Kicking Horse Canyon Project - Phase 4

RISK REVIEW REPORT

June 2019

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1. INTRODUCTION

1.1. PURPOSE

The purpose of this report is to document the risk analysis process for the Kicking Horse Canyon Project Phase 4 (Project) at the procurement stage. The Project is being delivered by the Province of British Columbia (the Province). Key areas covered by this report include:

- An overview of the Project's Risk Management Methodology
- Summary of the Risk Analysis conducted by the Project team

1.2. SCOPE AND CONTEXT

This report reflects the risk management work that has been completed by the Project Team to date. The process has primarily focused on identifying specific Project risks, allocating those risks between the Province and private partner (Contractor), developing potential risk management strategies and incorporating quantified risks into the financial analysis of the Project budget. The Risk Register has been reviewed and updated several times since it was initially created; this report and the Risk Register reflect the cumulative results of the reviews.

1.3. PROJECT BACKGROUND

The Kicking Horse Canyon Project Phase 4, is a four laning project on the TransCanada Highway, located east of the Town of Golden.

This final phase of the Project will:

- Widen the final 4.8 kilometres through the canyon from West Portal to Yoho Bridge to four lanes including median barrier and wider shoulders;
- Improve the alignment of the highway;
- Mitigate snow avalanche and rock fall hazards to improve safety and reliability; and
- Add wildlife exclusion fencing and wildlife passage to reduce vehicle-animal collisions.

For a more detailed description of the Project background and scope, refer to the Trans Canada Highway Kicking Horse Canyon Project Phase 4: West Portal to Yoho Bridge Business Case.

2. RISK MANAGEMENT METHODOLOGY

2.1. RISK IDENTIFICATION

The Risk Register for this project is a log of all identified risks and describes how the risks are identified, analyzed, their probability of occurrence, the category they belong to, their mitigation strategy, and when the risks might occur. The Risk Register utilized the preliminary risk assessment, completed for the Project in 2014. The Risk Register document includes:

- Risk Name and Number;
- A description of each risk and possible effect (budget (estimated minimum and maximum cost), schedule or reputation);
- Likelihood of occurrence;
- Impacts to project and inherent risk level based on Risk Matrix;
- Risk Response Strategy and Plan (accept, avoid, mitigate, transfer);
- Risk Owner – team member responsible to report and implement response plan;
- Risk Status – active or retired; and
- Fiscal year of risk exposure.

2.2. QUALITATIVE ANALYSIS

Qualitative analysis is conducted by consulting with Project Team members, subject matter experts, and key stakeholders throughout the project lifecycle. These occur through risk workshops.

During the risk workshop, participants:

- Review and update the status of existing risks;
- Identify new risks;
- Assign risk owners to the newly identified risks;
- Quantify new risks; and
- Determine responses to new and existing risks.

The Executive Project Director, Project Advisors, technical and procurement leads participated in multiple risk review workshops held in Vancouver in Summer 2018 and Winter 2019. The workshop participants represented the technical fields of road design, environmental design, geometric design, structural design, geotechnical design, avalanche design, as well as procurement, project management and construction.

Each risk was assigned to a Project Team member (i.e. risk owner) for on-going review of risks. The output of the detailed review was documented in the Risk Register including the likelihood and impact of the risk. The updated Risk Register was then reviewed by the Project's Lead Engineer, Lead Design Engineer and Construction Manager as internal due diligence. Follow-up sessions based on the internal due diligence recommendations were conducted with the risk owners.

2.3. QUANTITATIVE ANALYSIS

The Project uses the Monte Carlo method of quantitative risk analysis. A Monte Carlo analysis is a modeling technique used to predict the outcome of a specified set of uncertain events (risks), and the possible impact of these events in terms of cost or schedule. Risks are monetized and represented as a range of possible values with some measure of likelihood of occurrence. A Monte Carlo simulation can be thought of as a representation of the many "what-if" scenarios that could occur due to project risk. The outcome is used to quantify a risk estimate, often for contingency purposes, and to develop risk response strategies to monitor and control priority risks captured in the Risk Register.

The Project Team evaluated the cost impact of a risk on the overall Project objectives by estimating the cost should the individual risk event occur. For each risk, the risk owner must identify the most likely cost when the risk triggers, the minimum possible cost when the risk triggers, and the maximum possible cost when the risk triggers. Each risk is then assigned a likelihood against the most likely cost.

Risk quantification is performed in consultation with subject matter experts, project managers, project team leads, quantity estimators, other applicable team members.

To determine the severity of the risks identified, a probability and impact factor is assigned to each risk as shown in Table 2.1.

Table 2.1 – Probably/Impact Table

LIKELIHOOD		Insignificant	Minor	Significant	Major	Severe
Almost Certain	90-100%	LOW	MED	HIGH	EXT	EXT
Likely	55-89%	LOW	MED	HIGH	HIGH	EXT
Possible	25-54%	LOW	MED	MED	HIGH	HIGH
Unlikely	5-24%	LOW	LOW	MED	MED	MED
Rare	0-4%	LOW	LOW	LOW	LOW	LOW
Cost Impacts (Approval Level)		<$100K (PM)	$100K-$250K (RMPD)	$250K - $1M (RD)	$1M-$5M (ADM)	>$5M (DM)
Schedule Impacts		< 1 month	1-3 month	3-6 month	6-12 month	>12 month
				IMPACT		

This process allows the Project Team to prioritize risks based on the anticipated severity and probability of impact they may have on the Project.

The risk categories include:

- Project Management – risks associated with project owner/project organization including resources, market conditions and procurement, etc.
- Planning – risks associated with project planning including conflicts with local industry/development, climate changes and availability of engineering capacity, etc.
- Engineering Design – risks associated with design criteria, innovation, suitability of refence concept, etc.
- Geotechnical – risks associated with geotechnical uncertainties, unknown ground conditions, rock fall hazards, risks on structural foundations, etc.
- Environment – risks associated with all potential environmental impacts
- Archaeology – risks associated with archaeology impacts
- Properties – risks associated with land tenure
- Construction – risks associated with construction of the project including site safety, schedule, claims, traffic management, constructability, etc.
- Indigenous Relations – risks associated with negotiating with Indigenous Communities.
- Communications – risks associated with public support
- Third Party (Municipalities, Railways, Utilities) – risks associated with utility relocation, CP railway interface
- Funding – risks associated with cost escalation, inflation, uncertainties on current cost estimate, etc.

3. RISK REVIEW PROCESS

The 2014 Risk Register was reviewed including the Risk Assessment Worksheets to determine if they remain valid or should be updated. All previously identified risks were fully reviewed by the subject matter experts of the Project Team and any necessary updates were incorporated in the Risk Register prior to performing the Monte Carlo analysis. The Project Team identified a total of 70 risks which were evaluated and documented.

In 2019, the Risk Register (see Appendix A) was updated based on refinement of the reference concept and the Monte Carlo analysis was performed (see Appendix B).

The Risk Register serves as one component of the ongoing risk management process as the risk exposure and available data will change as the work progresses. The Project's Risk Management Plan establishes the process that will ensure the Risk Register is reviewed, updated by each risk owner and reported on as the work progresses.

3.1. RISK ANALYSIS

3.1.1. Monte Carlo Analysis

The Project Team completed a Monte Carlo analysis of the project risks associated with the Reference Concept utilizing the Risk Register. All risks have been categorized and assessment parameters of each risk were expanded into minimum/likely/maximum scenarios with respect to impact and anticipated contingency.

At the 90% confidence level, there is a 90% probability that the value of all risk will be less than or equal to the value estimated. Similarly, the 10% confidence level means that there is only a 10% chance that the value of risk will be less than or equal to the value estimated. There is no defined industry standard on the confidence level to be used for large public infrastructure projects, however the 70% to 80% confidence level is considered appropriate by many public jurisdictions in Canada.

Based on the Monte Carlo analysis of the Risk Register a contingency of [redacted] confidence level (see Appendix B).

3.1.2. Independent Contingency Estimate

To provide additional confidence in the Project cost estimates, Charter Project Delivery (CPD), an independent cost estimator, was engaged to carry out a “bottom-up” construction cost estimate from the perspective of a potential Contractor. A component of this estimate is an analysis of potential risks and contingency allocated to mitigate these risks. CPD’s cost estimate and risk/contingency estimate are based on the Project’s Reference Concept and draft construction schedule. The CPD analysis recommended a [redacted] (see Appendix C).

Additionally, the team has also obtained an independent review of the Risk Register by Partnerships BC (see Appendix D). The Risk Register was adjusted based on their feedback.

3.2. RISK REVIEW RESULTS

The risk rating system used for the Project follows the Government’s Core Policies and Procedure documents Chapter 14 on Risk Management.

The review process carried out a comprehensive analysis of risks, their attributes and cost. This approach is consistent with industry practice, and the material generated is suitable to be used as the active tracking tool to monitor and refine risk information throughout the life cycle of the Project.

Appropriate transfer of risk to the Contractor is essential. When a risk is transferred its impact assessment is then moved to reflect the influence on contract pricing. After the contract is awarded, the risks assigned to the Contractor will be retired from the Risk Register.

Top Project risks were identified by the Project Team based on the “Likelihood” rating at possible/likely/almost certain, and/or the “Impact” rating at significant/major/severe. The top risk groupings include:

- [redacted]

4. PROJECT CONTINGENCY ESTIMATE

Project contingency is an allocation of project funding that can be drawn from to offset costs associated with risk occurrence. Contingency is often set as a typical percentage of estimated capital cost or can be estimated where data is available for similar projects and risks can be expected to occur in accordance with past trends.

Based on the Monte Carlo analysis a base line contingency value was set at [redacted] confidence.

Due to its location, topography, geology and technical complexity, the Project is unique in nature. The Project Team recommends that the Project carry an additional [redacted] for additional risks and a total project contingency of [redacted] This represents approximately [redacted] of the estimated total project cost and corresponds to a confidence level between [redacted] from the Monte Carlo analysis.

The contingency can be further allocated based on which risks will be retained by the Owner and those that are transferred to the Contractor. Transferred risks are identified in the Risk Register. Prorating the risks based on their expected value in the Risk Register, produces the following distribution:

- Owner's contingency = [redacted]
- Contractor's contingency = [redacted]

As the Project advances the Risk Review process will be conducted regularly, allowing for adjustments specific to any risk events that may have occurred, eliminated or transferred, and for any new risks identified. This on-going process for monitoring and controlling risks is defined in the Project Risk Management Plan.

APPENDIX A – PROJECT RISK REGISTER

Note: Appendix A has been redacted in its entirety

APPENDIX B – MONTE CARLO ANALYSIS MEMO

MEMO

TO: Tim Stevens, Lead Engineer, Kicking Horse Canyon Phase 4

FROM: Nicholas Roberts, Advisory Services, WSP

REVIEWED BY: Razi Chagla, Advisory Services WSP

SUBJECT: **KHCP4 Risk Register – Notes to Monte Carlo Analysis (Update)**

DATE: June 2019 Update

The purpose of this memo is to issue an update on the risk analysis following the revised risk register for the June 2019 update

A Monte Carlo analysis is a modeling technique used to predict the outcome of a specified set of uncertain events (risks), and the possible impact of these events in terms of cost or schedule. Risks are monetized and represented as a range of possible values with some measure of likelihood of occurrence. A Monte Carlo simulation can be thought of as a representation of the many "what-if" scenarios that could occur due to project risk. The outcome is used to quantify a risk estimate often for contingency purposes and to develop risk response strategies to monitor and control priority risks captured in the risk register. The risk register should then be revisited intermittently throughout the project to account for residual risk and manage the effectiveness of risk response strategies (refer to the project's risk management plan).

Following the receipt of the updated risk register the Monte Carlo analysis was run in order to obtain updated results which are included in this memo as well as in the "Monte Carlo Output Paste" sheet of the Excel workbook.

Furthermore, a "Heatmap" has been inserted to provide a visual representation of the risks plotted on an x-y chart, with impact along the x-axis and likelihood along the y-axis.

Simulation

The stability of the model was checked using the software's automatic iterations function and convergence testing (which by default runs up to 50,000 iterations). Convergence testing means @Risk pauses throughout the simulation to check if it has stable results

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for the outputs. This takes time depending on how many times the software is set to check for convergence. For this analysis, the model was set to check results every 5,000 iterations. This produced consistent results, indicating that 5,000 iterations are reasonable for this model.

Confidence Levels

Different confidence levels have been reported in the risk register spreadsheet. Representing the results in terms of percentiles allows the decision maker to predict to varying levels of certainty what the potential impact to the project will be due to risk. It is common practice to consider between the 70th to 80th percentiles as the "most likely" outcome. The other two percentiles are displayed to show the "optimistic" outcome (10th percentile) and "pessimistic" outcome (95th percentile).

In other words, at the "most likely" outcome, there is a 75% probability that the value of risk will be less than or equal to the value reported. In the "optimistic" outcome, there is only a 10% chance that the value of risk will be less than or equal to the value reported. In the "pessimistic" outcome, you can be quite confident that the value of risk will be less than or equal to the value reported 95% of the time.

The three main percentiles are presented in Table 1 below and graphically on the following cumulative probability distribution graphs. Additional percentiles and statistical results of the analysis are shown on the last page. For reference Table 1 also shows the results from the risk analysis conducted on September 18, 2018 to highlight how changes to the risk register have impacted the total risk valuation.

Table 1 Project Risk by Confidence Level

Confidence Level	Total Risk Valuation (rounded)
75% (most likely)	[redacted]
10% (optimistic)	[redacted]
95% (pessimistic)	[redacted]

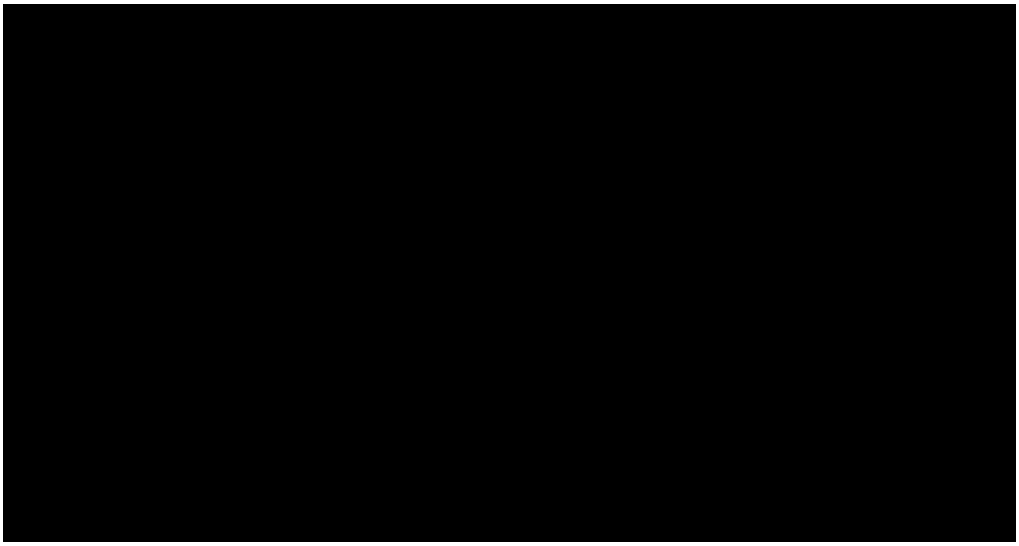


Figure 1 Total Risk at 10% Percentile

Total / Total

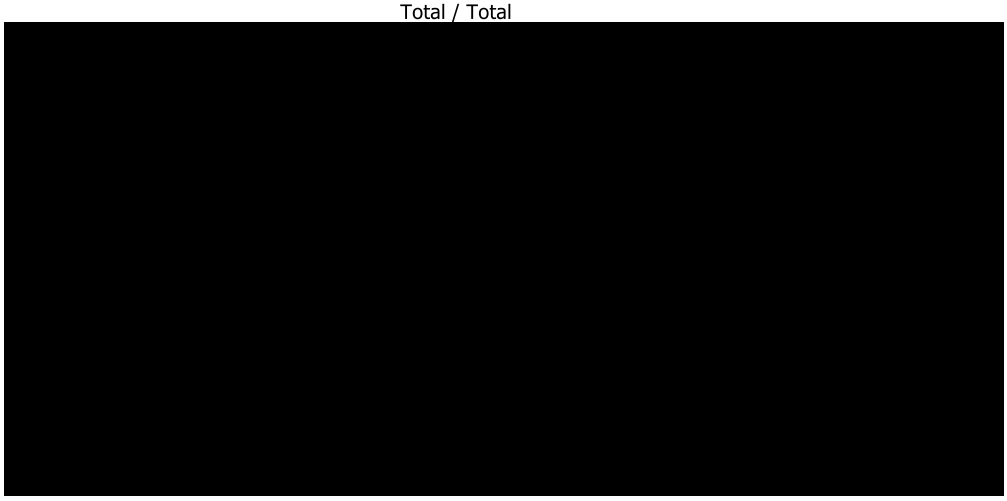


Figure 2 Total Risk at 75% Percentile

Total / Total

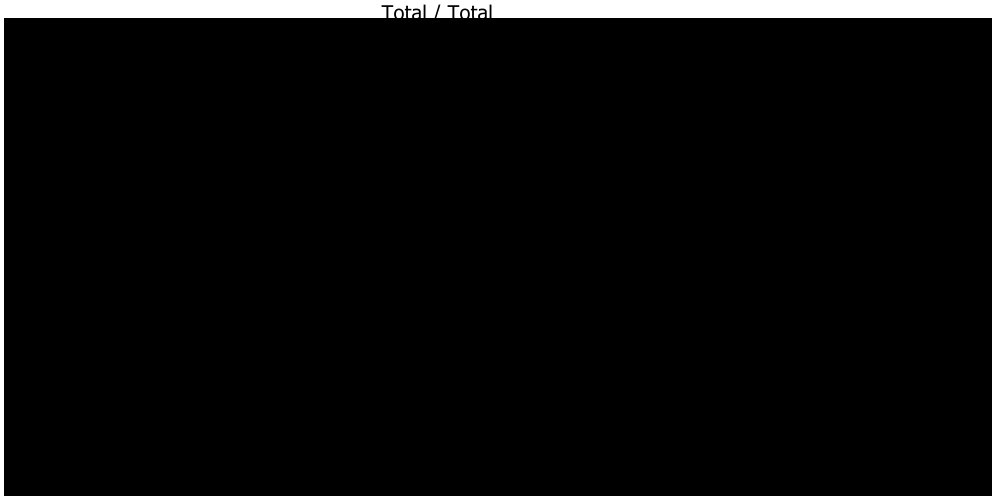


Figure 3 Total Risk at 95% Percentile

Total Risk Valuation, Monte Carlo Results

Table 2 Simulation Parameters

Parameter	Value
Minimum	[redacted]
Maximum	
Mean	
Mode	
Median	
Std Dev	
Skewness	0.9669
Kurtosis	4.127
Values	5000
Errors	0

Percentiles

Table 3 Risk Valuation Percentiles

Percentile	Total Risk Valuation
1%	[redacted]
5%	
10%	
15%	
20%	
25%	
30%	
35%	
40%	
45%	
50%	
55%	
60%	
65%	
70%	
75%	
80%	
85%	
90%	
95%	
99%	

RISK PROFILE HEAT MAP

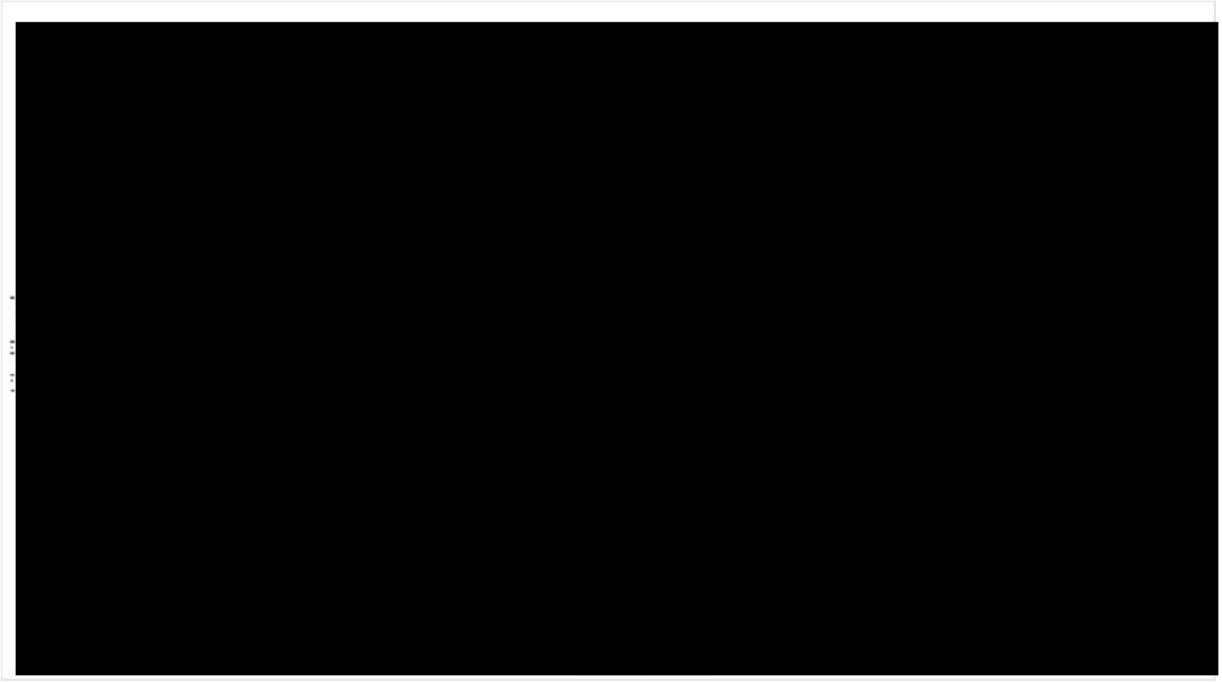
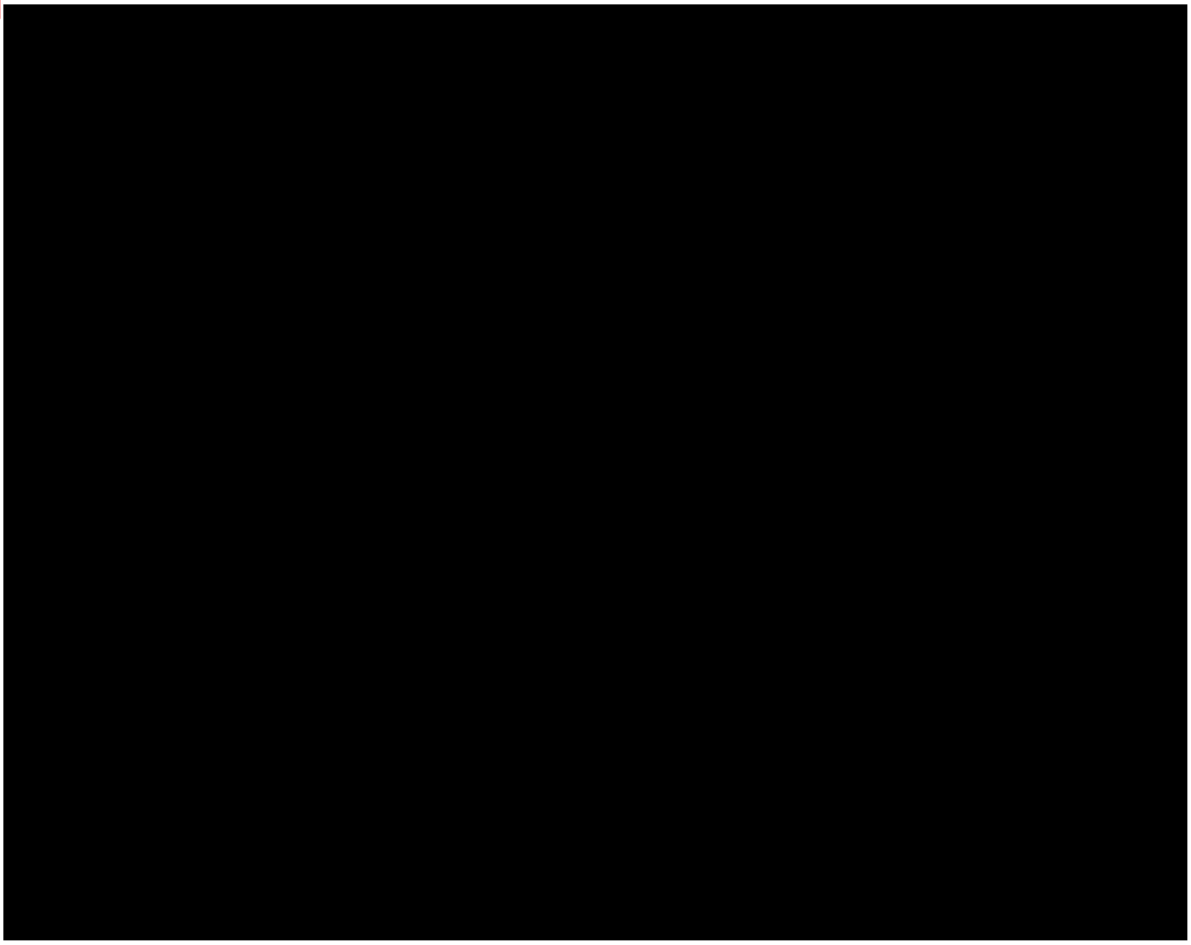


Figure 4 Risk Profile Heatmap (Current)

The risk heatmap is a visual aid to show the distribution of project risks according to their likelihood of occurrence (i.e. probability) and consequence (i.e. impact). This heatmap is useful to identify some of the key risks impacting the overall increase in risk for the KHCP4 project. Several risks have migrated from a relatively low probability/impact level to a higher probability and/or impact. Overall, some of the more notable risks are provided below in Table 4.

The risk IDs shown on the heatmap can be cross-referenced back to the risk register which identifies and provided further description of the risk.

Table 4 Notable Project Risks



APPENDIX C – CPD ESTIMATE

Kicking Horse Canyon - Phase 4

Table 1 - Project Cost Estimate Summary

CONTRACTOR ESTIMATED COSTS	[redacted]
DESIGN-BUILD CONTRACT MANAGEMENT	
GRADE CONSTRUCTION	
STRUCTURAL CONSTRUCTION	
UTILITY CONSTRUCTION	
CP RELATED WORKS	
TOTAL CONTRACTOR COSTS (without contingency)	

OWNERS RELATED COSTS	[redacted]
OWNERS PROJECT MANAGEMENT	
INDIGINOUS ACCOMMODATION	
BCIB ADMINISTRATIVE COSTS	
TOTAL OWNERS COSTS (without contingency)	

ESTIMATED CONTINGENCY COSTS	[redacted]
PROJECT CONTINGENCY	
SUBTOTAL PROJECT COSTS	

INTEREST DURING CONSTRUCTION	
INTEREST DURING CONSTRUCTION (IDC)	$ 23,000,000
TOTAL PROJECT COST	**$ 601,464,580**

APPENDIX D – PARTNERSHIPS BC MEMO

partnerships British Columbia

MEMO

To: Amanda Farrell

Cc: Murray Tekano

From: David Hubner

Date: April 8, 2019

Subject: KHCP4 Q4 Risk Review Meeting

On April 2nd, 2019, members of the KHCP4 project team conducted a risk review workshop at WSP's Vancouver office (840 Howe St.). The workshop comprised a review and re-evaluation of the existing risks previously identified at the KHCP4 Q3 2019 risk update meeting held in Kelowna on February 8, 2019.

The list of attendees for the April 2nd, 2019 workshop are indicated below:

Name	Project Role
David Hubner	Procurement Advisor
Ed Gohl	Lead Construction Manager
Ed Green	Project Advisor
Frank Margitan	Project Advisor
Justin Fox	Procurement Advisor
Lindsay Parker	Sr. Project Manager
Monty Knaus	Deputy Lead Engineer
Murray Tekano	Executive Director
Tim Stevens	Lead Engineer

As previously reported by the project team, the results of the Q3 workshop recommended retaining [redacted] in contingency, based on a confidence level of approx. [redacted] (representing an approx. [redacted] overall contingency). The main changes to the risk register at the April 2nd, 2019 workshop are as follows:

partnerships
British Columbia

- [redacted]
- [redacted]
- [redacted]
- [redacted]
- [redacted]
- [redacted]
- [redacted]
- [redacted]
- [redacted]

The net result is an additional provision for an overall Expected Value of Cost increase of approximately [redacted] to cover the items listed above. There was general consensus achieved by all the workshop attendees regarding these re-evaluated risk items. There will be a follow-up evaluation of the risk register at the next regular quarterly risk review.

In terms of the risk management process to date, a comprehensive range of risk events has been identified and addressed by the appropriately qualified members of the project team. There has been open and candid discussion about the nature of the risks, their consequences, and quantification of their impacts. The project team conducts regular reviews of the risks and the process overall is consistent with Partnerships BC's project risk management approach and guidance.

Yours truly,

David Hubner

Vice President, Transportation and Utilities