Knik Arm Crossing

Cost Estimate Review
Final – May 2009

Prepared by:


U.S. Department of Transportation
Federal Highway Administration

EXECUTIVE SUMMARY

The FHWA Innovative Program Delivery Office, the FHWA Office of Infrastructure, the FHWA Alaska Division Office, the Knik Arm Bridge and Toll Authority (KABATA), KABATA's consultant PND Engineers, Inc., and the National Constructor's Group conducted a workshop to review the cost estimate for the Knik Arm Crossing (Project). This Team met at the KABATA office in Anchorage, Alaska from February 23 through February 27, 2009 to assess the reasonableness of the current cost estimate and to develop a probability range for the cost estimate that represents the Project's current stage of development. A Cost Estimate Review for this project was previously performed by FHWA in April 2006. This CER is based on a more advanced design, an evaluation of resulting risks, and an updated cost estimate.

Significant results of the review:

- The proposed delivery of this Project is through a Public Private Partnership (P3) Concession contract. While this allows for a substantial innovation and flexibility in the Concession's design and construction methods, the final design of the project is not known at this time. Therefore, unlike traditional delivery methods such as design-bid-build, details of the design, construction and schedule will not be known until later in the procurement process. This CER used quantities developed from KABATA's design. The successful Concession will develop more accurate quantities based on their design, which may be considerably different from the ones used here.

- The environmental mitigation for threatened and endangered species has not been determined. It is important to determine the necessary environmental mitigations for this Project as soon as possible to manage the Project's budget.

- Because of the P3 procurement approach being proposed for this project, many details that would be known in a traditional project delivery method are not known yet, such as location of borrow sites on the east side of the Project; the bridge and embankment construction methods; and construction phasing to maximize revenue (toll) collection.

- KABATA should consider obtaining agreements with the Port of Anchorage, the U.S. Army Corps of Engineers, and the Elmendorf Air Force Base regarding access, material sources, and hauling prior to releasing the Request for Proposal (RFP). Securing borrow sources in advance of the RFP will provide more flexibility in construction staging for the Concession.

- Most of the Project's construction cost risk, which will be borne primarily by the Concession, is due to the uncertainty in escalation costs (especially for Phase 2) and due to the uncertainty in the Phase 2 construction cost.

- Because the final design is not known at this point in the P3 procurement process the overall length of the bridge, the number of spans and span lengths and the final approach embankments are unknown which may impact the accuracy of estimated construction cost. However, the Concession will make a "hard bid" offer for the procurement and will bear most of the risk for the construction cost.

- The results of the review indicate that there is a 90% likelihood that the range of all costs (e.g. construction, contingencies, support, environmental mitigations, engineering, utilities, right-of-way, tolling, etc.) for the entire Project will be between approximately $1.5 billion and $1.6 billion. For Phase 1, the 90% likelihood is between approximately $670 million and $740 million. For Phase 2, the 90% likelihood is between approximately $750 million and $920 million. For Phase 2, the review team had to develop assumptions for construction work that could be scheduled between 10 and 20 years out. For Phase 2, especially, the impact of cost escalation is the largest factor in the variability of costs.

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Chapter 1 - Review Summary

INTRODUCTION: The FHWA Innovative Program Delivery Office, the FHWA Office of Infrastructure, the FHWA Alaska Division Office, the Knik Arm Bridge and Toll Authority (KABATA), KABATA's consultant PND Engineers, Inc., and the National Constructor's Group conducted a workshop to review the cost estimate for the Knik Arm Crossing (Project). This Team met at the KABATA office in Anchorage, Alaska from February 23 through February 27, 2009. A Cost Estimate Review for this project was previously performed by FHWA in April 2006. This Cost Estimate Review is based on a more advanced design, an evaluation of resulting risks, and an updated KABATA cost estimate.

The objective of the review was to assess the reasonableness of the current cost estimate and to develop a probability range for the cost estimate that represents the Project's current stage of design. This document summarizes and reports the results of this review.

The Review Team's methodology was to conduct an unbiased risk-based review of the Project's cost. The Review Team was briefed by KABATA on the Project scope, current cost and schedule estimates, and status. The Review Team reviewed current relevant documents and reports on the Project.

The Safe, Accountable, Flexible, Efficient Transportation Equity Act: A Legacy for Users (SAFETEA-LU) (Pub.L. 109-59, 119 Stat. 1144) requires the financial plan for all Federal-aid projects with an estimated total cost of $500,000,000 or more to be approved by the Secretary (i.e., FHWA) based on reasonable assumptions. The $500,000,000 threshold includes all costs (NEPA, PE, CN, R/W, UT, CE, etc.). The FHWA has interpreted reasonable assumptions to be a risk based analysis. (Projects that are between $100 million and $500 million are subject to review at the discretion of the FHWA Division Office.) The cost estimate reviews are required to provide the risk based assessment of the estimate and are used in the review of the financial plan.

The Appendix of this Report includes the Review Team's draft close-out presentation given on February 27, 2009.

PROJECT BACKGROUND: The Knik Arm Crossing Project includes the construction of a bridge across the Upper Cook Inlet above Anchorage, Alaska, to connect the Municipality of Anchorage (MOA) with the Matanuska-Susitna (Mat-Su) Borough. The Project is expected to consist of the Initial Buildout in Phase 1 and a Future build-out in Phase 2 as described in the Final Environmental Impact Statement (EIS). The cost estimate review was consistent with Phase 1 and Phase 2 description in the EIS.

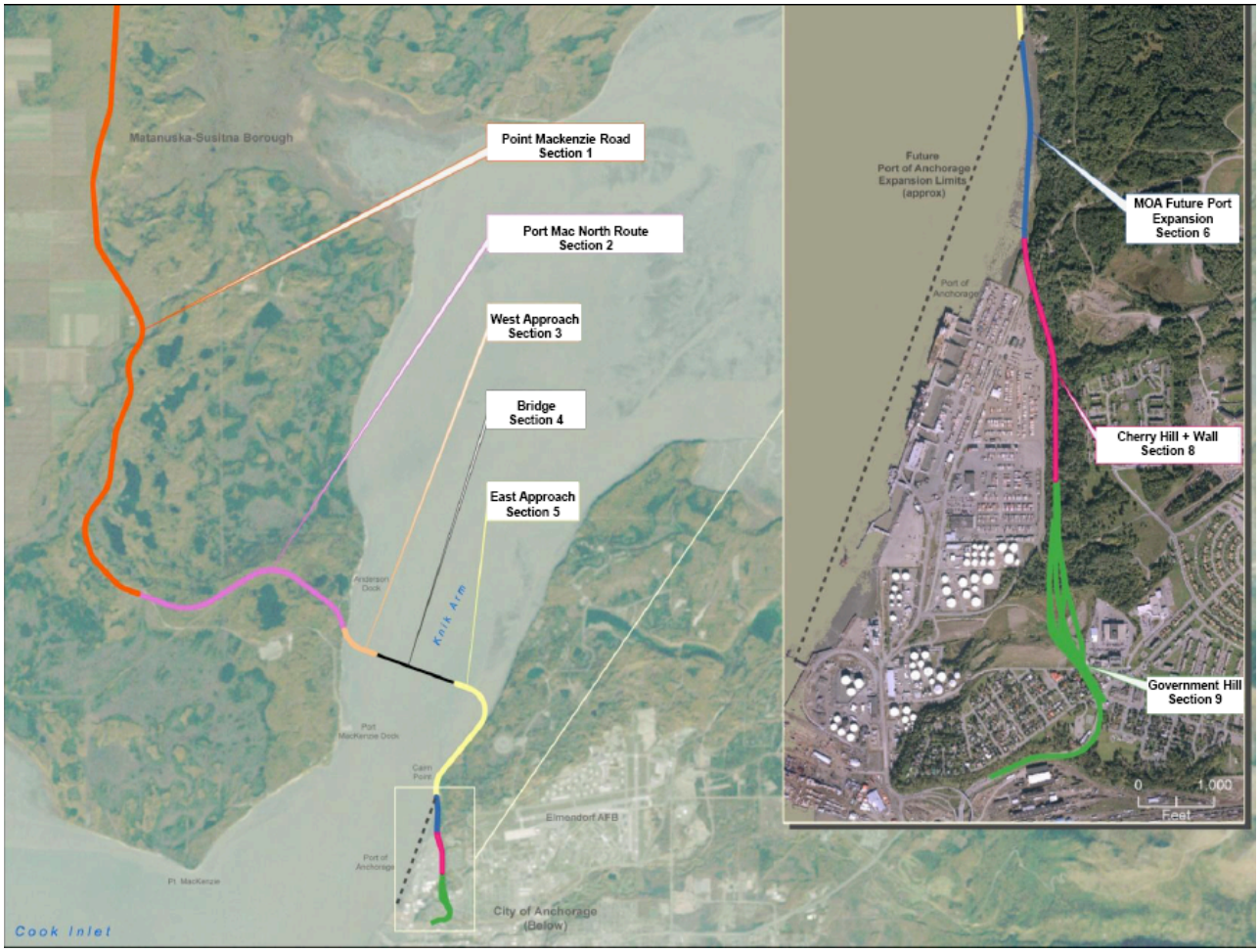
The EIS identified Phase 1 as a '2 lane' 2 way system. The EIS also requires the project eventually to be expanded to '4 lanes' along with a multi purpose pathway. The assumption was made during the review that a single bridge substructure would be built during Phase 1 that would accommodate the full design layout including a pedestrian

path, without the need for additional piles or piers. The Phase 1 embankments and roadways must also be capable of being expanded to '4 lanes' along with a multi purpose pathway. The EIS conceptual design does not provide for embankment construction in the tideland area during Phase 2. Phase 1 includes:

- Improving Point MacKenzie Road from the western bridge approach northward to Burma Road
- Constructing the west and east bridge approaches (constructed fill)
- Constructing the bridge
- Constructing a fill through the Port of Anchorage area (below the Cherry Hill bluff)
- Constructing a cut and cover tunnel through the Government Hill historic area, and
- Connecting the Knik Arm Crossing roadway to the "A" Street/"C" Street couplet.

Phase 2 is defined by the work necessary for 4 lane – 2 way traffic and the road connection to Ingra Street and Gamble Street. The Knik Arm Bridge and Toll Authority (KABATA) was established within the Alaska Department of Transportation and Public Facilities (ADOT&PF) to deliver the Project. The bridge that is to be constructed is expected to be 8,200 feet in length.

The Knik Arm Crossing will be part of the National Highway System (NHS), and the assumption was made during the review that the Project will be constructed in accordance with FHWA and Alaska Department of Transportation and Public Facility standards.


Point Mackenzie Road
Section 1
Port Mac North Route
Section 2
West Approach
Section 3
Bridge
Section 4
East Approach
Section 5
MOA Future Port
Expansion
Section 6
Cherry Hill + Wall
Section 8
Government Hill
Section 9
Matanuska-Susitna Borough
Future
Port of Anchorage
Expansion Limits
(approx)
Port of
Anchorage
Knik Arm
Anderson
Dock
Port
MacKenzie Dock
Cairn
Point
Elmendorf AFB
Port of
Anchorage
Pt MacKenzie
City of Anchorage
(Below)
Cook Inlet
0
1,000
Feet

COST SUMMARY:

The National Constructors Group developed a Knik Arm Crossing Conceptual Cost Estimate, dated January 2009, under contract with the ADOT&PF. The estimate was based on conceptual design documents provided by ADOT&PF and was developed based upon procedures utilized by heavy civil engineering contractors to prepare competitive bids to public transportation agencies. This estimate was made available to the review team prior to the review and was used to model construction costs for non-bridge work during the review.

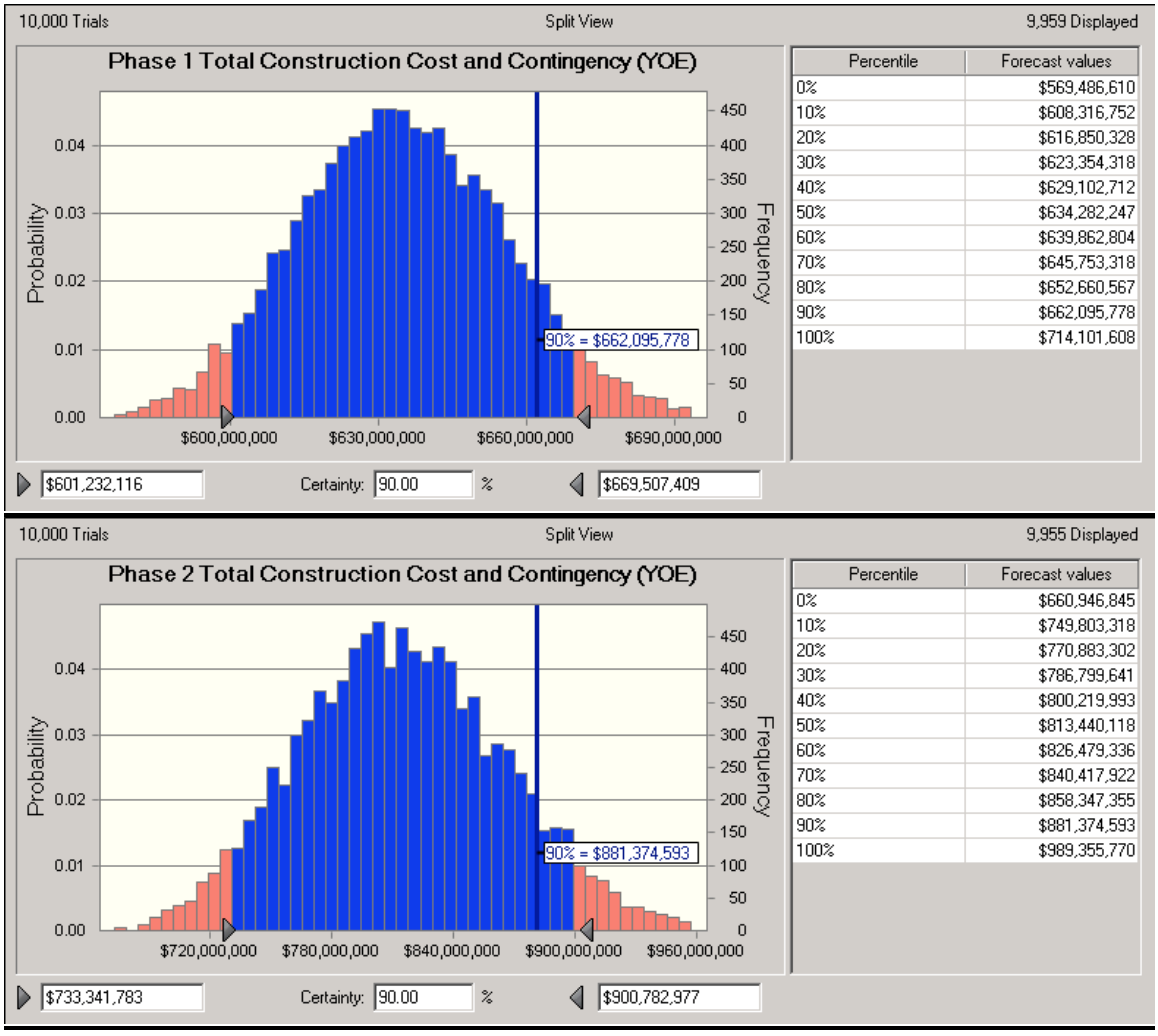
During the review, KABTA provided a cost estimate for the Project. The KABATA bridge estimate was used to model bridge costs.

Although the estimate model used during this review was based on the best available information, the Concession's cost estimate will be based on the Concession's design and that estimate may result in different design quantities and different pay items.

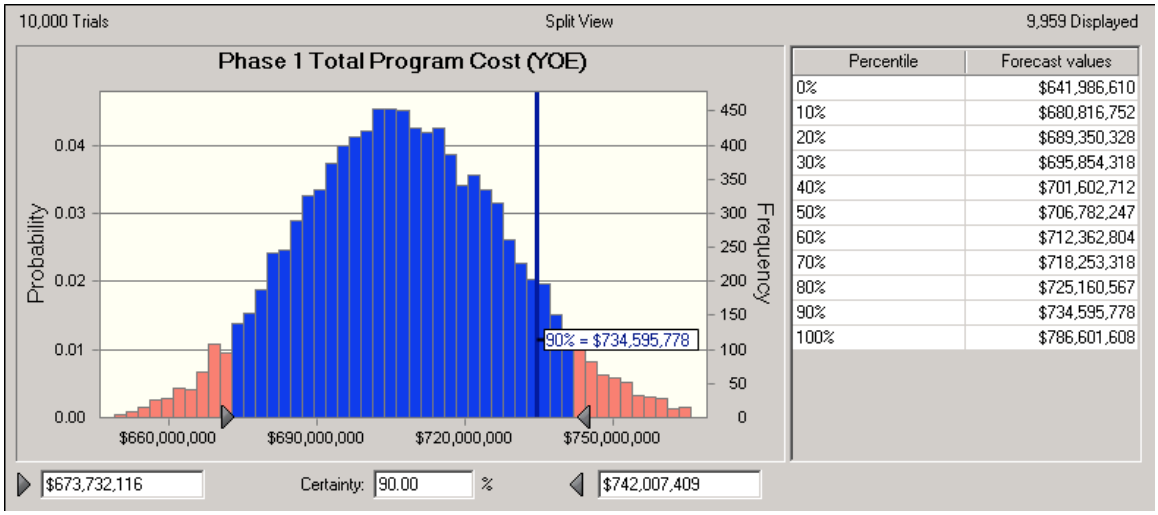
The construction cost estimate includes a 15% contingency which is intended to cover known costs that have not been included in the estimate (e.g. frontage roads and pedestrian paths) and unknown costs.

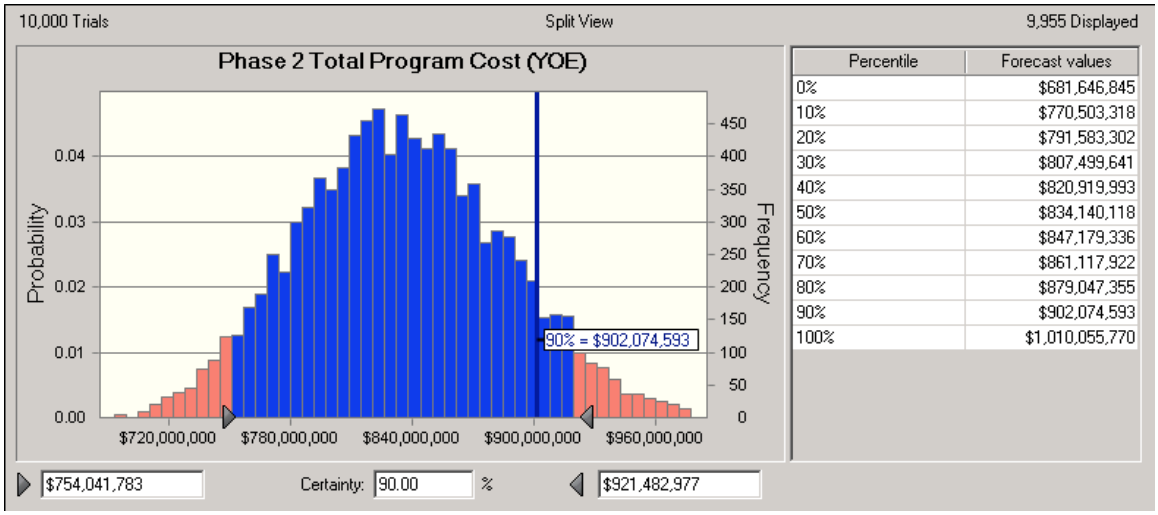
To express the estimate as a range, threats and opportunities were developed and the workshop review team selected assumption curves that best modeled the cost impacts and probabilities based on the uncertainty associated with those threats and opportunities. The assumption curves were incorporated into a Monte Carlo program to develop forecast curves that represent a cost estimate range for the Project. This simulation was performed on the revised estimate.

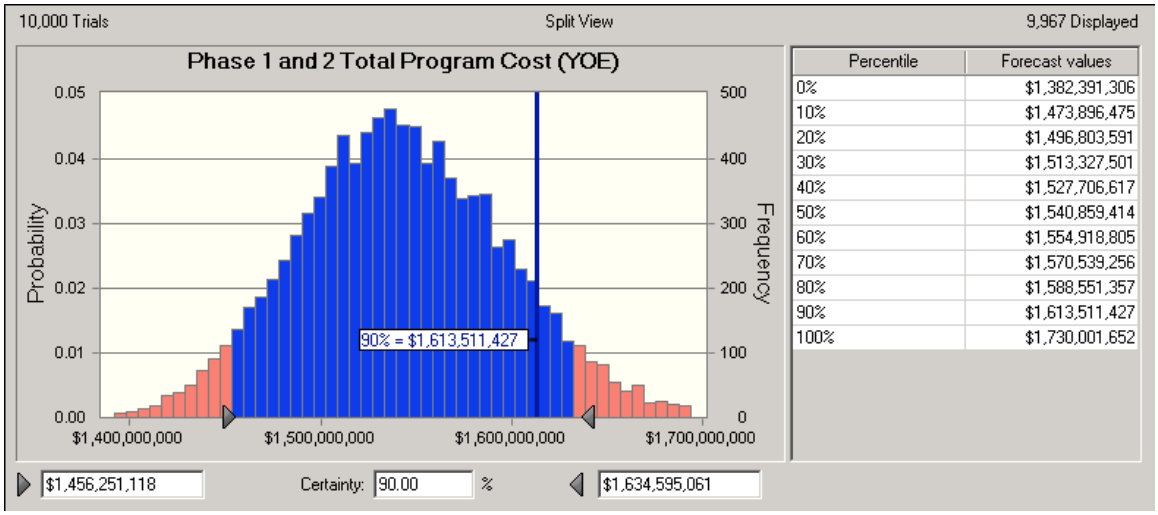
The following two charts show the year of expenditure construction cost estimates with contingency for Phase 1 and Phase 2. The certainty in the Chart (shown using the blue or darker shaded area) represents the likelihood that the total cost for the cost identified will be between the two values shown under the curve, based on the threats, opportunities and uncertainties modeled during the reviews. The certainty shown is based on the potential variability of the inputs used to derive the estimate. As such, it should be noted that events such as deflation or extreme inflation, the impact of world events, or other unforeseen extreme circumstances were not considered in the review.



The next three charts represent the simulation for the total overall program cost (including construction, contingencies support, environmental mitigations, engineering, utilities, right-of-way, tolling, etc.) of the Project for Phase 1, Phase 2, and for the combined Phase 1 and Phase 2. The certainty in the Chart (shown using the blue or darker shaded area) represents the likelihood that the total cost for the cost identified will be between the two values shown under the curve, based on the threats, opportunities and uncertainties modeled during the reviews. The certainty shown is based on the potential variability of the inputs used to derive the estimate. As such, it should be noted that events such as deflation or extreme inflation, the impact of world events, or other unforeseen extreme circumstances were not considered in the review.


10,000 Trials
Split View
9,959 Displayed
Phase 1 Total Program Cost (YOE)
Probability
Frequency
0.04
0.03
0.02
0.01
0.00
450
400
350
300
250
200
150
100
50
0
90% = $734,595,778
$660,000,000
$690,000,000
$720,000,000
$750,000,000
Percentile
Forecast values
0% $641,986,610
10% $680,816,752
20% $689,350,328
30% $695,854,318
40% $701,602,712
50% $706,782,247
60% $712,362,804
70% $718,253,318
80% $725,160,567
90% $734,595,778
100% $786,601,608
$673,732,116
Certainty: 90.00 %
$742,007,409


10,000 Trials
Split View
9,955 Displayed
Phase 2 Total Program Cost (YOE)
Probability
Frequency
0.04
0.03
0.02
0.01
0.00
450
400
350
300
250
200
150
100
50
0
90% = $902,074,593
$720,000,000
$780,000,000
$840,000,000
$900,000,000
$960,000,000
Percentile
Forecast values
0% $681,646,845
10% $770,503,318
20% $791,583,302
30% $807,499,641
40% $820,919,993
50% $834,140,118
60% $847,179,336
70% $861,117,922
80% $879,047,355
90% $902,074,593
100% $1,010,055,770
$754,041,783
Certainty: 90.00 %
$921,482,977


10,000 Trials
Split View
9,967 Displayed
Phase 1 and 2 Total Program Cost (YOE)
Probability
Frequency
0.05
0.04
0.03
0.02
0.01
0.00
500
400
300
200
100
0
90% = $1,613,511,427
$1,400,000,000
$1,500,000,000
$1,600,000,000
$1,700,000,000
Percentile
Forecast values
0% $1,382,391,306
10% $1,473,896,475
20% $1,496,803,591
30% $1,513,327,501
40% $1,527,706,617
50% $1,540,859,414
60% $1,554,918,805
70% $1,570,539,256
80% $1,588,551,357
90% $1,613,511,427
100% $1,730,001,652
$1,456,251,118
Certainty: 90.00 %
$1,634,595,061

SENSITIVITY ANALYSIS:

A Sensitivity Chart demonstrates the relative impact of each assumption curve in the estimate model. The following Charts show the relative impacts of the modeled uncertainly for the Phase 1, Phase 2 and total year of expenditure program cost:

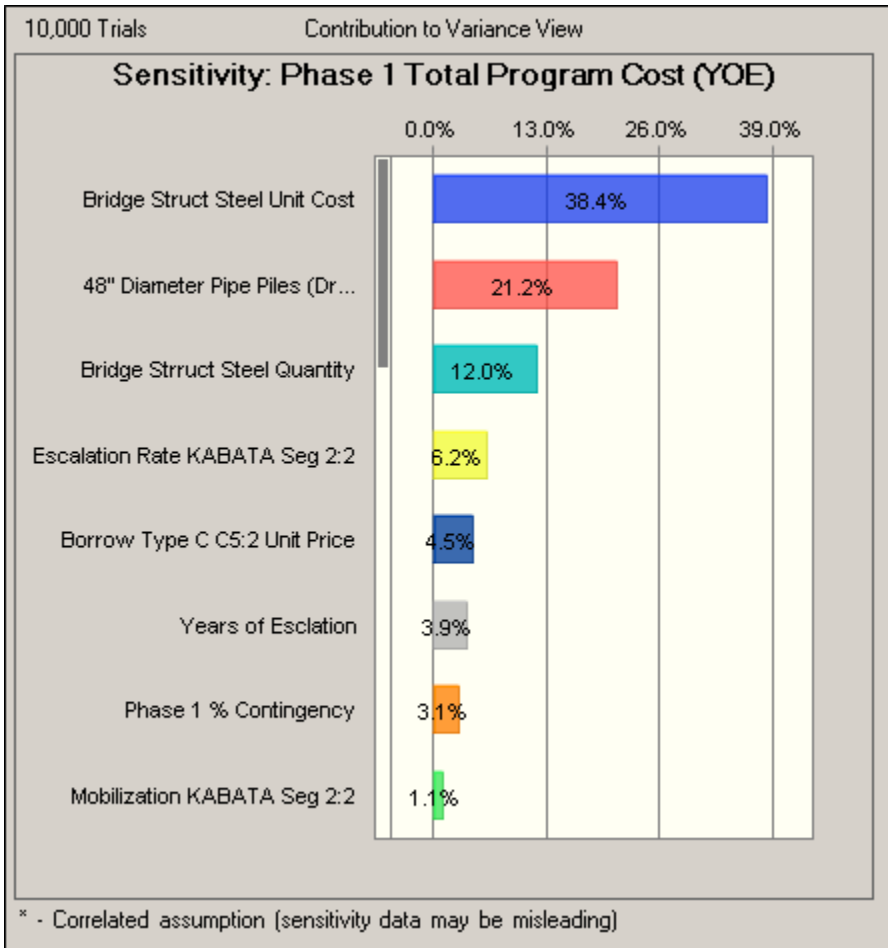


Figure 1

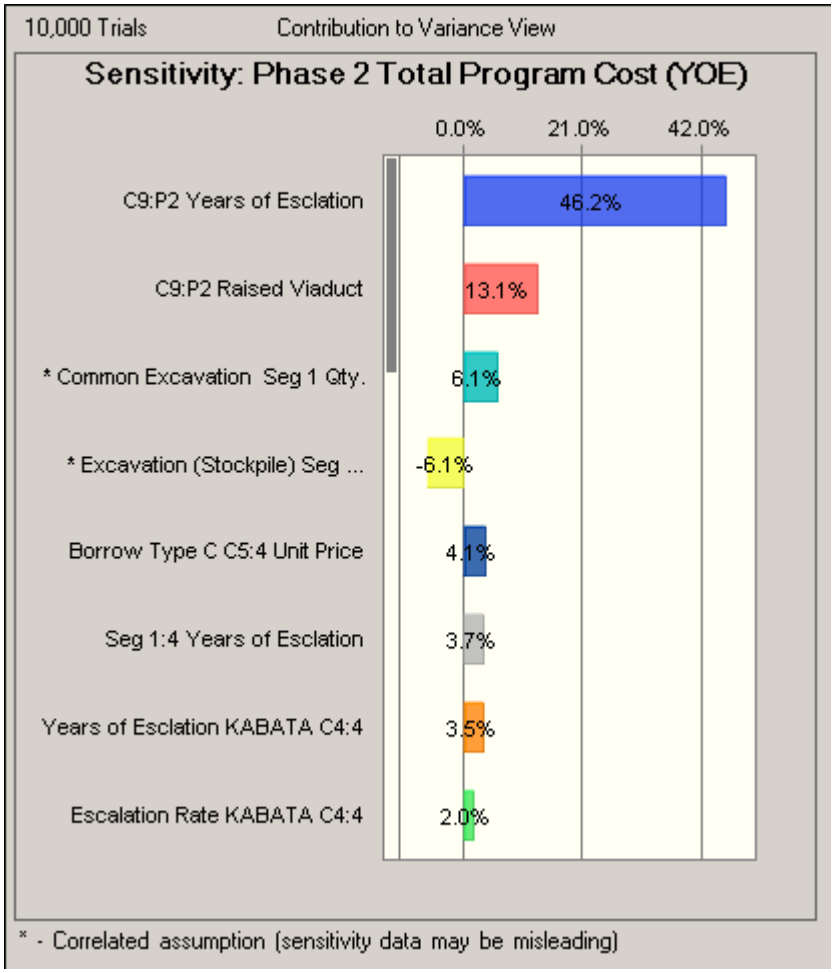

10,000 Trials
Contribution to Variance View
Sensitivity: Phase 2 Total Program Cost (YOE)
0.0%
21.0%
42.0%
C9:P2 Years of Esclation
46.2%
C9:P2 Raised Viaduct
13.1%
* Common Excavation Seg 1 Qty.
6.1%
* Excavation (Stockpile) Seg ...
-6.1%
Borrow Type C C5:4 Unit Price
4.1%
Seg 1:4 Years of Esclation
3.7%
Years of Esclation KABATA C4:4
3.5%
Escalation Rate KABATA C4:4
2.0%
* - Correlated assumption (sensitivity data may be misleading)

Figure 2

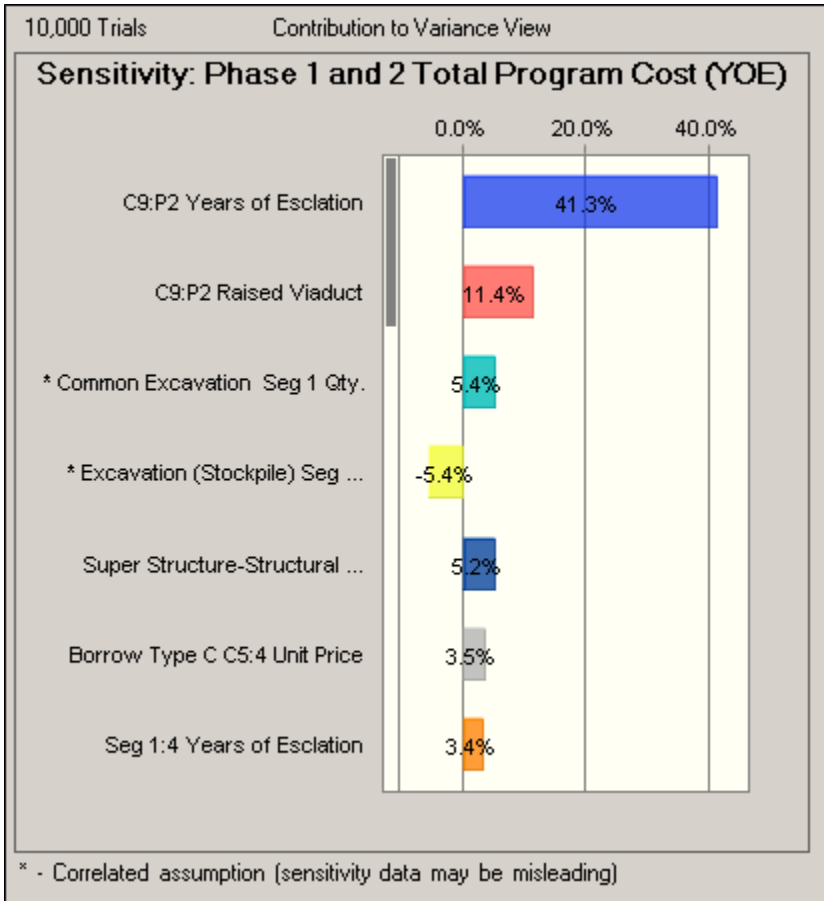


Figure 3

Overall, the greatest contribution to the variation in the total program cost estimate is due to estimated escalation costs for the construction costs for Phase 2 of Section 9 (Government Hill). (See Figure 3) The year of expenditure construction estimate for this work is over $400 million (including contingency). The escalation amount for this construction work was based on an estimated 18 years to the midpoint of construction. At this time, the construction phasing and schedule of the project is unknown since the Concession has significant flexibility to schedule Phase 2 improvements that maximizes revenues and minimizes construction cost. These factors contribute to a wide range of potential escalation cost. The impact of cost escalation is the largest factor in the variability of costs.

The second greatest contribution to the overall variation in the total cost estimate is due to the Viaduct construction cost for Phase 2 of Section 9 (Government Hill). (See Figure 3) The current year construction cost for the Viaduct is estimated at $93 million with a variance of plus or minus 20%.

Since the estimate model correlated the Common Excavation quantity with the Excavation quantity to reflect the potential for earthwork balancing, these times show up

on the Sensitivity Chart with a high contribution to the overall variation. However, this is misleading. As one quantity increases, the other decreases; therefore these two items do not provide a significant overall effect on the overall Project estimate.

The next contributor to the overall variation is the unit price for the Structural Steel for the bridge superstructure in Phase 1. There is uncertainty regarding this item due to the uncertainty in the final design affecting bridge length and spans, unknown contractor construction methods, unknown specifics in the structural steel fabrication; and the potential for strict construction tolerances. The total current year cost for this item is $187 million and the variance is plus or minus 12%.

RISK (THREATS AND OPPORTUNITIES) SUMMARY: During the course of the workshop the Review Team identified the following risks (threats and opportunities):

THREATS -

- Segment 1 - Maintaining existing Mat-Su Borough roads during construction.
- Segment 1 - Uncertainty in the quantity of muck excavation (Phase 2).
- Segment 2 – Uncertainty in the Port Mackenzie Egress Interchange design.
- Segments 3 and 5 - Constructing embankments below 20 feet (and below 30 feet) require working around the tidal influences of the Knik Arm. At this time, the design and construction details are not known and are expected to be finalized by the Concession.
- Segment 4 - Noise Attenuation requirements during installation of pipe piles.
- Segment 4 – Uncertainty in pile cap design and construction.
- Segment 4 – Uncertainty regarding mitigation requirements for wildlife and marine life (e.g. Beluga Whale and salmon) and its effects on construction operations.
- Segment 4 – Uncertainty about the financial approach regarding equipment for construction of the bridge.
- Segment 4 – Bridge design (e.g. span lengths and materials) may be impacted by threatened and endangered species mitigation.
- Segment 4 – Uncertainty in scour design (e.g. Armor Rock).
- Segment 5 - Borrow sites, material sources and haul distance are uncertain. Although this is a risk for all segments, the greatest potential impact is on Section 5 due to the limited availability of significant borrow near the project on the Anchorage side.
- Section 8 - Uncertainty of the stability and icing of Cherry Hill slope.
- Section 9 – Although surveyed, there is uncertainty in the quantity and severity of contamination.
- All segments – Possibility of seismic and volcano activity during construction.
- All segments – All projects have a potential for unknown risks (e.g. management reserve)
- All segments - All permits (including wetland mitigation) have not been obtained; therefore final permit conditions have not been established.
- All segments – Right-of-way has not been purchased.

- All segments – The impact of the American Recovery and Re-investment Act on the construction market is uncertain.
- All segments – Due to design and environmental uncertainties, identifying a contractor's risk tolerance is difficult.
- All segments – There is potential for schedule delays
    - ROD
    - NOAA-NMFS
    - Procurement
- All segments – Construction delays could impact Concession's revenue stream.

OPPORTUNITIES -

- Segments 3 and 5 - Reinforced earth walls or slopes could reduce the cost of the approach embankments.
- Segment 3 and 5 – Alternative methods to construction approach embankments (i.e. trestle system) could reduce costs.
- Segment 4 – Consideration for alternate foundations.
- Segment 8 – Flatten or steep slopes to reduce the amount of wall needed.
- Segment 8 – Consider the use of alternative wall concepts.
- Segment 8 – Evaluate moving alignment at Cherry Hill west to reduce cut and associated retaining wall costs.
- All segments - Develop a public information video and good public relations. This may include developing good communications with Government Hill and Anchorage residents to show how quickly cut and cover tunnels can be built.
- All segments – Maximizing design flexibility in a PPP procurement can save cost
- All segments - Obtain materials agreement with Elmendorf AFB for use of borrow pits prior to RFP.
- All segments – There is a potential to use 3 lane concept (with a reversible lane) to defer the need to expand to 4 lanes.
- All segments - Obtain access permission through Port of Anchorage prior to RFP.
- All segments (except Segment 4) – Optimize schedule and alignment to balance earthwork.
- All segments – Evaluate the use of dredged material from other operations (e.g. Army Corps contracts).
- All segments – Obtain permits with design flexibility prior to RFP to reduce permit uncertainty.

ISSUES NOT MODELED: Although not modeled in the simulation, the Team identified the following issues that require follow-up:

- Material and Access agreements should be executed before the Request for Proposals is issued.
- NEPA – The ROD with necessary environmental mitigations should be issued before the Request for Proposals is issued. The simulation did not model the cost impacts associated with a new location for the bridge or other major scope changes.

- IFP and PMP approvals – The Alaska Division Office must accept a Project Initial Financial Plan and a Project Management Plan before awarding a Concession contract.

REVIEW RECOMMENDATIONS: During the workshop, the Review Team developed the following recommendations for implementation:

- Continue to periodically update estimates.
- Continue to resolve environmental and permitting issues.
- Pursue agreements with ports and Elmendorf AFB regarding access, material sources, and hauling.
- Follow up with the development of a risk management plan to manage threats and opportunities – and update risk analysis

NEXT STEPS: These follow-up actions were developed at the end of the workshop:

- The closeout presentation made on February 27, 2009 completed the review. FHWA will prepare a draft report documenting review findings on or about 30 days after the review. After receipt of comments, FHWA will finalize the report within 30 days.

- The FHWA will use the results of this estimate review during the completion of the ROD process.

Chapter 2 - Review Methodology

STUDY OBJECTIVE: The objective of the review was to verify the accuracy and reasonableness of the current total cost estimate and schedule to complete the Project and to develop a probability range for the cost estimate that represents the Project's stage of design.

REVIEW TEAM: The Project Review Team was developed with the intent of having individuals with a strong knowledge of the Project and/or of major project work and expertise in specific disciplines of the Project. This Review Team participated together throughout the workshop, and individuals with specific Project expertise briefed the Review Team on that portion of the Project estimate development process, including the development of the Project cost estimate quantities, unit prices, assumptions, opportunities and risks.

The following organizations were represented at portions of the review:

- FHWA Alaska Division
- FHWA Office of Infrastructure
- FHWA Innovative Program Delivery Office – Project Delivery Team
- Knik Arm Bridge and Toll Authority (KABATA)
- PND Engineers, Inc.
- The National Constructor's Group

During the opening and close-out, the Alaska Department of Transportation and Public Facilities (Alaska DOT/FP) was represented.

DOCUMENTS REVIEWED: Documents provided by KABATA and the Alaska DOT/FP to the Review Team prior to and during the workshop:

- Knik Arm Crossing Conceptual Cost Estimate, dated January 2009, prepared by The National Constructor's Group for AK DOT/PF
- KABATA Bridge cost estimate prepared by PND
- Cost Estimate Review Study dated June 2006, prepared by PBS&J for FHWA, and updated by KABATA
- Project Environmental Impact Statement
- FHWA Memorandum dated February 17, 2006 from Joe Krolak, Senior Hydraulic Engineer, Office of Bridge Technology, Hydraulic and Scour Review of Knik Arm Bridge
- SHPO commitments
- Bid Tabs
    - Alaska DOT
    - Point Mackenzie (Mat-Su Borough)
    - Port of Anchorage Expansion: North Extension – Barge Berth
- Spin Fin Piles Report, prepared by PND

GOOD PRACTICES:

- Estimates were provided for all Project costs. (Construction, Agency, Support, Utilities, ROW, etc.)
- Use of the National Constructor's Group to develop a cost estimate.
- Update of the previous FHWA cost review from 2006
- Preparation of a cost risk analysis report
- Use of local consultant (PND) familiar with the local Alaska environment.
- Use of up to date unit price histories
- Use of contingencies (15%)

REVIEW PROCESS:

- Project Team input
    - FHWA, KABATA, The National Constructor's Group, PND)
- Methodology
    - Understanding of the estimate development process
    - Determining reasonableness of unit costs and quantities
    - Developing the Threats and Opportunities for various items
- Threats and Opportunities Analysis
    - Focused on major cost items
    - Determined impact and probability for identified risks
    - Developed probability assumption curves
- Performed Monte Carlo modeling of potential cost outcomes to determine a probabilistic estimate forecast
- Not an independent estimate
- Assumed a Public Private Partnership procurement
- Only valid for model assumptions

Chapter 3 – Probability Analysis

The objective of the probability analysis during the workshop was to determine the Review Team's confidence level in the current values being produced for the estimate. The results of this probability analysis could then be used to determine if the risk/contingency factors in the estimate are reasonable.

The Review Team discussed the current estimate, scope, schedule, threats and opportunities. Based on this review, probability assumption curves were selected for items in the Project estimate, considering the probability that the values would be within a certain range. Next, forecast curves were generated from the random sampling (10,000 iterations) of the input probability curves previously defined by the Review Team. This type of analysis provided a statistical level of certainty that the variation of the forecast distribution curve reflected the underlying variation of the cost inputs (in the form of assumption curves) as determined by the Review Team.

The resulting forecast curves were then analyzed to provide information on the confidence level in the Project cost estimates and remaining budgets.

The Review Team used a statistical software tool called Crystal Ball® in order to establish a sense of perspective on the cost expectations for the Project. This software selection is an add-in program for use with the Excel™ spreadsheet program and it permitted the application of Monte Carlo simulation technology to analyze key components of current cost estimates prepared by the Project delivery team. As is the case with many real-world problems involving elements of uncertainty, the analysis of the variables is much too complex to be solved by strict analytical methods. There are simply too many combinations of input values to calculate every possible result. In the case of this workshop cost model, the Monte Carlo simulation supplied random numbers for selected cells identified as "assumption cells", with these random numbers falling within the range of real-life possibilities defined by the study team. Each set of these random numbers is essential input to a "what-if" scenario. In this case, each scenario outcome represents a possible outcome from an expected real-world bidding and construction cycle. The model is recalculated for each scenario many times and builds a final forecast probability curve that reflects the combined uncertainty of the assumption cells on the model's output. This plotted probability curve provides a range that can be expected for a final Project cost, with degrees of certainty to model the potential final outcome.

The outcome depicted in this final probability curve is typically stated in the following manner:

"There is a 90% (or whatever percentage depicted) degree of certainty that the construction cost will be in a range from $x to $y, provided that our understandings and related assumptions do not change significantly between now and the end of construction."

For this to work correctly the Review Team must supply the program with the probable range of costs for each assumption cell in the spreadsheet, and must supply an indicative characterization for the probability spread for each of these cells. This is illustrated in the form of probability assumption curves.

The probability assumption curves depict how the Review Team considered modeling the cost elements. Based on these assumption curves, the Monte Carlo analysis selects a random number for each of these curves and sums each random selection for the resulting probabilities.

Appendix B includes all of the probability assumption curves used for the Project estimate.

Appendix A – Workshop Close-out Presentation –

Knik Arm Closeout Presentation.pdf

Appendix B – Crystal Ball Report

Crystal Ball Report.pdf

Appendix C – CER Estimate

Knik Arm Estimate.pdf