Basic Impact Analysis
(BIA)

Trans-Canada Highway
Rock Slope Reprofiling
2015 Works

Trans-Canada Highway: Sherbrooke Creek, Lower Sherbrooke Creek, Little Topple and Phyllite Rock Slopes
Yoho National Park, BC

May 2015

Parks Canada Parcs Canada

Canada

1. PROJECT TITLE

Rock Slope Reprofiling 2015 Works
Trans-Canada Highway (TCH): Sherbrooke, Lower Sherbrooke, Little Topple and Phyllite Rock Slopes.

2. PROJECT LOCATION

Yoho National Park, BC. (YNP)

3. PROJECT SITE(S)

The overall Project will occur along the TCH, between km 88 to 91 and between km 114 to 128. The 2015 Project works are occurring at four sites. Table 1 below identifies all locations in the overall Project to provide large-scale context, and highlights the areas where work will occur this year (2015). To identify slopes along the highway, the start and end points of existing and proposed slope cuts are provided relative to the eastern park boundary. This station system, provided by McElhanney Consulting (MCE), is measured in kilometres along the road centreline and uses the east gate of Banff National Park as Sta. 0+000.

Table 1: Slope Reference Table

Project (km)	Colloquial Name	Station Start (km)	Station End (km)	Included in 2015 Works?	Approximate Volume (m^3)[1]
88 to 91	Sherbrooke Soil Slope	88+200	88+500		
	Sherbrooke Creek Rock Slope	88+500	89+090	✓	161,800
	Lower Sherbrooke Creek Rock Slope	89+090	89+420	✓	18,740
	Upper Dustin's	89+540	89+900		
	Dustin's Slide	89+900	90+150		
	Spiral Tunnels Hill	90+150	90+900		
114 to 128	Through Cut (Left)	114+800	115+120		
	Through Cut (Right)	114+900	115+050		
	Big Topple	115+380	115+580	*	
	Little Topple	115+650	115+860	✓	27,600
	Mount Vaux	116+150	116+470		
	Lower Mount Vaux	116+910	117+200		
	Mount Vaux	116+470	116+900		
	Leanchoil East	123+100	123+400		
	Phyllite Slope	124+280	124+580	✓	100,780
	Western Boundary	125+820	125+940		
*As of April 30, 2015 Big Topple was flagged and logged but no other resloping works will occur at this site in 2015.					
[1]Exact volumes are subject to change as the Rock Cut designs are finalized. Approximate volumes current as of April 20, 2015.					

Additionally, two locations were identified near the project areas to be used for material storage during the 2015 Project.

Table 2: Storage Site Locations, Volumes and Areas

Project (km)	Storage Site Name	Station (km)	Location (UTM, zone 11U)	Approximate Storage Capacity Volume (m^3) based on 2H:1V*	Approximate Footprint (m^2)*
88 to 91	AB/BC Border	82+000	5700586.07 N 549850.58 E	65,000	9,500
114 to 128	Mount Vaux	119+500	5675948.29 N 529622.31 E	Up to 986,000	Up to 80,000
* Numbers based on information available in Tetra Tech EBA's Design Report, *Yoho National Park Trans-Canada Highway – Slope Reprofiling Km 88 To Km 91 And Km 114 To Km 128* as of April 1, 2015. Exact numbers subject to change with design finalization.					

4. PROPONENT

Parks Canada Agency (PCA): Ryan Syme, P.Eng. Engineer II – Highway Service Centre

BIA Author: Tetra Tech EBA Inc.

5. PROPONENT CONTACT INFORMATION

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6. PROJECT DATES

Work for the Project is expected to occur over the summer and fall of 2015 and will be limited by snowfall.

Planned commencement for 2015 work: 2015-06-15
Planned completion for 2015 work: 2015-10-31

Tetra Tech EBA notes that these works are part of a larger project anticipated to occur over the next three years (ending in 2017).

7. INTERNAL PROJECT FILE

8. PROJECT DESCRIPTION

Project Justification:

The project area slopes in YNP were constructed in the 1950s before controlled blasting was developed. The slopes have performed relatively well over the years; however, in the last 5 to 10 years, the slopes are showing increased distress in the form of rock falls, causing sections of the TCH to be closed during cleanup operations. The intent of reprofiling these slopes is to reduce both PCA's maintenance burden and the risk of failures affecting traffic on the highway.

Project Details:

This BIA considers only the work to be conducted in 2015. However, these works are part of a larger multi-phase project. The overall project occurs within the same area (between km 88 to 91 and between km 114 to 128 of the TCH) but includes different slopes and storage sites. These works are expected to be conducted in 2016 and 2017 and the activities will be similar to the 2015 works described below.

Work conducted in 2015 is expected to include slope excavation at Sherbrooke Creek Rock Slope, Lower Sherbrooke Creek Rock Slope, Little Topple Slope and Phyllite Slope. Estimated volumes for each slope are provided in Section 3, Table 1. Rock will be stored at these locations and/or removed from site to the storage locations via hauling along TCH. Catchment ditches and access roads will also be constructed to these areas. Project activities are generally comprised of the following:

- General limited clearing of vegetation, including tree felling[1], will be required at each 2015 reprofiling slope, as well as at one additional slope;
  - Sherbrooke/Lower Sherbrooke Slopes at 88+500 to 89+420 (right side).
  - Little Topple Slope at 115+650 to 115+860 (left side).
  - Phyllite Slope at 124+270 to 124+570 (right side).
  - (additional slope) Big Topple Slope at 115+380 to 115+580.
- Mobilization and Demobilization of all manpower, equipment, materials, and other resources necessary to execute the Work;
- Provision of traffic signage and traffic control;
- Slope Excavation;
  - Cut angles will be as steep as possible and uniform (not benched).
  - Controlled blasting (either trim blasting or production blasting) will be used on all final faces to limit damage to the rock behind the face and enhance long-term stability of the rock cuts. Large areas of blasting remnants will be removed.
  - Catchment ditches will be excavated between the toe of the rock cuts and shoulder to provide a catchment area for rock falls. Following slope remediation, removal of accumulated construction debris (rock fall) will be required for all locations. Rock and other debris which falls into the catchment area will be loaded into a truck with an excavator and transported to an appropriate disposal location.
  - Localized mitigation measures to enhance stability of the rock cuts will be performed where required. This may consist of rock reinforcement (dowels), scaling (by hand or excavator), rock removal (scaling, trim blasting or other excavation with light explosives, hydraulic splitters, chemical expanders or pneumatic hammers), dentition (shotcrete or masonry walls) and/or drainage (installing drain holes).Where required, rock support will be installed as the excavation proceeds. Detailed geotechnical mapping should be conducted as the excavation proceeds to identify areas that require rock support and to provide the basis for the final design of localized rock support.
- Storage Site preparation;
  - Vegetation clearing, including tree removal, will be required (see footnote 1).
    - AB/BC Border Storage Site at 82+000 (none expected).
    - Mount Vaux Storage Site at 119+550 (under storage footprint only).
  - Top soil will be stripped from Storage Sites where necessary and stockpiled or removed from site.
  - Materials excavated from slopes will be transferred to storage areas.
  - Volumes and area presented above in Section 3, Table 2.
- Repair of damaged road surface, if required.

9. VALUED COMPONENTS LIKELY TO BE AFFECTED

Following the background review of environmental information, potential Valued Components (VCs) were identified for the project, including biological resources (vegetation and wildlife), visitor experiences and visual and aesthetic

[1] Tree felling activities are being considered under a separate BIA (file # 2015-017Y) and are discussed only in general terms as it relates to other activities in this report. As of April 30, 2015 felling activities have been completed.

values. The potential VCs were assessed to determine if they are present near the rock slope remediation locations and if they are subject to stakeholder or regulatory concern. Based on these criteria and the professional judgment of the study team, Tetra Tech EBA professionals used this information to determine the final VC selection for the purposes of the environmental impact analysis.

Project activities that may interact with VCs are identified by investigating the various components of the works that have potential effect pathways to the receiving environment. The potential effects pathway for these projects involves rock slope remediation. The project pathway was compared to the list of identified VCs and the interactions were documented for further consideration in the BIA process. The documented interactions between the project's pathways and the VCs are used to identify potential impacts. Knowledge of both the projects and VCs are used to identify potential adverse effects of the projects on the environment and to ensure appropriate mitigations are established and industry best management practices are followed.

Background Information:

Yoho National Park, along with Jasper, Kootenay and Banff National Parks and three British Columbia provincial parks—Hamber Provincial Park, Mount Assiniboine Provincial Park, and Mount Robson Provincial Park—form the Canadian Rocky Mountain Parks UNESCO World Heritage Site. It was established in 1886 and occupies approximately 1,310 km^2 (Parks Canada, 2014).

Vegetation:

The Biogeoclimatic Ecosystem Classification (BEC) is a land classification system that groups similar ecosystems based on climate, soils and vegetation. This classification system was developed in British Columbia and is widely used as a framework for resource management as well as for scientific research. Vegetation of mature ecosystems is emphasized in BEC as it is considered the best indicator of the combined influence of the environmental factors affecting a site.

According to BEC mapping (BC Ministry of Forest and Range, 2011), the majority of the project area lies within the Montane Spruce dry cool (MSdk2) subzone. The Montane Spruce zone predominantly occupies the middle elevations of the Rocky Mountains and Rocky Mountain Trench above the elevation of the Interior Douglas Fir (IDF) zone and below the elevation of the Engelmann Spruce Subalpine Fir (ESSF) zone. It usually occupies a very narrow elevational band, between 300 m and 400 m wide (Meidinger and Pojar, 1991). In the project area, the MS zone largely occupies the Kicking Horse River valley. Generally, the climate within the MS zone is continental, characterized by warm, short summers and cold winters. The mean annual temperature ranges from 0.5°C to 4.7°C (Meidinger and Pojar, 1991).

The BEC zone at the very eastern end of the project area, between approximately km 88+000 and km 90+000, is within the Engelmann Spruce Subalpine Fir dry cool (ESSF dk2) subzone. The ESSF zone exists below the Interior Mountain-heather Alpine Zone (IMA) at elevations from 1500 to 2300 m and so is the upper most forested zone in the southern portion of interior BC (Meidinger and Pojar, 1991). Similar to the MS zone, the climate is mostly long cold winters with abundant snow cover with short, cool growing seasons with mean annual temperatures between -2°C and +2°C (Meidinger and Pojar, 1991).

Vegetation within the MS zone landscape is typically dominated by extensive, young and maturing stands of lodgepole pine (*Pinus contorta*) that have formed following fire. Hybrid white spruce (*Picea engelmannii x glauca*) and subalpine fir (*Abies lasiocarpa*) dominate climax stands. Forest understory is characterized by black huckleberry (*Vaccinium membranaceum*), Utah honeysuckle (*Lonicera utahensis*) and grouseberry (*Vaccinium scoparium*) (Meidinger and Pojar, 1991).

Vegetation within the ESSF zone is dominated by subalpine fir and Engelmann spruce in the tree layer with false azalea (*Menziesia ferruginea*), Utah honeysuckle, Indian hellebore (*Veratrum viride*), clasping twistedstalk (*Streptopus amplexifolius*), and grouseberry as common understory plants (Meidinger and Pojar, 1991).

The CDC Internet Mapping tool, BC Species and Ecosystems Explorer, and Parks Canada's Biotics Web Explorer were used to determine potential occurrences of rare vegetation species at or near the rock slope remediation areas. Search results are included in Appendix 4.

No sensitive vegetation species were documented at or immediately adjacent to either the Sherbrooke or Lower Sherbrooke (km 88+500 to 89+420) sites, at the Phyllite site (km 124+270 to 124+570) or at any of the two Storage Sites. An occurrence of Crawe's Sedge is documented adjacent to the Little Topple site (115+650 to 115+860). Several occurrences were documented as being located within 5 km of one or more of the sites and are described in Table 3 below.

Table 3: Rare Plant Species Known to Occur Near a Project Area

Name	Scientific Name	Shape ID	Proximate Site	Status	Habitat
Limber Pine	*Pinus flexilis*	67689	Sherbrooke & Lower Sherbrooke Slopes	BC (Red) COSEWIC (E)	Dry rocky sites at 1,500 m to 3,600 m.
Whitebark Pine	*Pinus albicaulis*	68450	Little Topple	BC (Blue) SARA (1-E) COSEWIC (E)	Thin, rocky soil near timberline (1,300-3,700 m).
		68416	Sherbrooke & Lower Sherbrooke Slopes		
Linear Leaf Moonwort	*Botrychium lineare*	88692	Sherbrooke & Lower Sherbrooke Slopes	BC (Red)	Diverse habitat preferences but generally at 1,500 to 3,000 m.
McCalla's Dwarf Braya	*Braya humilis ssp. maccallae*	52263	Sherbrooke & Lower Sherbrooke Slopes	BC (Red)	Sandy gravelly riverbanks & floodplains, sometimes on slopes and glacial moraines.
		52265	Mount Vaux Storage; Phyllite Slope		
Macoun's Fringed Gentian	*Gentianops is macounii*	2090	Mount Vaux Storage; Phyllite Slope	BC (Blue)	Wet to moist fens, meadows & streamsides in the montane zone.
		37895	Mount Vaux Storage; Phyllite Slope		
Crawe's Sedge	*Carex crawei*	3324	Mount Vaux Storage; Phyllite Slope	BC (Blue)	Wet meadows and fens in montane zone.
		46968	Little Topple		
		51299	Mount Vaux Storage; Phyllite Slope		

BC Provincial List
Red: Species that are extirpated, endangered, or threatened
Blue: Species considered to be of special concern (formerly vulnerable)

Species At Risk Act (SARA)
Schedule 1 (1)
Schedule 2 (2)
Schedule 3 (3)

Endangered (E)
Extirpated (XT)
Threatened (T)
Special Concern (SC)

Committee on the Status of Endangered Species in Canada (COSEWIC)
Extinct (X)
Extirpated (XT)
Endangered (E)
Threatened (T)
Special Concern (SC)
Not at Risk (NAR)
Data Deficient (DD)

Both limber pine and whitebark pine are predominantly found at higher elevations, though can be found in appropriate habitats at lower elevations. Neither species is likely to be encountered within the project areas. The other four plant species are found mostly in wet areas, such as the riparian zone of Kicking Horse River. Because the work areas of each slope or storage area are outside the riparian zone of any watercourse, there is low potential for these species to be encountered.

Wildlife:

A wildlife track survey, conducted by Tetra Tech EBA from January 28 to 30, 2015, identified two bird and six mammal species in the project area. A potential mammal den was identified at the Spiral Tunnels Hill Slope but it was not confirmed if it was active.

Table 4: Wildlife Species Observed During Winter Track Survey

Common Name	Scientific Name	Common Name	Scientific Name
Common Raven	*Corvus corax*	Stellar's Jay	*Cyanocitta stelleri*
American Red Squirrel	*Tamiasciurus hudsonicus*	American Marten	*Martes Americana*
Coyote	*Canis latrans*	Snowshoe Hare	*Lepus americanus*
Unidentified small mammal spp.			

Numerous other wildlife species are known to inhabit YNP and may occur at or near the Project Site. These include Moose (*Alces alces*), Canada Lynx (*Lynx canadensis*), Black Bear (*Ursus americanus*), Wolf (*Canis lupus*), White-Tailed and Mule Deer (*Odocoileus virginianus* and *O. hemionus*), Elk (*Cervus elaphus*) and Mountain Goat (*Oreamnos americanus*) among others.

There is regular Mountain Goat activity in the area between km 88+250 and where the Kicking Horse River crosses the TCH (approximately km 93+500) from spring to fall (especially in the early summer) mainly on the Sherbrooke and Lower Sherbrooke rock slopes and on the adjacent highway. In this area, goats are known to lick salt on the road and on the rock. It is unknown if goats cross the TCH (Personal Communication: Trevor Kinley, PCA Environmental Assessment Scientist with Anders Frappell, Tetra Tech EBA Team Leader, Rock Engineering Group, March 23, 2015).

There is an active raven nest on Sherbrooke Slope, directly across from the highway pullout. (Personal Communication: Trevor Kinley, PCA Environmental Assessment Scientist).

A list of wildlife species listed under SARA and COSEWIC known to occur within the project area was compiled by querying species ranges assembled by Ridgely (Ridgely, 2007), the International Union for Conservation of Nature 2014 (International Union for Conservation of Nature, 2014), and the BC Conservation Data Centre's (CDC) Species and Ecosystem Explorer and Parks Canada Biotics Web Explorer for YNP.

Table 5: Wildlife Species in Yoho National Park listed under SARA and COSEWIC

Common Name	Scientific Name	SARA Schedule	SARA Legal Status	COSEWIC Status
Amphibians				
Western Toad (non-calling population)	*Anaxyrus boreas pop. 3*	Schedule 1	Special Concern	Special Concern
Birds				
Bank Swallow	*Riparia riparia*	-	-	Threatened
Barn Swallow	*Hirundo rustica*	-	-	Threatened
Common Nighthawk	*Chordeiles minor*	Schedule 1	Threatened	Threatened
Olive-sided Flycatcher	*Contopus cooperi*	Schedule 1	Threatened	Threatened
Peregrine Falcon	*Falco Peregrinus anatum/tundrius*	Schedule 1	Special Concern	Special Concern
Short-eared Owl	*Asio flammeus*	Schedule 1	Special Concern	Special Concern
Western Grebe	*Aechmophorus occidentalis*	-	-	Special Concern
Yellow Rail	*Coturnicops noveboracensis*	Schedule 1	Special Concern	Special Concern
Red-necked Phalarope	*Phalaropus lobatus*			Special Concern

Common Name	Scientific Name	SARA Schedule	SARA Legal Status	COSEWIC Status
Mammals				
American Bison (Wood Bison subspecies)	*Bos bison*	Schedule 1	Threatened	Threatened
Grizzly Bear*	*Ursus arctos*	-	-	Special Concern
Little Brown Myotis*	*Myotis lucifugus*	Schedule 1	Endangered	Endangered
Wolverine (western population)*	*Gulo gulo pop.1*	-	-	Special Concern

Aquatics:

The TCH within the project area roughly parallels the Kicking Horse River. A desktop review of information pertaining to the Kicking Horse River and its tributaries within km 88 to 91 and km 114 to 128 was conducted. No field surveys for fish and fish habitat has been conducted in the project area to date. Shelley Humphries, Parks Canada Aquatics Specialist for Lake Louise-Yoho-Kootenay Field Unit, was contacted to obtain information on the watercourses discussed below. However, as of May 4, 2015 no comment was received. If Tetra Tech EBA receives information that would affect the outcomes of this BIA, PCA will be notified immediately.

- The Kicking Horse River (watershed code: 380) generally flows parallel to the TCH and is in the vicinity of all five slopes and storage sites, though generally greater than 30 m away. It is a Canadian Heritage River (CHRS 2011) with nine species of fish known to be present (see Table 6 below). Wapta Falls, with a 30 m drop, is located on the Kicking Horse River approximately 5 km southeast of km 124+270 (Phylitte Slope) and is considered a barrier to fish passage. However, Brook Trout and Rainbow Trout are identified in tributaries of Kicking Horse River upstream of Wapta Falls and are likely present in the River.
- Using the DataBC online mapping service, iMapBC, several smaller watercourses are proximate to the slope sites in addition to the Kicking Horse River. Two tributaries near the Sherbrooke Creek (unnamed tributary 95 m east of Sherbrooke Creek) and Little Topple Rock Slopes (Porcupine Creek) are present on the opposite site of the Kicking Horse River, have a very low potential to be impacted by the Project and are not discussed in this section:
    - Sherbrooke Creek Rock Slope (km 88+500 to 80+090)
        - Sherbrooke Creek (watershed code: 380-971100) crosses the TCH approximately 40 m east of km 88+500. It is a third order stream that flows into Kicking Horse River. No information was available for this watercourse in FIDQ but no barriers to fish passage were indicated on iMapBC therefore fish present in Kicking Horse River are potentially present in Sherbrooke Creek.
    - Lower Sherbrooke Creek Rock Slope (km 89+090 to 89+420)
        - An unnamed tributary with no watershed code is reportedly present at approximately 89+300 (Pers.Comm. Trevor Kinely, April 30, 2015) although it is not visible on iMapBC, HabitatWizard or the BC Water Resource Atlas. Fish species or barriers to fish passage on this watercourse are unknown.
        - An unnamed tributary with no watershed code is present approximately 345 m west of km 89+500. No information was available for this watercourse in FIDQ, but no barriers to fish passage were indicated on iMapBC, therefore fish present in Kicking Horse River are potentially present in this tributary.
    - Little Topple Rock Slope (km 115+650 to 115+860)
        - None.

- Phyllite Rock Slope (km 124+280 to 124+580)
  - An unnamed tributary (watershed code: 380-497100) is present approximately 290 m north of km 124+270. It flows eastward and crosses the TCH approximately 1.9 km east of km 124+270 before flowing through a wetland complex and into Kicking Horse River. No information was available for this watercourse in FIDQ, but no barriers to fish passage were indicated on iMapBC, therefore fish present in Kicking Horse River are potentially present in this tributary.
  - Another unnamed tributary with no watershed code flows parallel to the south side of TCH near km 124+570. Approximately 1500 m northwest of km 124+570 this tributary turns south and joins Kicking Horse River. No information was available for this watercourse in FIDQ, but no barriers to fish passage were indicated on iMapBC, therefore fish present in Kicking Horse River are potentially present in this tributary.

In addition to the Kicking Horse River, several unnamed tributaries with no watershed codes are present in the vicinity of the Storage Sites:

- Mount Vaux (km 119+500) - one tributary, > 30 m. No information was available in FIDQ but no barriers to fish passage were indicated on iMapBC, therefore fish present in Kicking Horse River are potentially present.
- AB/BC Border (km 82+000) – none.
  The AB/BC Border Storage Site is not located within the Kicking Horse River watershed. It is within the Bath Creek portion of the Upper Bow River system. The nearest watercourse visible on available mapping databases is almost 1 km east of the site.

Table 6: Fish Species Present in Kicking Horse River[2]

Bull Trout (*Salvelinus confluentus*)	Brook Trout (*Salvelinus fontinalis*)
Rainbow Trout (*Oncorhynchus mykiss*)	Kokanee (*Oncorhynchus nerka*)
Pygmy Whitefish (*Prosopium coulterii*)	Mountain Whitefish (*Prosopium williamsoni*)
Slimy Sculpin (*Cottus cognatus*)	Torrent Sculpin (*Cottus rhotheus*)
Mottled Sculpin (*Cottus spp.*)	Redsided Shiner (*Richardsonius balteatus*)*
*Recorded only in a tributary to Kicking Horse River	

None of these species are listed under Schedule 1 of SARA. However, COSEWIC has ranked Bull Trout as Special Concern and Kokanee as Endangered.

The Kicking Horse River, as well as its tributaries, contains and provides a source of water, food and nutrients to, fish and fish habitat and is, therefore, subject to the Federal *Fisheries Act.* No instream works are anticipated to occur during the Project and it is unlikely that harm to fish will occur if construction activities are appropriately mitigated. Since the proposed works will generally occur more than 30 m from a watercourse and mitigation measures presented herein are protective of the watercourses, it is unlikely that this Project would require a Request for Review or Authorization from Fisheries and Oceans Canada (DFO).

Cultural Resources:

Parks Canada describes a number of National Historic Sites (Abbot Pass Refuge Cabin, Spiral Tunnels) and Federal Heritage Buildings (Takkakaw Falls Warden Cabin, Yoho Ranch Cabin) within YNP. None of these sites are located directly within the 2015 project areas and are unlikely to be affected by the proposed rock reprofiling.

[2] Source: Fish Inventory Data Queries (FIDQ): http://www.env.gov.bc.ca/fish/fidq/index.html; habitat wizard: http://maps.gov.bc.ca/ess/sv/habwiz/ and McPhail 2007.

The transportation corridor from Field to Lake Louise is part of the Kicking Horse Pass National Historic Site (NHS). There are three identified historic sites associated with that NHS falling in the project area at the Lower Sherbrooke site. These include:

- The historic bridge (521T) across the highway from the Lower Sherbrooke rock slope;
- A historic CPR spur line (438T) upslope of the rock slope (at approximately 89+100 starting near the highway edge just east of the slope and diverging away from the slope to the west); and
- A train wreckage site (530T) on the south side of the spur, about 20 m from the rock edge.

LiDAR images show a depression near the Lower Sherbrooke rock slope that appears consistent with an arrester site, but no distinct features are discernable on Google Earth images, which shows only thick vegetation. A site visit conducted by Trevor Kinley of PCA on April 8, 2015 confirms that the spur line alignment roughly parallels the TCH at 89+100 but sharply turns westward at 89+200. Mr. Kinley also noted that there are artifacts from an old train scattered in the vegetation adjacent to the alignment, most of which are buried in the damp ground below the switch (Trevor Kinley, Pers. Comm., March 9, 2015). Certain sections of this historical location has potential to be affected by Project activities such as vegetation clearing, constructing access roads and reprofiling work, including blasting, depending on the methodology used to complete the work (i.e., machinery vs. hand equipment). According to Mr. Kinley, McElhanney indicated that the vegetation clearing and the access road for rock resloping can be cut below the spur line (438T) so that it is not impacted. Similarly, vegetation clearing near the train wreckage (530T) has been flagged approximately 3 m south of the wreck. If clearing and construction activity remains within the flagged boundaries the 530T site should not be impacted.

The historic bridge (521T) is gated and is not likely to be affected by the project.

A historic highway grade (439T) that is part of the Kicking Horse Trail is also present in the vicinity of the Little Topple slope. This grade will be used to access sites for clearing vegetation.

The Kicking Horse River was designated as a Canadian Heritage River in 1989. The Canadian Heritage Rivers System (CHRS) was established to conserve rivers with outstanding natural, cultural and recreational heritage. The Kicking Horse River is a classic example of a glacial mountain river and the valley provides excellent opportunity to explore natural features; the river valley also played a major role in the exploration and development of the Canadian West (CHRS 2011).

Visitor Use and Experience:
The Project area is within YNP, part of Canadian Rocky Mountains UNESCO World Heritage Site, which is renowned for its scenic splendour. The name “Yoho” is a Cree expression of awe and wonder (Parks Canada, 2014). With 28 peaks over 3000 m, unique geological formations and multiple waterfalls, YNP is an attractive destination. Visitors can participate in many outdoor activities such as hiking, camping, canoeing, skiing and cycling in addition to enjoying the natural viewscapes.

Direct human use of the Project area is primarily related to the TCH, the main transportation corridor through YNP. TCH will remain open to traffic but lane closures and traffic control will be required to conduct the rock slope reprofiling. It is expected that there will be traffic delays throughout the project.

Valued Components:

Valued components for which there is potential for project effects include:

- Plant and wildlife species (including rare species) – wildlife encounters, habitat disturbance or loss (vegetation removal etc.,);
- Vegetated areas within the work zones;

- Aquatic wildlife (amphibians) with potential to make use of the riparian area for breeding;
- Aquatic components – Kicking Horse River and tributaries water quality from the introduction of deleterious substances;
- Fish habitat identified within Kicking Horse River and tributaries;
- Visitor experience – traffic delays and altered viewscapes (changes to rock slopes and visible material storage along TCH); and
- Cultural resources (historic road grade, historic spur line and train wreckage site at Lower Sherbrooke rock slope and previously unidentified artifacts) – damage or destruction by equipment, blasting or rock removal.

10. EFFECTS ANALYSIS

Please see the Effects Identification Matrix in Appendix 1 for further identification of Direct Project effects. No indirect effects from the rock slope remediation works are anticipated given that the tasks are of a routine nature and all will take place in or immediately adjacent to an existing transportation corridor (TCH). The natural environment in transportation right-of-ways (ROW) is well understood and is considered to be previously disturbed.

Vegetation:

1. Vegetation clearing is anticipated to be minimal within each of the zones proposed for remediation. Where vegetation is established along cliff edges or close to edges of slopes, removal may be necessary as a safety consideration. These areas have been previously disturbed for highway development and use and during previous rock slope remediation programs which limits, but does not preclude, the presence of sensitive or rare species.
2. Tree felling will be required at all slopes and potentially at both storage sites.
3. Vegetation trampling may occur where construction crews are required to access the rock slopes.
4. Vegetation in the immediate vicinity of the proposed project works may be affected by dust accumulation caused by construction activities.
5. An accidental spill of a harmful substance on site could affect surrounding vegetation.
6. Rare vegetation species have potential to be encountered as previous occurrences have been identified within 5 km of the Project areas (See Section 9, Table 3) though none are known to occur at the Project areas. Although the habitat preferences of the identified species suggest it is unlikely they will be encountered in the Project areas, rare vegetation may be disturbed or destroyed by Project activities.
7. Colonization of non-native and/or invasive species may occur as a result of equipment not properly cleaned prior to coming to a site.

Wildlife:

1. Avoidance behaviors from local wildlife, including rare species, may occur as a result of increased noise and human presence from project activities resulting in disruption or impediment to wildlife movement.
2. Project activities are expected to overlap the nesting season and may impact nesting activities. Work conducted during the nesting season will require pre-construction nest sweep to identify bird nests that may be affected.
3. Local wildlife may be affected by an accidental spill of a harmful substance on site, particularly if spilled into a waterbody.
4. Dust generated from work activities may affect air quality, having a short-term negative effect on local wildlife, or on aquatic animals should excessive dust settle within nearby watercourses.
5. Garbage and waste generated by the construction activities may attract local wildlife and lead to human-wildlife interactions.
6. The potential mammal den that was identified during the winter track count at the Spiral Tunnels Hill Slope could be affected by project activities if the den is active.

Aquatics:

1. Deleterious substances (from equipment, construction materials, dust and worksite refuse) may enter waterbodies during construction and affect water quality and aquatic life at and downstream of the project site.
2. Aquatic life may be affected at and downstream of the project site should an accidental spill of harmful substance enter the Kicking Horse River or one of the tributaries.
3. Fish and aquatic wildlife (amphibians) may be negatively affected (e.g., physiological response, behavioural avoidance) by blasting activities that occur close to a watercourse.
4. Aquatic habitat may be destroyed or harmfully altered if construction activities occur within or adjacent to a watercourse (i.e., the riparian zone).
5. The proposed AB/BC Border Storage area is unlikely to have significant impacts to aquatic resources as the closest watercourse is almost 1 km east. The proposed Mt Vaux Storage Area is unlikely to have significant negative impacts to the Kicking Horse River or its tributaries given its placement within disturbed areas adjacent to the TCH. Sufficient distance appears available between the storage locations and any watercourse, and along with standard mitigation measures, this storage will be unlikely to negatively affect aquatic resources.

Cultural Resources:

1. Unknown cultural resources (e.g., unidentified archaeological sites) may be affected by vibrations during blasting activities, machinery use or reprofiling works.
2. The historical alignment of CPR spur (438T), the historic road grade (439T) and the semi-buried artifacts of a train wreckage (530T) near the Lower Sherbrooke slope may be disturbed or destroyed by vegetation clearing, constructing access roads and reprofiling work, including blasting, depending on the methodology used to complete the work (i.e., machinery vs. hand equipment).

Visitor Experience:

1. Traffic delays are likely to occur during the Project.
2. Visitors may experience temporary increased noise and vibration during blasting activities.
3. Project activities may result in a temporary increase of dust.
4. Viewscapes will be altered by rock slope reprofiling and temporary storage of materials.

11. MITIGATION MEASURES

Mitigation measures can be applied by adhering to operational protocol or through project design alterations adopted by the Project to reduce potential adverse effects to identified VCs.

Project Measures:
General

1. The Contractor is required to prepare an Environmental Protection Plan (EPP) in accordance with Parks Canada Environmental Procedures. The EPP shall include, but is not limited to:
    a. An access plan including access routes, type of equipment used for various construction phases, and lay down areas in order to prevent/minimize disturbance to vegetation and soils. Lay down areas shall occur on paved and/or hardened surfaces. Any new laydown areas will require approval from the Environmental Surveillance Officer (ESO) and Departmental Representative.
    b. Details on how the work limits will be marked and what procedures will be employed to ensure trespass outside these limits does not occur and to ensure that the environment is not impacted or damaged by workers or construction equipment beyond the work limits.
    c. Details on how to prevent/minimize impacts to the historic rail spur, historic road grade and train wreck sites located near the Lower Sherbrooke slope.

   d. An erosion and sediment control plan to prevent/minimize sedimentation and erosion into watercourses within or adjacent to the Project area and which will outline appropriate dewatering and erosion and sediment control measures for the project, if required.
   e. A Spill Response Plan will be prepared by the Contractor and shall detail the containment and storage, security, handling, use and disposal of empty containers, surplus product or waste generated in the application of these products, to the satisfaction of the Departmental Representative and the ESO and in accordance with all applicable federal and provincial legislation. The Plan shall include a list of products and materials to be used or brought to the work site that are considered or defined as hazardous or toxic to the environment. Such products include, but are not limited to, cement and/or resin based grout (for rock anchors), non-ANFO explosives and hydrocarbon products.
   f. An emergency response plan that outlines procedures to follow in the case of an emergency (e.g., wildlife encounter, equipment malfunction/failure, fire or blasting incident).
   g. A fire prevention plan which describes the fire prevention equipment (fire extinguishers etc.) and procedures on site in the event of a fire. Should a fire occur, Banff dispatch and the Fire Duty Officer must be notified immediately.
2. An on-site ESO will be assigned by PCA to provide periodic and unscheduled site visits to ensure that Project operations are conducted in accordance with all identified environmental protection measures (including, but not limited to those within this document, applicable legislation and construction Best Management Practices). The ESO maintains the right to halt any work that does not comply with all Project Approvals, Permits or Authorizations. The Contractor is responsible for undertaking environmental monitoring and follow up reporting of remediation works such that criteria in PCA Approvals and the EPP are being adhered to.
3. The ESO will have the authority to halt any work that does not comply with regulatory requirements or causes adverse environmental impacts. Failure to comply with or observe environmental protection procedures may result in the work being suspended pending rectification of the problems.
4. It is the responsibility of the Project Manager to ensure that all Project works are conducted in accordance with all applicable legislation, regulations and/or approvals including the *Fisheries Act, Species at Risk Act* and *Canada National Parks Act*.
5. The Contractor must obtain all necessary permits prior to the commencement of Project activities.
6. It is expected that all staff and contactors will understand and comply with all National Park regulations within the Park. All staff employed at the construction site will be required to attend an environmental briefing regarding their individual and collective responsibilities to ensure avoidable adverse environmental impact does not arise from their activities and personal choices. This information will be available on site and provided to any new workers and/or subcontractors such that subsequent environmental briefings can be presented by arrangement with the ESO through the Departmental Representative.
7. All contractors shall be subject to an environmental briefing regarding their individual and collective responsibilities to ensure avoidable adverse environmental impact does not arise from their activities and personal choices. This information should be available on-site and provided to any new workers and/or subcontractors such that subsequent environmental briefings can be presented by arrangement with the ESO through the Departmental Representative.
8. PCA and the Contractor should be prepared to change existing measures and BMPs should they fail or additional measures are required. The ESO/EM should be notified of any changes to ensure they are adequate and installed properly.
9. It is the responsibility of the Project Manager to provide Parks Canada staff with advance notifications of Project activities and ensure that this information be included in local media.
10. All site staff are required to wear appropriate Personal Protective Equipment (PPE) and be trained to standards that comply with Worksafe BC.
11. Firearms and pets are prohibited on site.
12. Fishing on site by Project crew is prohibited.
13. Park campgrounds will not be used for staff accommodation.
14. The Contractor assumes any risk to public safety as a result of Project activities.

Spill Management and Hazardous Materials:

15. The EPP shall contain a section specific to Spill Management. Spill response plans should include spill prevention and spill reporting requirements along with step-by-step procedures for responding to potential spill incidents.
16. Appropriately sized and stocked spill kits shall be on site and each piece of equipment. The kits shall be suitable for the quantities and types of material in use and stored at the site. They should be capable of dealing with 110% of the largest potential spill. All staff should be aware of their location(s) on site and trained in spill response procedures.
17. Any spill of a substance that is toxic, polluting, or deleterious to aquatic life should immediately be reported to Parks Canada Dispatch and the ESO/EM.
18. Hydrocarbon and coolant storage, if required on site, shall be within an impermeable containment facility capable of holding 110% of the storage tank contents. This may be achieved through the use of double-walled storage tanks or constructing a containment berm out of durable material. These containment basins shall be inspected daily for leaks and wear points, kept clean and any measurable rainwater removed and disposed of appropriately. If practical, the containment area should be covered to prevent infilling with rainwater. Where leaks and/or wear points are found, they shall be repaired promptly to restore full containment.
19. Contractors shall ensure that small containers (i.e., jerry cans) will be stored in a secure location, protected from weather. These containers must be designed solely for the purpose of storing and pouring fuel and shall not be more than 5 years old. Containers must not leak and must be sealed with a proper fitting cap or lid.
20. Hydraulic fluids for on-site equipment will be biodegradable in case of accidental loss of fluids.
21. Hazardous materials must be labelled and disposed of according to the Workplace Hazardous Materials Information System criteria and the Transportation of Dangerous Goods (TDG) Regulations.

Machinery and Equipment:

22. Equipment and machinery should be in good operating condition, clean (power washed), free of leaks, excess oil and grease and non-native plant species. Equipment leaking or producing excessive exhaust should be repaired or replaced. Any detected leaks from equipment on site will be addressed immediately and absorbent pads will be used under equipment with chronic leaks. Equipment stored overnight should be stored on tarps with appropriate containment if required.
23. Machinery should be situated to minimize track movement.
24. Equipment servicing and maintenance should not occur on site.
25. Refueling of equipment should occur on land at least 30 m from any watercourse, where possible. Where 30 m is not possible, a location as far as possible from the watercourse should be chosen. Topographic features and slope should be considered. The refueling area should have a spill containment kit immediately accessible and personnel should be knowledgeable in its use.
26. Generally, personal vehicles shall be parked at least 10 m from any watercourse.

Air Quality and Noise:

27. Dust-generating activities should be minimized as much as possible during windy periods.
28. The Blaster of Record will ensure the blast zone is clear of people and wildlife prior to detonation. Materials to be blasted may be covered with suitable material (i.e., blast mats), if necessary, to control fly-rock.
29. No burning of oils, rubber, tires and any other material should take place on site.
30. Stationary emission sources (e.g., portable diesel generators, compressors, etc.) should be used only as necessary. Equipment and vehicles should be turned off when not in active use to reduce noise and air pollution.

31. All equipment, vehicles and stationary emission sources should be well-maintained and used at optimal loads to encourage minimal noise and air emissions.
32. To minimize noise and dust generation, blasting activities should be conducted according to industry best management practices and tender specifications. Contractors should determine appropriate charge size, pattern design and spacing to create efficient blasting and minimize frequency/size of detonation while accomplishing the task.

Erosion and Sediment Control:

33. Plan and schedule Project activities for dry weather whenever possible. When significant wet weather is encountered, then additional measures may be required to minimize erosion potential.
34. Minimize construction and equipment travel during periods of heavy precipitation. Excavation activities should be halted during heavy rainfall events. Work may be stopped completely or works may require additional erosion and sediment control measures be implemented in order to permit work to continue.
35. Minimize the area of soil exposed at any one time by: phasing construction activities; retaining vegetation as much as possible; and, once construction works are completed, stabilize the exposed soils as soon as possible using temporary measures such as mulch, erosion sediment control blankets, hydroseeding, and/or plastic sheeting or planting long-term vegetation (if during the appropriate time of year).
36. Stockpile, or have readily available, supplies of erosion and sediment control materials as appropriate on-site such as (but not limited to) rock, gravel, grass seed, silt fencing, staking, polyethylene sheeting, etc.
37. Contractors shall stabilize any waste materials removed from the work site to prevent them from entering a watercourse. All storage of waste materials shall be kept a minimum of 30 m, or as far as practical, from any watercourse to reduce the potential for any deleterious substance entering the water.
38. Erosion and sediment control measures should be routinely inspected. After a heavy rain event, it is likely that many of the controls will require repair, clean out, or reinforcement. A quick response to assess and correct damages of the controls is required, especially before subsequent precipitation events.

Vegetation:

The following mitigation measures are suggested to reduce the potentially negative impacts to vegetation:

1. No clearing of whitebark pine or other rare vegetation species is to occur without acquisition of appropriate permits (e.g., SARA). The slopes scheduled for remediation in 2015 were inspected for rare tree species by Trevor Kinley (PCA Environmental Assessment Scientist) and no whitebark pine or limber pine were found.
2. All Contractor's equipment will be stored either on the road or on previously disturbed or hardened surfaces in order to avoid trampling roadside vegetation and compaction of soils.
3. Efforts shall be made to ensure the minimum amount of vegetation is cleared or disturbed at each site. Areas to be cleared should be visibly delineated to reduce potential for unnecessary vegetation removal.
4. The area(s) to be cleared should be clearly marked with highly visible materials (i.e., flagging tape, snow fencing) to ensure equipment operators are aware of the area they are to work in. Equipment operators should work carefully to ensure they do not cause mechanical damage to trees and other vegetation outside the designated clearing area.
5. Prior to accessing Yoho National Park, construction equipment, particularly tire treads, shall be pressure washed to prevent the introduction of non-native species.
6. Should non-native species be identified on-site and presence is suspected to have occurred during construction, PCA shall be notified and the appropriate removal should be undertaken.
7. Vegetation removal that will affect trees used by all birds and other wildlife should be avoided wherever possible while they are breeding, nesting, roosting or rearing young.
    - If vegetation removal is required during the nesting period, an appropriately qualified environmental professional should survey vegetation to be removed to identify any breeding, nesting, roosting or rearing birds and determine species-specific BMPs.

- o Environment Canada's General Regional Nesting Period for the Northern Rockies, Zone A4 is mid-April to mid-August (Environment Canada 2014). It is anticipated that the Project will occur between June and October 2015 which is during the sensitive nesting period of many bird species.

8. In addition to conducting a pre-disturbance nest survey, trees felled during the nesting period may require a Restricted Activity Permit from PCA. The contractor should consult with PCA to determine the need for and specific requirements of a RAP, including best management practices which *may* include (AXYS 1998):
   - o Minimizing tree removal as much as possible;
   - o Visibly marking the trees to be removed;
   - o Leaving a buffer of vegetation to maintain aesthetic values, where possible, when felling occurs within line-of-site of roads or trails. Consult with PCA to determine potential alternatives;
   - o Felling trees by hand where possible;
   - o Avoid felling obvious wildlife trees where possible;
   - o Avoid felling mature trees (DBH >30 cm) where possible;
   - o Salvage trees with DBH >15 cm for firewood or merchantable timber (may require a timber salvage permit from PCA);
   - o Timber decking sites should occur within the existing work space; and
   - o Preference is for slash to be piled and burned on site. Piles cannot exceed 2 m in width and 1.5 m in height. Piles must be located far enough from retained trees so that they are not damaged or killed. If chipping, chips may cover up to 25 m2/ha to a depth of < 8 cm.. note that burning is typically not approved within 100 m of a road, 200 m of a named watercourse or 500 m of residences/campgrounds.

     Tetra Tech EBA notes that Tree Felling activities are fully assessed in a separate BIA (File # 2015-017Y), which should be referred to for complete mitigation measures.
9. Vegetation in areas temporarily disturbed by heavy equipment and other construction-phase related activities (including lay-down sites, temporary work sites, and material stock pile sites) should be restored as quickly as possible. This may be accomplished by planting grass seed or hydroseeding (using certified "weed free" mixtures approved by PCA).
10. Should impacts to surrounding vegetation be detected, appropriate measures to re-vegetate and rehabilitate should be implemented using PCA approved methods and seed mix.

Wildlife:

The following mitigation measures are recommended to reduce the potentially negative impacts to wildlife:

1. Works shall be scheduled to occur outside sensitive wildlife periods (nesting, rutting, breeding etc.) as much as possible. Where works are required to occur within sensitive wildlife periods, care will be taken to prevent disturbance or harm to wildlife during the rock slope remediation activities.

   Tetra Tech EBA notes that Mountain Goats are potentially present near the Sherbrooke Slope and Lower Sherbrooke Slope (the west end). The project should be scheduled such that construction activities occur in these areas after August 15 and for Lower Sherbrooke Slope, as the last are worked on in the year.
2. Vegetation removal that will affect trees used by birds (both migratory and non-migratory) and other wildlife should be avoided wherever possible while they are breeding, nesting, roosting or rearing young.
   - o If vegetation removal is required during the nesting period, an appropriately qualified environmental professional should survey vegetation to be removed to identify any breeding, nesting, roosting or rearing birds and determine species-specific BMPs.
   - o Environment Canada's General Regional Nesting Period for the Northern Rockies, Zone A4 is mid-April to mid-August (Environment Canada 2014). It is anticipated that the Project will occur between June and October 2015 which is during the sensitive nesting period of many bird species.

3. PCA shall be notified immediately in the event of human-wildlife interactions, or activity or encounters with bears, goats, cougars, wolverine or any species at risk. In the event of encounters with dens, litters, nests, carcasses (road kills), bear activity or wildlife encounters in or around the site, the ESO and Departmental Representative shall be immediately notified. Other wildlife-related encounters shall be reported within 24 hours.
4. Feeding, harassment or destruction of any wildlife is strictly prohibited. Wildlife encountered at or near project locations will be allowed to passively disperse without undue harassment.
5. All efforts to prevent wildlife from accessing human food, garbage or other domestic wastes shall be made by the Contractor and contract staff while undertaking work in National Parks. Such wildlife attractants shall not be stored at the work site overnight. Lunches, coolers and food products, including waste food products, shall be securely stored away from access by animals. Daily removal from the Park and off-site disposal of food scraps, food wrappers, pop cans, domestic waste, and other potential wildlife attractants is mandatory. Existing Parks Canada waste receptacles shall not be used for disposal of such wastes without prior arrangement with PCA. Incidents involving wildlife accessing garbage or attractants should be reported immediately to PCA.
6. Where catchment ditch clearing is required prior to remediation works to increase catchment ditch area, ditches containing water shall be inspected for breeding amphibians. Timing of ditch clearing activities shall be scheduled to avoid sedimentation during periods when larvae or eggs may be destroyed, if possible. Any locations deemed to be permanent amphibian habitat by PCA shall be identified and avoided. If these areas are required for ditch clearing works, PCA shall be consulted to determine appropriate actions to avoid amphibian mortality.
7. Prior to blasting, the Contractor shall “sweep” the work area and maintain a continuous watch for wildlife that may be present. If wildlife is present, work shall be halted until the wildlife have passed through the area and/or have been hazed out of the area by the ESO, representative of Parks Canada or appropriately qualified biologist.
8. The Contractor shall describe the proposed type and quantities of explosives to be used to the satisfaction of the Departmental Representative and ESO. Blasting products that may produce high residual nitrogen concentrations (such as ANFO) will not be permitted.
9. Species at risk could potentially be observed on or near the Project locations. Should this occur, operations in the immediate vicinity of the species should be halted and should re-commence only when the species has left the immediate area. PCA Resource Conservation staff shall be notified immediately via Banff Dispatch at 403-762-4506 (emergencies) or the Wardens Office in Yoho at 250-343-6324 (non-emergencies).
10. All work activities shall meet or exceed the standards outlined in DFO’s “Guidelines for the Use of Explosives In or Near Canadian Fisheries Waters”; Canadian Technical Report of Fisheries and Aquatic Sciences 2107, 1998.
11. Best Management Practices for working in and around water will be applied when working near watercourses. Considerations for working near water, such as erosion and sediment control measures, are to be incorporated into the project EPP.
12. Construction traffic should yield right-of-way to wildlife. A Traffic Safety Plan will incorporate protocol for wildlife occurrences along roads within the project area, due to presence of bears, cougars, elk or moose which can be aggressive towards humans.
13. The potential mammal den that was identified during the winter track count at the Spiral Tunnels Hill Slope should be monitored to determine if it is active.

Aquatics:

Impacts to fisheries resources can be mitigated through application of Best Management Practices for working in or around water. Unless otherwise stated, the requirements related to sediment, drainage, and water quality management for the Project are applicable to all Project construction areas. The mitigation and monitoring measures described below will be used as the basis for preparing the final sediment, drainage, and water quality management plan:

1. The Contractor is responsible for ensuring that the Project avoids causing 'serious harm to fish' as per the *Fisheries Act*. While the Project is not anticipated to require input from DFO, 'measures to avoid causing harm to fish and fish habitat' (available at: http://www.dfo-mpo.gc.ca/pnw-ppe/measures-mesures/index-eng.html) are to be employed as appropriate. Advice within these Measures replaces former Operational Statements produced by DFO.
   Blasting activities will be conducted to meet or exceed the standards outlined in Department of Fisheries' and Ocean's (DFO's) "Guidelines for the Use of Explosives In or Near Canadian Fisheries Waters"; Canadian Technical Report of Fisheries and Aquatic Sciences 2107, 1998.
2. Disturbance to natural materials and vegetation that contribute to fish habitat or stream channel stability will be minimized. Should vegetation which contributes to fish habitat need to be removed, a restoration plan that meets the Parks Canada requirements for re-vegetation will be compiled subject to YNP review and acceptance.
3. The natural hydrological regimes should be maintained during all phases of activity where possible.
4. Regarding the unnamed tributary near 89+300 on Lower Sherbrooke slope:
   - Reprofiling will require disturbance to the riparian zone and wetted channel of this watercourse. Given the steep slope and that it appears to be a headwater stream, it is unlikely that fish are present (though this is unconfirmed). However, it does contribute nutrients and water to Kicking Horse River and should be protected from having deleterious substances, including sediments, enter it.
   - Flows should be maintained during reprofiling works. It may be necessary to dam the tributary well upstream of the reprofiling cut area and pump the water downslope to the ditch.
   - Reprofiling in the wetted area must be conducted such that a similar tributary "channel" exists post-work (i.e., the tributary must have similar morphology so that it enters the ditch at the point as the original channel).
5. If the work schedule requires working during high precipitation periods or high runoff periods, the area of work must be isolated and appropriate sediment and erosion controls must be installed to prevent the release of sediment laden water or any other deleterious substance. As works for the Project will involve the disturbance of soils, prevent the transport of sediment through application of appropriate erosion and sediment control mitigation guidelines as per DFO Measures.
6. No water is to be extracted from a local stream, river or other water body within a National Park without a Restricted Activity Permit.
7. Deleterious substance control and spill management will be incorporated into the project EPP and will include, but not be limited to, a Spill Response Plan, an Erosion and Sediment Control Plan and a Hazardous Waste Management Plan. The EPP is subject to PCA review.
8. Work will be undertaken and completed in such a manner as to prevent the release of sediment-laden water, raw concrete or concrete leachate, or any other deleterious substance into a watercourse, tributary or drainage ditch which leads to fish habitat.
9. Contractors shall identify equipment and vehicle fuelling locations for approval by PCA and the ESO. Vehicles and equipment will not be serviced or refuelled within 30 m of any watercourse, tributary or drainage ditch which connects to fish habitat. Tanks, hoses and connections will be inspected prior to use. All hose connections will be wrapped and secured with absorbent pads during fuel/oil transfers. All hoses, valves and equipment are to be kept in a containment area whenever possible. Hose length and the number of connections shall be minimized - use dripless connections if possible. Drain hoses when finished. Gravity fed systems are not permitted within YNP, manual or electric pump delivery systems shall be used.

Cultural:

Impacts to cultural resources can be avoided or minimized with the implementation of the following mitigation measures:

1. If artifacts or features are encountered, construction should be stopped and the onsite manager should wait for instructions before proceeding with the work. The YNP Environmental Surveillance Officer or Cultural Resource Management Officer should be notified who will contact Parks Canada's Terrestrial Archaeology Section for further guidance. In order to assess the situation, documentation should include, what was seen, the location of where the material was encountered, what the surrounding soil looked like, how deep it was from the ground surface, or if it was at ground surface. If possible, a photograph should be taken and sent along with the description information to the archaeologist. Preferably, artifacts should be left in place until a Parks Canada archaeologist has been consulted.
2. All known artifacts of historical importance at or near worksites will be left undisturbed.
    - The historic highway bridge across from the Lower Sherbrooke slope is to be avoided. Activities must be planned in such a way as to eliminate risk of impact to this structure by machinery, logs or other causes.
    - The train wreckage site is to be avoided. Activities must be kept as close to the rock edge as feasible.
    - Care must be taken to not impact the rail spur with heavy machinery or tracked vehicles without mitigating adverse effects on the rail grade. If feasible, hand falling is the preferred method of harvesting at this site.
    - Care must be taken to not impact the old highway grade with heavy machinery or tracked vehicles without mitigating the effects on the road grade.
3. Work around a known cultural resource should be conducted in a manner to minimize potential disturbance. This may include:
    - Designing access roads and slope profiles to minimize area of disturbance while accomplishing safety/maintenance objectives.
    - Visibly delineating boundaries of work areas to prevent unintentional disturbances.
    - Limit vegetation clearing and machinery movement to minimize physical disturbances.
    - Conduct an "artifact sweep" prior to physical disturbances. PCA should be contacted to assess whether it is feasible or desirable to salvage artifacts.
4. All wildlife artifacts (e.g. antlers, bones, skulls) at or near worksites will be left undisturbed.

Visitor Use and Experience:

Potential effects to human use of the Project area are expected to be temporary. By implementing the mitigation measures described in other sections, effects on human use will be reduced (e.g., Air Quality and Noise measures). Changes to the viewscape at the rock reprofiling sites will be permanent and cannot be mitigated however, these changes will occur along a transportation corridor that has been previously altered and represents a small portion of the total park area.

Changes to the viewscape at the Storage Sites are expected to be temporary. Although large stockpiles will change the visual aesthetics of the area, it is anticipated that the materials will be used for future road maintenance/upgrade projects within the YNP. Storage Sites are located in previously disturbed areas to further minimize impacts.

Accidents and Malfunctions:

During the Project, there will be potential for the release of deleterious substances and/or the risk of project related accidents/malfunctions. The following mitigation will be implemented during Project works:

1. An Environmental Protection Plan (EPP) will be developed and implemented by the Contractor prior to Project initiation. These plans will be submitted to the Yoho Field Unit or ESO for review prior to implementation. These plans will be available to all staff during project activities and will detail appropriate work methods, spill response procedures, erosion control methods, spill and emergency response contacts, and a fire suppression plan.
2. An on-site environmental professional should be used for construction/effects monitoring intermittently over the construction period or according to regulatory approval criteria.
3. A spill containment kit will be kept on site and readily accessible. All equipment on site will be equipped with a spill kit adequate for the specific type and size of individual items.

4. The storage of fuels and deleterious substances will be kept at least 100 m from any drainage course and will be sufficiently contained to accommodate at least 110% of the maximum volume stored. All fuels and deleterious substances will be stored in accordance with applicable Workplace Hazardous Materials Information System (WHMIS) standards.
5. All workers will be instructed to abide by all applicable Work Safe BC guidelines and will complete a project-specific worker safety orientation prior to working on site.
6. Public access to the Project work area will be denied during Project activities.
7. Erosion and sediment control devices will be kept in place and in good working order during the Project. These will be further specified in the EPP.
8. No fires are permitted at work sites and adequate fire response equipment will be available in order to respond to accidental fires.
9. In case of fire, the Contractor or worker shall immediately take action to extinguish the fire if safe to do so. The ESO and Departmental Representative shall be notified of any fire immediately. If not available, Banff Dispatch will be contacted (403-762-4506) and 911 (emergencies) or the Wardens Office in Yoho at (250-343-6324).

12. CONSIDERATION OF THE NEED FOR PUBLIC PARTICIPATION & ABORIGINAL CONSULTATION

12 a) Indicate whether opportunity for public participation should be offered:

__X__ No ____ Yes

12 b) Indicate whether there is a requirement for Aboriginal Consultation:

__X__ No ____ Yes

13. EFFECT SIGNIFICANCE

Temporary Effects:

Temporary effects resulting from the proposed project activities include:

- Possible avoidance behavior of local wildlife due to increased noise and human presence at the project site.
- Conversely, attraction of wildlife to site due to garbage and waste generated by the construction activities and crew.
- Potential spills and leaks resulting from the proposed project activities and equipment.
- Disturbance to vegetation due to construction activities, laydown areas or parking locations.
- Traffic delays.
- Increased noise and vibration from blasting activities.
- Altered viewscapes due to temporary storage of materials.

Permanent Effects:

- Altered landscape due to reprofiling activities (i.e., changes to viewscape).

Residual Effects:

It is anticipated that there will be no significant adverse residual environmental effects as a result of the proposed project activities provided all mitigation measures discussed in this report are followed. The majority of effects are limited in magnitude, geographic extent or duration which results in *no significant adverse effects.*

Although the altered landscape and changes to viewscape is a permanent effect, it is considered to be of low magnitude (slight decline in the resource) because it is congruent with transportation corridor appearances and is unlikely to considerably alter the overall visual merits of YNP.

14. SITE INSPECTION

Document whether a site inspection program will be required while the project is underway.

__X__ Site inspection required
____ Site inspection not required

As per mitigation measures above, an on-site ESO or other Parks Canada Representative will be available to oversee the construction activities. The ESO will complete periodic and unscheduled site visits to ensure that Project operations are conducted in accordance with all identified environmental protection measures. The ESO maintains the right to halt any work that does not comply with all Project Approvals, Permits or Authorizations. The Contractor is responsible for undertaking environmental monitoring and follow up reporting of remediation works such that criteria in PCA Approvals and the EPP are being adhered to.

15. SPECIES AT RISK MONITORING

There are not expected to be any adverse effects to species at risk prior to, during or following rock reprofiling along the Trans-Canada Highway provided mitigation measures outlined are adhered to.

16. SARA NOTIFICATION

Effects to SARA listed species are not expected to occur as a result of this Project provided mitigation measures identified herein are adhered to.

17. EXPERTS CONSULTED

Department/Agency/Institution: PCA	Date of Request: March 10, 2015
Expert's Name: Trevor Kinley	Title: Environmental Assessment Scientist
Contact Information: 250-347-6634 P.O. Box 220, Radium Hot Springs, BC V0A 1M0 trevor.kinley@pc.gc.ca	
Expertise Requested: Known wildlife observances, use, studies etc. within the project areas.	
Response: Information included in Section 9	
Department/Agency/Institution: Tetra Tech EBA	Date of Request: throughout BIA
Expert's Name: Anders Frappel, P.Eng. FGS	Title: Team Leader - Rock Engineering Group
Contact Information: 778-945-5833 Anders.Frappel@tetratech.com	
Expertise Requested: information regarding limits of project areas, volumes to be resloped, construction methods etc.	
Response: Information incorporated throughout BIA	

18. DECISION

Taking into account implementation of mitigation measures outlined in the analysis, the project is:

____ not likely to cause significant adverse environmental effects.

____ likely to cause significant adverse environmental effects.

19. SIGNATURES AND APPROVAL

EA Author *(Add additional signature blocks for multiple authors as required)*

Name: Shawneen Walker, R.PBio.,P.Biol. EP	Date: May 4, 2015
Position: Biologist	
Signature: **ISSUED FOR REVIEW**	

EA Review *(Add additional signature blocks for multiple authors as required)*

Name: Nigel Cavanagh, M.Sc., R.P.Bio., P.Biol.	Date: May 4, 2015
Position: Senior Biologist, Team Lead – Aquatics and Fisheries Discipline	
Signature: **ISSUED FOR REVIEW**	

Decision Approval

Name:	Date: YYYY-MM-DD
Position: (*Field Unit Superintendent, or Designate)*	
Signature:	

20. REFERENCE LIST

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21. ATTACHMENTS LIST

Appendix 1: Environmental Impact Analysis Tools: Effects Identification Matrix
Appendix 2: SARA-Compliant Authorization Decision Tool
Appendix 3: Cultural Resources Assessment Questionnaire (in development**)
Appendix 4: Species at Risk database search results

22. ADDITIONAL CONSIDERATIONS / COMMENTS

Use this space to record additional content as needed.

23. TRACKING SYSTEM

The project must be registered in the Parks Canada Interim Tracking System within the fiscal year the project took place. If the project is on hold, was cancelled, or was determined to be likely to cause significant adverse effects and did not go ahead, please indicate this information in the tracking system (see selections in the *Assessment Status/Decision* field).

Appendix 1 Environmental Impact Analysis Tools: Effects Identification Matrix

Use the matrix to identify potential impacts.

***Section A** focuses on direct effects of the project and **Section B** on indirect effects that are caused by changes to the environment.*

A. Direct Effects (during preparation/construction phases)

			Components potentially directly affected by the proposed project											
			Natural Resources					Cultural Resources		Visitor Experience				
			Air	Soil & landforms	Water (Kicking Horse River, tributatires, road drainage, etc.)	Flora	Fauna (birds, mammals, fish)	Heritage River (see "Water)	Historic Sites & buildings	Visitor access &	Recreational/Accomm. opportunities	Viewscapes and soundscapes	Visitor Safety	Essence of place
	Phase	Project Activities												
Project Components	Preparation / construction	Supply and storage of materials	☐	☒	☒	☒	☒	☐	☐	☒	☐	☐	☒	☐
		Clearing	☐	☐	☐	☒	☒	☐	☐	☒	☐	☒	☒	☐
		Disposal of waste	☐	☒	☒	☒	☒	☐	☐	☒	☐	☒	☒	☐
		Blasting	☒	☒	☒	☒	☒	☐	☐	☒	☐	☒	☒	☐
		Excavation of catchments	☒	☒	☒	☒	☒	☐	☐	☒	☐	☒	☒	☐
		Use of machinery	☒	☒	☒	☒	☒	☐	☐	☒	☐	☒	☒	☐
		Transport of materials/ equipment	☒	☒	☐	☐	☒	☐	☐	☒	☐	☐	☒	☐

SAR- species at risk

A. **Direct effects continued** (during operation/implementation/decommissioning phases)														
			Components potentially affected by the proposed project											
			Natural Resources					Cultural Resources		Visitor Experience				
			Air	Soil & landforms	Water (surface, ground, crossings, etc.)	Flora (specify, including SAR)	Flora (specify, including SAR)	Heritage River (see "Water")	Historic Sites & buildings	Visitor access & services	Recreational & Accomm. opportunities	Viewscapes and soundscapes	Visitor Safety	Essence of place
	Phase	**Examples of Associated Activities**												
Project Components	Operation/Implementation/Decommissioning	Waste disposal	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
		Wastewater disposal	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
		Maintenance	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
		Use	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
		Use/Removal of temporary facilities	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
		Use of Chemicals	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
		Active fire stage	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
		Prescribed burn cleanup	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
		Planting	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
		Culling	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
		Vehicle Traffic	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
		Other…	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐

Section B- next page

***Section B** of the matrix should be used to identify potential indirect effects that may result from impacts on components of the environment you have identified on the preceding pages (see Section A - direct effects to natural resources). This is required under CEAA 2012 Sections 5(1)(c) and 5(2)(b).*

No indirect effects are anticipated to occur as a result of this project.

B. Indirect Effects (all phases)				
		Impacts as a result of changes to the environment		
		With respect to non-Aboriginal peoples:	With respect to Aboriginal peoples:	
		Health and socio-economic conditions	Health & socio-economic conditions	Current use of lands and resources for traditional purposes
Phase	**Natural resource components affected by the project**			
All phases: Preparation /construction operation/implementation/decommissioning	Could impacts to air lead to adverse effects on…	☐	☐	☐
	Could impacts to soils and landforms lead to adverse effects on…	☐	☐	☐
	Could impacts to water (e.g. surface, ground water and water crossings) lead to adverse effects on…	☐	☐	☐
	Could impacts to flora (including SAR) lead to adverse effects on…	☐	☐	☐
	Could impacts to fauna (including SAR) lead to adverse effects on…	☐	☐	☐
	Other…	☐	☐	☐

Appendix 2: SARA-Compliant Authorization Decision Tool

(Note: Please consult a representative of the Species Conservation and Management team when completing this form)

Date:	Topic/Issue:	Species :	Where: (PCA site)	Who: (your name)

Part A – Is a SARA authorization required?	
1. Will the activity directly or indirectly affect a listed endangered, threatened or extirpated species at risk, its residence or critical habitat? *Affect = kill, harm, harass, capture, or take individuals; possess, collect, buy, sell or trade individuals or parts of individuals; damage or destroy residence; destroy any part of critical habitat*	
☒ **No**	**SARA authorization is NOT required.** *Provide explanation and **STOP HERE.*** • *Describe the activity and explain why there is no expected effect, including an explanation of mitigation measures taken to prevent potential effects on species at risk, their residence or their critical habitat.* • *If an environmental assessment (EA) process is being conducted, refer to the mitigations in the EA.* • ***Refer to Section 10 and 11 in BIA report***
☐ **Yes**	**SARA authorization IS required.** *Describe the activity and its effects on the species and continue to Question 2.* *Note: If you are contemplating an activity that may destroy critical habitat, it must be discussed with VPs and the CEO due to a recent federal court decision. If possible, find alternatives and mitigation measures to prevent destruction of critical habitat (i.e., to avoid an effect on the critical habitat and the requirement for an authorization).*
2. Is the activity already authorized in a final recovery document or required for public safety?	
☐ **Yes**	**SARA authorization is NOT required.** *Explain why the activity is exempt and **STOP HERE.*** • *Explain why the activity is needed for public safety and make a reference to the Act of Parliament under which the activity is authorized; OR* • *if the activity is authorized in a final recovery document, refer to the published recovery and explain why the activity is exempt under section 83 of SARA).*
☐ **No**	**SARA authorization is required.** *Continue to Part B.*
Part B – Can a SARA authorization be issued? ******Complete ONLY if you have answered Yes to Questions 1 or 2, above******	
3. Does the activity fall into one of the following three categories? *Check the appropriate box and continue to Question 4. If the proposed activity DOES NOT fit in any of the three categories below, the activity CANNOT be authorized and you should continue to Part C to summarize your decision.*	
☐ The activity is scientific research related to the conservation of the species and conducted by qualified persons; OR ☐ The activity benefits the species or is required to enhance its chance of survival in the wild ; OR ☐ Affecting the species is incidental to the activity (i.e., the purpose of the activity is not a prohibited activity, for example, fishing for a listed species cannot be permitted, but accidental by-catch *may* be, and repairs to a bridge that incidentally disturbs a nearby plant *may* be).	

4. If you concluded that the activity can be authorized, have alternatives that would reduce the impact(s) on the species been considered?	
☐ **No**	**The activity CANNOT be authorized as alternatives have not been/cannot be considered**. *Continue to Part C to summarize your decision*.
☐ **Yes**	**The activity MAY be authorized.** *Provide explanation and continue to Question 5.* • *Identify all reasonable alternatives that were considered to reduce the impact on the species (including alternatives to the project and alternative means of carrying out the project, including a "no action" alternative). The explanation must demonstrate that the best solution has been adopted.*
5. Will all feasible measures be taken to minimize the impact of the activity?	
☐ **No**	**The activity CANNOT be authorized.** *If it is <u>not possible</u> to implement all feasible measures, continue to Part C to summarize your decision.*
☐ **Yes**	**The activity MAY be authorized.** • *Identify all feasible measures to avoid or lessen potential impacts of the project on the species and continue to Question 6. Measures and conclusions must be consistent with existing recovery documents, COSEWIC assessments etc.* • *Note: If this authorization is considered as part of an EA process, the information provided should be consistent with the mitigation section of the EA.*
6. Will the activity jeopardize the survival or recovery of the species?	
☐ **Yes**	**The activity CANNOT be authorized.** *If the survival or recovery of the species <u>will</u> be jeopardized, continue to Part C to summarize your decision.*
☐ **No**	**The activity MAY be authorized.** *Provide explanation and continue to Part C.* • *A strong justification is required to demonstrate that the activity will not jeopardize survival or recovery. The justification must demonstrate that the activity will not jeopardize the achievement of the recovery goal and objectives identified in the recovery strategy (if available).* • *Provide a justification that the activity will not contribute to increasing an existing threat, or that it is not an activity that might destroy critical habitat for the species (if identified).* • *Indicate whether the project will increase mortality, decrease fertility/recruitment, affect a key life stage/cycle.* • *Make reference to known effects of similar activities based on existing literature.*
Part C – Summary - Will the SARA authorization be issued?	
7. Will the SARA Authorization be issued?	
☐ **No** *(indicate selection)*	**The activity WILL NOT be authorized because:** a. **The activity does not fit into one of the three required categories** *(see response to Question 3).* b. **Alternatives have not been considered** *(see response to Question 4).* c. **All feasible measures cannot be taken to minimize impacts** *(see response to Question 5).* d. **The activity will jeopardize the survival or recovery of the species** *(see response to question 6).*
☐ **Yes**	**The activity *WILL* be authorized, as the requirements in Part B have been met.**

Part D - How will the SARA authorization be issued?	
8. Which process will be used? *Existing PCA processes such as the EA process and the Research and Collection Permit System can be used to issue a SARA-compliant permit, as long as the SARA requirements are met.*	
☐ **SARA permit (s.73)**	• The SARA-compliant authorization must be issued (see template on intranet). • An explanation must be posted on the SARA public registry (using the information provided above) – see template on intranet.
☐ **An existing PCA process (and SARA s.74)**	• Explain which permitting process will be used (i.e. EA, research permit, etc.). • The SARA authorization cover letter must be attached to the EA or permit (see template on intranet). • An explanation must be posted on the SARA public registry (using the information provided above) – see template on intranet.

Appendix 3: Cultural Resources Assessment Questionnaire (in development**)

Please consult with or provide this form to a Cultural Resources Management Specialist.

** The National EA Team is working with the Heritage Conservation and Commemoration Directorate to provide a questionnaire that facilitates consideration of potential impacts to cultural resources. In the interim of the questionnaire being finalized, please work with a CRM specialist to ensure you have appropriately integrated information related to potential effects of the project on cultural resources.

Appendix 4: Species At Risk Database Search Results

Parks Canada Parcs Canada Canada

Biotics Web Explorer

Back

Scientific Name	Common Name	SARA Schedule	COSEWIC Status	Managed Area Name	Regularity	Distribution Confidence	SARA Legal Status
Contopus cooperi	Olive-sided Flycatcher	Schedule 1	Threatened (T)	Yoho National Park of Canada	Regularly occurring	Confident	Threatened
Myotis lucifugus	Little Brown Myotis	Schedule 1	Endangered (E)	Yoho National Park of Canada	Regularly occurring	Confident	Endangered
Oncorhynchus clarkii pop. 8	Westslope Cutthroat Trout - British Columbia population	Schedule 1	Special Concern (SC)	Yoho National Park of Canada	Regularly occurring	Confident	Special Concern
Pinus albicaulis	Whitebark Pine	Schedule 1	Endangered (E)	Yoho National Park of Canada	Regularly occurring	Confident	Endangered

Number Of Records Returned 4

Back

Date Modified: 2013-10-09

BC Species and Ecosystems Explorer Search Results

		Status					
Scientific Name	**English Name**	**Provincial**	**BC List**	**COSEWIC**	**SARA**	**Global**	**CF Priority**
Anaxyrus boreas	Western Toad	S3S4 (2010)	Blue	SC (2012)	1-SC (2005)	G4 (2008)	2
Gulo gulo luscus	Wolverine, *luscus* subspecies	S3 (2010)	Blue	SC (2014)		G4T4 (1996)	2
Hemphillia camelus	Pale Jumping-slug	S3 (2008)	Blue			G4 (2006)	2
Magnipelta mycophaga	Magnum Mantleslug	S2S3 (2008)	Blue	SC (2012)		G3 (2006)	2
Oncorhynchus clarkii lewisi	Cutthroat Trout, *lewisi* subspecies	S3 (2004)	Blue	SC (2006)	1-SC (2010)	G4T4 (2013)	2
Polites themistocles themistocles	Tawny-edged Skipper, *themistocles* subspecies	S3 (2013)	Blue			G5TNR	4
Salvelinus confluentus	Bull Trout	S3S4 (2011)	Blue	SC (2012)		G4 (2011)	2
Ursus arctos	Grizzly Bear	S3 (2010)	Blue	SC (2002)		G4 (2000)	2

Search Summary

Time Performed	Mon Mar 16 14:01:02 PDT 2015
Results	8 records.
Search Criteria	Search Type: Animal AND Forest Districts:Columbia Forest District (DCO) (Restricted to Red, Blue, and Legally designated species) AND MOE Regions:4- Kootenay (Restricted to Red, Blue, and Legally designated species) AND Municipalities: Golden (Restricted to Red, Blue, and Legally designated species) AND BGC Zone:ESSF, MS Sort Order:Scientific Name Ascending
Notes	1. Citation: B.C. Conservation Data Centre. 2015. BC Species and Ecosystems Explorer. B.C. Minist. of Environ. Victoria, B.C. Available: http://a100.gov.bc.ca/pub/eswp/ (accessed Mar 16, 2015). 2. Forest District, MoE Region, Regional District and habitat lists are restricted to species that breed in the Forest District, MoE Region, Regional District or habitat (i.e., species will not be placed on lists where they occur only as migrants).

Modify Search | New Search | Results

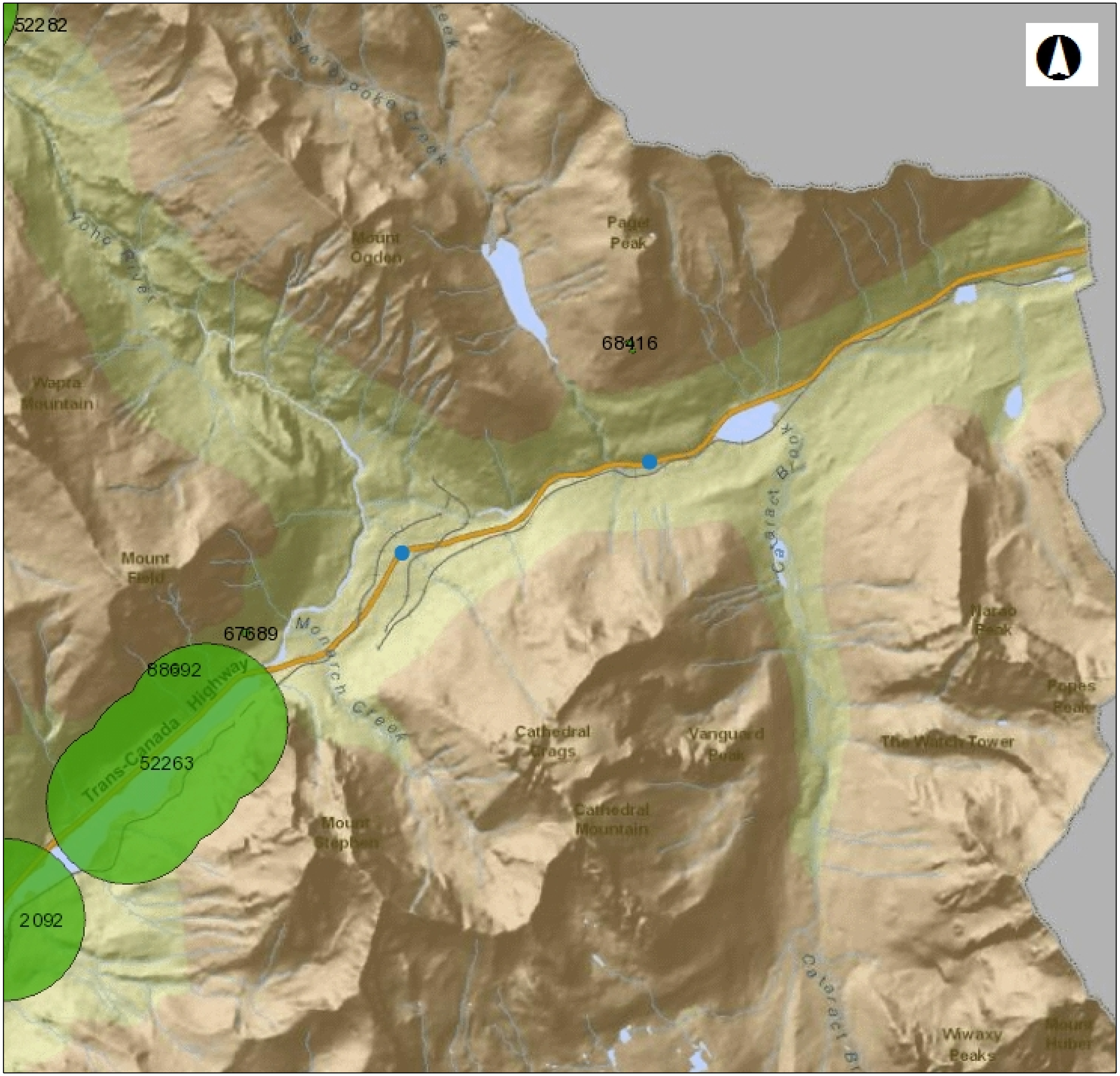
BC Species and Ecosystems Explorer Search Results

No matches could be found for your specified Search Criteria (see below). Please try again.

Search Summary

Time Performed	Mon Mar 16 13:55:43 PDT 2015
Results	0 records.
Search Criteria	Search Type: Plant AND SARA Schedule 1 Status:True AND COSEWIC Status:Endangered OR Threatened OR Special Concern AND Forest Districts:Columbia Forest District (DCO) (Restricted to Red, Blue, and Legally designated species) AND MOE Regions:4- Kootenay (Restricted to Red, Blue, and Legally designated species) AND Municipalities: Golden (Restricted to Red, Blue, and Legally designated species) AND BGC Zone:ESSF, MS Sort Order:Scientific Name Ascending
Notes	1. Citation: B.C. Conservation Data Centre. 2015. BC Species and Ecosystems Explorer. B.C. Minist. of Environ. Victoria, B.C. Available: http://a100.gov.bc.ca/pub/eswp/ (accessed Mar 16, 2015). 2. Forest District, MoE Region, Regional District and habitat lists are restricted to species that breed in the Forest District, MoE Region, Regional District or habitat (i.e., species will not be placed on lists where they occur only as migrants).

Modify Search | New Search | Results



BRITISH COLUMBIA

CDC Occurrence Map

km 88 to 91

Legend

Species and Ecosystems at
Available Occurrences - CD

FEATURE_CODE

- Animal - Vertebrate
- Animal - Invertebrate
- Plant - Vascular
- Plant - Non-vascular
- Ecological Community

Species and Ecosystems at
Secured) Publicly Available

Species and Ecosystems at
Publicly Available Occurrenc

FEATURE_CODE

- Animal - Vertebrate
- Animal - Invertebrate

0 1.42 2.84 km

1: 69,942

Copyright/Disclaimer

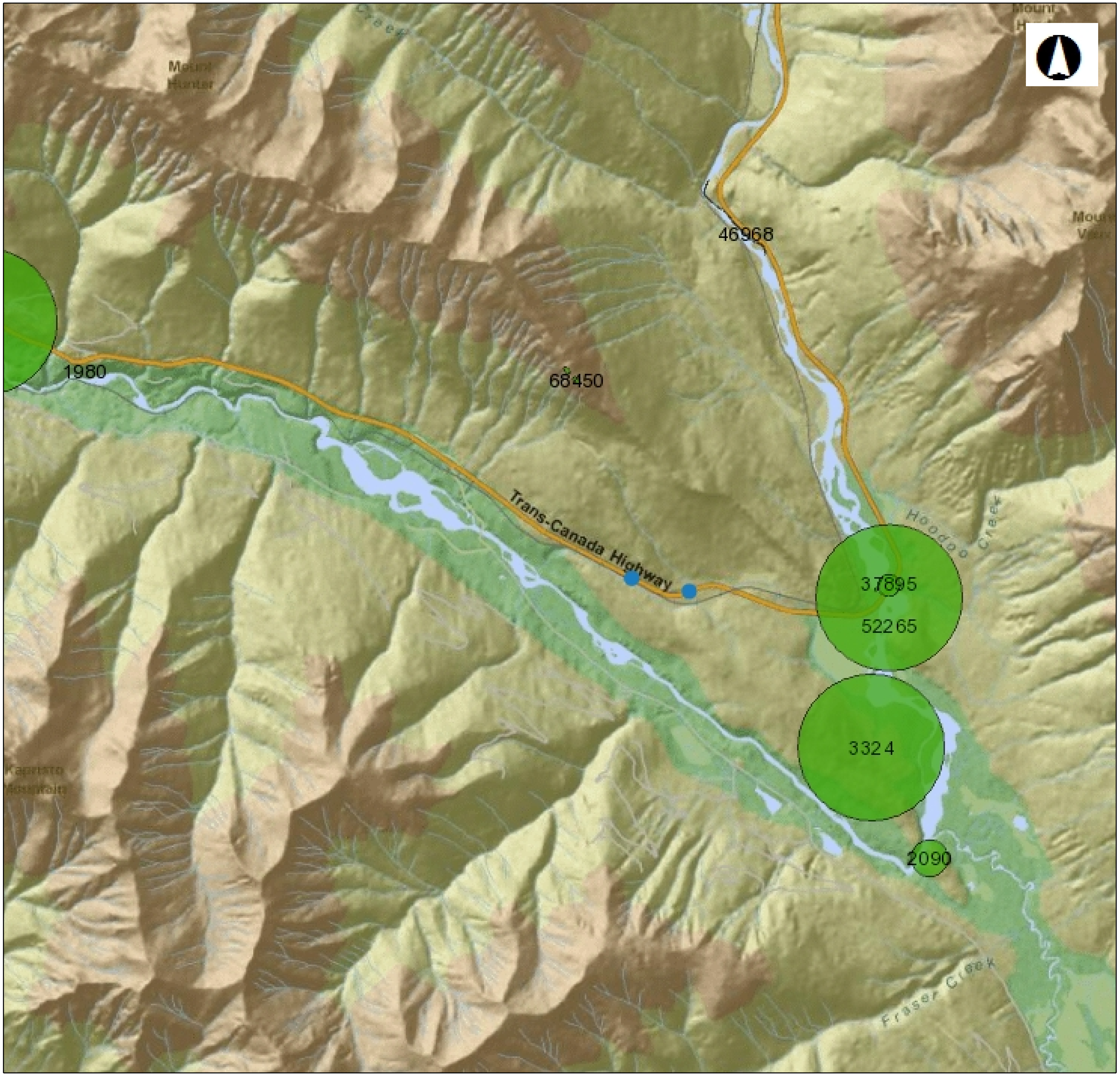
CAUTION: Maps obtained using this site are not designed to assist in navigation. These maps may be generalized and may not reflect current conditions. Uncharted hazards may exist. DO NOT USE THESE MAPS FOR NAVIGATIONAL PURPOSES.

Datum: NAD83
Projection: NAD_1983_BC_Environment_Albers

Key Map of British Columbia

BRITISH COLUMBIA

CDC Occurrence Map
Phyllite Site



Legend

Species and Ecosystems at
Available Occurrences - CD

FEATURE_CODE

- Animal - Vertebrate
- Animal - Invertebrate
- Plant - Vascular
- Plant - Non-vascular
- Ecological Community

Species and Ecosystems at
Secured) Publicly Available

Species and Ecosystems at
Publicly Available Occurrenc

FEATURE_CODE

- Animal - Vertebrate
- Animal - Invertebrate

0 1.58 3.16 km

1: 77,784

Copyright/Disclaimer

Datum: NAD83

Projection: NAD_1983_BC_Environment_Albers

Key Map of British Columbia

BC Conservation Data Centre: Occurrence Report
Occurrence ID: 1371

Scientific Name: *Gentianopsis macounii*
English Name: Macoun's fringed gentian

Identifiers

Occurrence ID: 1371
Shape ID: 2090
Taxonomic Class: dicots
Element Group: Vascular Plant

Status

Provincial Rank: S3
BC List: Blue
Global Rank: G5
COSEWIC:
SARA Schedule:

Locators

Survey Site: YOHO NATIONAL PARK, WAPTA FALLS
Directions:
Biogeoclimatic Zone:
Ecosection: SPK

Occurrence Information

First Observation Date: 1960-09-21 **Last Observation Date:** 1995

Occurrence Data:

1995: Observed along the trail into the falls in a fairly flat, damp area with no overstory (S. Runyan, pers. comm. 2007).

Area Description

General Description:

Vegetation Zone: Montane

Min. Elevation (m): **Max. Elevation (m):**
Habitat: TERRESTRIAL:

Occurrence Rank and Occurrence Rank Factors

Rank: E : Verified extant (viability not assessed)
Rank Date: 1995
Rank Comments:

Not enough information to rank this occurrence, but has persisted since 1960.

Condition of Occurrence:

[No data provided.]

Size of Occurrence:

[No data provided.]

Landscape Context:

[No data provided.]

Version

Version Date: 10/26/2007 12:00:00 AM **Version Author:** Donovan, M.

Mapping

Estimated Representation Accuracy: Low

Estimated Representation Accuracy Comments:

Confident that full extent is represented by Occurrence: N

Confidence Extent Comments: Confident full extent of EO is NOT known

Additional Inventory Needed: Y

Inventory Comments: To determine precise location, full extent and viability of population.

Documentation

References:

Biosystematic Research Centre., Agric. Can., Cent. Exp. Farm, Ottawa, K1A 0C6.

Runyan, S. Personal communication. Summit Environmental Consultants. Nelson, B.C.

Specimen: 823

BC Conservation Data Centre: Occurrence Report
Occurrence ID: 5370

Scientific Name: *Carex crawei*

English Name: Crawe's sedge

Identifiers

Occurrence ID: 5370
Shape ID: 3324
Taxonomic Class: monocots
Element Group: Vascular Plant

Status

Provincial Rank: S2S3
BC List: Blue
Global Rank: G5
COSEWIC:
SARA Schedule:

Locators

Survey Site: WAPTA FALLS, TRAIL TO
Directions:
Biogeoclimatic Zone:
Ecosection: SPK

Occurrence Information

First Observation Date: 1944-08-04 **Last Observation Date:** 1944-08-04

Occurrence Data:

Damp flat ground in open woods.

Area Description

General Description:

Vegetation Zone: Montane

Min. Elevation (m): 325 **Max. Elevation (m):**
Habitat: TERRESTRIAL; WOODLAND NEEDLELEAF

Occurrence Rank and Occurrence Rank Factors

Rank: H : Historical
Rank Date:
Rank Comments:

Condition of Occurrence:

Size of Occurrence:

Landscape Context:

Version

Version Date: 3/20/1996 12:00:00 AM **Version Author:** DOUGLAS, G.W.

Mapping

Estimated Representation Accuracy:

Estimated Representation Accuracy Comments:

Confident that full extent is represented by Occurrence:

Confidence Extent Comments:

Additional Inventory Needed: N

Inventory Comments:

Documentation

References:

University of British Columbia. Dep. Bot., Dep. Zool., Biol. Sci. Bldg., 6270 Univ. Blvd., Vancouver, BC.

Specimen: COLLECTOR: MCCALLA, W.C.

Please visit the website http://www.env.gov.bc.ca/cdc/gis/eo_data_fields_06.htm for definitions of the data fields used in this occurrence report.

Suggested Citation:

B.C. Conservation Data Centre. 2014. Occurrence Report Summary: 3324. B.C. Ministry of Environment. Available: http://www.maps.gov.bc.ca/ess/cdc, (accessed Mar 18, 2015).

BC Conservation Data Centre: Occurrence Report
Occurrence ID: 7473

Scientific Name: *Gentianopsis macounii*

English Name: Macoun's fringed gentian

Identifiers

Occurrence ID: 7473
Shape ID: 37895
Taxonomic Class: dicots
Element Group: Vascular Plant

Status

Provincial Rank: S3
BC List: Blue
Global Rank: G5
COSEWIC:
SARA Schedule:

Locators

Survey Site: YOHO NATIONAL PARK, KICKING HORSE RIVER
Directions: North side of Highway 1.
Biogeoclimatic Zone:
Ecosection: SPK

Occurrence Information

First Observation Date: 2004-09-24 **Last Observation Date:** 2004-09-24

Occurrence Data:

2004-09-24: Ca. 30 plants, mostly fruiting, but some still with flowers, widely but sparsely scattered in meadow. With Pentaphylloides floribunda, Carex crawei, Primula mistassinica and Anemone parviflora. Also observed on south side of Highway 1 in calcarous fen where it was more abundant (University of British Columbia herbarium).

Area Description

General Description:
Calcareous floodplain meadow and calcareous fen.

Vegetation Zone: Montane

Min. Elevation (m): **Max. Elevation (m):**
Habitat: RIVERINE: Floodplain; PALUSTRINE: Bog/Fen

Occurrence Rank and Occurrence Rank Factors

Rank: BC : Good or fair estimated viability
Rank Date: 2004-09-24
Rank Comments:
Medium-sized population that is reproducing and under no apparent threat.
Condition of Occurrence:
Plants were mostly fruiting, but some were still in flower (F. Lomer, pers. comm. 2004).
Size of Occurrence:
In 2004, 30 widely scattered plants in meadow and more abundant in fen on south side of highway (F. Lomer, pers. comm. 2004).
Landscape Context:

[No data provided.}

Version

Version Date: 10/26/2007 12:00:00 AM **Version Author:** Donovan, M.

Mapping

Estimated Representation Accuracy: Medium

Estimated Representation Accuracy Comments:

Confident that full extent is represented by Occurrence: ?

Confidence Extent Comments: Uncertain whether full extent of EO is known

Additional Inventory Needed: Y

Inventory Comments: To determine full extent and viability of population.

Documentation

References:

Lomer, F. Personal communication. Botanical Consultant.

University of British Columbia. Dep. Bot., Dep. Zool., Biol. Sci. Bldg., 6270 Univ. Blvd., Vancouver, BC.

Specimen: Lomer, F. (5511). 2004. UBC.

Please visit the website http://www.env.gov.bc.ca/cdc/gis/eo_data_fields_06.htm for definitions of the data fields used in this occurrence report.
Suggested Citation:

B.C. Conservation Data Centre. 2014. Occurrence Report Summary: 37895. B.C. Ministry of Environment. Available: http://www.maps.gov.bc.ca/ess/cdc, (accessed Mar 18, 2015).

BC Conservation Data Centre: Occurrence Report
Occurrence ID: 8029

Scientific Name: *Carex crawei*

English Name: Crawe's sedge

Identifiers

Occurrence ID: 8029
Shape ID: 46968
Taxonomic Class: monocots
Element Group: Vascular Plant

Status

Provincial Rank: S2S3
BC List: Blue
Global Rank: G5
COSEWIC:
SARA Schedule:

Locators

Survey Site: PORCUPINE CREEK, YOHO NATIONAL PARK
Directions: East bank of Kicking Horse River, above "Misko Station", west of Mt. Vaux.
Biogeoclimatic Zone:
Ecosection: SPK

Occurrence Information

First Observation Date: 1978-08-10 **Last Observation Date:** 1978-08-10

Occurrence Data:

Observed on low gravel flat by Kicking Horse River, with a few small Picea glauca and Betula occidentalis (Brayshaw 1978; Royal British Columbia Museum herbarium specimen).

Area Description

General Description:

Medium sized river in the Columbia Mountains, with gravelly bed and flats.

Vegetation Zone: Montane

Min. Elevation (m): 1097.28 **Max. Elevation (m):**
Habitat: RIVERINE: Floodplain, Sand/Gravel Bars

Occurrence Rank and Occurrence Rank Factors

Rank: E : Verified extant (viability not assessed)
Rank Date: 1978-08-10
Rank Comments:

There is insufficient information to rank this occurrence, but it is assumed to still be extant since located in a remote area in a National Park. A survey will be necessary to confirm the continued existence of this population.

Condition of Occurrence:

[No data]

Size of Occurrence:

[No data]

Landscape Context:

[No data]

Version

Version Date: 8/26/2009 12:00:00 AM **Version Author:** Hartwell, S.

Mapping

Estimated Representation Accuracy: Medium

Estimated Representation Accuracy Comments: Located using map, lat/long and elevation from Brayshaw 1978.

Confident that full extent is represented by Occurrence: ?

Confidence Extent Comments: Uncertain whether full extent of EO is known

Additional Inventory Needed: Y

Inventory Comments: Site has not been surveyed since 1978.

Documentation

References:

Brayshaw, T.C. 1978. Report on plant collections made in Yoho National Park: August, 1978. B.C. Provincial Museum. Victoria, BC. 5 pp.

Royal British Columbia Museum. 675 Belleville Street, Victoria, BC. V8V 1X4.

Specimen: Brayshaw, T.C. 78-548. (1978). 090394. V.

BC Conservation Data Centre: Occurrence Report
Occurrence ID: 8317

Scientific Name: *Carex crawei*
English Name: Crawe's sedge

Identifiers

Occurrence ID: 8317
Shape ID: 51299
Taxonomic Class: monocots
Element Group: Vascular Plant

Status

Provincial Rank: S2S3
BC List: Blue
Global Rank: G5
COSEWIC:
SARA Schedule:

Locators

Survey Site: KICKING HORSE RIVER, WEST SIDE
Directions: North of Highway 1.
Biogeoclimatic Zone:
Ecosection: SPK

Occurrence Information

First Observation Date: 2004-09-24 **Last Observation Date:** 2004-09-24

Occurrence Data:

2004-09-24: On calcareous floodplain with Pentaphylloides floribunda, Muhlenbergia glomerata, Primula mistassinica and Anemone parviflora (University of British Columbia herbarium).

Area Description

General Description:

Vegetation Zone: Montane

Min. Elevation (m): 1100 **Max. Elevation (m):** 1100
Habitat: RIVERINE: Floodplain

Occurrence Rank and Occurrence Rank Factors

Rank: E : Verified extant (viability not assessed)
Rank Date: 2004-09-24
Rank Comments:
There is not enough information to rank this occurrence.
Condition of Occurrence:
Dwarfed plants (University of British Columbia herbarium, 2004).
Size of Occurrence:
[No data provided].
Landscape Context:

[No data provided].

Version

Version Date: 12/9/2010 12:00:00 AM **Version Author:** Donovan, M.

Mapping

Estimated Representation Accuracy:	High
Estimated Representation Accuracy Comments:	
Confident that full extent is represented by Occurrence:	?
Confidence Extent Comments:	Uncertain whether full extent of EO is known
Additional Inventory Needed:	Y
Inventory Comments:	To determine full extent and viability of population.

Documentation

References:

Royal British Columbia Museum. 675 Belleville Street, Victoria, BC. V8V 1X4.

University of British Columbia. Dep. Bot., Dep. Zool., Biol. Sci. Bldg., 6270 Univ. Blvd., Vancouver, BC.

Specimen: Brayshaw, T.C. (78-548). 1978. #090394. V.; Lomer, F. (5509). 2004. #V230200. UBC.

BC Conservation Data Centre: Occurrence Report
Occurrence ID: 8335

Scientific Name: *Braya humilis* ssp. *maccallae*
English Name: McCalla's dwarf braya

Identifiers

Occurrence ID: 8335
Shape ID: 52263
Taxonomic Class: dicots
Element Group: Vascular Plant

Status

Provincial Rank: S1?
BC List: Red
Global Rank: G5T1T2Q
COSEWIC:
SARA Schedule:

Locators

Survey Site: KICKING HORSE RIVER, 2.5 KM EAST OF FIELD
Directions: A stretch of sandy flats of the Kicking Horse River that spans from 2-3 km east of Field (University of Alberta herbarium).
Biogeoclimatic Zone:
Ecosection: SPK

Occurrence Information

First Observation Date: 1943-06-24
Last Observation Date: 1982-06-26

Occurrence Data:

The element occurrence has been known since 1943 and was last surveyed for in the 1980s. 1980s: Specimen collected along the Kicking Horse River, 2 km above (upstream) of Field (University of Alberta herbarium). Two other historical specimens were collected; dates unknown (University of Alberta herbarium). Holotype specimen collected in 1943 on the sandy flats of the Kicking Horse River, opposite of Mt. Stephen and east of Field (University of Alberta herbarium).

Area Description

General Description:

The subpopulation is located on a stretch of sandy flats of the Kicking Horse River that spans from 2-3 km east of Field (University of Alberta herbarium).

Vegetation Zone: Lowland

Min. Elevation (m):
Max. Elevation (m):
Habitat: RIVERINE: Floodplain, Sand/Gravel Bars

Occurrence Rank and Occurrence Rank Factors

Rank: E : Verified extant (viability not assessed)
Rank Date: 1986-06-26
Rank Comments:

There is insufficient information to assign a viability rank.

Condition of Occurrence:

[No data provided.]

Size of Occurrence:

[No data provided.]

Landscape Context:

[No data provided.]

Version

Version Date: 12/19/2010 12:00:00 AM **Version Author:** Chytyk, P.

Mapping

Estimated Representation Accuracy: Low

Estimated Representation Accuracy Comments:

Confident that full extent is represented by Occurrence: N

Confidence Extent Comments: Confident full extent of EO is NOT known

Additional Inventory Needed: Y

Inventory Comments: To determine precise location and extent of population.

Documentation

References:

Cameron, K. Personal communication. Yoho Visitor Centre, Yoho National Park, Parks Canada.

University of Alberta. Dep. Zool., Edmonton, AB.

Specimen: McCalla, W.C. (9566). ND. ALTA.; McCalla, W.C. (7009). ND. ALTA.; McCalla, W.C. (7539). 1943. #90777. ALTA. Holotype.; Harris, J.G. (1634). 198-. ALTA, UVSC.

BC Conservation Data Centre: Occurrence Report
Occurrence ID: 8336

Scientific Name: *Braya humilis* ssp. *maccallae*
English Name: McCalla's dwarf braya

Identifiers

Occurrence ID: 8336
Shape ID: 52265
Taxonomic Class: dicots
Element Group: Vascular Plant

Status

Provincial Rank: S1?
BC List: Red
Global Rank: G5T1T2Q
COSEWIC:
SARA Schedule:

Locators

Survey Site: KICKING HORSE RIVER, SOUTH OF HOODOO CREEK
Directions: Approximately 5 km east of the west gate of Yoho National Park near where the Trans Canada Highway intersects the Kicking Horse River (Biosystematic Research Centre herbarium).
Biogeoclimatic Zone:
Ecosection: SPK

Occurrence Information

First Observation Date: 195--LATE
Last Observation Date: 195--LATE

Occurrence Data:

This occurrence has been known since the late 1950s and has not been subsequently surveyed for. Late 1950s: Specimen collected on an old gravel bar approximately 5 km east of the west gate of Yoho National Park near where the Trans Canada Highway intersects the Kicking Horse River (Biosystematic Research Centre herbarium).

Area Description

General Description:

The subpopulation is located on an old gravel bar approximately 5 km east of the west gate of Yoho National Park near where the Trans Canada Highway intersects the Kicking Horse River (Biosystematic Research Centre herbarium).

Vegetation Zone: Lowland

Min. Elevation (m):
Max. Elevation (m):
Habitat: RIVERINE: Floodplain, Sand/Gravel Bars

Occurrence Rank and Occurrence Rank Factors

Rank: H : Historical
Rank Date: 195--LATE
Rank Comments:

Condition of Occurrence:

[No data provided.]

Size of Occurrence:

[No data provided.]

Landscape Context:

[No data provided.]

Version

Version Date: 12/19/2010 12:00:00 AM **Version Author:** Chytyk, P.

Mapping

Estimated Representation Accuracy: Low

Estimated Representation Accuracy Comments:

Confident that full extent is represented by Occurrence: N

Confidence Extent Comments: Confident full extent of EO is NOT known

Additional Inventory Needed: Y

Inventory Comments: To determine precise location and extent of population.

Documentation

References:

Biosystematic Research Centre., Agric. Can., Cent. Exp. Farm, Ottawa, K1A 0C6.

Specimen: Taylor, R.L. and D.H. Ferguson. (2427). 195--LATE. DAO.

Please visit the website http://www.env.gov.bc.ca/cdc/gis/eo_data_fields_06.htm for definitions of the data fields used in this occurrence report.
Suggested Citation:

B.C. Conservation Data Centre. 2014. Occurrence Report Summary: 52265. B.C. Ministry of Environment. Available: http://www.maps.gov.bc.ca/ess/cdc, (accessed Mar 18, 2015).

BC Conservation Data Centre: Occurrence Report
Occurrence ID: 9487

Scientific Name: *Pinus flexilis*
English Name: limber pine

Identifiers

Occurrence ID: 9487
Shape ID: 67689
Taxonomic Class: conifers
Element Group: Vascular Plant

Status

Provincial Rank: S2
BC List: Red
Global Rank: G4
COSEWIC: E (NOV 2014)
SARA Schedule:

Locators

Survey Site: KICKING HORSE RIVER/MONARCH CREEK, 0.5 KM NORTHWEST OF CONFLUENCE
Directions: Mount Field. Above Monarch Campground, Yoho National Park.
Biogeoclimatic Zone:
Ecosection: SPK

Occurrence Information

First Observation Date: 2004-07-14 **Last Observation Date:** 2009-07-28

Occurrence Data:

The occurrence has been known since 2004 and was last surveyed in 2009. 2009-07-28: 42 live trees and 7 dead trees; 55.0% of live trees infected with whitebark pine rust. Eleven less than 50 cm tall seedlings and 6 greater than 50 cm tall seedlings; all with no evidence of whitebark pine rust (P. Achuff, pers. comm. 2013). 2008: Scattered individual trees or small groups within stands of Pseudotsuga menziesii, Pinus ponderosa and Juniperus scopulorum. Narrow habitat range on limestone cliff edges, ridges, outcrops and exposed sites (P. Achuff, pers. comm. 2008). 2004-07-14: 44 live trees and 6 dead trees; 27.3% of live trees infected with whitebark pine rust. Five less than 50 cm tall seedlings and 4 greater than 50 cm tall seedlings; all with no evidence of whitebark pine rust (P. Achuff, pers. comm. 2013).

Area Description

General Description:

Located on limestone cliff edges, ridges, outcrops and exposed sites.

Vegetation Zone: Montane

Min. Elevation (m): 1465 **Max. Elevation (m):**
Habitat: TERRESTRIAL: Forest Needleleaf

Occurrence Rank and Occurrence Rank Factors

Rank: BC : Good or fair estimated viability
Rank Date: 2009-07-28
Rank Comments:

In 2009, 55% of live trees were infected with whitebark pine rust as compared with 27% in 2004. In 2009, 16% of trees were dead..

Condition of Occurrence:

2004: 27.3% of live trees infected with whitebark pine rust. Five less than 50 cm tall seedlings and 4 greater than 50 cm tall seedlings; all with no evidence of whitebark pine rust (P. Achuff, pers. comm. 2013). 2008: Apparently healthy no signs of mountain pine beetle or blister rust (P. Achuff, pers. comm. 2008). 2009: 55.0% of live trees infected with whitebark pine rust. Eleven less than 50 cm tall seedlings and 6 greater than 50 cm tall seedlings; all with no evidence of whitebark pine rust (P. Achuff, pers. comm. 2013).

Size of Occurrence:

2004: 44 live trees and 6 dead trees (P. Achuff, pers. comm. 2013). 2008: At least one tree (P. Achuff, pers. comm. 2008). 2009: 42 live trees and 7 dead trees (P. Achuff, pers. comm. 2013).

Landscape Context:

[No data provided.]

Version

Version Date: 9/26/2013 12:00:00 AM **Version Author:** Sinclair, L. and P. Chytyk

Mapping

Estimated Representation Accuracy:	High
Estimated Representation Accuracy Comments:	
Confident that full extent is represented by Occurrence:	?
Confidence Extent Comments:	Uncertain whether full extent of EO is known
Additional Inventory Needed:	Y
Inventory Comments:	To determine full extent and viability of population.

Documentation

References:

Achuff, P. Personal communication.Scientist Emeritus, Ecological Integrity Branch, Parks Canada, Waterton Lakes National Park, AB.

Specimen:

Please visit the website http://www.env.gov.bc.ca/cdc/gis/eo_data_fields_06.htm for definitions of the data fields used in this occurrence report.
Suggested Citation:

B.C. Conservation Data Centre. 2014. Occurrence Report Summary: 67689. B.C. Ministry of Environment. Available: http://www.maps.gov.bc.ca/ess/cdc, (accessed Mar 18, 2015).

BC Conservation Data Centre: Occurrence Report
Occurrence ID: 9561

Scientific Name: *Pinus albicaulis*

English Name: whitebark pine

Identifiers

Occurrence ID: 9561
Shape ID: 68416
Taxonomic Class: conifers
Element Group: Vascular Plant

Status

Provincial Rank: S2S3
BC List: Blue
Global Rank: G3G4
COSEWIC: E (APR 2010)
SARA Schedule: 1

Locators

Survey Site: PAGET PEAK
Directions:
Biogeoclimatic Zone:
Ecosection: SPK

Occurrence Information

First Observation Date: 2003-07-10 **Last Observation Date:** 2003-07-10

Occurrence Data:

2003-07-10: Pinus albicaulis was observed (Glacier National Park).

Area Description

General Description:

Vegetation Zone: Subalpine

Min. Elevation (m): **Max. Elevation (m):**
Habitat: TERRESTRIAL: Subalpine

Occurrence Rank and Occurrence Rank Factors

Rank: E : Verified extant (viability not assessed)
Rank Date: 2003-07-10
Rank Comments:

Condition of Occurrence:
[No data provided.]
Size of Occurrence:
[No data provided.]
Landscape Context:

[No data provided.]

Version

Version Date: 3/31/2012 12:00:00 AM **Version Author:** Durand, R.

Mapping

Estimated Representation Accuracy: High

Estimated Representation Accuracy Comments:

Confident that full extent is represented by Occurrence: Y

Confidence Extent Comments: Confident full extent of EO is known

Additional Inventory Needed: N

Inventory Comments:

Documentation

References:

Glacier National Park. 2010. Glacier National Park 2003-04 Blister Rust Surveys. Parks Canada, BC.

Miller, M.T. 2011. Mapping Guidance for Whitebark pine in BC. Report prepared for the BC Conservation Data Centre. Victoria, BC. 14 pp.

Specimen:

BC Conservation Data Centre: Occurrence Report
Occurrence ID: 9564

Scientific Name: *Pinus albicaulis*

English Name: whitebark pine

Identifiers

Occurrence ID: 9564
Shape ID: 68450
Taxonomic Class: conifers
Element Group: Vascular Plant

Status

Provincial Rank: S2S3
BC List: Blue
Global Rank: G3G4
COSEWIC: E (APR 2010)
SARA Schedule: 1

Locators

Survey Site: WIEDENMAN CREEK, 2.3 KM NORTHEAST OF
Directions:
Biogeoclimatic Zone:
Ecosection: SPK

Occurrence Information

First Observation Date: 2003-07-09 **Last Observation Date:** 2003-07-09

Occurrence Data:

2003-07-09: Pinus albicaulis was observed (Glacier National Park).

Area Description

General Description:

Vegetation Zone: Subalpine

Min. Elevation (m): **Max. Elevation (m):**
Habitat: TERRESTRIAL: Subalpine

Occurrence Rank and Occurrence Rank Factors

Rank: E : Verified extant (viability not assessed)
Rank Date: 2003-07-09
Rank Comments:

Condition of Occurrence:

[No data provided.]

Size of Occurrence:

[No data provided.]

Landscape Context:

[No data provided.]

Version

Version Date: 3/31/2012 12:00:00 AM **Version Author:** Durand, R.

Mapping

Estimated Representation Accuracy: High

Estimated Representation Accuracy Comments:

Confident that full extent is represented by Occurrence: Y

Confidence Extent Comments: Confident full extent of EO is known

Additional Inventory Needed: N

Inventory Comments:

Documentation

References:

Glacier National Park. 2010. Glacier National Park 2003-04 Blister Rust Surveys. Parks Canada, BC.

Miller, M.T. 2011. Mapping Guidance for Whitebark pine in BC. Report prepared for the BC Conservation Data Centre. Victoria, BC. 14 pp.

Specimen:

Please visit the website http://www.env.gov.bc.ca/cdc/gis/eo_data_fields_06.htm for definitions of the data fields used in this occurrence report.
Suggested Citation:

B.C. Conservation Data Centre. 2014. Occurrence Report Summary: 68450. B.C. Ministry of Environment. Available: http://www.maps.gov.bc.ca/ess/cdc, (accessed Mar 18, 2015).

BC Conservation Data Centre: Occurrence Report
Occurrence ID: 11826

Scientific Name: *Botrychium lineare*
English Name: Linear-leaf moonwort

Identifiers

Occurrence ID: 11826
Shape ID: 88692
Taxonomic Class:
Element Group: Vascular Plant

Status

Provincial Rank: S1
BC List: Red
Global Rank: G2G3
COSEWIC:
SARA Schedule:

Locators

Survey Site: MOUNT FIELD, SOUTHWEST SLOPE, YOHO NATIONAL PARK
Directions: 3.5 km due northeast of town of Field.
Biogeoclimatic Zone:
Ecosection: SPK

Occurrence Information

First Observation Date: 2013-08-17 **Last Observation Date:** 2013-08-17

Occurrence Data:

2013-08-17: Two mature pale yellow-green; 2 plants in the same clump. Rather dry, 45% talus and scree slope with few Picea engelmannii, Pseudotsuga menziesii, under fringe of Juniperus communis (F. Lomer, pers. comm. 2013).

Area Description

General Description:

Vegetation Zone: Montane

Min. Elevation (m): 1600 **Max. Elevation (m):**
Habitat: TERRESTRIAL: Scree/Fine Talus

Occurrence Rank and Occurrence Rank Factors

Rank: B : Good estimated viability
Rank Date: 2013-08-17
Rank Comments:
Small population in national park.
Condition of Occurrence:
2013: Mature pale yellow-green plants (F. Lomer, pers. comm. 2013).
Size of Occurrence:
2013: 2 plants (F. Lomer, pers. comm. 2013).
Landscape Context:

[No data provided.]

Version

Version Date: 11/7/2013 12:00:00 AM **Version Author:** Donovan, M.

Mapping

Estimated Representation Accuracy:	High
Estimated Representation Accuracy Comments:	
Confident that full extent is represented by Occurrence:	?
Confidence Extent Comments:	Uncertain whether full extent of EO is known
Additional Inventory Needed:	Y
Inventory Comments:	To determine full extent and viability of population.

Documentation

References:

Lomer, F. Personal communication. Botanical Consultant.

Specimen:

Please visit the website http://www.env.gov.bc.ca/cdc/gis/eo_data_fields_06.htm for definitions of the data fields used in this occurrence report.
Suggested Citation:

B.C. Conservation Data Centre. 2014. Occurrence Report Summary: 88692. B.C. Ministry of Environment. Available: http://www.maps.gov.bc.ca/ess/cdc, (accessed Mar 18, 2015).

Basic Impact Analysis
(BIA)

Vegetation Removal for 2015 TCH Rock Reprofiling

Yoho National Park

April 16, 2015

Parks Canada Parcs Canada

Canada

1. PROJECT TITLE
Vegetation Removal for 2015 TCH Rock Reprofiling in Yoho National Park

2. PROJECT LOCATION
Yoho National Park

3. PROJECT SITE(S)
Adjacent to the Trans-Canada Highway in various locations. See Project Description.

4. PROPONENT
Ryan Syme

5. PROPONENT CONTACT INFORMATION
Ryan.Syme@pc.gc.ca
403.762.1334

6. PROJECT DATES
Planned commencement: 16 April 2015
Planned completion: 1 May 2015

7. INTERNAL PROJECT FILE #
2015-017Y

8. PROJECT DESCRIPTION
Slopes adjacent to the Trans-Canada Highway (TCH) in Yoho National Park (YNP) were constructed in the 1950s before controlled blasting was developed. The slopes have performed relatively well over the years but in the last 5 to 10 years, the slopes have shown increased distress in the form of rock falls, causing sections of the TCH to be closed during cleanup operations. The intent of reprofiling these slopes is to reduce both PCA's maintenance burden and the risk of failures affecting traffic on the highway.

An environmental assessment will be prepared for activities associated with reprofiling. However, in anticipation of the period needed for review and approval of that assessment, in light of the need to remove vegetation prior to reprofiling, and in consideration of the necessity to remove that vegetation prior to the initiation of the migratory bird breeding season, this BIA specifically covers vegetation removal. Therefore, for the purpose of this BIA, the project is defined as:

- Felling of trees and shrubs from the following sites (Figures 1a- 1f). This is to be accomplished through a combination of hand falling and mechanized removal.
    - Sherbrooke/Lower Sherbrooke Slopes at 88+500 to 89+420 (right side)
    - Little Topple Slope at 115+650 to 115+860 (left side)
    - Mount Vaux Slope at 116+150 to 116+900 (left side)
    - Phyllite Slope at 124+270 to 124+570 (right side)
    - Mount Vaux storage site at 119+550 (under storage footprint only; limited tree removal as site was previously logged and burned)
- Removal of logs and brush. Upon approval by an authorized representative of the LLYK Field Unit, this may include one or more of the following methods: removal and sale of logs, removal and use as firewood by Parks Canada, chipping on site, piling and burning, or bucking and scattering.
- Mobilization and demobilization of all manpower, equipment, materials, and other resources necessary to execute the work.
- Provision of traffic signage and traffic control as appropriate.

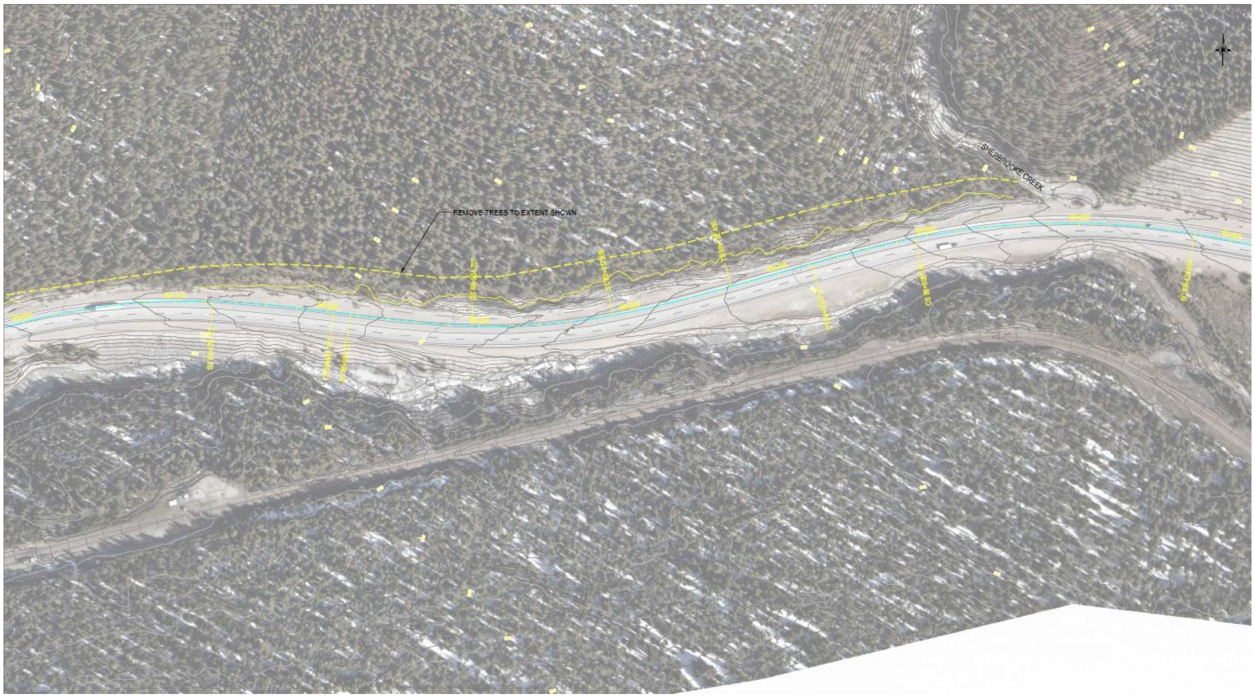


Figure 1a. Sherbrooke Slope at 88+500 to 89+200 (see north arrow in upper right-hand corner).

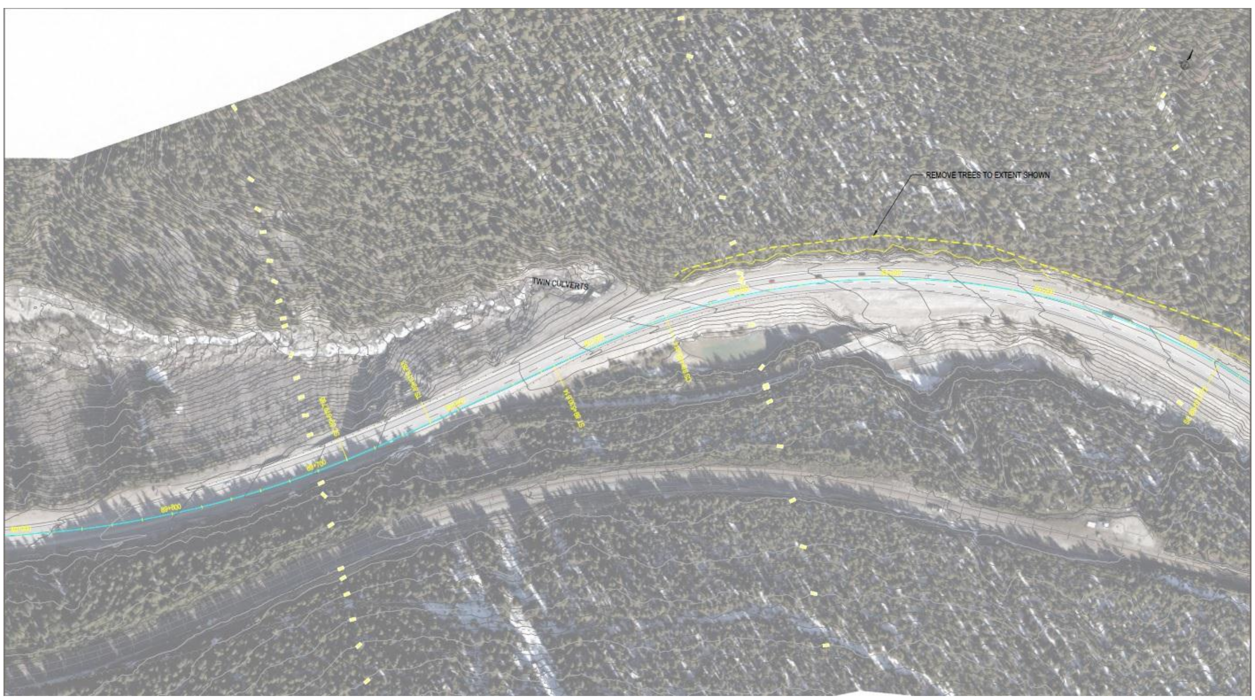


Figure 1b. Lower Sherbrooke Slope at 89+200 to 89+420.

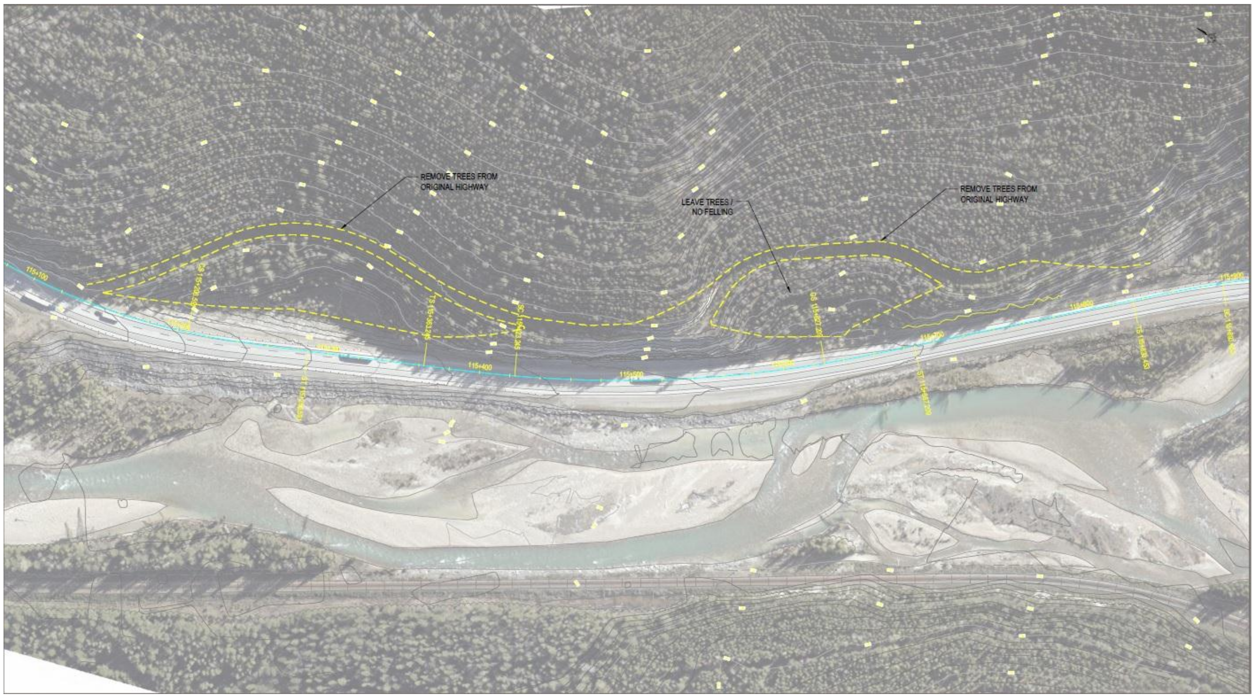


Figure 1c. Little Topple Slope at 115+650 to 115+860, and access to it via old road bed.

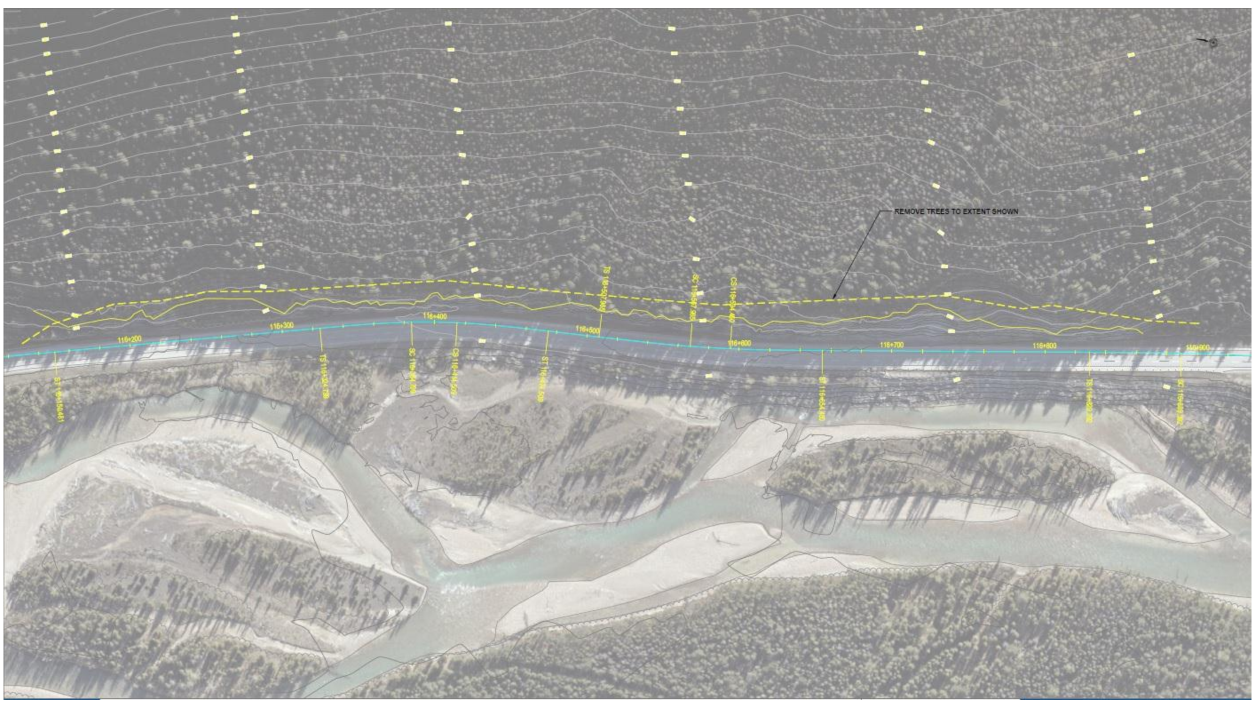


Figure 1d. Mount Vaux Slope at 116+150 to 116+900.

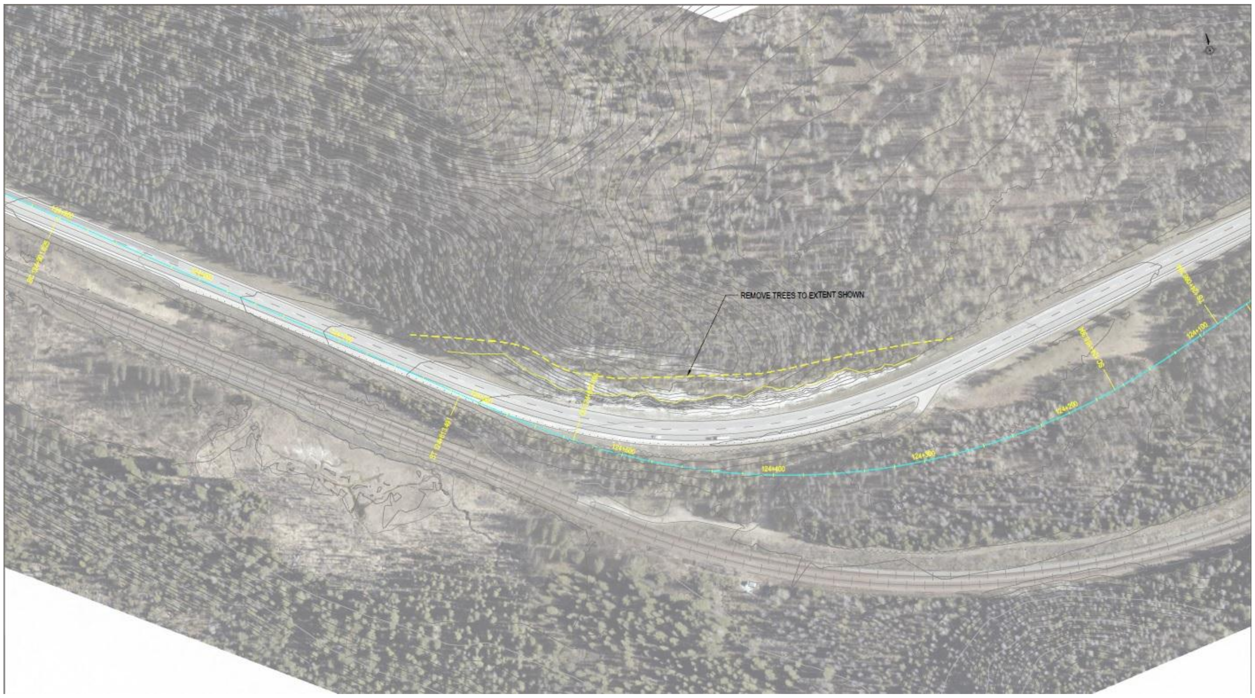


Figure 1e. Phyllite Slope at 124+270 to 124+570.

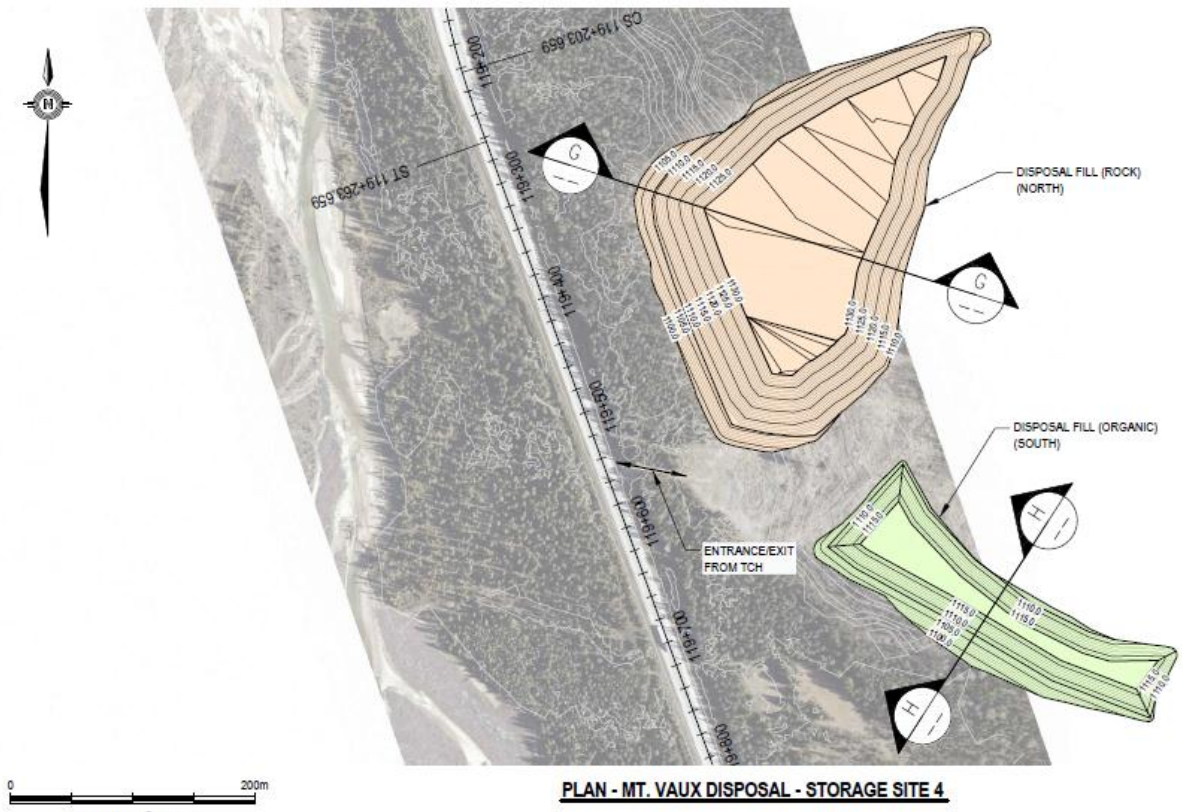


Figure 1f. Mount Vaux storage site at 119+550

9. VALUED COMPONENTS LIKELY TO BE AFFECTED

The following environmental components are likely to be affected by the project:

- Wildlife resources and movement
- Vegetation resources
- Cultural resources.

The extreme western end of the Lower Sherbrooke work site (approximately the km 89.4 point, immediately east of the "twin culverts" where the upper Kicking Horse River passes under the TCH) is frequented by mountain goats, as evidenced by goat hair in the forest immediately above that point, and observations of goats on or beside the TCH there. Goats appear to lick minerals from both the bank above the highway and from the highway surface itself. Based on random sightings since 1981 held by LLYK, there are no roadside records from December through April, with about 57% of records falling in May and June, 22% in July and August, and 22% from September through November.

Most of the work will be completed adjacent to disturbed areas of the TCH corridor, and in some cases on or adjacent to an older roadbed that preceded the TCH.

There are no anticipated effects to air quality. There will be minor increases in vehicle use during harvesting that could increase vehicle emissions. If on-site burning is required, it will be contained to small slash piles and will burned according to standard best management practices to minimize the effects of smoke.

There are no anticipated effects to public safety or visitor access during the harvesting operations. Minor and temporary traffic delays may be needed to accommodate equipment mobilization or demobilization, or log loading.

The transportation corridor from Field to Lake Louise is part of the Kicking Horse Pass National Historic Site. There are three identified historic sites associated with that NHS falling in the project area at the Lower Sherbrooke site. These include: the historic bridge (521T) across the highway from the Lower Sherbrooke rock slope; an historic CPR spur line (438T) upslope of the rock slope (starting near the highway edge just east of the slope and diverging away from the slope to the west); and a train wreckage site (530T) on the south side of the spur, about 20 m from the rock edge. There is also a historic highway grade (not part of the NHS) in the vicinity of the Little Topple and Mt. Vaux slopes. That grade would be used to access sites for clearing vegetation.

No aquatic resources will be affected by the tree-thinning operation.

10. EFFECTS ANALYSIS

Effects are anticipated to be minor through this operation.

Breeding birds would be affected if trees were removed during their breeding season. This project is timed to be completed by May 1, prior to the expected date of any significant breeding by migratory birds given the latitude and elevations of the work sites. Wary wildlife may be affected by the noise and presence of machinery. No known denning sites occur in the work sites. Based on the pattern of mountain goat sightings at the Lower Sherbrooke site reported in Section 9, disturbance to goats from April logging should be minimal to negligible.

Potential effects to vegetation include the loss of trees in the area. A survey conducted prior to logging will ensure that no whitebark or limber pines are affected, or if they are unavoidable a SARA exemption will be issued. There is also the potential of the introduction of non-native species.

Any significant soil disturbance is expected to be limited to the TCH right of way, the bed of the previous road alignment through YNP, or areas to be removed by subsequent rock scaling operations.

The historic bridge is gated and is not expected to be affected by this project. The spur line, train wreckage site and potentially present but currently undiscovered other remains associated with the spur line or wreck are susceptible to damage from machinery or possibly falling trees. With appropriate mitigation measures, little to no effect is likely to be realized. The historic road grade is potentially susceptible to damage from machine use on its surface. With appropriate mitigation measures, little to no effect is likely to be realized.

11. MITIGATION MEASURES

Project-Specific Measures

- A survey for limber pine and whitebark pine must be completed by a competent professional prior to vegetation removal. Any observations are to be reported to Parks Canada immediately. No activities are permitted that affect those species, above or below ground, unless written authorization under the Species at Risk Act has been provided by the field unit superintendent. Crew members are to be instructed in the identification and avoidance of five-needle pines, in the event that any are present and not detected during the survey.
- In managing debris from clearing, the removal and sale of logs is preferred where economically and logistically feasible. Other options include removal of logs for use as firewood by Parks Canada, piling and burning trees and slash, chipping trees and slash on site or, in exceptional circumstances, bucking logs and scattering the pieces.
- Preference is for slash to be piled and burned on site. Piles cannot exceed 2 m in width and 1.5 m in height. Piles must be located far enough from retained trees so that they are damaged or killed.
- If chipping, chips may cover up to 25 m^2/ha to a depth of < 8 cm.
- Retention of tree boles on site is not a preferred option but in exceptional circumstances the retention of up to 50 stems/ha will be considered.
- Wildlife trees are to be retained unless deemed to be dangerous per the BC Wildlife Tree Assessment criteria.
- A Restricted Activity Permit from Lake Louise – Yoho – Kootenay Field Unit is required prior to starting work. I will include such details as burning and communications regulations.
- Appropriate steps must be taken to avoid the introduction of non-native vegetation. Machinery and equipment must be cleaned and free from seeds and soil from other locations.
- Disturbed areas must be seeded with a Parks Canada approved native seed mix that is guaranteed free of non-native seeds.
- All sightings of bears, cougars, wolves, lynx, wolverines or mountain goats are to be immediately reported to Parks Canada. If any of those species appear on site, activity must cease until the animals are no longer present.
- A traffic management plan must be approved by the Highway Engineering Section and communicated to local Highway Service Centre staff.
- The historic highway bridge across from the Lower Sherbrooke slope is to be avoided. Activities must be planned in such a way as to eliminate risk of impact to this structure by machinery, logs or other causes.
- The train wreckage site is to be avoided. Activities must be kept as close to the rock edge as feasible.
- Care must be taken to not impact the rail spur with heavy machinery or tracked vehicles without mitigating adverse effects on the rail grade. If feasible, hand falling is the preferred method of harvesting at this site.
- Care must be taken to not impact the old highway grade with heavy machinery or tracked vehicles without mitigating the effects on the road grade.
- If artifacts or features are encountered, construction should be stopped and onsite manager should wait for instructions before proceeding with the work. The YNP Environmental Surveillance Officer or Cultural Resource Management Officer should be notified who will contact Parks Canada's Terrestrial Archaeology Section for further guidance. In order to assess the situation, documentation should include, what was seen, the location of where the material was encountered, what the surrounding soil looked like, how deep it was from the ground surface, or if it was at ground surface. If possible, a photograph should be taken and sent along with the description information to the archaeologist. Preferably, artifacts should be left in place until a Parks Canada archaeologist has been consulted.

The remaining mitigations are adapted from the document "Best Practices for Fire Management Operations" (Parks Canada 2007).

Fueling & Chemicals

- Equipment will be fuelled on hardened or impervious surfaces.
- Refueling motor vehicles and heavy equipment will be done on level terrain at least 100 m from water sources, riparian zones, and sensitive sites.
- All fuel storage containers/tanks shall be free of leaks. Fuel nozzles will be equipped with automatic shutoffs and hoses will have breakaway couplings.
- All fueling trucks must be equipped with adequate spill clean-up materials.
- Fuel, lubricants, petro-gels or oils will not be stored within 100 m of streams, wetlands, or sensitive sites.
- Stationary stores of liquid hazardous material (e.g. fuel) and stationary operating equipment with fuel tanks or hydraulic systems (e.g. pumps) will be located in a impervious secondary containment area (e.g. a bermed area with impervious liner) capable of holding 110% of the contents of the largest container in the area.
- Re-fuelling and maintenance of chainsaws shall be performed over impervious mini-berms with small (18"x 18") spill pads onsite.
- All hazardous materials transported to or from the project area and stored on-site will comply with Transportation of Dangerous Goods (TDG) and Workplace Hazardous Material Information System (WHMIS) labelling legislation.
- All service vehicles will carry a hydrocarbon spill kit suitable for a small spill clean-up on ground and water surfaces.
- Fuel cans for pump sites will be secured within a mini-berm or other containment to contain potential spills.
- A Spill Response Plan must be prepared
- Spill kits of sufficient size to contain and clean up 110% of the site’s largest possible fuel/chemical spill must be retained on site at each location of potential spills (sites where equipment is working). All personnel on site must be aware of the kits, their location and proper use.
- All fuel, lubricant, oil, hydraulic fluid, chemical or solvent spills must be contained, cleaned up and immediately reported to Parks Canada.

Equipment

- Ensure all equipment is properly tuned, free of leaks, in good operating order, and fitted with standard air emission control devices. Heavy equipment and vehicles should be equipped with a fire extinguisher.
- Complete daily inspections of heavy equipment, particularly hydraulic lines, and conduct preventative maintenance.
- Minimize idling of engines at all times to reduce air and noise pollution.
- Heavy equipment will be equipped with high floatation rubber tires or low-pressure tracks (LGP – low ground pressure).
- Repairs requiring draining or replacement of petro-chemical based fluids will be conducted over impervious containment.
- Harvesting heads will be placed in mini-berms to catch dripping oil.
- Used fluids and other hazardous wastes must be disposed of at approved recycling centers or transfer stations.

Staging Areas

- All food, garbage and litter must be stored in vehicles or wildlife proof containers and removed each day.
- Portable toilet facilities will be provided, regularly maintained and emptied at approved treatment facilities.

Tree Removal

- Trees will be felled outside the bird breeding window for this area which is May 1 to Aug 31.
- Safety of the workers and the public is the first priority during all operations.
- Fallers should be aware of the locations of all treatment boundaries and riparian zones, as well as the locations of sensitive ecological features.
- All trees should be felled away from, and no limbing and bucking should take place within, creeks, riparian zones or other sensitive ecological areas.

- Trees should be cut flush to the ground. A variety (number and distribution) of stump heights may be left as wildlife trees if determined and specified in the tree removal prescription.
- Felling breakage should be minimized where possible, but not at the expense of the remaining stand and site ecology. For example, a tree should not be felled into an ecologically sensitive area or into the residual stand simply to avoid breakage.
- Fallers should assess each tree individually. If a tree contains critical wildlife features not yet identified by the environmental impact assessment (i.e., raptor's nest) it should be left or assessed by a wildlife biologist.
- All trees should be limbed and bucked to meet the specified end use for the log. This may include non-commercial purposes such as providing woody debris for stream and terrestrial rehabilitation projects.
- The logs should be cut to shorter lengths if it will significantly help reduce site impacts or damage to residual stems during yarding and loading.
- All fallers should be WCB certified, well trained and have at least 5 years of experience.
- Chainsaws should be kept in good working condition and free of oil and fuel leaks.
- Where possible chain oil should be vegetable-based.
- Fueling of chainsaws should take place in designated fueling areas outside of riparian areas and other critical ecological features.

Yarding

- Except on sites that are to be removed through subsequent rock reprofiling, skidding or forwarding should be completed when the soil is dry, frozen or covered with snow. This can be further enhanced by using woodchips, sawdust, or slash on the skid trails or temporary roads.
- Skidders should be restricted to areas with slopes less than 35%.
- Except on sites that are to be removed through subsequent rock reprofiling, all site impacts caused by ground-based transportation should be rehabilitated according to the tree removal prescription.
- Except on sites that are to be removed through subsequent rock reprofiling, all machines should use low pressure distribution, accomplished by wide tires and wide track pads.
- In general, track skidders are preferable to wheeled machines as they generally have lower ground pressure, cause less compaction and do not require bladed trails. Flexible track systems are preferred over rigid track machines as they minimize any "pressure points" and cause less site degradation.
- Road systems designed for skidding should use fewer access roads and rely on longer skidding distances than those in traditional forestry.
- The layout of skid trails should be designed to minimize their overall length, avoid straight lines, avoid sharp turns, and to avoid all ecologically sensitive areas.
- Repeated use of the same skid trail should be avoided to prevent rutting and soil compaction.
- Avoid building bladed skid trails if possible.
- Back spar trails and bladed trails should only be constructed in specific locations as indicated in the approved plan.
- On steep slopes, set skid roads and trails at least 30 m away from streams, ponds and marshes.
- Locate skid roads off the tops and toes of banks and slopes.
- Where a skid trail is required, temporary crossings should be constructed at all stream channels, springs, seeps, sinkholes and other wet areas.
- Where possible, keep skid trail grades at less than 15%. When steep grades are unavoidable, break the grade, install drainage structures and use soil-stabilization practices to minimize runoff and erosion.
- If practical, position skid trails along the contour to reduce soil erosion.
- Skid trails should be planned to minimize damage to the residual stand.
  Skid trails should be covered with logging slash and organic debris (wood chips) to further reduce site degradation. This debris should be concentrated adjacent to the landing site and in areas where skidders must turn around.
- Floatation mats can also be considered in areas where debris does not provide adequate protection.
- The lead end of the log(s) should be elevated during skidding to minimize gouging of the skid trail.
- Skidders should not operate in ecologically sensitive areas. Aerial or skyline systems should be implemented to remove logs in these areas.

Log Loading & Transportation

- Landings should be as small as possible while accommodating skidding activity and truck loading. The activities on the landing should be managed carefully and efficiently so the smallest area possible is disturbed.
- The number and distribution of landings should be minimized and the roadside used where possible.
- Landings will be located in existing disturbed areas, along rights-of-ways, existing forest openings and openings created as part of thinning.
- Landings will be chosen and marked by Parks Canada in consultation with contractors, but will avoid all ecologically and culturally sensitive sites.
- Logs can be sorted at a secondary location, off-site, to help reduce the size of landings.
- Equipment for loading and hauling should be chosen primarily to ensure that logs can be safely removed while decreasing the area impacted.
- Swing loaders are recommended because they can operate on smaller landings, whereas front-end loaders require more space for sorting, storing and loading logs.
- Where possible, use rubber-tired loaders as they can pick up logs from scattered locations along the road.
- Choose transportation methods, which reduce the required road access footprint. If it will significantly decrease environmental impacts, the road should be designed to carry smaller trucks with lower load-carrying capability.
- Loading from landings adjacent to highways will require cautionary traffic signs and flag person(s).
- Transport of logs on public highways will be in accordance with Provincial Highway Traffic Acts and applicable forestry regulations.

Reclamation

- Reclamation of disturbed sites that are not on existing roadbeds and are not to be removed through subsequent rock reprofiling will start as soon as practical to reduce loss of soil, reduce weed establishment, and promote native re-vegetation.

12. CONSIDERATION OF THE NEED FOR PUBLIC PARTICIPATION & ABORIGINAL CONSULTATION

12 a) Indicate whether opportunity for public participation should be offered:

__X_ No ____ Yes

If yes, provide a simple rationale, describe the process used to involve participants and summarize comments received. Refer to results of other relevant consultations that addressed the same project (for example, in the context of management planning).

12 b) Indicate whether there is a requirement for Aboriginal Consultation in relation to project impacts:

__X__ No ____ Yes

If yes, provide a rationale including references to legal or other advice, describe the process used and summarize the outcomes.

13. EFFECT SIGNIFICANCE

Based on the information above, it is determined that the proposed project is not likely to result in significant adverse environmental effects. This determination is subject to the implementation of the mitigation measures identified here.

14. SURVEILLANCE

Document whether surveillance (also referred to as compliance monitoring or site inspection) will be required while the project is underway, to verify that required mitigation measures are implemented.

_X__ Surveillance required (there are templates on the EA intranet tools & guidance page)

____ Surveillance not required

Project surveillance will take place during tree harvesting. This will be performed periodically by the Highway 93 Project Manager and by the LLYK Environmental Assessment Specialist.

15. SPECIES AT RISK MONITORING

Not applicable, except in the event that a SARA-listed species is recorded on site.

16. SARA NOTIFICATION

N/A

17. EXPERTS CONSULTED

Include Parks Canada experts. Add as many entries as necessary for the project.

Department/Agency/Institution: Parks Canada, Archeology and History Branch	Date of Request: YYYY-MM-DD 2015-04-08
Expert's Name: Bill Perry	Title: Archeologist
Contact Information: 1300, 635- 8 Ave. S.W. Calgary, AB T2P 3M3 bill.perry@pc.gc.ca (403) 221-7989	
Expertise Requested: Cultural resources.	
Response: Identified cultural resources and provided mitigations within an archeological overview assessment.	

Department/Agency/Institution: Parks Canada, LLYK Field Unit, Fire and Vegetation	Date of Request: YYYY-MM-DD 2015-04-10
Expert's Name: Darren Quinn	Title: Project Manager
Contact Information: PO Box 220, Radium Hot Springs, BC V0A 1M0 darren.quinn@pc.gc.ca (250) 347-6155	
Expertise Requested: Logging standards.	
Response: Provided options for removal of trees and brush from site.	

18. DECISION

Taking into account implementation of mitigation measures outlined in the analysis, the project is:

__X__ not likely to cause significant adverse environmental effects.

____ likely to cause significant adverse environmental effects.

NOTE: If the project is identified as likely to cause significant adverse effects, CEAA 2012 prohibits approval of the project unless the Governor in Council (Cabinet) determines that the effects are justified in the circumstances. A finding of significant effects therefore means that the project CANNOT go ahead.

19. SIGNATURES AND APPROVAL

EA Author *(Add additional signature blocks for multiple authors as required)*

Name: Trevor Kinley	Date: YYYY-MM-DD 2015-04-16
Position: Environmental Assessment Scientist, Highway Engineering Unit	
Signature: Trevor Kinley	

Decision Approval

Name: Alex Kolesch	Date: YYYY-MM-DD 2015-04-16
Position: (*Field Unit Superintendent, or Designate)* Manager, Integrated Land Use, Policy and Planning	
Signature:	

20. REFERENCE LIST

N/A

21. ATTACHMENTS LIST

The archeological overview assessment is inserted below and available as a separate document (AOA YNP Rockscaling 2015-Perry.docx).

22. ADDITIONAL CONSIDERATIONS / COMMENTS

N/A

23. TRACKING SYSTEM

The project must be registered in the Parks Canada Interim Tracking System within the fiscal year the project took place. If the project is on hold, was cancelled, or was determined to be likely to cause significant adverse effects and did not go ahead, please indicate this information in the tracking system (see selections in the *Assessment Status/Decision* field).

Archaeological Overview Assessment
TCH Rock Reprofiling
Yoho National Park

Bill Perry, Terrestrial Archaeology, HCCD
February 2015

Introduction

Yoho National Park is undertaking rock scaling and vegetation removal at several locations along the TransCanada Highway through Yoho National Park (Fig. 1). Proposed work is scheduled for the 2015-16 fiscal year, likely beginning this spring (T. Kinley, pers. comm., 2015).

This archaeological overview assessment evaluates whether there is a requirement for an archaeological impact assessment due to the proposed construction activities. Construction activities that will impact ground surface will involve:

- Rock scaling at 8 locations along the TCH;
- Removal of vegetation at these same locations;
- Access to sections of an old road bed (Site 439T; old highway grade and site 438T; old railway spur grade);

Overview and Recommendations

Project manager Trevor Kinley (Environmental Assessment-Highway Service Centre, Parks Canada in Radium) has asked Terrestrial Archaeology in Calgary to conduct an archaeological overview assessment (AOA) of 8 sites within YNP along the TCH where rock scaling and vegetation removal are required. This also includes two locations where rock and soil will be temporarily stored. In general, rock scaling, vegetation removal and equipment access will impact all of the areas. One of the two stockpile areas (Mt. Vaux) will result in further impacts such as vegetation removal and soil stripping in a previously logged and burnt area. The other stockpile location at the BC/Alberta boundary is in previously disturbed context with no potential for archaeological resources. The following impacts are anticipated at the 8 locations:

1. Upper Sherbrook area (figure 2-at right). There are no known archaeological sites at this location. The landform is assessed as having low archaeological potential. **No further work is required.**
2. Lower Sherbrook area (figure 2- at left). This involves rock scaling and vegetation removal of the rock slope across the highway from the historic highway bridge, site 521T (figure 2 and 8).
    a. Upslope of the proposed rock scaling area is historic site 530T (figures 2 and 8), an historic railway- related train wreckage site and associated rail spur (Site 438T). All three of these historic resources are associated with the Kicking Horse Pass National Historic Site and therefore are of national significance. The train wreckage from site 430T is located 20m north of the edge of rock while the lower section of the rail grade is potentially vulnerable to impact from its use as a vehicle/equipment access way. **Site avoidance is recommended**. The rock scaling and vegetation removal should not impact the known location of the site but vegetation removal may result in the accidental uncovering of additional historic items. If this occurs, **please refer to the "accidental discovery clause**" contained in Appendix 1 of this document. **In addition, if the use of machinery to remove vegetation can be avoided, that would be preferable as removal by hand would minimise impact on the nearby historic scatter of artifacts**.

   b. The historic highway bridge, site 521T, will not be impacted from proposed construction (see figure 8). There is a possibility however, that construction staging/parking may take place in the gravel pull-out in front of the historic structure. **It is recommended that any such activity keep away from the actual bridge structure.**
   c. The historic rail grade, site 438T, is part of the Big Hill Safety Switch system put in place to deal with run-away trains before the construction of the Spiral Tunnels (a portion of this safety switch grade can be seen in figure 8). The lower portion of this rail grade where it has been impacted by the TCH may be vulnerable to proposed machinery access to the project area. It is **recommended that care should be taken to not impact the grade with heavy machinery or tracked vehicles without mitigating adverse effects on the rail grade**.
3. Phyllite Rock slope (figure 3). There are no known archaeological sites at this location and the landform is assessed as having low archaeological potential. **No further work is required.**
4. Little Topple Slope (figure 4). Site 439T, the historic highway grade, traverses the backside of the project area at this location as can be seen on the air photograph in figure 4. If access to the construction site is required through the use of this historic highway grade, it is recommended **that care should be taken to not impact the grade with heavy machinery or tracked vehicles without mitigating the effects on the road grade.** Otherwise, there are no known archaeological sites at this location and the project area affords low archaeological potential**.**
5. Mt. Vaux Rock Slope (figure 5). There are no known archaeological sites at this location and the landform is assessed as having low archaeological potential. **No further work is required**.
6. Access point for Equipment on old Roadbed near Porcupine Creek (figure 6). This is required to get equipment onto the upper slopes above the highway to access the "Little Topple" project area, located just to the south. The road bed is again, part of site 439T, the old highway grade which can be seen traversing the upper slopes in the air photograph in figure 6. If this historic highway grade is required to facilitate construction access, it is recommended **that care should be taken to not impact the grade with heavy machinery or tracked vehicles without mitigating the effects on the road grade.**
7. Stockpile area at B.C./Alberta boundary DUA-pull-off. This area has been identified as a temporary storage for stockpile. Extensive disturbances resulting from previous development and re-contouring of the landform negates archaeological concerns for this area**. No further work is required.**
8. A second stockpile area was identified on the lower colluvial slopes of Mt. Vaux (figure 7). This area has been subject to past burning and logging activities. Proposals call for stripping of the soils and surface preparations. This project area has no nearby known archaeological sites and the landform has low archaeological potential. No concerns are warranted. **No further work is required**.

This archaeological overview reflects a review of project information obtained from the project proponent (in this case, Trevor Kinley) as well as a search of available records, maps, photographs and known site locations contained within Terrestrial Archaeology, Calgary's records and databases. In addition, in the absence of an archaeological predictive model of the project areas, ecological landform information, examination of high resolution air photographs and the author's personal experience within YNP and surrounding mountain environments has also gone into determining the archaeological potential of project landforms where no previous archaeological investigations have been conducted. Having said that, the **recommendations noted above are given with the understanding that archaeological resources may exist in these project areas despite our professional assessment to the contrary. It is vital therefore, that the contractors doing the work be vigilant, especially in areas of known archaeology such as at the lower Sherbrooke project area, and follow the above**

recommendations and the "Accidental finds" guidelines outlined in Appendix 1 of this assessment.

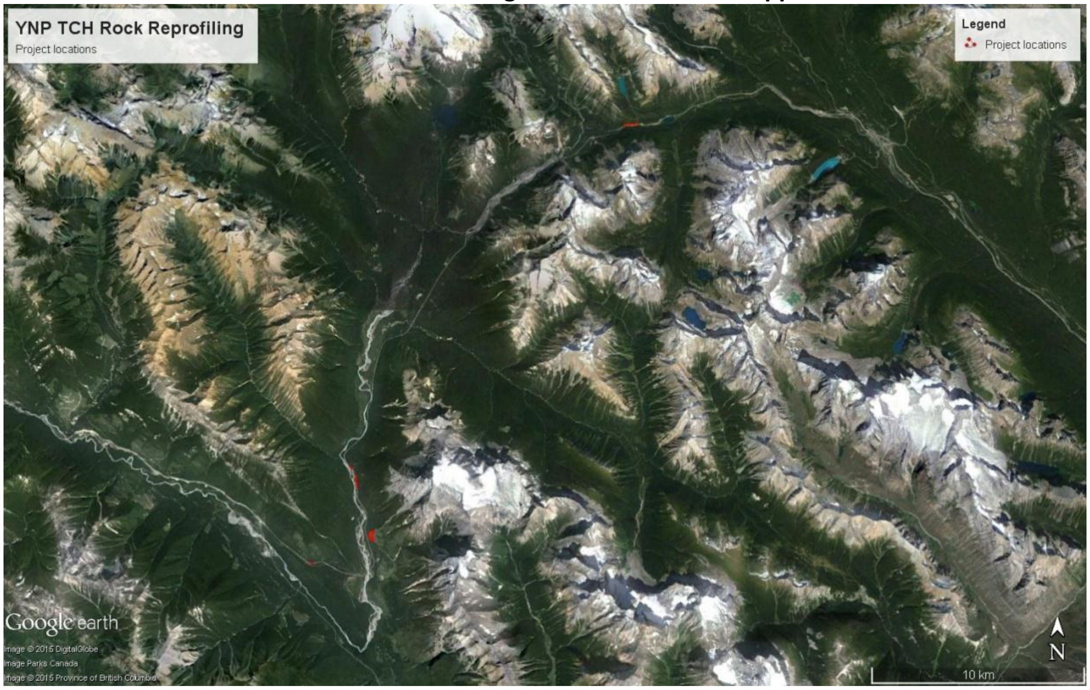


Figure 1. Project locations (in red), Yoho National Park.

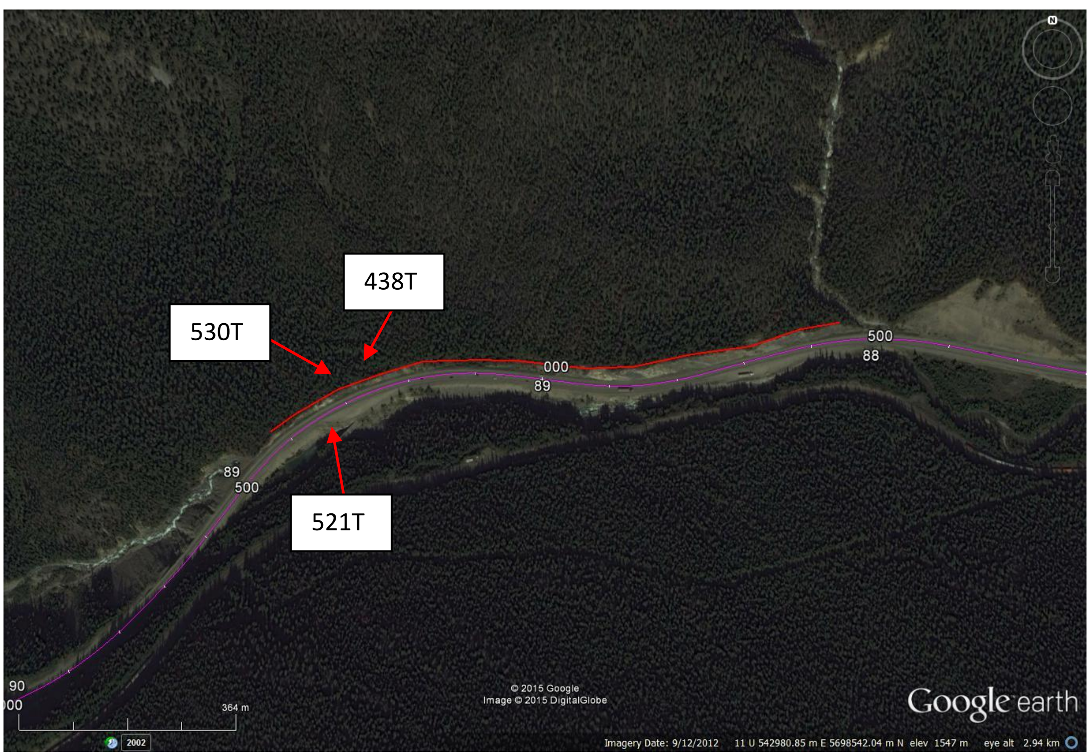


Figure 2 Upper (to the right) and lower Sherbrook (to the left) areas. Red line indicates area of proposed rock scaling and vegetation removal. Sites 521T, 530T and 438T are located at arrows.

Figure 3. Phyllite Rock Slope project area.

Figure 4. Little Topple Slope. Site 439T, the old highway grade can be seen behind the rock face.

Figure 5. Mt. Vaux Rock slope.

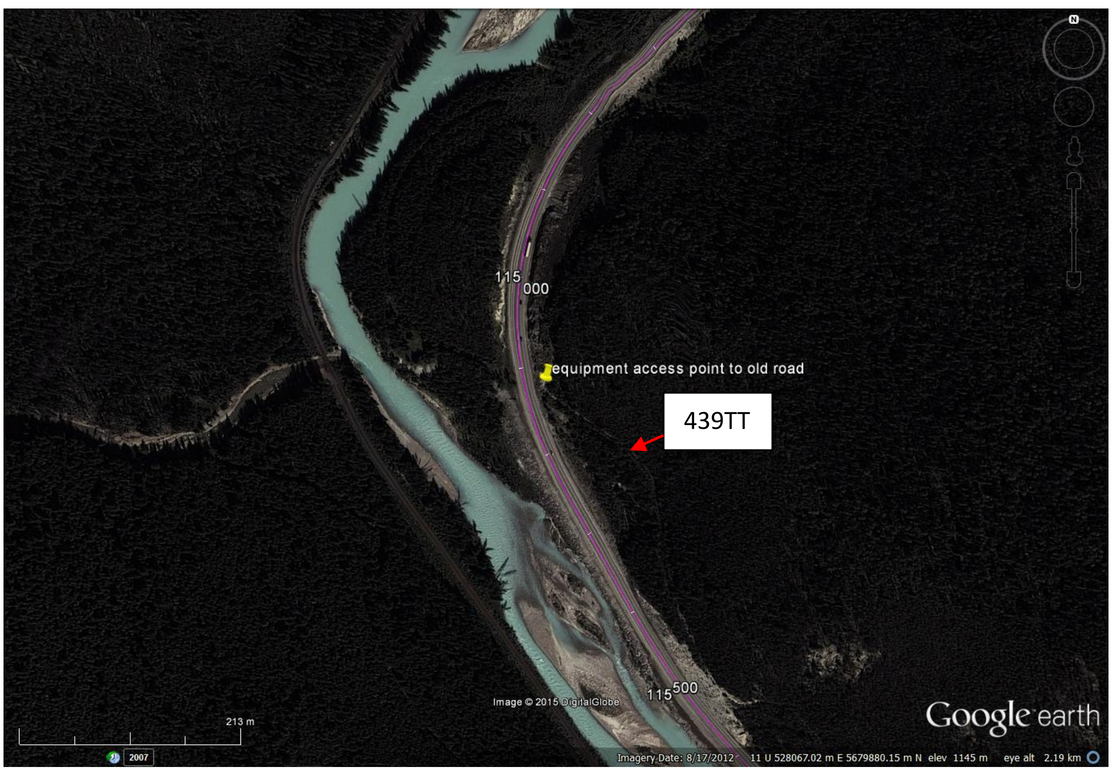


Figure 6. Access point for Little Topple. Site 439T can be seen traversing the slopes east of the TransCanada Highway on this air photograph.

Figure 7. Stockpile area at base of Mt. Vaux (outlined in red).

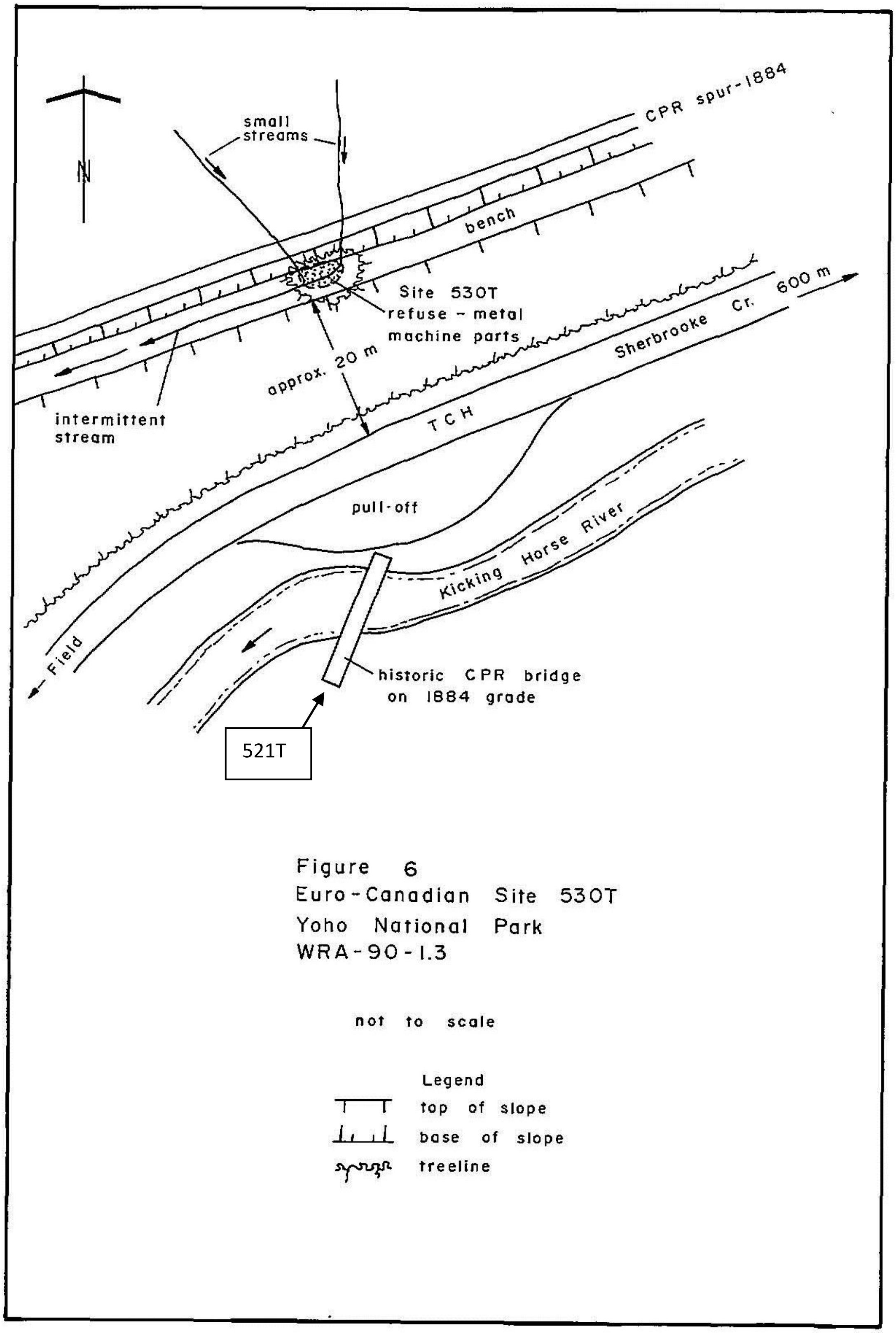


Figure 8. Sketch map of sites 530T and 521T.

Appendix 1 of Archeological Overview Assessment:

Accidental Discovery:

If artifacts or features are encountered, construction should be **stopped and onsite manager should wait for instructions before proceeding with the work. T**he YNP Environmental Surveillance Officer or Cultural Resource Management Officer should be notified who will contact Parks Canada's Terrestrial Archaeology Section for further guidance. In order to assess the situation, documentation should include, what was seen, the location of where the material was encountered, what the surrounding soil looked like, how deep it was from the ground surface, or if it was at ground surface. If possible, a photograph should be taken and sent along with the description information to the archaeologist. Preferably, artifacts should be left in place until a Parks Canada archaeologist has been consulted.

Appendix 1 Environmental Impact Analysis Tools: Effects Identification Matrix

Use the matrix to identify potential impacts. You may wish to change the components listed under the headings to specify the natural or cultural resource or visitor experience objectives that are priority considerations for your PCA site or for the specific project being reviewed.

***Section A** focuses on direct effects of the project and **Section B** on indirect effects that are caused by changes to the environment.*

A. Direct Effects (during preparation/construction phases)

			Components potentially directly affected by the proposed project											
			Natural Resources					Cultural Resources		Visitor Experience				
			Air	Soil & landforms	Water (surface, ground, crossings, etc.)	Flora (primarily conifers)	Flora (specify, including SAR)	CPR Safety Spur #1	Bed of former Golden-Banff Hwy	Visitor access & services	Recreational/Accomm. opportunities	Viewscapes and soundscapes	Visitor Safety	Essence of place
	Phase	Examples of Associated Activities												
Project Components	Preparation / construction	Supply and storage of materials	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
		Burning	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
		Clearing	☐	☒	☐	☒	☐	☒	☒	☐	☐	☐	☐	☐
		Demolition	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
		Disposal of waste	☐	☒	☐	☒	☐	☒	☒	☐	☐	☐	☐	☐
		Blasting/ Drilling	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
		Dredging	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
		Drainage	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
		Excavation	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
		Grading	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
		Backfilling	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
		Use of machinery	☐	☒	☐	☒	☐	☒	☒	☐	☐	☐	☐	☐
		Transport of materials/ equipment	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
		Building of fire breaks	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
		Use of Chemicals	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
		Set up of temporary facilities	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
		Other…	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐

SAR- species at risk

A. **Direct effects continued** (during operation/implementation/decommissioning phases)														
	You may wish to change the components listed under the headings to specify the natural or cultural resource or visitor experience objectives that are priority considerations for your PCA site or for the specific project being reviewed.		**Components potentially affected by the proposed project**											
			Natural Resources					Cultural Resources		Visitor Experience				
			Air	Soil & landforms	Water (surface, ground, crossings, etc.)	Flora (specify, including SAR)	Flora (specify, including SAR)	Insert heritage values for your site	Insert heritage values for your site	Visitor access & services	Recreationall & Accomm. opportunities	Viewscapes and soundscapes	Visitor Safety	Essence of place
	Phase	**Examples of Associated Activities**												
Project Components	Operation/Implementation/Decommissioning	Waste disposal	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
		Wastewater disposal	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
		Maintenance	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
		Use	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
		Use/Removal of temporary facilities	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
		Use of Chemicals	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
		Active fire stage	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
		Prescribed burn cleanup	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
		Planting	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
		Culling	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
		Vehicle Traffic	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
		Other…	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐

Section B- next page

***Section B** of the matrix should be used to identify potential indirect effects that may result from impacts on components of the environment you have identified on the preceding pages (see Section A - direct effects to natural resources). This is required under CEAA 2012 Sections 5(1)(c) and 5(2)(b).*
For example:

- *if the proposed project could lead to adverse effects to water quality and quantity, could this then effect the quantity and quality of water resources (e.g. potable water) used by an Aboriginal community?*
- *could there also be adverse socio-economic effects to a community that relies on recreational fishing tourism?*

B. Indirect Effects (all phases)				
You may wish to change the components listed under the headings to specify the natural or resources that are priority considerations for your PCA site or for the specific project being reviewed.		**Impacts as a result of changes to the environment**		
		With respect to non-Aboriginal peoples:	With respect to Aboriginal peoples:	
		Health and socio-economic conditions	Health & socio-economic conditions	Current use of lands and resources for traditional purposes
Phase	**Natural resource components affected by the project**			
All phases: Preparation /construction operation/implementation/decommissioning	Could impacts to <u>air</u> lead to adverse effects on…	☐	☐	☐
	Could impacts to <u>soils and landforms</u> lead to adverse effects on…	☐	☐	☐
	Could impacts to <u>water</u> (e.g. surface, ground water and water crossings) lead to adverse effects on…	☐	☐	☐
	Could impacts to <u>flora</u> (including SAR) lead to adverse effects on…	☐	☐	☐
	Could impacts to <u>fauna</u> (including SAR) lead to adverse effects on…	☐	☐	☐
	Other…	☐	☐	☐

Appendix 2: SARA-Compliant Authorization Decision Tool

(Note: Please consult a representative of the Species Conservation and Management team when completing this form)

Date this document was completed:	Where this activity will occur: (i.e., PCA site)	SAR implicated by this activity:	Title of proposed activity (e.g., Trail development in Blue Meadow):	Author of this Document:	*Collaborators involved in drafting this document:
*Identify at the outset who might have to be involved in this document from a cross-functional collaboration/review perspective.					

Part A – Is a SARA authorization required?	
1. Will the activity affect a listed endangered (En), threatened (Th) or extirpated (Ex) species at risk, its residence or critical habitat?	
Affect = kill, harm, harass, capture, or take individuals; possess, collect, buy, sell or trade individuals or parts of individuals; damage or destroy residence; destroy any part of critical habitat, or carry out an activity that is prohibited under a protection order. Note that indirect and direct effects of the activity on the species, residence, critical habitat, etc. must be considered.	
☒ **No**	**The activity will not affect a listed species (En, Th, or Ex), its residence, or its critical habitat AND the activity is not prohibited in a protection order. A SARA authorization is NOT required.** • If you checked NO, use this box to insert an explanation and STOP - you have completed the Tool.
	A survey for whitebark pine and limber pine is being conducted prior to logging.
☐ **Yes**	**The activity will affect a listed species (En, Th, or Ex), its residence, or its critical habitat OR the activity is prohibited in a protection order.** • If you checked YES, use this box to describe the activity and its effects on the species and continue to **Question 2**.
	Note – if you are contemplating an activity that may destroy critical habitat or is an activity prohibited in a protection order, it must be discussed with VPs and the CEO. If possible, find alternatives and mitigation measures to prevent destruction of critical habitat or non-compliance with an order prohibition (i.e., to avoid an effect on the critical habitat/prohibited activity and the requirement for an authorization).
2. Is the activity already authorized in a final recovery document or required for public safety, health, or national security AND authorized by or under another Act of Parliament?	
☐ **Yes**	**SARA authorization is NOT required.** • If you checked YES, use this box to explain why the activity is exempt and STOP – you have completed the Tool.
	• Explain why the activity is needed for public safety, health or national security and make a reference to the Act of Parliament under which the activity is authorized. OR • If the activity is authorized in a final recovery document, refer to the published recovery and explain why the activity is exempt under section 83 of SARA). Note - An activity that is exempt for public safety, health, or national security should be an activity that is imperative or an emergency-type situation pertaining to health and safety of the general public, and cannot be delayed for the normal SARA permitting process (e.g., wildfire control measures).
☐ **No**	**SARA authorization is required.**

	• If you checked NO, continue to **Part B**.

Part B – Can a SARA authorization be issued?

****Complete ONLY if you have answered NO to Question 2, above****

3. Does the activity fall into one of the following three categories?

*Check the appropriate box and continue to Question 4. An authorization can only be issued if it fits into one of the categories below (SARA s. 73[1]). If the proposed activity DOES NOT fit in any of the three categories below the activity CANNOT be authorized and you should continue to **Part E**.*

☐ The activity is scientific research related to the conservation of the species and conducted by qualified persons; OR

☐ The activity benefits the species or is required to enhance its chance of survival in the wild ; OR

☐ Affecting the species is incidental* to the activity (i.e., the purpose of the activity is not to engage in an activity that is prohibited under SARA e.g., kill, harm, harass ... an individual, destroy critical habitat, contravene a prohibition in an Emergency Protection Order, etc.).

*Affecting the species is incidental - For example, fishing for a listed species cannot be permitted, but accidental by-catch *may* be. Additionally, harm to a listed plant species cannot be permitted, but repairs to a bridge that incidentally disturb the plant *may* be.

4. If you concluded that the activity can be authorized, have alternatives that would reduce the impact(s) on the species been considered?

☐ **No**	**The activity CANNOT be authorized as alternatives have not been/cannot be considered**. • If you checked this box, continue to **Part E.**
☐ **Yes**	**The activity MAY be authorized.** • If you checked YES, use this box to explain the considered alternatives and continue to **Question 5**.
	Identify all reasonable alternatives that were considered to reduce the impact on the species (including alternatives to the project and alternative means of carrying out the project, including a "no action" alternative). The explanation must demonstrate that the best solution has been adopted.

5. Will all feasible measures be taken to minimize the impact of the activity?

☐ **No**	**The activity CANNOT be authorized.** • If you checked NO, continue to **Part E**.
☐ **Yes**	**The activity MAY be authorized.** • If you checked YES, use this box to identify the feasible measures that will be taken to avoid or lessen potential impacts of the project on the species and continue to **Question 6**.
	- Measures and conclusion must be consistent with exiting recovery documents, COSEWIC assessment reports, etc. - Note: If this authorization is considered as part of an impact assessment, the information provided should be consistent with the mitigation section of the impact assessment.

6. Will the activity jeopardize the survival or recovery of the species?

If an activity will not jeopardize the survival or recovery of the species, you should provide a sound rationale to demonstrate that the possible effect on recovery is minor and temporary AND that the species is capable of safely incurring such effects to its recovery.

☐ **Yes**	**The activity CANNOT be authorized.** • If you checked YES, continue to **Part E**.
☐ **No**	**The activity MAY be authorized.**

	• If you checked NO, use this box to explain why the activity will not jeopardize survival or recovery,, based on best available information, then continue to **Part C**.
	• Indicate whether the project will increase mortality, decrease fertility/recruitment, affect a key life stage/cycle. • Indicate whether the project will increase an existing threat to the point where survival/recovery might be jeopardized. • Make reference to known effects of similar activities based on existing literature. Discuss other factors relevant to assessing jeopardy for the species and site (e.g., likelihood of a negative impact on the population, species' sensitivity to the impact, potential cumulative effects from other impacts).

Part C - How will the SARA authorization be issued?

7. Under which process will the authorization be issued? Will the impact assessment (EIA) process or Research and Collection Permit System (RCPS) be used to issue the authorization?	
☐ **SARA permit (s.73)**	• If you checked this box, ensure that it is appropriate to use s. 73*, that a SARA authorization is issued (see template on intranet) and that an explanation is posted on the SAR Public Registry (using the information provided above – see template on intranet). *Note that PCA does not typically issue s. 73 permits. To do so, please contact a representative from the Species Conservation and Management team.
☐ **An existing PCA process (and SARA s.74)**	• If you checked this box, use this box to indicate whether the PCA EIA process or the PCA Research and Collection Permits System will be used to issue the authorization. Ensure that a SARA authorization is issued (see template on intranet) and that an explanation is posted on the SAR Public Registry (using the information provided above – see template on intranet).

Part D – How will the authorized activity impact ER, VE, and Agency priorities?

8. Will the activity impact ER or VE programs or Agency priorities? If so, we will work with colleagues to creatively address any potential loss of programming or opportunities.	
☐ **The authorized activity will not impact ER or VE programs or Agency priorities**	• If you checked this box, use this box to describe why the activity does not have an impact on ER or VE. Indicate if this decision was made with the support of ER or VE staff, and if so, whom.
☐ **The authorized activity will impact ER or VE programs or Agency priorities**	• If you checked this box, use this box to describe the impact that the activity will have on ER or VE. Indicate how this decision was made and who was involved. Identify next steps to creatively address potential loss of ER or VE programming or opportunities

Part E – Summary of Decisions

9. Does the activity require a SARA authorization and can a SARA authorization be issued? *Indicate selection.*	
☐	This activity does not require a SARA authorization. Refer to Questions 1 and 2 for explanation.
☐	This activity requires a SARA authorization but WILL NOT be authorized because it does not fit into one of the three required categories (see response to Question 3) OR it does not meet one of the

	SARA pre-conditions (see responses to Questions 4-6).
☐	This activity meets the SARA authorization requirements.

Part F – Signatures and Approval

Author *(Add additional signature blocks for multiple authors as required)*		
Name:		
Position:		Date: YYYY-MM-DD
Species Conservation Management Recommendation by		
Name:		
Position:		Date: YYYY-MM-DD
Was a legal opinion related to this activity requested?		
Name of Legal Counsel:		Date: YYYY-MM-DD
Summary of opinion/legal risks:		
Decision Approval		
Name:	A. KOLESCH	
Position (*Field Unit Superintendent, or Designate*):	MANAGER, ILUPP	
Signature:	A Kolesch	Date: YYYY-MM-DD 2015-04-17

TETRA TECH EBA

OQM | Organizational Quality Management Program

YOHO NATIONAL PARK
TRANS-CANADA HIGHWAY – SLOPE REPROFILING
km 88 to km 91 & km 114 to km 128
FACTUAL DATA REPORT

PRESENTED TO

Parks Canada Agency

FEBRUARY 2016

ISSUED FOR USE – REV 03

FILE: V13403095 & V13403096

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OQM | Organizational Quality Management Program

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LIMITATIONS OF REPORT

This report and its contents are intended for the sole use of Parks Canada Agency and their agents. Tetra Tech EBA Inc. (Tetra Tech EBA) does not accept any responsibility for the accuracy of any of the data, the analysis, or the recommendations contained or referenced in the report when the report is used or relied upon by any Party other than Parks Canada Agency, or for any Project other than the km 88 to km 91 and km 114 to 128 reprofiling work at the subject site. Any such unauthorized use of this report is at the sole risk of the user. Use of this report is subject to the terms and conditions stated in Tetra Tech EBA's Services Agreement. Tetra Tech EBA's General Conditions are provided in Appendix G of this report.

1.0 INTRODUCTION

1.1 General

At the request of Mr. Ryan Syme of Parks Canada Agency (PCA), Tetra Tech EBA Inc. (Tetra Tech EBA) undertook a field exploration program to collect relevant data for reprofiling existing rock slopes along the Trans-Canada Highway (TCH) in Yoho National Park (YNP), specifically along the Spiral Hill and Sherbrooke Hill Corridor (km 88 to 91) and along the western corridor of the park (km 114 to 128). Figure 1 (attached) shows the location of these sections of the highway within YNP.

Tetra Tech EBA has provided geotechnical services to PCA for over 45 years and has comprehensive records of slope inspections, maintenance programs, and rehabilitation schemes. According to these records, the slopes in YNP were constructed in the 1950s before controlled blasting was developed. The slopes have performed relatively well over the years; however, in the last 5 to 10 years, the slopes are showing increased distress in the form of rock falls, causing sections of the TCH to be closed during cleanup operations. The intent of reprofiling the slopes is to reduce both PCA's maintenance burden and the risk of failures affecting traffic on the highway.

A field investigation program was undertaken to characterize the rock mass conditions present at each slope location, including slope crest conditions, storage site locations, and potential geohazards to provide input to the design. Mr. Paul Kilkenny, P.Geo., Mr. Jack Price, E.I.T. and Ms. Sarah McAuley, E.I.T., completed site exploration between January 22 and February 4, 2015 with on-site review from Charles Hunt, P. Eng. and Anders Frappell, P.Eng. The team characterized soil material and slope conditions, and commented on the adequacy of existing soil slopes.

During the fieldwork however, there was between 0.5 m and 1.5 m of snow on the ground at each site. This limited rock outcrops available for field review and mapping data collection and may have obscured observations of small potentially salient failures along the slopes.

A subsequent site visit was therefore undertaken by Ms. Jennifer Pyliuk, P. Eng., and Ms. Sarah McAuley, E.I.T., between June 15 and 24, 2015. The purpose of this exploration was to collect detailed scanline mapping data along Sta. 89+500 to Sta. 90+100. Various geohazards identified through air photo mapping were also explored. Additional data was collected on an informal basis during the construction season.

This report summarizes the two site exploration programs and presents the data collected with respect to both rock and soil slopes located between km 88 to 91, and km 114 to 128.

1.2 Project Slope Station

To identify slopes along the highway, the start and end points of existing and proposed slope cuts are provided relative to the eastern park boundary. This station system, provided by McElhanney Consulting (MCE), is measured in kilometres along the road centreline and uses the east gate of Banff National Park as Sta. 0+000.

Historically, Tetra Tech EBA used a different station system within YNP. The historical station was measured relative to the western park boundary and increased towards the east. To ensure clarity and consistency, the MCE station has been adopted and used throughout this report.

Figure 2 shows the station on a map of the highway overlying published bedrock geology. A list of the slopes and their respective stations are presented in Table 1.1. Note, these chainages do not align directly with the design report as the alignment changed between the field investigation and writing of the design report. In the following table, the design chainages are shown in parentheses.

Table 1-1: Slope Reference Table

Project (km)	Colloquial Name	Station Start (km)	Station End (km)
88 to 91	Sherbrooke Soil Slope	88+200 (88+200)	88+500 (88+480)
	Sherbrooke Creek Rock Slope	88+500 (88+530)	89+090 (89+050)
	Lower Sherbrooke Creek Rock Slope	89+090 (89+195)	89+420 (89+430)
	Upper Dustin's	89+540 (89+600)	89+930 (89+925)
	Dustin's Slide	89+930 (89+925)	90+450 (90+220)
	Spiral Tunnels Hill	90+450 (90+220)	90+900 (90+635)
114 to 128	Through Cut (Left)	114+800 (114+840)	115+200 (115+140)
	Through Cut (Right)	114+860 (114+900)	115+100 (115+090)
	Big Topple	115+380 (115+370)	115+580 (115+600)
	Little Topple	115+650 (115+675)	115+860 (115+820)
	Mount Vaux	116+150 (115+155)	116+900 (116+865)
	Lower Mount Vaux	116+910 (116+980)	117+200 (117+190)
	Leanchoil East	123+100	123+400
	Leanchoil West	123+820	123+930
	Phyllite Slope	124+270	124+670
	Western Boundary	125+820	125+940

2.0 DESK STUDY

Before the site exploration, a desk study was completed to identify site characteristics by reviewing historic slope performance, typical climatic conditions, bedrock geology/surficial sediments, existing slope profiles, and other site specific characteristics. Additionally, available topographic data and aerial imagery from Google Earth were reviewed to identify evidence of existing or potential geohazards that could affect the highway or adjacent storage sites.

The site characteristics and potential geohazard areas identified from the desk study are summarized below.

2.1 Site Characteristics

2.1.1 Climate

The weather in YNP is variable, and differences in highway elevation, coupled with local topography, result in temperature and precipitation charges across the park. Generally, summer weather extends from mid-June to mid-September, with average daily temperature ranging from 5°C to 20°C. Winter weather conditions typically extend from November through April, with average daily temperatures ranging between -15°C and 5°C. Above an elevation of 1500 m above sea level (asl), freezing temperatures and snow are not uncommon in summer (Parks Canada, 2013).

Precipitation varies with elevation, such that Field (elevation 1,243 m asl) experiences an average annual rainfall of 314 mm and an average annual snowfall of 3.3 m, but the Kicking Horse Pass (elevation 1,625 m asl) annually averages 385 mm of rain and 4.6 m of snow (Parks Canada, 2013) .

The TCH elevation ranges between approximately 1,090 m asl and 1,590 m asl within the limits of these projects. These conditions promote freeze-thaw weathering in the spring and fall months, which can be detrimental to rock slopes resulting in ice jacking of open joints.

Climate records indicate that access to upper areas of the km 88 to 91 project site may be hindered by accumulations of snow between November and April, as well as heavy rainfall events during the fall months. Summers are typically hot, and construction activities may be suspended due to extreme fire hazard as per the BC Wildfire Act. The most favourable construction season is expected to extend from May until October.

2.1.2 Bedrock Geology

The Spiral Hill and Sherbrooke Hill Corridor of YNP (km 88 to 91) is located in the southern Canadian Rocky Mountains, which have been subject to substantial uplift, thrusting, and deformation due to tectonic processes. Bedrock geology in the area consists of Cambrian sedimentary layers belonging to the Lower Chancellor Formation. These rocks consist of limestone, slate, siltstone, and argillite, and include the Burgess shale (Massey, 2005).

The western corridor of the park (km 114 to 128) is also located in the southern Canadian Rocky Mountains. Bedrock geology consists of complexly folded early Paleozoic calcareous shale, thinly bedded limey mudstone, and minor quartzite (Massey, 2005).

Locally, intrusive quartz veins are present, and larger dyke and sill intrusions, though not observed, could exist. No regional faults are mapped within the project area, though smaller localized faulting was observed within rock outcrops along the highway. These were typically associated with little or no offset, and as such do not result in major changes to the rock mass joint set orientations.

Though outside of the project area, regional normal and thrust faults have been recorded by the CGS trending northwest/southeast, and appear similar in orientation to rock mass foliation observed at a number of locations.

A bedrock geological map of the area can be found in Figure 2.

2.1.3 Surficial Quaternary Geology

Quaternary fluvial deposits exist within the Kicking Horse River valley, where the river is observed to include an extensive flood plain proximal to and beyond the town of Field. The TCH is typically constructed on the slopes above the Kicking Horse River, and encounters colluvium and local alluvial deposits. In the Upper Kicking Horse Canyon the surficial deposits overlying the bedrock slopes along the TCH alignment are generally thin, with occurrences of thicker deposits between rock bluffs. Approaching Field, and within the southern extents of YNP, the TCH appears to be constructed on thick alluvial deposits associated with historical Kicking Horse River alignments.

Glaciation of the Rocky Mountains has resulted in typical ‘U’ shaped valleys with steep rock bluffs and associated talus slopes. The existing TCH traverses through a number of these valleys. Historically glacial outburst floods of water from a glacier in Cathedral Mountain has mobilized debris flows. Debris flows have been recorded since 1925, culminating with debris fans crossing the Trans-Canada Highway and the Canadian Pacific Railway mainline in 1985, which has resulted in the construction of protective structures to protect the rail line and the highway. A number of debris flow/flood channels occur across the TCH, and associated debris levees form localized cut slopes. The town of Field is constructed on a large debris fan, and similar deposits are observed at other locations within the park.

2.1.4 Seismicity

Since the previous revision of this report was issued, the Canadian Highway Bridge Design Code (CAN/CSA 2014) has come into effect. In accordance with CAN/CSA (2104) and British Columbia Ministry of Transportation and Infrastructure Supplement to S6-06 (BC MoTI 2007), the Annual Exceedance Probability (AEP) will be considered for the pseudostatic stability analysis of the soil slopes. The Peak Ground Acceleration (PGA) is obtained from the interactive website http://www.earthquakescanada.nrcan.gc.ca/index-eng.php. The PGA values for the AEP event(s) are provided in Table 2-1.

Table 2-1 Peak Ground Acceleration Values

Section	Annual Exceedance Probability Event		
	1 / 475	**1 / 975**	**1 / 2475**
88 to 91	0.061 g	0.086 g	0.125 g
114 to 128	0.062 g	0.087 g	0.127 g

2.1.5 Utility Information

Tetra Tech EBA submitted a utility locate request with BC One Call on February 13, 2015, and utility information was provided for Telus and BC Hydro (refer to the drawings in Appendix A). Utility information associated with the Canadian Pacific Railway (CPR) is not available through BC One Call; therefore, information on utilities associated with the rail track will need to be requested from CPR.

Between km 88 to 91, the drawings show a buried Telus cable running along the south side of the TCH, as well as a number of underground Telus ducts along the highway.

Between km 114 and 128, Telus indicated that an above ground line runs along the TCH. The drawings also show an underground Telus duct and a number of associated Telus facilities near Wapta Road. The drawings provided by BC Hydro show poles running parallel to the CPR track through this section of the alignment. Where the CPR track passes below the TCH near Sta. 123+500, an underground BC Hydro line is shown (referred to as “U/G Primary Existing Phase 3 Lines”).

2.1.6 Watercourses and Drainage

A desktop hydrological review of the two project areas was completed and existing watercourses and drainage paths were identified. Existing drainage infrastructure will be explored in the field by a hydrotechnical engineer. The proposed rock slope adjustments may alter existing drainage patterns.

Eleven watercourses were identified that cross the highway within the two project areas based on 1:20,000 digital TRIM mapping. Figure 3 highlights these watercourses as well as their associated catchment areas. It is suspected that there are additional unmapped watercourses.

2.2 Potential Geohazard Areas

From the desk study, potential geohazards were identified at the following locations:

Table 2-2: Potential Geohazard Areas Identified from Desk Study

Station Start	Station End	Location Description	Potential Geohazard
89+930	91+000	Dustin's Slide/Spiral Tunnels Hill	Rock Fall
91+200	91+300	Spiral Tunnels Hill	Debris Flows/Debris Floods
114+150	114+150	Finn Creek Crossing	Sediment Transport/Debris Floods
115+500	116+500	Large Topple/Small Topple/Mt. Vaux	Rock Fall / Avalanche
118+140	118+140	Ephemeral Creek	Debris Flows/Debris Floods
119+340	119+600	Mount Vaux Storage Site	Debris Flows/Debris Floods

Preliminary ground reconnaissance was completed at these sites to evaluate potential hazards as well as to determine the need for, and scope of additional geohazard assessment which should be undertaken as part of detailed design. Site-specific observations of these areas are discussed in Section 8.0 below. Each site is associated with a highway station, shown on Figure 4.

3.0 ENVIRONMENTAL REVIEW

Environmental review was conducted predominantly through desktop study; however, a wildlife tracking survey was completed at the end of January 2015.

3.1 Winter Tracking Survey

Kristen Mancuso and Mark Conboy, of Tetra Tech EBA conducted a winter tracking survey from January 28 to 30, 2015. Slopes of interest (Table 3-1) were surveyed on snowshoe to identify any wildlife tracks and other features (e.g., dens, salt licks etc.) that may affect the proposed slope reprofiling. Wildlife detected during the survey and any tracks and other important wildlife features were recorded.

Table 3-1: Slopes and Laydown Areas of Interest from the Winter Tracking Survey

Colloquial Name	UTM Coordinates (Zone 11 U)
Storage Site - AB/BC Border	549652 5700466
Sherbrooke Creek Rock Slope	543144 5698541
Lower Sherbrooke Creek Rock Slope	542605 5698464
Upper Dustin's to Spiral Tunnels Hill	5424645698303
Storage Site – Takkakaw Falls	538342 5696451
Through Cut - Left	528036 5680066
Through Cut - Right	528036 5680066
Big Topple and Little Topple	528147 5679623
Leanchoil East and West	528683 5678776
Storage Site - Old Quarry	529353 5674089
Phyllite Slope	526726 5674612

Tetra Tech EBA compiled a list of species of management concern known or potentially occurring within the project area (Table A) and is appended at the back of this report. The list was compiled by querying species ranges compiled by Ridgely (Ridgely, 2007), the International Union for Conservation of Nature 2014 (International Union for Conservation of Nature, 2014) and Parks Canada Biotics Web Explorer for YNP.

3.1.1 Results

Wildlife activity was generally low during the winter tracking survey. Two bird species and six mammal species were identified in the field, none of which are considered species of management concern. A potential mammal den was identified at the Spiral Tunnels Hill Slope (presented on Figure 4); however, no tracks were present to confirm whether or not it was an active site.

A summary of the species of management concern whose ranges overlap that of the project area, as well as the species identified during the mammal track survey are found appended in Table A.

3.1.2 Discussion

No species of management concern or important wildlife features requiring mitigation were identified during the mammal track survey.

Suitable habitat exists for breeding birds at the top of the slopes identified for scaling. The British Columbia *Wildlife Act* (Province of British Columbia 1996), the federal *Species at Risk Act* (Government of Canada 2002), and the *Migratory Birds Conventions Act* (Government of Canada 1994) all prohibit the destruction or disturbance of bird nests. Project-related habitat altering activities must occur outside of the breeding bird season (September to March). If clearing or rock blasting activities are scheduled to occur between April 1 and August 31, a pre-construction nest sweep must be conducted by a qualified biologist to identify bird nests that may be affected by the project.

If any important wildlife features (e.g., dens, breeding ponds, nests etc.) or wildlife species of management concern are identified during project activities, Parks Canada's Lake Louise-Yoho-Kootenay Field Unit and Environment Canada should be contacted to discuss mitigation options.

3.2 Aquatics Review

Tetra Tech EBA aquatic biologist Mr. Cameron Kulak, R.P.Bio., conducted a desktop review of information pertaining to the Kicking Horse River and its tributaries within km 88 to 91 and km 114 to 128 in the context of the rock slope reprofiling and storage sites proposed for the 2015 season. While a fish habitat assessment and fish sampling program is recommended, surveys have yet to be conducted due to the winter conditions in YNP at the time of writing. Review of the rock slope cuts along the TCH and adjacent to Kicking Horse River was based on the station presented in MCE's design, and locations for cuts and storage sites targeted in the 2015 reprofiling program and Google Earth imagery are:

- Project km 88 to 91: Sherbrooke (88+500 to 89+090), Lower Sherbrooke (88+090 to 89+420), and Spiral Tunnels Hill (90+450 to 90+900);
- Project km 114 to 128: Through Cut – Left (114+800 to 115+200), Through Cut – Right (114+860 to 115+160), and Small Topple Slope (115+650 to 115+860); and
- Storage Areas.

The Kicking Horse River (FWA watershed code: 300-906313) within YNP is designated as a Canadian Heritage River (CHRS 2011). Most fisheries data is obtained from a portion of the river downstream of Wapta Falls, which is approximately 3.8 km downstream of the TCH crossing and is an obstacle to upstream fish movement or migration due to its 20 m to 30 m vertical drop. All proposed 2015 rock cuts are upstream of Wapta Falls, where no fish presence/absence data has so far been obtained.

Nine species of fish are identified within the Kicking Horse River (Table 3-2), and all identified fish locations were below Wapta Falls. None of the nine species are listed under Schedule 1 of the Species At Risk Act; however, Bull Trout are designated as Special Concern by the Committee on the Status of Endangered Wildlife In Canada.

The Kicking Horse River is defined as a fish-bearing watercourse providing fish habitat for commercial, recreational and aboriginal fisheries, and as such is protected by the Fisheries Act. Additional surveys are required within tributaries to the Kicking Horse River to determine fish presence or if they provide water, food, and nutrient supply to the Kicking Horse River.

Table 3-2: Fish Species Present in Kicking Horse River ((Ministry of Environment, 2015), (Ministry of Environment, 2015), (McPhail, 2007))

Bull Trout (*Salvelinus confluentus*)	Brook Trout (*Salvelinus fontinalis*)
Rainbow Trout (*Oncorhynchus mykiss*)	Kokanee (*Oncorhynchus nerka*)
Pygmy Whitefish (*Prosopium coulterii*)	Mountain Whitefish (*Prosopium williamsoni*)
Slimy Sculpin (*Cottus cognatus*)	Torrent Sculpin (*Cottus rhotheus*)
Mottled Sculpin (*Cottus* spp.)	

Since construction work are expected to be a minimum of 30 m from the top of bank, the proposed 2015 rock slope reprofiling is unlikely to have significant negative impact to the Kicking Horse River or its tributaries, provided that standard mitigation measures are followed (to be detailed in future Impact Analysis documents. Reprofiling designs will attempt to employ similar lateral controls (corrugated steel pipes, armoured swales, etc.) to maintain flow paths into the existing infrastructure (i.e. streams, culverts, and ditches).

Most proposed Storage Areas are unlikely to have significant negative impacts to the Kicking Horse River or its tributaries given their placement within disturbed areas between the TCH and other PCA road infrastructure (Takkakaw Falls) or within historical borrow sites. The proposed temporary/daily storage area exists upslope of the Kicking Horse River along the shoulder of TCH westbound lane near the Spiral Tunnels. It is noted that sufficient distance appears available between the storage location and the river, and along with standard mitigation measures, this storage will be unlikely to negatively affect aquatic resources.

3.3 Vegetation Review

Tetra Tech EBA conducted an early season vegetation assessment which included searches for Vegetation Elements of Management Concern (VEMC) and confirmation of the land cover types encountered within the proposed areas for vegetation clearing and rock scaling. VEMC are considered to be any vegetation elements (i.e., species or ecological communities) that meet one or more of the following criteria:

- Species listed as ‘Special Concern’, ‘Threatened’, or ‘Endangered under Schedule 1 of the *Species at Risk Act*;
- Species assessed as ‘Special Concern’, ‘Threatened’, or ‘Endangered’ by the COSEWIC;
- Species listed under the British Columbia *Wildlife Act*; and
- Vascular plant species and ecological communities assessed to be of ‘conservation concern’ (i.e. red or blue listed) by the BC Conservation Data Centre.

Prior to commencing field surveys, Tetra Tech EBA conducted a desktop review of VEMC with potential to be encountered within the project area. This consisted of a search of the BC CDC Species and Ecosystem Explorer for all VEMC located within the Montane Spruce and Engelmann Spruce-Subalpine Fir Biogeoclimatic Zones and the Columbia-Shuswap Regional District.

A vegetation ecologist conducted the vegetation assessment from June 5 to 7, 2015, searching for habitats with potential to support VEMC by walking along a meandering transect within the proposed areas for disturbance. All detectable and identifiable vascular plant species were recorded. Tetra Tech EBA identified 117 vegetation species of which none were considered to be a VEMC.

4.0 ROCK SLOPE CHARACTERIZATION

4.1 Methodology

Site exploration of rock slopes was completed in two assessments. The first, by Mr. Jack Price, E.I.T. and Ms. Sarah McAuley, E.I.T., with senior on site review by Mr. Charles Hunt. P. Eng., and Mr. Anders Frappell, P. Eng. of Tetra Tech EBA, involved traversing existing rock cuts, geohazard locations, and potential storage sites. The winter site exploration program consisted of:

- General reconnaissance of existing rock slopes to provide comments on dimensions and slope performance;
- Reconnaissance of slope crests to identify potential geohazards, access conditions, and overburden thickness;
- Mapping of exposed rock faces, and collection of representative samples for Acid Rock Drainage (ARD) and Metal Leaching (ML) testing; and
- Assessment of potential storage/laydown sites for excavated material during construction.

The second site visit was undertaken by Ms. Jennifer Pyliuk, P. Eng., and Ms. Sarah McAuley, E.I.T., to collect detailed scanline mapping data along Sta. 89+500 to Sta. 90+100. Various geohazards identified through air photo mapping were also explored.

Photographs documenting observed site conditions were taken, and a select number are included within the Photographs section of this report to provide a visual indication of site conditions.

Both field explorations utilized a handheld Garmin Global Positioning System (GPS) to track the routes walked, and points of interest were identified to highlight specific geotechnical and geomorphological conditions or considerations. Tree density occasionally resulted in GPS inaccuracy greater than the ±5 m achieved in clear sky areas. As such, GPS tracks and points of interest should be considered accurate to ±10 m.

In addition to the Garmin GPS, an Apple iPad equipped with GPS was used to track locations relative to the proposed rock cuts.

The orientation of geomorphological features, slope orientations, and rock mass discontinuities were collected using a handheld compass. During field mapping, the compasses were set with a magnetic declination of 0° to ensure continuity between different devices. Subsequently, a magnetic declination of 16° east was applied to the data presented within this report.

Rock Mass Mapping data was collected while on site and is presented in Appendix B. Site reconnaissance points of interest, and site investigation locations are presented in Appendix C. All location data is provided in UTM zone 11U NAD 83 coordinates for northing and easting.

4.2 Slope Descriptions and Observations

4.2.1 Sta. 88+200 to 88+470 (Sherbrooke Soil Slope)

The Sherbrooke Soil Slope (km 88+200 to 88+470) is a cut slope approximately 60 m high and a face inclination of 35° built in the 1950s when the TCH was constructed through the valley. The slope is likely to comprise fluvio-glacial terrace deposit. The slope face is sparsely vegetated with immature conifer trees with more densely vegetated larger conifer trees along the crest line and upslope from the cut face. No groundwater or surface water runoff is evident and slope drainage is likely into Sherbrooke Creek. Sherbrooke Creek forms the southern boundary of the slope and discharges into the Kicking Horse River which runs parallel to the slope face, approximately 400 m from the toe of the slope.

Further exploration results can be seen in Sections 6.3 and 6.4.

4.2.2 Sta. 88+500 to 89+090 (Sherbrooke Creek Rock Slope)

This rock cut starts adjacent to Sherbrooke Creek, where it flows beneath the TCH and joins the Kicking Horse River, and continues approximately 590 m west.

This slope is characterized by beds of light and dark grey carbonaceous siltstone and light grey limestone dipping 45° towards the east. Rock mass jointing forms a blocky exposure and results in toppling of discrete blocks. The siltstone within this slope is more competent than other locations, with less dominant foliation jointing.

A small gully at the crest of the slope introduces water onto the slope face, and results in the formation of a 20 m wide ice flow during winter months. Some minor seepage was observed at a number of locations along the slope.

A granular deposit of about 14 m in thickness was encountered forming a convex deposit. This deposit was rounded to sub-rounded fine to medium, clast supported, GRAVEL of mixed lithologies with much medium to coarse sand. Field observations suggest that this deposit is dense. Excavations into this deposit show fining up sequences. Historically this section of slope has been covered by rock fall netting. Cross sections through this portion of the slope show that the material has been standing unsupported at least 43° since the TCH was cut through this section in the 1950s.

Existing Slope Profile and Crest Conditions

The existing rock slope at this location is up to approximately 35 m high, and standing at 65° to 75° with occasional overhangs. The upper slope varies between 5° and 25° towards the rock slope crest, occasionally dipping between 5° and 20° sub-parallel to the TCH at the eastern and western ends of this rock cut.

The crest is vegetated with approximately 30 trees per 100 m^2, and fairly consistent along the slope length. The maximum diameter of trees observed was 0.4 m (1.25 m girth). A number of bedrock outcrops were observed behind the slope crest, and little to no overburden was observed at the crest of the existing rock slope. This could indicate that bedrock is at or near surface along most of the slope crest.

Rock Mass Conditions

A number of rock mass qualities were assessed at each location, including spacing, condition and orientation of discontinuities and a field assessment of uniaxial compressive strength of the intact material, with the intent of classifying rock mass quality. A description of the numerous classification parameters is located in Appendix D.

Table 4-1 summarizes rock mass characteristics collected at this location.

Table 4-1: Summary of Rock Mass Conditions Observed Between Sta. 88+500 – 89+090

Parameter	Minimum	Maximum	Mean	Comments
ISRM Strength	R3	R5	R4/R5	The rock mass typically consists of inter-bedded inclined siltstone and limestone units with bedding dipping 50° to 60° towards 035. Bedding forms a dominant joint set that results in overhanging faces, and coupled with a second steeply dipping joint, forms toppling blocks.
ISRM Weathering	W1	W2	W1	
Joint Spacing (m)	0.05	4.00	1.15	
RQD (%)	50	100	75	
Roughness (JRC)	6	18	11	
$JCON_{89}$	15	30	24	
GSI	55	75	65	
RMR_{89}	54	92	75	

Joints within the limestone units are typically more undulating and rough than within the siltstone, resulting in an irregular rock mass, with less defined joint sets.

Historical blasting damage is frequent at the toe of the slope, with blockier material observed at the crest, possibly a result of collar stemming and reduced fracturing during blasting. This results in undercutting of competent beds higher up the rock face, detrimental to rock slope performance.

A thrust fault was observed at an orientation similar to the bedding joints. This thrust fault has resulted in locally reduced RQD, and appears to have distorted an additional, second joint set such that it folds into the fault zone. Though weakened, no major shear zone or infill was observed.

Existing Catchment Ditch Adequacy Assessment

Existing ditches were assessed using field observations and LiDAR data, and this data was compared with findings from the 2001 Oregon 'Rock Fall Catchment Area Design Guide', assuming 90% retention (Oregon Department of Transportation - Research Group, 2001).

As some rock slopes were out of the height range considered by Oregon Department of Transportation (ODoT) guidelines for slopes greater than 21.34 m, catchments were graphically interpolated to estimate this value.

The Oregon rock fall design manual (Oregon Department of Transportation - Research Group, 2001) states that "A rock fall catchment area is defined as an area between the slope toe and the edge of the pavement". This manual presents the catchment width for a variety of slope angles and slope heights based on the designed retention. The Oregon guidelines were developed from a series of practical rock fall tests. A total of 11,250 rocks were released and analysis undertaken for varying slope heights and catchments designs primarily for highway schemes.

Rock fall retention is critical parameter in the design of catchments; 100% catchment is often not practical to build or cost effective as highlighted in ODoT manual. On this basis, 90% retention level affords PCA with a low maintenance solution that is not overly conservative. Where cut heights in excess of 21.34 m have been proposed, the graphical data within the Oregon manual has been extrapolated to estimate the rollout of slopes higher than those tested.

Table 4-2 summarizes the existing rock slope profile at 40 m intervals and provides a rock fall retention percentage based on the Oregon empirical model. A number of the intervals examined exhibit a retention percentage below the proposed 90% objective for rock slopes within YNP.

Table 4-2: Slope Conditions Relative to Catchment Capacity – Sta. 88+500 to 89+090

Station	Ditch Width (m)	Slope Height (m)	Slope Angle (degrees)	Percent Retained (%)
88+560	7.5	15	50	95
88+600	5	15	65	80
88+640	6	32	75	65
88+680	5	36	60	75
88+720	5	30	65	65
88+760	7	30	70	90
88+800	9	32	70	95
88+840	8	35	75	80
88+880	5	25	65	75
88+920	6	21	60	85
88+960	10	15	45	95
89+000	5	8	65	85

Preliminary Access Observations

Access to the crest from the highway for tracked equipment could be achieved at approximately Sta. 89+100, where the existing rock face is between 1 m and 2 m high. Once the rock face is ascended, tracked equipment would need to ascend or descend slopes typically between 10° and 20° steep.

Locally, slopes are up to 25° steep, and to gain access along the full rock crest, localized blasting may be required due to the lack of overburden materials.

4.2.3 Sta. 89+090 to 89+420 (Lower Sherbrooke Creek Rock Slope)

This rock cut starts at the historical rail pullout and extends approximately 330 m to where the TCH crosses the Kicking Horse River.

This slope is characterized by beds of light and dark grey carbonaceous siltstone and light grey limestone inclining 45° towards 000°. Limestone forms the dominant rock type within this section of rock slope. Rock mass jointing form a blocky exposure, and results in toppling of discrete blocks. The siltstone within this slope is more competent than other locations, with less dominant foliation jointing.

Minimal, localized seepage was observed along this slope. A shallow gully and associated ice flow was observed within this rock face, with water directed along the ditch at the base.

Existing Slope Profile and Crest Conditions

The slope is approximately 15 m high and standing at 50° to 70°. The upper slope varies between 15° and 30° towards the TCH, with the crest occasionally dipping 20° to 30° sub-parallel to the TCH at the eastern and western ends of this rock cut.

The crest is vegetated with approximately 30 trees per 100 m^2, and is fairly consistent along the slope length. The maximum diameter of trees observed was 0.4 m (1.25 m girth). A number of bedrock outcrops were observed behind the slope crest, and little or no overburden was observed at the crest of the existing rock slope.

Rock Mass Conditions

Table 4-3 summarizes rock mass characteristics collected at this location.

Table 4-3: Summary of Rock Mass Conditions Observed – Sta. 89+090 to 89+420

Parameter	Minimum	Maximum	Mean	Comments
ISRM Strength	R2	R5	R4/R5	The rock mass typically consists of inter-bedded tilted siltstone and limestone units with bedding dipping at 50° to 60° towards 040. Bedding forms a dominant joint set within the siltstone units, resulting in overhanging faces and subsequent toppling. Within the limestone units, though bedding is still observed, bedding joints are frequently less dominant.
ISRM Weathering	W1	W2	W2	
Joint Spacing (m)	0.15	2.00	0.66	
RQD (%)	60	100	78	
Roughness (JRC)	2	16	9	
$JCON_{89}$	18	30	25	
GSI	50	70	63	
RMR_{89}	61	83	74	

Historical blasting damage is frequent at the toe of the slope, with blockier material observed at the crest. This results in undercutting of competent beds higher up the rock face, detrimental to rock slope performance.

Existing Catchment Ditch Adequacy Assessment

Existing ditches were assessed using field observations and LiDAR data, and this data was compared with findings from the 2001 Oregon 'Rock fall Catchment Area Design Guide' (Oregon Department of Transportation - Research Group, 2001).

Table 4-4 summarizes the existing rock slope profile at 40 m intervals and provides a rock fall retention percentage based on the Oregon empirical model. All of the intervals examined exhibit a retention percentage below the proposed 90% objective for rock slopes within YNP.

Table 4-4: Slope Conditions Relative to Catchment Capacity – Sta. 89+090 to 89+420

Station	Ditch Width (m)	Slope Height (m)	Slope Angle (degrees)	Percent Retained (%)
89+220	1	13	45	<50
89+260	3	9	68	50
89+300	5	15	55	80
89+340	3	12	55	80

Preliminary Access Observations

Access to the crest from the highway for tracked equipment could be achieved at approximately Sta. 89+100, where the existing rock face is between 1 m and 2 m high. Once the rock face is ascended, tracked equipment would need to ascend or descend slopes typically between 10° and 20° inclination.

Locally, slopes are up to 25º steep, and to gain access along the full rock crest, localized blasting may be required due to the lack of overburden materials.

4.2.4 Sta. 89+540 to 90+900 (Upper Dustin's, Dustin's Slide, and Spiral Tunnels Hill)

This rock cut begins on the southeastern bank of the Kicking Horse River, just beyond the TCH embankment crossing, and terminates at the Spiral Tunnels parking lot approximately 1.36 km west. For ease of reporting, the slopes associated with 'Upper Dustin's', 'Dustin's Slide', and 'Spiral Hill' have been combined; however these sections will be considered separately during the detailed design phase.

The rock mass typically comprises inter-bedded blocky quartzite and slate bands. The orientation of bedding results in a blocky rock mass prone to localized toppling failure where weaker beds are preferentially eroded.

The rock is folded, faulted with duplex type folding, which means that traditional kinematic analysis will not work. The slope has been prone to unravelling with recent failures. The rock is weathered to dark orange in locations.

The CP Mainline is located within 100 m of this section of rock slope, presenting possible access and construction complications.

A number of small gullies at the crest of the slope introduce water onto the slope face at numerous locations, notably at Stations 89+620, 89+890 and 89+900. The formation of a 50 m wide ice flow during winter months was observed at Sta. 89+620 during the January/February investigation, with the ice accumulation seen to have calved and caused disruption to the TCH. The culvert at this location was obscured by ice during the January/February site investigation but was observed to be in working condition in June 2015. Seepage was observed throughout the slope during the June 2015 investigation, particularly in the areas of Sta. 89+710 to 89+740, Sta. 89+790, Sta. 89+910 to 89+930, Sta. 89+970 and Sta. 90+030.

Existing Slope Profile and Crest Conditions

The existing rock slope at this location is typically between 10 m and 20 m high, with a maximum height of approximately 30 m, and is standing at between 45° and 75°. The upper slope typically dips towards the highway at between 15° and 30°, though locally as steep as 40°. Along slope, a number of deep gullies exist such that the crest occasionally dips 25° to 40° sub-parallel to the TCH; one such location is at Sta. 90+100. These sections are associated with small dry creeks, thought to flow during rainfall precipitation events.

The crest is generally vegetated with approximately 70 trees per 100 m^2, though in places tree density drops to 40 to 50 trees per 100 m^2. The maximum diameter of trees observed was 0.3 m (0.95 m girth). Bedrock outcrops were observed at various locations along the crest of the slope. Overburden was observed to be between 0.5 m and 3 m thick at the rock slope crest in a number of locations. The thicker overburden typically coincides with highly weathered zones, and this overburden could represent highly weathered bedrock. Overburden should then be considered locally deeper where significant weathering of the bedrock surface has occurred, or faulting / folding has created depositional zones.

Rock Mass Conditions

Table 4-5 summarizes rock mass characteristics collected at this location.

Table 4-5: Summary of Rock Mass Conditions Observed – Sta. 89+540 to 91+900

Parameter	Minimum	Maximum	Mean	Comments
ISRM Strength	R1	R5	R3	The rock mass typically consists of *inter*bedded *quartzite and slate*, dominated by bedding joints dipping at between 10° and 30° towards the 050. These joints are frequently open at the surface, likely as a result of historical blast
ISRM Weathering	W1	W3	W2	
Joint Spacing (m)	0.01	5.5	0.34	
RQD (%)	0	90	52	

Table 4-5: Summary of Rock Mass Conditions Observed – Sta. 89+540 to 91+900

Parameter	Minimum	Maximum	Mean	Comments
Roughness (JRC)	3	20	12	damage, and the rock mass is prone to toppling failure of discrete blocks. The thickness of beds varies from 0.05 m to 1 m, and affects the overall rock mass RQD substantially, resulting in differential weathering and subsequent toppling of competent beds.
$JCON_{89}$	0	30	23	
GSI	20	75	54	
RMR_{89}	28	87	61	

A section of the slope, 'Dustin's Slide' (Sta. 89+900 to 90+450), consists of highly weathered, low RQD quartzite and slate, with acute folding on the tens of metres scale. This fault and folding combination has resulted in large overhangs where weaker lower RQD rock has preferentially eroded, and left more competent beds of material higher up the slope. Many compressional regimes have faulted and folded the rock.

Failures occurring within Dustin's Slide have been observed to occur as a rock mass, likely a result of closely spaced joints, associated low RQD, and complex fold related kinematic failures. There have been failures at this slope in the past, up to 1,000 cubic metres.

Existing Catchment Ditch Adequacy Assessment

Existing ditches were assessed using field observations and LiDAR data, and this data was compared with findings from the 2001 Oregon 'Rock fall Catchment Area Design Guide' (Oregon Department of Transportation 2001).

Table 4-6 summarizes the existing rock slope profile at 40 m intervals and provides a rock fall retention percentage based on the Oregon empirical model. A considerable proportion of the intervals examined exhibit a retention percentage below the proposed 90% objective for rock slopes within YNP.

Table 4-6: Slope Conditions Relative to Catchment Capacity – Sta. 89+540 to 91+900

Station	Ditch Width (m)	Slope Height (m)	Slope Angle (degrees)	Percent Retained (%)
89+620	5	12	50	50
89+640	6	13	65	95
89+680	9	19	55	95
89+720	8	17	70	95
89+760	8	19	65	95
89+800	6	20	70	85
89+840	7	22	75	90
89+880	4	10	65	75
89+920	5	23	45	50
89+960	6	20	55	50
90+000	5	22	65	75
90+040	6	30	65	80
90+080	3	11	45	<50
90+120	6	20	45	65
90+160	5	20	70	75
90+200	5	18	60	75
90+240	3	13	65	50

Table 4-6: Slope Conditions Relative to Catchment Capacity – Sta. 89+540 to 91+900

Station	Ditch Width (m)	Slope Height (m)	Slope Angle (degrees)	Percent Retained (%)
90+280	4	22	65	50
90+320	5	20	70	75
90+360	5	17	70	75
90+400	6	15	55	90
90+440	5	10	65	85
90+480	6	13	75	99
90+560	5	8	60	85
90+760	1	17	40	<50

Preliminary Access Observations

This rock face could be accessed from both the eastern and western end of the rock cut, which would take advantage of the slope length and allow for simultaneous construction programs.

Eastern access could ascend a small rock face between 2 m and 4 m high at Sta. 89+550, then traverse a 15° slope with minimal vegetation. An existing 3 m high rock ridge would require blasting or ramping over, but once on top of this ridge, access to the crest of the slope between Sta. 89+500 and 90+000 would require traversing slopes between 15° and 30°. At Sta. 90+100, a gully exists with 35° to 40° slopes.

Western access could be achieved at a number of locations and would ascend a 20° to 25° slope. Some benching or excavator time will be required to reach the proposed top of cut.

In assessing access to the crest of this rock face, a temporary access trail could be constructed through one of two boulder fields/rock debris slides located at the eastern limit of the rock face (Sta. 90+770, and Sta. 90+615). These areas consist of numerous boulders, typically 3 m to 4 m in diameter, though locally larger, with no vegetation and minimal soil.

This option would likely require boulder busting and removal of surface boulders, filling the voids of deeper seated boulders to create a trail. The general slope gradient is 20°, and once atop the rock slope, access would traverse slopes dipping at between 25° and 40°.

4.2.5 Sta. 114+800 to 115+200 (Through Cut - Left)

This section of the highway passes through an existing rock through cut, with rock cuts present on either side of the highway. The orientation of rock cuts greatly affects their stability with respect to kinematic propensity, and as such, we have assessed each side of the highway separately.

This slope is located on the left side of the highway facing up station, forming the eastern rock slope. This slope is the longer of the two, at approximately 400 m, and forms the inside corner of an almost 90° curve in the TCH.

The rock mass at this location consists of shale, with sub-horizontal bedding joints, and some evidence of folding sub-parallel to sub-vertical cleavage joints. A second sub-vertical joint set exists resulting in toppling failures and localized planar failure.

Minor seepage was observed along this slope.

Existing Slope Profile and Crest Conditions

The existing rock face is approximately 15 m to 20 m high, and stands at 40° to 70°. The upper slope varies between 15° and 30° towards the rock slope crest, dipping 5° to 20° sub-parallel to the TCH at the lower and higher station ends.

The crest towards the north is generally sparsely vegetated within the proposed cut slope area. The southern end of the slope crest is consistent with other slopes, exhibiting between 50 and 60 trees per 100 square meters with a diameter between 0.1 m and 0.2 m (girth of 0.3 m and 0.6 m, respectively). Soil slopes were observed at both the upper and lower ends of the slope, and minimal overburden was observed at the crest of the slope. Bedrock was observed in locations along the crest, and bedrock is likely close to surface along this rock cut.

Rock Mass Conditions

Table 4-7 summarizes rock mass characteristics collected at this location.

Table 4-7: Summary of Rock Mass Conditions Observed – Sta. 114+800 to 115+200

Parameter	Minimum	Maximum	Mean	Comments
ISRM Strength	R5	R5	R5	The rock mass typically consists of shale with a strong intact rock strength and minimal weathering. Mapping of this rock mass identified undulating bedding joints and a number of folds, resulting in sub-horizontal joints dipping into or out of the face. This results in localized planar failure and toppling failure.
ISRM Weathering	W1	W2	W1	
Joint Spacing (m)	0.10	4.00	0.67	
RQD (%)	40	90	76	
Roughness (JRC)	4	20	10	
$JCON_{89}$	15	30	24	
GSI	50	65	59	
RMR_{89}	37	89	77	

The dominant foliation joint observed belongs to a regional cleavage joint set observed at rock slopes to either side of this section. This dips consistently at 80° towards 050, resulting in oblique flexural toppling of blocks, or direct toppling where bedding dips out of the face.

A number of highly persistent 60° joints were observed with a spacing in excess of 4 m. These were typically associated with quartz vein intrusions, also extending along cleavage joints.

At the down-station end of this rock face, rock at the crest is rounded, with striations/scour marks indicative of fluvial or glacial erosion.

Existing Catchment Ditch Adequacy Assessment

Existing ditches were assessed using field observations and LiDAR data, and this data was compared with findings from the 2001 Oregon 'Rock fall Catchment Area Design Guide' (Oregon Department of Transportation 2001).

Table 4-8 summarizes the existing rock slope profile at 40 m intervals and provides a rock fall retention percentage based on the Oregon empirical model. A considerable proportion of the intervals examined exhibit a retention percentage below the proposed 90% objective for rock slopes within YNP.

Table 4-8: Slope Conditions Relative to Catchment Capacity – Sta. 114+800 to 115+200

Station	Ditch Width (m)	Slope Height (m)	Slope Angle (degrees)	Percent Retained (%)
114+840	5	8	40	75
114+880	5	17	40	65
114+920	5	20	65	75
114+960	6	18	75	95
115+000	5	18	70	75
115+040	5	20	70	75
115+080	8	18	65	95
115+120	4	8	45	75

Preliminary Access Observations

Access could be achieved from the northern end of the rock slope where vegetation is minimal and the slope sits at 10° to 15°. Some ramping will be required, though there are minimal trees and appears to be some overburden soil for ramping.

4.2.6 Sta. 114+860 to 115+100 (Through Cut - Right)

This through cut rock slope is located directly opposite the rock slope outlined in Section 4.2.5, and the conditions experienced are similar.

This slope is located on the right side of the highway facing up station, forming the western rock slope. This slope is the shorter of the two, at approximately 240 m, and forms the outside rock slope of an almost 90° bend in the TCH.

An ancient fluvial erosion feature was noted along this rock face, exposing very high quality rock (RQD locally of 90). Round boulders, cobbles, gravel, and soils were also noted within a weathered joint suggesting fluvial deposition. This feature is incongruous with the rest of the outcrop.

Very little seepage was observed along this slope, but still indicated the presence of groundwater within the slope.

Existing Slope Profile and Crest Conditions

The current slope at this location is 10 m to 20 m high and stands at between 40° and 60°. The upper slope varies between 10° and 35° towards the rock slope crest, dipping 5° to 20° sub-parallel to the TCH at the northern and southern ends.

The crest is generally sparsely vegetated with young trees consistently along its length. Soil slopes were observed at both the northern and southern ends of the slope, and minimal overburden was observed at the crest of the slope. Bedrock was observed in locations along the crest, and bedrock is likely close to surface along this rock cut.

Rock Mass Conditions

Table 4-9 summarizes rock mass characteristics collected at this location.

Table 4-9: Summary of Rock Mass Conditions Observed – Sta. 114+860 to 115+100

Parameter	Minimum	Maximum	Mean	Comments
ISRM Strength	R5	R5	R5	The rock mass typically consists of shale with a strong intact rock strength and minimal weathering. Mapping of this rock mass identified undulating bedding joints and a number of folds, resulting in sub-horizontal joints dipping into or out of the face.
ISRM Weathering	W1	W2	W2	
Joint Spacing (m)	0.10	1.40	0.58	
RQD (%)	60	70	66	
Roughness (JRC)	8	20	11	
$JCON_{89}$	20	25	24	
GSI	50	60	54	
RMR_{89}	68	80	75	

The dominant foliation joint observed belongs to a regional cleavage joint set observed at rock slopes north and south of this section. This dips consistently at 80° towards 050°, resulting in oblique flexural toppling of blocks, or direct toppling where basal release planes exist.

A number or highly persistent 60° joints observed on the eastern rock face could be traced across the highway. Rock mass joint orientations appear consistent on both sides of the highway.

Existing Catchment Ditch Adequacy Assessment

Existing ditches were assessed using field observations and LiDAR data, and this data was compared with findings from the 2001 Oregon 'Rock fall Catchment Area Design Guide' (Oregon Department of Transportation - Research Group, 2001).

Table 4-10 summarizes the existing rock slope profile at 40 m intervals and provides a rock fall retention percentage based on the Oregon empirical model. All the intervals examined exhibit a retention percentage below the proposed 90% objective for rock slopes within YNP.

Table 4-10: Slope Conditions Relative to Catchment Capacity – Sta. 114+860 to 115+100

Station	Ditch Width (m)	Slope Height (m)	Slope Angle (degrees)	Percent Retained (%)
114+960	5	20	60	75
115+000	4	14	65	70
115+040	5	8	40	75

Site observations suggest that the rock fall source area is midway up the rock face, and it is unlikely rock will fall from the slope crest. Due to the toppling type failure observed, large blocks will not likely fail and have enough energy to reach the road. In addition to this, the existing highway is separated from this slope by concrete barriers, increasing the retention percentage.

Preliminary Access Observations

Access could be achieved from the up-station end of the rock slope, where a de-vegetated slope climbs at 10° to 15° up and over the ridge.

4.2.7 Sta. 115+380 to 115+580 (Big Topple)

This rock slope is located on the eastern side of the TCH, with a slope length of approximately 200 m. The rock mass consists of shale, and the slope appears to have been cut into benches with steep overhanging faces formed by cleavage joints striking sub-parallel to the highway. The orientation of these cleavage joints, in addition to their close spacing, results in flexural toppling failure dominating the stability of this rock slope.

Very little seepage was observed along this slope.

Existing Slope Profile and Crest Conditions

The existing rock slope at this location is approximately 30 m high, and cut at an overall slope angle of 60°. Individual bench faces are overhanging at 80° and formed by the dominant cleavage joint set. The upper slope varies between 0° and 45° dipping towards the rock slope crest, dipping 30° sub-parallel to the TCH at both ends.

The crest is vegetated, with approximately 30 to 40 trees per 100 m^2, and fairly consistent along the slope length. The maximum tree diameter observed was approximately 0.3 m (1.0 m girth). Overburden soil was observed at the southern end of the rock slope; however, no large accumulations of overburden soils were observed at the crest of the rock slope.

Rock Mass Conditions

Table 4-11 summarizes rock mass characteristics collected at this location.

Table 4-11: Summary of Rock Mass Conditions Observed – Sta. 115+380 to 115+580

Parameter	Minimum	Maximum	Mean	Comments
ISRM Strength	R3	R3	R3	The rock mass typically consists of shale with a moderate intact rock strength and minimal weathering. The rock face is dominated by flexural toppling of the rock mass on the regional cleavage joint also observed at nearby rock slopes, with faces delaminating and breaking at sub-horizontal bedding joints.
ISRM Weathering	W2	W2	W2	
Joint Spacing (m)	0.20	12.00	1.99	
RQD (%)	70	70	70	
Roughness (JRC)	10	20	15	
$JCON_{89}$	10	25	22	
GSI	40	65	53	
RMR_{89}	57	77	68	

Bedding plane orientation undulates over a metre scale along the rock slope, dipping both into and out of the rock face to the extent that large planar instabilities are unlikely to occur. Bedding joint roughness typically has a JRC of >18, owing to the micro-folding of bedding features present on these joint surfaces.

Sub-vertical joints form perpendicular ends for toppling failure. The joint spacing is typically between 5 m and 8 m, forming long, tall, slim blocks. The rock appears to fracture under bending moments, such that 'flakes' form with irregular release surfaces.

Existing Catchment Ditch Adequacy Assessment

Existing ditches were assessed using field observations and LiDAR data, and this data was compared with findings from the 2001 Oregon 'Rock fall Catchment Area Design Guide' (Oregon Department of Transportation - Research Group, 2001).

Table 4-12 summarizes the existing rock slope profile at 40 m intervals and provides a rock fall retention percentage based on the Oregon empirical model. Most intervals examined exhibit a retention percentage below the proposed 90% objective for rock slopes within YNP.

Table 4-12: Slope Conditions Relative to Catchment Capacity – Sta. 115+380 to 115+580

Station	Ditch Width (m)	Slope Height (m)	Slope Angle (degrees)	Percent Retained (%)
115+400	5	15	50	80
115+440	9	30	60	95
115+480	5	30	60	75
115+520	7	30	60	90
115+560	5	18	60	75

The failure mechanisms observed on site produce tabular slabs of rock that likely break up on impact. The retention capabilities of existing ditches may in fact be higher when considering localized rock fall, though material failing from near the crest will likely breach the current ditches.

Preliminary Access Observations

In assessing access to the crest of this slope, the old deactivated TCH, with access located north of the rock slope, was walked to determine existing conditions. The old TCH is densely vegetated with small trees approximately 0.05 m to 0.15 m in diameter (0.2 m to 0.5 m girth). Some localized rock fall has occurred resting on the old road grade, and old rock slope faces are dilated with fractured rock on the surface. The old road shoulder appears in good condition.

The route maintains a steady grade of about 5° before reaching the crest of the northern end of the existing rock slope. To access the proposed top of cut, tracked equipment will need to ascend a 35° slope for approximately 20 m.

4.2.8 Sta. 115+650 to 115+860 (Little Topple)

This rock slope is located on the left side of the TCH (looking up-station), with a slope length of approximately 210 m. The rock mass consists of shale, and the slope appears to have been cut into benches with overhanging faces formed by cleavage joints striking sub-parallel to the highway. The orientation of these cleavage joints, in addition to their close spacing, results in flexural toppling failure dominating the stability of this rock slope.

Very little seepage was observed along this slope.

Existing Slope Profile and Crest Conditions

The existing rock slope at this location is approximately 20 m high, and cut at an overall slope angle of 45° to 70°. Individual bench faces are overhanging at 80° and formed by the dominant cleavage joint set. The upper slope varies between 30° and 40° dipping towards the rock slope crest, and dips between 30° and 40° sub-parallel to the TCH at both ends. The down-station end connects with the slope described above (Section 4.2.6) along the old TCH.

The crest is vegetated, with approximately 30 to 40 trees per 100 m^2, and is fairly consistent along the slope length. The maximum tree diameter is approximately 0.3 m (1.0 m girth). Overburden soil was observed at the up-station end of the rock slope; however, no substantial overburden soils were observed at the crest of the rock slope.

Rock Mass Conditions

Table 4-13 summarizes rock mass characteristics collected at this location.

Table 4-13: Summary of Rock Mass Conditions Observed – Sta. 115+650 to 115+860

Parameter	Minimum	Maximum	Mean	Comments
ISRM Strength	R3	R3	R3	The rock mass is similar to that described in Section 5.6, and typically consists of shale with a moderate intact rock strength and minimal weathering. The rock face is dominated by flexural toppling of the rock mass on the regional cleavage joint also observed at nearby rock slopes, with faces delaminating and breaking at sub-horizontal bedding joints.
ISRM Weathering	W2	W2	W2	
Joint Spacing (m)	0.10	5.00	1.09	
RQD (%)	70	80	78	
Roughness (JRC)	4	20	13	
$JCON_{89}$	18	25	25	
GSI	50	55	55	
RMR_{89}	60	81	73	

Bedding plane orientation undulates over a metre scale along the rock slope, and dips both into and out of the rock face likely preventing planar instabilities. Bedding joint roughness is generally >18 due to micro-folding of these features.

Sub-vertical joints form perpendicular ends for toppling failure. Sub-vertical joint spacing is typically between 3 m and 5 m, forming long, tall, slim blocks. As observed during the field renaissance, the rock appears to fracture under bending moments, such that ‘flakes’ form with irregular release surfaces.

Existing Catchment Ditch Adequacy Assessment

Existing ditches were assessed using field observations and LiDAR data, and this data was compared with findings from the 2001 Oregon ‘Rock fall Catchment Area Design Guide’ (Oregon Department of Transportation - Research Group, 2001).

Table 4-14 summarizes the existing rock slope profile at 40 m intervals and provides a rock fall retention percentage based on the Oregon empirical model. Half the intervals examined exhibit a retention percentage above the proposed 90% objective for rock slopes within YNP.

Table 4-14: Slope Conditions Relative to Catchment Capacity – Sta. 115+650 to 115+860

Station	Ditch Width (m)	Slope Height (m)	Slope Angle (degrees)	Percent Retained (%)
115+680	5	11	55	95
115+720	6	18	65	85
115+760	7	10	70	95
115+800	10	23	45	85

The failure mechanisms observed on site produce tabular slabs of rock that likely break up on impact. The actual retention capabilities of existing ditches may in fact be higher when considering localized rock fall, though should material fail from near the crest, it will likely breach these ditches.

Preliminary Access Observations

The northern end of the slope is connected to the slope at Sta. 115+380 to115+580 (described in Section 5.6) along a second stretch of the old TCH. This stretch of the old TCH is not accessible from the existing TCH road grade, and would have to be accessed from the crest of the Sta. 115+380 to115+580 slope.

Work should commence on the Sta. 115+380 to115+580 slope initially, and proceed to this slope once access to the old TCH has been achieved. This stretch of old TCH is vegetated, and the old rock cut slopes may require scaling prior to construction access.

Access from the southern end of this rock slope would require ascending a 40° slope through mature vegetation, and the existing TCH has been constructed on an embankment in this location, making access to this slope more complex.

4.2.9 Sta. 116+150 to 117+200 (Mount Vaux and Lower Mount Vaux)

This slope is on the eastern side of the TCH and comprises four smaller slopes (Sta. 116+150 to 116+220, Sta. 116+300 to 116+450, Sta. 116+450 to 116+900, and Sta. 116+910 to 117+200), separated by gullies or vegetated areas. For this data report, these slopes have been combined, though they will be considered separately during the detailed design phase.

The slope typically comprises shale and mudstone. Some planar failures were observed while on site; however, these planes are less common throughout the rock mass. Toppling type failure was also observed through release on sub-vertical planes. Oblique wedges could be seen as the slope face changed in orientation along its length.

Existing Slope Profile and Crest Conditions

The current slope at this location is generally 10 m to 15 m high and is cut at about 75°. The upper slope varies between 0° and 35° towards the TCH, with the crest occasionally dipping 5° to 20° parallel to the TCH. The crest is generally moderately vegetated, which is consistent along its length. Soil was observed at the edges of the slope and within the various gullies; however, little overburden was noted above the slope.

Rock Mass Conditions

Table 4-15 summarizes rock mass characteristics collected at this location.

Table 4-15: Summary of Rock Mass Conditions Observed – Sta. 116+150 to 117+200

Parameter	Minimum	Maximum	Mean	Comments
ISRM Strength	R4	R4	R4	The rock mass typically consists of the dominant sub-vertical cleavage joint set forming direct and flexural toppling along the length of the rock exposure. The vertical release plane for direct toppling is afforded by a widely spaced sub-vertical joint set, plus random sub-vertical joints in a similar orientation.
ISRM Weathering	W1	W2	W2	
Joint Spacing (m)	0.10	10.00	1.20	
RQD (%)	60	90	76	
Roughness (JRC)	6	20	13	
$JCON_{89}$	18	25	25	
GSI	60	65	65	
RMR_{89}	65	84	75	

Bedding varies along the slope, initially presenting an oblique planar failure up-station, with bedding dipping out of the face at 50°. The interaction of this joint with two vertical joint sets also results in the potential for wedge failure. In the centre, near Sta. 116+750, bedding flattens off to approximately 10°, fluctuating dip direction into and out of the rock face. Towards the down-station end of the rock slope, bedding increases in dip angle to 86° at the end of the rock exposure, resulting again in oblique planar failures and then finally large wedge failures.

Bedding planes are typically very rough (JRC between 14 and 20), though where failures have occurred these are smoother (JRC 8 to 12).

The rock mass is typically slightly weathered with surface staining only. As in previous slopes, quartz veins exist, typically aligned with foliation joints.

Existing Catchment Ditch Adequacy Assessment

Existing ditches were assessed using field observations and LiDAR data, and this data was compared with findings from the 2001 Oregon 'Rock fall Catchment Area Design Guide' (Oregon Department of Transportation - Research Group, 2001).

Table 4-16 summarizes the existing rock slope profile at 40 m intervals and provides a rock fall retention percentage based on the Oregon empirical model. Most intervals examined exhibit a retention percentage below the proposed 90% objective for rock slopes within YNP.

Table 4-16: Slope Conditions Relative to Catchment Capacity – Sta. 116+150 to 117+200

Station	Ditch Width (m)	Slope Height (m)	Slope Angle (degrees)	Percent Retained (%)
116+160	8	14	50	85
116+200	7	12	75	99
116+240	6	8	40	85
116+320	7	14	60	95
116+360	5	14	60	80
116+400	7	13	65	95
116+440	4	8	55	90
116+480	6	11	60	95
116+520	8	12	55	99
116+560	6	8	55	95
116+600	5	9	65	85
116+640	5	12	70	85
116+680	6	20	60	85
116+720	7	25	50	80
116+760	8	9	60	99
116+800	5	28	60	75
117+080	5	9	60	85
117+120	5	11	60	85

Preliminary Access Observations

Access from the southern end of the rock face is recommended near Sta. 116+850 where the slope climbs at between 15° and 20°. Once at the crest of the slope, access along the crest will typically encounters slope angles of 15° to 25°, though locally steeper ground exists at the northern end of the rock slope.

For access along the rock slope between Sta. 117+010 and 117+170, tracked equipment will ascend slopes between 10° and 15°, with the slope crest typically 0° to 5°.

4.2.10 Sta. 123+100 to 123+400 (Leanchoil East)

This rock cut is located on the right side of the TCH (looking up-station), 400 m east of the TCH crossing of the CPR Mainline. The rock slope is approximately 270 m long. A second rock cut will likely be required on the other side of the highway opposite this slope, though snow cover and overburden soils made rock mass mapping and observations difficult. The conditions present within each of these slopes are likely similar.

This slope comprises weak phyllite and overburden soil. Phyllite is dominated by closely spaced undulating foliation joints aligned sub-parallel to the road alignment.

No seepage was observed along this rock cut.

Existing Slope Profile and Crest Conditions

This slope is typically 5 m to 6 m high, and standing at an angle of 40° to 50°. The slope appears to have been cut back to this angle, and the slope behind the slope crest is flat, such that in expanding the width of the TCH, these slopes will typically remain at their existing height, or decrease in height owing to the shallow or negative upper slope angle. Both ends of this rock cut ascend at between 10° and 15°.

The crest is sparsely vegetated, with approximately 20 trees per 100 m^2. This section of the highway is designated a 'natural blow down area', and a number of fallen trees were observed leaning over the slope crest.

Rock Mass Conditions

Table 4-17 summarizes rock mass characteristics collected at this location.

Table 4-17: Summary of Rock Mass Conditions Observed Between Sta. 123+100 – 123+400

Parameter	Minimum	Maximum	Mean	Comments
ISRM Strength	R3	R3	R3	This rock mass comprises weak phyllite rock, with occasional stronger quartz veins forming ridges that cut across foliation joints. With the slope face sub-horizontal to cleavage joints, flexural toppling failure dominates, though occasionally, back break appears to have occurred on widely/irregularly spaced planar joints
ISRM Weathering	W2	W2	W2	
Joint Spacing (m)	0.05	2.00	0.47	
RQD (%)	40	50	45	
Roughness (JRC)	4	18	9	
$JCON_{89}$	18	30	24	
GSI	45	50	48	
RMR_{89}	52	67	60	

Existing Catchment Ditch Adequacy Assessment

The existing ditches are between 3 m and 4 m wide, approximately 0.5 m deep, and clear of debris. An ODoT rock fall catchment area assessment of this slope was not completed as the slope height and slope angle are low.

Preliminary Access Observations

Access to this slope is possible from either side as the slope is generally less than 5 m in height, and ascends at 5° to 10° on both ends of the rock face.

4.2.11 Sta. 123+820 to 123+930 (Leanchoil West)

This rock cut is located on the left side (looking up station) of the TCH, 250 m west of the TCH crossing of the CPR Mainline. The rock slope is approximately 110 m long and forms the inside corner of the TCH.

As with the slope described in Section 5.9, this slope comprises weak phyllite dominated by closely spaced undulating foliation joints, such that oblique flexural toppling occurs.

No seepage was observed along this rock cut.

Existing Slope Profile and Crest Conditions

This slope is typically 5 m to 6 m high, and standing at an angle of 50° to 60°. The slope appears to have been cut back to this angle, and the slope behind the slope crest is flat, such that in cutting the slopes further back from the TCH, these slopes will typically remain at their existing height, or decrease in height owing to the shallow or negative upper slope angle. Both the eastern and western ends of this rock cut ascend at between 10° and 15°.

The crest is sparsely vegetated, with approximately 20 trees per 100 m^2. This section of the highway is designated a 'natural blow down area', and a number of fallen trees were observed leaning over the slope crest.

Rock Mass Conditions

Table 4-18 summarizes rock mass characteristics that were collected at this location.

Table 4-18: Summary of Rock Mass Conditions Observed – Sta. 123+820 to 123+930

Parameter	Minimum	Maximum	Average	Comments
ISRM Strength	R3	R3	R3	This rock mass comprises weak phyllite rock, with occasional stronger quartz veins forming ridges that cut across foliation joints. A number of sub-vertical joints were observed and, in addition to foliation joints, present the potential for toppling failure and localized planar and wedge failure.
ISRM Weathering	W2	W2	W2	
Joint Spacing (m)	0.05	2.00	0.47	
RQD (%)	40	50	45	
Roughness (JRC)	4	18	9	
$JCON_{89}$	18	30	24	
GSI	45	50	48	
RMR_{89}	52	67	60	

The rock mass is typically R2 to R3 in strength, and in high slopes may be subject to through rock failure, as experienced at Sta. 124+260.

A number of widely spaced planar joints were observed that appear to have resulted in wedge failures during excavation. These planes dip at approximately 40° out of the slope face, and form shallow slope face angles.

Existing Catchment Ditch Adequacy Assessment

The existing ditches are between 3 m and 4 m wide, approximately 0.5 m deep, and clear of debris. An ODoT rock fall catchment area assessment of this slope was not completed as the slope height and slope angle are low.

Preliminary Access Observations

Access to this slope is possible from either side as the slope is generally less than 5 m in height, and ascends at 5° to 10° on both the lateral extents of the rock face.

4.2.12 Sta. 124+270 to 125+670 (Phyllite Slope)

This rock cut is located on the inside curve of an almost 40° curve in the TCH and is approximately 400 m long.

This rock cut primarily comprises highly fractured phyllite that breaks down to cobble sized fragments upon impact with the ditch or road. Occasional more competent bands exist forming larger blocks, which when undercut or overhung by weathering of the weaker bands, present a more significant rock fall hazard.

The debris from a recent failure lies in the ditch marked with cones. This failure likely cast some material onto the highway. Observations of the slope above suggest that some scaling work should be completed as soon as practicable to remove two 'shields' of dilated rock from the current rock face.

Seepage was not observed within this rock slope, though surface water was seen to seep over the rock face from the surface as snow at the crest and on the face melted.

Existing Slope Profile and Crest Conditions

The current slope at this location is approximately 20 m to 25 m high and stands at 50° to 70°. The upper slope typically dips at between 0° and 30° towards the TCH, dipping between 10° and 15° sub-parallel to the TCH at the lateral ends of the rock cut.

The crest is sparsely vegetated, with approximately 20 trees per 100 m^2, and fairly consistent along the slope crest. Overburden soil was observed at both ends of the slope; however, little overburden was noted above the slope.

Rock Mass Conditions

Table 4-19 summarizes rock mass characteristics collected at this location.

Table 4-19: Summary of Rock Mass Conditions Observed – Sta. 124+270 to 125+670

Parameter	Minimum	Maximum	Average	Comments
ISRM Strength	R2	R2	R2	This rock mass typically consists of weak phyllite rock, with occasional stronger quartz veins, up to 0.4 m thick, forming ridges that cut across foliation joints. A number of folds and faults were observed that alter the rock mass jointing conditions, such that cleavage dips horizontally at the base of the rock face, but steeply at the crest. The intact rock material strength is low, with extensive well-developed cleavage and micaceous minerals resulting in a weak rock mass strength.
ISRM Weathering	W3	W3	W3	
Joint Spacing (m)	0.05	0.70	0.12	
RQD (%)	0	20	1	
Roughness (JRC)	4	14	6	
$JCON_{89}$	10	25	21	
GSI	15	25	24	
RMR_{89}	35	57	47	

The intact rock material strength is estimated at R2 where weathered and R3 where fresh. This low intact rock material strength, coupled with extensive closely spaced cleavage joints, results in a rock mass prone to through rock failure. Despite this, through rock failure appears to be initiated by toppling failure on cleavage joints at the slope crest.

Existing Catchment Ditch Adequacy Assessment

Existing ditches were assessed using field observations and LiDAR data, and this data was compared with findings from the 2001 Oregon 'Rock fall Catchment Area Design Guide' (Oregon Department of Transportation - Research Group, 2001).

Table 4-20 summarizes the existing rock slope profile at 40 m intervals and provides a rock fall retention percentage based on the Oregon empirical model. Most intervals examined exhibit a retention percentage below the proposed 90% objective for rock slopes within YNP.

Table 4-20: Slope Conditions Relative to Catchment Capacity – Sta. 124+270 to 125+670

Station	Ditch Width (m)	Slope Height (m)	Slope Angle (degrees)	Percent Retained (%)
124+340	6	12	50	80
124+380	6	19	50	75
124+420	5	22	70	75
124+460	7	27	60	90
124+500	6	22	60	85
124+540	5	21	45	50

Preliminary Access Observations

An existing access trail exists at the crest of this slope, likely from its initial construction, and this ascends a 10° to 15° slope from the eastern end of the rock cut. The bench is approximately 5 m wide, and though it provides initial access, the strength of the rock should be considered before positioning any equipment near the rock slope edge.

Behind the existing access trail, a second 30° to 35° slope exists behind which the slope is relatively flat.

4.2.13 Sta. 125+820 to 125+940 (Western Boundary)

This is a small rock slope located close to the western edge of the Park boundary on the northern side of the TCH. The slope comprises weak phyllite with some overburden soil. The slope is generally 5 m high, and soil was observed on either end.

Seepage was not observed along this rock slope.

Existing Slope Profile and Crest Conditions

This slope is typically 5 m to 6 m high, and standing at an angle of 50° to 60°. The slope appears to have been cut back to this angle, and the slope behind the slope crest is flat, such that in expanding the width of the TCH, these slopes will typically remain at their existing height, or decrease in height owing to the shallow or negative upper slope angle. Both the ends of this rock cut ascend at between 10° and 15°.

The crest is sparsely vegetated, with approximately 20 trees per 100 m^2. This section of the highway is designated a ‘natural blow down area’, and a number of fallen trees were observed leaning over the slope crest.

Rock Mass Conditions

Table 4-21 summarizes rock mass characteristics collected at this location.

Table 4-21: Summary of Rock Mass Conditions Observed – Sta. 125+820 to 125+940

Parameter	Minimum	Maximum	Average	Comments
ISRM Strength	R2	R2	R2	This rock mass comprises weak phyllite rock, with occasional stronger quartz veins forming ridges that cut across foliation joints. A number of sub-vertical joints were
ISRM Weathering	W2	W2	W2	
Joint Spacing (m)	0.02	12.00	0.84	

Table 4-21: Summary of Rock Mass Conditions Observed – Sta. 125+820 to 125+940

Parameter	Minimum	Maximum	Average	Comments
RQD (%)	0	100	70	observed and, in addition to foliation joints, present the potential for toppling failure and localized planar and wedge failure.
Roughness (JRC)	2	20	11	
$JCON_{89}$	0	30	24	
GSI	15	75	57	
RMR_{89}	32	92	72	

The rock mass is R2 in strength and in high slopes may be subject to through rock failure, as experienced at Sta. 124+260.

A number of widely spaced planar joints were observed that appear to have resulted in wedge failures during excavation.

Existing Catchment Ditch Adequacy Assessment

The existing ditches are between 3 m and 4 m wide, approximately 0.5 m deep, and clear of debris. An ODoT rock fall catchment area assessment of this slope was not completed as the slope height and slope angle are low.

Preliminary Access Observations

Access to this slope is possible from either side as the slope is generally less than 5 m in height, and ascends at 5° to 10° on both the eastern and western ends of the rock face.

5.0 GEOCHEMICAL CHARACTERIZATION

Geological and rock mass mapping of exposed rock faces and collection of lithologically representative samples was undertaken to complete a preliminary geochemical characterization test program. The characterization program was developed to identify potential for acid rock drainage (ARD) and metal leaching (ML) effects during construction and post-excavation to assess the suitability of excavated material to be used as fill materials.

Acid rock drainage results from the oxidation of sulphide minerals when exposed to oxygen and water. It is a naturally occurring process that can be accelerated by rock disturbances, such as excavation and blasting. Metal leaching is the release of metal constituents through leachate from the rock mass, and can occur under acidic and neutral drainage conditions. This preliminary geochemical characterization considers the potential for both ARD and ML effects.

The design of the characterization program, including sample number determination, sample collection methodology, analysis methods, and interpretation of data was completed in accordance with the recommendations presented in the Mine Environment Neutral Drainage (MEND) Prediction Manual for Drainage Chemistry from Sulphidic Geologic Materials (Price, 2009).

5.1.1 Sample Collection and Description

Nine samples were collected during the January/February 2015 site visit spatially distributed along the TCH alignment. These samples were acquired from freshly exposed rock. The initial sample selection was intended to provide an overview of the typical rock types expected to be generated during excavation and construction activities. Sampling was limited to accessible outcrops. The final volume of excavation material generated over the life of the project at each rock cut is not known at this time, and will need to be reviewed to determine sample numbers required for adequate characterization once final design is available.

A description of the samples collected and analyzed from the January/February 2015 site visit is provided in Table 5-1. Photographs of all samples collected and analyzed are included in the attached Appendix E.

Table 5-1: Summary of Samples Collected for Analysis (January/February 2015)

Sample ID	Station (km)	Material Type	Sample Description
TT15-R01	88+700	Carbonaceous Siltstone	Dark grey, fine grained, carbonaceous siltstone, sugary texture, moderate effervescence, minor thin white laminations, dominantly unweathered, no visible sulphides or carbonates, mm-scale black tabular inclusions.
TT15-R02	88+790	Carbonaceous Siltstone	Dark grey, fine grained, carbonaceous siltstone, sugary texture, moderate effervescence with 10% HCl, minor thin white laminations, dominantly unweathered, no visible sulphides or carbonates, mm-scale black tabular inclusions.
TT15-R03	88+810	Dolomitc Limestone	Light grey, fine to medium grained, very granular sugary texture, minor effervescence with 10% HCl, green/yellow color develops with addition of HCl, vesicular calcite cavities partially developed, no visible sulphides, minimal weathering, competent, non-foliated, non-structured massive sample, quartz and calcite dominated rock.
TT15-R04	89+890	Quartzite	Grey-brown, massive blocky structure, quartz dominated rock, medium to coarse grained, granular texture, minor weathering, no visible sulphides, no effervescence with 10% HCl, light green alteration (epidote?).
TT15-R05	90+060	Quartzite	White-grey, fine to medium grained, granular texture, quartzite, massive blocky structure, red iron alteration, no visible sulphides, no effervescence with 10% HCl, shiny crystalline sheen on surface of sample, possible fine grained garnet, minor biotite content.
TT15-R06	114+940	Shale	Black, very fine grained, shale, smooth surface sheen, minor lamination planes, curved joint fracture surfaces, sample contains 2 mm thick calcite vein on edge of sample, no visible sulphides.
TT15-R07	115+400	Shale	Black, very fine grained, shale, smooth sample surfaces, minor laminations and foliations, curved joint fractures surfaces, minor fine grained calcite vein inclusions.
TT15-R08	116+500	Cherty Shale	Black, fine grained, cherty mudstone/shale, smooth dull surfaces, slightly sugary or cherty texture, no visible sulphides, no effervescence with 10% HCl.
TT15-R09	124+300	Phyllite	Grey-green, very fine grained, phyllite, soft soapy texture from talc, heavily foliated, breaks into thin mm-scale laminations, smooth surface sheen, no visible sulphides, no effervescence with 10% HCl.

A second site visit and sample collection event was carried out on October 16, 2015, with a focus on the Phyllite Slope (Station 124+270 to 124+670) and Sherbrooke Creek Rock Slope (Station 88+500 to 89+090) which were currently undergoing excavation and re-profiling. The site visit was completed by Mr. Scott Kingston, B.Sc., P.Geo., from Tetra Tech EBA and involved a review of the outcrop geology, lithological variability, alteration, mineralogy and weathering.

Nine samples were collected from the Phyllite Slope (YNP15-01 to YNP15-09) and 14 samples were collected from the Sherbrook Creek Rock Slope (YNP15-10 to YNP15-23). The samples were collected from representative rock material along the length of the existing extent of rock excavation on each of the slopes. Sample collection was constrained to accessible outcrops and limited in certain sections due to active blasting and excavation. The samples collected represent an accurate cross section of all lithologies observed during the site visit on each of the respective rock slopes.

A description of the samples collected and analyzed from the October site visit is provided in Table 5-2. Photographs of all samples collected, including those that were not analyzed, are included in the attached Appendix E.

Table 5-2: Summary of Samples Submitted for Analysis (October 2015)

Sample ID	Station Marker[1] (km)	Material Type	Sample Description
YNP15-01	124+310	Phyllite	Grey-green, very fine grained, phyllite, soft soapy texture from talc, heavily foliated with minor crenulations, sample breaks into thin mm-scale planes, smooth surface sheen, strong effervescence with 10% HCl, no visible sulphides.
YNP15-03	124+410	Phyllite	As above, with residual rock flower on surface of sample
YNP15-05	124+490	Phyllite	As above
YNP15-07	125+570	Phyllite	As above
YNP15-08	124+380	Calcite (vein)	Opaque white, medium grained, calcite, massive blocky structure with smooth fracture surfaces, orange iron alteration on surface, minor weathering and small dissolution vugs, moderate to strong effervescence with 10% HCl, no visible sulphides.
YNP15-10	88+600	Carbonaceous Siltstone	Grey to dark grey, fine grained, carbonaceous siltstone, moderate calcite veining, slightly sugary texture, moderate weathering, strong effervescence with 10% HCL, no visible sulphides.
YNP15-12	88+615	Carbonaceous Siltstone	Dark grey, fine grained, carbonaceous siltstone, minor calcite veining, slightly sugary texture, moderate weathering, strong effervescence with 10% HCL, no visible sulphides.
YNP15-13	88+725	Carbonaceous Siltstone (foliated)	Grey-green, fine grained, carbonaceous siltstone, moderate tightly spaced (1-4mm) foliation, thin platy fracturing, moderately weathered, moderate fine grained disseminated micas, moderate to strong effervescence with 10% HCL, no visible sulphides.
YNP15-14	88+730	Carbonaceous Siltstone (foliated)	Grey-green, fine grained, carbonaceous siltstone, minor foliation, thin platy fracturing, minor weathering, 3mm iron oxidation halo on edge of select sample sections, minor fine grained disseminated micas, strong effervescence with 10% HCL, no visible sulphides.
YNP15-15	88+735	Limestone	Light grey-grey, medium grained, crystalline slightly sugary texture, limestone, generally massive structure, minor white clays on joint surfaces, strong effervescence with 10% HCL, minor fine grained disseminated pyrite.
YNP15-16	88+755	Carbonaceous Siltstone	Grey to dark grey, fine grained, carbonaceous siltstone, moderate calcite veining, slightly sugary texture, moderate weathering, strong effervescence with 10% HCL, no visible sulphides.
YNP15-17	88+760	Carbonaceous Siltstone	Grey to dark grey, fine grained, carbonaceous siltstone, cherty and sugary texture, moderate relic bedding as light dark bands, moderate calcite veining, slightly sugary texture, moderate weathering, strong effervescence with 10% HCL, no visible sulphides.
YNP15-19	88+900[2]	Carbonaceous Siltstone	Dark grey-black, fine grained, carbonaceous siltstone, abundant well-formed calcite crystals, strong effervescence with 10% HCL, no visible sulphides.
YNP15-20	88+800[2]	Limestone	White-black, coarse grained, limestone, granular texture, moderate relic bedding and definition of light-dark banding, mm-scale dissolution vugs in calcite bands, moderate effervescence with 10% HCL, no visible sulphides
YNP15-23	88+745	Carbonaceous Siltstone (foliated)	Grey-green, fine grained, carbonaceous siltstone, minor tightly spaced (1-4mm) foliation, thin platy fracturing, minor weathering, strong effervescence with 10% HCL, no visible sulphides, 3mm iron oxidation halo on edge of select sample sections, minor fine grained disseminated micas

[1]All station kilometers are approximate and based off of the available staking markers at the time of sampling.

[2]Sample station locations for YNP15-19 and YNP15-20 were estimated to within ±40m

5.1.2 Laboratory Test Program

All nine of the initial samples collected in January/February 2015 were submitted for analysis to provide an initial evaluation of geochemical parameters along the project alignment. An additional five samples from the Phyllite Slope and ten samples from the Sherbrooke Creek Rock Slope, collected in October 2015, were submitted for analysis. A summary of the number of samples analyzed from each rock slope is presented below in Table 5-3.

Table 5-3: Summary of samples analyzed from the rock slopes to date

Rock Slope	Estimated Rock Excavation Volume (m^3)	Sample IDs	Number of Samples Analyzed
Sherbrooke Creek Rock Slope	55,000	TT15-R01, TT15-R02, TT15-R03, YNP15-10, YNP15-12 to YNP15-17, YNP15-19, YNP15-20, YNP15-23	13
Phyllite Slope	42,000	TT15-R09, YNP15-01, YNP15-03, YNP15-05, YNP15-07, YNP15-08	6
Upper Dustin's	Unconfirmed	TT15-R04	1
Dustin's Slide	Unconfirmed	TT15-R05	1
Through Cut (right)	Unconfirmed	TT15-R06	1
Big Topple	Unconfirmed	TT15-R07	1
Mount Vaux	Unconfirmed	TT15-R08	1
Total			**24**

The number of samples selected for analysis from the Phyllite Slope and Sherbrooke Creek Rock Slope was determined based on the preliminary results, the estimated excavation volumes, and in consideration of the homogeneity of the rock types and analytical results. This is discussed further in the conclusions (Section 5.1.7).

The samples were submitted to the laboratory for acid-base accounting (ABA) analysis, whole rock metals analysis by inductively coupled plasma mass-spectrometry (ICP-MS), and shake flask extraction (SFE) analysis. These tests were completed by ALS Laboratories, at their testing facilities in North Vancouver, BC and Burnaby, BC.

ABA analysis was conducted to assess the potential for ARD to be produced. ABA analysis was conducted according to the methodologies presented in the MEND Prediction Manual (Price, 2009). Analysis includes whole rock paste pH, total sulphur and sulphide sulphur by LECO furnace, sulphate sulphur by HCl leach, neutralization potential by standard Sobek method (as outlined in the MEND Prediction Manual, from (Sobek, Schuller, Freeman, & Smith, 1978)), and fizz rating.

Total inorganic carbon was calculated from analytical results and total sulphur is used to calculate the maximum potential acidity (MPA). The net neutralization potential (NNP) was determined by subtracting the MPA from the Sobek NP. The Sobek NPR is the ratio of neutralization potential to the maximum potential acidity (Sobek NP:MPA). Carbonate NP is calculated from total inorganic carbon and used to calculate a carbonate NPR (Carbonate NP:MPA).

Many common rock forming minerals are capable of acid neutralization, but the reactions and reaction rates vary widely. The Sobek NP value includes contributions of NP from all sources in the rock, including carbonate minerals, aluminum and iron hydroxides, and oxides and silicate and aluminosilicate minerals. The Carbonate NP value includes contributions of NP only from carbonate minerals.

SFE analysis was completed to assess the potential for metal leaching from samples using a 3:1 fluid:solid ratio with distilled water according to the MEND procedure (Price, 2009). Distilled water was used to represent neutral or alkaline drainage conditions as indicated by the ABA results.

5.1.3 ARD/ML Classification Methods

Results were analyzed and interpreted based on guidelines for ARD/ML characterization referenced in the MEND Prediction Manual (Price, 2009).

The MEND Prediction Manual states that a sample with a neutralization potential ratio (NPR) of less than one is classified as potentially acid generating (PAG) and as non-acid generating (NAG) if the NPR is greater than two. Material characterized by an NPR of between one and two is classified as Uncertain, and requires additional information to determine ARD potential.

Results of the SFE analysis were compared against the Canadian Council of Minister of the Environment (Canadian Council of Ministers of the Environment, 2015) guidelines for the protection of freshwater aquatic life and the British Columbia Approved and Working Water Quality Guidelines (BCAWQ) for the protection of freshwater aquatic life (Ministry of Environment, 2006). This comparison provides a useful scale for evaluating leachable metal concentrations. Concentrations above an order of magnitude greater than the guideline values require additional consideration or attention.

5.1.4 Acid Rock Drainage Analysis Results

The ABA results indicate that all 24 samples analyzed are classified as NAG based on a Sobek NPR ratio of greater than two. A summary of the ARD classification for each of the rock types identified in the field and sampled is provided in Table 5-4.

Table 5-4: Summary of ARD Classification for Samples Analyzed

Material Type	ARD Classification – Number of Samples			ARD Classification
	PAG	NAG	Uncertain	
Sherbrooke Creek Rock Slope				
Carbonaceous Siltstone	-	7	-	NAG
Carbonaceous Siltstone (foliated)	-	3	-	NAG
Limestone	-	3	-	NAG
Phyllite Slope				
Phyllite	-	5	-	NAG
Calcite (Vein)	-	1	-	NAG
Other Rock Slopes				
Quartzite	-	2	-	NAG
Shale	-	2	-	NAG
Cherty Shale	-	1	-	NAG
Total	**-**	**9**	**-**	

Samples from the Sherbrooke Creek Rock Slope have NPR values ranging from 68.64 to 6611, with a median value of 723. Samples from the Phyllite Slope have NPR values ranging from 38.4 to 92.34 (phyllite samples; calcite vein NPR=2854), with a median value of 60.8. Samples from the other rock slopes range from 19.2 to 1312, with a median value of 32.21.

The classification of the materials is consistent across all rock types, however the different rock types encountered in the sampling vary in their composition of acid producing and neutralizing minerals. Two samples can have very similar NPR ratios with vastly different amounts of NP and MPA. For example, samples T15-R04 and TT15-R09 both have an NPR ratio of 38.4, but the measured Sobek NP in the TT15-R09 slate sample is 12 times higher than it is in the TT15-R04 quartzite sample. This is balanced in the ratio by a measurement of sulphide sulphur below the detection limit of testing in the quartzite sample and at 0.05 S% in the slate sample.

The carbonaceous siltstone, limestone, phyllite and shale/slate material all show high levels of measured Sobek NP. The Sobek NP value for carbonaceous siltstone samples ranges from 113 to 991 kg CaCO3/tonne, with a median value of 760 kg CaCO3/tonne. For the limestone samples, the Sobek NP ranges from 846 to 1040 kg CaCO3/tonne, with a median value of 1035 kg CaCO3/tonne. The phyllite samples have comparably lower Sobek NP values, ranging from 70 to 400 kg CaCO3/tonne, with a median value of 238 kg CaCO3/tonne.

The similarity between measured Sobek NP and calculated Carbonate NP values indicate that the majority of the measured Sobek NP is provided by carbonate minerals, with a smaller component of NP provided by other undefined minerals, which are likely silicates. Measured NP in the quartzite samples from Dustin's slide rock slope is low (3-6 kg CaCO3/tonne).

Sulphide sulphur content in the samples is below the detection limit of testing in both quartzite samples. The sulphide sulphur content in the carbonaceous siltstone samples varies from less than the detection limit of testing at 0.01 S% up to 0.14 S% in sample YNP15-17, and with a median value of 0.04 S%. The sulphide sulphur content in limestone samples is 0.01 S% in samples TT15-R03 and YNP15-20, and 0.35 S% in sample YNP15-15 (also the only sample with sulphides noted in hand sample). The sulphide sulphur content in the phyllite samples ranges from 0.03 S% to 0.15 S%, with a median value of 0.09 S%. The sulphur balance indicates that the majority of total sulphur measured in the samples is in the form of sulphide sulphur. A small component of sulphate sulphur is also present.

The paste pH values measured in the ABA analysis indicate alkaline or neutral conditions in the rock samples at the time of testing. This is consistent with the results of pH analysis from the SFE analysis also indicating alkaline or neutral conditions at the time of testing.

A detailed summary of the all measured parameters provided by the laboratory is provided in Table E1 and in lab certificates included in Appendix E. Table 5-5, Table 5-6, and Table 5-7 provides a summary of the key parameters considered in the evaluation of the NPR ratio used in the ARD sample classification.

Table 5-5: Summary of ABA Parameters (Sherbrooke Creek Rock Slope)

Lab Reported Values								Calculated Values	
Sample ID	Inorganic Carbon, C %	Inorganic Carbon, CO_2 %	Total Sulphur, S%	Sulphide Sulphur, S%	Maximum Potential Acidity (MPA) (kg CaCO3/tonne)	Sobek NP (kg CaCO3/tonne)	Sobek NPR (NP:MPA)	Carbonate NP[1] (kg CaCO3/tonne)	Carbonate NPR[1] (Carbonate NP:MPA)
TT15-R01	9.51	34.9	0.08	0.1	2.5	795	318	794	317
TT15-R02	10	36.7	0.06	0.06	1.9	830	442.7	835	439
TT15-R03	12.3	45.1	<0.01	0.01	<0.3	1035	6611	1026	6838
YNP15-10	11.7	42.9	0.01	<0.01	0.3	988	3162	976	3252
YNP15-12	11.75	43	0.01	<0.01	0.3	991	3171	978	3260
YNP15-13	2.15	7.9	<0.01	<0.01	<0.3	207	1325	180	1198
YNP15-14	5.7	20.9	0.09	0.06	2.8	468	166.4	475	170
YNP15-15	10.25	37.5	0.4	0.35	12.5	858	68.64	853	68
YNP15-16	8.77	32.1	0.12	0.09	3.8	730	194.65	730	192
YNP15-17	4.5	16.5	0.17	0.14	5.3	387	72.85	375	71
YNP15-19	11.8	43.3	0.01	<0.01	0.3	989	3165	985	3283
YNP15-20	12.65	46.3	0.01	0.01	0.3	1040	3328	1053	3510
YNP15-23	0.92	3.4	<0.01	<0.01	<0.3	113	723.2	77	515

[1]A value of 1/2 of the detection limit of testing was used in the calculation of the Carbonate NP and Carbonate NPR, where necessary.

Table 5-6: Summary of ABA Parameters (Phyllite Slope)

Lab Reported Values								Calculated Values	
Sample ID	Inorganic Carbon, C %	Inorganic Carbon, CO_2 %	Total Sulphur, S%	Sulphide Sulphur, S%	Maximum Potential Acidity (MPA) (kg CaCO3/tonne)	Sobek NP (kg CaCO3/tonne)	Sobek NPR (NP:MPA)	Carbonate NP[1] (kg CaCO3/tonne)	Carbonate NPR[1] (Carbonate NP:MPA)
TT15-R09	0.79	2.9	0.06	0.05	1.9	72	38.4	66	35
YNP15-01	1.03	3.8	0.05	0.03	1.6	95	60.8	86	54
YNP15-03	2.91	10.7	0.18	0.15	5.6	244	43.38	243	43
YNP15-05	4.82	17.7	0.14	0.11	4.4	404	92.34	403	91
YNP15-07	3.1	11.4	0.1	0.09	3.1	269	86.08	259	84
YNP15-08	5.49	20.1	<0.01	<0.01	<0.3	446	2854	457	3048

[1]A value of 1/2 of the detection limit of testing was used in the calculation of the Carbonate NP and Carbonate NPR, where necessary.

Table 5-7: Summary of ABA Parameters (Other rock slopes)

Lab Reported Values								Calculated Values	
Sample ID	Inorganic Carbon, C %	Inorganic Carbon, CO_2 %	Total Sulphur, S%	Sulphide Sulphur, S%	Maximum Potential Acidity (MPA) (kg CaCO3/tonne)	Sobek NP (kg CaCO3/tonne)	Sobek NPR (NP:MPA)	Carbonate NP[1] (kg CaCO3/tonne)	Carbonate NPR[1] (Carbonate NP:MPA)
TT15-R04	<0.05	<0.2	<0.01	<0.01	<0.3	6	38.4	2	15
TT15-R05	<0.05	<0.2	<0.01	<0.01	<0.3	3	19.2	2	15
TT15-R06	1.33	4.9	0.19	0.12	5.9	145	24.42	111	19
TT15-R07	1.77	6.5	0.15	0.13	4.7	151	32.21	148	31
TT15-R08	10.05	36.9	0.02	0.02	0.6	820	1312	839	1399

[1]A value of 1/2 of the detection limit of testing was used in the calculation of the Carbonate NP and Carbonate NPR, where necessary.

5.1.5 Whole Rock Metal Results

The results of the solid phase metal analysis were compared to the average crustal abundance for individual elements to assess the presence of elevated metals concentrations, as recommended by the MEND Prediction Manual (Price, 2009). This comparison is meant as guidance, and some element concentrations are naturally elevated relative to average crustal abundance. The whole rock metals results and comparisons to crustal abundance are presented in the appended Table E2a, Table E2b, and Table E2c (Appendix E), and lab certificates for the results are provided in Appendix E.

Concentrations of various metals are noted above crustal abundance in many of the samples, but generally below an order of magnitude greater. Calcium concentrations are typically highest in the carbonaceous siltstones and limestones from the Sherbrooke Creek Rock Slope, ranging from 4.08% to 39%, with a median value of 24.8%. By comparison the phyllite material from the Phyllite slope has concentrations of calcium which range from 2.68% to 17.2%, with a median value of 8.8%. This is consistent with the higher neutralization potential values noted in the ABA results for the Sherbrooke Creek Rock Slope samples. Sulphur values also correlate well with the ABA results. The highest sulphur content in both tests is noted in sample YNP15-15, with a value of 0.46 ppm in the whole rock metals analysis.

Concentrations of selenium are frequently noted at concentrations which are more than 10 times greater than the average crustal abundance. This is a function of reporting limits in the testing and frequently seen on multiple projects. The lower detection limit (LDL) of testing for selenium in the selected analysis package is 1ppm, and the precision at the LDL is ±1ppm.

5.1.6 Metal Leaching Results

Results of the SFE analysis and comparisons against the BCAWQ and CCME guideline values is provided in the appended Table E3a and Table E3b (Appendix E), and lab certificates for the results are provided in Appendix E.

Concentrations of leachable aluminium were measured at levels within an order of magnitude above the CCME guideline value in all samples except for TT15-R03, which has a concentration of leachable aluminum below the detection limit of testing. Samples TT15-R04 and TT15-R05 have measured concentrations of iron and lead at levels within an order of magnitude greater than the CCME value. The concentration of arsenic in sample TT15-R05 is measured within an order of magnitude greater than the CCME value.

The results of the shake flask extraction analysis indicate that the dominant leachable elements present are aluminum, calcium, magnesium, potassium, silicon and sodium. CCME does not provide guidelines for the protection of freshwater aquatic for these elements with the exception of aluminum, as noted above.

6.0 GEOTECHNICAL CHARACTERIZATION

All soils encountered during the geotechnical characterization program were logged in general accordance to with Tetra Tech EBA Method 4400 (which is generally consistent with ASTM D2488), by visual inspection of the hand-excavated material, and during the testpitting program the excavation walls, and sampling from the excavator bucket (when entry into the excavation was no longer safe).

Estimates of soil consistency were determined from observation of excavation difficulty and visual classification of recovered samples. The distribution of grain size within sample materials is based on an estimate of the percentage of the total volume of soil excavated. These estimates are based on engineering judgement and are subjective. Representative samples were collected from excavations as required. Samples were collected as grab bag samples and are therefore disturbed. Samples were sent to Tetra Tech EBA's geotechnical soil testing lab in Calgary for geotechnical index testing, and to the Tetra Tech EBA soil testing laboratory in Edmonton and Golders Associates laboratory in Calgary for advanced geotechnical testing.

An Apple iPad equipped with GPS, and a handheld Garmin GPS were used to survey and photograph test locations and points of interest relative to the soil slopes. The device's ability to receive a satellite signal can be impeded near steep slopes or areas of high vegetation density; therefore, the locations of the test locations and points of interest should be considered accurate to ±10 m.

6.1 Preliminary Site Reconnaissance

A preliminary site reconnaissance of the soil slopes above and adjacent to the proposed rock cuts was completed by Mr. Paul Kilkenny, P. Geo. of Tetra Tech EBA. This involved traversing the crest and upper slopes of the proposed rock cuts to document slope observations, soil conditions, and visible slope features.

Due to project scheduling requirements, the preliminary site reconnaissance was carried out from January 27 to January 29, 2015. The information retrieved was limited due to the winter conditions encountered. During this time, snow cover over the slopes was significant and obscured significant slope features. In addition to the snow cover, the hand auger test holes encountered refusal within the upper 2 m, which has been assumed to be either frozen ground or shallow bedrock. No field vanes were carried out due to limited thickness of fine-grained materials above the assumed shallow bedrock surface.

Table 6.1 presented in Appendix F outlines the observations recorded during the preliminary site reconnaissance exploration, and samples were retrieved and submitted for index testing. The results of the geotechnical testing are presented in Appendix F.

6.2 Additional Site Reconnaissance

An additional geotechnical site reconnaissance of the Sherbrooke Soil Slope, Dustin's Slide, and Throughcut Slope was completed by Mr. Paul Kilkenny, P. Geo., and Ms. Robyn Barnett, E.I., of Tetra Tech EBA in June 2015. This involved traversing the crest and upper slopes of the cuts to document geotechnical soil slope observations, soil conditions, visible slope features, and retrieve disturbed grab soil samples. Hand auger and shovel excavated testholes were drilled to retrieve the soil samples. The materials encountered were documented.

Table 6.2 presented in Appendix F outlines observations recorded during the additional site reconnaissance exploration. Soil samples retrieved during the additional site reconnaissance were submitted for index advanced geotechnical testing and the results of the geotechnical testing are presented in Appendix F.

6.3 Sherbrooke Testpit Program

The testpit program was carried out at Sherbrooke Soil Slope in October 2015 using a Hitachi Zaxis 250lc excavator equipped with a hydraulic thumb. Tetra Tech EBA's personnel were present during excavation to identify testpit locations, observe the excavation, log and take photos of the testpits and excavated material, and collect select samples for laboratory testing. Testpits were typically excavated to refusal, or where the equipment limitations were reached (full boom length, etc.). All testpits were backfilled with the excavated materials and were bucket compacted.

The testpit locations were surveyed using a handheld Garmin GPS device. The locations are presented in Table 6-3 below and are shown in Figure TBC. The testpit logs, photographs, and laboratory test results are provided in Appendix F.

Table 6-3: Sherbrooke Testpit Locations

Testpit	Easting (1)	Northing(1)	Final Depth (2) (m)	Comments
TP15-01	544666	5698857	0.9	Hand-dug testpit in borrow pit at km 87+150. Predominately fine to coarse compact sandy gravel.
TP15-02	543668	5698588	2.8	Testpits excavated at the toe of the slope. The material excavated was predominately fine to coarse loose gravel, with cobbles and boulders. Testpit terminated due to unstable excavation walls excavator
TP15-03	543733	5698581	2.9	
TP15-04	543545	5698614	2.4	

Note:

(1) Northing and Easting coordinates are provided in UTM coordinates from a handheld GPS device.

(2) Final depth is depth of material excavated.

6.4 Sherbrooke Geophysical Program

As part geotechnical exploration program there was a requirement to identify the overburden thickness / bedrock depth and piezometric surface (if present) within the overburden soils at Sherbrooke Soil Slope. Three geophysical techniques were used to achieve this objective;

- Seismic Refraction;
- Multi Array Surface Wave Analysis (MASW), and
- Electrical Resistivity Tomography (ERT).

Seismic refraction was chosen to determine the depth to bedrock and was not expected to reliably detect the presence of water under the anticipated soil conditions, so an additional technique of ERT was used for this purpose. The MASW method was a processing technique applied to the seismic refraction data to extract shear wave velocity parameters from the surficial soils and confirm the interpreted seismic refraction model.

The survey lines start in the north roadside ditch, adjacent to the westbound lane, and extend northwards up Sherbrooke Slope. The geophysical survey locations are shown in Figure GP01 and survey methodologies are presented in Appendix F.

6.5 Through Cut Undisturbed Block Sampling Program

An undisturbed block sampling program was carried out on material in the Through Cut slopes. The program was carried out to retrieve undisturbed block samples that could be used to prepare and test samples in a triaxial cell.

The undisturbed block sample locations are presented in Table 6-4.

Table 6-4: Summary of Through Cut Undisturbed Block Samples

Testpit	Easting (1)	Northing(1)	Comments
TCH15-UD01	528021	5680096	Undisturbed block sample on Throughcut (right) slope. Silty Gravel, with cobbles; fine to coarse grained, subangular, non-plastic fines, yellow brown, dry, cobbles up to 150 mm in diameter
TCH15-UD02	528073	5680108	Undisturbed block sample on Throughcut (left) slope. Silty Gravel, with cobbles; fine to coarse grained, angular to subangular, non-plastic fines, brown to yellow brown, dry, cobbles up to 170 mm in diameter
TCH15-UD03	528014	5680080	Undisturbed block sample on Throughcut (left) slope. Silty Gravel, with cobbles; fine to coarse grained, angular to subangular, non-plastic fines, brown to yellow brown, dry
TCH15-UD04	528069	5680021	Undisturbed block sample on Throughcut (right) slope. Silty Gravel, with cobbles; fine to coarse grained, angular to subangular, non-plastic fines, brown to yellow brown, dry

Note:

(1) Northing and Easting coordinates are provided in UTM coordinates from a handheld GPS device.

6.6 Geotechnical Laboratory Testing Program

The majority of laboratory tests were performed on transported soil samples at Tetra Tech EBA's laboratory in Calgary. Advanced Geotechnical Laboratory testing was performed in Tetra Tech EBA's laboratory in Edmonton and at Golder Associates Ltd. (Golder) laboratory in Calgary.

Laboratory tests were performed on grab soil samples collected during the preliminary site reconnaissance and site exploration, and on undisturbed soil samples collected during the Throughcut box sampling program. Table 6-5 summarizes the laboratory tests performed on samples retrieved.

Table 6-5: Summary of Laboratory Tests

Description	ASTM Standard	Laboratory	No. of Tests
Water Content	ASTM D2216	Tetra Tech EBA, Calgary	2
Atterberg Limits	ASTM D4318	Tetra Tech EBA, Calgary	4
Unit Weight	ASTM D4254	Golder Associates, Calgary	4
Particle Size Analysis (Sieve)	ASTM C136 / C117	Tetra Tech EBA, Calgary	3
Particle Size Analysis (Hydrometer)	ASTM D422	Tetra Tech EBA, Calgary	4
		Golder Associates, Calgary	4
Direct Shear	ASTM D3080	Tetra Tech EBA, Edmonton	1
		Golder Associates, Calgary	8

The results of the laboratory testing is included in Appendix F.

7.0 STORAGE SITES

7.1 Takkakaw East

The eastern option for a storage site is located beside the TCH overpass of the Kicking Horse River and covers an area of ground previously disturbed to direct the river beneath the bridge. An embankment was constructed to confine the river to its current alignment, and this embankment would form the eastern limit of the storage site. The western limit would be defined by the Yoho Valley Road, and the northern and southern limits would likely be controlled by visual impact to Park visitors.

The site is generally hummocky, with surface elevation variations of approximately 1 m. Some mature trees exist to the north and south of a clearing, and careful placement and zoning of the site could avoid damage or removal of the trees.

The approximate area of this site is 9,500 m^2. In estimating this area, we have assumed that placed material will not encroach on the TCH fill slopes, and a 1 m to 2 m buffer will be maintained.

This storage site was not selected due to the LLYK's concerns about aesthetics.

7.2 Takkakaw West

The western Yoho Valley Road disposal site also appears to have been disturbed in the past, and the location of the existing TCH has separated this area from the Kicking Horse River alluvial plain to the east.

The area is typically hummocky, with a number of mature trees that can be left undamaged by forming the lateral limits of the storage site, also providing some visual protection from the highway. The benefits of using this site include the minimal visual impact on visitors to the nearby campsite, and parking of trailers for visitors to Takakkaw Falls.

The approximate area of this site is 19,000 m^2. In defining this area, we have assumed that placed material will not encroach on the TCH fill slopes, and a 1 m to 2 m buffer will be allotted.

This storage site was not selected due to the LLYK's concerns about aesthetics.

7.3 Old Rock Quarry at Sta. 121+560

The site is a large area located adjacent to the existing TCH, with existing access. The site typically consists of flat to undulating ground, with some saturated areas suggesting groundwater level close to the existing ground surface. The site appears to be an old quarry, with an approximately 30 m high vertical rock face forming the western limit of the site.

Mature trees located to the north are assumed to represent the northern limit to this storage site, and an area could be used for crushing activities as required during construction, making use of mature trees for visual protection from the TCH. This would also act to reduce dust generated during crushing from reaching the highway.

The approximate area of this storage site is 15,700 m^2. Some rock fall debris was observed close to the base of the large rock slope, and a buffer of 5 m was assumed to maintain a safety exclusion zone for temporary construction access. Similarly, in defining this area, we have assumed that placed material will not encroach on the TCH fill slopes, and a 1 m to 2 m buffer will be allowed.

This storage site was not selected due to the LLYK's concerns about aesthetics.

7.4 Mount Vaux Storage Site at Sta. 119+500

This area was identified from the desk study as a potential geohazard, associated with the debris fans located along the base of the mountain slopes along the eastern edge of the site. This site appears to have been recently logged, and the ground is hummocky with tree stumps typically 0.15 m to 0.2 m in diameter (0.5 m – 0.6 m girth). Remaining stumps suggest trees were previously burnt, with evidence of pine beetle damage in adjacent vegetated areas. One large Douglas fir tree (0.7 m diameter, 2.2 m girth) was observed in the centre of the cut block. The hummocky ground extends to within approximately 100 m of the highway at his location.

The site is accessed from a gravel road at Sta. 119+500. Based on the general terrain conditions and previous logging activities, this site is potentially suitable for storing surplus material, especially since a buffer of dense forest cover approximately 80 m wide separates the site from the highway.

While the area of the site is considerable, the debris fans located along the eastern edge of the site appear to be active based on site observations and our review of the available aerial imagery (Google Earth). Frequent debris flows (since 2010) and debris flood events have deposited onto these fans as a result of glacial melting and mass-wasting processes within the steep bedrock gullies which extend a considerable distance up the mountain slopes. In addition, the hummocky ground present across much of the site may indicate older and much larger debris flow events affecting this area. Considering these potential geohazards, it would be prudent to use only the western half of the site with an approximate area of 100,000 m^2 available for storage.

7.5 AB/BC Border

This area, located in Banff National Park, was originally used as a lay down area for the km 76 to km 82 TCH twinning project. The potential storage area is situated about 10 m back from the TCH road barriers and ditch and bounded by earthen berms on two sides. The other two boundaries would be formed by the animal proof fencing. The approximate area of this storage site is 9,800 m^2.

A median barrier dividing the TCH at this location would require trucks to continue to the Icefields Parkway interchange for a U-turn route. However, by removing the barriers and using flagging personnel, the turnaround times could be reduced.

8.0 POTENTIAL GEOHAZARD AREAS

8.1 Sta. 90+000 to 91+000 (Dustin's Slide/Spiral Tunnels Hill)

Talus patches were observed from the aerial imagery on the slopes upslope (south) of the highway above the CPR line, indicating the potential for localized rock fall onto the highway from high upslope. We understand from discussions with CPR staff that occasional small rock falls occur along this slope and that these events are typically contained by the railway embankment.

No boulders were observed from the ground reconnaissance of the forested slope separating the highway from the CPR line, although deep snow cover (about 1.2 m) at the time of the reconnaissance could have obscured the presence of smaller boulders on the ground surface. No other obvious evidence of rock fall events (e.g., tree damage) was observed.

Based on the available information, the potential for rock falls to affect the highway through this area is judged to be low, however additional reconnaissance of this area should be completed when the site is free of snow in order to confirm these findings.

8.2 Gullies at Sta. 90+685 and 90+800

Two gullies were observed during the ground reconnaissance to cross the highway near the entrance to the Spiral Tunnels look-out at Sta. 90+685 and Sta. 90+800. These gullies are up to 40 m wide and 10 m deep and are situated on moderately steep forested slopes. The gullies are generally devoid of mature vegetation and contain unsorted bouldery deposits with individual boulder sizes up to 8 m in diameter. Based on our preliminary review, the gullies likely represent relict debris flow or rock fall chutes which pre-date highway construction through this area. While no signs of recent activity were observed, further rock fall and geohazard assessment should be carried out to assess these features in more detail. This assessment should include review of available aerial photographs, LiDAR data and terrain mapping, as well as additional ground reconnaissance of the area when the site is free of snow. Depending on the results of this assessment, more detailed studies may be needed to characterize the hazards and corresponding risks to workers and future road users.

8.3 Sta. 91+200 to 91+300 (Spiral Tunnels Hill)

A large, active debris flow chute is present upslope of the highway at this location, which has required considerable maintenance work by CPR over the past several decades due to the frequent deposition of debris flow material onto the rail tracks. According to Jackson et al. (1989), most of the large debris flow events from this chute are associated with jökulhlaups (glacial outburst floods) from Cathedral Glacier. Most recently, a debris flow event occurred in the early summer of 2014, depositing approximately 6 m of debris onto the CP Main Line. Based on discussions with CPR maintenance crews, we understand the following:

- Following the event, CPR constructed a large catchment area upslope of the tracks, intended to retain material before it reaches the tracks. The dimensions and storage capacity of this catchment are unknown.
- CPR currently use slide fences equipped with remote sensors to notify the Rail Traffic Controller of track disruption associated with rock fall, debris flows, or rock fall events.

CPR's mitigation measures significantly reduce the potential for debris flows to affect the highway at this location; however, further geohazard assessment should be carried out to characterize the debris flow hazard and the associated risks to the highway in general conformance with Porter and Morgenstern (2013) and the CSA (2002) guidelines. This assessment should include the items listed above in Section 8.2, as well as discussions with CPR personnel to understand the nature of the debris flow hazard and the design criteria / storage capacity of the upslope catchment structure. Depending on the results of this assessment, it may be necessary to incorporate a safety berm, deepened/armoured ditch, or other measures into the highway design.

8.4 Sta. 114+150 (Finn Creek Crossing)

Finn Creek is located at Sta. 114+150, approximately 650 m east of the proposed through cut, and flows north into the Kicking Horse River where a large alluvial fan has formed. A recreational area is located along the southern bank of the Kicking Horse River adjacent to its confluence with Finn Creek. The creek crosses the highway at an angle of approximately 45°.

Downstream of the highway, the creek is 10 m wide bank to bank and incised 2 m to 3 m into alluvial sediments typically consisting of silty alluvial sands and gravels with occasional cobbles. The creek bed dips at 5° down river, and consists of coarse gravel with occasional cobbles up to 0.3 m in diameter. The banks are 60° to 70° and vegetated with mature trees, a number of which have fallen into the creek, suggesting ongoing erosion of the banks is occurring. Finn Creek is drained by twin 1 m diameter culverts under the TCH. The creek grade steepens to 15° approximately 10 m upstream of the culvert, and piled material nearby suggests that occasional maintenance work may be required to clear sediment and debris blocking the culvert inlets during periods of high flow.

Upstream of the highway, the creek is 15 m wide bank to bank and incised 2 m into the alluvial deposits, the banks are between 50° and 60° and the creek grade is about 5°. The creek bed generally comprises cobbles and small boulders up to about 0.6 m in diameter, although larger boulders up to 1 m diameter were observed further upstream. In addition, an old dry creek channel was observed to the east of the current channel, vegetated with mature trees (approximately 0.2 m in diameter).

Based on our site observations and review of the available aerial imagery, Finn Creek appears to have a high sediment transport potential and may be subject to debris flood events. Further assessment should be undertaken to characterize these hazards and to verify that the highway culverts are sized appropriately to convey sediment and debris under the design flow event. The scope of this additional assessment would be similar to that described in Section 8.3 above.

8.5 Sta. 115+500 to 116+500 (Big Topple/Little Topple/Mt. Vaux)

A number of small rock outcrops and bluffs exist upslope of the existing highway between Sta. 115+500 and 116+500, and isolated patches of talus were noted from the available aerial imagery. Through this area, there is a large ditch formed below the eastbound lane of the TCH where the highway is constructed on approximately 4 m of fill. No obvious signs of previous rock fall activity were observed immediately upslope of the highway or along the ditch.

As part of the ground reconnaissance, a traverse was completed to assess potential upslope rock fall source areas between approximately 116+160 and 116+450. The slopes in this area are generally vegetated with medium to densely spaced mature trees with an average slope angle of 35° to 40°. Rock bluffs were observed about 250 m above the existing TCH, comprising low RQD and highly foliated rock. Patches of talus were observed at the base of these bluffs to within 150 m of the highway, generally comprising small rock fragments due to the poor rock mass quality. No large boulders were identified. A number of small snow avalanche tracks were also observed at the base of the rock bluffs, rock bluffs, terminating approximately 50 m to 100 m further downslope. Damage and toppling of mature trees was observed within these tracks, some of which appeared quite recent (estimated to be less than 1 week old).

While no evidence of rock fall or snow avalanches was observed within approximately 150 m of the highway, the potential for these events to reach the TCH should be further assessed during construction with the removal of trees from the slope crest and migration of the rock cut back into the hill side.

8.6 Sta. 119+500 (Mount Vaux Storage Site)

Refer to Section 7.4 for additional information on potential geohazards at this location. Further assessment should be undertaken to characterize the debris flow / debris flood hazard at this site and the associated risks to developing this site for storage purposes. The scope of this additional assessment would be similar to that described in Section 8.3 above.

9.0 SUMMARY

In summary, various data was collected by Tetra Tech EBA to determine the ease of design for rock cuts along the TCH in YNP between km 88 to 91 and km 114 to 128. This was completed with two site visits, spanning two-weeks and 1 week respectively during which the rock slopes, soil slopes, and environmental aspects were investigated by various Tetra Tech EBA personnel.

Table 9-1 shows a summary of the rock mass properties collected while on site.

Table 9-1: Summary of Rock Mass Conditions

Station	Average Spacing (m)	Average RQD	Average Roughness (JRC)	Average Joint Condition ($JCON_{89}$)	Average GSI	Average RMR_{89}
88+500 to 89+090	1.15	75	11	24	65	75
89+160 to 89+420	0.66	78	9	25	63	74
89+540 to 90+900	*0.34*	*52*	*12*	*23*	*54*	*61*
114+800 to 115+200	0.67	76	10	24	59	77
114+860 to 115+100	0.58	66	11	24	54	75
115+650 to 115+860	1.09	78	13	25	55	73
115+380 to 115+580	1.99	70	15	22	53	68
124+270 to 124+670	0.12	1	6	21	24	47
116+160 to 117+200	1.20	76	13	25	65	75
123+800 to 123+900	0.36	66	7	21	51	62
123+100 to 123+400	0.47	45	9	24	48	60
125+810 to 125+930	0.54	52	10	23	45	60
Overall Average	0.84	70	11	24	57	72

Nine samples were collected to determine the geochemical characterization of the rock. Results from this testing is summarized below:

- Samples tested from the project area are classified as NAG with low concentrations of leachable metals.
- It is anticipated that low leachable metal concentrations in potential leachate generated around excavation areas would be minimized by dilution upon contact with a water receptor or precipitation.
- Additional testing will be required during excavation of rock cuts along the alignment to satisfy the MEND Prediction Manual guidelines.

Soil Conditions encountered while on site consist of:

- km 88 to km 91 generally comprised of topsoil, underlain by shallow bedrock;
- km 114 to km 128 comprised of a topsoil layer, underlain by a gravelly silt layer, underlain by bedrock; and
- There is some occurrences of a thin clay layer interlayered between the topsoil and silt layers towards the end of km 114 to km 128.

Geohazards were identified from a desk study using Google Earth and were also investigated during the site visit. Further study is recommended for the following sites:

- Gullies at Sta. 90+685 and 90+800;
- Sta. 91+200 to 91+300 (Spiral Tunnels Hill);
- Sta. 114+150 (Finn Creek Crossing); and
- Sta. 115+500 to 116+500 (Big Topple/Little Topple/Mt. Vaux).

10.0 CLOSURE

We trust this report meets your present requirements. If you have any questions or comments, please contact the undersigned.

Respectfully submitted,
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CK/SK/SM/AF/tak

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ASTM C136. Standard Test Method for Sieve Analysis of Fine and Coarse Aggregates.

ASTM D422. Standard Test Method for Particle-Size Analysis of Soils.

ASTM D2216. Standard Test Methods for Laboratory Determination of Water (Moisture) Content of Soil and Rock by Mass.

ASTM D2487. Standard Practice for Classification of Soils for Engineering Purposes (United Soil Classification System)

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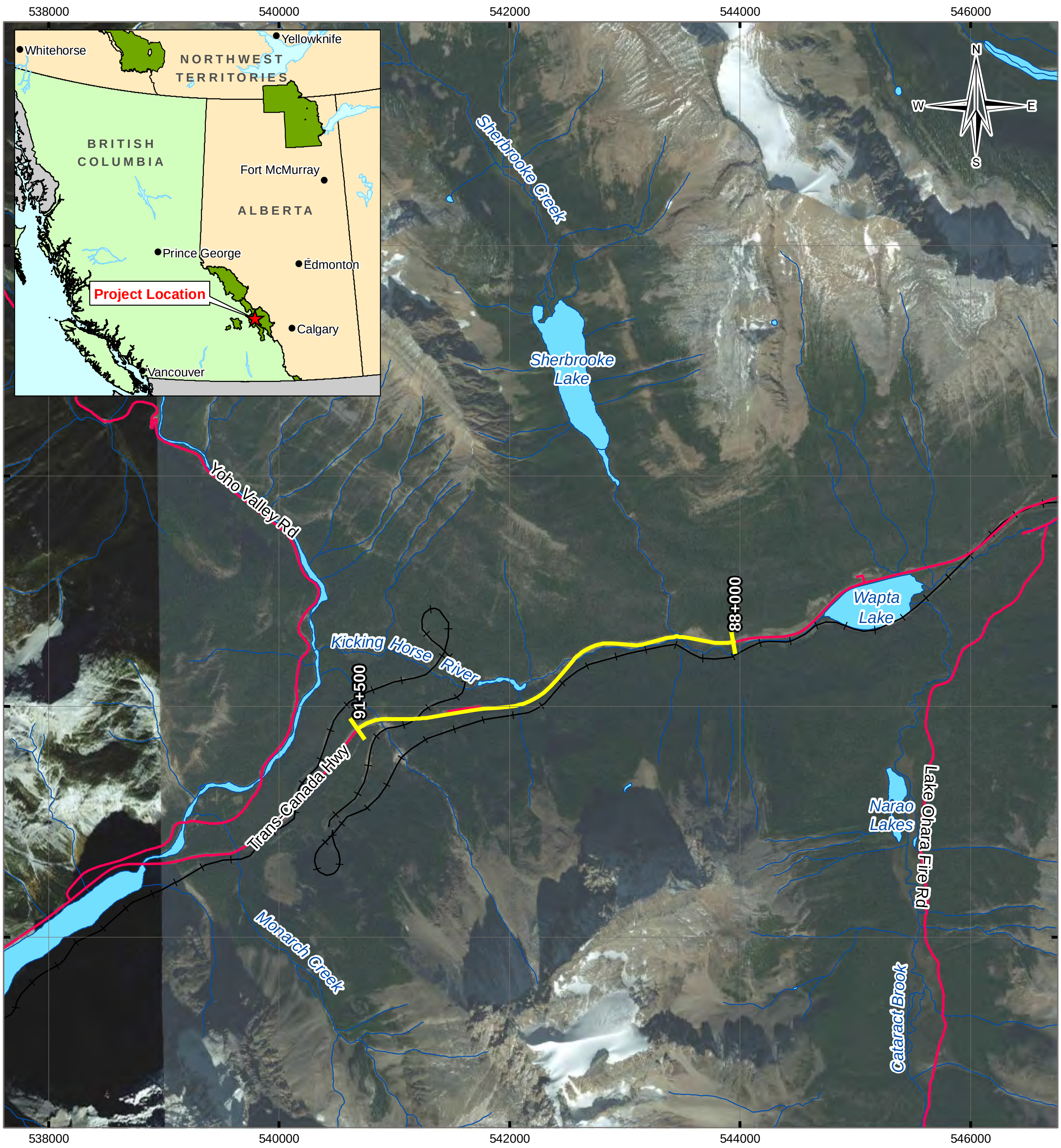
FIGURES



LEGEND

- Study Area
- Road
- Railway
- Watercourse
- Waterbody

NOTES
Base data source:
CanVec 1:50,000
Imagery from ESRI; DigitalGlobe (2012)

STATUS
ISSUED FOR USE

YNP TCH SLOPE REPROFILING

Site Location Plan

PROJECTION	DATUM	CLIENT
UTM Zone 11	NAD83	Parks Canada / Parcs Canada

Scale: 1:50,000
1 0.5 0 1
Kilometres

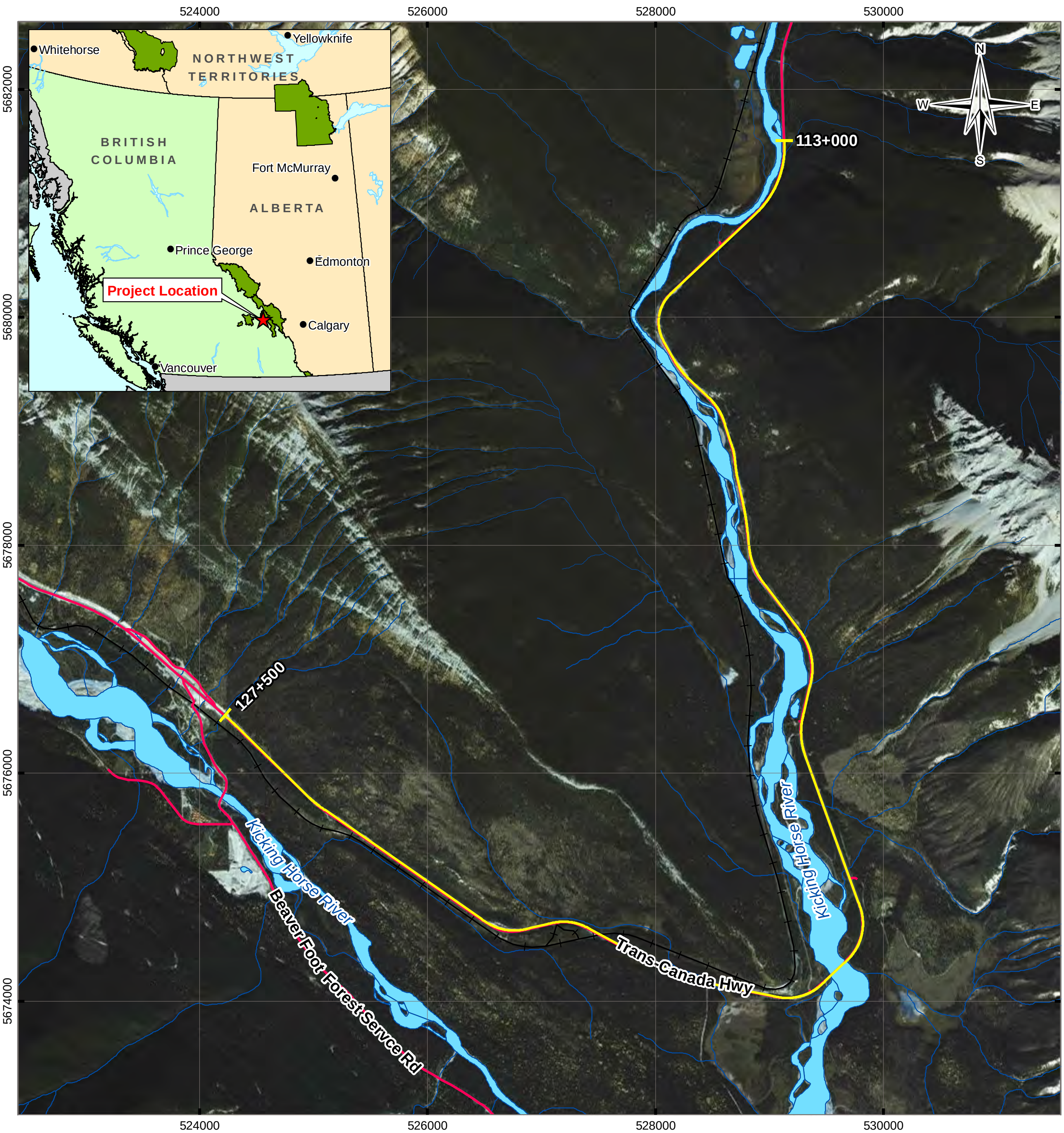
TETRA TECH EBA

FILE NO.
V13403095_01_Figure01a_SiteLocation.mxd

PROJECT NO.	DWN	CKD	APVD	REV
V13403095/96-01	MEZ	SL	SM	0

OFFICE	DATE
Tt EBA-VANC	February 18, 2015

Figure 1a



LEGEND

- Study Area
- Road
- Railway
- Watercourse
- Waterbody

NOTES
Base data source:
CanVec 1:50,000
Imagery from ESRI; DigitalGlobe (2010)

STATUS
ISSUED FOR USE

YNP TCH SLOPE REPROFILING

Site Location Plan

PROJECTION	DATUM	CLIENT
UTM Zone 11	NAD83	Parks Canada / Parcs Canada

Scale: 1:50,000
1 0.5 0 1
Kilometres

TETRA TECH EBA

FILE NO.
V13403096_01_Figure01b_SiteLocation.mxd

PROJECT NO.	DWN	CKD	APVD	REV
V13403095/96-01	MEZ	SL	SM	0

OFFICE	DATE
Tt EBA-VANC	February 18, 2015

Figure 1b

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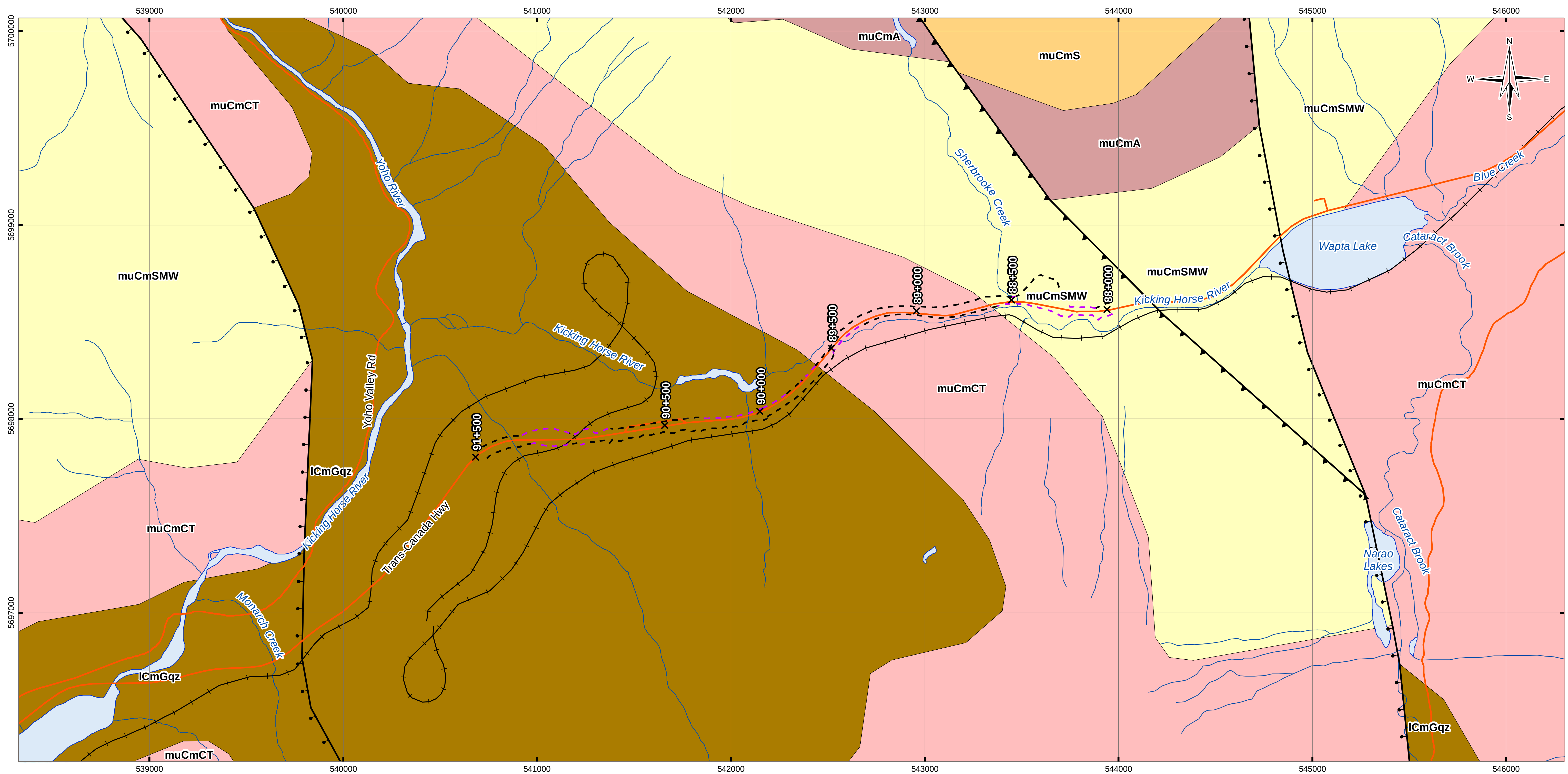

LEGEND

- ✕ Kilometre Marker
- Cut Slope
- Fill Slope
- Road
- Railway
- Watercourse
- Waterbody

Fault Type

- Normal Fault
- Thrust

Stratigraphic Unit

- lCmGqz - Paleozoic - Gog Group quartzite, quartz arenite sedimentary rocks
- muCmA - Paleozoic - Arctomys, Waterfowl Formations coarse clastic sedimentary rocks
- muCmCT - Paleozoic - Cathedral, Tanglefoot, Elko, Gordon Formations limestone, slate, siltstone, argillite
- muCmS - Paleozoic - Sullivan Formation mudstone, siltstone, shale fine clastic sedimentary rocks
- muCmSMW - Paleozoic - Stephen and Mount White Formations mudstone, siltstone, shale fine clastic sedimentary rocks

NOTES

Base data source: CanVec 1:50,000; Digital Geology Map of BC (Release 1.0, January 2005).

STATUS
ISSUED FOR USE

YNP TCH SLOPE REPROFILING

Bedrock Geology

PROJECTION	DATUM	CLIENT
UTM Zone 11	NAD83	Parks Canada / Parcs Canada

Scale: 1:20,000

400 200 0 400

Metres

TETRA TECH EBA

FILE NO.
V13403095-01_Figure02a_BedrockGeo.mxd

PROJECT NO.	DWN	CKD	APVD	REV
V13403095/96-01	SL	MEZ	SM	0

OFFICE	DATE
Tt EBA-VANC	February 18, 2015

Figure 2a

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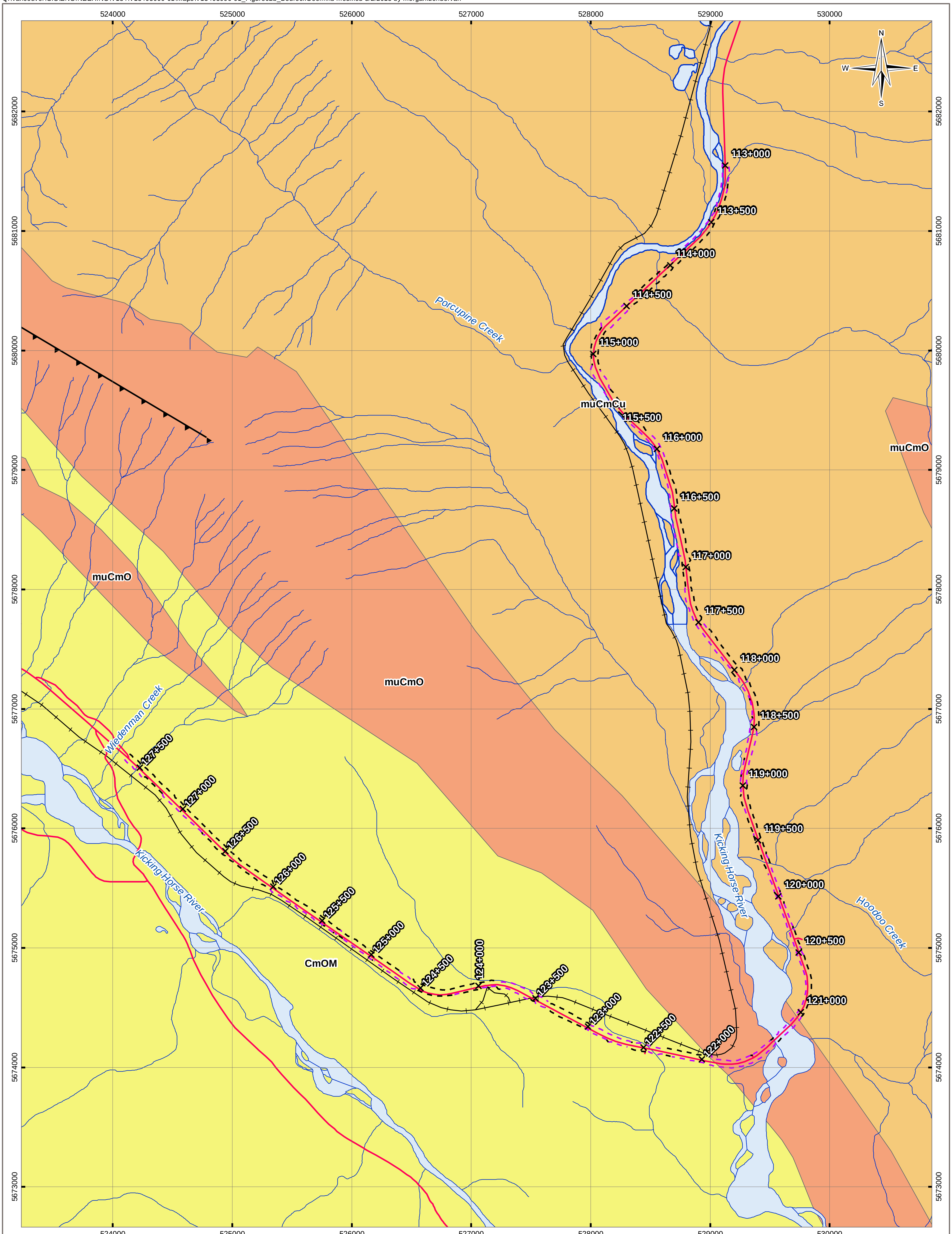


LEGEND

- ✕ Kilometre Marker
- Cut Slope
- Fill Slope
- Road
- Railway
- Watercourse
- Waterbody

Fault Type

- Thrust

Stratigraphic Unit

- CmOM - Paleozoic - McKay Group mudstone, siltstone, shale fine clastic sedimentary rocks
- muCmCu - Paleozoic - Chancellor Formation (Upper) limestone, slate, siltstone, argillite
- muCmO - Paleozoic - Ottertail Formation dolomitic carbonate rocks

NOTES
Base data source: CanVec 1:50,000; Digital Geology Map of BC (Release 1.0, January 2005).

STATUS
ISSUED FOR USE

YNP TCH SLOPE REPROFILING

Bedrock Geology

PROJECTION	DATUM	CLIENT
UTM Zone 11	NAD83	Parks Canada / Parcs Canada

Scale: 1:30,000
500 250 0 500
Metres

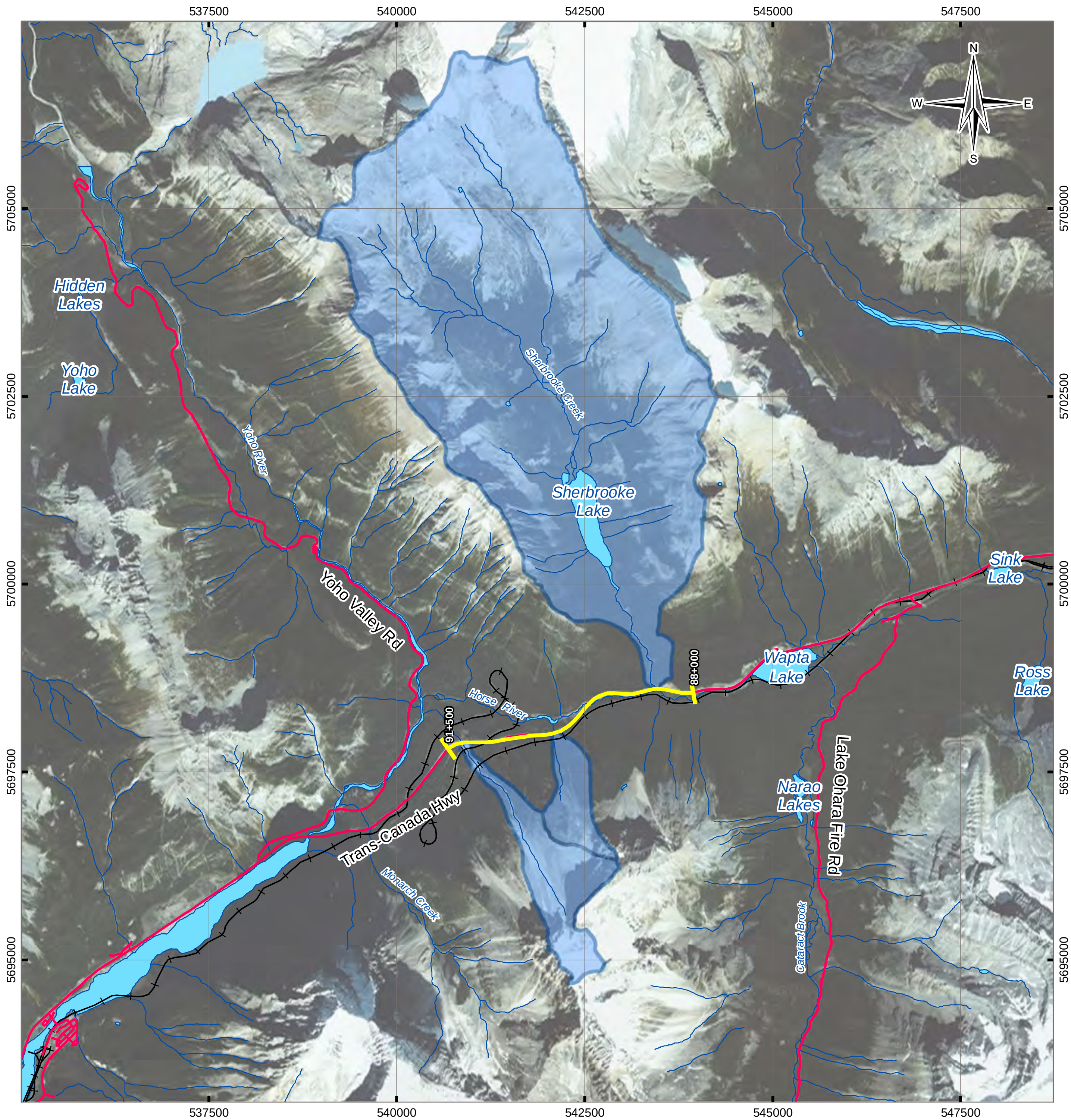
TETRA TECH EBA

FILE NO.
V13403096-01_Figure02b_BedrockGeo.mxd

PROJECT NO.	DWN	CKD	APVD	REV
V13403095/96-01	SL	MEZ	SM	0

OFFICE	DATE
Tt EBA-VANC	February 18, 2015

Figure 2b



LEGEND

- Study Area
- Watersheds for Km 88-91
- Road
- Railway
- Watercourse
- Waterbody

NOTES
Base data source:
CanVec 1:50,000
Imagery from ESRI; DigitalGlobe (2012)

STATUS
ISSUED FOR USE

YNP TCH SLOPE REPROFILING KM 88-91

Watersheds

PROJECTION	DATUM	CLIENT
UTM Zone 11	NAD83	Parks Canada / Parcs Canada

Scale: 1:75,000
1.25 0.625 0 1.25
Kilometres

TETRA TECH EBA

FILE NO.
V13403095_01_Figure03_Watersheds.mxd

PROJECT NO.	DWN	CKD	APVD	REV
V13403095-01	YL	MEZ	SM	0

OFFICE	DATE
Tt EBA-VANC	February 27, 2015

Figure 3a

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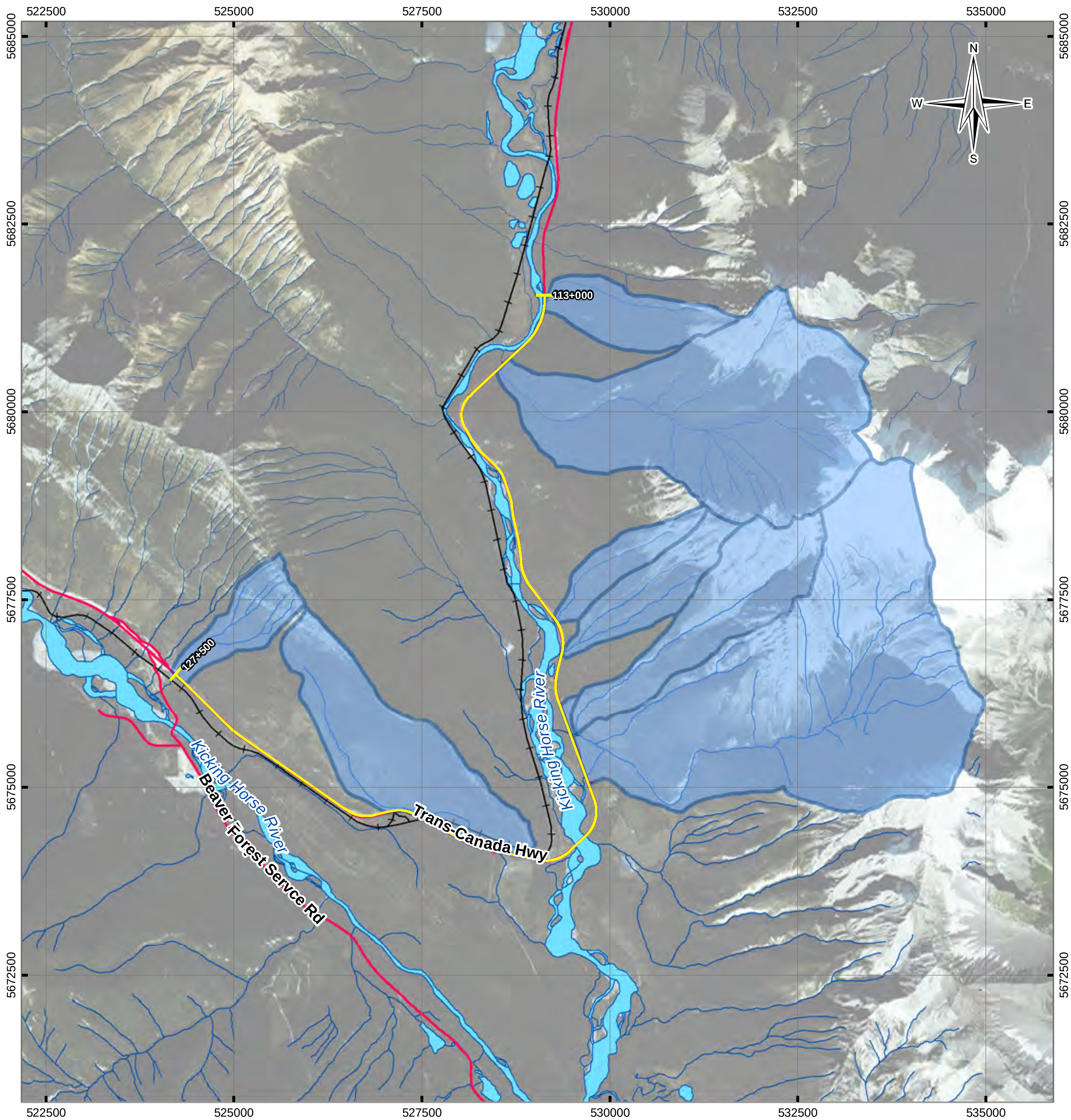

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LEGEND

- Study Area
- Watersheds for Km 114-128
- Road
- Railway
- Watercourse
- Waterbody

NOTES
Base data source:
CanVec 1:50,000
Imagery from ESRI; DigitalGlobe (2010)

STATUS
ISSUED FOR USE

YNP TCH SLOPE REPROFILING KM 114-128

Watersheds

PROJECTION	DATUM	CLIENT
UTM Zone 11	NAD83	Parks Canada / Parcs Canada

Scale: 1:75,000
1 0.5 0 1
Kilometres

TETRA TECH EBA

FILE NO.
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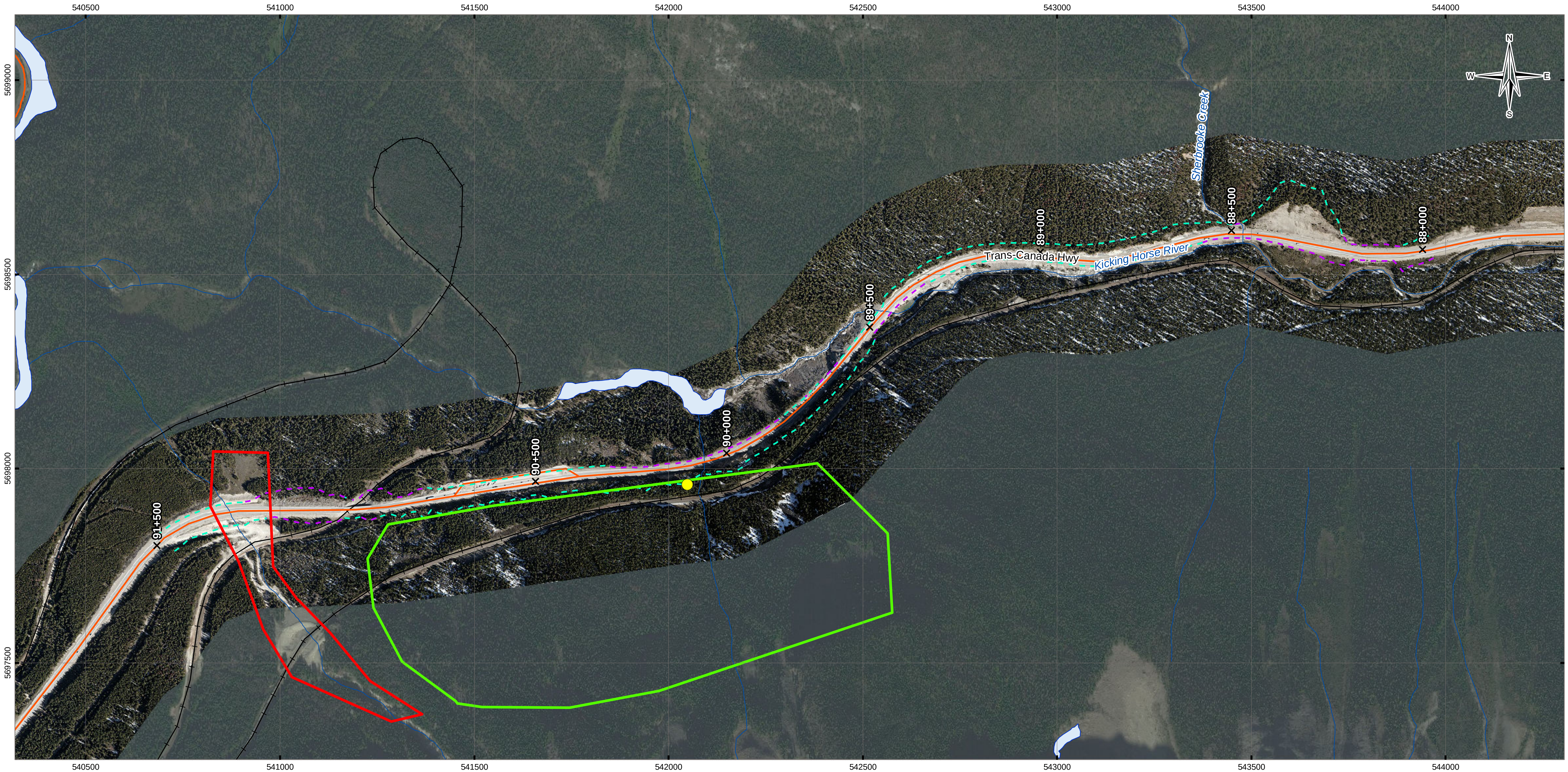
PROJECT NO.	DWN	CKD	APVD	REV
V13403096-01	YL	MEZ	SM	0

OFFICE	DATE
Tt EBA-VANC	February 27, 2015

Figure 3b



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LEGEND

- Mammal Den
- Kilometre Marker
- Cut Slope
- Fill Slope
- Railway
- Road
- Watercourse
- Waterbody

Geohazards

- Sta. 90+000 to 91+000 - Localized Rock Fall
- Sta. 91+200 - Debris Flow Potential

NOTES
Base data source:
CanVec 1:50,000
Imagery from Parks Canada and
ESRI; DigitalGlobe (2012)

STATUS
ISSUED FOR USE

YNP TCH SLOPE REPROFILING

Geohazards

PROJECTION	DATUM	CLIENT
UTM Zone 11	NAD83	Parks Canada / Parcs Canada

Scale: 1:10,000
200 100 0 200
Metres

TETRA TECH EBA

FILE NO.
V13403095-01_Figure04a_Geohazard.mxd

PROJECT NO.	DWN	CKD	APVD	REV
V13403095/96-01	MEZ	SL	SM	0

OFFICE	DATE
Tt EBA-VANC	March 2, 2015

Figure 4a

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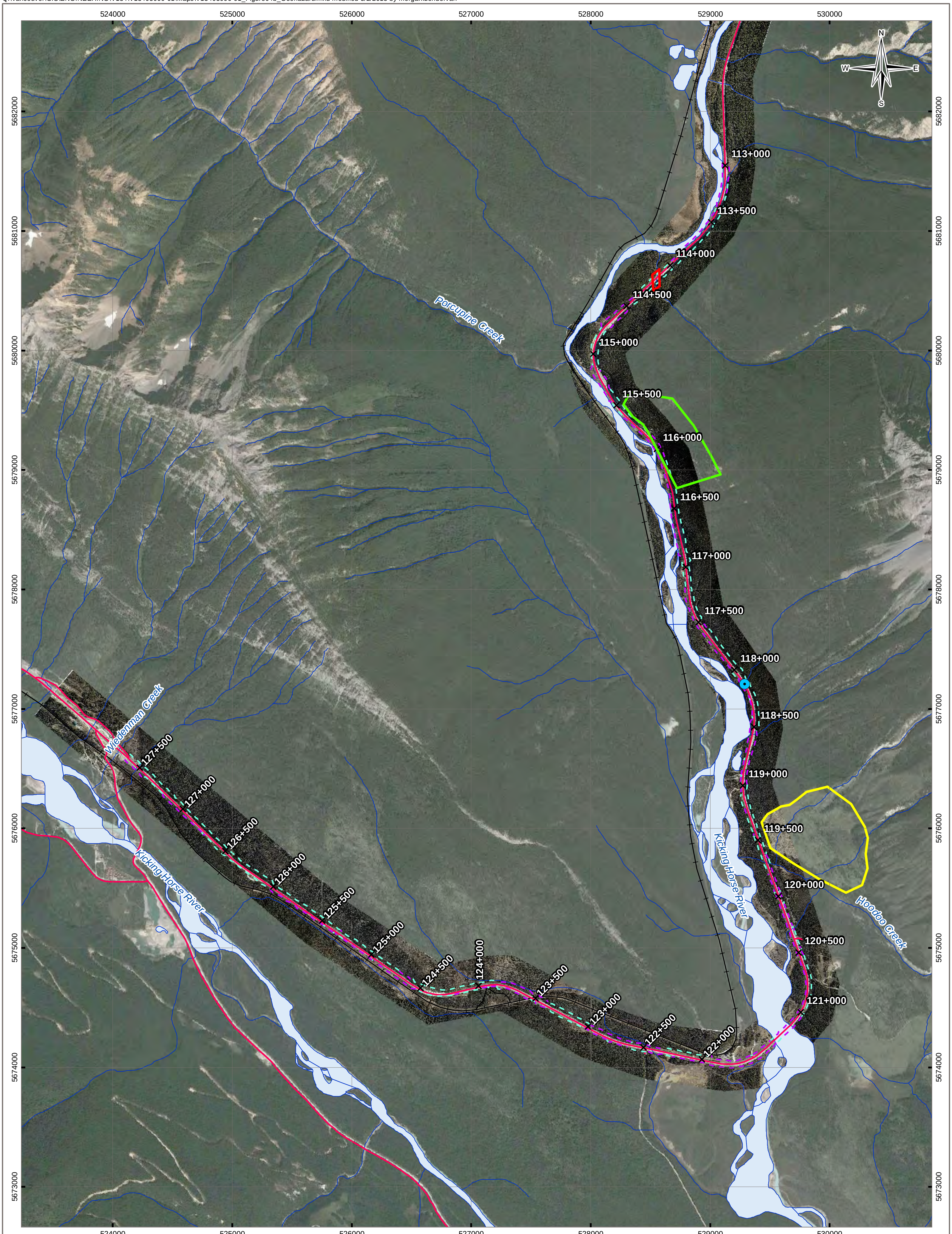


LEGEND

- ✕ Kilometre Marker
- Cut Slope
- Fill Slope
- Road
- Railway
- Watercourse
- Waterbody

Geohazards

- Sta. 114+150 - Finn Creek Debris Flow Potential
- Sta. 115+500 to 16+500 - Rock Fall Potential
- Sta. 119+340 to 119+600 - Rock Fall / Avalanche Potential
- Sta. 118+140 - Inspection of Ephemeral Creek

NOTES
Base data source:
CanVec 1:50,000
Imagery from Parks Canada and
GoogleI; DigitalGlobe (2012)

STATUS
ISSUED FOR USE

YNP TCH SLOPE REPROFILING

Geohazards

PROJECTION	DATUM	CLIENT
UTM Zone 11	NAD83	Parks Canada / Parcs Canada

Scale: 1:30,000
500 250 0 500
Metres

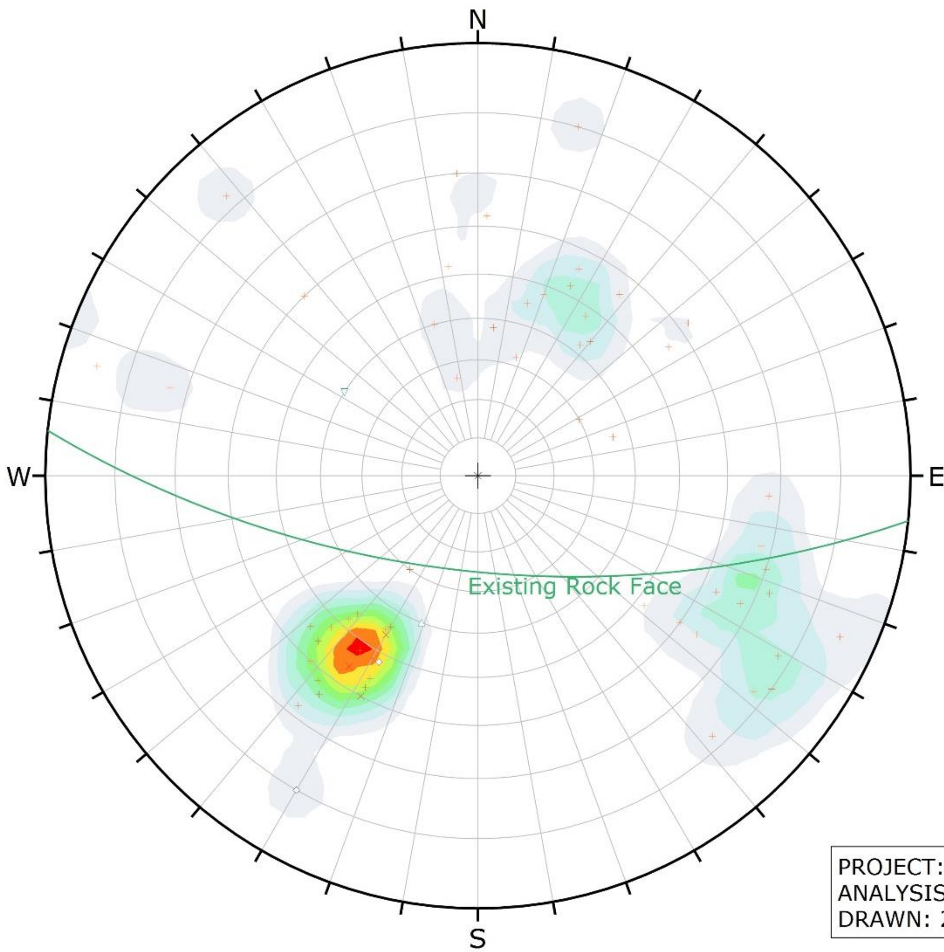
FILE NO.
V13403096-01_Figure04b_Geohazard.mxd

TETRA TECH EBA

PROJECT NO.	DWN	CKD	APVD	REV
V13403095/96-01	MEZ	SL	SM	0

OFFICE	DATE
Tt EBA-VANC	February 18, 2015

Figure 4b



Symbol	TYPE	Quantity
◇	B	6
×	BJ	9
△	F	1
+	J	134
▽	J/VN	2

Color	Density Concentrations
	0.00 - 1.80
	1.80 - 3.60
	3.60 - 5.40
	5.40 - 7.20
	7.20 - 9.00
	9.00 - 10.80
	10.80 - 12.60
	12.60 - 14.40
	14.40 - 16.20
	16.20 - 18.00
Maximum Density	17.29%
Contour Data	Pole Vectors
Contour Distribution	Fisher
Counting Circle Size	1.0%

	Color	Dip	Dip Direction	Label
User Planes				
1		65	186	Existing Rock Fac

Plot Mode	Pole Vectors
Vector Count	152 (61 Entries)
Hemisphere	Lower
Projection	Equal Angle

PROJECT: PCA - Yoho National Park - Slope Re-Design
ANALYSIS: Sta. 88+500 to 89+090
DRAWN: 2/13/2015 10:49:16 AM

LEGEND

1. Rock mass mapping data plotted using RocScience DIPS 6.0 software
2. Joint orientation data has been corrected for a magnetic declination of 16 degrees East.
3. 'Existing Rock Face' represents an average along the identified road section, and more detailed face orientation will be modelled during the design phase.

NOTES

DATA COLLECTED JAN 22, 2015

STATUS

ISSUED FOR USE

CLIENT

Parks Canada Parcs Canada

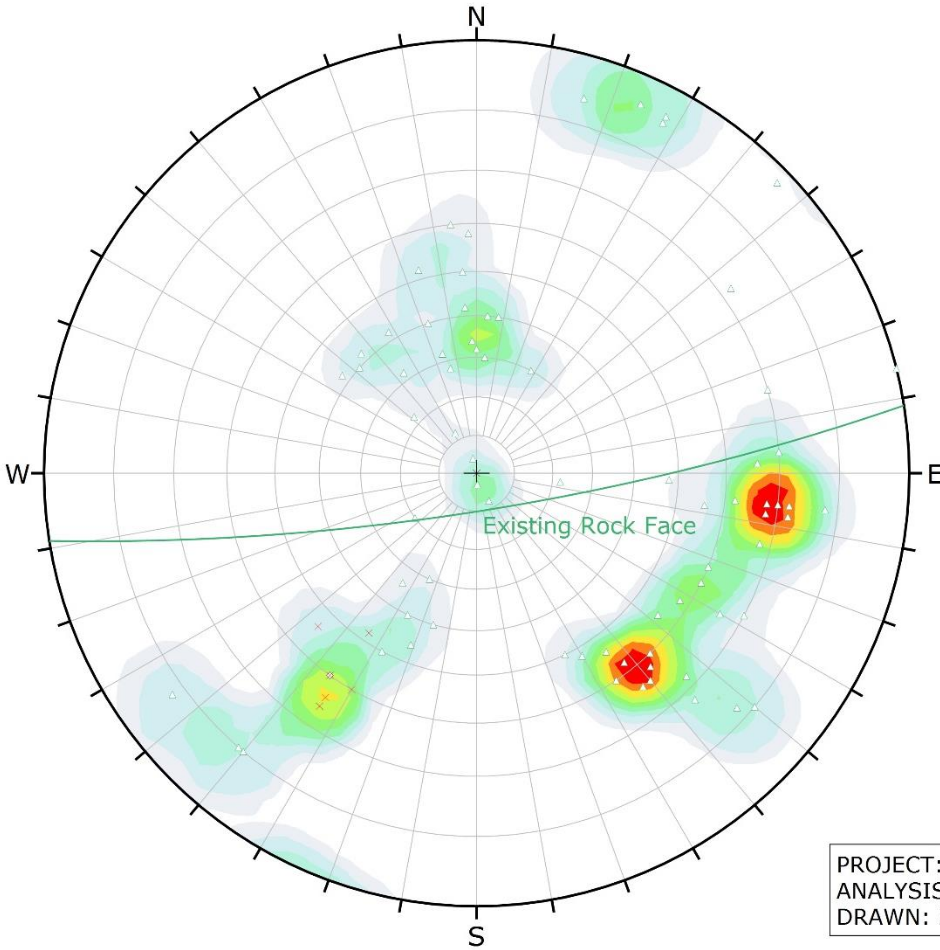
TETRA TECH EBA

PCA – YOHO NATIONAL PARK SLOPE REPROFILING

Preliminary DIPS Representation Sta. 88+500 to 89+090

PROJECT NO.	DWN	CKD	APVD	REV
V13403095	JP			00
OFFICE	DATE			
EBA-VANC	MARCH, 2015			

Figure 5a



Symbol	TYPE	Quantity
◇	B	1
×	BJ	13
△	J	120

Color	Density Concentrations
	0.00 - 1.00
	1.00 - 2.00
	2.00 - 3.00
	3.00 - 4.00
	4.00 - 5.00
	5.00 - 6.00
	6.00 - 7.00
	7.00 - 8.00
	8.00 - 9.00
	9.00 - 10.00
Maximum Density	9.96%
Contour Data	Pole Vectors
Contour Distribution	Fisher
Counting Circle Size	1.0%

	Color	Dip	Dip Direction	Label
		User Planes		
1		80	171	Existing Rock Fac

Plot Mode	Pole Vectors
Vector Count	134 (83 Entries)
Hemisphere	Lower
Projection	Equal Angle

PROJECT: PCA - Yoho National Park - Slope Re-Design
ANALYSIS: Sta. 89+160 to 89+420
DRAWN: 2/13/2015 10:55:27 AM

LEGEND

1. Rock mass mapping data plotted using RocScience DIPS 6.0 software
2. Joint orientation data has been corrected for a magnetic declination of 16 degrees East.
3. 'Existing Rock Face' represents an average along the identified road section, and more detailed face orientation will be modelled during the design phase.

NOTES

DATA COLLECTED JAN 23, 2015

STATUS

ISSUED FOR USE

CLIENT

Parks Canada Parcs Canada

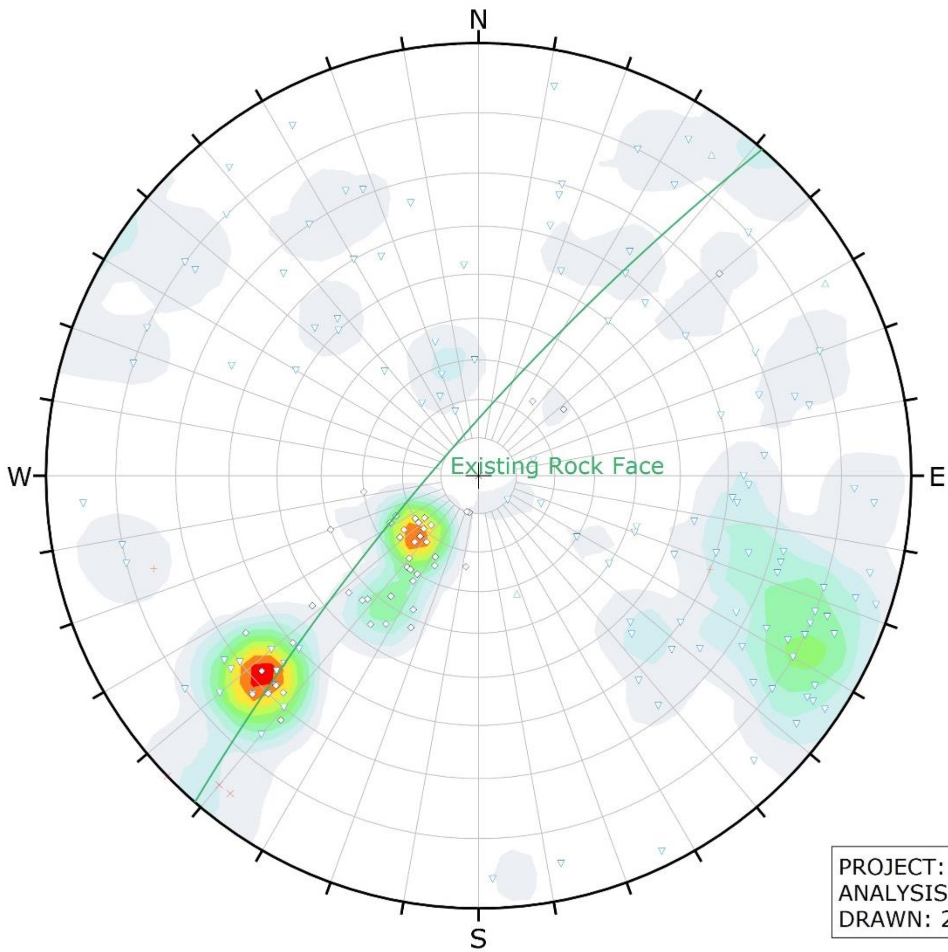
TETRA TECH EBA

PCA – YOHO NATIONAL PARK SLOPE REPROFILING

Preliminary DIPS Representation Sta. 89+160 to 89+420

PROJECT NO.	DWN	CKD	APVD	REV
V13403095	JP			00
OFFICE	**DATE**			
EBA-VANC	MARCH, 2015			

Figure 5b



Symbol	TYPE	Quantity
◇	BJ	81
×	CJ	7
△	F	3
+	F/J	2
▽	J	193

Color	Density Concentrations
	0.00 - 1.10
	1.10 - 2.20
	2.20 - 3.30
	3.30 - 4.40
	4.40 - 5.50
	5.50 - 6.60
	6.60 - 7.70
	7.70 - 8.80
	8.80 - 9.90
	9.90 - 11.00

Maximum Density	10.30%
Contour Data	Pole Vectors
Contour Distribution	Fisher
Counting Circle Size	1.0%

	Color	Dip	Dip Direction	Label
User Planes				
1		80	311	Existing Rock Fac

Plot Mode	Pole Vectors
Vector Count	286 (173 Entries)
Hemisphere	Lower
Projection	Equal Angle

PROJECT: PCA - Yoho National Park - Slope Re-Design
ANALYSIS: Sta. 89+540 to 90+900
DRAWN: 2/13/2015 11:18:00 AM

LEGEND

1. Rock mass mapping data plotted using RocScience DIPS 6.0 software
2. Joint orientation data has been corrected for a magnetic declination of 16 degrees East.
3. 'Existing Rock Face' represents an average along the identified road section, and more detailed face orientation will be modelled during the design phase.

NOTES

DATA COLLECTED JAN 27, 2015

STATUS

ISSUED FOR USE

CLIENT

Parks Canada Parcs Canada

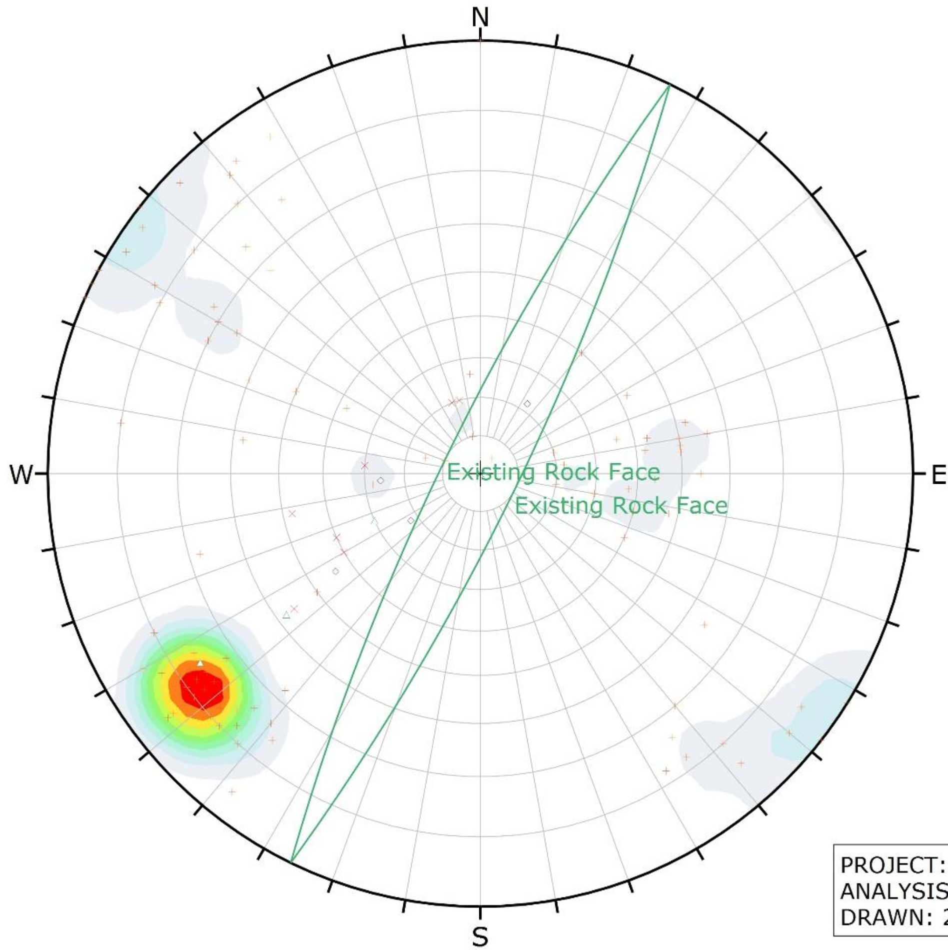
TETRA TECH EBA

PCA – YOHO NATIONAL PARK SLOPE REPROFILING

Preliminary DIPS Representation Sta. 89+540 to 90+900

PROJECT NO.	DWN	CKD	APVD	REV
V13403095	JP			00
OFFICE	**DATE**			
EBA-VANC	MARCH, 2015			

Figure 5c



Symbol	TYPE	Quantity
◇	B	4
×	BJ	12
△	F	4
+	J	165

Color	Density Concentrations
	0.00 - 2.80
	2.80 - 5.60
	5.60 - 8.40
	8.40 - 11.20
	11.20 - 14.00
	14.00 - 16.80
	16.80 - 19.60
	19.60 - 22.40
	22.40 - 25.20
	25.20 - 28.00
Maximum Density	27.94%
Contour Data	Pole Vectors
Contour Distribution	Fisher
Counting Circle Size	1.0%

	Color	Dip	Dip Direction	Label
		User Planes		
1		80	116	Existing Rock Fac
2		80	296	Existing Rock Fac

Plot Mode	Pole Vectors
Vector Count	185 (123 Entries)
Hemisphere	Lower
Projection	Equal Angle

PROJECT: PCA - Yoho National Park - Slope Re-Design
ANALYSIS: Sta. 114+860 to 115+100
DRAWN: 2/13/2015 11:38:50 AM

LEGEND

1. Rock mass mapping data plotted using RocScience DIPS 6.0 software
2. Joint orientation data has been corrected for a magnetic declination of 16 degrees East.
3. 'Existing Rock Face' represents an average along the identified road section, and more detailed face orientation will be modelled during the design phase.

NOTES

DATA COLLECTED JAN 29, 2015

STATUS

ISSUED FOR USE

CLIENT

Parks Canada Parcs Canada

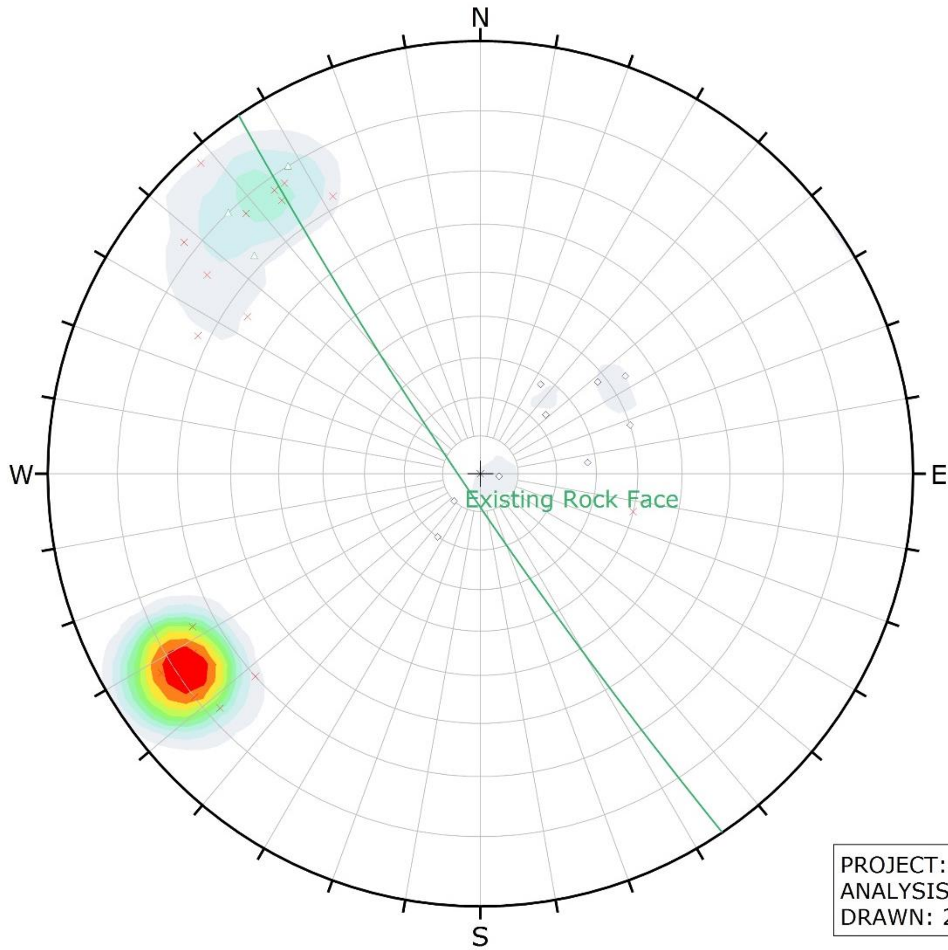
TETRA TECH EBA

PCA – YOHO NATIONAL PARK SLOPE REPROFILING

Preliminary DIPS Representation Sta. 114+860 to 115+100

PROJECT NO.	DWN	CKD	APVD	REV
V13403096	JP			00
OFFICE	**DATE**			
EBA-VANC	MARCH, 2015			

Figure 5d



Symbol	TYPE	Quantity
◇	BJ	10
×	J	30
△	SZ	3

Color	Density Concentrations
	0.00 - 3.90
	3.90 - 7.80
	7.80 - 11.70
	11.70 - 15.60
	15.60 - 19.50
	19.50 - 23.40
	23.40 - 27.30
	27.30 - 31.20
	31.20 - 35.10
	35.10 - 39.00
Maximum Density	38.47%
Contour Data	Pole Vectors
Contour Distribution	Fisher
Counting Circle Size	1.0%

	Color	Dip	Dip Direction	Label
User Planes				
1		85	236	Existing Rock Fac

Plot Mode	Pole Vectors
Vector Count	43 (36 Entries)
Hemisphere	Lower
Projection	Equal Angle

PROJECT: PCA - Yoho National Park - Slope Re-Design
ANALYSIS: Sta. 115+380 to 115+580
DRAWN: 2/13/2015 11:56:09 AM

LEGEND

1. Rock mass mapping data plotted using RocScience DIPS 6.0 software
2. Joint orientation data has been corrected for a magnetic declination of 16 degrees East.
3. 'Existing Rock Face' represents an average along the identified road section, and more detailed face orientation will be modelled during the design phase.

NOTES

DATA COLLECTED JAN 30, 2015

STATUS

ISSUED FOR USE

CLIENT

Parks Canada Parcs Canada

TETRA TECH EBA

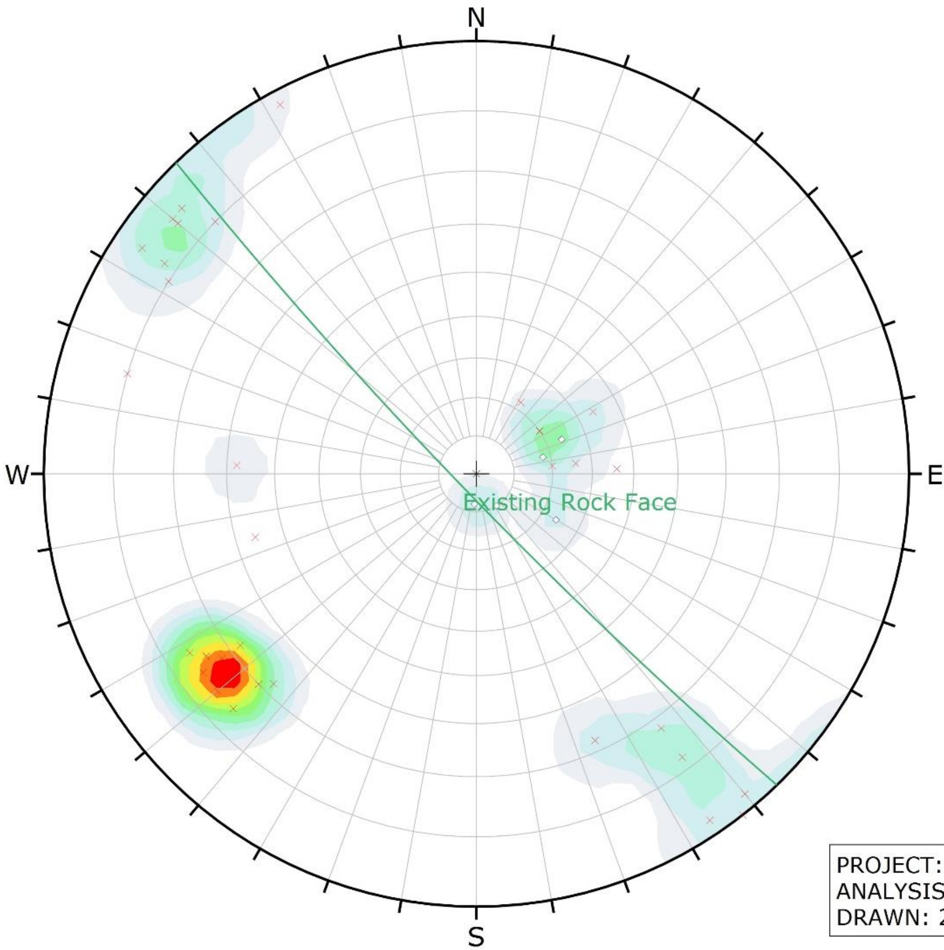
PCA – YOHO NATIONAL PARK SLOPE REPROFILING

Preliminary DIPS Representation Sta. 115+380 to 115+580

PROJECT NO.	DWN	CKD	APVD	REV
V13403096	JP			00

OFFICE	DATE
EBA-VANC	MARCH, 2015

Figure 5e



Symbol	TYPE	Quantity
◇	BJ	9
×	J	51

Color	Density Concentrations
	0.00 - 2.40
	2.40 - 4.80
	4.80 - 7.20
	7.20 - 9.60
	9.60 - 12.00
	12.00 - 14.40
	14.40 - 16.80
	16.80 - 19.20
	19.20 - 21.60
	21.60 - 24.00

Maximum Density	23.49%
Contour Data	Pole Vectors
Contour Distribution	Fisher
Counting Circle Size	1.0%

	Color	Dip	Dip Direction	Label
User Planes				
1		85	226	Existing Rock Fac

Plot Mode	Pole Vectors
Vector Count	60 (40 Entries)
Hemisphere	Lower
Projection	Equal Angle

PROJECT: PCA - Yoho National Park - Slope Re-Design
ANALYSIS: Sta. 115+650 to 115+860
DRAWN: 2/13/2015 12:05:56 PM

LEGEND

1. Rock mass mapping data plotted using RocScience DIPS 6.0 software
2. Joint orientation data has been corrected for a magnetic declination of 16 degrees East.
3. 'Existing Rock Face' represents an average along the identified road section, and more detailed face orientation will be modelled during the design phase.

NOTES

DATA COLLECTED JAN 30, 2015

STATUS

ISSUED FOR USE

CLIENT

Parks Canada Parcs Canada

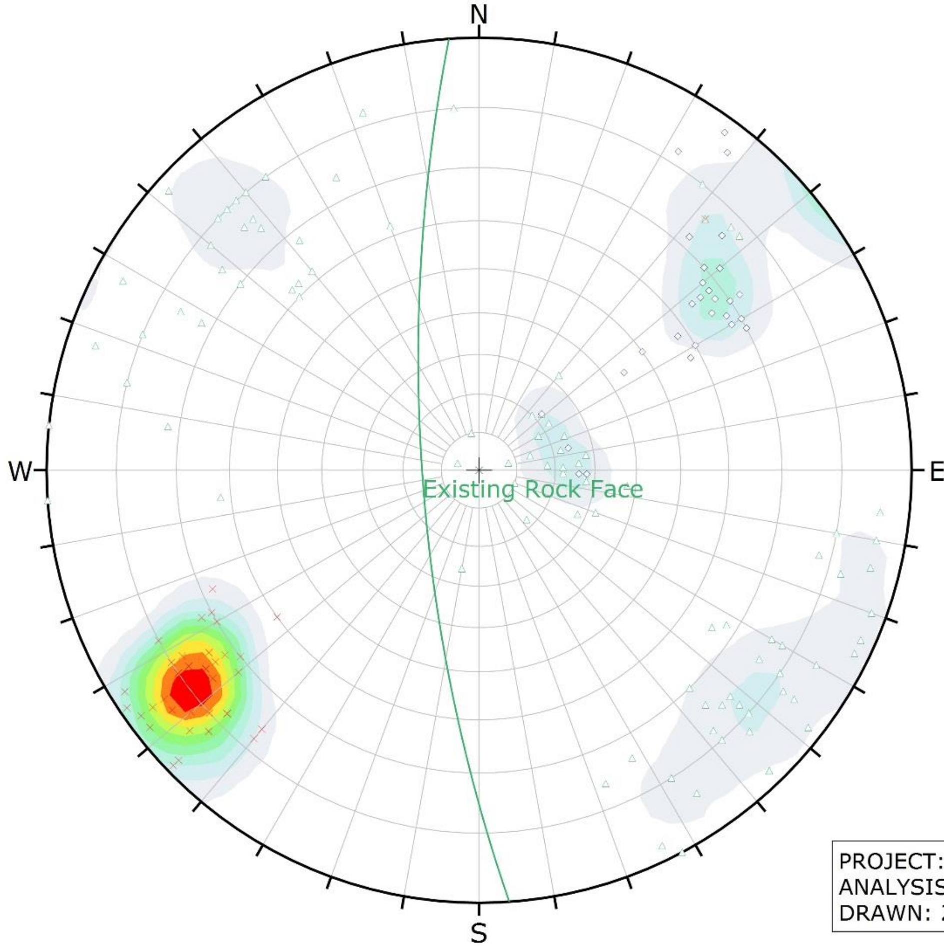
TETRA TECH EBA

PCA – YOHO NATIONAL PARK SLOPE REPROFILING

Preliminary DIPS Representation Sta. 115+650 to 115+680

PROJECT NO.	DWN	CKD	APVD	REV
V13403096	JP			00
OFFICE	DATE			
EBA-VANC	MARCH, 2015			

Figure 5f



Symbol	TYPE	Quantity
◇	BJ	45
×	CJ	98
△	J	126
+	VN	1

Color	Density Concentrations
	0.00 - 2.30
	2.30 - 4.60
	4.60 - 6.90
	6.90 - 9.20
	9.20 - 11.50
	11.50 - 13.80
	13.80 - 16.10
	16.10 - 18.40
	18.40 - 20.70
	20.70 - 23.00

Maximum Density	22.77%
Contour Data	Pole Vectors
Contour Distribution	Fisher
Counting Circle Size	1.0%

	Color	Dip	Dip Direction	Label
User Planes				
1		75	266	Existing Rock Fac

Plot Mode	Pole Vectors
Vector Count	270 (180 Entries)
Hemisphere	Lower
Projection	Equal Angle

PROJECT: PCA - Yoho National Park - Slope Re-Design
ANALYSIS: Sta. 116+150 to 117+200
DRAWN: 2/20/2015 8:22:15 AM

LEGEND

1. Rock mass mapping data plotted using RocScience DIPS 6.0 software
2. Joint orientation data has been corrected for a magnetic declination of 16 degrees East.
3. 'Existing Rock Face' represents an average along the identified road section, and more detailed face orientation will be modelled during the design phase.

NOTES

DATA COLLECTED FEB 1, 2015

STATUS

ISSUED FOR USE

CLIENT

Parks Canada Parcs Canada

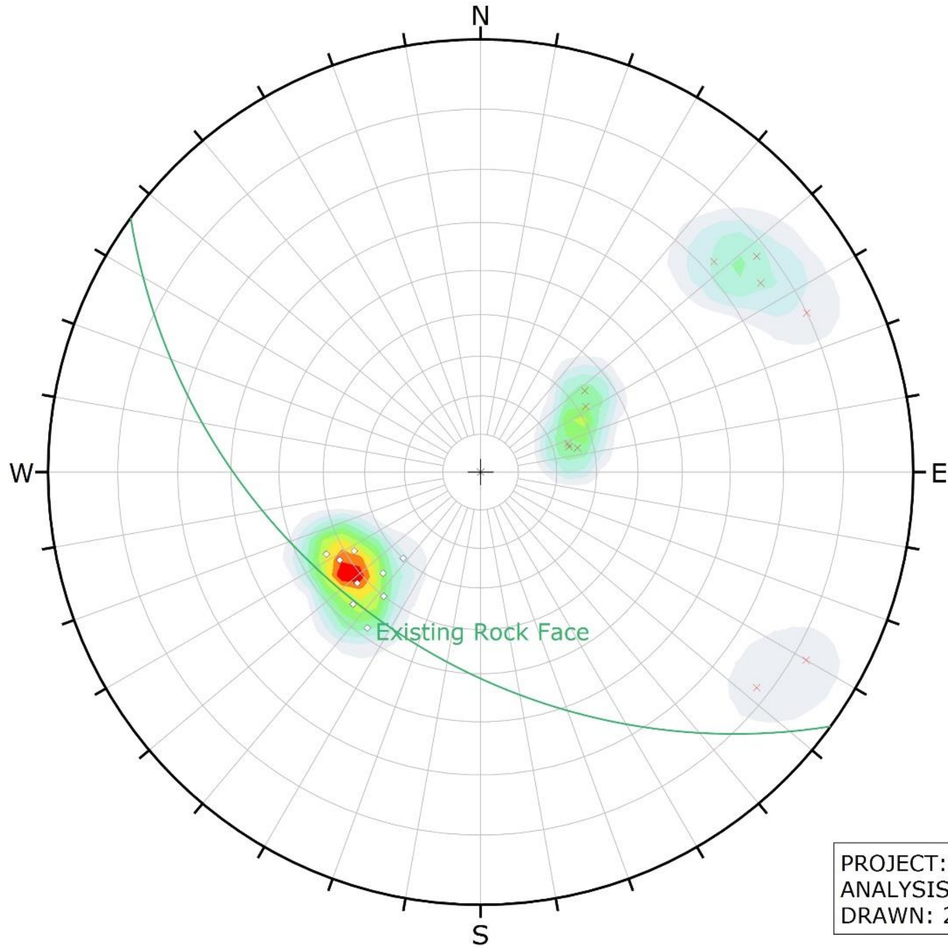
TETRA TECH EBA

PCA – YOHO NATIONAL PARK SLOPE REPROFILING

Preliminary DIPS Representation Sta. 116+150 to 117+200

PROJECT NO.	DWN	CKD	APVD	REV
V13403096	JP			00
OFFICE	DATE			
EBA-VANC	MARCH, 2015			

Figure 5g



Symbol	TYPE	Quantity
◇	CJ	15
×	J	15

Color	Density Concentrations
	0.00 - 3.00
	3.00 - 6.00
	6.00 - 9.00
	9.00 - 12.00
	12.00 - 15.00
	15.00 - 18.00
	18.00 - 21.00
	21.00 - 24.00
	24.00 - 27.00
	27.00 - 30.00

Maximum Density	29.99%
Contour Data	Pole Vectors
Contour Distribution	Fisher
Counting Circle Size	1.0%

	Color	Dip	Dip Direction	Label
User Planes				
1		45	216	Existing Rock Fac

Plot Mode	Pole Vectors
Vector Count	30 (20 Entries)
Hemisphere	Lower
Projection	Equal Angle

PROJECT: PCA - Yoho National Park - Slope Re-Design
ANALYSIS: Sta. 123+100 to 123+400
DRAWN: 2/13/2015 1:28:28 PM

LEGEND

1. Rock mass mapping data plotted using RocScience DIPS 6.0 software
2. Joint orientation data has been corrected for a magnetic declination of 16 degrees East.
3. 'Existing Rock Face' represents an average along the identified road section, and more detailed face orientation will be modelled during the design phase.

NOTES

DATA COLLECTED FEB 3, 2015

STATUS

ISSUED FOR USE

CLIENT

Parks Canada Parcs Canada

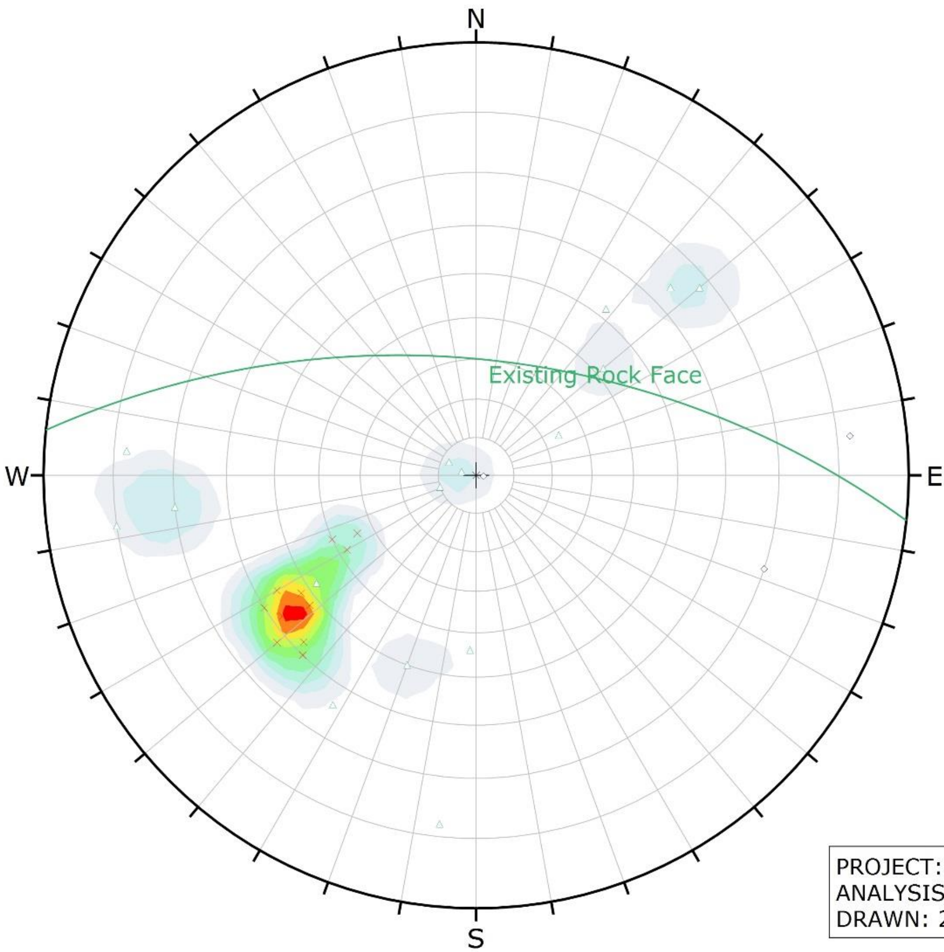
TETRA TECH EBA

PCA – YOHO NATIONAL PARK SLOPE REPROFILING

Preliminary DIPS Representation Sta. 123+100 to 123+400

PROJECT NO.	DWN	CKD	APVD	REV
V13403096	JP			00
OFFICE	**DATE**			
EBA-VANC	MARCH, 2015			

Figure 5h



Symbol	TYPE	Quantity
◇	BJ	3
×	CJ	20
△	J	23

Color	Density Concentrations
	0.00 - 2.80
	2.80 - 5.60
	5.60 - 8.40
	8.40 - 11.20
	11.20 - 14.00
	14.00 - 16.80
	16.80 - 19.60
	19.60 - 22.40
	22.40 - 25.20
	25.20 - 28.00
Maximum Density	27.02%
Contour Data	Pole Vectors
Contour Distribution	Fisher
Counting Circle Size	1.0%

	Color	Dip	Dip Direction	Label
User Planes				
1		60	6	Existing Rock Fac

Plot Mode	Pole Vectors
Vector Count	46 (31 Entries)
Hemisphere	Lower
Projection	Equal Angle

PROJECT: PCA - Yoho National Park - Slope Re-Design
ANALYSIS: Sta. 123+800 to 123+900
DRAWN: 2/13/2015 1:21:52 PM

LEGEND

1. Rock mass mapping data plotted using RocScience DIPS 6.0 software
2. Joint orientation data has been corrected for a magnetic declination of 16 degrees East.
3. 'Existing Rock Face' represents an average along the identified road section, and more detailed face orientation will be modelled during the design phase.

NOTES

DATA COLLECTED FEB 3, 2015

STATUS

ISSUED FOR USE

CLIENT

Parks Canada Parcs Canada

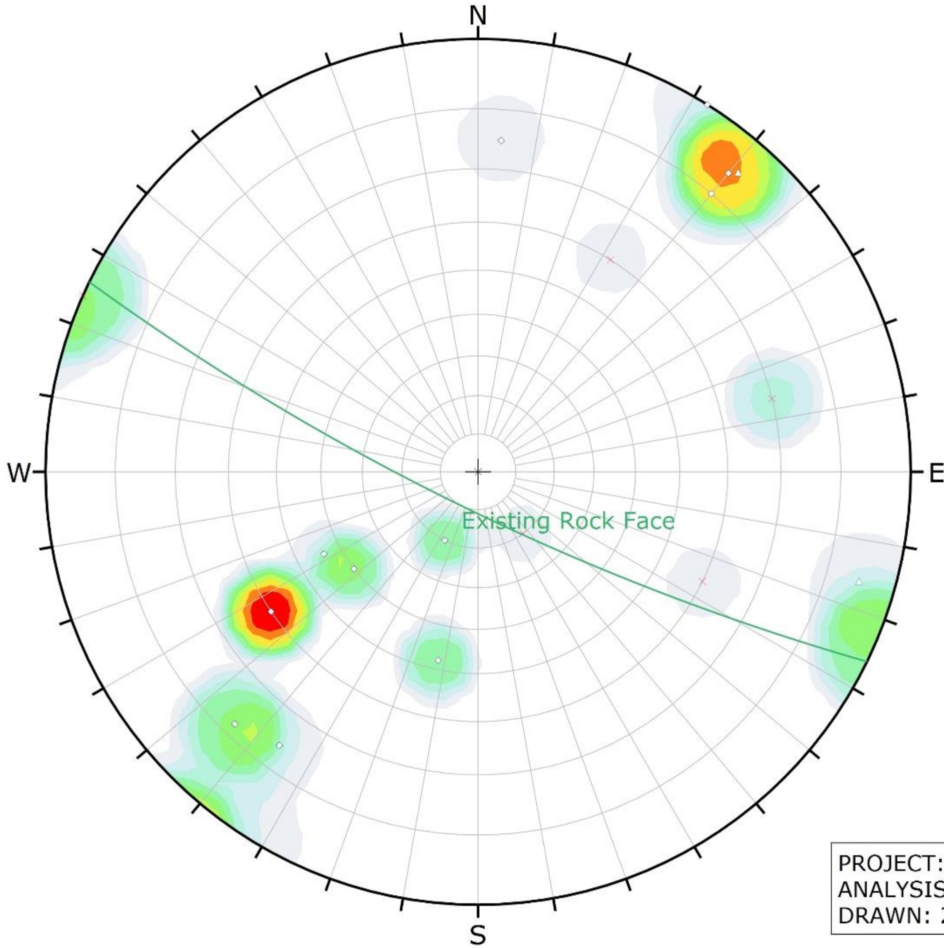
TETRA TECH EBA

PCA – YOHO NATIONAL PARK SLOPE REPROFILING

Preliminary DIPS Representation Sta. 123+800 to 123+900

PROJECT NO.	DWN	CKD	APVD	REV
V13403096	JP			00
OFFICE	DATE			
EBA-VANC	MARCH, 2015			

Figure 5i



Symbol	TYPE	Quantity
◇	CJ	23
×	J	11
△	SZ	2

Color	Density Concentrations
	0.00 - 1.70
	1.70 - 3.40
	3.40 - 5.10
	5.10 - 6.80
	6.80 - 8.50
	8.50 - 10.20
	10.20 - 11.90
	11.90 - 13.60
	13.60 - 15.30
	15.30 - 17.00
Maximum Density	16.65%
Contour Data	Pole Vectors
Contour Distribution	Fisher
Counting Circle Size	1.0%

	Color	Dip	Dip Direction	Label
User Planes				
1		80	206	Existing Rock Fac

Plot Mode	Pole Vectors
Vector Count	36 (19 Entries)
Hemisphere	Lower
Projection	Equal Angle

PROJECT: PCA - Yoho National Park - Slope Re-Design
ANALYSIS: Sta. 124+270 to 124+670
DRAWN: 2/13/2015 12:10:37 PM

LEGEND

1. Rock mass mapping data plotted using RocScience DIPS 6.0 software
2. Joint orientation data has been corrected for a magnetic declination of 16 degrees East.
3. 'Existing Rock Face' represents an average along the identified road section, and more detailed face orientation will be modelled during the design phase.

NOTES

DATA COLLECTED JAN 30, 2015

STATUS

ISSUED FOR USE

CLIENT

Parks Canada Parcs Canada

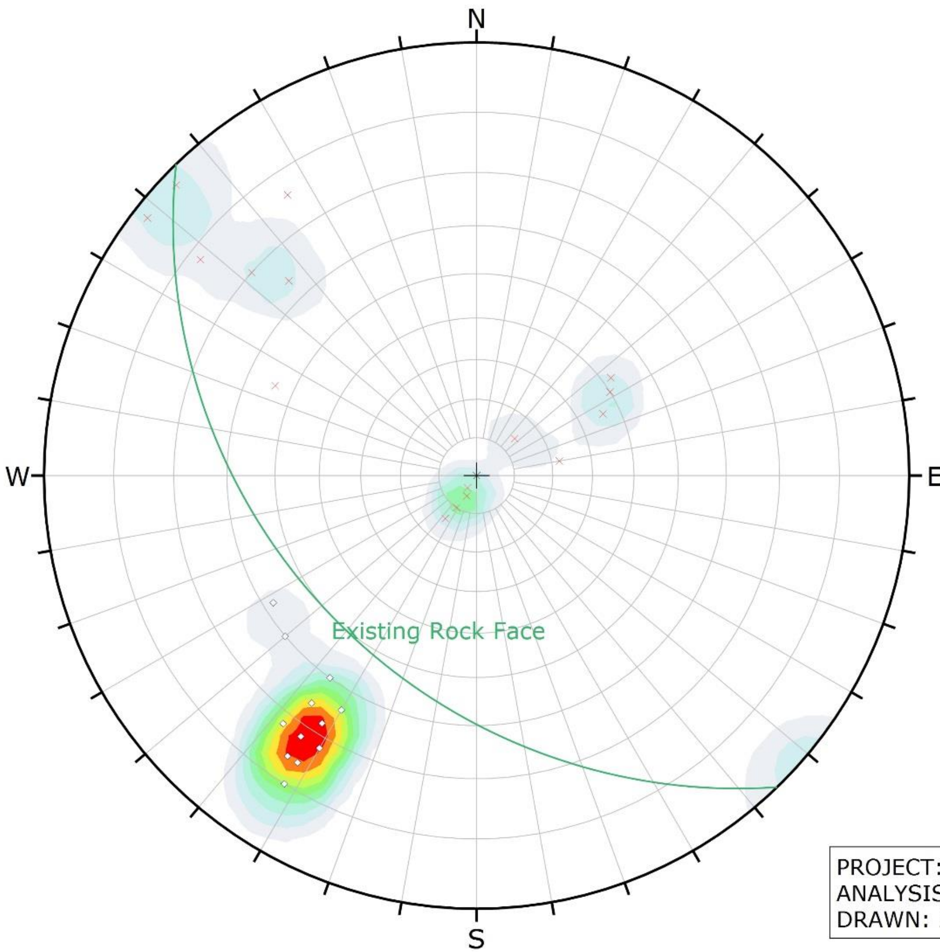
TETRA TECH EBA

PCA – YOHO NATIONAL PARK SLOPE REPROFILING

Preliminary DIPS Representation Sta. 124+270 to 124+670

PROJECT NO.	DWN	CKD	APVD	REV
V13403096	JP			00
OFFICE	**DATE**			
EBA-VANC	MARCH, 2015			

Figure 5j



Symbol	TYPE	Quantity
◇	CJ	19
×	J	22

Color	Density Concentrations
	0.00 - 2.90
	2.90 - 5.80
	5.80 - 8.70
	8.70 - 11.60
	11.60 - 14.50
	14.50 - 17.40
	17.40 - 20.30
	20.30 - 23.20
	23.20 - 26.10
	26.10 - 29.00

Maximum Density	28.58%
Contour Data	Pole Vectors
Contour Distribution	Fisher
Counting Circle Size	1.0%

	Color	Dip	Dip Direction	Label
User Planes				
1		40	226	Existing Rock Fac

Plot Mode	Pole Vectors
Vector Count	41 (29 Entries)
Hemisphere	Lower
Projection	Equal Angle

PROJECT: PCA - Yoho National Park - Slope Re-Design
ANALYSIS: Sta. 125+810 to 125+930
DRAWN: 2/13/2015 1:32:12 PM

LEGEND

1. Rock mass mapping data plotted using RocScience DIPS 6.0 software
2. Joint orientation data has been corrected for a magnetic declination of 16 degrees East.
3. 'Existing Rock Face' represents an average along the identified road section, and more detailed face orientation will be modelled during the design phase.

NOTES

DATA COLLECTED FEB 3, 2015

STATUS

ISSUED FOR USE

CLIENT

Parks Canada / Parcs Canada

TETRA TECH EBA

PCA – YOHO NATIONAL PARK SLOPE REPROFILING

Preliminary DIPS Representation Sta. 125+810 to 125+930

PROJECT NO.	DWN	CKD	APVD	REV
V13403096	JP			00
OFFICE	DATE			
EBA-VANC	MARCH, 2015			

Figure 5k

TABLES

Table A - Wildlife Species Detected and Species of Management Concern Potentially Found from km 88-91 and km 114-128 of TCH in Yoho National Park.

English Name	Scientific Name	Method of Detection	BC List[1]	COSEWIC[2]	SARA[3]	Federal Setback[4]		
						Distance (m)	Time of Year	Feature
Amphibians								
Western Toad	*Anaxyrus boreas*	-	Blue	Special Concern	Special Concern	50 - 100	Year-round	Breeding Ponds, Wintering Sites
Birds								
American Bittern	*Botaurus lentiginosus*	-	Blue					
American White Pelican	*Pelecanus erythrorhynchos*	-	Red	Not at Risk				
Bank Swallow	*Riparia riparia*	-	Yellow	Threatened				
Barn Swallow	*Hirundo rustica*	-	Blue	Threatened		100	May 1 - August 31	Active Nests
California Gull	*Larus californicus*		Blue					
Common Nighthawk	*Chordeiles minor*	-	Yellow	Threatened	Threatened	0 - 200	May 1 - August 31	Active Nests
Common Raven	*Corvus corax*	Observed	Yellow					
Ferruginous Hawk*	*Buteo regalis*	-	No status	Threatened	Threatened	50 - 1000	Year-round	Nests
Gyrfalcon	*Falco rusticolus*	-	Blue	Not at Risk				
Horned Grebe	*Podiceps auritus*	-	Yellow	Special Concern	Endangered	100	April 1 - August 31	wetland/waterbody containing nest
Le Conte's Sparrow	*Ammodramus leconteii*		Blue					
Lewis's Woodpecker	*Melanerpes lewis*	-	Red	Threatened	Threatened			
Olive-sided Flycatcher	*Contopus cooperi*	-	Blue	Threatened	Threatened	0 - 300	May 1 - August 31	Nest
Peregrine Falcon*	*Falco Peregrinus anatum/tun*	-	Red/unknown	Special Concern	Special Concern	300 - 2000	April 1 - August 15	Nest
Rusty Blackbird	*Euphagus carolinus*	-	Blue	Special Concern	Special Concern	0 - 300	May 1 - August 31	Nest
Short-eared Owl	*Asio flammeus*	-	Blue	Special Concern	Special Concern	100 - 200	April 1 - July 31	Nest
Steller's Jay	*Cyanocitta stelleri*	Observed	Yellow					
Swainson's Hawk	*Buteo swainsoni*	-	Red					
Tundra Swan	*Cygnus columbianus*	-	Blue					
Western Grebe	*Aechmophorus occidentalis*	-	Red	Special Concern				
Yellow Rail*	*Coturnicops noveboracensis*	-	Red	Special Concern	Special Concern			
Mammals								
American Bison	*Bos bison*		No status	Threatened				
American Red Squirrel	*Tamiasciurus hudsonicus*	Tracks/Sign/Observed	Yellow					
American Marten	*Martes americana*	Tracks	Yellow	Not at Risk				
Bighorn Sheep	*Ovis canadensis*	-	Blue					
Coyote	Canis latrans	Tracks	Yellow					
Fisher	*Martes pennanti*	-	Blue					
Grey Wolf	*Canis lupus*	Tracks	Yellow	Not at Risk				
Little Brown Myotis*	*Myotis lucifugus*	-	Yellow	Endangered	Endangered			
Small Mammal Spp.	-	Tracks	-	-				
Snowshoe Hare	*Lepus americanus*	Tracks	Yellow					
Spotted Bat	*Euderma maculatum*	-	Blue					
Woodland Caribou - Southern	*Ranger tarandus pop. 1*	-	Red	Threatened	Threatened			

Notes:
Species identified during survey
*Species identified in Parks Canada Biotics Web Explorer only.
[1] Yellow=Secure; Red=Extirpated, Endangered or Threatened; Blue=Special Concern (B.C. Conservation Data Centre 2015).
[2] Status under the Committee on the Status of Endangered Wildlife in Canada (Government of Canada 2014).
[3] Status under the Species at Risk Act (Government of Canada 2002).
[4] Federal Setbacks from Environment Canada 2011; P. Gregoire, personal communication, August 15, 2013.

PHOTOGRAPHS

Photo 1: Sta. 88+500 – 89+090

Photo 2: Sta. 88+500 – 89+090

Photo 3: Sta. 88+500 – 89+090

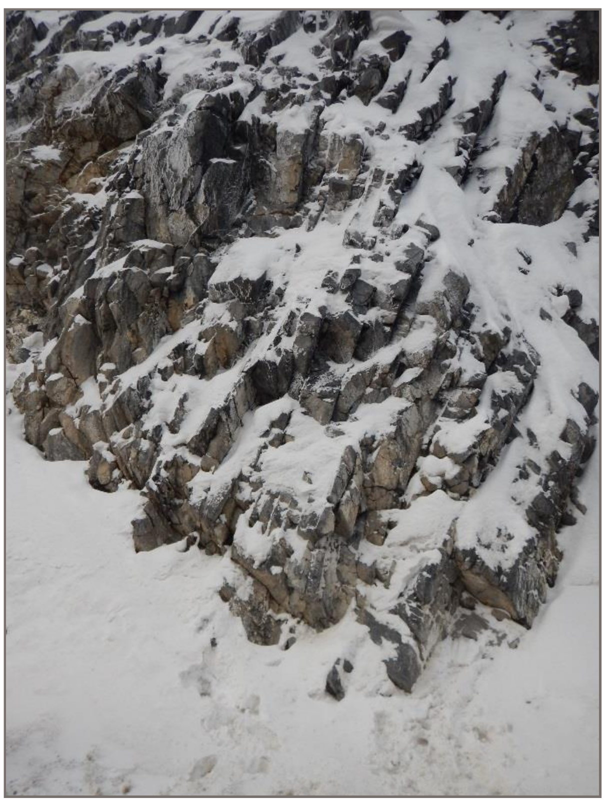


Photo 4: Sta. 88+500 – 89+090

Photo 5: Sta. 89+160 – 89+420

Photo 6: Sta. 89+160 – 89+420

Photo 7: Sta. 89+580 – 90+810

Photo 8: Sta. 89+580 – 90+810

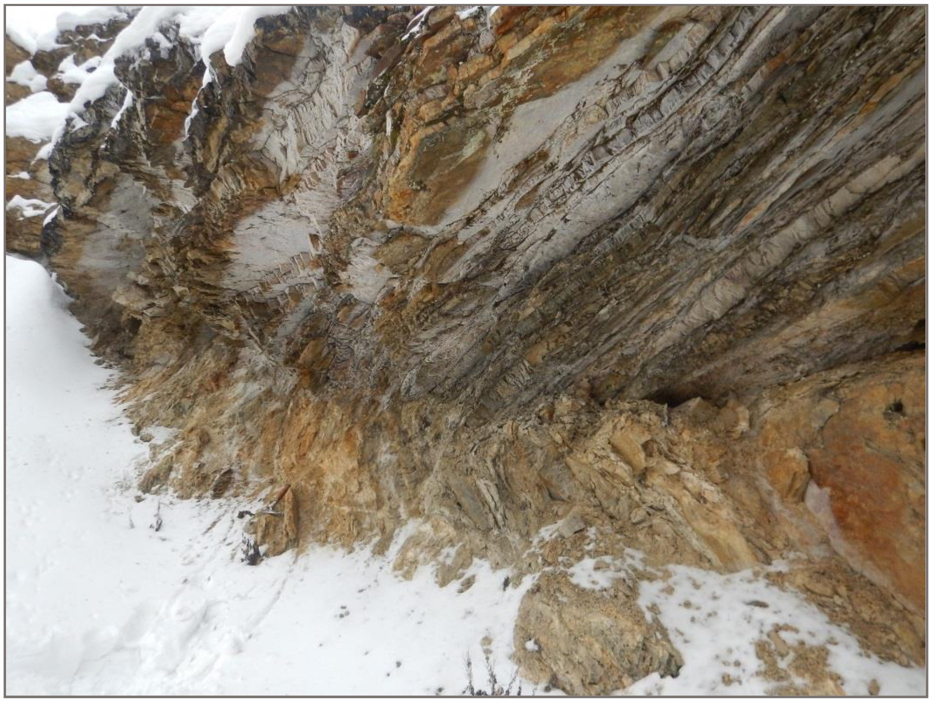


Photo 9: Sta. 89+580 – 90+810

Photo 10: Sta. 89+580 – 90+810

Photo 11: Sta. 89+580 – 90+810

Photo 12: Sta. 89+580 – 90+810

Photo 13: Sta. 89+580 – 90+810

Photo 14: Disposal site at Takakkaw Falls Trailer Parking, looking east.

Photo 15: Disposal site at Takakkaw Falls Trailer Parking, looking west.

Photo 16: Disposal site at Takakkaw Falls Trailer Parking, looking west.

Photo 17: Sta. 114+810 – 115+120 (East)

Photo 18: Sta. 114+810 – 115+120 (East)

Photo 19: Sta. 114+810 – 115+120 (East)

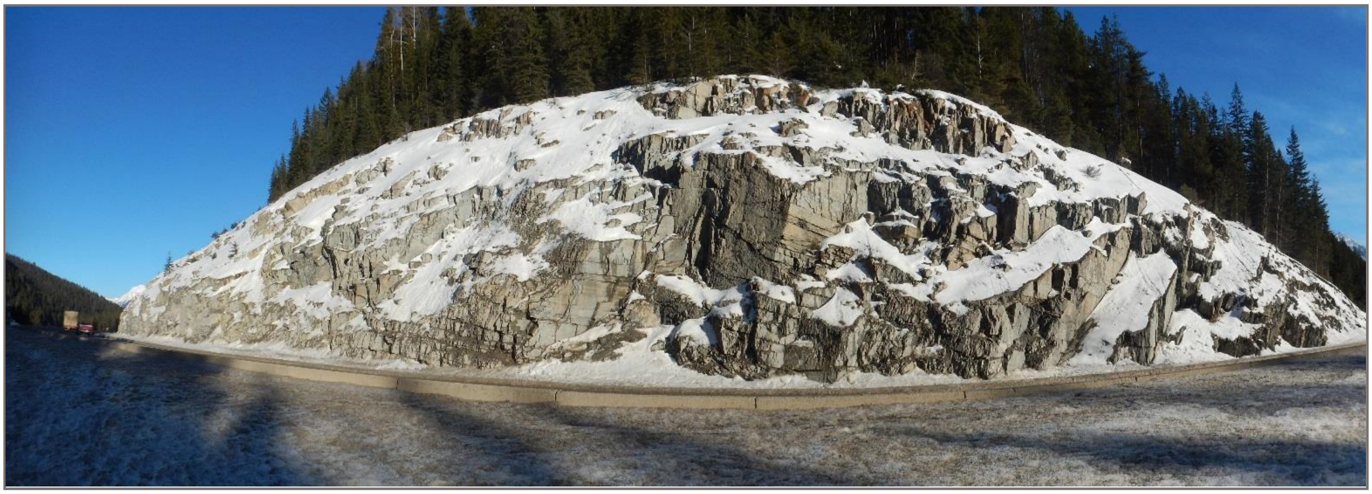


Photo 20: Sta. 114+810 – 115+120 (East)

Photo 21: Sta. 114+900– 115+120 (West)

Photo 22: Sta. 114+900– 115+120 (West)

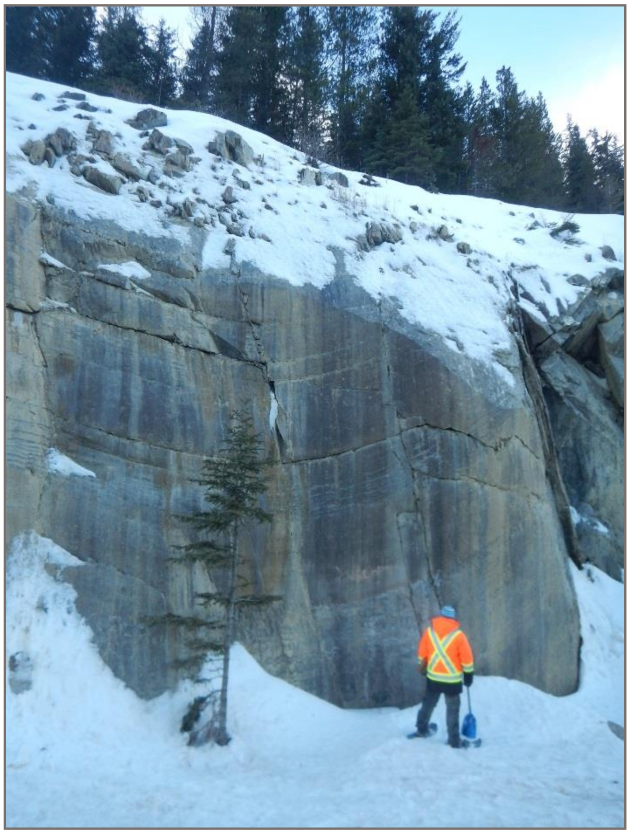


Photo 23: Sta. 114+900– 115+120 (West)

Photo 24: Sta. 114+900– 115+120 (West)

Photo 25: Sta. 115+380 – 115+580

Photo 26: Sta. 115+380 – 115+580

Photo 27: Sta. 115+670 – 115+780

Photo 28: Sta. 115+670 – 115+780

Photo 29: Sta. 116+160 – 117+170

Photo 30: Sta. 116+160 – 117+170

Photo 31: Sta. 116+160 – 117+170

Photo 32: Sta. 116+160 – 117+170

Photo 33: Sta. 116+160 – 117+170

Photo 34: Sta. 123+070 – 123+380

Photo 35: Sta. 123+100 – 123+370

Photo 36: Sta. 123+820 – 123+930

Photo 37: Sta. 124+280 – 124+580

Photo 38: Sta. 124+280 – 124+580

Photo 39: Sta. 124+280 – 124+580

Photo 40: Sta. 125+820 – 125+940

Photo 41: Old Quarry Disposal Site

Photo 42: Old Quarry Disposal Site

Photo 43: Conspicuous Disposal Site, looking south east

Photo 44: Conspicuous Disposal Site, looking north east

APPENDIX A
DESK STUDY SUPPORTING DOCUMENTS

2010 National Building Code Seismic Hazard Calculation

BC One Call Utility Drawings

2010 National Building Code Seismic Hazard Calculation

INFORMATION: Eastern Canada English (613) 995-5548 français (613) 995-0600 Facsimile (613) 992-8836
Western Canada English (250) 363-6500 Facsimile (250) 363-6565

Requested by: , February 16, 2015

Site Coordinates: 51.4343 North 116.3889 West

User File Reference:

National Building Code ground motions:
2% probability of exceedance in 50 years (0.000404 per annum)

Sa(0.2)	Sa(0.5)	Sa(1.0)	Sa(2.0)	PGA (g)
0.245	**0.141**	**0.067**	**0.038**	**0.125**

Notes. Spectral and peak hazard values are determined for firm ground (NBCC 2010 soil class C - average shear wave velocity 360-750 m/s). Median (50th percentile) values are given in units of g. 5% damped spectral acceleration (Sa(T), where T is the period in seconds) and peak ground acceleration (PGA) values are tabulated. Only 2 significant figures are to be used. ***These values have been interpolated from a 10 km spaced grid of points. Depending on the gradient of the nearby points, values at this location calculated directly from the hazard program may vary. More than 95 percent of interpolated values are within 2 percent of the calculated values.***

Ground motions for other probabilities:

Probability of exceedance per annum	0.010	0.0021	0.001
Probability of exceedance in 50 years	40%	10%	5%
Sa(0.2)	0.039	0.108	0.160
Sa(0.5)	0.024	0.063	0.092
Sa(1.0)	0.013	0.030	0.044
Sa(2.0)	0.008	0.017	0.025
PGA	0.024	0.061	0.086

References

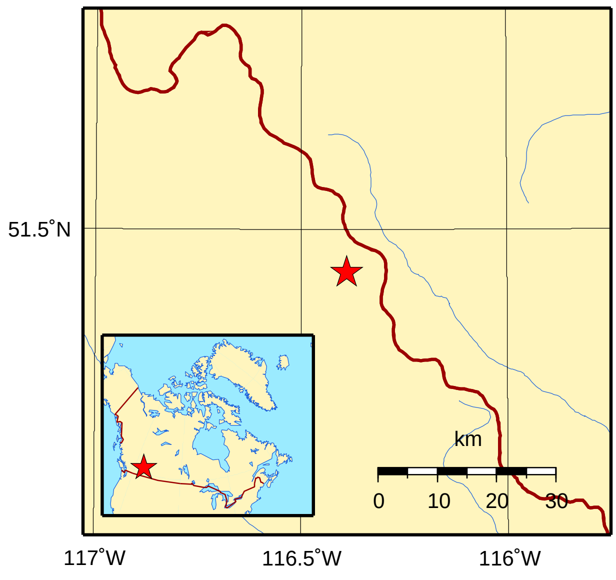
National Building Code of Canada 2010 NRCC no. 53301; sections 4.1.8, 9.20.1.2, 9.23.10.2, 9.31.6.2, and 6.2.1.3
Appendix C: Climatic Information for Building Design in Canada - table in Appendix C starting on page C-11 of Division B, volume 2

User's Guide - NBC 2010, Structural Commentaries NRCC no. 53543 (in preparation)
Commentary J: Design for Seismic Effects

Geological Survey of Canada Open File xxxx
Fourth generation seismic hazard maps of Canada: Maps and grid values to be used with the 2010 National Building Code of Canada (in preparation)

See the websites *www.EarthquakesCanada.ca* and *www.nationalcodes.ca* for more information

Aussi disponible en français



2010 National Building Code Seismic Hazard Calculation

INFORMATION: Eastern Canada English (613) 995-5548 français (613) 995-0600 Facsimile (613) 992-8836
Western Canada English (250) 363-6500 Facsimile (250) 363-6565

Requested by: , February 05, 2015

Site Coordinates: 51.217 North 116.5821 West

User File Reference:

National Building Code ground motions:
2% probability of exceedance in 50 years (0.000404 per annum)

Sa(0.2)	Sa(0.5)	Sa(1.0)	Sa(2.0)	PGA (g)
0.250	**0.146**	**0.070**	**0.039**	**0.127**

Notes. Spectral and peak hazard values are determined for firm ground (NBCC 2010 soil class C - average shear wave velocity 360-750 m/s). Median (50th percentile) values are given in units of g. 5% damped spectral acceleration (Sa(T), where T is the period in seconds) and peak ground acceleration (PGA) values are tabulated. Only 2 significant figures are to be used. ***These values have been interpolated from a 10 km spaced grid of points. Depending on the gradient of the nearby points, values at this location calculated directly from the hazard program may vary. More than 95 percent of interpolated values are within 2 percent of the calculated values.***

Ground motions for other probabilities:

Probability of exceedance per annum	0.010	0.0021	0.001
Probability of exceedance in 50 years	40%	10%	5%
Sa(0.2)	0.042	0.110	0.162
Sa(0.5)	0.026	0.064	0.094
Sa(1.0)	0.013	0.031	0.045
Sa(2.0)	0.008	0.018	0.025
PGA	0.026	0.062	0.087

References

National Building Code of Canada 2010 NRCC no. 53301; sections 4.1.8, 9.20.1.2, 9.23.10.2, 9.31.6.2, and 6.2.1.3
Appendix C: Climatic Information for Building Design in Canada - table in Appendix C starting on page C-11 of Division B, volume 2

User's Guide - NBC 2010, Structural Commentaries NRCC no. 53543 (in preparation)
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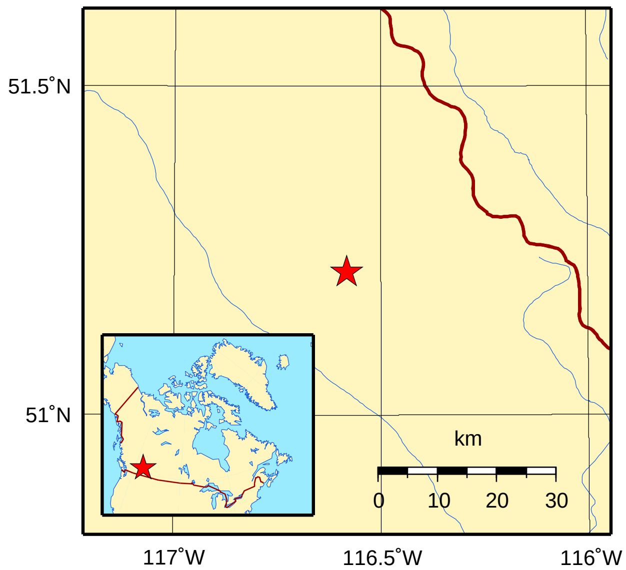
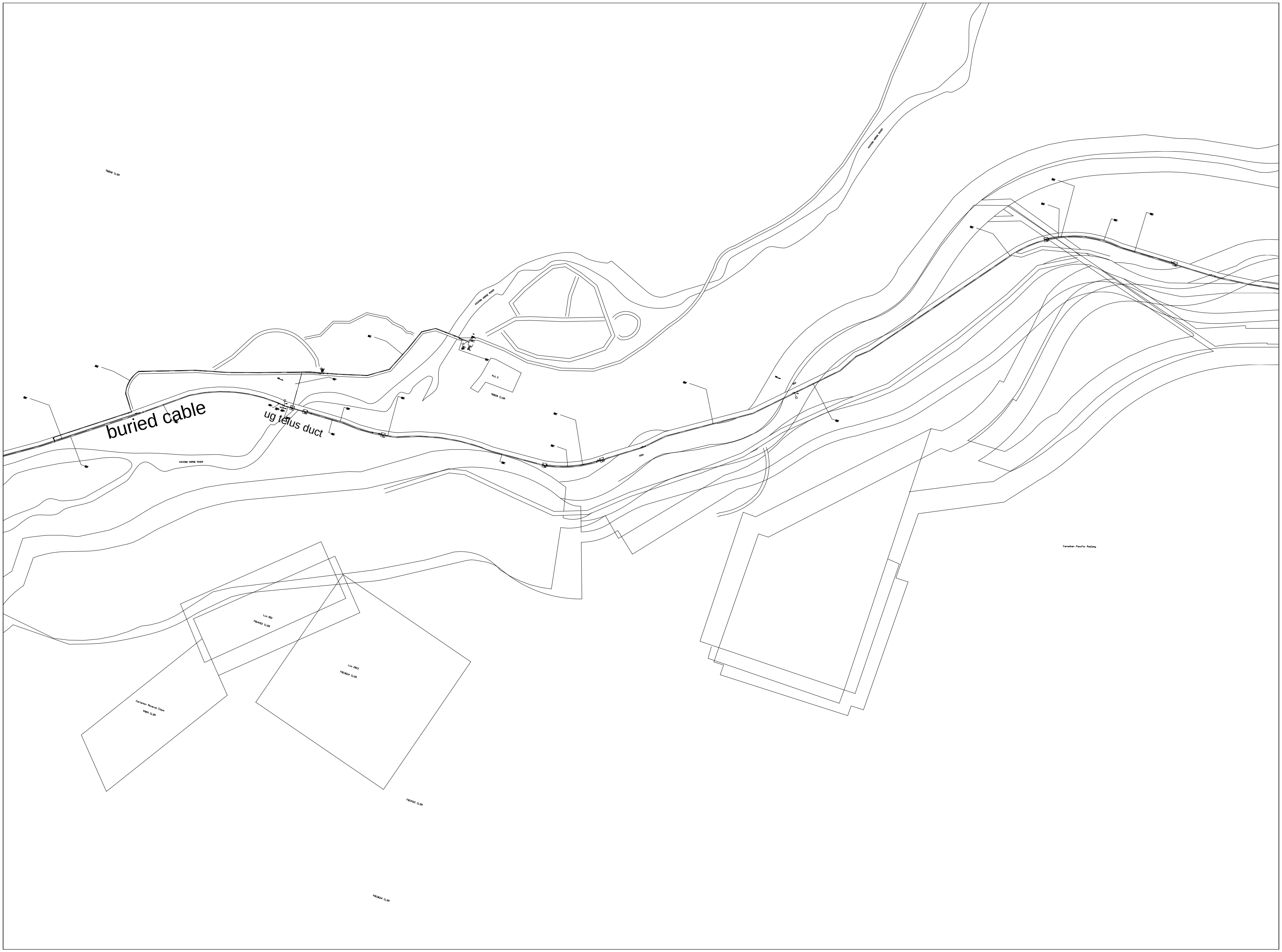
See the websites *www.EarthquakesCanada.ca* and *www.nationalcodes.ca* for more information



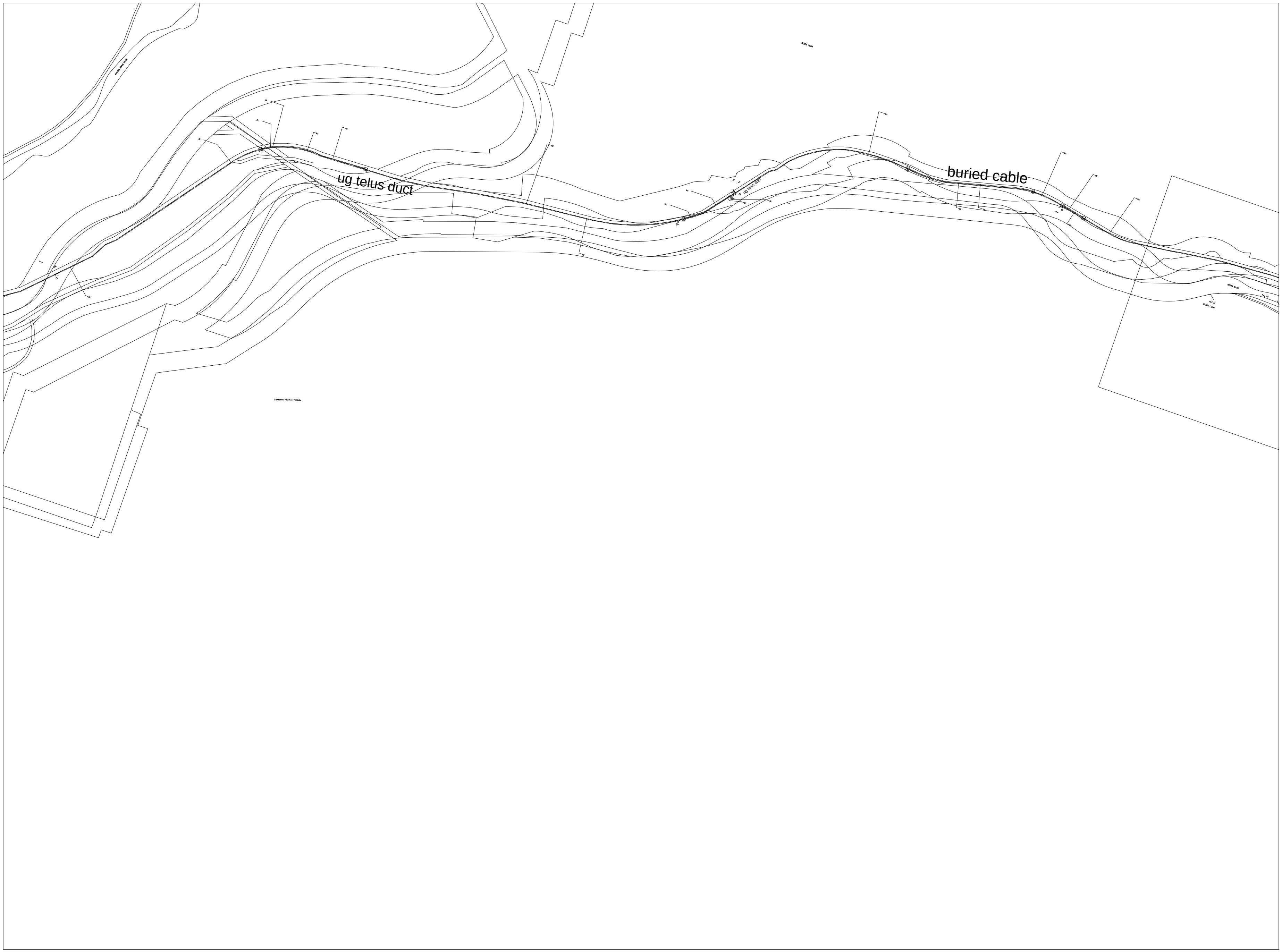
Aussi disponible en français



Date: 16/02/2015 **Time:** 7:36:17 AM

Notes: Thank you from TELUS. Please dig with Caution. Shelley - (604) 453-2588 / 1-877-453-2322 -

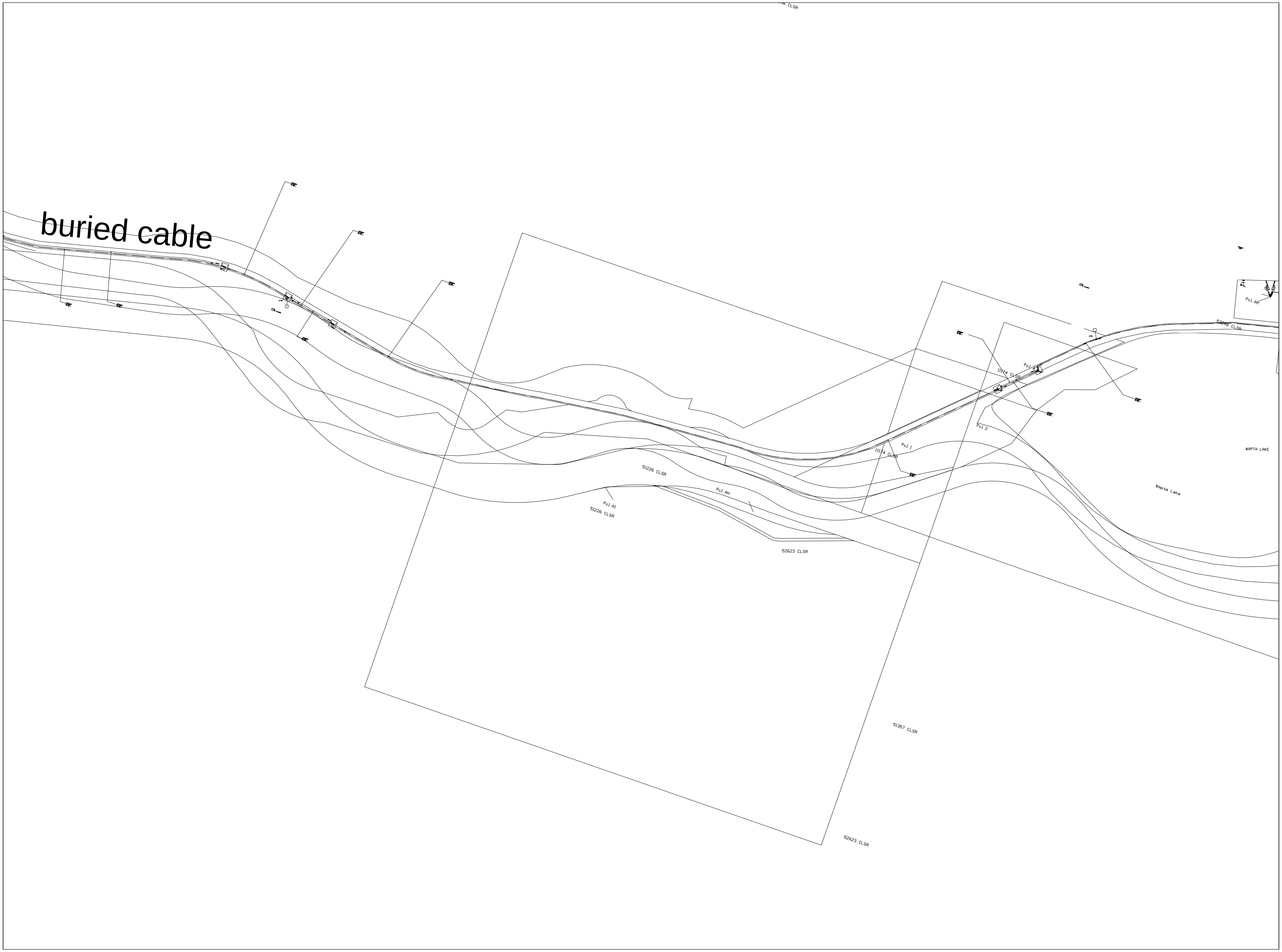
Field View



Date: 16/02/2015 **Time:** 7:40:28 AM

Notes: Thank you from TELUS. Please dig with Caution. Shelley - (604) 453-2588 / 1-877-453-2322 -

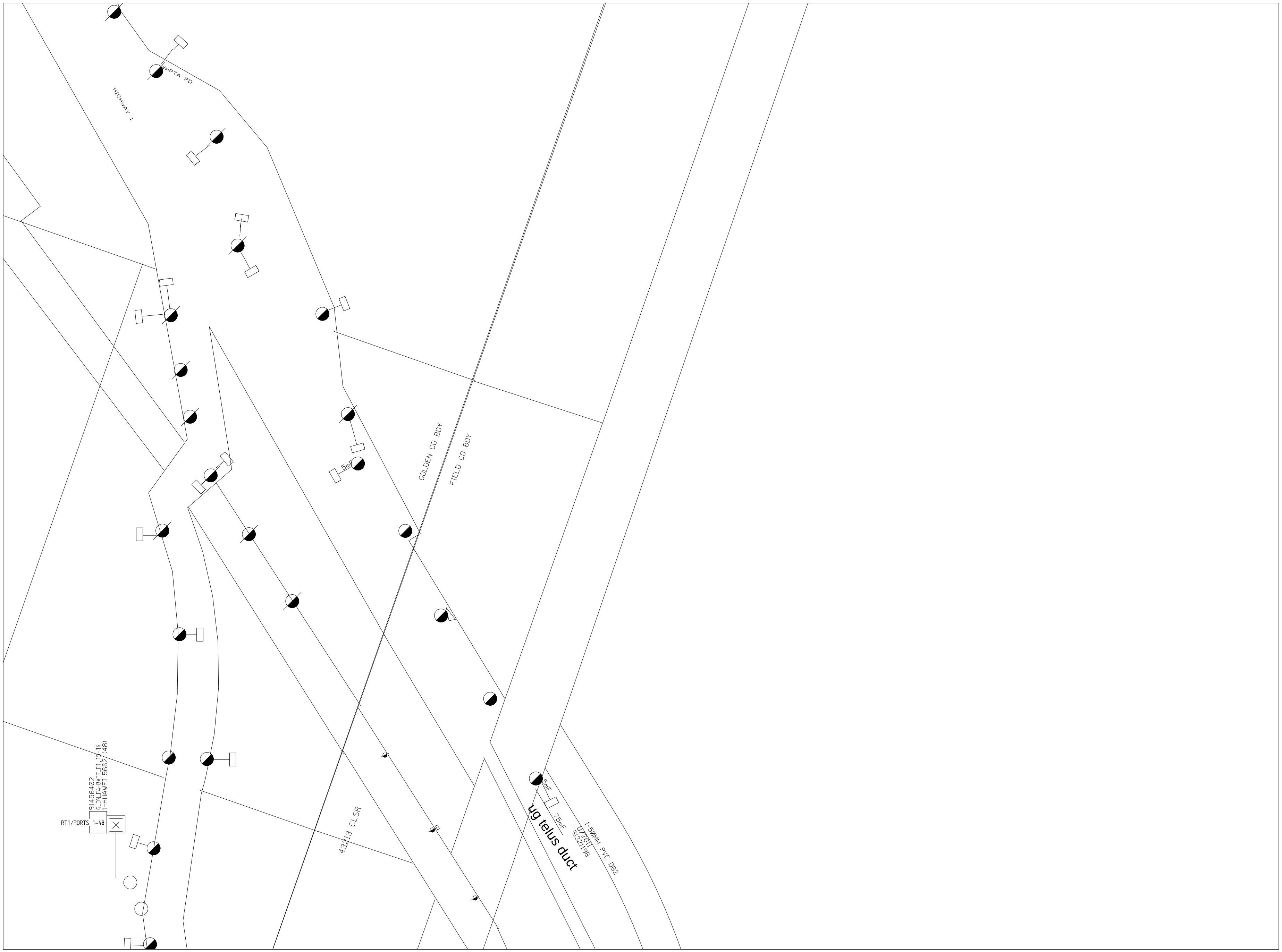
Field View



Date: 23/02/2015 **Time:** 11:38:24 AM

Notes: Thank you from TELUS. Please dig with Caution. Shelley - (604) 453-2588 / 1-877-453-2322 -

Field View



Date: 16/02/2015 **Time:** 7:46:48 AM

Notes: Thank you from TELUS. Please dig with Caution. Shelley - (604) 453-2588 / 1-877-453-2322 -

Field View

BC hydro

reliable power, at low cost, for generations

Underground Locates
BC 1 Call Phone: 1-800-474-6886
BC Hydro Phone: 1-866-960-3740
BC Hydro Fax: 1-866-844-3498
BC Hydro Email: bchlocates@bchydro.com

Location of B.C. Hydro's Distribution Underground Electrical System

The attached drawing shows the location of our underground electrical system.

The underground system can be at a depth of 1 to 5 feet, depending on terrain, and/or changes to streets, boulevards and private properties since the original installation.

- Attached are the available drawings showing BC Hydro underground distribution facilities in the area requested. No additional accuracy should be assumed by using electronic remote locating devices.
- In accordance with WCB regulations, the contractor remains responsible for locating the facilities in the field before starting to excavate or drill.

CAUTION ! Energized Cable
OBEY THESE RULES !

- First locate the underground facilities (a qualified locate contractor is recommended).
- Controlled excavation may be used to remove the excess overburden.
- Hand digging must then be used to expose facilities and prove exact location.
- Once exposed, mechanical digging may be used up to 50 cm from the facilities.
- Within 50 cm only hand digging is permitted.
- If a duct is exposed – the duct should be supported and protected to avoid sagging or damage. The duct shall be re-covered with 75 MM of clean sand below and 150 MM of clean sand above and beside the duct. The sand shall be hand tamped. Warning tape shall be re-established 400 – 600 MM above the duct in the native soil. The drawing on page 2 shows typical depths.
- **Do not excavate within one metre of a BC Hydro device (such as switchgear, transformers, pole, and others) as additional hazards (such as electrical limits-of-approach and device stability) may exist.**

DISCLAIMER

PLEASE NOTE:
BCHydro does not guarantee the location of our underground installation as shown on our drawings. Exact location of our underground plant must be proven by hand digging prior to excavating in proximity.

A locate contractor is recommended for all construction activity with one (1.0) meter from B.C. Hydro facilities.

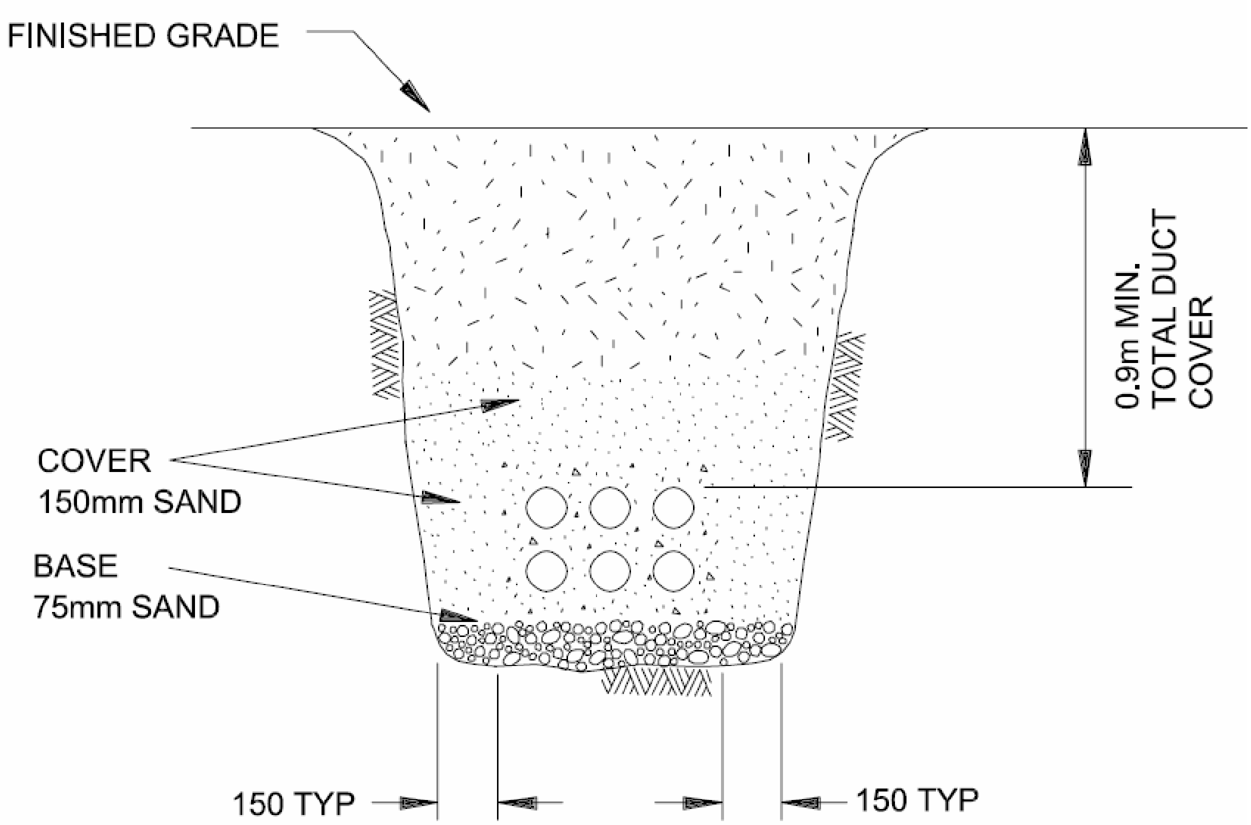
PLEASE DIG CAREFULLY AND SAFELY!

If through some unforeseen circumstances the ducts are damaged **stop** work immediately and call our office at 1-888-769-3766.

Please note: Our legend is dynamic and only displays underground electrical if it exists in the provided schematic.

The following attributes are above ground assets and are not included in the legend.

	Service Location - Existing Location
●	Pole - Existing Joint Use Location
□	Transmission - Structure Location
⊗	Transmission - Pole Location
X	Transmission - Clamp Location
—	Transmission - Overhead Line



TYPICAL TRENCH CROSS SECTION

BC hydro

Ticket No: 2015071431

Street No. From:
Street No. To:
Street: *** SEE ADD'L DIG IN
City: COLUMBIA – SHUSWAP

Name: ROBYN BARNETT
Company: TETRA TECH EBA

Phone No.: 6046088625
FAX No.:
Email: robyn.barnett@tetratech.com

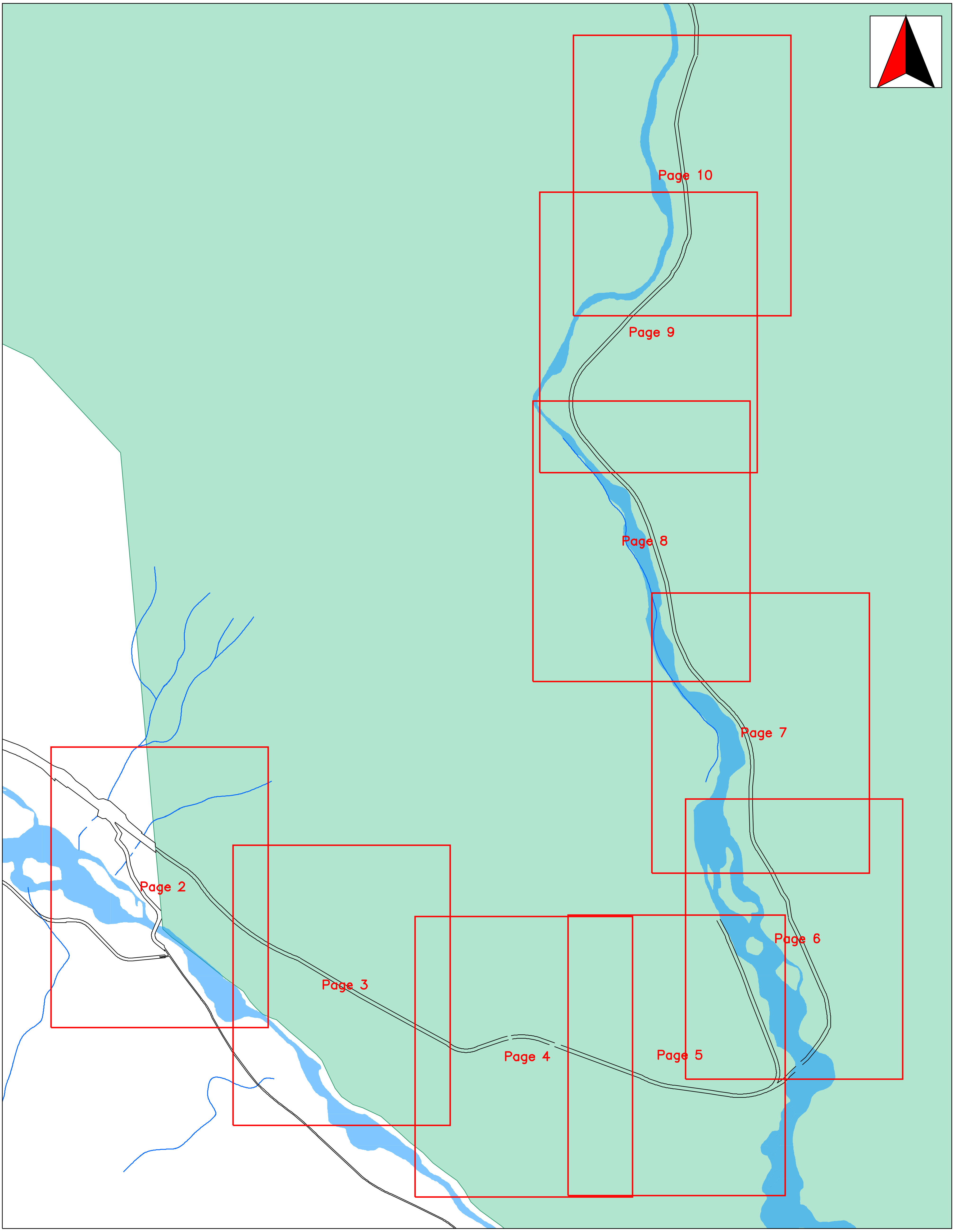
THIS IS A "B" SIZE
DRAWING 11 x 17

BC ONE CALL

2015-02-16

Scale: 1:30596

0m 300m 600m 900m 1200m 1500m



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BC Hydro does not accept any responsibility for errors or omissions. The information provided is the most accurate information we have available. Beware that underground electrical systems may exist that have not been record "AS CONSTRUCTED" yet.

The onus is on the operator to hand dig to locate the actual underground utility before any mechanized digging proceeds.

BChydro

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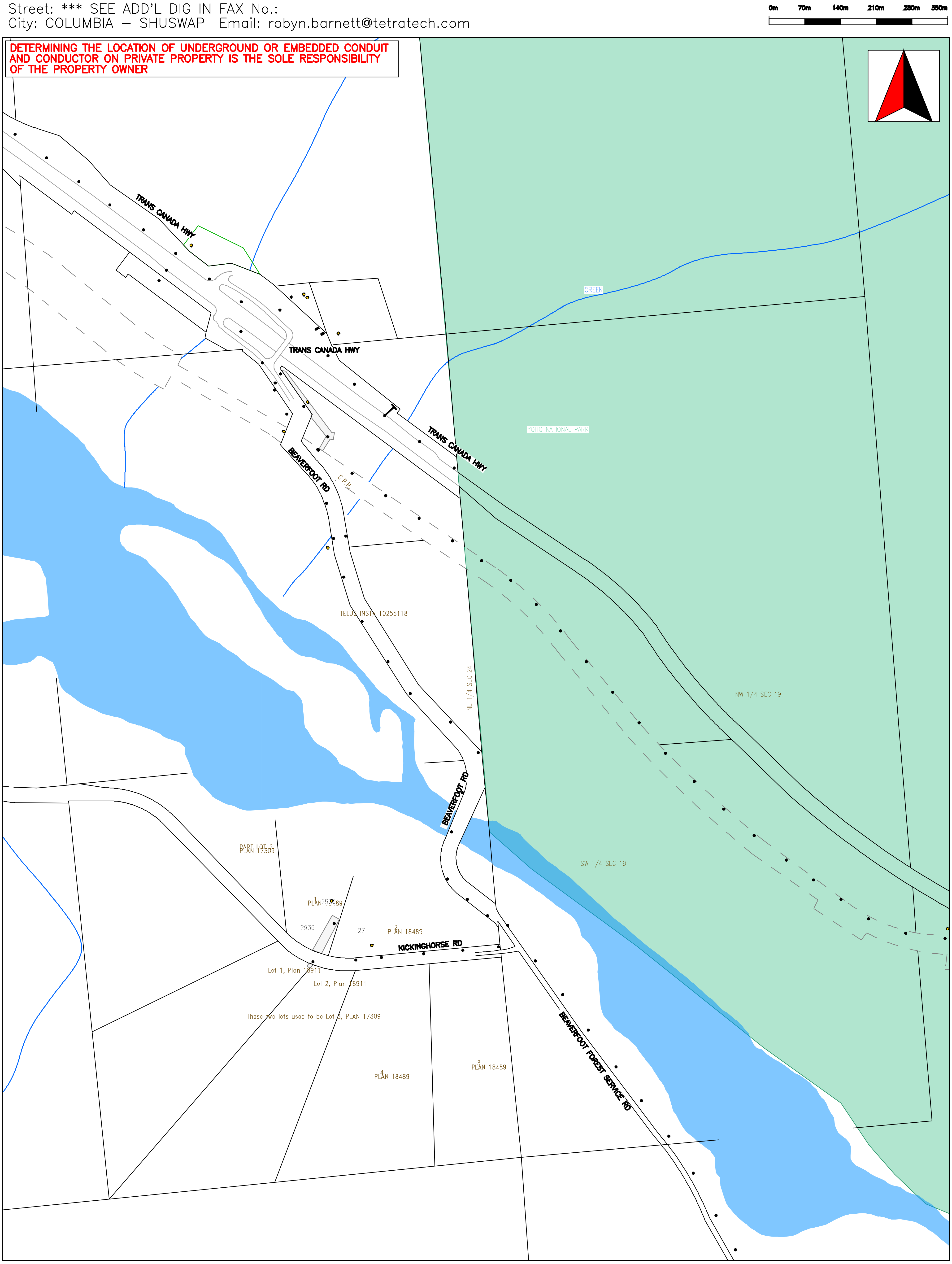
BC ONE CALL
2015-02-16
Scale: 1:7000

DETERMINING THE LOCATION OF UNDERGROUND OR EMBEDDED CONDUIT AND CONDUCTOR ON PRIVATE PROPERTY IS THE SOLE RESPONSIBILITY OF THE PROPERTY OWNER



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Legend

BC hydro

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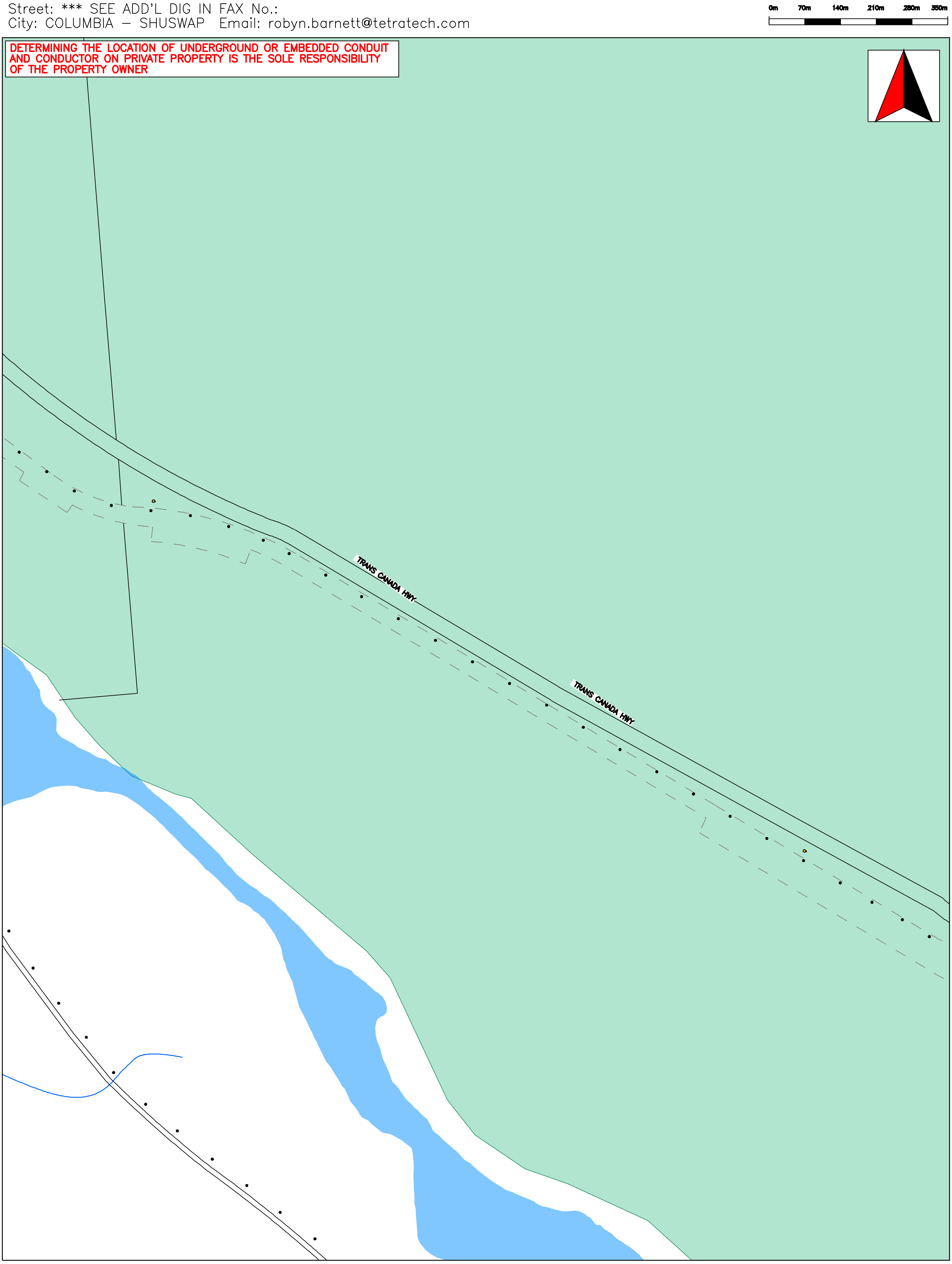

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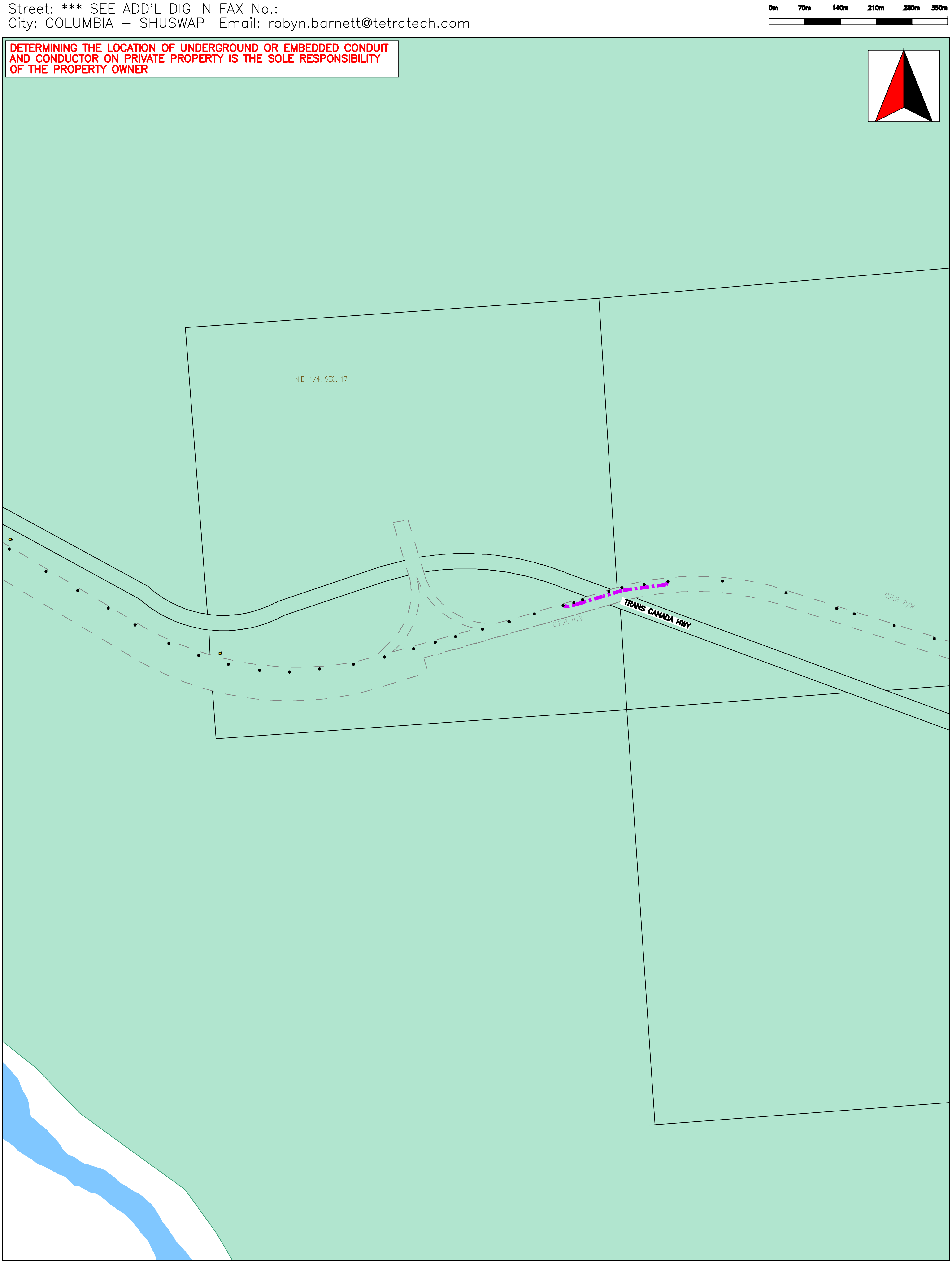

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Legend

distribution underground [Gis]

U/G Primary.Existing Phase 3 Line

BC hydro

BC ONE CALL

2015-02-16

Scale: 1:7000

0m 70m 140m 210m 280m 350m

Ticket No: 2015071431

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BC hydro

BC ONE CALL

2015-02-16

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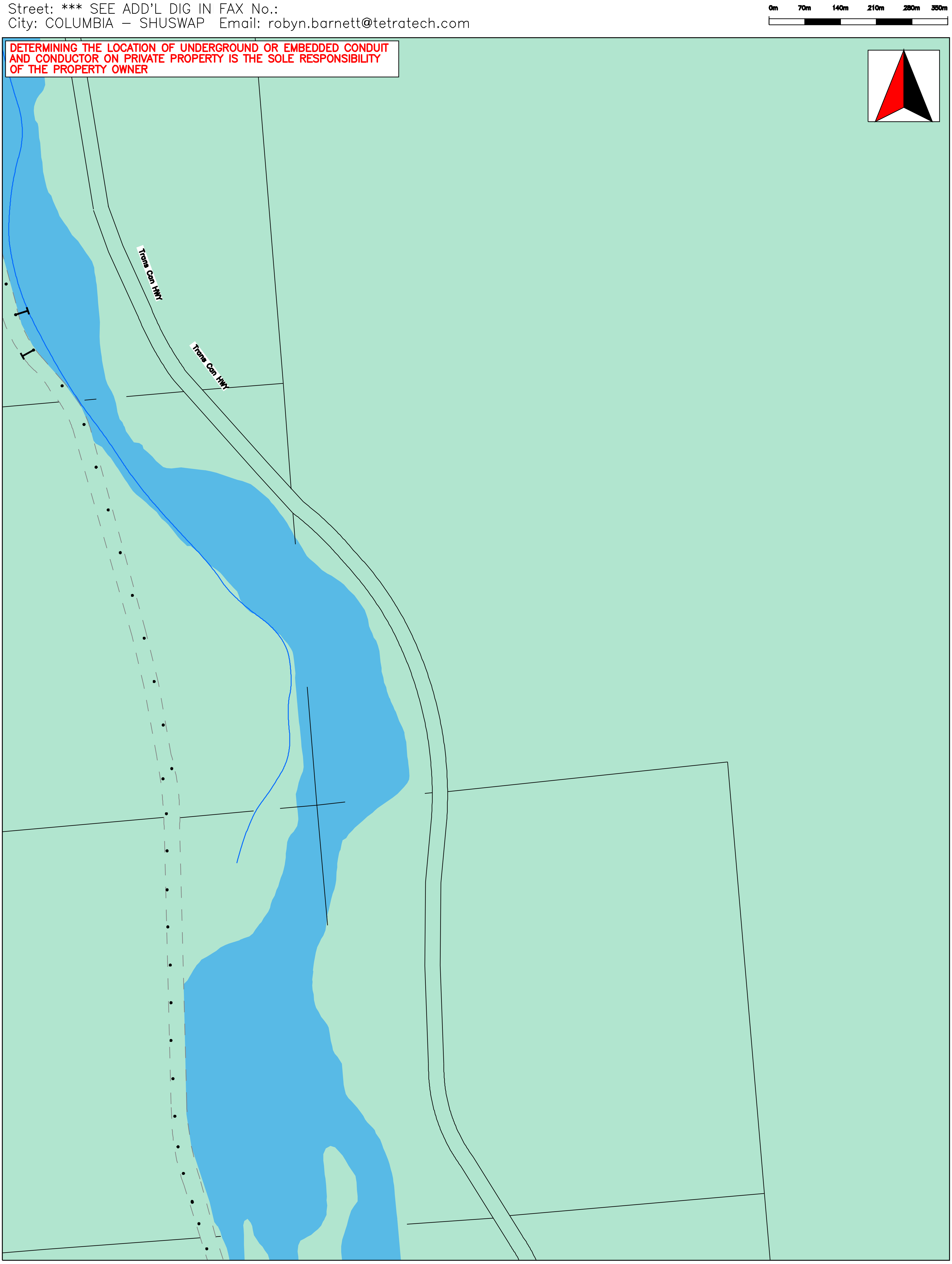

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Legend

BC hydro

BC ONE CALL

2015-02-16

Scale: 1:7000

0m 70m 140m 210m 280m 350m

Ticket No: 2015071431

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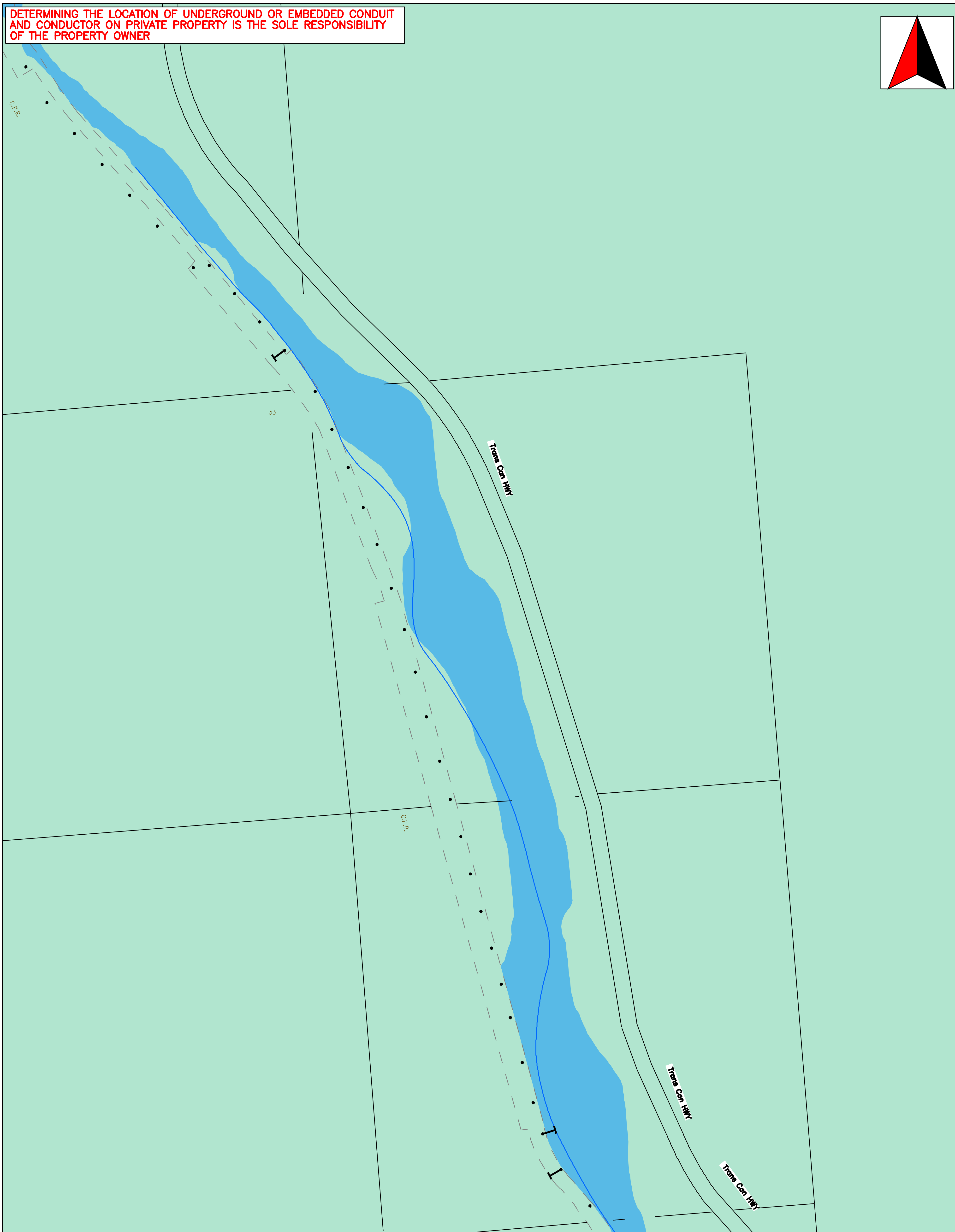

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BC hydro

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City: COLUMBIA - SHUSWAP

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BC ONE CALL
2015-02-16
Scale: 1:7000

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Legend

BC hydro

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Street: *** SEE ADD'L DIG IN
City: COLUMBIA – SHUSWAP

Name: ROBYN BARNETT
Company: TETRA TECH EBA

Phone No.: 6046088625
FAX No.:
Email: robyn.barnett@tetratech.com

THIS IS A "B" SIZE
DRAWING 11 x 17

BC ONE CALL

2015–02–16

Scale: 1:7000

0m 70m 140m 210m 280m 350m

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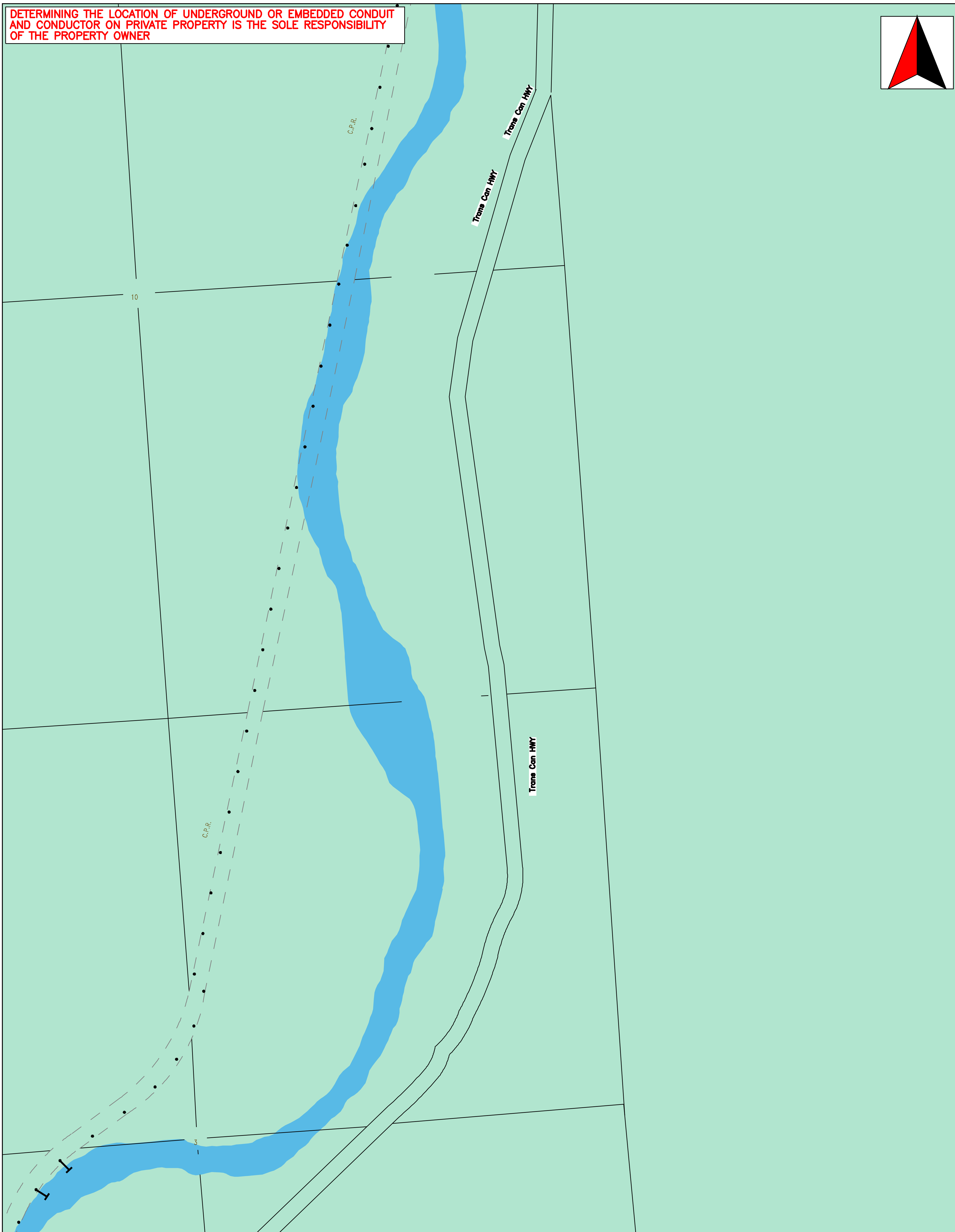

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Legend

APPENDIX B
ROCK MASS MAPPING DATA SHEETS

Project: PCA | **Location ID:** POI Start - 053 | **Date:** 22-Jan-15 | **Mapped By:** JP/SM | **Face DD (Corrected):** 186 | **Face Dip:** 65 | **Weather:** Sunny, -8°C - Snow On Ground

Location Chainage: Sta. 88+500 - 89+090 | **Colloquial Name:** Sherbrooke Creek Slope (East)

LOCATION	BEDROCK		DISCONTINUITY																		RMR89 PARAMETERS						COMMENTS
Station (POI)	Type	Strength	Weathering	Type	Dip	Dip Dir.*	DD** Corrected	Persistence (m)	Ends Visible	Spacing (m) Average	RQD	No. of Features	Shape	Roughness (JRC)	Aperture open/ tight	Aperture Width (mm)	Aperture Infill type	Water	Joint Condition (Jc)	GSI	RQD Factor	Strength Factor	Spacing Factor	Jcon	GW	RMR89	
53	MDST	R5	W1	J	45	15	31	10	0	1.6	100	3	PL	10	O	2		CD	25	75	20	12	15	25	15	87	Major set, toppling
53	MDST	R5	W1	J	70	160	176	3	1	1.4	100	2	PL	8	T			CD	30	75	20	12	15	30	15	92	Occasionally curved, forms rock face
53	MDST	R5	W1	J	44	14	30	10	0	1	70	3	PL	12	O	5		CD	20	70	13	12	15	20	15	75	toppling
53	MDST	R5	W1	J	40	148	164	3	1	0.5	70	3	PL	10	O	5		CD	20	65	13	12	10	20	15	70	possible blast damage
53	MDST	R5	W1	J	72	276	292	1	2	4	80	2	PL	8	T	1		CD	25	70	17	12	20	25	15	89	
53	MDST	R5	W2	J	46	25	41	5	1	0.5	90	3	PL	12	O	2		CD	25	65	17	12	10	25	15	79	
53	MDST	R5	W1	J	68	280	296	1	2	0.8	90	3	PL	8	O	1		CD	25	70	17	12	15	25	15	84	
53	MDST	R5	W2	J	48	184	200	4	1	0.7	90	2	PL	12	T			CD	30	75	17	12	15	30	15	89	
54	MDST	R4	W1	J/VN	40	106	122	4	1	2	50	2	PL	18	O	10		CD	15	60	8	7	15	15	15	60	multiple quartz veins, 5 mm vein
54	MDST	R4	W1	J	64	20	36	6	0	0.2	70	3	PL	10	O	1		CD	20	60	13	7	8	20	15	63	hairline aperture
54	MDST	R4	W1	J	48	198	214	2	1	1	70	2	PL	14	T			CD	25	60	13	7	15	25	15	75	
54	MDST	R4	W1	J	85	90	106	3	1	1.2	70	2	PL	12	T			CD	25	65	13	7	15	25	15	75	blast damage
54	MDST	R4	W1	J	56	12	28	10	0	1.5	90	3	PL	8	O	10		CD	20	65	17	7	15	20	15	74	
54	MDST	R4	W1	J	70	272	288	3	1	0.5	90	3	PL	10	O	1		CD	20	65	17	7	10	20	15	69	
54	MDST	R4	W1	J	45	180	196	3	1	0.8	60	3	PL	14	T			CD	30	65	13	7	15	30	15	80	
54	MDST	R4	W1	J	56	28	44	10	1	0.8	70	3	PL	10	T			CD	25	65	13	7	15	25	15	75	
54	MDST	R4	W1	J	26	152	168	4	1	0.5	70	3	PL	12	T			CD	25	65	13	7	10	25	15	70	
54	MDST	R4	W1	J	60	290	306	1	2	2	90	1	PL	12	T			CD	25	65	17	7	15	25	15	79	
54	MDST	R4	W1	J	55	32	48	10	0	0.8	90	3	PL	12	O	2		CD	25	70	17	7	15	25	15	79	
54	MDST	R4	W1	J	73	90	106	10	0	1.2	70	3	PL	10	T			CD	25	70	13	7	15	25	15	75	
54	MDST	R4	W1	J	42	202	218	5	0	0.7	70	3	PL	14	O	2		DR	20	70	13	7	15	20	4	59	
54	MDST	R4	W1	J	52	14	30	10	0	0.4	70	3	PL	10	O	2		CD	25	65	13	7	10	25	15	70	
54	MDST	R4	W1	J	82	122	138	6	1	1.2	70	3	PL	14	O	1		DR	20	65	13	7	15	20	4	59	
54	MDST	R4	W1	J	44	204	220	8	0	1	70	3	PL	14	O	2		DR	20	65	13	7	15	20	4	59	
55	MDST	R3	W1	J	62	22	38	4	1	0.2	50	2	PL	6	T			CD	25	55	8	4	8	25	15	60	similar to bedding
55	MDST	R3	W1	B	80	14	30	10	0	0.05	50	3	PL	6	T			CD	25	55	8	4	5	25	15	57	
55	MDST	R3	W1	J	52	156	172	3	1	0.3	50	2	UN	16	T			CD	30	55	8	4	10	30	15	67	quartz vein
55	MDST	R3	W1	BJ	60	12	28	6	0	0.5	60	3	PL	14	T			CD	25	60	13	4	10	25	15	67	
55	MDST	R3	W1	J	52	292	308	5	0	1	60	2	PL	14	T			CD	25	60	13	4	15	25	15	72	quartz vein visible, 10 - 15 mm wide
57	MDST	R3	W1	BJ	56	18	34	10	0	0.4	70	3	PL	10	T			CD	25	60	13	4	10	25	15	67	
57	MDST	R3	W1	J	52	28	44	3	2	1	70	2	PL	12	T			DR	25	60	13	4	15	25	4	61	
57	MDST	R3	W1	J	30	225	241	3	2		70	1	PL	12	O	2		CD	20	60	13	4	10	20	15	62	
57	MDST	R4	W1	BJ	46	14	30	10	0	0.7	70	3	PL	10	O	2		CD	20	60	13	7	15	20	15	70	
57	MDST	R4	W1	J	68	258	274	4	1	1	70	3	PL	12	T			CD	25	60	13	7	15	25	15	75	
57	MDST	R4	W1	J	62	166	182	1	1	0.6	70	2	PL	12	T			DR	20	65	13	7	10	20	4	54	
57	MDST	R4	W1	J	80	180	196	4	1	1	70	3	PL	12	T			CD	25	65	13	7	15	25	15	75	TT15-R01 sample
61	LST	R5	W2	J	60	120	136	10	0		100	1	PL	10	T			CD	25	75	20	12	10	25	15	82	Very persistant joint, random orientation, possible fault.
61	MDST	R4	W2	J	85	278	294	10	0	0.6	80	3	PL	10	T			CD	25	65	17	7	10	25	15	74	Dominant set
61	MDST	R4	W2	J	48	26	42	5	1	0.4	90	3	UN	12	O	3		CD	20	65	17	7	10	20	15	69	
61	MDST	R4	W2	J	56	220	236	2	1		80	1	PL	10	T			CD	25	65	17	7	10	25	15	74	
61	MDST	R4	W2	J	68	268	284	10	0	0.6	80	3	PL	10	T			CD	25	65	17	7	10	25	15	74	
61	MDST	R4	W2	F	40	5	21	20	0		60	1	UN	18	O	5-10		CD	20	55	13	7	10	20	15	65	Thrust fault, joints appears to bend. Orientation similar to bedding
61	LST	R5	W1	J	60	26	42	5	1	1	90	3	PL	16	T			CD	30	70	17	12	15	30	15	89	
61	LST	R5	W1	J	78	285	301	10	0	3	90	3	PL	10	T			CD	25	70	17	12	20	25	15	89	
61	LST	R5	W1	J	52	190	206	6	1	1.6	90	3	UN	10	O	1		CD	25	70	17	12	15	25	15	84	
61	LST	R5	W1	J	63	280	296	10	0	0.7	80	3	PL	6	T			CD	25	65	17	12	15	25	15	84	
61	LST	R5	W1	J	52	18	34	10	0	0.6	80	3	PL	6	O	1		CD	20	65	17	12	10	20	15	74	
61	LST	R5	W1	J	56	202	218	5	1	1.5	80	2	PL	6	O	1		CD	20	65	17	12	15	20	15	79	
61	MDST/LST	R4	W1	B	52	12	28	8	1	0.9	70	3	UN	6	T			CD	25	65	13	7	15	25	15	75	Unconformity mustone/limestone contact
61	LST	R4	W1	J	38	170	186	7	0	1.4	70	2	PL	6	T			CD	25	65	13	7	15	25	15	75	
61	MDST	R5	W1	J	78	292	308	5	1	3	70	3	PL	6	T			CD	25	65	13	12	20	25	15	85	
61	MDST	R5	W1	J	56	190	206	5	1	1.5	70	3	PL	6	O	1		CD	20	65	13	12	15	20	15	75	
61	MDST	R5	W1	J	30	20	36	6	1	0.9	80	2	PL	6	T			CD	25	65	17	12	15	25	15	84	
61	MDST	R5	W2	J	64	290	306	9	0	2.5	80	3	PL	8	T			CD	25	65	17	12	20	25	15	89	
61	MDST	R5	W1	J	62	218	234	2	1	3	80	2	PL	10	T			CD	25	65	17	12	20	25	15	89	
61	MDST	R5	W1	J	36	238	254	1.5	1	1	80	2	PL	8	O	1		CD	25	65	17	12	15	25	15	84	
61	MDST	R5	W2	J	78	302	318	8	0	3	70	3	PL	12	O	1		CD	25	65	13	12	20	25	15	85	
61	MDST	R5	W2	J	68	22	38	4	0	0.8	70	1	PL	10	T			CD	25	65	13	12	15	25	15	80	
61	MDST	R5	W2	J	32	182	198	5	1	1.4	70	2	PL	8	T			CD	25	65	13	12	15	25	15	80	
61	MDST	R5	W2	J	80	290	306	10	0	2.5	70	3	PL	14	T			CD	25	65	13	12	20	25	15	85	

Project: PCA	**Location ID:** POI Start - 053	**Date:** 22-Jan-15	**Mapped By:** JP/SM	**Face DD (Corrected):** 186	**Face Dip:** 65	**Weather:** Sunny, -8°C - Snow On Ground
Location Chainage: Sta. 88+500 - 89+090			**Colloquial Name:** Sherbrooke Creek Slope (East)			

LOCATION	**BEDROCK**		**DISCONTINUITY**																		**RMR89 PARAMETERS**						**COMMENTS**
Station (POI)	Type	Strength	Weathering	Type	Dip	Dip Dir.*	DD** Corrected	Persistence (m)	Ends Visible	Spacing (m) Average	RQD	No. of Features	Shape	Roughness (JRC)	Aperture open/ tight	Aperture Width (mm)	Aperture Infill type	Water	Joint Condition (Jc)	GSI	RQD Factor	Strength Factor	Spacing Factor	Jcon	GW	RMR89	
61	MDST	R5	W2	J	58	12	28	3	1	0.7	70	1	PL	10	T			CD	25	65	13	12	15	25	15	80	

ROCK EXPOSURE COMMENTS:

*Dip Direction with no magnetic declination correction

**Dip Direction with magnetic declination correction of 16 degrees east applied

Type	Type (ctd)	Shape	Termination	Water	Aperture	Infill
FT: Fault	CT: Contact	pl: Planar	2: Doubly Terminated	CD: Completely Dry	O: Open	C: Clay
SZ: Shear Zone	FO: Foliation	un: Undulating	1: Singly Terminated	D: Damp	T: Tight	S: Silt
JT: Joint	BZ: Broken Zone	st: Stepped	0: No Termination	W: Wet		S: Sand
VN:Vein		cu: Curved		DR: Dripping		
BD: Bedding				F: Flowing		

Project: PCA	**Location ID:** POI Start - 084	**Date:** 23-Jan-15	**Mapped By:** JP/SM	**Face DD (Corrected):** 171	**Face Dip:** 80	**Weather:** Cloudy, -1°C - Snow On Ground
Location Chainage:	Sta. 89+160 - 89+420		**Colloquial Name:**	Sherbrooke Creek Slope (West)		

LOCATION	BEDROCK		DISCONTINUITY																		RMR89 PARAMETERS						COMMENTS
Station (POI)	Type	Strength	Weathering	Type	Dip	Dip Dir.*	DD** Corrected	Persistence (m)	Ends Visible	Spacing (m) Average	RQD	No. of Features	Shape	Roughness (JRC)	Aperture open/ tight	Aperture Width (mm)	Aperture Infill type	Water	Joint Condition (Jc)	GSI	RQD Factor	Strength Factor	Spacing Factor	Jcon	GW	RMR89	
84	MDST	R4	W1	J	68	260	276	6	0	0.3	70	3	PL	4	T			CD	25	65	13	7	10	25	15	70	Toppling on 2 subvertical joints
84	MDST	R4	W1	J	70	260	276	6	0	0.3	70	1	PL	4	T			CD	25	65	13	7	10	25	15	70	
84	MDST	R4	W1	J	70	250	266	6	0	0.3	70	1	PL	4	T			CD	25	65	13	7	10	25	15	70	
84	MDST	R4	W1	J	72	262	278	6	0	0.3	70	1	PL	8	T			CD	25	65	13	7	10	25	15	70	
84	MDST	R4	W1	J	68	262	278	6	0	0.3	70	1	PL	8	T			CD	25	65	13	7	10	25	15	70	
84	MDST	R4	W1	J	50	12	28	4	1	0.15	70	3	PL	12	T			CD	30	65	13	7	8	30	15	73	
84	MDST	R4	W1	J	40	10	26	4	1	0.15	70	1	UN	12	T			CD	30	65	13	7	8	30	15	73	
84	MDST	R4	W1	J	40	360	16	4	1	0.15	70	1	UN	12	T			CD	30	65	13	7	8	30	15	73	
84	MDST	R4	W1	J	46	5	21	4	1	0.15	70	1	UN	12	T			CD	30	65	13	7	8	30	15	73	
84	MDST	R4	W1	J	34	18	34	4	1	0.15	70	1	UN	12	T			CD	30	65	13	7	8	30	15	73	
84	MDST	R4	W1	J	30	8	24	4	1	0.15	70	1	PL	12	T			CD	30	65	13	7	8	30	15	73	
84	MDST	R4	W1	J	32	164	180	1	0	0.3	70	1	UN	16	T			CD	30	65	13	7	10	30	15	75	
84	MDST	R4	W1	J	50	160	176	1	0	0.3	70	1	UN	16	T			CD	30	65	13	7	10	30	15	75	
84	MDST	R4	W1	J	60	158	174	1	0	0.3	70	1	UN	16	T			CD	30	65	13	7	10	30	15	75	
84	MDST	R4	W1	J	58	162	178	1	0	0.3	70	1	UN	16	T			CD	30	65	13	7	10	30	15	75	
85	MDST	R4	W1	J	66	252	268	10	0	0.8	90	3	PL	2	T			CD	20	70	17	7	15	20	15	74	
85	MDST	R4	W1	J	70	238	254	10	0	0.8	90	1	PL	2	O	1		CD	18	70	17	7	15	18	15	72	
85	MDST	R4	W1	J	78	260	276	10	0	0.8	90	1	PL	2	T			CD	18	70	17	7	15	18	15	72	
85	MDST	R4	W1	J	58	306	322	10	0	0.3	80	3	PL	6	T			CD	25	70	17	7	10	25	15	74	
85	MDST	R4	W1	J	52	314	330	10	0	0.3	80	1	PL	6	O	1		CD	20	70	17	7	10	20	15	69	
85	MDST	R4	W1	J	52	148	164	6	1	1.2	80	3	UN	12	O	1		DR	25	70	17	7	15	25	4	68	Undulating typically dipping as recorded, more joints on face but not accessible
85	MDST	R4	W1	J	42	120	136	6	1	1.2	80	1	UN	12	T			DR	28	70	17	7	15	28	4	71	
85	MDST	R4	W1	J	22	116	132	6	1	1.2	80	1	UN	12	T			DR	28	70	17	7	15	28	4	71	
86	LST	R5	W2	B	60	20	36	6	1	1.2	80	1	UN	12	T			DR	28	70	17	12	15	28	4	76	
86	LST	R5	W2	J	58	286	302	1	2	0.2	80	3	PL	8	T			CD	30	60	17	12	8	30	15	82	
86	LST	R5	W2	J	70	282	298	1	2	0.2	80	1	PL	8	T			CD	30	60	17	12	8	30	15	82	
86	LST	R5	W2	J	56	262	278	1	2	0.2	80	1	PL	8	T			CD	30	60	17	12	8	30	15	82	
86	LST	R5	W2	J	62	260	276	1	2	0.2	80	1	PL	8	T			CD	30	60	17	12	8	30	15	82	
86	LST	R5	W2	J	60	310	326	4	0	0.15	70	3	UN	16	T			CD	25	60	13	12	8	25	15	73	
86	LST	R5	W2	J	60	300	316	4	0	0.15	70	1	UN	16	T			CD	25	60	13	12	8	25	15	73	
86	LST	R5	W2	J	54	308	324	4	0	0.15	70	1	UN	16	T			CD	25	60	13	12	8	25	15	73	
86	LST	R5	W2	J	50	318	334	4	0	0.15	70	1	UN	16	T			CD	25	60	13	12	8	25	15	73	
86	LST	R5	W2	J	32	128	144	4	1	1.6	70	2	UN	12	O	1		CD	25	60	13	12	15	25	15	80	
86	LST	R5	W2	J	40	146	162	4	1	1.6	70	1	UN	12	O	1		CD	28	60	13	12	15	28	15	83	
86	MDST	R4	W2	J	62	302	318	7	0	0.6	100	3	PL	2	T			CD	25	65	20	7	10	25	15	77	4mm quartz vein dipping at 60/222
86	MDST	R4	W2	J	64	306	322	7	0	0.6	100	1	PL	2	T			CD	25	65	20	7	10	25	15	77	
86	MDST	R4	W2	J	64	304	320	7	0	0.6	100	1	PL	2	T			CD	25	65	20	7	10	25	15	77	
86	MDST	R4	W2	J	80	25	41	1	2	2	90	3	PL	8	O	1		CD	25	60	17	7	15	25	15	79	
86	MDST	R4	W2	J	20	38	54	1	2	2	90	1	PL	8	O	1		CD	25	60	17	7	15	25	15	79	
86	MDST	R4	W2	J	40	168	184	3	1	0.7	80	3	UN	8	T			CD	25	60	17	7	15	25	15	79	
86	MDST	R4	W2	J	42	160	176	3	1	0.7	80	1	UN	8	T			CD	25	60	17	7	15	25	15	79	
88	MDST	R4	W2	J	56	292	308	1	1	0.4	60	2	UN	14	T			CD	30	50	13	7	10	30	15	75	
88	MDST	R4	W2	J	48	256	272	1	1	0.4	60	1	UN	14	T			CD	30	50	13	7	10	30	15	75	
88	MDST	R4	W2	J	82	38	54	3	1	0.2	60	3	PL	4	T			CD	20	50	13	7	8	20	15	63	
88	MDST	R4	W2	J	88	210	226	3	1	0.2	60	1	PL	4	O	3		CD	18	50	13	7	8	18	15	61	
88	MDST	R4	W2	J	85	192	208	3	1	0.2	60	1	PL	4	T			CD	20	50	13	7	8	20	15	63	
88	MDST	R4	W2	J	42	132	148	1	2	0.5	68	2	UN	12	T			CD	25	50	13	7	10	25	15	70	
88	MDST	R4	W2	J	42	110	126	1	2	0.5	68	1	UN	12	T			CD	25	50	13	7	10	25	15	70	
88	MDST	R4	W2	J	40	116	132	1	2	0.5	68	1	UN	12	T			CD	25	50	13	7	10	25	15	70	
88	MDST	R2	W2	J	60	276	292	10	0	1.3	80	3	PL	10	T			CD	25	65	17	2	15	25	15	74	

Project: PCA	Location ID: POI Start - 084	Date: 23-Jan-15	Mapped By: JP/SM	Face DD (Corrected): 171	Face Dip: 80	Weather: Cloudy, -1°C - Snow On Ground
Location Chainage: Sta. 89+160 - 89+420			Colloquial Name: Sherbrooke Creek Slope (West)			

LOCATION	BEDROCK		DISCONTINUITY																		RMR89 PARAMETERS						COMMENTS
Station (POI)	Type	Strength	Weathering	Type	Dip	Dip Dir.*	DD** Corrected	Persistence (m)	Ends Visible	Spacing (m) Average	RQD	No. of Features	Shape	Roughness (JRC)	Aperture open/ tight	Aperture Width (mm)	Aperture Infill type	Water	Joint Condition (Jc)	GSI	RQD Factor	Strength Factor	Spacing Factor	Jcon	GW	RMR89	
88	MDST	R2	W2	J	60	300	316	10	0	1.3	80	1	PL	10	T			CD	25	65	17	2	15	25	15	74	
88	MDST	R2	W2	J	66	284	300	10	0	1.3	80	1	PL	10	T			CD	25	65	17	2	15	25	15	74	
88	MDST	R2	W2	J	68	298	314	10	0	1.3	80	1	PL	10	T			CD	25	65	17	2	15	25	15	74	
88	MDST	R2	W2	J	8	320	336	5	2	1.5	80	3	UN	8	T			CD	25	60	17	2	15	25	15	74	
88	MDST	R2	W2	J	12	136	152	5	2	1.5	80	1	UN	8	T			CD	25	60	17	2	15	25	15	74	
88	MDST	R2	W2	J	22	260	276	5	2	1.5	80	1	UN	8	T			CD	25	60	17	2	15	25	15	74	
88	MDST	R2	W2	J	84	180	196	1.5	1	0.15	70	3	UN	8	T			CD	25	60	13	2	8	25	15	63	Locally slatey
88	MDST	R2	W2	J	80	24	40	1.5	1	0.15	70	1	UN	8	T			CD	25	60	13	2	8	25	15	63	
91	MDST	R4	W2	J	72	260	276	3	1	0.7	80	3	UN	6	O	1		CD	20	65	17	7	15	20	15	74	
91	MDST	R4	W2	J	90	240	256	3	1	0.7	80	1	UN	6	O	2		CD	18	65	17	7	15	18	15	72	
91	MDST	R4	W2	J	86	188	204	4	0	0.4	80	3	UN	8	O	1		CD	20	65	17	7	10	20	15	69	
91	MDST	R4	W2	J	86	192	208	4	0	0.4	80	1	UN	8	T			CD	25	65	17	7	10	25	15	74	
91	MDST	R4	W2	J	72	218	234	4	0	0.4	80	1	UN	8	T			CD	25	65	17	7	10	25	15	74	
91	MDST	R4	W2	J	3	340	356	10	0	0.5	90	3	UN	6	O	1		CD	25	65	17	7	10	25	15	74	
91	MDST	R4	W2	J	4	150	166	10	0	0.5	90	1	UN	6	O	1		CD	25	65	17	7	10	25	15	74	
91	MDST	R4	W2	BJ	54	30	46	4	1	1	90	3	UN	14	O	1		CD	25	65	17	7	15	25	15	79	Minor folds visible, dominant but intermittent
91	MDST	R4	W2	BJ	48	18	34	4	1	1	90	1	UN	14	O	2		CD	25	65	17	7	15	25	15	79	
91	MDST	R4	W2	J	68	268	284	10	0	1.2	90	3	UN	10	T			CD	25	65	17	7	15	25	15	79	
91	MDST	R4	W2	J	30	168	184	10	0	1.1	90	3	UN	12	O	1		CD	25	65	17	7	15	25	15	79	
91	MDST	R4	W2	J	40	172	188	10	0	1.1	90	1	UN	12	O	1		CD	25	65	17	7	15	25	15	79	
91	MDST	R4	W2	BJ	66	18	34	10	1	1.5	90	3	UN	12	O	2		CD	25	65	17	7	15	25	15	79	Possibly Bedding Joint
91	MDST	R4	W2	BJ	64	18	34	10	1	1.5	90	1	UN	12	O	1		CD	25	65	17	7	15	25	15	79	
91	MDST	R4	W2	BJ	66	18	34	10	0	1	80	3	UN	14	O	1		CD	25	65	17	7	15	25	15	79	Blast induced damage
91	MDST	R4	W2	BJ	60	14	30	10	0	1	80	1	UN	14	T			CD	28	65	17	7	15	28	15	82	
91	MDST	R4	W2	BJ	60	20	36	10	0	1	80	1	UN	14	T			CD	28	65	17	7	15	28	15	82	
91	MDST	R4	W2	J	78	296	312	10	0	0.5	80	3	UN	6	T			CD	25	65	17	7	10	25	15	74	
91	MDST	R4	W2	J	80	294	310	10	0	0.5	80	1	UN	6	T			CD	25	65	17	7	10	25	15	74	
91	MDST	R4	W2	J	60	280	296	10	0	0.5	80	1	UN	6	T			CD	25	65	17	7	10	25	15	74	
91	MDST	R4	W2	J	72	300	316	10	0	0.5	80	1	UN	6	T			CD	25	65	17	7	10	25	15	74	
91	MDST	R4	W2	J	30	192	208	10	0	0.4	80	3	UN	8	O	2		CD	20	65	17	7	10	20	15	69	
91	MDST	R4	W2	J	28	150	166	10	0	0.4	80	1	UN	8	T			CD	25	65	17	7	10	25	15	74	
91	MDST	R4	W2	J	34	162	178	10	0	0.4	80	1	UN	8	T			CD	25	65	17	7	10	25	15	74	
91	MDST	R4	W2	J	32	148	164	10	0	0.4	80	1	UN	8	T			CD	25	65	17	7	10	25	15	74	

ROCK EXPOSURE COMMENTS:

*Dip Direction with no magnetic declination correction
**Dip Direction with magnetic declination correction of 16 degrees east applied

Type	Type (ctd)	Shape	Termination	Water	Aperture	Infill
FT: Fault	CT: Contact	pl: Planar	2: Doubly Terminated	CD: Completely Dry	O: Open	C: Clay
SZ: Shear Zone	FO: Foliation	un: Undulating	1: Singly Terminated	D: Damp	T: Tight	S: Silt
JT: Joint	BZ: Broken Zone	st: Stepped	0: No Termination	W: Wet		S: Sand
VN:Vein		cu: Curved		DR: Dripping		
BD: Bedding				F: Flowing		

Project: PCA	**Location ID:** POI Start - 172	**Date:** 25-Jan-15	**Mapped By:** JP/SM	**Face DD (Corrected):** 326	**Face Dip:** 80	**Weather:** Overcast, 1°C - Snow On Ground
Location Chainage:	Sta. 113+320 - 114+000		**Colloquial Name:**	Finn Creek		

LOCATION	BEDROCK		DISCONTINUITY													Aperture						RMR89 PARAMETERS						COMMENTS
Station (POI)	Type	Strength	Weathering	Type	Dip	Dip Dir.*	DD** Corrected	Persistence (m)	Ends Visible	Spacing (m) Average	RQD	No. of Features	Shape	Roughness (JRC)	open/ tight	Width (mm)	Infill type	Water	Joint Condition (Jc)	GSI	RQD Factor	Strength Factor	Spacing Factor	Jcon	GW	RMR89	
172	MDST	R5	W2	J	82	160	176	3	1	0.4	10	1	UN	14	T			CD	25	45	3	12	10	25	15	65	Iron stained, bedding visible, curved, possibly random
172	MDST	R5	W1	CJ	87	198	214	4	0	0.05	10	3	UN	6	T			CD	20	45	3	12	5	20	15	55	cleavage
172	MDST	R5	W1	CJ	82	196	212	2	0	0.05	10	1	UN	6	T			CD	20	45	3	12	5	20	15	55	
172	MDST	R5	W1	CJ	88	202	218	1	0	0.05	10	1	UN	6	T			CD	20	45	3	12	5	20	15	55	
172	MDST	R5	W1	CJ	85	190	206	1	0	0.05	10	1	UN	6	T			CD	20	45	3	12	5	20	15	55	
172	MDST	R5	W1	CJ	78	210	226	1	0	0.05	10	1	UN	6	T			CD	20	45	3	12	5	20	15	55	
172	MDST	R5	W1	BJ	24	198	214	2	1	1	10	3	PL	12	T			CD	25	45	3	12	15	25	15	70	Bedding prominent, not associated with dominant jointing in this location
172	MDST	R5	W1	BJ	24	184	200	2	1	1	10	1	PL	12	T			CD	25	45	3	12	15	25	15	70	
172	MDST	R5	W1	B	20	216	232	2	1	1	10	1	PL	12	T			CD	25	45	3	12	15	25	15	70	
172	MDST	R5	W1	BJ	24	214	230	2	1	1	10	1	PL	12	T			CD	25	45	3	12	15	25	15	70	
172	MDST	R5	W1	B	12	208	224	2	1	1	10	1	PL	12	T			CD	25	45	3	12	15	25	15	70	
172	MDST	R5	W1	B	26	208	224	2	1	1	10	1	PL	12	T			CD	25	45	3	12	15	25	15	70	
172	MDST	R5	W1	BJ	23	220	236	2	1	1	10	1	PL	12	T			CD	25	45	3	12	15	25	15	70	
172	MDST	R5	W1	J	88	330	346	2	2	0.3	80	2	UN	14	T			CD	25	50	17	12	10	25	15	79	Clevage not dominant joints at this location hence higher RQD
172	MDST	R5	W1	J	82	318	334	2	2	0.3	80	1	UN	14	T			CD	25	50	17	12	10	25	15	79	
172	MDST	R5	W1	BJ	23	172	188	5	1	0.7	80	3	UN	16	O	1		CD	25	50	17	12	15	25	15	84	
172	MDST	R5	W1	BJ	16	178	194	5	1	0.7	80	1	UN	14	T			CD	28	50	17	12	15	28	15	87	
172	MDST	R5	W1	BJ	28	192	208	5	1	0.7	80	1	UN	14	T			CD	28	50	17	12	15	28	15	87	
172	MDST	R5	W1	CJ	82	208	224	1	2	0.1	60	3	UN	6	T			CD	20	50	13	12	8	20	15	68	
172	MDST	R5	W1	CJ	83	207	223	1	2	0.1	60	1	UN	6	O	1		CD	25	50	13	12	8	25	15	73	
172	MDST	R5	W1	CJ	82	210	226	1	2	0.1	60	1	UN	6	O			CD	25	50	13	12	8	25	15	73	
172	MDST	R5	W2	J	88	62	78	4	0	0.1	80	1	UN	10	O	1		CD	20	50	17	12	8	20	15	72	Random joint forms rock face, may be blast induced conical shape
172	MDST	R5	W2	J	80	301	317	2	2	0.5	80	2	UN	12	T			CD	25	50	17	12	10	25	15	79	Bedding folded, sub horizontal anticline along cleavage
173	MDST	R5	W1	BJ	10	162	178	3	1	1	80	2	UN	12	O	1		CD	20	50	17	12	15	20	15	79	
173	MDST	R5	W1	BJ	8	128	144	3	1	1	80	1	UN	12	T			CD	25	50	17	12	15	25	15	84	
173	MDST	R5	W1	BJ	11	172	188	3	1	1	80	1	UN	12	T			CD	25	50	17	12	15	25	15	84	
173	MDST	R5	W1	CJ	79	214	230	5	0	0.1	70	3	PL	8	T			CD	20	50	13	12	8	20	15	68	
173	MDST	R5	W1	CJ	77	213	229	5	0	0.1	70	1	PL	8	T			CD	20	50	13	12	8	20	15	68	
173	MDST	R5	W1	CJ	85	218	234	5	0	0.1	70	1	PL	8	T			CD	20	50	13	12	8	20	15	68	
175	MDST	R3	W3	J	34	398	54	6	0	0.7	30	2	UN	12	O	3		CD	18	45	8	4	15	18	15	60	
175	MDST	R3	W3	J	38	288	304	6	0	0.7	30	1	UN	12	T			CD	20	45	8	4	15	20	15	62	
176	MDST	R4	W1	BJ	15	152	168	3	1	1	80	2	UN	12	O	1		CD	20	50	17	7	15	20	15	74	Local RQD low due to cleavage shear zones
176	MDST	R4	W1	B	16	166	182	3	1	1	80	1	UN	12	T			CD	25	50	17	7	15	25	15	79	
176	MDST	R4	W1	CJ	70	211	227	3	1	1	80	1	UN	12	O	1		CD	20	50	17	7	15	20	15	74	
176	MDST	R4	W1	SZ	75	207	223	3	1	1	80	1	UN	12	T			CD	25	50	17	7	15	25	15	79	
178	MDST	R4	W2	J	85	275	291	4	0	2	80	1	UN	18	T			CD	25	55	17	7	15	25	15	79	Forms rock face, undulating
178	MDST	R4	W2	J	85	300	316	8	0	2	80	2	UN	18	T			CD	25	55	17	7	15	25	15	79	
178	MDST	R5	W1	BJ	12	340	356	10	0	2	80	2	UN	16	O	5		CD	18	55	17	12	15	18	15	77	
179	MDST	R5	W2	J	78	148	164	10	0	1.2	70	1	UN	14	T			CD	20	55	13	12	15	20	15	75	dominant in domain
179	MDST	R5	W2	J	81	158	174	10	0	1.2	70	2	UN	14	T			CD	20	55	13	12	15	20	15	75	
179	MDST	R5	W2	J	76	128	144	10	0	1.2	70	1	UN	14	T			CD	20	55	13	12	15	20	15	75	
179	MDST	R5	W2	J	68	140	156	10	0	2	80	1	UN	18	T			CD	20	55	17	12	15	20	15	79	remnants of quartz vein on surface
179	MDST	R5	W2	J	68	141	157	10	0	2	80	1	UN	16	O	3		CD	18	55	17	12	15	18	15	77	
179	MDST	R5	W2	J	54	132	148	10	0	1.8	80	1	UN	18	T			CD	20	55	17	12	15	20	15	79	POI 180 QZ
179	MDST	R5	W1	CJ	68	218	234	2	2	0.6	70	1	PL	6	T			CD	25	60	13	12	10	25	15	75	
179	MDST	R5	W1	CJ	82	210	226	2	2	0.6	70	2	PL	6	T			CD	25	60	13	12	10	25	15	75	
179	MDST	R5	W1	CJ	83	222	238	0.7	2	0.6	70	1	PL	6	T			CD	25	60	13	12	10	25	15	75	
179	MDST	R5	W1	BJ	28	232	248	5	0	1.5	70	1	UN	14	O	2		CD	20	60	13	12	15	20	15	75	
179	MDST	R5	W1	BJ	40	218	234	10	0	1.6	60	3	PL	16	O	2		CD	20	60	13	12	15	20	15	75	steep along face
179	MDST	R5	W1	BJ	30	217	233	10	0	1.6	60	2	PL	16	T			CD	25	60	13	12	15	25	15	80	
179	MDST	R4	W2	J	64	130	146	8	0	3	70	1	UN	18	T			CD	20	60	13	7	20	20	15	75	qz vein on surface
179	MDST	R4	W2	J	77	135	151	8	0	3	70	2	UN	18	T			CD	20	60	13	7	20	20	15	75	
179	MDST	R4	W1	CJ	78	250	266	6	0	1	70	1	PL	8	T			CD	20	60	13	7	15	20	15	70	
179	MDST	R4	W1	CJ	77	220	236	6	0	1	70	3	PL	8	T			CD	20	60	13	7	15	20	15	70	
179	MDST	R4	W2	CJ	80	200	216	6	0	1	70	1	PL	8	T			CD	20	60	13	7	15	20	15	70	
179	MDST	R4	W1	BJ	15	204	220	6	0	0.6	70	1	UN	10	O	2		CD	20	60	13	7	10	20	15	65	
179	MDST	R4	W1	BJ	32	206	222	6	0	0.6	70	3	UN	12	T			CD	25	60	13	7	10	25	15	70	
181	MDST	R4	W2	J	77	281	297	5	1	2.1	60	1	UN	18	O	2		CD	20	60	13	7	20	20	15	75	forms face, qz on surface
181	MDST	R4	W2	J	82	273	289	5	1	2.1	60	2	UN	18	T			CD	25	60	13	7	20	25	15	80	random local joint
181	MDST	R4	W2	J	76	128	144	8	0	3	80	1	UN	16	T			CD	20	60	17	7	20	20	15	79	

Project: PCA	**Location ID:** POI Start - 172	**Date:** 25-Jan-15	**Mapped By:** JP/SM	**Face DD (Corrected):** 326	**Face Dip:** 80	**Weather:** Overcast, 1°C - Snow On Ground
Location Chainage:	Sta. 113+320 - 114+000		**Colloquial Name:**	Finn Creek		

LOCATION	BEDROCK		DISCONTINUITY																		RMR89 PARAMETERS						COMMENTS
Station (POI)	Type	Strength	Weathering	Type	Dip	Dip Dir.*	DD** Corrected	Persistence (m)	Ends Visible	Spacing (m) Average	RQD	No. of Features	Shape	Roughness (JRC)	Aperture open/ tight	Aperture Width (mm)	Aperture Infill type	Water	Joint Condition (Jc)	GSI	RQD Factor	Strength Factor	Spacing Factor	Jcon	GW	RMR89	
182	MDST	R4	W2	J	75	145	161	8	0	3	80	1	PL	16	T			CD	25	60	17	7	20	25	15	84	
182	MDST	R4	W2	J	80	278	294	10	0	2	70	1	UN	18	T			CD	25	60	13	7	15	25	15	75	
182	MDST	R4	W2	CJ	70	216	232	6	0	0.4	70	2	PL	8	T			CD	20	60	13	7	10	20	15	65	cleavage
182	MDST	R4	W2		68	214	230	6	0	0.4	70	3	PL	8	T			CD	20	60	13	7	10	20	15	65	
182	MDST	R4	W2	J	78	124	140	4	0	2	70	1	PL	12	T			CD	25	60	13	7	15	25	15	75	quartz on surface
182	MDST	R4	W2	J	56	125	141	10	0	1.2	70	1	PL	12	T			CD	20	60	13	7	15	20	15	70	toppling potential
182	MDST	R4	W2	J	78	128	144	10	0	1.2	70	2	PL	12	T			CD	20	60	13	7	15	20	15	70	
183	MDST	R4	W1	CJ	77	224	240	6	0	0.15	70	1	UN	10	T			CD	20	60	13	7	8	20	15	63	some quartz veind, <10 mm thick
183	MDST	R4	W1	CJ	81	221	237	6	0	0.15	70	3	UN	10	T			CD	20	60	13	7	8	20	15	63	
183	MDST	R4	W1	CJ	82	222	238	6	0	0.15	70	1	UN	10	T			CD	20	60	13	7	8	20	15	63	
183	MDST	R4	W1	J	70	158	174	4	0	0.2	70	1	UN	14	T			CD	22	60	13	7	8	22	15	65	J5
183	MDST	R4	W1	J	68	162	178	4	0	0.2	70	3	UN	14	T			CD	22	60	13	7	8	22	15	65	qz vein on surface
183	MDST	R4	W1	J	52	162	178	4	0	0.2	70	1	UN	14	T			CD	22	60	13	7	8	22	15	65	
183	MDST	R4	W1	J	60	158	174	4	0	0.2	70	1	UN	14	T			CD	22	60	13	7	8	22	15	65	
183	MDST	R4	W1	J	48	156	172	4	0	0.2	70	1	UN	14	T			CD	22	60	13	7	8	22	15	65	
183	MDST	R4	W1	J	56	170	186	4	0	0.2	70	1	UN	14	T			CD	22	60	13	7	8	22	15	65	
183	MDST	R4	W1	J	46	322	338	1	2	0.6	70	1	PL	8	T			CD	20	60	13	7	10	20	15	65	J6
183	MDST	R4	W1	J	45	325	341	1	2	0.6	70	3	PL	8	T			CD	20	60	13	7	10	20	15	65	short persistence, forms base of toppling blocks on cleavage and J5
183	MDST	R4	W1	J	31	315	331	1	2	0.6	70	1	PL	8	T			CD	20	60	13	7	10	20	15	65	
183	MDST	R4	W1	J	30	324	340	1	2	0.6	70	1	PL	8	T			CD	20	60	13	7	10	20	15	65	
183	MDST	R4	W1	J	30	318	334	1	2	0.6	70	1	PL	8	T			CD	20	60	13	7	10	20	15	65	
185	MDST	R4	W2	BJ	15	146	162	5	1	1	70	1	UN	14	O	2		CD	20	60	13	7	15	20	15	70	J1, micro folds visible
185	MDST	R4	W2	BJ	12	158	174	5	1	1	70	3	UN	14	O			CD	20	60	13	7	15	20	15	70	185 - J1, J2, J3, J5, no J6 or J4
185	MDST	R4	W2	BJ	16	182	198	5	1	1	70	1	UN	14	T			CD	25	60	13	7	15	25	15	75	
185	MDST	R4	W2	BJ	18	176	192	5	1	1	70	1	UN	14	T			CD	25	60	13	7	15	25	15	75	
185	MDST	R4	W2	J	62	142	158	0.5	2	0.1	70	1	UN	14	T			CD	30	60	13	7	8	30	15	73	J3
185	MDST	R4	W2	J	64	144	160	0.5	2	0.1	70	3	UN	14	T			CD	30	60	13	7	8	30	15	73	
185	MDST	R4	W2	J	66	138	154	0.5	2	0.1	70	1	UN	14	T			CD	30	60	13	7	8	30	15	73	
185	MDST	R4	W2	J	72	134	150	0.5	2	0.1	70	1	UN	14	T			CD	30	60	13	7	8	30	15	73	
185	MDST	R4	W2	J	78	150	166	0.5	2	0.1	70	1	UN	14	T			CD	30	60	13	7	8	30	15	73	
185	MDST	R4	W2	CJ	72	218	234	10	0	0.15	70	1	UN	10	T			CD	20	60	13	7	8	20	15	63	
185	MDST	R4	W2	CJ	68	206	222	10	0	0.15	70	3	UN	10	T			CD	20	60	13	7	8	20	15	63	
185	MDST	R4	W2	CJ	82	216	232	10	0	0.15	70	1	UN	10	T			CD	20	60	13	7	8	20	15	63	
185	MDST	R4	W2	CJ	86	208	224	10	0	0.15	70	1	UN	10	T			CD	20	60	13	7	8	20	15	63	
185	MDST	R4	W2	CJ	68	208	224	10	0	0.15	70	1	UN	10	T			CD	20	60	13	7	8	20	15	63	
185	MDST	R4	W2	CJ	68	206	222	10	0	0.15	70	1	UN	10	T			CD	20	60	13	7	8	20	15	63	
185	MDST	R4	W2	J	50	126	142	7	0	2.5	70	1	PL	14	T			CD	22	60	13	7	20	22	15	77	rock face forms overhangs, stepped face on bedding
185	MDST	R4	W2	J	58	134	150	7	0	2.5	70	3	PL	14	T			CD	22	60	13	7	20	22	15	77	
185	MDST	R4	W2	J	72	138	154	7	0	2.5	70	1	PL	14	T			CD	22	60	13	7	20	22	15	77	
185	MDST	R4	W2	J	60	130	146	7	0	2.5	70	1	PL	14	T			CD	22	60	13	7	20	22	15	77	
185	MDST	R4	W2	J	61	130	146	7	0	2.5	70	1	PL	14	T			CD	22	60	13	7	20	22	15	77	
186	MDST	R4	W2	J	28	346	2	10	0	2.5	90	1	ST	14	O	2		CD	20	60	17	7	20	20	15	79	
187	MDST	R4	W2	J	74	249	265	8	0	1.3	90	1	UN	18	T			CD	25	60	17	7	15	25	15	79	
187	MDST	R4	W2	BJ	50	218	234	8	0	1.3	90	2	UN	18	T			CD	25	60	17	7	15	25	15	79	
187	MDST	R4	W2	BJ	32	202	218	8	0	1.3	90	1	UN	18	T			CD	25	60	17	7	15	25	15	79	
188	MDST	R4	W2	J	80	104	120	10	0	1.3	95	1	PL	18	T			CD	25	60	20	7	15	25	15	82	

ROCK EXPOSURE COMMENTS:

*Dip Direction with no magnetic declination correction

**Dip Direction with magnetic declination correction of 16 degrees east applied

Type	Type (ctd)	Shape	Termination	Water	Aperture	Infill
FT: Fault	CT: Contact	pl: Planar	2: Doubly Terminated	CD: Completely Dry	O: Open	C: Clay
SZ: Shear Zone	FO: Foliation	un: Undulating	1: Singly Terminated	D: Damp	T: Tight	S: Silt
JT: Joint	BZ: Broken Zone	st: Stepped	0: No Termination	W: Wet		S: Sand
VN:Vein		cu: Curved		DR: Dripping		
BD: Bedding				F: Flowing		

Project: PCA	**Location ID:** POI Start - 263	**Date:** 27-Jan-15	**Mapped By:** JP/SM	**Face DD (Corrected):** 311	**Face Dip:** 80	**Weather:** Sunny, 1°C - Snow On Ground
Location Chainage:	Sta. 89+540 - 90+900		**Colloquial Name:**	Spiral Hill		

LOCATION	BEDROCK		DISCONTINUITY																		RMR89 PARAMETERS						COMMENTS
Station (POI)	Type	Strength	Weathering	Type	Dip	Dip Dir.*	DD** Corrected	Persistence (m)	Ends Visible	Spacing (m) Average	RQD	No. of Features	Shape	Roughness (JRC)	Aperture open/ tight	Width (mm)	Infill type	Water	Joint Condition (Jc)	GSI	RQD Factor	Strength Factor	Spacing Factor	Jcon	GW	RMR89	
263	MDST	R5	W2	J	66	30	46	2	0	0.2	90	2	UN	16	O	3	Calcite	CD	15	65	17	12	8	15	15	67	
263	MDST	R5	W1	J	60	290	306	2	1	0.15	90	2	UN	16	O	1		CD	25	65	17	12	8	25	15	77	
265	LST	R5	W2	J	72	30	46	10	0	0.25	90	3	PL	14	T			CD	25	65	17	12	10	25	15	79	
265	LST	R5	W2	J	76	34	50	10	0	0.25	90	1	PL	12	T			CD	25	65	17	12	10	25	15	79	
265	LST	R5	W2	J	54	300	316	1	1	0.4	90	3	PL	12	T			CD	25	65	17	12	10	25	15	79	
265	LST	R5	W2	J	62	296	312	1	1	0.4	90	1	PL	12	T			CD	25	65	17	12	10	25	15	79	
265	LST	R5	W2	J	62	306	322	1	1	0.4	90	1	PL	12	T			CD	25	65	17	12	10	25	15	79	
266	LST	R5	W2	J	64	34	50	5	0	0.2	70	3	UN	16	O	1		CD	25	60	13	12	8	25	15	73	
266	LST	R5	W2	J	76	24	40	5	0	0.2	70	1	UN	16	O	1		CD	25	60	13	12	8	25	15	73	
266	LST	R5	W2	J	70	36	52	6	0	0.1	60	3	PL	12	O	1		CD	20	55	13	12	8	20	15	68	
266	MDST	R4	W2	J	70	24	40	6	0	0.1	60	1	PL	10	T			CD	20	55	13	7	8	20	15	63	
266	MDST	R4	W2	J	68	28	44	6	0	0.1	80	1	PL	10	T			CD	20	55	17	7	8	20	15	67	
266	MDST	R4	W2	J	64	30	46	6	0	0.1	80	1	PL	14	T			CD	20	55	17	7	8	20	15	67	
266	MDST	R4	W2	J	30	286	302	0.4	2	0.5	80	3	UN	8	T			CD	25	55	17	7	10	25	15	74	
266	MDST	R4	W2	J	42	272	288	0.4	2	0.5	80	1	UN	8	T			CD	25	55	17	7	10	25	15	74	
266	MDST	R4	W2	J	52	276	292	0.4	2	0.5	80	1	UN	8	T			CD	25	55	17	7	10	25	15	74	
266	MDST	R4	W2	J	40	288	304	0.4	2	0.5	80	1	UN	14	T			CD	30	55	17	7	10	30	15	79	
266	MDST	R4	W2	J	54	266	282	0.4	2	0.5	80	1	UN	14	T			CD	30	55	17	7	10	30	15	79	
266	MDST	R4	W2	J	52	122	138	2	1	0.4	80	3	UN	10	O	1		CD	30	60	17	7	10	30	15	79	Forms overhangs
266	MDST	R4	W2	J	54	116	132	2	1	0.4	80	1	UN	10	O	1		CD	30	60	17	7	10	30	15	79	
266	MDST	R4	W2	J	50	120	136	2	1	0.4	80	1	UN	10	O	1		CD	30	60	17	7	10	30	15	79	
266	MDST	R4	W2	J	36	122	138	2	1	0.4	80	1	UN	10	O	1		CD	30	60	17	7	10	30	15	79	
266	LST	R4	W2	J	85	300	316	2	2	0.2	80	2	UN	12	T			CD	25	60	17	7	8	25	15	72	Random joint
266	LST	R4	W2	J	88	288	304	2	2	0.2	80	1	UN	12	T			CD	25	60	17	7	8	25	15	72	
266	LST	R4	W2	J	70	28	44	10	0	0.15	70	3	PL	10	T			CD	25	55	13	7	8	25	15	68	
266	LST	R4	W2	J	60	30	46	10	0	0.15	70	1	PL	14	T			CD	25	55	13	7	8	25	15	68	
266	LST	R4	W2	J	60	134	150	1	1	0.5	60	1	PL	10	T			CD	25	55	13	7	10	25	15	70	
269	LST	R4	W2	J	72	36	52	10	0	0.2	60	3	PL	8	O	2		CD	15	50	13	7	8	15	15	58	Bedding
269	LST	R4	W2	J	72	38	54	10	0	0.2	60	1	PL	8	O	2		CD	15	50	13	7	8	15	15	58	
269	LST	R4	W2	CJ	90	30	46	0.4	2	0.1	60	3	PL	8	T			CD	25	50	13	7	8	25	15	68	
269	LST	R4	W2	CJ	86	22	38	0.4	2	0.1	60	1	PL	8	T			CD	25	50	13	7	8	25	15	68	
269	LST	R4	W2	J	10	294	310	1	1	0.4	60	3	UN	12	O	1		CD	25	50	13	7	10	25	15	70	
269	LST	R4	W2	J	15	238	254	1	1	0.4	60	1	UN	12	T			CD	25	50	13	7	10	25	15	70	
269	LST	R4	W2	J	18	278	294	1	1	0.4	60	1	UN	12	T			CD	25	50	13	7	10	25	15	70	
269	LST	R4	W2	J	80	110	126	5	1	0.25	60	3	ST	14	T			CD	30	45	13	7	10	30	15	75	
269	LST	R4	W2	J	86	288	304	5	1	0.25	60	1	ST	14	T			CD	30	45	13	7	10	30	15	75	
269	LST	R4	W2	J	86	292	308	5	1	0.25	60	1	ST	14	T			CD	30	45	13	7	10	30	15	75	
269	LST	R4	W2	CJ	86	24	40	0.2	2	0.05	60	3	PL	6	T			CD	20	45	13	7	5	20	15	60	
269	LST	R4	W2	BJ	68	32	48	15	0	0.3	80	3	UN	16	T			CD	25	55	17	7	10	25	15	74	
269	LST	R4	W2	BJ	72	30	46	15	0	0.3	80	1	UN	16	T			CD	25	55	17	7	10	25	15	74	
269	LST	R4	W2	BJ	72	23	39	15	0	0.3	80	1	UN	16	T			CD	25	55	17	7	10	25	15	74	
269	LST	R4	W2	J	66	270	286	2	1	0.4	80	3	UN	12	T			CD	25	55	17	7	10	25	15	74	Planar failure
269	LST	R4	W2	J	64	256	272	2	1	0.4	80	1	UN	12	T			CD	25	55	17	7	10	25	15	74	
269	LST	R4	W2	J	36	146	162	1	2	0.6	80	3	UN	12	T			CD	25	55	17	7	10	25	15	74	Direct toppling
269	LST	R4	W2	J	52	104	120	1	2	0.6	80	1	UN	12	T			CD	25	55	17	7	10	25	15	74	
269	LST	R4	W2	J	24	126	142	1	2	0.6	80	1	UN	12	T			CD	25	55	17	7	10	25	15	74	
269	LST	R5	W2	BJ	70	28	44	15	0	0.3	70	3	UN	12	O	1		CD	25	55	13	12	10	25	15	75	
269	LST	R5	W2	BJ	68	26	42	15	0	0.3	70	1	UN	12	T			CD	25	55	13	12	10	25	15	75	
269	LST	R5	W2	BJ	68	28	44	15	0	0.3	70	1	UN	12	T			CD	25	55	13	12	10	25	15	75	
269	LST	R5	W2	J	68	282	298	2	1	0.4	70	3	PL	10	T			CD	25	55	13	12	10	25	15	75	planar joint
269	LST	R5	W2	J	80	280	296	2	1	0.4	70	1	PL	10	T			CD	25	55	13	12	10	25	15	75	
269	LST	R5	W2	J	28	144	160	2	1	0.3	70	3	PL	10	T			CD	25	55	13	12	10	25	15	75	
274	LST	R5	W2	BJ	60	32	48	10	0	0.4	70	3	UN	14	T			CD	25	55	13	12	10	25	15	75	
274	LST	R5	W2	BJ	66	40	56	10	0	0.4	70	1	UN	14	T			CD	25	55	13	12	10	25	15	75	
274	LST	R5	W2	BJ	52	36	52	10	0	0.4	70	1	UN	14	T			CD	25	55	13	12	10	25	15	75	
274	LST	R5	W2	J	52	298	314	0.3	1	0.2	70	3	UN	12	T			CD	25	55	13	12	8	25	15	73	planar joint
274	LST	R5	W2	J	42	274	290	0.3	1	0.2	70	1	UN	12	T			CD	25	55	13	12	8	25	15	73	
274	LST	R5	W2	J	66	292	308	0.3	1	0.2	70	1	UN	12	T			CD	25	55	13	12	8	25	15	73	
274	LST	R5	W2	J	30	162	178	1	2	0.3	70	3	PL	12	T			CD	25	55	13	12	10	25	15	75	
274	LST	R5	W2	J	18	144	160	1	2	0.3	70	1	PL	12	T			CD	25	55	13	12	10	25	15	75	

Project: PCA	Location ID: POI Start - 263	Date: 27-Jan-15	Mapped By: JP/SM	Face DD (Corrected): 311	Face Dip: 80	Weather: Sunny, 1°C - Snow On Ground
Location Chainage:	Sta. 89+540 - 90+900		Colloquial Name:	Spiral Hill		

LOCATION	BEDROCK		DISCONTINUITY																		RMR89 PARAMETERS						COMMENTS
Station (POI)	Type	Strength	Weathering	Type	Dip	Dip Dir.*	DD** Corrected	Persistence (m)	Ends Visible	Spacing (m) Average	RQD	No. of Features	Shape	Roughness (JRC)	Aperture open/ tight	Aperture Width (mm)	Infill type	Water	Joint Condition (Jc)	GSI	RQD Factor	Strength Factor	Spacing Factor	Jcon	GW	RMR89	
274	LST	R5	W2	J	23	138	154	1	2	0.3	70	1	PL	12	T			CD	25	55	13	12	10	25	15	75	
275	LST	R3	W3	BJ	46	20	36	10	0	0.15	20	3	CU	14	T			CD	20	35	3	4	8	20	15	50	New domain (D2)
275	LST	R3	W3	BJ	24	12	28	10	0	0.15	20	1	CU	14	T			CD	20	35	3	4	8	20	15	50	
275	LST	R3	W3	BJ	10	358	14	10	0	0.15	20	1	CU	14	T			CD	20	35	3	4	8	20	15	50	
275	LST	R3	W3	BJ	24	352	8	10	0	0.15	20	1	CU	14	T			CD	20	35	3	4	8	20	15	50	
275	LST	R3	W3	BJ	44	32	48	10	0	0.15	20	1	CU	14	T			CD	20	35	3	4	8	20	15	50	
275	LST	R3	W3	J	80	92	108	0.25	2	0.05	20	3	PL	10	T			CD	15	35	3	4	5	15	15	42	cleavage
275	LST	R3	W3	J	64	98	114	0.25	2	0.05	20	1	PL	10	T			CD	15	35	3	4	5	15	15	42	
275	LST	R3	W3	J	80	98	114	0.25	2	0.05	20	1	PL	10	T			CD	15	35	3	4	5	15	15	42	
275	LST	R3	W3	J	54	186	202	0.4	2	0.4	20	3	UN	14	T			CD	20	35	3	4	10	20	15	52	
275	LST	R3	W3	J	80	212	228	0.4	2	0.4	20	1	UN	14	T			CD	20	35	3	4	10	20	15	52	
275	LST	R3	W3	J	60	200	216	0.4	2	0.4	20	1	UN	14	T			CD	20	35	3	4	10	20	15	52	
275	LST	R3	W3	BJ	28	216	232	15	0	0.15	20	3	CU	14	T			CD	15	35	3	4	8	15	15	45	
275	LST	R3	W3	BJ	24	200	216	15	0	0.15	20	1	CU	14	T			CD	15	35	3	4	8	15	15	45	
276	LST	R4	W2	BJ	44	16	32	10	0	0.15	60	3	PL	8	T			CD	25	45	13	7	8	25	15	68	
276	LST	R4	W2	BJ	30	16	32	10	0	0.15	60	1	PL	8	T			CD	25	45	13	7	8	25	15	68	
276	LST	R4	W2	BJ	42	26	42	10	0	0.15	60	1	PL	8	T			CD	25	45	13	7	8	25	15	68	
276	LST	R4	W2	J	64	198	214	0.3	2	0.3	60	3	PL	14	T			CD	25	45	13	7	10	25	15	70	
276	LST	R4	W2	J	58	208	224	0.3	2	0.3	60	1	PL	14	T			CD	25	45	13	7	10	25	15	70	
276	LST	R4	W2	J	50	204	220	0.3	2	0.3	60	1	PL	14	T			CD	25	45	13	7	10	25	15	70	
276	LST	R4	W2	J	72	272	288	3	1	0.6	60	3	UN	10	T			CD	25	50	13	7	10	25	15	70	
276	LST	R4	W2	J	78	282	298	3	1	0.6	60	1	UN	10	T			CD	25	50	13	7	10	25	15	70	
276	LST	R4	W2	J	80	290	306	3	1	0.6	60	1	UN	10	T			CD	25	50	13	7	10	25	15	70	
277	LST	R3	W3	F	85	200	216	6	0		10	1	PL		O	2		CD	10	35	3	4	10	10	15	42	Photo 4150 - 4151, fault chemically weathered? Qtz grains
277	LST	R3	W3	F	32	326	342	10	0		10	1	UN		O	5	silt	CD	0	35	3	4	10	0	15	32	Surface under dustin's slide, preferential weathering?
277	LST	R3	W3	BJ	40	54	70	10	0	0.2	10	3	CU	12	T			CD	15	35	3	4	8	15	15	45	
277	LST	R3	W3	BJ	72	214	230	10	0	0.2	10	3	CU	12	T			CD	15	35	3	4	8	15	15	45	Fold axis beds = 100->10 (T->P)
278	LST	R4	W2	BJ	38	20	36	15	0	0.4	60	3	PL	14	O	2		CD	20	50	13	7	10	20	15	65	Fold axis 140-->10, hard to determine plunge
278	LST	R4	W2	BJ	42	8	24	15	0	0.4	60	1	PL	14	O	1		CD	20	50	13	7	10	20	15	65	
278	LST	R4	W2	BJ	43	27	43	15	0	0.2	60	1	PL	14	O	2		CD	20	50	13	7	8	20	15	63	
278	LST	R4	W2	BJ	38	10	26	15	0	0.2	60	1	PL	14	O	1		CD	20	50	13	7	8	20	15	63	
278	LST	R4	W2	J	71	142	158	3	1	1	70	2	PL	10	T			CD	25	50	13	7	15	25	15	75	
278	LST	R4	W2	J	72	139	155	3	1	1	70	1	PL	10	T			CD	25	50	13	7	15	25	15	75	
278	LST	R4	W2	J	61	259	275	2	1	0.5	70	3	PL	10	O	2		CD	20	50	13	7	10	20	15	65	
278	LST	R4	W2	J	63	254	270	2	1	0.3	60	1	PL	10	O	2		CD	20	50	13	7	10	20	15	65	
278	LST	R4	W2	J	67	250	266	2	1	0.3	60	1	PL	10	O	1		CD	20	50	13	7	10	20	15	65	
278	LST	R4	W2	J	72	287	303	0.5	2	0.2	60	2	PL	10	T			CD	25	50	13	7	8	25	15	68	
278	LST	R4	W2	J	77	291	307	0.5	2	0.2	60	1	PL	10	T			CD	25	50	13	7	8	25	15	68	
279	LST	R4	W2	BJ	26	46	62	5	0	0.15	40	3	CU	14	T			CD	25	40	8	7	8	25	15	63	
279	LST	R4	W2	BJ	30	66	82	5	0	0.15	40	1	CU	14	T			CD	25	40	8	7	8	25	15	63	
279	LST	R4	W2	J	60	272	288	0.3	2	0.2	40	3	UN	14	T			CD	25	40	8	7	8	25	15	63	
279	LST	R4	W2	BJ	20	40	56	20	0	0.1	70	3	CU	14	T			CD	25	45	13	7	8	25	15	68	
279	LST	R4	W2	BJ	10	2	18	20	0	0.1	70	1	CU	14	T			CD	25	45	13	7	8	25	15	68	
279	LST	R4	W2	BJ	18	28	44	20	0	0.1	70	1	CU	14	T			CD	25	45	13	7	8	25	15	68	
279	LST	R4	W2	J	82	256	272	1	2	0.15	70	3	PL	8	T			CD	25	45	13	7	8	25	15	68	
279	LST	R4	W2	J	85	272	288	1	2	0.15	70	1	PL	8	T			CD	25	45	13	7	8	25	15	68	
279	LST	R4	W2	J	85	258	274	1	2	0.15	70	1	PL	8	T			CD	25	45	13	7	8	25	15	68	
279	LST	R4	W2	J	74	240	256	1	2	0.15	70	1	PL	8	T			CD	25	45	13	7	8	25	15	68	
280	LST	R4	W2	J	85	286	302	20	0	1.5	60	3	PL	20	T			CD	25	50	13	7	15	25	15	75	dominant side of dustins slide, slope cut back to joint
281	LST	R4	W2	BJ	38	20	36	10	0	0.4	70	3	UN	14	T			CD	25	50	13	7	10	25	15	70	
281	LST	R4	W2	BJ	32	16	32	10	0	0.4	70	1	UN	14	T			CD	25	50	13	7	10	25	15	70	
281	LST	R4	W2	J	52	160	176	1	1	0.4	70	3	UN	14	T			CD	25	50	13	7	10	25	15	70	Face joint
281	LST	R4	W2	J	58	140	156	1	1	0.4	70	1	UN	14	T			CD	25	50	13	7	10	25	15	70	
281	LST	R4	W2	J	62	180	196	1	1	0.4	70	1	UN	14	T			CD	25	50	13	7	10	25	15	70	
281	LST	R4	W2	J	72	270	286	1	1	0.6	70	3	PL	12	T			CD	25	50	13	7	10	25	15	70	Sample TT15-R05
281	LST	R4	W2	J	80	272	288	1	1	0.6	70	1	PL	12	T			CD	25	50	13	7	10	25	15	70	
281	LST	R4	W2	J	62	260	276	1	1	0.6	70	1	PL	12	T			CD	25	50	13	7	10	25	15	70	
282	LST	R5	W2	BJ	20	30	46	15	0	0.5	90	3	PL	8	O	3		CD	20	65	17	12	10	20	15	74	
282	LST	R5	W2	BJ	22	28	44	15	0	0.5	90	1	PL	8	T			CD	20	65	17	12	10	20	15	74	
282	LST	R5	W2	BJ	28	24	40	15	0	0.5	90	1	PL	8	O	5		CD	10	65	17	12	10	10	15	64	

Project: PCA	**Location ID:** POI Start - 263	**Date:** 27-Jan-15	**Mapped By:** JP/SM	**Face DD (Corrected):** 311	**Face Dip:** 80	**Weather:** Sunny, 1°C - Snow On Ground
Location Chainage: Sta. 89+540 - 90+900			**Colloquial Name:** Spiral Hill			

LOCATION	BEDROCK		DISCONTINUITY												Aperture						RMR89 PARAMETERS						COMMENTS
Station (POI)	Type	Strength	Weathering	Type	Dip	Dip Dir.*	DD** Corrected	Persistence (m)	Ends Visible	Spacing (m) Average	RQD	No. of Features	Shape	Roughness (JRC)	open/ tight	Width (mm)	Infill type	Water	Joint Condition (Jc)	GSI	RQD Factor	Strength Factor	Spacing Factor	Jcon	GW	RMR89	
282	LST	R5	W2	J	70	130	146	4	1	0.6	90	3	UN	12	O	2		CD	15	65	17	12	10	15	15	69	Joint dominates face orientation
282	LST	R5	W2	J	85	136	152	4	1	0.6	90	1	UN	12	O	1		CD	15	65	17	12	10	15	15	69	
282	LST	R5	W2	J	66	150	166	4	1	0.6	90	1	UN	12	O	1		CD	15	65	17	12	10	15	15	69	
282	LST	R5	W2	J	80	284	300	2	1	1	90	3	UN	12	O	1		CD	25	65	17	12	15	25	15	84	
282	LST	R5	W2	J	86	268	284	2	1	1	90	1	UN	12	O	1		CD	25	65	17	12	15	25	15	84	
282	LST	R5	W2	BJ	22	28	44	20	0	1	90	3	PL	14	T			CD	25	65	17	12	15	25	15	84	Massive rock
282	LST	R5	W2	BJ	24	48	64	20	0	1	90	1	PL	14	T			CD	25	65	17	12	15	25	15	84	
282	LST	R5	W2	BJ	30	22	38	20	0	1	90	1	PL	14	T			CD	25	65	17	12	15	25	15	84	
282	LST	R5	W2	J	82	276	292	1	1	0.7	90	3	UN	12	O	1		CD	25	65	17	12	15	25	15	84	
282	LST	R5	W2	J	84	278	294	1	1	0.7	90	1	UN	12	O	1		CD	25	65	17	12	15	25	15	84	
282	LST	R5	W2	J	80	276	292	1	1	0.7	90	1	UN	12	O	1		CD	25	65	17	12	15	25	15	84	
282	LST	R5	W2	J	88	272	288	1	1	0.7	90	1	UN	12	O	1		CD	25	65	17	12	15	25	15	84	
282	LST	R5	W2	J	86	342	358	3	1	0.6	90	3	UN	12	T			CD	25	65	17	12	10	25	15	79	Face
282	LST	R5	W2	J	70	180	196	3	1	0.6	90	1	UN	12	T			CD	25	65	17	12	10	25	15	79	
282	LST	R5	W2	J	80	38	54	3	1	0.6	90	1	UN	12	T			CD	25	65	17	12	10	25	15	79	
282	LST	R5	W2	J	85	196	212	3	1	0.6	90	1	UN	12	T			CD	25	65	17	12	10	25	15	79	
282	LST	R5	W2	J	78	198	214	3	1	0.6	90	1	UN	12	T			CD	25	65	17	12	10	25	15	79	
283	LST	R5	W2	BJ	22	22	38	10	0	0.3	80	3	un	12	O	1		CD	20	60	17	12	10	20	15	74	Bedding Dipping out of face
283	LST	R5	W2	BJ	26	10	26	10	0	0.3	80	1	un	12	O	1		CD	20	60	17	12	10	20	15	74	
283	LST	R5	W2	BJ	22	28	44	10	0	0.3	80	1	un	12	O	1		CD	20	60	17	12	10	20	15	74	
283	LST	R5	W2	BJ	26	36	52	10	0	0.3	80	1	un	12	T			CD	25	60	17	12	10	25	15	79	
283	LST	R5	W2	J	68	306	322	2	2	0.6	80	3	un	10	T			CD	25	60	17	12	10	25	15	79	
283	LST	R5	W2	J	78	110	126	2	2	0.6	80	1	un	10	T			CD	25	60	17	12	10	25	15	79	
283	LST	R5	W2	J	80	120	136	2	2	0.6	80	1	un	10	T			CD	25	60	17	12	10	25	15	79	
283	LST	R5	W2	J	85	125	141	2	2	0.6	80	1	un	10	T			CD	25	60	17	12	10	25	15	79	
283	LST	R5	W2	J	80	234	250	1.5	1	0.3	80	3	un	8	T			CD	25	60	17	12	10	25	15	79	
283	LST	R5	W2	J	68	238	254	1.5	1	0.3	80	1	un	8	T			CD	25	60	17	12	10	25	15	79	
283	LST	R5	W2	J	70	230	246	1.5	1	0.3	80	1	un	8	T			CD	25	60	17	12	10	25	15	79	
284	LST	R5	W2	F	85	225	241	15				1	pl	12	O	50	SZ	CD	0		3	12	10	0	15	40	approximate 0.3 m offset, thrust faults minimal disturbance to bedding, local tilting, infill visible, 0.0
284	LST	R5	W2	BJ	20	36	52	15	0	0.2	70	3	un	16	O	2		CD	20	55	13	12	8	20	15	68	Spacing of bedding varies greatly from 0.2 to 1 m
284	LST	R5	W2	BJ	24	38	54	15	0	0.5	70	1	un	16	O	2		CD	20	55	13	12	10	20	15	70	
284	LST	R5	W2	BJ	18	36	52	15	0	0.3	70	1	un	16	T			CD	25	55	13	12	10	25	15	75	
284	LST	R5	W2	J	80	190	206	0.5	2	0.5	70	3	un	10	O	1		CD	20	55	13	12	10	20	15	70	Various subvertical joints with no clear set
284	LST	R5	W2	J	85	175	191	0.5	2	0.5	70	1	un	10	O	1		CD	20	55	13	12	10	20	15	70	
284	LST	R5	W2	J	68	180	196	0.5	2	0.5	70	1	un	10	T			CD	25	55	13	12	10	25	15	75	
284	LST	R5	W2	J	85	332	348	0.5	2	0.5	70	1	un	10	T			CD	25	55	13	12	10	25	15	75	
284	LST	R5	W2	J	88	318	334	0.5	2	0.5	70	1	un	10	O	1		CD	20	55	13	12	10	20	15	70	
286	LST	R5	W2	F/J	60	276	292	10	0			1	un	12	O	2	SZ	CD	10		3	12	10	10	15	50	Eastern edge of large wedge, possibly random joint, no off set to bedding.
286	LST	R5	W2	F/J	76	58	74	10	0			1	pl	10	O	2	SZ	CD	10		3	12	10	10	15	50	Western edge of large faults, possibly random joint, no off set to bedding.
286	LST	R5	W2	J	80	60	76	0.5	2	0.7	80	3	pl	10	T			CD	25	60	17	12	15	25	15	84	
286	LST	R5	W2	J	85	70	86	0.5	2	0.7	80	1	pl	10	T			CD	25	60	17	12	15	25	15	84	
286	LST	R5	W2	J	80	63	79	0.5	2	0.7	80	1	pl	10	T			CD	25	60	17	12	15	25	15	84	
286	LST	R5	W2	J	76	242	258	0.5	2	0.7	80	1	pl	10	T			CD	25	60	17	12	15	25	15	84	
286	LST	R5	W2	BJ	24	28	44	15	0	0.3	80	3	un	14	T			CD	25	60	17	12	10	25	15	79	
286	LST	R5	W2	BJ	30	20	36	15	0	0.3	80	1	un	14	T			CD	25	60	17	12	10	25	15	79	
286	LST	R5	W2	J	60	220	236	1	2	2	80	3	un	16	T			CD	25	65	17	12	15	25	15	84	
286	LST	R5	W2	J	74	282	298	1	2	2	80	1	un	16	T			CD	25	65	17	12	15	25	15	84	
286	LST	R5	W2	J	85	288	304	1	2	2	80	1	un	16	T			CD	25	65	17	12	15	25	15	84	Domint joint forming rock face
286	LST	R5	W2	J	72	268	284	1	2	2	80	1	un	16	T			CD	25	65	17	12	15	25	15	84	
286	LST	R5	W2	J	60	240	256	1	2	2	80	1	un	16	T			CD	25	65	17	12	15	25	15	84	
286	LST	R5	W2	J	80	278	294	1	2	2	80	1	un	16	T			CD	25	65	17	12	15	25	15	84	
286	LST	R5	W2	J	80	280	296	1	2	2	80	1	un	16	T			CD	25	65	17	12	15	25	15	84	
286	LST	R5	W2	J	66	120	136	8	0	1	60	1	pl	14	T			W	20	50	13	12	15	20	7	67	Dominat joint forming rock face.

Project:	PCA	Location ID:	POI Start - 263	Date:	27-Jan-15	Mapped By:	JP/SM	Face DD (Corrected):	311	Face Dip:	80	Weather:	Sunny, 1°C - Snow On Ground
Location Chainage:			Sta. 89+540 - 90+900			Colloquial Name:			Spiral Hill				

LOCATION	BEDROCK		DISCONTINUITY																		RMR89 PARAMETERS						COMMENTS
															Aperture												
Station (POI)	Type	Strength	Weathering	Type	Dip	Dip Dir.*	DD** Corrected	Persistence (m)	Ends Visible	Spacing (m) Average	RQD	No. of Features	Shape	Roughness (JRC)	open/ tight	Width (mm)	Infill type	Water	Joint Condition (Jc)	GSI	RQD Factor	Strength Factor	Spacing Factor	Jcon	GW	RMR89	

ROCK EXPOSURE COMMENTS:

*Dip Direction with no magnetic declination correction
**Dip Direction with magnetic declination correction of 16 degrees east applied

Type	Type (ctd)	Shape	Termination	Water	Aperture	Infill
FT: Fault	CT: Contact	pl: Planar	2: Doubly Terminated	CD: Completely Dry	O: Open	C: Clay
SZ: Shear Zone	FO: Foliation	un: Undulating	1: Singly Terminated	D: Damp	T: Tight	S: Silt
JT: Joint	BZ: Broken Zone	st: Stepped	0: No Termination	W: Wet		S: Sand
VN:Vein		cu: Curved		DR: Dripping		
BD: Bedding				F: Flowing		

Project: PCA	**Location ID:** POI Start - 397	**Date:** 29-Jan-15	**Mapped By:** JP/SM	**Face DD (Corrected):** 296	**Face Dip:** 80	**Weather:** Clear, -10°C - Snow On Ground
Location Chainage: Sta. 114+800 - 115+200			**Colloquial Name:** Through Cut East (Left) / CCC East (Left)			

LOCATION	BEDROCK		DISCONTINUITY																	RMR89 PARAMETERS							COMMENTS
Station (POI)	Type	Strength	Weathering	Type	Dip	Dip Dir.*	DD** Corrected	Persistence (m)	Ends Visible	Spacing (m) Average	RQD	No. of Features	Shape	Roughness (JRC)	Aperture open/ tight	Aperture Width (mm)	Aperture Infill type	Water	Joint Condition (Jc)	GSI	RQD Factor	Strength Factor	Spacing Factor	Jcon	GW	RMR89	
397	MDST	R5	W2	J	42	226	242	4	0		80	1	UN	12	T			CD	25	60	17	12	10	25	15	79	Quartz vein on top, J-1
397	MDST	R5	W2	J	76	42	58	2	0	0.2	80	3	PL	10	T			CD	25	60	17	12	8	25	15	77	J-2
397	MDST	R5	W2	J	80	38	54	2	0	0.4	80	1	PL	10	T			CD	25	60	17	12	10	25	15	79	
397	MDST	R5	W2	J	84	44	60	2	0	0.3	80	1	PL	10	T			CD	25	60	17	12	10	25	15	79	
397	MDST	R5	W2	J	80	48	64	2	0	0.4	80	1	PL	8	O	2		CD	18	60	17	12	10	18	15	72	
398	MDST	R5	W2	J	84	302	318	10	0	0.5	90	3	UN	6	T			CD	20	60	17	12	10	20	15	74	Possibly river scour/erosioin, smooth face forms overhanging face
398	MDST	R5	W2	J	86	294	310	10	0	1	90	1	UN	6	T			CD	20	60	17	12	15	20	15	79	
398	MDST	R5	W2	J	90	292	308	10	0	1	90	1	UN	6	T			CD	20	60	17	12	15	20	15	79	
398	MDST	R5	W2	J	20	262	278	3	0		90	1	UN	8	T			CD	25	60	17	12	10	25	15	79	
399	MDST	R5	W2	J	5	202	218	5	0	2.5	90	2	UN	14	O	1		CD	25	60	17	12	20	25	15	89	
399	MDST	R5	W2	J	20	238	254	5	0	2.5	90	1	UN	14	T			CD	25	60	17	12	20	25	15	89	
399	MDST	R5	W2	J	76	40	56	9	0	0.3	90	3	PL	10	O	1		CD	20	60	17	12	10	20	15	74	Cleavage, occasional quartz vein aligns with joint set
399	MDST	R5	W2	J	80	38	54	9	0	0.1	90	1	PL	10	T			CD	25	60	17	12	8	25	15	77	
399	MDST	R5	W2	J	82	42	58	9	0	0.5	90	1	PL	10	O	1		CD	20	60	17	12	10	20	15	74	
399	MDST	R5	W2	J	78	32	48	9	0	0.2	90	1	PL	10	T			CD	25	60	17	12	8	25	15	77	
399	MDST	R5	W2	B	44	40	56	10	0		90	1	UN		T			CD	30	60	17	12	10	30	15	84	
399	MDST	R5	W2	J	80	302	318	3	0	2	80	2	UN	18	T			CD	25	60	17	12	15	25	15	84	Forms rock face
399	MDST	R5	W2	J	90	286	302	3	0	2	80	1	UN	10	O	1		CD	20	60	17	12	15	20	15	79	
399	MDST	R5	W2	F	76	40	56	5	0	1	90	3	PL	16	T	20	QTZ	CD	25	60	17	12	15	25	15	84	Quartz vein, tight, normal fault, 20 mm wide, photo 4352
399	MDST	R5	W2	J	78	36	52	6	0	0.1	90	3	PL	8	T			CD	25	60	17	12	8	25	15	77	
399	MDST	R5	W2	J	80	36	52	6	0	0.2	90	1	PL	8	T			CD	25	60	17	12	8	25	15	77	
399	MDST	R5	W2	J	76	38	54	6	0	0.2	90	1	PL	8	T			CD	25	60	17	12	8	25	15	77	0.2 m wide, offset 1 m, normal fault breccia local RQD 40
400	MDST	R5	W2	F	30	50	66				40							W			8	12	10	0	7	37	
400	MDST	R5	W2	B	26	70	86	6	0	0.2	90	1	UN	8	T	20		CD	25	60	17	12	8	25	15	77	
400	MDST	R5	W2	J	50	98	114	2.5	0		90	1	UN	10	T			CD	25	60	17	12	10	25	15	79	
401	MDST	R5	W2	J	78	32	48	10	0	0.6	70	3	PL	4	T			CD	25	60	13	12	10	25	15	75	
401	MDST	R5	W2	J	80	30	46	10	0	0.4	70	1	PL	4	O	1		CD	20	60	13	12	10	20	15	70	
401	MDST	R5	W2	J	80	40	56	10	0	0.3	60	1	PL	16	T			CD	25	60	13	12	10	25	15	75	Qtz on surface
401	MDST	R5	W2	J	76	22	38	10	0	0.2	60	1	PL	6	O	1		CD	20	60	13	12	8	20	15	68	
401	MDST	R5	W2	J	50	38	54	6	0	0.8	70	3	UN	14	O	1		D	20	55	13	12	15	20	10	70	
401	MDST	R5	W2	J	50	248	264	6	0	0.3	70	1	UN	14	T			D	25	55	13	12	10	25	10	70	
401	MDST	R5	W2	J	43	242	258	6	0	0.3	70	1	UN	14	O	1		D	22	55	13	12	10	22	10	67	
401	MDST	R5	W2	J	50	248	264	6	0	1.6	70	1	UN	14	O	1		CD	22	55	13	12	15	22	15	77	
401	MDST	R5	W1	BJ	48	62	78	1	2	0.3	70	2	PL	8	T			CD	22	55	13	12	10	22	15	72	
401	MDST	R5	W1	BJ	40	50	66	1	2	0.4	70	1	UN	8	T			CD	22	55	13	12	10	22	15	72	
401	MDST	R5	W1	BJ	56	38	54	1	2	0.2	70	1	UN	8	T			CD	22	55	13	12	8	22	15	70	
401	MDST	R5	W1	J	92	298	314	3	1	1	60	1	UN	16	T			CD	25	60	13	12	15	25	15	80	sub vertical set
401	MDST	R5	W1	J	85	126	142	1	1	0.4	60	1	UN	18	T			CD	25	60	13	12	10	25	15	75	
401	MDST	R5	W1	J	74	308	324	1	1	0.5	60	1	UN	16	T			CD	25	60	13	12	10	25	15	75	
401	MDST	R5	W1	J	70	304	320	1	1	0.4	60	1	UN	16	T			CD	25	60	13	12	10	25	15	75	
402	MDST	R5	W1	J	22	248	264	4	1	0.6	90	3	UN	12	T			CD	25	65	17	12	10	25	15	79	Basal plane
402	MDST	R5	W1	J	50	244	260	4	1	0.7	90	1	UN	6	T			CD	25	65	17	12	15	25	15	84	
402	MDST	R5	W1	J	52	240	256	4	1	0.6	90	1	UN	8	T			CD	25	65	17	12	10	25	15	79	
402	MDST	R5	W1	J	42	246	262	4	1	0.6	90	1	UN	10	T			CD	25	65	17	12	10	25	15	79	
402	MDST	R5	W1	J	44	256	272	4	1	0.6	90	1	UN	8	T			CD	25	65	17	12	10	25	15	79	
402	MDST	R5	W1	J	80	36	52	6	0	0.4	80	3	PL	8	T			CD	25	65	17	12	10	25	15	79	
402	MDST	R5	W1	J	76	36	52	6	0	0.1	80	1	PL	8	T			CD	25	65	17	12	8	25	15	77	
402	MDST	R5	W1	J	78	40	56	6	0	0.3	80	1	PL	8	T			CD	25	65	17	12	10	25	15	79	
402	MDST	R5	W1	J	72	38	54	6	0	0.3	80	1	PL	8	T			CD	25	65	17	12	10	25	15	79	
402	MDST	R5	W1	J	78	36	52	6	0	0.3	80	1	PL	8	O	1		CD	20	65	17	12	10	20	15	74	
402	MDST	R5	W1	J	58	82	98	4	1	0.6	80	3	UN	10	T			CD	25	65	17	12	10	25	15	79	
402	MDST	R5	W1	J	60	96	112	1	1	0.4	80	1	UN	10	T			CD	25	65	17	12	10	25	15	79	
402	MDST	R5	W1	J	72	106	122	2	1	0.3	80	1	UN	10	T			CD	25	65	17	12	10	25	15	79	
402	MDST	R5	W1	J	74	118	134	1	1	0.5	80	1	UN	10	T			CD	25	65	17	12	10	25	15	79	
402	MDST	R5	W1	J	82	104	120	2	1	0.4	80	1	UN	10	T			CD	25	65	17	12	10	25	15	79	
403	MDST	R5	W1	F	58	38	54	7	1		70	1						CD			13	12	10	0	15	50	
403	MDST	R5	W1	J	40	268	284	8	0	1	70	3	UN	6	T			CD	25	65	13	12	15	25	15	80	
403	MDST	R5	W1	J	54	254	270	8	0	0.3	70	1	UN	6	T			CD	25	65	13	12	10	25	15	75	
403	MDST	R5	W1	J	50	246	262	8	0	0.5	70	1	UN	6	T			CD	25	65	13	12	10	25	15	75	
403	MDST	R5	W1	J	56	244	260	8	0	0.4	70	1	UN	6	T			CD	25	65	13	12	10	25	15	75	

Project: PCA	Location ID: POI Start - 397	Date: 29-Jan-15	Mapped By: JP/SM	Face DD (Corrected): 296	Face Dip: 80	Weather: Clear, -10°C - Snow On Ground
Location Chainage:	Sta. 114+800 - 115+200		Colloquial Name:	Through Cut East (Left) / CCC East (Left)		

LOCATION	BEDROCK		DISCONTINUITY																		RMR89 PARAMETERS						COMMENTS
Station (POI)	Type	Strength	Weathering	Type	Dip	Dip Dir.*	DD** Corrected	Persistence (m)	Ends Visible	Spacing (m) Average	RQD	No. of Features	Shape	Roughness (JRC)	Aperture open/ tight	Aperture Width (mm)	Aperture Infill type	Water	Joint Condition (Jc)	GSI	RQD Factor	Strength Factor	Spacing Factor	Jcon	GW	RMR89	
403	MDST	R5	W1	J	80	38	54	7	0	0.3	70	3	UN	6	T			CD	25	65	13	12	10	25	15	75	
403	MDST	R5	W1	J	78	32	48	7	0	0.4	70	1	UN	6	T			CD	25	65	13	12	10	25	15	75	
403	MDST	R5	W1	J	68	26	42	7	0	0.2	70	1	UN	6	T			CD	25	65	13	12	8	25	15	73	
403	MDST	R5	W1	J	78	38	54	7	0	1	70	1	UN	6	T			CD	25	65	13	12	15	25	15	80	
403	MDST	R5	W1	J	80	32	48	7	0	0.7	70	1	UN	6	T			CD	25	65	13	12	15	25	15	80	
403	MDST	R5	W1	J	38	100	116	2	1	0.6	80	3	UN	8	T			CD	25	60	17	12	10	25	15	79	
403	MDST	R5	W1	J	76	128	144	2	1	0.8	80	1	UN	8	T			CD	25	60	17	12	15	25	15	84	
403	MDST	R5	W1	J	85	132	148	2	1	0.7	80	1	UN	8	T			CD	25	60	17	12	15	25	15	84	
403	MDST	R5	W1	J	80	82	98	3	1	0.2	80	1	PL	16	T			CD	25	65	17	12	8	25	15	77	Release plane of face random, GPS 404
405	MDST	R5	W1	J	72	38	54	10	0	0.1	60	3	PL	8	T			CD	25	50	13	12	8	25	15	73	
405	MDST	R5	W1	J	80	26	42	10	0	0.1	60	1	PL	8	T			CD	25	50	13	12	8	25	15	73	
405	MDST	R5	W1	J	74	28	44	10	0	0.2	60	1	PL	8	T			CD	25	50	13	12	8	25	15	73	
405	MDST	R5	W1	J	82	36	52	10	0	0.15	60	1	PL	8	T			CD	25	50	13	12	8	25	15	73	
405	MDST	R5	W1	J	74	24	40	10	0	0.2	60	1	PL	8	O	2		CD	20	50	13	12	8	20	15	68	
405	MDST	R5	W1	J	88	106	122	3	1	0.3	60	3	PL	12	O	1		CD	20	50	13	12	10	20	15	70	
405	MDST	R5	W1	J	80	112	128	3	1	1	60	1	PL	12	O	1		CD	20	50	13	12	15	20	15	75	
405	MDST	R5	W1	J	90	98	114	3	1	1.1	60	1	PL	12	T			CD	25	50	13	12	15	25	15	80	
405	MDST	R5	W1	J	66	104	120	3	1	0.6	60	1	PL	12	T			CD	25	50	13	12	10	25	15	75	
405	MDST	R5	W1	J	30	264	280	10	0	0.7	80	3	UN	8	T			CD	25	55	17	12	15	25	15	84	
405	MDST	R5	W1	J	26	158	174	10	0	0.3	80	1	UN	8	T			CD	25	55	17	12	10	25	15	79	
405	MDST	R5	W1	J	36	240	256	10	0	1	80	1	UN	8	T			CD	25	55	17	12	15	25	15	84	
405	MDST	R5	W1	J	28	68	84	2	1	0.7	70	3	UN	20	O	1		CD	25	55	13	12	15	25	15	80	
405	MDST	R5	W1	J	22	40	56	2	1	0.9	70	1	UN	20	O	1		CD	25	55	13	12	15	25	15	80	
406	MDST	R5	W1	J	78	28	44	15	0	0.2	90	3	PL	8	T			CD	25	55	17	12	8	25	15	77	
406	MDST	R5	W1	J	76	30	46	15	0	0.3	90	1	PL	8	T			CD	25	55	17	12	10	25	15	79	
406	MDST	R5	W1	J	64	288	304	1	1	0.2	80	3	UN	14	T			CD	20	50	17	12	8	20	15	72	
406	MDST	R5	W1	J	88	110	126	1	1	0.4	80	1	UN	14	T			CD	20	50	17	12	10	20	15	74	
406	MDST	R5	W1	J	90	102	118	15	1	1	80	1	UN	18	T			CD	20	50	17	12	15	20	15	79	
406	MDST	R5	W1	J	80	102	118	4	1	0.6	80	1	UN	20	T			CD	20	50	17	12	10	20	15	74	
406	MDST	R5	W1	J	10	152	168	8	0	1	60	3	UN	12	O	1		CD	20	50	13	12	15	20	15	75	Bedding orientation varies grately
406	MDST	R5	W1	J	15	90	106	8	0	0.4	60	1	UN	12	O	2		CD	18	50	13	12	10	18	15	68	
406	MDST	R5	W1	J	10	94	110	8	0	0.6	60	1	UN	12	T			CD	25	50	13	12	10	25	15	75	
406	MDST	R5	W1	J	40	204	220	8	0	1.2	60	1	UN	12	O	5		CD	15	50	13	12	15	15	15	70	Higher upslope bedding dips out of face
407	MDST	R5	W1	J	48	266	282	12	1	4	70	3	PL	16	T			CD	25	60	13	12	20	25	15	85	
407	MDST	R5	W1	J	38	260	276	12	1	3	70	1	PL	16	T			CD	25	60	13	12	20	25	15	85	
407	MDST	R5	W1	J	40	278	294	12	1	1	70	1	PL	16	T			CD	25	60	13	12	15	25	15	80	
407	MDST	R5	W1	J	84	36	52	12	0	0.4	70	3	PL	8	O	2		CD	20	60	13	12	10	20	15	70	
407	MDST	R5	W1	J	86	22	38	12	0	0.3	70	1	PL	8	T			CD	25	60	13	12	10	25	15	75	
407	MDST	R5	W1	J	80	36	52	12	0	0.3	70	1	PL	8	T			CD	25	60	13	12	10	25	15	75	
407	MDST	R5	W1	J	85	36	52	12	0	0.3	70	1	PL	8	T			CD	25	60	13	12	10	25	15	75	
407	MDST	R5	W1	BJ	30	78	94	15	0	2	90	3	UN	12	O	2		CD	20	60	17	12	15	20	15	79	
407	MDST	R5	W1	BJ	40	44	60	15	0	2	90	1	UN	12	T			CD	20	60	17	12	15	20	15	79	
407	MDST	R5	W1	J	70	104	120	1	1	1	90	3	UN	14	T			CD	25	60	17	12	15	25	15	84	Toppling joint
407	MDST	R5	W1	J	70	100	116	2	1	1	90	1	UN	14	T			CD	25	60	17	12	15	25	15	84	
407	MDST	R5	W1	J	68	118	134	1	1	1	90	1	UN	14	T			CD	25	60	17	12	15	25	15	84	

ROCK EXPOSURE COMMENTS:

*Dip Direction with no magnetic declination correction
**Dip Direction with magnetic declination correction of 16 degrees east applied

Type	Type (ctd)	Shape	Termination	Water	Aperture	Infill
FT: Fault	CT: Contact	pl: Planar	2: Doubly Terminated	CD: Completely Dry	O: Open	C: Clay
SZ: Shear Zone	FO: Foliation	un: Undulating	1: Singly Terminated	D: Damp	T: Tight	S: Silt
JT: Joint	BZ: Broken Zone	st: Stepped	0: No Termination	W: Wet		S: Sand
VN:Vein		cu: Curved		DR: Dripping		
BD: Bedding				F: Flowing		

Project: PCA	**Location ID:** POI Start - 408	**Date:** 29-Jan-15	**Mapped By:** JP/SM	**Face DD (Corrected):** 116	**Face Dip:** 80	**Weather:** Clear, -10°C - Snow On Ground
Location Chainage: Sta. 114+860 - 115+100			**Colloquial Name:** Through Cut West (Right) / CCC West (Right)			

LOCATION	BEDROCK		DISCONTINUITY																	RMR89 PARAMETERS							COMMENTS
Station (POI)	Type	Strength	Weathering	Type	Dip	Dip Dir.*	DD** Corrected	Persistence (m)	Ends Visible	Spacing (m) Average	RQD	No. of Features	Shape	Roughness (JRC)	Aperture open/ tight	Aperture Width (mm)	Aperture Infill type	Water	Joint Condition (Jc)	GSI	RQD Factor	Strength Factor	Spacing Factor	Jcon	GW	RMR89	
408	MDST	R5	W1	BJ	20	142	158	6	0	1.2	70	3	UN	18	O	1		CD	25	60	13	12	15	25	15	80	
408	MDST	R5	W1	BJ	20	148	164	6	0	1	70	1	UN	18	T			CD	25	60	13	12	15	25	15	80	
408	MDST	R5	W2	J	80	36	52	6	0	0.4	70	3	PL	8	O	1		CD	25	60	13	12	10	25	15	75	
408	MDST	R5	W2	J	78	34	50	6	0	0.3	70	1	PL	8	T			CD	25	60	13	12	10	25	15	75	
408	MDST	R5	W2	J	82	34	50	6	0	0.5	70	1	PL	8	T			CD	25	60	13	12	10	25	15	75	
408	MDST	R5	W2	J	68	58	74	10	0	0.5	70	3	UN	10	T			CD	25	50	13	12	10	25	15	75	Face
408	MDST	R5	W2	J	90	100	116	10	0	0.4	70	1	UN	10	T			CD	25	50	13	12	10	25	15	75	
408	MDST	R5	W2	J	90	164	180	10	0	0.6	70	1	UN	10	T			CD	25	50	13	12	10	25	15	75	
408	MDST	R5	W2	J	80	38	54	15	0	0.1	60	3	PL	8	T			CD	25	50	13	12	8	25	15	73	Same set across both faces - carry this joint to other locations if split by GPS
408	MDST	R5	W2	J	78	38	54	15	0	0.2	60	1	PL	8	T			CD	25	50	13	12	8	25	15	73	
408	MDST	R5	W2	J	85	290	306	3	1	0.4	60	3	PL	8	O	2		CD	20	50	13	12	10	20	15	70	
408	MDST	R5	W2	J	78	308	324	3	1	0.2	60	1	PL	8	T			CD	20	50	13	12	8	20	15	68	
408	MDST	R5	W2	J	78	312	328	3	1	0.3	60	1	PL	8	T			CD	20	50	13	12	10	20	15	70	
408	MDST	R5	W2	B	22	198	214	3	1	0.3	60	1	PL	8	T			CD	20	50	13	12	10	20	15	70	folded bedding planes
408	MDST	R5	W2	B	22	40	56	3	1	0.3	60	1	PL	8	T			CD	20	50	13	12	10	20	15	70	folded bedding planes
408	MDST	R5	W2	J	90	112	128	4	0	1.4	70	3	UN	20	T			CD	25	55	13	12	15	25	15	80	
408	MDST	R5	W2	J	84	124	140	4	0	1.2	70	1	UN	20	T			CD	25	55	13	12	15	25	15	80	
408	MDST	R5	W2	J	80	122	138	4	0	1.1	70	1	UN	20	T			CD	25	55	13	12	15	25	15	80	

ROCK EXPOSURE COMMENTS:

*Dip Direction with no magnetic declination correction
**Dip Direction with magnetic declination correction of 16 degrees east applied

Type	Type (ctd)	Shape	Termination	Water	Aperture	Infill
FT: Fault	CT: Contact	pl: Planar	2: Doubly Terminated	CD: Completely Dry	O: Open	C: Clay
SZ: Shear Zone	FO: Foliation	un: Undulating	1: Singly Terminated	D: Damp	T: Tight	S: Silt
JT: Joint	BZ: Broken Zone	st: Stepped	0: No Termination	W: Wet		S: Sand
VN:Vein		cu: Curved		DR: Dripping		
BD: Bedding				F: Flowing		

Project: PCA	**Location ID:** POI Start - 440	**Date:** 30-Jan-15	**Mapped By:** JP/SM	**Face DD (Corrected):** 226	**Face Dip:** 85	**Weather:** Clear, -11°C - Snow On Ground
Location Chainage:	Sta. 115+650 - 115+860		**Colloquial Name:**	Little Topple		

LOCATION	BEDROCK		DISCONTINUITY																		RMR89 PARAMETERS						COMMENTS
Station (POI)	Type	Strength	Weathering	Type	Dip	Dip Dir.*	DD** Corrected	Persistence (m)	Ends Visible	Spacing (m) Average	RQD	No. of Features	Shape	Roughness (JRC)	Aperture open/ tight	Aperture Width (mm)	Infill type	Water	Joint Condition (Jc)	GSI	RQD Factor	Strength Factor	Spacing Factor	Jcon	GW	RMR89	
440	MDST	R3	W2	J	70	30	46	10	0	0.2	80	3	UN	10	O	3		CD	18	50	17	4	8	18	15	62	Major toppling joint
440	MDST	R3	W2	J	72	38	54	10	0	0.1	80	1	UN	10	T			CD	25	55	17	4	8	25	15	69	
440	MDST	R3	W2	J	68	38	54	10	0	0.15	80	1	UN	10	T			CD	25	55	17	4	8	25	15	69	
440	MDST	R3	W2	J	68	28	44	10	0	0.1	80	1	UN	10	T			CD	25	55	17	4	8	25	15	69	
440	MDST	R3	W2	J	76	30	46	10	0	0.2	80	1	UN	10	T			CD	25	55	17	4	8	25	15	69	
440	MDST	R3	W2	J	58	76	92	8	0	3	80	2	UN	14	T		Fe	CD	25	55	17	4	20	25	15	81	Vertical/sub vertical, widely spaced, Fe on surface
440	MDST	R3	W2	J	80	90	106	8	0	1.5	80	1	UN	14	T			CD	25	55	17	4	15	25	15	76	
440	MDST	R3	W2	J	56	58	74	8	0	2	80	1	UN	14	T			CD	25	55	17	4	15	25	15	76	
440	MDST	R3	W2	J	72	308	324	4	0	3	70	2	UN	14	T			CD	25	55	13	4	20	25	15	77	Vertical/sub vertical
440	MDST	R3	W2	J	88	304	320	4	0	1	70	1	UN	14	T			CD	25	55	13	4	15	25	15	72	
440	MDST	R3	W2	J	90	306	322	4	0	1	70	1	UN	14	T			CD	25	55	13	4	15	25	15	72	
440	MDST	R3	W2	J	88	310	326	7	0	3	70	1	UN	16	T			CD	25	55	13	4	20	25	15	77	
440	MDST	R3	W2	J	20	220	236	4	1	0.7	80	3	UN	14	T			CD	25	55	17	4	15	25	15	76	Horizontal bedding
440	MDST	R3	W2	J	22	196	212	3	1	1	80	1	UN	14	T			CD	25	55	17	4	15	25	15	76	
440	MDST	R3	W2	J	20	220	236	1	1	0.8	80	1	UN	14	T			CD	25	55	17	4	15	25	15	76	
440	MDST	R3	W2	J	26	248	264	5	1	0.4	80	1	UN	16	T			CD	25	55	17	4	10	25	15	71	
440	MDST	R3	W2	J	20	248	264	3	1	0.3	80	1	UN	14	T			CD	25	55	17	4	10	25	15	71	
440	MDST	R3	W2	J	74	40	56	10	0	0.3	70	3	UN	12	T			CD	25	55	13	4	10	25	15	67	Face, photo 4412
440	MDST	R3	W2	J	76	42	58	10	0	0.1	70	1	UN	12	O	2		CD	20	50	13	4	8	20	15	60	
440	MDST	R3	W2	J	76	38	54	10	0	0.3	70	1	UN	12	T			CD	25	55	13	4	10	25	15	67	
440	MDST	R3	W2	J	78	308	324	10	0	5	80	3	UN	16	T			CD	25	55	17	4	20	25	15	81	Sub-vertical
440	MDST	R3	W2	J	85	116	132	3.5	0	0.25	80	1	UN	8	T			CD	25	55	17	4	10	25	15	71	
440	MDST	R3	W2	J	84	114	130	2	0	0.5	80	1	UN	12	T			CD	25	55	17	4	10	25	15	71	
440	MDST	R3	W2	J	85	114	130	10	0	4	80	1	UN	14	T			CD	25	55	17	4	20	25	15	81	
440	MDST	R3	W2	BJ	8	348	4	15	0	2	80	3	CU	16	T			CD	25	55	17	4	15	25	15	76	horizontal - heavily folded/undulating, bedding
440	MDST	R3	W2	BJ	24	232	248	15	0	1.5	80	1	CU	16	T			CD	25	55	17	4	15	25	15	76	
440	MDST	R3	W2	BJ	18	240	256	15	0	1.6	80	1	CU	16	T			CD	25	55	17	4	15	25	15	76	
440	MDST	R3	W2	J	76	34	50	10	0	1.5	80	3	UN	12	T			CD	25	55	17	4	15	25	15	76	Face
440	MDST	R3	W2	J	72	36	52	10	0	1	80	1	UN	12	T			CD	25	55	17	4	15	25	15	76	
440	MDST	R3	W2	J	74	40	56	10	0	0.2	80	1	UN	12	T			CD	25	55	17	4	8	25	15	69	
440	MDST	R3	W2	J	34	226	242	5	0	0.3	80	3	UN	20	T			CD	25	55	17	4	10	25	15	71	Bedding crenulations result in very high JRC
440	MDST	R3	W2	J	36	252	268	5	0	1	80	1	UN	20	T			CD	25	55	17	4	15	25	15	76	
440	MDST	R3	W2	J	68	320	336	4	1	1.5	80	3	UN	12	T			CD	25	55	17	4	15	25	15	76	vertical/sub vertical
440	MDST	R3	W2	J	80	118	134	4	1	1.6	80	1	UN	12	T			CD	25	55	17	4	15	25	15	76	
440	MDST	R3	W2	J	80	106	122	4	1	0.3	80	1	UN	12	T			CD	25	55	17	4	10	25	15	71	
440	MDST	R3	W2	J	82	108	124	4	1	0.6	80	1	UN	12	T			CD	25	55	17	4	10	25	15	71	
440	MDST	R3	W2	J	88	136	152	4	1	0.6	80	1	UN	14	T			CD	25	55	17	4	10	25	15	71	
440	MDST	R3	W2	J	86	108	124	4	1	0.5	80	1	UN	4	T			CD	25	55	17	4	10	25	15	71	
440	MDST	R3	W2	BJ	24	284	300	9	0	0.5	80	3	UN	16	T			CD	25	55	17	4	10	25	15	71	Horizontal set
440	MDST	R3	W2	BJ	10	312	328	9	0	0.1	80	1	UN	16	T			CD	25	55	17	4	8	25	15	69	

ROCK EXPOSURE COMMENTS:

*Dip Direction with no magnetic declination correction
**Dip Direction with magnetic declination correction of 16 degrees east applied

Type	Type (ctd)	Shape	Termination	Water	Aperture	Infill
FT: Fault	CT: Contact	pl: Planar	2: Doubly Terminated	CD: Completely Dry	O: Open	C: Clay
SZ: Shear Zone	FO: Foliation	un: Undulating	1: Singly Terminated	D: Damp	T: Tight	S: Silt
JT: Joint	BZ: Broken Zone	st: Stepped	0: No Termination	W: Wet		S: Sand
VN:Vein		cu: Curved		DR: Dripping		
BD: Bedding				F: Flowing		

Project:	PCA	Location ID:	POI Start - 442	Date:	30-Jan-15	Mapped By:	JP/SM	Face DD (Corrected):	236	Face Dip:	85	Weather:	Clear, -11°C - Snow On Ground
Location Chainage:	Sta. 115+380 - 115+580					Colloquial Name:	Big Topple						

LOCATION	BEDROCK		DISCONTINUITY												Aperture						RMR89 PARAMETERS						COMMENTS
Station (POI)	Type	Strength	Weathering	Type	Dip	Dip Dir.*	DD** Corrected	Persistence (m)	Ends Visible	Spacing (m) Average	RQD	No. of Features	Shape	Roughness (JRC)	open/ tight	Width (mm)	Infill type	Water	Joint Condition (Jc)	GSI	RQD Factor	Strength Factor	Spacing Factor	Jcon	GW	RMR89	
442	MDST	R3	W2	J	78	40	56	30	0	0.2	70	3	PL	16	T			CD	25	55	13	4	8	25	15	65	Face, toppling
442	MDST	R3	W2	J	80	42	58	30	0	0.2	70	1	PL	16	O	2		CD	20	50	13	4	8	20	15	60	
442	MDST	R3	W2	J	78	32	48	30	0	0.3	70	1	PL	16	O	2		CD	20	50	13	4	10	20	15	62	
442	MDST	R3	W2	J	80	38	54	30	0	0.2	70	1	PL	16	T			CD	20	50	13	4	8	20	15	60	
442	MDST	R3	W2	SZ	72	118	134	30	0	8	70	1	UN	20	O	10	BRX	D	10	40	13	4	20	10	10	57	Breccia Infill
442	MDST	R3	W2	SZ	80	120	136	30	0	3	70	1	UN	20	O	10	BRX	D	10	40	13	4	20	10	10	57	Breccia Infill
442	MDST	R3	W2	SZ	80	132	148	30	0	5	70	1	UN	16	O	10	BRX	D	10	40	13	4	20	10	10	57	Breccia Infill
442	MDST	R3	W2	J	76	110	126	30	0	12	70	1	UN	16	T			CD	25	55	13	4	20	25	15	77	
442	MDST	R3	W2	BJ	5	262	278	15	0	0.2	70	2	UN	20	T			CD	25	55	13	4	8	25	15	65	
442	MDST	R3	W2	BJ	40	236	252	15	0	0.3	70	1	UN	20	T			CD	25	55	13	4	10	25	15	67	
442	MDST	R3	W2	BJ	20	18	34	15	0	0.5	70	1	UN	20	T			CD	25	55	13	4	10	25	15	67	
442	MDST	R3	W2	BJ	10	28	44	15	0	1.5	70	1	UN	20	T			CD	25	55	13	4	15	25	15	72	
442	MDST	R3	W2	BJ	28	248	264	15	0	0.3	70	1	UN	20	T			CD	25	55	13	4	10	25	15	67	
442	MDST	R3	W2	J	76	42	58	30	0	0.5	70	3	PL	10	T			CD	25	55	13	4	10	25	15	67	
442	MDST	R3	W2	J	74	46	62	30	0	0.3	70	1	PL	10	T			CD	25	55	13	4	10	25	15	67	
442	MDST	R3	W2	J	80	40	56	30	0	0.4	70	1	PL	10	T			CD	25	55	13	4	10	25	15	67	
442	MDST	R3	W2	J	88	122	138	1	2	1.5	70	1	UN	14	O	2		CD	20	50	13	4	15	20	15	67	
442	MDST	R3	W2	J	78	130	146	2	2	1.3	70	1	UN	14	O	1		CD	22	55	13	4	15	22	15	69	
442	MDST	R3	W2	J	76	128	144	20	2	2.5	70	1	PL	18	O	3		CD	18	50	13	4	20	18	15	70	
442	MDST	R3	W2	J	72	100	116	20	2	3	70	1	PL	18	T			CD	25	55	13	4	20	25	15	77	
442	MDST	R3	W2	J	72	136	152	20	2	8	70	1	PL	18	T			CD	25	55	13	4	20	25	15	77	
442	MDST	R3	W2	J	78	128	144	20	2	5	70	1	PL	18	T			CD	25	55	13	4	20	25	15	77	
442	MDST	R3	W2	BJ	44	220	236	20	0	0.7	70	1	UN	20	T			CD	25	55	13	4	15	25	15	72	
442	MDST	R3	W2	BJ	23	212	228	20	0	1	70	1	UN	20	T			CD	25	55	13	4	15	25	15	72	
442	MDST	R3	W2	BJ	38	216	232	20	0	0.5	70	1	UN	20	T			CD	25	55	13	4	10	25	15	67	
442	MDST	R3	W2	J	82	42	58	30	0	0.3	70	3	UN	10	O	1		CD	22	55	13	4	10	22	15	64	Face
442	MDST	R3	W2	J	80	36	52	30	0	0.2	70	1	UN	10	T			CD	22	55	13	4	8	22	15	62	
442	MDST	R3	W2	J	80	40	56	30	0	0.5	70	1	UN	10	T			CD	22	55	13	4	10	22	15	64	
442	MDST	R3	W2	J	70	32	48	30	0	0.3	70	1	UN	10	T			CD	22	55	13	4	10	22	15	64	
442	MDST	R3	W2	J	78	40	56	30	0	0.4	70	1	UN	10	T			CD	22	55	13	4	10	22	15	64	
442	MDST	R3	W2	J	80	42	58	30	0	0.2	70	1	UN	10	T			CD	22	55	13	4	8	22	15	62	
442	MDST	R3	W2	BJ	28	198	214	20	0	0.7	70	1	UN	14	T			CD	25	65	13	4	15	25	15	72	
442	MDST	R3	W2	J	66	108	124	20	0	4	70	1	PL	18	T			CD	25	55	13	4	20	25	15	77	
442	MDST	R3	W2	J	78	122	138	20	0	2	70	1	UN	12	T			CD	25	55	13	4	15	25	15	72	
442	MDST	R3	W2	J	82	112	128	20	0	2.5	70	1	UN	12	T			CD	25	55	13	4	20	25	15	77	
442	MDST	R3	W2	J	40	268	284	10	0	4	70	1	UN	12	T			CD	25	55	13	4	20	25	15	77	POI 443

ROCK EXPOSURE COMMENTS:

*Dip Direction with no magnetic declination correction

**Dip Direction with magnetic declination correction of 16 degrees east applied

Type	Type (ctd)	Shape	Termination	Water	Aperture	Infill
FT: Fault	CT: Contact	pl: Planar	2: Doubly Terminated	CD: Completely Dry	O: Open	C: Clay
SZ: Shear Zone	FO: Foliation	un: Undulating	1: Singly Terminated	D: Damp	T: Tight	S: Silt
JT: Joint	BZ: Broken Zone	st: Stepped	0: No Termination	W: Wet		S: Sand
VN:Vein		cu: Curved		DR: Dripping		
BD: Bedding				F: Flowing		

Project: PCA	**Location ID:** POI Start - 444	**Date:** 30-Jan-15	**Mapped By:** JP/SM	**Face DD (Corrected):** 206	**Face Dip:** 80	**Weather:** Clear, -11°C - Snow On Ground
Location Chainage: Sta. 124+270 - 124+670			**Colloquial Name:** Km 2.9 EBA Chainage - Phyllite			

LOCATION	BEDROCK		DISCONTINUITY																	RMR89 PARAMETERS						COMMENTS
														Aperture												
Station (POI)	Type	Strength	Weathering	Type	Dip	Dip Dir.*	DD** Corrected	Persistence (m)	Ends Visible	Spacing (m) Average	RQD	No. of Features	Shape	Roughness (JRC)	open/ tight	Width (mm)	Infill type	Water	Joint Condition (Jc)	GSI	RQD Factor	Strength Factor	Spacing Factor	Jcon	GW	RMR89	
444	PHYL	R2	W3	CJ	84	204	220	3	0	0.05	0	3	PL	4	T			CD	20	25	3	2	5	20	15	45	0.2 - 0.5 m competant quartz veins run with cleavage throughout (Photo 4446)
444	PHYL	R2	W3	CJ	80	204	220	3	0	0.05	0	1	PL	4	T			CD	20	25	3	2	5	20	15	45	
444	PHYL	R2	W3	CJ	90	196	212	3	0	0.05	0	1	PL	4	T			CD	20	25	3	2	5	20	15	45	
444	PHYL	R2	W3	J	20	308	324	2	1		0	1	PL	8	T			CD	22	25	3	2	10	22	15	52	
444	PHYL	R2	W2	J	60	280	296	2	1		0	1	PL	8	T			CD	22	25	3	2	10	22	15	52	Qtz veins along joints
444	PHYL	R2	W3	CJ	78	28	44	4	0	0.05	0	3	UN	4	T			CD	22	25	3	2	5	22	15	47	
444	PHYL	R2	W3	CJ	76	20	36	4	0	0.05	0	1	UN	4	T			CD	22	25	3	2	5	22	15	47	
446	PHYL	R2	W3	CJ	48	356	12	2	1	0.05	0	3	UN	4	T			CD	22	25	3	2	5	22	15	47	At toe
446	PHYL	R2	W3	CJ	75	168	184	4	1	0.05	0	1	UN	4	T			CD	22	25	3	2	5	22	15	47	At crest
447	PHYL	R2	W3	SZ	85	270	286	15	0	0.05	0	1	UN	4	T	100	BRECCIA	CD	10	15	3	2	5	10	15	35	Fault breccia
447	PHYL	R2	W3	SZ	85	205	221	8	0	0.05	0	1	UN	14	T			CD	20	25	3	2	5	20	15	45	toppling at crest along apparent joints
447	PHYL	R2	W3	CJ	40	36	52	20	0	0.05	0	3	UN	6	T			CD	20	25	3	2	5	20	15	45	
447	PHYL	R2	W2	CJ	44	46	62	20	0	0.05	0	1	UN	6	O	1		CD	18	25	3	2	5	18	15	43	openness from toppling
447	PHYL	R2	W2	J	60	196	212	6	0	0.3	0	1	UN	12	T			CD	20	25	3	2	10	20	15	50	
450	PHYL	R2	W3	J	60	40	56	20	0	0.05	0	3	UN	6	T			CD	20	25	3	2	5	20	15	45	at crest
450	PHYL	R2	W3	J	70	240	256	5	2	0.3	20	2	UN	10	O			CD	18	20	3	2	10	18	15	48	
451	PHYL	R2	W3	J	90	98	114	3	2	0.7	0	3	PL	8	O			CD	22	25	3	2	15	22	15	57	Local vertical set
451	PHYL	R2	W3	CJ	20	10	26	15	0	0.05	0	3	UN	6	T			CD	25	25	3	2	5	25	15	50	at toe
451	PHYL	R2	W3	CJ	60	40	56	15	0	0.05	0	3	UN	6	T			CD	25	25	3	2	5	25	15	50	at crest - estimate

ROCK EXPOSURE COMMENTS:

*Dip Direction with no magnetic declination correction
**Dip Direction with magnetic declination correction of 16 degrees east applied

Type	Type (ctd)	Shape	Termination	Water	Aperture	Infill
FT: Fault	CT: Contact	pl: Planar	2: Doubly Terminated	CD: Completely Dry	O: Open	C: Clay
SZ: Shear Zone	FO: Foliation	un: Undulating	1: Singly Terminated	D: Damp	T: Tight	S: Silt
JT: Joint	BZ: Broken Zone	st: Stepped	0: No Termination	W: Wet		S: Sand
VN:Vein		cu: Curved		DR: Dripping		
BD: Bedding				F: Flowing		

Project:	PCA	Location ID:	POI Start - 549	Date:	1-Feb-15	Mapped By:	JP/SM	Face DD (Corrected):	266	Face Dip:	75	Weather:	Overcast, -10°C - Snow On Ground
Location Chainage:			Sta. 116+910 - 117+200			Colloquial Name:			N/A				

LOCATION	BEDROCK		DISCONTINUITY												Aperture						RMR89 PARAMETERS						COMMENTS
Station (POI)	Type	Strength	Weathering	Type	Dip	Dip Dir.*	DD** Corrected	Persistence (m)	Ends Visible	Spacing (m) Average	RQD	No. of Features	Shape	Roughness (JRC)	open/ tight	Width (mm)	Infill type	Water	Joint Condition (Jc)	GSI	RQD Factor	Strength Factor	Spacing Factor	Jcon	GW	RMR89	
549	MDST	R4	W1	CJ	88	30	46	6	0	0.2	80	3	PL	10	T			CD	25	65	17	7	8	25	15	72	Upper slope about 5 degrees down, generally shallow
549	MDST	R4	W2	CJ	88	36	52	6	0	0.5	80	1	PL	12	T			CD	25	65	17	7	10	25	15	74	
549	MDST	R4	W2	CJ	84	36	52	6	0	0.4	80	1	PL	12	O	1		CD	22	60	17	7	10	22	15	71	Qtz vein on surface
549	MDST	R4	W2	CJ	86	38	54	6	0	0.3	80	1	PL	8	T			CD	25	60	17	7	10	25	15	74	
549	MDST	R4	W1	BJ	50	218	234	4	0	1.6	80	2	UN	16	T			CD	25	65	17	7	15	25	15	79	
549	MDST	R4	W1	BJ	44	220	236	4	0	1.5	80	1	UN	14	T			CD	25	65	17	7	15	25	15	79	
549	MDST	R4	W2	J	68	286	302	6	0		80	1	UN	8	T			CD	25	65	17	7	10	25	15	74	Vertical/sub vertical - random joint
549	MDST	R4	W2	J	82	146	162	2	1	2	80	1	UN	12	T			CD	25	65	17	7	15	25	15	79	
549	MDST	R4	W2	J	80	160	176	2	1	2	80	1	UN	12	T			CD	25	65	17	7	15	25	15	79	
550	MDST	R4	W2	J	86	260	276	8	0	3	90	1	UN	14	T			CD	25	65	17	7	20	25	15	84	Subvert, quartz on surface, dominant, forms rock face. Horizontal
550	MDST	R4	W2	J	10	274	290	6	0	2	90	2	UN	8	O	2		CD	22	60	17	7	15	22	15	76	
550	MDST	R4	W2	J	8	240	256	6	0	1.8	90	1	UN	8	O	2		CD	22	60	17	7	15	22	15	76	
550	MDST	R4	W2	CJ	80	32	48	8	0	1	90	3	PL	8	T			CD	25	65	17	7	15	25	15	79	
550	MDST	R4	W2	BJ	64	216	232	7	0	2	70	2	UN	16	T			CD	25	65	13	7	15	25	15	75	
550	MDST	R4	W2	BJ	58	226	242	7	0	2.5	70	1	UN	20	T			CD	25	65	13	7	20	25	15	80	
550	MDST	R4	W2	BJ	58	220	236	7	0	1.8	70	1	UN	10	T			CD	25	65	13	7	15	25	15	75	
550	MDST	R4	W2	CJ	84	38	54	8	0	0.2	90	3	UN	10	T			CD	25	65	17	7	8	25	15	72	Forms toppling at crest (flexural)
550	MDST	R4	W2	CJ	80	32	48	8	0	0.2	90	1	UN	8	T			CD	25	65	17	7	8	25	15	72	
550	MDST	R4	W2	CJ	78	42	58	8	0	0.25	90	1	UN	8	T			CD	25	65	17	7	10	25	15	74	
550	QTZ	R4	W2	VN	76	40	56	7	0		70	1	UN	18	T			CD	25	65	13	7	10	25	15	70	Quartz vein runs with cleavage
550	MDST	R4	W2	J	66	288	304	2	1	1	70	1	UN	8	T			CD	25	65	13	7	15	25	15	75	
550	MDST	R4	W2	J	80	88	104	2	2	1	70	1	UN	12	T			CD	25	65	13	7	15	25	15	75	
550	MDST	R4	W2	J	62	120	136	2	2	1	70	1	PL	14	O	1		CD	22	60	13	7	15	22	15	72	
550	MDST	R4	W2	BJ	70	220	236	5	0	1.8	80	2	PL	12	O	3		CD	20	60	17	7	15	20	15	74	
550	MDST	R4	W2	BJ	68	218	234	5	0	1.8	80	1	PL	20	T			CD	25	65	17	7	15	25	15	79	
550	MDST	R4	W2	CJ	84	36	52	4	0	0.2	80	3	PL	6	T			CD	25	65	17	7	8	25	15	72	
550	MDST	R4	W2	CJ	80	36	52	4	0	0.2	80	1	PL	6	T			CD	25	65	17	7	8	25	15	72	
550	MDST	R4	W2	J	90	80	96	8	0		80	1	UN	18	O	3		CD	18	60	17	7	10	18	15	67	Face
550	MDST	R4	W2	J	80	202	218	5	1	1.5	80	2	UN	14	T			CD	25	65	17	7	15	25	15	79	
550	MDST	R4	W2	CJ	84	32	48	8	0	0.15	70	3	UN	8	T			CD	25	65	13	7	8	25	15	68	
551	MDST	R4	W2	BJ	66	220	236	10	0	2	70	2	UN	14	T			CD	25	65	13	7	15	25	15	75	
551	MDST	R4	W2	BJ	68	222	238	10	0	2	70	1	UN	12	T			CD	25	65	13	7	15	25	15	75	
551	MDST	R4	W2	J	90	70	86	3	0		70	1	UN	12	O	2		CD	20	60	13	7	10	20	15	65	
551	MDST	R4	W2	J	84	310	326	3	1	2	70	2	UN	12	T			CD	25	65	13	7	15	25	15	75	
552	MDST	R4	W2	J	78	302	318	6	0	2	80	2	UN	12	T			CD	25	65	17	7	15	25	15	79	
552	MDST	R4	W2	J	82	270	286	10	0	2	80	2	PL	12	T			CD	25	65	17	7	15	25	15	79	
552	MDST	R4	W2	J	88	278	294	10	0	2	80	1	PL	12	O	2		CD	20	60	17	7	15	20	15	74	
553	MDST	R4	W2	CJ	88	42	58	10	0	0.3	80	3	UN	8	T			CD	25	65	17	7	10	25	15	74	
553	MDST	R4	W2	J	26	354	10	4	1		80	1	PL	6	O	1		CD	22	60	17	7	10	22	15	71	
553	MDST	R4	W2	CJ	88	38	54	10	0	0.4	80	3	UN	8	T			CD	25	65	17	7	10	25	15	74	
553	MDST	R4	W2	BJ	68	224	240	10	0	0.6	80	1	UN	12	T			CD	25	65	17	7	10	25	15	74	
553	MDST	R4	W2	J	88	300	316	5	0	2	80	1	UN	18	T			CD	25	65	17	7	15	25	15	79	Sub vert
553	MDST	R4	W2	J	88	116	132	5	0	2	80	1	UN	18	T			CD	25	65	17	7	15	25	15	79	
553	MDST	R4	W2	BJ	72	220	236	3	0	4	80	1	UN	20	T			CD	25	65	17	7	20	25	15	84	
553	MDST	R4	W2	CJ	82	30	46	10	0	0.3	80	3	PL	6	T			CD	25	65	17	7	10	25	15	74	
553	MDST	R4	W2	J	80	288	304	10	0	0.3	80	1	UN	18	O	2		CD	20	60	17	7	10	20	15	69	
553	MDST	R4	W2	J	74	112	128	3	1	0.3	80	1	PL	12	T			CD	25	65	17	7	10	25	15	74	
553	MDST	R4	W2	J	80	288	304	6	1	0.3	80	1	PL	18	T			CD	25	65	17	7	10	25	15	74	
553	MDST	R4	W2	BJ	70	224	240	4	0	2.5	90	2	PL	14	T			CD	25	65	17	7	20	25	15	84	
553	MDST	R4	W2	J	86	92	108	4	0	2.5	90	1	PL	18	T			CD	25	65	17	7	20	25	15	84	toppling

ROCK EXPOSURE COMMENTS:

*Dip Direction with no magnetic declination correction

**Dip Direction with magnetic declination correction of 16 degrees east applied

Type	Type (ctd)	Shape	Termination	Water	Aperture	Infill
FT: Fault	CT: Contact	pl: Planar	2: Doubly Terminated	CD: Completely Dry	O: Open	C: Clay
SZ: Shear Zone	FO: Foliation	un: Undulating	1: Singly Terminated	D: Damp	T: Tight	S: Silt
JT: Joint	BZ: Broken Zone	st: Stepped	0: No Termination	W: Wet		S: Sand
VN:Vein		cu: Curved		DR: Dripping		
BD: Bedding				F: Flowing		

Project: PCA | **Location ID:** POI Start - 554 | **Date:** 1-Feb-15 | **Mapped By:** JP/SM | **Face DD (Corrected):** 266 | **Face Dip:** 75 | **Weather:** Overcast, -10°C - Snow On Ground

Location Chainage: Sta. 116+450 - 116+900 | **Colloquial Name:** N/A

LOCATION	BEDROCK		DISCONTINUITY																		RMR89 PARAMETERS						COMMENTS
Station (POI)	Type	Strength	Weathering	Type	Dip	Dip Dir.*	DD** Corrected	Persistence (m)	Ends Visible	Spacing (m) Average	RQD	No. of Features	Shape	Roughness (JRC)	Aperture open/ tight	Aperture Width (mm)	Aperture Infill type	Water	Joint Condition (Jc)	GSI	RQD Factor	Strength Factor	Spacing Factor	Jcon	GW	RMR89	
554	MDST	R4	W2	CJ	76	36	52	15	0	0.3	70	3	PL	10	T			CD	25	65	13	7	10	25	15	70	554 = columnar instability
554	MDST	R4	W2	CJ	80	40	56	15	0	0.3	70	1	PL	10	T			CD	25	65	13	7	10	25	15	70	
554	MDST	R4	W2	CJ	78	40	56	15	0	0.3	70	1	PL	10	T			CD	25	65	13	7	10	25	15	70	
554	MDST	R4	W2	J	22	220	236	2	2	1	70	2	PL	10	T			CD	25	65	13	7	15	25	15	75	Horizontal set
554	MDST	R4	W2	J	14	238	254	2	2	0.8	70	1	PL	10	T			CD	25	65	13	7	15	25	15	75	
554	MDST	R4	W2	J	10	152	168	2	2	0.7	70	1	PL	10	T			CD	25	65	13	7	15	25	15	75	
554	MDST	R4	W2	J	76	120	136	4	1	1.3	70	1	UN	20	T			CD	25	65	13	7	15	25	15	75	
554	MDST	R4	W2	J	80	96	112	4	1	1.3	70	1	UN	20	T			CD	25	65	13	7	15	25	15	75	
554	MDST	R4	W2	J	80	122	138	1	1	1.3	70	1	UN	20	T			CD	25	65	13	7	15	25	15	75	
554	MDST	R4	W2	J	62	144	160	1	1	1.3	70	1	UN	20	T			CD	25	65	13	7	15	25	15	75	
554	MDST	R4	W2	J	80	312	328	2	2	1.5	70	3	UN	18	T			CD	25	65	13	7	15	25	15	75	Short sub vertical set
554	MDST	R4	W2	J	74	316	332	2	2	1.4	70	1	UN	20	T			CD	25	65	13	7	15	25	15	75	
554	MDST	R4	W2	J	70	300	316	2	2	1.7	70	1	UN	18	T			CD	25	65	13	7	15	25	15	75	
554	MDST	R4	W2	J	76	322	338	4	2	1	70	1	UN	16	T			CD	25	65	13	7	15	25	15	75	
554	MDST	R4	W2	J	90	316	332	4	2	0.9	70	1	UN	16	T			CD	25	65	13	7	15	25	15	75	
554	MDST	R4	W2	J	80	312	328	4	2	0.6	70	1	UN	16	T			CD	25	65	13	7	10	25	15	70	
554	MDST	R4	W2	CJ	80	38	54	20	0	0.3	60	3	PL	6	T			CD	25	65	13	7	10	25	15	70	
554	MDST	R4	W2	CJ	80	46	62	20	0	0.1	60	1	PL	6	T			CD	25	65	13	7	8	25	15	68	
554	MDST	R4	W2	CJ	70	36	52	20	0	0.1	60	1	PL	8	T			CD	25	65	13	7	8	25	15	68	
554	MDST	R4	W2	J	22	212	228	3	2	0.6	60	3	UN	12	T			CD	25	65	13	7	10	25	15	70	
554	MDST	R4	W2	J	22	252	268	3	2	0.4	60	1	UN	12	T			CD	25	65	13	7	10	25	15	70	
555	MDST	R4	W2	J	24	232	248	20	0	1.5	80	3	UN	14	O	2		CD	20	60	17	7	15	20	15	74	
555	MDST	R4	W2	J	26	250	266	20	0	1.3	80	1	UN	14	O	2		CD	20	60	17	7	15	20	15	74	
555	MDST	R4	W2	J	22	240	256	20	0	1	80	1	UN	14	T			CD	25	65	17	7	15	25	15	79	
555	MDST	R4	W2	CJ	80	40	56	15	0	0.1	80	3	PL	6	T			CD	25	65	17	7	8	25	15	72	
555	MDST	R4	W2	CJ	76	36	52	15	0	0.1	80	1	PL	6	T			CD	25	65	17	7	8	25	15	72	
555	MDST	R4	W2	CJ	80	40	56	15	0	0.1	80	1	PL	6	T			CD	25	65	17	7	8	25	15	72	
555	MDST	R4	W2	J	86	102	118	2	2		80	1	PL	18	T			CD	25	65	17	7	10	25	15	74	
555	MDST	R4	W2	J	88	274	290	4	2	0.5	80	1	PL	16	T			CD	25	65	17	7	10	25	15	74	
555	MDST	R4	W2	J	86	264	280	10	2	0.6	80	1	ST	18	T			CD	25	65	17	7	10	25	15	74	
555	MDST	R4	W2	J	76	288	304	2	2	0.6	80	1	PL	16	T			CD	25	65	17	7	10	25	15	74	
555	MDST	R4	W2	J	38	260	276	20	0		80	1	PL	14	T			CD	25	65	17	7	10	25	15	74	Persistant planar joint, GPS 556, quartz on surface
555	MDST	R4	W2	CJ	80	42	58	20	0	0.3	80	3	PL	12	T			CD	25	65	17	7	10	25	15	74	
555	MDST	R4	W2	CJ	76	38	54	20	0	0.3	80	1	PL	12	T			CD	25	65	17	7	10	25	15	74	
555	MDST	R4	W2	J	18	250	266	20	0	1	80	3	PL	12	T			CD	25	65	17	7	15	25	15	79	Basal planes for toppling
555	MDST	R4	W2	J	28	246	262	20	0	0.6	80	1	PL	12	T			CD	25	65	17	7	10	25	15	74	
555	MDST	R4	W2	J	28	260	276	20	0	0.8	80	1	PL	12	T			CD	25	65	17	7	15	25	15	79	
555	MDST	R4	W2	J	76	296	312	2	2	0.7	80	3	UN	8	T			CD	25	65	17	7	15	25	15	79	
555	MDST	R4	W2	J	76	298	314	2	2	0.7	80	1	UN	8	O	1		CD	22	65	17	7	15	22	15	76	
555	MDST	R4	W2	J	72	102	118	2	2		80	1	UN	12	T			CD	25	65	17	7	10	25	15	74	
555	MDST	R4	W2	J	88	280	296	10	0	10	90	2	PL	14	T			CD	25	65	17	7	20	25	15	84	estimate of crest from ground
557	MDST	R4	W2	CJ	74	40	56	30	0	0.2	80	3	PL	6	T			CD	25	65	17	7	8	25	15	72	
557	MDST	R4	W2	CJ	78	30	46	30	0	0.3	80	1	PL	6	T			CD	25	65	17	7	10	25	15	74	
557	MDST	R4	W2	J	22	256	272	15	0	0.3	80	3	PL	12	T			CD	25	65	17	7	10	25	15	74	
557	MDST	R4	W2	J	32	274	290	15	0	0.7	80	1	PL	12	T			CD	25	65	17	7	15	25	15	79	
557	MDST	R4	W2	J	60	118	134	2	1	1.5	80	1	PL	14	T			CD	25	65	17	7	15	25	15	79	
557	MDST	R4	W2	J	62	118	134	2	1	1.5	80	1	PL	14	T			CD	25	65	17	7	15	25	15	79	
557	MDST	R4	W2	J	62	124	140	2	1	1.5	80	1	PL	14	T			CD	25	65	17	7	15	25	15	79	
557	MDST	R4	W2	J	80	296	312	4	1		80	1	UN	18	T			CD	25	65	17	7	10	25	15	74	
557	MDST	R4	W2	BJ	28	256	272	5	1	2	80	3	UN	16	T			CD	25	65	17	7	15	25	15	79	
557	MDST	R4	W2	CJ	76	38	54	20	0	0.2	80	3	UN	10	T			CD	25	65	17	7	8	25	15	72	flexural toppling
557	MDST	R4	W2	CJ	89	30	46	20	0	0.4	80	1	UN	10	T			CD	25	65	17	7	10	25	15	74	
557	MDST	R4	W2	CJ	89	40	56	20	0	0.4	80	1	UN	10	T			CD	25	65	17	7	10	25	15	74	
557	MDST	R4	W2	J	76	102	118	4	1	3	80	2	UN	18	T			CD	25	65	17	7	20	25	15	84	face
557	MDST	R4	W2	J	84	290	306	4	1	3	80	1	UN	18	T			CD	25	65	17	7	20	25	15	84	
557	MDST	R4	W2	J	80	120	136	10	0	2	80	1	UN	18	T			CD	25	65	17	7	15	25	15	79	
557	MDST	R4	W2	BJ	26	256	272	6	0	1	80	3	UN	18	T			CD	25	65	17	7	15	25	15	79	Upper crest about 20 - 25 degrees
557	MDST	R4	W2	J	80	124	140	8	0	3	80	2	UN	14	O	1		CD	22	60	17	7	20	22	15	81	Quarts vein 20 mm with cleavage. Bedding folded therefor no persistent horizontal joints going bac
558	MDST	R4	W2	CJ	72	46	62	10	0	0.3	80	3	UN	10	T			CD	25	65	17	7	10	25	15	74	
558	MDST	R4	W2	CJ	78	36	52	10	0	0.4	80	1	UN	10	T			CD	25	65	17	7	10	25	15	74	

Project: PCA	**Location ID:** POI Start - 554	**Date:** 1-Feb-15	**Mapped By:** JP/SM	**Face DD (Corrected):** 266	**Face Dip:** 75	**Weather:** Overcast, -10°C - Snow On Ground	
Location Chainage:	Sta. 116+450 - 116+900		**Colloquial Name:**		N/A		

LOCATION	BEDROCK		DISCONTINUITY																		RMR89 PARAMETERS						COMMENTS
Station (POI)	Type	Strength	Weathering	Type	Dip	Dip Dir.*	DD** Corrected	Persistence (m)	Ends Visible	Spacing (m) Average	RQD	No. of Features	Shape	Roughness (JRC)	Aperture open/ tight	Aperture Width (mm)	Aperture Infill type	Water	Joint Condition (Jc)	GSI	RQD Factor	Strength Factor	Spacing Factor	Jcon	GW	RMR89	
558	MDST	R4	W2	CJ	72	34	50	10	0	0.2	80	1	UN	10	T			CD	25	65	17	7	8	25	15	72	
558	MDST	R4	W2	CJ	80	38	54	10	0	0.4	80	1	UN	10	T			CD	25	65	17	7	10	25	15	74	
558	MDST	R4	W2	CJ	82	38	54	10	0	0.3	80	1	UN	10	T			CD	25	65	17	7	10	25	15	74	
558	MDST	R4	W2	J	80	118	134	6	0	2	80	3	UN	10	T			CD	25	65	17	7	15	25	15	79	
558	MDST	R4	W2	J	78	114	130	6	0	2.1	80	1	UN	10	T			CD	25	65	17	7	20	25	15	84	
558	MDST	R4	W2	J	88	318	334	6	0	1.8	80	1	UN	10	T			CD	25	65	17	7	15	25	15	79	
558	MDST	R4	W2	J	80	128	144	6	0	1	80	1	UN	10	T			CD	25	65	17	7	15	25	15	79	
558	MDST	R4	W2	J	6	92	108	15	0	2.5	80	2	UN	16	T			CD	25	65	17	7	20	25	15	84	
559	MDST	R4	W2	CJ	82	34	50	15	0	0.1	60	3	UN	10	T			CD	25	65	13	7	8	25	15	68	
559	MDST	R4	W2	CJ	82	30	46	15	0	0.2	60	1	UN	10	T			CD	25	65	13	7	8	25	15	68	
559	MDST	R4	W2	CJ	78	40	56	15	0	0.15	60	1	UN	12	T			CD	25	65	13	7	8	25	15	68	
559	MDST	R4	W2	BJ	24	240	256	15	0	1.5	70	1	UN	12	O	2	SILT	CD	18	60	13	7	15	18	15	68	POI 560
559	MDST	R4	W2	BJ	22	212	228	15	0	1	70	3	UN	18	T			CD	25	65	13	7	15	25	15	75	

ROCK EXPOSURE COMMENTS:

*Dip Direction with no magnetic declination correction

**Dip Direction with magnetic declination correction of 16 degrees east applied

Type	Type (ctd)	Shape	Termination	Water	Aperture	Infill
FT: Fault	CT: Contact	pl: Planar	2: Doubly Terminated	CD: Completely Dry	O: Open	C: Clay
SZ: Shear Zone	FO: Foliation	un: Undulating	1: Singly Terminated	D: Damp	T: Tight	S: Silt
JT: Joint	BZ: Broken Zone	st: Stepped	0: No Termination	W: Wet		S: Sand
VN:Vein		cu: Curved		DR: Dripping		
BD: Bedding				F: Flowing		

Project: PCA	Location ID: POI Start - 561	Date: 1-Feb-15	Mapped By: JP/SM	Face DD (Corrected): 266	Face Dip: 75	Weather: Overcast, -10°C - Snow On Ground
Location Chainage: Sta. 116+300 - 116+450			Colloquial Name: N/A			

LOCATION	BEDROCK		DISCONTINUITY																		RMR89 PARAMETERS						COMMENTS
Station (POI)	Type	Strength	Weathering	Type	Dip	Dip Dir.*	DD** Corrected	Persistence (m)	Ends Visible	Spacing (m) Average	RQD	No. of Features	Shape	Roughness (JRC)	Aperture open/ tight	Aperture Width (mm)	Aperture Infill type	Water	Joint Condition (Jc)	GSI	RQD Factor	Strength Factor	Spacing Factor	Jcon	GW	RMR89	
561	MDST	R4	W2	J	80	264	280	4	0	3	60	1	PL	16	T			CD	25	65	13	7	20	25	15	80	
561	MDST	R4	W2	J	88	292	308	4	0	3	60	1	UN	16	T			CD	25	65	13	7	20	25	15	80	
561	MDST	R4	W2	J	72	82	98	15	0	3	60	1	UN	16	T			CD	25	65	13	7	20	25	15	80	
561	MDST	R4	W2	J	68	126	142	5	0	3	60	1	UN	18	T			CD	25	65	13	7	20	25	15	80	
561	MDST	R4	W2	J	74	138	154	15	0	3	60	1	UN	14	T			CD	25	65	13	7	20	25	15	80	
561	MDST	R4	W2	BJ	68	216	232	15	0	1.2	60	3	UN	20	T			CD	25	65	13	7	15	25	15	75	Cut slope at 70 degrees due to bedding. Dipping steeply out of the face
561	MDST	R4	W2	BJ	70	212	228	15	0	2	60	1	UN	20	T			CD	25	65	13	7	15	25	15	75	
561	MDST	R4	W2	BJ	70	226	242	15	0	2	60	1	UN	20	T			CD	25	65	13	7	15	25	15	75	
561	MDST	R4	W2	BJ	60	224	240	15	0	2	60	1	UN	20	T			CD	25	65	13	7	15	25	15	75	
561	MDST	R4	W2	CJ	78	38	54	15	0	0.4	60	3	UN	8	T			CD	25	65	13	7	10	25	15	70	
561	MDST	R4	W2	CJ	78	40	56	15	0	0.1	60	1	UN	8	T			CD	25	65	13	7	8	25	15	68	
561	MDST	R4	W2	CJ	76	38	54	15	0	0.3	60	1	UN	8	T			CD	25	65	13	7	10	25	15	70	
561	MDST	R4	W2	CJ	78	38	54	15	0	0.3	60	1	UN	8	T			CD	25	65	13	7	10	25	15	70	
561	MDST	R4	W2	BJ	66	216	232	15	0	0.3	60	3	UN	18	T			CD	25	65	13	7	10	25	15	70	
562	MDSR	R4	W2	BJ	72	206	222	10	0	0.5	70	3	PL	10	T			CD	25	65	13	7	10	25	15	70	
562	MDSR	R4	W2	BJ	72	214	230	2	0	0.7	70	1	UN	20	T			CD	25	65	13	7	15	25	15	75	POI 563, forms rock face
562	MDSR	R4	W2	BJ	68	214	230	2	0	2	70	1	UN	16	T			CD	25	65	13	7	15	25	15	75	
562	MDSR	R4	W2	CJ	78	24	40	15	0	0.2	70	3	UN	8	T			CD	25	65	13	7	8	25	15	68	
562	MDSR	R4	W2	CJ	74	38	54	15	0	0.5	70	1	UN	8	T			CD	25	65	13	7	10	25	15	70	
562	MDSR	R4	W2	CJ	78	30	46	15	0	0.15	70	1	UN	8	T			CD	25	65	13	7	8	25	15	68	
562	MDSR	R4	W2	J	32	204	220	1	2	1	70	2	UN	8	T			CD	25	65	13	7	15	25	15	75	horizontal set, not dominant through rock face
562	MDSR	R4	W2	J	18	300	316	1	2	0.6	70	1	UN	8	T			CD	25	65	13	7	10	25	15	70	
562	MDSR	R4	W2	J	18	224	240	1	2	1	70	1	UN	12	T			CD	25	65	13	7	15	25	15	75	
562	MDSR	R4	W2	J	28	278	294	1	2	0.5	70	1	UN	10	T			CD	25	65	13	7	10	25	15	70	
562	MDSR	R4	W2	J	20	208	224	1	2	0.8	70	1	UN	10	T			CD	25	65	13	7	15	25	15	75	
562	MDSR	R4	W2	J	88	300	316	4	1	1.5	70	1	UN	14	T			CD	25	65	13	7	15	25	15	75	subvertical, random
562	MDSR	R4	W2	J	82	290	306	4	1	1	70	1	UN	14	T			CD	25	65	13	7	15	25	15	75	
562	MDSR	R4	W2	J	78	296	312	4	1	0.6	70	1	UN	14	T			CD	25	65	13	7	10	25	15	70	
562	MDSR	R4	W2	J	78	268	284	4	1	0.6	70	1	UN	14	T			CD	25	65	13	7	10	25	15	70	
562	MDSR	R4	W2	J	70	112	128	2	1	0.5	70	1	UN	10	T			CD	25	65	13	7	10	25	15	70	
562	MDSR	R4	W2	J	76	122	138	2	1	0.4	70	1	UN	10	T			CD	25	65	13	7	10	25	15	70	
562	MDSR	R4	W2	J	76	284	300	2	1	0.5	70	1	UN	14	T			CD	25	65	13	7	10	25	15	70	
562	MDSR	R4	W2	J	78	212	228	10	0	2	90	3	PL	10	T			CD	25	65	17	7	15	25	15	79	more massive section of rock, higher RQD
562	MDSR	R4	W2	J	76	206	222	5	0	3	90	1	PL	10	T			CD	25	65	17	7	20	25	15	84	
562	MDSR	R4	W2	J	78	210	226	10	0	1.5	90	1	PL	12	T			CD	25	65	17	7	15	25	15	79	
562	MDSR	R4	W2	J	62	68	84	10	1		90	1	PL	14	T			CD	25	65	17	7	10	25	15	74	random joint
562	MDSR	R4	W2	CJ	70	46	62	10	0	0.2	90	3	PL	10	T			CD	25	65	17	7	8	25	15	72	
562	MDSR	R4	W2	CJ	74	40	56	10	0	0.4	90	1	PL	6	T			CD	25	65	17	7	10	25	15	74	
562	MDSR	R4	W2	CJ	78	30	46	10	0	0.3	90	1	PL	6	T			CD	25	65	17	7	10	25	15	74	
562	MDSR	R4	W2	J	84	284	300	4	1	0.6	80	2	PL	14	T			CD	25	65	17	7	10	25	15	74	
562	MDSR	R4	W2	J	74	122	138	1	2	0.5	80	2	PL	12	T			CD	25	65	17	7	10	25	15	74	
562	MDSR	R4	W2	J	82	298	314	10	0	1	80	1	PL	18	T			CD	25	65	17	7	15	25	15	79	
562	MDSR	R4	W2	J	80	302	318	4	0	0.8	80	1	UN	18	T			CD	25	65	17	7	15	25	15	79	
562	MDSR	R4	W2	BJ	76	210	226	5	0	2	80	1	UN	14	T			CD	25	65	17	7	15	25	15	79	
562	MDSR	R4	W2	CJ	72	38	54	10	0	0.2	80	3	UN	10	T			CD	25	65	17	7	8	25	15	72	
562	MDSR	R4	W2	CJ	76	38	54	10	0	0.2	80	1	UN	12	T			CD	25	65	17	7	8	25	15	72	
562	MDSR	R4	W2	CJ	76	24	40	10	0	0.2	80	1	UN	8	T			CD	25	65	17	7	8	25	15	72	
562	MDSR	R4	W2	CJ	76	206	222	10	0	1	80	2	PL	12	T			CD	25	65	17	7	15	25	15	79	

ROCK EXPOSURE COMMENTS:

*Dip Direction with no magnetic declination correction
**Dip Direction with magnetic declination correction of 16 degrees east applied

Type	Type (ctd)	Shape	Termination	Water	Aperture	Infill
FT: Fault	CT: Contact	pl: Planar	2: Doubly Terminated	CD: Completely Dry	O: Open	C: Clay
SZ: Shear Zone	FO: Foliation	un: Undulating	1: Singly Terminated	D: Damp	T: Tight	S: Silt
JT: Joint	BZ: Broken Zone	st: Stepped	0: No Termination	W: Wet		S: Sand
VN:Vein		cu: Curved		DR: Dripping		
BD: Bedding				F: Flowing		

Project: PCA	**Location ID:** POI Start - 564	**Date:** 1-Feb-15	**Mapped By:** JP/SM	**Face DD (Corrected):** 266	**Face Dip:** 75	**Weather:** Overcast, -10°C - Snow On Ground
Location Chainage: Sta. 116+150 - 116+220			**Colloquial Name:** N/A			

LOCATION	BEDROCK		DISCONTINUITY																		RMR89 PARAMETERS						COMMENTS
															Aperture												
Station (POI)	Type	Strength	Weathering	Type	Dip	Dip Dir.*	DD** Corrected	Persistence (m)	Ends Visible	Spacing (m) Average	RQD	No. of Features	Shape	Roughness (JRC)	open/ tight	Width (mm)	Infill type	Water	Joint Condition (Jc)	GSI	RQD Factor	Strength Factor	Spacing Factor	Jcon	GW	RMR89	
564	MDST	R4	W2	CJ	70	44	60	15	0	1	90	3	PL	12	T			CD	25	65	17	7	15	25	15	79	
564	MDST	R4	W2	CJ	68	50	66	15	0	1	90	1	PL	12	T			CD	25	65	17	7	15	25	15	79	
564	MDST	R4	W2	CJ	60	38	54	15	0	1	90	1	PL	12	T			CD	25	65	17	7	15	25	15	79	
564	MDST	R4	W2	BJ	82	196	212	15	0	3	90	1	PL	12	T			CD	25	65	17	7	20	25	15	84	Look at photos of slope whith no snow to examine joint failure plane under snow
564	MDST	R4	W2	BJ	88	200	216	15	0	3	90	1	PL	12	T			CD	25	65	17	7	20	25	15	84	
564	MDST	R4	W2	BJ	86	202	218	15	0	3	90	1	PL	12	T			CD	25	65	17	7	20	25	15	84	
564	MDST	R4	W2	J	78	284	300	15	0	3	90	2	PL	18	T			CD	25	65	17	7	20	25	15	84	Forms wedges with cleavage, no bottom release plane visible
564	MDST	R4	W2	J	74	300	316	15	0	3	90	1	PL	16	T			CD	25	65	17	7	20	25	15	84	
564	MDST	R4	W2	J	86	268	284	15	0	3	90	1	PL	18	T			CD	25	65	17	7	20	25	15	84	

ROCK EXPOSURE COMMENTS:

*Dip Direction with no magnetic declination correction
**Dip Direction with magnetic declination correction of 16 degrees east applied

Type	Type (ctd)	Shape	Termination	Water	Aperture	Infill
FT: Fault	CT: Contact	pl: Planar	2: Doubly Terminated	CD: Completely Dry	O: Open	C: Clay
SZ: Shear Zone	FO: Foliation	un: Undulating	1: Singly Terminated	D: Damp	T: Tight	S: Silt
JT: Joint	BZ: Broken Zone	st: Stepped	0: No Termination	W: Wet		S: Sand
VN:Vein		cu: Curved		DR: Dripping		
BD: Bedding				F: Flowing		

Project: PCA	**Location ID:** POI Start - 609	**Date:** 3-Feb-15	**Mapped By:** JP/SM	**Face DD (Corrected):** 6	**Face Dip:** 60	**Weather:** Light Snow, -3°C - Snow On Ground
Location Chainage:	Sta. 123+800 - 123+900		**Colloquial Name:**	N/A		

LOCATION	BEDROCK		DISCONTINUITY																		RMR89 PARAMETERS						COMMENTS
Station (POI)	Type	Strength	Weathering	Type	Dip	Dip Dir.*	DD** Corrected	Persistence (m)	Ends Visible	Spacing (m) Average	RQD	No. of Features	Shape	Roughness (JRC)	Aperture open/ tight	Aperture Width (mm)	Aperture Infill type	Water	Joint Condition (Jc)	GSI	RQD Factor	Strength Factor	Spacing Factor	Jcon	GW	RMR89	
609	MDST	R3	W2	J	48	40	56	4	0	0.05	40	3	PL	6	T			CD	20	40	8	4	5	20	15	52	
609	MDST	R3	W2	J	70	68	84	4	0	0.1	60	3	PL	8	T			CD	20	50	13	4	8	20	15	60	
609	MDST	R3	W2	J	78	78	94	4	0	0.3	70	1	PL	8	T			CD	20	50	13	4	10	20	15	62	
609	MDST	R3	W2	J	80	66	82	4	0	0.2	70	1	UN	8	T			CD	20	50	13	4	8	20	15	60	
609	MDST	R3	W2	CJ	58	30	46	4	0	0.15	70	3	PL	8	T			CD	20	50	13	4	8	20	15	60	
609	MDST	R3	W2	CJ	60	28	44	4	0	0.1	70	1	PL	8	O	2		CD	18	45	13	4	8	18	15	58	
609	MDST	R3	W2	CJ	62	34	50	4	0	0.2	70	1	PL	10	O	1		CD	18	45	13	4	8	18	15	58	
609	MDST	R3	W2	J	10	56	72	2	0	1.5	70	1	UN	4	T			CD	20	50	13	4	15	20	15	67	
609	MDST	R3	W2	J	8	100	116	2	0	1.7	70	1	UN	4	O	1		CD	18	45	13	4	15	18	15	65	
609	MDST	R3	W2	J	4	88	104	2	0	0.3	70	1	UN	10	T			CD	20	50	13	4	10	20	15	62	
610	MDST	R3	W2	CJ	60	42	58	2	0	0.15	70	3	PL	8	T			CD	20	50	13	4	8	20	15	60	
610	MDST	R3	W2	CJ	56	44	60	6	0	0.2	70	1	PL	6	T			CD	20	50	13	4	8	20	15	60	
610	MDST	R3	W2	CJ	58	38	54	5	0	0.15	70	1	PL	10	T			CD	20	50	13	4	8	20	15	60	
610	MDST	R3	W2	J	68	214	230	6	0	0.6	70	2	PL	6	T			CD	20	50	13	4	10	20	15	62	
610	MDST	R3	W2	J	52	202	218	3	0	0.3	70	1	PL	6	T			CD	20	50	13	4	10	20	15	62	
610	MDST	R3	W2	J	64	210	226	3	0	1	70	1	UN	12	T			CD	25	55	13	4	15	25	15	72	
610	MDST	R3	W2	J	50	4	20	3	1	0.2	70	2	UN	8	T			CD	25	55	13	4	8	25	15	65	
610	MDST	R3	W2	J	64	16	32	6	1	0.3	70	1	UN	4	T			CD	20	50	13	4	10	20	15	62	
610	MDST	R3	W2	J	78	350	6	6	1	0.2	70	1	UN	6	T			CD	20	50	13	4	8	20	15	60	
610	MDST	R3	W2	J	44	346	2	6	0		80	1	UN	6	T			CD	20	55	17	4	10	20	15	66	Forms face, possible planar failure
611	MDST	R3	W2	CJ	52	40	56	10	0	0.1	60	3	UN	6	T			CD	20	50	13	4	8	20	15	60	
611	MDST	R3	W2	CJ	52	36	52	6	0	0.05	60	1	UN	6	O	1		CD	18	50	13	4	5	18	15	55	
611	MDST	R3	W2	CJ	60	28	44	6	0	0.1	60	1	UN	8	T			CD	20	55	13	4	8	20	15	60	
611	MDST	R3	W2	BJ	70	272	288	6	1	0.1	60	1	UN	6	T			CD	22	55	13	4	8	22	15	62	
611	MDST	R3	W2	BJ	82	248	264	3	2	0.6	70	1	UN	6	T			CD	22	55	13	4	10	22	15	64	
611	MDST	R3	W2	BJ	2	262	278	2	1	0.9	60	1	UN	6	T			CD	22	55	13	4	15	22	15	69	
611	MDST	R3	W2	CJ	38	44	60	2	0	0.15	60	3	PL	6	T			CD	25	55	13	4	8	25	15	65	
611	MDST	R3	W2	CJ	34	48	64	8	0	0.1	60	1	UN	6	T			CD	25	55	13	4	8	25	15	65	
611	MDST	R3	W2	CJ	40	50	66	8	0	0.15	60	1	UN	8	T			CD	25	55	13	4	8	25	15	65	
611	MDST	R3	W2	J	42	214	230	1	2	0.3	60	2	UN	6	T			CD	25	55	13	4	10	25	15	67	
611	MDST	R3	W2	J	24	228	244	1	2	0.4	60	1	UN	8	T			CD	25	55	13	4	10	25	15	67	

ROCK EXPOSURE COMMENTS:

*Dip Direction with no magnetic declination correction
**Dip Direction with magnetic declination correction of 16 degrees east applied

Type	Type (ctd)	Shape	Termination	Water	Aperture	Infill
FT: Fault	CT: Contact	pl: Planar	2: Doubly Terminated	CD: Completely Dry	O: Open	C: Clay
SZ: Shear Zone	FO: Foliation	un: Undulating	1: Singly Terminated	D: Damp	T: Tight	S: Silt
JT: Joint	BZ: Broken Zone	st: Stepped	0: No Termination	W: Wet		S: Sand
VN:Vein		cu: Curved		DR: Dripping		
BD: Bedding				F: Flowing		

Project: PCA	**Location ID:** POI Start - 618	**Date:** 3-Feb-15	**Mapped By:** JP/SM	**Face DD (Corrected):** 216	**Face Dip:** 45	**Weather:** Light Snow, -3°C - Snow On Ground
Location Chainage: Sta. 123+100 - 123+400			**Colloquial Name:** N/A			

LOCATION	BEDROCK		DISCONTINUITY																		RMR89 PARAMETERS						COMMENTS
Station (POI)	Type	Strength	Weathering	Type	Dip	Dip Dir.*	DD** Corrected	Persistence (m)	Ends Visible	Spacing (m) Average	RQD	No. of Features	Shape	Roughness (JRC)	Aperture open/ tight	Aperture Width (mm)	Aperture Infill type	Water	Joint Condition (Jc)	GSI	RQD Factor	Strength Factor	Spacing Factor	Jcon	GW	RMR89	
618	MDST	R3	W2	CJ	46	28	44	10	0	0.1	40	3	UN	6	O	1		CD	20	45	8	4	8	20	15	55	Flexural toppling
618	MDST	R3	W2	CJ	42	32	48	10	0	0.08	40	1	UN	6	T			CD	25	45	8	4	8	25	15	60	
618	MDST	R3	W2	CJ	40	22	38	10	0	0.1	40	1	UN	6	T			CD	25	50	8	4	8	25	15	60	
618	MDST	R3	W2	J	82	284	300	4	0	0.4	40	1	PL	10	T			CD	25	50	8	4	10	25	15	62	
618	MDST	R3	W2	J	78	292	308	4	0	0.5	40	1	PL	10	O	1		CD	20	45	8	4	10	20	15	57	
618	MDST	R3	W2	J	32	222	238	0.5	2	0.4	50	2	PL	12	T			CD	25	50	8	4	10	25	15	62	
618	MDST	R3	W2	J	26	240	256	1	2	0.3	40	1	PL	10	T			CD	25	50	8	4	10	25	15	62	
618	MDST	R3	W2	J	72	212	228	4	0	1.5	50	2	UN	12	T			CD	25	50	8	4	15	25	15	67	Forms oblique planar/wedge
618	MDST	R3	W2	J	78	216	232	4	0	2	50	1	UN	12	T			CD	25	50	8	4	15	25	15	67	
618	MDST	R3	W2	J	76	220	236	4	0	2	50	1	UN	12	T			CD	25	50	8	4	15	25	15	67	
618	MDST	R3	W2	CJ	44	46	62	8	0	0.1	50	3	UN	6	T			CD	22	50	8	4	8	22	15	57	
618	MDST	R3	W2	CJ	36	28	44	8	0	0.15	50	1	UN	10	T			CD	22	50	8	4	8	22	15	57	
618	MDST	R3	W2	CJ	42	42	58	8	0	0.1	50	1	UN	8	O	1		CD	20	45	8	4	8	20	15	55	
618	MDST	R3	W2	J	34	216	232	0.8	2	0.3	50	2	PL	8	T			CD	30	50	8	4	10	30	15	67	
618	MDST	R3	W2	J	24	236	252	1	2	0.5	50	1	PL	6	T			CD	30	50	8	4	10	30	15	67	
618	MDST	R3	W2	CJ	38	42	58	6	0	0.05	40	3	UN	4	T			CD	22	45	8	4	5	22	15	54	
618	MDST	R3	W2	CJ	30	26	42	6	0	0.1	40	1	UN	6	T			CD	22	45	8	4	8	22	15	57	
618	MDST	R3	W2	CJ	48	20	36	6	0	0.06	40	1	PL	4	O	2		CD	20	45	8	4	5	20	15	52	
618	MDST	R3	W2	J	24	238	254	1	2	0.2	40	2	PL	8	T			CD	28	50	8	4	8	28	15	63	
618	MDST	R3	W2	J	80	228	244	4	1		40	1	UN	18	O	2		CD	18	45	8	4	10	18	15	55	

ROCK EXPOSURE COMMENTS:

*Dip Direction with no magnetic declination correction
**Dip Direction with magnetic declination correction of 16 degrees east applied

Type	Type (ctd)	Shape	Termination	Water	Aperture	Infill
FT: Fault	CT: Contact	pl: Planar	2: Doubly Terminated	CD: Completely Dry	O: Open	C: Clay
SZ: Shear Zone	FO: Foliation	un: Undulating	1: Singly Terminated	D: Damp	T: Tight	S: Silt
JT: Joint	BZ: Broken Zone	st: Stepped	0: No Termination	W: Wet		S: Sand
VN:Vein		cu: Curved		DR: Dripping		
BD: Bedding				F: Flowing		

Project: PCA | **Location ID:** POI Start - 627 | **Date:** 3-Feb-15 | **Mapped By:** JP/SM | **Face DD (Corrected):** 226 | **Face Dip:** 40 | **Weather:** Light Snow, -3°C - Snow On Ground

Location Chainage: Sta. 125+810 - 125+930 | **Colloquial Name:** N/A

LOCATION	BEDROCK		DISCONTINUITY																		RMR89 PARAMETERS						COMMENTS
Station (POI)	Type	Strength	Weathering	Type	Dip	Dip Dir.*	DD** Corrected	Persistence (m)	Ends Visible	Spacing (m) Average	RQD	No. of Features	Shape	Roughness (JRC)	Aperture open/ tight	Aperture Width (mm)	Aperture Infill type	Water	Joint Condition (Jc)	GSI	RQD Factor	Strength Factor	Spacing Factor	Jcon	GW	RMR89	
627	MDST/PHYL	R2	W2	CJ	72	18	34	10	0	0.04	40	3	UN	4	T			CD	22	45	8	2	5	22	15	52	Flexural toppling
627	MDST/PHYL	R2	W2	CJ	72	14	30	10	0	0.1	40	1	UN	4	T			CD	22	45	8	2	8	22	15	55	
627	MDST/PHYL	R2	W2	CJ	60	20	36	10	0	0.08	40	1	UN	6	O	1		CD	20	45	8	2	8	20	15	53	
627	MDST/PHYL	R2	W2	CJ	76	18	34	10	0	0.1	50	1	UN	4	T			CD	22	45	8	2	8	22	15	55	
627	MDST/PHYL	R2	W2	CJ	68	16	32	10	0	0.08	50	1	UN	6	T			CD	22	45	8	2	8	22	15	55	
627	MDST/PHYL	R2	W2	CJ	76	16	32	10	0	0.08	50	1	UN	6	O	1		CD	20	45	8	2	8	20	15	53	
627	MDST/PHYL	R2	W2	J	6	10	26	0.5	2	0.1	50	3	UN	12	T			CD	25	45	8	2	8	25	15	58	
627	MDST/PHYL	R2	W2	J	4	20	36	0.5	2	0.04	40	1	UN	12	T			CD	25	45	8	2	5	25	15	55	
627	MDST/PHYL	R2	W2	J	10	16	32	0.2	2	0.05	40	1	UN	12	T			CD	25	45	8	2	5	25	15	55	
627	MDST/PHYL	R2	W2	J	14	20	36	0.2	0	0.1	40	1	UN	12	T			CD	25	45	8	2	8	25	15	58	
627	MDST/PHYL	R2	W2	J	88	118	134	3	1	3	50	2	UN	10	T			CD	22	45	8	2	20	22	15	67	
627	MDST/PHYL	R2	W2	J	54	98	114	2	2	1	50	1	UN	14	T			CD	25	45	8	2	15	25	15	65	
627	MDST/PHYL	R2	W2	J	14	210	226	1	1	0.3	60	2	UN	10	T			CD	25	45	13	2	10	25	15	65	
627	MDST/PHYL	R2	W2	J	42	218	234	8	0		60	1	UN	12	T			CD	25	45	13	2	10	25	15	65	Forms planar face at POI 628
627	MDST/PHYL	R2	W2	CJ	80	16	32	10	0	0.1	60	3	UN	6	T			CD	22	45	13	2	8	22	15	60	
627	MDST/PHYL	R2	W2	CJ	66	20	36	10	0	0.06	60	1	UN	6	O	1		CD	20	45	13	2	5	20	15	55	
627	MDST/PHYL	R2	W2	CJ	72	22	38	10	0	0.02	60	1	UN	6	T			CD	22	45	13	2	5	22	15	57	
627	MDST/PHYL	R2	W2	CJ	72	14	30	10	0	0.1	60	1	UN	6	T			CD	22	45	13	2	8	22	15	60	
627	MDST/PHYL	R2	W2	J	36	228	244	4	0	2	60	2	PL	10	T			CD	25	45	13	2	15	25	15	70	Planar joint wide/irregular spacing
627	MDST/PHYL	R2	W2	J	40	222	238	4	0	1	60	1	PL	12	T			CD	25	45	13	2	15	25	15	70	
627	MDST/PHYL	R2	W2	CJ	64	14	30	10	0	0.05	60	3	UN	6	T			CD	22	45	13	2	5	22	15	57	
627	MDST/PHYL	R2	W2	CJ	60	34	50	10	0	0.08	60	1	UN	6	T			CD	22	45	13	2	8	22	15	60	
627	MDST/PHYL	R2	W2	CJ	58	42	58	10	0	0.1	60	1	UN	6	O	2		CD	18	45	13	2	8	18	15	56	Block beginning to topple
627	MDST/PHYL	R2	W2	J	64	120	136	3	1	1.5	50	2	UN	14	T			CD	25	45	8	2	15	25	15	65	
627	MDST/PHYL	R2	W2	J	70	116	132	3	1	0.8	50	1	UN	16	T			CD	25	45	8	2	15	25	15	65	
627	MDST/PHYL	R2	W2	J	76	130	146	3	1	1.2	50	1	UN	16	T			CD	25	45	8	2	15	25	15	65	
627	MDST/PHYL	R2	W2	J	78	112	128	3	1	0.9	50	1	UN	18	T			CD	25	45	8	2	15	25	15	65	
627	MDST/PHYL	R2	W2	J	22	244	260	4	1	1.5	50	1	UN	12	T			CD	25	45	8	2	15	25	15	65	
627	MDST/PHYL	R2	W2	J	88	112	128	2	0		50	1	UN	16	T			CD	25	45	8	2	10	25	15	60	

ROCK EXPOSURE COMMENTS:

*Dip Direction with no magnetic declination correction
**Dip Direction with magnetic declination correction of 16 degrees east applied

Type	Type (ctd)	Shape	Termination	Water	Aperture	Infill
FT: Fault	CT: Contact	pl: Planar	2: Doubly Terminated	CD: Completely Dry	O: Open	C: Clay
SZ: Shear Zone	FO: Foliation	un: Undulating	1: Singly Terminated	D: Damp	T: Tight	S: Silt
JT: Joint	BZ: Broken Zone	st: Stepped	0: No Termination	W: Wet		S: Sand
VN:Vein		cu: Curved		DR: Dripping		
BD: Bedding				F: Flowing		

APPENDIX C
DETAILED POINT OF INTEREST LOCATION TABLE

Name	Date Collected	EASTING	NORTHING
053	Jan 22	543436.64840	5698623.28020
054	Jan 22	543381.00580	5698610.79430
055	Jan 22	543327.86720	5698598.10800
057	Jan 22	543284.22490	5698580.38680
061	Jan 22	543163.07060	5698555.00170
084	Jan 23	542767.01300	5698551.66070
085	Jan 23	542746.39240	5698548.70710
086	Jan 23	542740.64930	5698545.54480
088	Jan 23	542691.71730	5698528.34040
091	Jan 23	542651.40710	5698502.53360
172	Jan 25	528721.26780	5680750.68420
173	Jan 25	528715.27990	5680761.21570
175	Jan 25	528740.96010	5680771.59130
176	Jan 25	528753.08410	5680773.88350
178	Jan 25	528773.05770	5680794.34750
179	Jan 25	528788.63510	5680815.12040
181	Jan 25	528876.54200	5680898.13450
182	Jan 25	528931.57140	5680948.15680
183	Jan 25	528969.19320	5680992.74310
185	Jan 25	529045.32980	5681108.61240
186	Jan 25	529087.32590	5681168.57160
187	Jan 25	529089.24870	5681186.15400
188	Jan 25	529111.36330	5681222.09000
263	Jan 27	542481.71880	5698294.80530
265	Jan 27	542429.07320	5698230.63840
266	Jan 27	542422.33960	5698221.12880
269	Jan 27	542389.40510	5698194.05090
274	Jan 27	542276.76720	5698087.45750
275	Jan 27	542242.60680	5698065.48650
276	Jan 27	542229.18000	5698058.25720
277	Jan 27	542209.57090	5698050.42060
278	Jan 27	542185.47910	5698038.20950
279	Jan 27	542160.38040	5698021.65260
280	Jan 27	542149.61520	5698028.79270
281	Jan 27	542119.00480	5698006.18460
282	Jan 27	542060.00740	5697994.68660
283	Jan 27	541984.82000	5697982.16600

Name	Date Collected	EASTING	NORTHING
284	Jan 27	541971.46830	5697982.61210
286	Jan 27	541925.00970	5697984.89870
397	Jan 29	528088.57760	5680134.28770
398	Jan 29	528072.51250	5680087.04590
399	Jan 29	528057.47470	5680068.72480
400	Jan 29	528023.75970	5680072.43270
401	Jan 29	528029.50020	5680056.00480
402	Jan 29	528042.73850	5680033.50120
403	Jan 29	528026.50960	5680016.06340
405	Jan 29	528030.54290	5679980.16410
406	Jan 29	528037.28580	5679959.07080
407	Jan 29	528038.28720	5679929.04910
408	Jan 29	528013.20190	5679961.94180
440	Jan 30	528402.64960	5679364.65480
442	Jan 30	528261.45060	5679500.66440
444	Jan 30	526788.46660	5674627.16290
446	Jan 30	526712.18400	5674618.09090
447	Jan 30	526689.54810	5674619.86370
450	Jan 30	526619.48170	5674637.51590
451	Jan 30	526607.31170	5674641.12280
549	Feb 1	528823.34780	5678053.03840
550	Feb 1	528826.21630	5678064.17570
551	Feb 1	528815.26060	5678126.05890
552	Feb 1	528811.48630	5678139.49430
553	Feb 1	528813.34720	5678156.07520
554	Feb 1	528770.28370	5678393.15880
555	Feb 1	528759.95600	5678467.72380
557	Feb 1	528737.07130	5678541.66240
558	Feb 1	528717.15530	5678671.22350
559	Feb 1	528714.68190	5678689.22590
561	Feb 1	528698.60090	5678782.10870
562	Feb 1	528692.44200	5678835.23340
564	Feb 1	528634.42270	5679003.61690
609	Feb 3	527170.43730	5674671.98680
610	Feb 3	527201.28450	5674675.70890
611	Feb 3	527230.03840	5674679.08650
627	Feb 3	525492.26670	5675412.71260

APPENDIX D
ROCK MASS CLASSIFICATION

D. ROCK MASS CLASSIFICATION

Tetra Tech EBA assessed the rock mass quality around the project site using the Rock Mass Rating (RMR_{89}) geomechanical classification system for rocks (after Bieniawski 1989). This system considers the following parameters:

1. Uniaxial compressive strength of intact rock material
2. Rock Quality Designation (RQD)
3. Spacing of discontinuities
4. Condition of discontinuities
5. Groundwater conditions
6. Orientation of discontinuities

Each of the six parameters are assigned a value and the sum of the six parameters is the "RMR89 value", which ranges between 0 and 100; a higher RMR89 indicates better quality rock.

Based on the RMR89 value, the rock mass is classified into five groups: very good, good, fair, poor, and, very poor (Table D.0).

Table D.0: Geomechanical Classification of Jointed Rock Masses (after Bieniawski 1989)

Class No.	RMR_{89} Value	RMR Description
I	<21	Very Poor Rock
II	21-40	Poor Rock
III	41-60	Fair Rock
IV	61-80	Good Rock
V	81-100	Very Good Rock

For practical purposes, the joint orientation parameter (item 6 above) was assigned a 'Very Favorable' rating, as the effect of joints and other structural defects are to be considered in the assessment of the rock mass kinematic stability. This is in accordance with the approach of calculating rock mass properties presented by Hoek, Kaiser, and Bawden (1996).

D.1 Overview of Rock Quality Designation

RQD was introduced by D.U. Deere (1964) as an index of assessing rock quality quantitatively. It is a sensitive index of rock quality.

$$RQD\ (\%) = \frac{Sum\ of\ sound\ segments\ \geq 100\ mm}{Total\ length\ observed} * 100$$

Based on the RQD value, the rock mass is classified as excellent, good, fair, poor, or very poor (Table D.1).

Table D.1: Summary of RQD Rating Values

RQD (%)	Rock Quality
<25	Very Poor
25-50	Poor
50-75	Fair
75-90	Good
90-100	Excellent

D.2 Rock Strength Estimate

The rock hardness was estimated in the field according to the International Society of Rock Mechanics (ISRM) descriptive terms for rock strength. ISRM classifies rock as very weak, weak, medium strong, strong, very strong, and extremely strong (Table D.2).

Table D.2: Summary of ISRM Classification of Rock Strength

Classification	UCS (MPa)	Description
R1	1-5	Very Weak
R2	5-25	Weak
R3	25-50	Medium Strong
R4	50-100	Strong
R5	100-250	Very Strong
R6	>250	Extremely Strong

D.3 Weathering

Weathering is used to describe the amount of degradation from natural processes on a joint and rock face. According to ISRM, the description and classification of the state of weathering is done by considering five weathering degrees: fresh, slightly weathered, moderately weathered, highly weathered, and completely weathered (Table D.3).

Table D.3: Summary of ISRM Degrees of Weathering

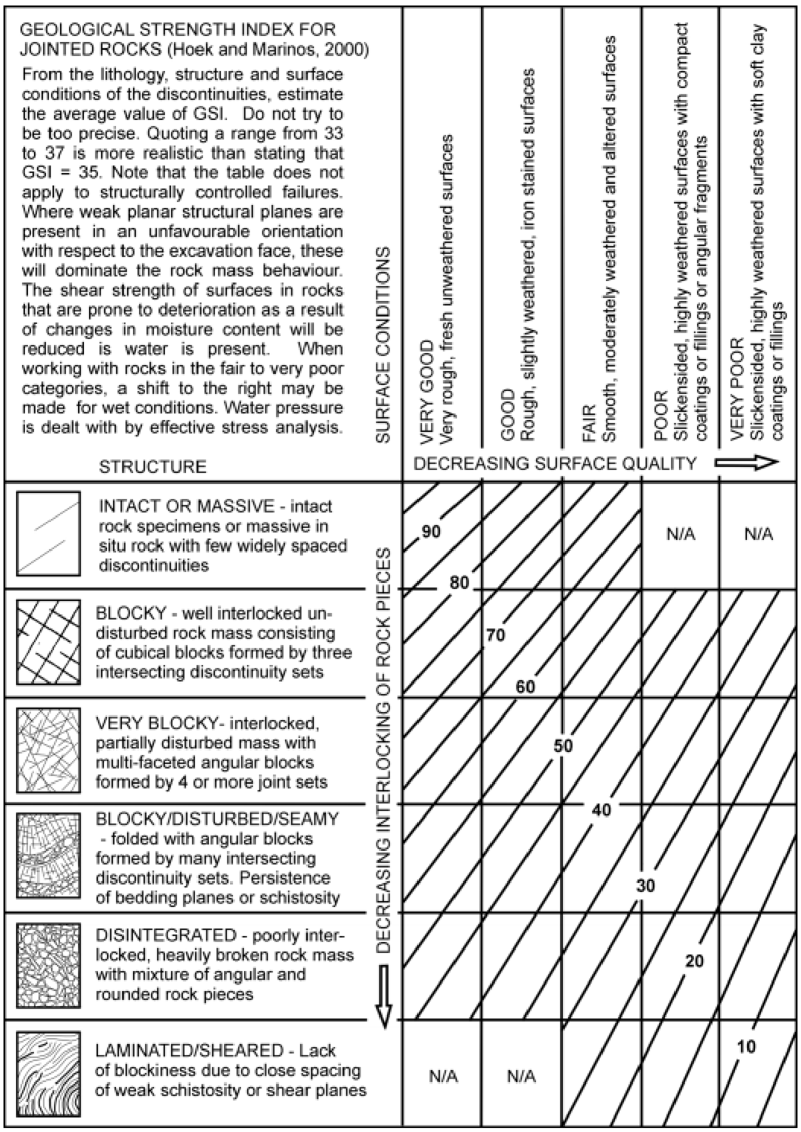
Symbol	Term	Definition
W1	Fresh	No visible sign of rock material weathering; perhaps slight discolouration on major discontinuity surfaces.
W2	Slightly weathered	Discolouration indicates weathering of rock material and discontinuity surfaces. All the rock material may be discoloured by weathering and may be somewhat weaker than its fresh condition.
W3	Moderately weathered	Less than half of the rock material is decomposed and/or disintegrated to a soil. Fresh or discoloured rock is present either as a discontinuous framework or as corestones.
W4	Highly weathered	More than a half of the rock material is decomposed and/or disintegrated to a soil. Fresh or discoloured rock is present either as a discontinuous framework or as corestones.
W5	Completely weathered	All rock material is decomposed and/or disintegrated to soil. The original mass structure is still largely intact.

D.4 Geological Strength Index

The Geological Strength Index (GSI), provides a number which, when combined with the intact rock properties, can be used for estimating the reduction in rock mass strength for different geological conditions (Hoek, 2015).

The strength of a jointed rock mass depends on the properties of the intact rock pieces as well as the ability of these pieces to slide and rotate under various conditions. This ability is controlled by the geometrical shape of the intact rock pieces and the condition of the surfaces separating the pieces. Angular rock pieces with clean, rough discontinuity surfaces will result in a much stronger rock mass than ones containing rounded particles surrounded by weathered and altered material. Table D.4 outlines GSI conditions.

Table D.4: Identification of GSI



D.5 Joint Condition

Joint condition ($JCON_{89}$) accounts for the separation or aperture of discontinuities. It also considers persistence, roughness, and wall condition (soft vs. hard), and accounts for infill. Table D.5 outlines JCON parameters (Brady & Brown, 1985).

Table D.5: Summary of ISRM Degrees of Weathering

JCON Rating	Fracture Condition
30	Very rough surfaces, fracture not continuous, no separation, un-weathered
25	Slightly rough surfaces, separation < 1 mm, slightly weathered walls
20	Slightly rough surfaces, separation < 1 mm, highly weathered walls
10	Slickensided surfaces or gouge < 5mm thick or separation 1 – 5 mm continuous
0	Soft gouge > 5 mm tick or separation > 5 mm, continuous

D.6 Joint Roughness Coefficient (JRC)

The joint roughness coefficient JRC is a number that can be estimated by comparing the appearance of a discontinuity surface with standard profiles published by Barton. The appearance of the discontinuity surface is compared visually with the profiles shown and the JRC value corresponding to the profile which most closely matches that of the discontinuity surface is chosen (Hoek, 2015).

Table D.6 outlines parameters based on 100 mm length.

Table D.6 - Summary of JRC

JRC Rating	Joint Description
0-5	Smooth, planar joint with few asperities
6-10	Generally planar with some asperities
11-15	Generally undulating with defined asperities
15-20	Rough and undulating with many asperities

APPENDIX E
GEOCHEMICAL CHARACTERIZATION

Table E1 – ABA Testing Results

Table E2a – Comparison of Metal Concentrations to Average Crustal Abundance (Sherbrooke Creek Rock Slope)

Table E2b – Comparison of Metal Concentrations to Average Crustal Abundance (Phyllite Rock Slope)

Table E2c – Comparison of Metal Concentrations to Average Crustal Abundance (Other rock slopes)

Table E3a – Shake Flask Analysis Results (Phase I Sampling – January/February 2015)

Table E3b – Shake Flask Analysis Results (Phase II Sampling – October 2015)

Photos 1-38 – Sample and Site Photos

ALS Minerals Lab Certificates – ABA and Whole Rock Metals

ALS Environmental Lab Certificates – Shake Flask Extraction

Table E1: ABA Testing Results

		Lab Reported Values												Calculated Values	
Sample ID	Material Type	Paste pH	Inorganic Carbon, C %	Inorganic Carbon, CO_2 %	Total Sulphur, S%	Sulphate Sulphur (HCl leach) S%	Sulphide Sulphur, S%	Maximum Potential Acidity (kg CaCO3/tonne)	Sobek NP (kg CaCO3/tonne)	Sobek NNP (kg CaCO3/tonne)	Fizz Rating	Sobek NPR (NP:MPA)	Carbonate NP (kg CaCO3/tonne)	Carbonate NPR (Carbonate NP:MPA)
Sherbrooke Creek Rock Slope														
TT15-R01	Carbonaceous Siltstone	8.4	9.51	34.9	0.08	<0.01	0.1	2.5	795	793	4	318	793.72	317
TT15-R02	Carbonaceous Siltstone	8.3	10	36.7	0.06	<0.01	0.06	1.9	830	828	4	442.7	834.65	439
TT15-R03	Dolomitic Limestone	8.5	12.3	45.1	<0.01	0.01	0.01	<0.3	1035	1035	4	6611	1025.69	6838
YNP15-10	Carbonaceous Siltstone	8.4	11.7	42.9	0.01	0.01	<0.01	0.3	988	988	4	3162	975.66	3252
YNP15-12	Carbonaceous Siltstone	8.6	11.75	43	0.01	0.02	<0.01	0.3	991	991	4	3171	977.93	3260
YNP15-13	Carbonaceous Siltstone	9.2	2.15	7.9	<0.01	0.02	<0.01	<0.3	207	207	4	1325	179.67	1198
YNP15-14	Carbonaceous Siltstone	9	5.7	20.9	0.09	0.02	0.06	2.8	468	465	4	166.4	475.32	170
YNP15-15	Limestone	8.6	10.25	37.5	0.4	0.03	0.35	12.5	858	846	4	68.64	852.85	68
YNP15-16	Carbonaceous Siltstone	8.9	8.77	32.1	0.12	0.04	0.09	3.8	730	726	4	194.65	730.04	192
YNP15-17	Carbonaceous Siltstone	9.1	4.5	16.5	0.17	0.01	0.14	5.3	387	382	4	72.85	375.25	71
YNP15-19	Carbonaceous Siltstone	8.6	11.8	43.3	0.01	0.01	<0.01	0.3	989	989	4	3165	984.75	3283
YNP15-20	Limestone	8.9	12.65	46.3	0.01	0.01	0.01	0.3	1040	1040	4	3328	1052.98	3510
YNP15-23	Carbonaceous Siltstone	9.3	0.92	3.4	<0.01	<0.01	<0.01	<0.3	113	113	3	723.2	77.32	515
Phyllite Slope														
TT15-R09	Phyllite	8.7	0.79	2.9	0.06	0.02	0.05	1.9	72	70	2	38.4	66	35
YNP15-01	Phyllite	9.1	1.03	3.8	0.05	0.01	0.03	1.6	95	93	3	60.8	86	54
YNP15-03	Phyllite	9	2.91	10.7	0.18	0.01	0.15	5.6	244	238	4	43.38	243	43
YNP15-05	Phyllite	9	4.82	17.7	0.14	0.01	0.11	4.4	404	400	4	92.34	403	91
YNP15-07	Phyllite	9.1	3.1	11.4	0.1	0.01	0.09	3.1	269	266	4	86.08	259	84
YNP15-08	Calcite (vein)	8.3	5.49	20.1	<0.01	0.01	<0.01	<0.3	446	446	4	2854	457	3048
Other rock slopes														
TT15-R04	Quartzite	8	<0.05	<0.2	<0.01	<0.01	<0.01	<0.3	6	6	1	38.4	2.27	15
TT15-R05	Quartzite	7.8	<0.05	<0.2	<0.01	<0.01	<0.01	<0.3	3	3	1	19.2	2.27	15
TT15-R06	Shale	8.9	1.33	4.9	0.19	0.01	0.12	5.9	145	139	3	24.42	111.44	19
TT15-R07	Shale	8.9	1.77	6.5	0.15	0.01	0.13	4.7	151	146	3	32.21	147.83	31
TT15-R08	Cherty Shale	8.3	10.05	36.9	0.02	<0.01	0.02	0.6	820	819	4	1312	839.20	1399

A value of 1/2 of the detection limit of testing was used for calculations of Carbonate NP and Carbonate NPR, where necessary.

Table E2a: Comparison of Metal Concentrations to Average Crustal Abundance (Sherbrooke Creek Rock Slope)

Metal	Units	TT15-R01	TT15-R02	TT15-R03	YNP15-10	YNP15-12	YNP15-13	YNP15-14	YNP15-15	YNP15-16	YNP15-17	YNP15-19	YNP15-20	YNP15-23	Average Crustal Abundance	10x Average Crustal Abundance
		Carbonaceous Siltstone	Carbonaceous Siltstone	Dolomitic Limestone	Carbonaceous Siltstone	Carbonaceous Siltstone	Carbonaceous Siltstone	Carbonaceous Siltstone	Limestone	Carbonaceous Siltstone	Carbonaceous Siltstone	Carbonaceous Siltstone	Limestone	Carbonaceous Siltstone		
Ag	ppm	0.04	0.03	0.02	0.01	0.01	0.03	0.02	0.04	0.02	0.02	0.01	0.01	0.02	0.075	0.75
Al	%	2.04	1.91	0.16	0.16	0.18	**8.3**	6.47	0.95	3.04	7.19	0.2	0.15	**9.16**	8.23	82.3
As	ppm	1.2	0.8	<0.2	<0.2	0.2	0.6	0.5	**4.1**	**1.9**	**2.6**	0.3	0.2	0.6	1.8	18
Ba	ppm	80	60	10	10	10	420	310	70	100	240	10	<10	**530**	425	4250
Be	ppm	0.66	0.51	<0.05	0.1	0.08	1.74	1.27	0.38	0.73	1.25	<0.05	<0.05	2.53	2.8	28
Bi	ppm	**0.09**	**0.08**	**0.04**	0.01	0.01	**0.13**	**0.1**	**0.08**	**0.08**	**0.13**	0.01	**0.03**	**0.14**	0.027	0.27
Ca	%	**28.7**	**27.7**	**19.65**	**37**	**34.9**	**7.03**	**15.8**	**31.3**	**24.8**	**12.25**	**36.3**	**21.5**	4.08	4.15	41.5
Cd	ppm	0.09	0.08	0.03	0.09	0.05	0.02	0.03	0.02	0.05	<0.02	<0.02	0.02	<0.02	0.15	1.5
Ce	ppm	49.6	22.6	1.58	2.92	2.29	65.6	63.8	20.4	46.7	65.3	2.51	2.06	**68.1**	66.5	665
Co	ppm	3.2	3.2	0.7	0.4	0.4	14	9.9	13.9	5.2	9.8	0.5	0.3	14.3	25	250
Cr	ppm	16	17	1	3	2	79	42	8	25	48	3	2	86	102	1020
Cs	ppm	0.8	0.5	0.06	0.07	0.09	**4.53**	**3.17**	0.42	1.43	2.89	0.09	0.06	**5.27**	3	30
Cu	ppm	7.6	10.2	2.7	2.4	2.2	11.6	6.4	36.2	3.9	8	1.5	1	0.9	60	600
Fe	%	0.94	0.74	0.9	0.09	0.09	4.47	3.01	1.26	1.45	3.36	0.12	1	4.02	5.63	56.3
Ga	ppm	5.4	5.17	0.54	0.41	0.44	**24.8**	16.2	2.31	7.87	17.8	0.51	0.4	**28.9**	19	190
Ge	ppm	0.19	0.22	0.21	0.06	0.09	0.17	0.18	0.11	0.15	0.18	0.07	0.09	0.21	1.5	15
Hf	ppm	0.8	0.4	0.1	0.1	0.1	1.5	1.1	0.2	0.7	1.2	0.1	<0.1	1.5	3	30
In	ppm	0.027	0.018	0.016	<0.005	<0.005	0.06	0.045	0.015	0.021	0.043	<0.005	0.014	0.057	0.16	1.6
K	%	0.46	0.82	0.01	0.06	0.08	**2.51**	1.83	0.24	0.74	1.76	0.07	0.03	**3.1**	2.09	20.9
La	ppm	17.5	11.9	0.8	1.8	1.3	33	34.2	8.2	24.6	35.4	1.3	1.2	32.1	39	390
Li	ppm	16.2	2.6	0.8	0.7	1.3	**90.2**	**47**	9.6	19.5	**79**	0.9	1.4	**92.8**	20	200
Mg	%	1.11	1.27	**11.95**	0.6	1.57	1.22	1.73	0.79	1.89	1.57	1.24	**12.85**	1.12	2.33	23.3
Mn	ppm	341	132	610	38	33	212	431	707	344	287	18	596	147	950	9500
Mo	ppm	0.47	0.17	0.13	0.15	0.11	0.13	0.18	**1.26**	0.16	0.11	0.43	0.19	0.09	1.2	12
Na	%	0.2	0.06	0.08	0.01	0.01	0.52	0.38	0.07	0.26	0.42	0.01	0.03	0.59	2.36	23.6
Nb	ppm	3.6	3	0.2	0.3	0.3	11.3	7.9	1.4	5.2	8.9	0.4	0.2	13.2	20	200
Ni	ppm	7.4	8.8	1.2	0.8	0.7	41.9	27.9	6.2	11.7	27.5	1.1	1	40.4	84	840
P	ppm	400	560	50	80	70	480	350	590	220	510	20	30	500	1050	10500
Pb	ppm	**21.2**	7.6	1.8	7.9	4.9	10.9	8.4	11.5	**38.6**	13.2	2.4	2.3	8.5	14	140
Rb	ppm	24.1	24.2	0.4	1.7	2	81.6	**98.1**	11.8	37	88.9	2.1	1.1	**93.3**	90	900
Re	ppm	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	0.0015	0.015
S	%	**0.09**	**0.12**	**0.05**	0.03	0.02	0.01	**0.09**	**0.46**	**0.13**	**0.18**	0.03	**0.04**	<0.01	0.035	0.35
Sb	ppm	**0.36**	0.17	0.07	0.09	0.08	0.09	0.09	0.12	0.09	0.1	0.06	0.11	0.09	0.2	2
Sc	ppm	4	3.5	0.3	0.3	0.3	14.3	9.4	1.8	4.7	10.2	0.3	0.3	15.3	22	220
Se	ppm	**1**	**1**	<1	<1	<1	**1**	**1**	<1	**1**	**1**	<1	<1	**1**	0.05	0.5
Sn	ppm	0.5	0.5	<0.2	0.2	<0.2	2	1.3	0.2	0.7	1.4	<0.2	<0.2	**2.4**	2.3	23
Sr	ppm	**584**	**523**	43.6	**564**	**517**	273	**418**	**569**	**609**	**457**	345	42.1	273	370	3700
Ta	ppm	0.23	0.21	<0.05	<0.05	<0.05	0.81	0.56	0.1	0.35	0.61	<0.05	<0.05	0.89	2	20
Te	ppm	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	0.002	0.02
Th	ppm	6.6	3.2	0.3	0.32	0.31	**11.35**	**10.2**	2.65	7.97	**10.6**	0.42	0.32	**11.1**	9.6	96
Ti	%	0.101	0.081	0.005	0.007	0.007	0.356	0.23	0.042	0.146	0.264	0.01	0.006	0.368	0.565	5.65
Tl	ppm	0.12	0.08	<0.02	<0.02	0.02	0.64	0.42	0.06	0.16	0.39	0.03	<0.02	**0.75**	0.6	6
U	ppm	0.8	0.9	0.5	1.1	0.8	1.4	1.2	1	0.9	1.4	0.5	1.8	1.2	2.7	27
V	ppm	14	13	2	2	2	75	47	7	21	51	3	2	84	120	1200
W	ppm	0.3	0.2	0.8	<0.1	0.1	0.8	0.6	0.1	0.3	0.6	<0.1	0.4	1	1.25	12.5
Y	ppm	9.8	6.2	0.5	2	1.2	9.5	10.5	7.6	8.9	11.6	0.5	0.5	9	33	330
Zn	ppm	30	17	5	16	10	**110**	57	11	**78**	**75**	4	5	**91**	70	700
Zr	ppm	24.7	13.4	2.5	2.1	2	48.5	39.6	8.7	26.8	39	2.2	1.7	52.9	165	1650

Metal concentrations exceeding the average crustal abundance are **bold**
Metal concentrations exceeding 10 times the average crustal abundance are **bold shaded**
The lower detection limit (LDL) of testing for selenium is 1ppm and has a precision of ±1ppm at the LDL.
Average crustal abundance values averaged from four references accessed from https://en.wikipedia.org/wiki/Abundance_of_elements_in_Earth%27s_crust

Table E2b: Comparison of Metal Concentrations to Average Crustal Abundance (Phyllite Rock Slope)

Metal	Units	TT15-R09	YNP15-01	YNP15-03	YNP15-05	YNP15-07	YNP15-08	Average Crustal Abundance	10x Average Crustal Abundance
		Phyllite	Phyllite	Phyllite	Phyllite	Phyllite	Calcite Vein		
Ag	ppm	0.03	0.02	0.02	0.03	0.01	0.01	0.075	0.75
Al	%	**9.28**	**8.57**	7.55	7.49	8.17	0.14	8.23	82.3
As	ppm	1.2	0.5	0.2	1	0.7	<0.2	1.8	18
Ba	ppm	**510**	**430**	360	340	420	50	425	4250
Be	ppm	**2.96**	2.33	1.85	1.57	1.83	<0.05	2.8	28
Bi	ppm	**0.21**	**0.26**	**0.17**	**0.17**	**0.13**	0.01	0.027	0.27
Ca	%	2.68	3.25	**8.19**	**15.35**	**9.41**	**17.2**	4.15	41.5
Cd	ppm	<0.02	0.15	0.06	0.11	0.05	0.08	0.15	1.5
Ce	ppm	**79.6**	**76.3**	**80.7**	**75.6**	**79.5**	9.93	66.5	665
Co	ppm	16.1	16.6	12.5	10.5	11.7	0.7	25	250
Cr	ppm	87	77	58	48	56	9	102	1020
Cs	ppm	**5.67**	**4.91**	**3.93**	**3.03**	**3.98**	0.12	3	30
Cu	ppm	18.8	15.7	18	16.5	23.5	2.5	60	600
Fe	%	3.68	4.18	3.3	3.03	3.62	0.44	5.63	56.3
Ga	ppm	**30.9**	**26.2**	**21**	18.65	**21.1**	0.47	19	190
Ge	ppm	0.24	0.16	0.15	0.14	0.17	0.07	1.5	15
Hf	ppm	2	1.6	1.6	1.5	1.7	<0.1	3	30
In	ppm	0.074	0.064	0.052	0.044	0.057	0.005	0.16	1.6
K	%	**2.56**	**2.42**	2.09	1.86	**2.27**	0.04	2.09	20.9
La	ppm	**40**	**40.1**	**45.2**	**44.4**	**44.6**	4.8	39	390
Li	ppm	**71.6**	**70.7**	**49.6**	**43.3**	**49.3**	1.2	20	200
Mg	%	1.23	1.39	1.27	1.38	1.46	0.11	2.33	23.3
Mn	ppm	232	288	400	372	388	929	950	9500
Mo	ppm	0.12	0.13	0.16	0.19	0.15	0.3	1.2	12
Na	%	1.06	0.9	0.75	0.73	0.79	0.02	2.36	23.6
Nb	ppm	17.7	14.4	12.7	11	12.9	0.2	20	200
Ni	ppm	40.5	39.9	27.3	24.9	30.2	2.9	84	840
P	ppm	350	330	330	420	300	10	1050	10500
Pb	ppm	13.8	**19.9**	**16.4**	**22.4**	10.3	12.9	14	140
Rb	ppm	79.6	69.1	86.4	80.3	**95.1**	1.7	90	900
Re	ppm	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	0.0015	0.015
S	%	**0.06**	**0.06**	**0.2**	**0.16**	**0.12**	<0.01	0.035	0.35
Sb	ppm	0.17	**0.26**	0.15	0.14	0.12	0.05	0.2	2
Sc	ppm	15.5	13.7	11.6	10	11.5	0.7	22	220
Se	ppm	**1**	**1**	**1**	**1**	<1	**1**	0.05	0.5
Sn	ppm	**2.7**	**2.4**	2	1.8	2.1	<0.2	2.3	23
Sr	ppm	**378**	345	**441**	**644**	**447**	**847**	370	3700
Ta	ppm	1.21	1	0.87	0.79	0.99	<0.05	2	20
Te	ppm	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	0.002	0.02
Th	ppm	**12.7**	**12.2**	**13.2**	**11.9**	**13.9**	0.29	9.6	96
Ti	%	0.421	0.362	0.318	0.299	0.337	0.006	0.565	5.65
Tl	ppm	**0.61**	0.47	0.39	0.33	0.44	0.02	0.6	6
U	ppm	1.6	1.5	1.9	1.9	1.9	0.1	2.7	27
V	ppm	78	74	62	53	63	1	120	1200
W	ppm	**1.4**	1.1	1	0.9	1.1	<0.1	1.25	12.5
Y	ppm	9.4	8.5	10.3	11.4	10.9	16.3	33	330
Zn	ppm	**80**	**114**	**76**	**82**	**85**	6	70	700
Zr	ppm	66.6	58.1	55.1	52.5	57.1	1.1	165	1650

Metal concentrations exceeding the average crustal abundance are **bold**
Metal concentrations exceeding 10 times the average crustal abundance are **bold shaded**
The lower detection limit (LDL) of testing for selenium is 1ppm and has a precision of ±1ppm at the LDL.
Average crustal abundance values averaged from four references accessed from https://en.wikipedia.org/wiki/Abundance_of_elements_in_Earth%27s_crust

Table E2c: Comparison of Metal Concentrations to Average Crustal Abundance (Other rock slopes)

Metal	Units	TT15-R04	TT15-R05	TT15-R06	TT15-R07	TT15-R08	Average Crustal Abundance	10x Average Crustal Abundance
		Quartzite	Quartzite	Shale	Shale	Cherty Shale		
Ag	ppm	0.06	0.05	0.04	0.04	0.02	0.075	0.75
Al	%	0.22	0.18	7.91	7.8	2.17	8.23	82.3
As	ppm	**2.2**	**4.7**	**3.5**	1.5	0.8	1.8	18
Ba	ppm	20	20	**460**	**520**	130	425	4250
Be	ppm	0.05	0.05	2.57	2.36	0.91	2.8	28
Bi	ppm	**0.07**	**0.05**	**0.33**	**0.26**	**0.05**	0.027	0.27
Ca	%	0.22	0.04	**4.85**	**5.07**	**29.8**	4.15	41.5
Cd	ppm	0.13	0.07	0.04	0.02	0.06	0.15	1.5
Ce	ppm	31	23.8	**71.9**	**85.4**	24.3	66.5	665
Co	ppm	3.5	1.4	18.4	18.4	3	25	250
Cr	ppm	15	27	77	72	14	102	1020
Cs	ppm	0.12	0.1	**4.45**	**5.98**	1.08	3	30
Cu	ppm	5.1	5	32.9	34.3	13.1	60	600
Fe	%	0.65	0.29	4.37	3.99	0.89	5.63	56.3
Ga	ppm	1.02	0.68	**25.9**	**25.1**	5.92	19	190
Ge	ppm	0.09	0.09	0.19	0.22	0.16	1.5	15
Hf	ppm	0.3	0.3	2	2.1	0.5	3	30
In	ppm	0.011	0.005	0.066	0.065	0.042	0.16	1.6
K	%	0.02	0.06	**2.15**	**2.39**	0.65	2.09	20.9
La	ppm	11	8.7	36.4	**42.7**	13.1	39	390
Li	ppm	3.4	0.7	**83.3**	**71.3**	8.1	20	200
Mg	%	0.1	0.01	1.7	1.61	0.38	2.33	23.3
Mn	ppm	72	28	407	349	**995**	950	9500
Mo	ppm	0.84	**1.48**	0.25	0.45	0.15	1.2	12
Na	%	0.01	0.01	0.88	1.16	0.35	2.36	23.6
Nb	ppm	0.5	0.9	16.3	16.9	2.8	20	200
Ni	ppm	3	3.7	41.6	39	5.2	84	840
P	ppm	540	70	290	330	220	1050	10500
Pb	ppm	8.9	7.5	**16.2**	10.2	12.3	14	140
Rb	ppm	0.9	2	60.7	89.8	36.5	90	900
Re	ppm	<0.002	<0.002	<0.002	<0.002	<0.002	0.0015	0.015
S	%	0.02	0.01	**0.21**	**0.16**	0.02	0.035	0.35
Sb	ppm	0.12	**0.29**	**1.06**	**0.43**	0.11	0.2	2
Sc	ppm	0.7	0.4	13.9	14.5	7.4	22	220
Se	ppm	<1	**1**	**1**	**1**	**1**	0.05	0.5
Sn	ppm	<0.2	0.2	**2.5**	**2.4**	0.5	2.3	23
Sr	ppm	10.2	18.4	**444**	**383**	**1245**	370	3700
Ta	ppm	<0.05	<0.05	1.2	1.18	0.21	2	20
Te	ppm	<0.05	<0.05	<0.05	<0.05	<0.05	0.002	0.02
Th	ppm	2.5	1.4	**10.8**	**12.6**	2.7	9.6	96
Ti	%	0.019	0.029	0.371	0.35	0.074	0.565	5.65
Tl	ppm	0.04	0.08	0.54	0.52	0.15	0.6	6
U	ppm	0.5	0.4	1.6	1.6	0.7	2.7	27
V	ppm	3	2	67	63	17	120	1200
W	ppm	0.1	0.1	**1.5**	**1.5**	0.3	1.25	12.5
Y	ppm	3.3	1.1	11.2	11.7	22.3	33	330
Zn	ppm	22	10	**110**	**120**	20	70	700
Zr	ppm	15	8.1	61	62.7	18.7	165	1650

Metal concentrations exceeding the average crustal abundance are **bold**
Metal concentrations exceeding 10 times the average crustal abundance are **bold shaded**
The lower detection limit (LDL) of testing for selenium is 1ppm and has a precision of ±1ppm at the LDL.
Average crustal abundance values averaged from four references accessed from https://en.wikipedia.org/wiki/Abundance_of_elements_in_Earth%27s_crust

Table E3a: Shake Flask Analysis Results (Phase I Sampling - January/February 2015)

Sample ID	TT15-R01	TT15-R02	TT15-R03	TT15-R04	TT15-R05	TT15-R06	TT15-R07	TT15-R08	TT15-R09	**Water Quality Guideline References**	
ALS Sample ID	L1579941-1	L1579941-2	L1579941-3	L1579941-4	L1579941-5	L1579941-6	L1579941-7	L1579941-8	L1579941-9	CCME - AL	BCAWQG - AL
Unit	Carbonaceous Siltstone	Carbonaceous Siltstone	Dolomitic Limestone	Quartzite	Quartzite	Shale	Shale	Cherty Shale	Slate	ug/L	ug/L
Physical Tests											
Moisture (%)	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	-	-
Leachable Anions & Nutrients (ug/L)											
Alkalinity, Total (as CaCO3)	47800	47400	94900	21500	7800	56000	54700	45000	48500	-	-
Bromide (Br)	<50	<50	205	<50	<50	<50	<50	<50	<50	-	-
Chloride (Cl)	2750	2270	22300	3040	18300	3740	8490	7930	28200	120,000	-
Conductivity (uS/cm)	102	116	232	49.8	114	127	149	112	212	-	-
Fluoride (F)	87	*167*	39	55	*162*	*282*	*424*	45	*394*	120	-
Nitrate (as N)	13.7	14.8	7.7	20.8	562	23.5	62.2	20.8	1150	13,000	-
Nitrite (as N)	2.4	2	<1.0	<1.0	<1.0	2.8	2.9	2.6	5.9	60	-
pH	9.00	9.02	9.54	9.24	8.28	9.00	9.11	9.00	9.27	6.5-9	6.5-9
Sulfate (SO4)	2910	9230	2280	<500	12900	3970	4580	3410	9630	-	-
Leachable Metals (ug/L)											
Aluminum (Al)-Leachable	*673*	*801*	<5.0	*419*	*130*	*864*	*1020*	*970*	*658*	100	-
Antimony (Sb)-Leachable	0.18	<0.10	0.14	<0.10	0.44	6.57	3.13	0.25	0.16	20	20
Arsenic (As)-Leachable	<1.0	<1.0	<1.0	1.9	***10.7***	1.7	1.1	<1.0	<1.0	5	5
Barium (Ba)-Leachable	<1.0	<1.0	7.1	4.6	12.2	1.4	1.5	1.7	<1.0	-	5,000
Beryllium (Be)-Leachable	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	-	5.3
Bismuth (Bi)-Leachable	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	1,000	-
Boron (B)-Leachable	<10	<10	<10	<10	<10	<10	<10	<10	12	1,500	1,200
Cadmium (Cd)-Leachable	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	0.09	0.015**
Calcium (Ca)-Leachable	8590	9910	6060	6490	6660	8240	6450	10300	5510	-	-
Chromium (Cr)-Leachable	<0.50	<0.50	<0.50	0.87	<0.50	<0.50	<0.50	<0.50	<0.50	8.9	1
Cobalt (Co)-Leachable	<0.10	<0.10	<0.10	2.11	3.03	<0.10	<0.10	<0.10	<0.10	-	110
Copper (Cu)-Leachable	<1.0	<1.0	<1.0	1.2	3.7	<1.0	<1.0	<1.0	<1.0	4*	2**
Iron (Fe)-Leachable	<30	<30	<30	*1270*	*567*	<30	<30	<30	052	300	1,000
Lead (Pb)-Leachable	<0.10	<0.10	<0.10	*1.03*	*4.77*	<0.10	<0.10	<0.10	<0.10	1*	21**
Lithium (Li)-Leachable	5.3	<5.0	8.3	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	-	-
Magnesium (Mg)-Leachable	2920	4610	21700	1080	2400	1440	1230	1090	351	-	-
Manganese (Mn)-Leachable	<0.50	<0.50	<0.50	61.00	8.00	<0.50	<0.50	1.04	<0.50	-	-
Mercury (Hg)-Leachable	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	0.026	-
Molybdenum (Mo)-Leachable	3.72	0.23	0.24	0.55	1.42	0.44	14.4	0.70	1.84	73	-
Nickel (Ni)-Leachable	<0.50	<0.50	<0.50	0.85	10.90	0.52	<0.50	<0.50	<0.50	25*	25**
Phosphorus (P)-Leachable	<300	<300	<300	<300	<300	<300	<300	<300	<300	15	-
Potassium (K)-Leachable	2920	6070	1220	0544	0922	10500	12600	5440	5760	-	373,000
Selenium (Se)-Leachable	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	1	2
Silicon (Si)-Leachable	1170	1160	985	13700	19900	1270	1500	1150	2210	-	-
Silver (Ag)-Leachable	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	0.1	**
Sodium (Na)-Leachable	5700	1580	5670	1530	9100	7980	13100	6370	31300	-	-
Strontium (Sr)-Leachable	108.0	110.0	25.6	19.9	31.5	57.5	57.2	318.0	51.9	-	-
Thallium (Tl)-Leachable	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	0.8	0.3
Tin (Sn)-Leachable	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	-	-
Titanium (Ti)-Leachable	<10	<10	<10	13	19	<10	<10	<10	<10	-	2,000
Uranium (U)-Leachable	0.03	0.08	<0.010	0.223	0.155	0.022	0.048	0.152	0.075	15	300
Vanadium (V)-Leachable	<1.0	<1.0	<1.0	1.3	<1.0	<1.0	1	<1.0	1.7	-	6
Zinc (Zn)-Leachable	<10	<10	<10	<10	<10	<10	<10	<10	<10	30	33**

Notes:

-	Not analyzed or no standard exists. Aluminum guideline is provided only for the dissolved fraction.
<	Concentration is less than the laboratory detection limit indicated.
CCME - AL	Canadian Council of Ministers of the Environment (CCME) (1999). Canadian Water Quality Guidelines for the Protection of Aquatic Life (Freshwater)
BCAWQG-AL	BC Approved and Working Water Quality Guidelines for the protection of freshwater aquatic life (April 2013).
Italics	Italics and shaded indicates an exceedance of the CCME AL limits.
Bold	Bold and shaded indicates an exceedance of the BCAWQG-AL limits
*	Standard varies with water hardness
**	Indicates that the guideline is derived from an equation or matrix.

Table E3b: Shake Flask Analysis Results (Phase II Sampling - October 2015)

Sample ID	YNP15-01	YNP15-03	YNP15-05	YNP15-07	YNP15-08	YNP15-10	YNP15-12	YNP15-13	YNP15-14	YNP15-15	YNP15-16	YNP15-17	YNP15-19	YNP15-20	YNP15-23	**Water Quality Guidelines**	
ALS Sample ID	L1692789-1	L1692789-2	L1692789-3	L1692789-4	L1692789-5	L1692789-6	L1692789-7	L1692789-8	L1692789-9	L1692789-10	L1692789-11	L1692789-12	L1692789-13	L1692789-14	L1692789-15		
Unit	Phyllite	Phyllite	Phyllite	Phyllite	Calcite Vein	Carbonaceous Siltstone	Carbonaceous Siltstone	Carbonaceous Siltstone	Carbonaceous Siltstone	Limestone	Carbonaceous Siltstone	Carbonaceous Siltstone	Carbonaceous Siltstone	Limestone	Carbonaceous Siltstone	CCME - AL	BCAWQG - AL
																mg/L	mg/L
Physical Tests																	
Moisture (%)	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	-	-
Leachable Anions & Nutrients (mg/L)																	
Acidity (as CaCO3)	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	-	-
Alkalinity, Total (as CaCO3)	31.2	31.3	30.8	27.7	16.7	18.8	17.5	29.7	29.1	24.9	31.4	28	23.1	23.6	26.1	-	-
Ammonia, Total Leachable (as N)	0.0349	*0.619*	0.183	0.0631	0.013	0.0775	0.0557	0.0302	0.259	0.0247	0.0459	0.0657	0.0429	0.158	0.0611	0.616	
Bromide (Br)	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	0.116	<0.050		
Chloride (Cl)	0.69	<0.50	<0.50	<0.50	0.86	1.84	0.72	<0.50	<0.50	<0.50	<0.50	<0.50	2.92	12	<0.50	120	
Conductivity (µS/cm)	90.6	112	98.3	86.5	45.1	47.9	41.7	58.8	59.7	77.8	81.4	58.9	62.4	101	48.3		
Fluoride (F)	0.118	*0.124*	*0.293*	*0.142*	<0.020	*0.166*	*0.177*	0.055	0.087	0.063	*0.393*	0.104	*0.17*	0.047	0.035	0.12	
Nitrate (as N)	0.0263	0.0318	0.0132	0.0122	<0.0050	0.0369	0.0057	0.0072	0.0123	<0.0050	<0.0050	<0.0050	0.0557	0.123	<0.0050	13	
Nitrite (as N)	0.0081	0.0053	0.0021	0.0012	0.0016	0.0038	0.0023	0.0039	0.0096	<0.0010	0.0021	0.0012	0.0025	0.0021	0.0037	0.06	
pH	8.63	8.9	8.97	***9.11***	***9.3***	***9.21***	***9.38***	8.89	***9.19***	***9.01***	***9.00***	***9.15***	***9.19***	***9.24***	***9.19***	6.5-9	6.5-9
Sulfate (SO4)	12	20.8	15.8	13.2	3.54	1.47	1.17	0.53	1.93	10.2	7.61	2.04	2.97	3.67	<0.50		
Leachable Metals (mg/L)																	
Aluminum (Al)-Leachable	*0.168*	*0.145*	*0.31*	*0.274*	*0.121*	*0.264*	*0.128*	*0.375*	*0.58*	*0.414*	*0.522*	*0.615*	*0.634*	*0.056*	*0.662*	0.1	
Antimony (Sb)-Leachable	0.00014	0.00184	0.00137	0.00084	<0.00010	0.00036	0.00025	<0.00010	0.00019	0.00051	0.00111	0.00137	0.0003	0.00195	0.00019	0.02	0.02
Arsenic (As)-Leachable	<0.0010	0.0015	0.001	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	0.003	0.0034	<0.0010	0.0016	<0.0010	0.005	0.005
Barium (Ba)-Leachable	0.0126	0.0055	0.0064	0.0105	0.101	0.0035	0.0022	0.001	0.0018	0.0253	<0.0010	<0.0010	0.0015	0.0014	0.0013		5
Beryllium (Be)-Leachable	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050		0.0053
Bismuth (Bi)-Leachable	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	1	
Boron (B)-Leachable	0.01	0.014	0.024	0.02	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	1.5	1.2
Cadmium (Cd)-Leachable	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	0.00009*	0.000015**
Calcium (Ca)-Leachable	9.11	7.21	7.43	6.3	7.08	6.79	6.06	8.87	6.31	10.1	8.65	6.94	7.09	7.64	6.44		
Chromium (Cr)-Leachable	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	0.0089	0.001
Cobalt (Co)-Leachable	<0.00010	0.0008	0.00026	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010		0.11
Copper (Cu)-Leachable	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	0.002-0.004**	0.002**
Iron (Fe)-Leachable	<0.030	<0.030	<0.030	<0.030	<0.030	<0.030	<0.030	<0.030	<0.030	<0.030	<0.030	<0.030	<0.030	<0.030	<0.030	0.3	1
Lead (Pb)-Leachable	<0.00010	0.00017	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	0.00014	<0.00010	<0.00010	<0.00010	<0.00010	0.0024**	0.021**
Lithium (Li)-Leachable	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	0.006	<0.0050		
Magnesium (Mg)-Leachable	3.17	5.97	4.39	4.08	0.492	0.74	1.08	0.671	2.22	2.26	3.52	2.09	1.43	3.79	1.73		
Manganese (Mn)-Leachable	<0.00050	0.00096	<0.00050	<0.00050	0.00071	<0.00050	<0.00050	<0.00050	<0.00050	0.00058	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050		
Mercury (Hg)-Leachable	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	0.000026	
Molybdenum (Mo)-Leachable	0.0015	0.00023	0.00018	<0.00010	0.00058	0.00108	0.00048	0.00067	0.00027	0.00117	0.00065	0.00011	0.00215	0.00615	0.00076	0.073	
Nickel (Ni)-Leachable	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	0.025**	0.025**
Phosphorus (P)-Leachable	<0.30	<0.30	<0.30	<0.30	<0.30	<0.30	<0.30	<0.30	<0.30	<0.30	<0.30	<0.30	<0.30	<0.30	<0.30	0.015	
Potassium (K)-Leachable	1.96	3.05	2.14	2.02	0.365	0.376	0.252	1.5	1.37	0.679	1.07	1.06	0.965	0.62	2.98		373
Selenium (Se)-Leachable	<0.00050	0.00149	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	0.001	0.002
Silicon (Si)-Leachable	2.36	1.67	1.53	1.48	0.753	0.549	0.337	1.77	1.3	0.547	0.922	1.18	0.914	0.568	1.91		
Silver (Ag)-Leachable	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	0.0001	
Sodium (Na)-Leachable	2.17	1.93	2.77	2.43	0.566	1.06	0.381	1.25	0.807	0.529	1	0.665	1.98	4.5	2.25		
Strontium (Sr)-Leachable	0.226	0.124	0.27	0.125	1.26	0.0776	0.0606	0.0152	0.0204	0.108	0.0704	0.0326	0.0554	0.0364	0.0122		
Thallium (Tl)-Leachable	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	0.0008	0.0003
Tin (Sn)-Leachable	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050		
Titanium (Ti)-Leachable	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010		2
Uranium (U)-Leachable	0.000167	0.000277	0.000157	0.000042	0.000107	0.0011	0.000437	0.000099	0.000058	0.000237	0.000113	0.000025	0.000091	0.00171	0.000121	0.015	0.3
Vanadium (V)-Leachable	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	0.0014		0.006
Zinc (Zn)-Leachable	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	0.03	0.033**

Notes:

-	Not analyzed or no standard exists. Aluminum guideline is provided only for the dissolved fraction.
<	Concentration is less than the laboratory detection limit indicated.
CCME - AL	Canadian Council of Ministers of the Environment (CCME) (1999). Canadian Water Quality Guidelines for the Protection of Aquatic Life (Freshwater).
BCAWQG-AL	BC Approved and Working Water Quality Guidelines for the protection of freshwater aquatic life (April 2013).
Italics	Underlined Italics and shaded indicates an exceedance of the CCME AL limits.
Bold	Bold and shaded indicates an exceedance of the BCAWQG-AL limits.
**	Indicates that the guideline is derived from an equation or matrix, based on water hardness

Photo 1: Sample TT15-R01

Photo 2: Sample TT15-R02

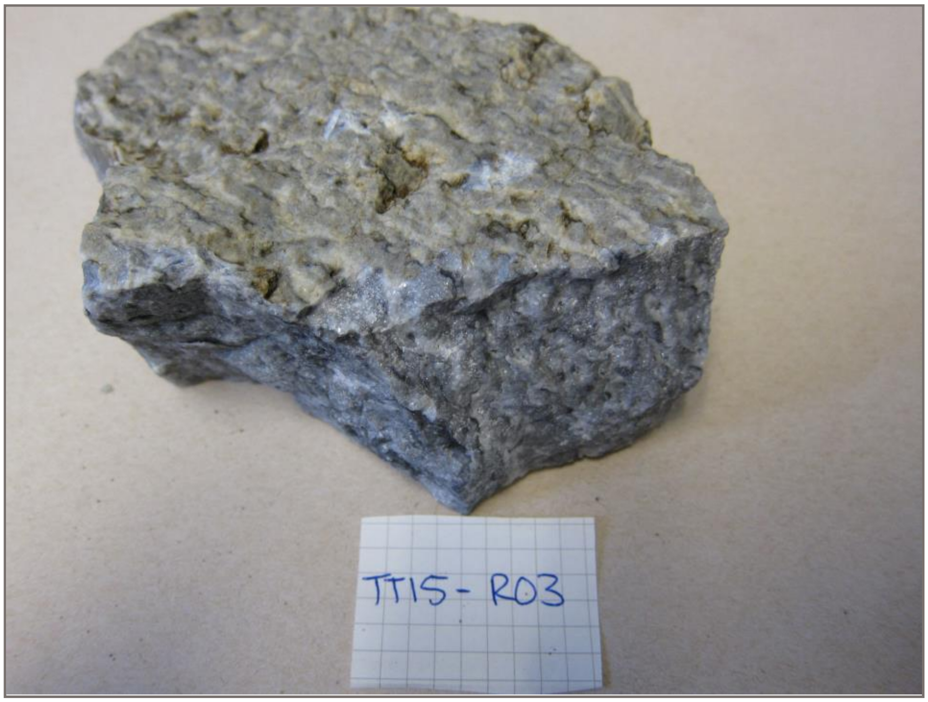


Photo 3: Sample TT15-R03

Photo 4: Sample TT15-R04

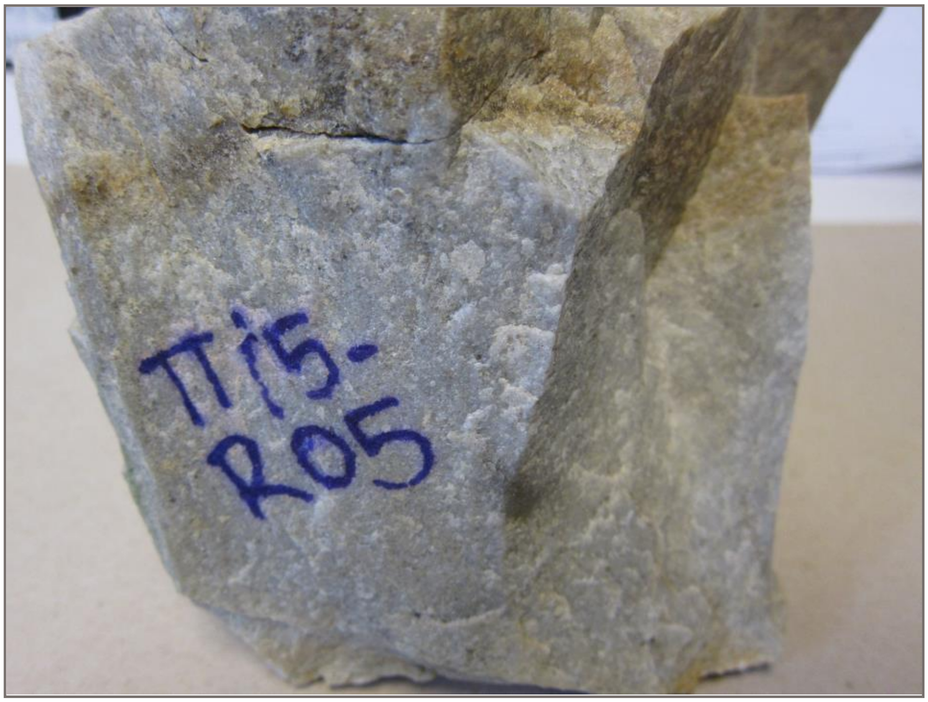


Photo 5: Sample TT15-R05

Photo 6: Sample TT15-R06

Photo 7: Sample TT15-R07

Photo 8: Sample TT15-R08

Photo 9: Sample TT15-R09

Photo 10: Sample YNP15-01

Photo 11: Sample YNP15-02

Photo 12: Sample YNP15-03

Photo 13: Sample YNP15-04

Photo 14: Sample YNP15-05

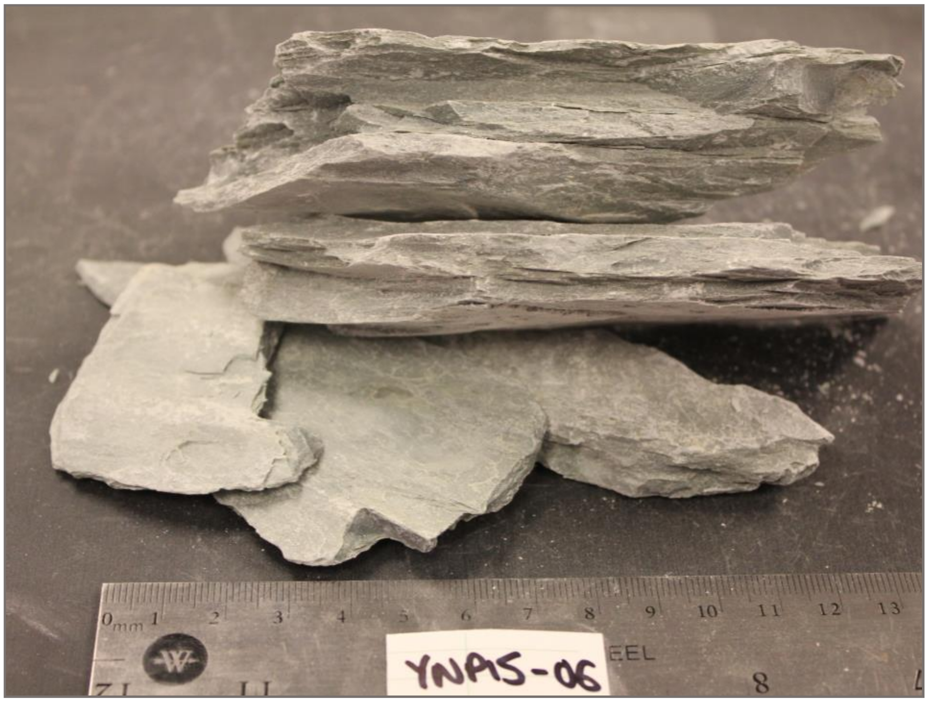


Photo 15: Sample YNP15-06

Photo 16: Sample YNP15-07

Photo 17: Sample YNP15-08

Photo 18: Sample YNP15-09

Photo 19: Sample YNP15-10

Photo 20: Sample YNP15-11

Photo 21: Sample YNP15-12

Photo 22: Sample YNP15-13

Photo 23: Sample YNP15-14

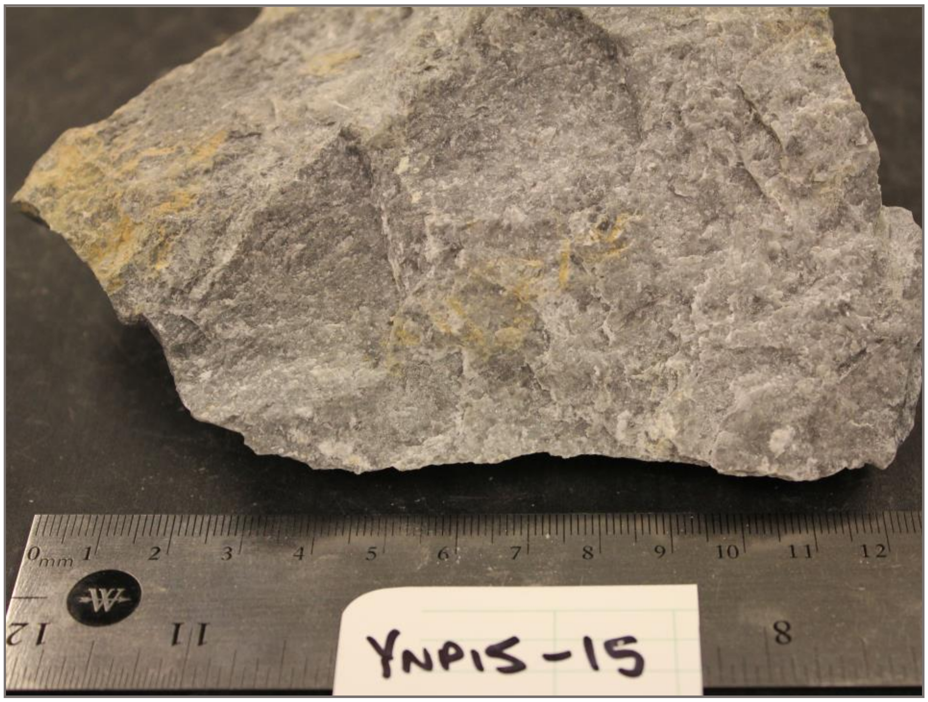


Photo 24: Sample YNP15-15

Photo 25: Sample YNP15-16

Photo 26: Sample YNP15-17

Photo 27: Sample YNP15-18

Photo 28: Sample YNP15-19

Photo 29: Sample YNP15-20

Photo 30: Sample YNP15-21

Photo 31: Sample YNP15-22

Photo 32: Sample YNP15-23

Photo 33: Typical excavation material at the base of the rock slopes within the Phyllite Rock Slope section. Observed lithology is a homogeneous carbonaceous phyllite unit, with minor interbedded quartz veining, oriented parallel to and perpendicular to phyllite foliation. Photo taken at Station 124+300.

Photo 34: Phyllite material disintegrates into a very fine grained, low density powder during excavation.

Photo 35: Quartz vein (30-40cm width) interbedded between the carbonaceous phyllite unit, at Station 124+550. Quartz veining was visually approximated to represent 5% of the exposed rock slope, with the homogeneous phyllite unit representing the remaining 95%.

Photo 36:

Photo 37:

Photo 38:

ALS Canada Ltd.
2103 Dollarton Hwy
North Vancouver BC V7H 0A7
Phone: 604 984 0221 Fax: 604 984 0218 www.alsglobal.com

To: TETRA TECH EBA INC.
885 DUNSMUIR STREET
VANCOUVER BC V6C 1N5

Finalized Date: 26- FEB- 2015
Account: TGM

CERTIFICATE VA15023706

Project: 704- V13403095

This report is for 9 Rock samples submitted to our lab in Vancouver, BC, Canada on 16- FEB- 2015.

The following have access to data associated with this certificate:

SCOTT KINGSTON		

SAMPLE PREPARATION

ALS CODE	DESCRIPTION
WEI- 21	Received Sample Weight
LOG- 22	Sample login - Rcd w/o BarCode
CRU- 21	Crush entire sample > 70% - 6 mm
SPL- 21X	Crush split for send out
SPL- 21	Split sample - riffle splitter
PUL- 31	Pulverize split to 85% <75 um

ANALYTICAL PROCEDURES

ALS CODE	DESCRIPTION	INSTRUMENT
S- GRA06a	Sulfate Sulfur (HCl leachable)	WST- SEQ
S- IR07	Sulphide Sulphur (Leco)	LECO
C- GAS05	Inorganic Carbon (CO2)	
ME- MS61	48 element four acid ICP- MS	
OA- VOL08	Basic Acid Base Accounting	
S- IR08	Total Sulphur (Leco)	LECO
OA- ELE07	Paste pH	

To: TETRA TECH EBA INC.
ATTN: SCOTT KINGSTON
885 DUNSMUIR STREET
VANCOUVER BC V6C 1N5

This is the Final Report and supersedes any preliminary report with this certificate number. Results apply to samples as submitted. All pages of this report have been checked and approved for release.

***** See Appendix Page for comments regarding this certificate *****

Signature:
Colin Ramshaw, Vancouver Laboratory Manager

ALS Minerals

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To: TETRA TECH EBA INC.
885 DUNSMUIR STREET
VANCOUVER BC V6C 1N5

Finalized Date: 26- FEB- 2015
Account: TGM

Project: 704- V13403095

CERTIFICATE OF ANALYSIS VA15023706

Sample Description	Method / Analyte / Units / LOR	WEI-21 Recvd Wt kg 0.02	OA-VOL08 FIZZ RAT Unity 1	OA-VOL08 MPA tCaCO3/1Kt 0.3	OA-VOL08 NNP tCaCO3/1Kt 1	OA-VOL08 NP tCaCO3/1Kt 1	OA-ELE07 pH Unity 0.1	OA-VOL08 Ratio (N Unity 0.01	S-IR08 S % 0.01	S-IR07 Sulphide % 0.01	C-GAS05 C % 0.05	C-GAS05 CO2 % 0.2	S-GRA06a S % 0.01	ME-MS61 Ag ppm 0.01	ME-MS61 Al % 0.01	ME-MS61 As ppm 0.2
TT15-R01		1.30	4	2.5	793	795	8.4	318.0	0.08	0.10	9.51	34.9	<0.01	0.04	2.04	1.2
TT15-R02		1.92	4	1.9	828	830	8.3	442.7	0.06	0.06	10.00	36.7	<0.01	0.03	1.91	0.8
TT15-R03		1.30	4	<0.3	1035	1035	8.5	6611	<0.01	0.01	12.30	45.1	0.01	0.02	0.16	<0.2
TT15-R04		1.66	1	<0.3	6	6	8.0	38.40	<0.01	<0.01	<0.05	<0.2	<0.01	0.06	0.22	2.2
TT15-R05		4.46	1	<0.3	3	3	7.8	19.20	<0.01	<0.01	<0.05	<0.2	<0.01	0.05	0.18	4.7
TT15-R06		1.66	3	5.9	139	145	8.9	24.42	0.19	0.12	1.33	4.9	0.01	0.04	7.91	3.5
TT15-R07		1.18	3	4.7	146	151	8.9	32.21	0.15	0.13	1.77	6.5	0.01	0.04	7.80	1.5
TT15-R08		0.56	4	0.6	819	820	8.3	1312.0	0.02	0.02	10.05	36.9	<0.01	0.02	2.17	0.8
TT15-R09		1.02	2	1.9	70	72	8.7	38.40	0.06	0.05	0.79	2.9	0.02	0.03	9.28	1.2

***** See Appendix Page for comments regarding this certificate *****

ALS Canada Ltd.
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ALS Minerals

To: TETRA TECH EBA INC.
885 DUNSMUIR STREET
VANCOUVER BC V6C 1N5

Finalized Date: 26- FEB- 2015
Account: TGM

Project: 704- V13403095

CERTIFICATE OF ANALYSIS VA15023706

Sample Description	Method / Analyte / Units / LOR	ME- MS61 Ba ppm 10	ME- MS61 Be ppm 0.0[illegible]	ME- MS61 Bi ppm 0.01	ME- MS61 Ca % 0.01	ME- MS61 Cd ppm 0.02	ME- MS61 Ce ppm 0.01	ME- MS61 Co ppm 0.1	ME- MS61 Cr ppm 1	ME- MS61 Cs ppm 0.05	ME- MS61 Cu ppm 0.2	ME- MS61 Fe % 0.01	ME- MS61 Ga ppm 0.05	ME- MS61 Ge ppm 0.05	ME- MS61 Hf ppm 0.1	ME- MS61 In ppm 0.005
TT15- R01		80	0.6[illegible]	0.09	28.7	0.09	49.6	3.2	16	0.80	7.6	0.94	5.40	0.19	0.8	0.027
TT15- R02		60	0.5[illegible]	0.08	27.7	0.08	22.6	3.2	17	0.50	10.2	0.74	5.17	0.22	0.4	0.018
TT15- R03		10	<0.05	0.04	19.65	0.03	1.58	0.7	1	0.06	2.7	0.90	0.54	0.21	0.1	0.016
TT15- R04		20	0.0[illegible]	0.07	0.22	0.13	31.0	3.5	15	0.12	5.1	0.65	1.02	0.09	0.3	0.011
TT15- R05		20	0.0[illegible]	0.05	0.04	0.07	23.8	1.4	27	0.10	5.0	0.29	0.68	0.09	0.3	0.005
TT15- R06		460	2.5	0.33	4.85	0.04	71.9	18.4	77	4.45	32.9	4.37	25.9	0.19	2.0	0.066
TT15- R07		520	2.3[illegible]	0.26	5.07	0.02	85.4	18.4	72	5.98	34.3	3.99	25.1	0.22	2.1	0.065
TT15- R08		130	0.9	0.05	29.8	0.06	24.3	3.0	14	1.08	13.1	0.89	5.92	0.16	0.5	0.042
TT15- R09		510	2.9[illegible]	0.21	2.68	<0.02	79.6	16.1	87	5.67	18.8	3.68	30.9	0.24	2.0	0.074

***** See Appendix Page for comments regarding this certificate *****

ALS Canada Ltd.
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ALS Minerals

To: TETRA TECH EBA INC.
885 DUNSMUIR STREET
VANCOUVER BC V6C 1N5

Finalized Date: 26- FEB- 2015
Account: TGM

Project: 704- V13403095

CERTIFICATE OF ANALYSIS VA15023706

Sample Description	Method / Analyte / Units / LOR	ME- MS61 K % 0.01	ME- MS61 La ppm 0.5	ME- MS61 Li ppm 0.2	ME- MS61 Mg % 0.01	ME- MS61 Mn ppm 5	ME- MS61 Mo ppm 0.05	ME- MS61 Na % 0.01	ME- MS61 Nb ppm 0.1	ME- MS61 Ni ppm 0.2	ME- MS61 P ppm 10	ME- MS61 Pb ppm 0.5	ME- MS61 Rb ppm 0.1	ME- MS61 Re ppm 0.002	ME- MS61 S % 0.01	ME- MS61 Sb ppm 0.05
TT15- R01		0.46	17.5	16.2	1.11	341	0.47	0.20	3.6	7.4	400	21.2	24.1	<0.002	0.09	0.36
TT15- R02		0.82	11.9	2.6	1.27	132	0.17	0.06	3.0	8.8	560	7.6	24.2	<0.002	0.12	0.17
TT15- R03		0.01	0.8	0.8	11.95	610	0.13	0.08	0.2	1.2	50	1.8	0.4	<0.002	0.05	0.07
TT15- R04		0.02	11.0	3.4	0.10	72	0.84	0.01	0.5	3.0	540	8.9	0.9	<0.002	0.02	0.12
TT15- R05		0.06	8.7	0.7	0.01	28	1.48	0.01	0.9	3.7	70	7.5	2.0	<0.002	0.01	0.29
TT15- R06		2.15	36.4	83.3	1.70	407	0.25	0.88	16.3	41.6	290	16.2	60.7	<0.002	0.21	1.06
TT15- R07		2.39	42.7	71.3	1.61	349	0.45	1.16	16.9	39.0	330	10.2	89.8	<0.002	0.16	0.43
TT15- R08		0.65	13.1	8.1	0.38	995	0.15	0.35	2.8	5.2	220	12.3	36.5	<0.002	0.02	0.11
TT15- R09		2.56	40.0	71.6	1.23	232	0.12	1.06	17.7	40.5	350	13.8	79.6	<0.002	0.06	0.17

***** See Appendix Page for comments regarding this certificate *****

ALS Canada Ltd.
2103 Dollarton Hwy
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Phone: 604 984 0221 Fax: 604 984 0218 www.alsglobal.com

To: TETRA TECH EBA INC.
885 DUNSMUIR STREET
VANCOUVER BC V6C 1N5

Finalized Date: 26- FEB- 2015
Account: TGM

Project: 704- V13403095

CERTIFICATE OF ANALYSIS VA15023706

Sample Description	Method / Analyte / Units / LOR	ME-MS61 Sc ppm 0.1	ME-MS61 Se ppm 1	ME-MS61 Sn ppm 0.2	ME-MS61 Sr ppm 0.2	ME-MS61 Ta ppm 0.05	ME-MS61 Te ppm 0.05	ME-MS61 Th ppm 0.2	ME-MS61 Ti % 0.005	ME-MS61 Tl ppm 0.02	ME-MS61 U ppm 0.1	ME-MS61 V ppm 1	ME-MS61 W ppm 0.1	ME-MS61 Y ppm 0.1	ME-MS61 Zn ppm 2	ME-MS61 Zr ppm 0.5
TT15- R01		4.0	1	0.5	584	0.23	<0.05	6.6	0.101	0.12	0.8	14	0.3	9.8	30	24.7
TT15- R02		3.5	1	0.5	523	0.21	<0.05	3.2	0.081	0.08	0.9	13	0.2	6.2	17	13.4
TT15- R03		0.3	<1	<0.2	43.6	<0.05	<0.05	0.3	0.005	<0.02	0.5	2	0.8	0.5	5	2.5
TT15- R04		0.7	<1	<0.2	10.2	<0.05	<0.05	2.5	0.019	0.04	0.5	3	0.1	3.3	22	15.0
TT15- R05		0.4	1	0.2	18.4	<0.05	<0.05	1.4	0.029	0.08	0.4	2	0.1	1.1	10	8.1
TT15- R06		13.9	1	2.5	444	1.20	<0.05	10.8	0.371	0.54	1.6	67	1.5	11.2	110	61.0
TT15- R07		14.5	1	2.4	383	1.18	<0.05	12.6	0.350	0.52	1.6	63	1.5	11.7	120	62.7
TT15- R08		7.4	1	0.5	1245	0.21	<0.05	2.7	0.074	0.15	0.7	17	0.3	22.3	20	18.7
TT15- R09		15.5	1	2.7	378	1.21	<0.05	12.7	0.421	0.61	1.6	78	1.4	9.4	80	66.6

***** See Appendix Page for comments regarding this certificate *****

ALS Canada Ltd.
2103 Dollarton Hwy
North Vancouver BC V7H 0A7
Phone: 604 984 0221 Fax: 604 984 0218 www.alsglobal.com

To: TETRA TECH EBA INC.
885 DUNSMUIR STREET
VANCOUVER BC V6C 1N5

Finalized Date: 26- FEB- 2015
Account: TGM

Project: 704- V13403095

CERTIFICATE OF ANALYSIS VA15023706

CERTIFICATE COMMENTS

ANALYTICAL COMMENTS

REE's may not be totally soluble in this method.

Applies to Method: ME- MS61

LABORATORY ADDRESSES

Processed at ALS Vancouver located at 2103 Dollarton Hwy, North Vancouver, BC, Canada.

Applies to Method:

C- GAS05	CRU- 21	LOG- 22	ME- MS61
OA- ELE07	OA- VOL08	PUL- 31	S- GRA06a
S- IR07	S- IR08	SPL- 21	SPL- 21X
WEI- 21			

Tetra Tech EBA Inc.
ATTN: Scott Kingston
1000 - 885 Dunsmuir Street, 10th floor
Vancouver BC V6E 1N5

Date Received: 19-FEB-15
Report Date: 26-FEB-15 18:29 (MT)
Version: FINAL

Client Phone: 604-685-0275

Certificate of Analysis

Lab Work Order #: **L1579941**

Project P.O. #: NOT SUBMITTED
Job Reference: 704-V13403095
C of C Numbers:
Legal Site Desc:

Brent Mack, B.Sc.
Account Manager

ALS ENVIRONMENTAL ANALYTICAL REPORT

	Sample ID	L1579941-1	L1579941-2	L1579941-3	L1579941-4	L1579941-5
	Description					
	Sampled Date					
	Sampled Time					
	Client ID	TT15-R01	TT15-R02	TT15-R03	TT15-R04	TT15-R05
Grouping	**Analyte**					
SOIL						
Physical Tests	Moisture (%)	<0.25	<0.25	<0.25	<0.25	<0.25
Leachable Anions & Nutrients	Alkalinity, Total (as CaCO3) (ug/L)	47800	47400	94900	21500	7800
	Bromide (Br) (ug/L)	<50	<50	205	<50	<50
	Chloride (Cl) (ug/L)	2750	2270	22300	3040	18300
	Conductivity (uS/cm)	102	116	232	49.8	114
	Fluoride (F) (ug/L)	87	167	39	55	162
	Nitrate (as N) (ug/L)	13.7	14.8	7.7	20.8	562
	Nitrite (as N) (ug/L)	2.4	2.0	<1.0	<1.0	<1.0
	pH (pH)	9.00	9.02	9.54	9.24	8.28
	Sulfate (SO4) (ug/L)	2910	9230	2280	<500	12900
Leachable Metals	Aluminum (Al)-Leachable (ug/L)	673	801	<5.0	419	130
	Antimony (Sb)-Leachable (ug/L)	0.18	<0.10	0.14	<0.10	0.44
	Arsenic (As)-Leachable (ug/L)	<1.0	<1.0	<1.0	1.9	10.7
	Barium (Ba)-Leachable (ug/L)	<1.0	<1.0	7.1	4.6	12.2
	Beryllium (Be)-Leachable (ug/L)	<0.50	<0.50	<0.50	<0.50	<0.50
	Bismuth (Bi)-Leachable (ug/L)	<0.50	<0.50	<0.50	<0.50	<0.50
	Boron (B)-Leachable (ug/L)	<10	<10	<10	<10	<10
	Cadmium (Cd)-Leachable (ug/L)	<0.050	<0.050	<0.050	<0.050	<0.050
	Calcium (Ca)-Leachable (ug/L)	8590	9910	6060	6490	6660
	Chromium (Cr)-Leachable (ug/L)	<0.50	<0.50	<0.50	0.87	<0.50
	Cobalt (Co)-Leachable (ug/L)	<0.10	<0.10	<0.10	2.11	3.03
	Copper (Cu)-Leachable (ug/L)	<1.0	<1.0	<1.0	1.2	3.7
	Iron (Fe)-Leachable (ug/L)	<30	<30	<30	1270	567
	Lead (Pb)-Leachable (ug/L)	<0.10	<0.10	<0.10	1.03	4.77
	Lithium (Li)-Leachable (ug/L)	5.3	<5.0	8.3	<5.0	<5.0
	Magnesium (Mg)-Leachable (ug/L)	2920	4610	21700	1080	2400
	Manganese (Mn)-Leachable (ug/L)	<0.50	<0.50	<0.50	61.0	8.00
	Mercury (Hg)-Leachable (ug/L)	<0.050	<0.050	<0.050	<0.050	<0.050
	Molybdenum (Mo)-Leachable (ug/L)	3.72	0.23	0.24	0.55	1.42
	Nickel (Ni)-Leachable (ug/L)	<0.50	<0.50	<0.50	0.85	10.9
	Phosphorus (P)-Leachable (ug/L)	<300	<300	<300	<300	<300
	Potassium (K)-Leachable (ug/L)	2920	6070	1220	544	922
	Selenium (Se)-Leachable (ug/L)	<0.50	<0.50	<0.50	<0.50	<0.50
	Silicon (Si)-Leachable (ug/L)	1170	1160	985	13700	19900
	Silver (Ag)-Leachable (ug/L)	<0.050	<0.050	<0.050	<0.050	<0.050
	Sodium (Na)-Leachable (ug/L)	5700	1580	5670	1530	9100
	Strontium (Sr)-Leachable (ug/L)	108	110	25.6	19.9	31.5

* Please refer to the Reference Information section for an explanation of any qualifiers detected.

ALS ENVIRONMENTAL ANALYTICAL REPORT

	Sample ID	L1579941-6	L1579941-7	L1579941-8	L1579941-9	
	Description					
	Sampled Date					
	Sampled Time					
	Client ID	TT15-R06	TT15-R07	TT15-R08	TT15-R09	
Grouping	**Analyte**					
SOIL						
Physical Tests	Moisture (%)	<0.25	<0.25	<0.25	<0.25	
Leachable Anions & Nutrients	Alkalinity, Total (as CaCO3) (ug/L)	56000	54700	45000	48500	
	Bromide (Br) (ug/L)	<50	<50	<50	<50	
	Chloride (Cl) (ug/L)	3740	8490	7930	28200	
	Conductivity (uS/cm)	127	149	112	212	
	Fluoride (F) (ug/L)	282	424	45	394	
	Nitrate (as N) (ug/L)	23.5	62.2	20.8	1150	
	Nitrite (as N) (ug/L)	2.8	2.9	2.6	5.9	
	pH (pH)	9.00	9.11	9.00	9.27	
	Sulfate (SO4) (ug/L)	3970	4580	3410	9630	
Leachable Metals	Aluminum (Al)-Leachable (ug/L)	864	1020	970	658	
	Antimony (Sb)-Leachable (ug/L)	6.57	3.13	0.25	0.16	
	Arsenic (As)-Leachable (ug/L)	1.7	1.1	<1.0	<1.0	
	Barium (Ba)-Leachable (ug/L)	1.4	1.5	1.7	<1.0	
	Beryllium (Be)-Leachable (ug/L)	<0.50	<0.50	<0.50	<0.50	
	Bismuth (Bi)-Leachable (ug/L)	<0.50	<0.50	<0.50	<0.50	
	Boron (B)-Leachable (ug/L)	<10	<10	<10	12	
	Cadmium (Cd)-Leachable (ug/L)	<0.050	<0.050	<0.050	<0.050	
	Calcium (Ca)-Leachable (ug/L)	8240	6450	10300	5510	
	Chromium (Cr)-Leachable (ug/L)	<0.50	<0.50	<0.50	<0.50	
	Cobalt (Co)-Leachable (ug/L)	<0.10	<0.10	<0.10	<0.10	
	Copper (Cu)-Leachable (ug/L)	<1.0	<1.0	<1.0	<1.0	
	Iron (Fe)-Leachable (ug/L)	<30	<30	<30	52	
	Lead (Pb)-Leachable (ug/L)	<0.10	<0.10	<0.10	<0.10	
	Lithium (Li)-Leachable (ug/L)	<5.0	<5.0	<5.0	<5.0	
	Magnesium (Mg)-Leachable (ug/L)	1440	1230	1090	351	
	Manganese (Mn)-Leachable (ug/L)	<0.50	<0.50	1.04	<0.50	
	Mercury (Hg)-Leachable (ug/L)	<0.050	<0.050	<0.050	<0.050	
	Molybdenum (Mo)-Leachable (ug/L)	0.44	14.4	0.70	1.84	
	Nickel (Ni)-Leachable (ug/L)	0.52	<0.50	<0.50	<0.50	
	Phosphorus (P)-Leachable (ug/L)	<300	<300	<300	<300	
	Potassium (K)-Leachable (ug/L)	10500	12600	5440	5760	
	Selenium (Se)-Leachable (ug/L)	<0.50	<0.50	<0.50	<0.50	
	Silicon (Si)-Leachable (ug/L)	1270	1500	1150	2210	
	Silver (Ag)-Leachable (ug/L)	<0.050	<0.050	<0.050	<0.050	
	Sodium (Na)-Leachable (ug/L)	7980	13100	6370	31300	
	Strontium (Sr)-Leachable (ug/L)	57.5	57.2	318	51.9	

* Please refer to the Reference Information section for an explanation of any qualifiers detected.

ALS ENVIRONMENTAL ANALYTICAL REPORT

Sample ID / Description / Sampled Date / Sampled Time / Client ID		L1579941-1 TT15-R01	L1579941-2 TT15-R02	L1579941-3 TT15-R03	L1579941-4 TT15-R04	L1579941-5 TT15-R05
Grouping	**Analyte**					
SOIL						
Leachable Metals	Thallium (Tl)-Leachable (ug/L)	<0.10	<0.10	<0.10	<0.10	<0.10
	Tin (Sn)-Leachable (ug/L)	<0.50	<0.50	<0.50	<0.50	<0.50
	Titanium (Ti)-Leachable (ug/L)	<10	<10	<10	13	19
	Uranium (U)-Leachable (ug/L)	0.031	0.079	<0.010	0.223	0.155
	Vanadium (V)-Leachable (ug/L)	<1.0	<1.0	<1.0	1.3	<1.0
	Zinc (Zn)-Leachable (ug/L)	<10	<10	<10	<10	<10

* Please refer to the Reference Information section for an explanation of any qualifiers detected.

ALS ENVIRONMENTAL ANALYTICAL REPORT

	Sample ID	L1579941-6	L1579941-7	L1579941-8	L1579941-9	
	Description					
	Sampled Date					
	Sampled Time					
	Client ID	TT15-R06	TT15-R07	TT15-R08	TT15-R09	
Grouping	**Analyte**					
SOIL						
Leachable Metals	Thallium (Tl)-Leachable (ug/L)	<0.10	<0.10	<0.10	<0.10	
	Tin (Sn)-Leachable (ug/L)	<0.50	<0.50	<0.50	<0.50	
	Titanium (Ti)-Leachable (ug/L)	<10	<10	<10	<10	
	Uranium (U)-Leachable (ug/L)	0.022	0.048	0.152	0.075	
	Vanadium (V)-Leachable (ug/L)	<1.0	1.0	<1.0	1.7	
	Zinc (Zn)-Leachable (ug/L)	<10	<10	<10	<10	

* Please refer to the Reference Information section for an explanation of any qualifiers detected.

Reference Information

QC Samples with Qualifiers & Comments:

QC Type Description	Parameter	Qualifier	Applies to Sample Number(s)
Matrix Spike	Silicon (Si)-Leachable	MS-B	L1579941-1, -2, -3, -4, -5, -6, -7, -8, -9
Matrix Spike	Calcium (Ca)-Leachable	MS-B	L1579941-1, -2, -3, -4, -5, -6, -7, -8, -9
Matrix Spike	Magnesium (Mg)-Leachable	MS-B	L1579941-1, -2, -3, -4, -5, -6, -7, -8, -9

Qualifiers for Individual Parameters Listed:

Qualifier	Description
MS-B	Matrix Spike recovery could not be accurately calculated due to high analyte background in sample.

Test Method References:

ALS Test Code	Matrix	Test Description	Method Reference**
ALK-SHKFLSK-COL-VA	Soil	Alkalinity by Colour (SHAKEFLASK)	BC MINISTRY OF ENERGY AND MINES

This analysis is based upon the extraction procedure outlined in "Guidelines and Recommended Methods for the Prediction of Metal Leaching and Acid Rock Drainage at Minesites in British Columbia" BC Ministry of Energy and Mines, (Dr. William A. Price, 1997). In summary, the sample is extracted at a 3:1 liquid to solids ratio for 24 hours using deionized water . The extract is then allowed to settle and subsequently filtered through a 0.45 micron membrane filter and analysed using procedures adapted from EPA Method 310.2 "Alkalinity".

BR-SHKFLSK-IC-VA	Soil	Bromide by IC (SHAKEFLASK)	BC MIN. OF ENERGY AND MINES/APHA 4110 B.

This analysis is based upon the extraction procedure outlined in "Guidelines and Recommended Methods for the Prediction of Metal Leaching and Acid Rock Drainage at Minesites in British Columbia" BC Ministry of Energy and Mines, (Dr. William A. Price, 1997). In summary, the sample is extracted at a 3:1 liquid to solids ratio for 24 hours using deionized water . The extract is then allowed to settle and subsequently filtered through a 0.45 micron membrane filter and analysis is carried out using procedures adapted from APHA Method 4110 B. "Ion Chromatography with Chemical Suppression of Eluent Conductivity" and EPA Method 300.0 "Determination of Inorganic Anions by Ion Chromatography". Anions routinely determined by this method include: bromide, chloride, fluoride, nitrate, nitrite and sulphate.

CL-SHKFLSK-IC-VA	Soil	Chloride by IC (SHAKEFLASK)	BC MIN. OF ENERGY AND MINES/APHA 4110 B.

This analysis is based upon the extraction procedure outlined in "Guidelines and Recommended Methods for the Prediction of Metal Leaching and Acid Rock Drainage at Minesites in British Columbia" BC Ministry of Energy and Mines, (Dr. William A. Price, 1997). In summary, the sample is extracted at a 3:1 liquid to solids ratio for 24 hours using deionized water . The extract is then allowed to settle and subsequently filtered through a 0.45 micron membrane filter and analysis is carried out using procedures adapted from APHA Method 4110 B. "Ion Chromatography with Chemical Suppression of Eluent Conductivity" and EPA Method 300.0 "Determination of Inorganic Anions by Ion Chromatography". Anions routinely determined by this method include: bromide, chloride, fluoride, nitrate, nitrite and sulphate.

EC-SHKFLSK-PCT-VA	Soil	EC by PCT (SHAKEFLASK)	BC MINISTRY OF ENERGY AND MINES

This analysis is based upon the extraction procedure outlined in "Guidelines and Recommended Methods for the Prediction of Metal Leaching and Acid Rock Drainage at Minesites in British Columbia" BC Ministry of Energy and Mines, (Dr. William A. Price, 1997). In summary, the sample is extracted at a 3:1 liquid to solids ratio for 24 hours using deionized water . The extract is then allowed to settle and subsequently filtered through a 0.45 micron membrane filter and analysed using procedures adapted from APHA Method 2510 "Conductivity".

F-SHKFLSK-IC-VA	Soil	Fluoride by IC (SHAKEFLASK)	BC MIN. OF ENERGY AND MINES/APHA 4110 B.

This analysis is based upon the extraction procedure outlined in "Guidelines and Recommended Methods for the Prediction of Metal Leaching and Acid Rock Drainage at Minesites in British Columbia" BC Ministry of Energy and Mines, (Dr. William A. Price, 1997). In summary, the sample is extracted at a 3:1 liquid to solids ratio for 24 hours using deionized water . The extract is then allowed to settle and subsequently filtered through a 0.45 micron membrane filter and analysis is carried out using procedures adapted from APHA Method 4110 B. "Ion Chromatography with Chemical Suppression of Eluent Conductivity" and EPA Method 300.0 "Determination of Inorganic Anions by Ion Chromatography". Anions routinely determined by this method include: bromide, chloride, fluoride, nitrate, nitrite and sulphate.

HG-SHKFLSK-CVAFS-VA	Soil	Mercury by CVAFS (SHAKEFLASK)	BC MINISTRY OF ENERGY AND MINES

This analysis is based upon the extraction procedure outlined in "Guidelines and Recommended Methods for the Prediction of Metal Leaching and Acid Rock Drainage at Minesites in British Columbia" BC Ministry of Energy and Mines, (Dr. William A. Price, 1997). In summary, the sample is extracted at a 3:1 liquid to solids ratio for 24 hours using deionized water . The extract is then allowed to settle and subsequently filtered through a 0.45 micron membrane filter and analysed using cold vapour atomic fluorescence spectrophotometry or atomic absorption spectrophotometry (EPA Method 245.7).

MET-SHKFLSK-ICP-VA	Soil	Metals by ICPOES (SHAKEFLASK)	BC MINISTRY OF ENERGY AND MINES

This analysis is based upon the extraction procedure outlined in "Guidelines and Recommended Methods for the Prediction of Metal Leaching and Acid Rock Drainage at Minesites in British Columbia" BC Ministry of Energy and Mines, (Dr. William A. Price, 1997). In summary, the sample is extracted at a 3:1 liquid to solids ratio for 24 hours using deionized water . The extract is then allowed to settle and subsequently filtered through a 0.45 micron membrane filter and analysed using inductively coupled plasma - optical emission spectrophotometry (EPA Method 6010B).

MET-SHKFLSK-MS-VA	Soil	Metals by ICPMS (SHAKEFLASK)	BC MINISTRY OF ENERGY AND MINES

This analysis is based upon the extraction procedure outlined in "Guidelines and Recommended Methods for the Prediction of Metal Leaching and Acid Rock Drainage at Minesites in British Columbia" BC Ministry of Energy and Mines, (Dr. William A. Price, 1997). In summary, the sample is extracted at a 3:1 liquid to solids ratio for 24 hours using deionized water . The extract is then allowed to settle and subsequently filtered through a 0.45 micron membrane filter and analysed using inductively coupled plasma - mass spectrophotometry (EPA Method 6020A).

MOISTURE-VA	Soil	Moisture content	ASTM D2974-00 Method A

This analysis is carried out gravimetrically by drying the sample at 105 C for a minimum of six hours.

NO2-SHKFLSK-IC-VA	Soil	Nitrite by IC (SHAKEFLASK)	BC MIN. OF ENERGY AND MINES/APHA 4110 B.

Reference Information

This analysis is based upon the extraction procedure outlined in "Guidelines and Recommended Methods for the Prediction of Metal Leaching and Acid Rock Drainage at Minesites in British Columbia" BC Ministry of Energy and Mines, (Dr. William A. Price, 1997). In summary, the sample is extracted at a 3:1 liquid to solids ratio for 24 hours using deionized water . The extract is then allowed to settle and subsequently filtered through a 0.45 micron membrane filter and analysis is carried out using procedures adapted from APHA Method 4110 B. "Ion Chromatography with Chemical Suppression of Eluent Conductivity" and EPA Method 300.0 "Determination of Inorganic Anions by Ion Chromatography". Anions routinely determined by this method include: bromide, chloride, fluoride, nitrate, nitrite and sulphate.

NO3-SHKFLSK-IC-VA	Soil	Nitrate by IC (SHAKEFLASK)	BC MIN. OF ENERGY AND MINES/APHA 4110 B.

This analysis is based upon the extraction procedure outlined in "Guidelines and Recommended Methods for the Prediction of Metal Leaching and Acid Rock Drainage at Minesites in British Columbia" BC Ministry of Energy and Mines, (Dr. William A. Price, 1997). In summary, the sample is extracted at a 3:1 liquid to solids ratio for 24 hours using deionized water . The extract is then allowed to settle and subsequently filtered through a 0.45 micron membrane filter and analysis is carried out using procedures adapted from APHA Method 4110 B. "Ion Chromatography with Chemical Suppression of Eluent Conductivity" and EPA Method 300.0 "Determination of Inorganic Anions by Ion Chromatography". Anions routinely determined by this method include: bromide, chloride, fluoride, nitrate, nitrite and sulphate.

PH-SHKFLSK-MAN-VA	Soil	pH by Manual Meter (SHAKEFLASK)	BC MINISTRY OF ENERGY AND MINES

This analysis is based upon the extraction procedure outlined in "Guidelines and Recommended Methods for the Prediction of Metal Leaching and Acid Rock Drainage at Minesites in British Columbia" BC Ministry of Energy and Mines, (Dr. William A. Price, 1997). In summary, the sample is extracted at a 3:1 liquid to solids ratio for 24 hours using deionized water . The extract is then allowed to settle and subsequently analysed using procedures adapted from APHA Method 4500-H "pH Value". The pH is determined in the laboratory using a pH electrode.

SO4-SHKFLSK-IC-VA	Soil	Sulfate by IC (SHAKEFLASK)	BC MIN. OF ENERGY AND MINES/APHA 4110 B.

This analysis is based upon the extraction procedure outlined in "Guidelines and Recommended Methods for the Prediction of Metal Leaching and Acid Rock Drainage at Minesites in British Columbia" BC Ministry of Energy and Mines, (Dr. William A. Price, 1997). In summary, the sample is extracted at a 3:1 liquid to solids ratio for 24 hours using deionized water . The extract is then allowed to settle and subsequently filtered through a 0.45 micron membrane filter and analysis is carried out using procedures adapted from APHA Method 4110 B. "Ion Chromatography with Chemical Suppression of Eluent Conductivity" and EPA Method 300.0 "Determination of Inorganic Anions by Ion Chromatography".

** ALS test methods may incorporate modifications from specified reference methods to improve performance.

The last two letters of the above test code(s) indicate the laboratory that performed analytical analysis for that test. Refer to the list below:

Laboratory Definition Code	Laboratory Location
VA	ALS ENVIRONMENTAL - VANCOUVER, BRITISH COLUMBIA, CANADA

Chain of Custody Numbers:

GLOSSARY OF REPORT TERMS

Surrogate - A compound that is similar in behaviour to target analyte(s), but that does not occur naturally in environmental samples. For applicable tests, surrogates are added to samples prior to analysis as a check on recovery.
mg/kg - milligrams per kilogram based on dry weight of sample.
mg/kg wwt - milligrams per kilogram based on wet weight of sample.
mg/kg lwt - milligrams per kilogram based on lipid-adjusted weight of sample.
mg/L - milligrams per litre.
< - Less than.
D.L. - The reported Detection Limit, also known as the Limit of Reporting (LOR).
N/A - Result not available. Refer to qualifier code and definition for explanation.

Test results reported relate only to the samples as received by the laboratory.
UNLESS OTHERWISE STATED, ALL SAMPLES WERE RECEIVED IN ACCEPTABLE CONDITION.
Analytical results in unsigned test reports with the DRAFT watermark are subject to change, pending final QC review.

ALS Canada Ltd.

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To: TETRA TECH EBA INC.
885 DUNSMUIR STREET
VANCOUVER BC V6C 1N5

Finalized Date: 5- NOV- 2015
Account: TGM

CERTIFICATE VA15160551

Project: V13403095- 02- 003

This report is for 15 Rock samples submitted to our lab in Vancouver, BC, Canada on 16- OCT- 2015.

The following have access to data associated with this certificate:

S. KINGSTON		

SAMPLE PREPARATION

ALS CODE	DESCRIPTION
WEI- 21	Received Sample Weight
LOG- 22	Sample login - Rcd w/o BarCode
PUL- QC	Pulverizing QC Test
CRU- 21	Crush entire sample > 70% - 6 mm
PUL- 31	Pulverize split to 85% < 75 um
SPL- 21	Split sample - riffle splitter
SPL- 21X	Crush split for send out

ANALYTICAL PROCEDURES

ALS CODE	DESCRIPTION	INSTRUMENT
S- GRA06a	Sulfate Sulfur (HCl leachable)	WST- SEQ
S- IR07	Sulphide Sulphur (Leco)	LECO
C- GAS05	Inorganic Carbon (CO2)	
ME- MS61	48 element four acid ICP- MS	
OA- VOL08	Basic Acid Base Accounting	
S- IR08	Total Sulphur (Leco)	LECO
OA- ELE07	Paste pH	

To: TETRA TECH EBA INC.
ATTN: S. KINGSTON
885 DUNSMUIR STREET
VANCOUVER BC V6C 1N5

This is the Final Report and supersedes any preliminary report with this certificate number. Results apply to samples as submitted. All pages of this report have been checked and approved for release.

***** See Appendix Page for comments regarding this certificate *****

Signature:
Colin Ramshaw, Vancouver Laboratory Manager

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Finalized Date: 5- NOV- 2015
Account: TGM

Project: V13403095- 02- 003

CERTIFICATE OF ANALYSIS VA15160551

Sample Description	Method / Analyte / Units / LOR	WEI- 21 Recvd Wt. kg 0.02	OA- VOL08 FIZZ RAT Unity 1	OA- VOL08 MPA tCaCO3/1Kt 0.3	OA- VOL08 NNP tCaCO3/1Kt 1	OA- VOL08 NP tCaCO3/1Kt 1	OA- VOL08 Ratio (N Unity 0.01	OA- ELE07 pH Unity 0.1	S- IR08 S % 0.01	S- IR07 Sulphide % 0.01	C- GAS05 C % 0.05	C- GAS05 CO2 % 0.2	S- GRA06a S % 0.01	ME- MS61 Ag ppm 0.01	ME- MS61 Al % 0.01	ME- MS61 As ppm 0.2
YNP15- 01		0.54	3	1.6	93	95	60.80	9.1	0.05	0.03	1.03	3.8	0.01	0.02	8.57	0.5
YNP15- 03		0.58	4	5.6	238	244	43.38	9.0	0.18	0.15	2.91	10.7	0.01	0.02	7.55	0.2
YNP15- 05		0.58	4	4.4	400	404	92.34	9.0	0.14	0.11	4.82	17.7	0.01	0.03	7.49	1.0
YNP15- 07		0.68	4	3.1	266	269	86.08	9.1	0.10	0.09	3.10	11.4	0.01	0.01	8.17	0.7
YNP15- 08		0.84	4	<0.3	446	446	2854	8.3	<0.01	<0.01	5.49	20.1	0.01	0.01	0.14	<0.2
YNP15- 10		0.56	4	0.3	988	988	3162	8.4	0.01	<0.01	11.70	42.9	0.01	0.01	0.16	<0.2
YNP15- 12		0.56	4	0.3	991	991	3171	8.6	0.01	<0.01	11.75	43.0	0.02	0.01	0.18	0.2
YNP15- 13		0.50	4	<0.3	207	207	1325.0	9.2	<0.01	<0.01	2.15	7.9	0.02	0.03	8.30	0.6
YNP15- 14		0.76	4	2.8	465	468	166.40	9.0	0.09	0.06	5.70	20.9	0.02	0.02	6.47	0.5
YNP15- 15		0.92	4	12.5	846	858	68.64	8.6	0.40	0.35	10.25	37.5	0.03	0.04	0.95	4.1
YNP15- 16		0.70	4	3.8	726	730	194.65	8.9	0.12	0.09	8.77	32.1	0.04	0.02	3.04	1.9
YNP15- 17		1.08	4	5.3	382	387	72.85	9.1	0.17	0.14	4.50	16.5	0.01	0.02	7.19	2.6
YNP15- 19		0.68	4	0.3	989	989	3165	8.6	0.01	<0.01	11.80	43.3	0.01	0.01	0.20	0.3
YNP15- 20		0.56	4	0.3	1040	1040	3328	8.9	0.01	0.01	12.65	46.3	0.01	0.01	0.15	0.2
YNP15- 23		0.56	3	<0.3	113	113	723.2	9.3	<0.01	<0.01	0.92	3.4	<0.01	0.02	9.16	0.6

***** See Appendix Page for comments regarding this certificate *****

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Finalized Date: 5- NOV- 2015
Account: TGM

Project: V13403095- 02- 003

CERTIFICATE OF ANALYSIS VA15160551

Sample Description	Method Analyte Units LOR	ME- MS61 Ba ppm 10	ME- MS61 Be ppm 0.05	ME- MS61 Bi ppm 0.01	ME- MS61 Ca % 0.01	ME- MS61 Cd ppm 0.02	ME- MS61 Ce ppm 0.01	ME- MS61 Co ppm 0.1	ME- MS61 Cr ppm 1	ME- MS61 Cs ppm 0.05	ME- MS61 Cu ppm 0.2	ME- MS61 Fe % 0.01	ME- MS61 Ga ppm 0.05	ME- MS61 Ge ppm 0.05	ME- MS61 Hf ppm 0.1	ME- MS61 In ppm 0.005
YNP15- 01		430	2.33	0.26	3.25	0.15	76.3	16.6	77	4.91	15.7	4.18	26.2	0.16	1.6	0.064
YNP15- 03		360	1.85	0.17	8.19	0.06	80.7	12.5	58	3.93	18.0	3.30	21.0	0.15	1.6	0.052
YNP15- 05		340	1.57	0.17	15.35	0.11	75.6	10.5	48	3.03	16.5	3.03	18.65	0.14	1.5	0.044
YNP15- 07		420	1.83	0.13	9.41	0.05	79.5	11.7	56	3.98	23.5	3.62	21.1	0.17	1.7	0.057
YNP15- 08		50	<0.05	0.01	17.20	0.08	9.93	0.7	9	0.12	2.5	0.44	0.47	0.07	<0.1	0.005
YNP15- 10		10	0.10	0.01	37.0	0.09	2.92	0.4	3	0.07	2.4	0.09	0.41	0.06	0.1	<0.005
YNP15- 12		10	0.08	0.01	34.9	0.05	2.29	0.4	2	0.09	2.2	0.09	0.44	0.09	0.1	<0.005
YNP15- 13		420	1.74	0.13	7.03	0.02	65.6	14.0	79	4.53	11.6	4.47	24.8	0.17	1.5	0.060
YNP15- 14		310	1.27	0.10	15.80	0.03	63.8	9.9	42	3.17	6.4	3.01	16.20	0.18	1.1	0.045
YNP15- 15		70	0.38	0.08	31.3	0.02	20.4	13.9	8	0.42	36.2	1.26	2.31	0.11	0.2	0.015
YNP15- 16		100	0.73	0.08	24.8	0.05	46.7	5.2	25	1.43	3.9	1.45	7.87	0.15	0.7	0.021
YNP15- 17		240	1.25	0.13	12.25	<0.02	65.3	9.8	48	2.89	8.0	3.36	17.80	0.18	1.2	0.043
YNP15- 19		10	<0.05	0.01	36.3	<0.02	2.51	0.5	3	0.09	1.5	0.12	0.51	0.07	0.1	<0.005
YNP15- 20		<10	<0.05	0.03	21.5	0.02	2.06	0.3	2	0.06	1.0	1.00	0.40	0.09	<0.1	0.014
YNP15- 23		530	2.53	0.14	4.08	<0.02	68.1	14.3	86	5.27	0.9	4.02	28.9	0.21	1.5	0.057

***** See Appendix Page for comments regarding this certificate *****

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ALS Minerals

To: TETRA TECH EBA INC.
885 DUNSMUIR STREET
VANCOUVER BC V6C 1N5

Finalized Date: 5- NOV- 2015
Account: TGM

Project: V13403095- 02- 003

CERTIFICATE OF ANALYSIS VA15160551

Sample Description	Method Analyte Units LOR	ME- MS61 K % 0.01	ME- MS61 La ppm 0.5	ME- MS61 Li ppm 0.2	ME- MS61 Mg % 0.01	ME- MS61 Mn ppm 5	ME- MS61 Mo ppm 0.05	ME- MS61 Na % 0.01	ME- MS61 Nb ppm 0.1	ME- MS61 Ni ppm 0.2	ME- MS61 P ppm 10	ME- MS61 Pb ppm 0.5	ME- MS61 Rb ppm 0.1	ME- MS61 Re ppm 0.002	ME- MS61 S % 0.01	ME- MS61 Sb ppm 0.05
YNP15- 01		2.42	40.1	70.7	1.39	288	0.13	0.90	14.4	39.9	330	19.9	69.1	<0.002	0.06	0.26
YNP15- 03		2.09	45.2	49.6	1.27	400	0.16	0.75	12.7	27.3	330	16.4	86.4	<0.002	0.20	0.15
YNP15- 05		1.86	44.4	43.3	1.38	372	0.19	0.73	11.0	24.9	420	22.4	80.3	<0.002	0.16	0.14
YNP15- 07		2.27	44.6	49.3	1.46	388	0.15	0.79	12.9	30.2	300	10.3	95.1	<0.002	0.12	0.12
YNP15- 08		0.04	4.8	1.2	0.11	929	0.30	0.02	0.2	2.9	10	12.9	1.7	<0.002	<0.01	0.05
YNP15- 10		0.06	1.8	0.7	0.60	38	0.15	0.01	0.3	0.8	80	7.9	1.7	<0.002	0.03	0.09
YNP15- 12		0.08	1.3	1.3	1.57	33	0.11	0.01	0.3	0.7	70	4.9	2.0	<0.002	0.02	0.08
YNP15- 13		2.51	33.0	90.2	1.22	212	0.13	0.52	11.3	41.9	480	10.9	81.6	<0.002	0.01	0.09
YNP15- 14		1.83	34.2	47.0	1.73	431	0.18	0.38	7.9	27.9	350	8.4	98.1	<0.002	0.09	0.09
YNP15- 15		0.24	8.2	9.6	0.79	707	1.26	0.07	1.4	6.2	590	11.5	11.8	<0.002	0.46	0.12
YNP15- 16		0.74	24.6	19.5	1.89	344	0.16	0.26	5.2	11.7	220	38.6	37.0	<0.002	0.13	0.09
YNP15- 17		1.76	35.4	79.0	1.57	287	0.11	0.42	8.9	27.5	510	13.2	88.9	<0.002	0.18	0.10
YNP15- 19		0.07	1.3	0.9	1.24	18	0.43	0.01	0.4	1.1	20	2.4	2.1	<0.002	0.03	0.06
YNP15- 20		0.03	1.2	1.4	12.85	596	0.19	0.03	0.2	1.0	30	2.3	1.1	<0.002	0.04	0.11
YNP15- 23		3.10	32.1	92.8	1.12	147	0.09	0.59	13.2	40.4	500	8.5	93.3	<0.002	<0.01	0.09

***** See Appendix Page for comments regarding this certificate *****

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To: TETRA TECH EBA INC.
885 DUNSMUIR STREET
VANCOUVER BC V6C 1N5

Finalized Date: 5-NOV-2015
Account: TGM

Project: V13403095-02-003

CERTIFICATE OF ANALYSIS VA15160551

Sample Description	Method / Analyte / Units / LOR	ME-MS61 Sc ppm 0.1	ME-MS61 Se ppm 1	ME-MS61 Sn ppm 0.2	ME-MS61 Sr ppm 0.2	ME-MS61 Ta ppm 0.05	ME-MS61 Te ppm 0.05	ME-MS61 Th ppm 0.01	ME-MS61 Ti % 0.005	ME-MS61 Tl ppm 0.02	ME-MS61 U ppm 0.1	ME-MS61 V ppm 1	ME-MS61 W ppm 0.1	ME-MS61 Y ppm 0.1	ME-MS61 Zn ppm 2	ME-MS61 Zr ppm 0.5
YNP15-01		13.7	1	2.4	345	1.00	<0.05	12.20	0.362	0.47	1.5	74	1.1	8.5	114	58.1
YNP15-03		11.6	1	2.0	441	0.87	<0.05	13.20	0.318	0.39	1.9	62	1.0	10.3	76	55.1
YNP15-05		10.0	1	1.8	644	0.79	<0.05	11.90	0.299	0.33	1.9	53	0.9	11.4	82	52.5
YNP15-07		11.5	<1	2.1	447	0.99	<0.05	13.90	0.337	0.44	1.9	63	1.1	10.9	85	57.1
YNP15-08		0.7	1	<0.2	847	<0.05	<0.05	0.29	0.006	0.02	0.1	1	<0.1	16.3	6	1.1
YNP15-10		0.3	<1	0.2	564	<0.05	<0.05	0.32	0.007	<0.02	1.1	2	<0.1	2.0	16	2.1
YNP15-12		0.3	<1	<0.2	517	<0.05	<0.05	0.31	0.007	0.02	0.8	2	0.1	1.2	10	2.0
YNP15-13		14.3	1	2.0	273	0.81	<0.05	11.35	0.356	0.64	1.4	75	0.8	9.5	110	48.5
YNP15-14		9.4	1	1.3	418	0.56	<0.05	10.20	0.230	0.42	1.2	47	0.6	10.5	57	39.6
YNP15-15		1.8	<1	0.2	569	0.10	<0.05	2.65	0.042	0.06	1.0	7	0.1	7.6	11	8.7
YNP15-16		4.7	1	0.7	609	0.35	<0.05	7.97	0.146	0.16	0.9	21	0.3	8.9	78	26.8
YNP15-17		10.2	1	1.4	457	0.61	<0.05	10.60	0.264	0.39	1.4	51	0.6	11.6	75	39.0
YNP15-19		0.3	<1	<0.2	345	<0.05	<0.05	0.42	0.010	0.03	0.5	3	<0.1	0.5	4	2.2
YNP15-20		0.3	<1	<0.2	42.1	<0.05	<0.05	0.32	0.006	<0.02	1.8	2	0.4	0.5	5	1.7
YNP15-23		15.3	1	2.4	273	0.89	<0.05	11.10	0.368	0.75	1.2	84	1.0	9.0	91	52.9

***** See Appendix Page for comments regarding this certificate *****

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To: TETRA TECH EBA INC.
885 DUNSMUIR STREET
VANCOUVER BC V6C 1N5

Finalized Date: 5- NOV- 2015
Account: TGM

Project: V13403095- 02- 003

CERTIFICATE OF ANALYSIS VA15160551

CERTIFICATE COMMENTS

ANALYTICAL COMMENTS

REE's may not be totally soluble in this method.

Applies to Method: ME- MS61

LABORATORY ADDRESSES

Processed at ALS Vancouver located at 2103 Dollarton Hwy, North Vancouver, BC, Canada.

Applies to Method:

C- GAS05	CRU- 21	LOG- 22	ME- MS61
OA- ELE07	OA- VOL08	PUL- 31	PUL- QC
S- GRA06a	S- IR07	S- IR08	SPL- 21
SPL- 21X	WEI- 21		

Tetra Tech EBA Inc.
ATTN: Scott Kingston
1000 - 885 Dunsmuir Street, 10th floor
Vancouver BC V6E 1N5

Date Received: 23-OCT-15
Report Date: 02-NOV-15 12:55 (MT)
Version: FINAL

Client Phone: 604-685-0275

Certificate of Analysis

Lab Work Order #: L1692789

Project P.O. #: NOT SUBMITTED
Job Reference: V13403095-02-003
C of C Numbers:
Legal Site Desc:

Brent Mack, B.Sc.
Account Manager

ALS ENVIRONMENTAL ANALYTICAL REPORT

	Sample ID	L1692789-1	L1692789-2	L1692789-3	L1692789-4	L1692789-5
	Description	Other	Other	Other	Other	Other
	Sampled Date					
	Sampled Time					
	Client ID	YNP15-01	YNP15-03	YNP15-05	YNP15-07	YNP15-08
Grouping	**Analyte**					
SOIL						
Physical Tests	Moisture (%)	<0.25	<0.25	<0.25	<0.25	<0.25
Leachable Anions & Nutrients	Acidity (as CaCO3) (mg/L)	<1.0	<1.0	<1.0	<1.0	<1.0
	Alkalinity, Total (as CaCO3) (mg/L)	31.2	31.3	30.8	27.7	16.7
	Ammonia, Total Leachable (as N) (mg/L)	0.0349	0.619	0.183	0.0631	0.0130
	Bromide (Br) (mg/L)	<0.050	<0.050	<0.050	<0.050	<0.050
	Chloride (Cl) (mg/L)	0.69	<0.50	<0.50	<0.50	0.86
	Conductivity (uS/cm)	90.6	112	98.3	86.5	45.1
	Fluoride (F) (mg/L)	0.118	0.124	0.293	0.142	<0.020
	Nitrate (as N) (mg/L)	0.0263	0.0318	0.0132	0.0122	<0.0050
	Nitrite (as N) (mg/L)	0.0081	0.0053	0.0021	0.0012	0.0016
	pH (pH)	8.63	8.90	8.97	9.11	9.30
	Sulfate (SO4) (mg/L)	12.0	20.8	15.8	13.2	3.54
Leachable Metals	Aluminum (Al)-Leachable (mg/L)	0.168	0.145	0.310	0.274	0.121
	Antimony (Sb)-Leachable (mg/L)	0.00014	0.00184	0.00137	0.00084	<0.00010
	Arsenic (As)-Leachable (mg/L)	<0.0010	0.0015	0.0010	<0.0010	<0.0010
	Barium (Ba)-Leachable (mg/L)	0.0126	0.0055	0.0064	0.0105	0.101
	Beryllium (Be)-Leachable (mg/L)	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050
	Bismuth (Bi)-Leachable (mg/L)	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050
	Boron (B)-Leachable (mg/L)	0.010	0.014	0.024	0.020	<0.010
	Cadmium (Cd)-Leachable (mg/L)	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050
	Calcium (Ca)-Leachable (mg/L)	9.11	7.21	7.43	6.30	7.08
	Chromium (Cr)-Leachable (mg/L)	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050
	Cobalt (Co)-Leachable (mg/L)	<0.00010	0.00080	0.00026	<0.00010	<0.00010
	Copper (Cu)-Leachable (mg/L)	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010
	Iron (Fe)-Leachable (mg/L)	<0.030	<0.030	<0.030	<0.030	<0.030
	Lead (Pb)-Leachable (mg/L)	<0.00010	0.00017	<0.00010	<0.00010	<0.00010
	Lithium (Li)-Leachable (mg/L)	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050
	Magnesium (Mg)-Leachable (mg/L)	3.17	5.97	4.39	4.08	0.492
	Manganese (Mn)-Leachable (mg/L)	<0.00050	0.00096	<0.00050	<0.00050	0.00071
	Mercury (Hg)-Leachable (mg/L)	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050
	Molybdenum (Mo)-Leachable (mg/L)	0.00150	0.00023	0.00018	<0.00010	0.00058
	Nickel (Ni)-Leachable (mg/L)	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050
	Phosphorus (P)-Leachable (mg/L)	<0.30	<0.30	<0.30	<0.30	<0.30
	Potassium (K)-Leachable (mg/L)	1.96	3.05	2.14	2.02	0.365
	Selenium (Se)-Leachable (mg/L)	<0.00050	0.00149	<0.00050	<0.00050	<0.00050
	Silicon (Si)-Leachable (mg/L)	2.36	1.67	1.53	1.48	0.753
	Silver (Ag)-Leachable (mg/L)	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050

* Please refer to the Reference Information section for an explanation of any qualifiers detected.

ALS ENVIRONMENTAL ANALYTICAL REPORT

	Sample ID	L1692789-6	L1692789-7	L1692789-8	L1692789-9	L1692789-10
	Description	Other	Other	Other	Other	Other
	Sampled Date					
	Sampled Time					
	Client ID	YNP15-10	YNP15-12	YNP15-13	YNP15-14	YNP15-15
Grouping	**Analyte**					
SOIL						
Physical Tests	Moisture (%)	<0.25	<0.25	<0.25	<0.25	<0.25
Leachable Anions & Nutrients	Acidity (as CaCO3) (mg/L)	<1.0	<1.0	<1.0	<1.0	<1.0
	Alkalinity, Total (as CaCO3) (mg/L)	18.8	17.5	29.7	29.1	24.9
	Ammonia, Total Leachable (as N) (mg/L)	0.0775	0.0557	0.0302	0.259	0.0247
	Bromide (Br) (mg/L)	<0.050	<0.050	<0.050	<0.050	<0.050
	Chloride (Cl) (mg/L)	1.84	0.72	<0.50	<0.50	<0.50
	Conductivity (uS/cm)	47.9	41.7	58.8	59.7	77.8
	Fluoride (F) (mg/L)	0.166	0.177	0.055	0.087	0.063
	Nitrate (as N) (mg/L)	0.0369	0.0057	0.0072	0.0123	<0.0050
	Nitrite (as N) (mg/L)	0.0038	0.0023	0.0039	0.0096	<0.0010
	pH (pH)	9.21	9.38	8.89	9.19	9.01
	Sulfate (SO4) (mg/L)	1.47	1.17	0.53	1.93	10.2
Leachable Metals	Aluminum (Al)-Leachable (mg/L)	0.264	0.128	0.375	0.580	0.414
	Antimony (Sb)-Leachable (mg/L)	0.00036	0.00025	<0.00010	0.00019	0.00051
	Arsenic (As)-Leachable (mg/L)	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010
	Barium (Ba)-Leachable (mg/L)	0.0035	0.0022	0.0010	0.0018	0.0253
	Beryllium (Be)-Leachable (mg/L)	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050
	Bismuth (Bi)-Leachable (mg/L)	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050
	Boron (B)-Leachable (mg/L)	<0.010	<0.010	<0.010	<0.010	<0.010
	Cadmium (Cd)-Leachable (mg/L)	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050
	Calcium (Ca)-Leachable (mg/L)	6.79	6.06	8.87	6.31	10.1
	Chromium (Cr)-Leachable (mg/L)	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050
	Cobalt (Co)-Leachable (mg/L)	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010
	Copper (Cu)-Leachable (mg/L)	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010
	Iron (Fe)-Leachable (mg/L)	<0.030	<0.030	<0.030	<0.030	<0.030
	Lead (Pb)-Leachable (mg/L)	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010
	Lithium (Li)-Leachable (mg/L)	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050
	Magnesium (Mg)-Leachable (mg/L)	0.740	1.08	0.671	2.22	2.26
	Manganese (Mn)-Leachable (mg/L)	<0.00050	<0.00050	<0.00050	<0.00050	0.00058
	Mercury (Hg)-Leachable (mg/L)	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050
	Molybdenum (Mo)-Leachable (mg/L)	0.00108	0.00048	0.00067	0.00027	0.00117
	Nickel (Ni)-Leachable (mg/L)	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050
	Phosphorus (P)-Leachable (mg/L)	<0.30	<0.30	<0.30	<0.30	<0.30
	Potassium (K)-Leachable (mg/L)	0.376	0.252	1.50	1.37	0.679
	Selenium (Se)-Leachable (mg/L)	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050
	Silicon (Si)-Leachable (mg/L)	0.549	0.337	1.77	1.30	0.547
	Silver (Ag)-Leachable (mg/L)	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050

* Please refer to the Reference Information section for an explanation of any qualifiers detected.

ALS ENVIRONMENTAL ANALYTICAL REPORT

Grouping	Analyte	L1692789-11	L1692789-12	L1692789-13	L1692789-14	L1692789-15
	Sample ID	L1692789-11	L1692789-12	L1692789-13	L1692789-14	L1692789-15
	Description	Other	Other	Other	Other	Other
	Sampled Date					
	Sampled Time					
	Client ID	YNP15-16	YNP15-17	YNP15-19	YNP15-20	YNP15-23
SOIL						
Physical Tests	Moisture (%)	<0.25	<0.25	<0.25	<0.25	<0.25
Leachable Anions & Nutrients	Acidity (as CaCO3) (mg/L)	<1.0	<1.0	<1.0	<1.0	<1.0
	Alkalinity, Total (as CaCO3) (mg/L)	31.4	28.0	23.1	23.6	26.1
	Ammonia, Total Leachable (as N) (mg/L)	0.0459	0.0657	0.0429	0.158	0.0611
	Bromide (Br) (mg/L)	<0.050	<0.050	<0.050	0.116	<0.050
	Chloride (Cl) (mg/L)	<0.50	<0.50	2.92	12.0	<0.50
	Conductivity (uS/cm)	81.4	58.9	62.4	101	48.3
	Fluoride (F) (mg/L)	0.393	0.104	0.170	0.047	0.035
	Nitrate (as N) (mg/L)	<0.0050	<0.0050	0.0557	0.123	<0.0050
	Nitrite (as N) (mg/L)	0.0021	0.0012	0.0025	0.0021	0.0037
	pH (pH)	9.00	9.15	9.19	9.24	9.19
	Sulfate (SO4) (mg/L)	7.61	2.04	2.97	3.67	<0.50
Leachable Metals	Aluminum (Al)-Leachable (mg/L)	0.522	0.615	0.634	0.0560	0.662
	Antimony (Sb)-Leachable (mg/L)	0.00111	0.00137	0.00030	0.00195	0.00019
	Arsenic (As)-Leachable (mg/L)	0.0030	0.0034	<0.0010	0.0016	<0.0010
	Barium (Ba)-Leachable (mg/L)	<0.0010	<0.0010	0.0015	0.0014	0.0013
	Beryllium (Be)-Leachable (mg/L)	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050
	Bismuth (Bi)-Leachable (mg/L)	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050
	Boron (B)-Leachable (mg/L)	<0.010	<0.010	<0.010	<0.010	<0.010
	Cadmium (Cd)-Leachable (mg/L)	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050
	Calcium (Ca)-Leachable (mg/L)	8.65	6.94	7.09	7.64	6.44
	Chromium (Cr)-Leachable (mg/L)	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050
	Cobalt (Co)-Leachable (mg/L)	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010
	Copper (Cu)-Leachable (mg/L)	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010
	Iron (Fe)-Leachable (mg/L)	<0.030	<0.030	<0.030	<0.030	<0.030
	Lead (Pb)-Leachable (mg/L)	0.00014	<0.00010	<0.00010	<0.00010	<0.00010
	Lithium (Li)-Leachable (mg/L)	<0.0050	<0.0050	<0.0050	0.0060	<0.0050
	Magnesium (Mg)-Leachable (mg/L)	3.52	2.09	1.43	3.79	1.73
	Manganese (Mn)-Leachable (mg/L)	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050
	Mercury (Hg)-Leachable (mg/L)	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050
	Molybdenum (Mo)-Leachable (mg/L)	0.00065	0.00011	0.00215	0.00615	0.00076
	Nickel (Ni)-Leachable (mg/L)	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050
	Phosphorus (P)-Leachable (mg/L)	<0.30	<0.30	<0.30	<0.30	<0.30
	Potassium (K)-Leachable (mg/L)	1.07	1.06	0.965	0.620	2.98
	Selenium (Se)-Leachable (mg/L)	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050
	Silicon (Si)-Leachable (mg/L)	0.922	1.18	0.914	0.568	1.91
	Silver (Ag)-Leachable (mg/L)	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050

* Please refer to the Reference Information section for an explanation of any qualifiers detected.

ALS ENVIRONMENTAL ANALYTICAL REPORT

	Sample ID	L1692789-1	L1692789-2	L1692789-3	L1692789-4	L1692789-5
	Description	Other	Other	Other	Other	Other
	Sampled Date					
	Sampled Time					
	Client ID	YNP15-01	YNP15-03	YNP15-05	YNP15-07	YNP15-08
Grouping	**Analyte**					
SOIL						
Leachable Metals	Sodium (Na)-Leachable (mg/L)	2.17	1.93	2.77	2.43	0.566
	Strontium (Sr)-Leachable (mg/L)	0.226	0.124	0.270	0.125	1.26
	Thallium (Tl)-Leachable (mg/L)	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010
	Tin (Sn)-Leachable (mg/L)	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050
	Titanium (Ti)-Leachable (mg/L)	<0.010	<0.010	<0.010	<0.010	<0.010
	Uranium (U)-Leachable (mg/L)	0.000167	0.000277	0.000157	0.000042	0.000107
	Vanadium (V)-Leachable (mg/L)	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010
	Zinc (Zn)-Leachable (mg/L)	<0.010	<0.010	<0.010	<0.010	<0.010

* Please refer to the Reference Information section for an explanation of any qualifiers detected.

ALS ENVIRONMENTAL ANALYTICAL REPORT

	Sample ID	L1692789-6	L1692789-7	L1692789-8	L1692789-9	L1692789-10
	Description	Other	Other	Other	Other	Other
	Sampled Date					
	Sampled Time					
	Client ID	YNP15-10	YNP15-12	YNP15-13	YNP15-14	YNP15-15
Grouping	**Analyte**					
SOIL						
Leachable Metals	Sodium (Na)-Leachable (mg/L)	1.06	0.381	1.25	0.807	0.529
	Strontium (Sr)-Leachable (mg/L)	0.0776	0.0606	0.0152	0.0204	0.108
	Thallium (Tl)-Leachable (mg/L)	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010
	Tin (Sn)-Leachable (mg/L)	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050
	Titanium (Ti)-Leachable (mg/L)	<0.010	<0.010	<0.010	<0.010	<0.010
	Uranium (U)-Leachable (mg/L)	0.00110	0.000437	0.000099	0.000058	0.000237
	Vanadium (V)-Leachable (mg/L)	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010
	Zinc (Zn)-Leachable (mg/L)	<0.010	<0.010	<0.010	<0.010	<0.010

* Please refer to the Reference Information section for an explanation of any qualifiers detected.

ALS ENVIRONMENTAL ANALYTICAL REPORT

	Sample ID	L1692789-11	L1692789-12	L1692789-13	L1692789-14	L1692789-15
	Description	Other	Other	Other	Other	Other
	Sampled Date					
	Sampled Time					
	Client ID	YNP15-16	YNP15-17	YNP15-19	YNP15-20	YNP15-23
Grouping	**Analyte**					
SOIL						
Leachable Metals	Sodium (Na)-Leachable (mg/L)	1.00	0.665	1.98	4.50	2.25
	Strontium (Sr)-Leachable (mg/L)	0.0704	0.0326	0.0554	0.0364	0.0122
	Thallium (Tl)-Leachable (mg/L)	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010
	Tin (Sn)-Leachable (mg/L)	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050
	Titanium (Ti)-Leachable (mg/L)	<0.010	<0.010	<0.010	<0.010	<0.010
	Uranium (U)-Leachable (mg/L)	0.000113	0.000025	0.000091	0.00171	0.000121
	Vanadium (V)-Leachable (mg/L)	<0.0010	<0.0010	<0.0010	<0.0010	0.0014
	Zinc (Zn)-Leachable (mg/L)	<0.010	<0.010	<0.010	<0.010	<0.010

* Please refer to the Reference Information section for an explanation of any qualifiers detected.

Reference Information

QC Samples with Qualifiers & Comments:

QC Type Description	Parameter	Qualifier	Applies to Sample Number(s)
Duplicate	Potassium (K)-Leachable	DUP-H	L1692789-15
Duplicate	Sodium (Na)-Leachable	DUP-H	L1692789-15
Duplicate	Uranium (U)-Leachable	DUP-H	L1692789-15
Matrix Spike	Calcium (Ca)-Leachable	MS-B	L1692789-1, -10, -11, -12, -13, -14, -2, -3, -4, -5, -6, -7, -8, -9
Matrix Spike	Magnesium (Mg)-Leachable	MS-B	L1692789-1, -10, -11, -12, -13, -14, -2, -3, -4, -5, -6, -7, -8, -9
Matrix Spike	Silicon (Si)-Leachable	MS-B	L1692789-1, -10, -11, -12, -13, -14, -2, -3, -4, -5, -6, -7, -8, -9
Matrix Spike	Strontium (Sr)-Leachable	MS-B	L1692789-1, -10, -11, -12, -13, -14, -2, -3, -4, -5, -6, -7, -8, -9
Matrix Spike	Calcium (Ca)-Leachable	MS-B	L1692789-15
Matrix Spike	Magnesium (Mg)-Leachable	MS-B	L1692789-15
Matrix Spike	Silicon (Si)-Leachable	MS-B	L1692789-15

Qualifiers for Individual Parameters Listed:

Qualifier	Description
DUP-H	Duplicate results outside ALS DQO, due to sample heterogeneity.
MS-B	Matrix Spike recovery could not be accurately calculated due to high analyte background in sample.

Test Method References:

ALS Test Code	Matrix	Test Description	Method Reference**
ACY-SHKFLSK-PCT-VA	Soil	Acidity by PCT (SHAKEFLASK)	BC MINISTRY OF ENERGY AND MINES

This analysis is based upon the extraction procedure outlined in "Prediction Manual for Drainage Chemistry from Sulphidic Geologic Materials (MEND Report 1.20.1)" (William A. Price, 2009). In summary, a sample is extracted with deionized water at a 3:1 liquid to solids ratio for 24 hours. The extract is then allowed to settle and subsequently filtered through a 0.45 micron membrane filter and analysed using procedures adapted from APHA Method 2310 "Acidity".

ALK-SHKFLSK-COL-VA	Soil	Alkalinity by Colour (SHAKEFLASK)	BC MINISTRY OF ENERGY AND MINES

This analysis is based upon the extraction procedure outlined in "Prediction Manual for Drainage Chemistry from Sulphidic Geologic Materials (MEND Report 1.20.1)" (William A. Price, 2009). In summary, a sample is extracted with deionized water at a 3:1 liquid to solids ratio for 24 hours. The extract is then allowed to settle and subsequently filtered through a 0.45 micron membrane filter and analysed using procedures adapted from EPA Method 310.2 "Alkalinity".

BR-SHKFLSK-IC-VA	Soil	Bromide by IC (SHAKEFLASK)	BC MIN. OF ENERGY AND MINES/APHA 4110 B.

This analysis is based upon the extraction procedure outlined in "Prediction Manual for Drainage Chemistry from Sulphidic Geologic Materials (MEND Report 1.20.1)" (William A. Price, 2009). In summary, a sample is extracted with deionized water at a 3:1 liquid to solids ratio for 24 hours. The extract is then allowed to settle and subsequently filtered through a 0.45 micron membrane filter. The analysis is carried out using procedures adapted from APHA Method 4110 B. "Ion Chromatography with Chemical Suppression of Eluent Conductivity" and EPA Method 300.0 "Determination of Inorganic Anions by Ion Chromatography". Anions routinely determined by this method include: bromide, chloride, fluoride, nitrate, nitrite and sulphate.

CL-SHKFLSK-IC-VA	Soil	Chloride by IC (SHAKEFLASK)	BC MIN. OF ENERGY AND MINES/APHA 4110 B.

This analysis is based upon the extraction procedure outlined in "Prediction Manual for Drainage Chemistry from Sulphidic Geologic Materials (MEND Report 1.20.1)" (William A. Price, 2009). In summary, a sample is extracted with deionized water at a 3:1 liquid to solids ratio for 24 hours. The extract is then allowed to settle and subsequently filtered through a 0.45 micron membrane filter. The analysis is carried out using procedures adapted from APHA Method 4110 B. "Ion Chromatography with Chemical Suppression of Eluent Conductivity" and EPA Method 300.0 "Determination of Inorganic Anions by Ion Chromatography". Anions routinely determined by this method include: bromide, chloride, fluoride, nitrate, nitrite and sulphate.

EC-SHKFLSK-PCT-VA	Soil	EC by PCT (SHAKEFLASK)	BC MINISTRY OF ENERGY AND MINES

This analysis is based upon the extraction procedure outlined in "Prediction Manual for Drainage Chemistry from Sulphidic Geologic Materials (MEND Report 1.20.1)" (William A. Price, 2009). In summary, a sample is extracted with deionized water at a 3:1 liquid to solids ratio for 24 hours. The extract is then allowed to settle and subsequently filtered through a 0.45 micron membrane filter and analysed using procedures adapted from APHA Method 2510 "Conductivity".

F-SHKFLSK-IC-VA	Soil	Fluoride by IC (SHAKEFLASK)	BC MIN. OF ENERGY AND MINES/APHA 4110 B.

This analysis is based upon the extraction procedure outlined in "Prediction Manual for Drainage Chemistry from Sulphidic Geologic Materials (MEND Report 1.20.1)" (William A. Price, 2009). In summary, a sample is extracted with deionized water at a 3:1 liquid to solids ratio for 24 hours. The extract is then allowed to settle and subsequently filtered through a 0.45 micron membrane filter. The analysis is carried out using procedures adapted from APHA Method 4110 B. "Ion Chromatography with Chemical Suppression of Eluent Conductivity" and EPA Method 300.0 "Determination of Inorganic Anions by Ion Chromatography". Anions routinely determined by this method include: bromide, chloride, fluoride, nitrate, nitrite and sulphate.

HG-SHKFLSK-CVAFS-VA	Soil	Mercury by CVAFS (SHAKEFLASK)	BC MINISTRY OF ENERGY AND MINES

This analysis is based upon the extraction procedure outlined in "Prediction Manual for Drainage Chemistry from Sulphidic Geologic Materials (MEND Report 1.20.1)" (William A. Price, 2009). In summary, a sample is extracted with deionized water at a 3:1 liquid to solids ratio for 24 hours. The extract is then allowed to settle and subsequently filtered through a 0.45 micron membrane filter and analysed using cold vapour atomic fluorescence spectrophotometry or atomic absorption spectrophotometry (EPA Method 245.7).

Reference Information

MET-SHKFLSK-MS-VA	Soil	Metals by ICPMS (SHAKEFLASK)	BC MINISTRY OF ENERGY AND MINES

This analysis is based upon the extraction procedure outlined in "Prediction Manual for Drainage Chemistry from Sulphidic Geologic Materials (MEND Report 1.20.1)" (William A. Price, 2009). In summary, a sample is extracted with deionized water at a 3:1 liquid to solids ratio for 24 hours. The extract is then allowed to settle and subsequently filtered through a 0.45 micron membrane filter and analysed using inductively coupled plasma - mass spectrophotometry (EPA Method 6020A).

MOISTURE-VA	Soil	Moisture content	ASTM D2974-00 Method A

This analysis is carried out gravimetrically by drying the sample at 105 C for a minimum of six hours.

NH3-SHKFLSK-F-VA	Soil	Ammonia by Fluoresence (SHAKE FLASK)	BC MIN. OF ENERGY AND MINES

This analysis is based upon the extraction procedure outlined in "Prediction Manual for Drainage Chemistry from Sulphidic Geologic Materials (MEND Report 1.20.1)" (William A. Price, 2009). In summary, a sample is extracted with deionized water at a 3:1 liquid to solids ratio for 24 hours. The extract is then allowed to settle and subsequently filtered through a 0.45 micron membrane filter. The analysis is carried out using procedures modified from J. Environ. Monit., 2005, 7, 37 - 42, The Royal Society of Chemistry, "Flow-injection analysis with fluorescence detection for the determination of trace levels of ammonium in seawater", Roslyn J. Waston et al.

NO2-SHKFLSK-IC-VA	Soil	Nitrite by IC (SHAKEFLASK)	BC MIN. OF ENERGY AND MINES/APHA 4110 B.

This analysis is based upon the extraction procedure outlined in "Prediction Manual for Drainage Chemistry from Sulphidic Geologic Materials (MEND Report 1.20.1)" (William A. Price, 2009). In summary, a sample is extracted with deionized water at a 3:1 liquid to solids ratio for 24 hours. The extract is then allowed to settle and subsequently filtered through a 0.45 micron membrane filter. The analysis is carried out using procedures adapted from APHA Method 4110 B. "Ion Chromatography with Chemical Suppression of Eluent Conductivity" and EPA Method 300.0 "Determination of Inorganic Anions by Ion Chromatography". Anions routinely determined by this method include: bromide, chloride, fluoride, nitrate, nitrite and sulphate.

NO3-SHKFLSK-IC-VA	Soil	Nitrate by IC (SHAKEFLASK)	BC MIN. OF ENERGY AND MINES/APHA 4110 B.

This analysis is based upon the extraction procedure outlined in "Prediction Manual for Drainage Chemistry from Sulphidic Geologic Materials (MEND Report 1.20.1)" (William A. Price, 2009). In summary, a sample is extracted with deionized water at a 3:1 liquid to solids ratio for 24 hours. The extract is then allowed to settle and subsequently filtered through a 0.45 micron membrane filter. The analysis is carried out using procedures adapted from APHA Method 4110 B. "Ion Chromatography with Chemical Suppression of Eluent Conductivity" and EPA Method 300.0 "Determination of Inorganic Anions by Ion Chromatography". Anions routinely determined by this method include: bromide, chloride, fluoride, nitrate, nitrite and sulphate.

PH-SHKFLSK-MAN-VA	Soil	pH by Manual Meter (SHAKEFLASK)	BC MINISTRY OF ENERGY AND MINES

This analysis is based upon the extraction procedure outlined in "Prediction Manual for Drainage Chemistry from Sulphidic Geologic Materials (MEND Report 1.20.1)" (William A. Price, 2009). In summary, a sample is extracted with deionized water at a 3:1 liquid to solids ratio for 24 hours. The extract is then allowed to settle and subsequently analysed using procedures adapted from APHA Method 4500-H "pH Value". The pH is determined in the laboratory using a pH electrode.

SO4-SHKFLSK-IC-VA	Soil	Sulfate by IC (SHAKEFLASK)	BC MIN. OF ENERGY AND MINES/APHA 4110 B.

This analysis is based upon the extraction procedure outlined in "Prediction Manual for Drainage Chemistry from Sulphidic Geologic Materials (MEND Report 1.20.1)" (William A. Price, 2009). In summary, a sample is extracted with deionized water at a 3:1 liquid to solids ratio for 24 hours. The extract is then allowed to settle and subsequently filtered through a 0.45 micron membrane filter. The analysis is carried out using procedures adapted from APHA Method 4110 B. "Ion Chromatography with Chemical Suppression of Eluent Conductivity" and EPA Method 300.0 "Determination of Inorganic Anions by Ion Chromatography".

** ALS test methods may incorporate modifications from specified reference methods to improve performance.

The last two letters of the above test code(s) indicate the laboratory that performed analytical analysis for that test. Refer to the list below:

Laboratory Definition Code	Laboratory Location
VA	ALS ENVIRONMENTAL - VANCOUVER, BRITISH COLUMBIA, CANADA

Chain of Custody Numbers:

GLOSSARY OF REPORT TERMS

Surrogate - A compound that is similar in behaviour to target analyte(s), but that does not occur naturally in environmental samples. For applicable tests, surrogates are added to samples prior to analysis as a check on recovery.
mg/kg - milligrams per kilogram based on dry weight of sample.
mg/kg wwt - milligrams per kilogram based on wet weight of sample.
mg/kg lwt - milligrams per kilogram based on lipid-adjusted weight of sample.
mg/L - milligrams per litre.
< - Less than.
D.L. - The reported Detection Limit, also known as the Limit of Reporting (LOR).
N/A - Result not available. Refer to qualifier code and definition for explanation.

Test results reported relate only to the samples as received by the laboratory.
UNLESS OTHERWISE STATED, ALL SAMPLES WERE RECEIVED IN ACCEPTABLE CONDITION.
Analytical results in unsigned test reports with the DRAFT watermark are subject to change, pending final QC review.

ALS Laboratory Group
ANALYTICAL CHEMISTRY & TESTING SERVICES

L1692789-COFC

ALS Minerals

Analysis Request Form

Date:	Oct 22, 2015
Reference Number	VA15160551
Analyzing Laboratory:	ALSE
Client Contact:	Scott Kingston
Company Name:	Tetra Tech EBA
Project:	V13403095-02-003
Number of Samples & Country of Origin:	15, Canada
Sample IDs:	See Attached
Sample Type: ☐ Drill Core ☐ Percussion ☐ Rock ☐ Soil ☐ Pulp ☐ Other	
Analysis Required:	Shake Flask Extraction (As per L1612739)
Special Instructions:	
Sample Disposition: ☐ Return ☐ Dispose after analysis	
Results to:	**Attention:** Scott Kingston Address: Tetra Tech EBA 1000 - 855 Dunsmuir Street Vancouver BC V6C1N5 Phone: Fax: Email: scott.kingston@tetratech.com
Invoice to:	**Attention:** Address: Same As Above Phone: Fax: Email:

Received by: lady OCT 23 2015 10:30AM 15.2°C

Sample ID
YNP15-01
YNP15-03
YNP15-05
YNP15-07
YNP15-08
YNP15-10
YNP15-12
YNP15-13
YNP15-14
YNP15-15
YNP15-16
YNP15-17
YNP15-19
YNP15-20
YNP15-23

L1692789-COFC

Lay

ALS Laboratory Group
ANALYTICAL CHEMISTRY & TESTING SERVICES

L1692789-COFC

ALS Minerals

Analysis Request Form

Date:	Oct 22, 2015
Reference Number	VA15160551
Analyzing Laboratory:	ALSE
Client Contact:	Scott Kingston
Company Name:	Tetra Tech EBA
Project:	V13403095-02-003
Number of Samples & Country of Origin:	15, Canada
Sample IDs:	See Attached
Sample Type: ☐ Drill Core ☐ Percussion ☐ Rock ☐ Soil ☐ Pulp ☐ Other	
Analysis Required:	Shake Flask Extraction (As per L1612739)
Special Instructions:	
Sample Disposition: ☐ Return ☐ Dispose after analysis	
Results to:	**Attention**: Scott Kingston Address: Tetra Tech EBA 1000 - 855 Dunsmuir Street Vancouver BC V6C1N5 Phone: Fax: Email: scott.kingston@tetratech.com
Invoice to:	**Attention**: Address: Same As Above Phone: Fax: Email:

Received by: lady OCT 2 3 2015 10:30AM 15.2°C

Sample ID	T
YNP15-01	
YNP15-03	
YNP15-05	
YNP15-07	
YNP15-08	
YNP15-10	
YNP15-12	
YNP15-13	
YNP15-14	
YNP15-15	
YNP15-16	
YNP15-17	
YNP15-19	
YNP15-20	
YNP15-23	

L1692789-COFC

Lay

APPENDIX F
GEOTECHNICAL CHARACTERIZATION

Preliminary Site Reconnaissance Observations

Sherbrooke Testpit Logs

Throughcut Undisturbed Block Sampling Photographs

Geotechnical Laboratory Testing Results

Table 6.1 – Preliminary Site Reconnaissance Observations

Test Location	Station	Offset	UTM Grid	Slope Angle	Description
TCH15-AU-01	Sta. ~114+850	~ 20 m left	528096 E 5680129 N 11 U	26-28°	▪ 0 - 0.1 m: Topsoil; dry to moist, loose, black, organic, odor; with tree debris. ▪ 0.1 - 0.7 m: SILT, gravelly; moist to wet (partly frozen), yellow brown; fine to medium subangular to subrounded gravel; trace clay. ▪ Sample TCH-AU15-01 @ 0.5 m (partly frozen). ▪ 0.7 m: Refusal on inferred bedrock.
TCH15-AU-02	Sta. ~115+000	~ 25 m right	528004 E 5679991 N 11 U	15°	▪ 0 - 0.1 m: Topsoil; moist, loose, black, organic, odor; with tree debris. ▪ 0.1 - 0.7 m: SILT, sandy; moist, yellow brown; fine to coarse sand; trace fine gravel; trace clay. ▪ 0.7 m: Refusal on inferred bedrock.
TCH15-AU-03	Sta. ~114+900	~ 40 m right	528016 E 5680110 N 11 U	20-25°	▪ 0 - 0.15 m: Topsoil; dry to moist, loose, black, organic, odor; with tree debris. ▪ 0.15 - 0.6 m: SILT, sandy; dry to moist, yellow brown; fine to medium sand; trace fine gravel; trace clay. ▪ 0.6 m: Refusal on inferred bedrock.
TCH15-AU-04	Sta. ~124+360	~ 20 m right	526736 E 5674634 N 11 U	30°	▪ 0 - 0.1m: Topsoil; wet, loose, black, organic, odor; with tree debris. ▪ 0.1 - 1.0 m: SILT; brown grey, dry to moist, low plasticity; trace fine to coarse angular to subangular gravel; trace coarse sand. Cobbles and/or boulders encountered at bottom of the hole during augering. ▪ Sample: TCH-AU15-04 @ 1.0 m. ▪ 1.2 m: Refusal on inferred bedrock. ▪ Test location on slope above rock bench (approx. 24.5 m above highway elevation).
TCH15-AU-05	Sta. ~124+600	~ 20 m right	526548 E 5674708 N 11 U	35-37°	▪ 0-0.1 m: Topsoil; moist, loose, black, organic, odor; with tree debris. ▪ 0.1 - 0.3 m: CLAY, silty; moist, low plasticity, light brown. ▪ 0.3 - 1 m: SILT; dry to moist, low plasticity, light brownish grey; trace fine to coarse angular gravel; trace medium to coarse sand. ▪ 1.0 m: Refusal on inferred bedrock.
TCH15-AU-06	Sta. ~124+580	~ 40 m right	526529 E 5674701 N 11 U	36-38°	▪ 0 - 0.15 m: Topsoil; black, dry to moist, loose, organic, odor; with tree debris, moss, etc. ▪ 0.15 - 0.4 m: CLAY, silty, sandy; moist, low plasticity, light brown; fine sand. ▪ 0.4 - 1.4 m: SILT; dry to moist, low plasticity, light brownish grey; trace fine angular gravel; trace medium sand. With rock fragments. ▪ 1.4 m: Refusal on inferred bedrock.

Test Location	Station	Offset	UTM Grid	Slope Angle	Description
TCH15-AU-07	Sta. ~88+330	~ 45 m right	543587 E 5698629 N 11 U	36-38°	▪ Several attempts to auger but refusal at slope surface beneath the snow cover. Auger grinding on hard material. ▪ Snow cover about 800–1000 mm. Removed snow cover to reveal slope surface. Large size cobbles and boulders (100–200 mm). Smaller grained material not evident. ▪ No visible evidence on the snow surface of overall slope or localized slope failures (e.g. slumping, localized slips, snow cover is uniform and undisturbed). ▪ Small to medium sized trees along the crest and side crest lines. ▪ Sherbrooke Creek flowing to the west of the slope. No drainage or diversion channels visible due to snow cover.
TCH15-AU-08	Sta. ~89+625	~ 25 m right	543617 E 5698623 N 11 U	25°	▪ Several attempts to auger but refusal at slope surface beneath the snow cover. Auger grinding on hard material. ▪ Snow cover about. 900 mm. Removed snow cover to reveal slope surface. Large size cobbles and boulders (150–200 mm). Smaller grained material not evident. ▪ No visible evidence on the snow surface of overall slope or localized slope failures (e.g. slumping, localized slips, snow cover is uniform and undisturbed). ▪ Small to medium sized trees along the crest and side crest lines. ▪ Sherbrooke Creek flowing to the west of the slope. No drainage or diversion channels visible due to snow cover.
TCH15-AU-09	Sta. ~89+650	~ 35 m left	542460 E 5698248 N 11 U	35-40°	▪ Several attempts to auger but refusal at surface. Inferred likely to be bedrock. ▪ No visible evidence on the snow surface of overall slope or localized slope failures.
TCH15-AU-10	Sta. ~89+700	~ 45 m left	542419 E 5698177 N 11 U	35-40°	▪ 0–0.15 m: Topsoil; black, organic, odor; contains tree debris, moss, etc. ▪ 0.15 m: auger refusal on hard material. Auger grinding, refusal inferred to be bedrock. ▪ Heavily vegetated area with large trees with no vertical deviation. Snow cover uniform. ▪ No visible evidence on the snow surface of overall slope or localized slope failures.
TCH15-AU-11	Sta. ~89+780	~ 50 m left	542370 E 5698121 N 11 U	10-15°	▪ 0–0.5 m: Topsoil; black, moist, loose, organic, odor; with tree debris, moss, etc. ▪ 0.5–0.6 m: Weathered fractured rock; retrieved as fine to coarse angular gravel; with fine to coarse sand; some clay. ▪ 0.6 m: Auger refusal on hard material, inferred likely bedrock. ▪ Slope at test location more gradual towards highway. Heavily vegetated area with large trees with no sign of vertical deviation or movement. Snow cover variable due to smaller vegetation and no visible evidence on the snow surface of overall slope or localized slope failures.

Test Location	Station	Offset	UTM Grid	Slope Angle	Description
TCH15-AU-12	Sta. ~89+870	~ 45 m left	542312 E 5698075 N 11 U	10°	▪ 0–0.2m: Topsoil; black and red brown, moist, loose, organic, odor; with tree debris, moss, etc. ▪ 0.2 m: Auger refusal on hard material, inferred as likely frozen ground or bedrock. ▪ Slope at test location more gradual towards highway. Heavily vegetated area with large trees with no sign of vertical deviation or movement. Snow cover variable due to smaller vegetation. Snow cover approx. 0.4 m to 0.7 m. ▪ No visible evidence on the snow surface of overall slope or localized slope failures.
TCH15-AU-13	Sta. ~89+890	~ 45 m left	542277 E 5698055 N 11 U	5-10°	▪ 0–0.15 m: Topsoil; black, moist, loose, organic, odor; with tree debris, moss, etc. ▪ 0.15 m: Auger refusal on hard material, inferred as bedrock. ▪ Slope at test location is flat. Heavily vegetated area with small trees with some larger trees. Vegetation show no signs of vertical deviation or movement. Snow cover variable due to smaller vegetation. Snow cover approx. 0.4 m. ▪ No visible evidence on the snow surface of overall slope or localized slope failures.
TCH15-AU-14	Sta. ~89+940	~ 40 m left	542228 E 5698034 N 11 U	25°	▪ 0–0.1 m: Topsoil; black, moist, loose, organic, odor; with tree debris, moss, etc. ▪ 0.1 m: Auger refusal on hard material, no recovery. Inferred as bedrock. ▪ Heavily vegetated area with larger trees. Vegetation show no signs of vertical deviation or movement. Snow cover slightly variable due to smaller vegetation. Snow cover approx. 0.6 m. ▪ No visible evidence on the snow surface of overall slope or localized slope failures.
TCH15-AU-15	Sta. ~90+035	~ 70 m left	542168 E 5697981 N 11 U	0°	▪ 0–0.15m: Topsoil; black, moist, loose, organic, odor; with some coarse gravel (fragmented highly weathered rock), tree debris, moss, etc. ▪ 0.15 m: Auger refusal on hard material, no recovery. Inferred as likely frozen ground or bedrock. ▪ Slope angle at test location is flat. Immediate vertical drop to the highway north, and immediate sub-vertical drop to the west of test location. Heavily vegetated area with small and larger trees. Vegetation show no signs of vertical deviation or movement. Snow cover slightly variable due to smaller vegetation. Snow cover approx. 0.4 m. ▪ No visible evidence on the snow surface of overall slope or localized slope failures.
TCH15-AU-16	Sta. ~89+565	~ 35 m left	542497 E 5698281 N 11 U	28-32°	▪ Several attempts to auger could not penetrate surface. Inferred boulders causing refusal. ▪ Slope likely formed from a boulder field. Limited vegetation, large boulders against some trees, snow cover variable and

Test Location	Station	Offset	UTM Grid	Slope Angle	Description
					hummocky. Larger trees show no sign of movement. Larger vegetation above boulder field area.
TCH15-AU-17	Sta. ~89+565	~ 35 m left	542451 E 5698218 N 11 U	30°	▪ 0–0.25 m: Topsoil; black, moist, loose, organic, odor; with tree debris, moss, etc. ▪ 0.25 m: Auger refusal. Grinding on hard material, inferred to be bedrock. No recovery. ▪ Rock observed exposed in a cut upslope at the railway line. Test location in heavily vegetated area with large size trees. ▪ No visible evidence on the snow surface of overall slope or localized slope failures.

Table 6.2 – Additional Site Reconnaissance Observations

Location ID	Station	Offset	UTM Grid	Purpose	Observations
	Sta. ~88+250	~ 200 m right	543686 E 5698768 N Zone 11 U	Field reconnaissance related to an apparent geomorphological lineation/trail in the vegetation identified at the top of Sherbrooke Soil Slope during the aerial photo interpretation	▪ No evidence of a geomorphological lineament or trail ▪ Hummocky ground ▪ Boulders noted on surface ▪ No sign of movement from trees (i.e. trees show no sign of ground movement and no deviation from the vertical) ▪ Ground heavy with moss
	Sta. ~88+250	~ 170 m right	543742 E 5698730 N Zone 11 U	Field reconnaissance related to an apparent circular depression identified at the top of Sherbrooke Soil Slope in aerial photo interpretation	▪ Located edge of depression, ▪ Depression face inclination at about 25 degrees ▪ No signs of movement/reasoning, ▪ Heavily vegetated, ▪ 0.5m moss cover, mature trees,
TP15-01 [Hand-dug]	Sta. ~88+230	~ 45 m right	543668 E 5698616 N 11 U	Field reconnaissance to identify the composition of Sherbrooke Soil Slope in-situ material and retrieve grab samples Excavation of a hand-dug testpit in the cut face above the rock slope to retrieve grab sample of insitu material	▪ 0 - 0.5 m: Sandy GRAVEL, trace silt; very loose, moist, fine to coarse subrounded to rounded gravel; fine to coarse sand; trace cobbles ▪ Testpit very unstable, constant wall collapse and excavation will not stay open ▪ Sample taken @ 0.4m Slope face material very loose gravel and sloughs underfoot when descending
TP15-02 [Hand-dug]	Sta. ~88+450	~ 80 m right	543573 E 5698669 N Zone 11 U	Field reconnaissance to identify the composition of Sherbrooke Soil Slope in-situ material and retrieve grab samples Excavation of a hand-dug testpit in the cut face above the rock slope to retrieve grab sample of insitu material	▪ 0 - 0.4 m: Sandy GRAVEL, trace silt; compact to dense, moist to wet, fine to coarse subrounded to rounded gravel; fine to coarse sand; trace cobbles ▪ Testpit hard to excavate due to very densely packed material encountered. ▪ Sample taken @ 0.4m ▪ Slope face material very loose gravel and sloughs underfoot when ascending
TP15-03 [Hand-dug]	Sta. ~89+950	~ 40 m right	542166 E 5698001 N 11 U	Field reconnaissance to identify the composition of the overburden material above Dustin's Slide slope.	▪ 0 - 0.1 m: Topsoil; dry to moist, loose, black, organic, odor; with tree debris. ▪ 0.15 - 0.6 m: Gravely SILT, some sand; dense, dry to moist, yellow brown to brown, fine to coarse

Location ID	Station	Offset	UTM Grid	Purpose	Observations
				Excavation of a hand-dug testpit above the rock slope face	angular to subangular gravel; fine to medium sand; trace clay. ▪ Difficulty excavating material due to densely packed gravel and abundance of angular cobbles
TP15-04 [Hand-dug]	Sta. ~90+050	~ 25 m right	542106 E 5697995 N 11 U	Field reconnaissance to identify the composition of the overburden material close to Dustin's Slide slope. Excavation of a hand-dug testpit	▪ 0 - 0.15 m: Topsoil; dry to moist, loose, black, organic, odor; with tree debris. ▪ 0.15 - 0.6 m: SILT; dry to moist, low plasticity, light brownish grey; trace fine to coarse angular gravel; trace medium to coarse sand.
TP15-05 [Hand-dug]	Sta. ~113+900	~25 m right	528033 E 5680116 N 11 U	Field reconnaissance to identify the composition of Through Cut (right) in-situ material Excavation of a hand-dug testpit in the cut face above the rock slope to retrieve grab sample of insitu material	▪ 0 - 0.6 m: Gravelly SILT, with sand, trace cobbles and boulders; loose to compact, dry, yellow brown to brown; fine to coarse angular to subangular gravel; fine to coarse sand; silt is non-plastic; trace clay. ▪ The surface layer is crusty and hard to penetrate with a shovel. Material becomes easier to excavate once below the crust layer. ▪ Cobbles up to 75mm and boulders up to 200 mm encountered
TP15-06 [Hand-dug]	Sta. ~114+0	~ 30 m right	528019 E 5680083 N 11 U	Field reconnaissance to identify the composition of Through Cut (right) in-situ material Excavation of a hand-dug testpit in the cut face above the rock slope to retrieve grab sample of insitu material	▪ 0 - 0.5 m: Gravelly SILT, some sand, with cobbles and boulders; loose to compact, dry, yellow brown to brown; fine to coarse angular to subangular gravel; fine to coarse sand; silt is non-plastic; trace clay. ▪ The surface layer is crusty and hard to penetrate with a shovel. Material becomes easier to excavate once below the crust layer. ▪ Cobbles up to 75mm and boulders up to 200 mm encountered
TP15-07 [Hand-dug]	Sta. ~114+850	~ 12 m left	543587 E 5698629 N 11 U	Field reconnaissance to identify the composition of Through Cut (left) in-situ material Excavation of a hand-dug testpit in the cut face above the	▪ 0 - 0.7 m: Gravelly SILT, some sand, with cobbles; loose to compact, dry, yellow brown to brown; fine to coarse angular to subangular gravel; fine to coarse sand; silt is non-plastic; trace clay. ▪ The surface layer is crusty and hard to penetrate with a shovel. Material

Location ID	Station	Offset	UTM Grid	Purpose	Observations
				rock slope to retrieve grab sample of insitu material	becomes easier to excavate once below the crust layer. ▪ Cobbles up to 75mm and boulders up to 120 mm encountered ▪ Sample @ 0.1 m.
TP15-08 [Hand-dug]	Sta. ~114+850	~ 20 m left	528096 E 5680129 N 11 U	Field reconnaissance to identify the composition of Through Cut (left) in-situ material Excavation of a hand-dug testpit in the cut face above the rock slope to retrieve grab sample of insitu material	▪ 0 - 0.6 m: SAND, with gravel, with silt; loose to compact, dry, yellow brown to brown, fine to coarse sand; fine to coarse angular to subangular gravel; silt is non-plastic; trace clay. ▪ The surface layer is crusty and hard to penetrate with a shovel. Material becomes easier to excavate once below the crust layer. ▪ Cobbles up to 75mm encountered ▪ Sample @ 0.3 m.
TP15-09 [Hand-dug]	Sta. ~114+950	~ 35 m left	528067 E 5680042 N 11 U	Field reconnaissance to identify the composition of Through Cut (left) in-situ material Excavation of a hand-dug testpit in the cut face above the rock slope to retrieve grab sample of insitu material	▪ 0 – 0.2; Topsoil ▪ 0.6 m: SAND, with gravel, with silt; loose to compact, dry, yellow brown to brown, fine to coarse sand; fine to coarse angular to subangular gravel; silt is non-plastic; trace clay. ▪ Cobbles up to 75mm encountered
	Sta. ~ 112+500 to ~114+950	~ 15 m to ~ 200 m		Field reconnaissance of the conditions of the current slope face and upslope from the crest of the face of Through Cut (left)	▪ Overburden material varies in thickness across the slope face ▪ Overburden material appears to thickest on the southeast side of the slope. ▪ Overburden may be a thin veneer over the bedrock, exposed outcrop is present sporadically across the slope ▪ Origins of the Silty GRAVEL / Silty SAND may be glaciolacustrine, although the presence of angular grains and rock indicate possible colluvium. ▪ The surface of the silt shows extensive disturbance (fluffy texture) typical of frost disturbance which could be the cause of shallow sloughing on the steeper sections of slope.

Location ID	Station	Offset	UTM Grid	Purpose	Observations
					▪ Glacial striations in exposed outcrops suggesting E-W/W-E glacial directions. ▪ In two locations, one on north and one on south of the cut, the rock face is smooth suggesting either river or glacial erosion. The presence of a pocket of rounded gravel on the south slope at road level points to river erosion. ▪ Near the middle of the south side there is a zone of thicker overburden silt which is directly across from the most severe slumped material on the northern slope. ▪ Extensive slumping has occurred behind the face over much of the high part of the cut. ▪ The tension cracks are 0.5 m to about 1.2 m high back-scarps to the slumps. ▪ Ground is very hummocky. ▪ Conditions are very wet, and thick moss is growing. ▪ Many fallen trees in the slump area with diameters of up to about 300 mm. ▪ The trees growing in the slumps are about 200 to 250 mm in diameter ▪ Tree roots and vegetation are restraining the slumps – not many pistol-butted trunks noted.

TP15-01

Date: 7-Oct-15

Logged By: Paul Kilkenny

Easting: 544666

Northing: 5698857

Zone: 11

Depth (m)		Soil Description	Sample No.	Sample Depth (m)	Moisture Content (%)
From	To				
0	0.9	Sandy GRAVEL, trace fines, trace cobbles; fine to coarse subrounded to rounded gravel, loose, dry, with fine to coarse sand. Cobbles up to 75 mm in diameter.	TP15-01	0.5	5.4

Notes:
No groundwater observed during excavation.
Hand-dug testpit in borrow pit located at km 87+150

TP15-02

Date: 7-Oct-15

Logged By: Paul Kilkenny

Easting: 543668

Northing: 5698588

Zone: 11

Depth (m)		Soil Description	Sample No.	Sample Depth (m)	Moisture Content (%)
From	To				
0	2.8	Sandy GRAVEL, with cobbles and boulders, trace fines; fine to coarse subangular to rounded gravel, loose, dry, with fine to coarse sand. Cobbles up to 75 mm and boulders up to 700 mm in diameter.	TP15-02	1.2	3.4

Notes:

No groundwater or seepage observed during excavation
Testpit walls very unstable
Testpit terminated due continuous wall collapse. Excavation would not stay open
Excavation backfilled and bucket compacted

TP15-03

Date: 7-Oct-15

Logged By: Paul Kilkenny

Easting: 543733

Northing: 5698581

Zone: 11

Depth (m)		Soil Description	Sample No.	Sample Depth (m)	Moisture Content (%)
From	To				
0	2.9	Sandy GRAVEL, with cobbles and boulders, trace fines; fine to coarse subangular to rounded gravel, loose, dry, with fine to coarse sand. Cobbles up to 75 mm and boulders up to 800 mm in diameter.	TP15-03	1.0	2.8

Notes:

No groundwater or seepage observed during excavation
Testpit walls very unstable
Testpit terminated due continuous wall collapse. Excavation would not stay open
Excavation backfilled and bucket compacted

TP15-04

Date: 7-Oct-15

Logged By: Paul Kilkenny

Easting: 543545

Northing: 5698614

Zone: 11

Depth (m)		Soil Description	Sample No.	Sample Depth (m)	Moisture Content (%)
From	To				
0	2.7	Sandy GRAVEL, with cobbles and boulders, trace fines; fine to coarse subangular to rounded gravel, loose, dry, with fine to coarse sand. Cobbles up to 75 mm and boulders up to 700 mm in diameter.	-	-	-

Notes:
No groundwater or seepage observed during excavation
Testpit walls very unstable
Testpit terminated due continuous wall collapse. Excavation would not stay open
Excavation backfilled and bucket compacted

AF-1.0 SHERBROOKE GEOPHYSICAL PROGRAM

As part geotechnical exploration program there was a requirement to identify the overburden thickness / bedrock depth and piezometric surface (if present) within the overburden soils at Sherbrooke Soil Slope. Three geophysical techniques were used to achieve this objective;

- Seismic Refraction;
- Multi Array Surface Wave Analysis (MASW), and
- Electrical Resistivity Tomography (ERT).

Seismic refraction was chosen to determine the depth to bedrock. Seismic refraction was not expected to reliably detect the presence of water under the anticipated soil conditions, so an additional technique of ERT was used for this purpose. The MASW method was processing technique applied to the seismic refraction data to extract shear wave velocity parameters from the surficial soils and confirm the interpreted seismic refraction model.

Figure GP01 shows the location of both the seismic and the ERT profiles on the Sherbrooke Soil Slope. The slope is immediately north of the TransCanada Highway with both profiles starting in the north side road ditch adjacent to the westbound lane.

AF-1.1 Seismic Refraction Method

The seismic refraction method involved setting up an array of geophones in a line and generating a seismic impulse at various points along the seismic line. The P-waves (compression waves), reflect at, or travel along (refract) layer boundaries where velocities differ notably, and are received at the geophones on the surface. The travel time of the first arrival of the P-waves is interpreted along with the known geometry information and a layered model is generated based on the travel times. An iterative inversion process is used to generate the final model from the travel times. Ray paths are checked comparing the calculated first arrivals with the observed first arrivals to determine the model root-mean-square (RMS) error.

A combined 48-channel seismic system was used that consisted of 48, 10 Hz geophones positioned at nominal 2 m centres, 2 seismic cables, 2 GEODE control units running in parallel, and a Betsy Firing Rod loaded with 400-grain shells as the seismic source. A recording time of 1 s was used at a sampling frequency of 0.0625 ms, resulting in 16,000 samples per seismic trace. Geophone positions were recorded by a Topcon HiPerLite and HiPer+ GPS/GLONASS units with one acting as the base and the other as the rover unit, resulting in relative GPS positional x,y,z accuracy of less than ±40 mm.

The seismic refraction survey was performed on September 17, 2015. The data collection occurred after setup was complete between approximately 14:00 hrs and 16:00 hrs. The weather at the time of the survey was overcast with light scattered showers. Temperatures ranged between approximately 4°C and 11°C. Surficial ground conditions were mostly dry.

There were three (3) total shot locations, two (2) off each end of the line at offsets of approximately 5.4 m and 5.7 m respectively, and one (1) in the centre of the line. Ideally, a seismic refraction survey has shots at the quarter points of the line from each end as well; however, due to the slope angle at approximately 34° from the horizontal and the amount of loose material, it was found to be unsafe to perform shots at those locations.

AF-1.2 Multi-Array Surface Wave Analysis (MASW) Method

The MASW method relies on generating a Rayleigh Wave (Ground Roll) and recording the response at an array of Geophones of known geometry in the same plane. Rayleigh Waves travel along density boundaries, in this case the boundary between air and soil, in an elliptical retrograde motion. One physical property of Rayleigh waves are that they are comprised of wave motion at a number of different frequencies. Higher frequencies generate motion in soil particles close to the surface while lower frequency components will impact soil particles at greater depths. A second physical property is that Rayleigh waves are dispersive, or in other words the higher frequency components will travel at a higher group velocity than the lower frequency components. The third property is that there is a constant correlation between the Rayleigh wave group velocities at different frequencies and the bulk Shear wave velocities of the material. This is due to the ground stiffness (which is controlled by the shear wave properties) impacting the ability of the ground to sustain a Rayleigh wave.

The data is collected in the same manner as seismic refraction data, the only difference being that longer time windows are required for data collection as the analysis requires that the ground roll signal be adequately captured, not just the first arrival time as is the case with refraction data.

The seismic data was collected at the Sherbrooke site with long time windows so it could be processed both for refraction analysis and MASW analysis.

AF-1.3 Electrical Resistivity Tomography (ERT) Method

ERT involves setting up an array of electrodes along a line, and connecting multi-core cables to a central control unit. The control unit is able to switch automatically through every electrode combination on the line, producing a 2D matrix of apparent resistivity data.

The resistivity values measured are bulk measurements of resistivity of various overlapping half spaces encompassed by the geometry of the four electrodes used in each measurement. As these values are not specific to a particular layer or material, they are termed apparent resistivity measurements. The apparent resistivity pseudo sections measured with this technique are processed by inversion software which results in modelled actual resistivity and depth values for a detected specific layered geological model along the profile. The end result is a colour contoured 2D depth profile of the survey line.

ERT data was recorded using IRIS Instruments Syscal 96 system, with 96 channels. Each channel was connected to an electrode with a nominal spacing of 2 m along the ground surface.

Electrode position were recorded using the same equipment detailed in Section 2.1 above. Some electrode positions could not be recorded accurately due to tree cover and were therefore interpolated off of a georeferenced aerial LiDAR image. Accurate elevation data is important for the calculation of apparent resistivity values from the measured resistances.

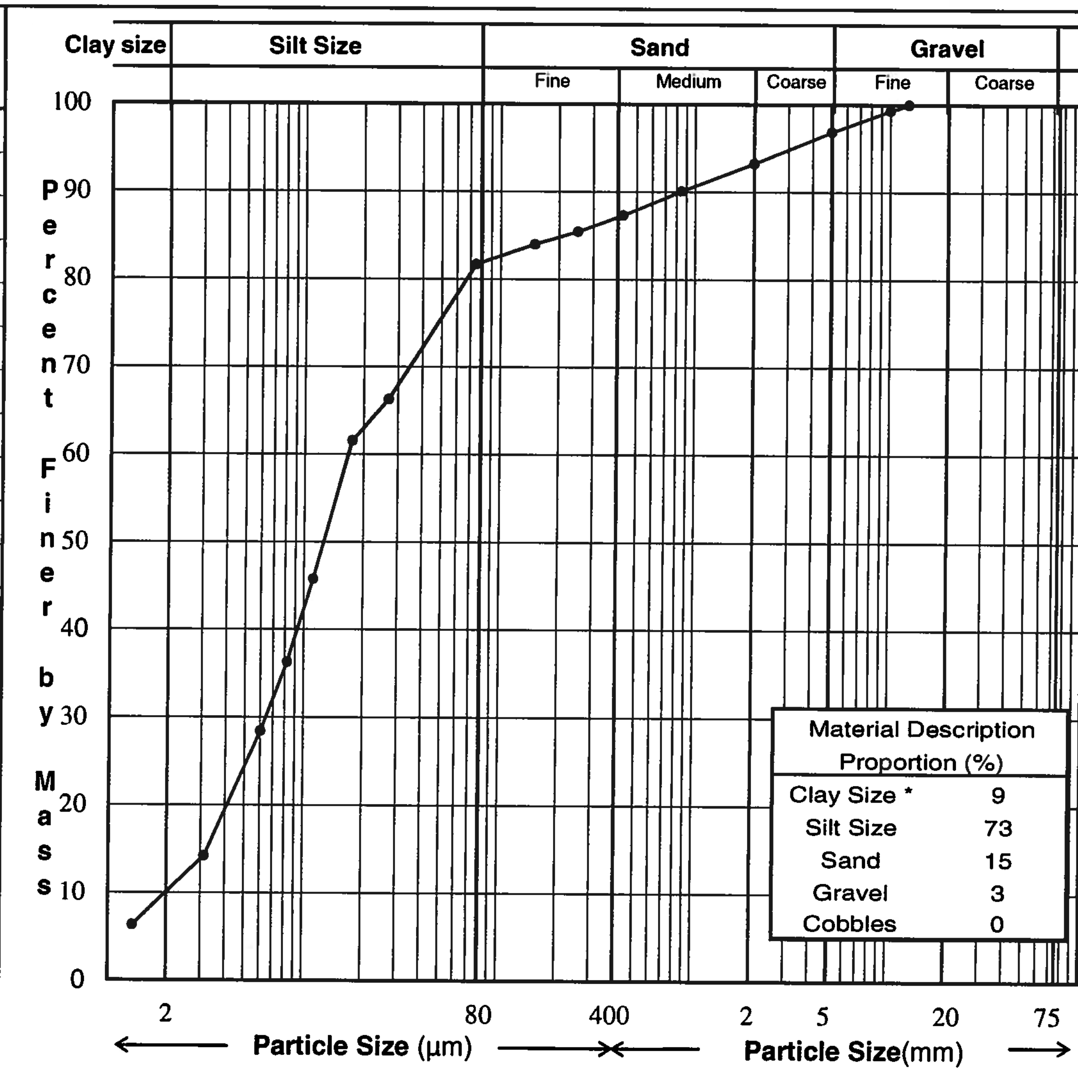
The ERT survey was performed on October 08, 2015. The GPS data collection occurred after setup was complete between approximately 13:00 hrs and 19:15 hrs. The weather at the time of the survey was overcast with light scattered showers. Temperatures ranged between approximately 1°C and 15°C. Surficial ground conditions were mostly dry below the upper several centimetres.

PARTICLE SIZE ANALYSIS (Hydrometer) TEST REPORT

ASTM D422

Project:	Yoho Slope Reprofiling Project	Sample No.:	TCH15-AU-04
Client:	Parks Canada	Borehole/ TP:	
Project No.:	V13403096-01	Depth:	1.0 m
Location:	KM 114 - 128 YOHO National Park	Date Tested	February 18, 2015
Description **:	SILT, some sand, trace clay, trace gravel	Tested By:	JB/MS

Particle Size	Percent Passing
100 mm	
75 mm	
50 mm	
38 mm	
25 mm	
19 mm	
13 mm	100
10 mm	99
5 mm	97
2 mm	93
850 µm	90
425 µm	87
250 µm	85
150 µm	84
75 µm	82
27 µm	66
18 µm	62
11 µm	46
8 µm	36
6 µm	28
3 µm	14
1 µm	6



Material Description	Proportion (%)
Clay Size *	9
Silt Size	73
Sand	15
Gravel	3
Cobbles	0

Remarks: * The upper clay size of 2 µm is as per the Canadian Foundation Manual.

** The description is behaviour based & subject to EBA description protocols.

Reviewed By: ______________ P.Geol.

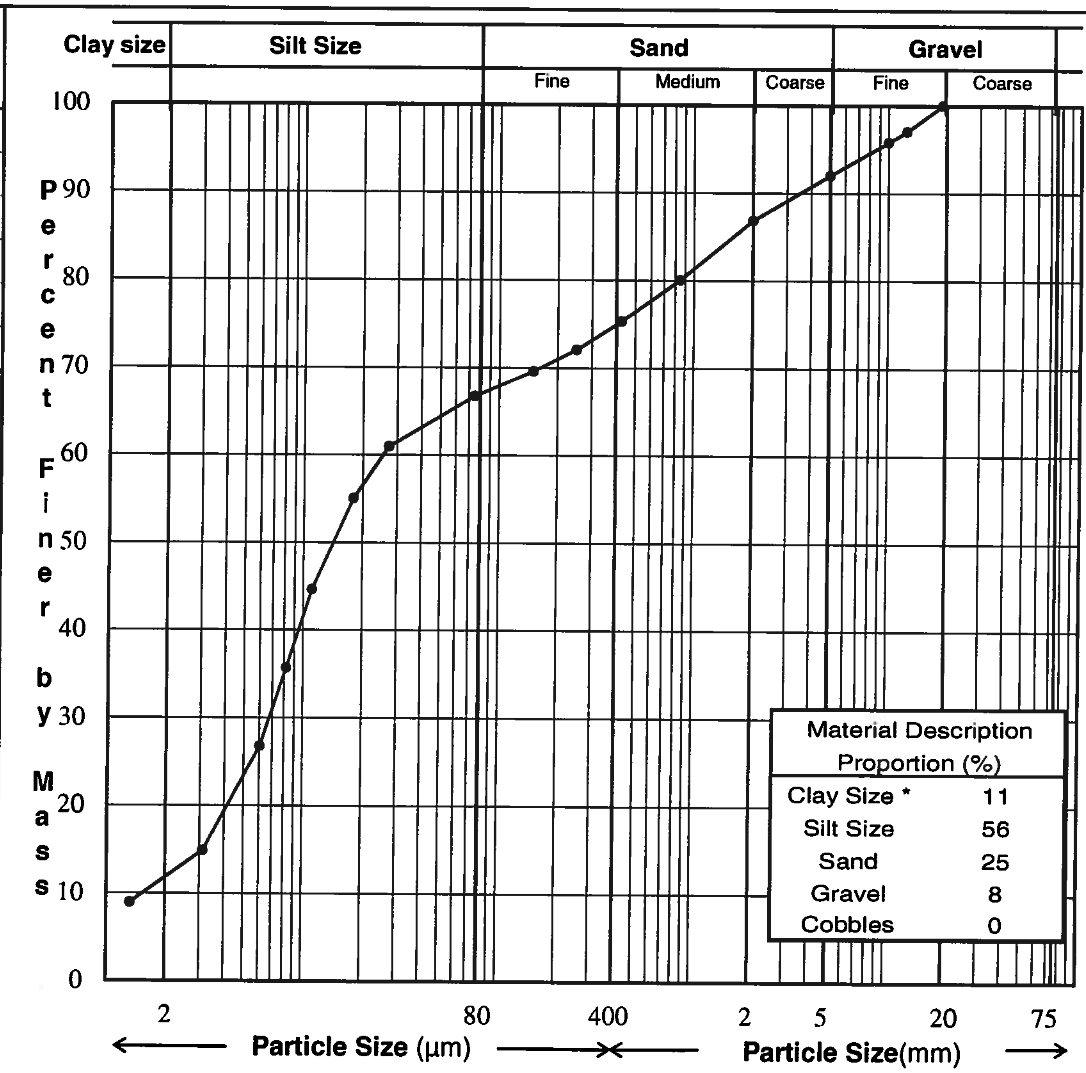
TETRA TECH

PARTICLE SIZE ANALYSIS (Hydrometer) TEST REPORT

ASTM D422

Project:	Yoho Slope Reprofiling Project	Sample No.:	TCH15-AU-01
Client:	Parks Canada	Borehole/ TP:	
Project No.:	V13403096-01	Depth:	0.5 m
Location:	KM 114 - 128 YOHO National Park	Date Tested	February 18, 2015
Description **:	SILT, sandy, some clay, trace gravel	Tested By:	JB/MS

Particle Size	Percent Passing
100 mm	
75 mm	
50 mm	
38 mm	
25 mm	
19 mm	100
13 mm	97
10 mm	96
5 mm	92
2 mm	87
850 µm	80
425 µm	75
250 µm	72
150 µm	70
75 µm	67
27 µm	61
18 µm	55
11 µm	45
8 µm	36
6 µm	27
3 µm	15
1 µm	9



Remarks: * The upper clay size of 2 µm is as per the Canadian Foundation Manual.
** The description is behaviour based & subject to EBA description protocols.

Reviewed By: ____________ P.Eng.

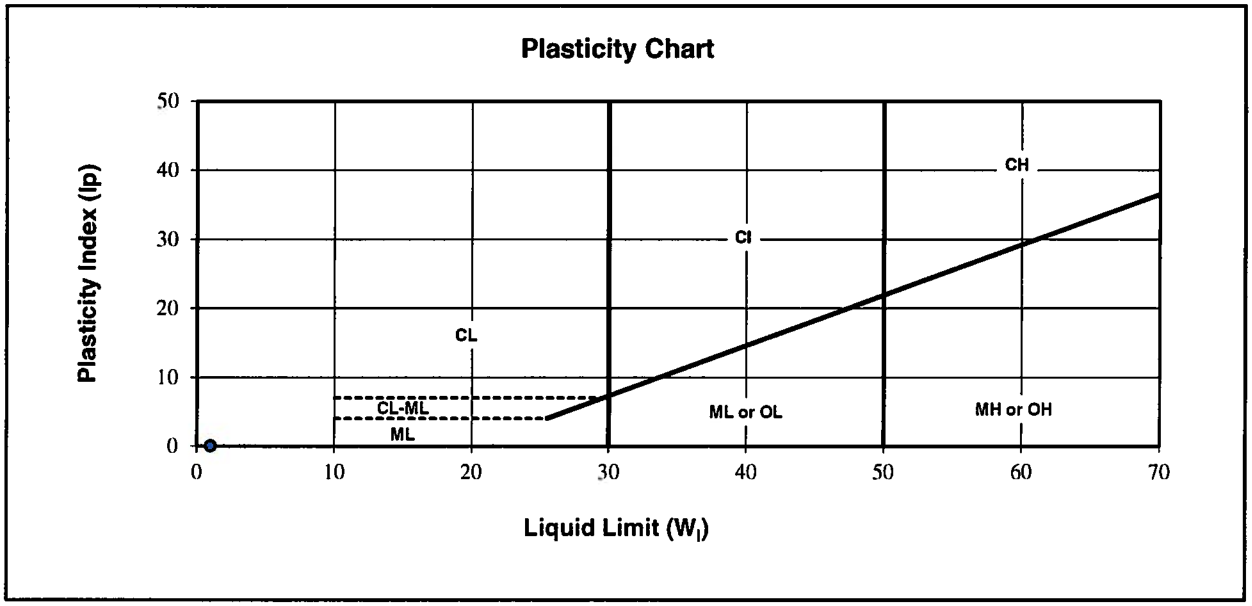
TETRA TECH

ATTERBERG LIMITS TEST REPORT

ASTM D4318

Project:	Yoho Slope Reprofiling Project	Sample Number:	TCH15-AU-01
		Borehole Number:	
Project No:	V13403096-01	Depth:	0.5 m
Client:	Parks Canada	Sampled By:	PK Tested By: MS
Attention:	Ryan Syme P.Eng.	Date Sampled:	February 6, 2015
Email:		Date Tested:	February 19, 2015

Sample Description: SILT, sandy, some clay, trace gravel



Liquid Limit (W_1):	N/A	Natural Moisture (%)	104.8
Plastic Limit :	N/A	Soil Plasticity:	Non Plastic
Plasticity Index (Ip) :	0	Mod.USCS Symbol:	ML

Remarks:

Reviewed By: P.Geol.

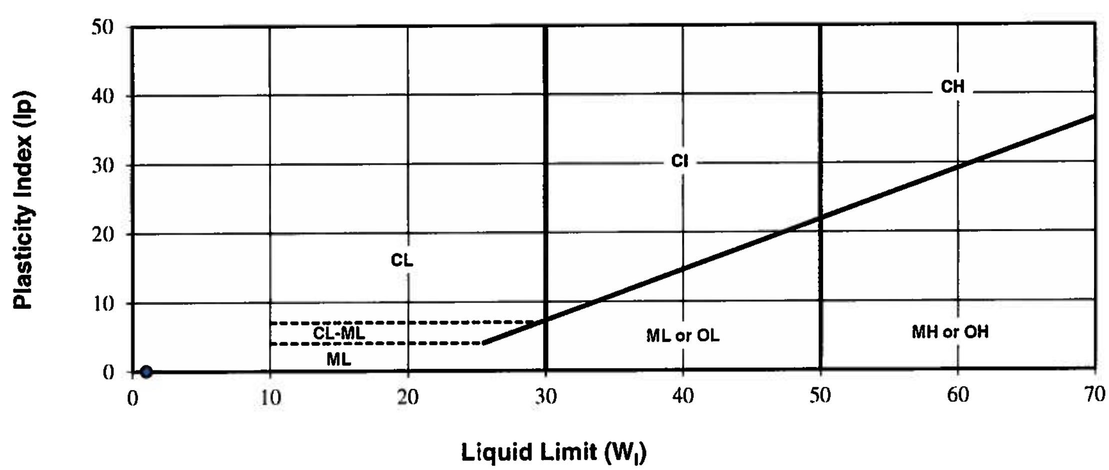
TETRA TECH

ATTERBERG LIMITS TEST REPORT

ASTM D4318

Project:	Yoho Slope Reprofiling Project	Sample Number:	TCH15-AU-04
		Borehole Number:	
Project No:	V13403096-01	Depth:	1.0 m
Client:	Parks Canada	Sampled By:	PK Tested By: MS
Attention:	Ryan Syme P.Eng.	Date Sampled:	February 6, 2015
Email:		Date Tested:	February 19, 2015

Sample Description: SILT, some sand, trace clay, trace gravel



Liquid Limit ($W_{1)}$:	N/A	Natural Moisture (%)	23.3
Plastic Limit :	N/A	Soil Plasticity:	Non Plastic
Plasticity Index (Ip) :	0	Mod.USCS Symbol:	ML

Remarks:

Reviewed By: ______________ P.Geol.

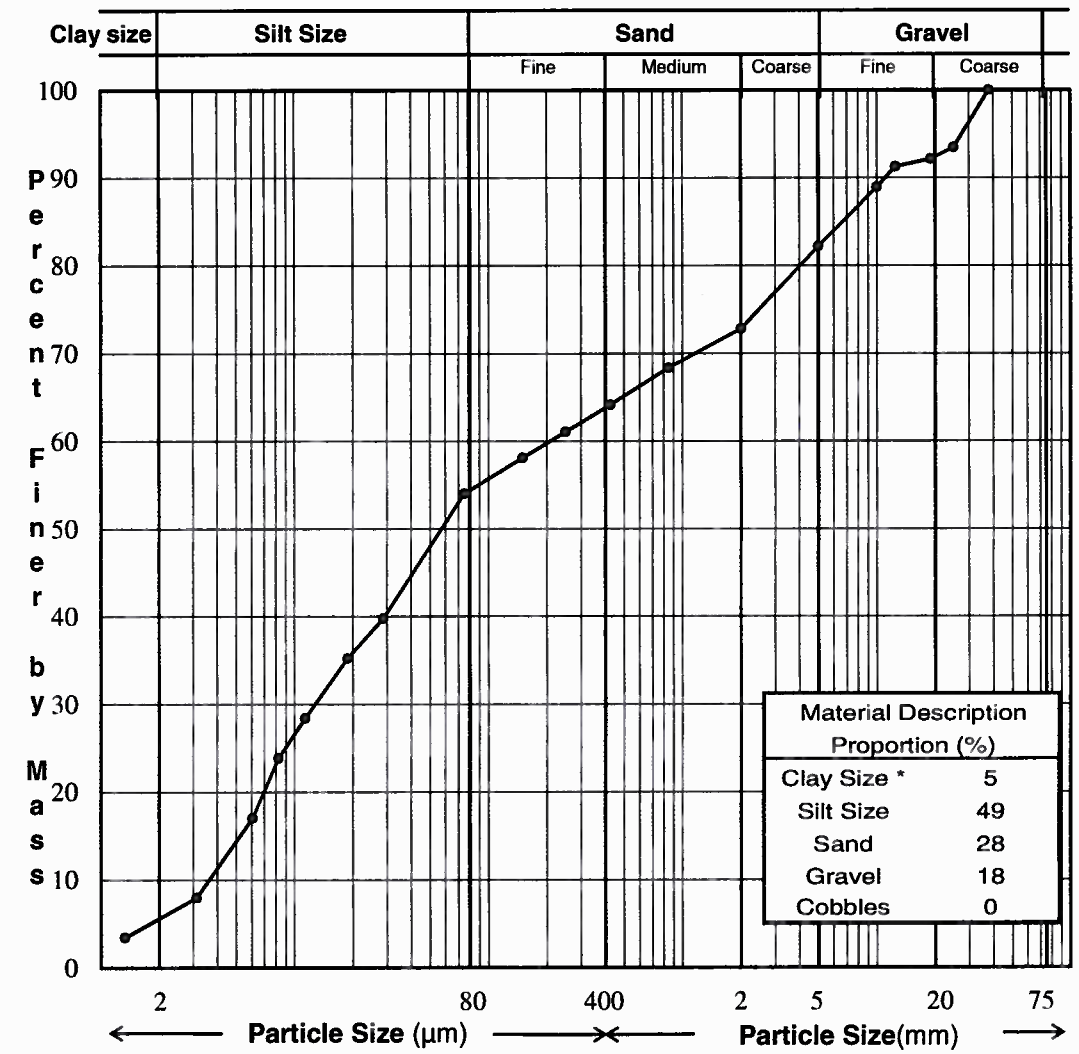
TETRA TECH

PARTICLE SIZE ANALYSIS (Hydrometer) TEST REPORT

ASTM D422

Project:	YOHO Slope Reprofiling	Sample No.:	S01
Client:	Parks Canada	Borehole/ TP:	TP15-07[Hand-dug]
Project No.:	V13403096	Depth:	0.1 m
Location:		Date Tested	June 15, 2015
Description **:	SILT, sandy, some gravel, trace clay	Tested By:	JB

Particle Size	Percent Passing
100 mm	
75 mm	
50 mm	
38 mm	100
25 mm	93
19 mm	92
13 mm	91
10 mm	89
5 mm	82
2 mm	73
850 µm	68
425 µm	64
250 µm	61
150 µm	58
75 µm	54
29 µm	40
19 µm	35
11 µm	28
8 µm	24
6 µm	17
3 µm	8
1 µm	3



Material Description	Proportion (%)
Clay Size *	5
Silt Size	49
Sand	28
Gravel	18
Cobbles	0

Remarks: * The upper clay size of 2 µm is as per the Canadian Foundation Manual.
** The description is behaviour based & subject to EBA description protocols.

Reviewed By: ________________ P.Geol.

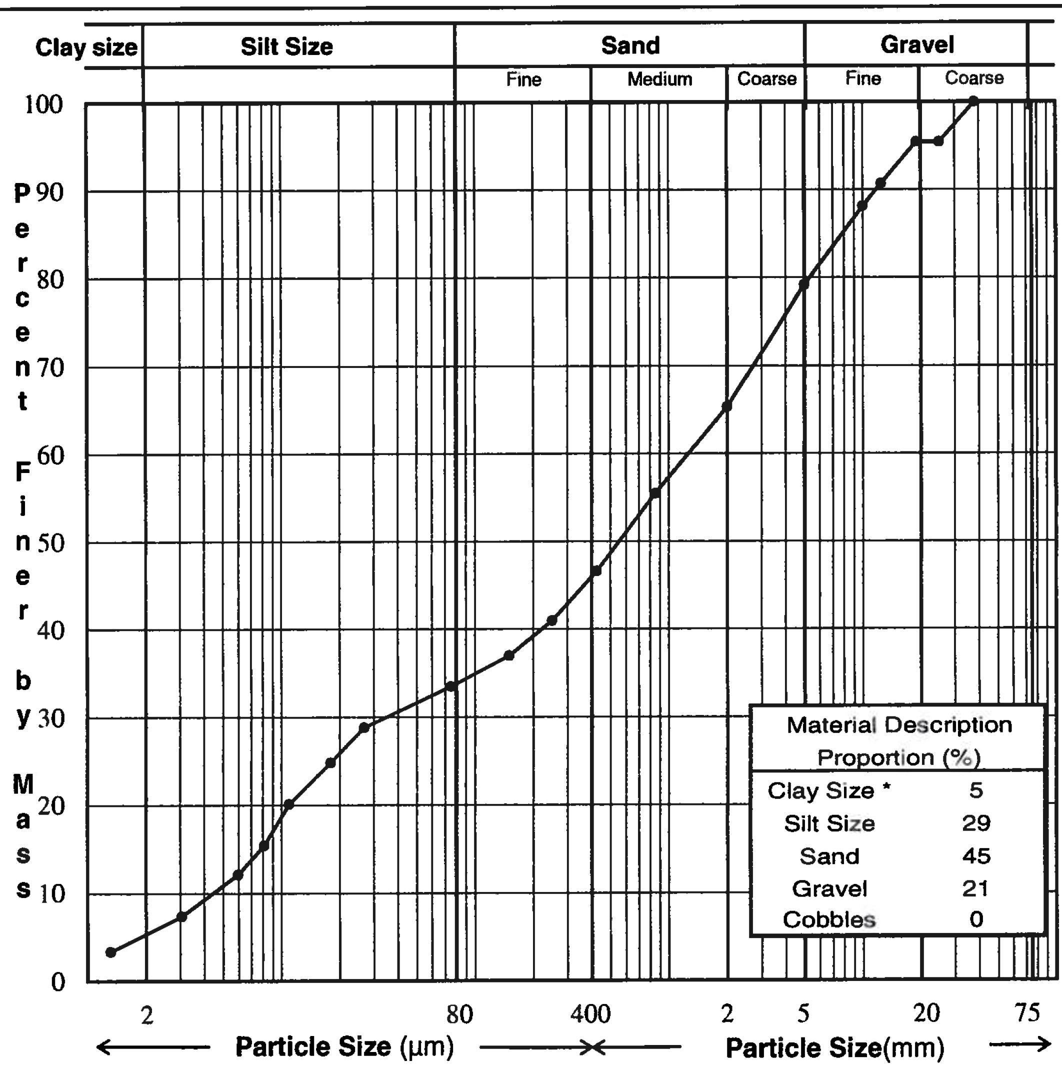
TETRA TECH

PARTICLE SIZE ANALYSIS (Hydrometer) TEST REPORT

ASTM D422

Project:	YOHO Slope Reprofiling	Sample No.:	S01
Client:	Parks Canada	Borehole/ TP:	TP15-08[Hand-dug]
Project No.:	V13403096	Depth:	0.3 m
Location:		Date Tested	June 15, 2015
Description **:	SAND, silty, gravelly, trace clay	Tested By:	JB

Particle Size	Percent Passing
100 mm	
75 mm	
50 mm	
38 mm	100
25 mm	95
19 mm	95
13 mm	91
10 mm	88
5 mm	79
2 mm	65
850 μm	55
425 μm	47
250 μm	41
150 μm	37
75 μm	33
27 μm	29
18 μm	25
11 μm	20
8 μm	15
6 μm	12
3 μm	7
1 μm	3



Material Description Proportion (%)	
Clay Size *	5
Silt Size	29
Sand	45
Gravel	21
Cobbles	0

Remarks: * The upper clay size of 2 μm is as per the Canadian Foundation Manual.
** The description is behaviour based & subject to EBA description protocols.

Reviewed By: ______________________ P.Geol.

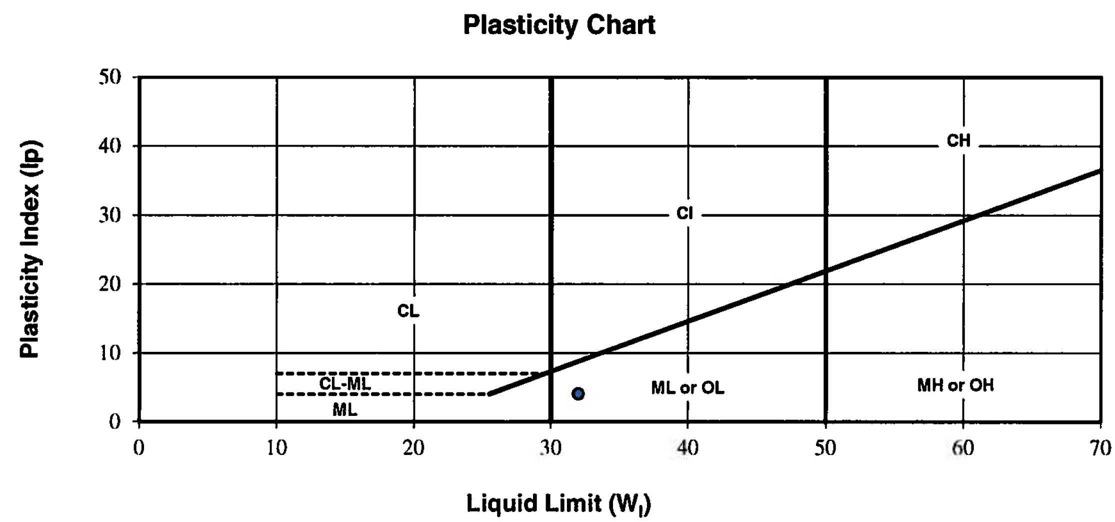
TETRA TECH

ATTERBERG LIMITS TEST REPORT

ASTM D4318

Project:	YOHO Slope Reprofiling	Sample Number:	S01
		Borehole Number:	TP15-07[Hand-dug]
Project No:	V13403096-01	Source:	0.1 m
Client:	Parks Canada	Sampled By:	Tested By: JB
Attention:		Date Sampled:	
Email:		Date Tested:	June 23, 2015

Sample Description: SILT, sandy, some gravel, trace clay



Liquid Limit (W_1):	32	Natural Moisture (%)	9.6
Plastic Limit :	28	Soil Plasticity:	Low
Plasticity Index (Ip) :	4	Mod.USCS Symbol:	ML

Remarks:

Reviewed By: P.Geol.

Data presented hereon is for the sole use of the stipulated client. Tetra Tech EBA is not responsible, nor can be held liable, for use made of this report by any other party, with or without the knowledge of Tetra Tech EBA. The testing services reported herein have been performed to recognized industry standards, unless noted. No other warranty is made. These data do not include or represent any interpretation or opinion of specification compliance or material suitability. Should engineering interpretation be required, Tetra Tech EBA will provide it upon written request.

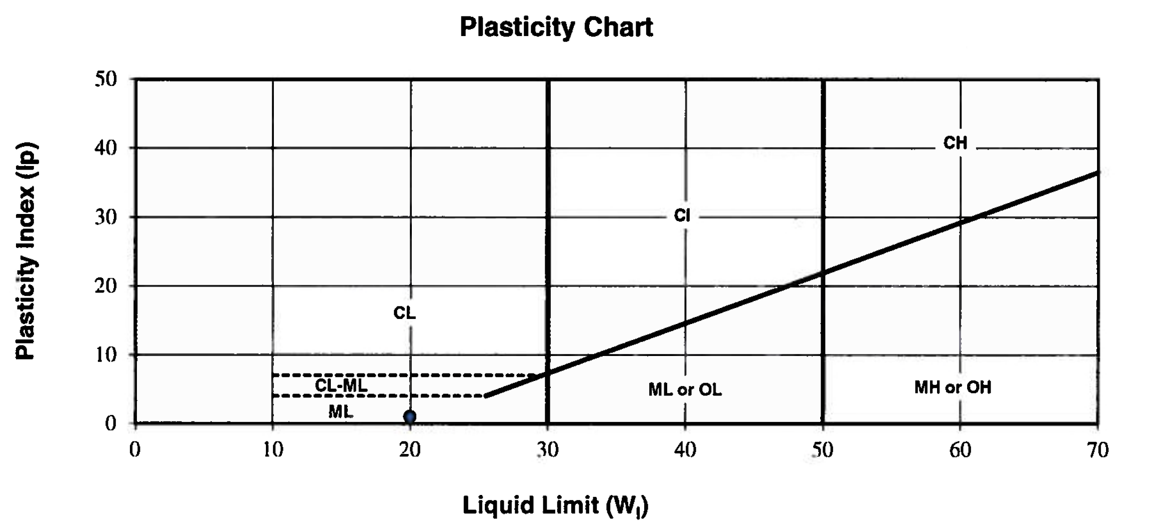
TETRA TECH

ATTERBERG LIMITS TEST REPORT

ASTM D4318

Project:	YOHO Slope Reprofiling	Sample Number:	S01
		Borehole Number:	TP15-08[Hand-dug]
Project No:	V13403096-01	Source:	0.3 m
Client:	Parks Canada	Sampled By:	Tested By: JB
Attention:		Date Sampled:	
Email:		Date Tested:	June 23, 2015

Sample Description: SAND, silty, gravelly, trace clay



Liquid Limit (W_1) :	20	Natural Moisture (%)	7.0
Plastic Limit :	19	Soil Plasticity:	Low
Plasticity Index (Ip) :	1	Mod.USCS Symbol:	ML

Remarks:

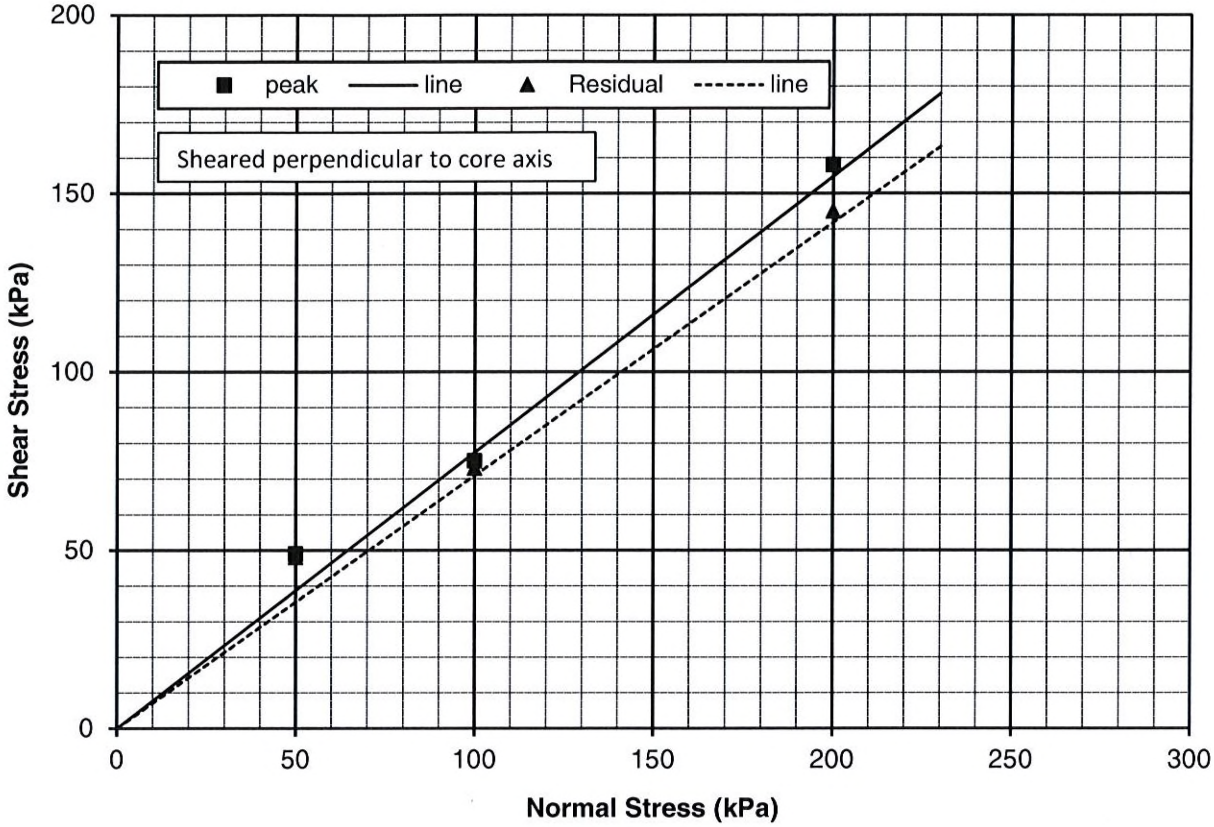
Reviewed By: P.Geol.

TETRA TECH

SUMMARY of DIRECT SHEAR TEST RESULTS

ASTM D3080

Project:	Yoho Slope Reprofiling	Test Hole:	TP15-08[Hand-dug]
Project No.:	**V13403096-01**	Depth:	0.30 m
Client:	**Parks Canada**	Date:	July 13, 2015
Attention:		Tested By:	SK
Email:		Office:	Edmonton

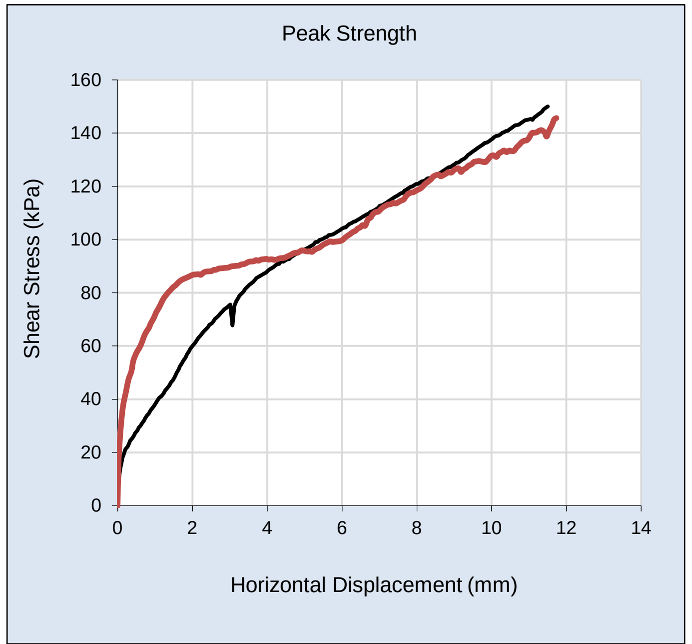


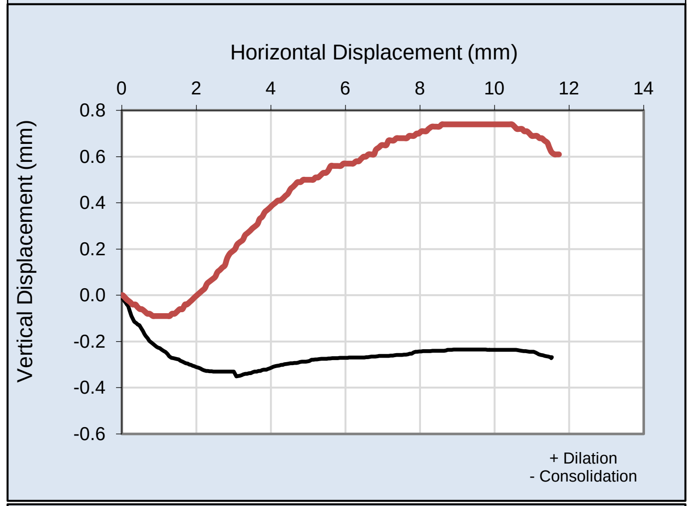
Inferred Shear Strength Parameters :-

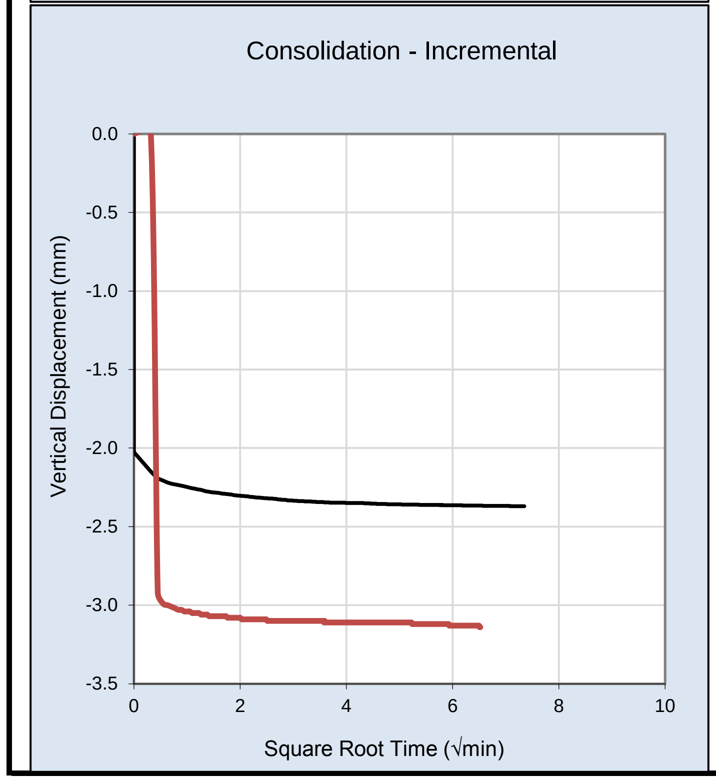
	Cohesion Intercept (kPa)	Inferred Angle of Shearing Resistance (Degrees)
Peak Strength:	**0**	**36.6**
Residual Strength:	**0**	**33.3**

Reviewed By: NJ P.Eng.

TETRA TECH







Project Identification

Project No.	1544214
Client	Tetra Tech EBA
Project	Tetra Tech/Direct Shear/Calgary
Structure	-
Location	-

Sample Identificaton

Borehole	TCH15-UD-01	Sample Date	-
Sample	1A	Depth	-
USCS :	GM	Elevation	-
Description:	SILTY GRAVEL, fine grain, sub angular, non plastic fines; yellow-brown		
Comments:	Sample contained 25% gravel(oversized) material		

Initial - Sample Dimensions

Trial No.	1	2	
Shear box geometry	Circle	Circle	
Graph Line Style			
Diameter, mm	63.5	63.5	
Depth, mm	25.40	25.40	
Area, cm^2	31.67	31.67	
Volume, cm^3	80.44	80.44	

Test Setup Parameters

Test No.	B675.01	B675-02
Sample Type	Undisturbed	Undisturbed
Normal Stress, kPa	75	125
Water type to fill Shear box	Tap	Tap

Sample Parameters

Initial Wet Wt, g	141.00	136.25
Initial Dry Wt, g	129.94	126.45
Initial w, %	8.51	7.75
Initial γ_{wet}, kg/m^3	1753	1694
Initial γ_{dry}, kg/m^3	1615	1572
Final w, % (2mm of shear plane)	n/a	n/a
Final w, % (away fr. shear plane)	16.83	15.72
Consolidated γ_{dry}, kg/m^3	1782	1794
Specific Gravity (assumed)	2.65	2.65
Initial Saturation,%	35.2	29.9
Initial Void Ratio, e	0.640	0.686
Consolidated Void Ratio, e	0.487	0.477

Consolidation Test Results

T90, min	1.21	4.41
T50,min	0.28	1.03
Delta H,mm	-2.37	-3.14
Shear Rate,mm/min (calculated)	0.2830	0.0776
Shear Rate,mm/min (peak)	0.0994	0.1346
Shear Rate,mm/min (residual)	0.0947	0.1329

Test Results (Area Corrected)

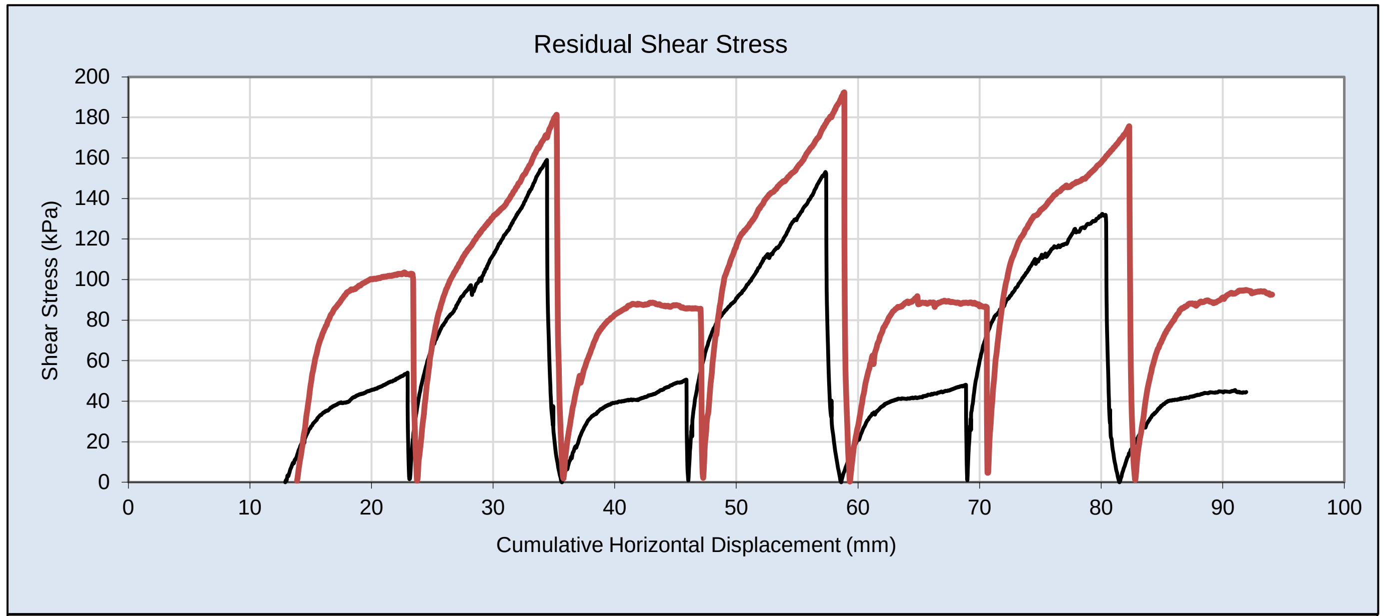
Displacement at Failure, mm	8	10
Peak Normal Stress, kPa	86	147
Peak Shear Stress, kPa	121	131
Displacement at Residual, mm	90	90
Residual Normal Stress, kPa	86	137
Residual Shear Stress, kPa	70	145

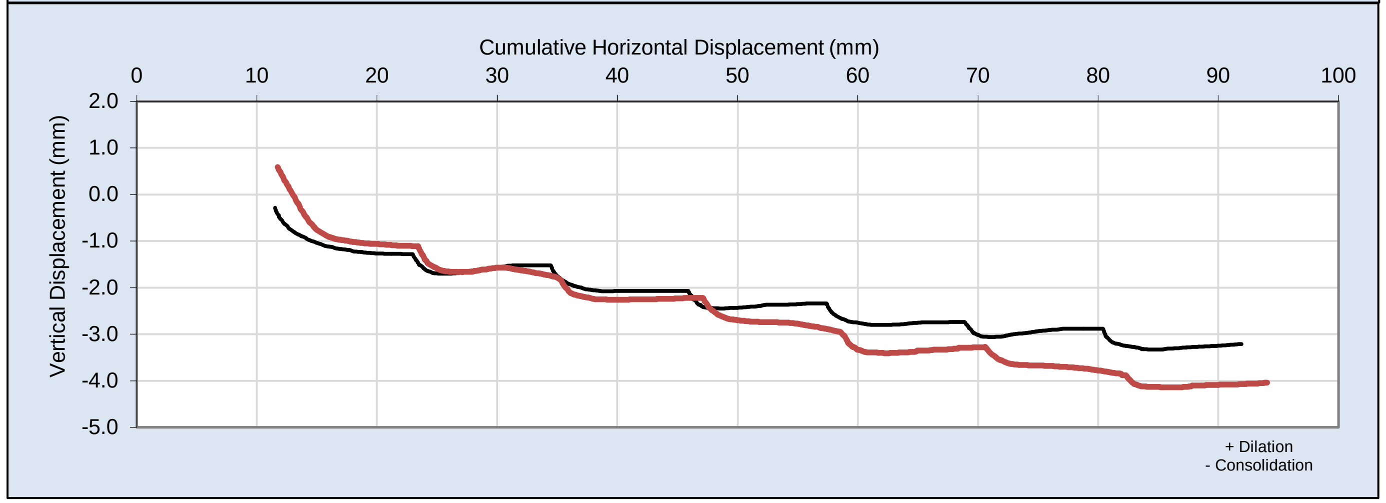
Equipment - KW Soil Direct/Residual Shear Box

Shear Box S/N	763	547
Axial LPT S/N	4024-ch3	4092-ch3
Normal Load Cell S/N	4024-ch4	4092-ch4
Shear Load Cell S/N	4024-ch1	4092-ch1
Vertical LPT S/N	4024-ch2	4092-ch2

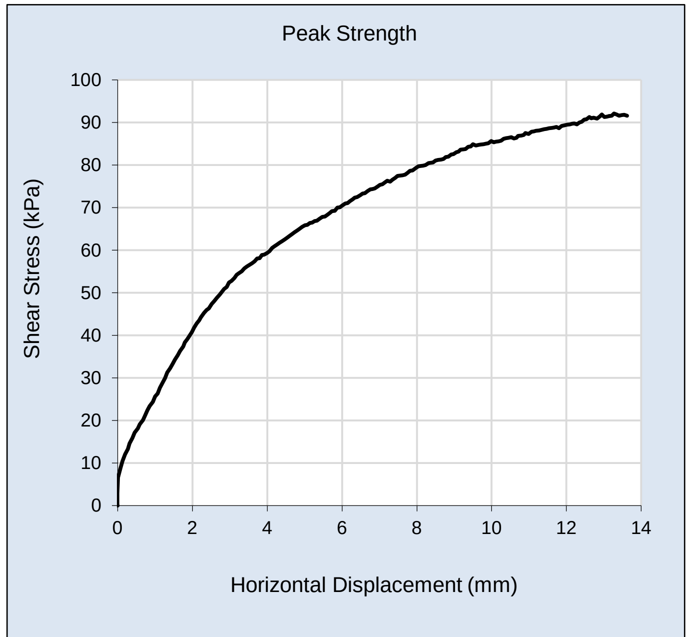
Index Test Results

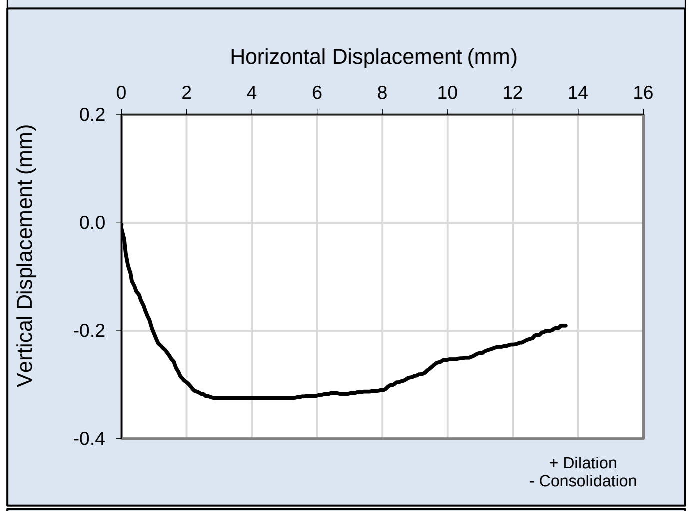
Liquid Limit	-	% Sand	-
Plastic Limit	-	% Silt	-
Plasticity Index	-	% Clay	-

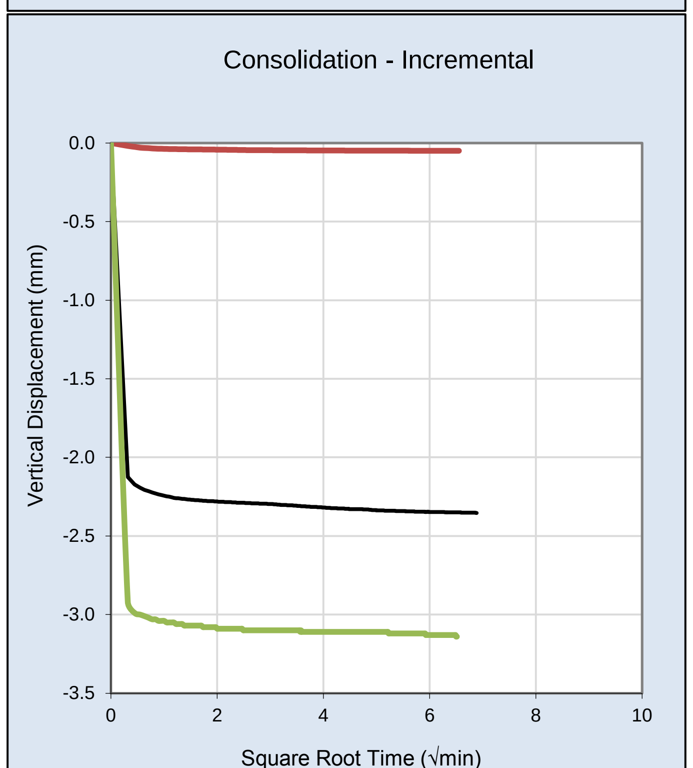




Client: Tetra Tech EBA	Tetra Tech/Direct Shear/Calgary
Golder Associates	DIRECT SHEAR TEST Borehole TCH15-UD-01 Sample 1A







Project Identification

Project No.	1544214
Client	Tetra Tech EBA
Project	Tetra Tech/Direct Shear/Calgary
Structure	-
Location	-

Sample Identificaton

Borehole	TCH15-02	Sample Date	-
Sample	2	Depth	-
USCS :	GM	Elevation	-
Description:	SILTY GRAVEL, fine grain, sub angular, non plastic fines; yellow-brown		
Comments:	Sample contained 25% gravel(oversized) material		

Initial - Sample Dimensions

Trial No.	1	2	3
Shear box geometry	Circle	Circle	Circle
Graph Line Style			
Diameter, mm	63.5	63.5	63.5
Depth, mm	25.40	19.04	25.40
Area, cm^2	31.67	31.67	31.67
Volume, cm^3	80.44	60.29	80.44

Test Setup Parameters

Test No.	B675-03	B675-03	B675-03
Sample Type	Undisturbed	Undisturbed	Undisturbed
Normal Stress, kPa	75	100	125
Water type to fill Shear box	Tap	Tap	Tap

Sample Parameters

Initial Wet Wt, g	146.90	-	140.36
Initial Dry Wt, g	126.93	-	121.94
Initial w, %	15.73	-	15.11
Initial γ_{wet}, kg/m^3	1826	-	1745
Initial γ_{dry}, kg/m^3	1578	-	1516
Final w, % (2mm of shear plane)	n/a	n/a	n/a
Final w, % (away fr. shear plane)	17.00	-	15.97
Consolidated γ_{dry}, kg/m^3	1739	-	1730
Specific Gravity (assumed)	2.65	2.65	2.65
Initial Saturation,%	61.4	-	53.5
Initial Void Ratio, e	0.679	-	0.748
Consolidated Void Ratio, e	0.524	-	0.532

Consolidation Test Results

T90, min	1.21	4.41	1.44
T50,min	0.28	1.03	0.34
Delta H,mm	-2.35	-0.05	-3.14
Shear Rate,mm/min (calculated)	0.2830	-	-
Shear Rate,mm/min (peak)	0.1337	-	-
Shear Rate,mm/min (residual)	0.1306	0.1304	0.1304

Test Results (Area Corrected)

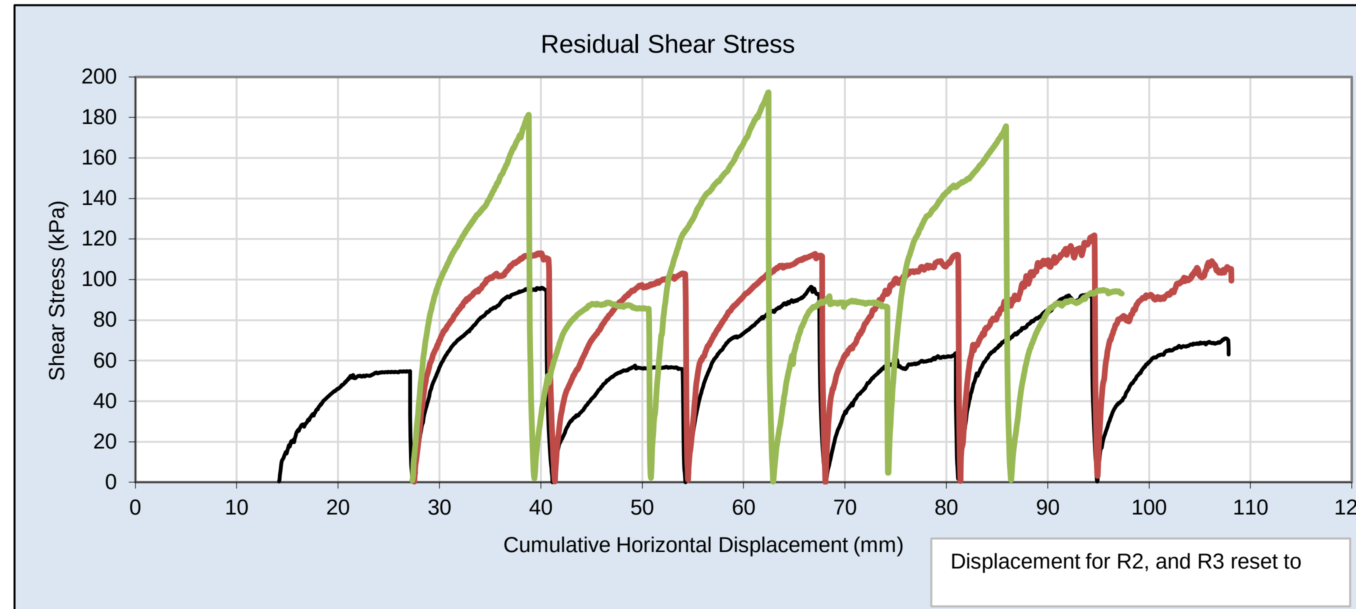
Displacement at Failure, mm	14	-	-
Peak Normal Stress, kPa	76	-	-
Peak Shear Stress, kPa	92	-	-
Displacement at Residual, mm	90.00	90.00	80.00
Residual Normal Stress, kPa	86	110	134
Residual Shear Stress, kPa	59	108	143

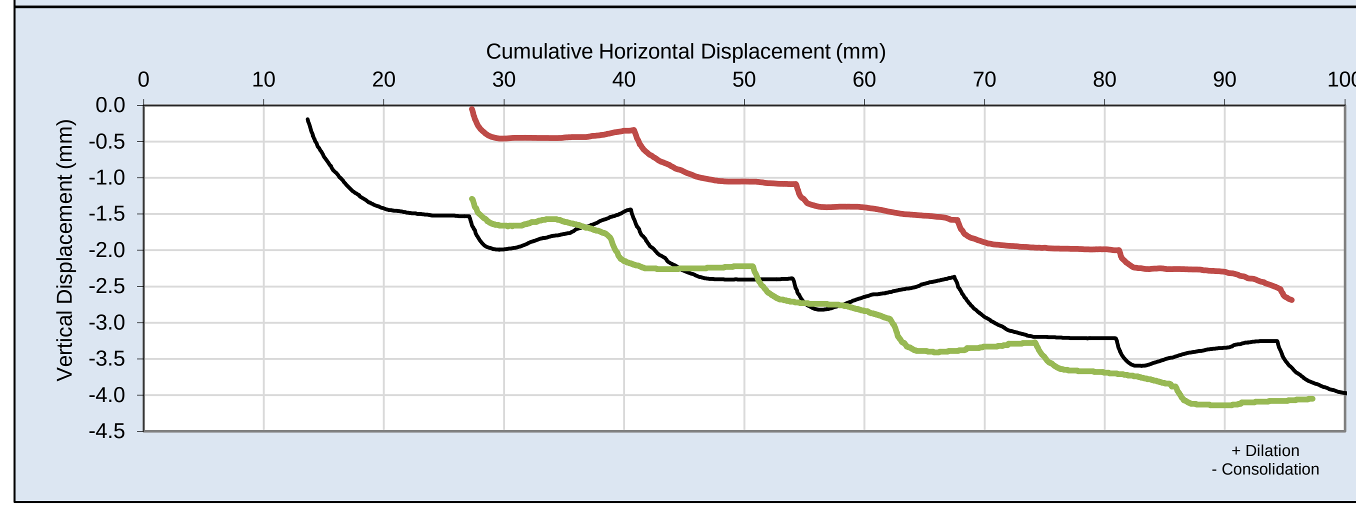
Equipment - KW Soil Direct/Residual Shear Box

Shear Box S/N	842	842	842
Axial LPT S/N	4120-ch3	4120-ch3	4120-ch3
Normal Load Cell S/N	4120-ch4	4120-ch4	4120-ch4
Shear Load Cell S/N	4120-ch1	4120-ch1	4120-ch1
Vertical LPT S/N	4120-ch2	4120-ch2	4120-ch2

Index Test Results

Liquid Limit	-	% Sand	23
Plastic Limit	-	% Silt	42
Plasticity Index	-	% Clay	9





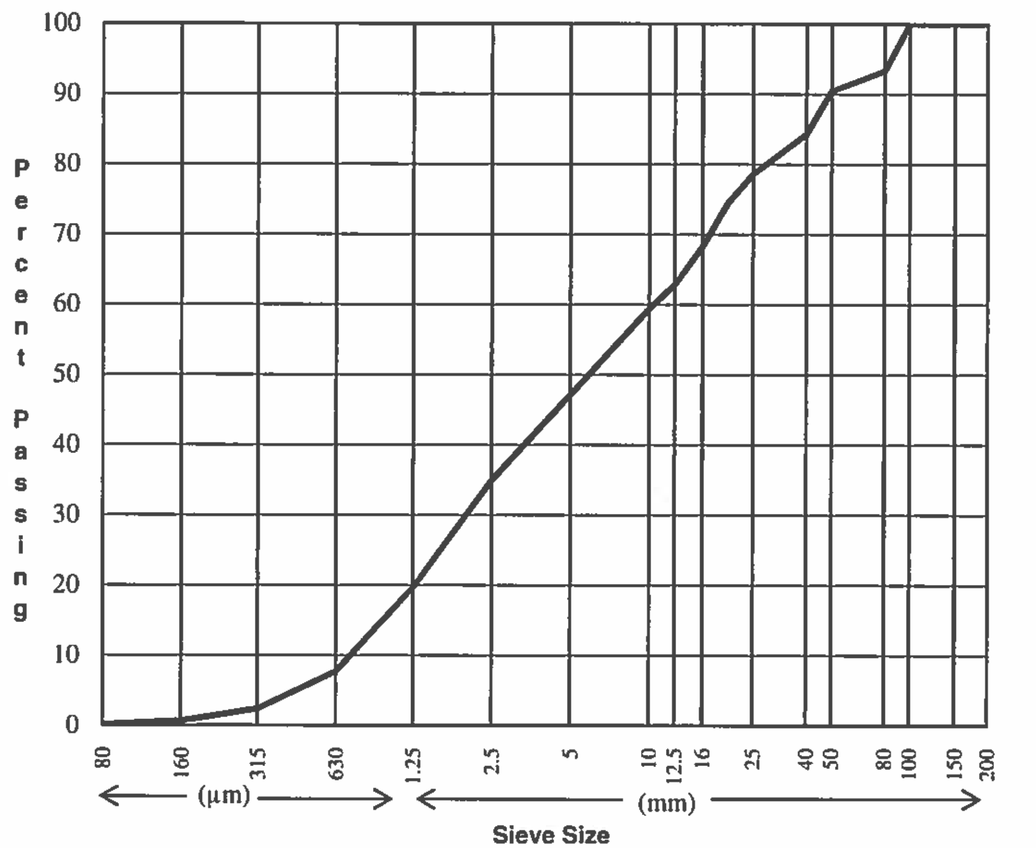
Client: Tetra Tech EBA	Tetra Tech/Direct Shear/Calgary
Golder Associates	DIRECT SHEAR TEST Borehole TCH15-02 Sample 2

SIEVE ANALYSIS REPORT

ASTM C136, C117

Project:	Yoho National Park	Sample No.:	TP15-01
Client:	Parks Canada	Date Sampled:	October 9, 2015
Project No.:	V13403095-02	Sampled By:	
Attention:		Date Tested:	November 4, 2015
Description:	GRAVEL and SAND	Tested By: JB	Lab: Calgary
Source:	TP15-01	No. Crushed Faces:	
Location:	0.5 m	Moisture Content:	5.4%
Specification:			

Sieve Size	Percent Passing
200 mm	
150 mm	
100 mm	100
80 mm	93
50 mm	90
40 mm	84
25 mm	79
20 mm	74
16 mm	68
12.5 mm	63
10 mm	59
5 mm	47
2.5 mm	35
1.25 mm	20
630 µm	8
315 µm	2
160 µm	1
80 µm	0.1



Remarks:

Reviewed By: ____________________ P.Geol.

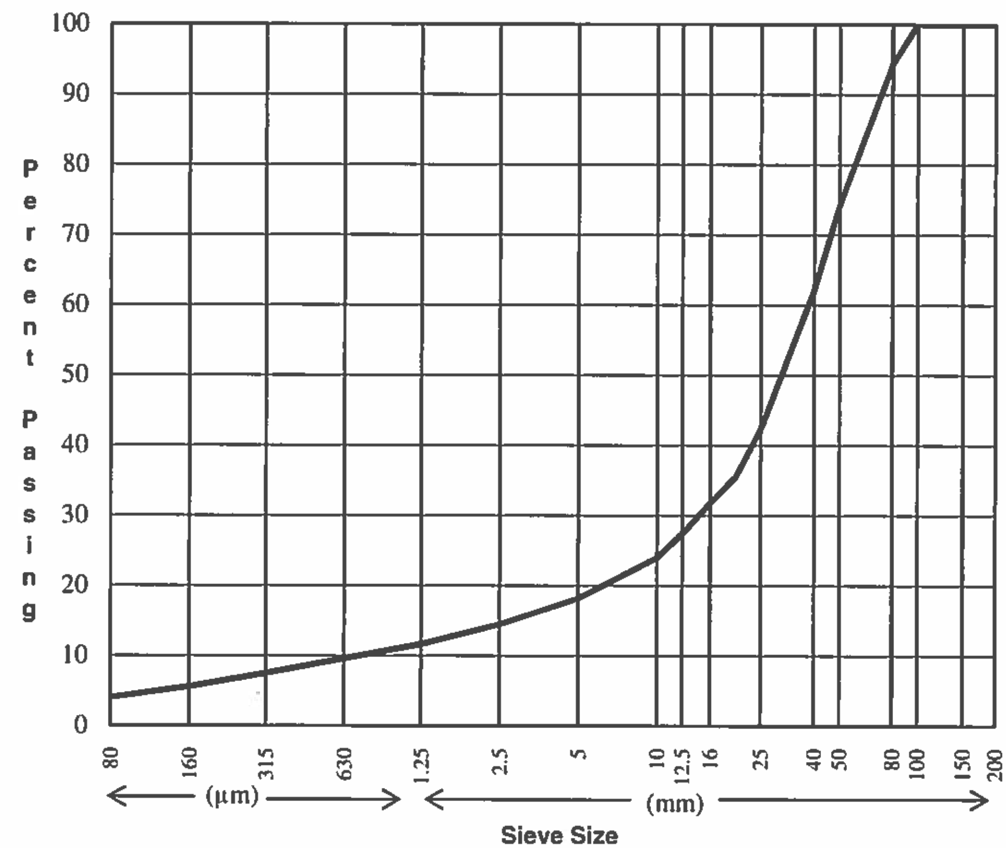
TETRA TECH

SIEVE ANALYSIS REPORT

ASTM C136, C117

Project:	Yoho National Park	Sample No.:	TP15-02
Client:	Parks Canada	Date Sampled:	October 9, 2015
Project No.:	V13403095-02	Sampled By:	
Attention:		Date Tested:	November 4, 2015
Description:	GRAVEL, some sand, trace silt	Tested By: JB	Lab: Calgary
Source:	TP15-02	No. Crushed Faces:	
Location:	1.2 m	Moisture Content:	3.4%
Specification:			

Sieve Size	Percent Passing
200 mm	
150 mm	
100 mm	100
80 mm	94
50 mm	74
40 mm	62
25 mm	42
20 mm	35
16 mm	32
12.5 mm	27
10 mm	24
5 mm	18
2.5 mm	14
1.25 mm	12
630 µm	10
315 µm	7
160 µm	6
80 µm	4.0



Remarks:

Reviewed By: ________________ P.Geol.

Data presented hereon is for the sole use of the stipulated client. Tetra Tech EBA is not responsible, nor can be held liable, for use made of this report by any other party, with or without the knowledge of EBA. The testing services reported herein have been performed to recognized industry standards, unless noted. No other warranty is made. These data do not include or represent any interpretation or opinion of specification compliance or material suitability. Should engineering interpretation be required, EBA will provide it upon written request.

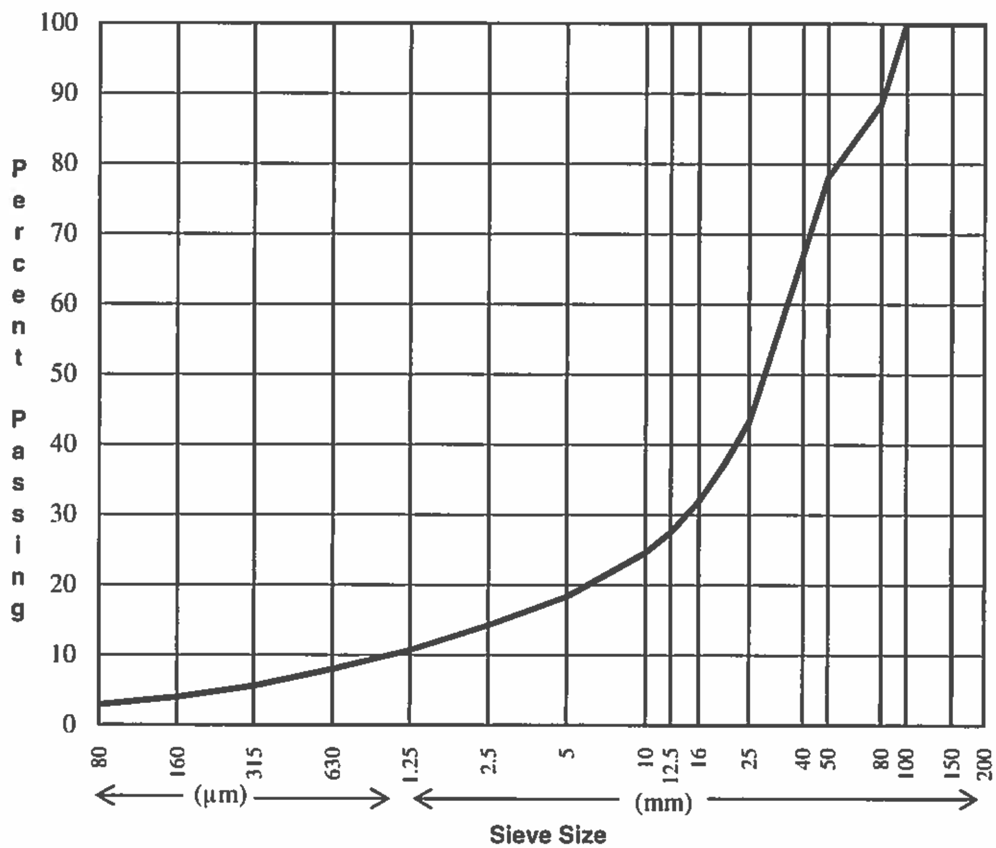
TETRA TECH

SIEVE ANALYSIS REPORT

ASTM C136, C117

Project:	Yoho National Park	Sample No.:	TP15-03
Client:	Parks Canada	Date Sampled:	October 9, 2015
Project No.:	V13403095-02	Sampled By:	
Attention:		Date Tested:	November 4, 2015
Description:	GRAVEL, some sand, trace silt	Tested By:	JB Lab: Calgary
Source:	TP15-03	No. Crushed Faces:	
Location:	1.0 m	Moisture Content:	2.8%
Specification:			

Sieve Size	Percent Passing
200 mm	
150 mm	
100 mm	100
80 mm	89
50 mm	78
40 mm	67
25 mm	43
20 mm	37
16 mm	32
12.5 mm	28
10 mm	25
5 mm	18
2.5 mm	14
1.25 mm	11
630 µm	8
315 µm	6
160 µm	4
80 µm	2.9



Remarks:

Reviewed By: ____________ P.Geol.

TETRA TECH

APPENDIX G
TETRA TECH EBA'S GENERAL CONDITIONS

GENERAL CONDITIONS

GEOTECHNICAL REPORT

This report incorporates and is subject to these "General Conditions".

1.0 USE OF REPORT AND OWNERSHIP

This geotechnical report pertains to a specific site, a specific development and a specific scope of work. It is not applicable to any other sites nor should it be relied upon for types of development other than that to which it refers. Any variation from the site or development would necessitate a supplementary geotechnical assessment.

This report and the recommendations contained in it are intended for the sole use of Tetra Tech EBA's Client. Tetra Tech EBA does not accept any responsibility for the accuracy of any of the data, the analyses or the recommendations contained or referenced in the report when the report is used or relied upon by any party other than Tetra Tech EBA's Client unless otherwise authorized in writing by Tetra Tech EBA. Any unauthorized use of the report is at the sole risk of the user.

This report is subject to copyright and shall not be reproduced either wholly or in part without the prior, written permission of Tetra Tech EBA. Additional copies of the report, if required, may be obtained upon request.

2.0 ALTERNATE REPORT FORMAT

Where Tetra Tech EBA submits both electronic file and hard copy versions of reports, drawings and other project-related documents and deliverables (collectively termed Tetra Tech EBA's instruments of professional service), only the signed and/or sealed versions shall be considered final and legally binding. The original signed and/or sealed version archived by Tetra Tech EBA shall be deemed to be the original for the Project.

Both electronic file and hard copy versions of Tetra Tech EBA's instruments of professional service shall not, under any circumstances, no matter who owns or uses them, be altered by any party except Tetra Tech EBA. Tetra Tech EBA's instruments of professional service will be used only and exactly as submitted by Tetra Tech EBA.

Electronic files submitted by Tetra Tech EBA have been prepared and submitted using specific software and hardware systems. Tetra Tech EBA makes no representation about the compatibility of these files with the Client's current or future software and hardware systems.

3.0 ENVIRONMENTAL AND REGULATORY ISSUES

Unless stipulated in the report, Tetra Tech EBA has not been retained to investigate, address or consider and has not investigated, addressed or considered any environmental or regulatory issues associated with development on the subject site.

4.0 NATURE AND EXACTNESS OF SOIL AND ROCK DESCRIPTIONS

Classification and identification of soils and rocks are based upon commonly accepted systems and methods employed in professional geotechnical practice. This report contains descriptions of the systems and methods used. Where deviations from the system or method prevail, they are specifically mentioned.

Classification and identification of geological units are judgmental in nature as to both type and condition. Tetra Tech EBA does not warrant conditions represented herein as exact, but infers accuracy only to the extent that is common in practice.

Where subsurface conditions encountered during development are different from those described in this report, qualified geotechnical personnel should revisit the site and review recommendations in light of the actual conditions encountered.

5.0 LOGS OF TESTHOLES

The testhole logs are a compilation of conditions and classification of soils and rocks as obtained from field observations and laboratory testing of selected samples. Soil and rock zones have been interpreted. Change from one geological zone to the other, indicated on the logs as a distinct line, can be, in fact, transitional. The extent of transition is interpretive. Any circumstance which requires precise definition of soil or rock zone transition elevations may require further investigation and review.

6.0 STRATIGRAPHIC AND GEOLOGICAL INFORMATION

The stratigraphic and geological information indicated on drawings contained in this report are inferred from logs of test holes and/or soil/rock exposures. Stratigraphy is known only at the locations of the test hole or exposure. Actual geology and stratigraphy between test holes and/or exposures may vary from that shown on these drawings. Natural variations in geological conditions are inherent and are a function of the historic environment. Tetra Tech EBA does not represent the conditions illustrated as exact but recognizes that variations will exist. Where knowledge of more precise locations of geological units is necessary, additional investigation and review may be necessary.

7.0 PROTECTION OF EXPOSED GROUND

Excavation and construction operations expose geological materials to climatic elements (freeze/thaw, wet/dry) and/or mechanical disturbance which can cause severe deterioration. Unless otherwise specifically indicated in this report, the walls and floors of excavations must be protected from the elements, particularly moisture, desiccation, frost action and construction traffic.

8.0 SUPPORT OF ADJACENT GROUND AND STRUCTURES

Unless otherwise specifically advised, support of ground and structures adjacent to the anticipated construction and preservation of adjacent ground and structures from the adverse impact of construction activity is required.

9.0 INFLUENCE OF CONSTRUCTION ACTIVITY

There is a direct correlation between construction activity and structural performance of adjacent buildings and other installations. The influence of all anticipated construction activities should be considered by the contractor, owner, architect and prime engineer in consultation with a geotechnical engineer when the final design and construction techniques are known.

10.0 OBSERVATIONS DURING CONSTRUCTION

Because of the nature of geological deposits, the judgmental nature of geotechnical engineering, as well as the potential of adverse circumstances arising from construction activity, observations during site preparation, excavation and construction should be carried out by a geotechnical engineer. These observations may then serve as the basis for confirmation and/or alteration of geotechnical recommendations or design guidelines presented herein.

11.0 DRAINAGE SYSTEMS

Where temporary or permanent drainage systems are installed within or around a structure, the systems which will be installed must protect the structure from loss of ground due to internal erosion and must be designed so as to assure continued performance of the drains. Specific design detail of such systems should be developed or reviewed by the geotechnical engineer. Unless otherwise specified, it is a condition of this report that effective temporary and permanent drainage systems are required and that they must be considered in relation to project purpose and function.

12.0 BEARING CAPACITY

Design bearing capacities, loads and allowable stresses quoted in this report relate to a specific soil or rock type and condition. Construction activity and environmental circumstances can materially change the condition of soil or rock. The elevation at which a soil or rock type occurs is variable. It is a requirement of this report that structural elements be founded in and/or upon geological materials of the type and in the condition assumed. Sufficient observations should be made by qualified geotechnical personnel during construction to assure that the soil and/or rock conditions assumed in this report in fact exist at the site.

13.0 SAMPLES

Tetra Tech EBA will retain all soil and rock samples for 30 days after this report is issued. Further storage or transfer of samples can be made at the Client's expense upon written request, otherwise samples will be discarded.

14.0 INFORMATION PROVIDED TO TETRA TECH EBA BY OTHERS

During the performance of the work and the preparation of the report, Tetra Tech EBA may rely on information provided by persons other than the Client. While Tetra Tech EBA endeavours to verify the accuracy of such information when instructed to do so by the Client, Tetra Tech EBA accepts no responsibility for the accuracy or the reliability of such information which may affect the report.