetation conditions in the Etsho RMZ and, more specifically, in the immediate vicinity of the Pipeline. Baseline information is derived from existing literature, government databases, and industry reports. Vegetation data received from existing sources such as the British Columbia Conservation Data Centre (BC CDC) and the Alberta Natural Heritage Information Centre (ANHIC) are presented in Appendix 13G.

To provide more site-specific information on vegetation resources within the Project area, Terrestrial Ecosystem Mapping (TEM) was undertaken for a two km-wide corridor centred on the Pipeline.

13.6.1.1 Regional Vegetation

The majority of the Pipeline (approximately 78 km) falls within the Moist Warm Boreal White and Black Spruce (BWBSmw2) biogeoclimatic variant of British Columbia. The remaining 5 km fall within the Wetland Mixedwood Subregion of the Boreal Forest Natural Region of Alberta. These two ecological regions are very similar in climatic and biophysical characteristics, and have been named under different provincial classification systems.

The BWBSmw2 variant consists of gently undulating topography and lowlands from near the Beatton River to the Northwest Territories and Yukon borders (Delong et al. 1990). Forest fires are frequent in the BWBS zone and maintain forests in a variety of successional stages (British Columbia Ministry of Forests 1996).

Aspen-white spruce (*Populus tremuloides*-*Picea glauca*) forests dominate relatively well drained sites in the BWBS zone while poorly drained sites are dominated by black spruce (*Picea mariana*) and tamarack (*Larix laricina*) (Delong et al. 1990). Lodgepole pine (*Pinus contorta*) occurs with black spruce on some poorly drained sites or in pure stands on well-drained sites on higher topographic positions (Delong et al. 1990). Balsam poplar (*Populus balsamifera*), white spruce, aspen, and paper birch (*Betula papyrifera*) can be found on floodplains of major water courses (Delong et al. 1990).

The Wetlands Mixedwood Subregion in the Boreal Forest Natural Region of Alberta is dominated by wetlands, peatlands, willow-sedge (*Salix* spp. – *Carex* spp.) complexes, and black spruce forests on poorly drained sites (Achuff 1994). Moist upland sites located on tills and glaciolacustrine material in this Subregion are dominated by black spruce or mixed black and white spruce forests with a well-developed moss layer comprised of feathermosses such as *Hylocomium splendens*, *Pleurozium schreberi*, and *Ptilium crista-castrensis* (Achuff 1994). Pine forests can be found on relatively dry till and glaciofluvial deposits while aspen-white spruce mixedwood forest are present on mesic till sites (Achuff

1994). White spruce-balsam poplar forests are present on fluvial terraces along the Hay River (Achuff 1994).

Peatlands are common wetland features throughout both the BWBSmw2 variant and the Wetland Mixedwood Subregion. Peatland complexes usually contain nutrient-poor, acidic bogs and nutrient-rich fens (Achuff 1994). Nutrient poor sites are dominated by black spruce, Labrador tea (*Ledum groenlandicum*), and peat mosses (*Sphagnum* spp.) while nutrient rich sites contain tamarack, dwarf birches (*Betula* spp.), sedges and brown mosses such as *Aulacomnium palustre*, *Tomenthypnum nitens*, and *Drepanocladus* spp. (Achuff 1994).

13.6.1.2 Community Level Diversity within Mapped Corridor

As mentioned in Section 13.6.1, TEM mapping was undertaken for a two km-wide corridor centered on the Pipeline alignment to provide a more detailed characterization of vegetation along the route. A description of methods used for TEM data collection is included in Appendix 13E. Table 13.6-1 summarizes the site series occurring within the corridor. The TEM methods were used in Alberta and British Columbia to facilitate assessment for the entire pipeline, as opposed to using one system for the Alberta portion and another for the British Columbia section.

The most common site series occurring in the two km-wide corridor is Lt-buckbean (BWBSmw2/10), covering 4637 ha (approximately 27 percent) of the corridor (Table 13.6-1). The Lt-buckbean site series is dominated by tamarack, scrub birch (*Betula glandulosa*), leatherleaf (*Chamaedaphne caloyculata*), Labrador tea (*Ledum groenlandicum*), buckbean (*Menyanthes trifoliate*), small bog cranberry (*Vaccinium oxycoccus*), and common red sphagnum (*Sphagnum capillaceum*) (DeLong et al. 1990). Cover of trees, shrubs, herbs, and mosses is approximately 25, 85, 70, and 90 percent respectively (DeLong et al. 1990). This site series is considered common, with no commercial management objectives at this time (DeLong et al. 1990).

The second most common site series in the corridor is SwAt – stepmoss (BWBSmw2/01), covering 3568 ha (approximately 21 percent) of the corridor (Table 13.6-1). The SwAt – stepmoss site series is dominated by species such as white spruce, trembling aspen, black spruce, highbush cranberry (*Viburnum edule*), prickly rose (*Rosa acicularis*), twinflower (*Linnaea borealis*), bunch berry (*Cornus canadensis*), step moss (*Hylocomium splendens*), knight's plume (*Ptilium crista-castrensis*) and red-stemmed feather moss (DeLong et al. 1990). Cover values for tree, shrub, herb, and moss layers are 70, 20, 20, and 60 percent, respectively. This site series is considered to be very common (DeLong et al. 1990). No specific management objectives are identified. However, white spruce is listed as a preferred species, clearcut is listed as the logging prescription, and the objective of site preparation in this area is to reduce debris, prepare planting sites, minimize future brush competition, improve access for reforestation, and increase soil temperature (DeLong et al. 1990).

Table 13.6-1 lists the area, and percent cover of all site series within the mapped corridor. Appendix 13G provides additional information on biophysical characteristics of each site series.

Table 13.6-1 Area of each Site Series Mapped Within the Mapped Corridor[5]

Site Series Description[1]	Area (ha)			Percent of Mapped Corridor
	Primary[2]	Secondary[3]	Total	
AH- Mountain Alder – Alaska paper birch – beaked sedge – horsetail	2,525	318	2,843	16.4
AM- Stepmoss	3,436	132	3,568	20.5
BS- Cloudberry – sphagnum	2,036	482	2,518	14.5
OW- Open shallow water	93	136	229	1.3
RI- River	203	19	222	1.3
SG- Sedge - Grass fen	1,122	1,046	2,168	12.5
SH- Currant – horsetail	1,128	8	1,136	6.5
TB- Buckbean	3,987	650	4,637	26.7
PD- Drill pad	23	0	23	<1
DV- Development	26	0	26	<1
RZ- Road	0	1	1	<1
Total			17,370[4]	100

Notes:
[1] All site series are located within the BWBS mw2 BGC.
[2] Area of the Site Series when classified as the primary vegetation type within the TEM polygon.
[3] Area of the Site Series when classified as the secondary unit in the TEM polygon.
[4] Total corridor area is smaller, 16,500 ha (82.5 km x 2 km), as mapping units were extended past the 2 km buffer at the Hay and Kotaro rivers to avoid dissecting map polygons in these areas. See Appendix 13E for additional detail.
[5] Mapped corridor is 2 km * 82.5 km

13.6.1.2.1 Structural Diversity

The Biodiversity Guidebook (British Columbia Ministry of Forests 1995) describes the Fort Nelson BWBSmw2 variant as a forest having frequent stand-initiating events. The mean fire return interval is about 100 years in stands where deciduous trees are predominant and 125 years in coniferous-dominated stands (British Columbia Ministry of Forests 1995). The resulting natural landscape is a mixture of even-aged stands.

In the mapped corridor, 70 percent of the forests are young (structural stage 0 through 5), 30 percent are mature (structural stage 6), and less than 1 percent are old growth (structural stage 7) (Table 13.6-2). For this Project, mature forests are defined as 80 to 140 years old and old growth is defined as trees over 140 years old (Ecosystems Working Group 1998). The old growth forest occurs in the SwAt – stepmoss (2 ha) and Sw – currant – horsetail (14 ha) site series. These areas are over 500 m off of the ROW and will not be disturbed by construction.

Table 13.6-2 Area of Forest Structural Stages Within the Study Corridor

Structural Stage	Area (ha)
0 (unclassified)	501
1 (sparse/bryoid)	0
2 (herb)	2167
3 (shrub/herb)	5186
4 (pole/sapling)	1724
5 (young forest – 40-80 years)	2539
6 (mature forest – 80-140 years)	5237
7 (old forest - > 140 years)	16
Totals	17370

Note: [1] Source: Ecosystems Working Group 1998

13.6.1.2.2 Wetlands

Wetland types were identified and mapped using the Alberta Wetland Inventory (AWI) Standards (Halsey and Vitt 1997). This classification involves identifying wetland features from 1:20,000 aerial photographs and the Terrestrial Ecosystem maps. Wetland polygons were delineated from air photos and each polygon was assigned one of five main wetland classes (Table 13.6-3). Potential wetland classes include two peatland types (bog and fen) and three non-peatland types (marsh, swamp, and shallow open water). In addition to these main wetland types, site modifiers are assigned to each wetland based on characteristics such as tree cover, permafrost, patterning, and internal lawns (Tables 13.6-3 and 13.6-4).

Table 13.6-3 AWI Wetland Classification Codes

Item	Description	AWI code
Wetland class	Bog	B
	Fen	F
	Swamp	S
	Marsh	M
	Shallow open water	W
	Non-wetland	Z
Vegetation modifier	Forested closed canopy >70% cover	F
	Wooded open canopy 6–70% cover	T
	Open: shrubs, sedges, graminoids, herbs <6% cover	O
Wetland complex landform modifier	Permafrost present	X
	Patterning present	P
	Permafrost or patterning not present	N
Landform modifier	Collapse scar	C
	Internal lawn with islands of forested peat plateau	R
	Internal lawns	I
	No internal lawns	N
	Shrub cover >25% when tree cover is <6%	S
	Graminoid dominated with shrub cover <25% when tree cover is <6%	G

Source: Halsey and Vitt (1997)

Table 13.6-4 Length of ROW Intercepts for Each Wetland Type

Wetland Type	Length on ROW (km)	Description
BTNN	<1	Wooded bog without internal lawns
BTXC	<1	Wooded permafrost bog (peat plateau) with collapse scars
BTXN	<1	Wooded permafrost bog without collapse scars
FONS	5	Nonpatterned, open, shrub-dominated fen
FTNI	3	Nonpatterned wooded fens with islands of internal lawns
FTNN	23	Nonpatterned, wooded fens with no internal lawns
FTNR	1	Nonpatterned, wooded fens with islands of forested peat plateau and internal lawns
MONG	<1	Marsh
SONS	10	Open deciduous swamp
STNN	<1	Wooded coniferous swamp
WONN	<1	Shallow open water
Z	34	Non-wetland

13.6.1.2.3 Rare Plant Communities

Information on rare plant communities was collected from existing data sources provided by the BC CDC and the ANHIC (Appendix 13G). This information was used to determine which rare plant communities may be found in the Project area and to determine if known occurrences exist within the two km-wide mapped corridor. These data will be supplemented with rare plant and community surveys to be conducted within the mapped corridor during the spring and summer of 2003.

One rare plant community is reported for the Fort Nelson Forest District and 19 are identified in the Boreal Forest Natural Region in Alberta (Appendix 13G). The potential rare plant community in the Fort Nelson Forest District is Black spruce/ Kinnikinnick/ Cladina (*Picea mariana*/ *Arctostaphylos*/ *Cladina*). The BC CDC does not currently have any mapped occurrences for this rare plant community in the Fort Nelson Forest District (Donovan 2002, pers. comm.).

One of the 19 potential rare plant communities identified for the Boreal Forest Natural Region of Alberta (i.e., *Elymus trachycaulus – Hierochloe odorata*) is reported to occur in northwest Alberta and may be present along the Hay River (Allen 2002). However, the Hay River in Alberta falls well north of the Project area. In addition, ANHIC does not have any recorded rare plant community occurrences in the Wetland Mixedwood Subregion of the Boreal Forest Natural Region (Rintoul 2002, pers. comm.).

13.6.1.3 Species Level Diversity

13.6.1.3.1 Rare Plants

Provincial tracking lists for rare vascular plants are maintained by the ANHIC and by the BC CDC. There are eight vascular plants on the Alberta Tracking List in the Wetland Mixedwood Subregion (Vujnovic and Gould 2002) (Appendix 13G, Table 13G-6). One vascular plant species, lance-leaved grape fern (*Botrychium lanceolatum*), is a rare species (S2G5 rank, Appendix 13G, Table 13G-6) that is known to be peatland-dependent in the Wetland Mixedwood Subregion (Vitt et al. 1996). There are currently no recorded occurrences of this species near the Pipeline (ANHIC 2002).

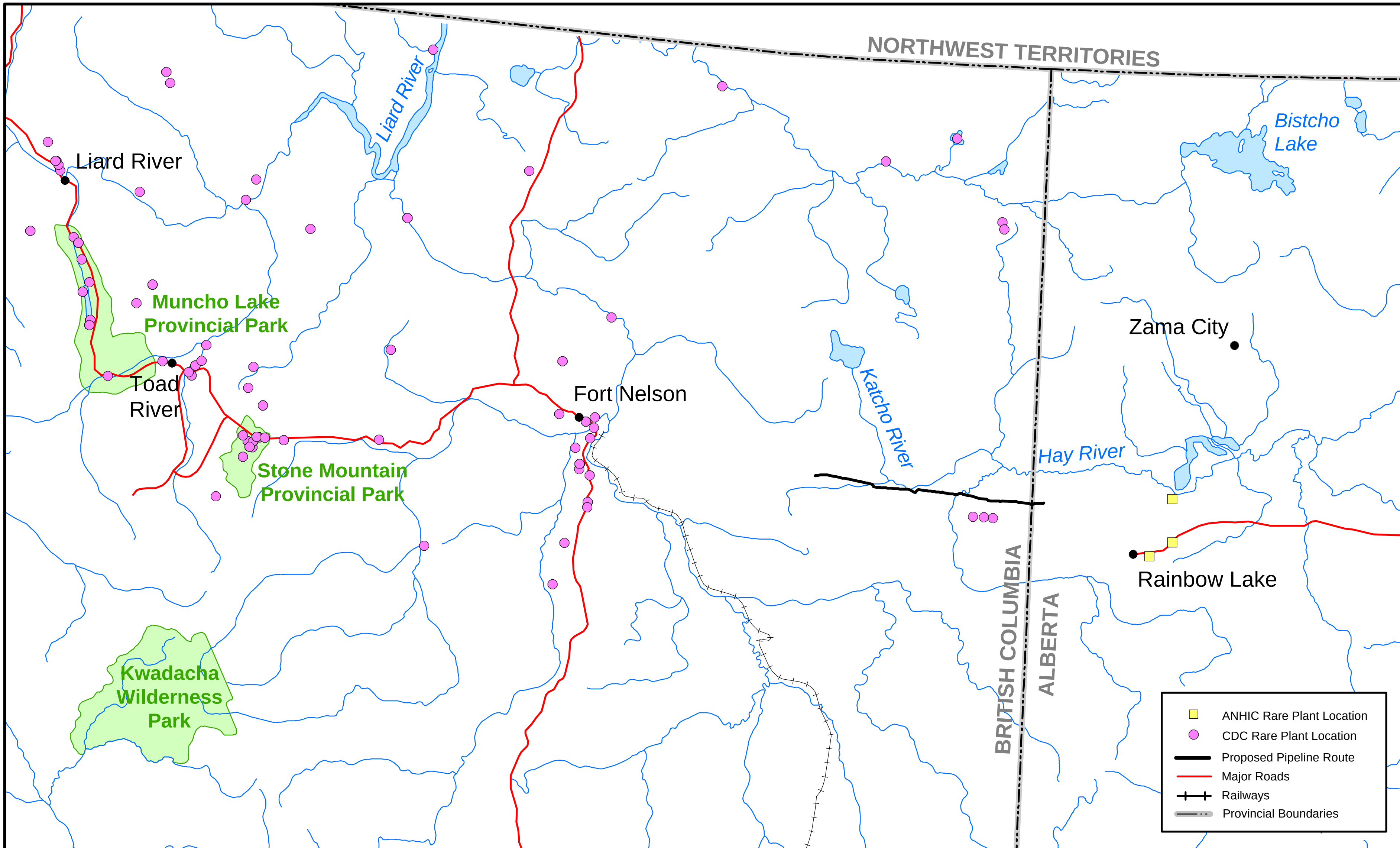
Eighty-six vascular plants are currently being tracked in the Fort Nelson Forest District in British Columbia (BC CDC 2002) (Appendix 13G, Table 13G-7). There are currently no known or mapped rare plant occurrences on or near the Pipeline ROW (Figure 13.6-1), however, lack of mapped occurrences does not indicate that rare plants are not present in the area. Rare plant field surveys will be conducted in conjunction with the rare community surveys during the spring and summer of 2003.

13.6.1.3.2 Traditional Use Plants

Aboriginal peoples use plants for a wide range of activities, such as food, medicine, fuel and smudges. Each aboriginal community, and frequently each family within a community, possesses different knowledge about the use of plants, the locations of the best harvest sites and the optimum time of year to harvest each species. Many species are common and occur in relatively common habitats (e.g., Labrador tea) and are not a concern, however other species (e.g., blueberry) occur in localized habitats that have been harvested for generations. Some medicinal plants have extremely specialized habitats and the locations are carefully protected and the populations managed. Site specific information about traditional use plant and collecting sites within the corridor will be obtained in conjunction with the rare plant and rare community surveys. The loss of plants growing in localized or specialized habitats can have a significant impact if the aboriginal community regularly harvests them, if the plant is rarely used but is considered valuable (i.e., it is used for a specific medical condition), or if the plant is uncommon.

13.6.1.4 Field Survey Program

To verify elements of the baseline information discussed above, and to provide additional detail for the mitigation strategies discussed in the following sections, a rare plant and rare plant community survey program is planned for spring and summer 2003. Results of these rare plant surveys will be submitted to the NEB upon finalization.



EKWAN PIPELINE PROJECT

Botany Database Rare Plant Locations

NORTH

20 0 20 40 60

Scale in kilometres

Acknowledgements:
Original drawing by AXYS Environmental Consulting Ltd.

ENCANA

PREPARED BY AXYS				
DRAFT DATE 10/December/2002			SCALE 1:2,000,000	
REVISION DATE 27/February/2003			PROJECT POG1045	FIGURE NO. 13.6-1
DRAWN TB	CHECKED	APPROVED	VOL	

Vegetation surveys will be conducted in June, and July or August 2003 and will follow the methods discussed in Lancaster (2000), and will satisfy the requirements of both the BC CDC and ANHIC. The associated technical report to be completed after the surveys will provide detailed description of survey methods, results, and recommended mitigation procedures where necessary, should species of management concern be encountered along the route.

13.6.2 Results of Issues Scoping

13.6.2.1 Project Effects Analysis

As discussed in the Terrain and Soils section, pipeline developments represent long but narrow disturbances on the landscape. Therefore, a singular pipeline development has little potential to significantly alter botanical characteristics at the regional or landscape scale. Instead, their effects are generally restricted to the actual developed ROW or immediately adjacent lands (i.e., within 10-50 m). In some cases, these localized effects can contribute to larger regional trends in botanical characteristics from cumulative surface development.

The following discussion summarizes the typical project-specific effects of a pipeline development on vegetation.

13.6.2.1.1 Vegetation Removal and Disturbance

To develop a safe, efficient work surface for the construction of a pipeline, a certain width of ROW has to be cleared of vegetation and then graded to provide a relatively flat working surface. In general, the width of ROW cleared increases with the diameter of pipeline and size of equipment required to handle the pipe. For the Ekwan Project, a maximum 25 m-wide ROW will be developed for the purposes of construction. Localized additional clearing and grading will also be required in strategic locations to accommodate stream crossings, heavy grade areas, road crossings, and other activities requiring extra workspace. Permanent above ground features developed as part of the Pipeline will be largely limited to block valves established at intervals along the route.

In summary, ROW development will primarily result in the localized alteration of vegetation composition and structural stage. Where the ROW encounters tree cover, construction will transform the forest community into an early seral stage dominated by grasses and forbs for the short to medium term. In flatter muskeg terrain, the contractor may choose to snow/frost pack the ROW to stabilize surface conditions for construction, with minimal grading of and disturbance to the ground vegetation. Consequently, disturbance to the ground stratum of vegetation will likely be reduced for this Project, relative to other pipeline developments in areas of greater topographic relief. Following construction, the majority of the ROW will be allowed to revegetate naturally and will gradually revert to a more natural botanical and structural composition.

From a biodiversity perspective, the restricted footprint of the Ekwan Pipeline ROW will not have a significant effect on landscape parameters such as forest patch size, area of upland vs. wetland cover, etc. The ROW will, for short stretches in forested terrain, represent new 'edge' where existing linear disturbances are not being followed by the Project (approximately 19 km). However, the Project area is dominated by natural open muskeg and associated 'edge' characteristics, and the 'new cut' ROW will not measurably influence this natural condition. The development of the ROW does, however, have the potential to locally change the structural and community diversity of ecosystem units if unusual or under-represented units (e.g., old growth, uncommon communities) are encountered by construction activities.

At the species level, the localized disturbance associated with a pipeline development can influence biodiversity through two main processes:

- disturbance to rare plants, rare communities, or traditional collecting sites
- introductions of non-native species

Rare plants, rare plant communities, and some traditional use plants are often highly specific to particular micro-habitat conditions, and the clearing, soil disturbance, or altered drainage patterns associated with ROW development can directly or indirectly affect the survival of local rare plant occurrences.

Construction equipment and vehicles used for pipeline development can be transport mechanisms for weed seeds. By combining a weed source with disturbed soil conditions associated with construction, pipeline development can introduce aggressive, persistent non-native, or agronomic plant species and associations into otherwise natural vegetation communities. This can also alter species diversity at a localized scale.

13.6.2.1.2 Drainage Alterations

As discussed under Terrain and Soils, ditch subsidence may occur over stretches of the Pipeline developed in deep organic landforms. This subsidence can, in turn, capture and re-direct surface and shallow subsurface water flows down ditchline, causing localized changes in drainage patterns. Additional terrain subsidence resulting from Project-related permafrost degradation can also result in changes to drainage patterns on and immediately adjacent to the ROW. In both cases, altered moisture regimes on either side of the ROW could cause localized shifts in vegetation composition adjacent to the ROW. Once again, these are not landscape level effects but rather localized effects on botanical composition.

13.6.2.2 Key Impact Questions

Based on the above discussion, the issues identified in Table 13.6-5 will be the focus of the vegetation component of the impact assessment:

Table 13.6-5 Summary of Key Impact Issues and Assessment Approaches

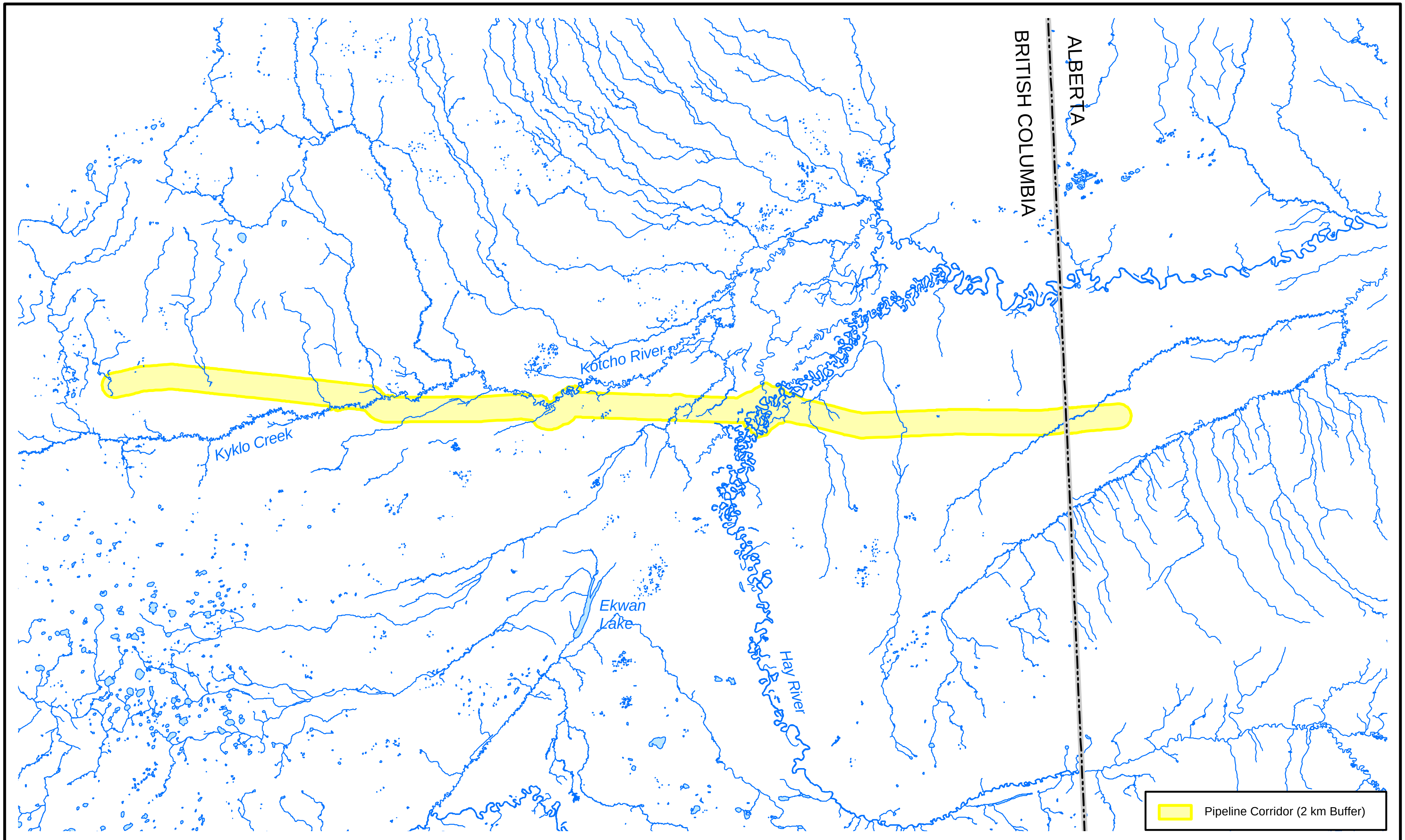
Key Impact Issue	Assessment Approach
How will the Project affect local plant community diversity?	Quantitative assessment of ecosystem unit area within mapped study corridor, and levels of disturbance within each unit. Qualitative discussion of possible changes to local drainage patterns (Terrain and Soils section) and associated effects on vegetation communities and diversity.
How will the Project affect local plant community structural diversity?	Quantitative assessment of ecosystem unit structural stage within mapped study corridor, and levels of disturbance within each structural stage.
How will the Project affect rare plants, rare plant communities and traditional use of vegetation resources?	Qualitative discussion of rare and/or traditionally used plant potential along the route and the implications of ROW development. Qualitative discussion of invasive non-native plant species problems in the Project area, and the implications of Project development.

13.6.3 Study Area

As discussed under the Baseline Section 13.6.1, known information on the regional botanical characteristics of the Project area was drawn from the BC CDC and ANHIC data bases, using the respective biogeoclimatic variant (in British Columbia) and ecological Subregion (in Alberta) as the study areas of interest.

For the purposes of characterizing botanical conditions at a more project specific level, TEM was undertaken for a two km-wide corridor centered on the alignment (see Figure 13.6-2, Vegetation Study Area). This corridor has also been used as the basis for assessing the level of Project impacts on vegetation, and for assessing Project contributions to local cumulative effects. This corridor was considered appropriate as a study area for assessing Project effects for the following reasons:

- A two km-wide corridor is wide enough to provide a representative picture of the botanical and structural diversity of vegetation in the area, and the cumulative land use pressures on those parameters.
- The Project footprint represents approximately 1.5 percent of the study area corridor. Therefore, Project effects will be measurable within the corridor. Adopting a larger regional study area would have obscured and trivialized Project effects and local trends of potential concern from a vegetation perspective.



EKWAN PIPELINE PROJECT

Vegetation Study Area

NORTH

4 0 4 8 12

Scale in kilometres

Acknowledgements:
Original drawing by AXYS Environmental Consulting Ltd.

ENCANA

PREPARED BY AXYS

DRAFT DATE 27/February/2003		SCALE 1:450,000	
REVISION DATE 27/February/2003		PROJECT POG1045	FIGURE NO. 13.6-2
DRAWN AO	CHECKED	APPROVED	VOL

13.6.4 Assessment Scenarios

To assess project effects on vegetation, the botanical conditions within the two km-wide study area have been described and compared for the following assessment periods:

Hypothetical Baseline – This represents the hypothetical condition of the land base in the absence of existing human-related disturbance. It has been developed by assigning site series classifications to existing disturbance features on the land base, based on the surrounding natural vegetation conditions.

Baseline – This represents the condition of the land base under existing baseline (early February 2002) conditions. By comparing baseline to hypothetical baseline, the degree of cumulative change in the vegetation resource to date can be assessed.

Construction – This represents the predicted condition of the land base at the time of construction (i.e., December 2003 to March 2004). By comparing construction to baseline conditions, the effects of construction activities on vegetation, as well as those associated with other new (i.e., since baseline) unrelated activities within the study corridor, can be tracked from baseline conditions.

Operations - This represents the predicted condition of the land base during Operations, five years into the future from baseline (i.e., 2007). By comparing operations to baseline conditions, the effects of operational activities on vegetation can be tracked from baseline conditions.

Abandonment – The effects of the Pipeline are not expected to have long-term significant effects after abandonment. The Pipeline will first be pigged to remove internal residues, prepared for in-ground containment and capped, and surface facilities will be removed. Decommissioning and abandonment activities will occur at only a few locations, such as end-points and river crossings, and work at these sites will be completed within several days. Access points required by the Pipeline will be reduced at this time as the remainder of the ROW will be permitted to revegetate to forest cover. As a result, Project effects on vegetation at abandonment would be low in magnitude, medium term, reversible, and should be positive in direction.

13.6.5 Proposed Mitigation

The majority of the site-specific mitigation details to be implemented by the Project to reduce impacts to vegetation will be developed after the detailed rare plant and rare community surveys are conducted during the spring and summer of 2003. However, the following general measures will also be adopted as part of best available practices and have been factored into the assessment of residual Project effects:

13.6.5.1 Construction

- All S1 ranked species or communities (see Section 13.6.1.5.2) will be avoided through routing modifications, unless such modifications present unacceptable risks or impacts to other resources in the area. Where modifications are not possible, EnCana will provide a detailed alternative mitigation plan for the protection of such resources.
- Where S2 ranked species/communities, identified uncommon site series (i.e., site series occupying less than 1 percent of mapped corridor) or species of traditional use importance are encountered by the ROW, the Project footprint will be minimized to the degree possible (i.e., to a 25 m-wide ROW or less), and no extra workspace will be developed in these areas.
- During ROW preparation, minimal surface grading will be undertaken in lowland (wetland) terrain types (i.e., fens, bogs) encountered by the ROW. Low ground pressure tracked vehicles will be used to pack snow, smooth and freeze in the ROW to facilitate vehicle travel. Minimal surface grading techniques will be a design specification for the contractor in known permafrost areas to reduce potential permafrost degradation.
- Where grading is required as part of ROW preparation, surface organics and topsoil will be stripped from the ROW and windrowed on both edges of the ROW. This material will be re-distributed back over the ROW during reclamation as a soil amendment and natural seed source for revegetation.
- At directionally drilled crossings (Kyklo Creek, Townsoitoi Creek, Hay River, Little Hay River), drill entry and exit points will be located at least 125 m back from the channel edge. Disturbance to the riparian areas will be limited to a temporary six m-wide travel corridor developed at the stream crossing site for construction vehicles.
- Drill entry and exit points associated with the Hay River crossing will avoid meander scars east of the Hay River to minimize disturbance to these uncommon vegetation features.
- All equipment entering the Project area will be cleaned of mud and vegetative debris to reduce the potential for the spread of weeds.

13.6.5.2 Reclamation

- Portions of the Pipeline encountering lowland (wetland) terrain types will not be re-seeded. The ROW will be allowed to revegetate naturally.
- Portions of the Pipeline encountering upland mineral soils will be seeded in late March 2004 as part of final clean-up. The following seed mix, approved by provincial forestry personnel, will be used where required.

Northern Rockies Seed Mix:
40% Slender Wheatgrass
20% Fowl Bluegrass
20% Cicer Milk Vetch (or Hairy Vetch)
15% Sheep Fescue
05% Annual Rye

- Gaps will be excavated in any elevated backfill at all natural drainage channels and at 100 m intervals in all lowland (wetland) terrain types to maintain cross-ROW drainage patterns.

13.6.5.3 Operations

- Vegetation maintenance along the ROW, if required, will be limited to an 8 m-wide corridor over ditchline to facilitate aerial surveillance. Maintenance activities will be extended over the width of the ROW at block valve sites to accommodate helicopter landings.
- Vegetation maintenance on the ROW, if required, will use mechanical brushing techniques only. No herbicides will be used for general vegetation maintenance.
- Noxious weed surveys will be undertaken along the ROW yearly for the first three years of operations. Outbreaks on the ROW will be controlled using mechanical techniques prior to seed production. For particularly aggressive weeds, herbicides may be used on a localized basis if approved by provincial forestry personnel. Weed control can impact rare plants, rare communities and traditional use plants, therefore, alignment sheets will be checked for sensitive plants before weed control is undertaken.

13.6.6 Residual Project Effects

The following assessment sections are based on the assumption that the mitigation measures discussed above are implemented and are effective. Where there is some doubt as to the effectiveness of mitigation, follow-up or monitoring requirements are discussed in Section 13.1.11.

13.6.6.1 Analytical Procedures

13.6.6.1.1 Community Level Diversity

Community level diversity was assessed within the two km-wide mapped corridor using the site series as the basic vegetation unit. The spatial extent and distribution of site series have been calculated for each of the four assessment scenarios discussed in Section 13.1.4. For baseline, construction and operation conditions, known and/or predicted footprints of disturbance were superimposed onto the mapped corridor to quantify the level of cumulative disturbance that has occurred or will occur in each of the site series. For construction and operation conditions, levels of disturbance have been calculated with and without the effects of the Project to demonstrate the incremental contributions of the Project at each assessment period.

The intent of this analysis is to:

- identify 'hypothetical' diversity of site series within the corridor in the absence of visible disturbance
- quantify the levels of Project disturbance by site series
- quantify the levels of cumulative disturbance by site series
- identify those site series whose long-term sustainability may be threatened within the corridor under current land use trends
- develop mitigation options for the Project to minimize or eliminate further disturbance to these site series of concern

Particular focus was directed on uncommon site series whose undisturbed area represents less than one percent of the corridor area.

As previously discussed, post-construction settlement along the ROW in lowland (wetland) site series could alter cross-ROW drainage patterns, potentially causing drying conditions on one side of the ROW and subsurface and surface water build-up on the other side of the ROW. This can also result in changes in community diversity, and has been discussed in a qualitative fashion.

13.6.6.1.1.1 Structural Diversity

Community level diversity is affected by the age and associated forest canopy structure of site series, as well as their botanical composition. Older structural stages are often limited in distribution and area due to the short fire interval of the area.

To understand the distribution of structural stages in the mapped corridor, all identified polygons were classified to one of seven structural stages. The spatial extent and distribution of each structural stage has been calculated for each of the four assessment scenarios discussed in Section 13.6.4. For baseline, construction and operation conditions, known and/or predicted footprints of disturbance have been superimposed onto the mapped corridor to quantify the level of cumulative disturbance that has occurred or will occur in each of the structural stages. For operation conditions, levels of disturbance have been calculated with and without the effects of the Project to demonstrate the incremental contributions of the Project.

The intent of this analysis is to:

- identify 'hypothetical' structural diversity within the corridor in the absence of visible disturbance
- quantify the levels of cumulative disturbance by structural stage

- identify those older structural stages that may be threatened within the corridor under current land use trends
- develop mitigation options for the Project to minimize or eliminate further disturbance to these older structural stages of concern

13.6.6.1.1.2 Rare Plant Communities

Rare communities will be evaluated during the 2003 spring and summer vegetation surveys.

13.6.6.2 Species Level Diversity

Species level diversity will be evaluated by during spring and summer vegetation surveys to be completed along the route in June and late July or August 2003. These surveys will be designed to:

- identify species at risk, based on the rankings of the BC CDC and ANHIC tracking systems
- identify collecting sites for traditional use plants
- develop mitigation options for the Project to minimize or eliminate effects to species of management concern

13.6.6.3 Results

There is potential for moderate impact to species diversity from both construction and operations. This impact may be long term and non-reversible. However, it does not have the potential to contribute measurably to cumulative effects. Other potential effects are low in magnitude and not considered to have potential to contribute measurably to cumulative effects.

Table 13.6-6 summarizes the predicted Project effects on vegetation in the study area. The table also identifies the potential for the Project to measurably contribute to regional cumulative effects. Footnotes below the table provide the definitions of the various categories for the impact descriptors. Subsections following the table provide the background and justification for these findings.

13.6.6.3.1 Community Level Diversity

Table 13.6-7 summarizes the total area of each site series mapped within the two km-wide corridor, and the area to be physically disturbed by the known Project footprint. In summary, the mapped corridor does not demonstrate a high level of natural diversity, with only six vegetated and two open water site series identified. All of the vegetated site series are well represented in the corridor, representing more than 6 percent of the corridor in every case.

Table 13.6-6 Summary of Project Effects for Vegetation

Assessment Scenario	Issue	Magnitude/ Extent[1]	Duration[2]	Reversible/ Non-Reversible[3]	Potential for Measurable Contribution to Cumulative Effects[4]
Construction	Community Diversity-effects from ROW preparation and drainage alteration	Low	N/A	N/A	No
	Structural Diversity-effects from ROW preparation	Low	N/A	N/A	No
	Species Diversity-effects from ROW preparation, altered drainage, and weed introductions	Moderate	Long-term	Non-reversible	No
Operations	Community Diversity-effects from ROW maintenance	Low	N/A	N/A	No
	Structural Diversity-effects from ROW maintenance	Low	N/A	N/A	No
	Species Diversity-effects from ROW maintenance, and weed introductions	Moderate	Long-term	Non-reversible	No

Notes: [1] **Magnitude/Extent** – refers to the degree of change (or risk) to biodiversity

Low – change in measurable parameter will have no effect on local community or species diversity (i.e., within 2 km mapped corridor)

Moderate – change in measurable parameter will have possible effect on local community or species diversity (i.e., within 2 km mapped corridor

High – change in measurable parameter will have possible measurable effect on community or species diversity within Etsho Resource Management Zone

[2] **Duration** – refers to the length of time over wich a project-related effect is measurable

Short term – less than 1 year

Medium term – greater than 1 year but not beyond life of project

Long term – beyond life of project

[3] **Reversibility/Non-reversibility**

Reversible – will likely revert to baseline conditions following end of project life or before

Non-reversible – unlikely to revert to baseline conditions following end of project life

[4] **Potential for Measurable Contribution to Cumulative Effects**

Yes – measurable contribution to CE within Etsho Resource Management Zone

No – no measurable contribution to CE within Etsho Resource Management Zone

Table 13.6-7 Change In Site Series From Hypothetical Baseline Through Operations

Site Series	Hypothetical Baseline		Baseline		Construction			Operations With Project			Operations, Without Project		
	Area (ha)	% of Mapped Corridor	Area (ha)	% Change from Hypothetical Baseline[1]	Area (ha)	% Change from Baseline[1]	% Change from Hypothetical Baseline[1]	Area (ha)	% Change from Baseline[1]	% Change from Hypothetical Baseline	Area (ha)	% Change from Baseline	% Change from Hypothetical Baseline
AH- Mountain Alder – Alaska paper birch – beaked sedge – horsetail	2,878	16.6	2,843	-1.2	2,817	-0.9	-2.1	2,817	-0.9	-2.1	2,843	0	-1.2
AM- Stepmoss	3,640	21	3,568	-2	3,536	-0.9	-2.9	3,529	-1.1	-3.0	3,561	-0.2	-2.2
BS- Cloudberry – sphagnum	2,573	14.8	2,518	-2.1	2,490	-1.1	-3.2	2,477	-1.6	-3.7	2,505	-0.5	-2.6
OW- Open shallow water	229	1.3	229	0	229	0	0	228	-0.4	-0.4	229	0	0
RI- River	222	1.3	222	0	222	0	0	221	-0.5	-0.5	222	0	0
SG- Sedge - Grass fen	2,001	11.5	2,168	8.3	2,117	-2.4	5.8	2,333	7.6	16.6	2,173	0.2	8.6
SH- Currant – horsetail	1,137	6.5	1,136	-0.1	1,128	-0.7	-0.8	1,128	-0.7	-0.8	1,136	0	-0.1
TB- Buckbean	4,690	27	4,637	-1.1	4,572	-1.4	-2.5	4,558	-1.7	-2.8	4,623	-0.3	-1.4
Anthropogenic	0		49		259			79			78		
Totals	17,370[2]		17,321	-0.3	17,111	-1.2	-1.5 ***	17,291	-0.2	-0.5	17,292	0.2	-0.4

Notes:
[1] Negative percentages indicate a reduced area relative to the reference period.
[2] Total corridor area is smaller, 16,500 ha (82.5 km x 2 km), as mapping units were extended past the 2 km buffer at the Hay and Kotaro rivers to avoid dissecting map polygons in these areas. See Appendix 13E for additional detail.

The most common vegetated site series is TB (Lt-buckbean), occupying 27 percent of the corridor, while the least common site series is SH (Sw-Currant-Horsetail), occupying 6.5 percent of the corridor.

Project Effects

Project disturbance will not significantly affect community diversity within the corridor or beyond. The majority of disturbance will fall within the TB (Lt—buckbean) site series, but construction will disturb only 1.4 percent of the available area within the corridor. From a percentage perspective, the SG (Sedge-Grass fen) site series will be most impacted, with 2.4 percent of its available area falling within the Project footprint.

Both of these site series are low-lying, poorly drained landforms that could also be locally affected by altered drainage patterns along the ROW. However, as previously discussed, grading and surface modifications will be minimized through such landforms as standard construction practice, and mitigation measures discussed in Section 13.6.8 will implemented to maintain natural cross-ROW drainage patterns. Therefore, it is concluded that all of the site series will remain well-represented with or without the effects of the Project, and botanical diversity at the community level will not be significantly affected.

In summary, while the Project will slightly modify the distribution and aerial extent of site series within the corridor for the long term, Project effects on actual site series diversity are considered to be Low Magnitude, as no site series will be eliminated from or threatened within the corridor.

Cumulative Effects

Table 13.6-7 tracks the cumulative change of site series areas within the corridor from all known and predicted cumulative effects. To better interpret the level of change, site series areas under Hypothetical Baseline conditions (i.e., in the absence of all known disturbance) has been used as the baseline reference point. Other assessment scenarios included in the table are Baseline, (2002), Construction (2003) and Operations (2007).

Under Baseline conditions, the greatest amount of existing cumulative disturbance has occurred within the AM site series, with 72 ha or 2 percent of the available site series affected. From a percentage perspective, the BS site series has been most impacted, with 2.1 percent of its available area falling within cumulative footprints. It should be noted that the SG site series actually shows an 8.3 percent increase in area from Hypothetical Baseline to Baseline. As much of the cumulative disturbance in the area (i.e., seismic lines) has recovered to a sedge-grass fen structure, this site series has demonstrated an increase in areal extent.

At the time of construction, the greatest amount of cumulative disturbance, including the Project, is predicted to occur within the TB site series, with 118 ha or 2.5 percent of the available site series affected. From a percentage perspective, the BS site series continues to be most impacted, with 3.2 percent of its available area falling within cumulative footprints. The area of the SG site series continues to be higher than for Hypothetical Baseline conditions, but less so than at Baseline as a result of the unreclaimed ROW being developed for the Project.

For the Operations scenario, changes in the site series areas result from the reclamation of the disturbed ROW to a classified site series and on-going disturbance from other operators in the area (e.g., EnCana, Nexen). The greatest amount of cumulative disturbance, including the Project, is predicted to occur within the TB site series, with 132 ha or 2.8 percent of the available site series being affected. From a percentage perspective, the BS site series continues to be most impacted, with 3.7 percent of its available area falling within cumulative footprints. The area of the SG site series increases to 17 percent above Hypothetical Baseline conditions as the assessment assumes that the reclaimed ROW will largely recover to this community.

As with project effects, cumulative developments within the corridor will slightly modify the distribution and aerial extent of site series for the long term. However, cumulative effects on actual site series diversity are predicted to be Low Magnitude, as no site series will be eliminated from or threatened within the corridor. Therefore, as neither project nor cumulative footprints are expected to measurable change community diversity within the study corridor, there is no requirement to assess cumulative effects on diversity at a broader regional scale (i.e., Etsho RMZ).

13.6.6.3.2 Structural Diversity

Table 13.6-8 summarizes the total area within the two km-wide corridor supporting each of the defined forest structural stages, All structural stages are well represented within the corridor at baseline, with the exception of structural stages 1 (not present) and 7 (old forest). The most common structural stage at baseline is mature forest (6), occupying 30.1 percent of the corridor, followed by structural stage 3 (shrub/herb structure typically associated with more open wetland areas) occupying 29.8 percent of the corridor. Old forest occupies less than 0.1 percent of the corridor, but is well removed from the Project footprint.

Project Effects

Project disturbance will not significantly affect structural diversity within the corridor relative to baseline conditions. The majority of disturbance will fall within the mature forest structural stage (s.s. 6), but construction will disturb only 1 percent of the available area within the corridor. From a percentage perspective, the herb structural stage (s.s.2) will be most impacted, with 2.3 percent of its available area falling within the Project footprint. It is of note that project-related clearing and reclamation will generally convert older structural stages into structural stages 2 and, to a lesser degree 3.

In summary, while the Project will slightly modify the distribution and aerial extent of structural stages within the corridor for the long term, Project effects on actual structural diversity are considered to be Low Magnitude, as no uncommon structural stages such as old forest, will be eliminated from or threatened within the corridor.

Cumulative Effects

Table 13.6-8 tracks the cumulative change of structural stage areas within the corridor, from all known and predicted cumulative effects. To better interpret the level of change, structural stage areas under Hypothetical Baseline conditions (i.e., in the absence of all known disturbance) has been used as the reference point. Other assessment scenarios included in the table are Baseline, (early February 2003), Construction (2003) and Operations (2007).

Under Baseline conditions, the greatest amount of existing cumulative disturbance has occurred within the mature forest structural stage (s.s.6), with 79 ha or 1.5 percent of the available structural stage affected. The herb structural stage (s.s. 2) was the only stage to increase in area as reclaimed disturbances are dominated by herbs for several years after reclamation the herb layer increased 166 ha or 8.3 per cent.

At the time of construction, the greatest amount of cumulative disturbance including the Project, is predicted to occur within the mature forest structural stage (s.s. 6), with 130 ha or 2.4 per cent affected. From a percentage perspective, the pole/sapling structural stage (s.s. 4) is most reduced, with 3.0 percent of its available area falling within cumulative footprints while the herb stage increases 5.8 percent.

For the Operations scenario, changes in the structural stage areas result from the reclamation of the disturbed ROW to a lower structural stage and on-going disturbance from other operators in the area (e.g., EnCana, Nexen). The greatest amount of cumulative disturbance, including the Project, is predicted to occur within the mature forest structural stage, with 141 ha or 2.7 percent of the available structural stage being affected. The area of the herb structural stage increases 16.6 percent above Hypothetical Baseline conditions as the assessment assumes that the reclaimed ROW will be dominated by herbs for several years after reclamation.

As with project effects, cumulative developments within the corridor will slightly modify the distribution and aerial extent of structural stages for the long term. However, cumulative effects on actual structural diversity are predicted to be low magnitude, as no structural stages will be eliminated from or threatened within the corridor. Therefore, as neither project nor cumulative footprints are expected to measurable change structural diversity within the study corridor, there is no requirement to assess cumulative effects on diversity at a broader regional scale (i.e., Etsho RMZ).

Table 13.6-8 Change in Structural Stage from Hypothetical Baseline Through Operations

	Hypothetical Baseline		Baseline		Construction			Operations without Project			Operations with Project		
Structural Stage	Area (ha)	Percent of Mapped Corridor	Area (ha)	% Change from Hypothetical Baseline	Area (ha)	% Change from Hypothetical Baseline	% Change From Baseline	Area (ha)	% Change from Hypothetical Baseline	% Change from Baseline	Area (ha)	% Change from Hypothetical Baseline	% Change from Baseline
0[1]	451	2.6	501	11.1	711	57.6	41.9	529	17.3	5.6	528	17.1	5.4
1	0	0	0	-	0	-	0.0	0	-	0.0	0	-	0.0
2	2001	11.5	2167	8.3	2117	5.8	-2.3	2173	8.6	0.3	2333	16.6	7.7
3	5262	30.3	5186	-1.4	5136	-2.4	-1.0	5177	-1.6	-0.2	5128	-2.5	-1.1
4	1754	10.1	1724	-1.7	1701	-3	-1.3	1721	-1.9	-0.2	1698	-3.2	-1.5
5	2570	14.8	2539	-1.2	2503	-2.6	-1.4	2527	-1.7	-0.5	2492	-3	-1.9
6	5316	30.6	5237	-1.5	5186	-2.4	-1.0	5227	-1.7	-0.2	5175	-2.7	-1.2
7	16	0.1	16	0	16	0	0.0	16	0	0.0	16	0	0.0
Total	17370		17370		17370			17370			17370		

Note: [1] Non-vegetated areas such as waterways.

13.6.6.3.3 Species Level Diversity

Project Effects

Species level diversity (rare plants and traditional use plants), and rare plant communities will be evaluated at a project effect level, as there are no records documenting past cumulative impacts in the study corridor. Species level diversity data will be collected in June and July or August, 2003. Surveys will be conducted to identify rare plants and rare communities. First Nations will assist with identifying traditionally important species and collecting sites.

At the time of Construction, the greatest risk is of direct loss of rare plants, rare communities and traditional plant collecting sites. Globally, Nationally, and S1 Provincially rare plants will be avoided, however, some individuals of S2 or S3 rare plants, and portions of traditional collecting sites may be affected by construction. Changes due to altered drainage and competition from non-native invasive species will be minimized, but some impacts may occur, resulting in impacts of Moderate Magnitude.

For the Operations scenario, impacts from changes in hydrology due to thermokarst and impacts from weed control could affect rare plants, rare communities or traditional plant collecting sites. These changes will be minimized (section 13.1.8), but some impacts may occur, resulting in impacts of Moderate Magnitude.

Any impacts to rare plants and rare communities will be Long Term, as rare plant populations are not only habitat specific, but may also depend on other unknown limiting factors, and cannot be easily reclaimed.

13.6.7 Cumulative Effects Implications

13.6.7.1 Combined Project Effects

13.6.7.1.1 Community Level Diversity

Vegetation clearing and altered local hydrology were assessed on an individual basis and were determined not to have significant impacts. The combined effects will slightly modify the distribution and aerial extent of site series and structural stages for the long term. However, combined Project effects on community level diversity are predicted to be Low Magnitude, as no site series or structural stages will be eliminated from or threatened within the corridor.

13.6.7.1.2 Species Level Diversity

Vegetation clearing, altered local hydrology, and weed introduction, were assessed on an individual basis. Vegetation clearing, altered hydrology and weed introduction may affect rare plants, rare plant communities and traditional plant collecting sites. Mitigation will address all three issues and ensure that the combined Magnitude will remain Moderate. Any impacts to rare plants and rare plant communities will be Long Term.

13.6.7.2 Project Contributions to Regional Cumulative Effects

As previously discussed, cumulative developments within the corridor will slightly modify the distribution and aerial extent of site series and structural stages for the long term. However, cumulative effects on actual botanical diversity are predicted to be Low Magnitude, as no site series or structural stages will be eliminated from or threatened within the corridor. Therefore, as neither Project nor cumulative footprints are expected to measurable change botanical diversity within the study corridor, there is no requirement to assess cumulative effects on diversity at a broader regional scale (i.e., Etsho RMZ).

13.6.8 Follow-up and Monitoring

A post-construction survey of the ROW will be conducted during the first growing seasons following construction (2004). This reconnaissance survey will focus on:

- the condition of access management measures (i.e., rollback areas),
- revegetation progress and weed outbreaks,
- erosion features on the ROW
- ditch and ROW subsidence, particularly in delineated permafrost areas
- the condition of specialty reclamation measures (i.e., bank reconstruction and transplants at stream crossings)

Depending on the results of the rare plant surveys and associated mitigation developed for the species at risk, the survey may be timed to also allow for an assessment of ROW conditions, plant survival and overall mitigation success at sites of particular concern.

Depending on the findings of this first survey, a second year of monitoring may be required to continue to track outstanding issues.