MEMORANDUM

TO:	MURRAY TEKANO
FROM:	DARCY GRYKULIAK, P.ENG AND ALEX IZETT, P.ENG.
SUBJECT:	KICKING HORSE CANYON PROJECT – PHASE 4 – COST ASSESSMENT
DATE:	JANUARY 23, 2014

Executive Summary

In July 2013, MOTI Executive requested that the Kicking Horse Canyon Project team assess the preliminary design of Phase 4 (4.8 kms) of the Trans-Canada Highway (TCH) improvements, five kilometres east of Golden, prepared in 2008 and determine a modified scope associated with completing the project with a [redacted] project cost estimate. The modified scope should hold paramount driver safety, highway reliability and capacity.

This memorandum summarizes the process employed in completing the assessment, the alignment and infrastructure elements associated with the five alternatives considered in the assessment, design rationale and considerations, procurement and construction considerations, and associated project cost estimates. Cost estimates below assume a detailed design start in 2014 with an estimated six-year project schedule, and includes escalation. Past and current planning, geotechnical investigations and engineering costs of approximately [redacted] have been previously allocated to the project.

Three alternatives – referred to as Z9A, Z9B and Z9C – were initially assessed, all of which had as their basis the 2008 preliminary design and associated preferred option Z9. The results of the assessment suggest that significant improvements to the TCH can be completed for under [redacted] with the Z9A, Z9B and Z9C alternatives but would stop short of providing a completed, divided four-lane cross-section. The three alternatives would provide approximately 2.6 kilometres of four lane improvements, 1.2 kilometres of improved highway with less than four lanes, and leave approximately 1 kilometre on the approach to Yoho (5-Mile) Bridge in its existing condition[1]. Subsequently, two extensions to alternatives Z9A and Z9C were developed that extended the four-laning to Yoho Bridge; referred to as Z9A-D and Z9C-E. Constructing either Z9A-D or Z9C-E would result in a four-lane divided highway for the corridor from the Town of Golden to the Yoho Park boundary. Features of the 2008 preferred option and the five alternatives are summarized in a table on page 3.

If it were decided to construct the entire 4.8 kilometres with either the Z9A-D or Z9C-E alternatives then completion of four lanes would come at a premium of approximately [redacted] It is possible to stage the Z9A-D and Z9C-E projects into two phases but this would add further costs for conditions such as overlapping work, remobilization, escalation, etc. Since it is uncertain at this time as to timing, the additional cost for staging the work has not been estimated.

Cost savings were realized by creating more curvilinear alignments than the Z9 alignment and eliminating tunnels and hazard protection sheds. The new alignments have horizontal and vertical alignments that meet the design speeds but have some areas that do not achieve the design speed sight distance as noted in the table on the following pages. Geotechnical hazards on all alignments

[1] Z9A would feature 2.6 kms of 4-lane highway, 0.3 kms of 3-lane highway and 0.9 kms of 2-lane highway. Z9B would feature 2.9 kms of 3-lane highway and 0.9 kms of 2-lane highway. Z9C would feature 2.6 kms of 4-lane highway, 0.3 kms of 3-lane highway and 0.9 kms of 2-lane highway.

have been mitigated through the use of a combination of high-energy rock fall attenuation mesh, wide ditches, retaining walls and other measures. While the risk of hazards will be much improved from the present conditions the alignments developed will not provide the same degree of reliability and certainty as the Z9 alignment, and the Province would realize operations and maintenance costs for maintaining the rockfall attenuator mesh and catchment ditches, and the need for on-going snow-avalanche monitoring.

The cost estimates for the alternatives prepared as part of this assessment include [redacted] and [redacted] for the level of design and risks associated with it. Escalation rates of between [redacted] were included in the estimates. The project team feels that the escalation provided is appropriate for a six-year project (2014-2019) starting in 2014. This escalation rate is lower than the current Ministry forecasts for highway construction but this project has a lower percentage of costs than typical highway projects that would be allocated to the most volatile construction cost inputs, being fuel and asphalt. Recent construction inflation numbers since 2008 have averaged less than [redacted] and the Canadian inflation rate since this time has averaged less than 2%. The current Ministry of Transportation and Infrastructure Service Plan calls for reduced expenditures on capital projects in 2014/15 and in 2015/16. By starting the project in early 2014 it is expected that there will be significant industry interest and escalation will be mitigated. Construction escalation costs are time sensitive and if the project does not start in 2014 the cost estimates should be revisited.

The project team feels that option Z9A-D most closely meets the original scope of improvement and design criteria for corridor consistency although its estimated cost to complete is above the target price of [redacted]. Option Z9A offers an option within the target price but it does not achieve the four-laning criteria for the entire Kicking Horse Canyon section.

Future design work would reduce risk and should be able to optimize structural options and inclusion of walls versus bridges, including consideration of cantilevered structures. Many procurement alternatives are available, but the Project cost estimate could be sensitive to which method is selected. Delivery of the project by Design-Build would provide the greatest opportunity for innovation and earliest time for construction.

Option	Z9	Z9A	Z9B	Z9C	Z9A-D	Z9C-E
Project Cost	[redacted] *Estimate updated 2011	Remaining Cost [redacted] Past Costs [redacted] Total Cost [redacted]	Remaining Cost [redacted] Past Costs [redacted] Total Cost [redacted]	Remaining Cost [redacted] Past Costs [redacted] Total Cost [redacted]	Remaining Cost [redacted] Past Costs [redacted] Total Cost [redacted]	Remaining Cost [redacted] Past Costs [redacted] Total Cost [redacted]
Length of Improvements	4.8 kms	3.8 kms	3.8 kms	3.8 kms	4.8 kms	4.8 kms
No. of Lanes	4	2 – 4 4 lanes ~ 2.6kms 3 lanes (2WB) ~ 0.3kms 2 lanes ~ 0.9kms	2 – 3 3 lanes (2EB) ~ 2.6kms 3 lanes (2WB) ~ 0.3kms 2 lanes ~ 0.9kms	2 – 4 4 lanes ~ 2.6kms 3 lanes (2WB) ~ 0.3kms 2 lanes ~ 0.9kms	4	4
Divided Highway	Yes	Yes	Yes	Yes	Yes	Yes
Geometry	100 km/h	100 km/h	100 km/h	80 km/h	100 km/h	80 km/h
Sight Lines	100 km/h	80 km/h min.	80 km/h min.	60 km/h min.	80 km/h min.	60 km/h min.
Tunnels	Yes	No	No	No	No	No
Hazard Protection Sheds	Yes	No	No	No	No	No
Rockfall Mesh	Yes	Yes	Yes	Yes	Yes	Yes
Wildlife Mitigation	Yes	Yes	Yes	Yes	Yes	Yes
Safety Ranking	1	3	5	6	2	4

1. BACKGROUND

The Kicking Horse Canyon portion of the Trans-Canada Highway (TCH) runs between the Town of Golden and the west boundary of Yoho National Park, and has seen significant improvements carried out on sections of this highway between 1999 and 2013. The Phase 4 Canyon portion of this highway has not seen any significant improvements since the 1950's and runs through extremely challenging terrain with the Kicking Horse River and the Canadian Pacific Railway below it.

As part of the Ministry's Cache Creek to the Rockies Program SNC Lavalin prepared a functional planning report in 2000 for improvements to the canyon portion of the TCH. The SNC Lavalin report developed 14 alignments for further study. In 2005 AECOM, Thurber Engineering, Hatch Mott McDonald and other subconsultants began preliminary engineering work and geotechnical investigations and issued a report in June 2008 that had a recommended alignment called Z9 meeting 100 km/h design criteria and included tunnels and hazard protection sheds to maintain a high degree of reliability. As part of the preliminary design work the KHCP team also conducted a Value Engineering Study, operations, maintenance and rehabilitation assessment, Constructability Review, Risk Register and Delivery Options Report. The cost for the Z9 alignment was approximately [redacted] million when the cost estimate was prepared in 2008. In 2011, this cost estimate was reviewed to reflect then-current costs, and was updated to [redacted].

In July 2013, MOTI Executive requested that the Kicking Horse Canyon Project team assess the preliminary design of Phase 4 improvements and determine a modified scope associated with a [redacted] project cost estimate. The modified scope should hold paramount driver safety, highway reliability and capacity.

2. ASSESSMENT ASSIGNMENT

2.1 PROCESS

In mid-July 2013, members of the Kicking Horse Canyon Project's (KHCP) Owner's Engineer Team (OE Team) met with MOTI to discuss the assignment and opportunities for reducing costs. Participants in that meeting are noted in Appendix 1. At that initial meeting there was agreement that, to achieve the type of cost savings that were required, elements of the preliminary design scope would have to be eliminated or reduced. These elements included:

- reducing the highway's cross-section, specifically the number of lanes;
- reducing the design speed;
- eliminating tunnels;
- eliminating hazard protection sheds;
- eliminating or shortening bridges, and replacing same with retaining walls;
- eliminating the Dart Creek forest service road interchange;
- eliminating the separate bicycle trail; and
- other miscellaneous cost savings.

In the meeting, MOTI and the OE Team identified three design alternatives that would be explored further and for which updated cost estimates would be prepared. The three design alternatives would commence at the east end of the currently-under-construction 4 Kilometre Wall project which is approximately 4.2 kilometres east of the Highway 1 / Highway 95 intersection in Golden. The three design alternatives were:

- Z9A: A 3.8 kilometre, divided highway improvement incorporating 100 km/h geometry that would feature four lanes for 2.6 kilometres, followed by two lanes for 0.9 kilometres, and followed by three lanes (two lanes westbound, or uphill) before tying into the existing three-lane, undivided cross-section west of Yoho Bridge.
- Z9B: A 3.8 kilometre, divided highway improvement incorporating 100 km/h geometry that would feature three lanes (two lanes eastbound, or uphill) for 2.6 kilometres, followed by two lanes for 0.9 kilometres, and followed by three lanes (two lanes westbound, or uphill) before tying into the existing three-lane, undivided cross-section west of Yoho Bridge.
- Z9C: A 3.8 kilometre, divided highway improvement incorporating 80 km/h geometry that would feature four lanes for 2.6 kilometres, followed by two lanes for 0.9 kilometres, and followed by three lanes (two lanes westbound, or uphill) before tying into the existing three-lane, undivided cross-section west of Five Mile (Yoho) Bridge.

Subsequently, in August 2013, the OE Team developed two additional design alternatives and cost estimates for completing four-laning on the TCH to the existing four-lane cross-section at Yoho Bridge. These were labeled Z9A-D and Z9C-E:

- Z9A-D: A 4.8 kilometre, four-lane divided highway improvement incorporating 100 km/h geometry.
- Z9C-E: A 4.8 kilometre, four-lane divided highway improvement incorporating 80 km/h geometry.

These two alternatives would present motorists with a driving experience similar to that for the balance of the rural section of the Trans-Canada Highway between Golden and Yoho National Park, in so far as the highway's cross-section, alignment and roadside environment.

Sketches for each of the alternatives, including plan and profile sheets are included in Appendix 2, and additional features regarding each are included in Table 1. Summaries of the cost estimates are provided in Appendix 5.

Table 1 – Summary of Phase 4 Design Alternatives

Kicking Horse Canyon Project

Phase 4 **904+171 to 909+080 (4.79 kms) – Design Alternative Z9**
904+171 to 907+940 (3.77 kms) – Design Alternatives Z9A, Z9B, Z9C
904+171 to 908+959 (4.79 kms) – Design Alternatives Z9A-D, Z9C-E

	Z9	Z9A	Z9B	Z9C	Z9A-D	Z9C-E
Predicted Safety Performance (Twenty years, 2020 through 2040 for Z9A, Z9B, Z9C, Z9A-D, and Z9C-E) (coll. – collisions)	Fatal Collisions: 1.2 coll. Injury Collisions: 46.9 coll. PDO Collisions: 97.0 coll. Total Collisions: 141.1 coll. *accidents over 25 years estimated in 2008 de Leur report	Fatal Collisions: 1.6 coll. Injury Collisions: 34.0 coll. PDO Collisions: 73.9 coll. Total Collisions: 109.4 coll.	Fatal Collisions: 1.7 coll. Injury Collisions: 37.3 coll. PDO Collisions: 81.1 coll. Total Collisions: 120.1 coll.	Fatal Collisions: 2.0 coll. Injury Collisions: 42.6 coll. PDO Collisions: 92.8 coll. Total Collisions: 137.4 coll.	Fatal Collisions: 1.4 coll. Injury Collisions: 29.7 coll. PDO Collisions: 65.2 coll. Total Collisions: 96.3 coll.	Fatal Collisions: 1.7 coll. Injury Collisions: 36.2 coll. PDO Collisions: 79.6 coll. Total Collisions: 117.5 coll.
Cost Estimate	Project: $670 million based on last estimate update in 2011	Remaining Project Costs: $348 million Past Costs: $10 million Total Project Costs: $358 million Construction: $[redacted] (incl resident engineering and contingency)	Remaining Project Costs: $322 million Past Costs: $10 million Total Project Costs: $332 million Construction: $[redacted] (incl resident engineering and contingency)	Remaining Project Costs: $337 million Past Costs: $10 million Total Project Costs: $347 million Construction: $[redacted] (incl resident engineering and contingency)	Remaining Project Costs: $422 million Past Costs: $10 million Total Project Costs: $432 million Construction: $[redacted] (incl resident engineering and contingency)	Remaining Project Costs: $412 million Past Costs: $10 million Total Project Costs: $422 million Construction: $[redacted] (incl resident engineering and contingency)
Cost Estimate Features:		Grading quantities are based on neat line quantities [redacted] pavement structure quantities are based on neat line quantities [redacted] Design-bid-build procurement, escalation rates of [redacted] through [redacted] and construction from 2016 through 2019 Includes Project costs to end-March 2014 of [redacted], contingency [redacted] and management reserve [redacted]				
Cross-Section	Number of lanes: 4	Number of lanes: 4 – 2 – 3 4 lanes: ~ 2.6 kms 2 lanes: ~ 0.9 kms 3 lanes: ~ 0.3 kms (2 lanes WB)	Number of lanes: 3 – 2 – 3 3 lanes: ~ 2.6 kms (2 lanes EB) 2 lanes: ~ 0.9 kms 3 lanes: ~ 0.3 kms (2 lanes WB)	Number of lanes: 4 – 2 – 3 4 lanes: ~ 2.6 kms 2 lanes: ~ 0.9 kms 3 lanes: ~ 0.3 kms (2 lanes WB)	Number of lanes: 4	Number of lanes: 4
Horizontal Alignment (minimum radius)	600m (meeting 100km/h criterion, when combined with vertical alignment)	450m (meets 100km/h criterion)	450m (meets 100km/h criterion)	280m (meets 80 km/h criterion)	446 m (meets 100km/h criterion)	280m (meets 80 km/h criterion)
Vertical Alignment – sag curve, crest curve, grade (minimum K and curve length)	Sag: K = 173, L = 800m (meets 100km/h criterion) Crest: K = 145, L = 1600m (meets 100km/h criterion) All comply with upper range of TAC design domain	Sag: K = 100, L = 150m (meets 100 km/h criterion) Crest: K = 80, L = 200m (meets 100 km/h criterion)	Sag: K = 100, L = 150m (meets 100 km/h criterion) Crest: K = 80, L = 200m (meets 100 km/h criterion)	Sag: K = 100, L = 150m (meets 80 km/h criterion) Crest: K = 113, L =1300m (meets 80 km/h criterion)	Sag: K = 100, L = 100m (meets 100 km/h criterion) Crest: K = 80, L = 200m (meets 100 km/h criterion)	Sag: K = 100, L = 100m (meets 80 km/h criterion) Crest: K = 113, L =1300m (meets 80 km/h criterion)
Notable Grades	7%: over a distance of 580m, to match existing highway at east end, otherwise 6% grade throughout	4%: 2 030 m 8%: to match existing highway at east end	4%: 2 030 m 8%: to match existing highway at east end	4%: 2 240 m 8%: to match existing highway at east end	4%: 2 030 m 7.2% - 8%: 640m	4%: 2 240 m 7.2% - 7.5%: 650m
Minimum Sight Distance	160m to 210m	114m (~80km/h)	114m (~80km/h)	90m (60km/h)	114m (~80km/h)	90m (60km/h)
Bridges, Tunnels, and/or Hazard Protection Sheds	Six bridges– 25 metres long to 420 metres long Two tunnels – 210 metres long and 340 metres long Four hazard protection sheds – 40m long to 350 metres long	Five bridges – 40 metres long to 350 metres long	Five bridges – 40 metres long to 350 metres long	Six bridges – 40 metres long to 235 metres long	Five bridges – 30 metres long to 400 metres long	Seven bridges – 20 metres long to 235 metres long
Retaining Walls & Snow-Avalanche Containment Walls	Eighteen	Twenty-four	Twenty-three	Twenty-one	Twenty-five	Twenty-four
Environmental	Wildlife exclusion fencing and wildlife crossing structures included ML / ARD potential, but mitigated through proper excavation, placement and capping operations in Dart Creek Valley					
Geotechnical Risks	Avalanche hazard mitigation meets design criteria requirements Rock fall hazards improved from present conditions Debris flow/flood hazards mitigation meet design criteria					
Utilities	Hydro and Telus plant relocated, and retained above ground					
Property Acquisition	Cost estimate includes allowance for [redacted]					

2.2 FEATURES OF ALTERNATIVE DESIGNS

2.2.1 Cross-Section Rationale

To achieve the cost reductions that were required, the OE Team concluded that the amount of rock and earth excavation would have to be reduced significantly along with the cross-sectional area of the bridges. To achieve this, it was determined that the number of lanes should be reduced.

For the Z9A and Z9C alternatives it was assumed that four lanes complete with geometric improvements should be provided starting from the east end of the current section under construction and proceed for as far as possible. Given the significant bridge length (420m in option Z9) required at the top of Five Mill Hill and given that the highway reaches a crest at this location, it was decided to reduce to two the number of lanes around the horizontal curve at this location. Once off the bridge, the highway would transition to a three-lane cross-section to match the existing highway width down Five Mile Hill.

For Z9B, the team considered initially providing only a two-lane cross-section proceeding from the east end of the section currently under construction to tie-in to the existing three-lane cross-section. However, owing to the sustained 4% grade that climbs west to east toward the top of Five Mile Hill over a distance of approximately 2 kilometres, consideration was given to providing a second eastbound lane. An assessment of commercial vehicle speeds using the Transportation Association of Canada's (TAC) vehicle performance curves (180 g/W) concluded that eastbound commercial vehicle speeds could reach as low as 35 km/h. Likewise, in the westbound direction on Five Mile Hill, the existing highway grade ascends at 8%, and flattening this grade for the length of Five Mile Hill (1.8 kilometres) is not feasible due to terrain conditions. From TAC's vehicle performance curves, westbound commercial vehicle speeds could reach as low as 23 km/h. Accordingly, there was consensus to provide climbing lanes in each direction to a point close to the crest of the vertical curves, and to provide two lanes over the bridges at the top of Five Mile Hill.

2.2.2 Divided Median Rationale

As illustrated in the drawings in the appendices, the cross-section incorporates a 3.3m paved median and concrete median barrier (CMB) within the limits of the improvements, including in improved areas featuring only two lanes and three lanes. The 3.3m median complies with MOTI's 2007 Supplement to TAC (Section 630) and is consistent with the median width in other sections of the Kicking Horse Canyon, where providing median width that would allow sight distances to be achieved was not economically feasible. On Five Mile Hill, the existing cross-section improved in 2001 through 2003 does not include a median.

There was concern that providing a paved median with CMB on two-lane and three-lane sections of the highway was unconventional, and may restrict passage in single lane directions in the event of a vehicle incident (face of roadside barrier to face of median barrier on single lane sections would be a minimum of 7.2m wide). On the other hand, providing a paved separation between opposing lanes is known to improve safety and installation of a median barrier further still. At the mid-July meeting there was consensus to include the median and CMB for cost-estimating purposes, and the final decision could be deferred on whether or not the paved median with CMB would be included in the two-lane and three-lane sections.

2.2.3 Achieving a Four-Lane Cross Section

As indicated in section 2.1, three of the five alternatives considered as part of this assessment include partial completion of four laning through the Canyon.

Alt.	Sta. (approx.)	Sta. (approx.)	Scope	Project Cost (not incl past costs)
Z9A	904+171	907+940	Construct 2.6 kms of four lanes, 0.9 kms of two lanes then 0.3 kms of three lanes; divided highway with CMB employing 100 km/h geometry; five bridges, retaining walls; attenuator mesh and snow avalanche / debris flow stopping walls	[redacted]
Z9B	904+171	907+940	Construct 2.9kms of three lanes and 0.9 kms of two lanes; divided highway with CMB employing 100 km/h geometry; five bridges, retaining walls; attenuator mesh and snow avalanche / debris flow stopping walls	[redacted]
Z9C	904+171	907+940	Construct 2.6 kms of four lanes, 0.9 kms of two lanes then 0.3 kms of three lanes; divided highway with CMB employing 80 km/h geometry; six bridges, retaining walls; attenuator mesh and snow avalanche / debris flow stopping walls	[redacted]

In order to increase the length of four-laning and to develop alternatives Z9A-D and Z9C-E, the following changes were required to alternatives Z9A and Z9C, respectively:

- control line realignment and profile adjustment;
- revisions to and addition of walls;
- widening and lengthening of bridges; and
- increase in quantities due to width and alignment of roadway.

Alt.	Sta. (approx.)	Sta. (approx.)	Scope	Project Cost
Z9A-D	904+171	908+959	Construct 4.8 kms of four lanes, divided highway with CMB employing 100 km/h geometry; five bridges, retaining walls; attenuator mesh and snow avalanche / debris flow stopping walls	[redacted]
Z9C-E	904+171	908+959	Construct 4.8 kms of four lanes, divided highway with CMB employing 80 km/h geometry; seven bridges, retaining walls; attenuator mesh and snow avalanche / debris flow stopping walls	[redacted]

Due to the topography at the top of Five Mile Hill, at Bus Corner, the cost of structures increases significantly when adding two lanes, however there are potential savings when considering the effect of alignment and cross section should a four-lane section be adopted initially. By providing alignments that do not have to accommodate both an interim two-lane roadway and future four-lane roadway (and traffic staging between), the width of structures can be minimized. Of note, in the area of Bus Corner, slight horizontal and vertical alignment shifts can significantly affect the scope of required retaining walls and bridges. Future design work and collaboration between roadway, structural and geotechnical design teams may be able to optimize structural requirements. Such future work must also consider the potential effects on constructability and traffic accommodation.

2.2.4 Natural Hazards and Mitigation

Eliminating the Z9 twin-tunnels and the hazard protection sheds from the design alternatives required additional rockfall and snow avalanche mitigation measures for all alternatives. However, design return periods in these alternatives were held consistent with return periods adopted in design for previous (built) improvements to the TCH through the Canyon. Incorporating mitigation measures to a standard less than those that feature in preliminary design option Z9 would require that MOTI continue to monitor rockfall and snow-avalanche activity in the Canyon and, in years of significant snowfall, MOTI may be required to conduct active snow-avalanche control.

2.2.4.1 Rockfall and Mitigation

Appendix 3 includes a memorandum that discusses significant natural hazards within the assessment area and what forms of mitigation were incorporated into preliminary design option Z9. In order to reduce the estimated capital cost the Z9 tunnels and hazard protection sheds were replaced with other protection systems. The memo describes the systems (high-energy rockfall attenuation mesh, over-widened ditches and catchment benches) that were incorporated into alternatives Z9A through Z9C-E, including associated alignment changes. While these systems will provide significant improvements to safety and reliability relative to the existing condition, they will be less reliable than the sheds and tunnels incorporated into preliminary design alignment Z9.

2.2.4.2 Snow-Avalanche and Mitigation

The memorandum in Appendix 4 briefly speaks to how the effects of snow-avalanche are mitigated in the development of the design alternatives. It also presents details of the hazards associated with each of the snow avalanche paths that could affect the highway, and further discusses mitigation alternatives.

In the case of the preliminary design option Z9, there is a high probability that avalanche and rockfall events would not affect the highway, and that related avalanche control costs would be minimal. Avalanche encroachment into the highway at the sheds would not occur. In the Z9A through Z9C-E alternatives the avalanche design will meet the criteria for avalanche mitigation used elsewhere on the project.

3. ROAD SAFETY

Upon completing the geometric and cross-section details for each of the alternatives, Dr. Paul de Leur, P.Eng. completed a safety modeling exercise to estimate the expected safety performance associated with each. This safety modeling allowed for the explicit assessment of many design features, allowing for road safety to be quantified in terms of the expected number of collisions based on an understanding of how each design feature would affect safety. The primary differences between the five alternatives were related to differences in the laning (i.e., the extent of number of lanes provided) and the alignment or design speed (i.e., 100 km/h design speed versus 80 km/h design speed).

Of the five alternatives evaluated, Z9A-D provided the best safety performance (i.e., the least number of expected collisions) due to its 100km/h design speed and its four-lane cross-section for the length of the design section. The next best design alternative from a safety perspective was Z9A. Although this alternative does include two- and three-lane sections for one-third of its length, there are approximately 2.5 kms of four-lane cross-section, and the alignment is designed to 100km/h. This higher design speed causes a higher level of design consistency, which is evaluated in the safety model. Ranked third, the safety performance associated with Z9C-E is due to its four-lane cross-section for the length of the design section, but the level of safety for this 80 km/h alignment is less than Z9A-D because of its lower design speed. Ranked fourth is Z9B, which provides a three-lane cross-section over most of the corridor and provides a 100 km/h design speed. The least desirable alternative from a safety perspective is Z9C, which provides a four-lane cross-section over two-thirds of its length but features an 80 km/h design speed, affecting the level of design consistency and safety.

4. FUTURE DESIGN OPPORTUNITIES

The work in this current assessment was carried out to a conceptual design level given the limited time available. The cost estimates include [redacted] and [redacted] for the level of design and uncertainties and risks associated with it. With the benefit of additional time for engineering, refinements and enhancements to the design could be made to reduce the contingency and project risks as well as identify other project improvements including ways of lowering operational and maintenance costs through modest capital costs.

Such opportunities include:

- shortening bridge lengths by considering alternative retaining wall designs that would increase / maximize their height;
- replacing sections of bridge with combination retained-earth / cantilever structures;
- focused rockfall analysis to minimize rockfall catchment ditches;
- optimize rockfall / snow-avalanche mitigation design through combination of rock-containment structures and narrower ditches; and
- additional geotechnical drilling and site investigation at new bridge and wall locations to reduce geotechnical risks.

5. CANADIAN PACIFIC RAILWAY

Throughout the term of the Kicking Horse Canyon Project, MOTI and the OE Team have maintained communication with CP Rail and have shared information. This current assessment has made an allowance in each of the five cost estimates of [redacted] for provision of track personnel (to monitor overhead activity during construction), a limited amount of rockfall fencing and other mitigation that may be required.

Prior to final design of the Phase 4 improvements, MOTI and CP Rail should agree to operations and maintenance responsibilities, particularly as it relates to rockfall and snow-avalanche monitoring, mitigation and cleanup.

6. DESIGN AND CONSTRUCTION DELIVERY

6.1 PROCUREMENT AND PACKAGING

Improvements to date on the Kicking Horse Canyon Project have been contracted under multiple delivery scenarios:

- Design-Bid-Build (DBB): Phase 1, Phase 3 East, Intelligent Transportation Systems improvements, Golden Bike Path, Golden Hill 4th Lane Paving and Drainage, Golden Hill Landscaping and Revegetation and Phase 3 West (4KM Wall and Approaches)
- Design-Build (DB): Phase 3 West (Golden Hill to West Portal)
- Design-Build-Finance-Operate (DBFO): Phase 2
- Day Labour: Golden Hill Fourth Lane Grading

For this current assessment, conceptual designs and cost estimates were prepared assuming a design-bid-build scenario that features a twenty-one month design schedule (including procurement of design services and geotechnical testing and investigations) followed by a four year (2016 through 2019) tender and construction schedule. Construction would be let under a single construction contract.

It is expected that for this project to proceed federal funding will be needed in partnership with provincial funding. Current federal funding guidelines call for projects in excess of $100 million to undergo screening to assess suitability for P3 procurement. This process will need to be undertaken early on in the delivery of this project.

There are a number of considerations associated with different delivery methods:

Benefits of DBB

- During design process, MOTI can have control over aspects that may influence operation and maintenance costs.
- MOTI has more control over project risks during the design process.
- MOTI has more control proceeding with work in a manner that suits its constraints.

- MOTI has more control over the project scope.
- Opportunity to have more construction contractors bidding on the work.

Challenges of DBB

- There is less opportunity for innovation by the contractor although Value Engineering can be conducted on the design, and standard Ministry contracts do allow for VE proposals.
- Schedule may be a little longer than a DB delivery.
- MOTI assumes more scope risk.
- MOTI must organize more resources, including project management, design and field services than under a DB delivery.

Benefits of DB

- With concurrent design and construction, it may be possible to advance Project completion schedule by one year.
- DB contractors have a better opportunity to present innovations to the design.
- DB contractors would be responsible for organizing most of the resources with MOTI providing oversight, management and quality surveillance of the DB Agreement.
- DB contractor would assume most of the scope risk.

Challenges of DB

- Significant geotechnical engineering and structural engineering would be required by the proponents as they prepare their proposals. MOTI would have to consider conducting geotechnical investigations and some additional design work in order to achieve better pricing from proponents as part of procurement. Without additional work DB proponents may price in a high level of risk.
- MOTI does not have as much control over design and construction that can have an effect on Operations, Maintenance and Rehabilitation (OM&R) requirements for the new highway facility.
- MOTI has less control over project risks during the design process.
- MOTI has less control proceeding with work in a manner that suits its constraints.
- MOTI has less control over the project scope.

Benefits of a PPP

- A new Concessionaire would assume almost all project risks and be responsible for the OM&R on the new asset. With concurrent design and construction, it may be possible to advance Project completion schedule by one year.
- Concessionaire has a better opportunity to present innovations to the design.
- Concessionaire would be responsible for organizing most of the resources with MOTI providing management and quality surveillance of the new Concession Agreement.
- The OM&R of the new asset would be competitively bid.

Challenges of a PPP

- The existing Concession Agreement would need to be terminated and the Province would incur break costs.

- Significant geotechnical engineering and structural engineering would be required by the proponents as they prepare their proposals. MOTI would have to consider conducting geotechnical investigations and some additional design work in order to achieve better pricing from proponents as part of procurement. Without additional work DB proponents may price in a high level of risk.
- MOTI does not have as much control over design and construction.
- MOTI has less control over project risks during the design process.
- MOTI has less control proceeding with work in a manner that suits its constraints.
- MOTI has less control over the project scope.

Delivery of the project by DBB would open the opportunity to deliver the project with more than one construction contract. Construction contracts could be divided into separate grading and bridge contracts or contracts separated by location of work. While this has not been explored in detail with the time provided there are some possible benefits to doing this, but there are challenges.

A single contract of this size would likely be beyond the capacity of local British Columbia highway construction contractors who would need to meet the necessary bonding and insurance requirements. If the project were broken up into more than one contract this would provide more local British Columbia firms the opportunity to bid on the work and may achieve better pricing with less overheads and more competition. In addition the Ministry would be better able to control the scope and schedule of the project to match funding availability.

Challenges in delivering the project under more than one construction contract include traffic management, costs of temporary works for lane transitions, site safety responsibility and require MOTI administration and field services resources. Multiple contracts may expose the province to risks associated with the effect of delays of one contractor on other contractors. Further, delivering the project under more than one construction contract may require additional construction time and associated escalation costs.

Similarly, constructing anyone of alternatives Z9A, Z9B or Z9C with the view to deferring four-lane improvements to some time in the future would introduce incremental costs greater than simply the difference between, say, Z9A and Z9A-D or Z9C and Z9C-E. These incremental costs have not been quantified, but future construction of unfinished improvements could result in incrementally higher costs associated with escalation, smaller quantities, traffic management, 'sliver' cuts and fills, additional structural elements and geotechnical hazard mitigation.

6.2 CONSTRUCTABILITY

The construction for this project is extremely challenging for this stretch of highway. For this exercise the Owner's Engineer team included construction advisors who were able to review the alignment alternatives presented, scope of work, project schedule and the cost estimates produced as part of this exercise, and provide the team with their input. Previous work on the Z9 alignment included a constructability review by members of the construction industry.

6.2.1 Traffic Management

Cost estimates developed as part of this assessment all assume that construction would take place during normal operations of the highway with limited highway closures, consistent with previously completed sections of the TCH through the Kicking Horse Canyon. Generally, these highway closures (outside of long weekend periods) are:

- random minor interruption (not more than 5 minute stoppage);
- short duration day closures (30 minutes or less);
- short duration evening closures (60 minutes or less from 1900 hrs to 2000 hrs); and
- longer duration closures (3 hours from 2200 hrs to 0600 hrs).

The 2007 Kicking Horse Canyon Project Constructability Workshop recommended consideration be given to closing the TCH through the Canyon making allowances only for emergency services, CP Rail and weekday school bus service between Golden and Field. Under this scenario, public traffic would be detoured through Radium to Castle Junction on Highway 1, 25 kilometres east of Lake Louise. Closing the highway through the Kicking Horse Canyon during this time is expected to bring with it significant construction cost reductions and schedule efficiencies, although these have yet to be quantified. These may be offset, although to what degree is unknown, by costs required to improve Highway 93 from Castle Junction to Radium and Highway 95 south of Golden. The Ministry would need to consult with affected parties, including but not limited to, Parks Canada, Town of Radium and local businesses before pursuing this.

6.2.2 CP Rail

The 2007 Kicking Horse Canyon Project Constructability Workshop recommended that MOTI confirm with CP Rail mitigation requirements including the possibility of incorporating temporary and/or permanent structures upslope of the railway tracks in risky locations during construction prior to tendering the construction work to provide contractors a basis for their bids.

6.2.3 Design Requirements

The 2007 Kicking Horse Canyon Project Constructability Workshop recommended allowance of MSE walls up to 15 metres in height (up from 12 metres) and considering reducing the design speed (which was done in this exercise).

6.2.4 Utilities

There is an existing overhead small voltage, three phase power and communication line in the corridor that provides the only service to the Town of Field. It was recommended that early in the design process MOTI should engage BC Hydro to review the alignment and confirm a pole relocation strategy or portions where BC Hydro may wish to go underground with their utility.

6.2.5 Product Delivery

The 2007 Kicking Horse Canyon Project Constructability Workshop recommended that in the event the project was to go by a P3 or Design-Build delivery model proponents should be allowed flexibility in selecting the final alignment. Another recommendation was to allow the industry enough time to prepare bids and tenders in this challenging project.

Additional recent recommendations by the Owner's Engineer team include providing advance notification of the project through industry organizations such as APEGBC, CEBC, BC Road Builders and the BC Construction Association to gather industry interest and allow for industry to establish resources and teams for the work.

Other considerations are provided in Section 6.1 in this memorandum.

6.3 PROJECT RISKS

Previous work on the Z9 alignment included development of a risk register. Risks were divided into three categories. The risk categories were Management, External and Technical. Each risk was provided rankings for impacts to costs, schedule, scope and quality. The likelihood of the risk occurrence was also estimated. Contingency estimates were prepared and mitigation strategies developed and risk owners identified. While many of the risks remain the same for the new alternatives developed it is recommended the risk register be updated should the project proceed.

The risks included the following:

6.3.1 Management Risks

[redacted]

6.3.2 External Risks

[redacted]

6.3.3 Technical Risks

[redacted]

7. CONCLUSIONS

Although a limited amount of time was made available to complete this exercise, this assessment has concluded that it is possible to make additional significant improvements to the TCH through the Kicking Horse Canyon Project for [redacted]. These improvements would result in a reduction in travel time, much improved reliability and safety benefits with a predicted 70% to 75% (approximate) reduction in the number of predicted collisions between 2020 and 2040. Putting a cap on the investment means that future improvements would still be necessary to completely four lane the TCH between Golden and Yoho National Park. All alternatives developed feature significant natural hazard mitigation improvement over the existing condition, but less so than in the preliminary design option Z9. After construction, on-going maintenance measures would be required for natural hazard mitigation works.

Z9A provides an additional 2.6 kilometres of four-lane divided highway to 100 km/h geometry for [redacted]. On some horizontal curves, achieved sight lines across the outside shoulder would be restricted to 80 km/h.

Z9B provides a two- and three-lane divided highway over 3.8 kms to 100 km/h geometry for [redacted] In spite of its lower capital cost, this alternative is the least favoured of the three given the narrower cross-section that would be realized.

Z9C allows an additional 2.6 kilometres of four-lane divided highway to 80 km/h geometry for [redacted] On the outside of a horizontal curve in one location, achieved sight lines would be restricted to an equivalent 60 km/h.

Z9A-D allows for complete four-laning of the highway to 100 km/h geometry for [redacted] On some horizontal curves, achieved sight lines across the outside shoulder would be restricted to 80 km/h.

Z9C-E allows for complete four-laning of the highway to 80 km/h geometry for [redacted]. On the outside of a horizontal curve in one location, achieved sight lines would be restricted to an equivalent 60 km/h.

The project team feels that the scope of options developed represents a comprehensive array of alternatives to improve the difficult Kicking Horse Canyon section. Each option will improve the safety and reliability in the corridor managing major risks of vehicle incidents, snow avalanche, debris flows and rock fall. Only two options, Z9A-D and Z9C-E provide a complete four lane connection between the Phase 3 West improvements and Yoho Bridge which provides corridor consistency meeting the provincial target to four lane the TransCanada Highway from Kamloops to the Alberta border. The variable cross section options Z9A and Z9C provide the opportunity to complete the four laning in the future, however the project team believes that the future cost to do so would be significantly higher than the incremental cost of fully completing the four laning under one project developed as options Z9A-D and Z9C-E.

The project team feels that option Z9A-D most closely meets the original scope of improvement and design criteria for corridor consistency although its estimated cost is above the target price of [redacted] Option Z9A offers an option within the target price but it does not achieve the four laning criteria for the entire Kicking Horse Canyon section.

Future design work would reduce risk and should be able to optimize structural options and inclusion of walls versus bridges. Cantilevered structures may also be possible. Many procurement alternatives are available, but the Project cost estimate could be sensitive to which method is selected. Delivery of the project by Design-Build would provide the greatest opportunity for innovation and earliest time for construction.

Appendix 1

Phase 4 Cost Assessment – Participants

Summer 2013

Murray Tekano	Project Director	BC MoT
Steve Sirrett	District Program Manager	BC MoT
Darcy Grykuliak, P.Eng.	Lead Engineer	KHCP OE Team
Alex Izett, P.Eng.	Design Manager	KHCP OE Team
Terry Coulter, P.Eng.	Geotechnical Manager	KHCP OE Team
Larry Louis, P.Eng.	Structural Manager	KHCP OE Team
Ernest Wolski, A.Sc.T.	Cost Estimator	KHCP OE Team
Egils Anderson, P.Eng.	Assistant Cost Estimator	KHCP OE Team
John Gregson	Construction Advisor	KHCP OE Team
Roy Buettner	Construction Advisor	KHCP OE Team
Steve Nevill, P.Eng.	Senior Roadway Design Engineer	Focus Corporation
Art Hibbs, C.Tech.	Senior Transportation Technologist	Focus Corporation
Wayne Jentsch	Construction Advisor	Focus Corporation
David Curr	Transportation Technologist	Focus Corporation

Summer 2013

Murray Tekano	Project Director	BC MoT
Steve Sirrett	District Program Manager	BC MoT
Darcy Grykuliak, P.Eng.	Lead Engineer	KHCP OE Team
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Terry Coulter, P.Eng.	Geotechnical Manager	KHCP OE Team
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Roy Buettner	Construction Advisor	KHCP OE Team
Steve Nevill, P.Eng.	Senior Roadway Design Engineer	Focus Corporation
Art Hibbs, C.Tech.	Senior Transportation Technologist	Focus Corporation
Wayne Jentsch	Construction Advisor	Focus Corporation
David Curr	Transportation Technologist	Focus Corporation

Appendix 2

Sketches of Assessment Alternatives – Z9A, Z9B, Z9C, Z9A-D and Z9C-E

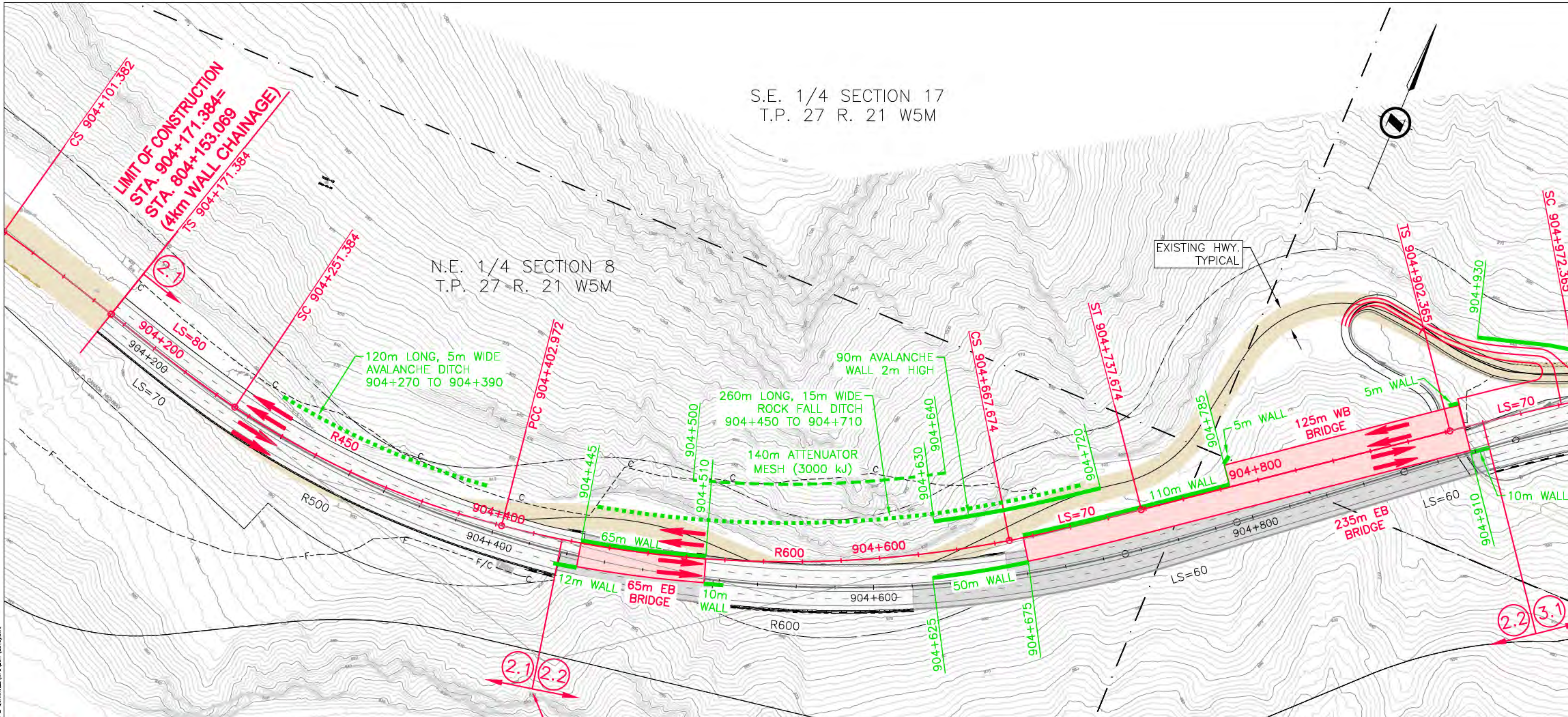
BRITISH COLUMBIA

Ministry of Transportation and Infrastructure

KICKING HORSE CANYON PROJECT
PHASE 4 - CONCEPT ESTIMATE DRAWINGS

ALIGNMENT OPTION Z9A (100 km/h)
4 LANE - 2 LANE - 3 LANE

SEPTEMBER 2013

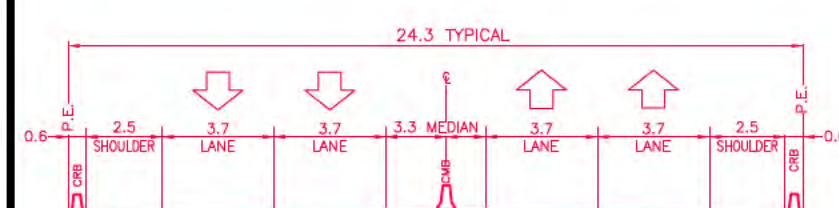


NOTES

1 DIVIDED HIGHWAY WEST OF STATION 907+655
UNDIVIDED HIGHWAY EAST OF STATION 907+655.

LEGEND

- PREVIOUS DESIGN CENTRELINE
- PROPOSED CENTRELINE
- PROPOSED AVALANCHE/ROCK DITCH
- PROPOSED ATTENUATOR MESH
- PROPOSED WALL
- PROPOSED LANE ARROW
- PROPOSED DESIGN BRIDGE
- PREVIOUS DESIGN ROAD
- PREVIOUS DESIGN BRIDGE
- EXISTING HIGHWAY



TYPICAL ROADWAY CROSS SECTION THIS SHEET

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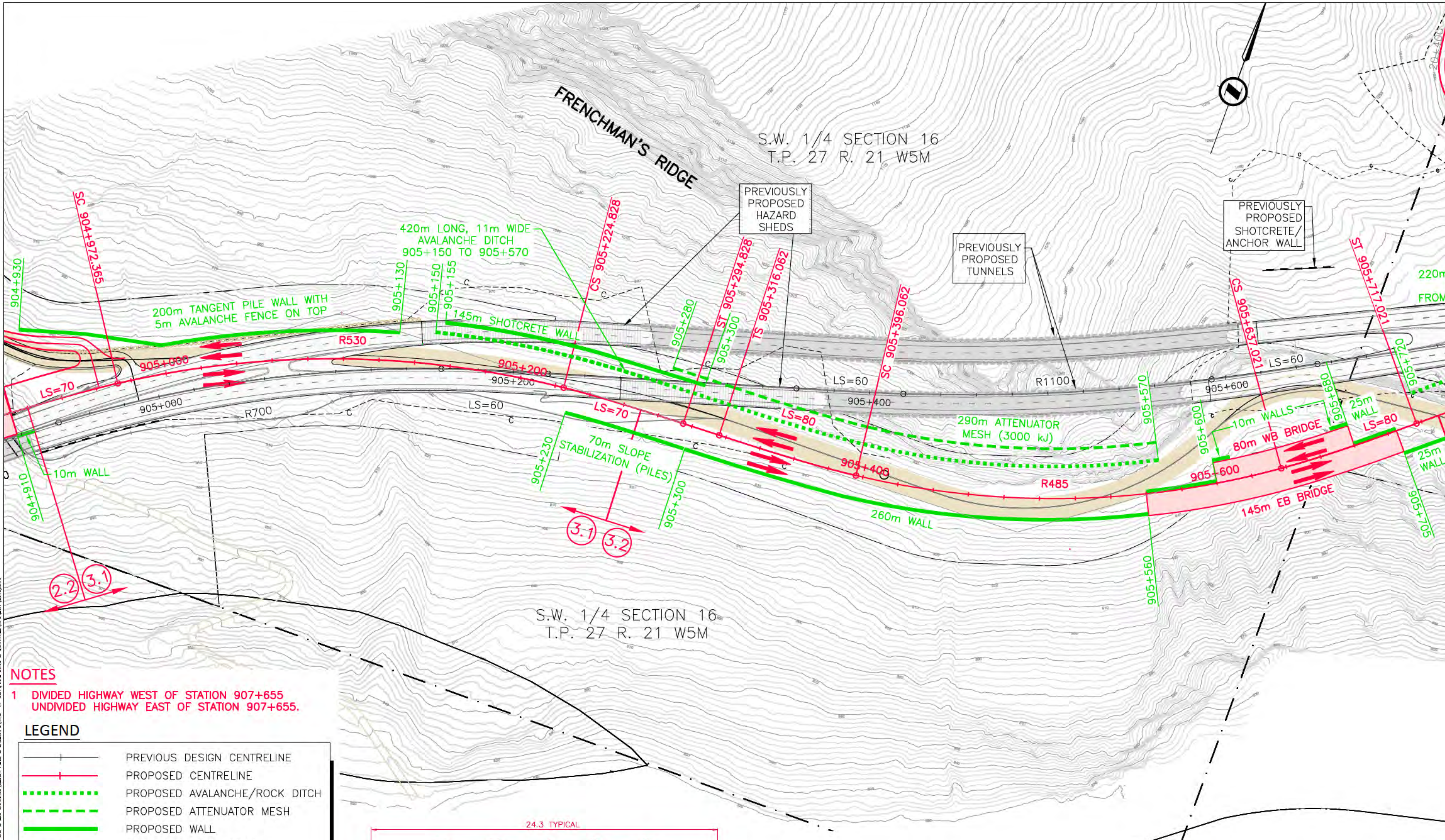
FILE NUMBER 061300134	DATE SEPT. 2013	SCALE 1:2000	SHEET NUMBER 1 OF 5



NOTES

1 DIVIDED HIGHWAY WEST OF STATION 907+655
UNDIVIDED HIGHWAY EAST OF STATION 907+655.

LEGEND

- PREVIOUS DESIGN CENTRELINE
- PROPOSED CENTRELINE
- PROPOSED AVALANCHE/ROCK DITCH
- PROPOSED ATTENUATOR MESH
- PROPOSED WALL
- PROPOSED LANE ARROW
- PROPOSED DESIGN BRIDGE
- PREVIOUS DESIGN ROAD
- PREVIOUS DESIGN BRIDGE
- EXISTING HIGHWAY

24.3 TYPICAL

0.6 | P.E. | 2.5 SHOULDER | 3.7 LANE | 3.7 LANE | 3.3 MEDIAN | 3.7 LANE | 3.7 LANE | 2.5 SHOULDER | P.E. | 0.6

TYPICAL ROADWAY CROSS SECTION THIS SHEET

0 20 1:2000 100m

Ministry of Transportation and Infrastructure	KICKING HORSE CANYON PROJECT PHASE 4 - CONCEPT ESTIMATE DRAWING		
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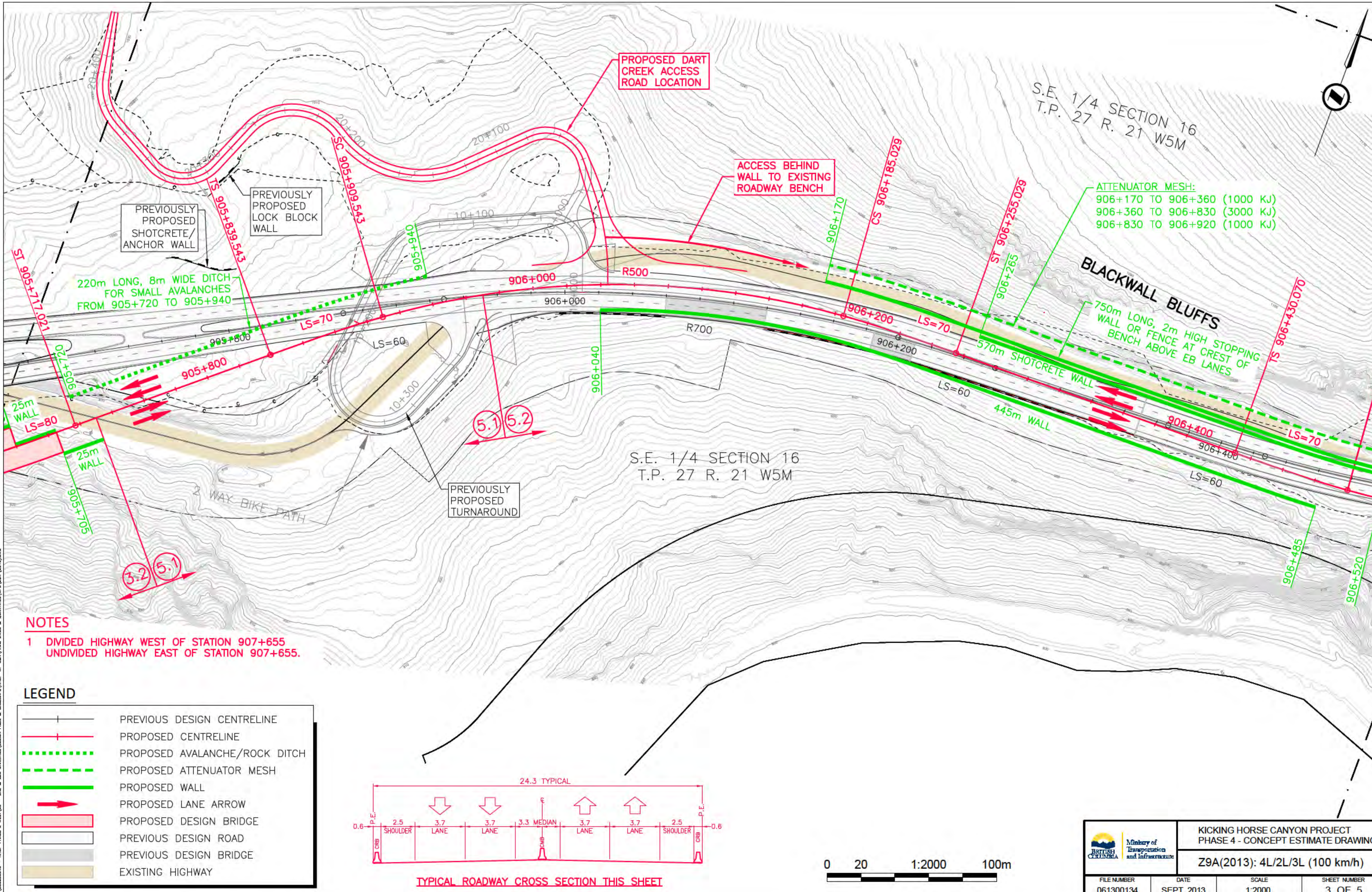

PROPOSED DART CREEK ACCESS ROAD LOCATION
S.E. 1/4 SECTION 16 T.P. 27 R. 21 W5M
ACCESS BEHIND WALL TO EXISTING ROADWAY BENCH
ATTENUATOR MESH:
906+170 TO 906+360 (1000 KJ)
906+360 TO 906+830 (3000 KJ)
906+830 TO 906+920 (1000 KJ)
BLACKWALL BLUFFS
PREVIOUSLY PROPOSED LOCK BLOCK WALL
PREVIOUSLY PROPOSED SHOTCRETE/ ANCHOR WALL
ST 905+717.021
TS 905+839.543
SC 905+909.543
CS 906+185.029
ST 906+255.029
TS 906+430.070
220m LONG, 8m WIDE DITCH FOR SMALL AVALANCHES FROM 905+720 TO 905+940
750m LONG, 2m HIGH STOPPING WALL OR FENCE AT CREST OF BENCH ABOVE EB LANES
570m SHOTCRETE WALL
445m WALL
25m WALL
25m WALL
R500
R700
LS=70
LS=60
LS=80
906+000
906+200
906+400
905+800
905+940
905+720
905+705
906+040
906+170
906+265
906+485
906+520
10+100
10+300
20+100
20+200
20+300
20+400
S.E. 1/4 SECTION 16 T.P. 27 R. 21 W5M
2 WAY BIKE PATH
PREVIOUSLY PROPOSED TURNAROUND
3.2
5.1
5.2
NOTES
1 DIVIDED HIGHWAY WEST OF STATION 907+655 UNDIVIDED HIGHWAY EAST OF STATION 907+655.
LEGEND
PREVIOUS DESIGN CENTRELINE
PROPOSED CENTRELINE
PROPOSED AVALANCHE/ROCK DITCH
PROPOSED ATTENUATOR MESH
PROPOSED WALL
PROPOSED LANE ARROW
PROPOSED DESIGN BRIDGE
PREVIOUS DESIGN ROAD
PREVIOUS DESIGN BRIDGE
EXISTING HIGHWAY
24.3 TYPICAL
0.6
2.5 SHOULDER
3.7 LANE
3.7 LANE
3.3 MEDIAN
3.7 LANE
3.7 LANE
2.5 SHOULDER
0.6
TYPICAL ROADWAY CROSS SECTION THIS SHEET
0 20 1:2000 100m
KICKING HORSE CANYON PROJECT
PHASE 4 - CONCEPT ESTIMATE DRAWING
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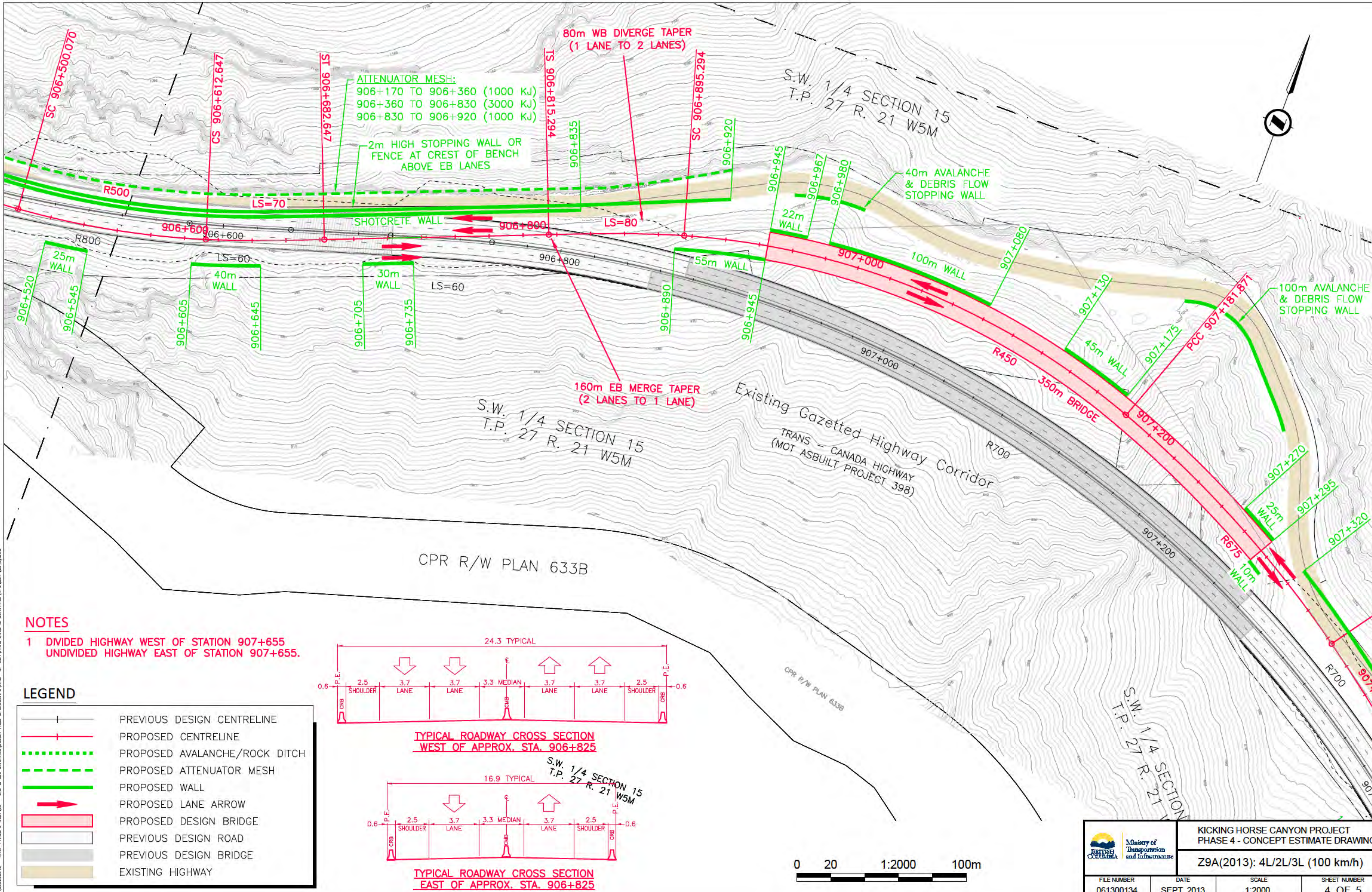
FILE NUMBER 061300134
DATE SEPT. 2013
SCALE 1:2000
SHEET NUMBER 3 OF 5



80m WB DIVERGE TAPER
(1 LANE TO 2 LANES)
SC 906+500.070
CS 906+612.647
ST 906+682.647
TS 906+815.294
SC 906+895.294
ATTENUATOR MESH:
906+170 TO 906+360 (1000 KJ)
906+360 TO 906+830 (3000 KJ)
906+830 TO 906+920 (1000 KJ)
2m HIGH STOPPING WALL OR FENCE AT CREST OF BENCH ABOVE EB LANES
S.W. 1/4 SECTION 15
T.P. 27 R. 21 W5M
40m AVALANCHE & DEBRIS FLOW STOPPING WALL
100m AVALANCHE & DEBRIS FLOW STOPPING WALL
R500
LS=70
SHOTCRETE WALL
906+800
LS=80
R800
906+600
LS=60
25m WALL
40m WALL
30m WALL
55m WALL
22m WALL
100m WALL
45m WALL
25m WALL
10m WALL
906+520
906+545
906+605
906+645
906+705
906+735
906+835
906+890
906+920
906+945
906+967
906+980
907+000
907+080
907+130
907+175
907+200
907+270
907+295
907+320
PCC 907+181.871
R450
350m BRIDGE
R675
R700
160m EB MERGE TAPER
(2 LANES TO 1 LANE)
Existing Gazetted Highway Corridor
TRANS - CANADA HIGHWAY
(MOT ASBUILT PROJECT 398)
CPR R/W PLAN 633B
NOTES
1 DIVIDED HIGHWAY WEST OF STATION 907+655
UNDIVIDED HIGHWAY EAST OF STATION 907+655.
LEGEND
PREVIOUS DESIGN CENTRELINE
PROPOSED CENTRELINE
PROPOSED AVALANCHE/ROCK DITCH
PROPOSED ATTENUATOR MESH
PROPOSED WALL
PROPOSED LANE ARROW
PROPOSED DESIGN BRIDGE
PREVIOUS DESIGN ROAD
PREVIOUS DESIGN BRIDGE
EXISTING HIGHWAY
24.3 TYPICAL
0.6 2.5 SHOULDER 3.7 LANE 3.7 LANE 3.3 MEDIAN 3.7 LANE 3.7 LANE 2.5 SHOULDER 0.6
TYPICAL ROADWAY CROSS SECTION
WEST OF APPROX. STA. 906+825
16.9 TYPICAL
0.6 2.5 SHOULDER 3.7 LANE 3.3 MEDIAN 3.7 LANE 2.5 SHOULDER 0.6
TYPICAL ROADWAY CROSS SECTION
EAST OF APPROX. STA. 906+825
0 20 1:2000 100m
British Columbia Ministry of Transportation and Infrastructure
KICKING HORSE CANYON PROJECT
PHASE 4 - CONCEPT ESTIMATE DRAWING
Z9A(2013): 4L/2L/3L (100 km/h)
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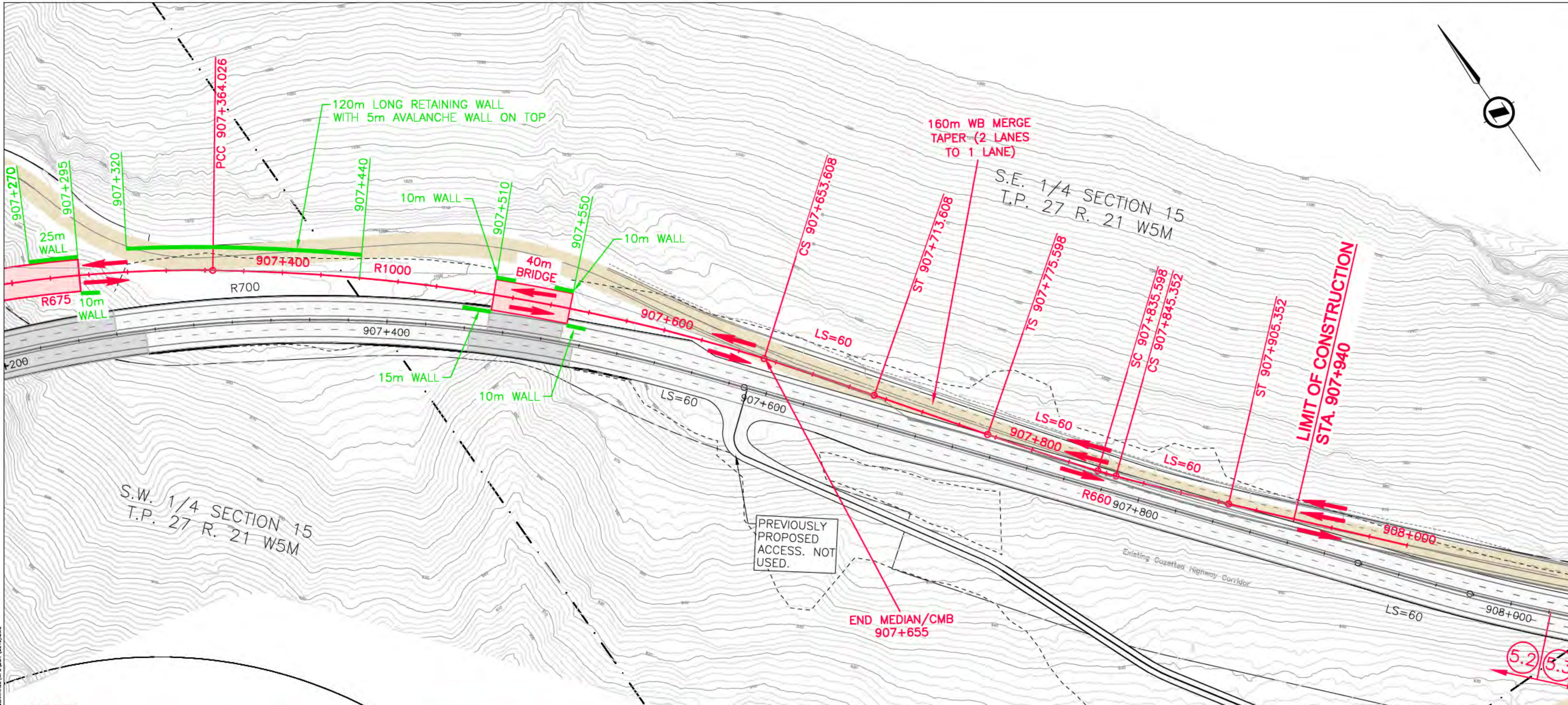
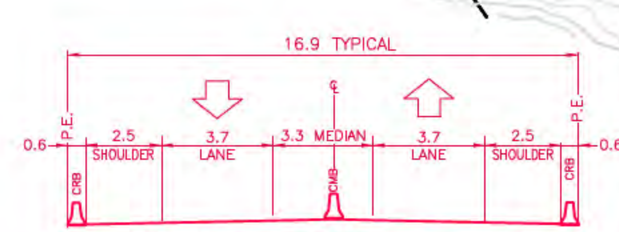


NOTES

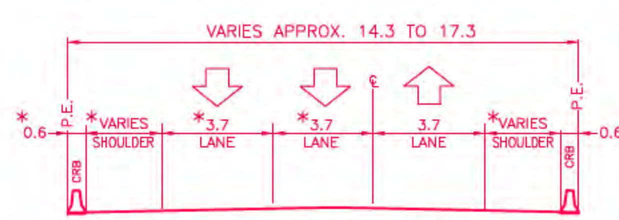
1 DIVIDED HIGHWAY WEST OF STATION 907+655
UNDIVIDED HIGHWAY EAST OF STATION 907+655.

LEGEND

	PREVIOUS DESIGN CENTRELINE
	PROPOSED CENTRELINE
	PROPOSED AVALANCHE/ROCK DITCH
	PROPOSED ATTENUATOR MESH
	PROPOSED WALL
	PROPOSED LANE ARROW
	PROPOSED DESIGN BRIDGE
	PREVIOUS DESIGN ROAD
	PREVIOUS DESIGN BRIDGE
	EXISTING HIGHWAY



TYPICAL ROADWAY CROSS SECTION
WEST OF APPROX. STA. 907+655



TYPICAL ROADWAY CROSS SECTION
EAST OF APPROX. STA. 907+655

* LANE WIDTHS VARY TO ACCOMMODATE WESTBOUND MERGE, SHOULDERS VARY TO TIE TO EXISTING

0 20 1:2000 100m

British Columbia — Ministry of Transportation and Infrastructure

KICKING HORSE CANYON PROJECT
PHASE 4 - CONCEPT ESTIMATE DRAWING

Z9A(2013): 4L/2L/3L (100 km/h)

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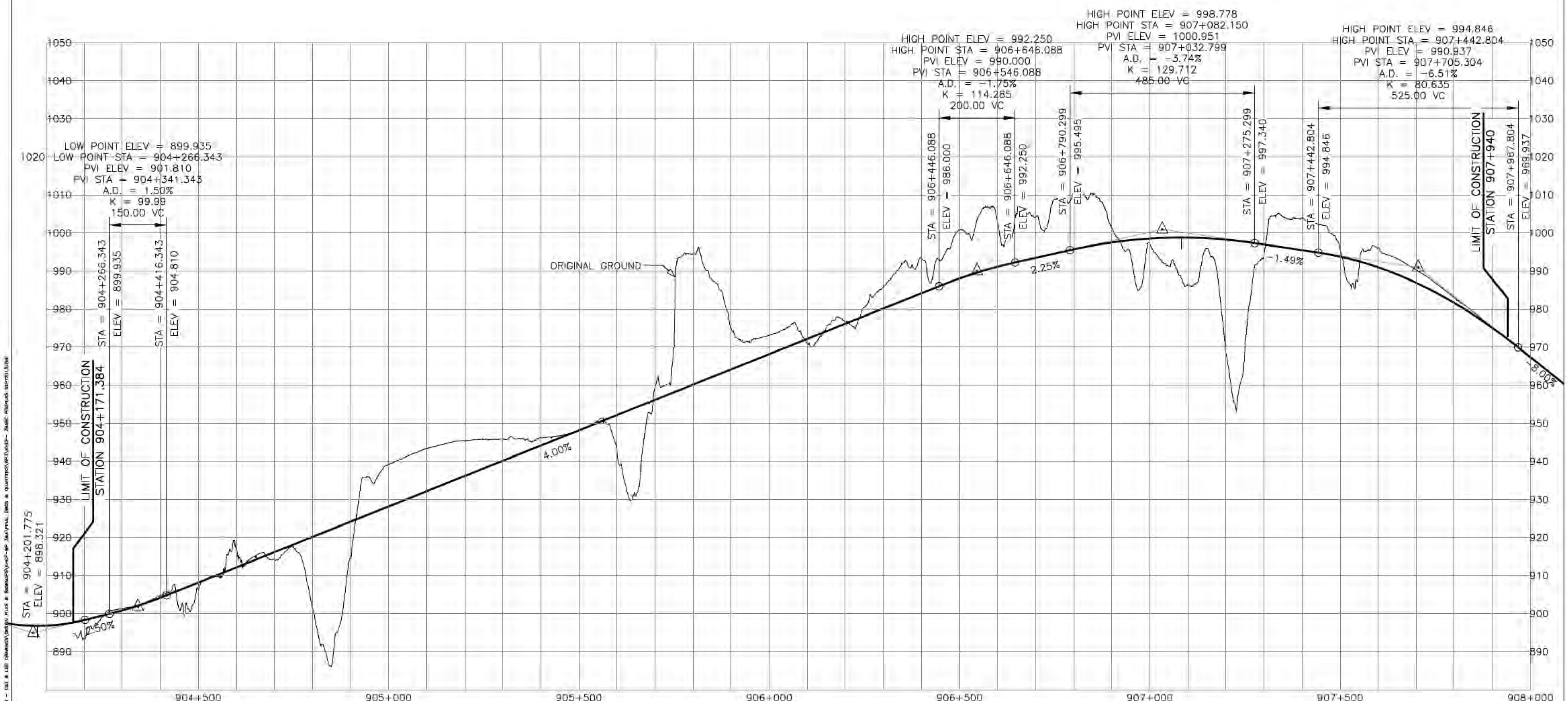


Ministry of Transportation and Infrastructure	KICKING HORSE CANYON PROJECT PHASE 4 - CONCEPT ESTIMATE DRAWING
	Z9A & Z9B PROFILE (100 km/h)

FILE NUMBER	DATE	SCALE	SHEET NUMBER
061300134	SEPT. 2013	1:10,000 (HORIZ.)	6

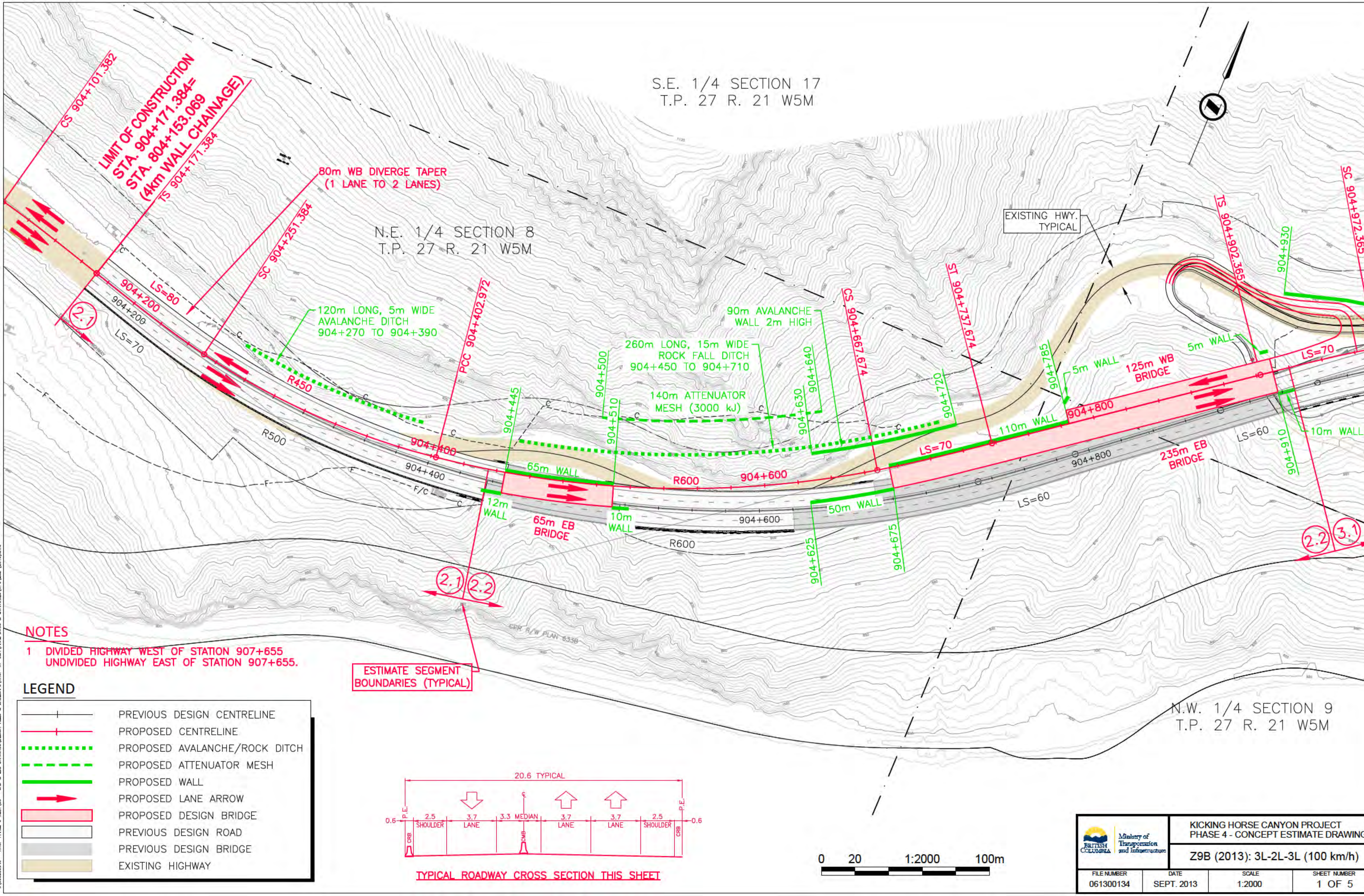
BRITISH COLUMBIA | Ministry of Transportation and Infrastructure

KICKING HORSE CANYON PROJECT
PHASE 4 - CONCEPT ESTIMATE DRAWINGS

ALIGNMENT OPTION Z9B (100 km/h)

3 LANE - 2 LANE - 3 LANE

SEPTEMBER 2013



S.E. 1/4 SECTION 17
T.P. 27 R. 21 W5M
N.E. 1/4 SECTION 8
T.P. 27 R. 21 W5M
N.W. 1/4 SECTION 9
T.P. 27 R. 21 W5M
CS 904+101.382
LIMIT OF CONSTRUCTION
STA. 904+171.384=
STA. 804+153.069
(4km WALL CHAINAGE)
TS 904+171.384
80m WB DIVERGE TAPER
(1 LANE TO 2 LANES)
SC 904+251.384
120m LONG, 5m WIDE
AVALANCHE DITCH
904+270 TO 904+390
PCC 904+402.972
260m LONG, 15m WIDE
ROCK FALL DITCH
904+450 TO 904+710
90m AVALANCHE
WALL 2m HIGH
140m ATTENUATOR
MESH (3000 kJ)
CS 904+667.674
ST 904+737.674
EXISTING HWY.
TYPICAL
TS 904+902.365
SC 904+972.365
904+930
904+785
904+720
904+640
904+630
904+510
904+500
904+445
904+625
904+675
904+910
5m WALL
5m WALL
125m WB
BRIDGE
110m WALL
10m WALL
65m WALL
12m
WALL
65m EB
BRIDGE
10m
WALL
50m WALL
235m EB
BRIDGE
LS=80
LS=70
LS=70
LS=70
LS=60
LS=60
R450
R500
R600
R600
904+200
904+400
904+600
904+800
F/C
CPR R/W PLAN 6330
2.1
2.2
3.1
ESTIMATE SEGMENT
BOUNDARIES (TYPICAL)
NOTES
1 DIVIDED HIGHWAY WEST OF STATION 907+655
UNDIVIDED HIGHWAY EAST OF STATION 907+655.
LEGEND
PREVIOUS DESIGN CENTRELINE
PROPOSED CENTRELINE
PROPOSED AVALANCHE/ROCK DITCH
PROPOSED ATTENUATOR MESH
PROPOSED WALL
PROPOSED LANE ARROW
PROPOSED DESIGN BRIDGE
PREVIOUS DESIGN ROAD
PREVIOUS DESIGN BRIDGE
EXISTING HIGHWAY
20.6 TYPICAL
P.E.
0.6
2.5 SHOULDER
3.7 LANE
3.7 LANE
3.3 MEDIAN
3.7 LANE
3.7 LANE
2.5 SHOULDER
0.6
CRB
CMB
TYPICAL ROADWAY CROSS SECTION THIS SHEET
0 20 1:2000 100m
BRITISH COLUMBIA
Ministry of Transportation and Infrastructure
KICKING HORSE CANYON PROJECT
PHASE 4 - CONCEPT ESTIMATE DRAWING
Z9B (2013): 3L-2L-3L (100 km/h)
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061300134
DATE
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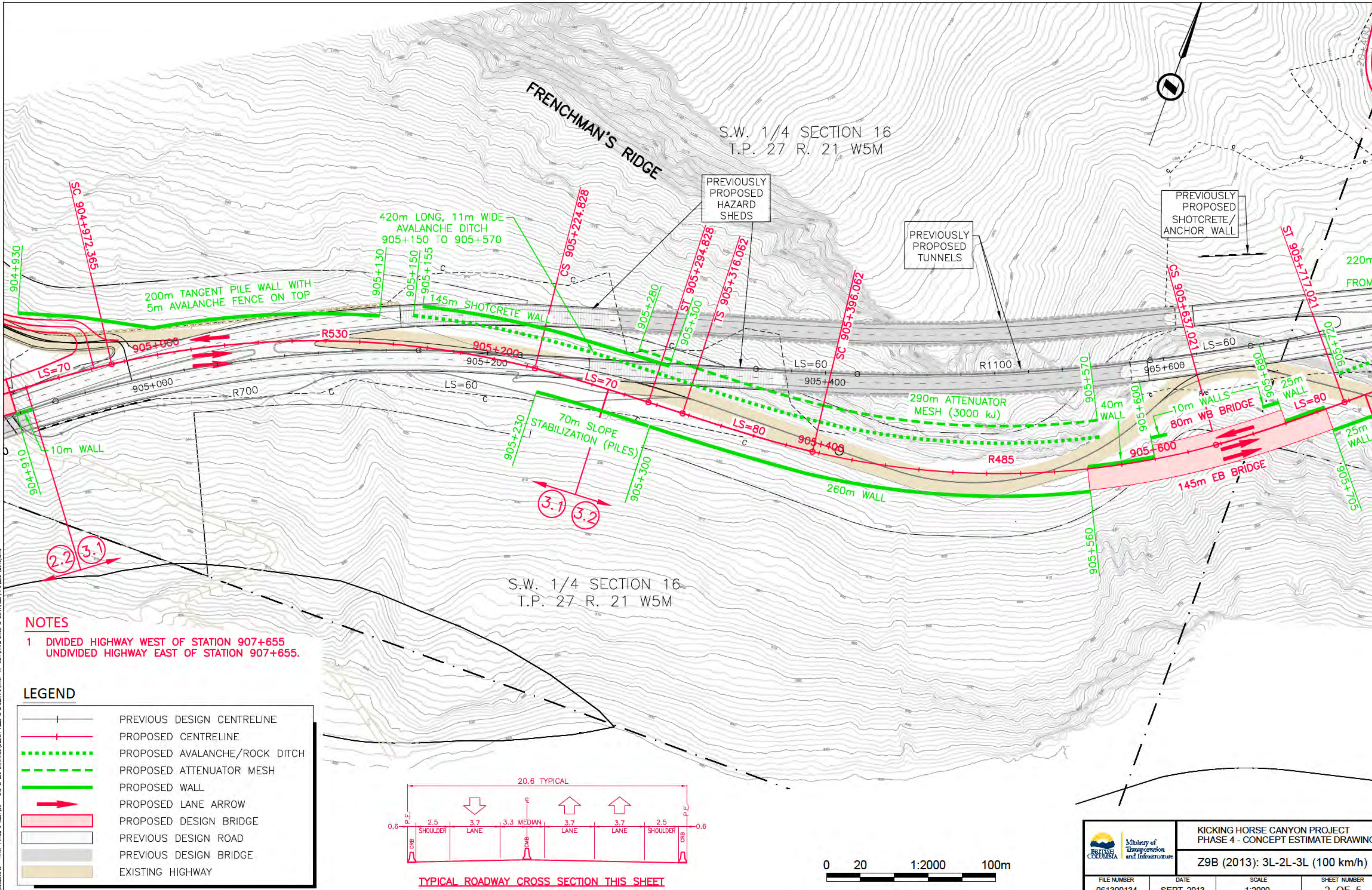

TYPICAL ROADWAY CROSS SECTION THIS SHEET

NOTES

1 DIVIDED HIGHWAY WEST OF STATION 907+655
UNDIVIDED HIGHWAY EAST OF STATION 907+655.

LEGEND

- PREVIOUS DESIGN CENTRELINE
- PROPOSED CENTRELINE
- PROPOSED AVALANCHE/ROCK DITCH
- PROPOSED ATTENUATOR MESH
- PROPOSED WALL
- PROPOSED LANE ARROW
- PROPOSED DESIGN BRIDGE
- PREVIOUS DESIGN ROAD
- PREVIOUS DESIGN BRIDGE
- EXISTING HIGHWAY

BRITISH COLUMBIA Ministry of Transportation and Infrastructure

KICKING HORSE CANYON PROJECT
PHASE 4 - CONCEPT ESTIMATE DRAWING

Z9B (2013): 3L-2L-3L (100 km/h)

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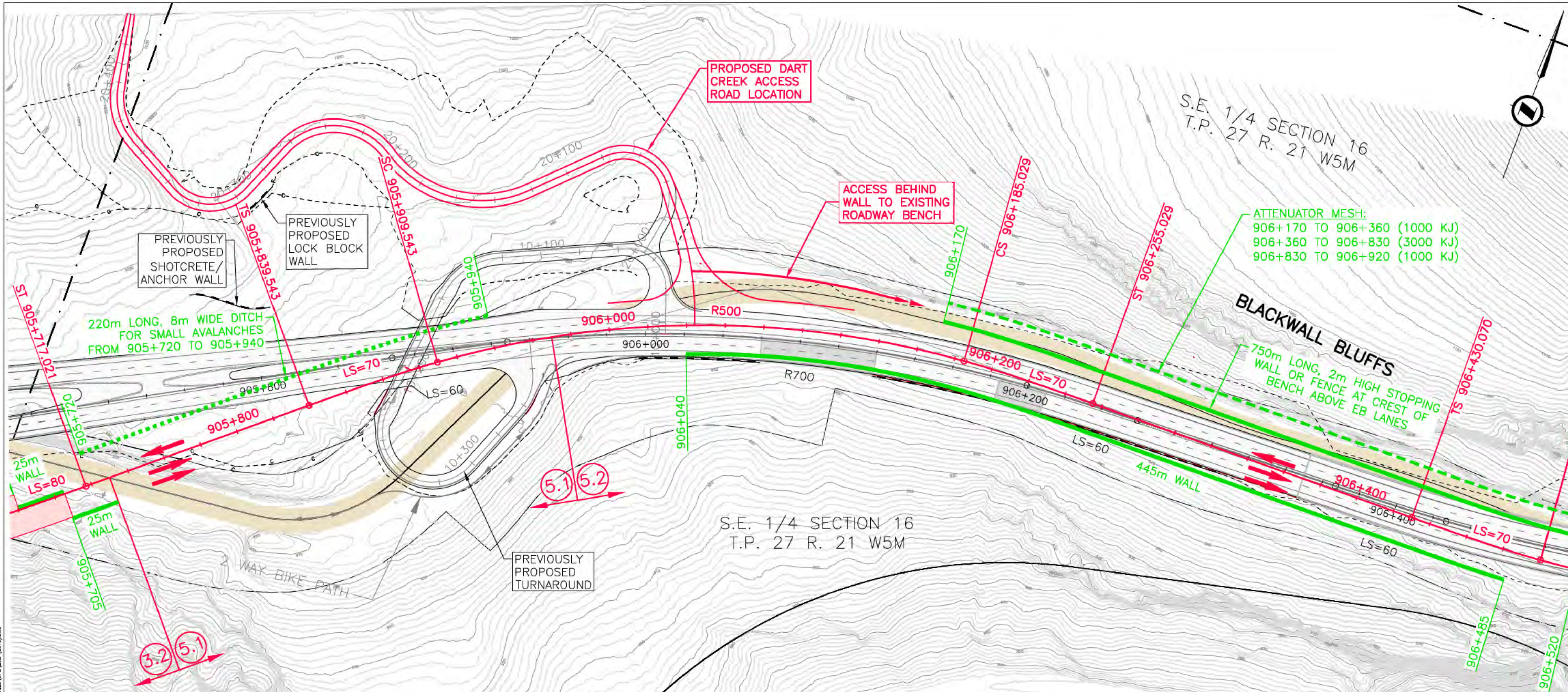
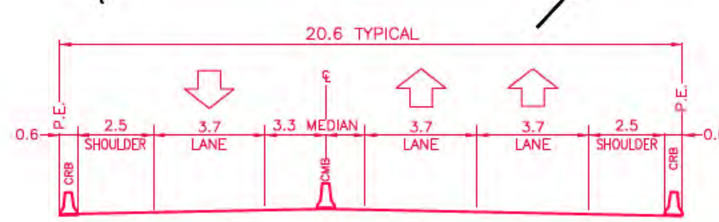


NOTES

1 DIVIDED HIGHWAY WEST OF STATION 907+655
UNDIVIDED HIGHWAY EAST OF STATION 907+655.

LEGEND

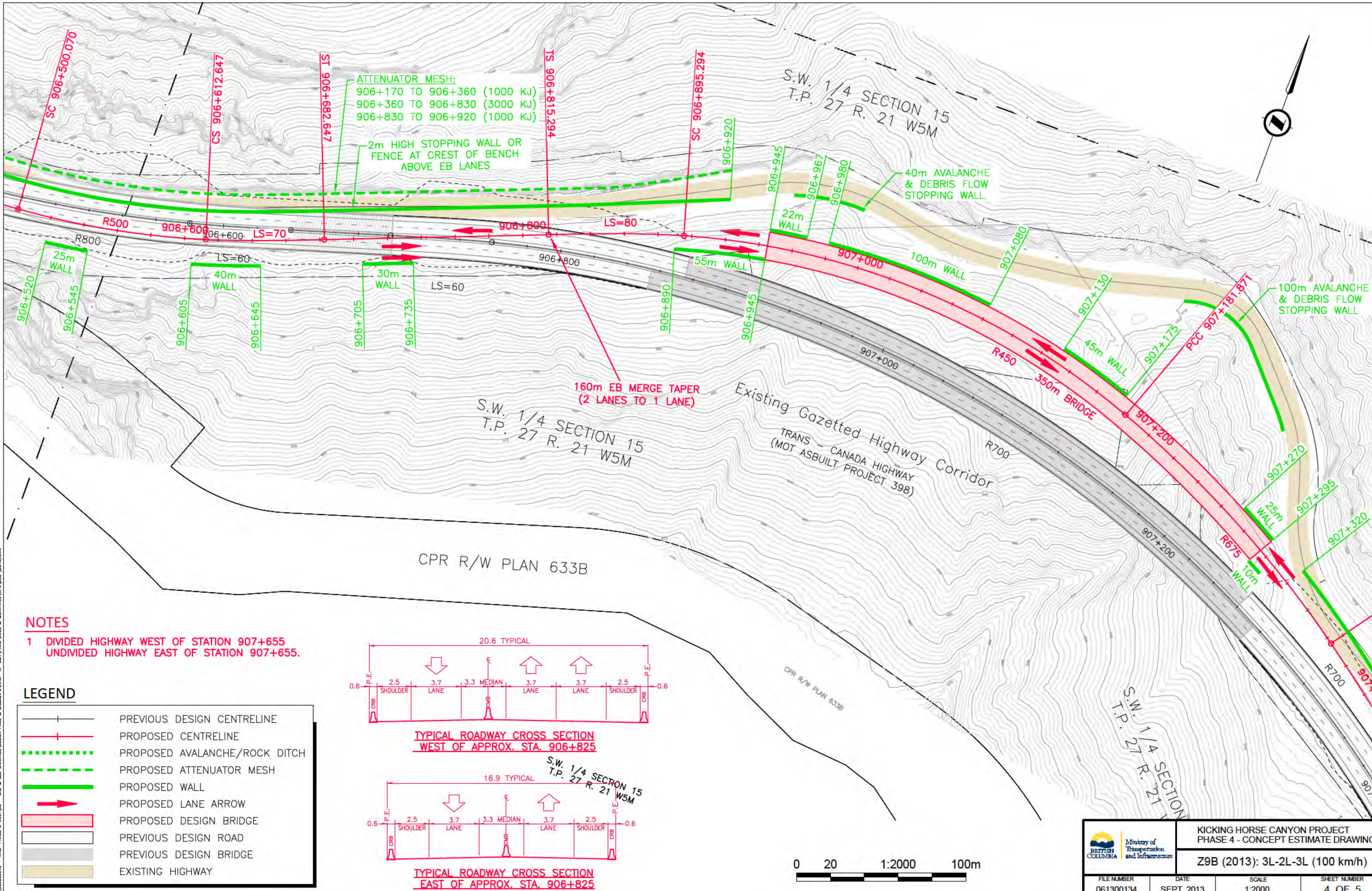
- PREVIOUS DESIGN CENTRELINE
- PROPOSED CENTRELINE
- PROPOSED AVALANCHE/ROCK DITCH
- PROPOSED ATTENUATOR MESH
- PROPOSED WALL
- PROPOSED LANE ARROW
- PROPOSED DESIGN BRIDGE
- PREVIOUS DESIGN ROAD
- PREVIOUS DESIGN BRIDGE
- EXISTING HIGHWAY



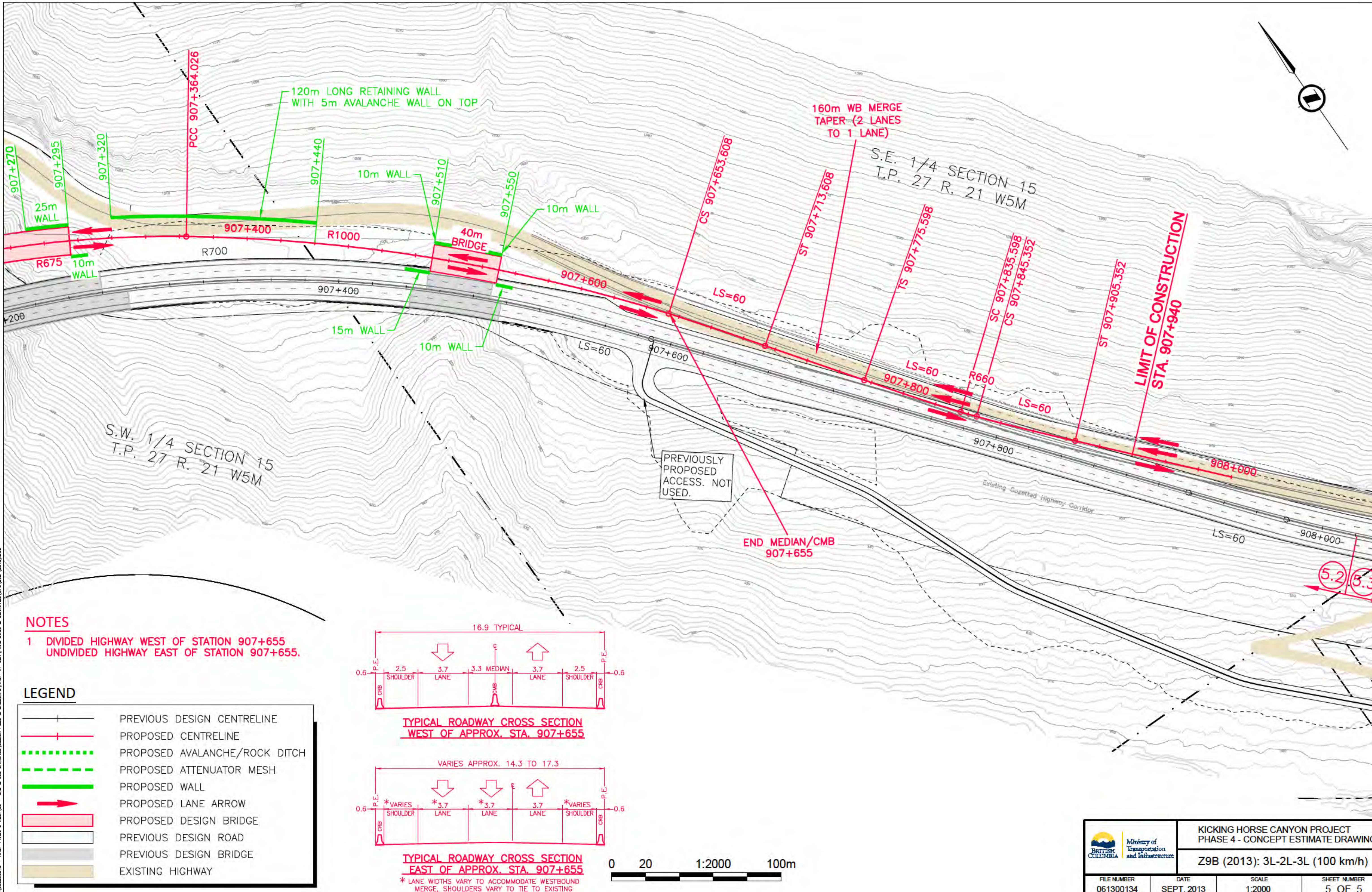
TYPICAL ROADWAY CROSS SECTION THIS SHEET

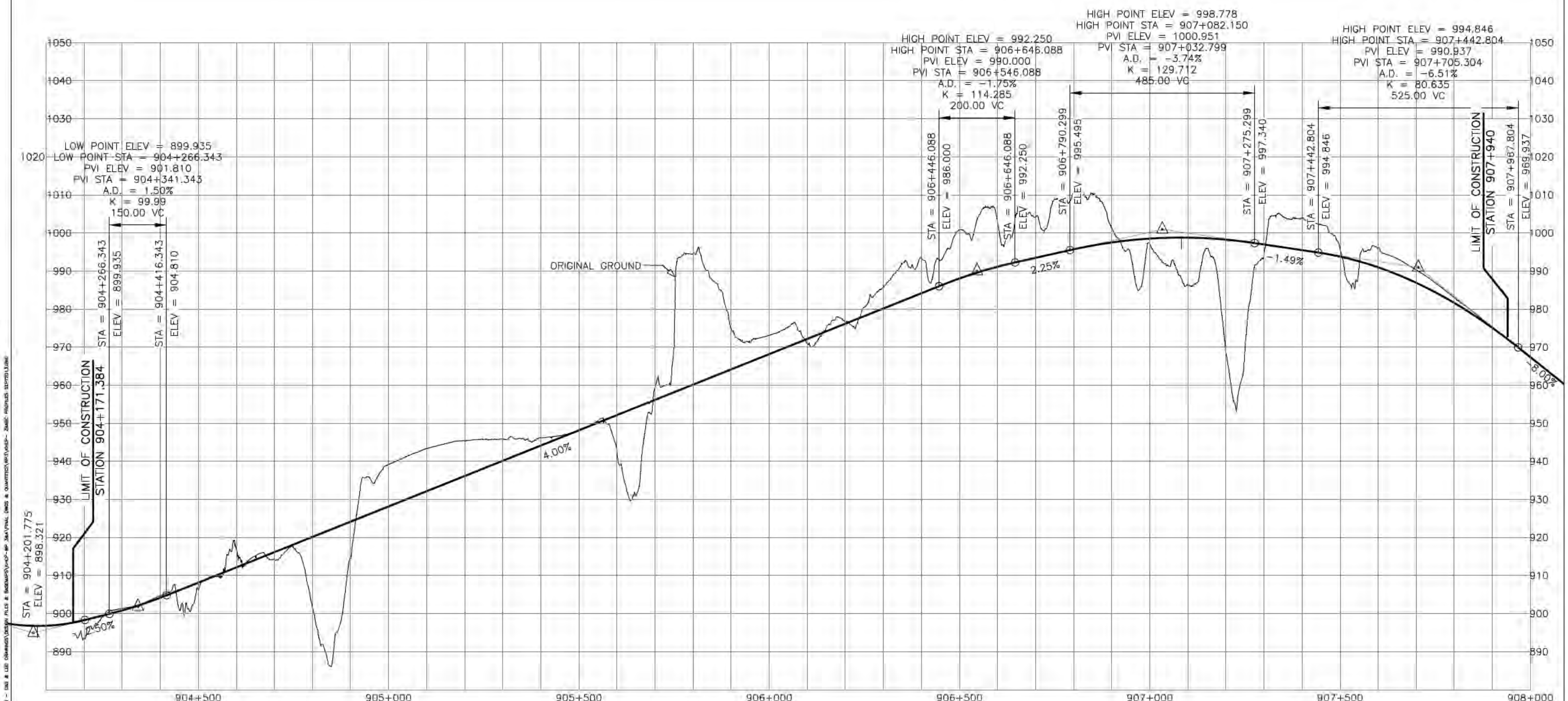
0 20 1:2000 100m

British Columbia Ministry of Transportation and Infrastructure	KICKING HORSE CANYON PROJECT PHASE 4 - CONCEPT ESTIMATE DRAWING		
	Z9B (2013): 3L-2L-3L (100 km/h)		
FILE NUMBER 061300134	DATE SEPT. 2013	SCALE 1:2000	SHEET NUMBER 3 OF 5



SC 906+500.070
CS 906+612.647
ST 906+682.647
TS 906+815.294
SC 906+895.294
ATTENUATOR MESH:
906+170 TO 906+360 (1000 KJ)
906+360 TO 906+830 (3000 KJ)
906+830 TO 906+920 (1000 KJ)
2m HIGH STOPPING WALL OR FENCE AT CREST OF BENCH ABOVE EB LANES
S.W. 1/4 SECTION 15 T.P. 27 R. 21 W5M
40m AVALANCHE & DEBRIS FLOW STOPPING WALL
100m AVALANCHE & DEBRIS FLOW STOPPING WALL
R500
R800
906+600
LS=70
LS=60
906+800
LS=80
25m WALL
40m WALL
30m WALL
55m WALL
22m WALL
100m WALL
45m WALL
25m WALL
10m WALL
906+520
906+545
906+605
906+645
906+705
906+735
906+890
906+920
906+945
906+967
906+980
907+000
907+080
907+130
907+175
PCC 907+181.871
907+200
907+270
907+295
907+320
907+400
R450
350m BRIDGE
R675
R700
160m EB MERGE TAPER (2 LANES TO 1 LANE)
Existing Gazetted Highway Corridor
TRANS - CANADA HIGHWAY (MOT ASBUILT PROJECT 398)
CPR R/W PLAN 633B
NOTES
1 DIVIDED HIGHWAY WEST OF STATION 907+655 UNDIVIDED HIGHWAY EAST OF STATION 907+655.
LEGEND
PREVIOUS DESIGN CENTRELINE
PROPOSED CENTRELINE
PROPOSED AVALANCHE/ROCK DITCH
PROPOSED ATTENUATOR MESH
PROPOSED WALL
PROPOSED LANE ARROW
PROPOSED DESIGN BRIDGE
PREVIOUS DESIGN ROAD
PREVIOUS DESIGN BRIDGE
EXISTING HIGHWAY
20.6 TYPICAL
0.6 2.5 SHOULDER 3.7 LANE 3.3 MEDIAN 3.7 LANE 3.7 LANE 2.5 SHOULDER 0.6
TYPICAL ROADWAY CROSS SECTION WEST OF APPROX. STA. 906+825
16.9 TYPICAL
0.6 2.5 SHOULDER 3.7 LANE 3.3 MEDIAN 3.7 LANE 2.5 SHOULDER 0.6
TYPICAL ROADWAY CROSS SECTION EAST OF APPROX. STA. 906+825
0 20 1:2000 100m
BRITISH COLUMBIA Ministry of Transportation and Infrastructure
KICKING HORSE CANYON PROJECT
PHASE 4 - CONCEPT ESTIMATE DRAWING
Z9B (2013): 3L-2L-3L (100 km/h)
FILE NUMBER 061300134
DATE SEPT. 2013
SCALE 1:2000
SHEET NUMBER 4 OF 5


120m LONG RETAINING WALL
WITH 5m AVALANCHE WALL ON TOP
PCC 907+364.026
907+270
907+295
907+320
907+440
25m WALL
10m WALL
907+510
907+550
10m WALL
40m BRIDGE
10m WALL
907+400
R1000
R675
R700
10m WALL
+200
907+400
15m WALL
10m WALL
907+600
160m WB MERGE
TAPER (2 LANES
TO 1 LANE)
S.E. 1/4 SECTION 15
T.P. 27 R. 21 W5M
CS 907+653.608
ST 907+713.608
TS 907+775.598
SC 907+835.598
CS 907+845.352
ST 907+905.352
LIMIT OF CONSTRUCTION
STA. 907+940
LS=60
LS=60
LS=60
LS=60
R660
907+600
907+800
907+800
908+000
908+000
LS=60
Existing Gazetted Highway Corridor
PREVIOUSLY
PROPOSED
ACCESS. NOT
USED.
END MEDIAN/CMB
907+655
S.W. 1/4 SECTION 15
T.P. 27 R. 21 W5M
5.2
5.3
NOTES
1 DIVIDED HIGHWAY WEST OF STATION 907+655
UNDIVIDED HIGHWAY EAST OF STATION 907+655.
LEGEND
PREVIOUS DESIGN CENTRELINE
PROPOSED CENTRELINE
PROPOSED AVALANCHE/ROCK DITCH
PROPOSED ATTENUATOR MESH
PROPOSED WALL
PROPOSED LANE ARROW
PROPOSED DESIGN BRIDGE
PREVIOUS DESIGN ROAD
PREVIOUS DESIGN BRIDGE
EXISTING HIGHWAY
16.9 TYPICAL
0.6 2.5 SHOULDER 3.7 LANE 3.3 MEDIAN 3.7 LANE 2.5 SHOULDER 0.6
P.E. CRB CMB CRB P.E.
TYPICAL ROADWAY CROSS SECTION
WEST OF APPROX. STA. 907+655
VARIES APPROX. 14.3 TO 17.3
0.6 *VARIES SHOULDER *3.7 LANE *3.7 LANE 3.7 LANE *VARIES SHOULDER 0.6
TYPICAL ROADWAY CROSS SECTION
EAST OF APPROX. STA. 907+655
* LANE WIDTHS VARY TO ACCOMMODATE WESTBOUND
MERGE, SHOULDERS VARY TO TIE TO EXISTING
0 20 1:2000 100m
BRITISH COLUMBIA Ministry of Transportation and Infrastructure
KICKING HORSE CANYON PROJECT
PHASE 4 - CONCEPT ESTIMATE DRAWING
Z9B (2013): 3L-2L-3L (100 km/h)
FILE NUMBER 061300134
DATE SEPT. 2013
SCALE 1:2000
SHEET NUMBER 5 OF 5



Ministry of Transportation and Infrastructure

KICKING HORSE CANYON PROJECT
PHASE 4 - CONCEPT ESTIMATE DRAWING

Z9A & Z9B PROFILE (100 km/h)

FILE NUMBER	DATE	SCALE	SHEET NUMBER
061300134	SEPT. 2013	1:10,000 (HORIZ.)	6

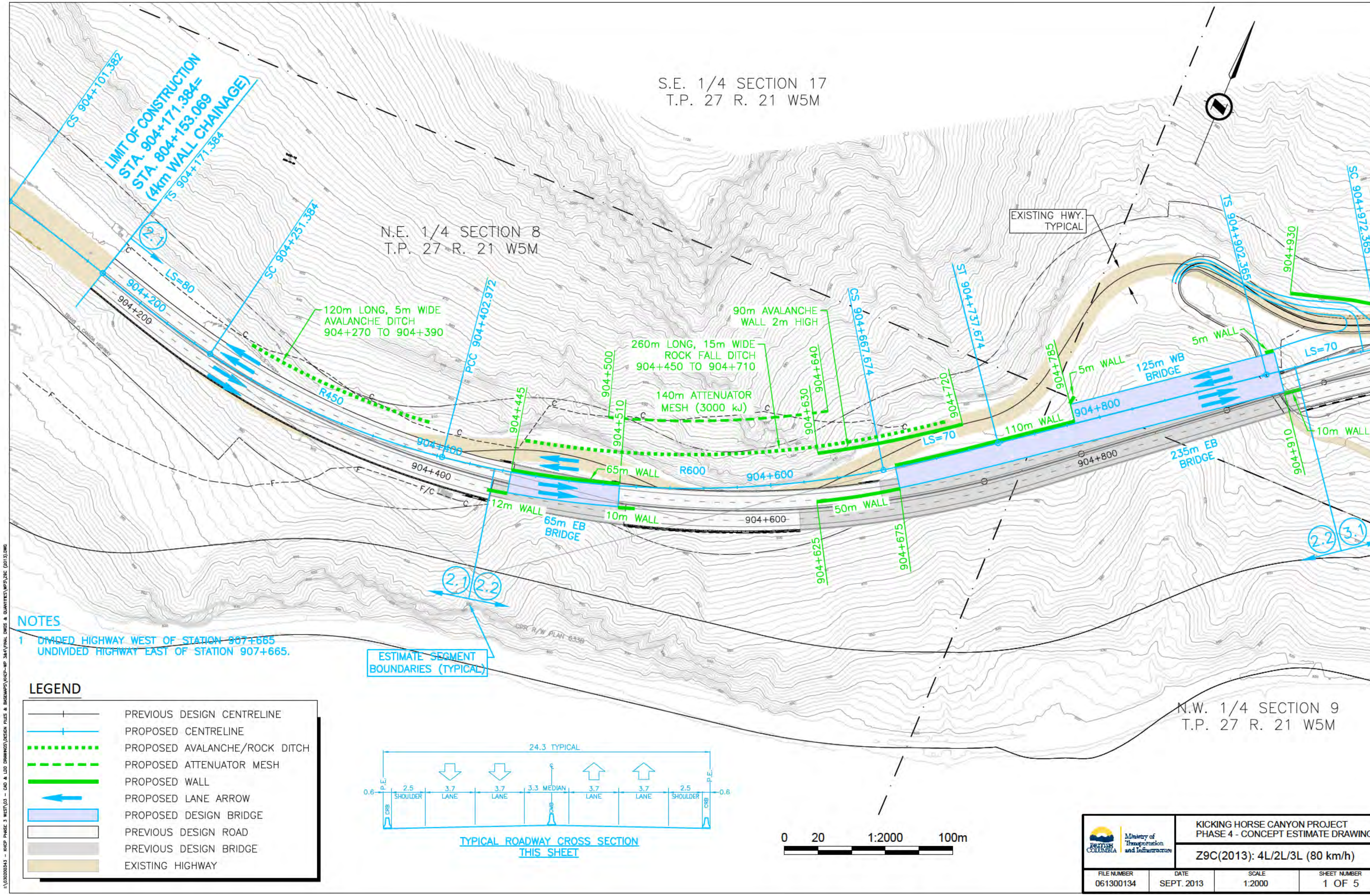
BRITISH COLUMBIA

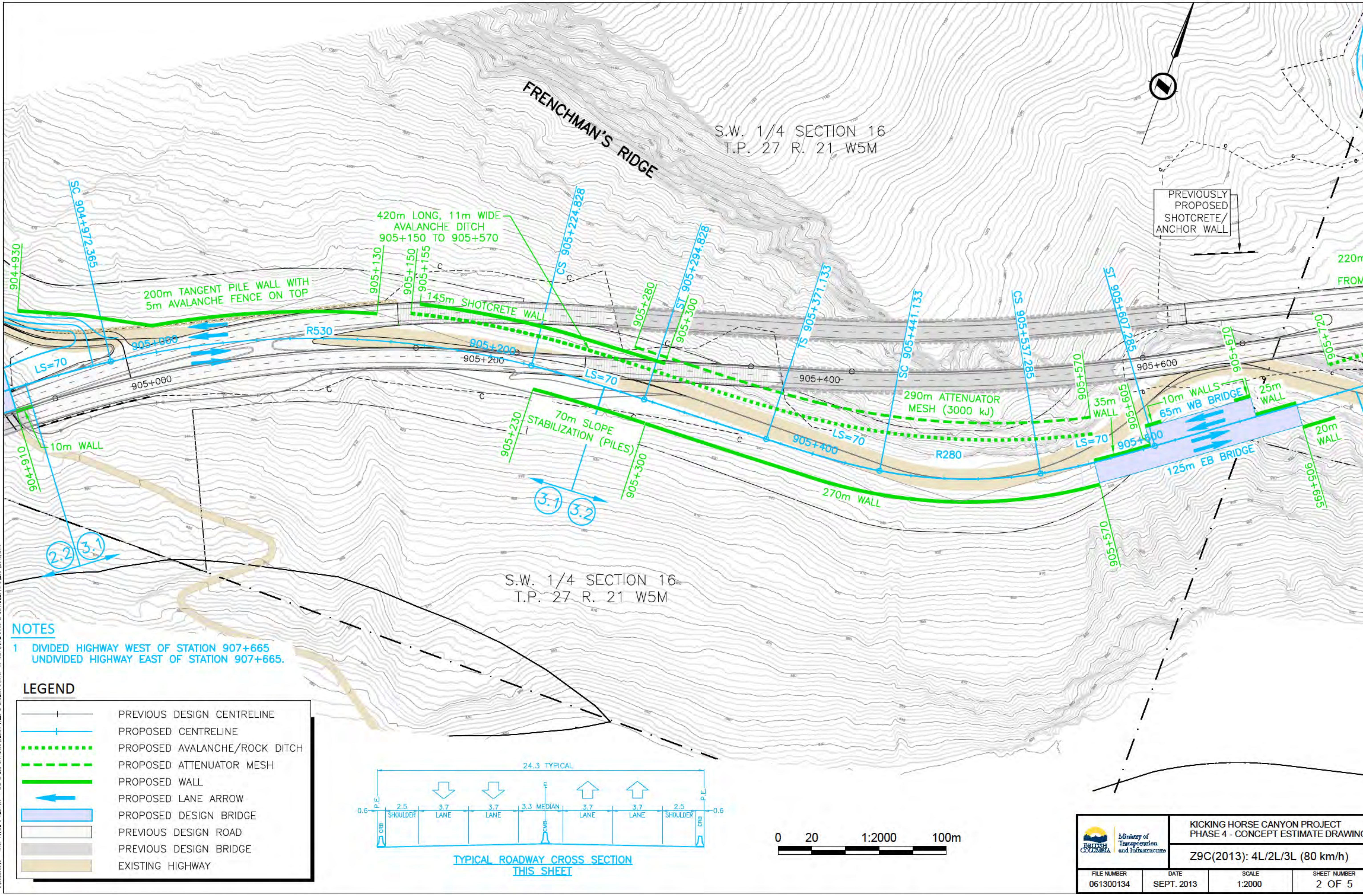
Ministry of Transportation and Infrastructure

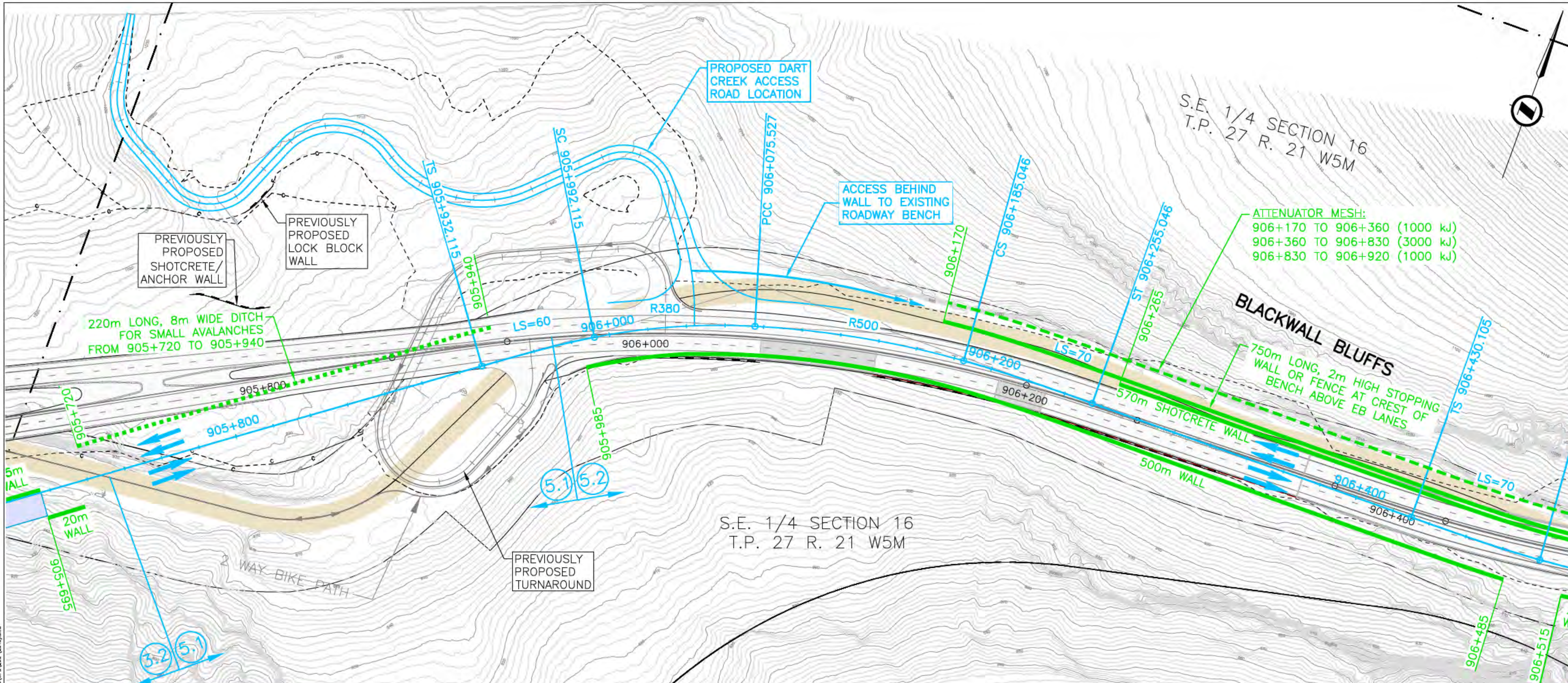
KICKING HORSE CANYON PROJECT
PHASE 4 - CONCEPT ESTIMATE DRAWINGS

ALIGNMENT OPTION Z9C (80 km/h)
4 LANE - 2 LANE - 3 LANE

SEPTEMBER 2013


S.E. 1/4 SECTION 17
T.P. 27 R. 21 W5M
N.E. 1/4 SECTION 8
T.P. 27 R. 21 W5M
N.W. 1/4 SECTION 9
T.P. 27 R. 21 W5M
LIMIT OF CONSTRUCTION
STA. 904+171.384=
STA. 804+153.069
(4km WALL CHAINAGE)
CS 904+101.382
TS 904+171.384
SC 904+251.384
PCC 904+402.972
CS 904+667.674
ST 904+737.674
TS 904+902.365
SC 904+972.365
LS=80
LS=70
R450
R600
120m LONG, 5m WIDE
AVALANCHE DITCH
904+270 TO 904+390
260m LONG, 15m WIDE
ROCK FALL DITCH
904+450 TO 904+710
90m AVALANCHE
WALL 2m HIGH
140m ATTENUATOR
MESH (3000 kJ)
EXISTING HWY.
TYPICAL
65m WALL
12m WALL
10m WALL
50m WALL
110m WALL
5m WALL
65m EB
BRIDGE
235m EB
BRIDGE
125m WB
BRIDGE
904+200
904+400
904+445
904+500
904+510
904+600
904+625
904+630
904+640
904+675
904+720
904+785
904+800
904+910
904+930
2.1
2.2
3.1
ESTIMATE SEGMENT
BOUNDARIES (TYPICAL)
NOTES
1 DIVIDED HIGHWAY WEST OF STATION 907+665
UNDIVIDED HIGHWAY EAST OF STATION 907+665.
LEGEND
PREVIOUS DESIGN CENTRELINE
PROPOSED CENTRELINE
PROPOSED AVALANCHE/ROCK DITCH
PROPOSED ATTENUATOR MESH
PROPOSED WALL
PROPOSED LANE ARROW
PROPOSED DESIGN BRIDGE
PREVIOUS DESIGN ROAD
PREVIOUS DESIGN BRIDGE
EXISTING HIGHWAY
24.3 TYPICAL
0.6
2.5 SHOULDER
3.7 LANE
3.7 LANE
3.3 MEDIAN
3.7 LANE
3.7 LANE
2.5 SHOULDER
0.6
TYPICAL ROADWAY CROSS SECTION
THIS SHEET
0 20 1:2000 100m
KICKING HORSE CANYON PROJECT
PHASE 4 - CONCEPT ESTIMATE DRAWING
Z9C(2013): 4L/2L/3L (80 km/h)
FILE NUMBER 061300134
DATE SEPT. 2013
SCALE 1:2000
SHEET NUMBER 1 OF 5


FRENCHMAN'S RIDGE
S.W. 1/4 SECTION 16
T.P. 27 R. 21 W5M
PREVIOUSLY PROPOSED SHOTCRETE/ ANCHOR WALL
420m LONG, 11m WIDE AVALANCHE DITCH 905+150 TO 905+570
200m TANGENT PILE WALL WITH 5m AVALANCHE FENCE ON TOP
145m SHOTCRETE WALL
SC 904+972.365
CS 905+224.828
ST 905+294.828
TS 905+371.133
SC 905+441.133
CS 905+537.285
ST 905+607.285
904+930
905+130
905+150
905+155
905+280
905+300
905+570
905+605
905+670
905+720
R530
R280
LS=70
905+000
905+200
905+400
905+600
290m ATTENUATOR MESH (3000 kJ)
70m SLOPE STABILIZATION (PILES)
905+230
10m WALL
904+910
35m WALL
10m WALLS
65m WB BRIDGE
25m WALL
20m WALL
125m EB BRIDGE
270m WALL
905+695
2.2
3.1
3.2
S.W. 1/4 SECTION 16
T.P. 27 R. 21 W5M
220m
NOTES
1 DIVIDED HIGHWAY WEST OF STATION 907+665
UNDIVIDED HIGHWAY EAST OF STATION 907+665.
LEGEND
PREVIOUS DESIGN CENTRELINE
PROPOSED CENTRELINE
PROPOSED AVALANCHE/ROCK DITCH
PROPOSED ATTENUATOR MESH
PROPOSED WALL
PROPOSED LANE ARROW
PROPOSED DESIGN BRIDGE
PREVIOUS DESIGN ROAD
PREVIOUS DESIGN BRIDGE
EXISTING HIGHWAY
24.3 TYPICAL
0.6
2.5 SHOULDER
3.7 LANE
3.7 LANE
3.3 MEDIAN
3.7 LANE
3.7 LANE
2.5 SHOULDER
0.6
TYPICAL ROADWAY CROSS SECTION THIS SHEET
0 20 1:2000 100m
Ministry of Transportation and Infrastructure
KICKING HORSE CANYON PROJECT
PHASE 4 - CONCEPT ESTIMATE DRAWING
Z9C(2013): 4L/2L/3L (80 km/h)
FILE NUMBER 061300134
DATE SEPT. 2013
SCALE 1:2000
SHEET NUMBER 2 OF 5

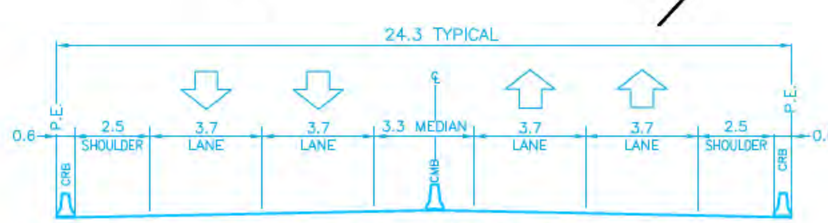


NOTES

1 DIVIDED HIGHWAY WEST OF STATION 907+665
UNDIVIDED HIGHWAY EAST OF STATION 907+665.

LEGEND

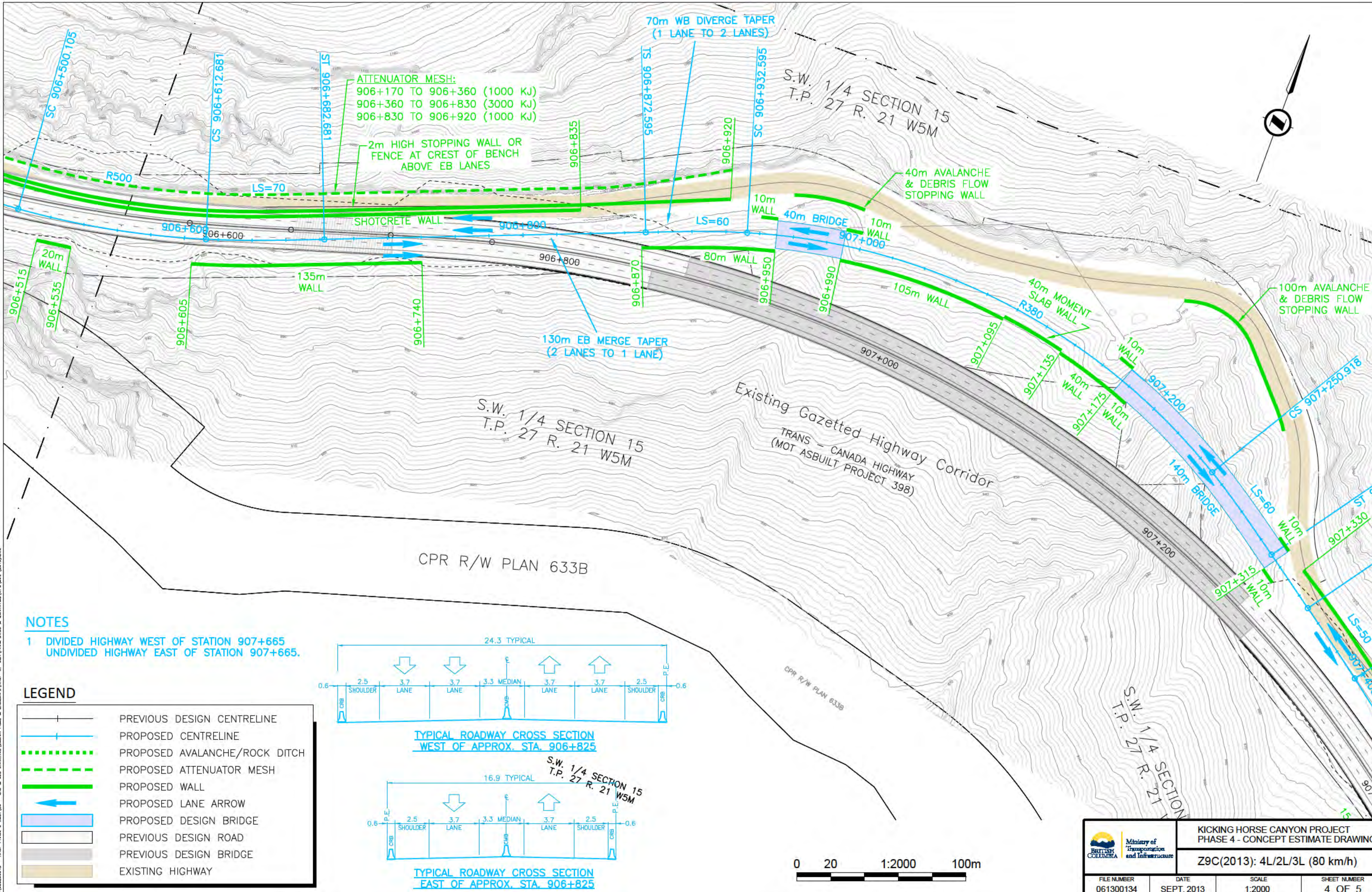
	PREVIOUS DESIGN CENTRELINE
	PROPOSED CENTRELINE
	PROPOSED AVALANCHE/ROCK DITCH
	PROPOSED ATTENUATOR MESH
	PROPOSED WALL
	PROPOSED LANE ARROW
	PROPOSED DESIGN BRIDGE
	PREVIOUS DESIGN ROAD
	PREVIOUS DESIGN BRIDGE
	EXISTING HIGHWAY

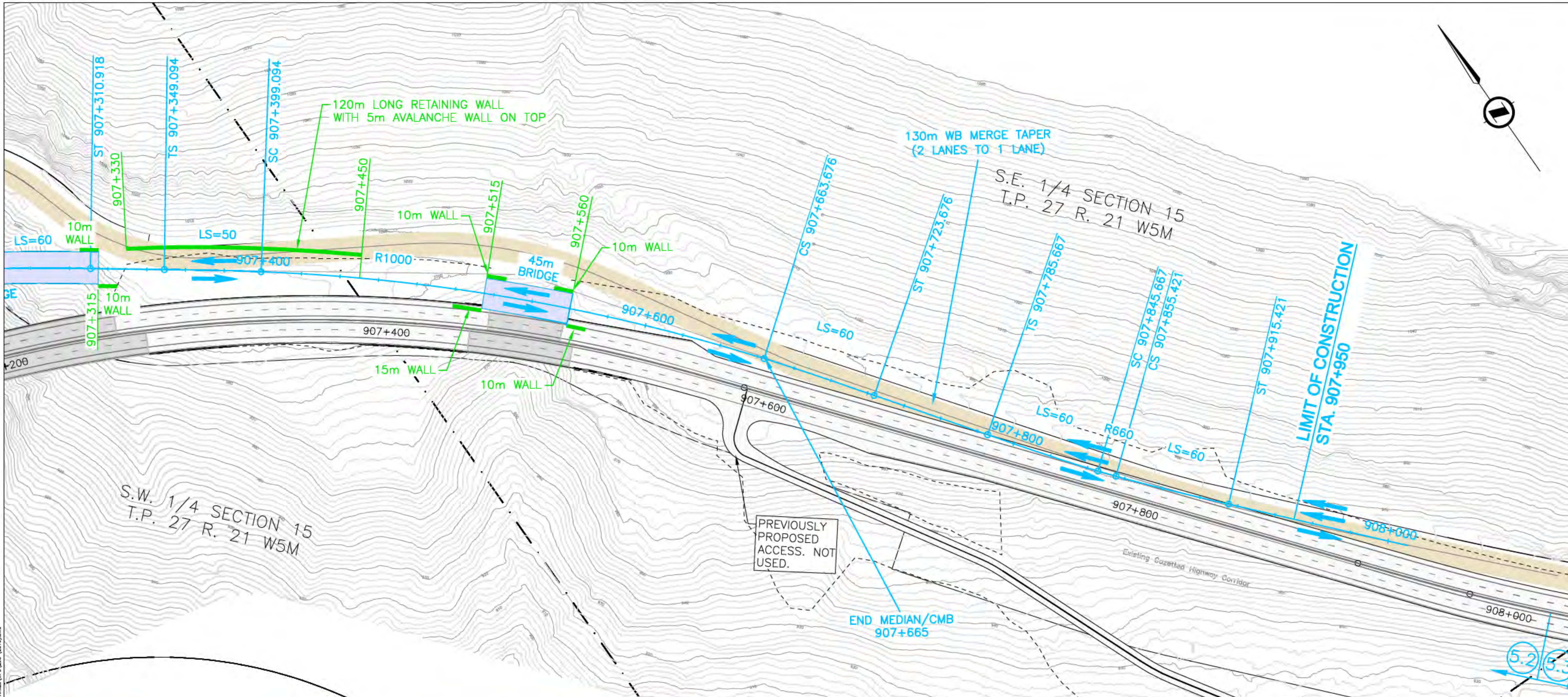


TYPICAL ROADWAY CROSS SECTION
THIS SHEET

0 20 1:2000 100m

Ministry of Transportation and Infrastructure	KICKING HORSE CANYON PROJECT PHASE 4 - CONCEPT EST MATE DRAWING		
	Z9C(2013): 4L/2L/3L (80 km/h)		
FILE NUMBER 061300134	DATE SEPT. 2013	SCALE 1:2000	SHEET NUMBER 3 OF 5


70m WB DIVERGE TAPER (1 LANE TO 2 LANES)
ATTENUATOR MESH:
906+170 TO 906+360 (1000 KJ)
906+360 TO 906+830 (3000 KJ)
906+830 TO 906+920 (1000 KJ)
2m HIGH STOPPING WALL OR FENCE AT CREST OF BENCH ABOVE EB LANES
SC 906+500.105
CS 906+612.681
ST 906+682.681
TS 906+872.595
SC 906+932.595
S.W. 1/4 SECTION 15 T.P. 27 R. 21 W5M
40m AVALANCHE & DEBRIS FLOW STOPPING WALL
SHOTCRETE WALL
40m BRIDGE
80m WALL
135m WALL
20m WALL
105m WALL
40m MOMENT SLAB WALL
R380
R500
LS=70
LS=60
LS=50
100m AVALANCHE & DEBRIS FLOW STOPPING WALL
130m EB MERGE TAPER (2 LANES TO 1 LANE)
Existing Gazetted Highway Corridor
TRANS - CANADA HIGHWAY (MOT ASBUILT PROJECT 398)
140m BRIDGE
CS 907+250.918
CPR R/W PLAN 633B
NOTES
1 DIVIDED HIGHWAY WEST OF STATION 907+665
UNDIVIDED HIGHWAY EAST OF STATION 907+665.
LEGEND
PREVIOUS DESIGN CENTRELINE
PROPOSED CENTRELINE
PROPOSED AVALANCHE/ROCK DITCH
PROPOSED ATTENUATOR MESH
PROPOSED WALL
PROPOSED LANE ARROW
PROPOSED DESIGN BRIDGE
PREVIOUS DESIGN ROAD
PREVIOUS DESIGN BRIDGE
EXISTING HIGHWAY
24.3 TYPICAL
2.5 SHOULDER 3.7 LANE 3.7 LANE 3.3 MEDIAN 3.7 LANE 3.7 LANE 2.5 SHOULDER
TYPICAL ROADWAY CROSS SECTION WEST OF APPROX. STA. 906+825
16.9 TYPICAL
2.5 SHOULDER 3.7 LANE 3.3 MEDIAN 3.7 LANE 2.5 SHOULDER
TYPICAL ROADWAY CROSS SECTION EAST OF APPROX. STA. 906+825
0 20 1:2000 100m
KICKING HORSE CANYON PROJECT
PHASE 4 - CONCEPT ESTIMATE DRAWING
Z9C(2013): 4L/2L/3L (80 km/h)
FILE NUMBER 061300134
DATE SEPT. 2013
SCALE 1:2000
SHEET NUMBER 4 OF 5

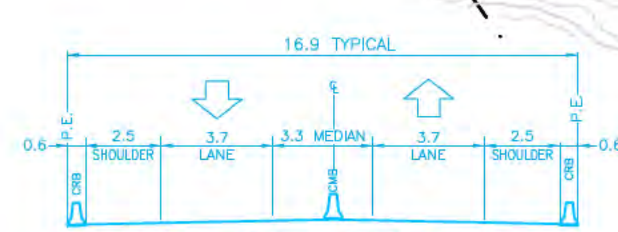


NOTES

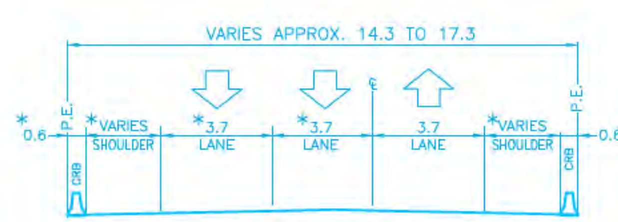
1 DIVIDED HIGHWAY WEST OF STATION 907+665
UNDIVIDED HIGHWAY EAST OF STATION 907+665.

LEGEND

	PREVIOUS DESIGN CENTRELINE
	PROPOSED CENTRELINE
	PROPOSED AVALANCHE/ROCK DITCH
	PROPOSED ATTENUATOR MESH
	PROPOSED WALL
	PROPOSED LANE ARROW
	PROPOSED DESIGN BRIDGE
	PREVIOUS DESIGN ROAD
	PREVIOUS DESIGN BRIDGE
	EXISTING HIGHWAY



TYPICAL ROADWAY CROSS SECTION
WEST OF APPROX. STA. 907+665



TYPICAL ROADWAY CROSS SECTION
EAST OF APPROX. STA. 907+665

* LANE WIDTHS VARY TO ACCOMMODATE WESTBOUND MERGE, SHOULDERS VARY TO TIE TO EXISTING

0 20 1:2000 100m

British Columbia — Ministry of Transportation and Infrastructure	KICKING HORSE CANYON PROJECT PHASE 4 - CONCEPT ESTIMATE DRAWING
	Z9C(2013): 4L/2L/3L (80 km/h)

FILE NUMBER	DATE	SCALE	SHEET NUMBER
061300134	SEPT. 2013	1:2000	5 OF 5

Ministry of Transportation and Infrastructure	KICKING HORSE CANYON PROJECT PHASE 4 - CONCEPT ESTIMATE DRAWING
	Z9C PROFILE (80 km/h)

FILE NUMBER	DATE	SCALE	SHEET NUMBER
061300134	SEPT. 2013	1:10.000 (HORIZ.)	6

BRITISH COLUMBIA

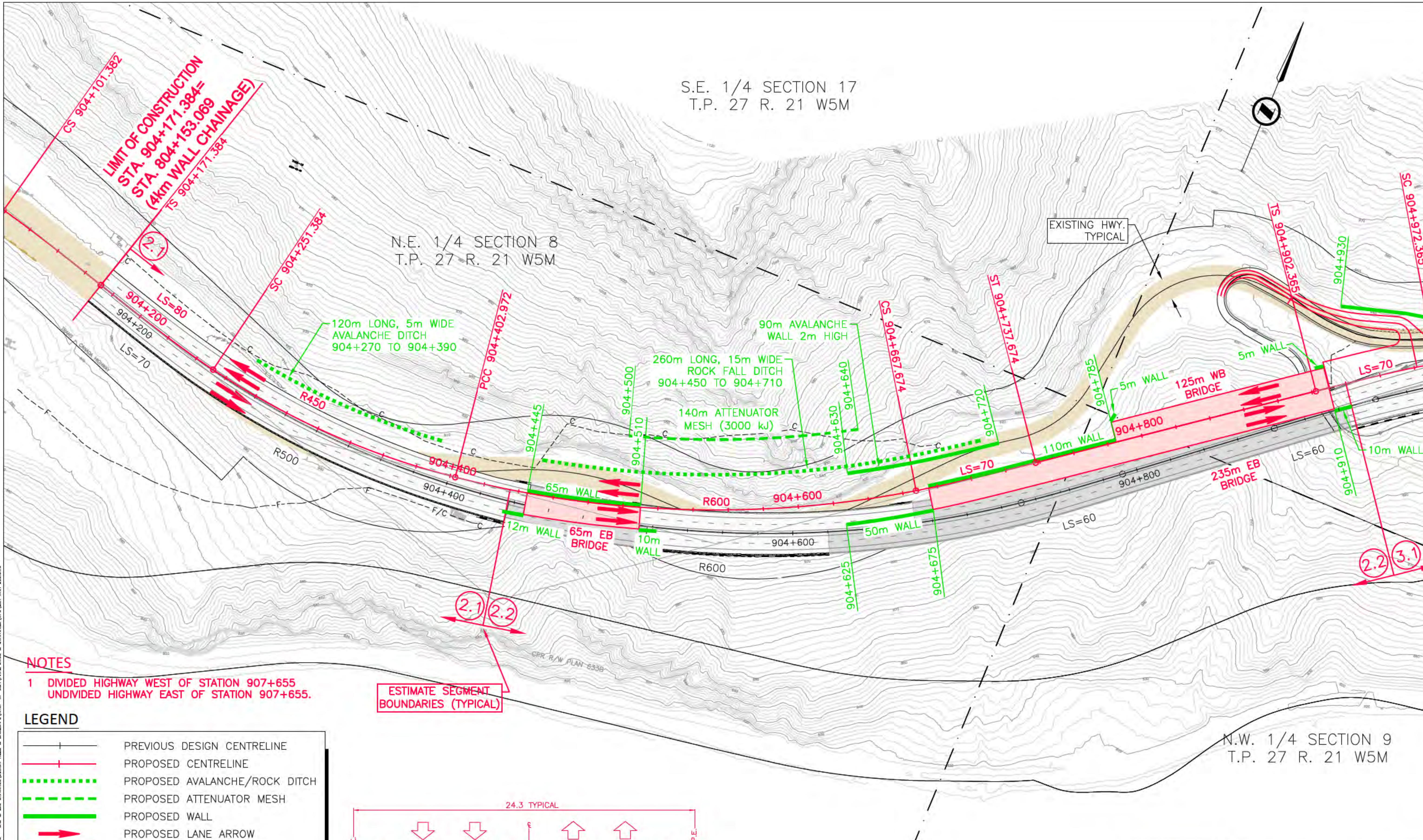
Ministry of Transportation and Infrastructure

KICKING HORSE CANYON PROJECT
PHASE 4 - CONCEPT ESTIMATE DRAWINGS

ALIGNMENT OPTION Z9A-D (100 km/h)

4 LANE - ALL 4 WORK PACKAGES

SEPTEMBER 2013

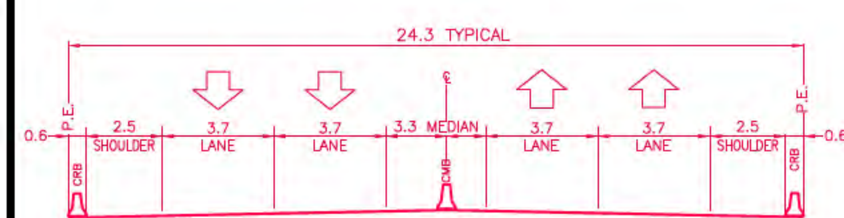


NOTES

1 DIVIDED HIGHWAY WEST OF STATION 907+655
UNDIVIDED HIGHWAY EAST OF STATION 907+655.

LEGEND

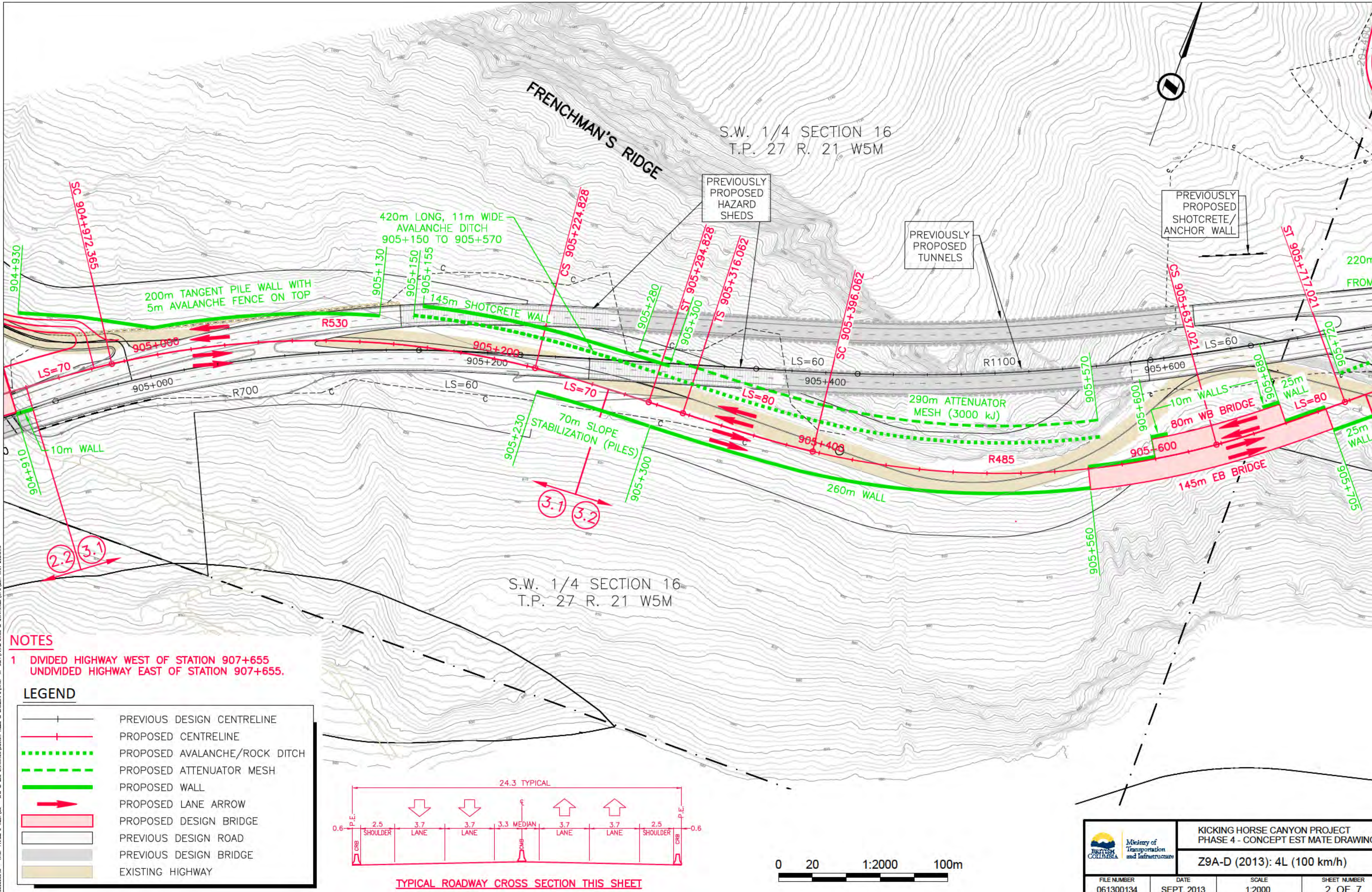
- PREVIOUS DESIGN CENTRELINE
- PROPOSED CENTRELINE
- PROPOSED AVALANCHE/ROCK DITCH
- PROPOSED ATTENUATOR MESH
- PROPOSED WALL
- PROPOSED LANE ARROW
- PROPOSED DESIGN BRIDGE
- PREVIOUS DESIGN ROAD
- PREVIOUS DESIGN BRIDGE
- EXISTING HIGHWAY



TYPICAL ROADWAY CROSS SECTION THIS SHEET

0 20 1:2000 100m

Ministry of Transportation and Infrastructure	KICKING HORSE CANYON PROJECT PHASE 4 - CONCEPT EST MATE DRAWING		
	Z9A-D (2013): 4L (100 km/h)		
FILE NUMBER 061300134	DATE SEPT. 2013	SCALE 1:2000	SHEET NUMBER 1 OF 7



NOTES

1 DIVIDED HIGHWAY WEST OF STATION 907+655
UNDIVIDED HIGHWAY EAST OF STATION 907+655.

LEGEND

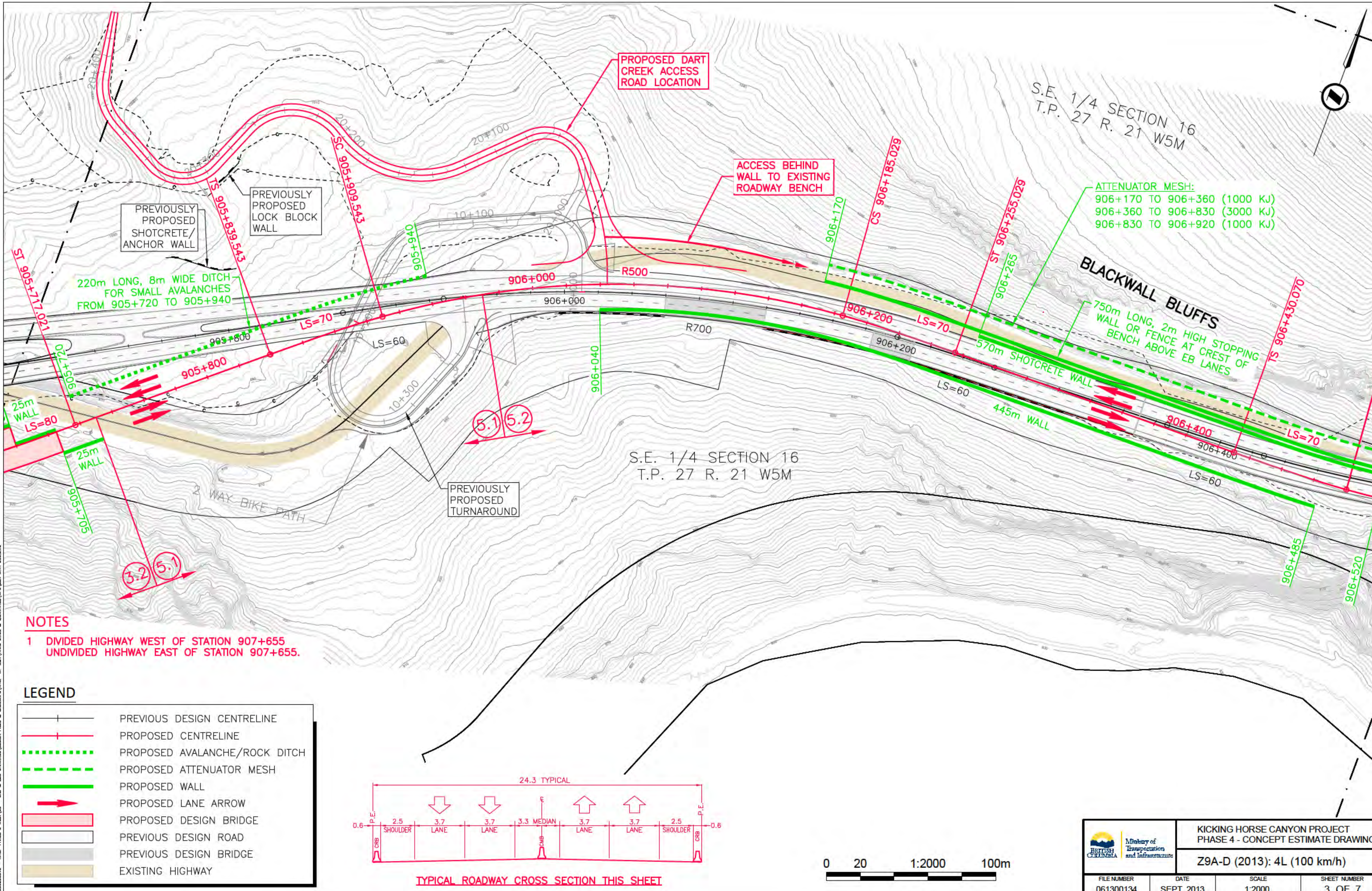
- PREVIOUS DESIGN CENTRELINE
- PROPOSED CENTRELINE
- PROPOSED AVALANCHE/ROCK DITCH
- PROPOSED ATTENUATOR MESH
- PROPOSED WALL
- PROPOSED LANE ARROW
- PROPOSED DESIGN BRIDGE
- PREVIOUS DESIGN ROAD
- PREVIOUS DESIGN BRIDGE
- EXISTING HIGHWAY

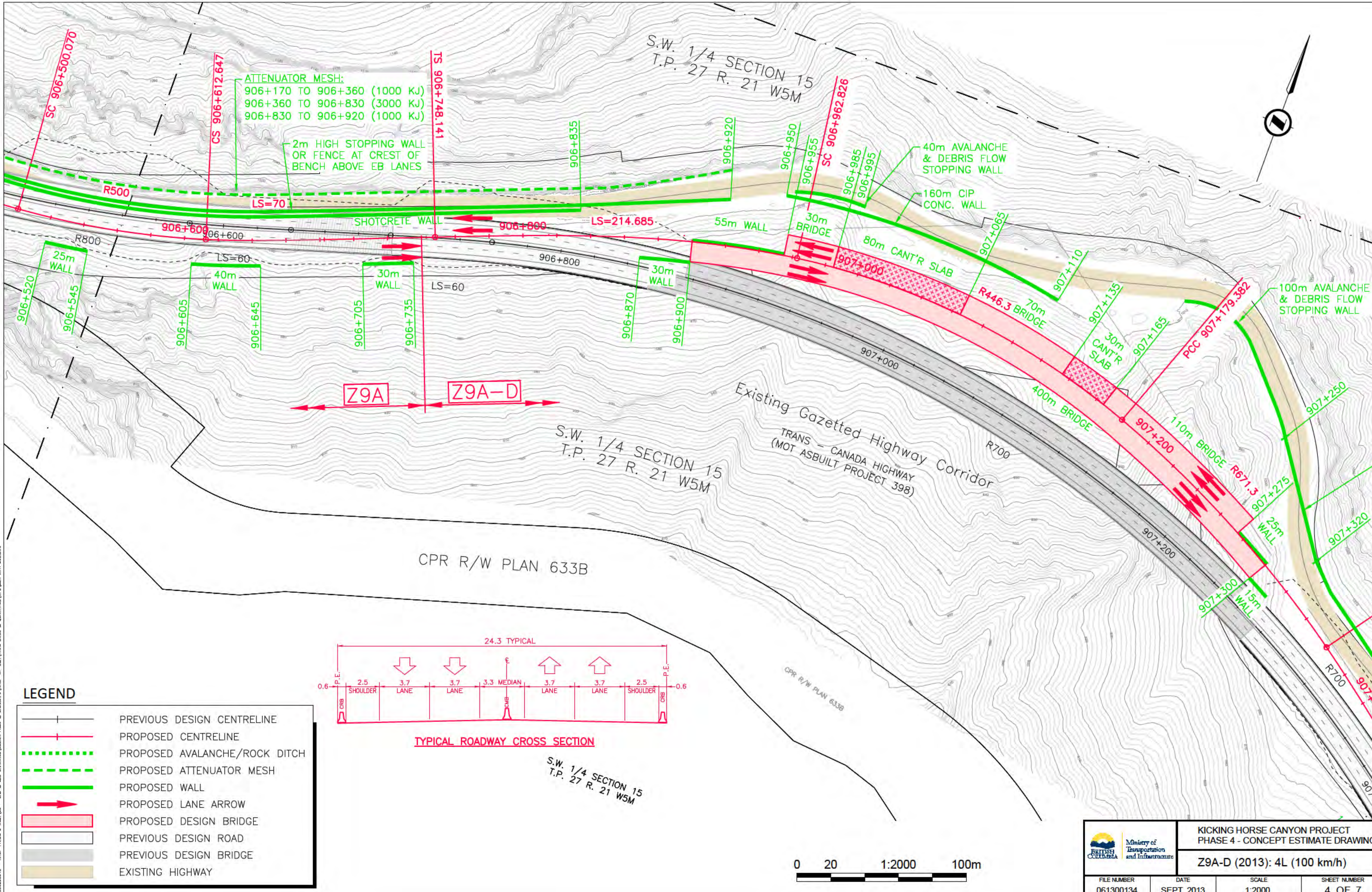
Ministry of Transportation and Infrastructure

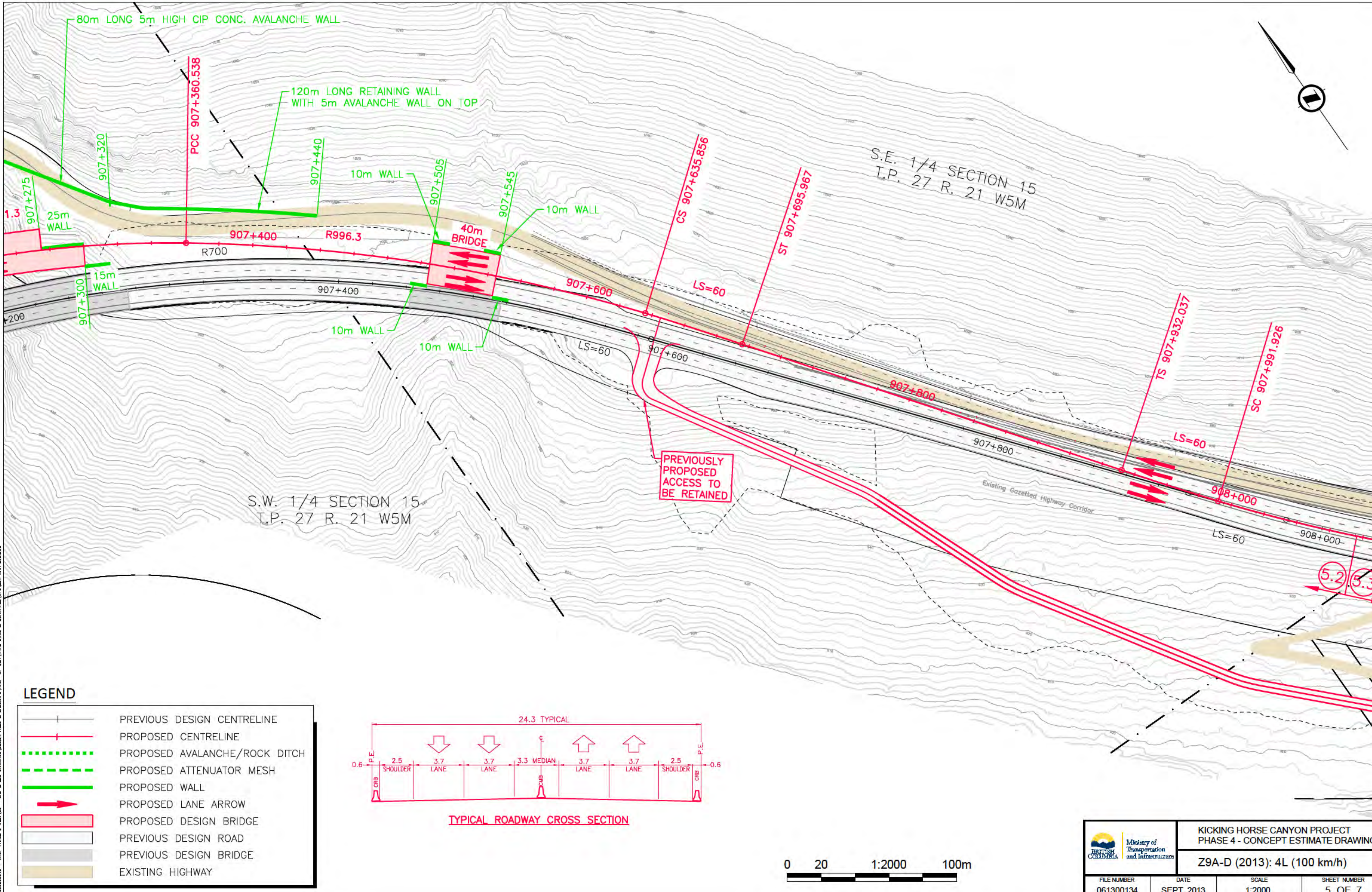
KICKING HORSE CANYON PROJECT
PHASE 4 - CONCEPT ESTIMATE DRAWING

Z9A-D (2013): 4L (100 km/h)

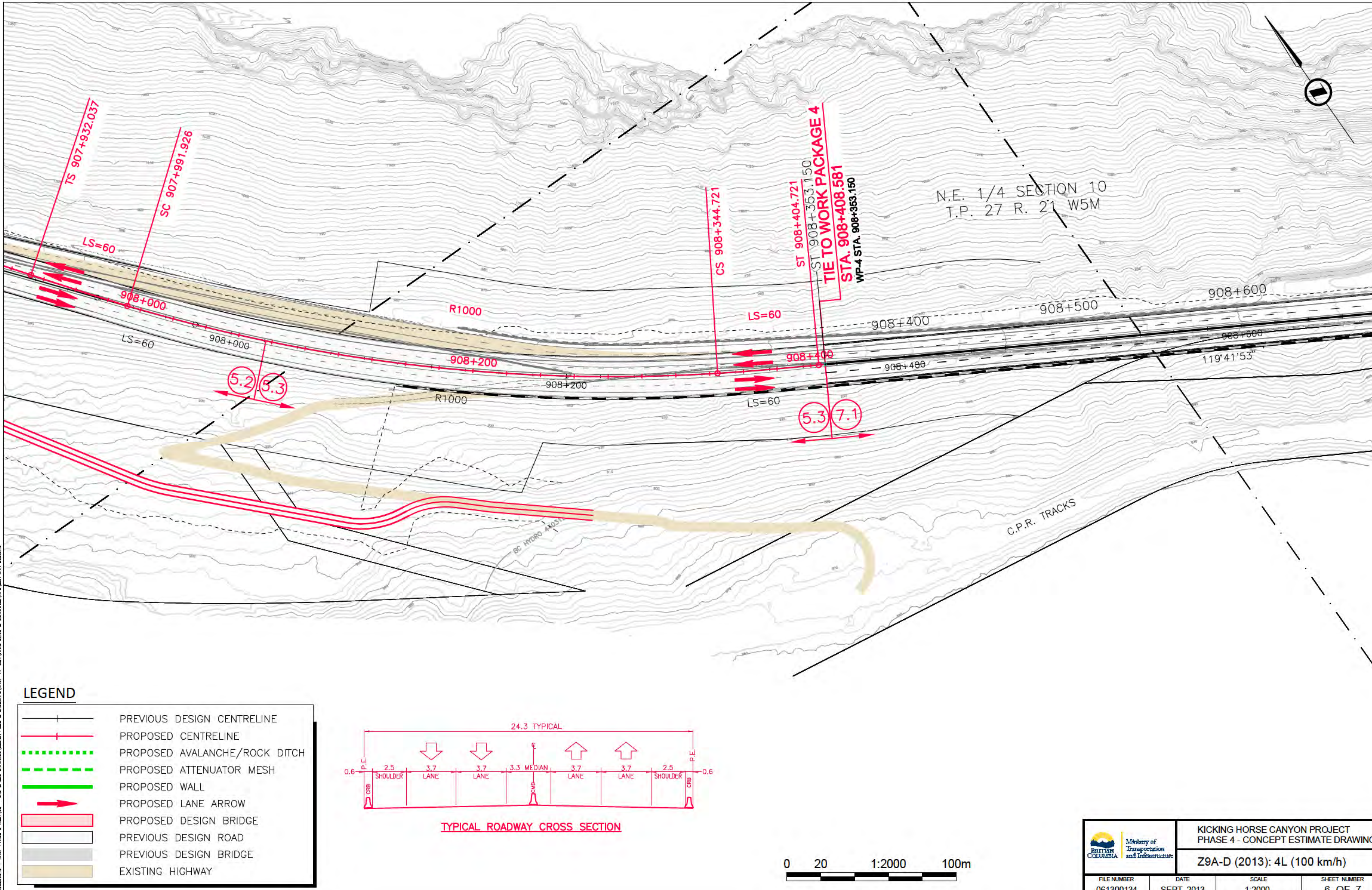
FILE NUMBER	DATE	SCALE	SHEET NUMBER
061300134	SEPT. 2013	1:2000	2 OF 7


PROPOSED DART CREEK ACCESS ROAD LOCATION
ACCESS BEHIND WALL TO EXISTING ROADWAY BENCH
PREVIOUSLY PROPOSED LOCK BLOCK WALL
PREVIOUSLY PROPOSED SHOTCRETE/ ANCHOR WALL
PREVIOUSLY PROPOSED TURNAROUND
S.E. 1/4 SECTION 16 T.P. 27 R. 21 W5M
S.E. 1/4 SECTION 16 T.P. 27 R. 21 W5M
BLACKWALL BLUFFS
ATTENUATOR MESH:
906+170 TO 906+360 (1000 KJ)
906+360 TO 906+830 (3000 KJ)
906+830 TO 906+920 (1000 KJ)
750m LONG, 2m HIGH STOPPING WALL OR FENCE AT CREST OF BENCH ABOVE EB LANES
570m SHOTCRETE WALL
445m WALL
220m LONG, 8m WIDE DITCH FOR SMALL AVALANCHES FROM 905+720 TO 905+940
25m WALL
25m WALL
2 WAY BIKE PATH
ST 905+717.021
TS 905+839.543
SC 905+909.543
CS 906+185.029
ST 906+255.029
TS 906+430.070
905+720
905+705
905+940
906+040
906+170
906+265
906+485
906+520
905+800
906+000
906+200
906+400
R500
R700
LS=80
LS=70
LS=60
20+400
20+200
20+100
10+100
10+300
NOTES
1 DIVIDED HIGHWAY WEST OF STATION 907+655
UNDIVIDED HIGHWAY EAST OF STATION 907+655.
LEGEND
PREVIOUS DESIGN CENTRELINE
PROPOSED CENTRELINE
PROPOSED AVALANCHE/ROCK DITCH
PROPOSED ATTENUATOR MESH
PROPOSED WALL
PROPOSED LANE ARROW
PROPOSED DESIGN BRIDGE
PREVIOUS DESIGN ROAD
PREVIOUS DESIGN BRIDGE
EXISTING HIGHWAY
24.3 TYPICAL
0.6
2.5 SHOULDER
3.7 LANE
3.7 LANE
3.3 MEDIAN
3.7 LANE
3.7 LANE
2.5 SHOULDER
0.6
TYPICAL ROADWAY CROSS SECTION THIS SHEET
0 20 1:2000 100m
Ministry of Transportation and Infrastructure
KICKING HORSE CANYON PROJECT
PHASE 4 - CONCEPT ESTIMATE DRAWING
Z9A-D (2013): 4L (100 km/h)
FILE NUMBER 061300134
DATE SEPT. 2013
SCALE 1:2000
SHEET NUMBER 3 OF 7


S.W. 1/4 SECTION 15
T.P. 27 R. 21 W5M
SC 906+500.070
CS 906+612.647
TS 906+748.141
SC 906+962.826
PCC 907+179.382
ATTENUATOR MESH:
906+170 TO 906+360 (1000 KJ)
906+360 TO 906+830 (3000 KJ)
906+830 TO 906+920 (1000 KJ)
2m HIGH STOPPING WALL OR FENCE AT CREST OF BENCH ABOVE EB LANES
40m AVALANCHE & DEBRIS FLOW STOPPING WALL
160m CIP CONC. WALL
100m AVALANCHE & DEBRIS FLOW STOPPING WALL
R500
LS=70
LS=214.685
SHOTCRETE WALL
906+600
906+800
R800
LS=60
55m WALL
30m BRIDGE
80m CANT'R SLAB
907+000
R446.3
70m BRIDGE
30m CANT'R SLAB
400m BRIDGE
907+200
110m BRIDGE
R671.3
25m WALL
15m WALL
25m WALL
40m WALL
30m WALL
30m WALL
Z9A
Z9A-D
Existing Gazetted Highway Corridor
TRANS - CANADA HIGHWAY
(MOT ASBUILT PROJECT 398)
R700
CPR R/W PLAN 633B
24.3 TYPICAL
SHOULDER
LANE
MEDIAN
TYPICAL ROADWAY CROSS SECTION
LEGEND
PREVIOUS DESIGN CENTRELINE
PROPOSED CENTRELINE
PROPOSED AVALANCHE/ROCK DITCH
PROPOSED ATTENUATOR MESH
PROPOSED WALL
PROPOSED LANE ARROW
PROPOSED DESIGN BRIDGE
PREVIOUS DESIGN ROAD
PREVIOUS DESIGN BRIDGE
EXISTING HIGHWAY
0 20 1:2000 100m
Ministry of Transportation and Infrastructure
KICKING HORSE CANYON PROJECT
PHASE 4 - CONCEPT ESTIMATE DRAWING
Z9A-D (2013): 4L (100 km/h)
FILE NUMBER 061300134
DATE SEPT. 2013
SCALE 1:2000
SHEET NUMBER 4 OF 7

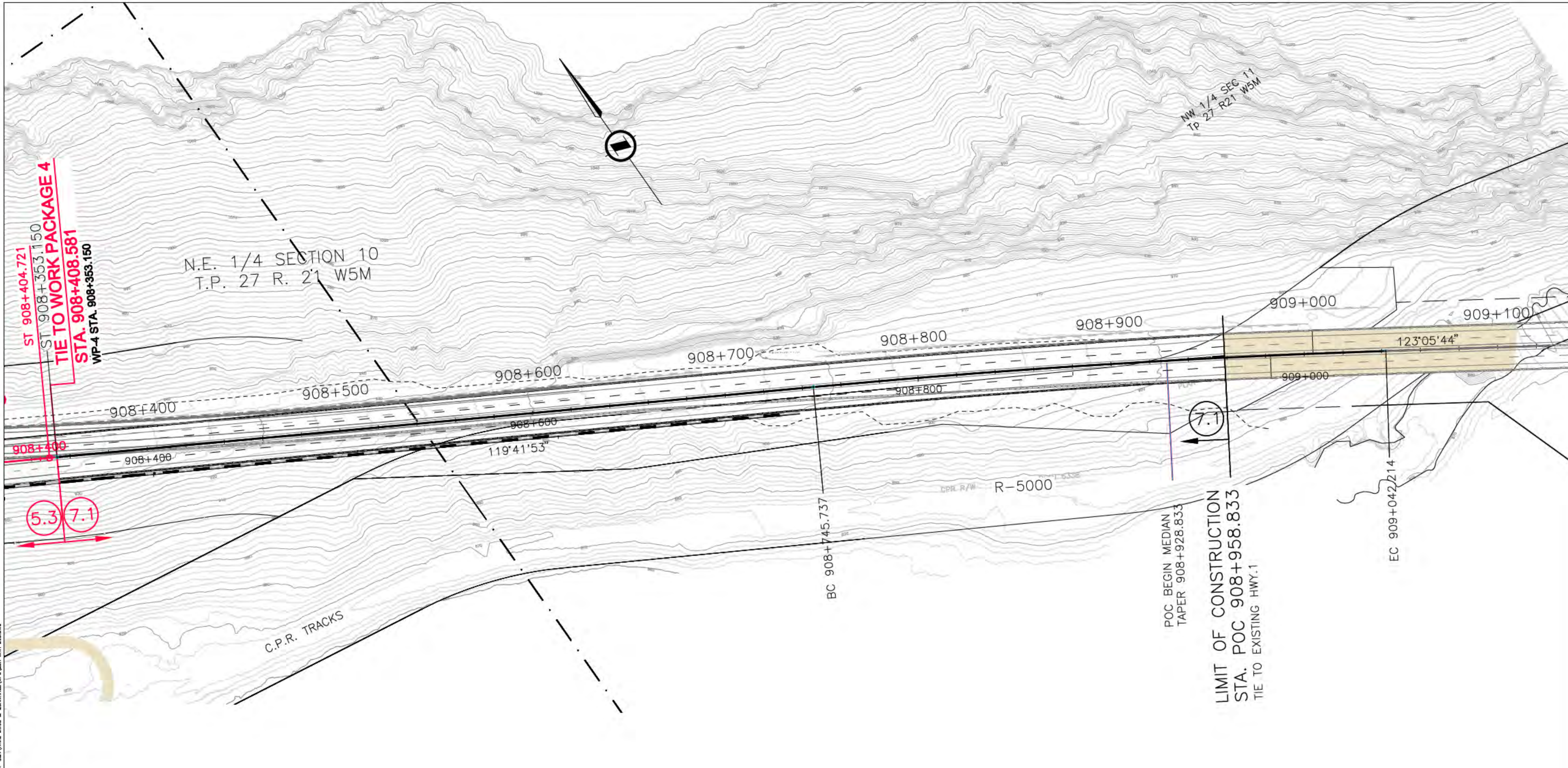


80m LONG 5m HIGH CIP CONC. AVALANCHE WALL
120m LONG RETAINING WALL
WITH 5m AVALANCHE WALL ON TOP
PCC 907+360.538
907+320
907+440
907+275
907+300
25m WALL
15m WALL
10m WALL
907+505
907+545
40m BRIDGE
907+400
R996.3
R700
907+600
LS=60
CS 907+635.856
ST 907+695.967
S.E. 1/4 SECTION 15
T.P. 27 R. 21 W5M
907+800
TS 907+932.037
SC 907+991.926
908+000
PREVIOUSLY PROPOSED ACCESS TO BE RETAINED
Existing Gazetted Highway Corridor
S.W. 1/4 SECTION 15
T.P. 27 R. 21 W5M
5.2
5.3
LEGEND
PREVIOUS DESIGN CENTRELINE
PROPOSED CENTRELINE
PROPOSED AVALANCHE/ROCK DITCH
PROPOSED ATTENUATOR MESH
PROPOSED WALL
PROPOSED LANE ARROW
PROPOSED DESIGN BRIDGE
PREVIOUS DESIGN ROAD
PREVIOUS DESIGN BRIDGE
EXISTING HIGHWAY
24.3 TYPICAL
0.6
2.5 SHOULDER
3.7 LANE
3.7 LANE
3.3 MEDIAN
3.7 LANE
3.7 LANE
2.5 SHOULDER
0.6
TYPICAL ROADWAY CROSS SECTION
0 20 1:2000 100m
Ministry of Transportation and Infrastructure
KICKING HORSE CANYON PROJECT
PHASE 4 - CONCEPT ESTIMATE DRAWING
Z9A-D (2013): 4L (100 km/h)
FILE NUMBER 061300134
DATE SEPT. 2013
SCALE 1:2000
SHEET NUMBER 5 OF 7



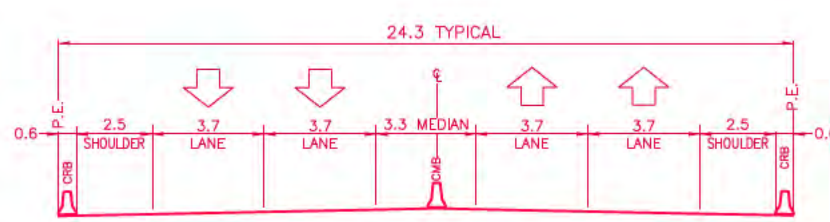
Ministry of Transportation and Infrastructure	KICKING HORSE CANYON PROJECT PHASE 4 - CONCEPT ESTIMATE DRAWING
	Z9A-D (2013): 4L (100 km/h)

FILE NUMBER	DATE	SCALE	SHEET NUMBER
061300134	SEPT. 2013	1:2000	6 OF 7



LEGEND

	PREVIOUS DESIGN CENTRELINE
	PROPOSED CENTRELINE
	PROPOSED AVALANCHE/ROCK DITCH
	PROPOSED ATTENUATOR MESH
	PROPOSED WALL
	PROPOSED LANE ARROW
	PROPOSED DESIGN BRIDGE
	PREVIOUS DESIGN ROAD
	PREVIOUS DESIGN BRIDGE
	EXISTING HIGHWAY



TYPICAL ROADWAY CROSS SECTION

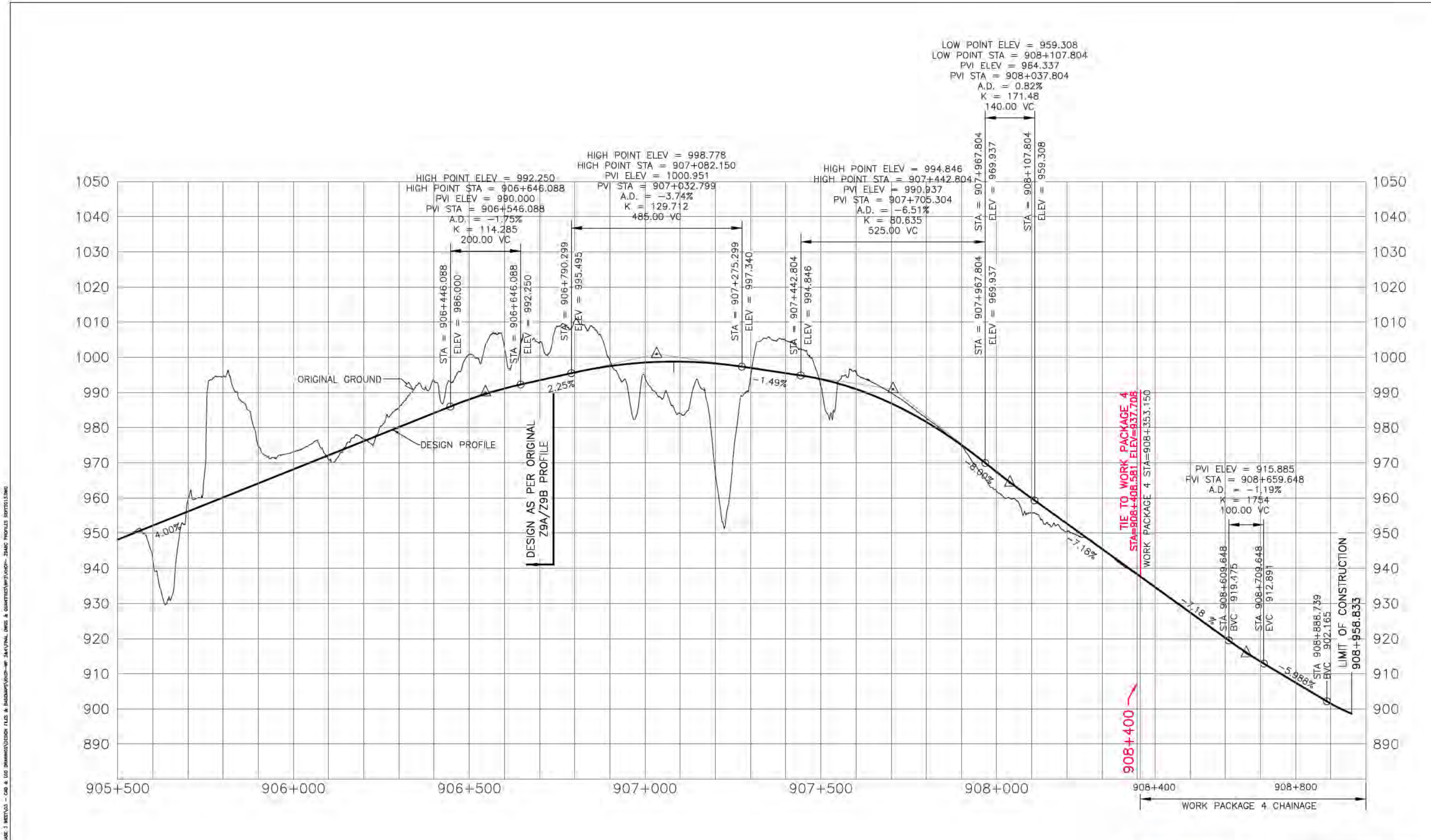
0 20 1:2000 100m

Ministry of Transportation and Infrastructure

KICKING HORSE CANYON PROJECT
PHASE 4 - CONCEPT ESTIMATE DRAWING

Z9A-D (2013): 4L (100 km/h)

FILE NUMBER	DATE	SCALE	SHEET NUMBER
061300134	SEPT. 2013	1:2000	7 OF 7



Ministry of Transportation and Infrastructure

KICKING HORSE CANYON PROJECT
PHASE 4 - CONCEPT ESTIMATE DRAWING

Z9A-D PROFILE (100 km/h)

FILE NUMBER	DATE	SCALE	SHEET NUMBER
061300134	SEPT. 2013	1:10,000 (HORIZ.)	8

BRITISH COLUMBIA

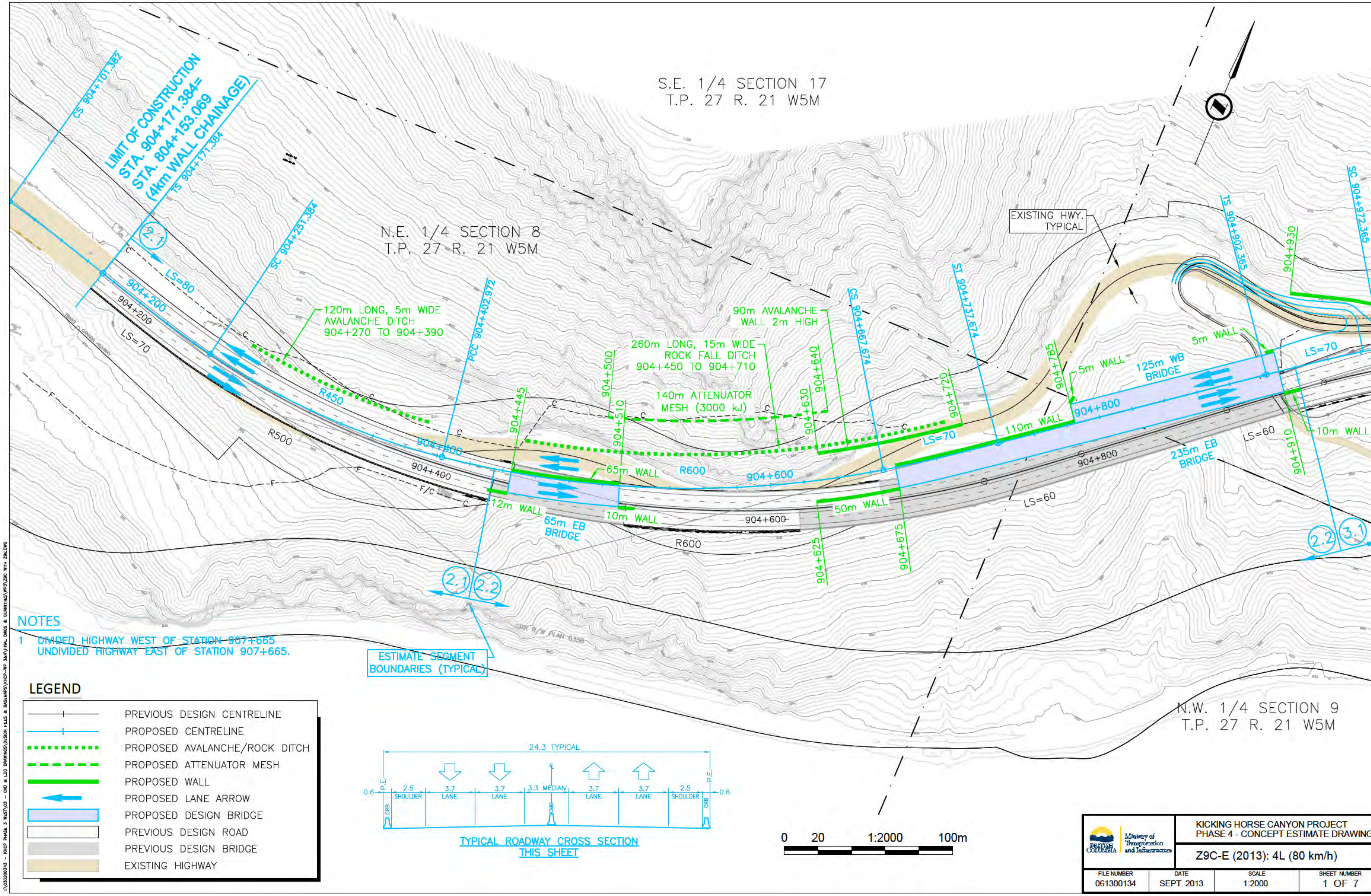
Ministry of Transportation and Infrastructure

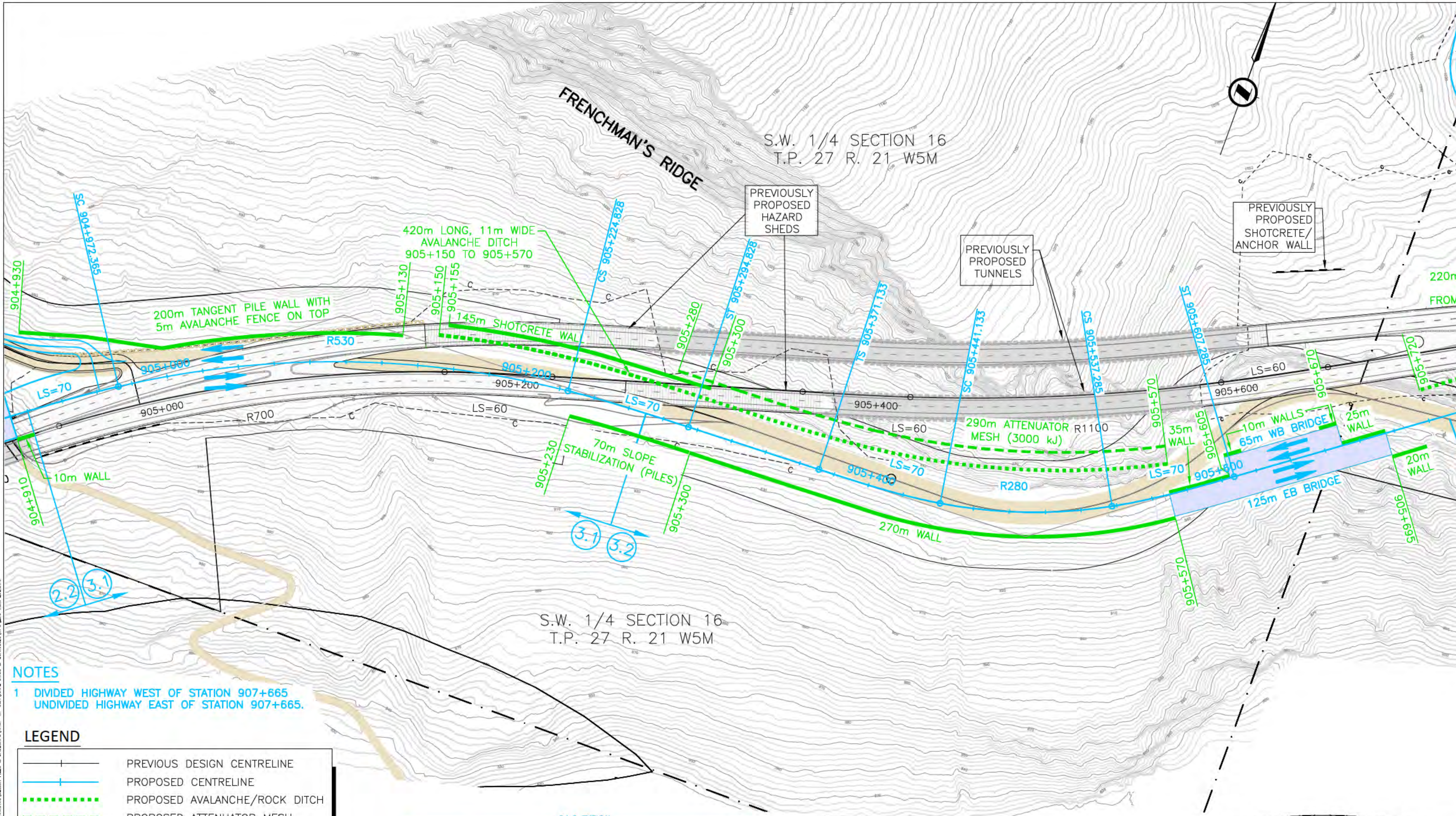
KICKING HORSE CANYON PROJECT
PHASE 4 - CONCEPT ESTIMATE DRAWINGS

ALIGNMENT OPTION Z9C-E (80 km/h)
4 LANE - ALL 4 WORK PACKAGES

SEPTEMBER 2013

I:\030200343 - KHCP PHASE 3 WEST\03 - CAD & LDD DRAWINGS\DESIGN FILES & BASEMAPS\KHCP-WP 3&4\FINAL DWGS & QUANTITIES\WP3\ESTIMATEDWG\TITLEPAGES.DWG


S.E. 1/4 SECTION 17
T.P. 27 R. 21 W5M
N.E. 1/4 SECTION 8
T.P. 27 R. 21 W5M
N.W. 1/4 SECTION 9
T.P. 27 R. 21 W5M
LIMIT OF CONSTRUCTION
STA. 904+171.384=
STA. 804+153.069
(4km WALL CHAINAGE)
CS 904+101.382
TS 904+171.384
SC 904+251.384
PCC 904+402.972
CS 904+667.674
ST 904+737.674
TS 904+902.365
SC 904+972.365
EXISTING HWY.
TYPICAL
120m LONG, 5m WIDE
AVALANCHE DITCH
904+270 TO 904+390
260m LONG, 15m WIDE
ROCK FALL DITCH
904+450 TO 904+710
90m AVALANCHE
WALL 2m HIGH
140m ATTENUATOR
MESH (3000 kJ)
65m WALL
12m WALL
10m WALL
50m WALL
110m WALL
5m WALL
5m WALL
10m WALL
65m EB
BRIDGE
125m WB
BRIDGE
235m EB
BRIDGE
LS=80
LS=70
LS=70
LS=70
LS=60
LS=60
R450
R500
R600
R600
904+200
904+400
904+600
904+800
904+445
904+500
904+510
904+625
904+630
904+640
904+675
904+720
904+785
904+910
904+930
2.1
2.2
3.1
CPR R/W PLAN 6338
ESTIMATE SEGMENT
BOUNDARIES (TYPICAL)
NOTES
1 DIVIDED HIGHWAY WEST OF STATION 907+665
UNDIVIDED HIGHWAY EAST OF STATION 907+665.
LEGEND
PREVIOUS DESIGN CENTRELINE
PROPOSED CENTRELINE
PROPOSED AVALANCHE/ROCK DITCH
PROPOSED ATTENUATOR MESH
PROPOSED WALL
PROPOSED LANE ARROW
PROPOSED DESIGN BRIDGE
PREVIOUS DESIGN ROAD
PREVIOUS DESIGN BRIDGE
EXISTING HIGHWAY
24.3 TYPICAL
0.6
2.5 SHOULDER
3.7 LANE
3.7 LANE
3.3 MEDIAN
3.7 LANE
3.7 LANE
2.5 SHOULDER
0.6
TYPICAL ROADWAY CROSS SECTION
THIS SHEET
0 20 1:2000 100m
BRITISH COLUMBIA
Ministry of Transportation and Infrastructure
KICKING HORSE CANYON PROJECT
PHASE 4 - CONCEPT ESTIMATE DRAWING
Z9C-E (2013): 4L (80 km/h)
FILE NUMBER 061300134
DATE SEPT. 2013
SCALE 1:2000
SHEET NUMBER 1 OF 7

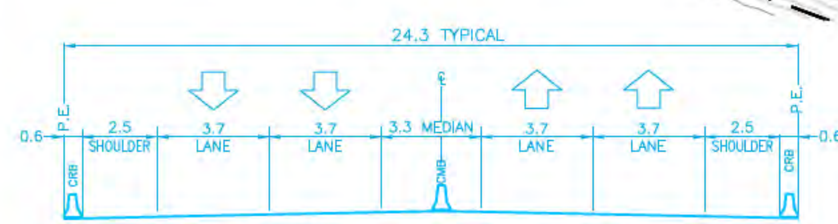


NOTES

1 DIVIDED HIGHWAY WEST OF STATION 907+665
UNDIVIDED HIGHWAY EAST OF STATION 907+665.

LEGEND

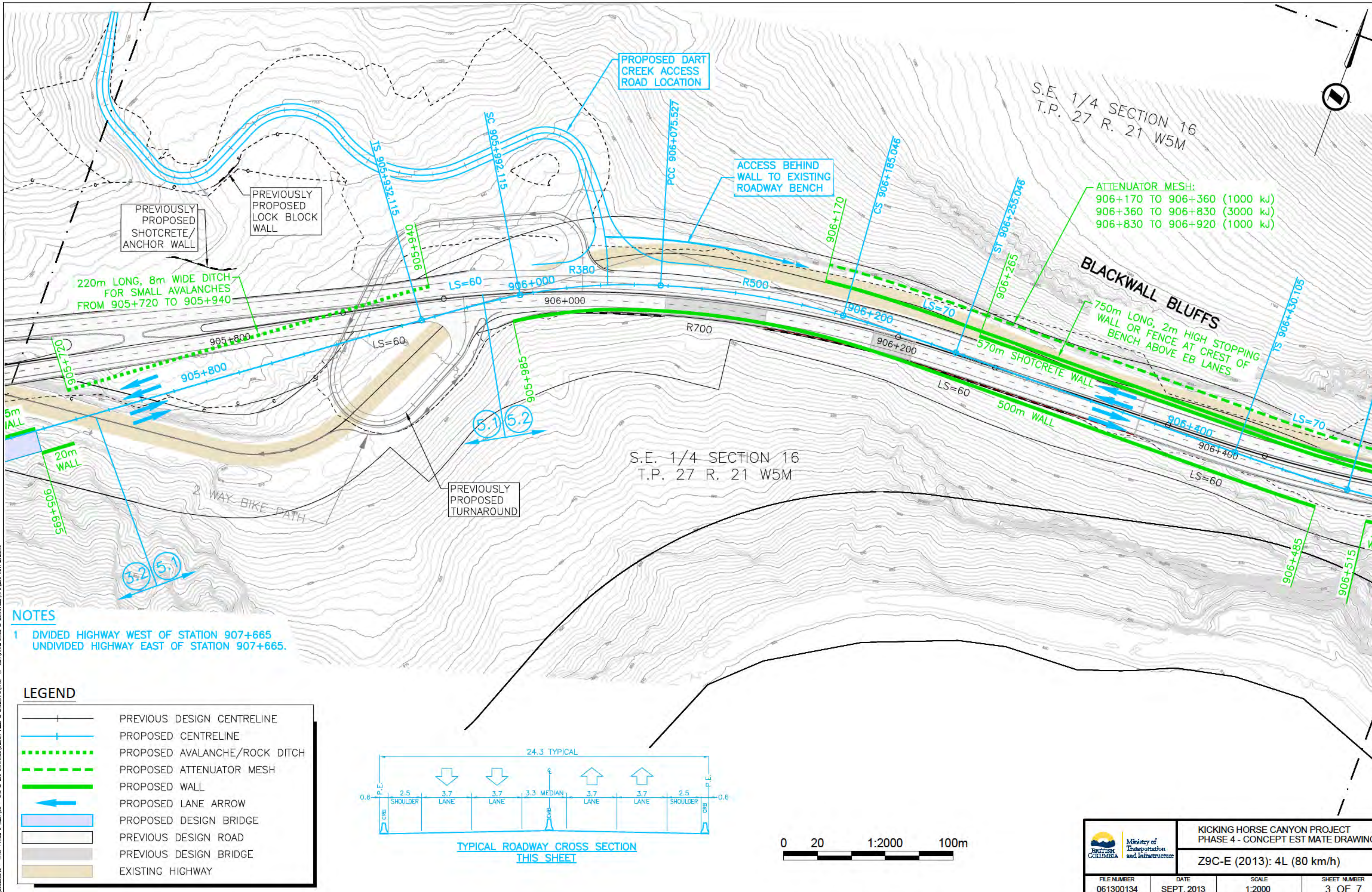
- PREVIOUS DESIGN CENTRELINE
- PROPOSED CENTRELINE
- PROPOSED AVALANCHE/ROCK DITCH
- PROPOSED ATTENUATOR MESH
- PROPOSED WALL
- PROPOSED LANE ARROW
- PROPOSED DESIGN BRIDGE
- PREVIOUS DESIGN ROAD
- PREVIOUS DESIGN BRIDGE
- EXISTING HIGHWAY

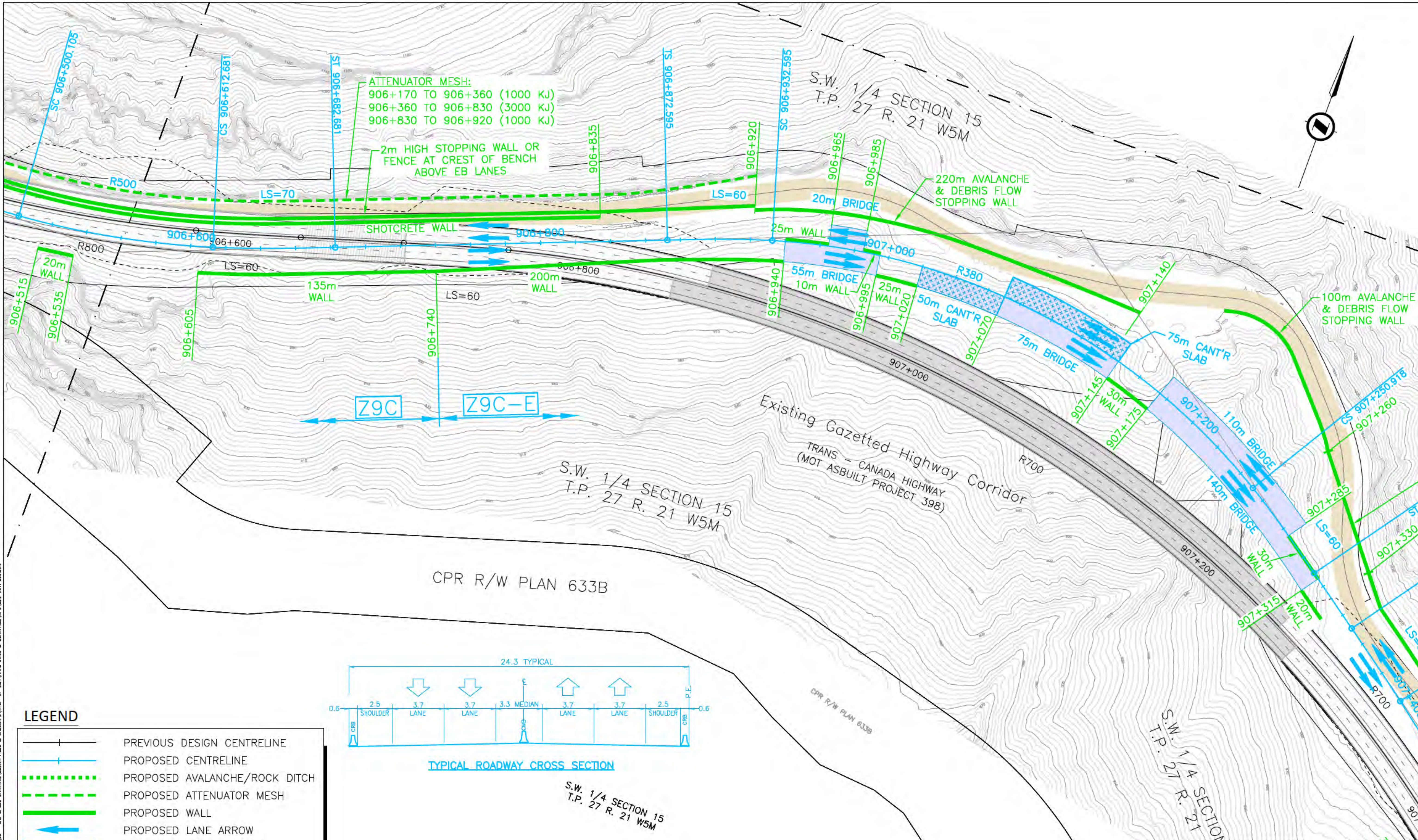


TYPICAL ROADWAY CROSS SECTION
THIS SHEET

0 20 1:2000 100m

Ministry of Transportation and Infrastructure	KICKING HORSE CANYON PROJECT PHASE 4 - CONCEPT ESTIMATE DRAWING		
	Z9C-E (2013): 4L (80 km/h)		
FILE NUMBER 061300134	DATE SEPT. 2013	SCALE 1:2000	SHEET NUMBER 2 OF 7


PROPOSED DART CREEK ACCESS ROAD LOCATION
PREVIOUSLY PROPOSED SHOTCRETE/ ANCHOR WALL
PREVIOUSLY PROPOSED LOCK BLOCK WALL
TS 905+932.115
SC 905+992.115
PCC 906+075.527
ACCESS BEHIND WALL TO EXISTING ROADWAY BENCH
CS 906+185.046
ST 906+255.046
S.E. 1/4 SECTION 16
T.P. 27 R. 21 W5M
ATTENUATOR MESH:
906+170 TO 906+360 (1000 kJ)
906+360 TO 906+830 (3000 kJ)
906+830 TO 906+920 (1000 kJ)
BLACKWALL BLUFFS
750m LONG, 2m HIGH STOPPING WALL OR FENCE AT CREST OF BENCH ABOVE EB LANES
TS 906+430.105
220m LONG, 8m WIDE DITCH FOR SMALL AVALANCHES FROM 905+720 TO 905+940
R380
R500
R700
LS=60
LS=70
906+000
905+800
906+200
906+400
905+940
905+720
905+985
906+170
906+265
570m SHOTCRETE WALL
500m WALL
20m WALL
905+695
906+485
906+515
2 WAY BIKE PATH
PREVIOUSLY PROPOSED TURNAROUND
S.E. 1/4 SECTION 16
T.P. 27 R. 21 W5M
NOTES
1 DIVIDED HIGHWAY WEST OF STATION 907+665
UNDIVIDED HIGHWAY EAST OF STATION 907+665.
LEGEND
PREVIOUS DESIGN CENTRELINE
PROPOSED CENTRELINE
PROPOSED AVALANCHE/ROCK DITCH
PROPOSED ATTENUATOR MESH
PROPOSED WALL
PROPOSED LANE ARROW
PROPOSED DESIGN BRIDGE
PREVIOUS DESIGN ROAD
PREVIOUS DESIGN BRIDGE
EXISTING HIGHWAY
24.3 TYPICAL
0.6
2.5 SHOULDER
3.7 LANE
3.7 LANE
3.3 MEDIAN
3.7 LANE
3.7 LANE
2.5 SHOULDER
0.6
TYPICAL ROADWAY CROSS SECTION THIS SHEET
0 20 1:2000 100m
Ministry of Transportation and Infrastructure
KICKING HORSE CANYON PROJECT
PHASE 4 - CONCEPT ESTIMATE DRAWING
Z9C-E (2013): 4L (80 km/h)
FILE NUMBER 061300134
DATE SEPT. 2013
SCALE 1:2000
SHEET NUMBER 3 OF 7

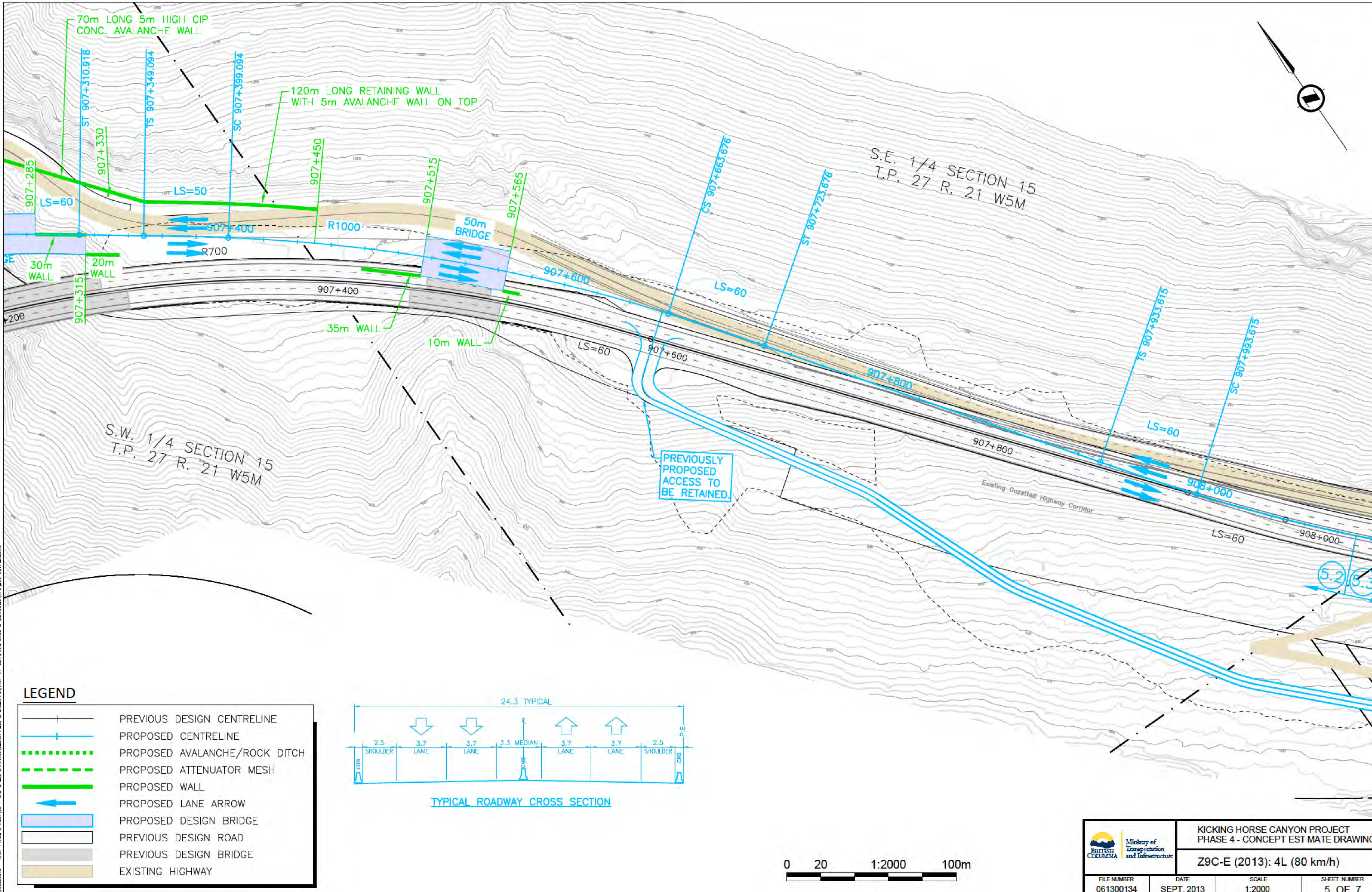


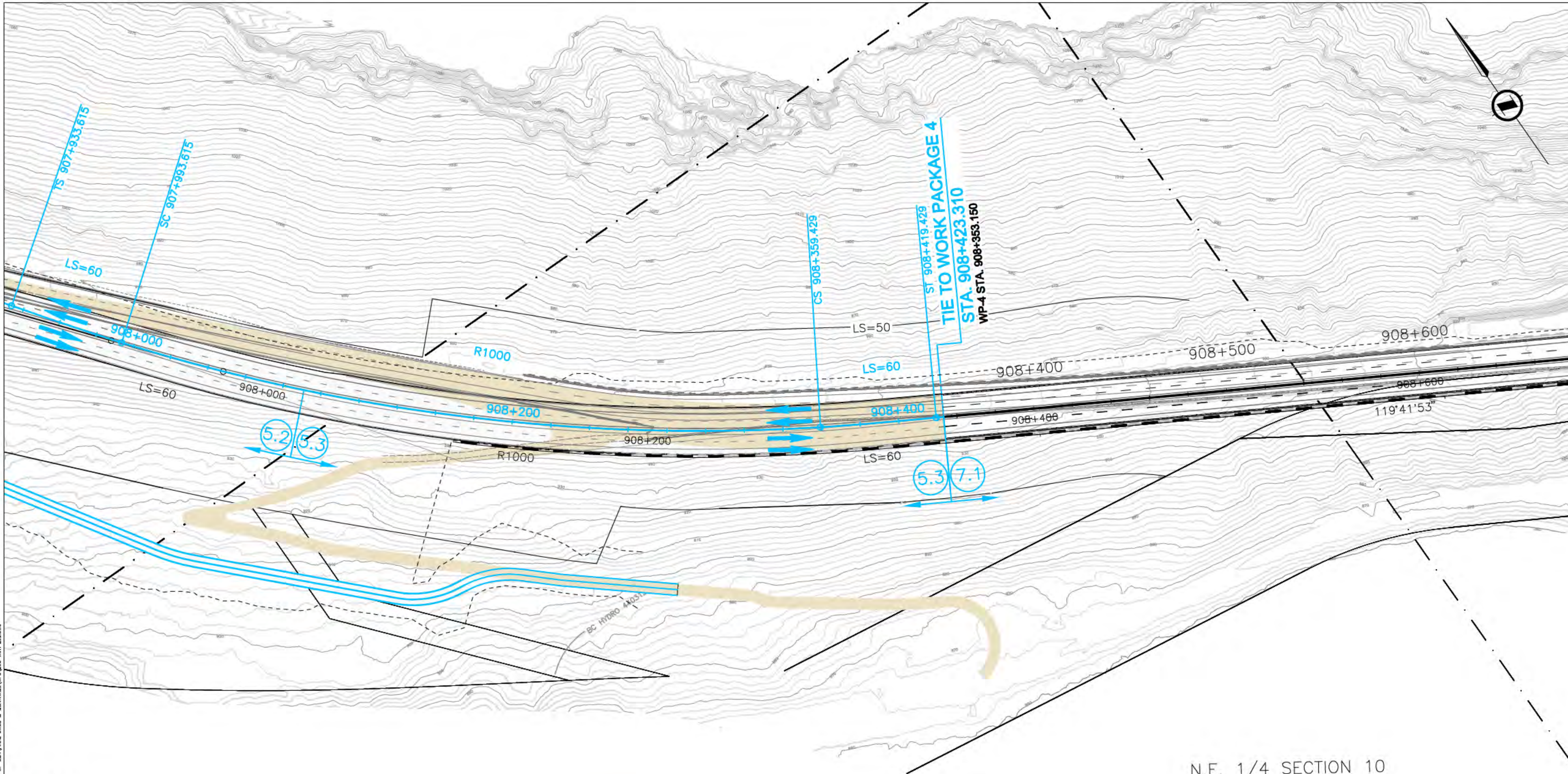
Ministry of Transportation and Infrastructure

KICKING HORSE CANYON PROJECT
PHASE 4 - CONCEPT ESTIMATE DRAWING

Z9C-E (2013): 4L (80 km/h)

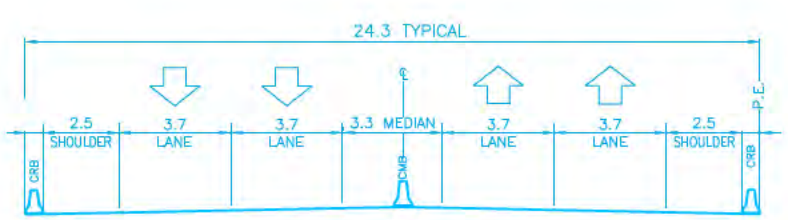
FILE NUMBER	DATE	SCALE	SHEET NUMBER
061300134	SEPT. 2013	1:2000	4 OF 7


70m LONG 5m HIGH CIP CONC. AVALANCHE WALL
120m LONG RETAINING WALL WITH 5m AVALANCHE WALL ON TOP
ST 907+310.918
TS 907+349.094
SC 907+399.094
CS 907+663.676
ST 907+723.676
TS 907+933.615
SC 907+993.615
907+285
907+330
907+450
907+515
907+565
907+315
LS=60
LS=50
907+400
R1000
R700
50m BRIDGE
30m WALL
20m WALL
35m WALL
10m WALL
907+600
907+800
908+000
S.E. 1/4 SECTION 15
T.P. 27 R. 21 W5M
S.W. 1/4 SECTION 15
T.P. 27 R. 21 W5M
PREVIOUSLY PROPOSED ACCESS TO BE RETAINED.
Existing Gazetted Highway Corridor
5.2
5.3
LEGEND
PREVIOUS DESIGN CENTRELINE
PROPOSED CENTRELINE
PROPOSED AVALANCHE/ROCK DITCH
PROPOSED ATTENUATOR MESH
PROPOSED WALL
PROPOSED LANE ARROW
PROPOSED DESIGN BRIDGE
PREVIOUS DESIGN ROAD
PREVIOUS DESIGN BRIDGE
EXISTING HIGHWAY
24.3 TYPICAL
2.5 SHOULDER
3.7 LANE
3.7 LANE
3.3 MEDIAN
3.7 LANE
3.7 LANE
2.5 SHOULDER
CRB
CMB
P.E.
TYPICAL ROADWAY CROSS SECTION
0 20 1:2000 100m
Ministry of Transportation and Infrastructure
KICKING HORSE CANYON PROJECT
PHASE 4 - CONCEPT ESTIMATE DRAWING
Z9C-E (2013): 4L (80 km/h)
FILE NUMBER 061300134
DATE SEPT. 2013
SCALE 1:2000
SHEET NUMBER 5 OF 7



LEGEND

	PREVIOUS DESIGN CENTRELINE
	PROPOSED CENTRELINE
	PROPOSED AVALANCHE/ROCK DITCH
	PROPOSED ATTENUATOR MESH
	PROPOSED WALL
	PROPOSED LANE ARROW
	PROPOSED DESIGN BRIDGE
	PREVIOUS DESIGN ROAD
	PREVIOUS DESIGN BRIDGE
	EXISTING HIGHWAY



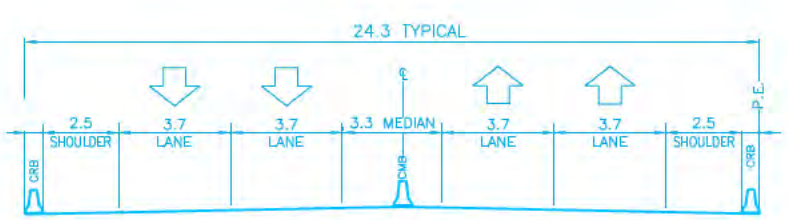
TYPICAL ROADWAY CROSS SECTION

0 20 1:2000 100m

Ministry of Transportation and Infrastructure	KICKING HORSE CANYON PROJECT PHASE 4 - CONCEPT EST MATE DRAWING		
	Z9C-E (2013): 4L (80 km/h)		
FILE NUMBER	DATE	SCALE	SHEET NUMBER
061300134	SEPT. 2013	1:2000	6 OF 7

LEGEND

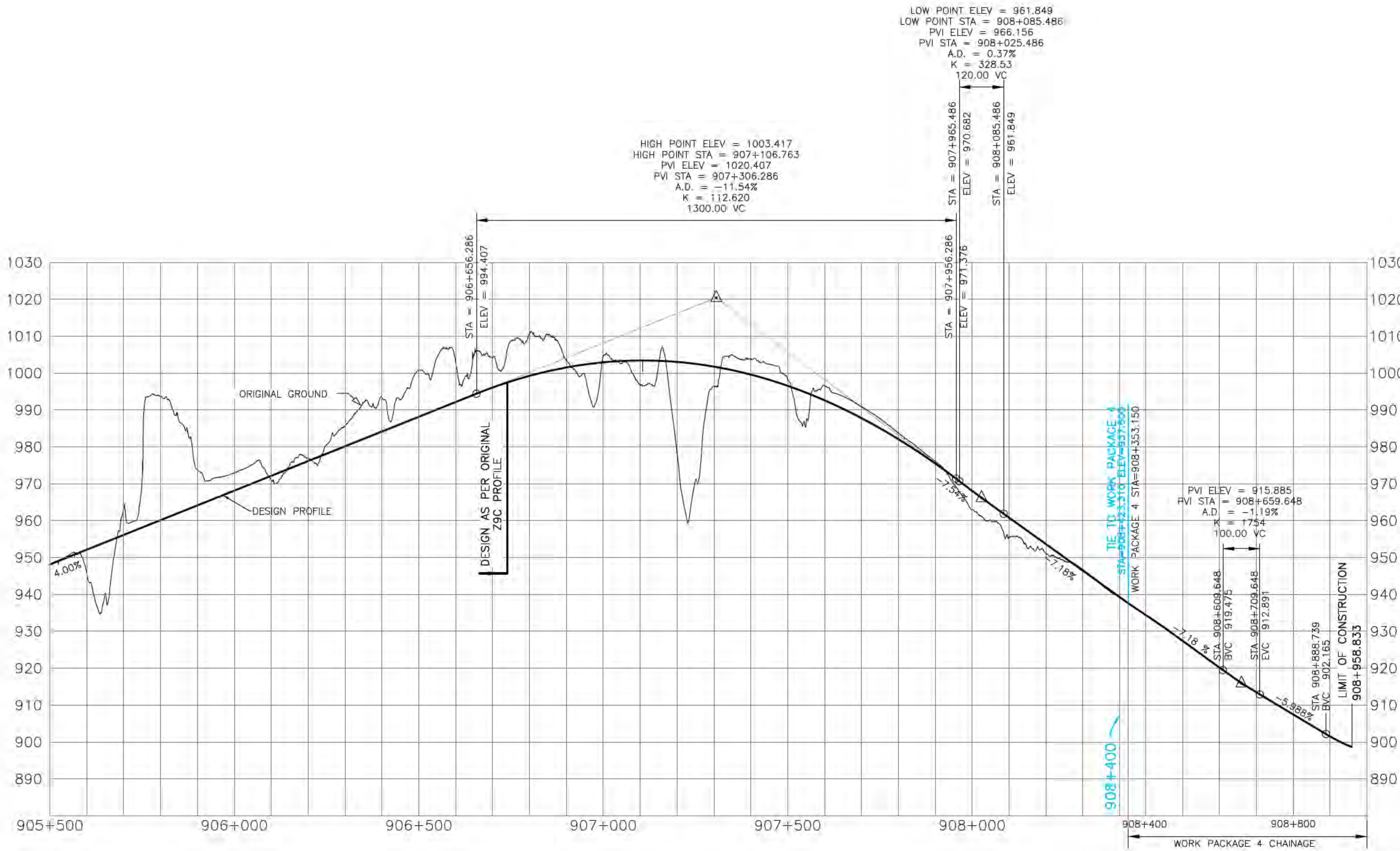
	PREVIOUS DESIGN CENTRELINE
	PROPOSED CENTRELINE
	PROPOSED AVALANCHE/ROCK DITCH
	PROPOSED ATTENUATOR MESH
	PROPOSED WALL
	PROPOSED LANE ARROW
	PROPOSED DESIGN BRIDGE
	PREVIOUS DESIGN ROAD
	PREVIOUS DESIGN BRIDGE
	EXISTING HIGHWAY



TYPICAL ROADWAY CROSS SECTION

0 20 1:2000 100m

Ministry of Transportation and Infrastructure	KICKING HORSE CANYON PROJECT PHASE 4 - CONCEPT ESTIMATE DRAWING		
	Z9C-E (2013): 4L (80 km/h)		
FILE NUMBER	DATE	SCALE	SHEET NUMBER
061300134	SEPT. 2013	1:2000	7 OF 7



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KICKING HORSE CANYON PROJECT
PHASE 4 - CONCEPT ESTIMATE DRAWING

Z9C-E PROFILE (80 km/h)

FILE NUMBER	DATE	SCALE	SHEET NUMBER
061300134	SEPT. 2013	1:10,000 (HORIZ.)	8

Appendix 3

Natural Hazard Mitigation for Proposed Z9A Through Z9A-E Routes

KICKING HORSE CANYON PROJECT
NATURAL HAZARD MITIGATION FOR PROPOSED Z9A TO Z9E ROUTES
T.S. Coulter September 13, 2013

The alignments described as Z9A through Z9E were recently developed as possible modifications of the original Z9 alignment which was developed in the Preliminary Design of the Kicking Horse Canyon Project. These alignments are along the remaining section between approximately LKI 4.2 and LKI 9 (Yoho Bridge) which has not yet been upgraded to four lanes.

Due to the difficult topography and the range of natural hazards that affect the corridor in the Kicking Horse Canyon between Golden and Yoho National Park, alignments developed in conceptual designs since the mid 1980s have included one or more tunnels, particularly in the most difficult stretch between LKI 4.2 and 9.0.

The Z9 alignment included features to provide a very high level of reliability and protection from a variety of natural hazards including landslides, debris flows and floods, avalanches, and rock falls that are encountered fairly frequently along the route. Much effort was made in the Z9 Preliminary Design to investigate such hazards, to assess the frequency and severity of the events, and to determine possible methods for mitigation, including avoidance.

NATURAL HAZARDS

The attached drawings show the location of the proposed Z9A alignment and natural hazards in the corridor, and the proposed mitigation measures.

Three major bluffs are encountered in the sector, centered at approximately LKI 4.7, 5.7 and 6.7. Mitigation of rock falls associated with these locations presents a major cost for Z9 due to the inclusion of protection structures. The rock fall criteria are summarized in the following table, including the consideration of the Design Likely and Design Maximum Particle sizes with the associated frequency of occurrence.

Shed No. /Fall Height	Location Station		Length	Particle Size	Particle Size	Velocity Range	Energy
(m)	From	To	(m)	(Criterion)	(cu.m)	(m/sec)	(kJ)
1 / 180	904+525	904+615	90	Recorded Max.	2.2	25 - 30	1800
				Design Likely (1:20 yr)	3		2500
				Design Max. (1:200yr)	5		4000
2WB / 250	905+150	905+270	120	Recorded Max	5	30 – 33	6000
				Design Likely	5		6000
2EB / 250	905+260	905+370	110	Design Max.	7		8300
3 / 180	906+350	906+700	350	Recorded Max.	2.2	25 - 30	1800
				Design Likely	4		3300
				Design Max.	6		5000

It should be noted that the Z9 protection works also contain the avalanches at these locations and maintenance of rock fall and snow avalanche events would be minimized. The structures would also provide a much greater certainty of control and protection of these events than other options.

Z9 also included a relatively short twin bore tunnel through Frenchman's Ridge (LKI 5.5). To achieve the necessary pillar on the south side and between the bores, the alignment had to be sufficiently far north of the present road such that the bore lengths were 210m in the eastbound and 340m in the westbound directions. The proposed hazard sheds were therefore a necessary requirement of this alignment.

Mitigation measures to reduce the cost of highway improvement in this sector involved elimination of the tunnel with a slight degradation of the alignment.

Elimination of the hazard sheds was achieved by:

At Shed 1

- Making a major rock excavation (80m high) with a wide catchment (15m) ditch at highway level,
- Installing a high energy rock fall attenuation mesh on the slope to reduce the potential for rocks reaching the highway.

At Shed 2

- Diverting the alignment along the existing one and including measures to protect the downslope side from landslide hazards such as occurred during previous improvements on this portion of the highway in 1950s and 1960s.
- Including a high energy rock fall attenuation mesh at the crest of the north side excavation,
- Making a wide ditch (11m) at the north side of the highway for rockfall and avalanche control.

At Shed 3

- Shifting the alignment to the south such that portion of the existing highway could be retained and used as catchment for rock falls and snow avalanches.
- Installing high energy rock fall attenuation mesh in the most severe rock fall location and providing a lower energy mesh elsewhere. Keeping part of the existing road as a bench for containing rock particles would mean attenuator mesh could likely be installed using a crane and man lift on the bench and thereby facilitating installation and future maintenance.

While a variety of energy absorbing meshes and nets are available for rock fall protection, attenuator mesh was considered to be the most appropriate in the present situation. This system is similar to hanging mesh currently in place at Blackwall Bluffs, but has a much higher energy absorption capability. The suitability of these more recently developed products was discussed with major manufacturers, rock fall consultants, and MoT Rockwork staff, and it is noted that such material has been installed by CPRail. (See attached brochure for details.)

Rock fall attenuation mesh is currently available with a maximum energy rating of 3000kJ. As seen in the table, this energy level is close to or, in the case of the bluff at LKI 4.7 less than, in the estimated 1:20 year rock fall event. Should the 1:20 year rock fall event exceed the system capacity, the mesh would sufficiently retard the energy of the rock fall so that it would be retained within the catchment ditch. In all cases the mesh would not withstand a 1:200 year event, but it is likely that the fall would also be contained within the catchment ditch. The major difference between the Design Likely and Design Maximum events would be in the severity of damage to the mesh system, including anchors, posts and mesh.

It must be noted that the proposed hazard protection measures would not be as robust as having sheds. The proposed rock fall mesh will not withstand the same level of kinetic energy as sheds. There is therefore a greater risk of particles reaching the highway, and of having more frequent and costlier maintenance of rock fall mesh.

Under the Z9 case, there is a high probability that avalanches and rockfalls would not affect the highway and that related maintenances costs would be minimal. Avalanche encroachment into the highway at the sheds would be much less than allowed under the design criteria used elsewhere within the corridor.

In the Z9A and related alignments, the avalanche design will meet the criteria for avalanche encroachment used elsewhere on the project. It must be recognized that avalanche protection measures such as at Blackwall Bluffs Sta 905+500 are hampered by the difficulty in creating wide catchment ditches. Separate avalanche fencing may be required and it is possible that such installations may be severely damaged by rockfalls. Similarly the rock fall protection measures may be affected by snow avalanches.

Thus while the avalanche and rock fall hazards will be much improved from the present conditions, the Z9A and related alignments will not provide the same degree of reliability and certainty that the Z9 alignment would provide.

Attachments:

Natural Hazard Plans for Z9A Alignment
Attenuator Brochure

SEPTEMBER 4, 2013

TERRAIN HAZARD LEGEND:

- DEBRIS SLIDE OR DEBRIS FLOW TRACK
- 60 — TERRAIN POLYGON NUMBER (refer to Maynard (2005) for details)
- 4.8 — AVALANCHE (flow path) (refer to MoT Avalanche Atlas for details)
- HIGH HAZARD ROCKFALL POLYGON
- HIGH HAZARD SLIDE POLYGON
- HIGH HAZARD DEBRIS FLOW POLYGON
- LANDSLIDE SCARP

ALIGNMENT LEGEND:

- PROPOSED WALL
- PROPOSED AVALANCHE / ROCK DITCH
- PROPOSED ATTENUATOR MESH
- APPROXIMATE EXTENT OF CUTS
- PROPOSED DESIGN BRIDGE

TERRAIN HAZARD NOTES:

1. Terrain Hazard polygons with high likelihood of activity of geomorphic process shown shaded.
2. Refer to Maynard (2005) for definition and description of processes and hazards.
3. Upper Hazard map includes rockfalls and / or small rockslides.
4. Lower Hazard map includes one or more of the following:

    Debris slides - slumps
    Debris falls
    Ravelling
    Debris floods
    Erosional scouring

GENERAL NOTES:

1. Landslide and terrain hazard figures have been prepared from a variety of sources and are not warranted as accurate.
2. The reader should refer to the original source for complete details.

KICKING HORSE CANYON PROJECT

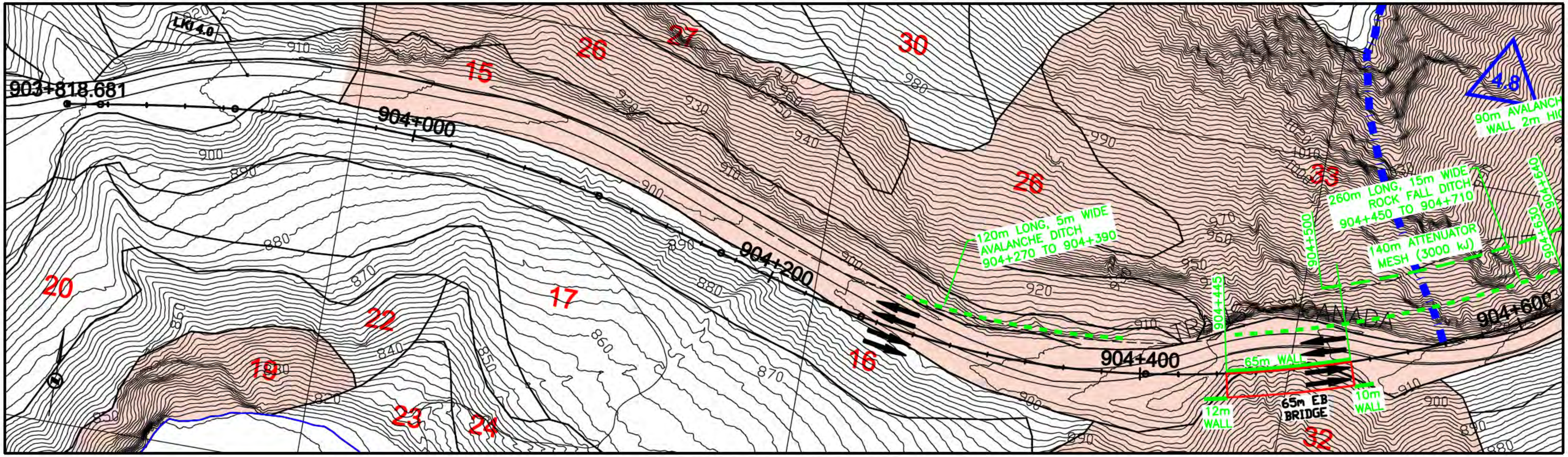
PHASE 3 CANYON - Z9A ALIGNMENT
NATURAL HAZARDS

SCALE: 1:2000

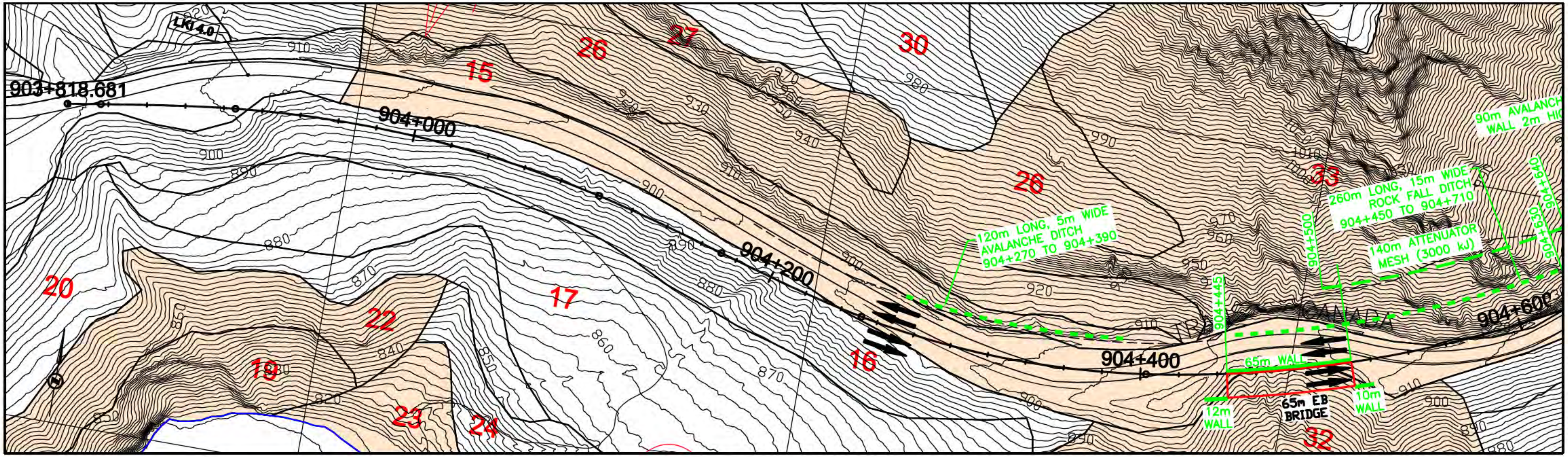
FIGURE 1

TED0424.DWG

File Number: 19-1618-165



ROCKFALL AND AVALANCHE HAZARDS



SLIDES AND DEBRIS FLOW HAZARDS

0 20 40 60 80 100 120m
SCALE 1:2000

NATURAL HAZARDS; STA. 903+818 to 904+600

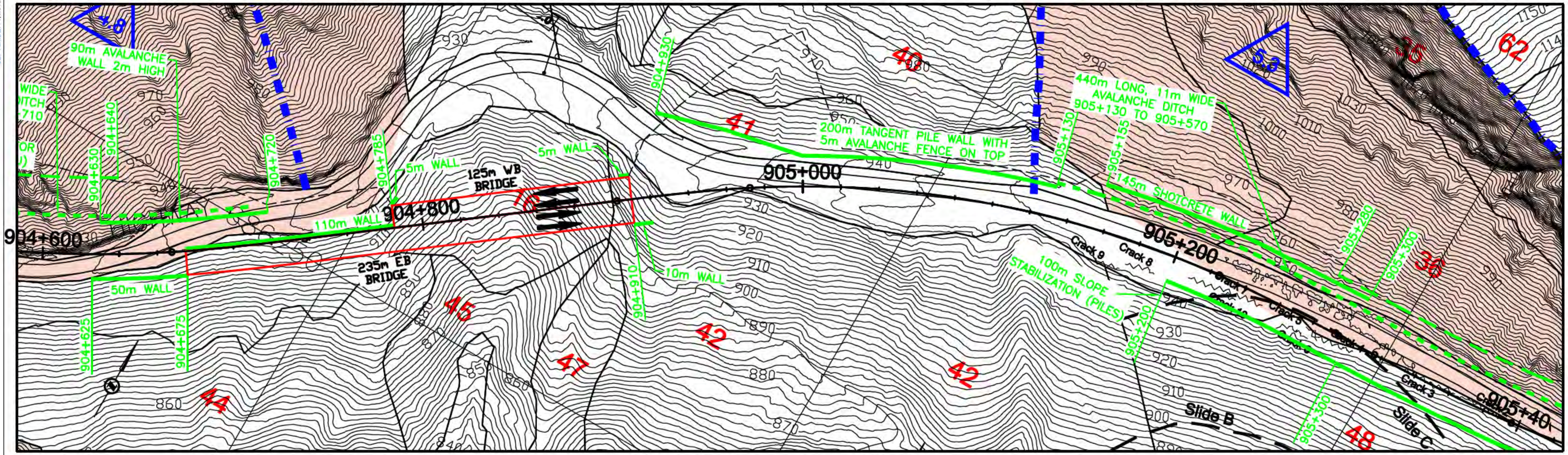
FIGURE 2

SCALE: 1:2000

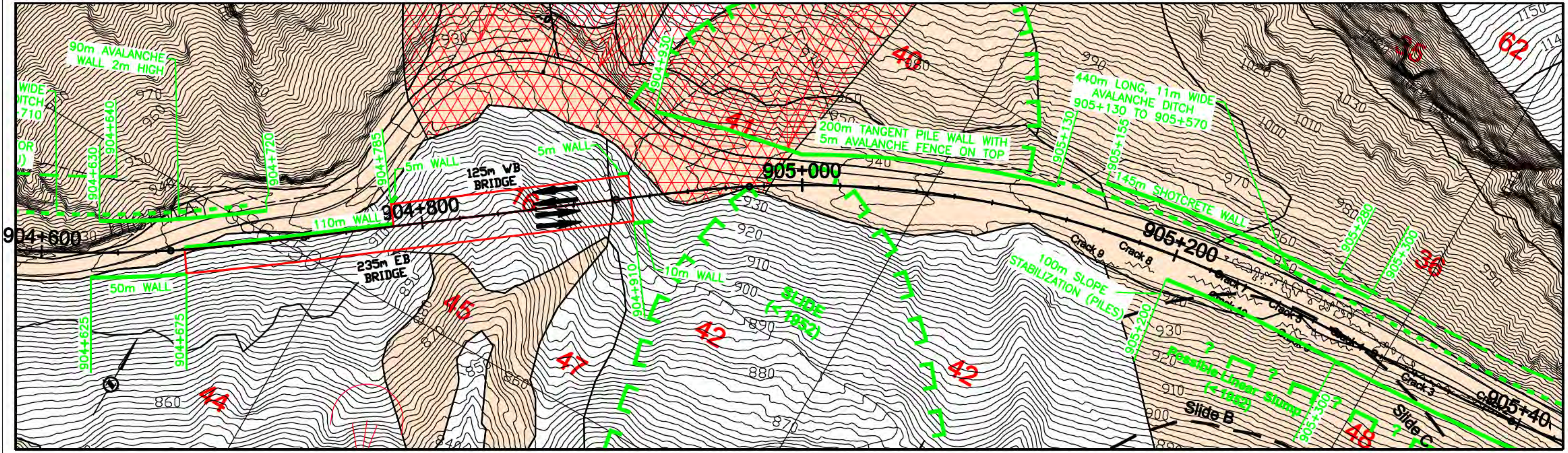
File Number: 19-1618-165

SEPTEMBER 4, 2013

TED04224.DWG



ROCKFALL AND AVALANCHE HAZARDS



SLIDES AND DEBRIS FLOW HAZARDS

0 20 40 60 80 100 120m

SCALE 1:2000

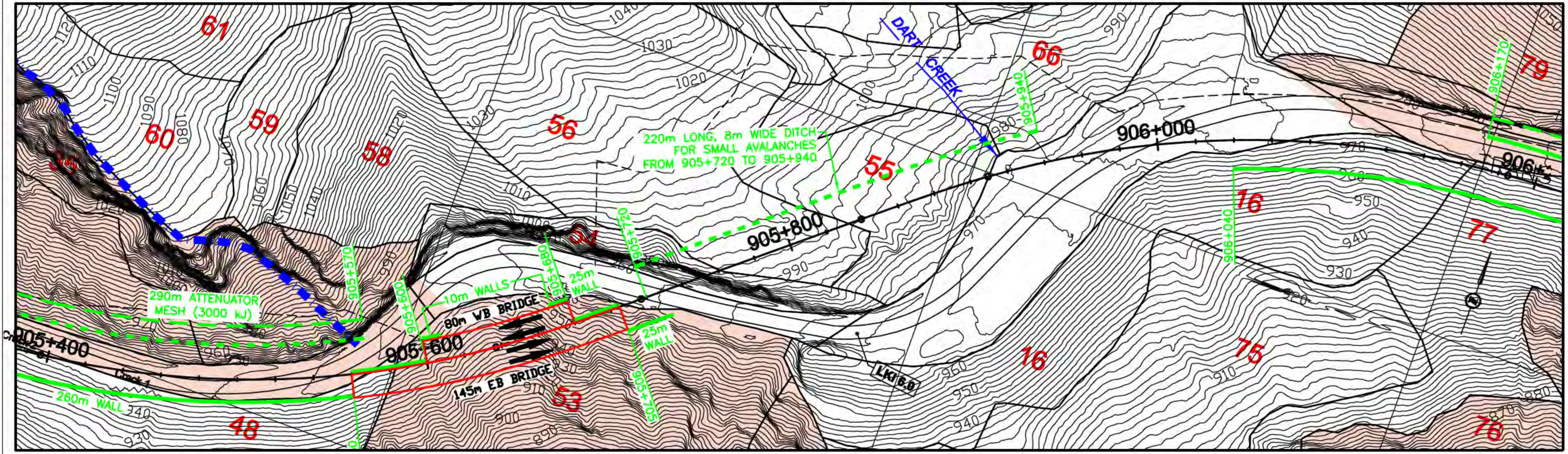
NATURAL HAZARDS; STA. 904+600 to 905+400

FIGURE 3

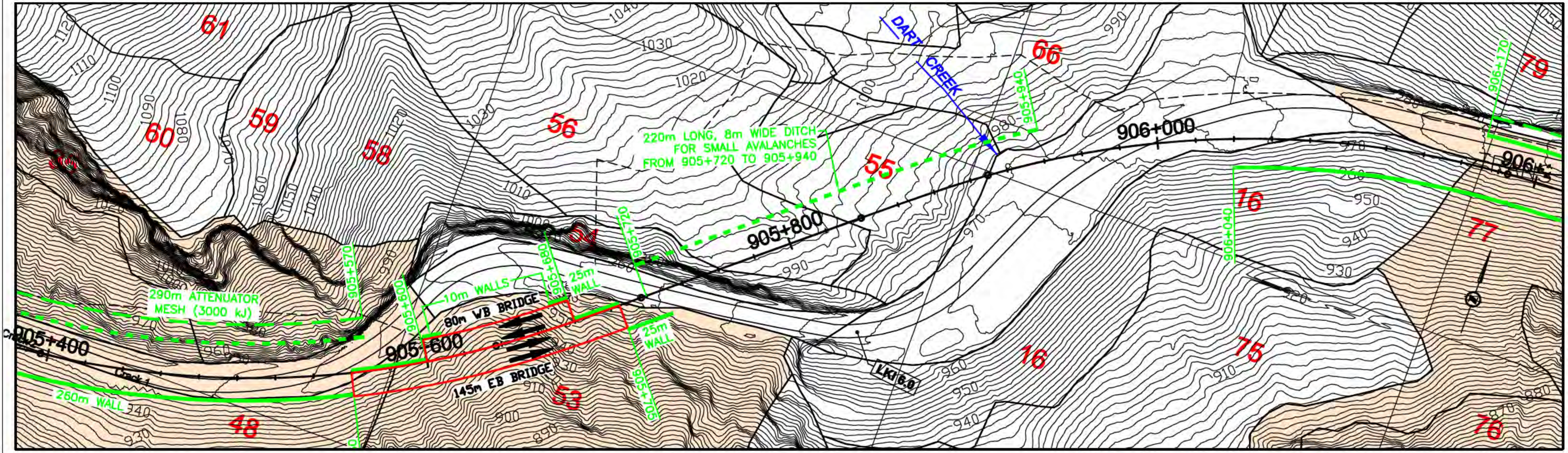
SCALE: 1:2000

File Number: 19-1618-165

SEPTEMBER 4, 2013



ROCKFALL AND AVALANCHE HAZARDS



SLIDES AND DEBRIS FLOW HAZARDS

TED0424.DWG

0 20 40 60 80 100 120m

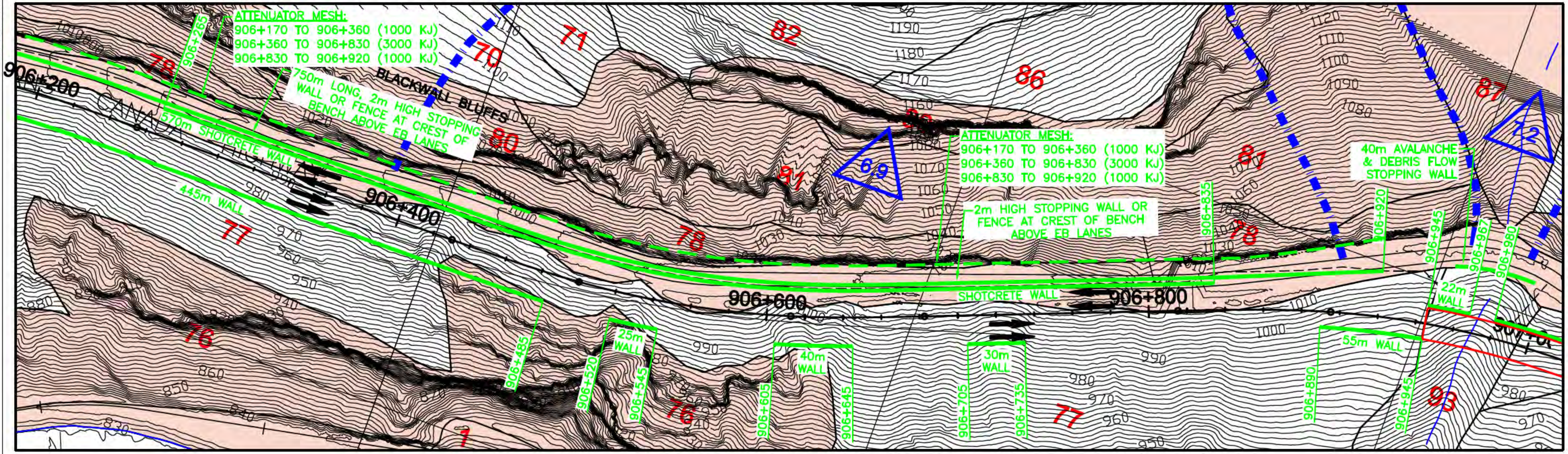
SCALE 1:2000

File Number: 19-1618-165

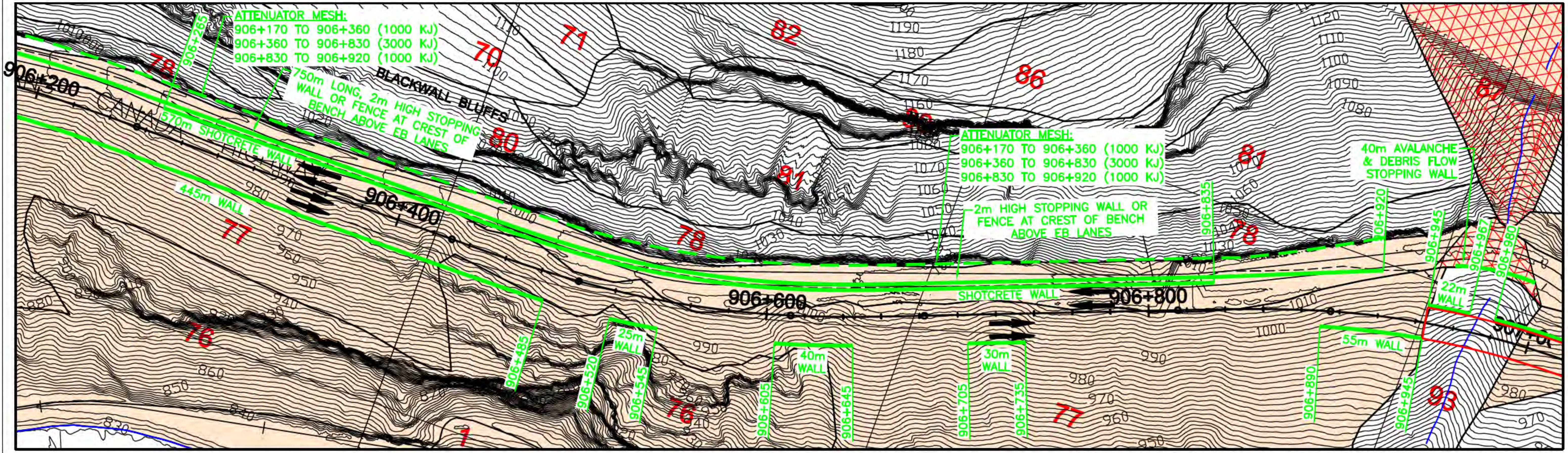
NATURAL HAZARDS; STA. 905+400 to 906+200

FIGURE 4

SCALE: 1:2000



ROCKFALL AND AVALANCHE HAZARDS



SLIDES AND DEBRIS FLOW HAZARDS

0 20 40 60 80 100 120m
SCALE 1:2000

File Number: 19-1618-165

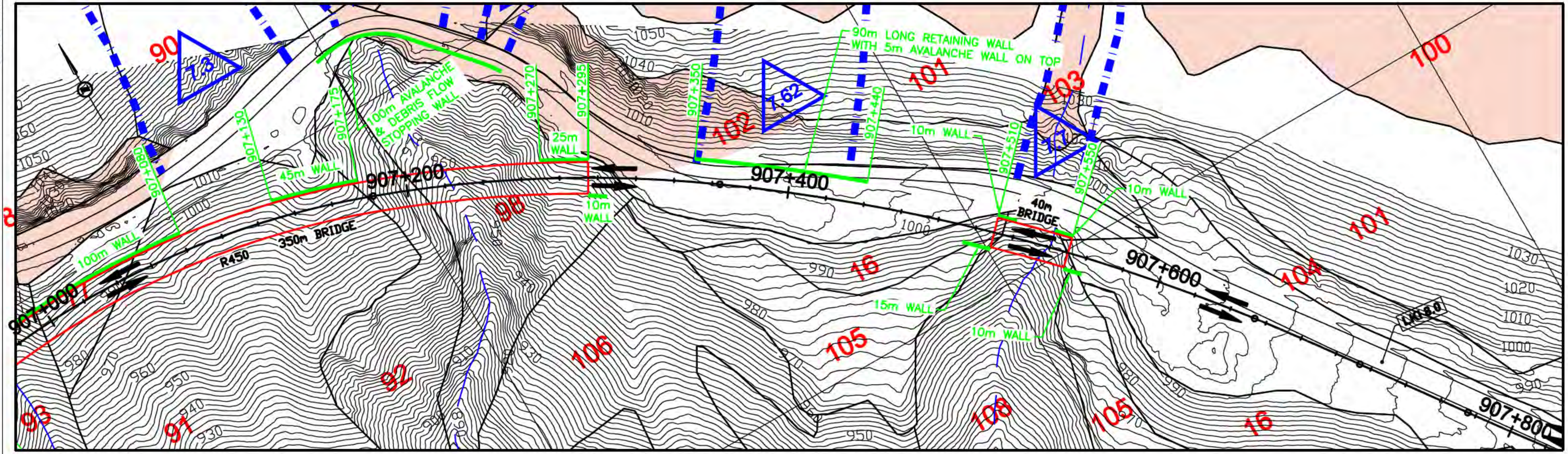
NATURAL HAZARDS; STA. 906+200 to 907+000

FIGURE 5

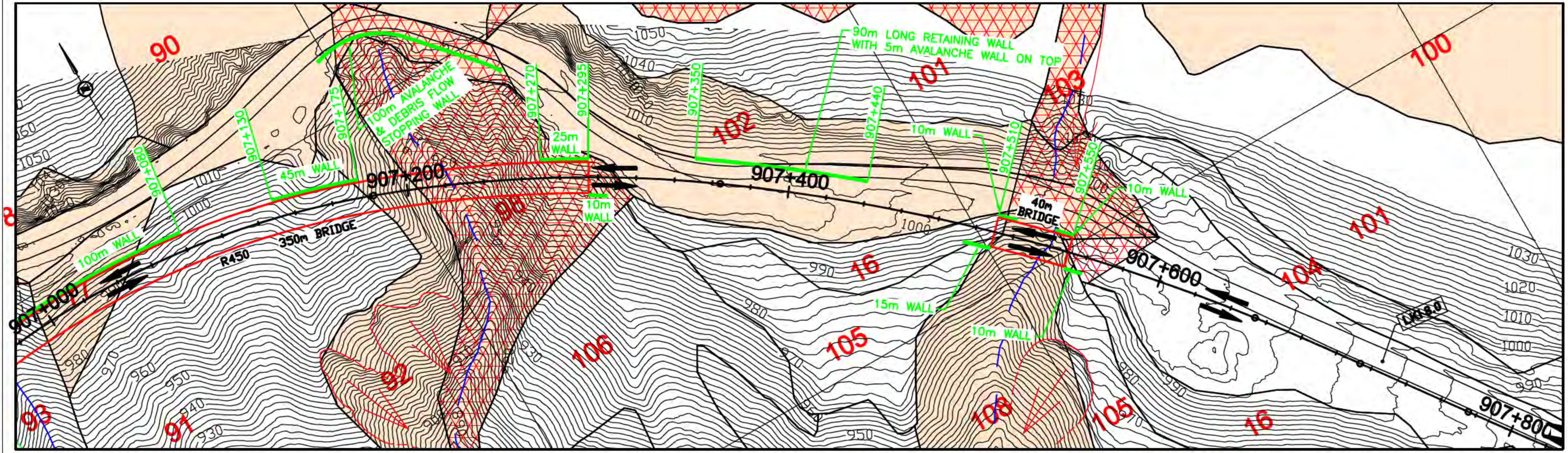
SCALE: 1:2000

SEPTEMBER 4, 2013

SEPTEMBER 4, 2013



ROCKFALL AND AVALANCHE HAZARDS



SLIDES AND DEBRIS FLOW HAZARDS

TED0424.DWG

0 20 40 60 80 100 120m

SCALE 1:2000

File Number: 19-1618-165

NATURAL HAZARDS; STA. 907+000 to 907+800

FIGURE 6

SCALE: 1:2000

Rockfall Attenuator System

Rockfall attenuator and GBE barrier
Cascade Subdivision mile 10.20, Fraser Canyon, British Columbia / Canada

Photo documentation / October 2011

Rockfall attenuator system and GBE barrier mitigate rockfall and limited access maintenance

Tony Morris, P.Geo.	Canadian Pacific tony_morris@cpr.ca, 403-319-6617
Duncan C. Wyllie, P. Eng.	Wyllie & Norrish Rock Engineers Ltd. dwyllie@wnrockeng.com, 604-691-1717
Calvin Ecklund	Emil Anderson Construction cecklund@eac.bc.ca, 250-417-7160
Tim Shevlin, PG	Geobrugg North America tim.shevlin@geobrugg.com , 503-423-7258

Project:	Cascade Subdivision, mile 10.20
Location:	Fraser Canyon, British Columbia, Canada
Year of Installation:	2010
Problem:	Highly active, high hazard rock fall area
Protected object:	Busy railway track
Protection measure:	Attenuator net and GBE-500A barrier
Installation:	Crane, man-lift and helicopter
Dimensions:	
Attenuator net:	42 meter length, reaching over the rockfall chute
GBE barrier:	32 meter length, protecting the tunnel entrance

On the west side of the Fraser Canyon, British Columbia, along a short stretch of railway track there have been over 110 rock falls reported between 1975 and 2009 resulting in over eight train hits, one derailment and damage to rail infrastructure. A detailed site investigation identified the rockfall source area approximately 270 meters above the track. The rockfall were concentrated down a rockfall chute where an Attenuater system was proposed to mitigate the rockfall hazard.

The 42 meter hybrid attenuator system was constructed as a hanging system to intercept and dampen the rockfall energy in the major rockfall chute area. The design was intended to guide the rockfall trajectory under a tail drape, dissipating the kinetic energy of the falling rock. This type of system was also chosen because of its ability to reduce maintenance, particularly cost effective in a region that has such a high event rate and remote access.

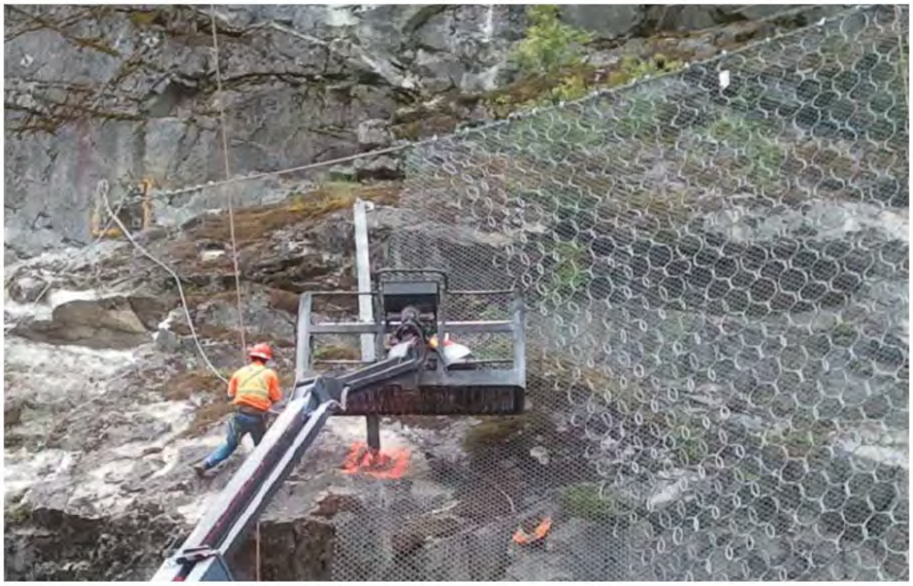
Geobrugg ROCCO® high tensile steel wire rings were used in the hanging attenuator system. In addition, sections of the system were designed to accommodate various anticipated load conditions over 1,000 kJ. The net spanned both sides of the chute area.

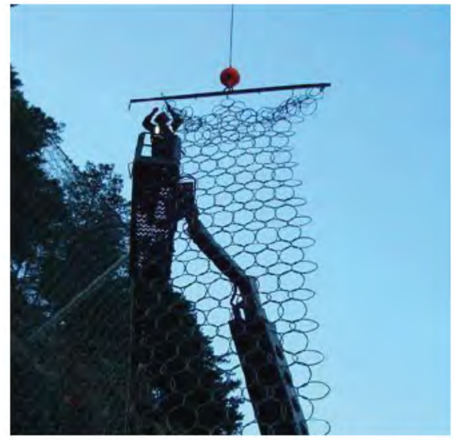
Above the nearby tunnel portal with no fallout zone, the solution of a 32 meter GBE-500A rockfall barrier with TECCO® mesh was implemented. The modular design of the GBE barrier enabled the system to be installed by helicopter in 30 minutes. The TECCO® mesh was then "curtained" between the posts along the top and bottom support ropes. The issues of site access and active train scheduling were accommodated by the quick installation of both systems. Construction required a 50 ton crane, a 20 meter reach man-lift, and a helicopter. The mitigation design for this site was developed by Wyllie & Norrish Rock Engineers.

Site overview

Source area of the rockfall

Close proximity of the railway track to the rock face





Top: Helicopter installation of the rockfall barrier and attenuator

Left: Side flank installation of the attenuator system spanning to both sides of the rockfall chute

Top: 20 m manlift crane in action for the installation

Left: Installed attenuator net

Installation of the rockfall barrier post positioned by helicopter

GBE-500A rockfall barrier protecting the tunnel entrance

Rockfall barriers

Rockfall drapes

Slope stabilization systems

Debris flow barriers

Avalanche prevention structures

Open pit rockfall barriers

Special applications

Geobrugg protects people and infrastructures from the forces of nature

It is the task of our engineers and partners to analyze the problem together with you in detail and then, together with local consultants, to present solutions. Painstaking planning is not the only thing you can expect from us, however; since we have our own production plants on four continents, we can offer not only short delivery paths and times, but also optimal local customer service. With a view towards a trouble-free installation, we deliver preassembled and clearly identified system components right to the construction site. There we provide support, if desired, including technical support – from installation right on up until acceptance of the structure.

wyllie& norrish ROCK ENGINEERS

CANADIAN PACIFIC

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Appendix 4

Preliminary Review of Avalanche Hazards to the KHCP Phase 4 Z9A (2013) Concept

MEMO

Memo to: Terry Coulter, P.Eng.
Coulter Consulting Ltd.

From: Alan Jones, P.Eng.
Dynamic Avalanche Consulting Ltd.

Date: September 3, 2013

RE: Preliminary review of avalanche hazards to the KHCP Phase 4 Z9A (2013) Concept

Alan Jones, P.Eng. of Dynamic Avalanche Consulting Ltd. (DAC) completed a preliminary review of avalanche hazard to the Kicking Horse Canyon Project (KHCP) Phase 4 Z9A (2013) Concept. A preliminary plan drawing[1] and cross sections[2] were reviewed, supplemented by information from previous reviews by Alan Jones of several concepts in the same project area.

The following memorandum presents preliminary conclusions with respect to avalanche hazard to the proposed alignment, as well as potential avalanche risk mitigation options.

1.0 Avalanche Hazard Overview

Table 1 presents a preliminary summary of avalanche hazard to the Z9A (2013) alignment, divided into discrete sections based on common avalanche hazard. Stations are presented as per the plan and cross sections, avalanche paths (location) and avalanche sizes are similar to those presented in DAC (2011[3]), alignment/structures gives a brief description of the proposed design (e.g. cut, fill, bridges, etc.), a summary of changes compared to the Z9 (2011) alignment is provided, followed by risk mitigation options. Where the alignment has not changed significantly, options are comparable to those provided in DAC (2011).

The proposed concept takes a mostly overland routing, which differs from the Z9 (2011) concept which included snow sheds in the 904+525 to 904+615 area, a tunnel and sheds in the Frenchman's Bluff and Dart Creek area, and a shed in the Blackwall Bluffs area. These mitigation options have been replaced in the Z9A (2013) concept by large rock/soil cuts with expanded rockfall catchments, structurally reinforced fills, and bridges/viaducts in different locations. The alignment has been moved closer to the slope in some locations.

The following summary points highlight the most important conclusions for our review.

1. **904+440 to 904+640**: Two mitigation options were previously considered at this location: 90 m long snow shed and a large rock cut with 20 m wide rockfall catchment. The Z9A (2013) concept presents a similar extensive rock cut with a 15 m wide rockfall catchment.

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[1] Focus Corporation (2013a). Kicking Horse Canyon Project Phase 4 – Concept Estimate Drawing. Z9A (2013): 4L-2L-3L (100 km/h). Sept. 2013.
[2] Focus Corporation (2013b). Cross sections for 904+171 to 907+000, included in digital PDF files: Z9A-2013-2.1, Z9A-2013-2.2, Z9A-2013-3.1, Z9A-2013-3.2, Z9A-2013-5.1, and Z9A-2013-5.2).
[3] Dynamic Avalanche Consulting Ltd. (DAC) 2011. Kicking Horse Canyon Project Phase 4: Snow Avalanche Loading on Hazard Protection Structures Z9 Alignment, 904+000 to 908+000. Update report, August 25, 2011.

This catchment should mitigate most (if not all) of the avalanche risk from Path 4.65 in this area, but will require a detailed analysis to confirm this.

2. **904+640 to 904+720**: The Z9A (2013) alignment is similar to the Z9 (2011) alignment, but is 18-20 m closer to the slope with a wider (15 m) wide catchment. Path 4.8 is a larger path that has the potential to cross this catchment and affect the highway, so the previously proposed 5 m high rock fall fence may still be required in this area to stop avalanches. A lower fence option (or other stopping wall type) can be considered.

3. **904+940 to 905+150** (west approach to Frenchman's Bluff): Z9A (2013) alignment is typically 5-13 m closer to the slope than Z9 (2011), but a 6 m wide catchment will mitigate avalanche risk that originates from the cut slopes and natural slopes above the cut.

4. **905+150 to 905+570 (Frenchman's Bluff)**: The Z9 (2011) snow/rock fall sheds are replaced by large rock cuts, 10-40 m high with a 10 m wide rock fall catchment. The catchment will mitigate risk from the smaller avalanches at the eastern end of the bluff (e.g. east of approximately 905+550) and the more frequent, smaller avalanches at the western end of this section. However, larger avalanches in the western part of this section could be expected to cross the catchment and affect the highway. More detailed analyses will be required to estimate the frequency and mitigation requirements in this section. Additional protection requirements (e.g. stopping barriers, fences) should be anticipated at the larger gully locations noted in Table 1.

5. **905+720 to 905+960 (Dart Creek)**: The move of the alignment away from Dart Creek removes the requirement for tunnel portal protection sheds. However, the large (20-80 m long) soil cuts may produce small (Size 1-2), frequent avalanches. The 8-10 m wide catchment will provide adequate protection where included, but ditch capacity should be evaluated for 905+850 to 905+960 where a smaller ditch is currently proposed.

6. **906+420 to 906+750 (Blackwall Bluffs)**: The Z9 (2011) shed from 906+350 to 906+700 is replaced with 10-15 m high rock cuts with a 10-15 m wide rock fall catching bench. Benches would stop small, more frequent avalanches, but in major snow winters the bench would fill with snow and larger (Size 2.5) avalanches could be expected to affect the highway. Additional protection requirements (e.g. barriers on the south end of the catching bench) should be anticipated in key areas, particularly the distinct gullies noted in Table 1. This area will require detailed analyses of these small terrain features to determine mitigation requirements.

7. **906+940 to 907+010 (Path 7.2)**: The Z9A (2013) alignment is approximately 35 m closer to the slope, and the 4 m bridge clearance at the gully (906+980) is insufficient to pass avalanches. Either additional clearance will need to be provided for dense, flowing avalanches or a stopping wall/fence structure will be required at the current highway grade. A 5-6 m height by 50 m length can be used for preliminary costing purposes.

8. **907+060 to 907+150 (Path 7.3)**: Path 7.3 is a somewhat indistinct path which passed under the bridge on the Z9 (2011) alignment. The Z9A (2013) alignment is 40-45 m closer to the slope and we assume will be an overland construction (no sections were available for evaluation). Detailed analyses may show that most avalanches will stop on the current highway grade; if not, then additional mitigation (e.g. bridge clearance above gully or stopping barrier at current highway grade) may be required.

9. **907+280 to 907+460 (Path 7.62)**: The Z9A (2013) alignment is 20-30 m closer to the slope than the Z9 (2011) alignment, which increases the risk from Path 7.62. No sections were available, but we assume that this will be an overland construction. Additional detailed analyses will allow us to refine the exact locations of avalanche effect, but expect mitigation requirements to include an additional stopping barrier at highway level (estimate 80 m long by 5-6 m high).

10. **907+500 to 907+560 (Path 7.7)**: The Z9A (2013) alignment is 15-20 m closer to the slope than the Z9 (2011) alignment, which increases the risk from Path 7.7. Assuming an overland construction, an approximately 6 m high by 70 m long stopping wall should be anticipated at this location, similar to the previously recommended wall.

11. **907+560 to 908+000**: Cross sections were not available, but we anticipate there may be longer soil/rock cuts required in this section that could produce small avalanches. There are no distinct avalanche paths, but adequate catchment width should be provided to retain sloughing snow and small avalanches from any longer cut slopes.

2.0 Summary

The preceding section and Table 1 summarize anticipated avalanche hazards and mitigation options for the proposed Z9A (2013) concept, with comparison to the previous Z9 (2011) alignment where applicable.

The previous tunnel and snow shed concepts have been replaced by a combination of rock/soil cuts and wide rock fall catchments. In some areas these will be sufficient to mitigate avalanche hazards on their own; in other areas with larger avalanche hazards and/or more frequent avalanches, additional mitigation measures will be required, namely highway-level barriers.

Specific barrier types should be evaluated in conjunction with the rock fall mitigation requirements, but it may be assumed that where the is limited width available adjacent to the highway, wire mesh rock fall fences should be considered, as was discussed in DAC (2011) and previous work by Wyllie & Norrish Rock Engineers. Where there is sufficient construction area available (e.g. on the existing highway at gullies at the eastern end of the alignment), then other standard barriers should be considered (e.g. lock block, gabion, earth fill).

With respect to avalanche hazards, the Z9A (2013) concept appears feasible, with a reduction in costs associated with tunnels and snow/rock fall sheds being replaced with some additional requirements for highway level stopping barriers.

This primarily overland construction concept will require additional, more detailed analyses of avalanche hazards, with additional consideration of smaller, terrain features (e.g. gullies) within previously identified avalanche areas. These areas were not previously evaluated where snow / rockfall sheds provided protection since the sheds mitigated risk from all terrain features in these sections. Detailed analyses will allow us to determine specific areas where additional barriers may be required versus areas where wide catchments will mitigate avalanche risk.

I trust that the information presented in this memorandum provides sufficient information for costing purposes for the Z9A (2013) concept. Please contact me should you have questions about information provided in this memorandum, or require additional work on the next phases of this project.

Sincerely,

Dynamic Avalanche Consulting Ltd.

Alan Jones, P.Eng.
Principal

From (km)	To (km)	Section Length (m)	Location/Path	Avalanche Size	Alignment/Structures	Changes from Previous (Z9 2011) Alignment	Risk Mitigation Options for Avalanche Hazards
Western Limit of Construction at 904+171							
904+171	904+280	109	4.6	Size 2, infrequent 2 5	Fill with some improved ditch sections	Alignment same as previous.	Tie in recommendations with previous recommendations for 4km Wall section. Additional ditch width may be required to accomodate Size 2 avalanches from cut and above.
904+280	904+440	160	4 6 and 4 65	Size 2, infrequent 2 5	Mostly at current grade, minor cut	Mostly along same alignment, approx. 6 m closer to slope near 904+440	Same recommendation as previous WNRE (2008a), 5 m high rock fall fence. Lower fence option (as low as 3 m) possible with wider ditch, or just a wide ditch (5-6 m) option.
904+440	904+640	200	4 65 and 4 8	Size 2 in 4 65, Size 2-3 in 4 8	EB bridge (and some at grade), WB full bench on existing grade, 15 m wide rockfall catchment	Alignment 6-18 m closer to existing slope than 2011 alignment, but will be > 15 m from slope with catchment. Z9-2011 had shed 904+525 to 904+615. Previous (2011) alternative 904+500 - 904+630 was for 20 m wide catchment, comparable to the Z9A (2013) cut/catchment.	15 m catchment will mitigate most avalanche risk in Path 4.65 and western part of 4.8, residual risk in Path 4 8 would remain (approx. east of 904+640, detailed review required for location).
904+640	904+720	80	4.8	Size 2-3	EB bridge/retaining wall, WB on existing grade with 15 m catchment.	Alignment 18-20 m closer to existing slope than 2011 alignment, but will be > 15 m from slope with catchment.	Same recommendation as previous WNRE (2008a), 5 m high rock fall fence. Lower fence option (as low as 3 m).
904+720	904+940	220	4.9	No effect	Mostly on bridge or approaches on partial bench (current highway).	Alignment 13-20 m closer to existing slope than 2011.	None required. Alignment is located well away from avalanche hazards.
904+940	905+100	60	West end of 5.3 (Frenchmans Bluff)	Size 1-2	1 5H:1V soil cut with tangent pile wall, 6 m wide catchment	Alignment 7-13 m closer to existing slope than 2011.	6 m catchment will mitigate Size 2 avalanche hazard from cut slope.
905+100	905+150	50	West end of 5.3 (Frenchmans Bluff)	Size 1-2	Tangent pile wall, 6 m wide catchment	Alignment 0-7 m closer to existing slope than 2011, but will be 6 m from slope with catchment	6 m catchment will mitigate Size 2 avalalanche hazard from natural slope above pile wall.
905+150	905+570	420	5.3 (Frenchmans Bluff)	Size 2-3	10-40 m high rock cut, highway on full bench, 10 m wide catchment	Alignment trends away from Frenchmans Bluff from 905+170 eastwards, EB and WB lanes mostly along existing alignment but below current grade. Z9-2011 included tunnel and portal sheds.	10 m wide catchment will be effective for smaller, more frequent avalanches, but larger (Size 3) avalanches would still affect the highway. Additional barrier (fence) may be required at some locations, notably the larger gullies (905+180, 905+230, 905+260, 905+280, 905+300, 905+320). Catchment may be adequate for paths at eastern end of Frenchman's Bluff. Detailed analyses will be required for these paths.
905+570	905+600	30	5.3 (Frenchmans Bluff)	Size 2	Highway on partial bench, transition to bridge, 10 m wide catchment	Alignment moves away from slope, Z9-2011 in tunnel/sheds	No hazard, small avalanches stop in catchment.
905+600	905+720	120	Dart Creek	No effect	Bridge and approaches	Alignment spans gully whilhe Z9-2011 in Dart Creek area with east portal sheds.	No hazard, small avalanches stop on current highway bench.
905+720	905+960	240	Dart Creek	Size 1-2 Potential	20-80 m soil cuts, some rock cuts and wide (8-10 m) catchment	Alignment located downslope (south) of Z9-2011 alignment, alignments merge near 905+960.	Potential creation of long (up to 80 m), steep (1 5H:1V) soil cuts, no effect to highway where wide catchment, but requires evaluation for sufficient ditch capacity for sluffing and small avalanches for 905+850 to 905+960.
905+960	906+180	220	No path	No effect	Combination full bench with small cuts and retaining wall on fill.	Close to original Z9-2011 alignment	Minor slouging off cuts will stop in ditch, no avalanche hazard.
906+180	906+420	240	Smaller, steep cliffs west of Blackwall Bluffs	Sluffing off cut/bluffs, Size 1-2 from above trees	Small, steep cuts with 6-10 m wide rockfall stopping bench, small ditch, some fill retaining walls.	Close to original Z9-2011 alignment	Bench and small ditch will capture most Size 2 avalanches and sluffing.
906+420	906+750	330	6 9 (Blackwall Bluffs)	Size 1-2.5	10-15 m high rock cuts with 10-15 m wide rockfall catching bench above.	Alignment 7-10 m south (away from slope) compared to Z9-2011. Previous shed 906+350 to 906+700.	Catching bench will stop smaller avalanches, but larger (Size 2 5) wil continue and plunge onto highway off rock cut. Additional stopping wall/fence structure will likely be required in key locations (e g. 906+530, 906+590, 906+620, 906+680, 906+700, 906+720, 906+740)
906+750	906+880	130	6.9 and 7.0 (east end of Blackwall Bluffs)	Size 2	15 m high rock cuts with 8-10 m wide rockfall catching bench above.	Alignment closer to slope by 0-20 m at eastern end of segment. Z9-2011 crosses gully further to the south.	Catching bench should catch most small avalanches, otherwise ditch will catch remainder. No additional mitigation expected. Evaluate path 7 which reaches highway near 906+860 to see if there is potential to reach highway with bench above.
906+940	907+010	70	7.2	Size 2 5-3.5	EB lanes on bridge or cantilevered bridge, WB lane below current highway fill	Alignment approx. 35 m closer to slope at gully crossing	4 m bridge clearance at gully centreline (906+980) insufficient to pass Size 3 avalanches. Will require combination stopping wall and enlarged catchment at current highway to reduce risk.
907+060	907+150	90	7.3	Size 2 5-3.5	No sections available. Assume WB lanes on cut, EB partially on bridge or reinforced fill.	Alignment approx. 40-45 m closer to slope at gully crossing.	Most avalanches will stop on current highway bench, but potential for larger avalanches to reach highway. Requires additional evaluation. Mitigation options include stopping wall on current grade and/or increased catchment area. Likely insufficient bridge clearance for avalanches to flow under the bridge.
907+180	907+280	100	7.4, 7.6 (Bus Corner)	Size 2 5-3.5	No sections available. Assume bridge spans gully completely.	Alignment approx. 40 m closer to slope at gully crossing.	Most avalanches will stop on current highway bench, larger avalanches will continue down gully and are expected to pass underneath the bridge. Reinforced piers may be required if located in gully.
907+280	907+460	180	7 62	Size 2 5-3.0	No sections available. Assume highway mostly at grade with rock/soil cuts.	Alignment approx. 20-30 m closer to slope than Z9-2011.	More detailed analysis required to determine areas of increased hazard from 7 62 at highway. Path currently mapped as affecting a wide area, but could be refined. May require catchment bench and/or stopping wall above highway.
907+500	907+560	60	7.7	Size 2 5-3.0	No sections available. Assume highway mostly at grade with rock/soil cuts.	Alignment approx. 15-20 m closer to slope than Z9-2011.	Assume insufficient bridge clearance for avalanches, so construct 6 m high x 70 m long earth fill stopping dam on old highway bench (as per previous recommendation).
907+560	908+000	440	No path	Size 1-2 sluffing potential off cut slopes	No sections available. Assume highway at grade with rock and soil cuts.	Alignment approx. 10-15 m closer to slope than Z9-2011.	No avalanche paths identified in this section, Path 8.4 starts to affect highway east of alignment endpoint. May be sluffing potential off any long rock/soil cuts, provide adequate catchment for longer slopes.
Eastern Limit of Construction at 908+000							

Appendix 5

Cost Estimates Summaries

		ALIGNMENT Z9A-SUM-2013		**4L-2L-3L (100Km)**		
		WP-01,02 & 03			**Management**	**Total Costs**
	SUMMARY BY ACTIVITY LEVEL		**Base**	**Contingency**	**Reserve and**	
			(2013$)	**(2013$)**	**Escalation**	
2000		PROJECT MANAGEMENT	[redacted]			
-------------	-----------	--				
2500		PLANNING				
3000		PRELIMINARY DESIGN				
3500		DETAILED DESIGN				
		Total Engineering				
-------------	-----------	--				
4000		LAND ACQUISITION				
-------------	-----------	--				
5000		GRADE CONSTRUCTION				
5200		ROAD SIDE CONSTRUCTION				
5300		OTHER CONSTRUCTION				
5500		STRUCTURAL CONSTRUCTION				
6000		PAVING CONSTRUCTION				
6500		OPERATIONAL CONSTRUCTION				
6700		UTILITY CONSTRUCTION				
6800		RESIDENT ENGINEERING				
		Total Construction				
-------------	-----------	--				
9700		CONTINGENCY				
-------------	-----------	--				
		SUB-TOTAL				
9800		MANAGEMENT RESERVE (2013$)				
-------------	-----------	--				
		TOTAL				
-------------	-----------	--				
9900		ESCALATION- BASED ON A DEFINED CASH FLOW -STARTING IN 2014 AND COMPLETING IN 2019				
-------------	-----------	--				
		TOTAL COST in (2013$ and 2019)				
========	======	=================================				
9900		**Note to Escalation**				
		If the cash flow is changed due to timing				
		then the escalation will change.				

		ALIGNMENT ZA-D-SUM-2013		**4L-4L (100Km)**		
		WP-01, 02, 03 & 04			**Management**	**Total Costs**
	SUMMARY BY ACTIVITY LEVEL		**Base**	**Contingency**	**Reserve and**	
			(2013$)	**(2013$)**	**Escalation**	
2000		PROJECT MANAGEMENT	[redacted]			
-------------	------------	--	-------			
2500		PLANNING				
3000		PRELIMINARY DESIGN				
3500		DETAILED DESIGN				
		Total Engineering				
-------------	------------	--	-------			
4000		LAND ACQUISITION				
-------------	------------	--	-------			
5000		GRADE CONSTRUCTION				
5200		ROAD SIDE CONSTRUCTION				
5300		OTHER CONSTRUCTION				
5500		STRUCTURAL CONSTRUCTION				
6000		PAVING CONSTRUCTION				
6500		OPERATIONAL CONSTRUCTION				
6700		UTILITY CONSTRUCTION				
6800		RESIDENT ENGINEERING				
		Total Construction				
-------------	------------	--	-------			
9700		CONTINGENCY				
-------------	------------	--	-------			
		SUB-TOTAL				
9800		MANAGEMENT RESERVE (2013$)				
-------------	------------	--	-------			
		TOTAL				
-------------	------------	--	-------			
9900		ESCALATION- BASED ON A DEFINED CASH FLOW -STARTING IN 2014 AND COMPLETING IN 2019				
-------------	------------	--	-------			
		TOTAL COST in (2013$ and 2019)				
========	=======	==================================	====			
9900		**Note to Escalation**				
		If the cash flow is changed due to timing				
		then the escalation will change.				

		ALIGNMENT Z9B-SUM-2013		**3L-2L-3L (100Km)**		
		WP-01,02 & 03			**Management**	**Total Costs**
	SUMMARY BY ACTIVITY LEVEL		**Base**	**Contingency**	**Reserve and**	
			(2013$)	**(2013$)**	**Escalation**	
2000		PROJECT MANAGEMENT	[redacted]			
-------------	------------	--	----			
2500		PLANNING				
3000		PRELIMINARY DESIGN				
3500		DETAILED DESIGN				
		Total Engineering				
-------------	------------	--	----			
4000		LAND ACQUISITION				
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5000		GRADE CONSTRUCTION				
5200		ROAD SIDE CONSTRUCTION				
5300		OTHER CONSTRUCTION				
5500		STRUCTURAL CONSTRUCTION				
6000		PAVING CONSTRUCTION				
6500		OPERATIONAL CONSTRUCTION				
6700		UTILITY CONSTRUCTION				
6800		RESIDENT ENGINEERING				
		Total Construction				
-------------	------------	--	----			
9700		CONTINGENCY				
-------------	------------	--	----			
		SUB-TOTAL				
9800		MANAGEMENT RESERVE (2013$)				
-------------	------------	--	----			
		TOTAL				
-------------	------------	--	----			
9900		ESCALATION- BASED ON A DEFINED CASH FLOW -STARTING IN 2014 AND COMPLETING IN 2019				
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		TOTAL COST in (2013$ and 2019)				
========	=======	==================================	==			
9900		**Note to Escalation**				
		If the cash flow is changed due to timing				
		then the escalation will change.				

		ALIGNMENT ZC-SUM-2013		**4L-2L-3L (80Km)**		
		WP-01,02 & 03			**Management**	**Total Costs**
	SUMMARY BY ACTIVITY LEVEL		**Base**	**Contingency**	**Reserve and**	
			(2013$)	**(2013$)**	**Escalation**	
2000		PROJECT MANAGEMENT	[redacted]			
-------------	------------	--	------			
2500		PLANNING				
3000		PRELIMINARY DESIGN				
3500		DETAILED DESIGN				
		Total Engineering				
-------------	------------	--	------			
4000		LAND ACQUISITION				
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5000		GRADE CONSTRUCTION				
5200		ROAD SIDE CONSTRUCTION				
5300		OTHER CONSTRUCTION				
5500		STRUCTURAL CONSTRUCTION				
6000		PAVING CONSTRUCTION				
6500		OPERATIONAL CONSTRUCTION				
6700		UTILITY CONSTRUCTION				
6800		RESIDENT ENGINEERING				
		Total Construction				
-------------	------------	--	------			
9700		CONTINGENCY				
-------------	------------	--	------			
		SUB-TOTAL				
9800		MANAGEMENT RESERVE (2013$)				
-------------	------------	--	------			
		TOTAL				
-------------	------------	--	------			
9900		ESCALATION- BASED ON A DEFINED CASH FLOW -STARTING IN 2014 AND COMPLETING IN 2019				
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		TOTAL COST in (2013$ and 2019)				
========	=======	==================================	===============	==============	=============	================
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9900		**Note to Escalation**				
		If the cash flow is changed due to timing				
		then the escalation will change.				

		ALIGNMENT ZC-E-SUM-2013		**4L-4L (80Km)**		
		WP-01, 02, 03 & 04			**Management**	**Total Costs**
	SUMMARY BY ACTIVITY LEVEL		**Base**	**Contingency**	**Reserve and**	
			(2013$)	**(2013$)**	**Escalation**	
2000		PROJECT MANAGEMENT	[redacted]			
2500		PLANNING				
3000		PRELIMINARY DESIGN				
3500		DETAILED DESIGN				
		Total Engineering				
4000		LAND ACQUISITION				
5000		GRADE CONSTRUCTION				
5200		ROAD SIDE CONSTRUCTION				
5300		OTHER CONSTRUCTION				
5500		STRUCTURAL CONSTRUCTION				
6000		PAVING CONSTRUCTION				
6500		OPERATIONAL CONSTRUCTION				
6700		UTILITY CONSTRUCTION				
6800		RESIDENT ENGINEERING				
		Total Construction				
9700		CONTINGENCY				
		SUB-TOTAL				
9800		MANAGEMENT RESERVE (2013$)				
		TOTAL				
9900		ESCALATION- BASED ON A DEFINED CASH FLOW -STARTING IN 2014 AND COMPLETING IN 2019				
		TOTAL COST in (2013$ and 2019)				
9900		Note to Escalation				
		If the cash flow is changed due to timing				
		then the escalation will change.				