PORT COLBORNE CBRA – ECOLOGICAL RISK ASSESSMENT

NATURAL ENVIRONMENT

Volume I – Main Report

Project No. ONT33828

Prepared for

Inco Limited
145 King Street West, Suite 1500
Toronto, Ontario M5H 4B7

Prepared by

Jacques Whitford Limited
7271 Warden Avenue
Markham, Ontario
L3R 5X5

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This document represents results and findings of the Ecological Risk Assessment for the natural environment, a component of the Community Based Risk Assessment (CBRA) that is being conducted in the City of Port Colborne. This report should not be taken out of the overall context, goals and scope of the CBRA being conducted by Jacques Whitford Limited.

Ron Huizer, B.Sc. (Hons)
Manager, Risk Assessment-Natural Environment

Cecile Willert, B.A.Sc., P.Eng.
Senior Risk Assessment Reviewer

Matt Holder, M.Sc.
Risk Assessment-Natural Environment

Oliver Curran, B.Sc. (Hons)
Risk Assessment-Natural Environment

William Stiebel, M.Sc., P.Geo.
Project Officer

Eric Veska, Ph.D., P. Geo., C.Chem.
Project Manager

FOREWORD

This report presents the Ecological Risk Assessment for the Natural Environment prepared by Jacques Whitford Limited for the Community Based Risk Assessment (CBRA), Port Colborne, Ontario. Following two years of field investigations (2001-2002) a draft of the report was completed in July 2003 and provided to the CBRA's Public Liaison Committee (PLC) for public review and comment. In addition, the draft report received independent third party review. The report presented under this cover has taken into account the comments provided by this review process and, where required, comments have been addressed within the body of this report.

This report has been prepared for submission to the PLC and Ontario Ministry of the Environment as one component of the CBRA that is being conducted in the City of Port Colborne. Should public or government agency review and comment of this report require Jacques Whitford to address specific aspects of this report, addenda to the report will be prepared and submitted to the PLC and MOE.

ES0 EXECUTIVE SUMMARY

ES1 Introduction

This report presents details on the Ecological Risk Assessment (ERA) conducted for Inco Limited (Inco) by Jacques Whitford Limited (Jacques Whitford) as part of the Port Colborne Community Based Risk Assessment (CBRA).

The City of Port Colborne (the City) is located along the north shore of Lake Erie in the Regional Municipality of Niagara, in southern Ontario. The Welland Canal divides the City into east and west, and runs north-south across the Niagara Peninsula from the City northward to Lake Ontario and the City of St. Catharines. The City of Port Colborne has a population of 18,450. Over 80% of the City's developed areas (commercial/residential) lie on the west side of the Canal.

Inco has operated a nickel refinery in the City of Port Colborne since 1918. Peak commercial production for nickel occurred during the 1940s and operations for the production of electrolytic nickel ended in 1984. Particulate emissions resulting from refinery operations between 1918 and 1960 principally contributed to the accumulation of particulate matter and increased levels of metals in local soils, particularly downwind of the Refinery.

Inco has acknowledged responsibility for airborne dust emissions resulting from their operations and is the proponent of the CBRA process. The purpose of the CBRA process is to assess the potential environmental and human health risks of these residual depositions in soils.

ES1.1 CBRA

Inco has committed itself to the community of Port Colborne (represented by the Public Liaison Committee, or PLC), the City and the Ontario Ministry of the Environment (MOE) to conduct a CBRA. The CBRA was conducted for the chemicals of concern (CoCs) in the Port Colborne area that have elevated concentrations in soil as a result of historical emissions from the Inco Refinery. Presented under a separate cover, the CoCs were determined to be:

- Nickel,
- Copper,
- Cobalt, and
- Arsenic.

The ERA is one component of the overall CBRA process. The components of the CBRA process include:

- An evaluation to confirm that all relevant CoCs have been considered;
- A quantitative ecological risk assessment (ERA) for the natural environment (**the focus of this report**);
- Quantitative crop studies (phytotoxicity testing);
- A quantitative Human Health Risk Assessment; and
- An evaluation of all applicable remediation options.

The ERA was conducted under two component studies, the ERA-Natural Environment, and ERA-Crop Studies. For the assessment of potential risk of CoCs in soils to vascular plants, the ERA-Natural Environment investigated the potential risk to woody vascular plants (trees and shrubs). The results of the ERA-Crop Studies, which conducted dose-response experiments under controlled greenhouse trials and test field plots, will be used to assess the potential risk to naturally occurring populations of non-woody vascular plants.

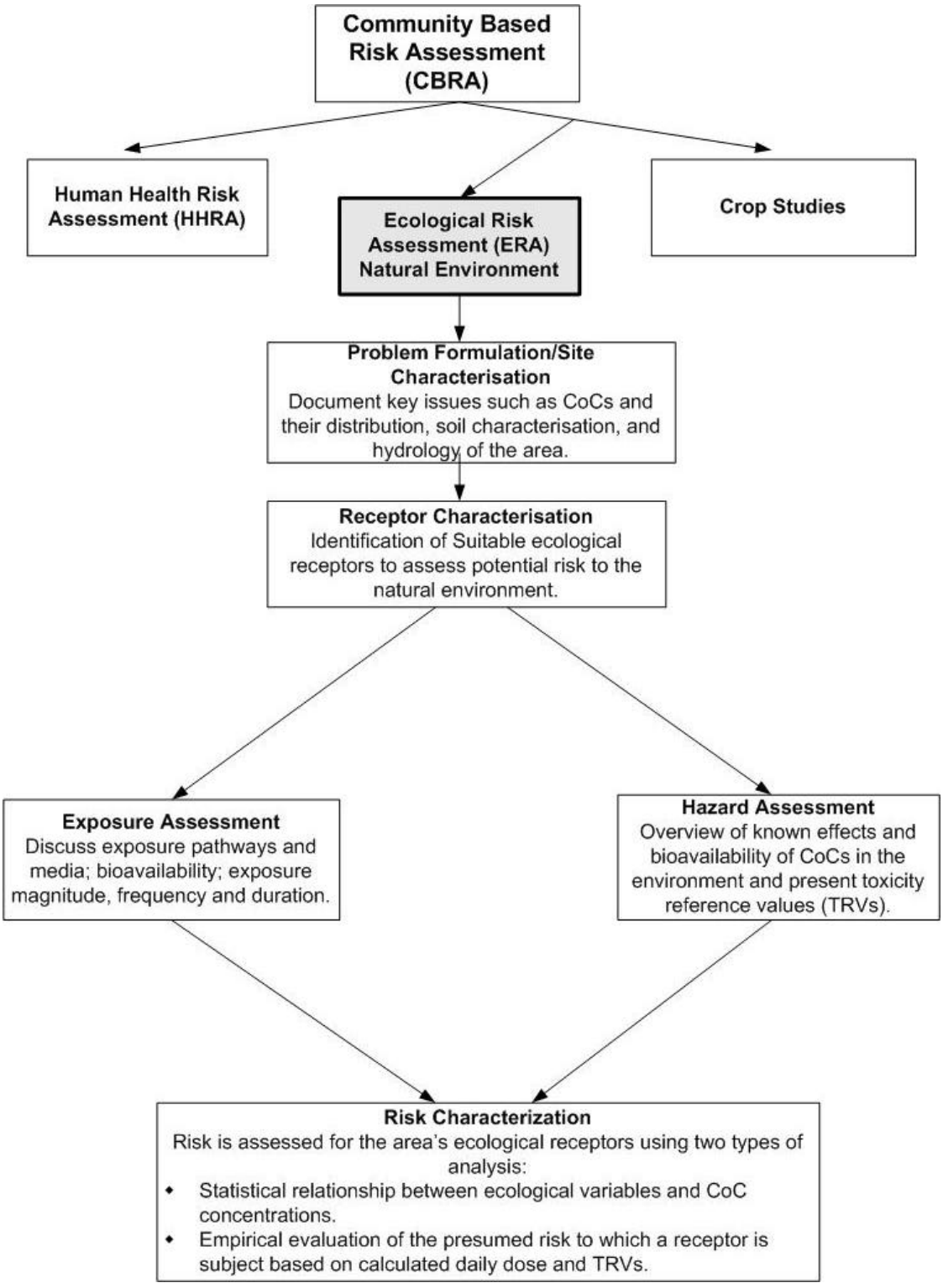
ES1.2 ERA Process

The ERA for the natural environment was conducted according to accepted Canadian and Ontario guidelines, including, *A Framework for Ecological Risk Assessment, General Guidance-National Contaminated Sites Remediation Programme (*CCME 1996*); A Framework for Ecological Risk Assessment-Technical Appendices (*CCME 1997a*) and Guidance on Site Specific Risk Assessment Use at Contaminated Sites in Ontario* (MOE 1997b). Following these guidelines, the ERA conducted assessment and analysis that included:

- Site Characterization;
- Problem Formulation and Identification of CoCs;
- Hazard Assessment;
- Receptor Characterization
- Exposure Assessment; and
- Risk Characterization.

A deterministic approach was used for this ERA, following a detailed quantitative assessment methodology based on a combination of site-specific data collected and existing information found in the literature. The steps involved in a site-specific risk assessment approach are illustrated in Figure ES-1.

Figure ES-1: Design Approach to Site-Specific Risk Assessment



ES.1.2.1 ERA Objectives

The primary objective of the ERA-Natural Environment was to determine if CoCs in soils, as a result of Refinery emissions, present a potentially unacceptable risk to the natural environment found in the Port Colborne area. For the ERA, an unacceptable risk is defined as an estimated risk linked to the occurrence of soil concentrations of CoCs that prevents sustainable populations(s) of flora and fauna, or prevents a sustainable level of ecological functioning, within the defined Study Area. If an unacceptable risk was estimated, the ERA had the follow-up objective of estimating the levels to which CoCs must be lowered or controlled in order to produce safe or acceptable levels at which adverse effects on populations or ecological processes are not expected.

ES1.3 Scope of Work

Since the present ERA focuses on the natural environment, human-influenced environments such as parks, playgrounds, gardens, residential yards and rock quarries were not considered natural environments for the ERA. Livestock and pets, which are not naturally occurring fauna, were not considered as receptors for the ERA. For the determination of potential risk to the natural environment, assessment of risk was undertaken for naturally occurring receptors found in the terrestrial environments including woodlot and field habitats and the shoreline of Lake Erie. However, the aquatic environment of Lake Erie was not examined within the scope of the ERA, as water and sediment in Lake Erie are potentially influenced by factors other than those associated with the chemical and physical behaviour of soils. Inland aquatic environments, including ponds, ditches and municipal drains were considered to have a direct linkage to the occurrence of CoCs in soils, and as a result of public concern for potential exposure of amphibians to CoCs, these inland aquatic environments were included within the scope of the ERA.

Generally, Inco lands directly associated with the Refinery site and identified within the Refinery site's Closure Plan were excluded from the ERA's scope of work. The environmental management of these lands is pursuant to the requirements of the *Mining Act* of Ontario and is outside the CBRA process. However, a limited set of field data were collected from the eastern portion of the lands covered by the Closure Plan, where significant natural areas were identified and where soil CoC concentrations were known to be high. Although these natural areas occurred on lands identified within the Closure Plan, it was apparent that the simple presence of a road and fence would not provide a barrier to the movement of bird and mammal receptors.

ES1.4 Study Design and Approach

For conducting the ERA, the lands east of the Refinery site where soil nickel concentrations exceeded the MOE generic guideline of 200 mg/kg were identified as the Study Area for investigation. Based on soil data collected by the Ministry of the Environment in 1998 and 1999, a Study Area of approximately 22 km^2 of natural environment was identified. Within this Study Area, a Primary Study Area was identified where soil nickel concentration were greater than 500 mg/kg, according to 1998 and 1999 MOE data. A Secondary Study Area was identified where soil nickel values ranged from 200 to 500 mg/kg, according to the aforementioned MOE data. These two nested study areas were identified to direct data collection efforts in areas where soil CoCs are high to moderate.

The characterization of potential risk to a receptor, or valued ecological component (VEC), was based on potential exposure to a VEC's population. For the purpose of this ERA, a VEC's population was defined as all individuals of a species (plant or animal) that inhabit or occur within the entire Study Area (both Primary and Secondary Study Areas combined). To determine various exposures of biota in the Study Area to CoCs, two natural habitat types – fields and woodlots – were identified, and two soil types – clay soils and organic soils – were identified. Data were collected, where possible, based on the following matrix:

Habitat Type	Primary Study Area (>500 mg/kg Ni)		Secondary Study Area (<500 to 200 mg/kg Ni)	
	Clay Soil	Organic Soil	Clay Soil	Organic Soil
Fallow/Old Fields	X	X	X	X
Woodlots	X	X	X	X

The ERA was conducted using site-specific data of sufficient scope to represent all natural lands and biota in the CoC impacted areas. The data were collected following data collection protocols that were specifically developed for the CBRA. Site-specific parameters were used to the maximum extent practical to calculate a receptor's exposure to the CoCs. Site-specific field data collected for the CBRA and used in the ERA include:

- Soil types (clay, organic);
- Ecological Land Classification (ecosite);
- Significant Natural Areas;
- Species inventory (trees, shrubs, birds, mammals, reptiles, amphibians, earthworms and insects);

- Soil CoC concentrations;
- Groundwater CoC concentrations (drilled wells);
- Surface water CoC concentrations (ponds, ditches, municipal drains);
- Sediment CoC concentrations (ponds, ditches, municipal drains);
- Ambient air/dust CoC concentrations;
- biotic tissue CoC concentrations (plant, animal, maple sap, invertebrate);
- Maple leaf health;
- Woodlot health; and
- Leaf litter decomposition

In addition to the data collected from the field, the following specific studies were undertaken using site-specific clay and organic soils:

- Relative oral bioavailability of nickel from soils to mammals;
- Bioaccessibility of copper and cobalt;
- Maple seed germination-sapling growth dose response greenhouse trials; and,
- Earthworm toxicity tests.

Data were collected over a two year period, during which detailed species inventories were conducted and over 700 site-specific samples were collected for analysis. Combined, the qualitative and quantitative data collected for the study represents the largest site specific data set ever collected for conducting an ERA in Canada.

ES2 Problem Formulation

For the ERA it is necessary to describe the nature and scope of the CoCs released to the environment from the Refinery in order to identify the key issues and concerns to help focus the efforts of the studies. Based on an assessment of historic emissions from the Inco Refinery, peak particulate air emissions occurred during the operation period from 1918-1930, during which nickel emissions approached 700 tonnes annually.

The local natural environment predominantly downwind (northeast) of the Refinery was exposed to the greatest atmospheric deposition of particulates for a period of approximately forty years (1918-1960). It is during this period that the particulate matter principally accumulated in the local soils. From the 1980s, and particularly through the 1990s to the present, potential harmful environmental effects on local biota due to direct atmospheric depositions are considered to have been greatly reduced compared to past-elevated levels. The levels of historic accumulated

particulate matter in the local surface soils have remained unchanged from the late 1970s through to the present.

Analyses of soils for the CBRA have found that soil CoC concentrations decrease with distance from the source in a north-easterly direction, since prevailing winds from the southwest distribute the majority of particulate emissions in a northeast direction across the Study Area. Based on the results of soil sampling in the Study Area, surface (0-20 cm depth) soil CoC concentrations are similar for both the organic and clay soils that are located at similar distance northeast from the Refinery, even though the organic soils are more permeable than the clays. To determine the vertical distribution of CoCs in soil, a test-pitting program was conducted to a depth of 1.0 m in Study Area soils. Generally, it was determined that CoCs are restricted to upper regions of the soil profile from 0 to 20 cm, for both clay and organic soils. For this study, the 0-5 cm horizon is considered to represent the area of primary interaction of soil CoCs with most biological receptors. In addition, for both clay and organic soils, the 0-5 cm soil depth interval represents a zone where CoC values can be considered to be representative of higher concentrations. The 0-5 cm soil depth interval therefore is the depth at which most soil samples were obtained and chemically analyzed throughout the Study Area.

Tables ES-1 and ES-2 present a summary of the concentrations of the CoCs in the 0-5 cm soil layer in the fields and woodlots of the Study Area and reference area.

Table ES-1 Soil CoCs in Fields

Calculation	Primary Study Area (mg/kg)				Secondary Study Area (mg/kg)				Reference (mg/kg)			
	Nickel (Ni)	Copper (Cu)	Cobalt (Co)	Arsenic (As)	Ni	Cu	Co	As	Ni	Cu	Co	As
Minimum (Min)	103	30	8	2.9	16	1	4	0.5	13	9	3	1.3
Maximum (Max)	10525	1400	153	48.1	1280	139	24	19.9	1100	140	27	10.0
Mean	1354	177	30	10.4	293	49	11	5.0	81	27	9	3.9
Standard Deviation (SD)	1391	173	20	7.4	225	27	4	3.6	111	15	4	1.5
Sample Size (N)	127	127	127	114	36	36	36	36	112	112	112	104

Derived from Jacques Whitford, MOE, AMEC data. For a listing of data please refer to Volume III

Table ES-2 Soil CoCs in Woodlots

Calculation	Primary Study Area (mg/kg)				Secondary Study Area (mg/kg)				Reference Area (mg/kg)			
	Ni	Cu	Co	As	Ni	Cu	Co	As	Ni	Cu	Co	As
Min	303	52	9	4.0	126	31	7	2.8	16	8	1	0.9
Max	33000	3930	427	137.0	2110	275	57	15.4	185	55	12	11.0
Mean	7158	921	110	43.1	777	115	22	7.5	96	28	7	5.6
SD	8196	1083	112	40.6	540	62	13	3.2	51	15	3	2.6
N	38				17				23			

Derived from Jacques Whitford and MOE data. For a listing of data refer to Volume III

Further analysis of the distribution of the CoCs in the local soils determined that woodlots nearest the Refinery had the highest concentrations, when compared to fields, and that the highest levels in woodlots were found on the western, windward edge of the woodlots closest to the Refinery (Table ES-3).

Table ES-3 A Comparison of Soil Nickel Concentrations in Woodlots and Adjacent Fields at Various Distances from the Inco Refinery

Approximate Linear Distance of Woodlot from Refinery (km)	Woodlot Soil Ni Concentration (mg/kg)	Approximate Linear Distance of Woodlot from Adjacent Field (km)	Adjacent Field Ni Concentration (mg/kg)
1.0	33 000 (A3-0-5)	0.35	1860 (I-H-3)
4.2	709 (LL6)	0.7	145 (I-M-2)
4.8	550 (LL10)	0.4	156 (I-M-4)

*Code in brackets represents field sample/laboratory code.

Sampling of sediments in ponds and ditches found that CoC concentrations in sediment generally follow a pattern similar to soil CoCs, with the CoC concentrations increasing in sediment as one moves closer to the source of the emissions. Sampling of surface water found trends related to distance from the source and habitat type. On average, higher nickel concentrations in surface water occur in areas closer to the Refinery. Also, nickel concentrations in surface water were found to be greater in woodlots compared to fields (Table ES-4).

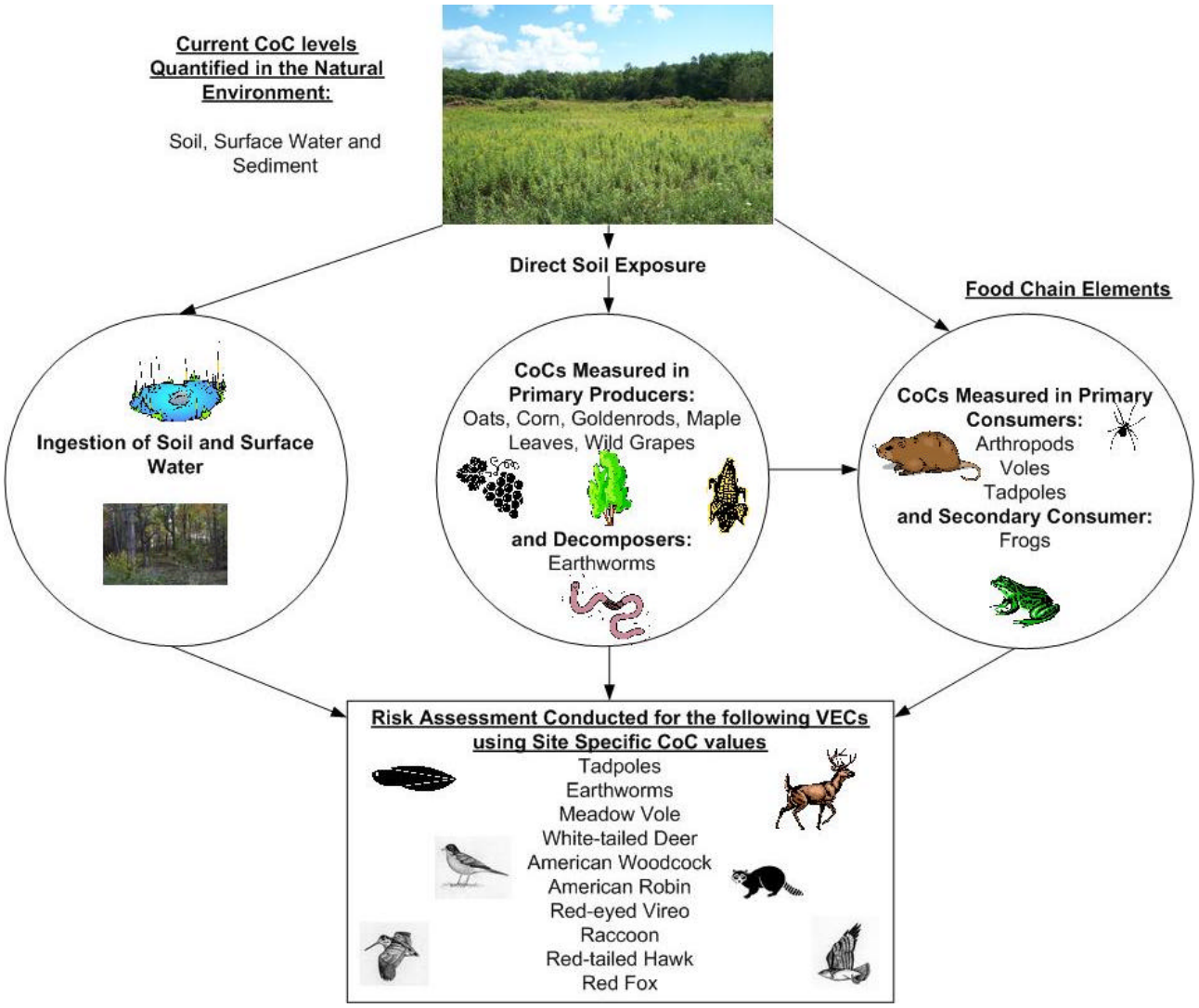
Table ES-4 Mean Surface Water CoC Values

Calculation	Primary Study Area (mg/kg)				Secondary Study Area (mg/kg)				Reference Area (mg/kg)			
	Ni	Cu	Co	As	Ni	Cu	Co	As	Ni	Cu	Co	As
Min	0.004	0.0015	0.0001	0.001	0.003	0.0014	0.0002	0.001	0.001	0.0005	0.0001	0.001
Max	0.884	0.0820	0.0377	0.038	0.092	0.0124	0.0042	0.001	0.013	0.0137	0.0041	0.001
Mean	0.159	0.0179	0.0064	0.004	0.040	0.0063	0.0018	0.001	0.005	0.0045	0.0011	0.001
SD	0.302	0.0295	0.0119	0.011	0.028	0.0035	0.0013	0.001	0.005	0.0045	0.0014	0.001
N	11				13				8			
Mean pH	7.2				7.1				7.3			
Site Codes	(S1-S4,S8,S19-S20,S22,S28,S31-S32)				(S5-S6,S9,S11,S13-S18,S21,S29,S33)				(S23-S26,S34-S37)			

Ambient air quality was monitored between 11 August and 10 September 2001 at various locations in and near Port Colborne. The results of this analysis found CoC ambient air concentrations are elevated in the Study Area when compared to the reference area, however, all measured CoCs in ambient air during this sampling program within the Study Area were within MOE guidelines.

Information gathered for the ERA indicates that historical atmospheric particulate emissions from the Refinery have resulted in deposition of CoCs in soil of the Study Area at concentrations greater than MOE generic soil quality guidelines. The CoCs have been identified to be present in four environmental media: soil, sediment, surface water (in ditches and ponds) and ambient air. Since CoC concentrations in soil exceed MOE Guidelines, a potential risk exists for plants (primary producers) and soil fauna (decomposers) from direct soil exposure, and to fauna through exposure to soil, water and diet. A potential risk to the natural environment is a product of a hazard (CoCs), a receptor (or VEC), and a route of exposure. Thus, a risk to a VEC from a CoC can only occur if there is an operational route of exposure. Based on the assessment of the occurrence of CoCs in the environment, Figure ES-2 presents the conceptual model for the ERA.

Figure ES-2: Schematic Illustration of the Conceptual Model for Natural Environment Receptors



ES3 Ecological Site Characterization

Field investigations and review of existing reports identified that the Port Colborne area is representative of much of the Niagara Region's natural landscape, where only small pockets of historically cut and logged woodlots remain. In this respect, the lands east of the Refinery are typical for the region, with only a highly altered and significantly fragmented natural landscape remaining. Much of the Study Area is agricultural land consisting of cash crops (mostly feed corn), hay/pasture lands and fallow lands. Forested areas, represented by small woodlots, represent only 15% of the Study Area. Due primarily to the rarity of forest habitat in the Niagara Region, two woodlots within the Study Area in close proximity to the Refinery have been identified by the Regional Municipality of Niagara as Environmentally Sensitive Areas. Table ES-5 presents the Significant Natural Areas identified for the ERA.

Table ES-5 Known Significant Natural Areas

Natural Feature		Area (ha)	Designation*
Primary Study Area			
1	Nickel Beach Wetland	58	PSW
2	Nickel Beach Woodlot	47	ESA
Secondary Study Area			
3	Weaver Road Woodlot	82	ESA
4	Humberstone Swamp/Forest	380	PSW, ESA, ANSI

* PSW – Provincially Significant Wetland, as evaluated by the Ontario Wetland Evaluation System, MNR
ESA – Environmentally Sensitive Area, Regional Municipality of Niagara Environmentally Sensitive Area
ANSI – Area of Natural and Scientific Interest, MNR

Within the Study Area, the sand dunes along the lakeshore are, for the most part, disturbed by historical human activity associated with Nickel Beach. Nevertheless, select pockets of the dunes are representative of active dune communities, a community type that is under threat in southern Ontario. In addition the provincially rare Hop-Tree (*Ptelea trifoliata*) is present in this community.

Field investigations found that plant and animal species common to Niagara Region were also found to be widespread and common in the Study Area. No significant obvious gaps in species occurrence or representation were noted during the assessment. Thirty-eight tree species and forty six shrub species were recorded for the Study Area. Although the total area of woodlands in the Study Area is relatively small (<50 ha), the number of woody plant species recorded is considered to represent high species richness for woodlots in southern Ontario. Based on the known

distribution of tree and shrub species in the Niagara Region and their habitat requirements, over 90% of the tree species and 80% of the shrub species that should occur were recorded in the Primary Study Area. In addition to the observed species richness, four tree species found to occur in the Primary Study Area are considered rare in the province: Pignut Hickory (*Carya glabra*), Pin Oak (*Quercus palustris*), Swamp White Oak (*Q. bicolor*), and Hop-Tree.

During this study, a total of 78 species of birds were considered to be breeding in the Study Area, the majority of which (80%) were associated with the woodlot habitats. Evidence of breeding was observed for three provincially significant species and for an additional three species considered regionally significant. A total of 20 mammal species were recorded in the Study Area, representing approximately 50% of the Region's mammal species. Mammal species not recorded may well occur in the Study Area, as the vast majority of those species not recorded are small mammals (e.g., bats, shrews, voles and moles) that are difficult to detect and/or identify. Nine species of amphibian and five species of reptile were documented during field surveys. Of particular interest was the identification of a breeding site for the provincially and nationally threatened Fowler's Toad (*Bufo fowleri*), a species which is limited to shoreline dune habitats along the north shore of Lake Erie.

ES4 Receptor Characterization

A critical element of the ERA was the selection of receptors or VECs on which a risk assessment was undertaken. The selection of VECs for the study was based on specific criteria developed for the ERA, on information gathered during site characterisation, and on input from the PLC and MOE. Criteria for determining suitable VECs for this ERA included the following:

- The potential VEC represents organisms in a major trophic level;
- The potential VEC is prevalent in, and typical of, the Study Area;
- The potential VEC represents a major vegetation component in the Study Area;
- The potential VEC is an important ecosystem process; and/or,
- For animals in higher trophic levels, life history and metabolic data necessary for quantitative risk assessment are either readily available or could be estimated using recognized (standard) equations.

Based on these factors, Table ES-6 presents the 14 VECs that were identified for the risk assessment.

Table ES-6 VECs Selected for the ERA

Decomposers	**Plants**	**Birds**
Earthworms	Maple (leaves/seeds)	Red-tailed Hawk
Woodlot litter (decomposition by invertebrates/ bacteria/fungi)	Woodlots (tree species)	American Woodcock
		American Robin
		Red-eyed Vireo
Amphibians	**Mammals**	
Frogs, general (adults/tadpoles)	Meadow Voles	
Fowler's Toad	Raccoon	
	Red Fox	
	White-tailed Deer	

ES5 Toxicity and Hazard Assessment

The toxicity assessment attempts to identify how chemicals can enter and move through the environment and their potential effects on biota (e.g., mortality of an individual, reduction in growth, reduced reproduction, etc.). A detailed review of the toxicological properties for each CoC was conducted and evaluated based upon literature pertaining to routes of exposure and site specific properties of the chemical.

Literature reviews for each of the four CoCs were conducted to establish Toxicity Reference Values (TRVs) that are protective of the ecological receptors identified for the ERA. The selection of appropriate endpoints (e.g., mortality or reduced weight) was guided by the protection goals for the ERA. In the current assessment, a sustainable level of a population or ecological functioning was selected as the most appropriate level of protection and thus the assessment goal.

Up to a 20% effect level of a non-severe nature (i.e., Effect Concentration - EC_{20}) was selected in this study as an adequate measure of protection for survival of the species. The 20% effect level has been applied in numerous assessments and criteria for quickly reproducing species such as plants, microbes, earthworms and fish. The 20% effect level or less has been referenced as a No Observable Effect Concentration (NOEC) in plants, soil and litter invertebrates and heterotrophic processes. For slower reproducing species with less dense populations, such as larger mammals, a 20% decrease in population may not be acceptable. For these types of populations, an effect level at or near the Lowest Observable Adverse Effect Level (LOAEL) was considered a more appropriate endpoint, provided the effect is not severe (e.g., reduced weight gain). Where LOAEL

for non-severe effects were not available, No Observed Adverse Effect Levels (NOAELs) were considered more appropriate endpoints.

ES6 Exposure Assessment

Exposure to a chemical describes any contact a plant or animal may have to that chemical or media carrying that chemical. The potential exposures of VECs to CoCs were assessed using reasonable exposure pathways and site specific data for various environmental media. Bringing together selected receptor characteristics with routes of exposure and medium-specific CoC concentrations, the exposure assessment established the frequency, duration, and magnitude of potential exposures.

ES6.1 Routes of Exposure

For mammal and bird VECs, potential exposure though ingestion, including water, soil and dietary items, was identified as the primary exposure route. Potential exposure through air inhalation and dermal exposure was not considered in the exposure assessment due to a lack of a developed methodology for evaluation of these exposure routes. For frogs and toads, exposure of tadpoles to CoCs in surface water was identified for evaluation in the exposure assessment. Tadpole ingestion of sediment and diet was identified as a potential CoC exposure route, but no literature based effects to tadpoles due to this exposure route for the CoCs were found. For trees, shrubs and earthworms, exposure to CoCs found in the surface soils was identified as the primary exposure route.

ES6.2 CoC Concentrations in the Environment

Statistical analyses of data found that accumulation of CoCs did vary based on soil types (clay and organic), but that habitat type (fields or woodlot) was generally a poor predictor of accumulation of CoCs. Examination of the data demonstrated that the relationship between the plants and animals to CoCs in soils, sediment and water, and the bioavailability of CoCs through a food chain varies significantly between the four CoCs. However, it is clear that a receptor's tissue concentration of nickel is positively related to nickel concentrations in soil and sediment. This relationship was also found to be similar for cobalt, though not as strongly as for nickel. Increasing concentrations of arsenic in soil, sediment or water were not found to be a reliable predictor of increased concentrations in biological receptors. For copper, only increasing concentrations in aquatic media (water, sediment) were found to be able to predict increased concentrations in aquatic

receptors. Increasing concentrations of copper in terrestrial soils did not result in significantly higher concentrations in tissues of terrestrial plants and animals (except for earthworms, where copper in gut soil is related to copper levels in the soil).

ES6.3 Availability of CoCs

A VEC's exposure to CoCs in the environment is dependent on CoC concentrations in soils, water and dietary items. Analyses of animal and plant tissues collected from the Study Area identified that CoC concentrations in biotic receptors are significantly lower than those found in soils, and only very small amounts of CoCs transfer from soils to higher trophic levels. Analyses of soils and vegetation tissue identified that the movement of CoCs through the food chain is significantly reduced due to a soil-plant barrier. These findings indicate that the primary source of exposure to CoCs for primary and secondary consumers in the food chain is through the ingestion of soil.

ES6.4 Bioavailability of CoCs Soil Concentrations

The bioavailability of a CoC describes its ability to be absorbed into the body and reach the blood stream or ability to be taken up by a plant. Many of the selected TRVs used in the ERA are based upon studies that examined specific forms of chemicals that are typically highly bioavailable. However, these forms of chemicals are not necessarily the same as those found in the Port Colborne soils.

For the determination of exposure to CoCs through a VEC's diet, concentrations found in plant and animal tissues were considered to be 100% bioavailable. For nickel in soils, bioavailability experiments using rats and Port Colborne clay and organic soils found that, the percentage relative bioavailability for mammals was 3.2% for organic soils and 3.9% for clay soils, compared to the bioavailability of nickel in the TRV study.

For copper, cobalt and arsenic, the bioaccessibility of these CoCs in Port Colborne clay and organic soils was assessed using a two-stage laboratory extraction method to mimic the stomach digestion and intestinal digestion in humans. The results of these tests of the bioaccessibility of cobalt, copper and arsenic in Port Colborne clay and organic soils are presented in Table ES-7.

Table ES-7 Mean Percent Bioaccessibility of Copper, Cobalt and Arsenic in Port Colborne Organic and Clay Soils using Mammalian Intestinal Phase Extraction.

Soil Type	Stage 2		
	Mean Percent Bioaccessible (n=2)		
	Cu	Co	As
Organic	5.3	4.2	37.0
Welland Clay	2.9	2.2	13.5

The ERA used the percentage relative bioaccessibility as presented in Table ES-7 to estimate how much copper, cobalt and arsenic is bioavailable to mammals in the Port Colborne area. For nickel, the percentage bioavailability for mammals was used. It is likely that the relative bioavailability of the CoCs for mammals and birds are alike, but given some differences in digestion physiology between birds and mammals, the ERA used double the mammal bioavailability and bioaccessibility values for birds (i.e. an uncertainty factor of 2 was applied).

For tadpoles, CoC concentrations found in surface water were considered to be 100% bioavailable via direct absorption through the skin. For earthworms, the primary exposure route is via concentrations of CoCs in the soil porewater. Concentrations of CoCs in porewater were not directly measured from field collected soils. Rather, results from aqueous extraction and acid ammonium oxalate extraction of clay and organic Port Colborne soils were used.

ES6.5 Medium-Specific CoC Concentrations

Site-specific CoC concentrations were used to estimate the exposure a VEC receives from food items and surrounding media (soil, surface water) when occupying the affected area. Exposure was assessed for different scenarios to help determine risks associated with different soil types or habitats. The exposure scenarios used in the ERA are as follows: overall Study Area (pooling all data from woodlots and fields, organic and clay), fields on clay soils, fields on organic soils, woodlots on clay soils, and woodlots on organic soils. Where possible, the average daily dose (ADD) was derived for each of the scenarios using scenario-specific data sets; these scenario-specific data sets were possible for soils, arthropods and earthworms. Other data sets (e.g., maple leaf tissue concentrations, frog tissue concentrations) could not be separated according to these scenarios; only an overall number was derived for these other data.

To determine what CoC concentrations should be employed to calculate a VEC's ADD, two approaches were followed, where appropriate. Where data were numerous, an Upper Confidence Limit of the Mean (UCLM) was calculated. This is an upper estimate of the mean concentration with 95%. For each set of data, the UCLM was calculated using raw data collected from the Study Area, without transformation, since this gave a more conservative (higher) value than UCLMs calculated on log-transformed data. For several data sets, observations were too few (i.e., less than 10 samples) to derive UCLMs. Instead, actual values from the data were chosen to represent a conservative (over-) estimate of the CoC concentrations available to the VECs from that source. Overall concentrations of CoCs in relevant media are presented in Table ES-8. Scenario-specific values for soils, arthropods and earthworms are presented in ES-9. These values were used to calculate the ADD of the receptors.

Table ES-8 CoC Concentrations in Exposure Media within the Study Area and Local Environs used to Calculate CoC Doses.

	Nickel[7]	**Copper**[7]	**Cobalt**[7]	**Arsenic**[7]
Soil (mg/kg)[1]	2650	350	47	18
Surface Water (mg/l)[6]	0.178	0.018	0.006	0.005
Maple Tissue – leaves (mg/kg)	12.3	10.5	0.4	0.4
Goldenrod Tissue (mg/kg)[3]	29.6	12.4	1.4	0.3
Corn Tissue – seeds (mg/kg) [2,3]	2.7	3.2	0.3	0.2
Oat Tissue – seeds (mg/kg) [2,3]	62.3	6.8	0.2	0.1
Oat Tissue – leaves (mg/kg) [2,3]	23.6	9.9	0.4	1.9
Wild Grape Tissue (mg/kg)	1.6	12.0	0.03	0.1
Frog Tissue (mg/kg)[4]	3.9	36.0	0.4	0.5
Meadow Vole Tissue (mg/kg)[5]	18.6	11.0	1.3	0.6

Notes

1 Based on all data (clay and organic, field and woodlot combined) sampled by MOE and Jacques Whitford in the Study Area and within 2km of the eastern boundary. Only data from the 0-5cm depth were used.
2 Calculated from analytical results of crops growing on unamended clay soils and, for corn, supplementary 2002 sampling.
3 Data on which these calculations are based are available in Jacques Whitford (2003a).
4 Based on total frog (weighted average of tissue concentrations, using mass)
5 Based on total vole (weighted average of tissue concentrations, using mass)
6 Total CoC concentration.
7 Identification of values as either UCLMs or maximums is presented in Table 6-16.

Table ES-9 CoC Concentrations in Soils, Arthropods and Earthworms within the Study Area used to Calculate CoC Doses for the Four Habitat/Soil Type Scenarios.

		Clay		Organic	
		Woodlot	**Field**	**Woodlot**	**Field**
Soil	**Ni**	1630	1090	15,200	2020
	Cu	180	140	2020	308
	Co	33	27	219	37
	As	12	8	83	20
Worms[1]	**Ni**[2]	180	180	180	180
	Cu[2]	52	52	52	52
	Co	10.1	13.7	21.9	10.6
	As	4.2	9.6	8.9	8.2
Arthropods	**Ni**[2]	12.5	12.5	12.5	12.5
	Cu	29.6	57.0	72.6	44.6
	Co[2]	0.46	0.46	0.46	0.46
	As	0.3	0.3	0.8	0.5

Notes

1 Corrected using ratios in Table 6-10.

2 UCLM of all scenarios combined.

ES7 Risk Characterization

The ERA approach for assessing risk to the ERA's VECs involved two series of analyses. The first analysis was a statistical examination of the relationship between ecological variables, such as biomass, and concentrations of CoCs in the local environment. The second analysis was an empirical evaluation of the presumed risk to which a VEC is subject. This was based on the Quotient Method using toxicity reference values (TRVs) taken from published studies and an average daily dose (calculated using site-specific data and parameter estimates based on other published studies) or an estimated exposure concentration. A quotient is derived by dividing the TRV into the average daily dose or exposure concentration. Following the Quotient Method, a calculated ratio of greater than one was considered to represent a potential risk that should be more closely examined. A quotient value of less than one was considered to indicate that no adverse effects are expected.

Taken as a whole, the risk to receptors was assessed using a line of evidence approach, with the characterization of risk integrating results of the conservative risk calculations following the Quotient Method, qualitative field observations and experimental results for specific VECs. Following the examination of these lines of evidence, characterization of risk was based on informed professional judgement to reach conclusions of whether VECs are potentially at risk.

Generally, the study found that the populations of primary producers (plants), secondary consumers (birds, mammals, frogs/toads) and top predators (birds and mammals) are not at risk in the Study Area. However, the study identified that very high levels of CoCs in the woodlots nearest the Refinery, on organic soils, are likely having an adverse effect on the decomposer community. This potential adverse effect was indicated by lower numbers of earthworms and increased amounts of forest litter found in these woodlots. However, the level of the effect on the decomposer community, and therefore the nutrient cycle, in these woodlots, is not at a level that is impacting long-term health or productivity of these woodlots.

A summary of the overall evaluation of the results is presented below.

ES7.1 Decomposers

For an assessment of risk to the soil decomposer fauna, earthworms were studied in the field and in controlled toxicity tests. Potential risk was also calculated following the Quotient Method based on a review of published TRVs and soil CoC concentrations. Results of these lines of evidence were found not be supportive of one another with respect to what concentrations of soil CoCs produce a potential adverse effect. Ultimately, the results of field observations and studies, which sampled the earthworm community to document species richness, overall abundance and overall biomass, were considered the most reasonable line of evidence to assess risk to earthworms. The results showed that no negative response to increases in soil CoC concentrations was evident. Only for soils with very high concentrations of nickel (20,000 mg/kg) and copper (3600 mg/kg) were significant reductions in species richness and abundances of earthworms found. However, even in these soils, reproduction was found to occur. The results of the study found that the earthworm species populations across the Study Area are not at significant risk due to exposure to CoCs in soil.

In addition to the assessment of earthworms, potential impacts to decomposition of forest litter and the nutrient cycle was assessed by measuring standing litter (dry weight) in woodlots in the Study Area and control reference sites. Investigations into litter found that increasing soil CoCs were likely resulting in slower rates of decomposition, particularly for woodlots on organic soils nearest to the Refinery. However, although the rate of decomposition may be slowed, current rates of decomposition are sufficient to maintain equilibrium between fresh litter input and amount of litter decomposing each year. This assessment indicates that no significant impairment in the woodlots' nutrient cycles is occurring. This result is supported by the general assessment of individual woodlots, which found that there was no significant difference in woodlot productivity in the Study Area when compared to woodlots in reference sites. This was true even for woodlots located nearest to the Refinery where the highest soil CoC concentrations were recorded for the study (i.e., 33,000 mg/kg Ni). Based on the assessment of a number of different but linked factors, the ERA concludes that existing soil CoC levels found in the woodlots of the Study Area do not pose a significant adverse effect on the nutrient cycle or a risk to woodlot health, either for the short term or long term.

ES7.2 Woody Vascular Plants

For this component of the ERA, assessment of risk to woody vascular plants was undertaken through the field inventory of tree and shrub species, and a detailed assessment of potential risk to maple trees. Assessment of risk to non-woody vascular plants is addressed based on the results of the ERA-Crops Studies. Soft maple (including Red Maple, *Acer rubrum*, and Freeman's Maple, *A. X freemani*) was identified as representative of woody vascular plants. These trees are the predominant trees species of the Study Area's woodlots, and soft maple is reported in the literature to be sensitive to soil metals, including nickel.

Assessment of risk of soil CoCs to maple trees was undertaken following three lines of evidence: 1) maple seed germination and sapling growth in a controlled greenhouse setting; 2) leaf health assessment of naturally occurring maples trees east of the Refinery; and, 3) a general woodlot health assessment.

Greenhouse experiments that assessed maple seed germination success, sapling growth and leaf health found that no significant negative effect was found for clay or organic soils for varying soil nickel concentrations up to 3000 mg/kg of nickel. Assessment of leaf health for leaves collected from trees in the Study Area found that existing levels of CoCs in the soils did not have a significant influence on the frequency or incidence of unhealthy leaves. A review of the

concentrations of CoCs in leaf tissue for trees in the area with highest soil nickel concentrations (over 20,000 mg/kg for nickel) found that tissue levels are below the MOE current upper limit of normal concentrations for metals in tree foliage. In addition, an assessment of woodlot health for 18 woodlots in the Study Area, many of which had maples as a predominant component, found no significant difference in stand structure or productivity when compared to areas with different soil CoC concentrations within the Study Area or control reference woodlots located east and west of the Study Area.

It is concluded that existing soil CoC levels as found in the Study Area do not pose an unacceptable risk to maple tree populations, measured as either long term health of trees or decrease in populations. In addition, as soft maple had been identified as a sensitive species to soil metals, the low potential risk identified for this species indicates that populations of other woody vascular plant species in the Study Area are also not at risk. This conclusion is also supported by field inventory results, which documented a high species diversity of trees and shrubs in the Study Area.

ES7.3 Amphibians

Frogs and toads were examined to determine if existing soil CoC levels, as reflected in surface water concentrations, are having significant adverse effects on their populations. Two lines of evidence were used in the assessment: 1) potential risk to tadpoles using the Quotient Method; and, 2) the collection of field data to record the incidence and relative abundance of local frogs in the Study Area. Based on the assumption of 100% exposure to concentrations of CoCs in breeding ponds sampled, tadpoles are not at risk due to exposure to arsenic and cobalt concentrations. However, the analysis identified that nickel and copper concentrations in pond water pose a potential risk to tadpoles, with the calculated quotient values of 18 and 2 respectively. For the rare Fowler's Toad, the nickel TRV specific to this species and low levels of the CoCs in its specific breeding environment (the lakeshore) give a calculated quotient of 0.05 for nickel and <0.01 for copper. Therefore, the potential that this species is at risk is very low. For other frog and toad species, it was determined that approximately 80% of the ponds sampled throughout the Study Area have nickel concentrations that would put tadpoles potentially at risk, based on sensitive TRVs derived from the literature.

Structured spring field surveys conducted throughout the Study Area found that frog and toad species richness, incidence and relative abundance (based on calling codes) were not influenced by soil nickel concentrations. Based on this line of evidence, the calculated potential risk for nickel and copper was not found to be supported by general field observations or an analysis of field data as it relates to soil nickel in the Study Area. However, based on field surveys of calling male frogs, it was noted that the expected very high densities at quality breeding sites for some species (Spring Peeper, Chorus Frog) were not encountered. These observations indicate, at least qualitatively, that there may be some suppression in population numbers, but not at levels that affect the long term persistence of the frog and toad populations in the Study Area. Based on all available information, it is concluded that the potential risk of soil CoCs adversely affecting the maintenance of frog and toad populations in the Study Area is low.

ES7.4 Birds and Mammals

To assess the risk to terrestrial vertebrates, four species of bird and four species of mammal were identified as VECs for which risk calculations would be undertaken. Collectively, these species were selected because they represent species that occur in the Study Area and have life histories that are representative of the mammal and bird species known to occur in the Study Area. In addition, the species represent primary and secondary consumers in the ecosystem with specific and generalist dietary requirements. Taken as a whole, assessment of potential risk to these eight species is considered to represent an assessment of potential risk to all mammal and bird species that have been documented to occur in the Study Area.

Only the Quotient Method was used to determine the potential risk posed by soil CoC concentrations to these species. For the exposure assessment, the expected average daily dose (ADD) was calculated from biological tissue, water, and soil collected from the Study Area. The use of an extensive set of data collected from the Study Area for the determination of the ADD for each receptor significantly increases the relevance of the calculated risk quotients.

A summary of the findings of risk characterization for the eight receptors is provided in Table ES-10 below. For a measure of the uncertainty of the Quotient Method, values which are <0.1 are considered to represent a high certainty of no risk. For values greater than one, a possible risk cannot be ruled out based on the analysis performed.

Table ES-10 Summary of Calculated Quotient for Birds and Mammals

Receptor	Calculated Quotient for CoCs (Highest value of all soil types and habitat types)			
	Ni	Cu	Co	As
Red-tailed Hawk	0.01	0.01	0.01	0.01
American Woodcock	0.24	0.12	0.50	0.21
American Robin	0.12	0.18	0.11	0.11
Red-eyed Vireo	0.07	0.27	0.05	0.07
Meadow Vole	0.18	0.01	<0.01	0.03
White-tailed Deer	0.03	0.03	<0.01	0.01
Racoon	0.13	0.28	0.01	0.07
Red Fox	0.05	0.09	0.01	0.07

The results of the assessment show that the potential risk of soil CoCs to bird and mammal populations of the Study Area is very low. The assessment found that no receptor was considered to be at risk on clay soils or organic soils associated with field or woodlot habitats. The calculated quotients for birds and mammals are low, even where high levels of soil CoCs occur, due to the fact that the occurrence of the four CoCs in the environment is significantly reduced at the soil-plant interface, thereby restricting the transfer of CoCs through subsequent trophic levels. For the bird and mammal species assessed, the American Woodcock can be considered to be the most sensitive to CoCs in the environment, as this species' diet consists of earthworms that contain soils in their gut and are captured by the bird by probing soils. However, even for this species, using exposure data for organic soil woodlots with 15,200 mg/kg soil nickel, the calculated average daily dose for nickel was 14.29 (mg/kg d) resulting in a quotient of only 0.24, a ratio that is well below our potential risk threshold of 1.

Based on this study's findings, it is concluded that existing soil CoC concentrations in the Study Area do not present an unacceptable risk to the populations of mammals and birds found in the Study Area. This conclusion is supported by field observations, which noted a high number of bird and mammal species occurring at expected abundance levels.

ES8 Uncertainty Analysis

In an attempt to limit the uncertainty in the ERA, while still ensuring its desired conservative nature, the ERA has:

- Collected a considerable amount of site specific biogeochemical data on CoC concentrations in the Port Colborne area;
- Conducted numerous laboratory studies using Port Colborne soils; and,
- Conducted a rigorous review of literature values selected for use in all aspects of the ERA.

The overall confidence in the risk characterization is considered high and the potential risks to VECs in the Port Colborne area are not underestimated. The use of Port Colborne specific data, scientifically defensible and regulatory accepted data from the literature, coupled with scientifically credible sampling and analysis protocols, has produced an ecological risk assessment with a high degree of confidence in its conclusions.

ES9 Conclusions

For the ERA, detailed assessment of potential risk was undertaken for 14 ecological components (VECs), including mammal and bird species, amphibians (frogs and toads), earthworms, maple trees, leaf litter and woodlots. Combined, the VECs selected were considered representative of the species and ecological processes in the local area's natural environment. An assessment of potential risk to these VECs was used to determine if existing CoC soil concentrations represent a risk to the local natural environment, both now and into the future.

The objective of the CBRA was to assess the risk of adverse effects, at the scale of the community, caused by soil concentrations of CoCs. For this ERA, risk was considered unacceptable if soil concentrations of CoCs are at a level that prevents sustainability of ***population(s)*** of flora and fauna or to prevent the sustainability of ecological functioning within the defined Study Area. Based on both qualitative and quantitative assessments, the evaluation of potential risk to the Study Area's flora, fauna, and natural processes found no unacceptable risk. This description of risk to the natural environment is based on analysis of an extensive series of data specific to the soils of the Port Colborne area. In addition, the study's sampling design allowed for the collection of data in natural areas with the highest soil concentrations of the four CoCs.

Following a number of lines of evidence to assess potential risk caused by soil CoCs, no unacceptable risk to elements of the natural environment in the Study Area as a whole was identified. As a result of these findings, no *immediate* need to mitigate or manage risk to the natural environment has been identified.

ES10 Recommendations

The results of this assessment indicate that current concentrations of nickel, copper, cobalt and arsenic in the Port Colborne environment do not pose an unacceptable risk to the local populations of flora (trees, shrubs) and fauna. However the study did identify that very high soil concentrations of CoCs (>20,000 mg Ni/kg) in woodlots located directly adjacent to the Refinery site is potentially causing a local effect on earthworm abundance. Additionally, these high soil CoC concentrations may be affecting other soil decomposers, as indicated by an assessment of leaf litter decomposition. Even though these localized potential effects are not found elsewhere in the Study Area and CoCs do not pose a risk to the earthworm community or the productivity of woodlots in the Study Area on the whole, it is recommended that management of potential risk to the natural elements of these woodlots should be considered.

Based on the assessment of risk for the various VECs considered in this ERA, it is proposed that potential risk to earthworms be considered to determine "safe" soil CoC values for the purpose of assessing future management options. This recommendation is based on the following considerations:

- Earthworms, as soil-dwelling animals, have the greatest exposure to soil CoCs;
- Due to their low mobility in the environment, local earthworm communities are at a higher potential risk in woodlots and fields with high CoC concentrations;
- Earthworms are a key component for decomposition and the nutrient cycle, a process that has been identified as potentially impaired in woodlots with high soil CoCs based on an assessment of leaf litter; and,
- A "safe" soil CoC concentration for earthworms would be protective for other flora and fauna that inhabit these areas of high soil CoCs.

Based on a review of the three lines of evidence, Table ES-11 presents the recommended "safe" soil CoC concentrations based on potential adverse effects to earthworms as identified by the ERA. "Safe" soil concentrations of nickel and copper are derived from the results of soil sampling, balanced with consideration for literature-derived TRVs. "Safe" cobalt concentrations for earthworms are derived from the TRV. "Safe" arsenic concentrations in clay soils are derived

from MOE's generic table guidelines, while the results of field surveys are the basis for "safe" arsenic concentrations in organic soils.

Table ES-11 Recommended "Safe" Soil CoC Concentrations for Earthworms

Soil Type	Safe Soil CoC Concentration (mg/kg) for Earthworms			
	Ni	Cu	Co	As
Organic	3500	550	3000	40
Clay	3000	350	3000	25

It is not known which of the CoCs, or a combination of CoCs, is responsible for an observed effect in the field surveys or toxicity tests. However, for the woodlots on organic soil with very high nickel concentrations, it is assumed that nickel is the major cause of the observed effect. As a result, it is recommended that management options for these woodlots should target the reduction of soil nickel concentrations.

LIST OF REPORTS FOR THE

PORT COLBORNE COMMUNITY BASED RISK ASSESSMENT

Technical Scope of Work – Community Based Risk Assessment Plan for Port Colborne, Ontario. JW Project No. 33826. November 2000.

Summary Report on Chemicals of Concern Evaluation. Port Colborne Community Based Risk Assessment, Port Colborne, Ontario, JW Project No. 34645. November 2001.

Potential CoC Identification using Soil Chemical Concentration Data in Exceedance of MOE Generic Guidelines. Port Colborne Community Based Risk Assessment, Port Colborne, Ontario, JW Project No. 34645. November 2001.

Potential CoC Identification Using Emission Inventories and Dispersion Modelling of Inco and Algoma Operations. JW Project No. 34648. November 2001.

Potential CoC Identification using Statistical Analyses . Port Colborne Community Based Risk Assessment, Port Colborne, Ontario, JW Project No. 34647. November 2001.

Re-evaluation of Lead as a Potential Chemical of Concern (CoC). . Port Colborne Community Based Risk Assessment, Port Colborne, Ontario, Volume 1-Main Report, JW Project No. 35313. June 2004.

Bioaccessibility of Copper, Nickel, Cobalt and Arsenic in Soils Northeast of Inco Refinery, Port Colborne. Environmental Sciences Group, Royal Military College, Kingston, Ontario, Queen's University Analytical Services Unit, Kingston, Ontario. November 2002.

Port Colborne CBRA - Human Health Risk Assessment, Volume I - Main Report. Jacques Whitford Limited. December 2004.

Port Colborne CBRA - Human Health Risk Assessment, Volume II through V – Supporting Documentation. Jacques Whitford Limited. December 2004.

Port Colborne CBRA – Ecological Risk Assessment-Natural Environment, Volume I – Main Report. Jacques Whitford. September 2004.

Port Colborne CBRA – Ecological Risk Assessment-Natural Environment, Volume I through V – Supporting Documentation. Jacques Whitford. September 2004.

Port Colborne CBRA – Crop Studies, Volume I – Main Report. Jacques Whitford Limited. In Press.

Port Colborne CBRA – Crop Studies, Volume II through IV – Supporting Documentation. Jacques Whitford Limited. In Press.

GLOSSARY OF ABBREVIATIONS AND ACRONYMS

Acceptable risk	- A level of risk to flora and fauna due exposure to CoCs in Port Colborne soils that is acceptable to the Ontario Ministry of the Environment.
ADD	- Average Daily Dose
Analyte	- The substance one analyses in an experiment.
ANSI	- Area of Natural and Scientific Interest as identified by the Ontario Ministry of Natural Resources.
Aqueous	- A water based solution.
Arthropod	- Phylum (including major classes Insecta, Crustacea, Myriapoda, Arachnida), characterised by a rigid external skeleton, paired and jointed legs and a haemocoel (cavity where organs are).
As	- Symbol for the metalloid arsenic.
BAF	- Bioaccumulation Factors.
Basal Area	- The total area of a forest plot covered by the area a tree trunks.
Beak	- Beak International Inc., the PLC's consultant for the CBRA. Now known as Stantec Limited.
Bioaccumulate	- To accumulate into a biological system.
Bioavailability	- The fraction of a total chemical that can interact with a biological target (e.g., a plant or animal).
Bioconcentration	- The increase in concentration of a chemical in an organism resulting from tissue absorption levels exceeding the rate of metabolism and excretion.
Biomagnify	- Increase in concentration of a chemical from one link in a food chain to another.
Biomass	- Total mass of living matter within a given unit of environmental area.
Biota	- All living organisms in an environment.
Biotic Receptor	- An organism or group of organisms in an environment that in a risk assessment is/are identified as being potentially exposed to chemicals of concern.
BW	- Body Weight.
CBRA	- Community Based Risk Assessment.
CCME	- Canadian Council of Ministers of the Environment.
CEC	- Cation Exchange Capacity.
City	- The City of Port Colborne.

GLOSSARY OF ABBREVIATIONS AND ACRONYMS
(Continued)

Clay Soils	- Mineral soils where soil particles of <0.002 mm diameter represent 30% of the soil.
Closure Plan	- A plan developed by Inco to be submitted to the Ontario Ministry of the Environment detailing the requirements for the closure of the Port Colborne Inco Refinery Site.
Co	- Symbol for the metal element cobalt.
CO_2	- Carbon dioxide.
CoCs	- Chemicals of concern, identified for the CBRA. The CoCs are as follows, nickel, copper, cobalt, and arsenic.
Community	- All potential receptors (human and ecological) within an area of Port Colborne defined by previous MOE studies as having concentrations of CoCs in soil from Inco's historical operations above the MOE generic Table A guideline.
Confidence Limits	- An interval estimate for the mean, generating an upper and lower limit for the mean. These limits give an indication of how much uncertainty there is in the estimate of the true mean.
COSEWIC	- Committee of the Status of Endangered Wildlife in Canada. A committee that ranks species rarity in Canada based on a number of criteria
Cu	- Symbol for the metal element copper.
Detritus	- Dead and decaying plant organic matter.
Dose-Response Experiments	- Experiments designed to identify the concentration or amount of a substance that result in a measured effect on a test receptor.
Downwind	- In the direction towards which the wind blows – prevailing winds from the southwest distribute the majority of particulate emissions in a northeast direction across the Study area
DTPA	- Diethylenetriamine pentaacetic acid
DW	- Dry Weight. The mass of dried tissue (dry matter) remaining from plant parts after drying in an oven at 65 ° C for a time period allowing the plant matter to reach a stable dried weight (48 to 72 hours).
EC_{20}	- Effects Concentration where 20% of the population shows an effect.
EC_{50}	- Effects Concentration where 50% of the population shows an effect.

GLOSSARY OF ABBREVIATIONS AND ACRONYMS
(Continued)

Edaphic Factors	- Factors pertaining to soil.
ELC	- Ecological Land Classification. A standard method for defining amd mapping vegetation communities.
Emissions	- That which is sent out, or put in circulation.
EQL	- Estimated Quantitation Limit the lowest level of a parameter that can be identified with confidence by an analytical laboratory.
ERA	- Ecological Risk Assessment, as defined in the TSOW.
ERA Study Area	- Area of land located east of the Welland Canal where risk of soil CoCs to flora and fauna is assessed. Specifically, natural or agricultural lands where soils contain nickel concentrations of 200 mg/kg or greater occur, based on data collected in 1998 and 1999 by the Ontario Ministry of the Environment, excluding residential areas, the Inco Refinery site proper and large quarry located northeast of the refinery.
ESA	- Environmental Sensitive Area, as identified by the Niagara Region.
Exposure Pathway	- Routes for transfer of CoCs to biotic receptors.
Fallow	- Agricultural lands not in active crop production.
Fauna	- Animal life.
Fields	- Lands were cover by woody species (trees and shrubs) is 25% or less, including agricultural lands that are either actively cultivated or fallow.
Flora	- Plant life.
glm	- Generalized linear models. A statistical analysis method.
GPS	- Global Positioning System. Refers to a method for accurately determining locations on the surface of the earth using electronic triangulation using satellites.
HCl	- Hydrochloric acid.
Heterogeneous	- Made up of parts that are not alike, or varied.
HGAA	- Hydride Generation Atomic Absorption.
HHRA	- Human Health Risk Assessment, as defined in the TSOW.
HI-	- Hazard Index.
Hybrid	- The offspring of two animals or plants of different species or varieties.

GLOSSARY OF ABBREVIATIONS AND ACRONYMS
(Continued)

IBA	- Important Bird Area.
ICPMS	- Inductively Coupled Plasma Mass Spectrometry. An analytical technique used for the detection of trace elements in environmental samples.
ILCR -	- Incremental Lifetime Cancer Risk.
In vivo	- In the living body of an animal.
In vitro	- Outside the living body and in an artificial environment.
Inco	- Inco Limited.
Ingestion	- To take into body by mouth for digestion or absorption.
Invertebrates	- mites, collembola, nematodes, earthworms, insects, millipedes, molluscs.
Isolines / Isopleths	- Lines used to represent points of equal value.
Jacques Whitford	- Jacques Whitford Limited.
LC_{50}	- Lethal Concentration, where 50% of the population dies.
LCL	- Lower Confidence Limit.
LD_{50}	- Lethal dose where 50% of a test population dies.
Line of evidence approach	- Information derived from different sources or by different techniques that can be used to describe and interpret risk estimates. Unlike the term "weight of evidence", it does not necessarily imply assignment of quantitative weightings to information.
LOAEL	- Lowest Observed Adverse Effects Level. A level at which an adverse effect is first measurable for a receptor. Typically used as an assessment endpoint in conducting risk analysis.
LOEC	- Lowest Observed Effect Concentration. A concentration of a chemical at which an effect is first measurable for a receptor. Typically used as an endpoint in conducting risk analysis.
Microbes	- Bacteria, fungi & protozoa.
Mg/kg-day	- Milligrams of chemical exposure or dose per kilogram body weight per day.
MNR	- Ontario Ministry of Natural Resources.
MOE	- Ontario Ministry of the Environment.
NAWQC	- National Ambient Water Quality Criteria.
NC	- not calculated (due to small sample size).

GLOSSARY OF ABBREVIATIONS AND ACRONYMS
(Continued)

ND	- Non-detect, or non-detectable.
NHIC	- Natural Heritage Information Centre, A data base compiled and administered by the Ontario Ministry of Natural Resources.
Ni	- Symbol for the metal element nickel.
NOAEL	- No Observed Adverse Effects Level. A level at which no adverse effect is measurable for a receptor. Typically used as an assessment endpoint in conducting risk analysis.
NOEC	- No Observed Effects Concentration. A concentration of a chemical at which no effect is measurable for a receptor. Typically used as an endpoint in conducting risk analysis.
Non-linear regression models	- Regression models in which the terms do not enter in a purely additive fashion.
OMAFRA	- Ontario Ministry of Agriculture Food & Rural Affairs
Order of Magnitude	- An exponential change of plus or minus 1 in the value of a quantity or unit. Generally used in conjunction with power of 10 scientific notation.
Organic Soils	- Soil of 40 cm or depth with 30% or more organic matter, or 17% or more organic carbon.
PCBs	- Polychlorinated Biphenyls.
Phytotoxicity	- Being toxic to plants.
PLC	- The Public Liaison Committee of the City of Port Colborne CBRA.
Port Colborne area	- The City of Port Colborne and the rural regions around it potentially impacted by historical emissions of CoCs from the Inco Refinery.
ppm	- Parts per million – equivalent to milligrams of analyte per kilogram of medium (mg/kg) or milligrams per litre (mg/l).
Primary Consumers	- Soil and terrestrial invertebrates & and planting vertebrates.
Primary Producers	- (soil microfauna & plants).
Primary Study Area	- Lands with the Study Area where soil nickel concentration are greater or equal to 500 mg/kg.
Proponent	- A supporter of something.
Protocol	- Sets of procedures used to define how the Phytotoxicity Testing was to be carried out. These were presented to and reviewed by Beak, the TSC and the PLC.

GLOSSARY OF ABBREVIATIONS AND ACRONYMS
(Continued)

PSC	- PSC Analytical Services.
PSW	- Provincially Significant Wetland.
Purged (worms)	- Worms that have no food or soils in their gut.
Quadrants	- A standard square measure with a defined area used to standardised the collection of field data.
Qualitative	- Of, relating to, or expressed as a quality, not a measured amount.
Quantitative	- Of, relating to, or expressed as a quantity, measure or amount.
Quotient Method	- A standardised risk assessment method using estimated dose exposure of a CoC to a receptor against a literature based toxicity dose value for the CoC and receptor or surrogate.
Receptor	- Ecosystem component, biotic or abiotic, that is exposed to Chemicals of Concern.
Reference Area	- For the purpose of this ERA, a reference area is defined as any area where the soil value of nickel is below 200 mg/kg.
Refinery	- The Inco facility at Port Colborne, Ontario.
RfD	- Reference Dose.
SD	- Standard deviation.
Secondary Consumers	- (birds, mammals, amphibians).
Secondary Study Area	- Lands within the Study Area where soil nickel concentration are between 200 and 500 mg/kg.
Sediment	- Mineral and organic matter that has settled to the bottom of a lake, pond or stream.
SRM	- Standard Reference Materials.
SSRA	- Site Specific Risk Assessment.
Stantec	- The PLC's consultant.
Top predators	- A bird or mammal that is located at the top of a food chain.
Toxicological	- Pertaining to toxicology, the study of toxins and their effect.
Transect	- A straight line through a woodlot or field along which field data is collected.
Trophic Level	- A level within the food chain.
TRV -	- Toxicity Reference Value.
TSC -	- Technical Sub-Committee to the PLC.
TSOW	- Technical Scope of Work.
TSP -	- Total Suspended Particulate Matter in air.

GLOSSARY OF ABBREVIATIONS AND ACRONYMS
(Continued)

UCL	- Upper Confidence Limit.
UCLM -	- Upper Confidence Limit for the Mean.
USEPA -	- United States Environmental Protection Agency.
Unacceptable Risk	- For the characterisation of risk for this ERA, an unacceptable risk to a VEC's population is defined as an estimated risk linked to the occurrence of soil concentrations of CoCs that prevents sustainable population(s) of flora and fauna or sustainable level of ecological functioning within the defined study area.
VEC	- Valued Ecological Component, a species, population or process identified for conducting Risk Assessment.
VEC's Population	- For the purpose of this ERA, a VEC's population is defined as all individuals of species (plant or animal) that inhabit or occur within the entire Study Area as defined by this ERA.
Woodlots	- Natural forested habitats where trees (woody vegetation greater than 6 m in height) cover 60% or more of an area.

LIST OF ECOLOGICAL RISK ASSESSMENT VOLUMES

VOLUME II: **FIELD DATA COLLECTION AND ANALYSIS PROTOCOL**

VOLUME III: **SUPPORTING DATA**

VOLUME IV: **CONSULTANTS REPORT**

VOLUME V: **QUALITY ASSURANCE/QUALITY CONTROL AND LABORATORY ANALYTICAL DATA**

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MAIN REPORT

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