BRITISH COLUMBIA | Ministry of Transportation and Infrastructure

Millennium Line Broadway Extension Project

Risk Report

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partnerships
British Columbia

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1 INTRODUCTION

1.1 PURPOSE

The purpose of this report is to document the risk analysis process for the Millennium Line Broadway Extension Project (the Project) at the business case stage. The Project is being delivered by Province of British Columbia, "the Province". Key areas covered by this report include:

- An overview of Partnerships BC's project risk management approach and guidance from the planning stages through to implementation;
- The methodology by which risks were assessed, quantified, and incorporated into the financial analysis of the Business Case; and
- The results of the risk analysis conducted.

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 (also referred to as the Contractor) for the selected procurement models, developing potential risk management strategies and incorporating quantified risks into the financial analysis of the Business Case. 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.

As discussed in Section 3 of the Business Case, the two procurement models analyzed in this report are the Design-Build (DB, also referred to as the Traditional) model and the Design, Build, Finance (DBF, also referred to as the Partnership) model.

1.3 PROJECT BACKGROUND

The Project will extend rapid transit westward from VCC Station along Broadway Avenue to Arbutus Street (Broadway Corridor), providing convenient, frequent, and rapid transit service and alleviating traffic congestion by removing the 99 B-line buses from the Broadway Corridor. The Project will expand the reach of the existing rapid transit network, delivering a reliable alternative to the single occupant vehicle for travel.

The overall MLBE project includes a 5.7-km extension of the existing Millennium Line from VCC station to Arbutus Street along Broadway Avenue. The extent of the Project and its relation to the existing transit network is illustrated in the figure below.

Figure 1 SkyTrain Network Map

The Project includes the following major capital components.

- Construction of six (6) underground stations;
- Tunnel length of 5.7km;
- 700m of elevated guideway; and
- An interconnection at VCC-Clark Station.

The capital budget for the Project is estimated to be in the order of $2.8 billion.

For a more detailed description of the project background and scope refer to the MLBE Project Business Case.

2 RISK MANAGEMENT METHODOLOGY

2.1 PARTNERSHIPS BC GUIDANCE

Project risk is defined as the chance of an event or condition happening which could cause the actual project circumstances to differ from those assumed when forecasting project outcomes or objectives. Risk is an inherent part of any project, and to ensure a successful project outcome, risk must be effectively managed. Depending on the amount of information available, risk can be measured both qualitatively and, in some instances, quantitatively.

Risk management includes the actions or planned actions that impact the probability and consequences of a risk event in order to ensure that the level of risk assumed falls within an acceptable limit for the Project team. Every project must consider and manage risk in order to be successful. A project's risk exposure is fluid and adjustments will need to be made as the project moves through its various stages. Careful risk management allow the Project team to anticipate key vulnerabilities and develop proactive strategies on how to best deal with them. The following Figure 2 provides an overview of the risk management process.

Figure 2: Risk Management Overview

Risk management in the context of large capital infrastructure projects does not simply involve transferring all project-related risks to the private sector. The goal of an effective contractual arrangement is to allocate project risks to the party best able to manage them at the lowest cost. This can be further enhanced when assigned risks are supported by appropriate incentives and penalties through the use of performance-based contracts. For example, under any procurement model, the Contractor is better suited than the Province to manage the physical construction activities so construction risk is transferred to the Contractor.

An efficient or optimal allocation of risk between the public and private sector participants will ultimately maximize value for money for taxpayers.

The Government of British Columbia, through Partnerships BC and in conjunction with the Risk Management Branch (RMB) of the Ministry of Finance, has established a guideline with respect to risk management for large capital infrastructure projects through the stages of planning, procurement and implementation. Notwithstanding differences in terminology, the Province's guideline is generally consistent with the principles, framework and process described in the ISO 31000:2009 Risk Management Principles and Guidelines.

A failure to fully take account of risk is one of the key factors when public projects are not delivered on time, on budget or to specification. Partnerships BC's guidance on risk management takes a systematic approach to risk, estimating the range of potential impacts of risk on a risk-by-risk basis through the project's planning, procurement and design and construction and operating phases.

This systematic approach to risk considers:

- An extensive risk matrix to ensure a comprehensive assessment;
- The range of possible outcomes or consequences;
- The risks associated with capital, operating and life cycle costs; and
- Specific characteristics of unique risks.

Partnerships BC uses a standardized risk matrix (also referred to as a risk register) template as a tool to consolidate risk information (refer to Section 2.2.4 for additional information about the risk matrix).

Risk analysis is dynamic and should be revisited throughout the life of a project. The Project team should plan regular updates to the risk matrix as part of ongoing risk management efforts. As a project moves through the planning phase and into procurement, and more information emerges, new risks not previously recognized will be identified (especially through development of the legal documents or "Contract"[1] and associated payment mechanism). These risks should be added to the risk matrix, allocated appropriately and quantified where possible. Similarly, some risks previously identified may no longer exist and should be reassessed.

During negotiations and financial close, the main subject for negotiations becomes the Contract. The risk matrix allows for the identification and allocation of risks at a high level, but the detailed risk allocation will be reflected in the Contract wording.

2.2 RISK ASSESSMENT

Risk assessment is the overall process of risk identification, risk analysis and risk evaluation. It allows the Project team to better understand how risk can affect achievement of the project objectives and ensure that effective treatment strategies and project controls are developed.

During the business case phase of the project, risk assessment can be broken down into the following steps:

1. Identifying and clearly describing the major potential risk events for a project;

[1] The term Contract in this context refers to either a stipulated sum contract in the case of a DB or a project agreement in the case of a DBF.

2. Analyzing the range of possible consequences of the risks identified;
3. Evaluating the likelihood and potential impact of those consequences;
4. Developing prevention and mitigation strategies for identified risks; and
5. Quantifying, where possible, the dollar value of these outcomes to the project; and
6. Recording the results of this process in a risk matrix.

2.2.1 Risk Identification and Description

The first step in the risk assessment process involves identifying and describing the potential material risks (from both technical and financial perspectives), the causes and potential consequences. The aim of this step is to generate a comprehensive list of risks based on those events that might create, enhance, prevent, degrade, accelerate or delay the achievement of project objectives.

For ease of tracking, risks are organized by the stage of the project life cycle in which they are expected to occur. There are generally two key periods in a project's development:

- Planning, procurement, design and construction and transition/commissioning of the project leading up to service commencement (herein referred to as Capital Risks); and
- Operating period risks (herein referred to as Operating Risks) are identified, allocated and evaluated but not quantified for financial modelling and value for money purposes since the procurement method compares a DB and a DBF.

During preparation of the Business Case, the Project is in the planning stage. Technical and financial information about the Project is gathered, analyzed and compiled into a comprehensive document that becomes the Business Case. The information is subject to due diligence at this stage, however there can be further refinement and modification throughout the project's life cycle. It is important at this stage to specify sufficient detail about each risk event, as a comprehensive description can help inform the risk quantification and the development of potential scenarios.

When preparing documentation in anticipation of the procurement stage, the risk matrix can be used to guide or confirm the risk allocation contained in the Project's Contract.

2.2.2 Risk Allocation

Once the risks have been identified, each one is evaluated to determine which party (the Province or the private sector) is exposed under each procurement model and which party is best able to manage the risk at the lowest cost. From the perspective of the Province, a risk can be transferred to the private sector, shared with the private sector or retained. One of the key differences between procurement models is how risk is allocated between the parties and subsequently managed by the responsible party.

As the Project progresses during the procurement process, it may become apparent that the initial allocation does not provide the best value for money for the Province, in which case the allocation may be amended as appropriate. For example, a geotechnical risk may initially be classified as transferred during the business case stage. Further geotechnical studies completed after the Business Case may reveal unexpected ground conditions. Rather than fully transfer the risk, it may be more cost-efficient at that point to share the risk exposure with the private sector. This example illustrates the importance of keeping a risk management plan up to date throughout a project's development.

The transferred risks, together with the portion of the shared risks expected to be transferred to the private sector, are incorporated into the draft Contract. Until negotiations with the preferred proponent begin, it is assumed that each shared risk will be "split" equally between the private sector and the Province. This assumed split is further refined during the procurement stage of the process as the contract is developed and comments are received from proponents during the Request for Proposals (RFP) stage.

The retained risks are expected to be retained by the Province and are used in part to assess the size of the project reserve necessary to protect against the risk exposure.

Project teams will typically not quantify risks that may be high impact, but have a very small probability of occurring. These include natural disasters and other "high impact, very low probability" events. Typically speaking, broader provincial emergency plans (which are beyond the scope of this analysis) would come into play under such circumstances.

2.2.3 Risk Treatment: Prevention and Mitigation

The risk allocation described above is part of an ongoing risk management process that enables parties to reduce the probability of a risk occurring as well as mitigating the consequences of a risk should it occur. A primary objective of risk management is to reduce potential negative outcomes by identifying risks, analyzing them and implementing strategies to deal with them on an ongoing basis.

While risks are often thought of as events with only negative consequences, proactive risk management can create value. For example, a comprehensive investigative testing program carried out in advance of procurement may provide the Project team with more complete information and less uncertainty. New information may reduce the probability of a risk materializing or may provide the Project team with an opportunity to proactively deal with the issue at a lower cost.

The treatment strategies developed should be clear and realistic and involve the necessary Project team resources. The risk management process should form an integral part of the Project team's broader project management.

2.2.4 Risk Matrix

A risk matrix is the key document produced in the risk management process. Developed through a series of risk workshops, it consolidates and provides a record of the following information:

- The identification and description of all relevant risks;
- Risk allocation between the Province and the private sector;
- Identification of high level prevention and mitigation strategies; and
- Where possible, quantification of the risks based on the best available information at the time.

Attachment 1 illustrates how the risk matrix is organized and describes the information captured in the various columns. The risk matrix is a living document that informs the risk management strategies developed by the Project team. It should serve as a key project management tool and be updated at key project milestones (e.g. before the release of the procurement documents, just after contract execution, regularly during design and construction, etc.).

2.3 RISK QUANTIFICATION

A comprehensive quantitative evaluation of risk presents a range of likely cost outcomes and provides a reliable means of testing value for money between procurement models. It also encourages bidding competition during procurement by creating confidence in the financial rigor of the Province's risk-adjusted project cost estimate that was used to set the affordability ceiling to which proponents must bid.

Risk quantification occurs once the risk identification, description, allocation and categorization activities have been completed to a sufficient degree. Selected risks are quantified to ensure sufficient money in the all-in project budget to successfully deliver the project. The risk adjustment included in the project budget must account for both transferred risks (which the Contractor will include in its bid) and retained risks (which will form part of the Province's project reserve).

If a risk is transferred, it is quantified from the perspective of the Contractor and what the Project team estimates would be included in a reasonable and competitive financial proposal. If a risk is retained, it is quantified from the perspective of the Province and the cost impact the risk would have on the project.

Risk quantification can be a time consuming exercise and should focus on the most material risks to the project. Typically, only 10 – 20 of the potentially hundreds of risks are quantified. In some cases a single quantified risk can capture the potential impact of multiple risks. While risks are quantified individually, the total quantified risk values should be viewed from a portfolio perspective. It is expected that some risks will come to pass, some will not and, of those that do occur, the impact may be greater or lower than expected. The expectation is that, by quantifying the key material risks, the Project team will have a sufficient reserve in place to adequately address risk events within the Project budget. The impact of individual risks on the total capital risk value is illustrated and described in section 3.3.1.

Project teams consider several factors in determining which risks to quantify. These may include:

- Materiality – If the risk were to materialize, would it have a significant impact (financial, schedule, public perception, program delivery)?
- Estimable – Can the risk impact be reasonably and accurately estimated?
- Risk Ranking – How high is the risk ranking (low/medium/high/extreme)?

The decision on which risks to quantify involves examining past precedent projects, as well as considering unique project-specific risks that warrant further attention.

Most risks are quantified using a triangular distribution which involves inputting three key variables: low/best case (5th percentile), most likely (50th percentile), and high/worst case (95th percentile). Using a triangular distribution is often regarded as a good proxy for a normal distribution but is much more straightforward in terms of obtaining the appropriate inputs. Refer to section 2.3.2 for additional information.

2.3.1 Risk Quantification and the Project Contingency

The contingency is a critically important item in the project budget and should not be removed and replaced with the quantified risk amount.

In traditional cost estimating, large contingencies are often added to the expected cost, reflecting the fact that unforeseen circumstances may arise that could result in additional costs or delays. These contingencies represent an initial estimate, based on the quantity surveyor (QS)'s experience, of the expected additional costs that may be attributed to risks usually associated with changes or unanticipated events.

Contingencies are not dealt with consistently across all QS estimates. The QS examines how developed the project planning is and bases the contingency on previous experience. When the QS creates the contingency for the Project's indicative design estimate, the QS assumes the contingency will be spent, which means the contingency cannot be regarded as a substitute for risk costing. The Project team should review the contingency with the QS to confirm costs are not being double counted.

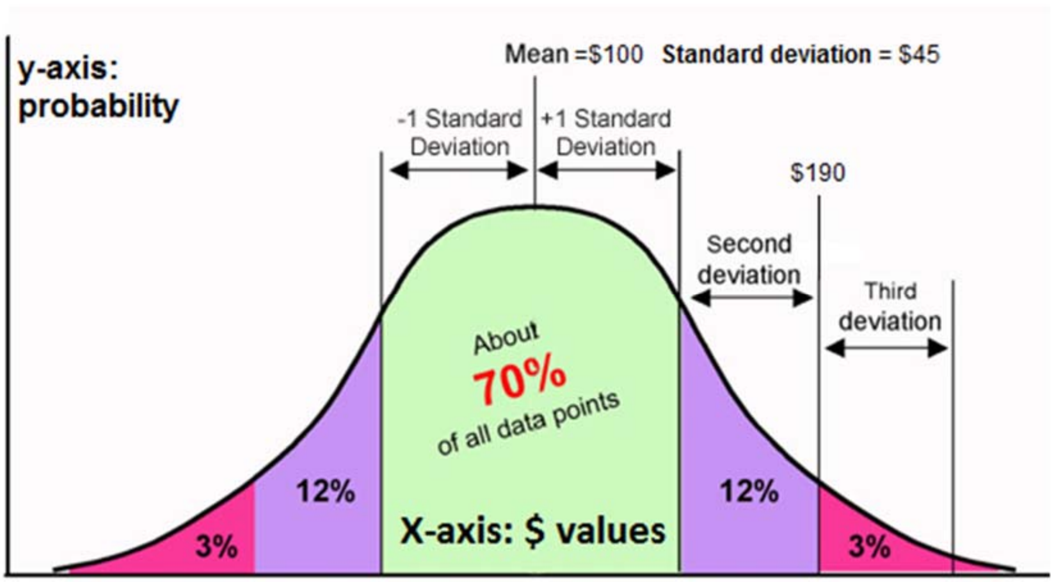
2.3.2 Monte Carlo Analysis and Risk Distributions

The expected value of each quantified risk is calculated based on the assumed distribution and the estimated probabilities and scenario outcomes for each risk. In order to quantify the overall risks and develop aggregated distributions, Partnerships BC uses statistical software, called @Risk, to perform a

Monte Carlo analysis[2]. Monte Carlo analysis provides a means of evaluating the effect of uncertainty using a large number of scenarios. It is a tool used to estimate the total variation of project risk resulting from the individual quantified risks. The Monte Carlo analysis takes the assumptions for each risk, aggregates them, and then runs thousands of simulations to produce a distribution of the total value of quantified risks.

The Monte Carlo analysis produces distributions that often approximate a normal distribution curve, also known as a bell curve, as illustrated in the figure below.

Figure 3: Example Normal Distribution Curve



To help understand the distribution, the mean of $100 refers to the average data point and the standard deviation of $45 refers to the amount of variability. Generally most risks are expected to fall close to the mean as illustrated by the green section. Approximately 70% of the risk outcomes are expected to fall between $55 and $145. If one refers to the three percent indicated by the pink area on the far right (also referred to as the 97th percentile), one can say that there is an estimated 97% chance that the risk values will be at or below $190. This is equivalent to saying there is an estimated three percent chance that the risk values will exceed $190.

When developing the project budget, the percentile point that is selected on the risk distribution curve will depend on the level and quality of information available and the Project team's level of risk aversion. This is discussed further in section 3.2.1.

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2 Monte Carlo analysis involves a series of computational algorithms that rely on repeated random sampling to compute their results.

3 PROJECT RISK PROCESS

3.1 RISK WORKSHOPS

The first step in the Project's risk management process was to identify the risks. Multiple risk workshops, facilitated by Partnerships BC and KPMG, were held in June through August in 2016 and the risks were updated in August and September in 2017. Risks were separated into two broad categories:

- Capital Risks – planning, approval, procurement, design and construction; and
- Operating Risks – operations, maintenance and life cycle.

Financial and commercial risks were captured either in the Capital or Operating Risks as appropriate.

A variety of professionals from the private and public sectors participated in the risk identification and quantification exercise. These participants are subject matter experts in one or more of the following areas: procurement, engineering, cost estimating, design and construction, project management, finance, commercial and operations and maintenance.

Participants included representatives from: Partnerships BC, the Province, TransLink, and consultants retained by the Project team including the Owner's Engineer, Technical Advisor, Business Advisor and others. A brief biography for each participant can be found in Attachment 4.

The QS reviewed the quantified risks to ensure that risks being quantified were not already included in the Project's contingency estimates. The DB and DBF risk values are calculated on the base costs before contingencies. Furthermore, DB and DBF risk estimates assume that prudent and reasonable mitigation, before and after risk events, has been or will be completed.

During the workshops, participants thoroughly reviewed a pre-populated list of Project risks and updated it as appropriate for the Project. Attachment 2 of this report contains the Project's complete risk matrix.

After the initial risk assessment, various Project team members were engaged to quantify certain risks to assess the initial cost implications to the Project under both procurement models in the event the risks materialize.

Once the Project team provided its initial estimates for the quantified risks, Partnerships BC reviewed the estimates and provided feedback to ensure the estimates were properly documented with sufficient justification, and that the assumptions were reasonable and consistent with the Project scope and risk description. This feedback resulted in further adjustments to the initial assumptions. The risks were then further reviewed through a series of due diligence meetings, which included individuals from the risk workshops. The completed risk quantification results and worksheets are included in Attachment 2.

3.2 RISK RESULTS ANALYSIS

The Project team quantified a total of [redacted]. There were no quantified Operating Risks since the value for money analysis of a DBF procurement method does not include a quantified analysis of the operating period. Operating risks were still discussed for determining the amount of withholding required for the warranty period after the construction of the Project. The allocation of the quantified risks are presented later in Table 2.

The Monte Carlo analysis produced simulation results for the Capital Risks for the DB and DBF models, capturing the total, retained and transferred risk amounts. These results are discussed in sections 3.3.

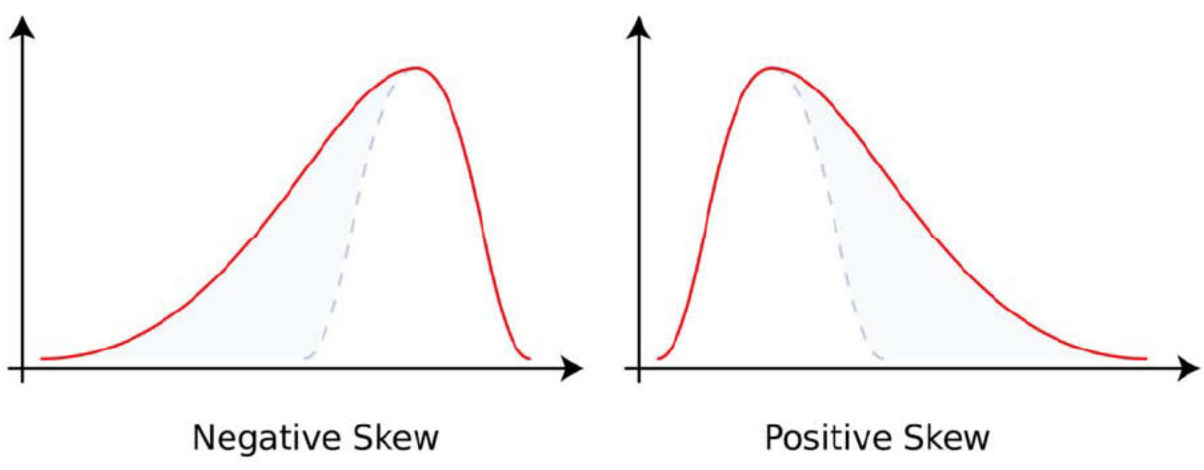
3.2.1 Selected Risk Percentile

The 67th percentile of the risk distributions was selected to reflect a prudent level of risk aversion given the stage of Project planning and the large number of unknowns related to the Project. Selecting the 67th percentile is equivalent to saying that the Project has sufficient risk money included in the budget approximately two of out every three times. As the Project moves forward and is further developed, the quantified risks and the risk percentile can be revisited as more information becomes available and the level of uncertainty decreases.

3.2.2 Skewness Effect

Skewness is a statistic that measures the asymmetry in a distribution. Figure 4 illustrates the effect of negative and positive skew on a normal bell curve. Skewness causes a curve to appear distorted or skewed either to the left or the right and is common in quantified risks.

Figure 4: Skewness Effect



Skewness effect precludes simply adding together the retained and transferred distribution curves to get an accurate total risk value. Care was taken when determining the values of the risks entered into the financial model to account for the skewness effect and ensure the selected values summed to the 67th percentile of the total risk curve and not the 67th percentile of the individual retained and transferred risk curves.

3.2.3 Correlation

Correlation is a measure of the extent of interdependence between two or more variables. A positive correlation means that as one value increases, the other value increases as well. A negative correlation means that as one value increases, the other value decreases. Correlation does not, however, imply causation. While certain quantified risks are likely to be correlated, this risk analysis has not included any correlation assumptions. This is a conservative assumption and tends to understate the aggregate risk value.

3.3 QUANTIFIED CAPITAL RISK RESULTS

Figure 5 overlays the overall Capital Risk distribution (which approximates a normal distribution) for the DB and DBF models. The graph indicates the relative level of risk between the two procurement models, but does not differentiate between the risks held by the Province and those which would be transferred to the Contractor. The 67th percentile values were incorporated into the financial model and are summarized in Table 1.

As Figure 5 illustrates, the total capital risk value under a DBF model is [redacted] while under a DB model, the total capital risk value is expected to be [redacted]. The figure also illustrates that there is an approximately one in three chance that capital risks will exceed [redacted] in the DBF model, whereas in the DB model, the chance of exceeding [redacted] is approximately [redacted].

Figure 5: Total Capital Risk Overlay Graph – DB vs DBF Nominal $000

[redacted]

Figure 6 below presents an overlay of the retained Capital Risk distribution. It illustrates that there is an approximately one in three chance the retained risks under the DBF model will exceed [redacted] compared to a [redacted] chance under the DB model.

Figure 6: Total Transferred Capital Risk Overlay Graph – DB vs DBF Nominal $'000s

[redacted]

Table 1 summarizes the results of the Monte Carlo analysis for the Capital Risks in Nominal (inflated) dollars[3].

Table 1: Capital Risk Value Summary (Nominal $ Millions at 67th percentile)

Capital Risk	DB	DBF
Risks retained by the Province	[redacted]	[redacted]
Transferred risk added to the construction contract by the Contractor		
Total[1]		

[1] Due to the skewness effect described in section 3.2.2, the retained and transferred risk values in this table have been adjusted slightly downward in order to equal the total 67th percentile value of the respective total distr bution.

Values may not add up due to rounding.

[3] All references to nominal dollars (inflation adjusted) will be entered in the financial model based on the assumed timing of the risk.

3.3.1 Capital Risk Sensitivity Analysis

Figure 7 illustrates the individual quantified risks that have the most significant impact on the total DB Capital Risks. The most significant risk, in this case [redacted] is at the top, with other risks following in descending order of impact. The baseline value at the bottom represents the 67th percentile of the total DB Capital Risk. The top risk can be interpreted as saying that the [redacted] depending on whether the risk materializes and its impact if it does. The figure illustrates the wide impact that risk can have on a project budget and can inform the decision to allocate Project team resources to the most material risks. The figure also demonstrates the importance of viewing the quantified risk from a portfolio perspective, recognizing that there is a wide range of potential outcomes for any particular risk.

Figure 7: Tornado Graph: Top 5 DB Capital Risks (at the 67th percentile)

[redacted]

Figure 8 presents the tornado graph for the total DBF Capital Risks. The risk exposure for the DBF differs from the DB as reflected by the different order of risks and different sized bars. The top ranked risk in this case is also [redacted], which can cause the total DBF Capital Risk exposure to range anywhere from a cost of [redacted] to [redacted].

Figure 8: Tornado Graph: Top 5 DBF Capital Risks (at the 67th percentile)

[redacted]

3.4 UNQUANTIFIED RISKS

In addition to the quantified risks, there are a number of Project risks that have not been quantified or assigned a contingency, but should nonetheless be closely managed by the Project team as the Project progresses. These include:

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

Since the construction corridor is in a densely populated area, to alleviate [redacted] the Project team will engage the municipality and stakeholders throughout the delivery of the Project.

To mitigate the [redacted] early and ongoing meetings will be hosted with key stakeholders to identify scope terms and to establish an understanding of site conditions and constraints. Municipal agreements will also be negotiated in advance of procurement.

The Project team is aware of the risk mitigation strategies in the risk matrix and will be actively working to manage the risks to minimize the probability of occurrence and the impact if these risks do materialize.

3.5 RISK QUANTIFICATION SUMMARY

The quantified risks and their allocation between the Province and the Contractor are summarized in Table 2 and for the DB and DBF respectively.

Table 2: Project Risk Allocation Summary:

No.	Type of Risk	Allocation of Risk			
		DB		DBF	
		Province	Contractor	Province	Contractor
Capital Risks					
[redacted]					

No.	Type of Risk	Allocation of Risk			
		DB		DBF	
		Province	Contractor	Province	Contractor
[redacted]					

No.	Type of Risk	Allocation of Risk			
		DB		DBF	
		Province	Contractor	Province	Contractor
[redacted]					

Table 3 summarizes the risk quantification amounts included in the financial analysis. As discussed in section 3.2.2, the retained and transferred risk totals were adjusted downward for both models so that the sum equals the 67th percentile of the total risk distributions.

Table 3: Risk Quantification Summary (Nominal $ Millions at 67th percentile)

Financial Model Risk	DB	DBF
Capital Risk		
Risks retained by the Province	[redacted]	
Transferred risk added to the construction contract by the Contractor		
Total		

[1] Due to the skewness effect described in section 3.2.2, the retained and transferred risk values in this table have been adjusted slightly downward in order to equal the total 67th percentile value of the respective total distribution.
Values may not add up due to rounding.

The DBF model is considered more efficient in transferring the risk and therefore the same risk transfer can be achieved at a lower cost than in the DB model. This efficiency is realized through the inclusion of private finance at risk and due diligence that both the lenders and the sponsors would commit to the Project.

3.5.1 Net Present Cost Analysis

In order to include the risk costs in the financial model, assumptions were made to simplify the development of a risk cash flow profile. Each risk potentially occurs at different times through the Project's life cycle. A net present cost (NPC) approach was used to compare the risks on a consistent basis. The cash flows were discounted at 4.4% to October 1, 2017. This discount rate is consistent with the one used in the rest of the Business Case. Table 4 presents the NPC of both models' risk totals, separated out by the anticipated allocation.

Table 4: Risk Quantification Summary (NPC \$ Millions at 67th percentile, discounted at 4.4% to October 1, 2017)

Financial Model Risk	DB	DBF
Capital Risk		
Risks retained by the Province	[redacted]	
Transferred risk added to the construction contract by the Contractor		
Total		

4 NEXT STEPS AND PROJECT / MANAGEMENT RESERVE

As illustrated in the previous section, the DBF is estimated to provide positive VFM over the DB. Under the proposed DBF model, the Project team should actively track the Project's risk exposure and update the risk matrix at the following key milestones:

- During the affordability cost refresh prior to the release of the RFP. At this stage, the Project team should create a transferred risk memo that examines whether the transferred risks identified in the risk matrix have been reflected in the proposed draft Contract;
- During the RFP process if there are material risk allocation issues during the collaborative meetings (e.g. geotechnical); and
- Upon reaching financial close in anticipation of the design and construction implementation activities. This would include an update of the transferred risk memo to confirm that the final Contract will in fact transfer the expected risks.

4.1 MITIGATION STRATEGY

As indicated in the risk register, mitigation strategies have been developed for each identified risk. The likelihood and consequences of the risks were assessed taking into account the anticipated impacts of the treatment description / mitigation strategy.

In addition to the milestones listed above, it is the Project team's intends to revisit the risk rating during the development of the procurement documents as the pre-procurement works and investigations are completed. The risk review will be assigned to the individual working groups that are tasked with the development of the relevant documents and treatment descriptions indicated in the risk register.

For many of the transferred risks such as geotechnical, construction & commissioning, utilities, traffic the Project team, between business case stage and procurement, will address the risk allocation within the project procurement documents. A risk allocation reconciliation memo will be drafted by the Project legal team, which will reviews the risks identified during the Business Case development that were expected to be transferred to the private partner, and confirms the allocation of these risks in the project agreement

See Attachment 3 of this report for a summary of the key risks identified by the Project team.

ATTACHMENT 1: RISK MATRIX SECTION DESCRIPTIONS

The following attachment explains the different sections of the template risk matrix. It is organized into categories, each of which is explained in the figures below.

Figure 9: First Portion of Risk Matrix

Category	ID#	Risk Name	Quantify (Y/N)	Description	Cause	Effect	L	C	Inherent Risk (Risk Rating)

Category: This categorizes the risks into sub-groups for ease of reference.

ID#: This is the number column for tracking the risks. The convention is to group related risks and assign a letter/number combination.

Risk Name: This column captures the assigned name for the risk.

Quantify (Y/N): There are a large number of risks in the matrix, many of which can't be quantified or, if quantified, the cost impact would be immaterial. The two possible letters for this column are "Y" for quantified and "N" for not quantified.

Description: This column is where the detailed description of the risk is inserted. It is important to specify sufficient detail about each risk event to develop appropriate and effective risk management and allocation strategies. A comprehensive description can help inform the risk quantification and the development of potential scenarios and outcomes.

Cause: Events that could cause the risk to materialize.

Effect: Potential impacts if the risk does materialize.

Risk Assessment: The last three columns in Figure 9 are described below in the tables.

Table 5: Likelihood and Severity of Consequence

Column	Description
L	Likelihood of occurrence
C	Severity of consequence
Inherent Risk (Risk Rating)	Inherent risk ranking and is a product of L X C. The possible outcomes are low, medium, high or extreme.

Table 6: Likelihood of Occurrence Description

LIKELIHOOD			
Descriptor		Approximate Probability (range / single value)	Frequency (for example, in a 30-year context)
5	Almost Certain	.90 - 1.00 [.95]	e.g. Once a year or more
4	Likely	.55 - .89 [.72]	e.g. Once every three years
3	Possible	.25 - .54 [.40]	e.g. Once every ten years
2	Unlikely	.05 - .24 [.15]	e.g. Once every thirty years
1	Rare	.00 - .04 [.02]	e.g. Once every hundred years

Table 7: Severity of Consequence Description

CONSEQUENCE		
	Descriptor	Effect
5	Catastrophic	Project or program irrevocably finished
4	Major	Program or project re-design, re-approval; i.e. fundamental re-work
3	Significant	Delay in accomplishing program or project objectives
2	Minor	Normal administrative difficulties
1	Insignificant	Negligible effects

Table 8: Inherent Risk Ranking Description

RISK RANKING					
5	LOW	MED	HIGH	EXT	EXT
4	LOW	MED	HIGH	HIGH	EXT
3	LOW	MED	MED	HIGH	HIGH
2	LOW	LOW	MED	MED	MED
1	LOW	LOW	LOW	LOW	LOW
LIKELIHOOD	1	2	3	4	5
	CONSEQUENCE				

LIKELIHOOD (L) x CONSEQUENCE (C)		
Score	0 - 5 =	LOW
Score	6 - 10 =	MED
Score	12 -16 =	HIGH
Score	20 - 25 =	EXT

Figure 10 shows the next columns of the risk matrix. Each of them is explained in further detail below.

Figure 10: Next Portion of Risk Matrix

Initial Allocation under DB	Initial Allocation under DBFOMR	Treatment Description	Status

Initial Allocation: This refers to the initial allocation of the risk under the specific procurement models being analyzed. The possibilities are transferred, retained or shared.

Treatment Description: This is the field where potential management and mitigation strategies are described. These strategies are determined based on experience and knowledge pertaining to the risk event and relate to the Initial Allocation field. Even when a risk is transferred, this field needs to be completed as there still may be actions required in order to successfully transfer the risk at a reasonable price.

Status: This refers to the current status of the mitigation action. A risk can either be identified, active or treated, as described below.

Table 9: Status Option Descriptions

Options	Description
Identified	Risk that are known to exist but are expected to occur well into the future. The project has not yet moved forward into a phase where it makes sense to actively manage the risk.
Active	Risks that continue to exist and are being actively managed.
Treated	Risks that have been mitigated. Take a geotechnical risk, for example, where the mitigation strategy was to drill bore holes and distribute the data to proponents. Once this is done, the risk should be considered 'treated'.

In addition to the columns described above, project teams have the option of including additional information as they see fit to help make the risk matrix a more useful project management tool. For example, the following columns can be added at the Project team's discretion:

- a 'Risk Owner' column to assign people to manage specific risks;
- a 'Project Agreement' column that can describe during the procurement where in the contract a particular risk is addressed; and
- a 'Treatment Option' column with three separate possibilities:
  - Accept and Influence: Refers to a risk that is best managed by the Province but is not under its direct control.

- Accept and Control: Refers to a risk that cannot be transferred to the private sector or that is best managed and mitigated by the Province.
- Transfer: Refers to a risk that can be transferred effectively to the private sector.

ATTACHMENT 2: PROJECT RISK MATRIX AND QUANTIFICATION WORKSHEETS

Note: Attachment 2 has been redacted in its entirety.

ATTACHMENT 3: PROJECT KEY RISKS SUMMARY

Note: Attachment 3 has been redacted in its entirety.

ATTACHMENT 4: RISK ANALYSIS PARTICIPANTS

Derek Bacchioni

Derek has been the Treasury Manager of TransLink since October 2008. His responsibilities focus on cash management and short- and long-term borrowing. He played a key role in securing $500 million revolving line of credit and a $300-million inaugural 10-year bond for TransLink, the first offerings of this kind in the organization's history. Since then he has been instrumental in the raising a further $880 million of bond financing for TransLink. He also worked on the TransLink financial evaluation team on the Golden Ears Bridge project and also helped with the value for money analysis of the Canada Line project. A chartered accountant, Derek received his Canadian CA designation in 2000. Prior to joining TransLink in 1999, he worked at Canada Mortgage and Housing Corporation and prior to that spent 10 years working in corporate and investment banking in South Africa. Completing his South African Chartered Accountant designation in 1991, Derek articled with Price Waterhouse Coopers and holds a Bachelor of Commerce and a Bachelor of Accounting from the University of the Witwatersrand in Johannesburg.

Jeffrey Busby

Jeffrey Busby is the Director, Infrastructure Program Management, for TransLink. He leads a team responsible for development of transit, bike and road capital projects; asset management; bridge operations and maintenance; operation and management of TransLink-owned cycling facilities; and administration of multi-modal cost share programs.

His prior professional experience includes work in strategic and operations planning at the Chicago Transit Authority and as a consultant. Jeff holds a Master of Science in Transportation from the Massachusetts Institute of Technology and is a registered Professional Engineer.

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Magnus Enfeldt

Magnus Enfeldt is an Associate Director at the City of Vancouver. Magnus joined the City in June 2014 from KPMG's Infrastructure practice where he worked on a multitude of projects – from governmental procurement to operational audits and P3 contract compliance reviews. He had a key role in the procurement and implementation to the tolling operations services for the Port Mann Bridge and was involved with the development of the performance-based agreement which he later on managed as the Authority Representative on behalf of the owner, Transportation Investment Corp. Prior to that, as the Venue General Manager for Richmond Olympic Oval, he was responsible to plan, operationalize, and successfully deliver the speed skating events at the 2010 Olympics. Through hands-on experience, Magnus brings and understanding of the complexities with planning, constructing an operationalizing infrastructure with an interdisciplinary team in a multi-stakeholder environment and he has a proven track record in public sector procurement and in developing and managing performance based contracts.

Magnus is an Olympian and holds a MBA from the University of Karlstad, Sweden.

Rachel Jamieson

Rachel Jamieson is a Project Manager in TransLink's Infrastructure Management and Engineering Division. She has worked closely with the City of Vancouver as TransLink's project manager on Granville pedestrian and transit mall reconstruction, Canada Line Station intermodal integration and TransLink's Bicycle Infrastructure Capital Cost sharing program. Earlier in her career in the private sector, she played a key role in the Business Case for improved sidewalks on the Lion's Gate Bridge reconstruction and mobility analysis on the Sea to Sky Highway redesign. She has also managed numerous multi-jurisdictional transportation projects for TransLink including upgrades to the 26-km BC Parkway pedestrian and bike route along the Expo Line SkyTrain in four municipalities and expanding the bus lanes into North and West Vancouver when working with the B.C. Ministry of Transportation on the Marine Drive corridor on the North Shore.

Dave Stewart

Dave Stewart is Executive Director, Finance Major Projects at the Ministry of Transportation and Infrastructure. He brings a unique combination of expert financial management and strategic planning skills to this role. He has extensive knowledge of government budget and capital planning processes, along with an ability to forge productive relationships across government and with external stakeholders. Previously, Dave worked at Partnerships BC and also six years with the Ministry of Transportation and Infrastructure as its Chief Financial Officer. He was responsible for managing the Ministry's operating budget and also overseeing the BC Transportation Financing Authority's multi-billion capital program. While with the Ministry, he also worked for a year as Executive Director, Major Projects, responsible for financial and project management of the Evergreen Rapid Transit Line and the George Massey Tunnel Replacement projects. Prior to this, Dave worked at the Ministry of Finance as Executive Director, Treasury Board Staff, with responsibility for fiscal planning and capital planning for all government ministries and crown agencies. Dave achieved a designation as a Chartered Accountant with the Canadian Institute of Chartered Accountants in 1995 and holds a Bachelor of Commerce degree from the University of British Columbia.

Jesse Koehler

Jesse Koehler is the Project Director, Millennium Line Broadway Extension. Prior to his work on the MLBE Project, Jesse served as the Project Director for TransLink's Phase One Investment Plan, which was approved in November 2016 and funded the first significant expansion of transit in the Metro Vancouver region since 2009. Jesse previously held positions in the planning divisions of TransLink and the San Francisco County Transportation Authority. He holds Bachelor of Civil Engineering and Master of Public Administration degrees from Cornell University.

George Kyriakelis

George Kyriakelis is a Project Director at Partnerships BC, with a focus on the transportation and energy sectors. George joined Partnership BC in May 2013 and has been involved in the planning, procurement and implementations of several health, education, transportation and energy projects, at various roles such as financial modeller, evaluation manager, procurement director and owner's compliance manager. George joined Partnerships BC from Peter Kiewit Infrastructures Group where he worked in various management capacities on some of the largest transportation projects in BC, including the Port Mann Highway 1 signature span, the Pitt River Bridge, and the Sea to Sky Highway Improvement Work Package 2 and the Sea to Sky Highway Improvement DBFO projects. George brings strong practical knowledge of planning, procurement and implementation of large heavy civil projects from both the owner's and contractor's side.

Alan Hartley

Alan Hartley, Stantec Vice President of Major Projects, is Design Director of the Millennium Line Broadway Extension Project. Alan has over 16 years of experience in alternative procurement as a design team lead on Canadian and International infrastructure projects. In British Columbia, Alan has been involved with the Millennium SkyTrain Line, the Canada Line P3, the RCMP E Division Headquarters Relocation P3, and the Kelowna and Vernon Hospitals P3.

Prior to joining the Stantec Project Delivery Office in 2011, Alan served as a Vice President and Director of Stantec Architecture, a 1,000 person architectural practice with offices in Canada, the US, the UK and

Middle East. During his practice leadership Stantec Architecture grew substantially and gained recognition as a Top 25 global design practice.

Ian MacPhee

Ian MacPhee is a Planner in the City of Vancouver's Transit Projects and Policy Group. He began his work at the City of Vancouver in the Planning Department focused on the Metro Core with a focus on job space in the Central Broadway area. After moving to the Transit Projects and Policy Group five years ago, he has been involved in a number of initiatives including the Downtown Bus Service Review, the update of Vancouver's Pedestrian Wayfinding system and most importantly, the Millennium Line Broadway Extension. He brings firsthand experience of previous studies of rapid transit options in the Broadway Corridor as well as a strong understanding of the land use plans and policies that affect the Corridor.

Andrew McClune

Andrew is a Partner in KPMG's Global Infrastructure Advisory practice based in Vancouver. He is an astute financial and commercial manager who draws on over 20 years of experience in the negotiation, commercial evaluation and financing of multi-million dollar project finance and PPP projects:

- 8 years project finance/PPP advisory to public clients on large, complex international infrastructure projects;
- 7 years bid-side PPP financial structuring within a major UK PPP contractor; and
- 6 years project finance analysis and financial modeling within the international oil and gas sector.

Fergus O'Neill

Fergus O'Neill is a Principal and a Senior Project Manager within Stantec's Program and Project Management, Project Delivery office. Fergus has in excess of 25 years' experience in managing medium to very large scale projects in both Canada and Europe. Throughout his career, he has managed projects in various industrial sectors including Oil & Gas, Semiconductor, Pharmaceutical, Bio-Technology, Transport, Education, Retail and Commercial. He brings a wealth of knowledge and experience in both project management and project controls. A Project Management Professional with P3 DBFO project experience, Fergus has worked on a diverse array of complex programs and projects throughout his career in various sectors and some of his larger public and private sector clients have included City of Ottawa, Capital Regional District, TransLink, University of Alberta, Canada Post, Wyeth, Pfizer's, Xerox, Saudi Aramco and Intel.

Chris Robertson

Chris Robertson is a Senior Planner in the City of Vancouver's City-wide and Regional Planning Division. In 2005, he joined the City's Rapid Transit Office to work on the implementation and integration of the Vancouver segment of the Canada Line construction project. Chris' experience with large-scale rapid transit planning and construction is extensive. As a City of Vancouver representative, he has been directly involved in rapid transit planning, design, regulatory reviews and construction processes for projects like TransLink's Faregate implementation program and Expo Line station upgrades. Since 2009, Chris has been part of a team working on the Project including the 2012 alternatives analysis, and the more recent conceptual alignment and station location reference case design. Chris has an extensive working knowledge of the MLBE project and brings a strong understanding of land use planning and polices that affect the Broadway Corridor.

Stephanie Robillard

Stephanie Robillard, P.Eng., is a Project Engineer with McMillen Jacobs Associates in Vancouver, BC. She is trained as a geotechnical engineer and has focused on its application for the design and construction of underground structures. Stephanie joined McMillen Jacobs in 2010 and has been involved in the design and implementation of a number of large underground infrastructure projects, including transportation, water and wastewater tunnels, hydropower tunnels, and gas pipelines. Stephanie's focus has been on transportation projects, including design and procurement for the Ottawa Light Rail Transit Project, Evergreen Line and now as the deputy design lead for tunnels and stations for the Broadway Line Extension.

Stephanie holds a Bachelor and Master of Applied Science from the Queen's University, Kingston, ON, and is a registered professional engineer in the province of British Columbia.

Tony Steadman

Tony Steadman is a Chartered Quantity Surveyor with over forty seven years of managerial and technical experience in the practice of cost management, estimating, and contract administration in the construction industry. In addition to working as a consultant, experience has been gained working for a contractor, and within a client's project management organization. Work experience has included 29 years based in Canada, 10 years based in Africa, extended periods in the Far East with four years in Hong Kong, commencing work in the United Kingdom.

Work has covered the management and preparation of costs from the conceptual through tender and construction stages of major projects including all the transit projects within the Lower Mainland of British Columbia, a number of bridge projects including the Skytrain Bridge in New Westminster, Deh Cho Bridge in the Northern Territories, Groat Road Bridge in Edmonton, Lions Gate Bridge in Vancouver, and the Bennett Bridge in Kelowna. When estimates of costs are prepared, his work takes into account the outputs and costs of each resource together with construction methodology required to carry out each aspect of the work. Parallel experience includes contract administration, document preparation, and claims management. This experience has been combined for project cost control from initiating budgets, controlling costs during design and construction, preparing cost effective contract strategies, ensuring the contract documentation reflects the projects constraints and ideals effectively, and claims management during construction.

John Stolz

John M. Stolz, P.E., is Principal with McMillen Jacobs Associates in San Francisco, CA. He has 35-plus years of underground construction experience in cost estimating, risk analysis, contract delivery methods, “front-end” contract specifications and measurement and payment, and disputes resolution and claims analysis. John joined McMillen Jacobs in 1989 and has been involved in varying degrees with a large number of MJA’s large underground infrastructure projects, including transportation, water and wastewater tunnels, hydropower tunnels, and gas pipelines. John’s experience with transportation projects includes serving as the Claims Manager on the Los Angeles Red-Line Segment extension, claims-related consultation on the design-build Tren Urbano project in Puerto Rico, design manager for preliminary design on the California High Speed Rail Segment between San Jose and Merced, lead estimator on the Downtown Transit Extension Project for rail services in San Francisco, lead estimator for the Central Subway Project, also in San Francisco, lead estimator and Specifications Manager for the Caldecott 4th Bore Road Tunnel Project in Berkeley, CA, lead estimator for underground work and assistance with tender document preparation for the Ottawa Light Rail Transit Project, and the lead estimator for tunnels and stations for the Broadway Line Extension.

John holds a Bachelor of Science from the Colorado School of Mines in Golden, CO, and is a registered professional engineer in the state of California.

Samuel Swartz

Samuel Swartz, P.E., is a Lead Associate with McMillen Jacobs Associates in Seattle, WA, USA. He is trained as a geotechnical engineer but has spent his career focused on design and construction of underground structures. Sam joined McMillen Jacobs in 1998 and has been involved in the design and implementation of a number of large underground infrastructure projects, including transportation, water and wastewater tunnels, and hydropower tunnels. Sam’s focus has been on transportation projects over the last decade, including design and design support during construction for the University Link and Northgate Link Projects in Seattle, WA, preliminary design for the Ottawa Light Rail Transit Project, design and construction support for the Evergreen Line, and now as the project manager for tunnels and stations for the Broadway Line Extension.

Sam holds a Bachelors of Science degree in Civil Engineering from the University of Michigan, a Masters of Science degree in Geotechnical Engineering from the University of California at Berkeley, and is a registered professional engineer in the states of California and Washington

Stephen Tsuen

Stephen is a Senior Manager in KPMG's Global Infrastructure Advisory practice based in Vancouver. He has over 11 years of project finance experience and PPP advisory to public clients on large, complex international infrastructure projects. Stephen's expertise is in the areas of financial modeling, risk quantification (including Monte Carlo analysis), reviewing financial capacity of proponents, RFQ and RFP bid evaluation, development of payment mechanisms and advising on preferred proponent negotiations.

Prior to joining KPMG, Stephen was an Assistant Vice President in PricewaterhouseCoopers' Infrastructure and Project Finance group.

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Ian Wardley

Ian Wardley is an economist, project manager and strategic advisor with more than 25 years' experience in a variety of assignments within Canada and the U.S. with a particular emphasis on transportation and public transit infrastructure. During his career, he has applied his education along with his strong project management and interpersonal skills to projects in the areas of transit, transportation, finance, design, engineering, and government.

Specifically, Ian's infrastructure project experience includes the Millennium Line and Evergreen Line SkyTrain projects, Edmonton's Valley Line LRT project, the Golden Ears Bridge project, and TransLink's Compass Card project. Ian's involvement in these projects, which include both traditional and Public Private Partnership projects, covers a broad spectrum of project-related activities from project set-up, developing and authoring Business Cases for a projects initial justification and funding, assessing various project delivery models including participating in risk workshops, liaising with public and private sector stakeholders, providing strategic advice regarding procurement process, authoring and reviewing procurement documents, assembling and managing multi-disciplinary project teams, and managing day-to-day issues necessary to ensure the project's success.

Gary Webster

Gary has been a practicing Professional Engineer for more than 25 years and has specialized in the organization, procurement and implementation of large scale infrastructure projects and, in doing so, he has worked for both the Public and Private sector participants. Gary has led the Business Case assessment, procurement and contract implementation stages for a number of Public Infrastructure Programs that have included all forms of contracting from conventional delivery through to some of the largest PPP transactions in Canada. His experience includes setting up program optimization systems, managing through the regulatory processes, risk assessment, obtaining government approvals, Business Case development, producing contract and procurement documentation, managing the selection process, engineering design, construction supervision, asset management, revenue collection systems and maintenance management. This experience has been gained across a variety of infrastructure sectors, including institutional, health, marine, transit, highway and bridges and water and wastewater.