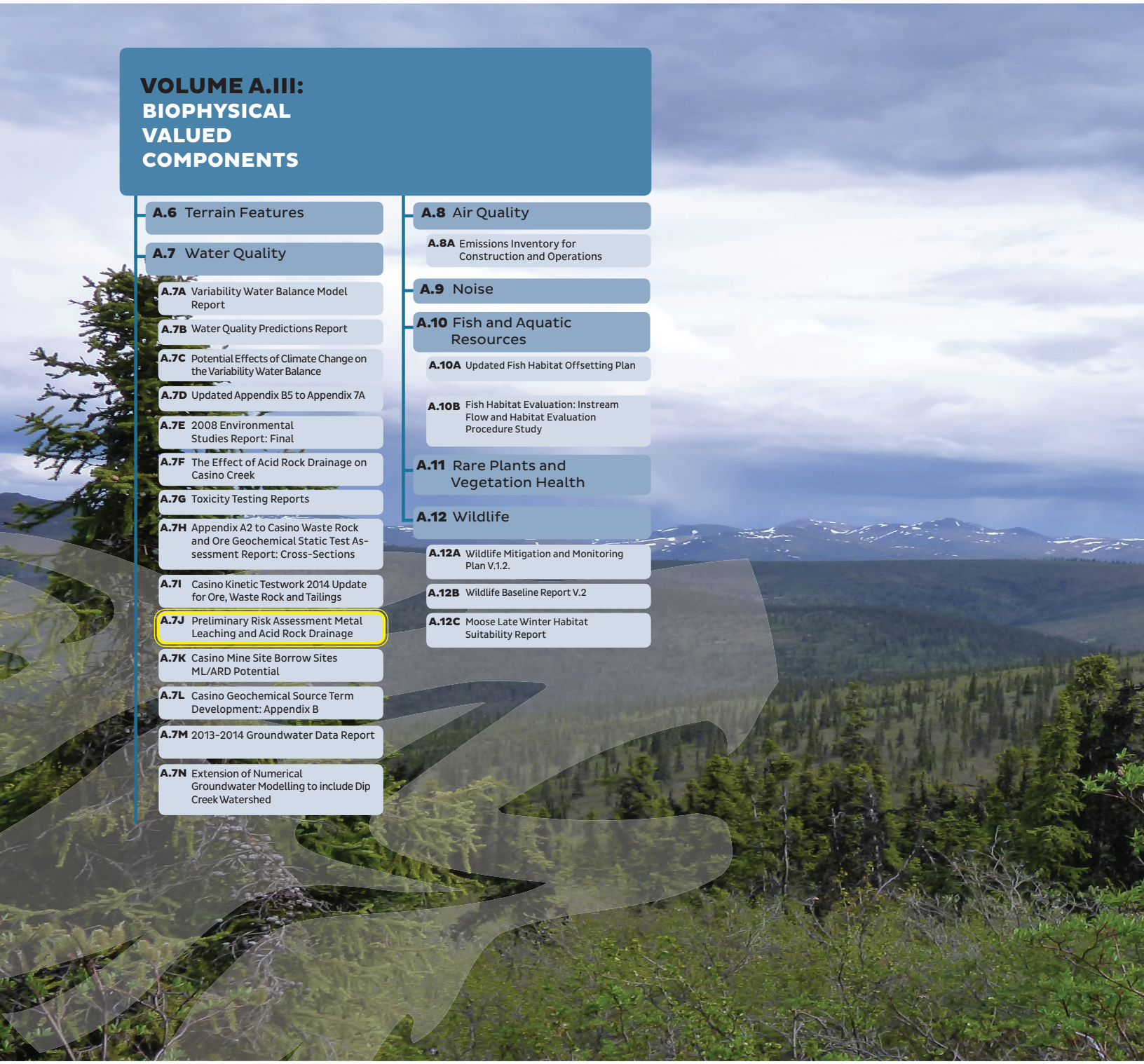
APPENDIX A.7J: Preliminary Risk Assessment Metal Leaching and Acid Rock Drainage



western
COPPER AND GOLD

Western Copper and Gold Corporation

Casino Road:
Preliminary Risk Assessment
Metal Leaching and Acid Rock Drainage

January 2012

LORAX
ENVIRONMENTAL

Executive Summary

western
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Executive Summary

The proposed Casino Access Road will connect Western Copper and Gold Corporation's Casino property with the existing Yukon road system. As road construction has the potential to produce metal leaching / acid rock drainage (ML / ARD), Lorax Environmental Services Ltd. has completed a risk assessment in order to assess the ML / ARD potential along the proposed road alignment. This allows for areas of higher ML / ARD potential to be determined, in order to highlight areas where further work may be needed.

The risk assessment indicates that the majority of the road is low risk for ML / ARD; however, there are 16 sections of road over 38.25 km of the total 133 km long alignment that are deemed to have moderate-low risk or greater. These sections are generally in the final 50 km of the road alignment: from kilometer station 86+500 to 98+300 and 108+030 to 124+430. There are three exceptions to this, kilometer station 1+290 to 5+960, 13+420 to 18+400 and 78+420 to 79+010 also have an overall risk that is considered moderate-low or greater.

These sections were found to have a high enough ML / ARD risk potential that further work in these areas is recommended. This should include further sampling along these 16 sections of road, ideally by drilling in areas where bedrock will be disturbed. As fish sampling has not taken place in the westernmost sections, over a distance of roughly 50 km of the proposed road alignment, further characterization of the streams along this section of the road alignment will allow for an improved understanding of the risk to aquatic ecosystems in this area, and may reduce the potential risk of some of the road sections in this area. Additional rock and surficial material sampling will also be necessary once quarry locations are finalized in order to ensure that the material will not cause ML / ARD.

The risk assessment was completed by defining a stressor (ML / ARD), a pathway (surface water runoff) and a receptor (the aquatic ecosystems). The road was divided into sections based on the geology, the major watersheds, the type of cut and the stream crossings in order to keep the stressor, pathway and receptor consistent. The stressor rating was defined by the geology and the cut volume along sections of road. Each of the bedrock units was assigned a rock type rating, which was modified by the type of surficial material. The cut volume was used to determine the amount of disturbance, as areas of higher disturbance have a greater ML / ARD risk. The pathway was defined by the drainage area of the catchment up-gradient from the road, to determine an approximation for surface water volume. This term was modified using the cut volume

to determine a pathway ratio, which was used to determine the pathway rating. The receptor rating takes both the sensitivity of the species present and the flow regime in the aquatic ecosystem directly downstream of the road.

Each of these terms is given a risk rating. These ratings are multiplied to determine the overall risk for each road section. Sections of road with an overall risk rating of greater than 100 are considered moderate-low risk or greater and are highlighted for further work. Sections with an overall risk rating less than 100 are considered to have sufficiently low risk and no further consideration of these sections is required.

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COPPER AND GOLD

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1. Introduction

1. Introduction

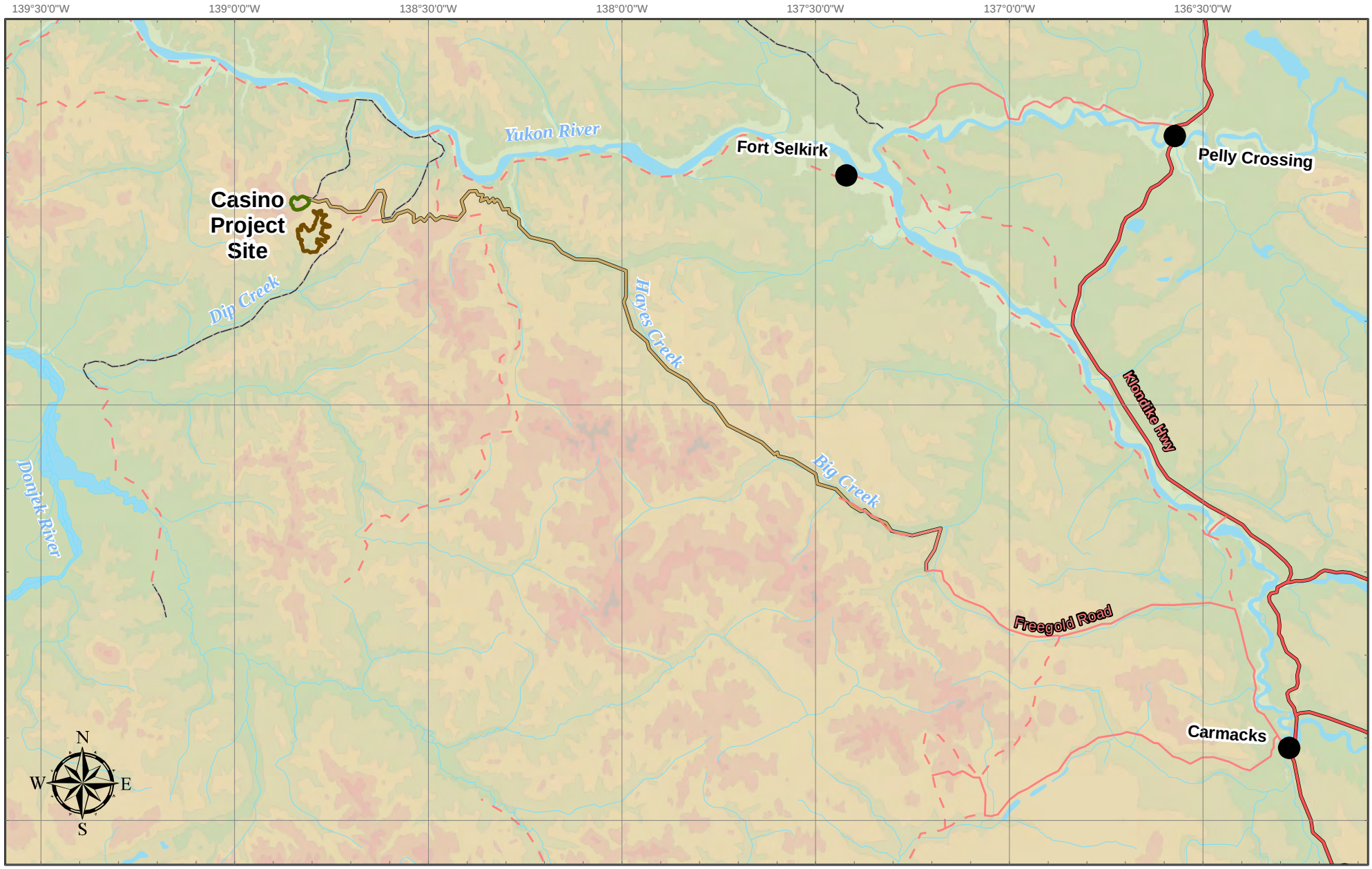
Western Copper and Gold Corporation retained Lorax Environmental Services Ltd. (Lorax) to undertake a preliminary assessment of the risk of potential metal leaching / acid rock drainage (ML / ARD) associated with the construction of a new road required for the further development of the Casino property in the Yukon. The proposed road is required to provide access between the Casino mineral deposit and the port of Skagway, Alaska via the Freegold Road and the Klondike Highway (M3 Engineering, 2011; see Figure 1-1).

This study is based on readily available information supplemented by an initial round of geochemical sampling and analysis. The analysis is considered adequate to indicate areas where the risk associated with ML / ARD is low, and areas where the potential risk or level of uncertainty are higher, and additional work may be warranted.

1.1 Study Objectives

The specific objectives of this study are to:

- Provide a general and preliminary indication of the level of risk associated with ML / ARD along the road alignment;
- Undertake the most robust analysis possible given the information available;
- Describe the methodology and results of the study in a way that is procedurally transparent, intuitive and easy to understand, reproducible, and appropriate given the information available to base the assessment on; and
- Provide the basis for more detailed investigation, where warranted.



Legend

- Cities/Communities
- Open Pit
- Tailings Storage Facility
- Proposed Road Corridor
- Existing Road
- Resource Road/Trail
- Historical Road
- Highway

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REVIEWED:	BM
VERSION:	4

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Projection: *Mercator*
Datum: *WGS 1984*
Units: *Meter*

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0 10 20 30 Km

CLIENT: western COPPER AND GOLD

LORAX ENVIRONMENTAL

PROJECT:

Casino 2010 Project

TITLE: Proposed Casino Access Road Location

PROJECT #: J862-3

FIGURE: 1-1

P:\J862 (Casino)\Road\Drafting\MXDs\LocationMap of Proposed RoadV4.mxd

1.2 Project Description

Western Copper and Gold Corporation is developing its Casino property, which hosts a gold-copper-molybdenum porphyry. The property is located approximately 300 km northwest of Whitehorse, Yukon. An access road is proposed as an extension of the existing Freegold Road, a gravel road which originates at the Klondike Highway at Carmacks, and extends northwest for a distance of roughly 70 km, currently terminating at Freegold Ventures Limited mineral tenures (M3 Engineering, 2011; see Figure 1-1). The Freegold Road is currently maintained by the Yukon government. The proposed extension of the road to the Casino property will be maintained primarily by Western Copper and Gold (M3 Engineering, 2011).

The proposed road would be approximately 133 km long and reach the Casino mineral exploration camp. Current access to the site is by air, by barge or winter routes from either Burwash Landing or Carmacks (M3 Engineering, 2011; see Figure 1-1). The proposed road would provide a year-round access route for delivering supplies to the mine site and for transporting copper concentrate from the mine to the port of Skagway during operations.

The proposed route can be divided into eastern, central and western sections:

> The Eastern Section: From the Freegold Road the road descends through the Bow and Seymour drainages, reaching Big Creek approximately 40 km upstream of its confluence with the Yukon River, at an elevation of approximately 700m above sea level (asl). The road then ascends the Big Creek valley running alongside the river, and then ascends to the height of land that separates the Big Creek drainage from the Hayes Creek drainage, at an elevation of approximately 1100 m asl. The eastern section is approximately 43 km in length.
>
> The Central Section: The central section descends through the Hayes Creek Valley and runs along the creek for approximately 44 km to an elevation of 500 m asl. After this point, Hayes Creek continues northward to its confluence with the Yukon River, while the road would continue westward, towards a ridge to the northwest up to a watershed divide at approximately 1000 m asl. The central section is 53 km long.
>
> The Western Section: The western section continues westward along the ridge from an elevation of approximately 1000 m asl to 1300 m asl. It passes through three main watersheds: Mascot Creek, Idaho/Isaac/Sunshine Creeks and Casino Creek, before joining an existing road on the Casino property. This section is approximately 37 km in length.

Surficial material in the Eastern and Central Sections is mainly colluvium, with some fluvial material (alluvium) (Summit, 2011). The route traverses through colluvium and exposed bedrock through the Western Section.

1.3 Risk Assessment Overview

The basic approach for this risk assessment is to evaluate the risk associated with a specific stressor (ML / ARD), entering a pathway (surface water runoff and flow in watercourses that the road crosses) that could impact specific receptors (aquatic ecosystems at and immediately downstream of the road crossing).

There have been several examples where road construction has lead to the development of ML / ARD in Canada and the United States. The potential for the development of ML / ARD is dependent on the geology and the amount of disturbance. For example, bedrock with high sulphide content and low calcium carbonate content will have a greater ML / ARD potential than rock that contains little or no sulphide. In addition, the ML / ARD risk will vary depending on the type of material. ML / ARD is greatest for bedrock, followed by colluvium, followed by alluvium. Unconsolidated colluvial and alluvial deposits have been exposed to the elements and have often undergone extensive weathering and oxidation that has already depleted any acid generating sulphide minerals that may have been present in the parent bedrock from which the colluvium or alluvium was derived. This is particularly true of alluvial deposits that have been exposed. A second variable that contributes to ML / ARD impact is the volume of material that is disturbed with ML / ARD potential. Increasing the amount of disturbance increases the ML / ARD potential.

This study does not consider the potential effects of other stressors that may be associated with road construction, such as erosion, or the release of hydrocarbons or other contaminants from any other source. Nor does this study consider the cumulative effects of potential ML / ARD with other stressors.

The pathway as defined in this study considers surface water runoff generated up-gradient of a given section of road that mixes with runoff from exposed material from the road and transports any contaminants derived from ML / ARD to a downstream receptor. Other potential pathways through which ML / ARD could affect the receiving environment, such as through groundwater, for example, are assumed to ultimately report to the same surface water pathway in this assessment.

The receptors defined in this study are based on an initial consideration of aquatic ecosystems at and downstream of each section of road. The details of this consideration are described in more detail below.

Following this introduction, Chapter 2 provides an overview of the study approach and methodology. Chapter 3 discusses the rating system used in the risk assessment. Chapter 4 discusses the results of the risk assessment, highlighting areas with a higher risk. Recommendations are presented in Chapter 5.

2. Methodology

2. Methodology

Western Copper and Gold Corporation is undertaking work in preparation for detailed mine planning and permitting for its Casino property. It is anticipated that development of the mine will require approvals pursuant to the Yukon Environmental and Socioeconomic Assessment Act (YESAA), potentially the Canadian Environmental Assessment Act (CEAA), the Yukon Water Act, and other relevant legislation and regulations. It is anticipated that assessment of the potential for ML / ARD will be required for every aspect of the Project, including construction of the new access road, in support of permit applications. As the first step in addressing this requirement, the work summarized here is intended to identify areas that will require excavation and placement of native soil and rock ('cut' and 'fill') that represent a higher risk with respect to potential ML / ARD, and therefore may warrant some further investigation.

2.1 ML / ARD Approach

Based on MEM & MOE (1998) and MEND (2009), it is generally recognized that ML / ARD programs follow three main steps:

1. Determine the lithology or material type of the material that will be disturbed.
2. Determine the ML / ARD potential of this material. This may include static and/or kinetic testing.
3. Create mitigation and monitoring plans based on the ML / ARD potential to minimize impacts to the environment.

This study addresses the first step, by providing a description of the geology along the proposed road alignment. The second and third steps are addressed at a preliminary level. For the second step, static tests were conducted for an initial round of sampling completed along the proposed road alignment. The third step was initiated by identifying areas of lower risk where mitigation and monitoring may not be warranted, and areas where the risk is higher or uncertainty greater, which may warrant additional investigation, mitigation and/or monitoring.

In the absence of specific regulations and guidance for the Yukon, the approach for this study has taken MEM & MOE (1998), Price & Errington (1998), MEND (2009) and MOT (2004) guidelines for ML / ARD sampling into account, as well as the general methodology for ML / ARD studies along road routes proposed by Gusek *et al.* (2008), from the lithological determination stage to the monitoring stage. These include:

- Policy for Metal Leaching and Acid Rock Drainage at Minesites in British Columbia (MEM & MOE, 1998);
- Guidelines for Metal Leaching and Acid Rock Drainage at Minesites in British Columbia (Price & Errington, 1998);
- Policy for ARD Testing at Quarry and Rock Cut Sites (MOT, 2004);
- Prediction Manual for Drainage Chemistry from Sulphidic Geologic Materials (MEND, 2009); and
- A New Guidance Document for Mitigating Impacts from Acid-Producing Rock Formations in Tennessee Road Construction Projects (Gusek *et al.*, 2008).

2.2 Information Sources

In order to assess the ML / ARD potential along the proposed road alignment, relevant information was obtained from the following sources:

- Yukon Geological Survey Bedrock Geology base map (Gordey and Makepeace, 1999)
- Geological Descriptions of units along the proposed road alignment (Carlson, 1987; Payne *et al.*, 1987)
- Proposed Casino Road Alignment and Surficial Material polygons from Summit Environmental Consultants (2011)
- Geochemical results from sampling completed by Lorax personnel along the proposed road route and geochemical results from work completed for the Casino deposit
- Cut and Fill information from Associated Engineering (2011)
- Drainage Areas calculated based on topography
- Fish Presence and Stream data (Summit, 2011; supplemented by 2011 work by EDI (Kearns, pers. comm., 2011)

2.3 Risk Assessment Framework

The general risk assessment framework proposed by Pollard *et al.* (1995) was adopted. The stressor, pathway and receptors were characterized as follows:

- Stressor: the stressor that was the focus of this study was metal leaching / acid rock drainage (ML / ARD). The information available included the bedrock geology and surficial material along the road alignment, the results of an initial

round of static tests on rock, colluvium and alluvium samples, and preliminary estimates of the excavated volume of rock and soil.

- Pathway: Surface water drainage provides the main pathway through which any products of ML / ARD may interact with excavated ('cut') or permanent disposal ('fill') of soil and rock, and then be conveyed into the receiving environment. Information available included the size of catchments and the location of watercourses. A very general characterization of flow volumes was available for the purpose of this assessment.
- Receptor: The receptor of interest is the aquatic ecosystems in the watercourses in the vicinity of the proposed road. Information available was based on the results of preliminary studies in the major watercourses, some opportunistic efforts to characterize species presence by electrofishing, and information in the public domain.

This level of analysis corresponds with a preliminary quantitative ecological risk assessment (ERA) as defined by CCME (1996), as field data is combined with information from the literature. This is the second stage of assessment outlined in the CCME document. It is an intermediate step between a screening assessment, which relies solely on data in the literature, and a detailed quantitative ERA, which primarily uses field data. These three levels vary from simply describing the situation (screening assessment) to creating predictions on the outcomes (detailed quantitative ERA). In a risk assessment, each category must be defined qualitatively and, in quantitative risk assessments, it will also be assigned a numerical value representing the level of risk (Pollard *et al.*, 1995).

3. Analysis and Risk Ratings

3. Analysis and Risk Ratings

The analysis for this study was undertaken as a series of five major steps, as follows:

1. Dividing the proposed road alignment into sections that are homogenous with respect to the geology, type of cut (soil or rock), and aquatic receiving environment;
2. Assigning a risk rating for ML / ARD potential that considers both geological characteristics as well as the level of disturbance (*i.e*. the volume of cut and fill);
3. Assigning a rating for the pathway reflecting the amount of dilution that can be anticipated;
4. Assigning a rating for the aquatic receiving environment reflecting its importance and sensitivity (*i.e.* likely presence of fish species of commercial or recreational importance, and/or species at risk); and
5. Using the assigned ratings to determine an overall risk rating for each section of road, which is appropriate to serve as the basis for recommendations.

Each of these principal steps in the analysis and associated risk considerations and assumptions are described in the sections below.

3.1 Road Sections

For the purposes of this assessment, the road was divided into discrete sections to ensure that the stressor, pathway and receptor were generally consistent. The divisions were based on:

- Changes in geology
- Major watershed divides
- Changes in type of cut (soil or rock)
- The road route crossing a stream

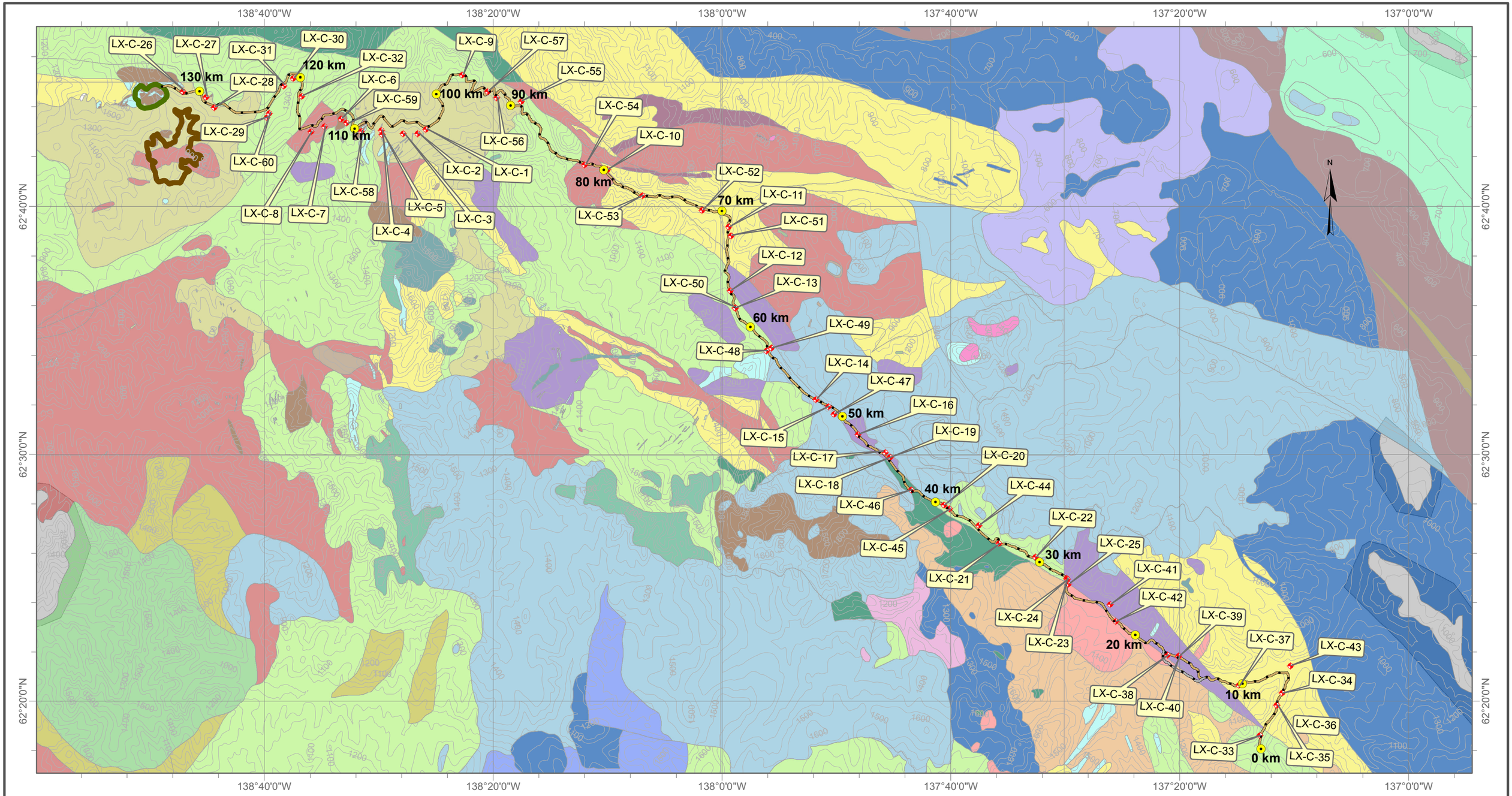
The procedure is as follows:

1. The geological boundaries along the road were determined and used to subdivide the road based on data obtained from the Yukon Geological Survey (YGS) website;

2. The divides between the "soil cut" and "rock cut" zones were determined based on information provided as part of the preliminary road design (Associated Engineering, 2011) and were used to further subdivide the road;
3. The major watershed divides were determined based on topographical and watercourse mapping obtained from Canadian Digital Elevation Data and the National Hydro Network (www.GeoBase.ca), and were used to further subdivide the road; and
4. The locations where the road crosses a major stream were determined, and used to further subdivide the road.

Using this procedure, the proposed road alignment is divided into 81 sections, each of which is homogenous with respect to underlying geology, the nature of material that will be disturbed (bedrock, colluvium or alluvium), and the drainage basin through which they traverse. The shortest road section is 40m, while the longest is 9,040m.

The up-gradient catchment area for each road section was then defined (see Section 3.4 for further discussion). An overview of the road route and the bedrock geology is provided in Figure 3-1. The road sections, and associated road section catchments, are show in Figure 3-2a to 3-2c.



LEGEND

- Proposed Road Corridor
- Optional Road Alignment
- 1 Km Markers
- 10 Km Markers
- Sample Locations
- Open Pit
- Tailings Storage Facility
- Elevations (100m)

Q	Unconsolidated glacial, glaciofluvial and glaciolacustrine deposits
TQS	Vesicular to massive basalt flows; minor pillow basalt; basaltic tuff and breccia
lES2	Hornblende-feldspar porphyritic tuff, flow breccia; volcaniclastic mudstone, sandstone and conglomerate; dacite flows and dykes; flow-banded rhyolite and felsic dykes and sills
ETqN	Leucocratic, biotite granite; miarolitic alaskite; mafic-poor biotite granite; biotite-hornblende granite to leucocratic granodiorite; biotite quartz monzonite
LKdP	Coarsely crystalline gabbro and diorite
LKfP	Quartz-feldspar porphyry
LKqP	Quartz monzonite, biotite quartz-rich granite; porphyritic alaskite; biotite and hornblende quartz monzodiorite, granite and leucocratic granodiorite
LKyP	Syenite
uKC1	Augite olivine basalt and breccia; hornblende feldspar porphyry andesite and dacite flows
uKC2	Vitric crystal tuff, lapilli tuff and welded tuff; felsic volcanic flow rocks
uKC3	Poorly sorted, coarse to fine grained sandstone, pebble conglomerate, shale, tuff and coal
uKW	Quartz-phyric dacite flows, ash and lapilli tuff; dacite and basalt flows
mKdW	Hornblende diorite, biotite-hornblende quartz diorite and hypersthene-hornblende diorite, quartz diorite and gabbro
mKgW	Biotite-hornblende granodiorite, hornblende quartz diorite and hornblende diorite
mKqW	Biotite quartz-monzonite, biotite granite and leucogranite, granophyric quartz monzonite
mKN	Andesite to dacite flows, breccia and tuff
uJKT	Massive to thickly bedded chert pebble conglomerate and quartz-chert-feldspar sandstone
EJgA	Medium- to coarse- grained, foliated biotite-hornblende granodiorite and hornblende diorite to monzodiorite
EJqL	Fine to coarse grained biotite, biotite-muscovite and biotite-hornblende quartz monzonite to granite
EJyL	Coarse to very coarse grained mesocratic hornblende syenite
uTrP	Augite or feldspar phyric andesitic basalt flows, breccia, tuff, sandstone and argillite
CPA1	Variably altered and foliated oceanic mafic volcanics
DMgPW	Biotite granite gneiss to biotite or hornblende granodiorite gneiss
DMN2	Marble
DMN3	Quartzite, micaceous quartzite, quartz muscovite schist and minor metaconglomerate and metagrit
DMN5	Dark grey to black strongly graphitic quartzite with lesser grey micaceous quartzite and quartz mica schist
PPN1	Dark grey to brown, biotite-muscovite-quartz-feldspar schist, quartzite and micaceous quartzite and felsic chlorite-biotite orthogneiss
PPa	Metamorphosed mafic rocks, including amphibolite and ultramafic rocks
	Unclassified

Bedrock Geology

Gordey, S.P. and Makepeace, A.J. (comp.) 1999: Yukon bedrock geology in Yukon digital geology, S.P. Gordey and A.J. Makepeace (comp.); Geological Survey of Canada Open File D3826 and Exploration and Geological Services Division, Yukon, Indian and Northern Affairs Canada, Open File 1999-1(D)

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CLIENT:

western COPPER AND GOLD

LORAX ENVIRONMENTAL

PROJECT:

Casino 2010 Project

TITLE:

Casino Road With Bedrock Geology

PROJECT #: J862-3 *FIGURE:* 3-1

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137°50'0"W 137°40'0"W 137°30'0"W 137°20'0"W 137°10'0"W

62°30'0"N 62°25'0"N 62°20'0"N 62°15'0"N

50 km
40 km
30 km
20 km
10 km
0 km

Big Creek
Bow Creek
Seymour Creek

N

LEGEND

- Proposed Road Corridor
- Optional Road Alignment
- 1 Km Markers
- 10 Km Markers
- River
- Elevations (100m)
- Lake
- Road Section Catchments

Bedrock Geology

LKdP	EJgA
LKfP	EJqL
LKqP	EJyL
uKC1	DMgPW
mKgW	DMN3
mKqW	DMN5
mKN	

Coordinate System: *World Mercator*
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Datum: *North American 1983*
Units: *Metres*

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0 5 10 Km

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LORAX ENVIRONMENTAL

PROJECT:

Casino 2010 Project

TITLE:

Eastern Section
Road Section Catchments

PROJECT #: J862-3 *FIGURE:* 3-2a

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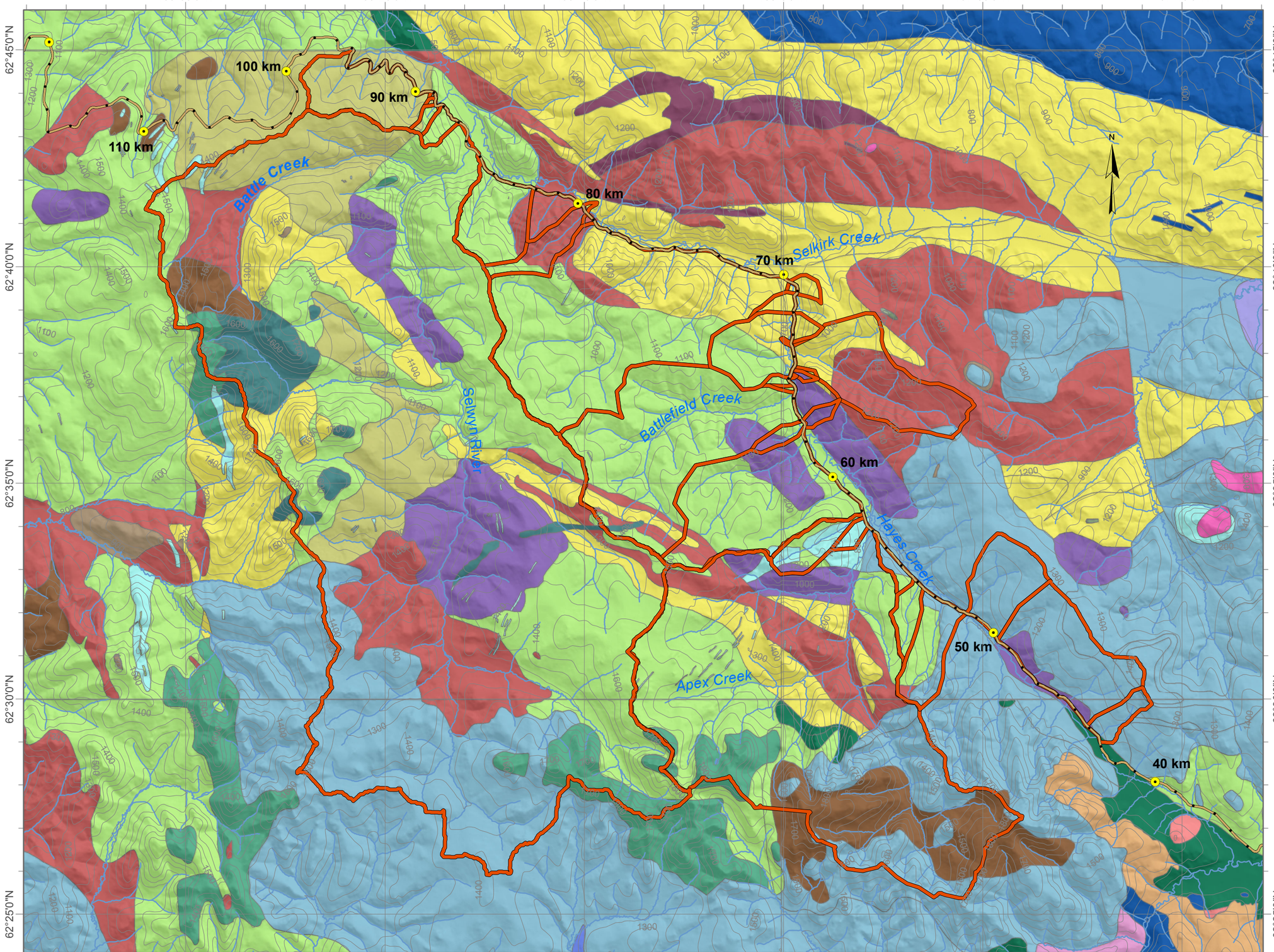

LEGEND

- Proposed Road Corridor
- River
- Elevations (100m)
- Lake
- Road Section Catchments
- 1 Km Markers
- 10 Km Markers

Bedrock Geology

TQS	mKgW
LKdP	mKqW
LKfP	mKN
LKqP	EJgA
LKyP	EJqL
uKC1	EJyL
uKC2	DMgPW
uKC3	DMN3
uKW	DMN5
mKdW	PPa

Coordinate System: *World Mercator*
Projection: *Mercator*
Datum: *North American 1983*
Units: *Metres*

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0 5 10 Km

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VERSION:	1

CLIENT:

western COPPER AND GOLD

LORAX ENVIRONMENTAL

PROJECT:

Casino 2010 Project

TITLE:

Central Section
Road Section Catchments

PROJECT #: J862-3 *FIGURE:* 3-2b

P:\J862 (Casino)\Road\Drafting\MXDs\Figures for report\Sivanol\Casino Road Central Section - Road Section Catchments.mxd

138°50'0"W 138°40'0"W 138°30'0"W 138°20'0"W

62°50'0"N 62°45'0"N 62°40'0"N

Canadian Creek
Britannia Creek
Sunshine Creek
Isaac Creek
Mascot Creek
Yukon River
Casino Creek
Dip Creek
Victor Creek
Battle Creek

120 km
130 km
100 km
90 km
110 km

N

LEGEND

- Proposed Road Corridor
- 1 Km Markers
- 10 Km Markers
- Elevations (100m)
- River
- Lake
- Open Pit
- Tailings Storage Facility
- Road Section Catchments

Bedrock Geology

- LKdP
- LKfP
- LKqP
- uKC2
- uKC3
- mKdW
- mKgW
- mKqW
- DMgPW
- DMN3
- DMN5

Coordinate System: *World Mercator*
Projection: *Mercator*
Datum: *North American 1983*
Units: *Metres*

1:220,000

0 5 10 Km

DATE SAVED:	Jan 11, 2012
DRAWN BY:	SSS
REVIEWED:	BM
VERSION:	1

CLIENT:

western COPPER AND GOLD

LORAX ENVIRONMENTAL

PROJECT:

Casino 2010 Project

TITLE:

Western Section
Road Section Catchments

PROJECT #:	*FIGURE:*
J862-3	3-2c

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3.2 Stressor Rating

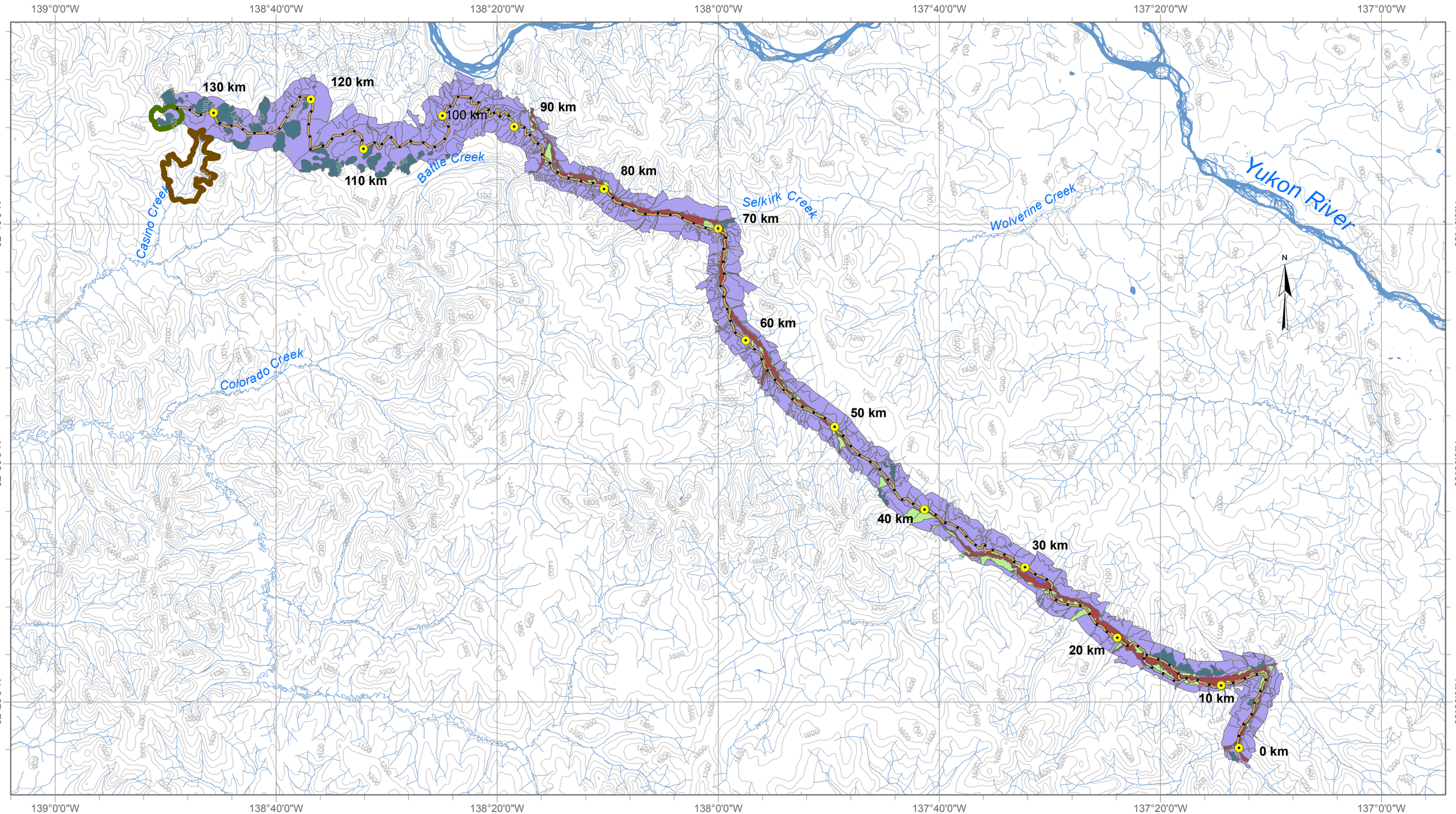
The stressor rating was calculated based on the designated risk posed by each geologic unit, and a risk rating assigned corresponding with the volume of material anticipated to be disturbed. The overall geology rating and the cut rating were multiplied to determine the stressor rating for each section of road

Each geologic unit was given a risk rating based on the expected mineral assemblage with each lithologic / stratigraphic unit and the available geochemical data. The cut volume is also included as part of the stressor risk as it is a measure of disturbance along each section of the proposed road. Areas of greater disturbance have a higher ML / ARD risk, as a greater area is exposed.

3.2.1 Geology

The development of ML / ARD from road construction is primarily controlled by the mineral composition of the construction material. The most critical mineral relationship is the relative amounts of sulphide and carbonate minerals (*i.e.*, the dominant acid-generating and acid neutralizing minerals). Determination of the likely mineral assemblages, specifically the sulphide abundance, that are typically associated with the predominant lithologies in a stratigraphic unit provides a method to qualitatively assess ML / ARD potential.

For the current study, the bedrock geology has been assessed from the geological map created from data from the Yukon Geological Survey website (Figure 3-1). More detailed descriptions of the geological units were reviewed from Carlson (1987) and Payne *et al.* (1987). The surficial material has been assessed from geology terrain maps from Summit Environmental Consultants (2011). An overview of the general surficial geology (bedrock, colluvium or alluvium) along the proposed road alignment is provided in Figure 3-3.



LEGEND

- Proposed Road Corridor
- Optional Road Alignment
- 1 Km Markers
- 10 Km Markers
- Elevations (100m)
- River
- Lake
- Open Pit
- Tailings Storage Facility

SURFICIAL MATERIAL

- Anthropogenic
- Colluvium
- Old fluvial deposits
- Active fluvial deposits
- Organic
- Bedrock

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VERSION:	1

Coordinate System: *World Mercator*
Projection: *Mercator*
Datum: *North American 1983*
Units: *Metres*

1:600,000

0 10 20 Km

CLIENT: Western Copper and Gold

Lorax Environmental

PROJECT: **Casino 2010 Project**

TITLE: Casino Road With Surficial Geology

PROJECT #: J862-3 FIGURE: 3-3

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The proposed road route crosses seven geological units. The Whitehorse Suite (mKW) is divided into three subunits so nine rock types are considered in all. These units are:

1. Nasina Unit (DMN3, DMN5)
2. Pelly Gneiss Suite (DMgPW)
3. Long Lake Suite (EJyL)
4. Whitehorse Suite - Diorite (mKdW)
5. Whitehorse Suite – Granodiorite (mKgW)
6. Whitehorse Suite – Granodiorite to quartz monzonite (mKqW)
7. Mount Nansen Unit (mKN)
8. Carmacks Unit (uKC1)
9. Prospector Mountain Suite (LKfP, LKqP)

Table 3-1 provides a summary of each of the units. The Nasina Unit (DMN) includes both DMN3 and DMN5. Due to a lack of information on the lithological description of the subunits, they were combined as DMN for the purposes of this study. However, both units are shown on the bedrock geology maps. The Prospector Mountain Suite (LKP) includes the stock (LKqP) and the dykes (LKfP). In addition to these bedrock units, the proposed route will cross areas covered by colluvium and fluvial material.

A ML / ARD risk value from 1 to 5 was assigned to each unit, with 1 being the lowest risk and 5 being the highest risk. A brief rationale for the ML / ARD risk rating for each unit is provided in Table 3-1. This provides the rock type rating. It is typically based on the presence or absence of carbonates and pyrite, taking any available geochemistry data into account, as described below. The 1 to 5 scoring method of characterization was deemed appropriate to reflect the range and variation in the level of risk that could potentially result from the rock and soil types present. A simpler system, such as a low-moderate-high rating system would not have fully captured the ability to differentiate the ML / ARD risk associated with these rock types given the information available.

The Nasina Unit (DMN) and Whitehorse Suite Granodiorite to Quartz Monzonite (mKqw) were rated as having the highest ML / ARD potential of the rock types that occur along the road, 4 out of 5. The Pelly Gneiss Suite (DMgPW), Whitehorse Suite “Casino Granodiorite” (MKgW) and Prospector Mountain Suite (LKP) were rated as having moderate ML / ARD potential, (3 out of 5), and the Long Lake Unit (EJyL), Whitehorse Suite Diorite (mKdW), and Carmacks Unit (mKN) were rated low (2 out of 5).

Table 3-1:
Summary of Geology and Geology Risk

Map Code	Unit (YGS name)	Name (original document)	Rock Type (based on Carlson, 1987 and Payne *et al.*, 1987)	Alteration and pyrite/calcite presence from petrographic description in Carlson (1987)	ARD risk	Reasoning for ARD risk
DMN (DMN3 / DMN5)	Nasina	Yukon Metamorphic Complex (Payne *et al.*, 1987) / Wolverine Creek Metamorphic Suite (Johnston, 1995)	Meta-sedimentary quartzite and quartz-mica schist. The composition varies in the amount of mica. Generally banded. General composition: quartz (50-80%), mica (20-50%), feldspar (1-5%) and opaques (0-5%).	sericitic alteration, no mention of any pyrite or calcite	4	Unit includes variable lithologies which increases the potential variability and risk. Includes gneiss and schists, which may have elevated S content in the parent rock.
DMgPW	Pelly Gneiss Suite	Wolverine Creek Metamorphic Suite (Johnston, 1995) / Simpson Allochthonous Assemblage - Selwyn Gneiss (Tempelman-Kluit, 1984)	Meta-igneous schist and gneiss. Amount of metamorphism varies. Plagioclase is the dominant mineral (60-75%), with lesser K-feldspar, quartz, hornblende and biotite.	plagioclase to sericite alteration common, occasionally epidote and calcite alteration, pyrite: none to 0.3% calcite: none to 4%	3	Sulphide minerals reported, but sericitic alteration often includes carbonates. Some subunits include limestone.
EJyL	Long Lake Suite	Big Creek Syenite (Tempelman-Kluit, 1984)	Syenitic granitic rocks, monzonite to granodiorite and hornblendite. General composition of syenite: K-feldspar (30-50%), hornblende (20-75%), plagioclase (10-30%), quartz (0-20%) and minor sphene and apatite.	sericitic alteration, no mention of any pyrite or calcite	2	Presence of mafic silicate minerals which provide buffering capacity for low levels of acidity and sericitic alteration which may include carbonate minerals.
mKdW	Whitehorse Suite	Dawson Range Batholith (Johnston, 1995)	Diorite. General composition: plagioclase (50-60%), mafic minerals (25-30%), quartz (15%) and minor K-feldspar.		2	Phyllic alteration of hypogene samples in the Casino deposit typically contain > 1% carbonate content. Lower sulphide content is expected in this unit outside the deposit. Contains mafic minerals that can buffer low levels of acidity.

Map Code	Unit (YGS name)	Name (original document)	Rock Type (based on Carlson, 1987 and Payne *et al.*, 1987)	Alteration and pyrite/calcite presence from petrographic description in Carlson (1987)	ARD risk	Reasoning for ARD risk
mKgW	Whitehorse Suite	Casino granodiorite (Tempelman-Kluit, 1984) / Dawson Range Batholith (Johnston, 1995) / Dawson Range Suite (Payne, 1987) / Hornblende granodiorite (Tempelman-Kluit, 1984)	Granodiorite. General composition: plagioclase (50-60%), quartz (15-20%), K-feldspar (15-20%), biotite & hornblende (15%).	plagioclase altered to sericite, biotite altered to chlorite, no mention of pyrite or calcite	3	Lower levels of mafic silicate minerals from granodiorite than diorite.
mKqW	Whitehorse Suite	Coffee Creek Granite (Tempelman-Kluit, 1984) / Dawson Range Batholith (Johnston, 1995)	Granodiorite to quartz monzonite. General composition: quartz (25-35%), plagioclase (20-40%), K-feldspar (25-40%), biotite (5-10%), hornblende (<5%), minor pyrite, apatite, sphene and zircon.	plagioclase altered to sericite and clay, no mention of pyrite or calcite	4	Lower levels of mafic silicate minerals in quartz monzonite. Carbonate content would likely be restricted in this more silicate rich rock type, particularly in clay altered zones.
mKN	Mount Nansen	Mount Nansen Group (Tempelman-Kluit, 1984)	Volcanic flows and subvolcanic intrusions. The main rock type is an andesite typically with a fine grained matrix and visible plagioclase, hornblende, clinopyroxene and biotite. Phenocrysts are dominantly plagioclase and make up 35-55% of the rock. Groundmass is plagioclase, quartz, K-feldspar, chlorite and opaques.	sericite and clay alteration, some calcite, chlorite and epidote alteration pyrite: none to minor calcite: none to minor	2	Calcite content in mafic flows typically more abundant than sulphide content.

Map Code	Unit (YGS name)	Name (original document)	Rock Type (based on Carlson, 1987 and Payne *et al.*, 1987)	Alteration and pyrite/calcite presence from petrographic description in Carlson (1987)	ARD risk	Reasoning for ARD risk
uKC1	Carmacks	Carmacks Suite (Payne, 1987) / Carmacks Group (Johnston, 1995)	A volcanic sequence with a lower rhyolite to rhyodacite subunit, a middle andesite subunit and an upper basalt subunit.	plagioclase alters to clay or sericite, clinopyroxene alters to ankerite or calcite, pyrite: not mentioned, calcite: none, one sample has 7-8% ankerite, another sample has 2-3% calcite	2	Carbonate is typically reported in this unit. Basalt containing mafic silicate minerals capable of buffering low levels of acid production.
LKP (LKfP / LKqP)	Prospector Mountain Suite	Prospector Mountain Plutonic Suite (Johnston, 1995)	Quartz-rich monzonite stock (LKqP) with porphyritic latite and quartz-rich latite dykes (LKfP).		3	Limited mafic silicate content. Unit likely has variable ARD risk. In the Casino deposit typically contains carbonate but has elevated S content, which makes this unit PAG.
Surficial material			**Description**			
Colluvium			Clay to cobble sized fragments from past mass movements.		Bedrock rating -1	Moderate but variable risk dependent on the parent rock type.
Fluvial			Clay to cobble sized fragments. Includes both present river banks and old floodplains.		1	Low risk due to high degree of physical and chemical weathering.

The rock type rating was reduced for colluvium and alluvium. The risk factor for colluvium is lower than that of the parent rock type (the rating was reduced by 1, from 3 out of 5 in the case of the Pelly Gneiss Suite, to 2 out of 5 for colluvium derived from it, for example) as colluvium has been exposed to the elements for a longer period of time and will, therefore, be more weathered with the acid generating minerals depleted. This rationale depends on the assumption that the colluvium has not been transported a great distance so the parent rock type is the same as that of the underlying bedrock. The risk rating for alluvium is low (1) based on the same principle of advanced weathering and associated oxidation. In cases where both colluvium and alluvium are present in a particular section of road, the more conservative risk factor for colluvium is used.

Based on preliminary road design (Associated Engineering, 2011) the road will require excavation of soil (alluvium and colluvium) only, through the Eastern and Central section, from station 0-316 to station 86+120. In contrast, excavations are entirely in bedrock in the Western Section from station 86+120 (from roughly the western boundary of the Hayes Creek drainage basin) to station 132+410, where the new access road will join with the existing road on the Casino property.

3.2.2 Geochemical Analytical Results

In determining the ML / ARD risk described above, geochemical results were taken into consideration. Geochemical data is available both from data obtained as part of previous work at the Casino deposit itself, and preliminary sampling completed along the route for this 2011 study.

The geochemical testing from work completed in the Casino deposit was part of other Lorax studies and is not presented here. However, as the geological units encountered in the proposed pit also have restricted occurrence along the road alignment, the results were considered in determining the ML / ARD risk for the road assessment. However, the Casino ore deposit is unique in that it is a highly mineralized zone that would contain higher sulphide content than occurrences of the same stratigraphic units along the road alignment. The data includes mineral assemblages and static test results.

In June 2011, sixty samples were collected along the proposed route in support of this study. In total, thirty-nine bedrock samples, fifteen colluvium samples and six alluvium samples were collected (Appendix I). All samples were 1-5 kg, to allow for sufficient sample volume to complete all testing, as outlined in MEND (2009).

In order to obtain a preliminary characterization of the material along the proposed road route, an effort was made to collect samples from the main bedrock units and along a good distribution along the proposed road route. Where possible, samples were collected

in areas where a large amount of disturbance is expected, including areas of high cut and fill for colluvium and bedrock and at river crossings in the case of fluvial material. In some cases this was not possible, as permafrost prevented sediment sampling in several areas. This made it difficult to sample colluvium, as only areas without permafrost could be sampled, such as old cuts and areas with heavier vegetation. When quarry sites are finalized, further sampling may be required, based on the MEND (2009) sampling guidelines for tonnes of material disturbed.

The 2011 samples from along the road alignment were sent to SGS-CEMI in Burnaby, B.C for static testing. All samples were analyzed for rinse and paste pH, Acid-Base Accounting tests and Metals by Aqua Regia Digestion with ICP-MS Finish. The median values for ABA results for the different units are included in Table 3-2.

Table 3-2:
Summary of ABA results from the samples collected along the proposed road route (values presented are medians)

Median	Rinse pH	CaNP	C(T) %	S(T) %	Modified NP	NPR NP/AP	n
Rock Type							
DMN	9.12	11.7	0.15	0.02	11.4	18.2	3
DMgPW	9.07	4.17	0.06	0.01	8.30	27.7	4
mKW	7.25	0.83	0.06	0.01	5.90	18.5	28
mKN	9.14	118	1.49	0.01	72.6	242	1
uKC1	8.71	14.2	0.18	0.01	41.8	139	3
Surficial Material							
Colluvium	6.72	0.83	0.19	0.02	5.60	12.7	15
Alluvium	6.71	0.83	0.28	0.01	9.45	31.5	6

Note: DMN – Nasina, DMgPW – Pelly Gneiss Suite, mKW – Whitehorse Suite, mKN – Mount Nansen, uKC1 – Carmacks

Based on the geochemistry results, all samples were determined to be low risk due to low sulphur values (Table 3-2 and Appendix II-A). In general, the concentration of metals found in the rock samples is below three times the continental crustal abundance (Appendix II-B).

One notable exception is the concentration of arsenic measured in colluvium and alluvium samples (Appendix II-B). Although elevated concentrations of a parameter in the solid-phase may identify potential parameters of concern it does not necessarily mean that the parameter will be a source of metal leaching. Notwithstanding, the potential for arsenic leaching from these unconsolidated materials will be evaluated in Phase II testing.

The geology rating was not based solely on the data collected from sampling along the road, as the rock samples collected along the proposed road route were all collected from

the surface of outcrops and would have been exposed to more weathering relative to samples at a greater depth. Although all the samples have low ML / ARD risk, rock cuts will be made during road construction that may expose "fresher" material which hasn't been weathered, and potentially has a greater ML / ARD potential. Drilling along the proposed route in order to collect unweathered samples was not deemed necessary at this stage. Using a combination of the geologic description, the road sampling geochemistry, and the data from core samples from near the Casino deposit, allowed for a ML / ARD risk rating to be assigned with precision reasonable level of confidence for the purpose of this preliminary risk assessment.

3.2.3 Cut Volume

In general, the potential for ML / ARD increases in proportion with the amount of soil or rock that is disturbed, as the surface area of material exposed to air and water increases, and there is an increasing probability of higher variability in lithology. It is for this reason that the guidelines require more samples for a greater area or volume (Price & Errington, 1998; MEND, 2009).

This factor was included in the risk assessment by categorizing the total disturbance within a given road section (with uniform bedrock geology and confined to a given catchment area as explained above). Preliminary estimates of cut and fill volumes are available for the entire road alignment.

The cut volumes were provided for each 20m section of road. These values were added together to generate a total estimate for each of the 81 road sections which have been defined for the purposes of this risk assessment (See Table 4-1 and Appendix III). It was assumed that all of the cut volume would be placed ('filled') within the same road section, and if additional fill is required within any section, it was assumed that it will be sourced from a quarry with low ML / ARD potential. Consequently, fill volume is not directly included in the analysis.

A value between 1 and 5 was assigned for the cut volume based on guidelines from MEND (2009) and MEM & MOE (1998). The analysis takes swell factors and average densities into consideration. The soil cut volume (noted as excavated m^3 or em^3 in the table below) was calculated by multiplying the mass of disturbed material (the estimate provided as part of the preliminary road design in metric tonnes) by a swell factor of 1.05, and then dividing by an average soil density of 1350 kg/m^3 (1.35 g/cm^3). The soil density is based on Yu *et al.* (1993). Rock cut volume was calculated by multiplying the mass of disturbed material (given in tonnes) by a swell factor of 1.35, and then dividing by an average rock specific gravity of 2.7 (*i.e.* 2.7 tonnes per m^3) (www.edumine.com). The rating system is summarized in the table below.

Table 3-3:
Cut Volume Rating System

Mass of Disturbed Material (tonnes)	Soil Cut Volume (em^3)[a]	Rock Cut Volume (em^3)[b]	Cut Volume Rating	Rationale
0	0	0	0	No risk, as there is no disturbed material
< 1,000	< 780	< 500	1	Based on the minimum mass for which ML / ARD prediction is required (MEM & MOE, 1998)
1,000-10,000	780 - 7800	500 - 5000	2	
10,000-100,000	7800 - 78000	5000 - 50000	3	Based on the MEND (2009) mass for requiring 3 samples (10,000 tonnes)
100,000-1,000,000	78000 - 780000	50000 - 500000	4	Based on the MEND (2009) mass for requiring 8 samples (100,000 tonnes)
> 1,000,000	> 780000	> 500000	5	Based on the MEND (2009) mass for requiring 26 samples (1,000,000 tonnes)

[a] Soil cut volume was calculated based on an average soil density of 1.35 g/cm^3 (Yu *et al.*, 1993) and a swell factor of 1.05
[b] Rock cut volume was calculated based on an average rock specific gravity of 2.7 (www.edumine.com) and a swell factor of 1.35

3.3 Pathway Rating

It was assumed that the main pathway by which ML / ARD products would be exposed to receptors is via surface water drainage. The catchment area up-gradient of a given road section, as far as the nearest height of land, is the area over which precipitation will collect and interact with any ML / ARD products, whether through overland ('sheet') flow or water flowing in a watercourse to which drainage from the road is discharged (whether free-flowing or through constructed road ditches).

The surface area of up-gradient catchments (in hectares) was used as a proxy for surface water volume, based on the assumption that precipitation does not vary significantly along the road alignment. This was considered to be a reasonable assumption, given that the road traverses semi-arid terrain, across the northeast-facing slopes of the Dawson Range in the rain shadow of the St. Elias Mountains. There is some variation in elevation, which could cause some variability in the amount of precipitation across the road alignment, but this is considered to be a minor variable in the context of this analysis.

The volume of water interacting with any potential ML / ARD products establishes the pathway, but would also dilute metal concentrations and reduce acidity. Consequently, it was assumed that the worst case scenario would be a large cut volume with a small up-gradient catchment area. The best case scenario would be a small cut volume with a large up-gradient catchment area.

With these considerations in mind, the pathway rating was determined based on a ratio of the total cut in a section of road (in em^3) to the drainage area (in hectares). While this

provides a general indication of the affect of various pathways along the road alignment, it is imprecise. Consequently, it was deemed appropriate to assign a pathway rating, from 0 to 4, based on the order of magnitude of the ratio. Areas with a very low cut volume relative to the size of the up-gradient catchment area have a very low ratio, less than one in several cases. Areas with a very large cut volume relative to the up-gradient catchment area have a very high ratio. The highest ratio is 5973, and there are 20 sections of the road where the ratio is 101 or higher, equivalent to a pathway rating of 3 or higher.

This rating system is shown in the table below, along with the range in ratios, and number of road sections included in each pathway rating (Table 3-4). The ratio, and corresponding 'pathway rating', for each of the 81 road sections is included as Table 4-1.

Table 3-4:
Pathway Rating System

Pathway Ratio	Pathway Rating	No. of Road Sections	Range: Lowest and Highest Ratio
0	0	20	n/a
>0-10	1	17	0.0307 – 7.54
11-100	2	24	10.5 – 94.5
101-1000	3	15	133 - 781
1001-10000	4	5	1155 - 5973
TOTAL	**n/a**	**81**	**n/a**

The drainage area for each section was determined as the area upslope of the road to the height of land, as noted above, and these areas are shown in Figures 3-2a to 3-2c. In order to do this, Digital Elevation Model (DEM) data was downloaded at 1:50,000 scale (GeoBase.ca) and divided into watersheds using MapWindow GIS. The watersheds were subdivided into smaller areas manually in AutoCAD while following topography contours uphill to the height of land and then back down to the road. These subdivisions were based on changes in geology intersecting the road, watershed boundaries, streams intersecting the road and cut type (soil or rock).

This approach is considered adequate for an initial consideration of pathways in this preliminary risk assessment. While other pathways, including most notably groundwater, will ultimately influence the amount and concentration of potential ML / ARD products that may affect receptors, it is assumed for the purposes of this report that groundwater impacted by the stressor will report to the surface water pathway at a similar point as surface drainage from the road. The analysis summarized above helps to identify those areas where the inherent risk of ML / ARD due to bedrock geology, larger cut volumes, and relatively little dilution, coincide.

3.4 Receptor Rating

An important consideration is the importance of the aquatic ecosystems that may be affected by ML / ARD products through surface water drainage. These may range from benthic invertebrate communities excluding fish in the case of small, ephemeral headwater streams, to habitat that is critical for spawning and early life stages of important commercial species such as Chinook salmon, in the case of larger streams that are accessible to anadromous salmonids.

The importance and sensitivity of receptors has been evaluated based on the DFO Practitioners Guide to the Risk Management Framework (n.d.). This guide proposes that receptors be evaluated based on four primary considerations: (1) species sensitivity, (2) species' dependence on habitat, (3) species rarity, and (4) habitat resiliency. Species sensitivity is the sensitivity of the fish species present to changes in the environment. Species' dependence on habitat is how the habitat is used. For example, a section of stream that is only used for migration will have a lower value than a section of stream that is used for spawning. Rarity includes both species and habitat rarity. A rare species is defined as one that is listed as rare or endangered on the Species at Risk Public Registry. Rare habitat could be any type of habitat that is uncommon in the system and that is required for all or part of the year or for one or more life stages. Habitat resiliency can take both thermal regime and flow regime into account.

Of these four categories, only species sensitivity and habitat resiliency are included, as there was not sufficient information available with respect to the other two considerations. Species sensitivity and habitat resiliency were rated independently, as described below, and were added to derive an overall receptor rating.

The two factors that were used to characterize receptors (aquatic ecosystems) in the vicinity of the proposed road were incorporated to derive a receptor rating from 1 to 3. The rating system is summarized in the table below.

Table 3-5:
Receptor Rating System

Receptor Rating	Species Presence	Habitat Resiliency (Flow Regime)
1 - Low	Benthic Invertebrates and/or arctic grayling only	Ephemeral flow – stream only contains water after a rainstorm
2 - Moderate	Fish community including arctic grayling and slimy sculpin, overwintering habitat	Intermittent flow – stream only contains water seasonally
3 - High	Fish community including Chinook salmon, spawning and overwintering habitat	Permanent flow – stream contains water year-round

3.4.1 Species Sensitivity

Species sensitivity was rated based on the fish species present in the streams (Table 3-5). There are no species that are listed in the Species At Risk public registry found in the area around the proposed road. Salmon are the most sensitive species in the area; therefore, areas where they are known to be present are assigned a higher rating. A moderate rating is assigned to areas where slimy sculpin occur, as these fish remain in areas that provide overwintering habitat, and often coincide with other species including arctic grayling. A low risk rating is assigned to areas where only arctic grayling are present, as they use small ephemeral and intermittent streams as summer rearing habitat, or there are likely no fish present, based on no fish being caught during electrofishing surveys. In determining the receptor rating, an assumption was made that the furthest known upstream occurrence is the extent of the range and the particular species will not be found upstream of this point.

Data for fish presence was obtained from a recent report documenting the results of a preliminary habitat assessment (Summit, 2011), as well as the results of recent supplemental field work (Kearns, pers. comm., 2011). These information sources include what is known of fish presence in the streams that the road intersects from previous studies and field work completed in August 2010. These sources provide information on the section of road up to approximately station 90+000. Data for the Western Section of the road (the westernmost 40 km) is limited. Additional information on this section of road was provided by the Casino Project team, based on inspection of satellite imagery available for the area. In this way, it was determined that several of the Hayes Creek and Isaac Creek tributaries have potential for fish habitat, but the Sunshine Creek tributary is unlikely to support fish. However, uncertainty still remains for several sections of road. In these areas, the most conservative rating, corresponding to a more sensitive and/or diverse ecosystem was assigned.

3.4.2 Habitat Resiliency

Habitat resiliency was rated based on the flow regime (Table 3-5). The main stems of both Big Creek and Hayes Creek are considered to have permanent flow as they are both major streams in the area. Sections of the headwaters for both of these creeks are rated as ephemeral based on field photos provided by the Casino Project team. In areas where the flow regime is uncertain, a conservatively high rating of 3 was assigned, corresponding with permanent flow that could support fish populations year round. The thermal regime was not considered as it is assumed that all streams in the area are cold water streams and that thermal conditions are not a limiting factor.

3.4.3 Summary of Receptor Ratings

Based on the criteria outlined above, all 81 sections of the road were rated for Species Sensitivity and Habitat Resiliency. A summary of these ratings is provided in Table 3-6. These were added to determine the overall receptor rating. A summary of the receptor ratings is shown in Table 3-7. The majority of the road sections (72 of 81) have high receptor ratings (5 or 6).

Table 3-6:
Summary of Species Sensitivity and Habitat Resiliency Ratings

Rating	Species Sensitivity (Number of Sections)	Habitat Resiliency (Number of Sections)
1 (Low Importance or Sensitivity)	9	5
2	33	0
3	39	76
Total	**81**	**81**

Table 3-7:
Summary of Receptor Ratings

Receptor Rating	No of Road Sections (of 81)
1	0
2	5
3	0
4	4
5	33
6	39
Total	**81**

3.5 Overall Risk Rating System

Ratings were then assigned for each section of road to reflect available information about:

- The stressor: the risk associated with the ML / ARD potential of the underlying bedrock, together with the volume of soil or rock that is anticipated to be disturbed, based on the preliminary road design;
- The pathway: the amount of dilution that is expected, given the size of the up-gradient surface water catchment area;

- The receptors: the fish species anticipated to be present at, and immediately downstream, of the road, as well as the nature of the flow regime in each section (permanent flow, intermittent (*i.e*. seasonal) flow, or ephemeral flow (*i.e*. flow during storm events only).

A risk rating was derived for each section of the road, based on the following formula:

Stressor Risk (0 to 25) x Pathway (0 to 4) x Receptor Sensitivity (2 to 6)

The lowest possible outcome is 0 (0x0x2), while the highest possible outcome is 600 (25x4x6). The actual results of the analysis range from 0 to 288. These numerical results are equated with risk as shown in the following table (Table 3-8).

Table 3-8:
Risk Rating and Corresponding Risk Category

Overall Risk Rating	Risk Category
0-49	Very low risk
50-99	Low risk
100-149	Moderate-low risk
150-199	Moderate risk
>200	Moderate-high risk

4. Results

4. Results

All relevant values, ratings and results are presented in the Risk Assessment Matrix for each of the sections of road (Table 4-1).

A total of 16 road sections are considered to have moderate-low risk or greater (an overall risk rating of 100 or greater), representing a total road length of 38.25 km (or 29% of the 133 km total alignment). These road sections are summarized in Tables 4-2 and 4-3 and are discussed in greater detail below. The low risk sections have an overall risk less than 100 and cover 94.7 km (approximately 71%) of the proposed road alignment.

These 16 sections with moderate-low risk or greater are first presented in order from the Freegold Road to the Casino Property, for reference purposes. They are then described in more detail in order from the highest risk to the lowest, for the purpose of further describing the results, and for providing recommendations.

The 16 sections with moderate-low risk or greater are generally located in two main sections of road: (1) an 11.8 km section from 86+500 to 98+300, and (2) a 16.4 km section from 108+030 to 124+430. These sections are both in areas where rock cuts will be required (as opposed to excavating soil). In addition, there are three other road sections where the ML / ARD risk is considered to be moderate-low or greater: (3) 1+290 to 5+960, (4) 13+420 to 18+400, and (5) 78+420 to 79+010. The moderate-low risk and higher road sections are discussed in greater detail in sections 4.1-4.3.

The majority of the road (94.68 km) can be considered to have low risk for ML / ARD and no further work is recommended for these sections. These sections were determined to have little ML / ARD potential based on a low stressor, pathway or receptor rating, or a combination of the three. These sections have an overall risk of less than 100. The low risk sections are briefly addressed in section 4.5.

Table 4-1:
Risk Assessment Matrix

Chainage			**Overall Risk**		**Stressors**						**Stressor**			**Pathway**			**Receptor**		**Receptor**
From	To				Rock Code	Rock Type Rating	Colluvium (c), alluvium (a) or bedrock (r)	Overall Geology Rating	Total cut (Soil or Rock) (em^3)	Cut Rating	**Rating**		Drainage Area (hectares)	Pathway Ratio	**Rating**		Species Sensitivity	Habitat resiliency	**Rating**
Bow Creek																			
0-316	0-150		72		mKgW	3	a/c	2	807	2	**4**		1.09	741	**3**		3	3	**6**
0-150	0+260		72		mKgW	3	a/c	2	2,461	2	**4**		3.85	639	**3**		3	3	**6**
0+260	0+410		24		mKgW	3	a/c	2	846	2	**4**		15,778	0.05	**1**		3	3	**6**
Seymour Creek																			
0+410	1+250		72		mKgW	3	a/c	2	12,699	3	**6**		136	94	**2**		3	3	**6**
1+250	1+290		0		mKqW	4	a/c	3	0	0	**0**		5.21	0	**0**		3	3	**6**
1+290	5+960		108		DMgPW	3	a/c	2	50,032	3	**6**		376	133	**3**		3	3	**6**
Big Creek (main stem)																			
5+960	11+860		72		DMgPW	3	a/c	2	17,689	3	**6**		1,396	13	**2**		3	3	**6**
11+860	12+280		6		mKqW	4	a	1	33	1	**1**		19.6	2	**1**		3	3	**6**
12+280	12+520		0		mKqW	4	a	1	0	0	**0**		11.9	0	**0**		3	3	**6**
12+520	13+420		6		mKqW	4	a	1	363	1	**1**		1,603	0.23	**1**		3	3	**6**
13+420	18+400		144		mKqW	4	a/c/r	4	42,061	3	**12**		1,730	24	**2**		3	3	**6**
18+400	18+570		0		mKqW	4	a/c	3	0	0	**0**		83.2	0	**0**		3	3	**6**
18+570	19+180		6		mKN	2	a	1	161	1	**1**		4,068	0.040	**1**		3	3	**6**
19+180	20+010		24		EJyL	2	a/c	1	2,344	2	**2**		142	17	**2**		3	3	**6**
20+010	22+600		36		mKN	2	a/c	1	22,086	3	**3**		1,126	20	**2**		3	3	**6**
22+600	23+890		18		mKqW	4	a/c	3	279	1	**3**		3,424	0.082	**1**		3	3	**6**
23+890	26+780		36		mKN	2	a/c	1	11,742	3	**3**		811	14	**2**		3	3	**6**
26+780	26+840		0		mKN	2	c	1	0	0	**0**		14.4	0	**0**		3	3	**6**
26+840	26+880		0		mKqW	4	a/c	3	0	0	**0**		21.0	0	**0**		2	3	**5**
26+880	27+500		45		mKqW	4	a/c	3	10,368	3	**9**		1,962	5	**1**		2	3	**5**
27+500	33+250		60		mKgW	3	a/c	2	25,257	3	**6**		1,907	13	**2**		2	3	**5**
Big Creek headwaters																			
33+250	34+240		30		mKgW	3	a/c	2	8,414	3	**6**		1,116	8	**1**		2	3	**5**
34+240	34+640		30		DMN	4	c	3	234	1	**3**		7.91	30	**2**		2	3	**5**
34+640	37+280		40		mKgW	3	c	2	6,095	2	**4**		192	32	**2**		2	3	**5**
37+280	37+360		0		uKC1	2	c	1	0	0	**0**		95.7	0	**0**		2	3	**5**
37+360	40+100		8		mKgW	3	a/c	2	7,416	2	**4**		987	8	**1**		1	1	**2**
40+100	40+300		0		uKC1	2	c	1	0	0	**0**		34.2	0	**0**		1	1	**2**
40+300	42+820		12		DMN	4	c	3	880	2	**6**		508	2	**1**		1	1	**2**
Hayes Creek headwaters																			
42+820	43+750		0		DMN	4	c	3	0	0	**0**		268	0	**0**		1	1	**2**
43+750	49+240		36		mKqW	4	a/c	3	36,759	3	**9**		1,841	20	**2**		1	1	**2**
49+240	51+200		8		uKC1	2	a/c	1	6,633	2	**2**		925	7	**1**		1	3	**4**
51+200	53+280		24		uKC1	2	a/c	1	20,518	3	**3**		744	28	**2**		1	3	**4**
53+280	53+900		16		mKgW	3	a/c	2	1,796	2	**4**		273	7	**1**		1	3	**4**
53+900	56+570		36		uKC1	2	a/c	1	27,549	3	**3**		139	198	**3**		1	3	**4**
56+570	56+920		0		uKC1	2	c	1	0	0	**0**		14,314	0	**0**		2	3	**5**
56+920	57+340		0		LKfP	3	a/c	2	0	0	**0**		102	0	**0**		2	3	**5**
57+340	57+480		0		mKgW	3	a	1	0	0	**0**		446	0	**0**		2	3	**5**
Hayes Creek (valley bottom)																			
57+480	62+260		30		mKgW	3	a/c	2	18,292	3	**6**		2,770	7	**1**		2	3	**5**
62+260	62+650		20		mKgW	3	a	1	2,033	2	**2**		86.5	24	**2**		2	3	**5**
62+650	64+000		30		mKgW	3	a/c	2	19,790	3	**6**		4,414	4	**1**		2	3	**5**
64+000	64+300		90		mKqW	4	a/c	3	6,610	2	**6**		18.9	350	**3**		2	3	**5**
64+300	64+740		0		mKgW	3	a/c	2	0	0	**0**		43.9	0	**0**		2	3	**5**
64+740	64+930		0		mKgw	3	a/c	2	0	0	**0**		3.49	0	**0**		2	3	**5**
64+930	65+100		0		DMgPW	3	a/c	2	0	0	**0**		26.7	0	**0**		2	3	**5**
65+100	65+260		0		mKqW	4	a/c	3	0	0	**0**		18.8	0	**0**		2	3	**5**
65+260	66+210		10		DMgPW	3	a/c	2	60	1	**2**		1,951	0.031	**1**		2	3	**5**

Chainage		Overall Risk	Stressors						Stressor			Pathway		Receptor		Receptor
From	To		Rock Code	Rock Type Rating	Colluvium (c), alluvium (a) or bedrock (r)	Overall Geology Rating	Total cut (Soil or Rock) (em^3)	Cut Rating	**Rating**	Drainage Area (hectares)	Pathway Ratio	**Rating**	Species Sensitivity	Habitat resiliency	**Rating**
Hayes Creek (valley bottom), continued															
66+210	66+320	0	DMgPW	3	a	1	0	0	**0**	5.63	0	**0**	2	3	**5**
66+320	67+780	0	DMgPW	3	a	1	0	0	**0**	101	0	**0**	2	3	**5**
67+780	68+500	5	DMgPW	3	a	1	91	1	**1**	104	1	**1**	2	3	**5**
68+500	69+380	20	DMgPW	3	a	1	976	2	**2**	90.8	11	**2**	2	3	**5**
69+380	78+420	60	DMgPW	3	a/c	2	65,716	3	**6**	6,232	11	**2**	2	3	**5**
78+420	79+010	135	DMN	4	a/c	3	8,023	3	**9**	16.4	489	**3**	2	3	**5**
79+010	79+400	0	DMN	4	a	1	0	0	**0**	12.3	0	**0**	3	3	**6**
79+400	81+740	0	DMN	4	a/c	3	0	0	**0**	272	0	**0**	3	3	**6**
81+740	84+750	72	mKgW	3	a/c	2	17,603	3	**6**	984	18	**2**	3	3	**6**
84+750	86+120	24	mKgW	3	a/c	2	1,403	2	**4**	39,611	0.035	**1**	3	3	**6**
Rock Cut															
Hayes Creek (rock cut area)															
86+120	86+500	72	mKgW	3	r	3	2,663	2	**6**	34.9	76	**2**	3	3	**6**
86+500	87+750	162	mKgW	3	r	3	46,159	3	**9**	136.5	338	**3**	3	3	**6**
87+750	87+900	144	mKdW	2	r	2	11,090	3	**6**	2.05	5,409	**4**	3	3	**6**
87+900	88+040	72	mKgW	3	r	3	4,390	2	**6**	73.2	60	**2**	3	3	**6**
88+040	88+280	144	mKdW	2	r	2	13,616	3	**6**	10.5	1,293	**4**	3	3	**6**
88+280	88+720	216	mKgW	3	r	3	7,435	3	**9**	6.43	1,156	**4**	3	3	**6**
88+720	95+460	144	mKdW	2	r	2	360,110	4	**8**	1,162	310	**3**	3	3	**6**
95+460	95+650	216	mKgW	3	r	3	21,110	3	**9**	3.53	5,973	**4**	3	3	**6**
Mascot Creek															
95+650	98+300	162	mKgW	3	r	3	23,394	3	**9**	120	195	**3**	3	3	**6**
98+300	106+670	72	mKdW	2	r	2	34,819	3	**6**	631	55	**2**	3	3	**6**
Idaho/Isaac/Sunshine Creek															
106+670	108+030	72	mKdW	2	r	2	16,677	3	**6**	270	62	**2**	3	3	**6**
108+030	108+410	162	mKgW	3	r	3	12,156	3	**9**	64.0	190	**3**	3	3	**6**
108+410	108+490	108	LKqP	3	r	3	914	2	**6**	1.17	781	**3**	3	3	**6**
108+490	108+540	36	LKfP	3	r	3	72	1	**3**	0.849	85	**2**	3	3	**6**
108+540	109+380	288	LKqP	3	r	3	51,831	4	**12**	30.1	1,721	**4**	3	3	**6**
109+380	112+460	108	mKgW	3	r	3	41,383	3	**9**	873	47	**2**	3	3	**6**
112+460	115+640	216	DMN	4	r	4	37,436	3	**12**	275	136	**3**	3	3	**6**
115+640	124+430	180	mKgW	3	r	3	86,893	4	**12**	551	158	**3**	2	3	**5**
Casino Creek															
124+430	126+060	40	mKdW	2	r	2	3,369	2	**4**	43.1	78	**2**	2	3	**5**
126+060	126+920	0	mKdW	2	r	2	0	0	**0**	12.4	0	**0**	2	3	**5**
126+920	127+660	15	mKgW	3	r	3	18	1	**3**	17.4	1	**1**	2	3	**5**
127+660	129+300	90	mKdW	2	r	2	15,573	3	**6**	78.6	198	**3**	2	3	**5**
129+300	129+840	30	mKgW	3	r	3	266	1	**3**	5.74	46	**2**	2	3	**5**
129+840	132+410	60	mKdW	2	r	2	10,605	3	**6**	112	94	**2**	2	3	**5**
132+410	132+610	90	LKfP	3	r	3	2,824	2	**6**	20.2	140	**3**	2	3	**5**
	average						15,567			1,456					
	median						2,663			112					
	median (ignore 0)						8,414			-					
	min						0			0.85					
	min (ignore 0)						17.7			-					
	max						360,110			39,611					
	Total						1,260,920			117,911					

Overall Risk Rating

<49 - Very low risk	
50-99 - Low risk	
100-149 - Moderate-low risk	
150-199 - Moderate risk	
>200 - Moderate-high risk	

Rating is uncertain, conservative

Rock Codes	
DMN	Nasina - quartzite and quartz-mica schist
DMgPW	Pelly Gneiss suite - schist and gneiss
EJyL	Long Lake suite - syenitic granitc rocks
mKdW	Whitehorse suite - diorite
mKgW	Whitehorse suite - granodiorite
mKqW	Whitehorse suite - granodiorite to quartz monzonite
mKN	Mount Nansen - volcanic flows and subvolcanic intrusions
uKC1	Carmacks - volcanic sequence
LKP	Prospector Mountain suite - quartz-rich monzonite stock (LKqP) with latite dykes (LKfP)

Table 4-2:
Road Sections with Moderate-Low Risk or Greater, from Freegold Road to Casino Property

Ref. No.	Chainage		Length (km)	Overall Risk
	From	To		
1	1+290	5+960	4.67	108
2	13+420	18+400	4.98	144
3	78+420	79+010	0.59	135
4	86+500	87+750	1.25	162
5	87+750	87+900	0.15	144
6	88+040	88+280	0.24	144
7	88+280	88+720	0.44	216
8	88+720	95+460	6.74	144
9	95+460	95+650	0.19	216
10	95+650	98+300	2.65	162
11	108+030	108+410	0.38	162
12	108+410	108+490	0.08	108
13	108+540	109+380	0.84	288
14	109+380	112+460	3.08	108
15	112+460	115+640	3.18	216
16	115+640	124+430	8.79	180

Table 4-3:
Moderate-low to Moderate-high Risk Road Sections

Chainage		Length (km)	Drainage Basin	Overall Risk	Risk
From	To				
108+540	109+380	0.84	Idaho/Isaac/Sunshine	288	Moderate-High
88+280	88+720	0.44	Hayes Creek	216	
95+460	95+650	0.19	Hayes Creek	216	
112+460	115+640	3.18	Idaho/Isaac/Sunshine	216	
115+640	124+430	8.79	Idaho/Isaac/Sunshine	180	Moderate
86+500	87+750	1.25	Hayes Creek	162	
95+650	98+300	2.65	Mascot Creek	162	
108+030	108+410	0.38	Idaho/Isaac/Sunshine	162	
87+750	87+900	0.15	Hayes Creek	144	Moderate-Low (Rock Cut)
88+040	88+280	0.24	Hayes Creek	144	
88+720	95+460	6.74	Hayes Creek	144	
108+410	108+490	0.08	Idaho/Isaac/Sunshine	108	
109+380	112+460	3.08	Idaho/Isaac/Sunshine	108	
13+420	18+400	4.98	Big Creek	144	Moderate-Low (Soil Cut)
78+420	79+010	0.59	Hayes Creek	135	
1+290	5+960	4.67	Seymour Creek	108	

4.1 Moderate-High Risk (4) Sections

There are four sections with an overall risk rating greater than 200. These are all in the section of road where all the cut volume is in rock. There is uncertainty in both the species sensitivity and the habitat resiliency through this section, so the receptor rating may be reduced if it is found that the streams in this area do not support fish or are not permanent watercourses (these have been assigned conservatively high values, with a receptor rating of 6).

The section with the highest risk (288) is a 0.84 km section from 108+540 to 109+380. This section is through the Prospector Mountain Suite (LKqP), with an overall geology rating of 3. There is also a high volume cut rating (4) which results in a stressor rating of 12. The pathway rating is high as well (4), due to a high cut volume in the context of the small catchment area.

The remaining moderate-high risk sections have an overall risk rating of 216. The second (88+280 to 88+720) and third (95+460 to 95+650) sections are through the Whitehorse Suite granodiorite (mKgW). These sections have a moderate geology rating of 3, but the amount of cut is fairly high (3), as is the pathway rating (4).

The fourth section (112+460 to 115+640) with a moderate-high risk rating is through the Nasina quartzite and quartz-mica schist (DMN), which has a high risk rating (4). Both the cut rating and the pathway rating are moderate (3).

4.2 Moderate Risk (4) Sections

There are four moderate risk sections. These are within the rock cut section, where there is uncertainty in the receptor rating. As is the case with the sections in the moderate-high risk category, the receptor rating may be reduced based on the results from further fieldwork.

All of these sections are through the Whitehorse Suite granodiorite (mKgW), with an overall geology rating of 3. The road section from 115+640 to 124+430 has an overall risk rating of 180, with a high cut rating (4) and a moderate pathway rating (3). The species sensitivity rating is estimated conservatively as a 2, based on the assessment of satellite imagery of the area. It was concluded that the tributaries in this area are unlikely to support fish; however, fish sampling has not been completed in this area, and so a conservatively high rating was assigned to this section of road. The overall receptor rating for this section of road is 5.

The other three moderate risk sections listed in Table 4-1 have an overall risk rating of 162 with a moderate cut rating (3), a moderate pathway rating (3) and a conservatively high receptor rating (6).

4.3 Moderate-Low Risk (8) Sections

4.3.1 Rock Cut: 86+120 to 132+610

There are five sections within the rock cut section which have a moderate risk rating. The first three cross the Whitehorse Suite diorite (mKdW) and all have an overall risk rating of 144. These have a relatively low geology rating (2) but a moderate to high (3-4) cut rating. The pathway rating is also moderate to high (3-4), depending on the section. There is uncertainty in the fish species present in this area as well as uncertainty in the flow regime, which results in a conservatively high receptor risk rating (6). The section from 108+410 to 108+490 has an overall risk rating of 108 and crosses the Prospector Mountain suite (LKqP). It has a geology rating of 3 and a cut rating of 2. The pathway rating is moderate (3). The receptor rating is conservatively high, due to uncertainty. The final section (109+380 to 112+460) also has an overall risk rating of 108. It crosses the Whitehorse Suite granodiorite (mKgW) and has a moderate stressor rating of 9 (3x3). The pathway rating is low (2) as the drainage area is large relative to the cut volume. The receptor rating is high (6), again due to the uncertainty in the fish presence and the flow regime in the area.

4.3.2 Soil Cut: 0-316 to 86+120

There are three sections with a moderate-low risk rating in the first section of road where all the cut is predicted to be soil. These are (1) section 13+420 to 18+400, (2) from 78+420 to 79+010, and (3) from 1+290 to 5+960.

The highest rating (144) for these three sections is for the section from 13+420 to 18+400. This section is through the Whitehorse Suite granodiorite to quartz-monzonite (mKqW). The surficial geology air photos indicate that there is bedrock in this section, resulting in a high (4) overall geology rating. The cut rating is moderate (3), which results in a high (12) stressor rating. As this section of road runs along the main stem of Big Creek, the receptor rating is high (6). The overall rating is kept down by a relatively low pathway rating (2), as the cut volume is low relative to the up gradient catchment area.

Within this road section from approximately kilometre mark 12+800 to 17+000, there are two possible road route options. The route to the north of Big Creek, which includes the section discussed above, is currently considered the primary option. However, both

routes are shown on the maps (see Figures 3-1 and 3-2a). However, the secondary route will likely have a lower ML / ARD risk, based on the geology and the absence of bedrock at surface along this alignment. This option crosses the Long Lake Suite (EJyL) and the Carmacks unit (mKN). Both of these units have a low (2) ARD risk and this risk will be reduced further to 1 as colluvium and alluvium are the surficial materials in this area. The section of road from 17+000 to 18+400 is through the Whitehorse Suite granodiorite to quartz-monzonite (mKqW) and must be re-evaluated if this option is chosen to determine its overall risk, as the drainage area will be smaller, relative to the larger drainage area for the section through mKqW in the primary option. However, there is no bedrock in this area, so the geology rating would be reduced to 3.

The next highest risk section is in the Hayes Creek (valley bottom) drainage (78+420 to 79+010), with an overall risk rating of 135. It is through the Nasina quartzite and quartz-mica schist (DMN). This unit has a rock type rating of 4, which is modified to an overall geology rating of 3 as the surficial material in the area includes colluvium. The cut and pathway ratings are moderate (3) and the receptor rating is fairly high (5), due to the presence of slimy sculpin and Arctic grayling and the permanent flow in Hayes Creek.

The third section (1+290 to 5+960) is through the Pelly Gneiss suite (DMgPW). It has an overall risk rating of 108. The overall geology rating is fairly low (2), since the rock type rating is modified by colluvium being present. The cut rating is moderate (3), as is the pathway rating (3). The receptor rating is high (6), as Chinook salmon are present in Seymour Creek and flow is likely permanent.

4.4 Uncertainty

While the 16 road sections with moderate-low risk or greater are deemed to have a higher ML / ARD risk, including consideration of the surface water pathway and aquatic ecosystem receptors, there is a high degree of uncertainty in the results. This uncertainty can be reduced by obtaining additional information related to all three aspects of the risk assessment, and recommendations for additional work to achieve this objective are provided below. Further characterization will be required for the sections rated as having moderate-low risk or greater, in order to determine if there will be any ML / ARD issues during or following road construction.

4.5 Low Risk Sections

The low risk sections have an overall risk less than 100 and cover 94.7 km (approximately 71%) of the proposed road alignment. In general, these sections are in the first 87 km of the road where it's predicted to be all soil (and no rock) cut. The stressor rating is generally fairly low through this section as alluvium and colluvium

generally have a lower risk rating relative to bedrock. Furthermore, this section generally has lower cut volumes and lower pathway ratios relative to the rock cut section. The final section of the road route from 124+430 to 132+610 is considered low risk, due to moderate to low stressor and pathway ratings. No further work is recommended for these sections, as the overall risk is low enough to determine that ML / ARD will not be an issue during or following road construction.

5. Recommendations

5. Recommendations

The ML / ARD risk assessment of the proposed Casino access road identified 16 sections representing 38.25 km (29 %) of the road alignment with potential for ML / ARD issues. Thirteen of the 16 sections are located in two areas: 86+500 to 98+300 and 108+030 to 124+430. These sections are both within the rock cut area. The three remaining sections are 1+290 to 5+960, 13+420 to 18+400 and 78+420 to 79+010.

Further work is recommended for all of these road sections in order to fully assess the level of ML / ARD risk to aquatic ecosystems during and following road construction. In addition, the ML / ARD potential of the quarry locations must be assessed.

Further work should include:

1. Further characterization of the streams. Further work from 86+120 to the Casino property may reduce the receptor rating, and the overall risk, if it is determined that the streams in this area are not fish-bearing and/or do not have permanent flow. This may reduce the overall risk in some sections to less than 100 and decrease the area of further sampling along the proposed road.
2. Collecting bedrock or surficial material samples from along these 16 sections. In areas where there will be rock cut, the ideal sampling method would be by drilling, in order to fully characterize the weathering at different depths and to obtain “fresh” rock samples. For surficial material samples, sampling from below the organic layer would be sufficient. The number of samples collected should be based on the excavated volume of material, as per the MEND (2009) guidelines. These samples should be submitted for the same suite of static tests which were completed on the initial 60 samples. In addition, the arsenic leaching potential of colluvial and alluvial materials should be evaluated by conducting shake flask extractions on a sub-set of representative samples. This will allow for a more complete characterization of the ML / ARD potential of the rock or surficial material along the higher risk sections of road and it will determine if mitigation strategies are required.
3. Finalizing the proposed road alignment between 12+800 and 17+000, in order to assess the ML / ARD risk along this section and to determine which option has a lower ML / ARD risk.
4. Finalizing quarry locations. Quarry locations should take the overall geology risk rating into account. The three bedrock units with the lowest ML / ARD risk rating (2) are the Long Lake Suite (EJyL), the Whitehorse Suite diorite (mKdW)

and the Carmacks volcanics (uKC1). Where possible, bedrock quarries should be located in these units. If granular quarries are required, alluvial material has a lower risk rating relative to colluvium, and colluvium lower than bedrock. However, based on the results of the risk assessment, excavation of colluvium generally has a low risk when the excavated volume remains relatively low (less than about 10,000 m^3) or the bedrock geology rating is 3 or lower. This would result in an overall geology rating of 2. Based on this, areas should be avoided where the colluvial parent material is from the Nasina unit (DMN) or the Whitehorse Suite granodiorite to quartz monzonite (mKqW).

5. Sampling quarry locations, once they are finalized. The number of samples should be based on the MEND (2009) and the MOT (2004) guidelines. This will ensure that the material to be used as fill will have a low ML / ARD risk

In the event that further testing determines that certain areas are potentially acid producing, there are several possible mitigation measures that may be employed to minimize the development of ML / ARD along the proposed road alignment. Ideally, material with high acid generating potential will be avoided during road construction, in favour of selecting an alignment and construction materials that have a low acid generating potential.

In cases where this is not possible, the two main options are (1) mixing potentially acid generating material with acid consuming material and (2) placing the material away from important aquatic ecosystems. The first option allows for neutral pH to be maintained in runoff, which will result in a lower concentration of metals and other geochemical parameters. The second option requires placing any potentially acid producing material in a location where the pathway rating is low (*e.g.* in an area where there is little or no connection between the stressor and the receptor), reducing the concentrations of ML / ARD products in the aquatic environment. Both of these options will minimize the impact on the aquatic ecosystem.

ML / ARD monitoring should continue during the construction phase for any areas which are determined to be potentially acid generating. This should include sampling and static testing of geotechnical drill core or blasted rock from these sections of road. Prior to receiving the testing results, any material which may have acid generating potential should be placed in a location away from streams, to minimize impact to aquatic ecosystems. The results of this secondary testing will determine how the material must ultimately be handled.

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Appendix I: Selected Photos of Rock, Colluvium and Alluvium Samples

western
COPPER AND GOLD

Appendix I: Selected Photos of Rock, Colluvium and Alluvium Samples

Nasina Unit (DMN)

Pelly Gneiss Suite (DMgPW)

Whitehorse Suite (mKw)

Mount Nansen Unit (mKN)

Carmacks Unit (uKC1)

Colluvium

Alluvium

Appendix II: Geochemical Results from Samples Collected Along the Proposed Road Alignment

APPENDIX IIA: ABA RESULTS

APPENDIX IIB: METALS BY AQUA REGIA WITH ICP-MS FINISH

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APPENDIX IIA: ABA RESULTS

Appendix II-A: ABA Results

Sample ID	Approx. Location (km)	Sample Type	Rock Code	Rinse* pH	Paste pH	TIC %	CaCO3 NP	C(T) %	S(T) %	S(SO4) %	S(S-2) %	Insoluble S %	AP	Modified NP	NPR NP/AP	Net NP	CaNP/AP	Fizz Test
Method Code				Sobek	Sobek	CSB02V	Calc	CSA01V	CSA06V	CSA07V	CSA08V	Calc	Calc	Modified		Sobek		Sobek
LOD				0.20	0.20	0.01	#N/A	0.01	0.01	0.01	0.01	#N/A	#N/A	0.50		Calc		#N/A
LX-C-54	82	orthogneiss	DMN	9.12	9.28	0.14	11.7	0.15	0.02	<0.01	0.02	<0.01	0.6	11.4	18.2	10.8	18.7	Slight
LX-C-55	89	metamorphic rock	DMN?	9.19	8.60	12	1000.0	12.2	<0.01	<0.01	<0.01	<0.01	<0.3	1020.1	3400.3	1020.1	3333.3	Strong
LX-C-8	115	gneiss	DMN	7.14	8.18	<0.01	<0.8	0.04	0.02	<0.01	<0.01	0.02	<0.3	3.3	11.0	3.3	2.7	None
LX-C-34	5	metamorphic diorite	DMgPW	9.11	9.44	0.07	5.8	0.07	<0.01	<0.01	<0.01	<0.01	<0.3	10.2	34.0	10.2	19.4	None
LX-C-43	6	foliated granodiorite	DMgPW	9.03	9.09	0.03	2.5	0.04	<0.01	<0.01	<0.01	<0.01	<0.3	6.4	21.3	6.4	8.3	None
LX-C-52	72	gneiss	DMgPW	9.19	9.12	0.22	18.3	0.26	0.01	<0.01	0.01	<0.01	0.3	17.2	55.0	16.9	58.7	None
LX-C-53	76	meta-igneous rock	DMgPW	6.24	7.79	0.01	0.8	0.05	0.12	<0.01	0.1	0.02	3.1	2.4	0.8	-0.7	0.3	None
LX-C-39	16	leucocratic granodiorite	mKW	9.21	9.59	0.11	9.2	0.11	<0.01	<0.01	<0.01	<0.01	<0.3	8.9	29.7	8.9	30.6	Slight
LX-C-24	27	granite/granodiorite	mKW	7.27	8.67	0.01	0.8	0.02	<0.01	<0.01	<0.01	<0.01	<0.3	3.9	13.0	3.9	2.8	None
LX-C-44	36	granite/granodiorite	mKW	6.97	7.45	<0.01	<0.8	0.03	<0.01	<0.01	<0.01	<0.01	<0.3	3.4	11.3	3.4	2.7	None
LX-C-45	39	leucocratic granitoid	mKW	6.59	7.64	<0.01	<0.8	0.01	<0.01	<0.01	<0.01	<0.01	<0.3	0.6	2.0	0.6	2.7	None
LX-C-20	40	granitic rock	mKW	8.77	9.36	<0.01	<0.8	<0.01	<0.01	<0.01	<0.01	<0.01	<0.3	1.5	5.0	1.5	2.7	None
LX-C-19	45	granodiorite	mKW	7.16	8.41	<0.01	<0.8	0.03	<0.01	<0.01	<0.01	<0.01	<0.3	3.9	13.0	3.9	2.7	None
LX-C-17	46	granodiorite	mKW	6.65	8.47	<0.01	<0.8	0.02	<0.01	<0.01	<0.01	<0.01	<0.3	2.8	9.3	2.8	2.7	None
LX-C-13	62	granodiorite	mKW	7.25	8.97	0.02	1.7	0.05	<0.01	<0.01	<0.01	<0.01	<0.3	5.4	18.0	5.4	5.6	None
LX-C-50	62	granodiorite	mKW	8.43	8.92	0.02	1.7	0.04	<0.01	<0.01	<0.01	<0.01	<0.3	4.5	15.0	4.5	5.6	None
LX-C-12	63	granodiorite	mKW	8.38	9.03	0.05	4.2	0.16	<0.01	<0.01	<0.01	<0.01	<0.3	6.6	22.0	6.6	13.9	None
LX-C-56	92	granodiorite	mKW	7.68	8.50	0.01	0.8	0.04	0.02	<0.01	0.01	0.02	0.3	6.4	20.5	6.1	2.7	None
LX-C-57	93	granodiorite	mKW	8.83	8.99	0.08	6.7	0.08	0.05	<0.01	0.05	<0.01	1.6	11.2	7.2	9.6	4.3	None
LX-C-9	97	granodiorite	mKW	6.05	8.07	<0.01	<0.8	0.06	<0.01	<0.01	<0.01	<0.01	<0.3	5.6	18.7	5.6	2.7	None
LX-C-1	103	granodiorite	mKW	7.20	8.20	<0.01	<0.8	0.05	<0.01	<0.01	<0.01	<0.01	<0.3	6.1	20.3	6.1	2.7	None
LX-C-2	104	granodiorite	mKW	7.25	8.77	<0.01	<0.8	0.03	0.02	<0.01	<0.01	0.02	<0.3	5.8	19.3	5.8	2.7	None
LX-C-4	106	diorite	mKW	6.50	8.15	<0.01	<0.8	0.31	0.03	<0.01	<0.01	0.03	<0.3	6.6	22.0	6.6	2.7	None
LX-C-58	110	granodiorite	mKW	6.57	7.73	<0.01	<0.8	0.06	<0.01	<0.01	<0.01	<0.01	<0.3	1.1	3.7	1.1	2.7	None
LX-C-59	111	granodiorite	mKW	8.58	9.13	0.05	4.2	0.09	<0.01	<0.01	<0.01	<0.01	<0.3	6.5	21.7	6.5	13.9	None
LX-C-6	112	diorite	mKW	8.16	8.84	0.05	4.2	0.14	0.02	<0.01	0.02	<0.01	0.6	8.8	14.1	8.2	6.7	None
LX-C-7	114	granodiorite	mKW	8.33	8.44	0.04	3.3	0.18	0.03	<0.01	0.02	0.01	0.6	8.0	12.8	7.4	5.3	None
LX-C-32	119	granodiorite	mKW	8.41	8.83	0.01	0.8	0.07	0.02	<0.01	<0.01	0.02	<0.3	6.1	20.3	6.1	2.8	None
LX-C-30	121	granodiorite	mKW	5.99	7.91	<0.01	<0.8	0.07	<0.01	<0.01	<0.01	<0.01	<0.3	6.0	20.0	6.0	2.7	None
LX-C-31	122	granodiorite	mKW	6.60	8.46	0.01	0.8	0.06	0.01	<0.01	<0.01	0.01	<0.3	5.8	19.3	5.8	2.8	None
LX-C-29	124	granodiorite	mKW	6.16	8.04	<0.01	<0.8	0.06	0.02	<0.01	<0.01	0.02	<0.3	6.4	21.3	6.4	2.7	None
LX-C-60	124	granodiorite	mKW	7.31	8.32	0.01	0.8	0.04	0.01	<0.01	<0.01	0.01	<0.3	5.1	17.0	5.1	2.8	None
LX-C-28	128	diorite/granodiorite	mKW	6.65	8.33	0.01	0.8	0.05	<0.01	<0.01	<0.01	<0.01	<0.3	9.1	30.3	9.1	2.8	None
LX-C-27	130	diorite	mKW	8.00	8.91	0.07	5.8	0.08	0.05	<0.01	0.03	0.02	0.9	17.1	18.2	16.2	6.2	None
LX-C-26	131	granodiorite	mKW	5.71	8.27	<0.01	<0.8	0.02	0.02	<0.01	<0.01	0.02	<0.3	5.6	18.7	5.6	2.7	None
LX-C-42	22	fine grained matrix, visible plagioclase	mKN	9.14	8.74	1.41	117.5	1.49	<0.01	<0.01	<0.01	<0.01	<0.3	72.6	242.0	72.6	391.7	Slight
LX-C-18	45	volcanic rock	uKC	8.61	8.84	0.17	14.2	0.18	0.05	<0.01	0.04	0.01	1.3	19.7	15.8	18.5	11.3	Slight
LX-C-47	50	vesicular basalt	uKC	8.71	8.70	<0.01	<0.8	0.01	<0.01	<0.01	<0.01	<0.01	<0.3	41.8	139.3	41.8	2.7	None
LX-C-14	52	volcanic rock	uKC	9.13	8.76	1.12	93.3	1.19	0.01	<0.01	<0.01	0.01	<0.3	96.3	321.0	96.3	311.1	Slight

Appendix II-A: ABA Results

Sample ID	Approx. Location (km)	Sample Type	Rock Code	Rinse* pH	Paste pH	TIC %	CaCO3 NP	C(T) %	S(T) %	S(SO4) %	S(S-2) %	Insoluble S %	AP	Modified NP	NPR NP/AP	Net NP	CaNP/AP	Fizz Test
			Underlying bedrock type															
LX-C-33	1	colluvium	mKgW	6.72	7.75	0.01	0.8	0.16	<0.01	<0.01	<0.01	<0.01	<0.3	8.1	27.0	8.1	2.8	None
LX-C-35	4	ash		6.89	7.72	<0.01	<0.8	0.1	0.02	<0.01	<0.01	0.02	<0.3	2.9	9.7	2.9	2.7	None
LX-C-36	4	colluvium	DMgPW	6.54	7.84	0.22	18.3	0.93	0.03	<0.01	0.02	-0.02	0.6	18.0	28.8	17.4	29.3	Slight
LX-C-37	10	soil	DMgPW	5.40	5.68	0.02	1.7	8.04	0.06	0.03	0.02	0.01	0.6	-4.6	-7.4	-5.2	2.7	None
LX-C-40	16	colluvium	mKqW	7.08	8.44	0.18	15.0	0.24	0.02	<0.01	<0.01	0.02	<0.3	15.4	51.3	15.4	50.0	Slight
LX-C-38	17	colluvium	mKqW	7.68	8.20	0.02	1.7	0.35	<0.01	<0.01	<0.01	<0.01	<0.3	4.9	16.3	4.9	5.6	None
LX-C-23	27	colluvium	mKqW	7.79	8.23	0.01	0.8	0.06	<0.01	<0.01	<0.01	<0.01	<0.3	3.5	11.7	3.5	2.8	None
LX-C-22	30	colluvium	mKgW	8.63	8.78	0.05	4.2	0.08	<0.01	<0.01	<0.01	<0.01	<0.3	5.6	18.7	5.6	13.9	None
LX-C-21	34	colluvium	mKgW	8.56	8.17	0.24	20.0	0.28	0.18	<0.01	0.15	0.03	4.7	21.9	4.7	17.2	4.3	Slight
LX-C-46	42	colluvium	DMN	5.09	5.62	<0.01	<0.8	1.4	0.01	<0.01	<0.01	0.01	<0.3	8.4	28.0	8.4	2.7	None
LX-C-16	48	sandy soil & rock fragments	mKqW	5.81	7.05	<0.01	<0.8	0.07	0.02	0.01	<0.01	0.01	<0.3	1.1	3.7	1.1	2.7	None
LX-C-48	58	colluvium	mKgW	6.37	7.28	<0.01	<0.8	0.19	<0.01	<0.01	<0.01	<0.01	<0.3	3.8	12.7	3.8	2.7	None
LX-C-51	68	colluvium	DMgPW	7.43	7.56	0.03	2.5	0.48	0.45	0.43	0.02	<0.01	0.6	6.0	9.6	5.4	4.0	None
LX-C-3	105	colluvium	mKdW	5.93	8.18	<0.01	<0.8	0.08	<0.01	<0.01	<0.01	<0.01	<0.3	5.8	19.3	5.8	2.7	None
LX-C-5	107	colluvium	mKdW	6.36	7.91	<0.01	<0.8	0.1	0.02	<0.01	<0.01	0.02	<0.3	1.8	6.0	1.8	2.7	None
LX-C-41	23	fluvial		6.54	6.57	0.01	0.8	0.82	0.02	<0.01	<0.01	0.02	<0.3	7.6	25.3	7.6	2.8	None
LX-C-25	27	fluvial		6.88	8.23	0.01	0.8	0.08	<0.01	<0.01	<0.01	<0.01	<0.3	11.3	37.7	11.3	2.8	None
LX-C-15	51	fluvial		7.03	8.14	0.01	0.8	0.29	<0.01	<0.01	<0.01	<0.01	<0.3	12.5	41.7	12.5	2.8	None
LX-C-49	58	fluvial		6.45	7.67	0.01	0.8	0.25	0.03	<0.01	0.03	<0.01	0.9	5.4	5.8	4.5	0.9	None
LX-C-11	68	fluvial		5.84	6.76	<0.01	<0.8	0.64	<0.01	<0.01	<0.01	<0.01	<0.3	4.2	14.0	4.2	2.7	None
LX-C-10	80	fluvial		8.40	8.86	0.16	13.3	0.27	<0.01	<0.01	<0.01	<0.01	<0.3	17.6	58.7	17.6	44.4	Slight
Duplicates																		
LX-C-1					8.36									5.2				None
LX-C-11										<0.01								
LX-C-13											<0.01							
LX-C-20					9.32									2.1				None
LX-C-21					8.07									21.9				Slight
LX-C-30								0.07	0.01									
LX-C-40					8.51	0.18								15.8				Slight
LX-C-41					6.62									8.1				None
LX-C-54										<0.01	0.02							
LX-C-56								0.04	0.02									
LX-C-60					8.34	0.01								6.3				None
QC																		
RTS-1									1.67									
SY-4						0.91		1.04										
RTS-3A											2.3							
PD-1										4.39								
NBM-!														43.0				Slight
NBM-!														43.9				Slight
Expected Value						0.95		1.00	1.66	4.27	2.34			42.0				Slight
Tolerance +/-						0.06		0.2	0.08	0.43	0.23			3.0				

Note:

AP = Acid potential in tonnes CaCO3 equivalent per 1000 tonnes of material. AP is determined from sulphide sulphur content.

NP = Neutralization potential in tonnes CaCO3 equivalent per 1000 tonnes of material. Acid addition based on TIC content.

NET NP = Modified NP - AP

Carbonate NP is calculated from TIC originating from carbonates and is expressed in kg CaCO3/tonne.

Sulphate Sulphur determined by 25% HCL with S by ICP Finish

Sulphide Sulphur determined by Sobek 1:7 Nitric Acid with Gravimetric Finish

Insoluble S is acid insoluble S (Total S - (Sulphate S + Sulphide S)).

Rinse pH on the -2 mm fraction.

APPENDIX IIB: METALS BY AQUA REGIA WITH ICP-MS FINISH

Appendix II-B: Metals by Aqua Regia with ICP-MS Finish

Sample ID	Approx. Location (km)	Sample Type	Rock Code	Ag	Al	As	Au	B	Ba	Bi	Ca	Cd	Co	Cr	Cu	Fe	Ga	Hg	K	La	Mg	Mn	Mo	Na	Ni	P	Pb	S	Sb	Sc	Se	Sr	Te	Th	Ti	Tl	V	W	Zn
				ppm	%	ppm	ppb	ppm	ppm	ppm	%	ppm	ppm	ppm	ppm	%	ppm	ppm	%	ppm	%	ppm	ppm	%	ppm	%	ppm	%	ppm	ppm	ppm	ppm	ppm	ppm	%	ppm	ppm	ppm	ppm
Method Code				1 DX	1 DX	1 DX	1 DX	1 DX	1 DX	1 DX	1 DX	1 DX	1 DX	1 DX	1 DX	1 DX	1 DX	1 DX	1 DX	1 DX	1 DX	1 DX	1 DX	1 DX	1 DX	1 DX	1 DX	1 DX	1 DX	1 DX	1 DX	1 DX	1 DX	1 DX	1 DX	1 DX	1 DX	1 DX	1 DX
LOD				0.1	0.01	0.5	0.5	20	1	0.1	0.01	0.1	0.1	1	0.1	0.01	1	0.01	0.01	1	0.01	1	0.1	0.001	0.1	0.001	0.1	0.05	0.1	0.1	0.5	1	0.2	0.1	0.001	0.1	2	0.1	1
LX-C-54	82	orthogneiss	DMN	*0.1*	0.3	*0.5*	*0.5*	*20*	29	0.2	0.45	*0.1*	1.6	85	2.9	0.75	1	*0.01*	0.15	50	0.08	189	0.6	0.032	3.7	0.018	5.9	*0.05*	0.4	0.8	*0.5*	12	*0.2*	28.3	0.003	*0.1*	2	0.2	15
LX-C-55	89	metamorphic rock	DMN?	*0.1*	*0.01*	5.7	1.1	*20*	43	*0.1*	35.58	0.2	0.3	3	0.5	0.09	*1*	*0.01*	*0.01*	*1*	0.19	116	*0.1*	*0.001*	2.9	0.008	0.9	0.13	*0.1*	0.2	*0.5*	231	*0.2*	*0.1*	*0.001*	*0.1*	*2*	*0.1*	2
LX-C-8	115	gneiss	DMN	*0.1*	0.44	2.1	1.3	*20*	27	0.2	0.06	*0.1*	2.8	88	8.2	1.17	3	*0.01*	0.26	26	0.19	147	0.5	0.039	4.3	0.02	8	*0.05*	0.5	2	*0.5*	4	*0.2*	33.7	0.05	0.2	10	*0.1*	18
LX-C-34	5	metamorphic diorite	DMgPW	*0.1*	1.55	1.7	1.7	*20*	299	*0.1*	0.87	0.1	13.3	57	2.5	3.13	6	*0.01*	0.61	5	1.28	635	0.1	0.096	4.9	0.06	2.9	*0.05*	*0.1*	6.3	*0.5*	14	*0.2*	2	0.235	*0.1*	93	*0.1*	62
LX-C-43	6	foliated granodiorite	DMgPW	*0.1*	1.13	*0.5*	*0.5*	*20*	226	*0.1*	0.29	*0.1*	8.1	93	2	2.44	5	*0.01*	0.73	26	0.59	444	0.3	0.06	4.2	0.038	1.9	*0.05*	*0.1*	2.4	*0.5*	17	*0.2*	7.9	0.151	0.2	37	*0.1*	49
LX-C-52	72	gneiss	DMgPW	*0.1*	0.26	1.1	0.6	*20*	38	0.2	0.7	*0.1*	2.7	128	6.3	0.54	1	*0.01*	0.08	6	0.14	385	0.7	0.012	8.7	0.011	4.8	*0.05*	*0.1*	0.8	*0.5*	10	*0.2*	1.9	0.005	*0.1*	5	*0.1*	13
LX-C-53	76	meta-igneous rock	DMgPW	*0.1*	0.49	2.3	*0.5*	*20*	50	0.3	0.13	*0.1*	2.8	76	8.2	1.05	2	*0.01*	0.15	14	0.21	101	0.9	0.035	4.7	0.017	3.6	0.12	0.3	0.9	*0.5*	8	*0.2*	18.1	0.006	*0.1*	3	*0.1*	17
LX-C-39	16	leucocratic granodiorite	mKW	*0.1*	0.18	4.7	*0.5*	*20*	61	0.1	0.29	*0.1*	0.8	78	10.2	0.52	*1*	*0.01*	0.15	25	0.01	213	0.9	0.034	2.6	0.007	14.9	*0.05*	0.1	0.4	*0.5*	10	*0.2*	17.3	*0.001*	*0.1*	*2*	*0.1*	8
LX-C-24	27	granite/granodiorite	mKW	*0.1*	0.5	*0.5*	*0.5*	*20*	65	*0.1*	0.13	*0.1*	3.1	95	2.4	1.23	3	*0.01*	0.18	24	0.3	555	0.4	0.044	5.6	0.038	4	*0.05*	*0.1*	2.6	*0.5*	8	*0.2*	29.9	0.04	0.2	19	*0.1*	31
LX-C-44	36	granite/granodiorite	mKW	*0.1*	0.31	4.5	*0.5*	*20*	49	*0.1*	0.09	*0.1*	3.3	94	4.5	1.41	1	0.18	0.14	20	0.08	692	0.3	0.042	4.7	0.037	4.3	*0.05*	0.8	3.3	*0.5*	6	*0.2*	25.4	0.019	0.3	19	*0.1*	28
LX-C-45	39	leucocratic granitoid	mKW	*0.1*	0.17	5.1	*0.5*	*20*	24	0.1	0.02	*0.1*	2.4	79	3.3	0.22	*1*	0.08	0.07	2	*0.01*	118	5.6	0.025	2.8	0.003	15.1	*0.05*	1.1	1.3	*0.5*	17	*0.2*	17.5	0.002	0.1	*2*	0.1	5
LX-C-20	40	granitic rock	mKW	*0.1*	0.13	8.7	0.8	*20*	17	*0.1*	0.02	*0.1*	0.4	78	1.9	0.17	*1*	0.01	0.09	3	*0.01*	777	0.5	0.033	2.3	0.002	5.8	*0.05*	0.3	0.6	*0.5*	13	*0.2*	10	*0.001*	*0.1*	*2*	0.2	3
LX-C-19	45	granodiorite	mKW	*0.1*	0.63	*0.5*	0.9	*20*	84	*0.1*	0.14	*0.1*	4.4	89	6	1.62	3	*0.01*	0.37	18	0.44	568	0.3	0.052	5.1	0.03	2.4	*0.05*	*0.1*	4.4	*0.5*	8	*0.2*	14.6	0.09	0.3	33	*0.1*	37
LX-C-17	46	granodiorite	mKW	*0.1*	0.65	*0.5*	*0.5*	*20*	58	*0.1*	0.08	*0.1*	3.8	83	3.1	1.47	3	*0.01*	0.38	15	0.41	502	0.2	0.051	2.8	0.025	2.2	*0.05*	*0.1*	4.3	*0.5*	5	*0.2*	17.5	0.084	0.4	29	*0.1*	32
LX-C-13	62	granodiorite	mKW	*0.1*	0.64	*0.5*	0.8	*20*	98	*0.1*	0.15	*0.1*	5.2	77	1.9	1.68	4	*0.01*	0.34	17	0.44	617	0.5	0.055	3.1	0.033	2.2	*0.05*	*0.1*	4.8	*0.5*	6	*0.2*	14.9	0.065	0.2	34	*0.1*	41
LX-C-50	62	granodiorite	mKW	*0.1*	0.59	0.5	0.7	*20*	105	*0.1*	0.17	*0.1*	4.3	91	1.9	1.57	3	*0.01*	0.37	14	0.39	530	0.5	0.064	3.2	0.03	2.5	*0.05*	*0.1*	4.3	*0.5*	6	*0.2*	12.6	0.077	0.2	33	*0.1*	36
LX-C-12	63	granodiorite	mKW	*0.1*	0.59	*0.5*	1	*20*	126	*0.1*	0.27	*0.1*	4.8	72	2.5	1.58	3	*0.01*	0.26	24	0.38	661	0.4	0.042	3	0.033	4.1	*0.05*	0.2	4.1	*0.5*	10	*0.2*	18.4	0.037	0.1	26	*0.1*	37
LX-C-56	92	granodiorite	mKW	*0.1*	1.84	*0.5*	*0.5*	*20*	986	*0.1*	0.52	*0.1*	12.8	67	18.4	3.02	5	*0.01*	0.87	9	1.03	495	0.7	0.17	5.9	0.074	1.8	*0.05*	*0.1*	4.3	*0.5*	43	*0.2*	7.7	0.217	0.4	108	1.1	44
LX-C-57	93	granodiorite	mKW	*0.1*	1.51	*0.5*	*0.5*	*20*	618	*0.1*	0.77	*0.1*	11.1	74	21	2.66	5	*0.01*	0.59	13	0.94	450	0.7	0.141	5.4	0.078	1.8	0.06	*0.1*	4.2	*0.5*	38	*0.2*	11	0.168	0.3	85	0.2	39
LX-C-9	97	granodiorite	mKW	*0.1*	1.34	*0.5*	*0.5*	*20*	1562	*0.1*	0.38	*0.1*	8.4	76	7.5	2.37	4	*0.01*	0.73	6	0.72	396	0.3	0.116	4.2	0.056	1.8	*0.05*	*0.1*	1.9	*0.5*	26	*0.2*	5.9	0.227	0.3	66	0.1	38
LX-C-1	103	granodiorite	mKW	*0.1*	1.31	0.9	3.4	*20*	339	0.1	0.49	*0.1*	7.8	76	6.8	2.58	5	*0.01*	0.74	15	0.74	526	0.3	0.124	4	0.062	5.8	*0.05*	*0.1*	2.6	*0.5*	22	*0.2*	15.9	0.219	0.4	66	*0.1*	48
LX-C-2	104	granodiorite	mKW	*0.1*	1.1	*0.5*	2	*20*	272	*0.1*	0.38	*0.1*	6.1	85	3.1	2.12	4	*0.01*	0.57	15	0.59	385	0.3	0.117	4.4	0.041	3.9	*0.05*	*0.1*	2.4	*0.5*	24	*0.2*	8.9	0.178	0.3	52	*0.1*	36
LX-C-4	106	diorite	mKW	*0.1*	1.91	0.7	1.9	*20*	650	0.2	0.71	*0.1*	6.9	68	17.7	2.49	6	*0.01*	0.75	11	0.66	522	1	0.198	3.9	0.058	3.6	*0.05*	*0.1*	3.1	*0.5*	77	*0.2*	9.8	0.174	0.6	55	0.4	46
LX-C-58	110	granodiorite	mKW	*0.1*	0.27	*0.5*	*0.5*	*20*	33	*0.1*	0.02	*0.1*	0.4	106	1.7	0.73	2	0.02	0.15	11	0.03	105	0.5	0.037	3.1	0.004	5.5	*0.05*	0.4	1.3	*0.5*	2	*0.2*	16.3	0.004	0.1	*2*	0.2	14
LX-C-59	111	granodiorite	mKW	*0.1*	1.24	*0.5*	*0.5*	*20*	447	0.1	0.37	*0.1*	7.5	77	8.2	2.42	5	*0.01*	0.7	19	0.76	647	0.2	0.109	4.1	0.043	3.2	*0.05*	*0.1*	4.9	*0.5*	22	*0.2*	16.7	0.164	0.8	62	0.7	47
LX-C-6	112	diorite	mKW	*0.1*	1.51	*0.5*	*0.5*	*20*	767	*0.1*	0.72	*0.1*	6.8	73	17.5	2.43	5	*0.01*	0.57	17	0.67	460	1.3	0.163	4.8	0.069	4.6	*0.05*	*0.1*	2.8	*0.5*	68	*0.2*	12.4	0.171	0.3	55	0.4	42
LX-C-7	114	granodiorite	mKW	*0.1*	1.12	*0.5*	*0.5*	*20*	362	*0.1*	0.42	0.1	6.8	78	3.2	2.3	5	*0.01*	0.58	21	0.71	453	0.3	0.1	3.9	0.043	4.5	*0.05*	0.1	2.8	*0.5*	21	*0.2*	27.6	0.191	0.4	61	*0.1*	43
LX-C-32	119	granodiorite	mKW	*0.1*	1.44	*0.5*	1.3	*20*	362	*0.1*	0.67	0.1	10	78	16.9	2.39	5	*0.01*	0.37	15	0.87	442	0.4	0.095	5	0.058	4.6	*0.05*	0.5	2.6	*0.5*	31	*0.2*	10.2	0.187	0.2	65	0.3	41
LX-C-30	121	granodiorite	mKW	*0.1*	1.67	*0.5*	0.8	*20*	1010	*0.1*	0.56	*0.1*	10.6	74	11.7	2.78	5	*0.01*	0.68	9	0.93	389	0.2	0.141	5	0.072	3	*0.05*	*0.1*	3.1	*0.5*	57	*0.2*	6	0.239	0.3	84	*0.1*	42
LX-C-31	122	granodiorite	mKW	*0.1*	1.41	*0.5*	1.6	*20*	419	*0.1*	0.58	*0.1*	10	70	17.2	2.37	5	*0.01*	0.46	13	0.8	357	1.3	0.139	5.4	0.058	3	*0.05*	*0.1*	2.7	*0.5*	37	*0.2*	12.7	0.175	0.3	73	*0.1*	37
LX-C-29	124	granodiorite	mKW	*0.1*	2.48	*0.5*	*0.5*	*20*	1643	*0.1*	1.1	*0.1*	8.2	63	13.9	2.46	6	*0.01*	0.64	10	0.69	254	0.2	0.29	3.4	0.078	2	*0.05*	*0.1*	3.9	*0.5*	108	*0.2*	4.9	0.234	0.3	58	*0.1*	33
LX-C-60	124	granodiorite	mKW	*0.1*	2.5	*0.5*	*0.5*	*20*	900	*0.1*	1.35	*0.1*	5.8	66	11.1	1.73	6	*0.01*	0.31	15	0.51	178	0.2	0.356	3.5	0.048	2.3	*0.05*	*0.1*	3.3	*0.5*	141	*0.2*	8.8	0.163	0.2	35	0.3	26
LX-C-28	128	diorite/granodiorite	mKW	*0.1*	3.12	*0.5*	*0.5*	*20*	641	*0.1*	1.42	*0.1*	13.7	48	7.2	2.41	6	*0.01*	0.89	6	1.36	349	0.2	0.193	9.2	0.07	2.2	*0.05*	*0.1*	2.6	*0.5*	108	*0.2*	7.7	0.236	0.4	81	*0.1*	32
LX-C-27	130	diorite	mKW	0.1	4.33	0.8	1.2	*20*	511	*0.1*	2.57	*0.1*	16.8	41	32.2	3.81	9	0.01	0.3	8	1.26	353	0.7	0.326	8.9	0.156	3.9	*0.05*	*0.1*	2.4	*0.5*	240	*0.2*	2.6	0.167	*0.1*	124	*0.1*	38
LX-C-26	131	granodiorite	mKW	*0.1*	1.52	2	0.7	*20*	384	0.1	0.59	*0.1*	10.5	71	18.5	2.61	5	*0.01*	0.51	13	0.89	407	0.7	0.134	5	0.064	5.1	*0.05*	0.3	2.9	*0.5*	36	*0.2*	10.4	0.22	0.3	82	0.2	51
LX-C-42	22	fine grained matrix, visible plagioclase	mKN	*0.1*	0.89	2.1	0.7	*20*	115	*0.1*	2.35	*0.1*	11.4	42	21.5	3.35	2	*0.01*	0.15	20	1.2	815	0.8	0.074	15.5	0.228	2.8	*0.05*	*0.1*	6.8	*0.5*	164	*0.2*	3.2	0.014	*0.1*	81	*0.1*	64
LX-C-18	45	volcanic rock	uKC	*0.1*	1.38	3.3	0.6	*20*	399	0.1	1.16	0.1	10.3	63	14.6	3.02	7	*0.01*	0.08	13	0.95	966	1.3	0.09	14.2	0.142	6.2	0.07	0.1	3.8	*0.5*	72	*0.2*	3.2	0.085	*0.1*	55	0.1	42
LX-C-47	50	vesicular basalt	uKC	*0.1*	0.96	*0.5*	1.8	*20*	54	*0.1*	0.89	*0.1*	14.3	55	19.6	2.74	3	*0.01*	0.09	22	1.47	379	1	0.127	49.7	0.186	4.2	*0.05*	*0.1*	1.7	*0.5*	101	*0.2*	4.2	0.098	*0.1*	81	*0.1*	62
LX-C-14	52	volcanic rock	uKC	*0.1*	1.16	1.3	1.5	*20*	61	*0.1*	3.12	*0.1*	19.2	107	36.2	3.53	4	*0.01*	0.08	21	1.71	808	0.6	0.13	61.3	0.18	2.6	*0.05*	*0.1*	7.5	*0.5*	212	*0.2*	3.1	0.034	*0.1*	88	*0.1*	65
Surficial material sample			**Underlying bedrock type**																																				
LX-C-33	1	colluvium	mKgW	0.2	1.13	13.5	5.3	*20*	122	0.7	0.4	0.3	10.1	77	37.9	2.68	6	*0.01*	0.21	21	0.7	460	0.8	0.041	9.3	0.083	21.8	*0.05*	0.3	4.6	*0.5*	22	*0.2*	18.8	0.095	0.2	63	0.6	55
LX-C-35	4	ash		*0.1*	0.24	*0.5*	1.8	*20*	28	*0.1*	0.2	*0.1*	1.7	21	3.7	0.54	1	*0.01*	0.07	1	0.07	42	*0.1*	0.125	1.5	0.032	0.3	*0.05*	*0.1*	*0.1*	*0.5*	29	*0.2*	0.2	0.035	*0.1*	19	*0.1*	8
LX-C-36	4	colluvium	DMgPW	0.2	0.59	125.7	11.1	*20*	121	0.5	0.74	1.1	7	71	23	2.36	2	0.01	0.15	13	0.36	303	1	0.014	8.6	0.055	27.5	*0.05*	2.4	2.2	*0.5*	22	*0.2*	6.8	0.006	0.1	23	0.3	128
LX-C-37	10	soil	DMgPW	0.1	0.84	23.2	7.9	*20*	186	0.9	0.7	0.1	7.5	53	57.7	2	3	0.03	0.11	13	0.35	293	1.8	0.028	12.6	0.066	5.4	0.05	0.7	2.8	*0.5*	43	*0.2*	2.9	0.052	0.2	40	0.7	31
LX-C-40	16	colluvium	mKqW	0.3	0.54	6.8	1.4	*20*	320	0.4	0.66	0.2	5.3	73	10.2	1.5	2	*0.01*	0.19	35	0.18	651	2.3	0.015	11.3	0.03	21.4	*0.05*	0.3	1.5	*0.5*	28	*0.2*	15.6	0.004	0.1	10	*0.1*	42
LX-C-38	17	colluvium	mKqW	*0.1*	0.83	7.9	1.9	*20*	169	0.2	0.31	0.1	7.4	93	13.8	2.03	3	*0.01*	0.15	16	0.38	634	1.5	0.048	17.2	0.042	8.4	*0.05*	0.3	3.1	*0.5*	26	*0.2*	11.7	0.046	*0.1*	40	0.4	34
LX-C-23	27	colluvium	mKqW	*0.1*	0.53	2.6	1.1	*20*	62	*0.1*	0.15	*0.1*	3.6	97	6.3	1.21	3	*0.01*	0.11	25	0.3	427	0.3	0.032	6.5	0.035	6.1	*0.05*	0.2	2	*0.5*	8	*0.2*	27.2	0.007	*0.1*	14	0.7	30
LX-C-22	30	colluvium	mKgW	*0.1*	0.29	1.3	0.8	*20*	118	*0.1*	0.25	*0.1*	2.5	84	2.1	0.96	1	*0.01*	0.12	23	0.08	621	0.3	0.029	4.8	0.03	10.1	*0.05*	*0.1*	1.9	*0.5*	9	*0.2*	26.2	0.002	*0.1*	8	0.2	23
LX-C-21	34	colluvium	mKgW	*0.1*	0.85	20.8	*0.5*	*20*	52	*0.1*	1.01	0.1	8	52	12.3	1.86	3	*0.01*	0.09	15	0.48	314	0.9	0.023	7.6	0.065	12.1	0.19	0.4	1.8	*0.5*	38	*0.2*	2.9	*0.001*	*0.1*	14	*0.1*	58
LX-C-46	42	colluvium	DMN	*0.1*	1.53	3.2	2.2	*20*	106	*0.1*	0.49	*0.1*	22.8	86	32.3	3.27	4	*0.01*	0.06	12	2.02	470	0.5	0.053	147.6	0.11	4	*0.05*	*0.1*	2.6	*0.5*	50	*0.2*	1.2	0.051	*0.1*	72	*0.1*	43
LX-C-16	48	sandy soil & rock fragments	mKqW	*0.1*	0.4	178.7	0.8	*20*	57	*0.1*	0.11	*0.1*	3.6	83	3.9	1.09	1	0.12	0.11	16	0.12	431	0.3	0.013	5.3	0.028	10.3	*0.05*	5.7	2	*0.5*	10	*0.2*	20	0.008	0.2	11	0.3	23
LX-C-48	58	colluvium	mKgW	0.2	0.85	15.3	2.4	*20*	132	0.2	0.35	0.7	5.8	63	13.9	1.69	4	0.01	0.1	11	0.31	434	0.9	0.068	9.9	0.061	22.1	*0.05*	0.3	1.9	*0.5*	35	*0.2*	4.5	0.041	*0.1*	30	*0.1*	74
LX-C-51	68	colluvium	DMgPW	0.6	0.87	21.6	60.8	*20*	104	2.7	0.71	0.3	12.5	97	151.8	2.6	3	*0.01*	0.32	29	0.9	222	1.1	0.037	88.7	0.022	14	0.45	1.9	1.9	*0.5*	17	0.3	15.4	0.042	0.2	17	2.5	35
LX-C-3	105	colluvium	mKdW	*0.1*	1.07	1.3	1.7	*20*	268	0.4	0.53	*0.1*	6.5	69	5.8	2.24	4	*0.01*	0.23	19	0.5	436	0.4	0.096	6.7	0.085	16.7	*0.05*	0.2	1.8	*0.5*	45	*0.2*	12.4	0.112	0.3	41	0.8	43
LX-C-5	107	colluvium	mKdW	*0.1*	0.42	4	2	*20*	125	*0.1*	0.08	*0.1*	2.3	93	6.3	1.17	2	*0.01*	0.13	19	0.09	312	0.5	0.029	5.1	0.009	5.5	*0.05*	0.8	1.4	*0.5*	8	*0.2*	15.9	0.017	0.1	7	0.1	18
LX-C-41	23	fluvial		0.1	0.75	13.4	3	*20*	116	0.3	0.46	0.3	8.6	82	15.3	2.33	3	0.02	0.09	9	0.47	407	0.9	0.053	23.2	0.081	13.5	*0.05*	0.7	2.1	*0.5*	49	*0.2*	3.5	0.057	*0.1*	63	0.3	56
LX-C-25	27	fluvial		*0.1*	1.15	9.2	1	*20*	118	0.4	0.72	0.2	10.9	91	37.5	2.53	5	*0.01*	0.18	12	0.94	496	1	0.086	37.7	0.144	10.8	*0.05*	0.7	2.6	*0.5*	61	*0.2*	5.8	0.099	*0.1*	65	0.2	62
LX-C-15	51	fluvial		*0.1*	1.06	10.6	1.8	*20*	80	0.5	0.57	0.2	13.8	84	34.7	2.89	5	*0.01*	0.11	17	1.15	646	1	0.041	48.7	0.16	14.2	*0.05*	0.5	2.3	*0.5*	46	*0.2*	7	0.103	*0.1*	74	0.4	66
LX-C-49	58	fluvial		0.2	0.75	14.7	*0.5*	*20*	121	0.5	0.31	0.4	6.3	81	23.9	1.75	3	*0.01*	0.15	14	0.42	479	2	0.039	12.9	0.071	21.9	*0.05*	0.5	1.8	*0.5*	23	*0.2*	9.1	0.054	0.1	38	0.3	69
LX-C-11	68	fluvial		0.1	0.83	16.8	1.4	*20*	131	0.4	0.3	0.3	7.6	83	16.7	2.01	3	*0.01*	0.12	15	0.46	497	1.7	0.032	18.6	0.065	20.5	*0.05*	0.5	2	*0.5*	32	*0.2*	8.3	0.048	*0.1*	41	0.4	65
LX-C-10	80	fluvial		*0.1*	1.16	6.2	*0.5*	*20*	134	0.8	1	*0.1*	11.4	88	19.4	2.27	4	*0.01*	0.08	8	0.88	436	0.7	0.035	19.4	0.074	6.7	*0.05*	0.2	2.7	*0.5*	47	*0.2*	4.5	0.104	*0.1*	51	0.1	46
Cont. Crust Abundance				0.075	8.23	1.8	4	-	425	0.0085	4.15	0.15	25	102	60	5.6	19	0.085	2.09	39	2.3	950	1.2	2.36	84	0.105	14	0.035	0.2	22	0.05	370	-	9.6	0.565	0.85	120	1.25	70
3xs				0.225	24.69	5.4	12	-	1275	0.0255	12.45	0.45	75	306	180	16.8	57	0.255	6.255	117	6.9	2850	3.6	7.065	252	0.315	42	0.105	0.6	66	0.15	1110	-	28.8	1.695	2.55	360	3.75	210
10xs				0.75	82.3	18	40	-	4250	0.085	41.5	1.5	250	1020	600	56	190	0.85	20.85	390	23	9500	12	23.55	840	1.05	140	0.35	2	220	0.5	3700	-	96	5.65	8.5	1200	12.5	700
100xs				7.5	823	180	400	-	42500	0.85	415	15	2500	10200	6000	560	1900	8.5	208.5	3900	230	95000	120	235.5	8400	10.5	1400	3.5	20	2200	5	37000	-	960	56.5	85	12000	125	7000
Duplicates																																							
LX-C-16				*0.1*	0.41	183	0.7	*20*	55	*0.1*	0.13	*0.1*	3.7	83	4.2	1.13	2	0.14	0.12	15	0.12	445	0.3	0.014	6	0.03	9.8	*0.05*	5.6	2.4	*0.5*	11	*0.2*	19.9	0.008	0.2	11	0.3	23
LX-C-50				*0.1*	0.59	0.6	1.2	96	109	*0.1*	0.16	*0.1*	4.2	89	1.6	1.54	3	*0.01*	0.38	14	0.39	486	0.3	0.063	3.1	0.029	2.6	*0.05*	*0.1*	4.3	*0.5*	7	*0.2*	12.9	0.078	0.2	33	*0.1*	36
QC																																							
DS8				1.8	0.92	26.4	91	*20*	303	6.1	0.71	2.4	7.9	111	119.1	2.47	5	0.22	0.4	14	0.64	604	13.9	0.087	40.7	0.091	114.6	0.17	4.3	2.1	5.7	61	5.3	6.5	0.105	5.5	42	2.8	328
DS8				1.6	0.88	23.5	88.2	*20*	273	5.9	0.7	2.2	7.5	119	111.4	2.38	5	0.17	0.37	14	0.58	590	14.4	0.086	39.3	0.074	118.2	0.16	3.7	2	4.9	63	5.1	6.1	0.115	5	41	2.5	297
DS8				1.9	0.87	27.4	103.5	*20*	289	6.7	0.67	2.5	7.5	112	113.5	2.45	5	0.19	0.4	12	0.59	594	12.2	0.085	40.8	0.078	125.4	0.17	3.5	1.6	4.9	63	5	6	0.105	5.3	39	2.6	311
DS8 Reference				1.69	0.93	26	107	2.6	279	6.67	0.7	2.38	7.5	115	110	2.46	4.7	0.192	0.41	14.6	0.6045	615	13.44	0.0883	38.1	0.08	123	0.1679	4.8	2.3	5.23	67.7	5	6.89	1130	5.4	41.1	3	312
DS8 Tolerance %				27	17	19	28	Below DL	15	18	18	23	18	17	15	16	58	25	20	36	18	15	16	27	16	18	15	15	23	50	34	20	60	18	20	19	25	22	15
OREAS45CA				0.3	3.62	3.6	48.7	*20*	170	0.2	0.44	0.1	91.5	730	515.2	16.38	20	0.03	0.07	15	0.14	941	0.9	0.006	254.5	0.042	20.4	*0.05*	*0.1*	36.1	0.7	16	*0.2*	6.9	0.118	*0.1*	212	*0.1*	61
OREAS45CA				0.2	3.76	3.5	42.1	*20*	160	0.2	0.44	0.1	94.9	748	516	16.91	18	0.03	0.08	16	0.14	919	0.9	0.009	258.3	0.038	20.8	*0.05*	*0.1*	37.4	*0.5*	15	*0.2*	6.5	0.155	*0.1*	216	*0.1*	66
OREAS45CA				0.3	3.6	2.6	31.6	*20*	153	0.2	0.39	*0.1*	89	703	488.3	15.94	18	0.02	0.07	15	0.14	907	0.7	0.01	246.9	0.036	19.6	*0.05*	*0.1*	36.2	*0.5*	15	*0.2*	6.7	0.135	*0.1*	207	*0.1*	60
OREAS45CA Reference				0.275	3.592	3.8	43	-	164	0.19	0.4265	0.1	92	709	494	15.69	18.4	0.03	0.0717	15.9	0.1358	943	1	0.0075	240	0.0385	20	0.021	0.13	39.7	0.5	15	0.06	7	0.128	0.073	215	-	60
OREAS45CA Tolerance %				30	21	40	125	-	20	120	20	105	15	25	15	20	20	90	45	25	35	15	55	60	20	20	35	Below DL	200	20	200	35	Below DL	30	30	Below DL	20	-	20

Note: *0.X* indicates less than the detection limit

Appendix III: Expanded Stressor Term

western
COPPER AND GOLD

Appendix III: Expanded Stressor Term

Chainage		Stressors													Stressor
						Rock				Soil					
From	To	Rock Code	Rock Type rating	Colluvium (c), alluvium (a) or bedrock (r)	Overall Geology Rating	Cut (bm^3)	Cut (em^3)	Fill (em^3)	Net (cut-fill, em^3)	Cut (bm^3)	Cut (em^3)	Fill (em^3)	Net (cut-fill, em^3)	Total cut (Soil or Rock) (em^3)	Cut Rating	**Rating**
Bow Creek															
0-316	0-150	mKgW	3	a/c	2	0	0	0	0	769	807	916	-109	807	2	**4**
0-150	0+260	mKgW	3	a/c	2	0	0	0	0	2,344	2,461	6,697	-4,236	2,461	2	**4**
0+260	0+410	mKgW	3	a/c	2	0	0	0	0	806	846	607	239	846	2	**4**
Seymour Creek															
0+410	1+250	mKgW	3	a/c	2	0	0	0	0	12,094	12,699	10,530	2,169	12,699	3	**6**
1+250	1+290	mKqW	4	a/c	3	0	0	0	0	0	0	1,719	-1,719	0	0	**0**
1+290	5+960	DMgPW	3	a/c	2	0	0	0	0	47,650	50,032	82,666	-32,634	50,032	3	**6**
Big Creek (main stem)															
5+960	11+860	DMgPW	3	a/c	2	0	0	0	0	16,846	17,689	75,351	-57,662	17,689	3	**6**
11+860	12+280	mKqW	4	a	1	0	0	0	0	32	33	1,788	-1,755	33	1	**1**
12+280	12+520	mKqW	4	a	1	0	0	0	0	0	0	2,870	-2,870	0	0	**0**
12+520	13+420	mKqW	4	a	1	0	0	0	0	346	363	11,190	-10,827	363	1	**1**
13+420	18+400	mKqW	4	a/c/r	4	0	0	14,388	-14,388	40,058	42,061	93,661	-51,599	42,061	3	**12**
18+400	18+570	mKqW	4	a/c	3	0	0	0	0	0	0	4,317	-4,317	0	0	**0**
18+570	19+180	mKN	2	a	1	0	0	1,443	-1,443	153	161	11,538	-11,377	161	1	**1**
19+180	20+010	EJyL	2	a/c	1	0	0	11,090	-11,090	2,232	2,344	4,010	-1,666	2,344	2	**2**
20+010	22+600	mKN	2	a/c	1	0	0	8,545	-8,545	21,035	22,086	43,405	-21,318	22,086	3	**3**
22+600	23+890	mKqW	4	a/c	3	0	0	23,264	-23,264	266	279	3,740	-3,461	279	1	**3**
23+890	26+780	mKN	2	a/c	1	0	0	25,613	-25,613	11,183	11,742	27,388	-15,647	11,742	3	**3**
26+780	26+840	mKN	2	c	1	0	0	0	0	0	0	1,002	-1,002	0	0	**0**
26+840	26+880	mKqW	4	a/c	3	0	0	0	0	0	0	474	-474	0	0	**0**
26+880	27+500	mKqW	4	a/c	3	0	0	0	0	9,875	10,368	4,836	5,533	10,368	3	**9**
27+500	33+250	mKgW	3	a/c	2	0	0	62,948	-62,948	24,055	25,257	62,360	-37,103	25,257	3	**6**
Big Creek headwaters															
33+250	34+240	mKgW	3	a/c	2	0	0	20,070	-20,070	8,013	8,414	7,295	1,119	8,414	3	**6**
34+240	34+640	DMN	4	c	3	0	0	4,660	-4,660	223	234	453	-219	234	1	**3**
34+640	37+280	mKgW	3	c	2	0	0	19,327	-19,327	5,805	6,095	14,433	-8,338	6,095	2	**4**
37+280	37+360	uKC1	2	c	1	0	0	0	0	0	0	1,112	-1,112	0	0	**0**
37+360	40+100	mKgW	3	a/c	2	0	0	32,565	-32,565	7,063	7,416	32,745	-25,329	7,416	2	**4**
40+100	40+300	uKC1	2	c	1	0	0	4,000	-4,000	0	0	0	0	0	0	**0**
40+300	42+820	DMN	4	c	3	0	0	42,963	-42,963	838	880	9,003	-8,124	880	2	**6**
Hayes Creek headwaters															
42+820	43+750	DMN	4	c	3	0	0	3,591	-3,591	0	0	14,409	-14,409	0	0	**0**
43+750	49+240	mKqW	4	a/c	3	0	0	0	0	35,009	36,759	83,766	-47,007	36,759	3	**9**
49+240	51+200	uKC1	2	a/c	1	0	0	0	0	6,317	6,633	49,263	-42,630	6,633	2	**2**
51+200	53+280	uKC1	2	a/c	1	0	0	0	0	19,541	20,518	29,521	-9,002	20,518	3	**3**
53+280	53+900	mKgW	3	a/c	2	0	0	7,497	-7,497	1,711	1,796	4,315	-2,519	1,796	2	**4**
53+900	56+570	uKC1	2	a/c	1	0	0	3,056	-3,056	26,237	27,549	29,443	-1,894	27,549	3	**3**
56+570	56+920	uKC1	2	c	1	0	0	2,890	-2,890	0	0	4,784	-4,784	0	0	**0**
56+920	57+340	LKfP	3	a/c	2	0	0	9,367	-9,367	0	0	0	0	0	0	**0**
57+340	57+480	mKgW	3	a	1	0	0	2,834	-2,834	0	0	0	0	0	0	**0**
Hayes Creek (valley bottom)															
57+480	62+260	mKgW	3	a/c	2	0	0	28,196	-28,196	17,421	18,292	52,524	-34,232	18,292	3	**6**
62+260	62+650	mKgW	3	a	1	0	0	0	0	1,936	2,033	9,311	-7,278	2,033	2	**2**
62+650	64+000	mKgW	3	a/c	2	0	0	0	0	18,848	19,790	18,419	1,371	19,790	3	**6**
64+000	64+300	mKqW	4	a/c	3	0	0	0	0	6,295	6,610	5,248	1,361	6,610	2	**6**
64+300	64+740	mKgW	3	a/c	2	0	0	2,136	-2,136	0	0	9,821	-9,821	0	0	**0**
64+740	64+930	mKgw	3	a/c	2	0	0	0	0	0	0	4,544	-4,544	0	0	**0**
64+930	65+100	DMgPW	3	a/c	2	0	0	0	0	0	0	3,678	-3,678	0	0	**0**
65+100	65+260	mKqW	4	a/c	3	0	0	0	0	0	0	3,895	-3,895	0	0	**0**
65+260	66+210	DMgPW	3	a/c	2	0	0	4,940	-4,940	57	60	14,590	-14,530	60	1	**2**
66+210	66+320	DMgPW	3	a	1	0	0	0	0	0	0	4,308	-4,308	0	0	**0**
66+320	67+780	DMgPW	3	a	1	0	0	0	0	0	0	42,002	-42,002	0	0	**0**
67+780	68+500	DMgPW	3	a	1	0	0	0	0	86	91	16,832	-16,741	91	1	**1**
68+500	69+380	DMgPW	3	a	1	0	0	0	0	929	976	16,165	-15,190	976	2	**2**
69+380	78+420	DMgPW	3	a/c	2	0	0	33,440	-33,440	62,587	65,716	184,188	-118,473	65,716	3	**6**
78+420	79+010	DMN	4	a/c	3	0	0	0	0	7,641	8,023	14,583	-6,561	8,023	3	**9**
79+010	79+400	DMN	4	a	1	0	0	1,698	-1,698	0	0	7,529	-7,529	0	0	**0**
79+400	81+740	DMN	4	a/c	3	0	0	60,946	-60,946	0	0	3,497	-3,497	0	0	**0**
81+740	84+750	mKgW	3	a/c	2	0	0	20,149	-20,149	16,765	17,603	37,884	-20,282	17,603	3	**6**
84+750	86+120	mKgW	3	a/c	2	0	0	19,589	-19,589	1,336	1,403	6,208	-4,805	1,403	2	**4**

Appendix III: Expanded Stressor Term

Chainage		Stressors														Stressor
From	To	Rock Code	Rock Type rating	Colluvium (c), alluvium (a) or bedrock (r)	Overall Geology Rating	Rock				Soil				Total cut (Soil or Rock) (em^3)	Cut Rating	**Rating**
						Cut (bm^3)	Cut (em^3)	Fill (em^3)	Net (cut-fill, em^3)	Cut (bm^3)	Cut (em^3)	Fill (em^3)	Net (cut-fill, em^3)			
Rock Cut																
Hayes Creek (rock cut area)																
86+120	86+500	mKgW	3	r	3	1,973	2,663	3,533	-870	0	0	0	0	2,663	2	**6**
86+500	87+750	mKgW	3	r	3	34,192	46,159	10,193	35,966	0	0	0	0	46,159	3	**9**
87+750	87+900	mKdW	2	r	2	8,215	11,090	0	11,090	0	0	0	0	11,090	3	**6**
87+900	88+040	mKgW	3	r	3	3,252	4,390	224	4,166	0	0	0	0	4,390	2	**6**
88+040	88+280	mKdW	2	r	2	10,086	13,616	1,606	12,010	0	0	0	0	13,616	3	**6**
88+280	88+720	mKgW	3	r	3	5,507	7,435	6,312	1,123	0	0	0	0	7,435	3	**9**
88+720	95+460	mKdW	2	r	2	266,748	360,110	57,701	302,409	0	0	0	0	360,110	4	**8**
95+460	95+650	mKgW	3	r	3	15,637	21,110	151	20,959	0	0	0	0	21,110	3	**9**
Mascot Creek																
95+650	98+300	mKgW	3	r	3	17,329	23,394	23,803	-410	0	0	0	0	23,394	3	**9**
98+300	106+670	mKdW	2	r	2	25,792	34,819	121,949	-87,130	0	0	0	0	34,819	3	**6**
Idaho/Isaac/Sunshine Creek																
106+670	108+030	mKdW	2	r	2	12,354	16,677	22,113	-5,436	0	0	0	0	16,677	3	**6**
108+030	108+410	mKgW	3	r	3	9,004	12,156	3,221	8,935	0	0	0	0	12,156	3	**9**
108+410	108+490	LKqP	3	r	3	677	914	669	245	0	0	0	0	914	2	**6**
108+490	108+540	LKfP	3	r	3	53	72	957	-886	0	0	0	0	72	1	**3**
108+540	109+380	LKqP	3	r	3	38,393	51,831	931	50,900	0	0	0	0	51,831	4	**12**
109+380	112+460	mKgW	3	r	3	30,654	41,383	42,633	-1,250	0	0	0	0	41,383	3	**9**
112+460	115+640	DMN	4	r	4	27,731	37,436	29,613	7,823	0	0	0	0	37,436	3	**12**
115+640	124+430	mKgW	3	r	3	64,365	86,893	87,916	-1,023	0	0	0	0	86,893	4	**12**
Casino Creek																
124+430	126+060	mKdW	2	r	2	2,495	3,369	24,500	-21,131	0	0	0	0	3,369	2	**4**
126+060	126+920	mKdW	2	r	2	0	0	13,157	-13,157	0	0	0	0	0	0	**0**
126+920	127+660	mKgW	3	r	3	13	18	10,781	-10,763	0	0	0	0	18	1	**3**
127+660	129+300	mKdW	2	r	2	11,535	15,573	18,532	-2,959	0	0	0	0	15,573	3	**6**
129+300	129+840	mKgW	3	r	3	197	266	5,987	-5,721	0	0	0	0	266	1	**3**
129+840	132+410	mKdW	2	r	2	7,855	10,605	34,000	-23,396	0	0	0	0	10,605	3	**6**
132+410	132+610	LKfP	3	r	3	2,092	2,824	274	2,550	0	0	0	0	2,824	2	**6**
	average					7,360	9,936	12,246		5,363	5,631	14,652		15,567		
	median					0	0	2,834		0	0	3,895		2,663		
	median (ignore 0)					9,545	12,886	10,781		6,317	6,633	9,311		8,414		
	min					0	0	0		0	0	0		0		
	min (ignore 0)					13	18	151		32	33	453		18		
	max					266,748	360,110	121,949		62,587	65,716	184,188		360,110		
	Total					596,149	804,801	991,960		434,398	456,118	1,186,832		1,260,920		

Rock Codes

DMN	Nasina - quartzite and quartz-mica schist
DMgPW	Pelly Gneiss suite - schist and gneiss
EJyL	Long Lake suite - syenitic granitc rocks
mKdW	Whitehorse suite - diorite
mKgW	Whitehorse suite - granodiorite
mKqW	Whitehorse suite - granodiorite to quartz monzonite
mKN	Mount Nansen - volcanic flows and subvolcanic intrusions
uKC1	Carmacks - volcanic sequence
LKP	Prospector Mountain suite - quartz-rich monzonite stock (LKqP) with latite dykes (LKfP)