

Parks Canada Agency

ISSUED FOR USE

GEOTECHNICAL AND PAVEMENT ASSESSMENT  
TRANS CANADA HIGHWAY TWINNING PROJECT KM 82-88  
ALBERTA AND BRITISH COLUMBIA, CANADA

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## 1.0 INTRODUCTION

EBA Engineering Consultants Ltd. (EBA) is pleased to submit the following report outlining our preliminary Geotechnical/Pavement Assessment for the proposed twinning of the Trans Canada Highway (TCH) between Km 82+000 and 88+000. The work has been undertaken for Parks Canada Agency (PCA), with preliminary road design information provided by McElhanney Consulting Services Ltd. (McElhanney), by email dated August 23, 2010. We understand that this report will be used for the Environmental Assessment and furthering the design of twinning this section of the TCH.

This report contains factual data from a subsurface investigation as well as preliminary analysis and design recommendations.

## 2.0 PROJECT DETAILS

The following list a general summary of anticipated construction based on the plan and cross sections provided by McElhanney:

- New border welcome stations for eastbound and westbound lanes, between Km 81+600 and Km 82+100 involving significant fills along the south side of the highway;
- Four proposed wildlife crossings;
- General highway widening; and
- Potential rock cuts between approximately Km 83+400 and Km 84+900.

The cross sections indicate that the vertical alignment of the twinned highway will remain very close to the existing vertical alignment. No significant horizontal realignments are proposed at this stage of the design.

## 3.0 SCOPE OF WORK

EBA's scope of work was detailed in the proposal titled "Work Plan and Cost Estimate: Geotechnical, Environmental, and Avalanche Studies, TCH Twinning Project Km 82-88" dated August 23, 2010. Authorization to proceed was received from PCA on August 24, 2010. The general site location is shown on Figure 1. The environmental and avalanche reports will be prepared as stand alone documents and are not discussed within this report.

The scope of work for the Geotechnical/Pavement Assessment included the following tasks:

- Shallow drilling investigation to assess the existing pavement structure and subgrade materials;
- Deep drilling to assess the potential for settlement or instability in areas requiring large fills;



- Test pitting to assess native soil conditions in areas outside of the existing road alignment;
- Lab testing of samples obtained during drilling and test pitting;
- Recommendations for rock and soil slope stability;
- Geotechnical considerations for soft or compressible soils where encountered;
- Bulking and shrinkage factors for soils encountered along the highway alignment;
- Assessment of borrow pit potential; and
- Pavement recommendations.

We understand that the easternmost two kilometres of highway construction may be tendered in the winter of 2011 for potential construction in early spring. Therefore we have been requested to provide detailed design information for this section of the project.

The deep rotary drilling was not completed due to delays in obtaining permits for the drilling investigation and drill rig availability. Recommendations have been provided in Section 5 where further investigation should be considered.

## 4.0 BACKGROUND REVIEW

### 4.1 DOCUMENTS REVIEWED

A limited desktop review was conducted in which existing project information was collected and reviewed. EBA reviewed the following documents as part of the desktop review:

- Letter Report titled “Geotechnical Investigation KM 76 to 83, Trans Canada Highway, near Lake Louise, Alberta, Canada” prepared by EBA, dated April, 2009;
- Letter Report titled “Trans Canada Highway Section 1 – Km 65.5 to 71.5 plus ramps, Section 2 – KM 44 to 55, Section 3 – Km 73.5 to 83, and Section 4 Km 264 to 44, Banff National Park, Pavement Design Report” prepared by LVM, Jegel, dated March 12, 2010;
- Letter Report titled “Geotechnical Investigation Twinning of Trans Canada Highway Kilometre 48 to 83 Banff National Park” prepared by EBA, dated January 8, 2004.

## 5.0 GEOTECHNICAL/PAVEMENTS INVESTIGATION

### 5.1 SUBSURFACE INVESTIGATION PROGRAM

Truck mounted auger drilling was completed to characterize the existing pavement structure and the shallow subsurface material. Test pits were excavated adjacent to the existing highway outside the existing embankment, where possible, to investigate the shallow



subsurface conditions in natural materials and obtain samples from a proposed borrow location to assess borrow material suitability.

Traffic control for all activities during the investigation was provided by Crossroads Traffic Control from Golden, BC. Coordinates were obtained with a hand held GPS unit and surveying of borehole and test pit locations is currently being undertaken by others. Utility locates for borehole and test pit locations were completed in advance of the site investigations by Advanced Location Services. EBA provided full time supervision of utility locates, drilling, testing pitting and logged soil, rock and groundwater conditions and obtained representative disturbed samples. Figures 2 through 10 provide the locations of all test pits and boreholes, based on GPS coordinates.

### 5.1.1 Test Pitting Investigation

The test pitting investigation was completed between September 29, 2010 and October 1, 2010 using a 2007 Hitachi ZX 200 LC3 tracked excavator operated and supplied by Dawson Construction Ltd. of Kamloops, B.C. A total of 23 test pits were excavated during the investigation with 16 on the north side of the TCH and 7 on the south side of the TCH. Test pit locations were located in advance outside of environmentally or potentially environmentally sensitive areas and in locations that could be safely accessed by the excavator.

Test pits were excavated to depths between 0.7 m and 4.3 m. Excavation of test pits was terminated once refusal was encountered, the reach of the excavator was exhausted, the test pit depth was deemed to be sufficient, or excessive seepage causing caving was encountered.

Written logs were recorded in the field, including visual descriptions and thicknesses of all soil layers encountered. Disturbed soil samples were collected at selected locations for further soil classification and laboratory testing. Particles larger than 75 mm in diameter were excluded from the samples. Detailed test pit logs and laboratory testing results are presented in Appendix A and B respectively.

### 5.1.2 Drilling Investigation

The drilling investigation was completed between September 28, 2010 and September 29, 2010. Beck Drilling and Environmental Services Ltd. from Calgary, Alberta provided the drilling services.

A truck mounted solid stem auger drill rig was used to assess pavement structure conditions and layer thicknesses. Shallow drilling refusal was encountered at some borehole locations. Auger drills are unable to penetrate large, frequent cobbles and boulders and drill refusal likely resulted when these soil conditions were encountered. Final borehole depths ranged between 1.1 m and 9.1 m.



## 5.2 SUBSURFACE CONDITIONS

### 5.2.1 Test Pits

The soil conditions encountered at the 23 test pit locations were reasonably consistent, as shown on the test pit logs. A typical soil profile encountered in the test pits included a thin layer of topsoil, underlain by gravelly sand and silt to approximately 0.5 m, underlain by sand and gravel mixtures to the limit of excavation. The sand and gravel mixtures also contained variable quantities of cobbles and boulders. Thin layers and lenses of low plastic silt and clay at depths of approximately 0.1 to 0.5 m were found at some locations.

Two test pits located at the base of a rock slope (TP2010-12 and TP2010-14) contained bedrock at depths of 0.25 and 0.6 m. The upper 0.5 to 0.75 m of the bedrock was found to be rippable.

### 5.2.2 Auger Drilling

Shallow auger holes were advanced approximately every 500 m alternating between the west and east bound lanes to assess the existing pavement structure. One additional borehole (AH2010-12) was drilled in a pullout area near the BC/Alberta border. Boreholes were drilled in the center of the lanes and on the shoulders. Care was taken to select borehole locations outside of the wheel path of the lanes.

Asphalt thicknesses on the highway ranged between 140 mm and 250 mm at the borehole locations. Pavement thickness in borehole AH2010-12 located in the pullout area was 75 mm thick.

A contrast between layers of crushed base course and sub base was not observed in the auger holes. Typically the granular portion of the pavement structure consisted of gravelly sand with varying amounts of cobbles and silt. Based on colour, AH2010-01, AH2010-03 and AH2010-05 may have been derived from a different borrow source. Underlying the asphalt in AH2010-08 was reddish brown sand with some gravel, silt and cobbles to a depth of 1.4 m, where refusal was encountered. In general the gravel and cobbles ranged from sub-rounded to angular. The pavement subgrade typically had a fines content ranging between 5 and 10% and contained some material larger than 75 mm, which would not meet PCA and MoT specifications for base or sub base.

In boreholes AH2010-01, AH2010-02, AH2010-06, AH2010-07, AH2010-09, AH2010-10 and AH2010-11 the gravelly sand material extended to the end of the holes. In AH2010-4 and AH2010-12 the gravelly sand material graded to sand with varying amounts of gravel and silt at approximately 2 m depth to the limits of the boreholes. At 3.0 m depth in AH2010-03 and AH2010-05 silty layers with varying amounts of sand and gravel were encountered.

Refusal due to boulders occurred while drilling AH2010-02, AH2010-06, AH2010-08, AH2010-09, AH2010-10 and AH2010-11. In general, material recovery became very poor beyond 6 m.



### 5.3 LABORATORY TESTING

Laboratory testing was completed on disturbed soil samples obtained during drilling and test pitting. Sieve analyses, hydrometers, fracture counts, and moisture contents were completed on discrete soil layers to supplement the investigations. Lab testing results are included on the borehole and test pit logs in Appendix A. Grain size analyses are included in Appendix B.

### 5.4 GROUND WATER CONDITIONS

At the time of drilling seepage was encountered in a number of drill holes and test pits. Groundwater was noted at the following locations:

**TABLE 1: GROUND WATER CONDITIONS**

Borehole Name	Depth to Seepage (m)	Groundwater Elevation (m)	Comments
AH2010-01	Between 3 and 4.6	Between 1557.6 and 1559.2	Extracted material changed from dry to wet between these depths
AH2010-05	4.5	1587	Extracted material became wet at 4.5 m
TP2010-01	1.5	1560.3	Excavation filled with water
TP2010-06	1.6	1585.8	Excavation filled with water
TP2010-07	1.8	1586.4	Excavation filled with water

Groundwater was not observed at other locations.

## 6.0 GEOTECHNICAL RECOMMENDATIONS AND CONSIDERATIONS

### 6.1 GENERAL

In general the subsurface conditions appear to be satisfactory for the proposed highway twinning.

Subsurface investigation indicates that stripping of the upper 0.3 to 0.5 m will be required to remove soil with a high organic content, prior to placing road fill. Forested areas may require additional stripping and grubbing to remove roots and organics. In localized areas deeper excavation may be required to remove compressible soils or stumps.

The proposed twinning requires widening of the road prism by placing additional fill adjacent to the existing embankment. When placing new fill it is important to remove all loose material and organics from the edge of the existing embankment and 'key-in' the new fill by benching the existing embankment to ensure adequate compaction of the interface between the new and existing fill.



### 6.1.1 Kilometre 81+600 to 82+100

As outlined in Section 2.0 significant widening is required between Km 81+600 and Km 82+100 for construction of the new welcome stations. Construction of the welcome stations will involve fills of up to 14 m in height, which will exert significant loading on the underlying subgrade soils.

Due to access constraints all of the test pits were completed along the north side of the highway in this section and no investigation has been undertaken to the south of the highway where the large fills are proposed. The subsurface conditions to the north of the highway consist of sand and gravels, and dense till-like soils (over-consolidated). These soil conditions are not highly settlement prone and the majority of settlement is expected to occur during fill placement.

Due to the height of the proposed fills and the distance they extend beyond the existing embankment, additional investigation is recommended to the south of the highway. The proposed embankment extends as much as 60 m beyond the existing embankment and the investigation completed is not considered sufficient to rule out the presence of soft soils and associated settlement concerns in all areas.

Should compressible soils be encountered they would likely require sub excavation and/or preloading to minimize differential settlement of the proposed and existing fill embankments.

Additional investigation could occur when access is created for the initial stages of construction, in the spring of 2011. Alternatively PCA could accept the risk of settlement and/or increased construction costs should significant over excavation be required.

### 6.1.2 Kilometre 82+100 to 83+300

The section of highway twinning between Km 82+100 and Km 83+000 generally involves cut slopes up to 10 m in height along the north side of the highway and fills up to 5 m in height along the south side of the highway. Recommended slopes for cut and fill areas are provided in Section 5.2.

Soil conditions generally consist of sand and gravel material to the north of the highway, with some silt identified south of the highway near Km 82+500. If the silt zone is continuous along the south side of the highway differential settlement of the fill slopes may be a concern.

One wildlife crossing is proposed near Km 83+700. Investigations of the subsurface conditions at the proposed locations of the wildlife crossings were not part of EBA's scope of work. Future investigation of the overpass structures will provide valuable information for assessing the potential for compressible soils, as identified above.



### 6.1.3 Kilometre 83+300 to 85+800

Shallow bedrock was encountered at two test pits conducted near Km 83+400 and Km 84+200. Recommendations for these rock slopes are discussed in detail in Section 6.0. Generally the rock is considered too hard to rip beyond approximately 1 m depth, and therefore blasting will likely be required.

There is limited fill required though this section, with the exception of the area between Km 83+800 and Km 84+400. Test pit information along this section of proposed fill indicates that subsurface soils consist predominantly of sand and gravel.

### 6.1.4 Kilometre 85+800 to 87+000

The section of highway twinning between Km 85+800 and 87+700 extends past Wapta Lake, which is located to the south of the highway. Highway widening through this section mainly involves cuts to the north of the highway with limited fills.

Soil conditions indicate the presence of compressible silt through portions of this section of highway. Provided the vertical alignment of the highway remains close to its existing profile and the fills are minimized through this area we do not anticipate significant geotechnical concerns through this area.

### 6.1.5 Kilometre 87+000 to 88+000

Cross sections between Km 87+00 and 88+000 were not provided, however plan and profile sections indicate changes to the vertical alignment.

Subsurface information indicates the potential for compressible materials between Km 87+00 and 87+300, which currently involves a 300 mm increase in grade at the center line of the highway. This section is followed by a large cut between Km 87+300 and 87+600. Provided the grade increases are minimal as shown in the profile section, settlement treatment such as preloading is not considered necessary.

## 6.2 STABILITY OF CUT AND FILL SOIL SLOPES

Based on the materials encountered the following table has been prepared outlining cut/fill slopes for local materials. Soil slopes have been specified based on a factor of safety of at least 1.5. For long slopes the consequence of boulders or cobbles becoming dislodged due to freeze thaw or wet dry cycles or by animal traffic should be considered. Typically rolling material would be dealt with by enlarged ditches, benched slopes, or reduced slope angles.

A maximum temporary slope inclination of 1H:1V is recommended for the granular soils encountered at the site, however localized sloughing may occur at this slope angle. The height to which this inclination is appropriate should be considered on a case by case basis based on the risk of failure, by a qualified geotechnical engineer.



**TABLE 2: SUMMARY OF MAXIMUM CUT AND FILL SLOPES**

Soil Type	Soil Friction Angle	Maximum Fill Slope	Maximum Cut Slope
Sandy Gravel to Gravelly Sand	38°	2H : 1V	1.5H : 1V
Sand	33°	2.5H : 1V	2H : 1V
Sandy Silt to Silt	26-30°	3H : 1V	3H : 1V (site specific)

As part of our stability assessment of cut/fill slopes, EBA reviewed the Typical Sections Drawing prepared by McElhanney (Reference Drawing 2511 00203-0). This drawing set has been included in Appendix E for reference.

The tables provided on the Typical Sections Drawing indicate a maximum slope angle of 2:1 for both cut and fill slopes and do not give consideration to soil type. Provided sand and gravel borrow material is used for fill slope construction, a slope angle of 2H:1V is considered acceptable. Cut slopes should be assessed based on soil type as outlined in table 2. Sandy or silty soil conditions may not provide an adequate factor of safety at a 2H:1V slope angle and these slopes may need to be flattened. Table 3 shows our assessment of maximum cut and fill slope by station. It is stressed that these slopes are based on a discreet test pits conducted at 500 m intervals and the soil conditions may not be indicative of the entire section.

It is recognized that slopes of 1.5H:1V are present and performing satisfactorily along many of the existing embankment slopes in this section of the TCH. 1.5H:1V slopes are likely to be stable under long term conditions; however localized sloughing and erosion may occur prior to vegetation becoming established. Larger failures could occur if localized weak soil layers are present

### 6.2.1 Cut and Fill Slopes by Station

Table 3 outlines preliminary cut and fill slopes based on interpolation of the test pitting information and visual observations recorded on-site. It is important to note that this table is a guide for slope angles and the assumed soil conditions would need to be verified during construction.

**TABLE 3: SUMMARY OF CUT AND FILL SLOPES BY STATION**

Approximate Station	Assumed Soil Type	Maximum Fill Slope	Maximum Cut Slope
81+500 to 82+700	Gravelly Sand and Till-like material	2H : 1V (South of Highway)	1.5H : 1V (North of Highway)
82+800 to 83+500	Silty Sand to Gravelly Sand	2H : 1V (South of Highway)	Rock Cut (See Section 7.0)
83+500 to 83+800	Sand to Silty Sand	2.5H : 1V* (South of Highway)	2H : 1V (North of Highway)



**TABLE 3: SUMMARY OF CUT AND FILL SLOPES BY STATION**

Approximate Station	Assumed Soil Type	Maximum Fill Slope	Maximum Cut Slope
83+800 to 83+950	Sand to Silty Sand	2.5H : 1V* (North and South of Highway)	N/A
83+950 to 84+870	Gravelly Sand and Till-like material	2H : 1V (South of Highway)	1.5H : 1V (North of Highway)
84+870 to 85+100	Gravelly Sand	2H : 1V (North of Highway)	N/A
85+100 to 85+800	Gravelly Sand	N/A	Rock Cut (See Section 7.0)
85+800 to 86+800	Gravelly Sand to Silty Sand	2H : 1V (North of Highway)	2H : 1V (North of Highway)
86+800 to 88+00	Gravelly Sand to Sand	2H : 1V (South of Highway)	2H : 1V (North of Highway)

\* Provided acceptable borrow material is utilized for fill slope construction a 2H:1V slope will be acceptable. Silty materials will likely be difficult to compact and should be constructed with a maximum slope angle of 2.5H:1V.

### 6.3 BORROW SOURCES AND BACKFILL MATERIALS

It is understood that the existing borrow pit located at Km 87.5 may be used to source material for some of the fills required along the highway alignment. Three sieves were completed on this material indicating sandy gravel with less than 5% fines content. One sample obtained from the borrow pit area contained 7% fines. Due to the low fines content and coarse gravel content this material is considered to be a good source for general borrow material.

The approximate extents of the existing borrow area are shown on Figure 9 and Photos taken within the borrow area are provided in Appendix C.

The borrow material could likely be used as a sub base material with limited sorting. Material larger than 75 mm may need to be screened out of the material. Further lab testing would be required regarding the quantity of coarse rock and durability, for the material to be considered for base course or asphalt aggregate.

Most of the granular materials encountered throughout the alignment are considered suitable for use as general embankment fill. Due to the potential for frost heave, silty material is not recommended within the upper 1 m of the road embankment, below the underside of sub base elevation. Till-like materials may be used as general embankment fill provided the correct compaction procedures are used. Silt should not be used as general embankment fill.



## 6.4 BULKING AND SHRINKAGE OF FILL MATERIALS

Bulking and shrinkage refers to the change in the volume of a material during excavation and placement. More specifically bulking is the net change in volume from the bank (in-place) to a dump truck (loose condition). Shrinkage is the net change in volume from the bank to the compacted condition. Table 4 outlines typical bulking and shrinkage factors for the local materials observed.

**TABLE 4: TYPICAL BULKING AND SHRINKAGE FACTORS**

Material Type	Typical Bulking Factor	Typical Shrinkage Factor
Rock	50 - 80%	+15 % to + 25%
Sandy Gravel to Gravelly Sand	5 - 15%	-5 % to -10 %
Sand	5 - 10%	-10%
Sandy Silt to Silt	20 - 40%	N/A

## 7.0 ROCK SLOPE ASSESSMENT AND CONSIDERATIONS

The main rock slopes that are visible adjacent to the highway are from approximately Km 82+700 to 85+800. The following sections describe the existing rock slopes and provide recommendations on cut slope angles, and ditch dimensions based on visual observation and material sampling. All chainages are approximate.

### 7.1 ROCK TYPES ALONG THE ALIGNMENT

The following rock types were observed and described along the highway alignment.

*Quartzite:* Moderately strong to strong, light grey to white, medium grained, fresh to slightly weathered, Quartzite (metamorphosed sandstone). Thin laminations of shale/mudstone can be seen in the quartzite where it forms rock slopes.

*Shale:* Moderately strong, dark bluish grey, fine grained, slightly weathered Shale. Contains some larger grains that could be relict grains or porphyroblasts.

*Mudstone:* Moderately weak, light yellowish-brown, very fine grained, slightly to moderately weathered, Mudstone.

*Limestone:* Strong to very strong, dark bluish grey, fine grained, fresh to slightly weathered, slightly metamorphosed, Limestone.

### 7.2 ROCK SLOPE CHARACTERIZATION

The following section characterizes the rock slopes observed along the alignment.



**Slope 1 (Km 82+700 to 83+000):**

The rock consists of quartzite with occasional layers of foliated shale. The maximum slope height is approximately 6 m, and the slope face is steeply dipping. Two main joint sets can be distinguished. The first joint set dips shallowly towards the west. The joints are moderately spaced, highly persistent, with slightly rough planar surfaces. The joints appear to have formed along bedding planes.

The second joint set dips sub-horizontally to the south. The joints are widely spaced, moderately persistent and the surfaces are slightly rough and planar. The condition of the rock mass is “good” based on the RQD. There is minor rock debris at the base of the slope. Photograph 1 in Appendix D shows a representative section of this slope.

**Slope 2 (Km 83+300 to 83+500):**

The rock consists of interbedded quartzite and foliated mudstone layers. The maximum slope height is 10 m, and the slope face is steeply dipping. Two main joint sets can be distinguished. The first set dips shallowly towards the west. The joints are moderately spaced, highly persistent, and joint surfaces are slightly rough and undulating. The joints were likely formed along relict undulating bedding planes, as joints and foliation appear undulated. Slickensides are present on the joint surfaces, which could be a result of flexural slip (caused by folding of the bedding planes).

The second joint set dips sub-horizontally towards north. The joints are very widely spaced, moderately persistent, and joint surfaces are slightly rough and linear. A plane of weakness exists at the interface of the quartzite and the shale/mudstone, which is evident from intact failure between beds. The condition of the rock mass is “very poor” based on the RQD. There is minor rock debris at the base of the slope. Photograph 2 in Appendix D shows a representative section of this slope.

**Slope 3 (Km 85+000 to 85+200):**

The rock consists of limestone, with a maximum slope height of approximately 10 m and a steeply dipping face. Two main joint sets can be distinguished. The first joint set dips sub-horizontally towards the west. The joints are very widely spaced, highly persistent with slightly rough linear joint surfaces. The second joint set dips sub-horizontally towards south. The joints are assumed to be widely spaced and highly persistent. The condition of the rock mass is “good” based on the RQD. There is little rock debris at the base of the slope. Photograph 3 in Appendix D shows a representative section of this slope.

**Slope 4 (Km 85+200 to 85+400):**

The rock consists of limestone, with a maximum slope height of approximately 12 m and a steeply dipping face. The rock mass is moderately to highly fractured. The notable joint set within the slope dips sub-horizontally towards the west. The joints are widely spaced, moderately to highly persistent, and joint surfaces are slightly rough to rough. There are also two randomly oriented joint sets. The condition of the rock mass is “poor” based on



the RQD. There is approximately 3 m of overburden overlying the limestone which will require removal. There are fans of soil at the base of the slope, which include some rock debris, due to surface runoff channelling down the overburden above. Photograph 4 in Appendix D shows a representative section of this slope.

#### **Slope 5 (Km 85+400 to 85+500)**

The rock consists of limestone, with a maximum slope height of approximately 10 m and a steeply dipping face. Two main joint sets can be distinguished. The first joint set dips sub-horizontally towards the west. The joints are very widely spaced, moderately to highly persistent with slightly rough to rough linear joint surfaces. The second joint set dips sub-horizontally towards south. The joints are assumed to be widely spaced and highly persistent. The condition of the rock mass is “good” based on the RQD. There is little rock debris at the base of the slope. Photograph 5 in Appendix D shows a representative section of this slope.

#### **Slope 6 (Km 85+500 to 85+800):**

The rock consists of massive limestone, with a maximum slope height of approximately 12 m and a near vertical face. A joint set can be distinguished which dips sub-horizontally towards the west. The joints are widely spaced, medium to highly persistent, with slightly rough linear surfaces. The condition of the rock mass is “very good” based on the RQD. There is little rock debris at the base of the slope. Photograph 6 in Appendix D shows a representative section of this slope.

### **7.3 RECOMMENDED CUT ANGLES**

Table 5 summarizes the rock slopes found along the alignment and provides recommended cut slope angles and ditch dimensions.

**TABLE 5: SUMMARY OF CUT SLOPE RECOMMENDATIONS**

Slope ID	Km From	Km To	Rock Type	Maximum Proposed Slope Height (m)*	Recommended Cut Angle	Recommended Ditch Width for at 1V:4H Ditch Angle (m)	Recommended Ditch Depth (m)
Slope 1	82+700	83+000	Quartzite and Shale	10	70°	4.5	1.1
Slope 2	83+300	83+500	Quartzite and Mudstone	17	70°	6.5	1.6
Slope 3	85+000	85+200	Limestone	24	80°	12	3
Slope 4	85+200	85+400	Limestone	24	65°	8	2.0
Slope 5	85+400	85+500	Limestone	25	80°	12.5	3.1
Slope 6	85+500	85+800	Limestone	26	80°	13	3.2

\*Maximum proposed slope height has been determined from McElhanney preliminary cross section drawings.



The recommended ditch width and depth were estimated using the Rockfall Catchment Area Design Guide (Pierson et al., 2001). The catchment areas were designed to retain 99 % of rockfall material. Some of the ditch widths may need to be increased in order to satisfy PCA's minimum required distance of 11 m from the fog line. Figure 11 shows a schematic section of the ditch with and depths for the rock catchments. Further protection against rockfall material rollout may be required for these slopes, such as guard rails (Jersey barriers). As outlined in BC MoT supplement to TAC, barrier, clear zone and drainage requirements should be reviewed during the detailed design phase. Further analysis using the program Rockfall is recommended for all rock slopes with a height greater than 15 m.

#### 7.4 RECOMMENDATIONS FOR ADDITIONAL WORK

The previous section provides preliminary design recommendations for the rock cuts. Recommended work for further design includes detailed kinematic analyses of all rock slopes in order to identify potential instabilities. Detailed geotechnical mapping of the slopes is recommended to form the basis of the kinematic analyses and to obtain joint orientation data. Further analysis may be required to determine if benching is required for the high rock cuts in fractured rock. It is recommended that final designs be reviewed for constructability and access restrictions. The potential for Acid Rock Drainage (ARD) and Metal Leaching (ML) should be considered during the next phase of design.

It should be noted that the investigations undertaken for this report were to provide an overview of the rock cut stability and preliminary recommendations for the angle of the cut slopes. In order to finalize this design, the recommendations for additional work should be undertaken. This work should be carried out once the height and extent of the rock cuts are known along the alignment. The work will allow the rockfall hazard to be fully characterized, and particular rock slopes to be optimized both in terms of slope angle and rock catchment. This optimization should provide savings to the project in terms of the quantities of excavated rock.

### 8.0 PAVEMENT RECOMMENDATIONS AND CONSIDERATIONS

The general condition of the asphalt concrete pavement (ACP) was observed at the time of the drilling investigation. Detailed strength and condition surveys were not undertaken, as they were outside of the scope of this assignment. Preliminary pavement recommendations have been provided based on the drilling results, the observed pavement condition, the anticipated future traffic and the roadway sections provided.

The current highway twinning design indicates the highway surface will be increased in grade slightly throughout most of the alignment. Highway widening will require new pavement structure. In areas where the grades remain close to the existing surface, it may be possible to rehabilitate the existing ACP and incorporate it into the final design.



## 8.1 DESIGN TRAFFIC

Representative historic traffic volumes for the Km 82 to Km 88 section of the TransCanada Highway (TCH) were obtained from the Alberta Transportation Pavement Publications and Roadway Data for Equivalent Single Axle Loadings (ESAL) for Pavement Design. The total number of ESALS/day/dir for the year 2009 for Highway 1, control section 2, traffic control section 4 were used in determining the estimated 20-year design ESALs for the project roadway. This traffic data is from the East Gate of the park, and considered reasonably representative of the traffic on the project section of Highway 1.

Review of AT's traffic data indicated that this section of Highway 1 was subject to 224 Single Unit Trucks and 1306 Tractor Trailer Combination vehicles for a total of 1530 daily ESALs / direction of travel. Review of historic recorded traffic count numbers suggests that the project roadway will be subject to a 3% annual increase in traffic volumes. It is anticipated that the lane distribution of commercial traffic will account for 85% of the roadways design ESALs located in the governing (outside) travel lane.

The methodology used in determining the 20-year design ESALs was based on both engineering judgment and the design process documented in AT's "Pavement Design Manual, 1997". The estimated 20-year design ESALs are summarized in Table 6.

TABLE 6: 20-YEAR DESIGN ESALS			
ESALs / Day / Direction	Lane Split	Estimated Traffic Growth Rate	20-Year Design ESALs / Direction
1530	0.85	3%	$12.8 \times 10^6$

Based on the functional classification of this section of roadway, and the anticipated performance requirements of the City, the 20-year design ESALs noted in Table 6 were used in developing a suitable pavement structure for the project roadway.

These traffic levels are considerably higher than has been used historically for pavement analysis in the park.

## 8.2 EXISTING PAVEMENT CONDITION

Existing ACP thickness was observed to range between 140 mm and 250 mm based on the borehole information. Generally thicker ACP was observed west of Wapta Lake and thinner pavement was observed east of Wapta Lake. Ravelling and oxidation of the existing pavement was observed in select locations throughout the area investigated and varying ages of pavement were observed. Table 7 outlines the observed ACP thickness and a general assessment of the existing pavement condition.



**TABLE 7: SUMMARY OF EXISTING PAVEMENT CONDITION AND THICKNESS BY STATION**

Approximate Station	Measured Asphalt Thickness	Observed Pavement Condition	Typical Surface Distress
81+500 to 82+500	165 mm (75 mm in pullout area)	Poor to Moderate	-Moderate Severity LJC -Localized Moderate Severity AC - Moderate Severity PEC -Moderate Severity TC
82+500 to 83+500	140 mm to 190 mm	Poor to Moderate	-Moderate Severity LJC - Localized, High Severity PEC -Moderate Severity MLC
83+500 to 84+500	165 mm to 190 mm	Moderate	-Moderate and High Severity LJC -Moderate Severity MLC
84+500 to 85+500	150 mm to 165 mm	Moderate	-Moderate and High Severity LJC -Low to Moderate Severity TC -Moderate Severity MLC -Localized Moderate Severity AC
85+500 to 86+200	165 mm to 215 mm	Moderate	-Moderate and High Severity LJC - Moderate Severity TC -Moderate Severity MLC
86+200 to 88+000	230 mm to 255 mm	Moderate to Good	-Low to Moderate Severity LJC - Low Severity TC

LJC - Longitudinal Joint Cracking  
 PEC - Pavement Edge Cracking  
 TC - Transverse Cracking  
 AC - Alligator Cracking  
 MLC - Meandering Longitudinal Cracking

The soils encountered below the ACP would not meet typical specifications for a well graded base.

### 8.3 NEW PAVEMENT CONSTRUCTION

New full depth pavement structure will be necessary in areas of highway widening or in areas where grade changes of existing ACP do not allow for rehabilitation of the pavement structure. The typical pavement structure previously used by PCA consists of the following:

- 230 mm of ACP
- 150 mm of GBC
- 275 mm WGB
- 500 mm SGSB (reduced to 300 mm in cut sections)

For the 12.8 M ESALs and 95% reliability, the combination of SGSB (300 to 500 mm) and underlying material should provide a minimum subgrade support of 45 MPa to provide a 20-year design period.



Three lift construction is envisaged for the ACP. The recommended ACP types and lift thicknesses are as follows:

- 60 mm H1 Mix with a PG 58-37 asphalt binder; over
- Two (2) lifts of 85 mm S3 Mix with a PG 58-34 asphalt binder.

## 8.4 REHABILITATION OF EXISTING PAVEMENTS

Rehabilitation may be considered where the existing ACP is to be retained in the final design. Several options for rehabilitation can be considered. To provide a rehabilitated pavement that has a similar structural capacity as the new construction, a structural overlay could be placed. In areas where the grades of the new highway do not allow for the retention of the pavement, the new pavement structure should be utilized.

In areas where the existing ACP thickness is greater than 200 mm and in fair to good condition, an 85 mm overlay (the typical strategy used by PCA) would provide similar structural capacity of the rehabilitated pavement compared to a new pavement structure. This generally corresponds to the area between km 86 and 88.

In area with less than 200 mm of existing ACP, or in areas of poor pavement condition, a thicker overlay, or treatment of the existing ACP prior to overlay, may be required to provide a structurally equivalent pavement to new. This generally corresponds to the area between Km 82 and 86. The additional treatments prior to an overlay could include milling of the worst surface distresses, and a thicker structural overlay or Full Depth Reclamation (FDR) with base stabilization of the existing ACP.

Localized repairs (full depth ACP) of areas of distress should be completed prior to the overlay. These options would be anticipated to have a service life of 8 to 12 years, prior to the next major rehabilitation. If the localized repairs are not completed, a service life of 4 to 7 years prior to the next rehabilitation would be anticipated.

Gravels observed during the site investigation did not meet typical standards for a well graded base. It is considered likely that some improvements to the existing base course gravel will be likely to improve the drainage below the existing ACP.

### 8.4.1 Alternative Design Concept

A FDR strategy could be considered an alternative to new construction. For the purposes of this example, and existing two-lane roadway is being widened for two additional lanes. The subgrade is widened as required and the sub-base layer is constructed (300 mm to 500 mm). The upper 400 mm of the existing pavement (asphalt concrete and granular) is pulverized and redistributed across the entire new roadway footprint. With the addition of 15-20% aggregate additive, a 250 mm layer across all lanes is stabilized. Two 50 mm lifts of HMA are provided to complete the pavement structure. Table 8 compares the structural equivalencies of the FDR alternative to new construction.



**TABLE 8: FDR PAVEMENT STRUCTURE COMPARISON**

Pavement Layer	Layer Coefficient	Thickness (mm)	
		New Construction	FDR Alternative
New Asphalt Concrete	0.40	230	100
New Granular Base	0.14	150	-
Stabilized FDR	0.30	-	250
Old Granular Base	0.12	-	80
New Granular Sub-base	0.12	275	-
Old Granular Sub-base	0.10	-	275
Resulting Structural Number (SN)	-	146	147

As shown the FDR alternative provides an equivalent SN, and service life to new construction. Potential benefits of the FDR alternative include a consistent pavement structure (and design life) across the entire roadway footprint, and the elimination of all longitudinal and transverse construction joints.

An FDR would be anticipated to have a service life of 15 to 20 years.

## 8.5 DISCUSSION

It is recommended that a detailed pavement strength and condition assessment be undertaken prior to completing detailed pavement design. Previous network level strength analysis of the pavement in the areas of Km 82 to 83 used significantly lower traffic loading, and thicker pavement structures than those determined by EBA. The results of this previous network level analysis therefore would overstate the structural adequacy of the existing pavement. A review of the construction history of the existing pavement would also be beneficial in determining the best suited pavement strategy for the area. Grades will need to be finalized taking into account the information provided above.

Once a detailed investigation has been completed, the options for rehabilitation and new construction should be presented to PCA. The risk and benefits of each option should be presented, and PCA as the owner of the roadway should provide input on selecting the option that best represents the level of risk versus capital costs.

## 9.0 LIMITATIONS OF REPORT

This report and its contents are intended for the sole use of Parks Canada Agency and their agents. 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 proposed development 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 EBA's Services Agreement and in the General Conditions provided in Appendix F of this report.

## 10.0 CLOSURE

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

Respectfully submitted,  
EBA Engineering Consultants Ltd.

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# FIGURES









Q:\Vanconver\Transportation\331\Projects\33101067 - Km 82-88 Enviro, Geotech and Avalanche Studies\Geotechnical\Bore hole plan\Bore hole plan.dwg [FIGURE 2] December 15, 2010 - 11:32:40 am (BY: SOO KAIM, ALEX)

MATCH LINE FIGURE 3

LEGEND/NOTES

- BOREHOLE
- TEST PIT



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GEOTECHNICAL INVESTIGATION  
TCH TWINNING KM 82 - 88

BOREHOLE/TEST PIT  
LOCATION PLAN KM 81+500 TO KM 82+300

PROJECT NO. V33101067	DWN ASK	CKD RB	REV 0
OFFICE VANC	DATE December 2010		

Figure 2

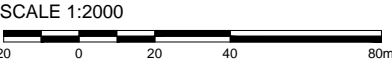


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LEGEND/NOTES

-  BOREHOLE
-  TEST PIT



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<div>EBA Engineering Consultants Ltd.</div> <div></div>		<div>PROJECT NO.</div> <div>V33101067</div>	<div>DWN</div> <div>ASK</div>	<div>CKD</div> <div>RB</div>	<div>REV</div> <div>0</div>	<div>Figure 3</div>
		<div>OFFICE</div> <div>VANC</div>	<div>DATE</div> <div>December 2010</div>			

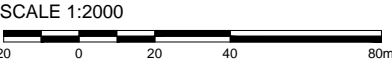


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LEGEND/NOTES

-  BOREHOLE
-  TEST PIT



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LEGEND/NOTES

- BOREHOLE
- TEST PIT



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		<div>OFFICE</div> <div>VANC</div>	<div>DATE</div> <div>December 2010</div>			


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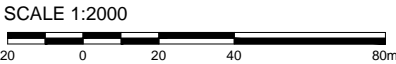


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TCH TWINNING KM 82 - 88

BOREHOLE/TEST PIT  
LOCATION PLAN KM 84+700 TO KM 85+400

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OFFICE VANC	DATE December 2010		

Figure 6



Q:\Vanconver\Transportation\331\Projects\V33101067 - Km 82-88 Enviro, Geotech and Avalanche Studies\Geotechnical\Bore hole plan\Bore hole plan.dwg [FIGURE 7] December 15, 2010 - 11:47:12 am (BY: SOO KAIM, ALEX)





MATCH LINE FIGURE 8

LEGEND/NOTES

-  BOREHOLE
-  TEST PIT



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<div>EBA Engineering Consultants Ltd.</div> <div></div>		<div>PROJECT NO.</div> <div>V33101067</div>	<div>DWN</div> <div>ASK</div>	<div>CKD</div> <div>RB</div>	<div>REV</div> <div>0</div>	<div>Figure 7</div>
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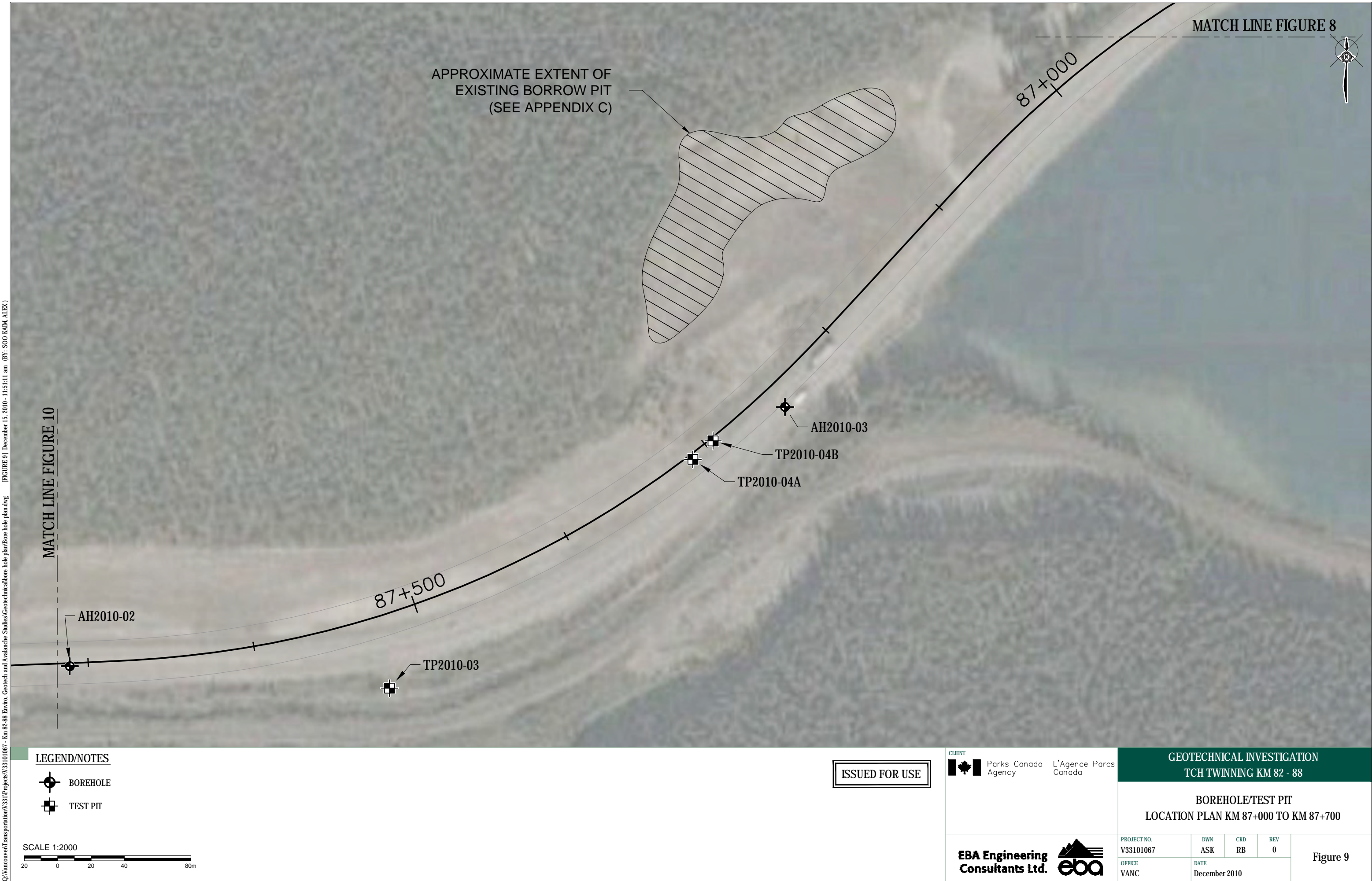


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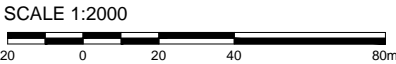


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LEGEND/NOTES

-  BOREHOLE
-  TEST PIT



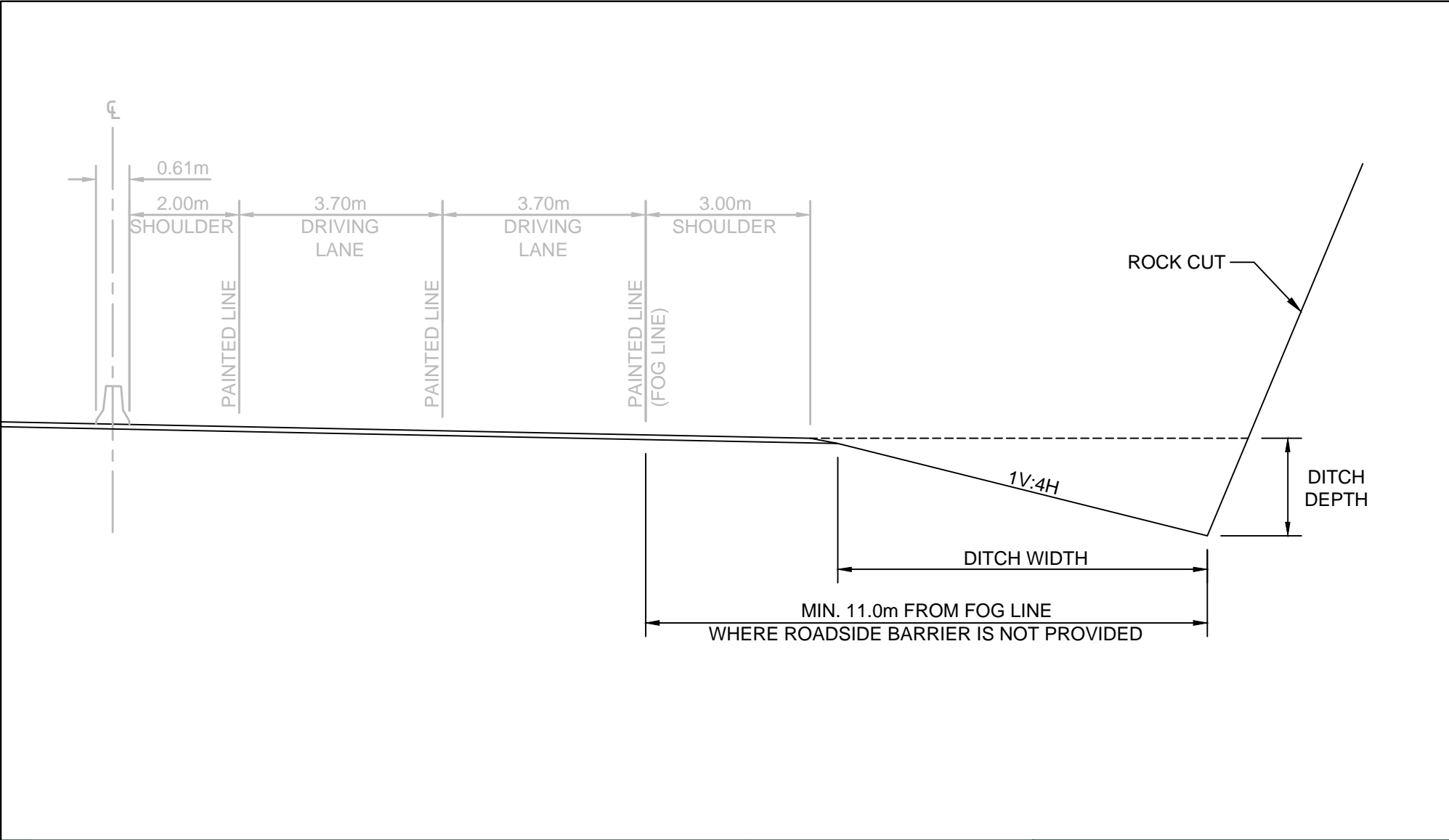
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		<div>BOREHOLE/TEST PIT</div> <div>LOCATION PLAN KM 87+700 TO 88+500</div>				
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REFER TO FIGURE 251100203-0 FOR TYPICAL ROADWAY DIMENSIONS.

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**GEOTECHNICAL INVESTIGATION**

TCH TWINNING KM 82 - 88

**SCHEMATIC SECTION:  
DITCH WIDTH AND DEPTH FOR ROCK CATCHMENTS**



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VANC

DWN  
ASK  
DATE  
December 2010

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Figure 11



# APPENDIX A

## APPENDIX A BOREHOLE AND TEST PIT LOGS



PCA 2 Km 82-88 Geotechnical Assessment		Parks Canada - Yoho National Park		PROJECT NO. - BOREHOLE NO.					
N. 5698591.4 E. 543558.8		Truck Mounted Solid Stem Auger		V33101067 - AH2010-01					
		Eastbound Lane, Middle		ELEVATION: 1562.2m					
SAMPLE TYPE <input checked="" type="checkbox"/> DISTURBED <input type="checkbox"/> NO RECOVERY <input checked="" type="checkbox"/> SPT <input type="checkbox"/> A-CASING <input type="checkbox"/> SHELBY TUBE <input type="checkbox"/> CORE BACKFILL TYPE <input checked="" type="checkbox"/> BENTONITE <input checked="" type="checkbox"/> PEA GRAVEL <input type="checkbox"/> SLOUGH <input type="checkbox"/> GROUT <input type="checkbox"/> DRILL CUTTINGS <input type="checkbox"/> SAND									
Depth (m)	SOIL DESCRIPTION	SAMPLE TYPE	SAMPLE NUMBER	USC	SOIL SYMBOL	MOISTURE CONTENT			Elevation (m)
							PLASTIC	M.C.	
								<div style="display: flex; justify-content: space-between;"> <div> 20   40   60   80 </div> <div> <div style="width: 100%; height: 10px; background: linear-gradient(to right, black 50%, white 50%);"></div> </div> </div>	
								<div style="display: flex; justify-content: space-between;"> <div> 20   40   60   80 </div> <div> <div style="width: 100%; height: 10px; background: linear-gradient(to right, black 50%, white 50%);"></div> </div> </div>	
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								<div style="display: flex; justify-content: space-between;"> <div> 20   40   60   80 </div> <div> <div style="width: 100%; height: 10px; background: linear-gradient(to right, black 50%, white 50%);"></div> </div> </div>	
								<div style="display: flex; justify-content: space-between;"> <div> 20   40   60   80 </div> <div> <div style="width: 100%; height: 10px; background: linear-gradient(to right, black 50%, white 50%);"></div> </div> </div>	
								<div style="display: flex; justify-content: space-between;"> <div> 20   40   60   80 </div> <div> <div style="width: 100%; height: 10px; background: linear-gradient(to right, black 50%, white 50%);"></div> </div> </div>	
								<div style="display: flex; justify-content: space-between;"> <div> 20   40   60   80 </div> <div> <div style="width: 100%; height: 10px; background: linear-gradient(to right, black 50%, white 50%);"></div> </div> </div>	
								<div style="display: flex; justify-content: space-between;"> <div> 20   40   60   80 </div> <div> <div style="width: 100%; height: 10px; background: linear-gradient(to right, black 50%, white 50%);"></div> </div> </div>	
								<div style="display: flex; justify-content: space-between;"> <div> 20   40   60   80 </div> <div> <div style="width: 100%; height: 10px; background: linear-gradient(to right, black 50%, white 50%);"></div> </div> </div>	
								<div style="display: flex; justify-content: space-between;"> <div> 20   40   60   80 </div> <div> <div style="width: 100%; height: 10px; background: linear-gradient(to right, black 50%, white 50%);"></div> </div> </div>	
								<div style="display: flex; justify-content: space-between;"> <div> 20   40   60   80 </div> <div> <div style="width: 100%; height: 10px; background: linear-gradient(to right, black 50%, white 50%);"></div> </div> </div>	
								<div style="display: flex; justify-content: space-between;"> <div> 20   40   60   80 </div> <div> <div style="width: 100%; height: 10px; background: linear-gradient(to right, black 50%, white 50%);"></div> </div> </div>	
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								<div style="display: flex; justify-content: space-between;"> <div> 20   40   60   80 </div> <div> <div style="width: 100%; height: 10px; background: linear-gradient(to right, black 50%, white 50%);"></div> </div> </div>	
								<div style="display: flex; justify-content: space-between;"> <div> 20   40   60   80 </div> <div> <div style="width: 100%; height: 10px; background: linear-gradient(to right, black 50%, white 50%);"></div> </div> </div>	
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								<div style="display: flex; justify-content: space-between;"> <div> 20   40   60   80 </div> <div> <div style="width: 100%; height: 10px; background: linear-gradient(to right, black 50%, white 50%);"></div> </div> </div>	
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								<div style="display: flex; justify-content: space-between;"> <div> 20   40   60   80 </div> <div> </div></div>	



PCA 2 Km 82-88 Geotechnical Assessment		Parks Canada - Yoho National Park		PROJECT NO. - BOREHOLE NO.							
N. 5698607.1 E. 544239.2		Truck Mounted Solid Stem Auger		V33101067 - AH2010-02							
		Westbound Lane, Middle		ELEVATION: 1584m							
SAMPLE TYPE <input checked="" type="checkbox"/> DISTURBED <input type="checkbox"/> NO RECOVERY <input checked="" type="checkbox"/> SPT <input type="checkbox"/> A-CASING <input type="checkbox"/> SHELBY TUBE <input type="checkbox"/> CORE											
BACKFILL TYPE <input checked="" type="checkbox"/> BENTONITE <input checked="" type="checkbox"/> PEA GRAVEL <input type="checkbox"/> SLOUGH <input type="checkbox"/> GROUT <input type="checkbox"/> DRILL CUTTINGS <input checked="" type="checkbox"/> SAND											
Depth (m)	SOIL DESCRIPTION	SAMPLE TYPE	SAMPLE NUMBER	USC	SOIL SYMBOL	MOISTURE CONTENT					Elevation (m)
							STANDARD PENETRATION (N) 20 40 60 80 UNCONFINED (kPa) 50 100 150 200 POCKET PEN. (kPa) 100 200 300 400				
0	ASPHALT. (255 mm)				ASPHALT						1584.0
1	SAND, gravelly, well graded sand and gravel, angular to sub-rounded, dry, beige. (FILL) Fracture Count (1 face) - 73.7 % EOH 1.1 m - Refusal on a boulder. *Borehole backfilled with cuttings and patched with asphalt.	<input checked="" type="checkbox"/>	1		SWG	1.8					1583.0
2											1582.0
3											1581.0
4											1580.0
5											1579.0
6											1578.0
7											1577.0
8											1576.0
9											1575.0
10											1574.0



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 REVIEWED BY: KW  
 DRAWING NO:

COMPLETION DEPTH: 1.1m  
 COMPLETE: 9/29/2010  
 Page 1 of 1



PCA 2 Km 82-88 Geotechnical Assessment		Parks Canada - Yoho National Park		PROJECT NO. - BOREHOLE NO.			
N. 5698762.9 E. 544668.8		Truck Mounted Solid Stem Auger		V33101067 - AH2010-03			
		Eastbound Lane, Middle		ELEVATION: 1588.4m			
SAMPLE TYPE <input checked="" type="checkbox"/> DISTURBED <input checked="" type="checkbox"/> NO RECOVERY <input checked="" type="checkbox"/> SPT <input type="checkbox"/> A-CASING <input type="checkbox"/> SHELBY TUBE <input type="checkbox"/> CORE							
BACKFILL TYPE <input checked="" type="checkbox"/> BENTONITE <input checked="" type="checkbox"/> PEA GRAVEL <input type="checkbox"/> SLOUGH <input type="checkbox"/> GROUT <input type="checkbox"/> DRILL CUTTINGS <input type="checkbox"/> SAND							
Depth (m)	SOIL DESCRIPTION	SAMPLE TYPE SAMPLE NUMBER	USC	SOIL SYMBOL	MOISTURE CONTENT PLASTIC M.C. LIQUID 20 40 60 80	STANDARD PENETRATION (N) 20 40 60 80 UNCONFINED (kPa) 50 100 150 200 POCKET PEN. (kPa) 100 200 300 400	Elevation (m)
0	ASPHALT. (230 mm)		ASPHAL				1588.0
1	SAND, gravelly, well graded sand, fine gravel, sub-angular to angular, grey. (FILL)  Fracture Count (1 face) - 48.8 %	1	SWG		5		1587.0
2	SAND, gravelly, medium to coarse sand, well graded gravel, sub-angular to angular, beige.	2	SWG				1586.0
3	SAND and GRAVEL, some silt, trace clay, well graded sand and gravel, sub-angular to angular, beige. (39 % sand, 15 % silt, 6 % clay)	3					1585.0
4	Note: The sand and gravel could have been mixed with the silt from the action of the auger.	4			18		1584.0
5	-Trace coarse gravel below 4.6 m.	5	MLS				1583.0
6	No recovery.						1582.0
7							1581.0
8	EOH 7.6 m - No recovery. Driller communicated that it felt like a softer material with little to no gravel.  *Borehole was backfilled with cuttings, along with 2-3 bags of sand, a bentonite layer and an asphalt patch.						1580.0
9							1579.0
10							



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DRAWING NO:

COMPLETION DEPTH: 7.6m

COMPLETE: 9/28/2010

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PCA 2 Km 82-88 Geotechnical Assessment		Parks Canada - Yoho National Park		PROJECT NO. - BOREHOLE NO.									
N. 5699227.8 E. 545745.3		Truck Mounted Solid Stem Auger		V33101067 - AH2010-05									
		Eastbound Lane, Middle		ELEVATION: 1591.5m									
SAMPLE TYPE <input checked="" type="checkbox"/> DISTURBED <input checked="" type="checkbox"/> NO RECOVERY <input checked="" type="checkbox"/> SPT <input type="checkbox"/> A-CASING <input type="checkbox"/> SHELBY TUBE <input type="checkbox"/> CORE													
BACKFILL TYPE <input checked="" type="checkbox"/> BENTONITE <input checked="" type="checkbox"/> PEA GRAVEL <input type="checkbox"/> SLOUGH <input type="checkbox"/> GROUT <input type="checkbox"/> DRILL CUTTINGS <input type="checkbox"/> SAND													
Depth (m)	SOIL DESCRIPTION	SAMPLE TYPE	SAMPLE NUMBER	USC	SOIL SYMBOL	MOISTURE CONTENT	PLASTIC	M.C.	LIQUID	STANDARD PENETRATION (N)	UNCONFINED (kPa)	POCKET PEN. (kPa)	Elevation (m)
0	ASPHALT. (215 mm)			ASPHAL									1591.0
	GRAVEL, sandy, trace silt, fine gravel, well graded sand, sub-angular to angular, dry, grey. (FILL)			GPS									
1	SAND, gravelly, trace to some silt, well graded sand and gravel, sub-rounded to sub-angular, beige. (FILL)		1										
			2										
2	Sand becoming medium to coarse below 1.5 m.			SWG									1590.0
			3										1589.0
3	SILT and SAND, trace clay, well graded sand, soft to firm, damp, non-plastic, grey. (40 % sand, 49 % silt, 6 % clay)		4	SW-SM		31							1588.0
4	SILT, sandy, fine, soft, grey.			MLS									1587.0
	SAND, some silt, fine to medium sand, wet, grey to brown.		5	SW									1586.0
5			6										1585.0
6	No recovery.												1584.0
7													1583.0
8	EOH 7.6 m - No recovery. Two boulders could be seen down the hole which were obstructing the augers as they were being pulled up.												1582.0
9	*Borehole backfilled with cuttings and patched with asphalt.												
10													



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COMPLETION DEPTH: 7.6m

COMPLETE: 9/28/2010

Page 1 of 1



PCA 2 Km 82-88 Geotechnical Assessment		Parks Canada - Yoho National Park		PROJECT NO. - BOREHOLE NO.							
N. 5699634.1 E. 546346.0		Truck Mounted Solid Stem Auger		V33101067 - AH2010-06							
		Westbound Lane, Middle		ELEVATION: 1598.8m							
SAMPLE TYPE <input checked="" type="checkbox"/> DISTURBED <input type="checkbox"/> NO RECOVERY <input checked="" type="checkbox"/> SPT <input type="checkbox"/> A-CASING <input type="checkbox"/> SHELBY TUBE <input type="checkbox"/> CORE											
BACKFILL TYPE <input checked="" type="checkbox"/> BENTONITE <input checked="" type="checkbox"/> PEA GRAVEL <input type="checkbox"/> SLOUGH <input type="checkbox"/> GROUT <input type="checkbox"/> DRILL CUTTINGS <input type="checkbox"/> SAND											
Depth (m)	SOIL DESCRIPTION	SAMPLE TYPE	SAMPLE NUMBER	USC	SOIL SYMBOL	MOISTURE CONTENT	PLASTIC M.C. LIQUID	STANDARD PENETRATION (N)	UNCONFINED (kPa)	POCKET PEN. (kPa)	Elevation (m)
0	ASPHALT. (165 mm)			ASPHAL							
1	SAND, gravelly, trace silt, occasional cobbles, well graded sand and gravel, dense, beige to light brown. (FILL)		1	SWG		1.7					1598.0
2	Fracture Count (1 face) - 52.8 %										
2	EOH 1.5 m - Refusal on a boulder.										1597.0
3	*Borehole backfilled with cuttings and patched with asphalt.										1596.0
4											1595.0
5											1594.0
6											1593.0
7											1592.0
8											1591.0
9											1590.0
10											1589.0



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 COMPLETE: 9/29/2010  
 Page 1 of 1



PCA 2 Km 82-88 Geotechnical Assessment		Parks Canada - Yoho National Park		PROJECT NO. - BOREHOLE NO.				
N. 5699799.4 E. 546738.0		Truck Mounted Solid Stem Auger		V33101067 - AH2010-07				
		Eastbound Lane, Middle		ELEVATION: 1607.6m				
SAMPLE TYPE <input checked="" type="checkbox"/> DISTURBED <input type="checkbox"/> NO RECOVERY <input checked="" type="checkbox"/> SPT <input type="checkbox"/> A-CASING <input type="checkbox"/> SHELBY TUBE <input type="checkbox"/> CORE BACKFILL TYPE <input checked="" type="checkbox"/> BENTONITE <input checked="" type="checkbox"/> PEA GRAVEL <input type="checkbox"/> SLOUGH <input type="checkbox"/> GROUT <input type="checkbox"/> DRILL CUTTINGS <input type="checkbox"/> SAND								
Depth (m)	SOIL DESCRIPTION	SAMPLE TYPE SAMPLE NUMBER	USC	SOIL SYMBOL	MOISTURE CONTENT	STANDARD PENETRATION (N)		Elevation (m)
						20   40   60   80	100   150   200	
					PLASTIC   M.C.   LIQUID 20   40   60   80	◆ UNCONFINED (kPa) ◆ 50   100   150   200 ▲ POCKET PEN. (kPa) ▲ 100   200   300   400		
0	ASPHALT. (150 mm)		ASPHAL					1607.0
1	SAND, gravelly, well graded sand and gravel, sub-rounded to sub-angular, beige. (FILL)	1	SWG					1607.0
2	SAND, some gravel, trace silt, well graded sand and gravel, sub-rounded to sub-angular, beige.	2	SW					1606.0
3	SAND, gravelly, trace to some silt, well graded sand and gravel, sub-angular to angular, beige.		SWG					1605.0
4		3						1604.0
5	SAND and GRAVEL, trace to some silt, well graded sand and gravel, sub-angular to angular, beige.	4	SWG					1603.0
6	EOH 6.1 m							1602.0
7	*Borehole backfilled with cuttings and patched with asphalt.							1601.0
8								1600.0
9								1599.0
10								1598.0



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DRAWING NO:

COMPLETION DEPTH: 6.1m

COMPLETE: 9/28/2010

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PCA 2 Km 82-88 Geotechnical Assessment		Parks Canada - Yoho National Park		PROJECT NO. - BOREHOLE NO.				
N. 5700014.1 E. 547383.3		Truck Mounted Solid Stem Auger		V33101067 - AH2010-08				
		Westbound Lane, Middle		ELEVATION: 1627.3m				
SAMPLE TYPE <input checked="" type="checkbox"/> DISTURBED <input type="checkbox"/> NO RECOVERY <input checked="" type="checkbox"/> SPT <input type="checkbox"/> A-CASING <input type="checkbox"/> SHELBY TUBE <input type="checkbox"/> CORE								
BACKFILL TYPE <input checked="" type="checkbox"/> BENTONITE <input checked="" type="checkbox"/> PEA GRAVEL <input type="checkbox"/> SLOUGH <input type="checkbox"/> GROUT <input type="checkbox"/> DRILL CUTTINGS <input type="checkbox"/> SAND								
Depth (m)	SOIL DESCRIPTION	SAMPLE TYPE	USC	SOIL SYMBOL	MOISTURE CONTENT	PLASTIC M.C. LIQUID 	STANDARD PENETRATION (N) UNCONFINED (kPa) POCKET PEN. (kPa)	Elevation (m)
0	ASPHALT. (165 mm)		ASPHAL					1627.0
	SAND, some silt, occasional cobbles, well graded sand and gravel, reddish brown. (FILL)		SW					
1								1626.0
	EOH 1.4 m - Refusal on a boulder.							
2	*Borehole backfilled with cuttings and patched with asphalt.							1625.0
3								1624.0
4								1623.0
5								1622.0
6								1621.0
7								1620.0
8								1619.0
9								1618.0
10								



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 DRAWING NO:

COMPLETION DEPTH: 1.4m  
 COMPLETE: 9/29/2010  
 Page 1 of 1



PCA 2 Km 82-88 Geotechnical Assessment		Parks Canada - Yoho National Park		PROJECT NO. - BOREHOLE NO.				
N. 5700328.9 E. 548130.3		Truck Mounted Solid Stem Auger		V33101067 - AH2010-09				
		Eastbound Lane, Middle		ELEVATION: 1645.3m				
SAMPLE TYPE <input checked="" type="checkbox"/> DISTURBED <input type="checkbox"/> NO RECOVERY <input checked="" type="checkbox"/> SPT <input type="checkbox"/> A-CASING <input type="checkbox"/> SHELBY TUBE <input type="checkbox"/> CORE								
BACKFILL TYPE <input checked="" type="checkbox"/> BENTONITE <input checked="" type="checkbox"/> PEA GRAVEL <input type="checkbox"/> SLOUGH <input type="checkbox"/> GROUT <input type="checkbox"/> DRILL CUTTINGS <input type="checkbox"/> SAND								
Depth (m)	SOIL DESCRIPTION	SAMPLE TYPE SAMPLE NUMBER	USC	SOIL SYMBOL	MOISTURE CONTENT	PLASTIC M.C. LIQUID 	STANDARD PENETRATION (N) 20 40 60 80 UNCONFINED (kPa) 50 100 150 200 POCKET PEN. (kPa) 100 200 300 400	Elevation (m)
0	ASPHALT. (190 mm)			ASPHAL				1645.0
1	SAND, gravelly, trace to some silt, well graded sand and gravel, sub-angular to angular, dry, beige. (FILL)	1						1644.0
2	-Gravel becoming sub-rounded to sub-angular below 1.5 m.	2		SWG				1643.0
3								1642.0
4	EOH 3.8 m - Refusal - the driller communicated that refusal may be on a boulder.  *Borehole backfilled with cuttings and patched with asphalt.	3						1641.0
5								1640.0
6								1639.0
7								1638.0
8								1637.0
9								1636.0
10								



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DRAWING NO:

COMPLETION DEPTH: 3.8m

COMPLETE: 9/28/2010

Page 1 of 1



PCA 2 Km 82-88 Geotechnical Assessment		Parks Canada - Yoho National Park		PROJECT NO. - BOREHOLE NO.								
N. 5700392.8 E. 548684.6		Truck Mounted Solid Stem Auger		V33101067 - AH2010-10								
		Westbound Lane, Middle of Outside Lane		ELEVATION: 1646.9m								
SAMPLE TYPE <input checked="" type="checkbox"/> DISTURBED <input type="checkbox"/> NO RECOVERY <input checked="" type="checkbox"/> SPT <input type="checkbox"/> A-CASING <input type="checkbox"/> SHELBY TUBE <input type="checkbox"/> CORE												
BACKFILL TYPE <input checked="" type="checkbox"/> BENTONITE <input checked="" type="checkbox"/> PEA GRAVEL <input type="checkbox"/> SLOUGH <input type="checkbox"/> GROUT <input type="checkbox"/> DRILL CUTTINGS <input type="checkbox"/> SAND												
Depth (m)	SOIL DESCRIPTION	SAMPLE TYPE	SAMPLE NUMBER	USC	SOIL SYMBOL	MOISTURE CONTENT					Elevation (m)	
							STANDARD PENETRATION (N) 20 40 60 80 UNCONFINED (kPa) 50 100 150 200 POCKET PEN. (kPa) 100 200 300 400					
0	ASPHALT. (140 mm) SAND, gravelly, trace silt, well graded sand and gravel, angular to sub-rounded, dense, beige to brown. (FILL)		1		ASPHALT SWG		PLASTIC M.C. LIQUID 20 40 60 80				1646.0	
1												1645.0
2	EOH 1.5 m - Refusal on rock. *Borehole backfilled with cuttings and patched with asphalt.											1644.0
3												1643.0
4												1642.0
5												1641.0
6												1640.0
7												1639.0
8												1638.0
9												1637.0
10												1637.0



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 DRAWING NO:

COMPLETION DEPTH: 1.5m  
 COMPLETE: 9/29/2010  
 Page 1 of 1



PCA 2 Km 82-88 Geotechnical Assessment		Parks Canada - Yoho National Park		PROJECT NO. - BOREHOLE NO.					
N. 5700456.1 E. 549381.6		Truck Mounted Solid Stem Auger		V33101067 - AH2010-11					
		Eastbound Lane, Middle		ELEVATION: 1644m					
SAMPLE TYPE <input checked="" type="checkbox"/> DISTURBED <input type="checkbox"/> NO RECOVERY <input checked="" type="checkbox"/> SPT <input type="checkbox"/> A-CASING <input type="checkbox"/> SHELBY TUBE <input type="checkbox"/> CORE									
BACKFILL TYPE <input checked="" type="checkbox"/> BENTONITE <input checked="" type="checkbox"/> PEA GRAVEL <input type="checkbox"/> SLOUGH <input type="checkbox"/> GROUT <input type="checkbox"/> DRILL CUTTINGS <input type="checkbox"/> SAND									
Depth (m)	SOIL DESCRIPTION	SAMPLE TYPE	SAMPLE NUMBER	USC	SOIL SYMBOL	MOISTURE CONTENT			Elevation (m)
							PLASTIC	M.C.	
								STANDARD PENETRATION (N) 20 40 60 80 UNCONFINED (kPa) 50 100 150 200 POCKET PEN. (kPa) 100 200 300 400	
0	ASPHALT. (165 mm)				ASPHAL				1644.0
	SAND, gravelly, trace to some silt, occasional cobbles, well graded sand and gravel, angular to sub-rounded, dry to damp, beige. (FILL)								
1	Fracture Count (1 face) - 63.6 %	<input checked="" type="checkbox"/>	1	SWG		2			1643.0
	SAND, gravelly, trace to some silt, well graded sand and gravel, angular to sub-angular, dry, beige.								
2		<input checked="" type="checkbox"/>	2	SWG					1642.0
3	EOH 3.0 m - Refusal								1641.0
	*Borehole backfilled with cuttings and patched with asphalt.								
4									1640.0
5									1639.0
6									1638.0
7									1637.0
8									1636.0
9									1635.0
10									1634.0



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 DRAWING NO:

COMPLETION DEPTH: 3m  
 COMPLETE: 9/29/2010  
 Page 1 of 1



PCA 2 Km 82-88 Geotechnical Assessment		Parks Canada - Yoho National Park		PROJECT NO. - BOREHOLE NO.				
N. 5700493.8 E. 549587.8		Truck Mounted Solid Stem Auger		V33101067 - AH2010-12				
		Westbound Lane, Pullout Near Banff/Yoho Border		ELEVATION: 1642.5m				
SAMPLE TYPE <input checked="" type="checkbox"/> DISTURBED <input checked="" type="checkbox"/> NO RECOVERY <input checked="" type="checkbox"/> SPT <input type="checkbox"/> A-CASING <input type="checkbox"/> SHELBY TUBE <input type="checkbox"/> CORE								
BACKFILL TYPE <input checked="" type="checkbox"/> BENTONITE <input checked="" type="checkbox"/> PEA GRAVEL <input type="checkbox"/> SLOUGH <input type="checkbox"/> GROUT <input type="checkbox"/> DRILL CUTTINGS <input type="checkbox"/> SAND								
Depth (m)	SOIL DESCRIPTION	SAMPLE TYPE SAMPLE NUMBER	USC	SOIL SYMBOL	MOISTURE CONTENT	STANDARD PENETRATION (N)		Elevation (m)
						20 40 60 80	100 150 200	
					PLASTIC M.C. LIQUID 20 40 60 80	50 100 150 200	100 200 300 400	
0	ASPHALT. (75 mm) SAND, gravelly, trace to some silt, well graded sand and gravel, angular to sub-angular, brown. (FILL)			ASPHALT				1642.0
1		1	SWG		2.6			1641.0
2	SAND, some gravel, trace to some silt, fine sand and gravel, sub-angular to sub-rounded, light grey.  Driller indicated that there was less gravel from 2.4 to 3 m.	2	SW					1640.0
3	SAND, some silt, trace gravel, fine sand and gravel, sub-rounded, dry, beige.							1639.0
4	-Damp below 3.7 m.	3	SP					1638.0
5	SAND, some gravel, trace silt, well graded sand and gravel, beige.	4						1637.0
6								1636.0
7		5	SW					1635.0
8								1634.0
9	-Increase in gravel content below 8.5 m.	6						1633.0
10	EOH 9.1 m - Poor recovery.  *Borehole backfilled with cuttings and patched with asphalt.							1633.0



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COMPLETION DEPTH: 9.1m  
COMPLETE: 9/29/2010  
Page 1 of 1



PCA 2 Km 82-88 Geotechnical Assessment		Parks Canada - Yoho National Park		PROJECT NO. - BOREHOLE NO.					
N. 5698610.0 E. 543566.3		2007 Hitachi ZX 200 LC3 Excavator		V33101067 - TP2010-01					
		North Side of Highway 1		ELEVATION: 1561.8m					
SAMPLE TYPE <input checked="" type="checkbox"/> DISTURBED <input type="checkbox"/> NO RECOVERY <input checked="" type="checkbox"/> SPT <input type="checkbox"/> A-CASING <input type="checkbox"/> SHELBY TUBE <input type="checkbox"/> CORE									
BACKFILL TYPE <input type="checkbox"/> BENTONITE <input checked="" type="checkbox"/> PEA GRAVEL <input type="checkbox"/> SLOUGH <input type="checkbox"/> GROUT <input type="checkbox"/> DRILL CUTTINGS <input checked="" type="checkbox"/> SAND									
Depth (m)	SOIL DESCRIPTION	SAMPLE TYPE	SAMPLE NUMBER	USC	SOIL SYMBOL	MOISTURE CONTENT			Elevation (m)
							PLASTIC	M.C.	
								STANDARD PENETRATION (N) 20 40 60 80 UNCONFINED (kPa) 50 100 150 200 POCKET PEN. (kPa) 100 200 300 400	
0	SAND, trace to some silt, trace gravel, well graded sand, fine gravel, moist, dark brown, with rootlets and trace wood debris. (TOPSOIL) -Material was easy to excavate. SAND, gravelly, fine to medium sand, well graded gravel, brown, moist.		1	SW					1561.0
1			2	SWG					
			3						
2	End of Excavation 1.6 m - Refusal on till.								1560.0
3									1559.0
4									1558.0
5									1557.0
6									1556.0



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COMPLETION DEPTH: 1.6m  
 COMPLETE: 9/29/2010  
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PCA 2 Km 82-88 Geotechnical Assessment		Parks Canada - Yoho National Park		PROJECT NO. - BOREHOLE NO.									
N. 5698578.3 E. 543960.5		2007 Hitachi ZX 200 LC3 Excavator		V33101067 - TP2010-02									
		North Side of Highway 1		ELEVATION: 1578.7m									
SAMPLE TYPE <input checked="" type="checkbox"/> DISTURBED <input type="checkbox"/> NO RECOVERY <input checked="" type="checkbox"/> SPT <input type="checkbox"/> A-CASING <input type="checkbox"/> SHELBY TUBE <input type="checkbox"/> CORE													
BACKFILL TYPE <input type="checkbox"/> BENTONITE <input checked="" type="checkbox"/> PEA GRAVEL <input type="checkbox"/> SLOUGH <input type="checkbox"/> GROUT <input type="checkbox"/> DRILL CUTTINGS <input checked="" type="checkbox"/> SAND													
Depth (m)	SOIL DESCRIPTION	SAMPLE TYPE	SAMPLE NUMBER	USC	SOIL SYMBOL	MOISTURE CONTENT	PLASTIC	M.C.	LIQUID	STANDARD PENETRATION (N)	UNCONFINED (kPa)	POCKET PEN. (kPa)	Elevation (m)
0	SAND, trace to some silt, trace gravel, well graded sand, fine gravel, moist, dark brown with rootlets and trace wood debris. (TOPSOIL)		1	SW									1578.0
1	SAND, gravelly, trace silt, fine to medium sand, well graded gravel, rounded to sub-rounded, damp, beige.												1577.0
2	-Occasional cobbles below 2 m.			SWG									1576.0
3			2										1575.0
4	End of excavation 3.4 m - Maximum practical depth.												1574.0
5													1573.0
6													



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 DRAWING NO:

COMPLETION DEPTH: 3.4m  
 COMPLETE: 9/29/2010  
 Page 1 of 1



PCA 2 Km 82-88 Geotechnical Assessment		Parks Canada - Yoho National Park		PROJECT NO. - BOREHOLE NO.								
N. 5698593.9 E. 544431.2		2007 Hitachi ZX 200 LC3 Excavator		V33101067 - TP2010-03								
		South Side of Highway 1		ELEVATION: 1583.4m								
SAMPLE TYPE <input checked="" type="checkbox"/> DISTURBED <input type="checkbox"/> NO RECOVERY <input checked="" type="checkbox"/> SPT <input type="checkbox"/> A-CASING <input type="checkbox"/> SHELBY TUBE <input type="checkbox"/> CORE BACKFILL TYPE <input type="checkbox"/> BENTONITE <input checked="" type="checkbox"/> PEA GRAVEL <input type="checkbox"/> SLOUGH <input type="checkbox"/> GROUT <input type="checkbox"/> DRILL CUTTINGS <input checked="" type="checkbox"/> SAND												
Depth (m)	SOIL DESCRIPTION	SAMPLE TYPE	SAMPLE NUMBER	USC	SOIL SYMBOL	MOISTURE CONTENT					Elevation (m)	
							<div style="display: flex; justify-content: space-between;"> <div> PLASTIC   M.C.   LIQUID  </div> <div> STANDARD PENETRATION (N)  20   40   60   80  ◆ UNCONFINED (kPa) ◆  50   100   150   200  ▲ POCKET PEN. (kPa) ▲  100   200   300   400 </div> </div>					
0	SILT, sandy, well graded sand, moist, dark brown, with rootlets. (TOPSOIL) SAND, gravelly, some silt, well graded sand, sub-rounded to sub-angular, firm, black, with rootlets. SAND and GRAVEL, trace silt, occasional cobbles and boulders, well graded sand and gravel, very dense, beige.	<input checked="" type="checkbox"/>	1	MLS							1583.0	
1		<input checked="" type="checkbox"/>	2	SWG		2.1						1582.0
2												1581.0
3												1580.0
4												1579.0
5												1578.0
6												
End of excavation 2.1 m - Maximum practical depth.						LOGGED BY: TG		COMPLETION DEPTH: 2.1m				
						REVIEWED BY: KW		COMPLETE: 10/1/2010				
						DRAWING NO:		Page 1 of 1				



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PCA 2 Km 82-88 Geotechnical Assessment		Parks Canada - Yoho National Park		PROJECT NO. - BOREHOLE NO.									
N. 5698731.4 E. 544613.4		2007 Hitachi ZX 200 LC3 Excavator		V33101067 - TP2010-04A									
		North Side of Highway 1		ELEVATION: 1587.3m									
SAMPLE TYPE <input checked="" type="checkbox"/> DISTURBED <input type="checkbox"/> NO RECOVERY <input checked="" type="checkbox"/> SPT <input type="checkbox"/> A-CASING <input type="checkbox"/> SHELBY TUBE <input type="checkbox"/> CORE													
BACKFILL TYPE <input checked="" type="checkbox"/> BENTONITE <input checked="" type="checkbox"/> PEA GRAVEL <input type="checkbox"/> SLOUGH <input type="checkbox"/> GROUT <input type="checkbox"/> DRILL CUTTINGS <input type="checkbox"/> SAND													
Depth (m)	SOIL DESCRIPTION	SAMPLE TYPE	SAMPLE NUMBER	USC	SOIL SYMBOL	MOISTURE CONTENT	PLASTIC	M.C.	LIQUID	STANDARD PENETRATION (N)	UNCONFINED (kPa)	POCKET PEN. (kPa)	Elevation (m)
0	SAND, some silt, well graded sand, moist, dark brown. (TOPSOIL)		1	SW-SM									1587.0
1	SILT, clayey, some sand, some gravel, fine to medium sand, well graded gravel, sub-rounded to sub-angular, damp to moist, beige. SAND, some silt, some gravel, fine to medium sand, fine gravel, damp to moist, beige.		2	ML									1586.0
2	End of excavation 1.4 m - Encountered a layer of asphalt of unknown origin.												1585.0
3													1584.0
4													1583.0
5													1582.0
6													



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 DRAWING NO:

COMPLETION DEPTH: 1.4m  
 COMPLETE: 9/29/2010  
 Page 1 of 1



PCA 2 Km 82-88 Geotechnical Assessment		Parks Canada - Yoho National Park		PROJECT NO. - BOREHOLE NO.									
N. 5698742.5 E. 544625.6		2007 Hitachi ZX 200 LC3 Excavator		V33101067 - TP2010-04B									
		North Side of Highway 1		ELEVATION: 1587.4m									
SAMPLE TYPE <input checked="" type="checkbox"/> DISTURBED <input checked="" type="checkbox"/> NO RECOVERY <input checked="" type="checkbox"/> SPT <input type="checkbox"/> A-CASING <input type="checkbox"/> SHELBY TUBE <input type="checkbox"/> CORE													
BACKFILL TYPE <input checked="" type="checkbox"/> BENTONITE <input checked="" type="checkbox"/> PEA GRAVEL <input type="checkbox"/> SLOUGH <input type="checkbox"/> GROUT <input type="checkbox"/> DRILL CUTTINGS <input type="checkbox"/> SAND													
Depth (m)	SOIL DESCRIPTION	SAMPLE TYPE	SAMPLE NUMBER	USC	SOIL SYMBOL	MOISTURE CONTENT	PLASTIC	M.C.	LIQUID	STANDARD PENETRATION (N)	UNCONFINED (kPa)	POCKET PEN. (kPa)	Elevation (m)
0	SAND, gravelly, occasional cobbles, fine to medium sand, well graded gravel, moist, brown, with rootlets. Easy to excavate. -Increase in gravel and cobbles past 0.27 m.												1587.0
1	-At 1 m depth a 0.25 m thick lense was exposed consisting of SILT and CLAY, some sand, trace gravel, well graded sand, fine gravel, damp, firm, beige. (13% sand, 67 % silt, 16 % clay) End of excavation 1.4 m - Material was caving in and cracks were forming around the excavation.		1	SWG		19							1586.0
2			2										1585.0
3													1584.0
4													1583.0
5													1582.0
6													



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 DRAWING NO:

COMPLETION DEPTH: 1.4m  
 COMPLETE: 9/29/2010  
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PCA 2 Km 82-88 Geotechnical Assessment		Parks Canada - Yoho National Park		PROJECT NO. - BOREHOLE NO.	
N. 5699085.9 E. 545050.0		2007 Hitachi ZX 200 LC3 Excavator		V33101067 - TP2010-06	
		North Side of Highway 1		ELEVATION: 1587.4m	
SAMPLE TYPE <input checked="" type="checkbox"/> DISTURBED <input type="checkbox"/> NO RECOVERY <input checked="" type="checkbox"/> SPT <input type="checkbox"/> A-CASING <input type="checkbox"/> SHELBY TUBE <input type="checkbox"/> CORE					
BACKFILL TYPE <input checked="" type="checkbox"/> BENTONITE <input checked="" type="checkbox"/> PEA GRAVEL <input type="checkbox"/> SLOUGH <input type="checkbox"/> GROUT <input type="checkbox"/> DRILL CUTTINGS <input type="checkbox"/> SAND					

Depth (m)	SOIL DESCRIPTION	SAMPLE TYPE	SAMPLE NUMBER	USC	SOIL SYMBOL	MOISTURE CONTENT					Elevation (m)
0	SAND, some silt, some gravel, well graded sand and gravel, rounded to sub-rounded, damp to moist, dark brown, with rootlets. (TOPSOIL)  SAND, gravelly, well graded sand and gravel, rounded to sub-angular, brown and grey. -Occasional cobbles below 0.24 m.		1	SW-SM							1587.0
1			2	SWG							
			3								1586.0
	-Water table encountered at 1.6 m.										
2	End of excavation 1.8 m - Excavation filling with water.										
3											1585.0
4											1584.0
5											1583.0
6											1582.0

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		REVIEWED BY: KW	COMPLETE: 9/29/2010
		DRAWING NO:	Page 1 of 1



PCA 2 Km 82-88 Geotechnical Assessment		Parks Canada - Yoho National Park		PROJECT NO. - BOREHOLE NO.									
N. 5699179.3 E. 545423.3		2007 Hitachi ZX 200 LC3 Excavator		V33101067 - TP2010-07									
		North Side of Highway 1		ELEVATION: 1588.2m									
SAMPLE TYPE <input checked="" type="checkbox"/> DISTURBED <input type="checkbox"/> NO RECOVERY <input checked="" type="checkbox"/> SPT <input type="checkbox"/> A-CASING <input type="checkbox"/> SHELBY TUBE <input type="checkbox"/> CORE													
BACKFILL TYPE <input checked="" type="checkbox"/> BENTONITE <input checked="" type="checkbox"/> PEA GRAVEL <input type="checkbox"/> SLOUGH <input type="checkbox"/> GROUT <input type="checkbox"/> DRILL CUTTINGS <input type="checkbox"/> SAND													
Depth (m)	SOIL DESCRIPTION	SAMPLE TYPE	SAMPLE NUMBER	USC	SOIL SYMBOL	MOISTURE CONTENT	PLASTIC	M.C.	LIQUID	STANDARD PENETRATION (N)	UNCONFINED (kPa)	POCKET PEN. (kPa)	Elevation (m)
0	SILT, sandy, some gravel, some boulders, trace clay, fine to medium sand, well graded gravel, dark brown, with rootlets.		1	MLS		53							1588.0
1	SAND, gravelly, silty, occasional cobbles, fine to medium sand, well graded gravel, rounded to sub-angular, moist, brown, with rootlets.		3			90							1587.0
	-Pockets of black material.		2	SWG									
2	End of excavation 1.8 m - Water table encountered.												1586.0
3													1585.0
4													1584.0
5													1583.0
6													



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 DRAWING NO:

COMPLETION DEPTH: 1.8m  
 COMPLETE: 9/29/2010  
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PCA 2 Km 82-88 Geotechnical Assessment		Parks Canada - Yoho National Park		PROJECT NO. - BOREHOLE NO.									
N. 5699363.5 E. 546074.1		2007 Hitachi ZX 200 LC3 Excavator		V33101067 - TP2010-08									
		South Side of Highway 1		ELEVATION: 1591.3m									
SAMPLE TYPE <input checked="" type="checkbox"/> DISTURBED <input checked="" type="checkbox"/> NO RECOVERY <input checked="" type="checkbox"/> SPT <input checked="" type="checkbox"/> A-CASING <input checked="" type="checkbox"/> SHELBY TUBE <input checked="" type="checkbox"/> CORE													
BACKFILL TYPE <input checked="" type="checkbox"/> BENTONITE <input checked="" type="checkbox"/> PEA GRAVEL <input checked="" type="checkbox"/> SLOUGH <input checked="" type="checkbox"/> GROUT <input checked="" type="checkbox"/> DRILL CUTTINGS <input checked="" type="checkbox"/> SAND													
Depth (m)	SOIL DESCRIPTION	SAMPLE TYPE	SAMPLE NUMBER	USC	SOIL SYMBOL	MOISTURE CONTENT	PLASTIC	M.C.	LIQUID	STANDARD PENETRATION (N)	UNCONFINED (kPa)	POCKET PEN. (kPa)	Elevation (m)
0	SILT and SAND, well graded sand, damp to moist, soft, with rootlets. (TOPSOIL)			SM-ML									1591.0
1	GRAVEL, sandy, some silt, trace clay, occasional cobbles and boulders, well graded gravel and sand, sub-rounded to sub-angular, damp, very stiff, beige/red/brown. (32 % sand, 14 % silt, 2 % clay)		1	MLS		11							1590.0
2	SAND, gravelly, trace silt, well graded sand and gravel, sub-rounded to angular, moist, very dense, grey.		2	SWG									1589.0
3	SAND, some gravel, well graded sand and gravel, moist to wet, dense, grey. -Layers approximately 0.4 m thick with higher gravel content were encountered.		3	SW		16							1588.0
4	End of excavation 2.4 m - Maximum practical depth.												1587.0
5													1586.0
6													



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DRAWING NO:

COMPLETION DEPTH: 3.1m  
COMPLETE: 10/1/2010  
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PCA 2 Km 82-88 Geotechnical Assessment		Parks Canada - Yoho National Park		PROJECT NO. - BOREHOLE NO.									
N. 5699638.1 E. 546331.9		2007 Hitachi ZX 200 LC3 Excavator		V33101067 - TP2010-09									
		North Side of Highway 1		ELEVATION: 1597.6m									
SAMPLE TYPE <input checked="" type="checkbox"/> DISTURBED <input checked="" type="checkbox"/> NO RECOVERY <input checked="" type="checkbox"/> SPT <input type="checkbox"/> A-CASING <input type="checkbox"/> SHELBY TUBE <input type="checkbox"/> CORE													
BACKFILL TYPE <input checked="" type="checkbox"/> BENTONITE <input checked="" type="checkbox"/> PEA GRAVEL <input type="checkbox"/> SLOUGH <input type="checkbox"/> GROUT <input type="checkbox"/> DRILL CUTTINGS <input type="checkbox"/> SAND													
Depth (m)	SOIL DESCRIPTION	SAMPLE TYPE	SAMPLE NUMBER	USC	SOIL SYMBOL	MOISTURE CONTENT	PLASTIC	M.C.	LIQUID	STANDARD PENETRATION (N)	UNCONFINED (kPa)	POCKET PEN. (kPa)	Elevation (m)
0	SAND, gravelly, trace to some silt, medium to coarse sand, fine gravel, damp, dark brown, with rootlets. (TOPSOIL)		1	SWG									
1	SAND, gravelly, some silt, occasional cobbles, medium to coarse sand, fine gravel, rounded to sub-angular, damp, beige.												1597.0
	-Material was easy to excavate and the walls did not slough.												
2			2	SWG									1596.0
3			3			10							1595.0
4													1594.0
5	End of excavation 4.3 m - Maximum practical depth.												1593.0
6													1592.0



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COMPLETION DEPTH: 4.3m  
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PCA 2 Km 82-88 Geotechnical Assessment		Parks Canada - Yoho National Park		PROJECT NO. - BOREHOLE NO.					
N. 5699829.4 E. 546878.9		2007 Hitachi ZX 200 LC3 Excavator		V33101067 - TP2010-10					
		South Side of Highway 1		ELEVATION: 1611.1m					
SAMPLE TYPE <input checked="" type="checkbox"/> DISTURBED <input checked="" type="checkbox"/> NO RECOVERY <input checked="" type="checkbox"/> SPT <input type="checkbox"/> A-CASING <input type="checkbox"/> SHELBY TUBE <input type="checkbox"/> CORE									
BACKFILL TYPE <input type="checkbox"/> BENTONITE <input type="checkbox"/> PEA GRAVEL <input type="checkbox"/> SLOUGH <input type="checkbox"/> GROUT <input type="checkbox"/> DRILL CUTTINGS <input type="checkbox"/> SAND									
Depth (m)	SOIL DESCRIPTION	SAMPLE TYPE	SAMPLE NUMBER	USC	SOIL SYMBOL	MOISTURE CONTENT			Elevation (m)
							PLASTIC	M.C.	
							20	40	
							50	100	
							150	200	
							250	300	
							350	400	
0	SILT, sandy, well graded sand, moist, dark brown, rootlets. (TOPSOIL)			MLS					1611.0
	SAND, silty, gravelly, some cobbles, occasional boulders, well graded sand and gravel, angular to sub-rounded, moist, beige.		1	SW-SM					
1	SAND, gravelly, some silt, occasional cobbles and boulders, well graded sand and gravel, angular to sub-rounded, moist, grey.			SWG					1610.0
	GRAVEL, some sand, well graded gravel and sand, angular to sub-angular.								
2			2	GWS					1609.0
3									1608.0
4									1607.0
5									1606.0
6									
End of excavation 3.3 m - Maximum practical depth.									





PCA 2 Km 82-88 Geotechnical Assessment		Parks Canada - Yoho National Park		PROJECT NO. - BOREHOLE NO.							
N. 5699904.5 E. 547004.5		2007 Hitachi ZX 200 LC3 Excavator		V33101067 - TP2010-11							
		North Side of Highway 1		ELEVATION: 1617.2m							
SAMPLE TYPE <input checked="" type="checkbox"/> DISTURBED <input type="checkbox"/> NO RECOVERY <input checked="" type="checkbox"/> SPT <input type="checkbox"/> A-CASING <input type="checkbox"/> SHELBY TUBE <input type="checkbox"/> CORE											
BACKFILL TYPE <input checked="" type="checkbox"/> BENTONITE <input checked="" type="checkbox"/> PEA GRAVEL <input type="checkbox"/> SLOUGH <input type="checkbox"/> GROUT <input type="checkbox"/> DRILL CUTTINGS <input type="checkbox"/> SAND											
Depth (m)	SOIL DESCRIPTION	SAMPLE TYPE	SAMPLE NUMBER	USC	SOIL SYMBOL	MOISTURE CONTENT	PLASTIC M.C. LIQUID		STANDARD PENETRATION (N)		Elevation (m)
							20 40 60 80	50 100 150 200	20 40 60 80	50 100 150 200	
0	SAND, gravelly, trace to some cobbles, medium to coarse sand, well graded gravel, damp, dark brown, with rootlets in the top 0.25 m.  -Easy to excavate.	<input checked="" type="checkbox"/>	1	SWG		3.8					1617.0
1	SAND, gravelly, some silt, occasional cobbles, medium to coarse sand, well graded gravel, damp, dense, beige.  -Material is dense and difficult to excavate (Till-like)	<input checked="" type="checkbox"/>	2	SWG							1616.0
2		<input checked="" type="checkbox"/>	3	SWG							1615.0
3	End of excavation 2.4 m - Maximum practical depth.										1614.0
4											1613.0
5											1612.0
6											



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COMPLETION DEPTH: 2.4m  
 COMPLETE: 9/29/2010  
 Page 1 of 1



PCA 2 Km 82-88 Geotechnical Assessment		Parks Canada - Yoho National Park		PROJECT NO. - BOREHOLE NO.							
N. 5700025.6 E. 547379.4		2007 Hitachi ZX 200 LC3 Excavator		V33101067 - TP2010-12							
		North Side of Highway 1		ELEVATION: 1625.9m							
SAMPLE TYPE <input checked="" type="checkbox"/> DISTURBED <input type="checkbox"/> NO RECOVERY <input checked="" type="checkbox"/> SPT <input type="checkbox"/> A-CASING <input type="checkbox"/> SHELBY TUBE <input type="checkbox"/> CORE											
BACKFILL TYPE <input checked="" type="checkbox"/> BENTONITE <input checked="" type="checkbox"/> PEA GRAVEL <input type="checkbox"/> SLOUGH <input type="checkbox"/> GROUT <input type="checkbox"/> DRILL CUTTINGS <input type="checkbox"/> SAND											
Depth (m)	SOIL DESCRIPTION	SAMPLE TYPE	SAMPLE NUMBER	USC	SOIL SYMBOL	MOISTURE CONTENT					Elevation (m)
							STANDARD PENETRATION (N) 20 40 60 80 UNCONFINED (kPa) 50 100 150 200 POCKET PEN. (kPa) 100 200 300 400				
0	SAND, gravelly, trace to some silt, well graded sand and gravel, damp, dark brown, with rootlets. -Material was easy to excavate. BEDROCK. The excavator was able to rip the top 0.75 m of rock. -Excavation was difficult.		1	SWG							
1	End of excavation 1.0 m - Refusal due to bedrock.		2	BEDROCK							
2											1625.0
3											1624.0
4											1623.0
5											1622.0
6											1621.0
											1620.0



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COMPLETION DEPTH: 1m  
 COMPLETE: 9/29/2010  
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PCA 2 Km 82-88 Geotechnical Assessment		Parks Canada - Yoho National Park		PROJECT NO. - BOREHOLE NO.			
N. 5700186.6 E. 547790.8		2007 Hitachi ZX 200 LC3 Excavator		V33101067 - TP2010-13			
		South Side of Highway 1		ELEVATION: 1635m			
SAMPLE TYPE <input checked="" type="checkbox"/> DISTURBED <input type="checkbox"/> NO RECOVERY <input checked="" type="checkbox"/> SPT <input type="checkbox"/> A-CASING <input type="checkbox"/> SHELBY TUBE <input type="checkbox"/> CORE							
BACKFILL TYPE <input checked="" type="checkbox"/> BENTONITE <input checked="" type="checkbox"/> PEA GRAVEL <input type="checkbox"/> SLOUGH <input type="checkbox"/> GROUT <input type="checkbox"/> DRILL CUTTINGS <input type="checkbox"/> SAND							
Depth (m)	SOIL DESCRIPTION	SAMPLE TYPE SAMPLE NUMBER	USC	SOIL SYMBOL	MOISTURE CONTENT PLASTIC M.C. LIQUID 20 40 60 80	STANDARD PENETRATION (N) 20 40 60 80 ◆ UNCONFINED (kPa) ◆ 50 100 150 200 ▲ POCKET PEN. (kPa) ▲ 100 200 300 400	Elevation (m)
0	SAND, some silt, trace gravel, well graded sand, fine gravel, black, with rootlets. (TOPSOIL) SAND, silty, gravelly, some cobbles, medium to coarse sand, well graded gravel, angular to sub-rounded, damp, beige, with occasional wood debris.		SW				1635.0
1		1	SW-SM		8		1634.0
2	SILT, stiff, black/grey, rootlets. SAND, silty, some gravel, occasional cobbles, well graded sand and gravel, beige.		ML				1633.0
3		2	SW-SM				1632.0
4	End of excavation 3.5 m - Maximum practical depth. -Material was easy to excavate.						1631.0
5							1630.0
6							1629.0



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COMPLETION DEPTH: 3.5m  
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PCA 2 Km 82-88 Geotechnical Assessment		Parks Canada - Yoho National Park		PROJECT NO. - BOREHOLE NO.									
N. 5700345.3 E. 548123.4		2007 Hitachi ZX 200 LC3 Excavator		V33101067 - TP2010-14									
		North Side of Highway 1		ELEVATION: 1644.3m									
SAMPLE TYPE <input checked="" type="checkbox"/> DISTURBED <input type="checkbox"/> NO RECOVERY <input checked="" type="checkbox"/> SPT <input type="checkbox"/> A-CASING <input type="checkbox"/> SHELBY TUBE <input type="checkbox"/> CORE													
BACKFILL TYPE <input checked="" type="checkbox"/> BENTONITE <input checked="" type="checkbox"/> PEA GRAVEL <input type="checkbox"/> SLOUGH <input type="checkbox"/> GROUT <input type="checkbox"/> DRILL CUTTINGS <input type="checkbox"/> SAND													
Depth (m)	SOIL DESCRIPTION	SAMPLE TYPE	SAMPLE NUMBER	USC	SOIL SYMBOL	MOISTURE CONTENT	PLASTIC	M.C.	LIQUID	STANDARD PENETRATION (N)	UNCONFINED (kPa)	POCKET PEN. (kPa)	Elevation (m)
0	SAND, silty, some gravel, fine to medium sand, fine gravel, damp to moist, dark brown, some rootlets. Some pieces of rock from the adjacent slope are intermixed with the soil.	<input checked="" type="checkbox"/>	1	SW-SM									1644.0
	SAND, some gravel, well graded sand, fine gravel, moist, beige. Some pieces of rock from the adjacent slope are intermixed with the soil.	<input checked="" type="checkbox"/>	2	SW									
1	BEDROCK. Excavator was able to rip through the top 0.5 m of rock.	<input checked="" type="checkbox"/>		BEDROCK									
	End of excavation 1.1 m - Refusal due to bedrock.												
2													
3													
4													
5													
6													





PCA 2 Km 82-88 Geotechnical Assessment		Parks Canada - Yoho National Park		PROJECT NO. - BOREHOLE NO.									
N. 5700335.1 E. 548361.5		2007 Hitachi ZX 200 LC3 Excavator		V33101067 - TP2010-15									
		South Side of Highway 1		ELEVATION: 1645m									
SAMPLE TYPE <input checked="" type="checkbox"/> DISTURBED <input checked="" type="checkbox"/> NO RECOVERY <input checked="" type="checkbox"/> SPT <input type="checkbox"/> A-CASING <input type="checkbox"/> SHELBY TUBE <input type="checkbox"/> CORE													
BACKFILL TYPE <input checked="" type="checkbox"/> BENTONITE <input checked="" type="checkbox"/> PEA GRAVEL <input type="checkbox"/> SLOUGH <input type="checkbox"/> GROUT <input type="checkbox"/> DRILL CUTTINGS <input type="checkbox"/> SAND													
Depth (m)	SOIL DESCRIPTION	SAMPLE TYPE	SAMPLE NUMBER	USC	SOIL SYMBOL	MOISTURE CONTENT	PLASTIC	M.C.	LIQUID	STANDARD PENETRATION (N)	UNCONFINED (kPa)	POCKET PEN. (kPa)	Elevation (m)
0	SAND, some silt, trace gravel, well graded sand, fine gravel, black, rootlets. (TOPSOIL) SAND, gravelly, well graded sand and gravel, wet, grey. (FILL)			SW									1645.0
1	SILT, some sand, occasional cobbles, well graded sand, moist, firm, black, with wood debris.	1		ML									1644.0
	SILT and CLAY, sandy, some gravel, occasional cobbles and boulders, well graded sand and gravel, very stiff, red/brown/beige. (29 % sand, 38 % silt, 19 % clay)	2		CH-ML		23							
2	SAND, gravelly, occasional cobbles and boulders, well graded sand and gravel, wet, dense, beige.		3	SWG									1643.0
3	End of excavation 2.9 m - Maximum practical depth.												1642.0
4													1641.0
5													1640.0
6													1639.0



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PCA 2 Km 82-88 Geotechnical Assessment		Parks Canada - Yoho National Park		PROJECT NO. - BOREHOLE NO.							
N. 5700401.7 E. 548682.6		2007 Hitachi ZX 200 LC3 Excavator		V33101067 - TP2010-16							
		North Side of Highway 1		ELEVATION: 1645.9m							
SAMPLE TYPE <input checked="" type="checkbox"/> DISTURBED <input checked="" type="checkbox"/> NO RECOVERY <input checked="" type="checkbox"/> SPT <input type="checkbox"/> A-CASING <input type="checkbox"/> SHELBY TUBE <input type="checkbox"/> CORE											
BACKFILL TYPE <input type="checkbox"/> BENTONITE <input type="checkbox"/> PEA GRAVEL <input type="checkbox"/> SLOUGH <input type="checkbox"/> GROUT <input type="checkbox"/> DRILL CUTTINGS <input type="checkbox"/> SAND											
Depth (m)	SOIL DESCRIPTION	SAMPLE TYPE	SAMPLE NUMBER	USC	SOIL SYMBOL	MOISTURE CONTENT	PLASTIC M.C. LIQUID		STANDARD PENETRATION (N)		Elevation (m)
							20 40 60 80	50 100 150 200	20 40 60 80	50 100 150 200	
0	SAND, silty, some gravel, fine to medium sand, fine gravel, damp to moist, dark brown, with rootlets. Some pieces of rock from the adjacent slope are intermixed with the soil. -Material was easy to excavate. SAND, some to trace clay, some to trace gravel, trace silt, fine sand, well graded gravel, sub-rounded, moist, beige. SAND, some to trace clay, trace silt, trace cobbles, fine sand, well graded gravel, sub-rounded, moist, beige. End of excavation at 0.7 m - Refusal at bedrock.	<input checked="" type="checkbox"/>	1	SW-SM							1645.0
		<input checked="" type="checkbox"/>	2	SP							
		<input checked="" type="checkbox"/>	3	SP							
1											
2											
3											
4											
5											
6											



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COMPLETION DEPTH: 0.7m  
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PCA 2 Km 82-88 Geotechnical Assessment		Parks Canada - Yoho National Park		PROJECT NO. - BOREHOLE NO.									
N. 5700410.2 E. 549054.6		2007 Hitachi ZX 200 LC3 Excavator		V33101067 - TP2010-17									
		South Side of Highway 1		ELEVATION: 1643m									
SAMPLE TYPE <input checked="" type="checkbox"/> DISTURBED <input checked="" type="checkbox"/> NO RECOVERY <input checked="" type="checkbox"/> SPT <input type="checkbox"/> A-CASING <input type="checkbox"/> SHELBY TUBE <input type="checkbox"/> CORE													
BACKFILL TYPE <input type="checkbox"/> BENTONITE <input type="checkbox"/> PEA GRAVEL <input type="checkbox"/> SLOUGH <input type="checkbox"/> GROUT <input type="checkbox"/> DRILL CUTTINGS <input type="checkbox"/> SAND													
Depth (m)	SOIL DESCRIPTION	SAMPLE TYPE	SAMPLE NUMBER	USC	SOIL SYMBOL	MOISTURE CONTENT	PLASTIC	M.C.	LIQUID	STANDARD PENETRATION (N)	UNCONFINED (kPa)	POCKET PEN. (kPa)	Elevation (m)
0	SAND, some silt, well graded sand, moist, soft, black, with rootlets. (TOPSOIL)			SW									1643.0
	SAND, gravelly, occasional cobbles, well graded sand and gravel, grey. (FILL)		1	SWG									
	SILT, some sand, trace gravel, fine sand and gravel, moist, firm, black, rootlets.		2	ML									
1	SAND, silty, fine sand, damp to moist, light grey, rootlets.			SP-SM									1642.0
	SAND, some silt, well graded sand, damp, dense, brown to beige.			SW									
	SAND, silty, some gravel, some clay, occasional cobbles and boulders, well graded sand and gravel, beige. (42 % sand, 25 % silt, 13 % clay)												
2	Difficult to excavate due to boulders.		3	MLS		13							1641.0
3	End of excavation 3.0 m - Refusal on a boulder.												1640.0
4													1639.0
5													1638.0
6													1637.0



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COMPLETION DEPTH: 3m  
 COMPLETE: 9/28/2010  
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PCA 2 Km 82-88 Geotechnical Assessment		Parks Canada - Yoho National Park		PROJECT NO. - BOREHOLE NO.					
N. 5700475.3 E. 549369.3		2007 Hitachi ZX 200 LC3 Excavator		V33101067 - TP2010-18					
		North Side of Highway 1		ELEVATION: 1642.4m					
SAMPLE TYPE <input checked="" type="checkbox"/> DISTURBED <input type="checkbox"/> NO RECOVERY <input checked="" type="checkbox"/> SPT <input type="checkbox"/> A-CASING <input type="checkbox"/> SHELBY TUBE <input type="checkbox"/> CORE									
BACKFILL TYPE <input checked="" type="checkbox"/> BENTONITE <input checked="" type="checkbox"/> PEA GRAVEL <input type="checkbox"/> SLOUGH <input type="checkbox"/> GROUT <input type="checkbox"/> DRILL CUTTINGS <input type="checkbox"/> SAND									
Depth (m)	SOIL DESCRIPTION	SAMPLE TYPE	SAMPLE NUMBER	USC	SOIL SYMBOL	MOISTURE CONTENT	STANDARD PENETRATION (N)		Elevation (m)
							20 40 60 80	100 150 200	
							PLASTIC M.C. LIQUID 20 40 60 80	UNCONFINED (kPa) 50 100 150 200 POCKET PEN. (kPa) 100 200 300 400	
0	SAND, some gravel, occasional cobbles, well graded sand, fine gravel, moist, grey, with rootlets.			SW					1642.0
	SAND, gravelly, some silt, occasional cobbles and boulders, well graded sand and gravel, moist, orangey beige, with rootlets.		1	SWG					
1	GRAVEL, some sand, some silt, occasional cobbles and boulders, well graded gravel and sand, sub-rounded to sub-angular, moist, beige to brown.			GW					1641.0
	SAND, some gravel, trace silt, occasional cobbles and boulders, fine to medium sand, well graded gravel, damp to moist, grey.		2						
2				SW					1640.0
			3						
3	End of excavation 2.95 m - Maximum practical depth.								1639.0
4									1638.0
5									1637.0
6									



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COMPLETION DEPTH: 2.95m  
 COMPLETE: 9/30/2010  
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PCA 2 Km 82-88 Geotechnical Assessment		Parks Canada - Yoho National Park		PROJECT NO. - BOREHOLE NO.									
N. 5700504.9 E. 549586.6		2007 Hitachi ZX 200 LC3 Excavator		V33101067 - TP2010-19									
		North Side of Highway 1		ELEVATION: 1642.1m									
SAMPLE TYPE <input checked="" type="checkbox"/> DISTURBED <input type="checkbox"/> NO RECOVERY <input checked="" type="checkbox"/> SPT <input type="checkbox"/> A-CASING <input type="checkbox"/> SHELBY TUBE <input type="checkbox"/> CORE													
BACKFILL TYPE <input checked="" type="checkbox"/> BENTONITE <input checked="" type="checkbox"/> PEA GRAVEL <input type="checkbox"/> SLOUGH <input type="checkbox"/> GROUT <input type="checkbox"/> DRILL CUTTINGS <input type="checkbox"/> SAND													
Depth (m)	SOIL DESCRIPTION	SAMPLE TYPE	SAMPLE NUMBER	USC	SOIL SYMBOL	MOISTURE CONTENT	PLASTIC	M.C.	LIQUID	STANDARD PENETRATION (N)	UNCONFINED (kPa)	POCKET PEN. (kPa)	Elevation (m)
0	SAND, silty, fine sand, brown and black, rootlets. (TOPSOIL)			SP-SM									1642.0
1	SAND, gravelly, occasional cobbles, well graded sand and gravel, moist to wet, dense, grey to brown.		1	SWG									1641.0
2	SAND, trace gravel, fine sand, well graded gravel, damp, dense, grey.		2	SW									1640.0
3	End of excavation 3.2 m - Maximum practical depth.												1639.0
4													1638.0
5													1637.0
6													



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COMPLETION DEPTH: 3.2m  
 COMPLETE: 9/30/2010  
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PCA 2 Km 82-88 Geotechnical Assessment		Parks Canada - Yoho National Park		PROJECT NO. - BOREHOLE NO.								
N. 5700522.3 E. 549643.3		2007 Hitachi ZX 200 LC3 Excavator		V33101067 - TP2010-20								
		North Side of Highway 1		ELEVATION: 1644.5m								
SAMPLE TYPE <input checked="" type="checkbox"/> DISTURBED <input checked="" type="checkbox"/> NO RECOVERY <input checked="" type="checkbox"/> SPT <input type="checkbox"/> A-CASING <input type="checkbox"/> SHELBY TUBE <input type="checkbox"/> CORE												
BACKFILL TYPE <input checked="" type="checkbox"/> BENTONITE <input checked="" type="checkbox"/> PEA GRAVEL <input type="checkbox"/> SLOUGH <input type="checkbox"/> GROUT <input type="checkbox"/> DRILL CUTTINGS <input type="checkbox"/> SAND												
Depth (m)	SOIL DESCRIPTION	SAMPLE TYPE	SAMPLE NUMBER	USC	SOIL SYMBOL	MOISTURE CONTENT					Elevation (m)	
							STANDARD PENETRATION (N) <input checked="" type="checkbox"/> 20 40 60 80 UNCONFINED (kPa) <input checked="" type="checkbox"/> 50 100 150 200 POCKET PEN. (kPa) <input checked="" type="checkbox"/> 100 200 300 400					
0	SAND, silty, some gravel, fine sand, coarse gravel, black, with rootlets. (TOPSOIL)				SP-SM							
	SILT, some sand, some cobbles, some boulders, fine sand, damp, firm, reddish brown.		1		ML							1644.0
	SAND, gravelly, cobbly, some silt, well graded sand and gravel, sub-angular to sub-rounded, moist to wet, brown.		2		SWG							
1	SAND, gravelly, occasional cobbles, well graded sand and gravel, sub-angular to sub-rounded, moist to wet, grey.											1643.0
2			3		SWG							1642.0
3												1641.0
4	End of excavation 3.7 m - Maximum practical depth.											1640.0
5												1639.0
6												



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COMPLETION DEPTH: 3.7m  
 COMPLETE: 9/28/2010  
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PCA 2 Km 82-88 Geotechnical Assessment		Parks Canada - Yoho National Park		PROJECT NO. - BOREHOLE NO.									
N. 5700548.6 E. 549786.0		2007 Hitachi ZX 200 LC3 Excavator		V33101067 - TP2010-22									
		North Side of Highway 1		ELEVATION: 1643.6m									
SAMPLE TYPE <input checked="" type="checkbox"/> DISTURBED <input type="checkbox"/> NO RECOVERY <input checked="" type="checkbox"/> SPT <input type="checkbox"/> A-CASING <input type="checkbox"/> SHELBY TUBE <input type="checkbox"/> CORE													
BACKFILL TYPE <input checked="" type="checkbox"/> BENTONITE <input checked="" type="checkbox"/> PEA GRAVEL <input type="checkbox"/> SLOUGH <input type="checkbox"/> GROUT <input type="checkbox"/> DRILL CUTTINGS <input type="checkbox"/> SAND													
Depth (m)	SOIL DESCRIPTION	SAMPLE TYPE	SAMPLE NUMBER	USC	SOIL SYMBOL	MOISTURE CONTENT	PLASTIC	M.C.	LIQUID	STANDARD PENETRATION (N)	UNCONFINED (kPa)	POCKET PEN. (kPa)	Elevation (m)
0	SAND, silty, some gravel, fine sand, coarse gravel, black, rootlets. (TOPSOIL)		1	MLS									
1	SILT, sandy, some gravel, occasional cobbles and boulders, fine sand, well graded gravel, sub-rounded to sub-angular, moist to wet, reddish brown.												
1	SAND, gravelly, some silt, occasional cobbles and boulders, well graded sand and gravel, moist to wet, brown.												1643.0
2	SAND, gravelly, occasional cobbles, well graded sand and gravel, moist to wet, grey. Some boulders near the bottom of the excavation.		2			5							1642.0
3	End of excavation 3.0 m - Refusal on a boulder. -Material was difficult to excavate.												1641.0
4													1640.0
5													1639.0
6													1638.0



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COMPLETION DEPTH: 3m  
COMPLETE: 9/28/2010  
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PCA 2 Km 82-88 Geotechnical Assessment		Parks Canada - Yoho National Park		PROJECT NO. - BOREHOLE NO.							
N. 5700528.0 E. 549932.5		2007 Hitachi ZX 200 LC3 Excavator		V33101067 - TP2010-23							
		South Side of Highway 1		ELEVATION: 1639.6m							
SAMPLE TYPE <input checked="" type="checkbox"/> DISTURBED <input type="checkbox"/> NO RECOVERY <input checked="" type="checkbox"/> SPT <input type="checkbox"/> A-CASING <input type="checkbox"/> SHELBY TUBE <input type="checkbox"/> CORE											
BACKFILL TYPE <input checked="" type="checkbox"/> BENTONITE <input checked="" type="checkbox"/> PEA GRAVEL <input type="checkbox"/> SLOUGH <input type="checkbox"/> GROUT <input type="checkbox"/> DRILL CUTTINGS <input type="checkbox"/> SAND											
Depth (m)	SOIL DESCRIPTION	SAMPLE TYPE	SAMPLE NUMBER	USC	SOIL SYMBOL	MOISTURE CONTENT	PLASTIC M.C. LIQUID		STANDARD PENETRATION (N)		Elevation (m)
							20 40 60 80	50 100 150 200	20 40 60 80	50 100 150 200	
0	SILT, some sand, some gravel, some cobbles, some boulders, well graded sand and gravel, soft to firm, black.			ML							
	SILT, some sand, some gravel, occasional cobbles and boulders, well graded sand and gravel, firm, reddish brown to beige.		1	ML							1639.0
	SAND, silty, trace to some gravel, well graded sand and gravel, wet, dense, light beige.		2	SP-SM		20					
1	SILT, some sand, some gravel, occasional cobbles, well graded sand and gravel, sub-angular to sub-rounded. (TILL)										
				ML							1638.0
2											
	End of excavation 2.5 m - Refusal on a large boulder.										1637.0
3											
											1636.0
4											
											1635.0
5											
											1634.0
6											



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LOGGED BY: TG  
 REVIEWED BY: KW  
 DRAWING NO:

COMPLETION DEPTH: 2.5m  
 COMPLETE: 9/28/2010  
 Page 1 of 1



PCA 2 Km 82-88 Geotechnical Assessment		Parks Canada - Yoho National Park		PROJECT NO. - BOREHOLE NO.					
N. 5700545.7 E. 549890.0		2007 Hitachi ZX 200 LC3 Excavator		V33101067 - TP2010-24					
		North Side of Highway 1		ELEVATION: 1640.3m					
SAMPLE TYPE <input checked="" type="checkbox"/> DISTURBED <input type="checkbox"/> NO RECOVERY <input checked="" type="checkbox"/> SPT <input type="checkbox"/> A-CASING <input type="checkbox"/> SHELBY TUBE <input type="checkbox"/> CORE									
BACKFILL TYPE <input checked="" type="checkbox"/> BENTONITE <input checked="" type="checkbox"/> PEA GRAVEL <input type="checkbox"/> SLOUGH <input type="checkbox"/> GROUT <input type="checkbox"/> DRILL CUTTINGS <input type="checkbox"/> SAND									
Depth (m)	SOIL DESCRIPTION	SAMPLE TYPE	SAMPLE NUMBER	USC	SOIL SYMBOL	MOISTURE CONTENT			Elevation (m)
							PLASTIC	M.C.	
							20	40	
							50	100	
							150	200	
							250	300	
							350	400	
0	SAND, gravelly, some silt, well graded sand, fine gravel, rootlets. (FILL)  -Water seeping along the interface of the fill and underlying till.		1	SWG					1640.0
1	SILT and SAND, gravelly, trace clay, occasional cobbles, well graded sand and gravel, sub-rounded to sub-angular, very dense, beige. (TILL) (33 % sand, 33 % silt, 8 % clay)		2	ML		7			1639.0
2									1638.0
3	End of excavation 2.5 m - Refusal on a boulder.								1637.0
4									1636.0
5									1635.0
6									



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LOGGED BY: TG  
REVIEWED BY: KW  
DRAWING NO:

COMPLETION DEPTH: 2.5m  
COMPLETE: 9/28/2010  
Page 1 of 1



# APPENDIX B

## APPENDIX B LABORATORY TESTING



## GRAIN SIZE DISTRIBUTION

ASTM C136 & D422

Project: PCA Km 82-88 Geotechnical Assessment

Project Number: V33101067

Date Tested: 10/8/2010

Borehole Number: AH2010-01 Sample 1

Depth: 0.9 m

Soil Description: GRAVEL, sandy, trace fines

Cu: 39.9

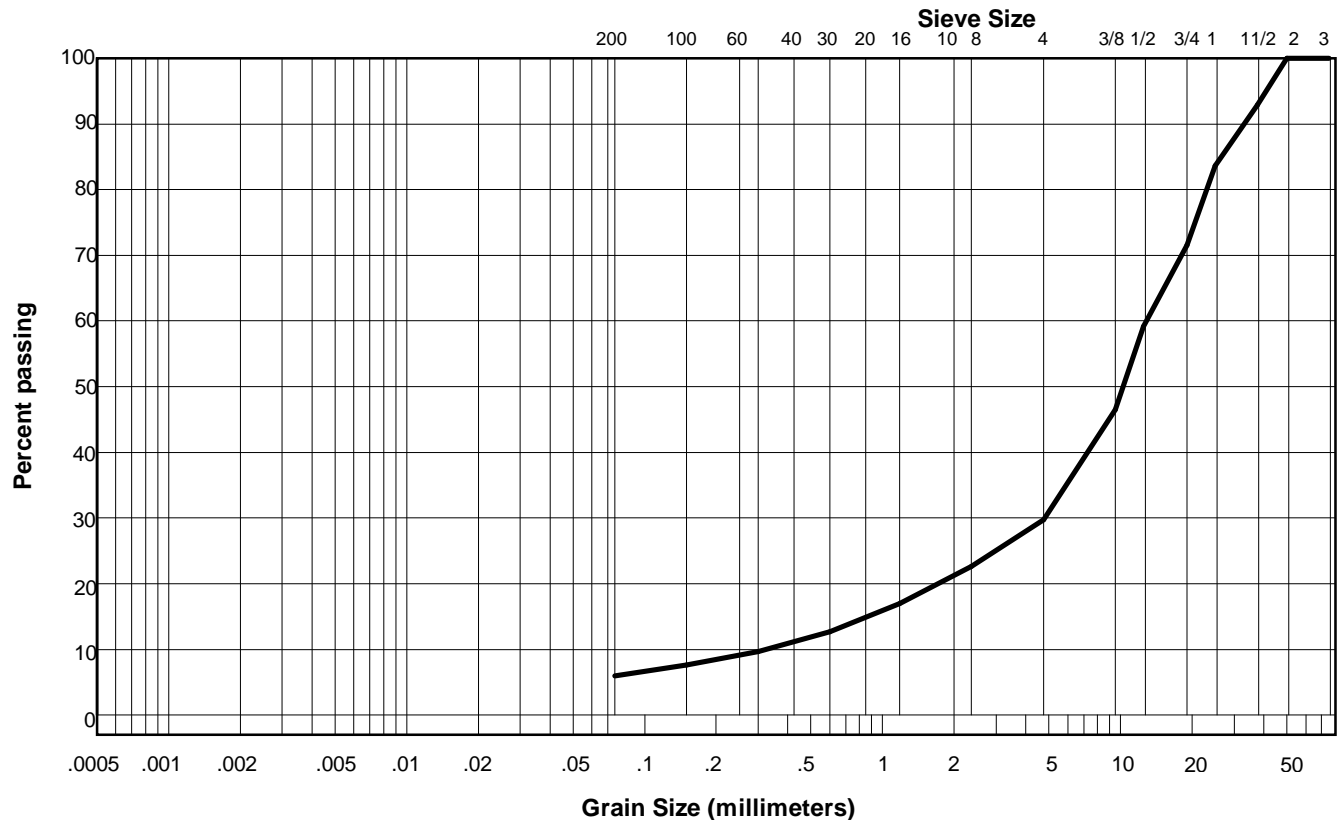
Cc: 5.6

Natural Moisture Content: 1%

Remarks: Fracture Count 61.2 %, by procedures of the BC MOT Manual  
of Test Procedures, Section 11.3.

Sieve Size	Percent Passing
75.000	100
50.000	100
37.500	93
25.000	84
19.000	72
12.500	59
9.500	47
4.750	30
2.360	23
1.180	17
0.600	13
0.300	10
0.150	8
0.075	6.0

Clay	Silt	Sand			Gravel	
		Fine	Medium	Coarse	Fine	Coarse



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## GRAIN SIZE DISTRIBUTION

ASTM C136 & C117

Project: PCA Km 82-88 Geotechnical Assessment

Project Number: V33101067

Date Tested: 10/13/2010

Borehole Number: AH2010-02 Sample 1

Depth: 0.7 m

Soil Description: GRAVEL, sandy, some silt

Cu: N/A

Cc: N/A

Natural Moisture Content: 1.8%

Remarks: Fracture Count 73.7%, by procedures of the BC MOT Manual  
of Test Procedures, Section 11.3.

Sieve Size	Percent Passing
50.000	100
37.500	100
25.000	100
19.000	87
12.500	67
9.500	59
4.750	43
2.000	33
0.850	25
0.425	20
0.250	16
0.150	13
0.075	10.1

Clay	Silt	Sand			Gravel	
		Fine	Medium	Coarse	Fine	Coarse



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## GRAIN SIZE DISTRIBUTION

ASTM C136 & D422

Project: PCA Km 82-88 Geotechnical Assessment

Project Number: V33101067

Date Tested: 10/11/2010

Borehole Number: AH2010-03 Sample 1

Depth: 0.9 m

Soil Description: GRAVEL and SAND, trace fines

Cu: 31.0

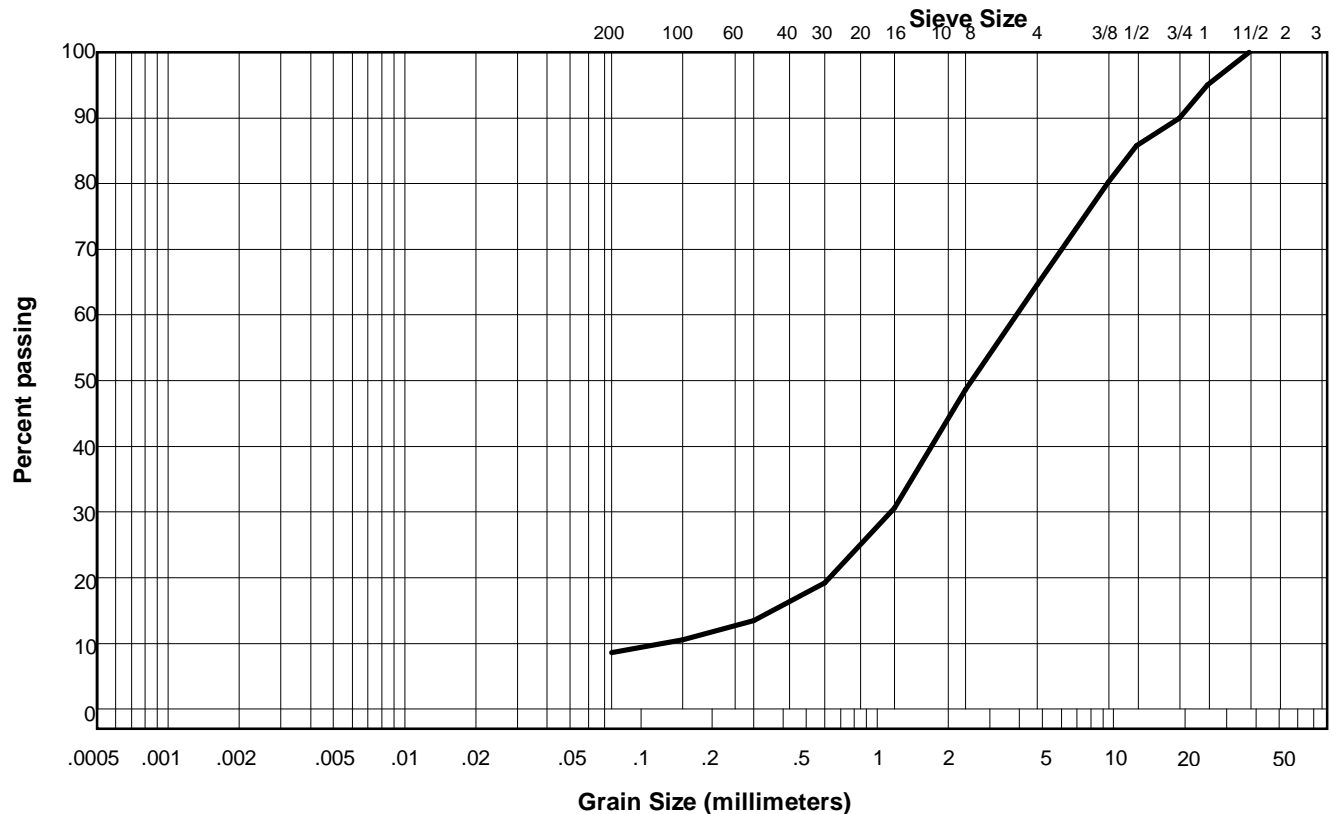
Cc: 2.7

Natural Moisture Content: 5%

Remarks: Fracture Count 48.8 %, by procedures of the BC MOT Manual of Test Procedures, Section 11.3.

Sieve Size	Percent Passing
75.000	100
50.000	100
37.500	100
25.000	95
19.000	90
12.500	86
9.500	80
4.750	65
2.360	49
1.180	31
0.600	19
0.300	13
0.150	11
0.075	8.6

Clay	Silt	Sand			Gravel	
		Fine	Medium	Coarse	Fine	Coarse



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## GRAIN SIZE DISTRIBUTION

ASTM C136 & D422

Project: PCA Km 82-88 Geotechnical Assessment

Project Number: V33101067

Date Tested: 10/11/2010

Borehole Number: AH2010-4 Sample 1

Depth: 0.9 m

Soil Description: GRAVEL and SAND, trace fines

Cu: N/A

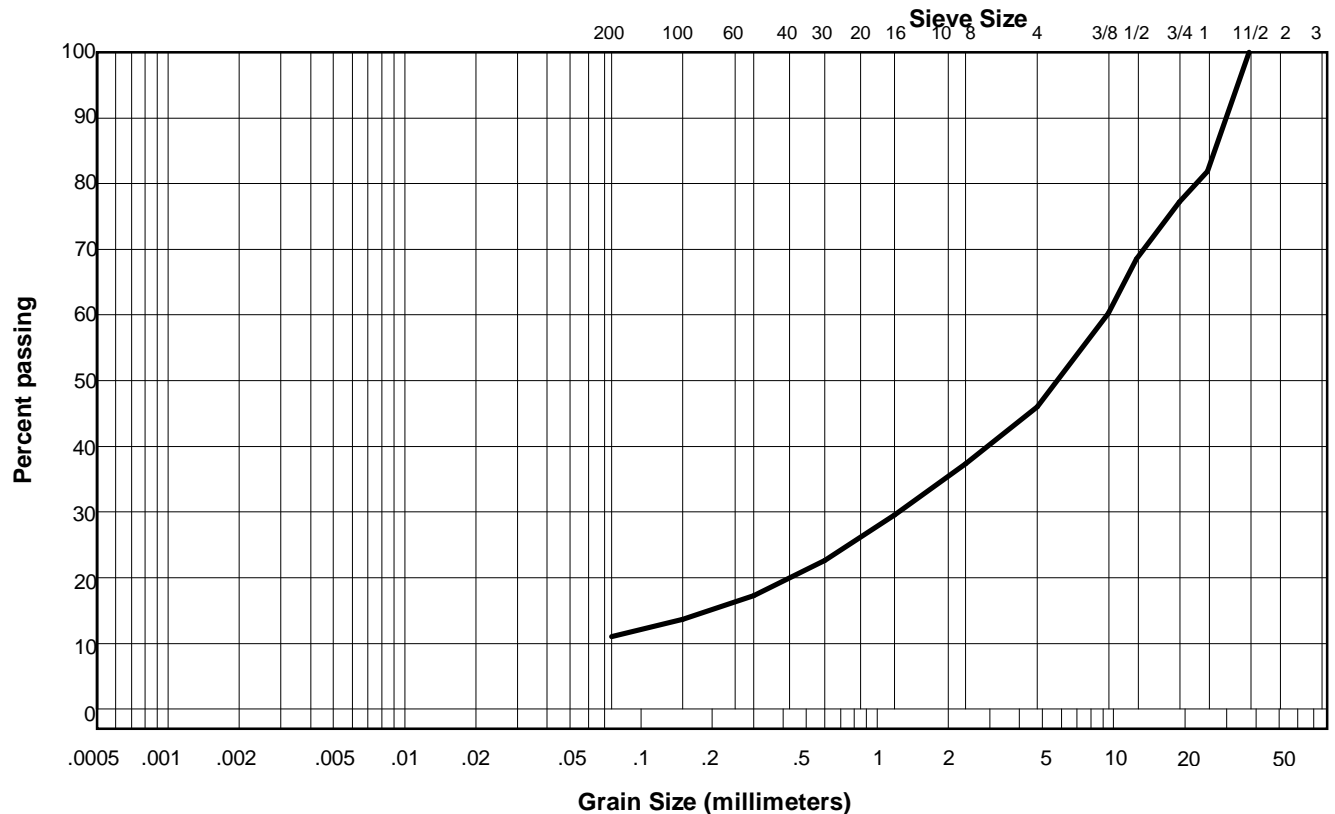
Cc: N/A

Natural Moisture Content: 3%

Remarks: Fracture Count 65.3 %, by procedures of the BC MOT Manual of Test Procedures, Section 11.3.

Sieve Size	Percent Passing
75.000	100
50.000	100
37.500	100
25.000	82
19.000	77
12.500	69
9.500	60
4.750	46
2.360	37
1.180	30
0.600	23
0.300	17
0.150	14
0.075	11.0

Clay	Silt	Sand			Gravel	
		Fine	Medium	Coarse	Fine	Coarse



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## GRAIN SIZE DISTRIBUTION

ASTM C136 & D422

Project: PCA Km 82-88 Geotechnical Assessment

Project Number: V33101067

Date Tested: 13/10/2010

Borehole Number: AH2010-06 Sample 1

Depth: 0.9 m

Soil Description: GRAVEL, sandy, trace silt

Cu: 212.5

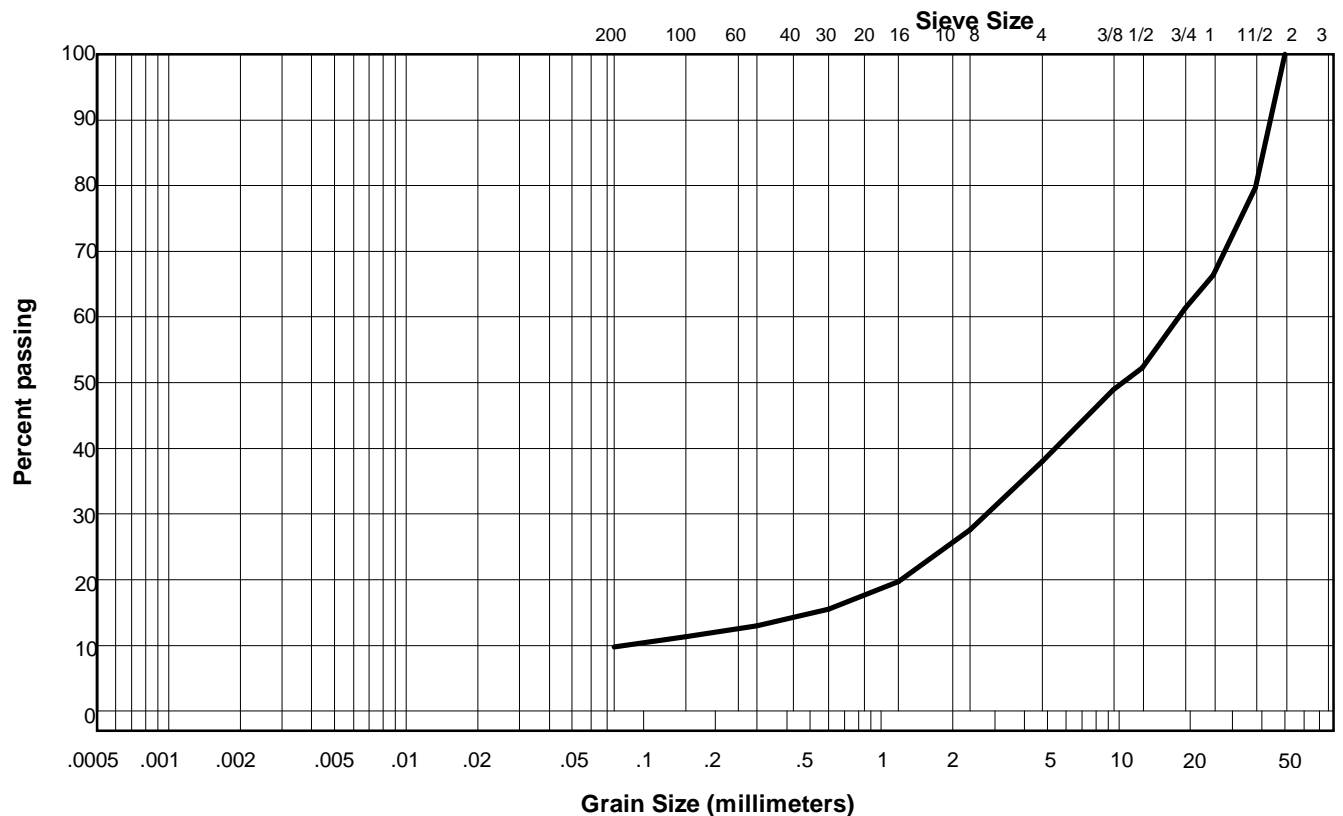
Cc: 5.1

Natural Moisture Content: 2%

Remarks: Fracture Count 52.8 %, by procedures of the BC MOT Manual of Test Procedures, Section 11.3.

Sieve Size	Percent Passing
75.000	100
50.000	100
37.500	80
25.000	66
19.000	61
12.500	52
9.500	49
4.750	38
2.360	28
1.180	20
0.600	15
0.300	13
0.150	11
0.075	9.7

Clay	Silt	Sand			Gravel	
		Fine	Medium	Coarse	Fine	Coarse



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## GRAIN SIZE DISTRIBUTION

ASTM C136 & D422

Project: PCA Km 82-88 Geotechnical Assessment

Project Number: V33101067

Date Tested: 10/11/2010

Borehole Number: AH2010-11 Sample 1

Depth: 0.9 m

Soil Description: GRAVEL, sandy, trace silt

Cu: 215.5

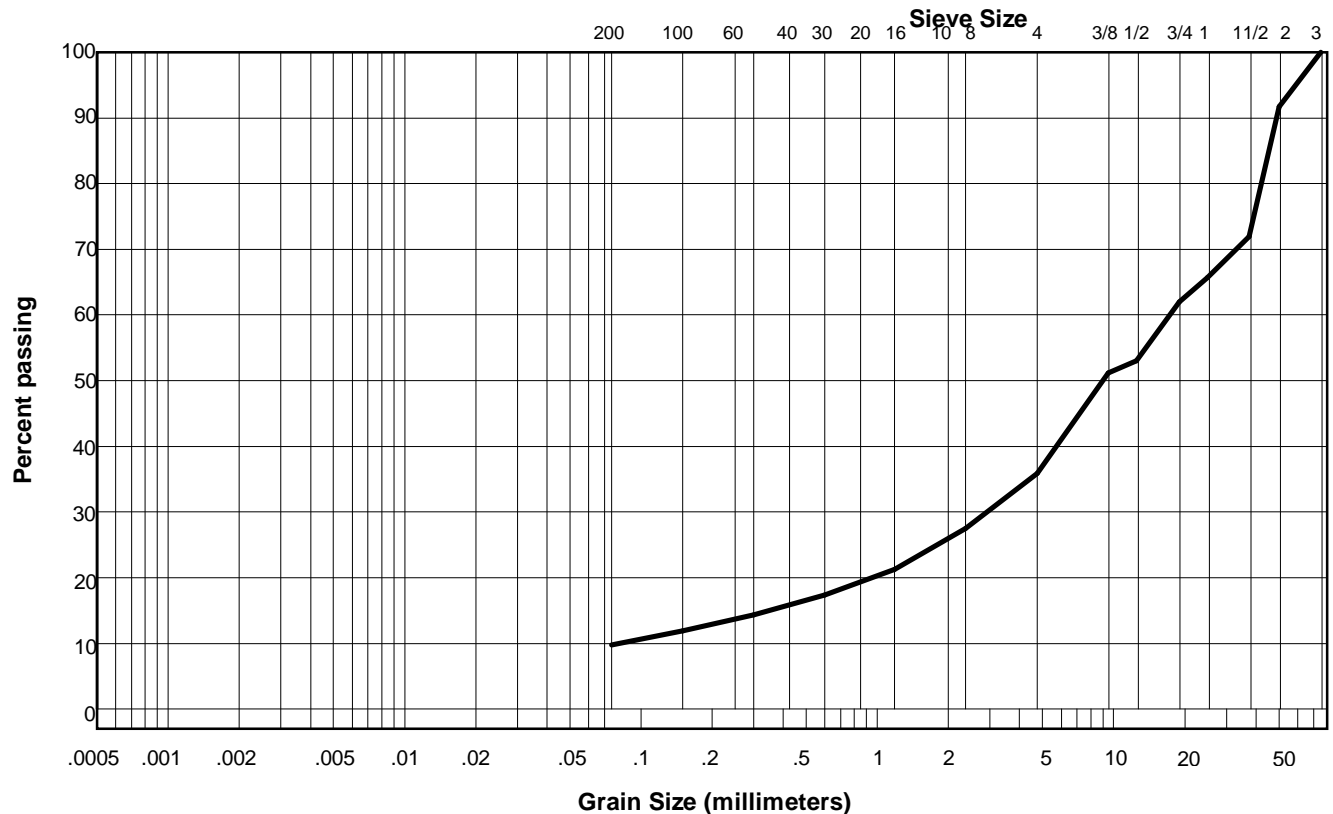
Cc: 6.1

Natural Moisture Content: 2%

Remarks: Fracture Count 63.6 %, by procedures of the BC MOT Manual of Test Procedures, Section 11.3.

Sieve Size	Percent Passing
75.000	100
50.000	92
37.500	72
25.000	66
19.000	62
12.500	53
9.500	51
4.750	36
2.360	28
1.180	21
0.600	17
0.300	14
0.150	12
0.075	9.8

Clay	Silt	Sand			Gravel	
		Fine	Medium	Coarse	Fine	Coarse



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## GRAIN SIZE DISTRIBUTION

ASTM C136 & D422

Project: PCA Km 82-88 Geotechnical Assessment

Project Number: V33101067

Date Tested: 10/11/2010

Borehole Number: AH2010-12 Sample 1

Depth: 1.3 m

Soil Description: GRAVEL, sandy, trace fines

Cu: 156.8

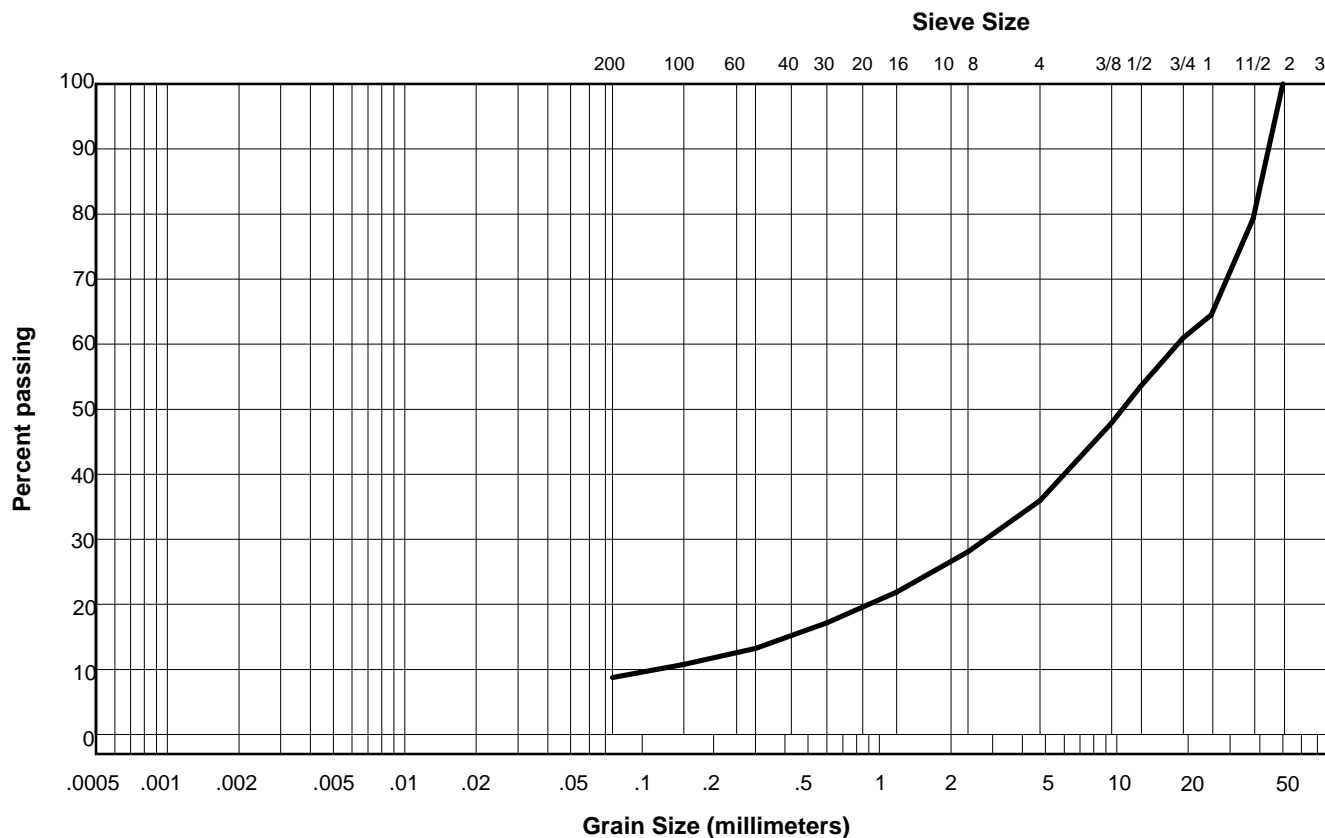
Cc: 3.8

Natural Moisture Content: 3%

Remarks: \_\_\_\_\_

Sieve Size	Percent Passing
50.000	100
37.500	79
25.000	64
19.000	61
12.500	53
9.500	48
4.750	36
2.360	28
1.180	22
0.600	17
0.300	13
0.150	11
0.075	8.8

Clay	Silt	Sand			Gravel	
		Fine	Medium	Coarse	Fine	Coarse



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## GRAIN SIZE DISTRIBUTION

ASTM C136 & D422

Project: PCA Km 82-88 Geotechnical Assessment

Project Number: V33101067

Date Tested: 10/11/2010

Borehole Number: TP2010-08 Sample 3

Depth: 2.4 m

Soil Description: SAND, some silt, some gravel

Cu: N/A

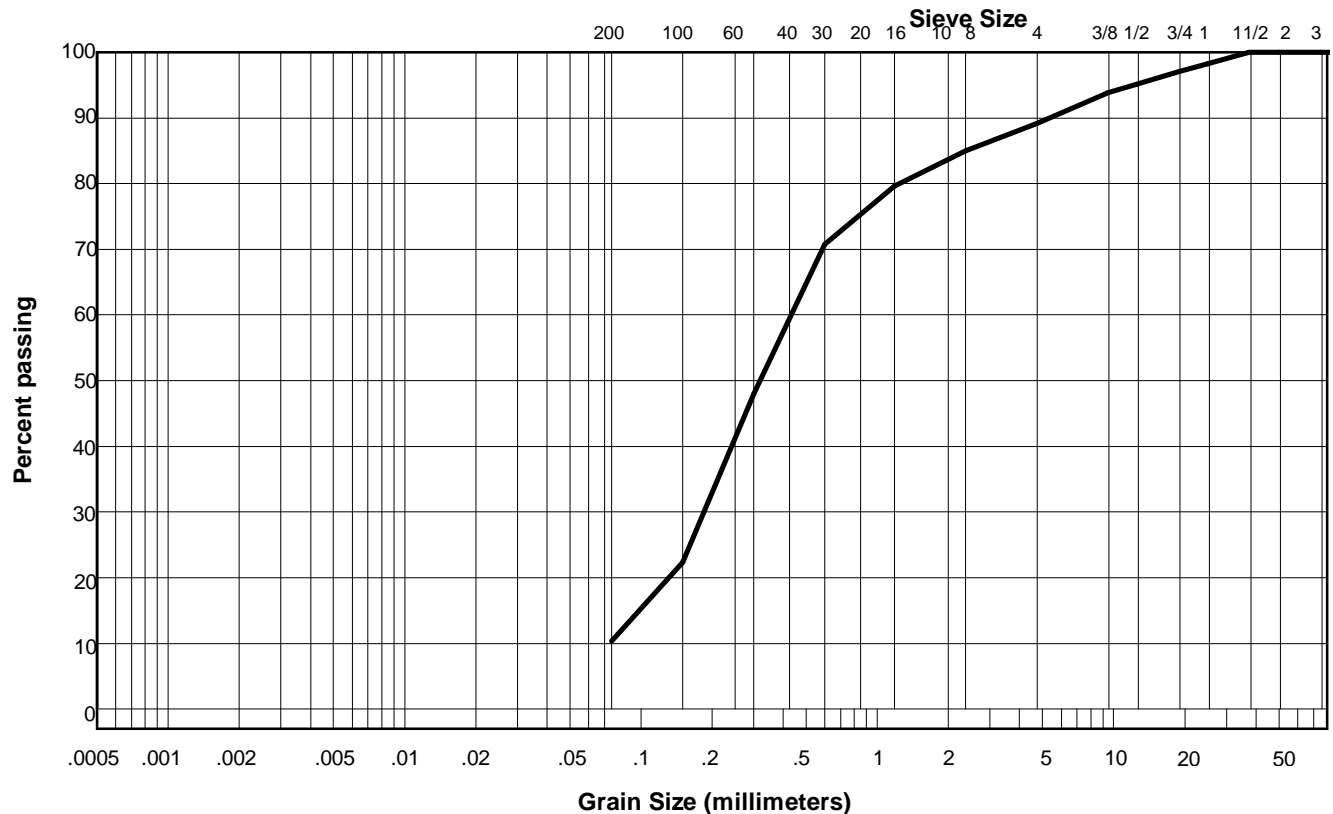
Cc: N/A

Natural Moisture Content: 16%

Remarks: \_\_\_\_\_

Sieve Size	Percent Passing
75.000	100
50.000	100
37.500	100
25.000	98
19.000	97
12.500	95
9.500	94
4.750	89
2.360	85
1.180	80
0.600	71
0.300	48
0.150	22
0.075	10.4

Clay	Silt	Sand			Gravel	
		Fine	Medium	Coarse	Fine	Coarse



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## GRAIN SIZE DISTRIBUTION

ASTM C136 & D422

Project: PCA Km 82-88 Geotechnical Assessment

Project Number: V33101067

Date Tested: 13/10/2010

Borehole Number: TP2010-09 Sample 3

Depth: 3.0 m

Soil Description: Gravelly SAND, some fines

Cu: N/A

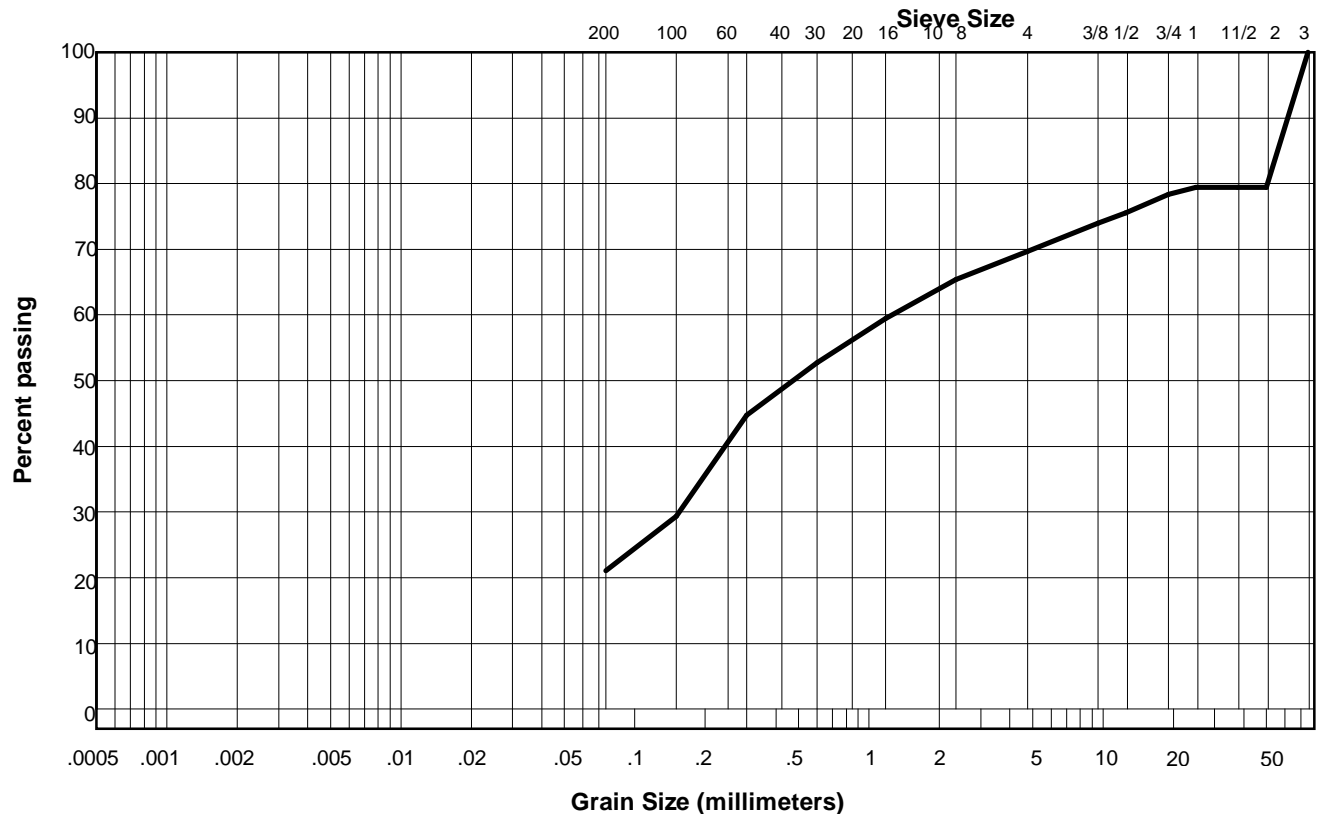
Cc: N/A

Natural Moisture Content: 10%

Remarks: Clay lumps accounted for 15% of the sample by mass

Sieve Size	Percent Passing
75.000	100
50.000	79
37.500	79
25.000	79
19.000	78
12.500	76
9.500	74
4.750	70
2.360	65
1.180	59
0.600	53
0.300	45
0.150	29
0.075	21.1

Clay	Silt	Sand			Gravel	
		Fine	Medium	Coarse	Fine	Coarse



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## GRAIN SIZE DISTRIBUTION

ASTM C136 & C117

Project: PCA Km 82-88 Geotechnical Assessment

Project Number: V33101067

Date Tested: 10/8/2010

Borehole Number: TP2010-11 Sample 3

Depth: 0.9 m

Soil Description: GRAVEL and SAND, coarse, trace silt, trace cobbles

Cu: N/A

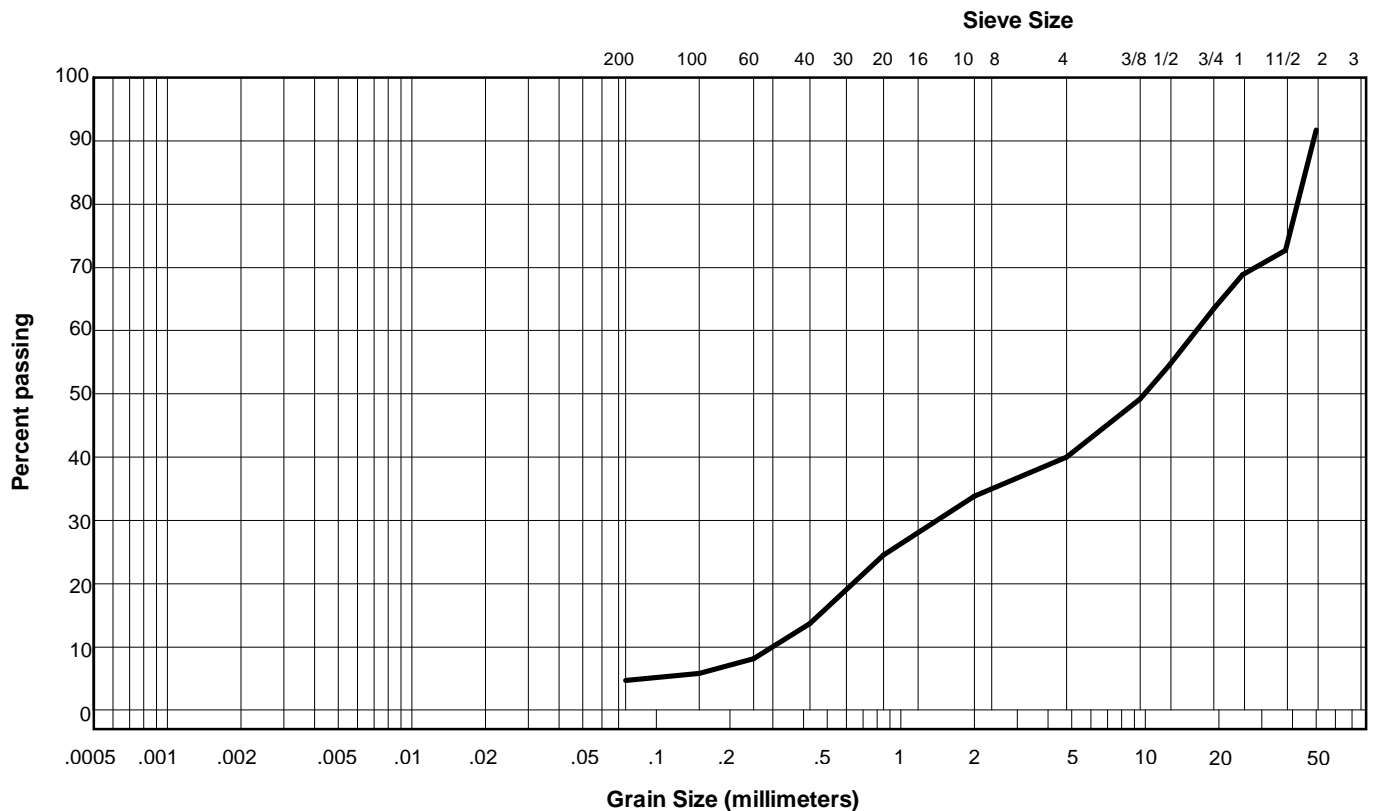
Cc: N/A

Natural Moisture Content: 3.8%

Remarks: \_\_\_\_\_

Sieve Size	Percent Passing
50.000	92
37.500	73
25.000	69
19.000	63
12.500	55
9.500	49
4.750	40
2.000	34
0.850	24
0.425	14
0.250	8
0.150	6
0.075	4.7

Clay	Silt	Sand			Gravel	
		Fine	Medium	Coarse	Fine	Coarse



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## GRAIN SIZE DISTRIBUTION

ASTM C136 & D422

Project: PCA Km 82-88 Geotechnical Assessment

Project Number: V33101067

Date Tested: 10/13/2010

Borehole Number: TP2010-13 Sample 1

Depth: 0.8 m

Soil Description: SAND, gravelly, silty

Cu: N/A

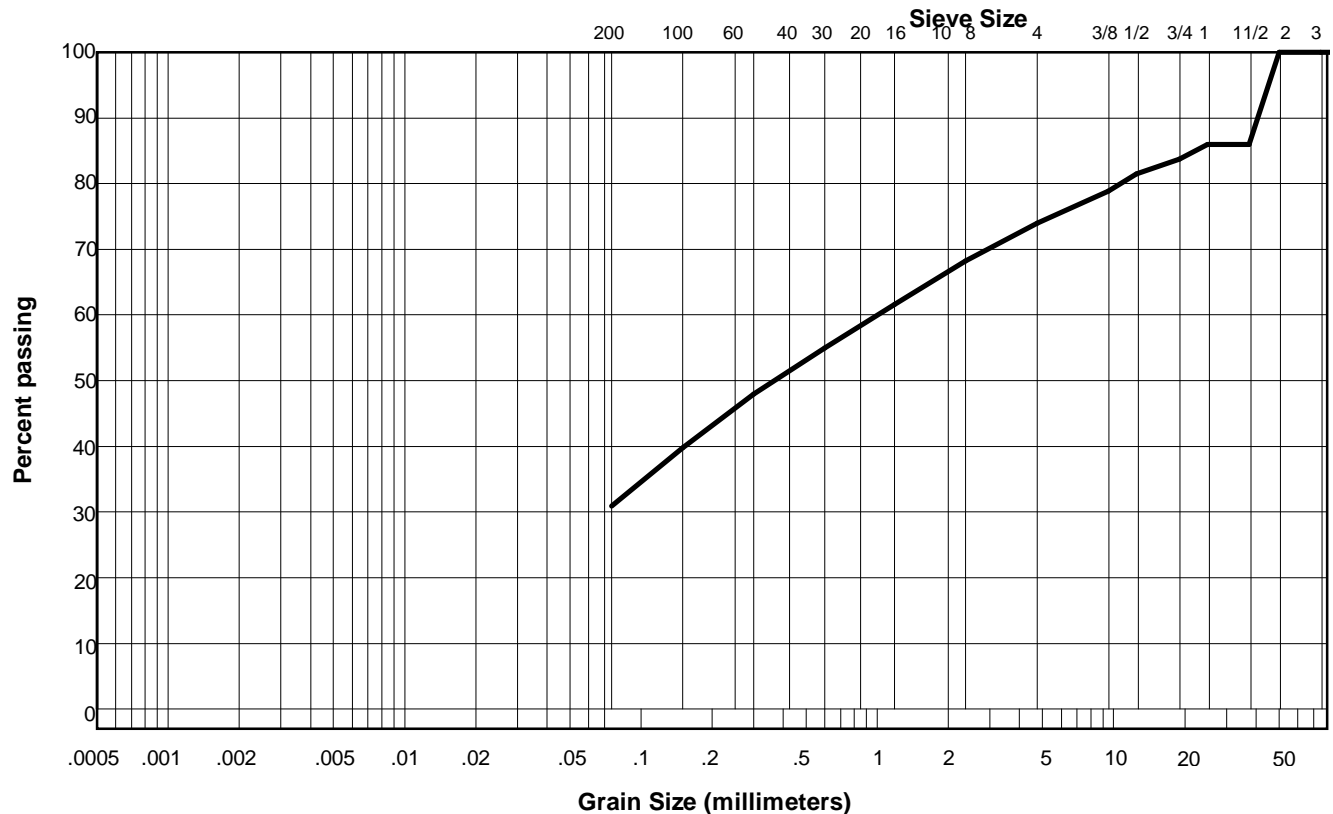
Cc: N/A

Natural Moisture Content: 8%

Remarks: \_\_\_\_\_

Sieve Size	Percent Passing
75.000	100
50.000	100
37.500	86
25.000	86
19.000	84
12.500	81
9.500	79
4.750	74
2.360	68
1.180	62
0.600	55
0.300	48
0.150	40
0.075	30.9

Clay	Silt	Sand			Gravel	
		Fine	Medium	Coarse	Fine	Coarse



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## GRAIN SIZE DISTRIBUTION

ASTM C136 & D422

Project: PCA Km 82-88 Geotechnical Assessment

Project Number: V33101067

Date Tested: 10/11/2010

Borehole Number: Borrow Pit - Km 87.5 - Sample 1

Depth: 0.3 m

Soil Description: GRAVEL and SAND, trace silt

Cu: 79.2

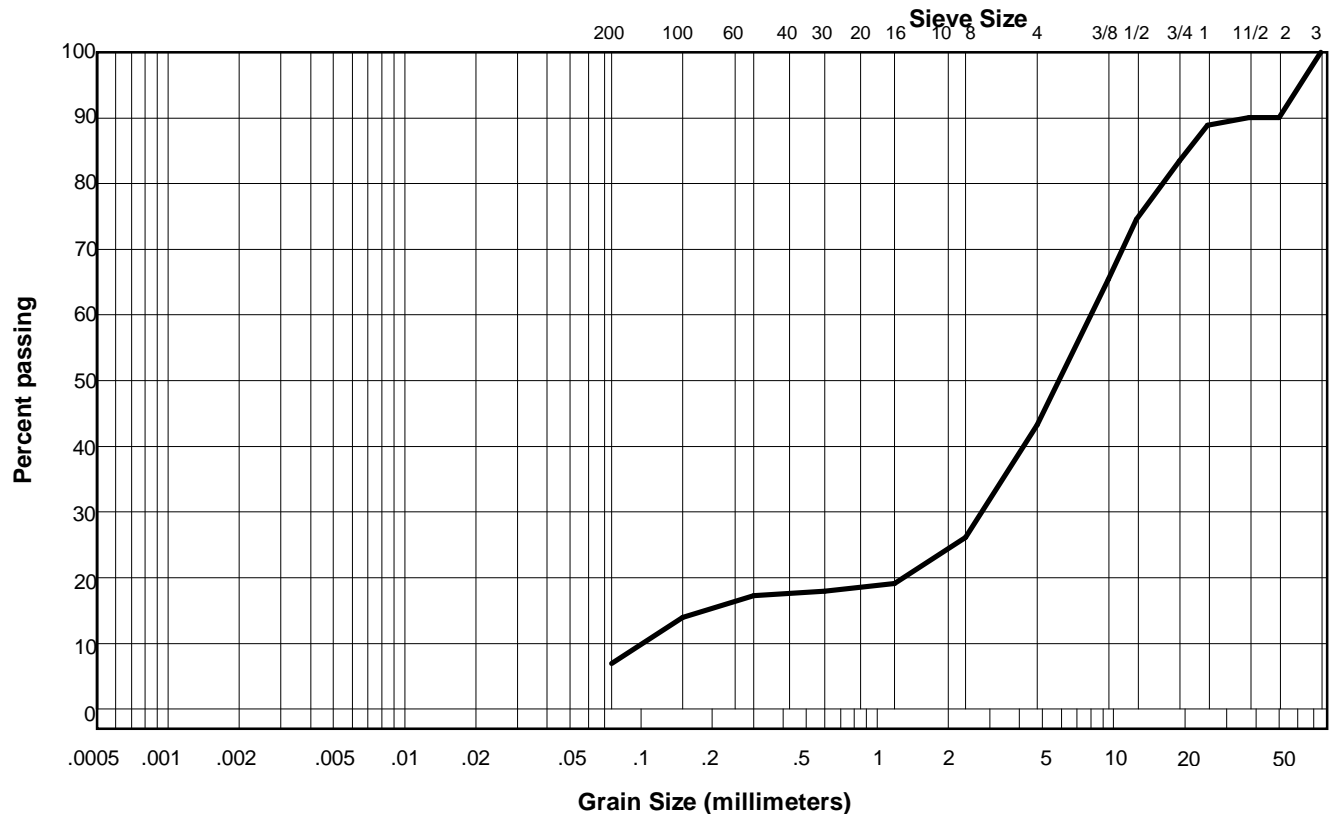
Cc: 9.3

Natural Moisture Content: 5%

Remarks: \_\_\_\_\_

Sieve Size	Percent Passing
75.000	100
50.000	90
37.500	90
25.000	89
19.000	83
12.500	75
9.500	65
4.750	43
2.360	26
1.180	19
0.600	18
0.300	17
0.150	14
0.075	7.0

Clay	Silt	Sand			Gravel	
		Fine	Medium	Coarse	Fine	Coarse



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## GRAIN SIZE DISTRIBUTION

ASTM C136 & D422

Project: PCA Km 82-88 Geotechnical Assessment

Project Number: V33101067

Date Tested: 10/11/2010

Borehole Number: Borrow Pit - Km 87.5 - Sample 4

Depth: 0.3 m

Soil Description: GRAVEL and SAND, trace fines

Cu: 6.4

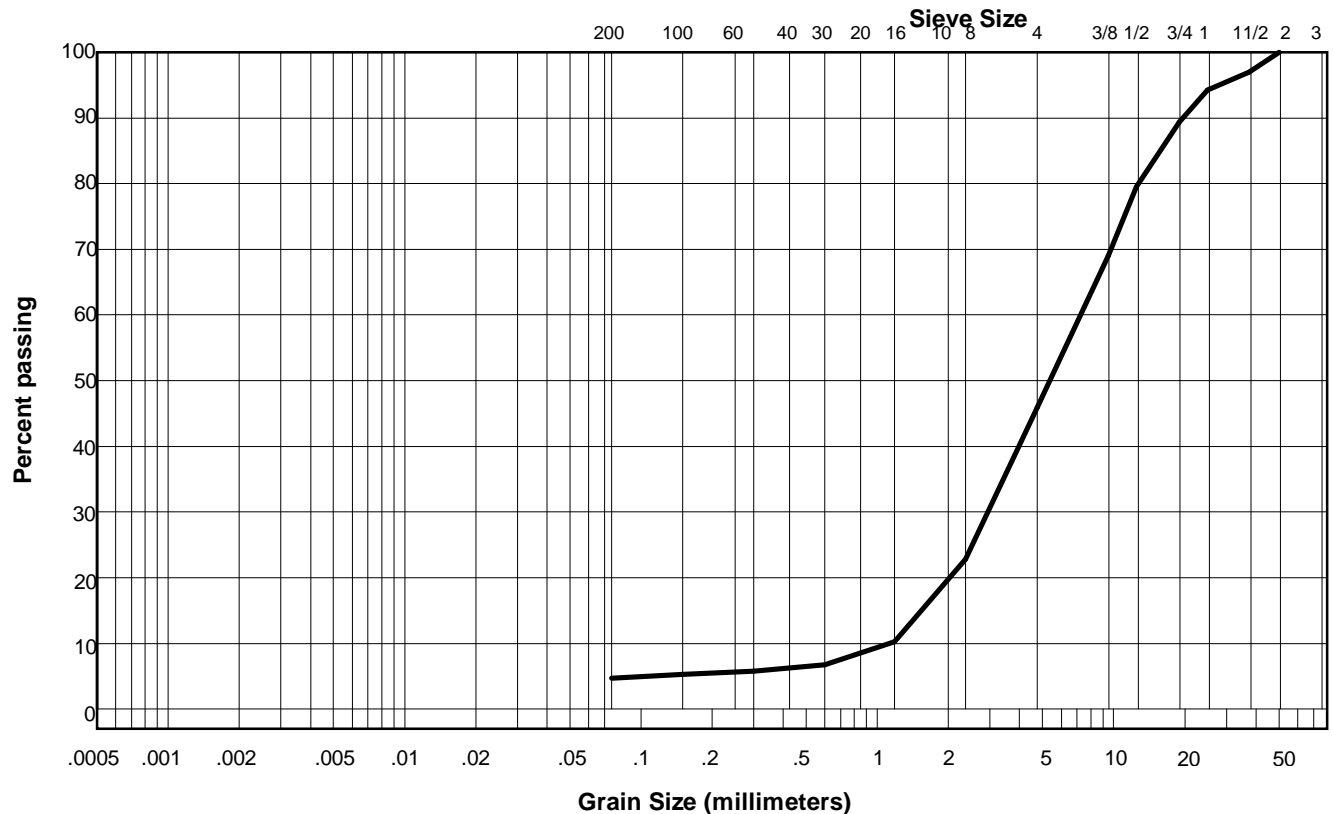
Cc: 1.0

Natural Moisture Content: 3%

Remarks: \_\_\_\_\_

Sieve Size	Percent Passing
75.000	100
50.000	100
37.500	97
25.000	94
19.000	89
12.500	79
9.500	69
4.750	46
2.360	23
1.180	10
0.600	7
0.300	6
0.150	5
0.075	4.7

Clay	Silt	Sand			Gravel	
		Fine	Medium	Coarse	Fine	Coarse



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## GRAIN SIZE DISTRIBUTION

ASTM C136 & D422

Project: PCA Km 82-88 Geotechnical Assessment

Project Number: V33101067

Date Tested: 11/10/2010

Borehole Number: Borrow Pit - Km 87.5 - Sample 5

Depth: 0.3 m

Soil Description: GRAVEL, sandy, trace fines

Cu: 6.3

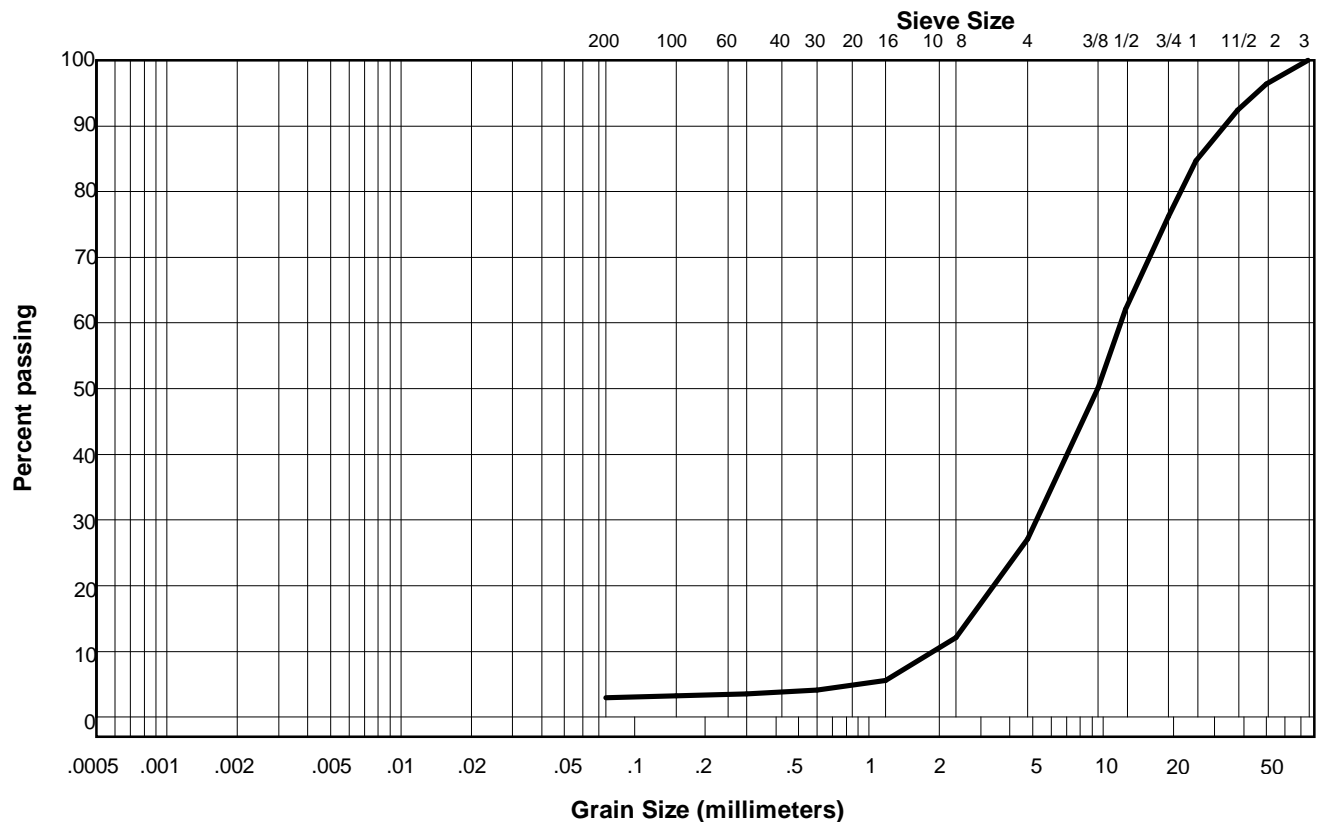
Cc: 1.2

Natural Moisture Content: 2%

Remarks: \_\_\_\_\_

Sieve Size	Percent Passing
75.000	100
50.000	96
37.500	92
25.000	85
19.000	76
12.500	62
9.500	50
4.750	27
2.360	12
1.180	6
0.600	4
0.300	4
0.150	3
0.075	3.0

Clay	Silt	Sand			Gravel	
		Fine	Medium	Coarse	Fine	Coarse



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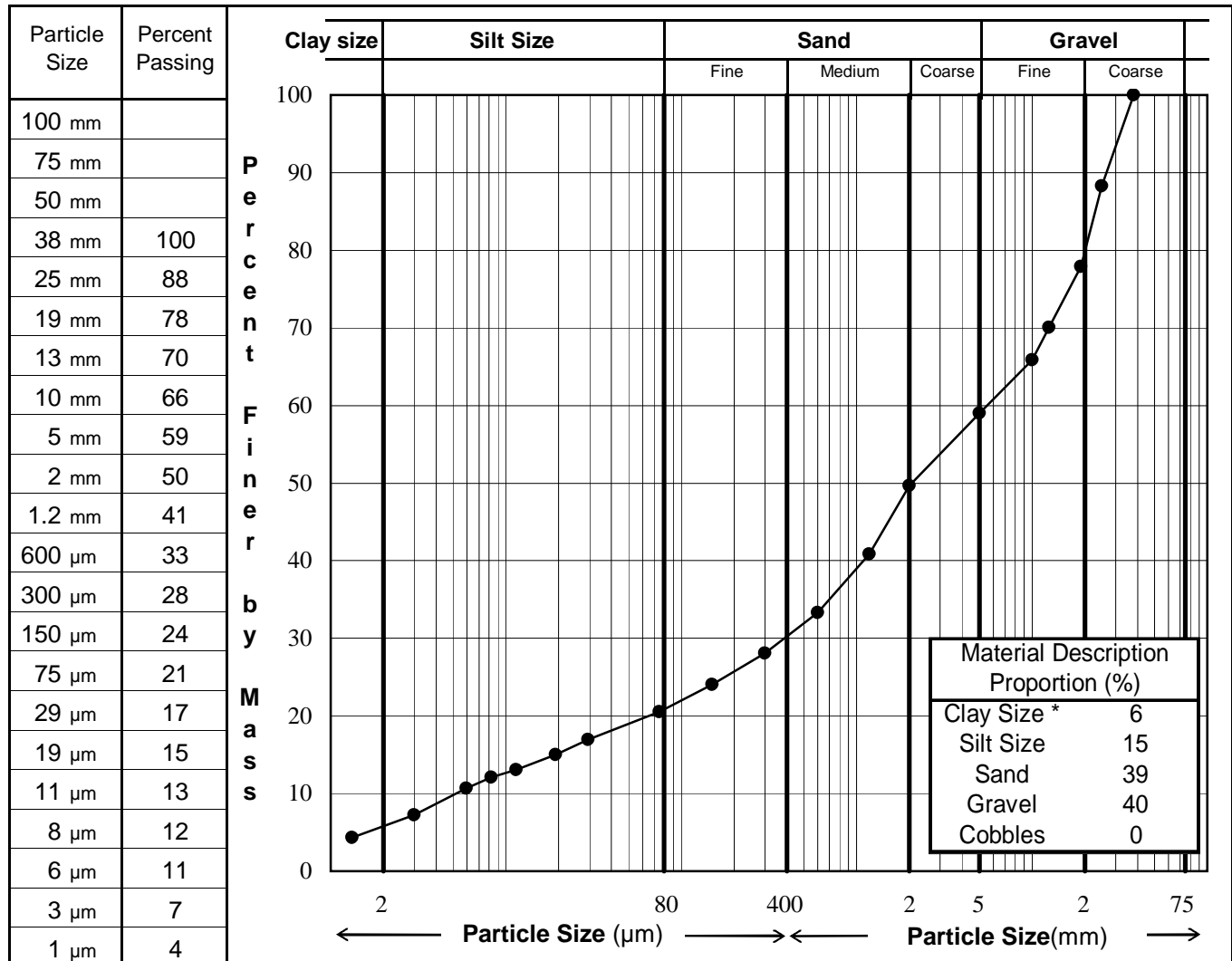




# PARTICLE SIZE ANALYSIS (Hydrometer) TEST REPORT

ASTM D422

Project: **PCA Km 82-88 Geotechnical Assessment**  
 Client: **Parks Canada Agency**  
 Project No.: **V33101067**  
 Location: **Yoho National Park**  
 Sample No.: **AH2010-03 Sample 4**  
 Depth: **3.4m**  
 Description\*\*: **SAND and GRAVEL, some silt, trace clay**



**Remarks:** \* The upper clay size of 2 µm is as per the Canadian Foundation Manual.  
 \*\* The description is visually based & subject to EBA description protocols.

Reviewed By: DB

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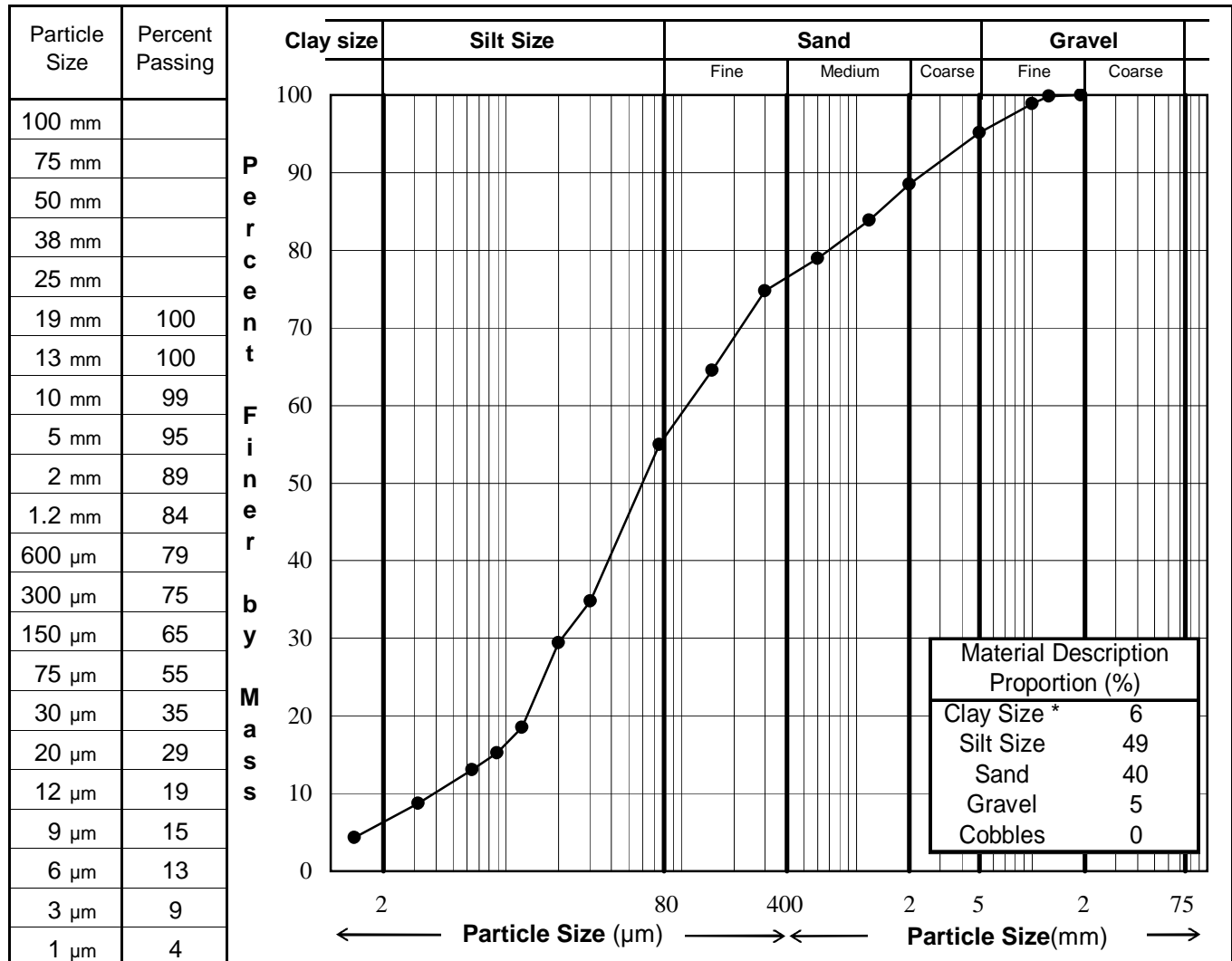




# PARTICLE SIZE ANALYSIS (Hydrometer) TEST REPORT

ASTM D422

Project: **PCA Km 82-88 Geotechnical Assessment**  
 Client: **Parks Canada Agency**  
 Project No.: **V33101067**  
 Location: **Yoho National Park**  
 Sample No.: **AH2010-05 Sample 4**  
 Depth: **3.3 m**  
 Description\*\*: **SAND and SILT, trace gravel, trace clay.**



**Remarks:** \* The upper clay size of 2 µm is as per the Canadian Foundation Manual.  
 \*\* The description is visually based & subject to EBA description protocols.

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Consultants Ltd.

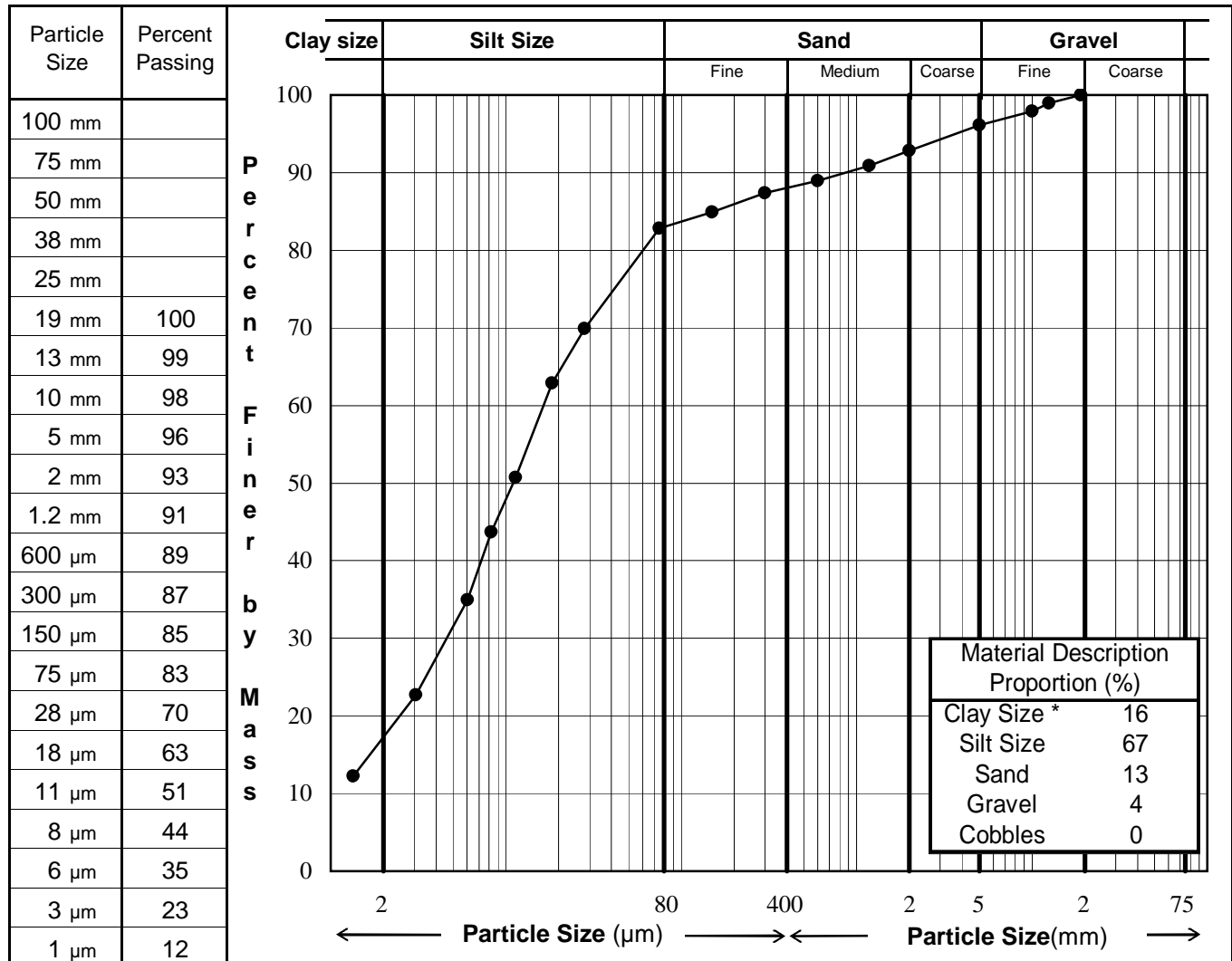




# PARTICLE SIZE ANALYSIS (Hydrometer) TEST REPORT

ASTM D422

Project: **PCA Km 82-88 Geotechnical Assessment**  
 Client: **Parks Canada Agency**  
 Project No.: **V33101067**  
 Location: **Yoho National Park**  
 Sample No.: **TP2010-4B Sample 2**  
 Depth: **0.95 m**  
 Description\*\*: **SILT, some clay, some sand, trace gravel**



**Remarks:** \* The upper clay size of 2 µm is as per the Canadian Foundation Manual.  
 \*\* The description is visually based & subject to EBA description protocols.

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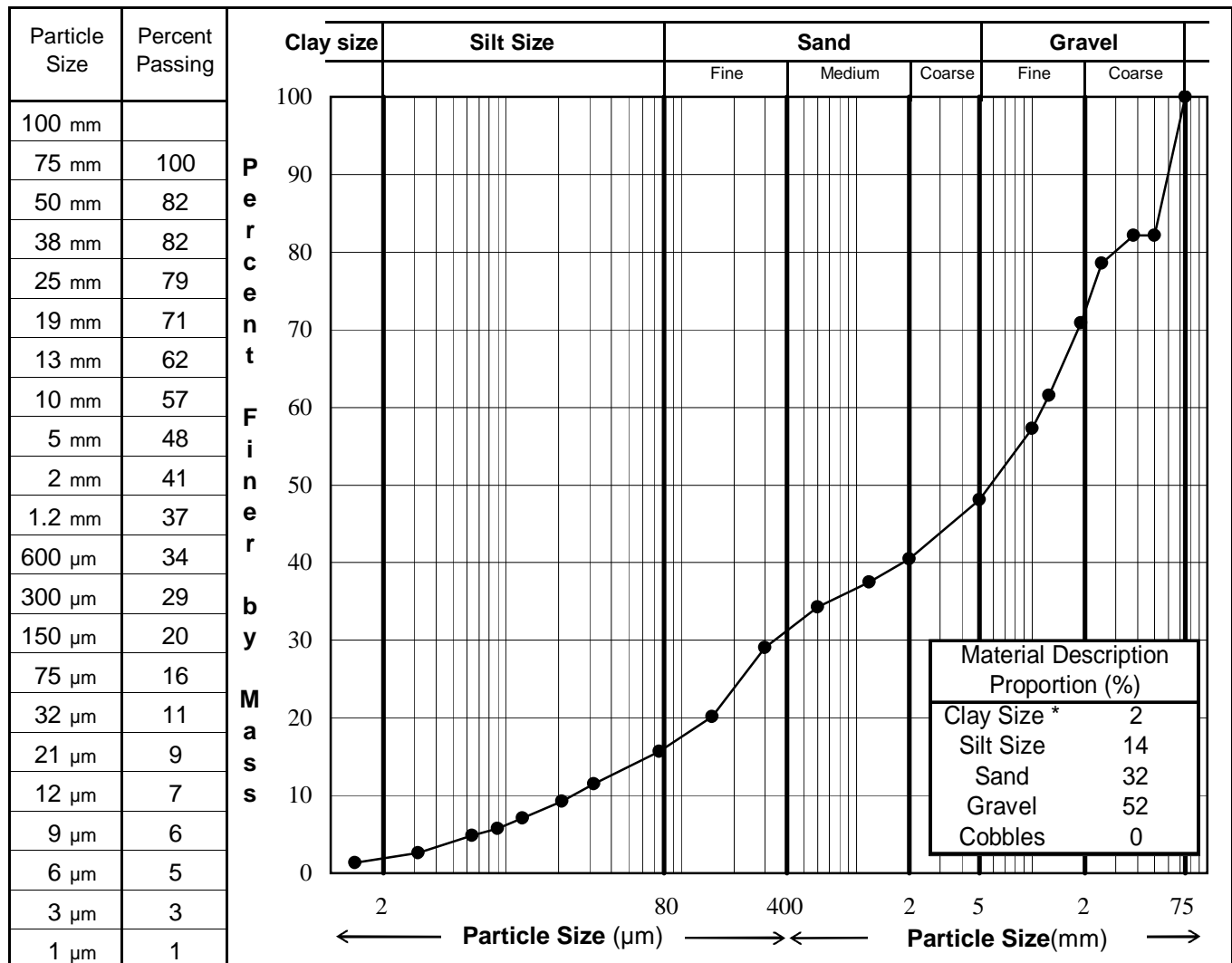




# PARTICLE SIZE ANALYSIS (Hydrometer) TEST REPORT

ASTM D422

Project: **PCA Km 82-88 Geotechnical Assessment**  
 Client: **Parks Canada Agency**  
 Project No.: **V33101067**  
 Location: **Yoho National Park**  
 Sample No.: **TP2010-08 Sample 1**  
 Depth: **0.3 m**  
 Description\*\*: **GRAVEL, sandy, some silt, trace clay**



**Remarks:** \* The upper clay size of 2 µm is as per the Canadian Foundation Manual.  
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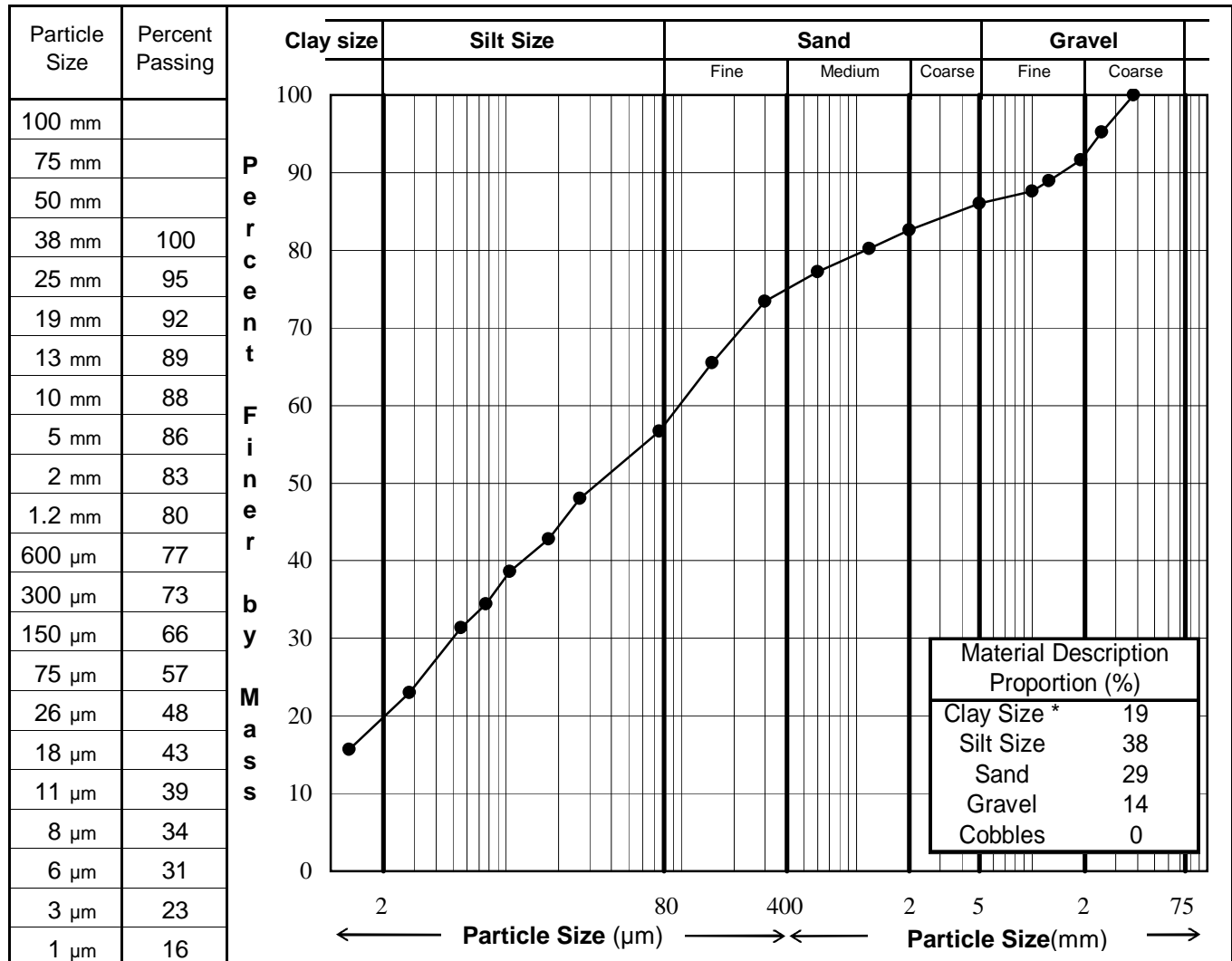




# PARTICLE SIZE ANALYSIS (Hydrometer) TEST REPORT

ASTM D422

Project: **PCA Km 82-88 Geotechnical Assessment**  
 Client: **Parks Canada Agency**  
 Project No.: **V33101067**  
 Location: **Yoho National Park**  
 Sample No.: **TP2010-15 Sample 2**  
 Depth: **1.3 m**  
 Description\*\*: **CLAY, silty, sandy, some gravel**



**Remarks:** \* The upper clay size of 2 µm is as per the Canadian Foundation Manual.  
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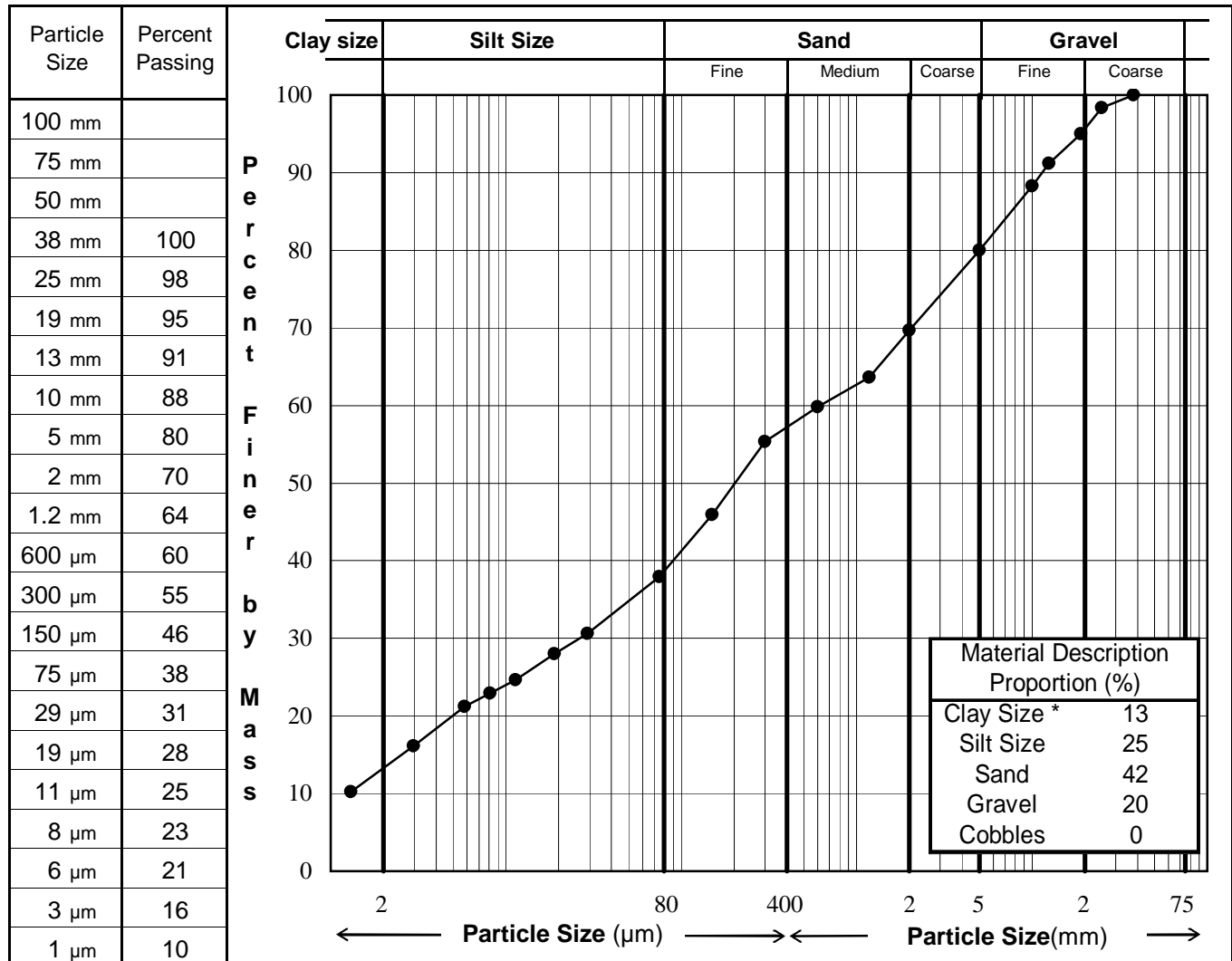




# PARTICLE SIZE ANALYSIS (Hydrometer) TEST REPORT

ASTM D422

Project: **PCA Km 82-88 Geotechnical Assessment**  
 Client: Parks Canada Agency  
 Project No.: V33101067  
 Location: Yoho National Park  
 Sample No.: TP2010-17 Sample 3  
 Depth: 2.0 m  
 Description\*\*: SAND, silty, some gravel, some clay



**Remarks:** \* The upper clay size of 2 µm is as per the Canadian Foundation Manual.  
 \*\* The description is visually based & subject to EBA description protocols.

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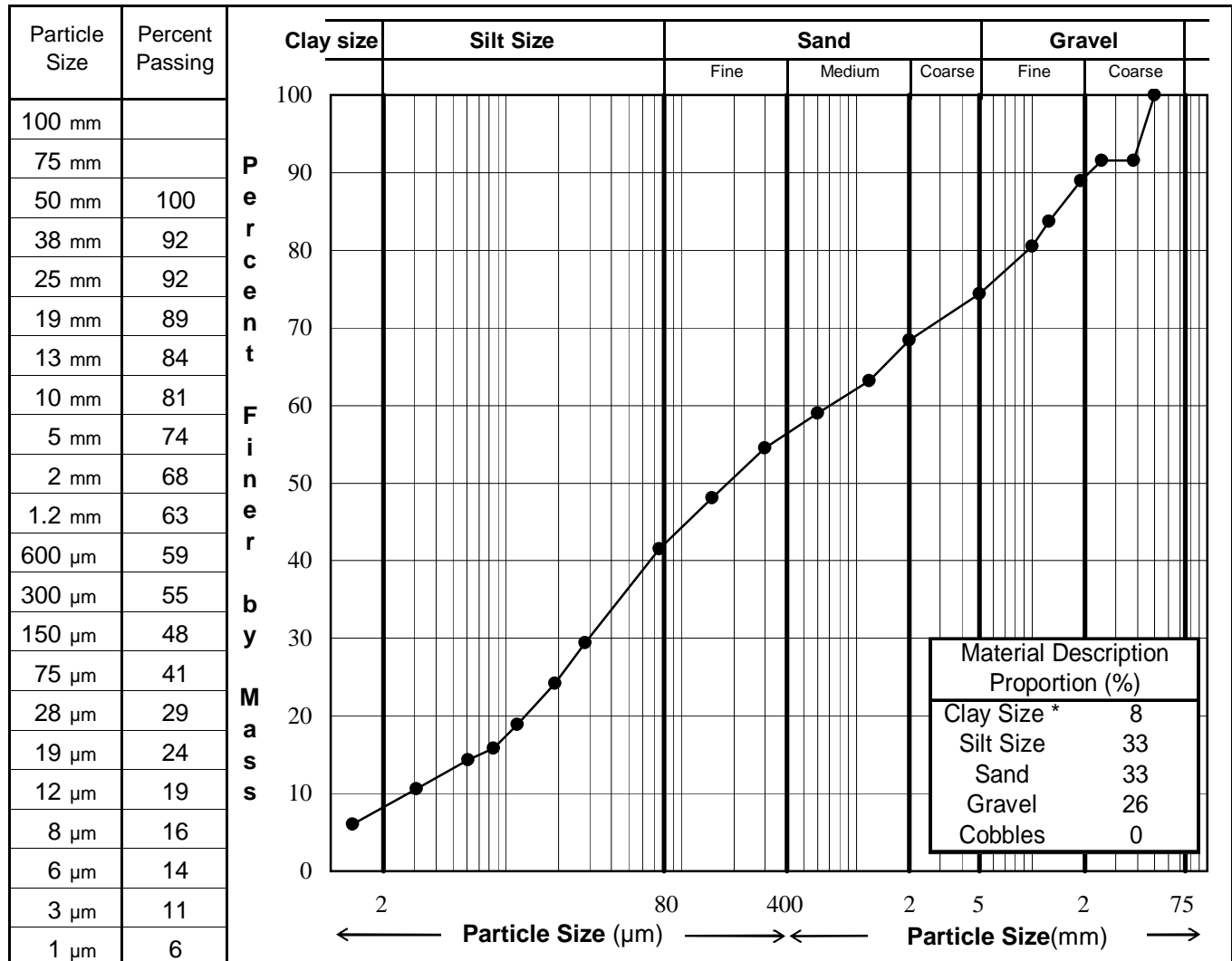




# PARTICLE SIZE ANALYSIS (Hydrometer) TEST REPORT

ASTM D422

Project: **PCA Km 82-88 Geotechnical Assessment**  
 Client: **Parks Canada Agency**  
 Project No.: **V33101067**  
 Location: **Yoho National Park**  
 Sample No.: **TP2010-24 Sample 2**  
 Depth: **1 m**  
 Description\*\*: **SAND and SILT, gravelly, trace clay**



**Remarks:** \* The upper clay size of 2 µm is as per the Canadian Foundation Manual.  
 \*\* The description is visually based & subject to EBA description protocols.

Reviewed By: DB



# APPENDIX C

APPENDIX C BORROW PIT PHOTOS





**Photo 1**  
Existing Borrow Pit at Km 87.5 – Looking West



**Photo 2**  
Existing Borrow Pit at Km 87.5 – Looking East



# APPENDIX D

APPENDIX D ROCK SLOPE PHOTOS





**Photo 1**  
Slope 1: Km 82+700 to 83+000



**Photo 2**  
Slope 2: Km 83+300 to 83+500





**Photo 3**  
Slope 3: Km 85+000 to 85+200



**Photo 4**  
Slope 4: Km 85+200 to 85+400





**Photo 5**  
Slope 5: Km 85+400 to 85+500



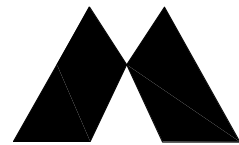
**Photo 6**  
Slope 6: Km 85+500 to 85+800



# APPENDIX E

APPENDIX E PRELIMINARY DRAWING SET #2511 00203





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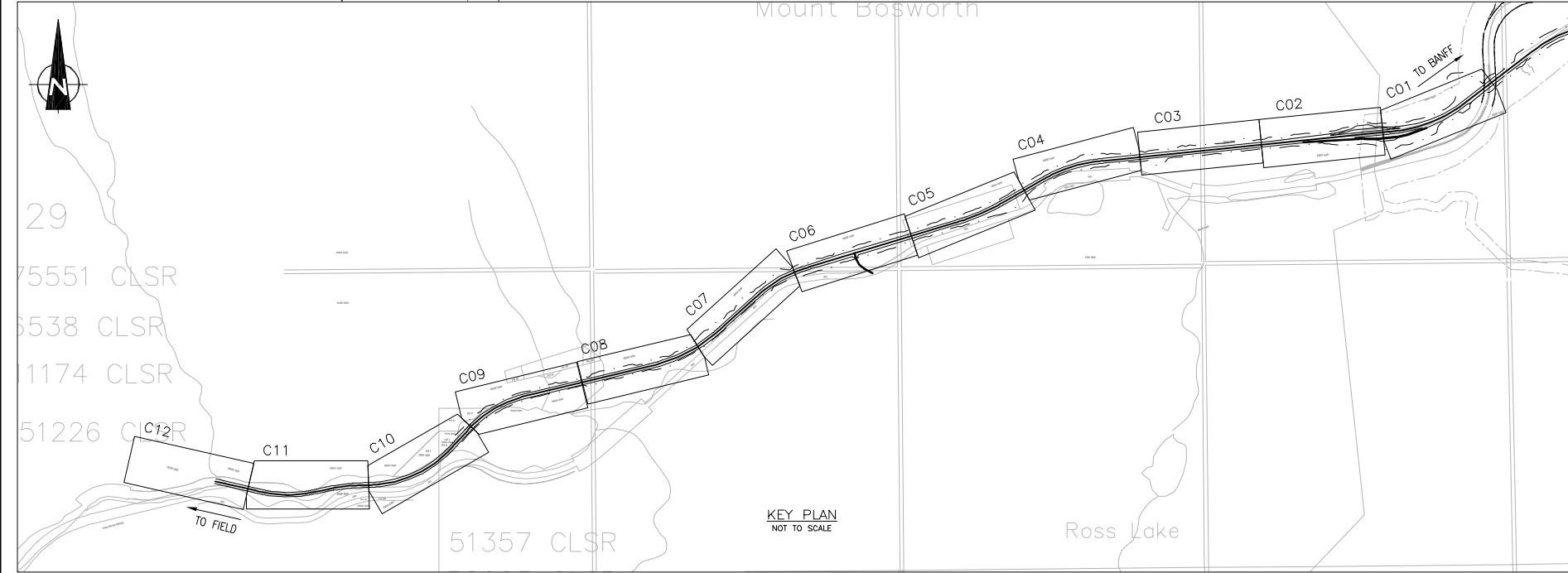
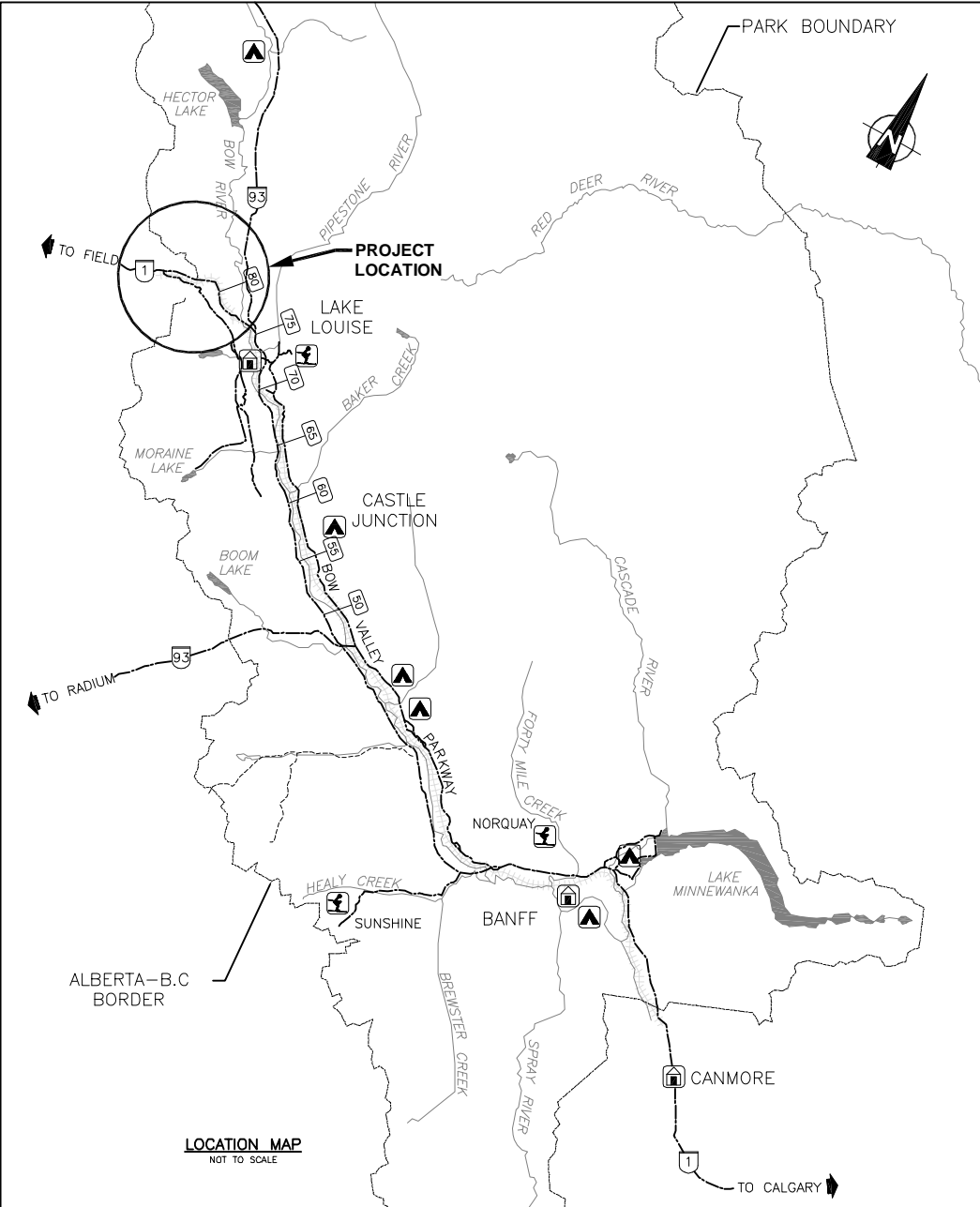
km 82 - km 88

TRANS CANADA HIGHWAY  
TWINNING  
YOHO NATIONAL PARK, ALBERTA

**AUGUST 2010**



August 23, 2010 14:32:21  
 Plotter:  
 File name: G:\Projects\2011 00203 0 Parks km 82 to km 88\10.0 Drawing\10.0 Current\2511-000.dwg\300



LEGEND

ALIGNMENT ABBREVIATIONS

- POC - POINT ON CURVE  
 PCC - POINT OF COMPOUND CURVATURE  
 PC - POINT OF CURVATURE  
 PT - POINT OF TANGENCY  
 TC - TANGENT TO CURVE  
 CC - CURVE CENTRE  
 CS - CURVE TO SPIRAL  
 SC - SPIRAL TO CURVE  
 CT - CURVE TO TANGENT  
 TS - TANGENT TO SPIRAL  
 ST - SPIRAL TO TANGENT  
 BVC - BEGINNING OF VERTICAL CURVE  
 EVC - END OF VERTICAL CURVE  
 PVI - POINT OF VERTICAL INTERSECTION  
 ELEV - ELEVATION  
 PI - POINT OF INTERSECTION  
 STA - STATION

MISCELLANEOUS ABBREVIATIONS

- BH - BORE HOLE  
 BW - BACK OF SIDEWALK  
 CB - CATCH BASIN  
 C&G - CURB AND GUTTER  
 C.I.P. - CAST IN PLACE CONCRETE  
 CI - CULVERT INLET  
 CO - CULVERT OUTLET  
 DES - DESIGN  
 EOP - EDGE OF PAVEMENT  
 EX - EXISTING  
 LOG - LIP OF GUTTER  
 LS - LIGHT STANDARD  
 MH - MANHOLE  
 PROP - PROPOSED  
 PP - POWER POLE  
 S - SANITARY  
 ST - STORM  
 W - WATER  
 NB - NORTHBOUND  
 SB - SOUTHBOUND  
 EB - EASTBOUND  
 WB - WESTBOUND  
 N.I.C. - NOT IN CONTRACT

ROAD CONSTRUCTION

EXISTING	DESCRIPTION	PROPOSED
	TEST PIT & ID	3 BH98-27
	BORE HOLE & ID	67+500
	CONTROL LINE AND STATIONING	T.S. 55+325.101
	ALIGNMENT TIE POINTS & STATIONING	
	EDGE OF PAVEMENT	
	EDGE OF PAVED SHOULDER	
	SUBGRADE ELEVATION	
	BARRIER	
	CONCRETE MEDIAN BARRIER	
	DRAINAGE SIDE DITCH	DIRECTION OF FLOW
	DRAINAGE MEDIAN DITCH	DIRECTION OF FLOW
	DAY LIGHT LINE	
	MILL AND INLAY NEW PAVEMENT	
	NEW PAVEMENT	
	PAVEMENT REMOVAL	
	SURVEY GRID (NAD 83)	
	TREE LINE	
	WATER LINE	
	CULVERT	
	RETAINING WALL	
	450mm DROP INLET	
	SMALL CSP CULVERT	
	CATCH BASIN AND 300mm PIPE	
	CONCRETE BARRIER DRAIN SYSTEM FOR HIGH SLOPES	
	WILDLIFE FENCING	
	CLEARING LINE	
	CONTROL POINT	CP 03.01
	GATE	

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B		B source drawing no. de dessin no.		
C		C detail on drawing no. détail sur dessin no.		

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Project title/Titre du projet
 

TRANS CANADA HIGHWAY  
 TWINNING KM 82 - KM 88

YOHO NATIONAL PARK, BC

Drawing title/Titre du dessin
 

LOCATION PLAN, DRAWING INDEX  
 AND LEGEND

Surveyed by/Arpenté par	Drawn by/Dessiné par	Date/Date
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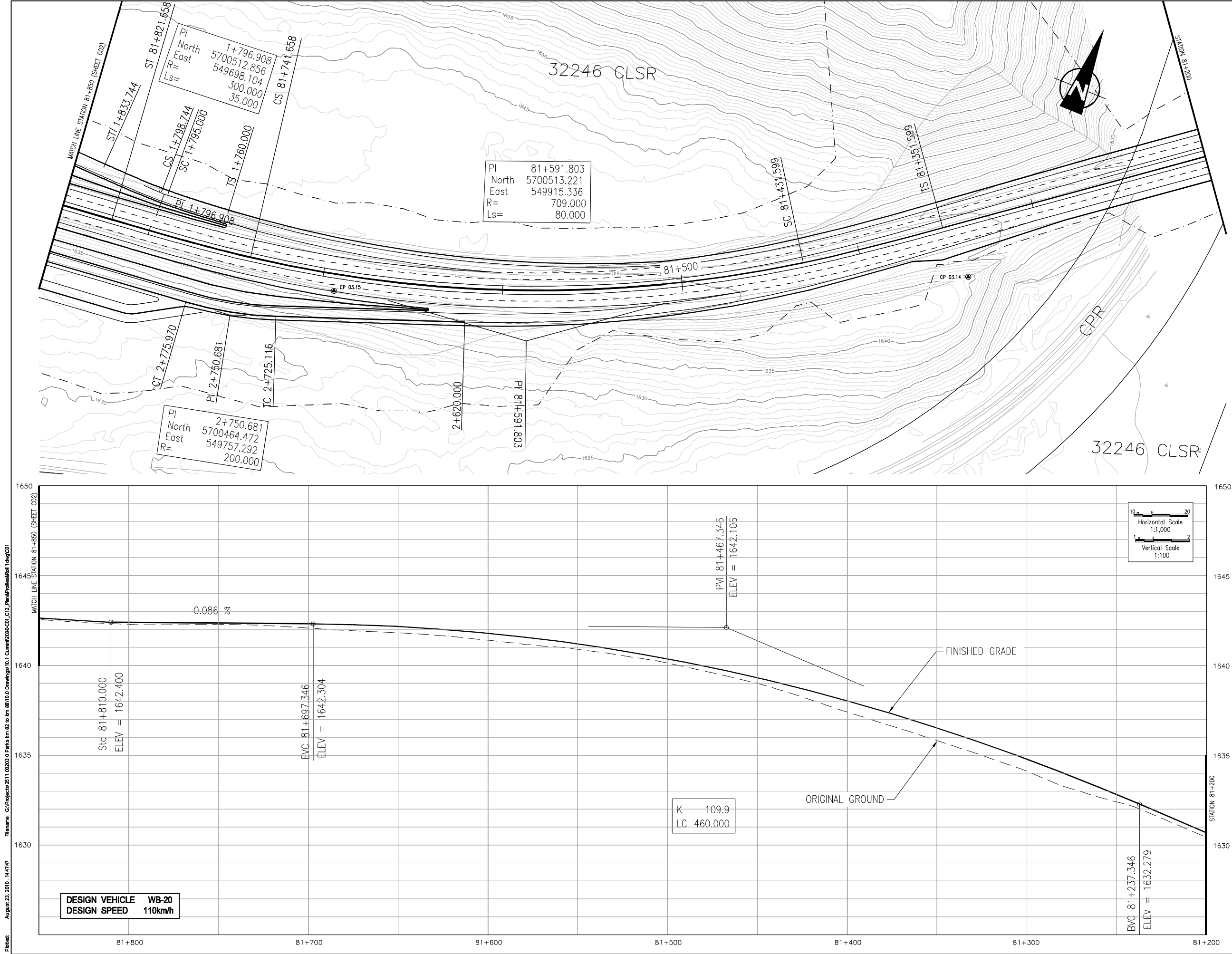
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2511 00203 -0		



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Plot: A1 841 x 594 mm



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18.24	5700267.9018	547886.6329	1639.9230
18.25	5700159.3084	547728.7887	1635.1430
18.26	5700062.3498	547503.6838	1629.7850

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Nom de l'expert-conseil

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TWINNING KM 82 - KM 88

YOHO NATIONAL PARK, BC

Drawing title/Titre du dessin

PLAN & PROFILE  
STA 81+200 TO STA 81+850

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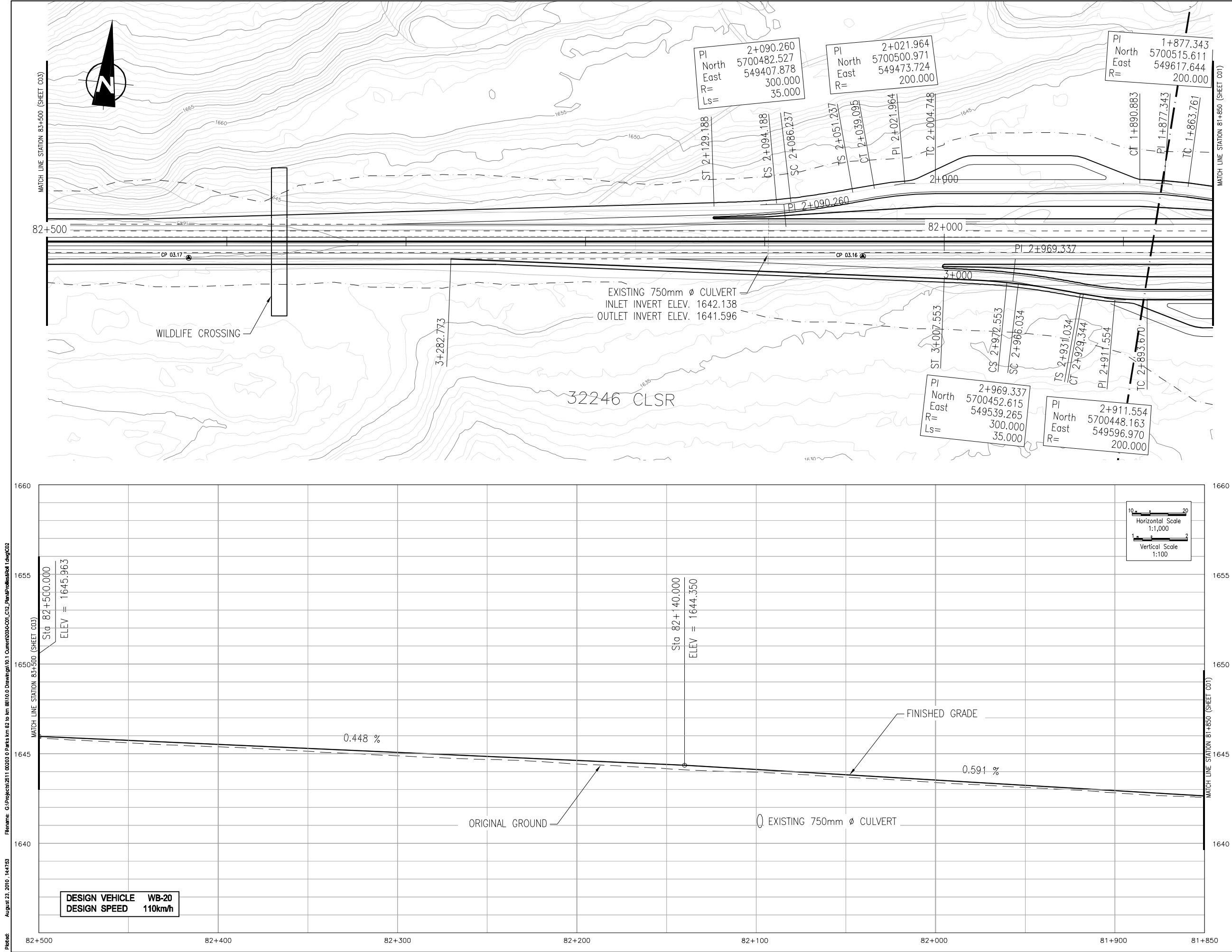
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Consultant's Name  
Nom de l'expert-conseil

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TRANS CANADA HIGHWAY  
TWINNING KM 82 - KM 88

YHO NATIONAL PARK, BC

Drawing title/Titre du dessin

PLAN & PROFILE  
STA 81+850 TO STA 82+500

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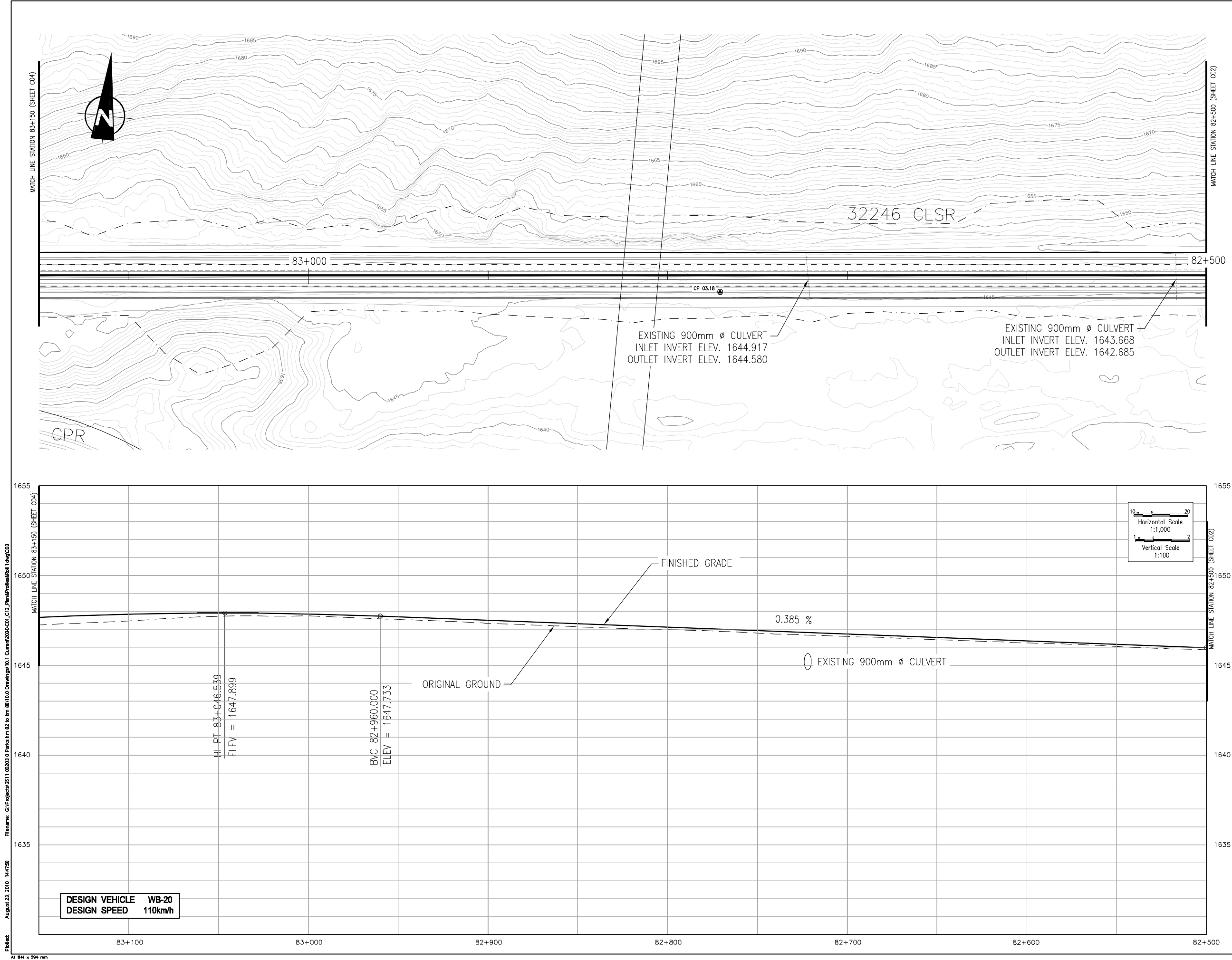
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10.80	5700358.6438	548301.5376	1646.6190
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Région

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Nom de l'expert-conseil

McElhanney

Project title/Titre du projet

TRANS CANADA HIGHWAY  
TWINNING KM 82 - KM 88

YOHO NATIONAL PARK, BC

Drawing title/Titre du dessin

PLAN & PROFILE  
STA 82+500 TO STA 83+150

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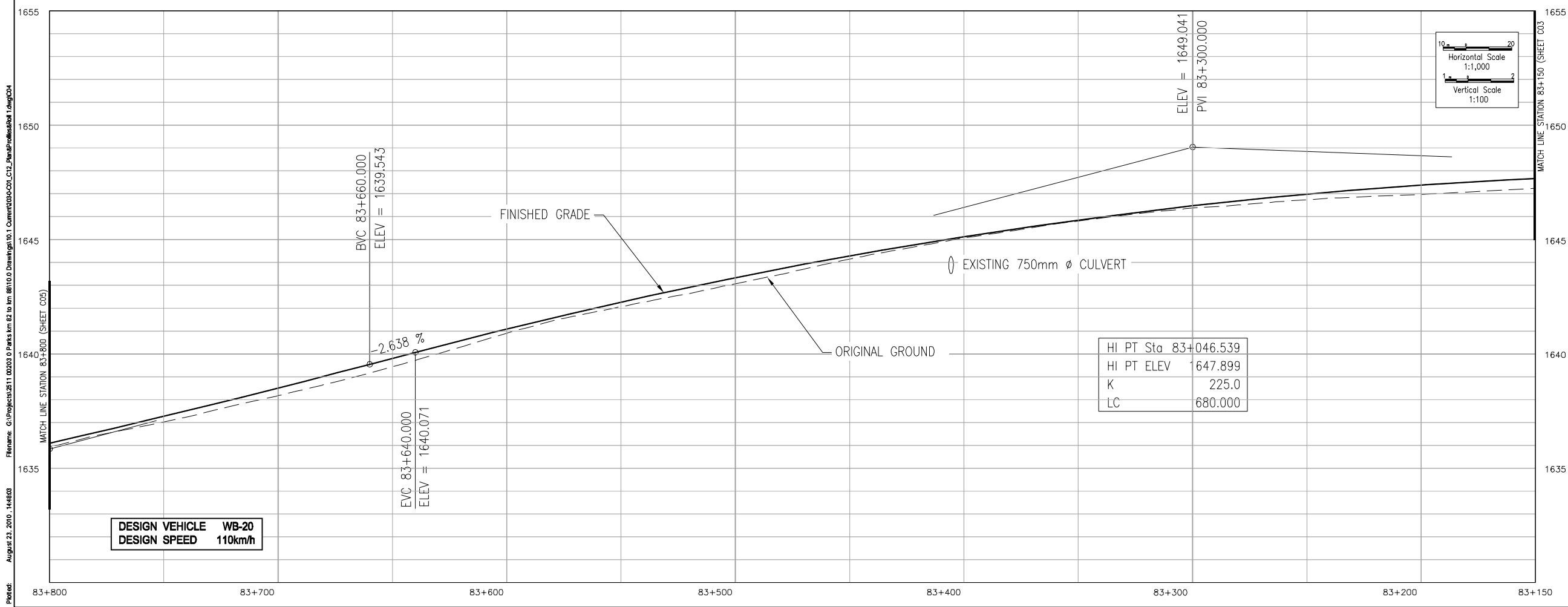
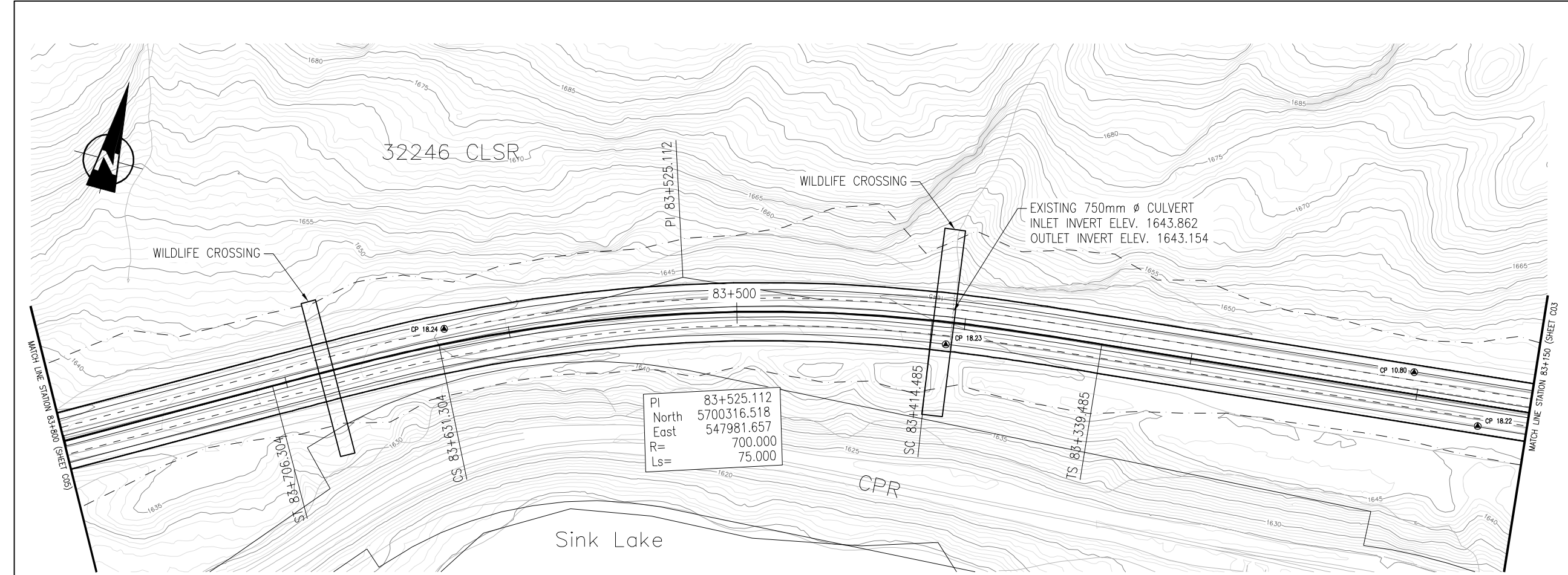
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Point	North	East	Elevation
03.14	5700639.0410	550129.9297	1640.5832
03.15	5700498.6099	549805.8500	1642.0724
03.16	5700458.1580	549454.8160	1643.3982
03.17	5700419.1732	549080.9550	1644.6503
03.18	5700383.6213	548733.1510	1646.2547
10.80	5700358.6438	548301.5376	1646.6190
18.22	5700342.9300	548334.4488	1646.5400
18.23	5700317.7249	548100.4125	1644.4140
18.24	5700267.9018	547886.6329	1639.9230
18.25	5700159.3084	547728.7887	1635.1430
18.26	5700062.3498	547503.6838	1629.7850

No.	Date/Date	Description/Description	Drawn by Dessiné par	Approved Approuvé
0	27/07/10	INITIAL SUBMISSION	VB	RP

Revision / Revision

A	B	C
detail number numéro de détail	source drawing no. de dessin no.	detail on drawing no. détail sur dessin no.

Consultant's Stamp  
Sceau de l'expert-conseil

Eng. Stamp  
Sceau de l'ingénieur

Client/client

Parks Canada  
Agence  
Western and  
Northern Region

L'Agence Parcs  
Canada  
Ouest et Nord  
Région

Consultant's Name  
Nom de l'expert-conseil

McElhanney

Project title/Titre du projet

TRANS CANADA HIGHWAY  
TWINNING KM 82 - KM 88

YOHO NATIONAL PARK, BC

Drawing title/Titre du dessin

PLAN & PROFILE  
STA 83+150 TO STA 83+800

NOT FOR CONSTRUCTION

Surveyed by/Arpenté par	Drawn by/Dessiné par	Date/Date

Designed by/Concept par	Reviewed by/Revisé par	Scale/Echelle
		H: 1:1000 V: 1:100

Parks Canada Project Manager/Administrateur de Projets Parcs Canada

Client Acceptance/Acceptation du client	Approved by/Approuvé par

Parks Canada Responsible Officer/Responsable Projets Parcs Canada

Parks Canada Project Manager/Administrateur de Projets Parcs Canada

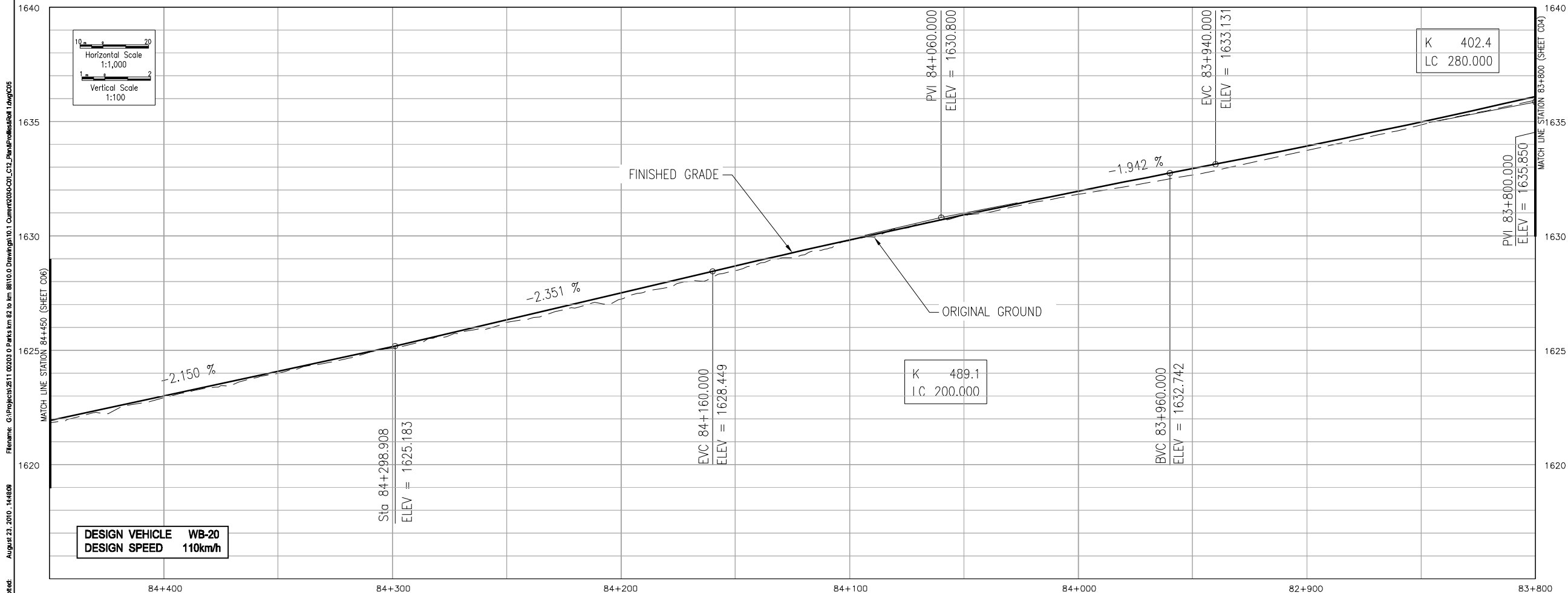
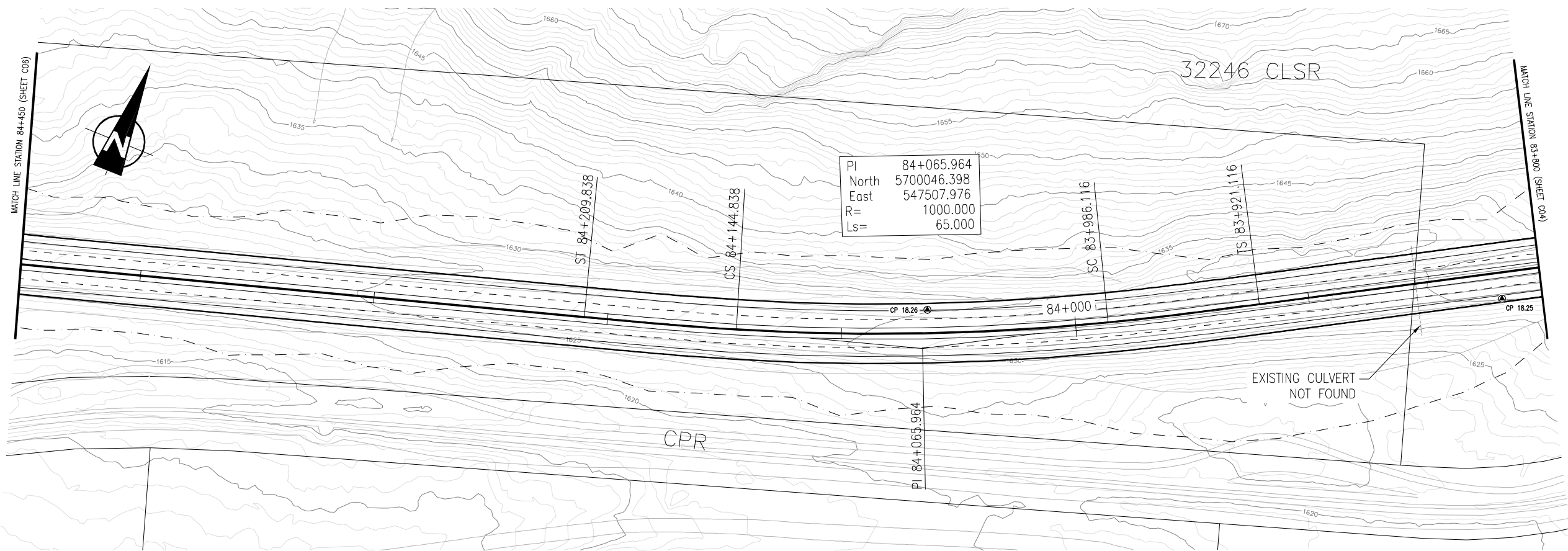
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		C04

Drawing Reference No./No. de référence du dessin

2511 00203 - 0



Plotted: August 23, 2010 - 14:40:08  
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User: JCS



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Point	Northing	Easting	Elevation
03.14	5700639.0410	550129.9297	1640.5832
03.15	5700498.6099	549805.8500	1642.0724
03.16	5700458.1980	549454.8160	1643.3982
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No.	Date/Date	Description/Description	Drawn by Dessiné par	Approved Approuvé
0	27/07/10	INITIAL SUBMISSION	VB	RP

Revision / Révision	
A	detail number numéro de détail
B	source drawing no. de dessin no.
C	detail on drawing no. détail sur dessin no.

Consultant's Stamp  
Sceau de l'expert-conseil

Eng. Stamp  
Sceau de l'ingénieur

Client/client

Parks Canada  
Agence  
Western and  
Northern Region

L'Agence Parcs  
Canada  
Ouest et Nord  
Région

Consultant's Name  
Nom de l'expert-conseil

McElhanney

Project title/Titre du projet

TRANS CANADA HIGHWAY  
TWINNING KM 82 - KM 88

YOHO NATIONAL PARK, BC

Drawing title/Titre du dessin

PLAN & PROFILE  
STA 83+800 TO STA 84+450

NOT FOR CONSTRUCTION

Surveyed by/Arpenté par	Drawn by/Dessiné par	Date/Date

Designed by/Concept par	Reviewed by/Revisé par	Scale/Echelle

Parks Canada Project Manager/Administrateur de Projets Parcs Canada

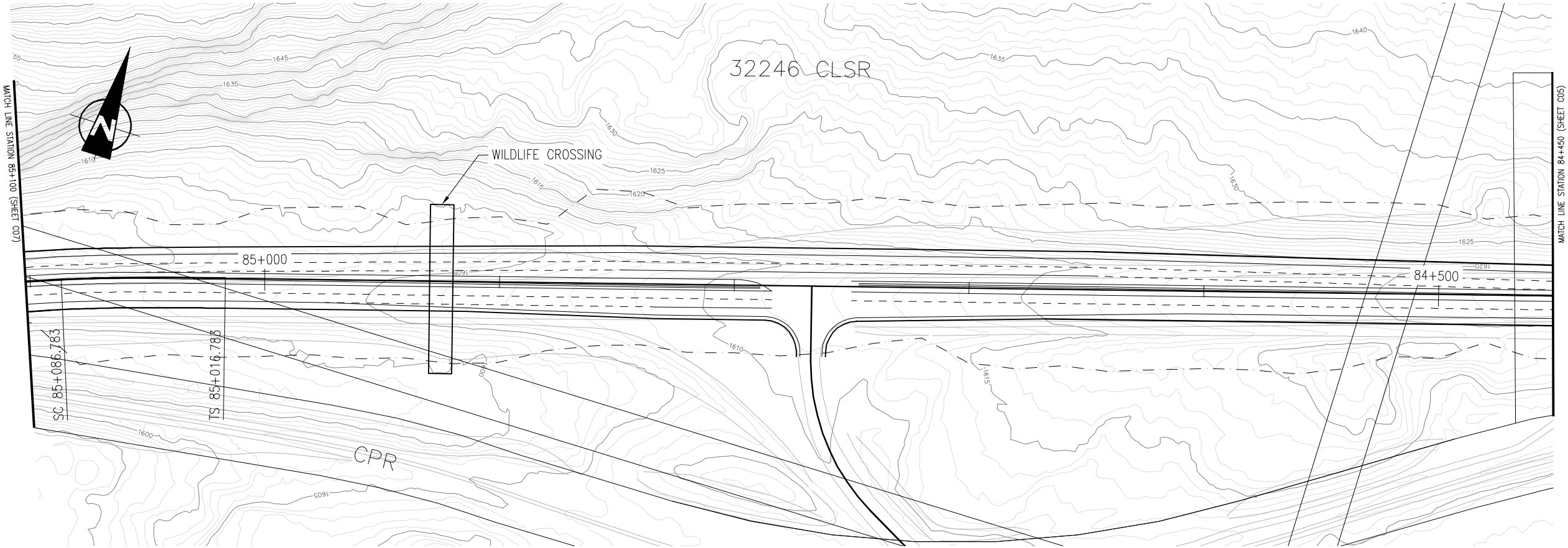
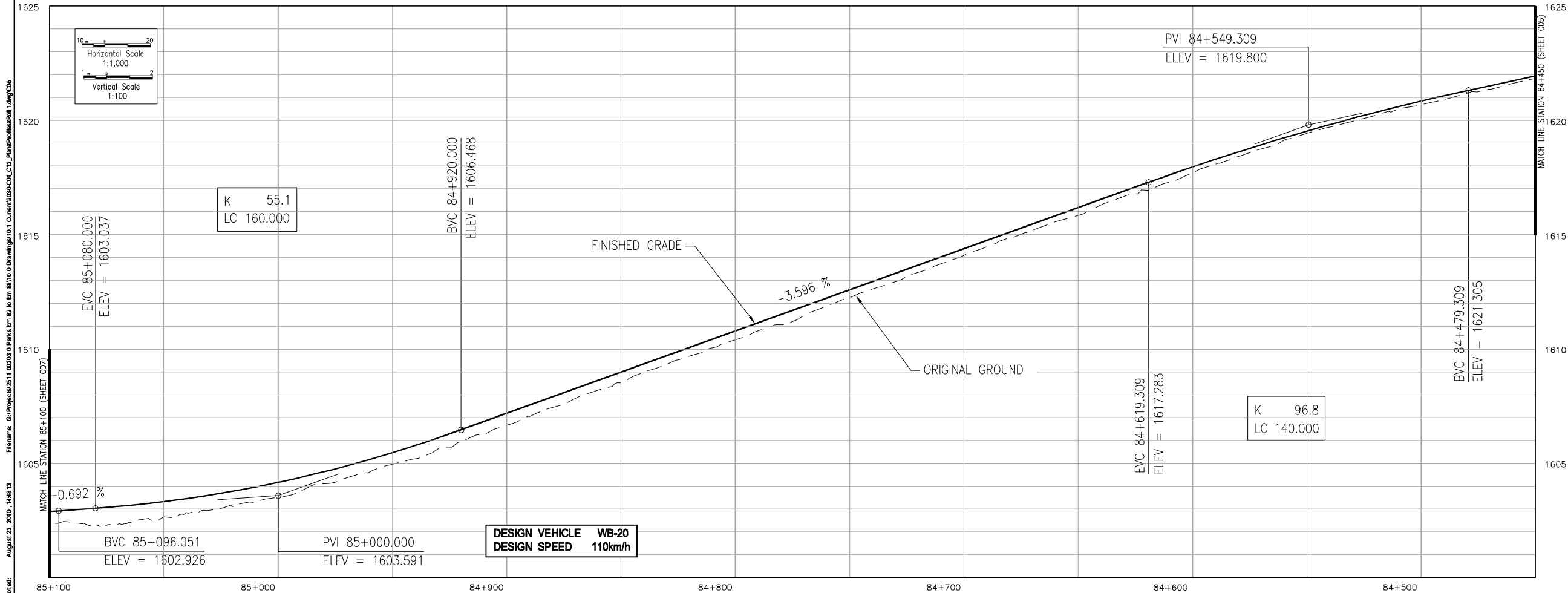
Client Acceptance/Acceptation du client	Approved by/Approuvé par

Project No./No. du projet		Asset No./No. du bien	Sheet No./ No. de la feuille
2511 00203 - 0			C05

Drawing Reference No./No. de référence du dessin



Plotted: August 23, 2010 - 144813  
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User: jcoo



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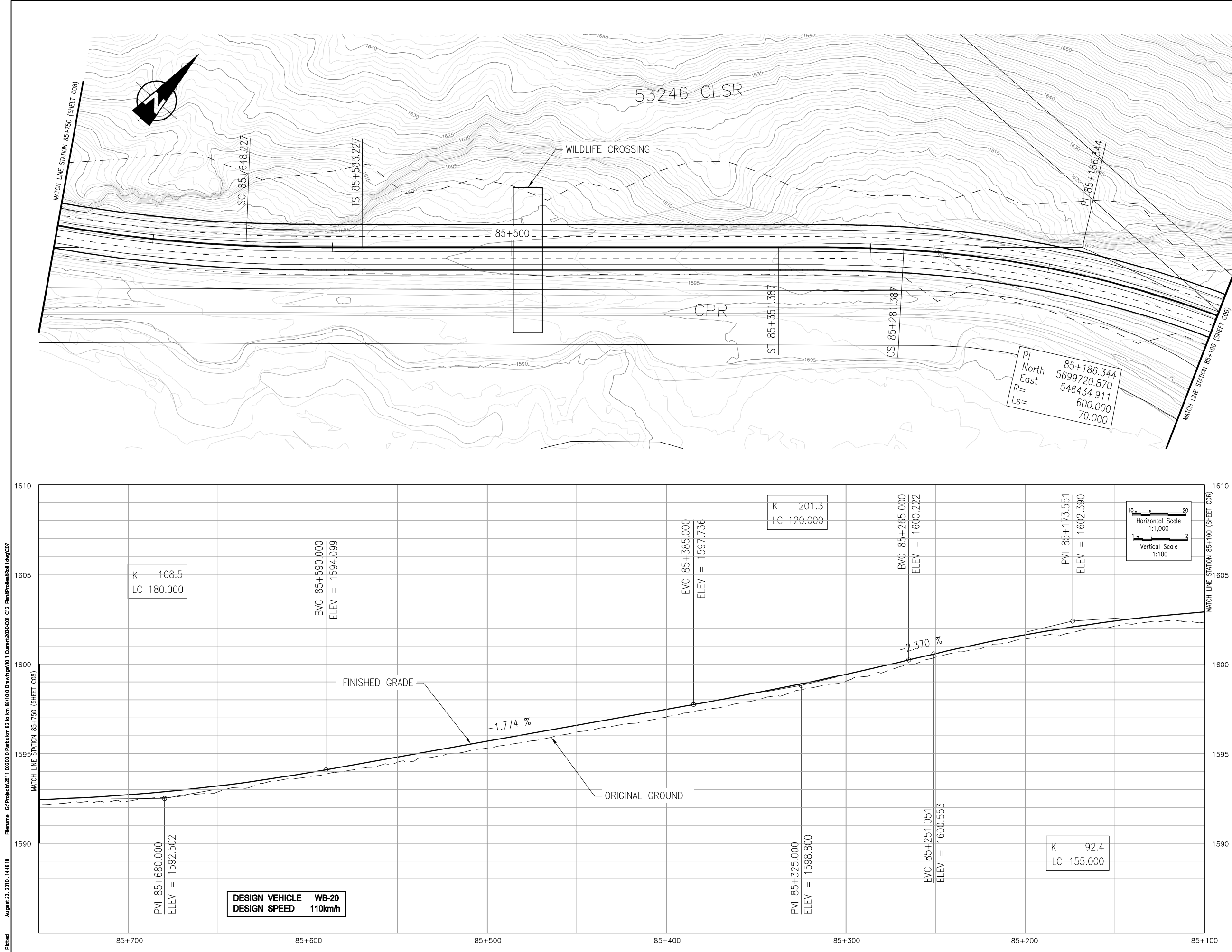
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0	27/07/10	INITIAL SUBMISSION	VB	RP
No.	Date/Date	Description/Description	Drawn by Dessiné par	Approved Approuvé
Revision / Révision				
A detail number numéro de détail				
B source drawing no. de dessin no.				
C detail on drawing no. détail sur dessin no.				
Consultant's Stamp Sceau de l'expert-conseil			Eng. Stamp Sceau de l'ingénieur	
Client/client				
Parks Canada Agence Western and Northern Region				
L'Agence Parcs Canada Ouest et Nord Région				
Consultant's Name Nom de l'expert-conseil				
Project title/Titre du projet				
TRANS CANADA HIGHWAY TWINNING KM 82 - KM 88				
YOHO NATIONAL PARK, BC				
Drawing title/Titre du dessin				
PLAN & PROFILE STA 84+450 TO STA 85+100				
NOT FOR CONSTRUCTION				
Surveyed by/Aspentié par		Drawn by/Dessiné par		Date/Date
Designed by/Concept par		Reviewed by/Revisé par		Scale/Echelle H: 1:1000 V: 1:100
Parks Canada Project Manager/Administrateur de Projets Parcs Canada				
Client Acceptance/Acceptation du client			Approved by/Approuvé par	
Parks Canada Responsible Officer/Agent Responsable Projets Parcs Canada				
Project No./No. du projet		Asset No./No. du bien		Sheet No./ No. de la feuille C06
Drawing Reference No./No. de référence du dessin 2511 00203 - 0				



Plotted: August 23, 2010 14:48:18  
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C07



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No.	Date/Date	Description/Description	Drawn by Dessiné par	Approved Approuvé
0	27/07/10	INITIAL SUBMISSION	VB	RP

Revision / Révision

A	B	C
detail number numéro de détail	source drawing no. de dessin no.	detail on drawing no. détail sur dessin no.

Consultant's Stamp  
Sceau de l'expert-conseil

Eng. Stamp  
Sceau de l'ingénieur

Client/client

Parks Canada  
Agence  
Western and  
Northern Region

L'Agence Parcs  
Canada  
Ouest et Nord  
Région

Consultant's Name  
Nom de l'expert-conseil

McElhanney

Project title/Titre du projet

TRANS CANADA HIGHWAY  
TWINNING KM 82 - KM 88

YHOHO NATIONAL PARK, BC

Drawing title/Titre du dessin

PLAN & PROFILE  
STA 85+100 TO STA 85+750

NOT FOR CONSTRUCTION

Surveyed by/Arpenté par	Drawn by/Dessiné par	Date/Date

Designed by/Concept par	Reviewed by/Revisé par	Scale/Echelle
		H: 1:1000 V: 1:100

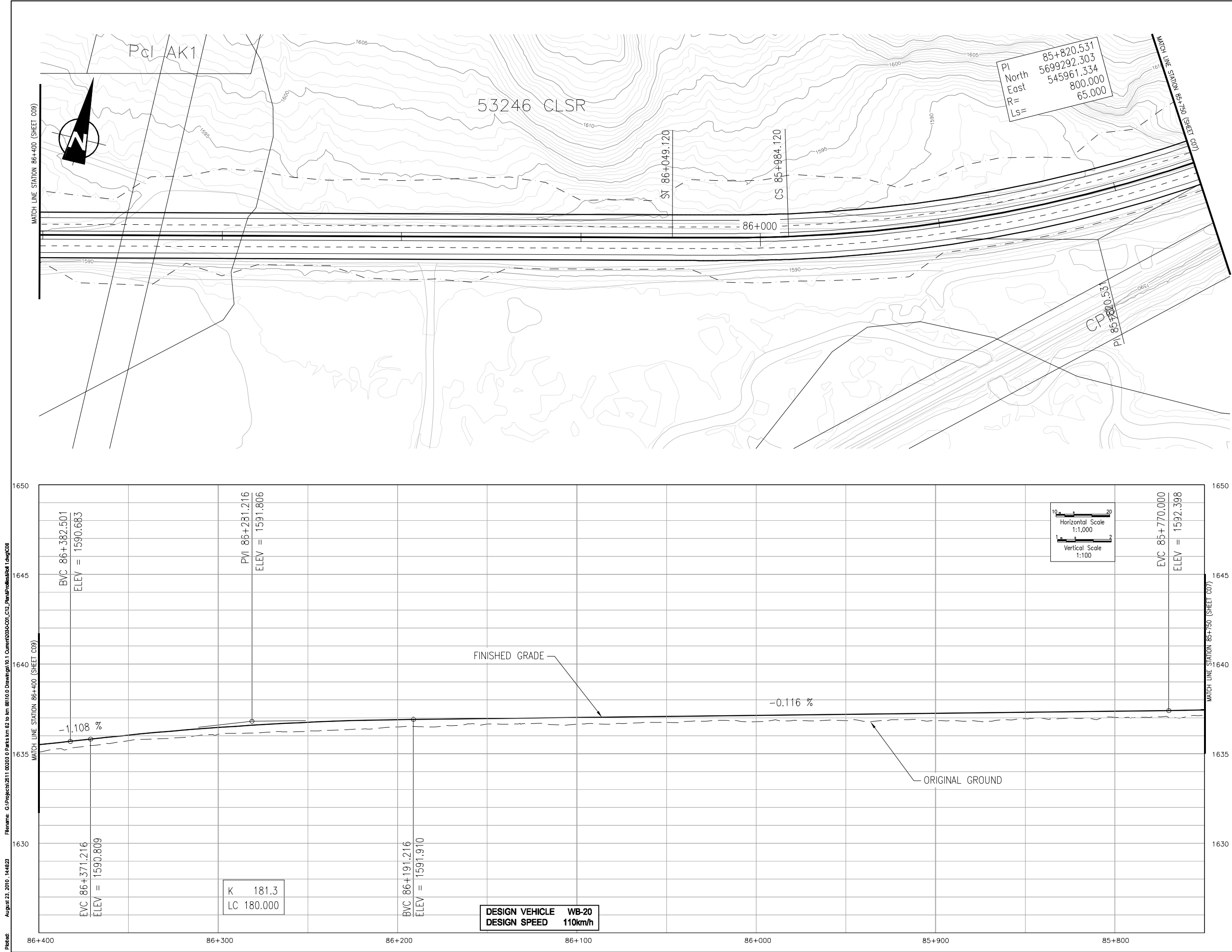
Parks Canada Project Manager/Administrateur de Projets Parcs Canada

Client Acceptance/Acceptation du client	Approved by/Approuvé par

Parks Canada Responsible Officer/Agent Responsable Parcs Canada

Project No./No. du projet	Asset No./No. du bien	Sheet No./ No. de la feuille
2511 00203 - 0		C07





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Point	North	East	Elevation
03.14	5700639.0410	550129.9287	1640.5832
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03.16	5700458.1580	549454.8160	1643.3982
03.17	5700419.1732	549080.9550	1644.6503
03.18	5700383.6213	548733.1510	1646.2547
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No.	Date/Date	Description/Description	Drawn by Dessiné par	Approved Approuvé
0	27/07/10	INITIAL SUBMISSION	VB	RP

Revision / Révision

A	B	C
detail number numéro de détail	source drawing no. de dessin no.	detail on drawing no. détail sur dessin no.

Consultant's Stamp  
Sceau de l'expert-conseil

Eng. Stamp  
Sceau de l'ingénieur

Client/Client

Parks Canada  
Agence  
Western and  
Northern Region

L'Agence Parcs  
Canada  
Ouest et Nord  
Région

Consultant's Name  
Nom de l'expert-conseil

McElhanney

Project title/Titre du projet

TRANS CANADA HIGHWAY  
TWINNING KM 82 - KM 88

YOHO NATIONAL PARK, BC

Drawing title/Titre du dessin

PLAN & PROFILE  
STA 85+750 TO STA 86+400

NOT FOR CONSTRUCTION

Surveyed by/Arpenté par	Drawn by/Dessiné par	Date/Date

Designed by/Concept par	Reviewed by/Revisé par	Scale/Echelle
		H: 1:1000 V: 1:100

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Project No./No. du projet	Asset No./No. de bien	Sheet No./ No. de la feuille
		C08

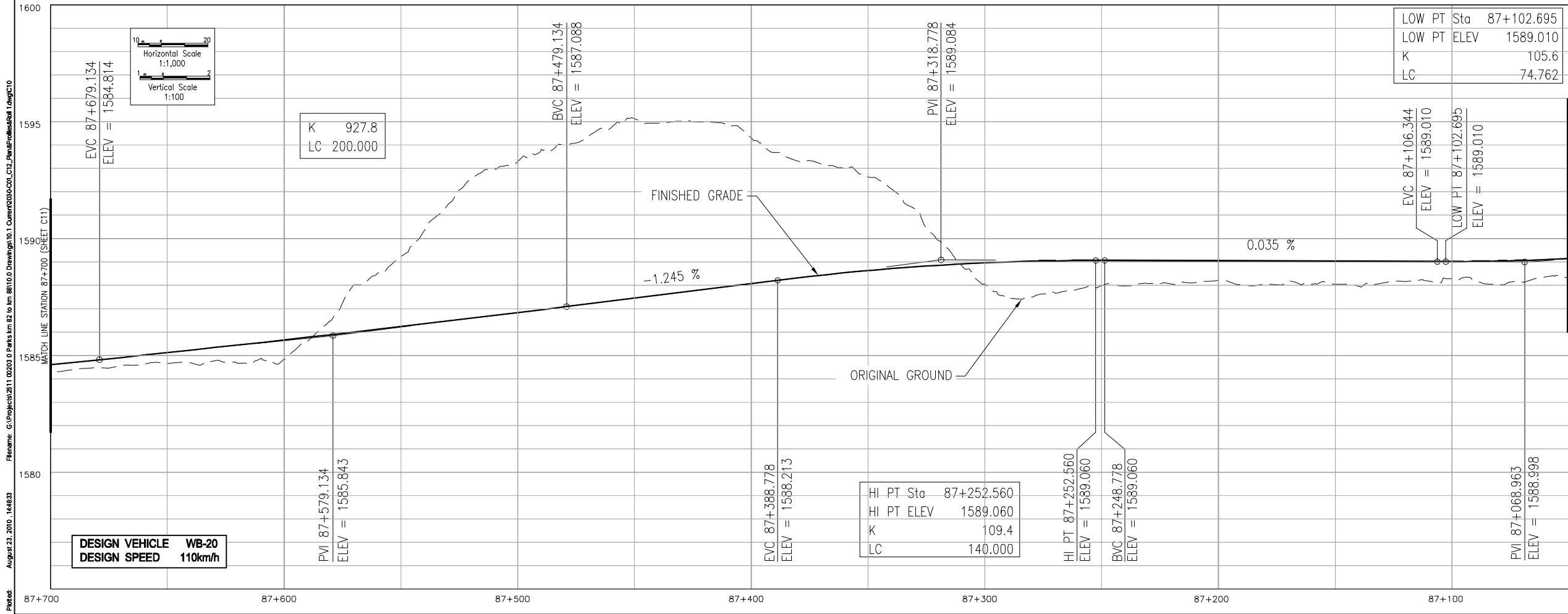
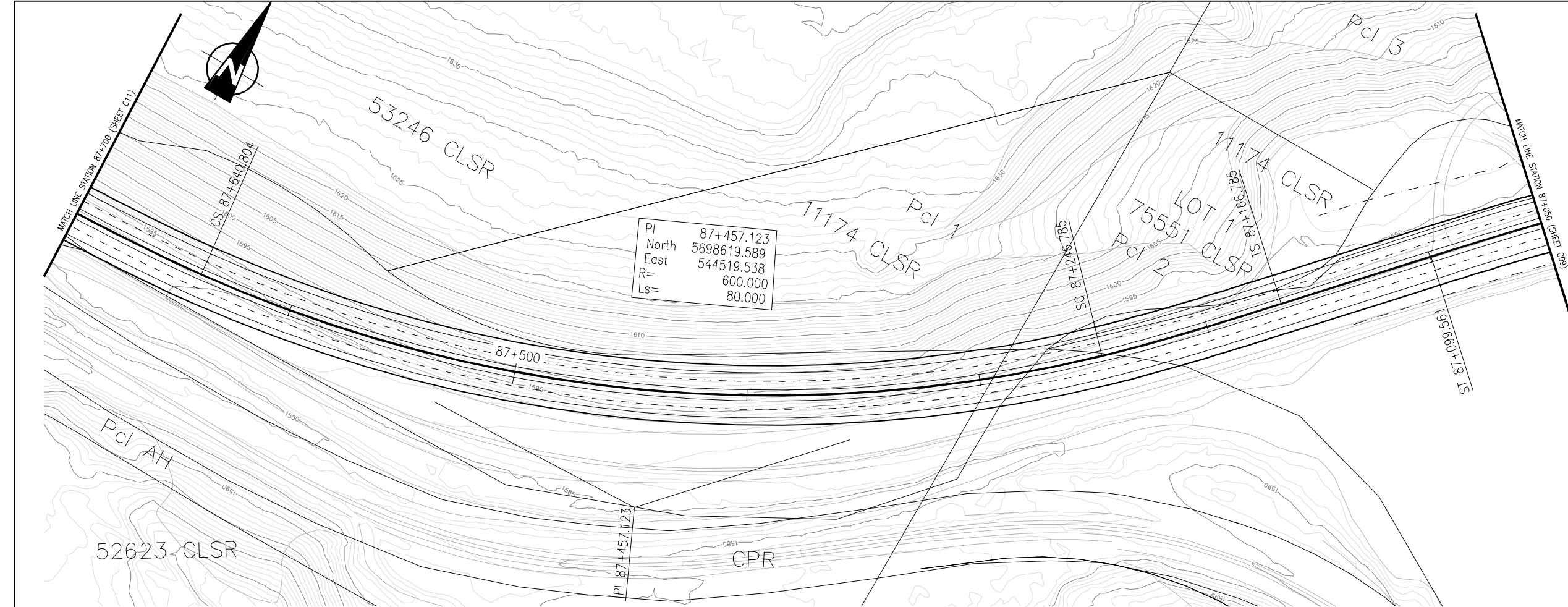
Drawing Reference No./No. de référence du dessin

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0	27/07/10	INITIAL SUBMISSION	VB	RP

Revision / Révision

A	B	C
detail number numéro de détail	source drawing no. de dessin no.	detail on drawing no. détail sur dessin no.

Consultant's Stamp  
Sceau de l'expert-conseil

Eng. Stamp  
Sceau de l'ingénieur

Client/client

Parks Canada  
Agence  
Western and  
Northern Region

L'Agence Parcs  
Canada  
Ouest et Nord  
Région

Consultant's Name  
Nom de l'expert-conseil

McElhanney

Project title/Titre du projet

TRANS CANADA HIGHWAY  
TWINNING KM 82 - KM 88

YHOHO NATIONAL PARK, BC

Drawing title/Titre du dessin

PLAN & PROFILE  
STA 87+050 TO STA 87+700

NOT FOR CONSTRUCTION

Surveyed by/Arpenté par	Drawn by/Dessiné par	Date/Date

Designed by/Concept par	Reviewed by/Revisé par	Scale/Echelle
		H: 1:1000 V: 1:100

Parks Canada Project Manager/Administrateur de Projets Parcs Canada

Client Acceptance/Acceptation du client	Approved by/Approuvé par

Parks Canada Responsible Officer/Agent Responsable Projets Parcs Canada

Project No./No. du projet	Asset No./No. du bien	Sheet No./ No. de la feuille
2511 00203 -0		C10

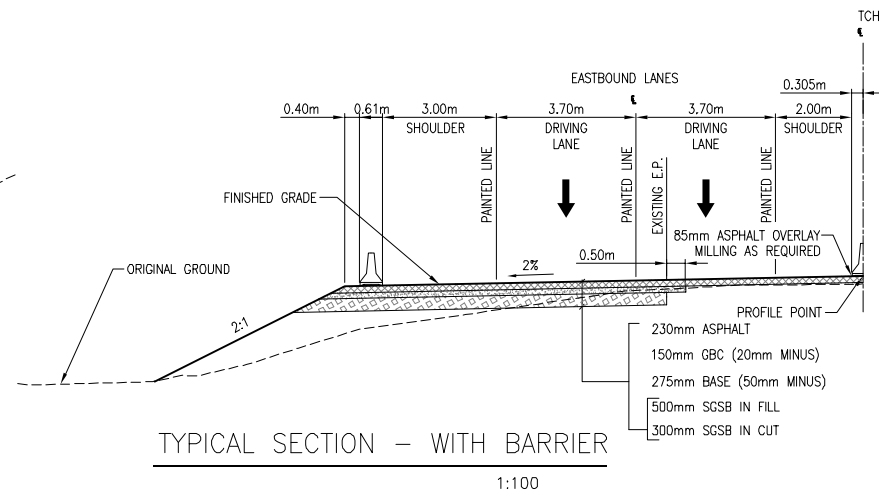
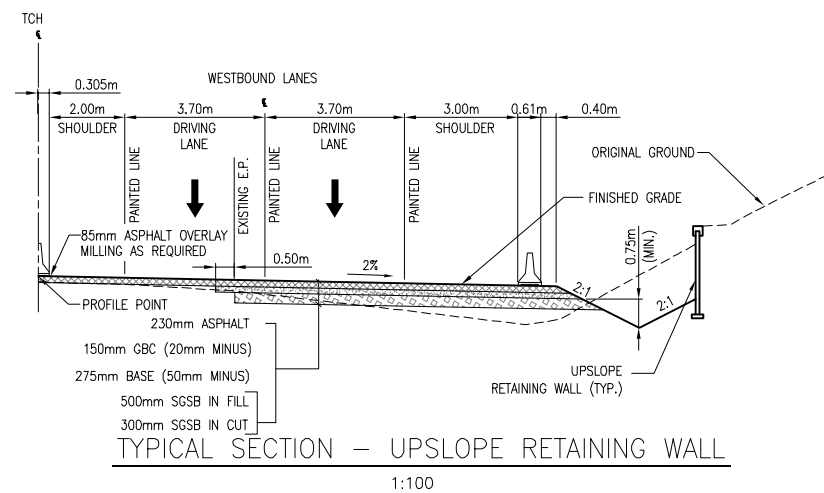
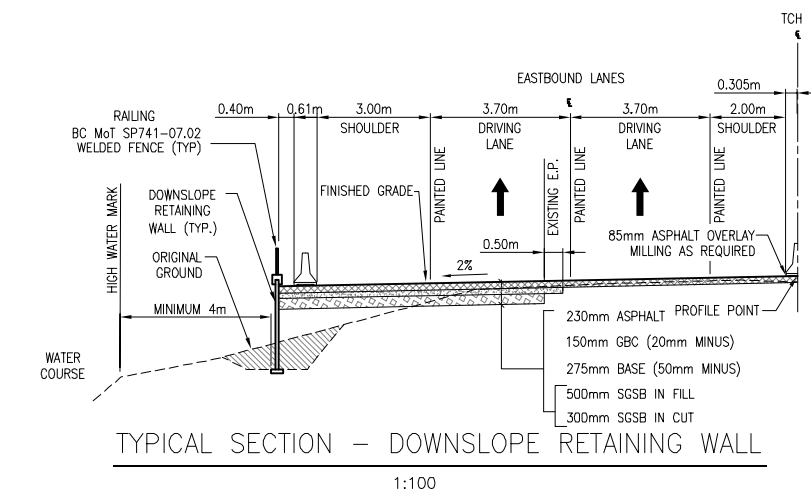
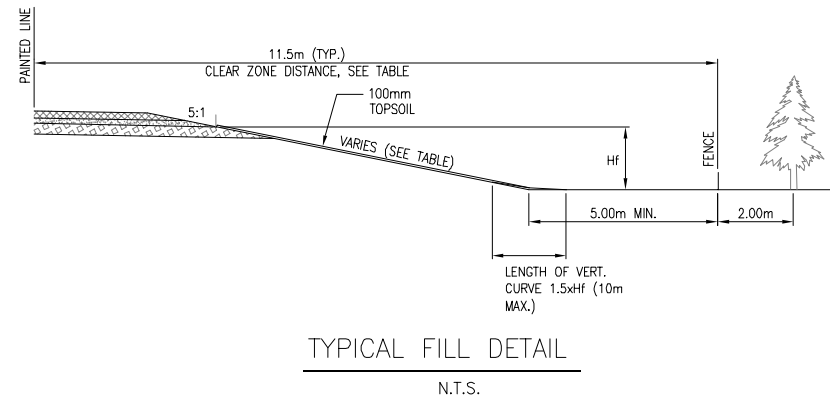
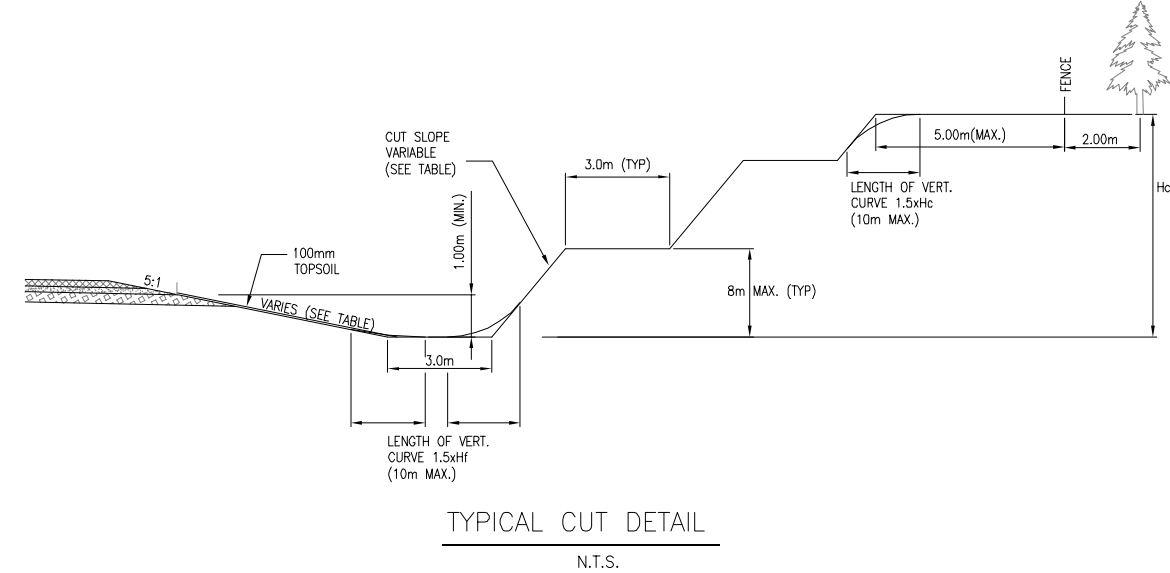
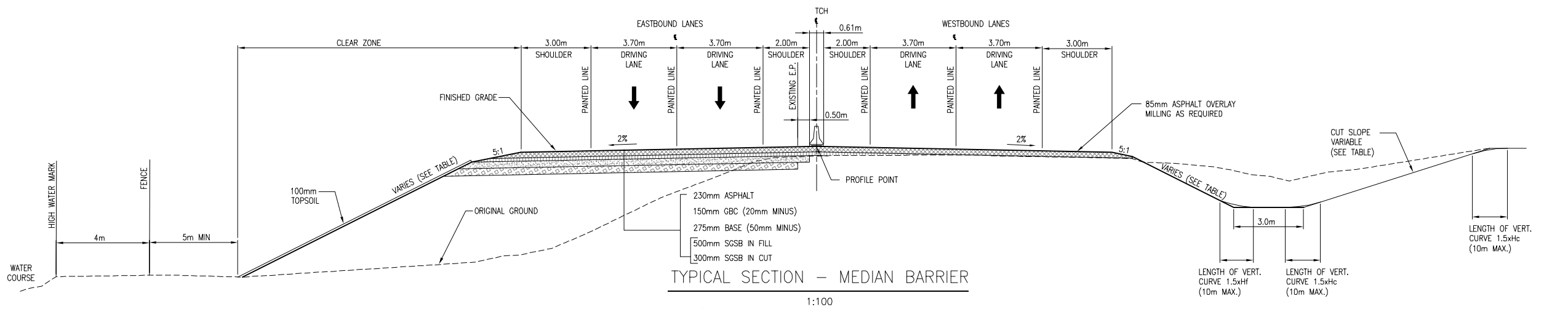
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August 23, 2010 15:14:23  
Plotted: A1 841 x 594 mm



CUT SLOPE TABLE	
CUT DEPTH (Hc)	SLOPE
≤1.0m	5:1
1.0m - 3.0m	4:1
3.0m - 4.0m	3:1
>4.0m	2:1
ROCK CUT	VARIABLE

\*BENCHES 3.0m WIDE TO BE PROVIDED AT 8.0m VERTICAL INTERVALS OR AS ACCEPTED BY THE ENGINEER

FILL SLOPE TABLE	
FILL HEIGHT (Hf)	SLOPE
≤1.0m	5:1
>1.0m - 2.5m	4:1
>2.5m	3:1
MOUNTAINSIDE/RIVERSIDE	2:1 WITH BARRIER

CLEAR ZONE DISTANCE TABLE			
	CUT SLOPE	FILL SLOPE	
		4:1	5:1
TANGENT SECTIONS AND CURVES OF R>900m	9.0	14.0	11.5
OUTSIDE CURVES	10.8	16.8	13.8

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No.	Date/Date	Description/Description	Drawn by Dessiné par	Approved Approuvé
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Revision / Révision	
A	detail number numéro de détail
B	source drawing no. de dessin no.
C	detail on drawing no. détail sur dessin no.

Consultant's Stamp Sceau de l'expert-conseil	Eng. Stamp Sceau de l'ingénieur
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Client/client	Parks Canada Agence Western and Northern Region	L'Agence Parcs Canada Ouest et Nord Région
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Consultant's Name Nom de l'expert-conseil	<b>McElhanney</b>
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Project title/Titre du projet	<b>TRANS CANADA HIGHWAY TWINNING KM 82 - KM 88</b>
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Yoho National Park, BC
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Drawing title/Titre du dessin	<b>TYPICAL SECTIONS</b>
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Surveyed by/Arpenté par	Drawn by/Dessiné par	Date/Date
Designed by/Concept par	Reviewed by/Revisé par	Scale/Echelle AS SHOWN

Parks Canada Project Manager/Administrateur de Projets Parcs Canada
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Client Acceptance/Acceptation du client	Approved by/Approuvé par
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Parks Canada Responsible Officer/Agent Responsable Parcs Canada	Parks Canada Project Manager/Administrateur de Projets Parcs Canada
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Project No./No. du projet	Asset No./No. du bien	Sheet No./ No. de la feuille
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Drawing Reference No./No. de référence du dessin	<b>C13</b>
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# APPENDIX F

APPENDIX F GEOTECHNICAL REPORT - GENERAL CONDITIONS



## GEOTECHNICAL REPORT – GENERAL CONDITIONS

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 EBA's Client. 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 EBA's Client unless otherwise authorized in writing by 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 EBA. Additional copies of the report, if required, may be obtained upon request.

### 2.0 ALTERNATE REPORT FORMAT

Where EBA submits both electronic file and hard copy versions of reports, drawings and other project-related documents and deliverables (collectively termed 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 EBA shall be deemed to be the original for the Project.

Both electronic file and hard copy versions of EBA's instruments of professional service shall not, under any circumstances, no matter who owns or uses them, be altered by any party except EBA. EBA's instruments of professional service will be used only and exactly as submitted by EBA.

Electronic files submitted by EBA have been prepared and submitted using specific software and hardware systems. 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, 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. 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. 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 SURFACE WATER AND GROUNDWATER CONDITIONS

Surface and groundwater conditions mentioned in this report are those observed at the times recorded in the report. These conditions vary with geological detail between observation sites; annual, seasonal and special meteorologic conditions; and with development activity. Interpretation of water conditions from observations and records is judgemental and constitutes an evaluation of circumstances as influenced by geology, meteorology and development activity. Deviations from these observations may occur during the course of development activities.

## 8.0 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.

## 9.0 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.

## 10.0 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.

## 11.0 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.

## 12.0 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.

## 13.0 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.

## 14.0 SAMPLES

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.