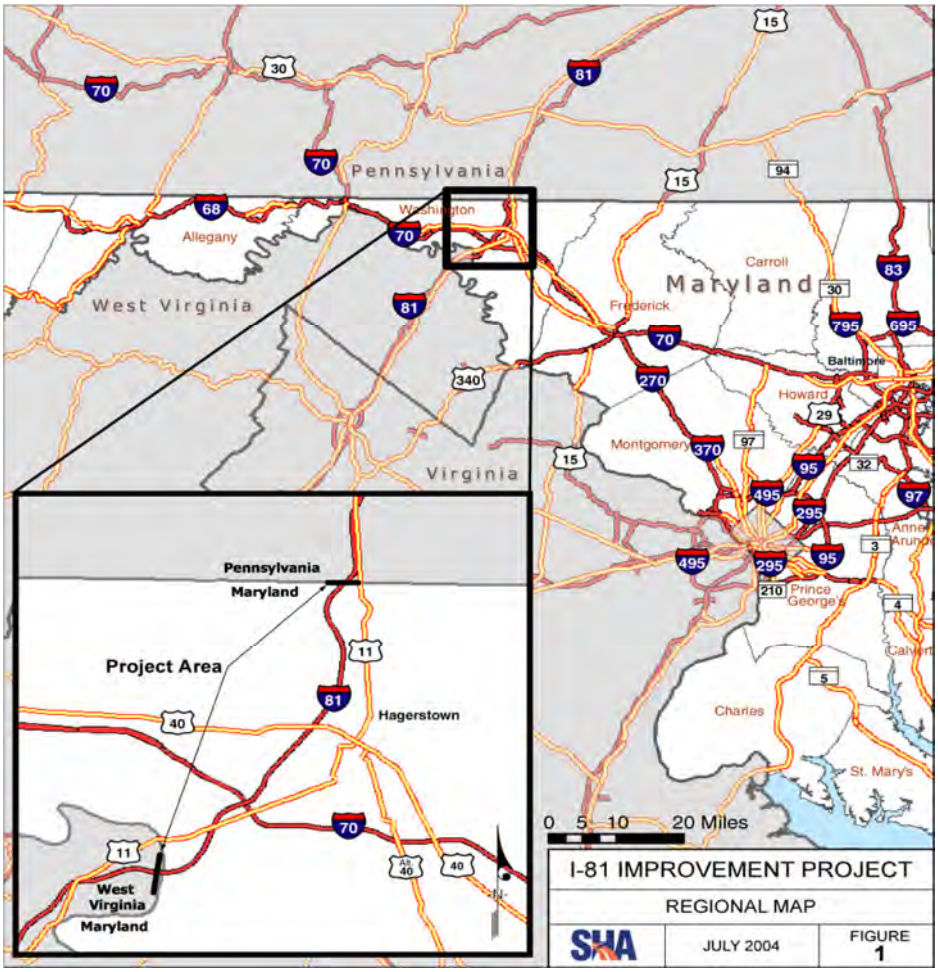
# MARYLAND I-81 IMPROVEMENT PROJECT




## FHWA Cost Estimate Review
## Final Report: April 2016

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## EXECUTIVE SUMMARY

A review team consisting of the Federal Highway Administration (FHWA), the Maryland State Highway Administration (MSHA), and their consultants conducted a Cost Estimate Review (CER) workshop to review the cost and schedule estimates for the I-81 Improvement Project in Washington County, Maryland. The workshop was held at the MSHA HQ Office in Baltimore, MD from February 9 – 11, 2016.

The objective of the review was to verify the accuracy and reasonableness of the project's cost estimate and schedule and to develop a probability range for the cost estimate that represents the project's current stage of development. The results will be used as the basis for setting the project's baseline total cost in the Initial Financial Plan.

The purpose of this project is to improve traffic operations and safety along the Maryland portion of I-81 from the West Virginia state line to the Pennsylvania state line. As part of the contract documents for Phase 1 of the I-81 Improvement Project, at the request of West Virginia Division of Highways (WVDOH) MSHA will include improvements in West Virginia from the Potomac River Bridge crossing south to merge with previous West Virginia improvements at US 11 (not part of MSHA's Major Project - NEPA document). MSHA is in the process of entering into a Memorandum of Understanding (MOU) with the WVDOH on the sharing of costs and responsibilities for implementation of the project. The project improvements are primarily related to widening to the existing median, and thus there are no right-of-way costs to purchase additional land for the project corridor.

As MSHA will be including the work in WV in their contract, the cost estimate review included the cost of the work in WV in this cost estimate review. Per the FHWA guidance, major project is defined by the scope of the work included in the approved NEPA document. For this reason, MSHA's Initial Financial Plan will discuss project cost and project funding for the bridge and the work in Maryland. The IFP will include an MOU between the MSHA and WVDOH stipulating that the WVDOH will be responsible for reimbursing MSHA for constructing WV portion of the highway work.

The project is divided into 5 phases, with Phases 1 and 1A being funded and having designs near completion and ready for construction bidding. These funded phases of the project had a pre-CER estimate of approximately $101 million cost to complete in current year (CY) dollars with a scheduled completion date of June 2019. Phases 2, 3 and 4 are currently unfunded, at a conceptual design phase, and were estimated to be executed in series over the next 18 years to

develop Year of Expenditure values for the study. With these unfunded phases included, the total project pre-CER estimate in CY dollars was $560 million, with an anticipated project completion date of June 2034. The above costs include environmental, engineering, utilities, construction costs, and contingencies. It should be noted that financing and operation and maintenance costs are not included in this estimate. Costs to date of just over $9 million are also excluded from the above values.

During the review, cost and schedule risks were identified, quantified, and then added to the estimate. Inflation rates were discussed to the midpoints of expenditure for all years based on information provided by MSHA staff. The review team also identified a number of adjustments to the base estimate amounting to approximately $22 million in additional costs, and modified the base estimate to reflect these changes. The major adjustment was the inclusion of an allowance for potential change orders during construction.

Based on the revised base estimate, and on this risk assessment, the Monte Carlo simulation for the funded Phases 1 and 1A of the project resulted in a range of total project costs between approximately $110 and $138 million (YOE). The estimate at the 70% confidence level is $125 million (YOE). These values include the previous $9 million in expenditures for the project. For the total project, including the unfunded Phases 2-4, the simulation resulted in a range from $631 to $935 million, with the 70% confidence level amount at $811 million (YOE). This 70% amount is typically identified in the project's initial financial plan to show that adequate funding is available to construct the project. However, this estimate is a snapshot in time and is expected that through further project development, such as the on-going procurement activities and future funding decisions and timing, the estimate will change. The initial financial plan should detail any changes in the project estimate since the completion of the CER.

Review findings/observations are as follows:

- This project has 5 phases; Phases 1 and 1-A are funded while Phase 2, 3, and 4 are the unfunded phases.
- MSHA is the lead agency in administrating the funded Phase 1 and 1A of this project. WVDOH is the partner agency for Phase 1 due to that WVDOH is contributing to portion of the bridge work in MD and to all of the work in WV included in Phase 1.
- The NEPA decision (for WVDOH)/Reevaluation (for MSHA) documents for both states have not been approved.
- The Phase 1 will be advertised as one contract including all the work in Maryland and West Virginia.
- Some of the additional Risks (Drainage, Permits, Noise Walls, Landscaping, In stream Work and some of West Virginia-funded work items) were added/modified to the Risk

register which was not included in the original risks register list submitted for the purpose of the CER.

- MSHA provided a basic schedule for funded and unfunded phases for the CER workshop. The schedule for the unfunded phases is at conceptual stage.
- There are only two Utility relocations identified in Phase 1.
- Positive Market conditions are identified for Phase 1.
- The funded phases of the project will be delivered using Design-Bid-Build method.
- Level of design for the funded phases used for the estimate and workshop was (+/-95%).
- Estimate was updated in Current Year (CY) dollars, using conservative unit costs based on bid history and modified with current unit item cost.
- Project team and subject matter experts were familiar with project and estimate.
- Planning level base estimates (including the 35% contingencies) were provided for the unfunded phases of the project.

The following recommendations are provided based on this review:

- Complete the NEPA/Reevaluation process in Maryland and West Virginia.
- Should develop more detailed Schedule for funded phases of the project up to project award.
- Work proactively with Permitting Agencies to avoid delays.
- Work proactively with WVDOH to finalize the MOU addressing roles and responsibilities.
- Work proactively to finalize the Utility Agreements.
- Work proactively with WVDOH to establish Contract Administration activities.
- Continue to work with FHWA Maryland Division office liaison to make sure all necessary project requirements are met.

# CHAPTER 1 – REVIEW PROCESS

A review team consisting of the FHWA, the MSHA, and their consultants conducted a CER workshop to review the cost and schedule estimates for the I-81 Improvement Project in Washington County, Maryland. The workshop was held at the MSHA Offices in Baltimore, MD from February 9 – 11, 2016.

The purpose of this chapter is to provide a general overview of the cost estimate review process. This chapter includes a discussion of the review objective, team, documentation provided and methodology.

## REVIEW OBJECTIVE

The objective of the cost estimate review was to conduct an unbiased risk-based review to verify the accuracy and reasonableness of the current total cost estimate to complete the Project and to develop a probability range for the cost estimate that represents the current stage of Project design. The review team also reviewed the proposed Project schedule to determine potential schedule impact on the Project cost.

## BASIS OF REVIEW

The Moving Ahead for Progress in the 21st Century Act (MAP-21) required the financial plan for all Federal-aid projects with an estimated total cost of $500 million or more to be approved by the U.S. Department of Transportation Secretary (i.e. FHWA) based on reasonable assumptions. This requirement has remained in place with the current Fixing America's Surface Transportation (FAST) Act. The $500 million threshold includes all project costs, such as engineering, construction, ROW, utilities, construction engineering, and inflation. The FHWA has interpreted 'reasonable assumptions' to be a risk based analysis. The cost estimate review provides this risk based assessment and is used in the approval of the financial plan. This is an independent review, but does not use an independent FHWA estimate. The review team used an estimate provided by the MSHA project team.

## REVIEW TEAM

The 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 team participated together throughout the workshop, and individuals with specific Project expertise briefed the review team on portions of the Project or estimate development process.

The review team also discussed the development of the Project cost estimate quantities, unit prices, assumptions, opportunities and threats. A sign-in sheet is provided in the Appendices.

The review team was comprised of members of the following organizations:

**FHWA:**

- Sajid Aftab- Major Projects Engineer- FHWA- CER Lead
- Dave Carter- Consultant- Crystal Ball/Model Developer
- Peter Clogston- Advisor to CER Team
- Daniel Suarez – Area Engineer-Maryland Division- FHWA- CER Team

**MSHA:**

- John Narer- Office of Structure
- Jason Harris- Project Management Division
- Puskar Kar- Project Management Division
- Barrett Kiedrowski- Project Management Division
- ROW/Utilities- District 6 Staff- Dave DeMaine and Dave Felker
- Railgul Obul- Project Management Division

**RKK:**

- Dennis McMahon

**McCormick & Taylor:**

- Bob Maimone- Environmental Planning

## DOCUMENTS REVIEWED

Documents provided by MSHA and reviewed prior to and during the workshop included:

- Project Cost Estimate
- Project Schedule
- Project Risk Register
- Project Draft Environmental Document link

## METHODOLOGY

The methodology for this cost estimate review is outlined as follows:

- Verify accuracy of cost estimate
  - Understand project scope and cost estimate development process
  - Discuss assumptions for contingencies and projected inflation rates

    - Review major cost elements
    - Identify threats and opportunities (Risks)
- Model uncertainties
    - Establish base estimate variability
    - Model variation of inflation
    - Determine probability of occurrence and schedule and cost impacts for significant project threats and opportunities
    - Model anticipated market conditions at the time of letting
- Perform Monte Carlo simulation to model variability and risks and generate likely range of project cost and schedule
- Communicate results
    - Report methodology and results in a close-out presentation
    - Document review in a final report that will be used to inform the public and develop the financial plan

The following discussion provides more detail about the concepts utilized during the review.

## Verify Accuracy of Cost Estimate

The review team was provided an overview of the estimation process used to develop the project's estimate. This overview included understanding the scope of the project, stage of design, and assumptions used to develop the estimate. The review team interviewed the project team and discussed the accuracy of each major cost element.

## Model Uncertainties

In general, uncertainties in the estimate can be described as those relating to base variability, market risks, and cost and schedule risk events. Each of these are discussed and modeled to reflect the total uncertainty.

Base variability is a measure of uncertainty applied to the base estimate that represents the inherent randomness associated with the estimating process. Base variability is a function of the project's current level of design and the process used to develop the estimate. This may be demonstrated by the fact that two estimators using the same data source and following the same general estimate development guidance will generate different estimates. Additionally, the lack of details about the project and assumptions that should be used to develop the estimate would cause more uncertainty and variability in the estimate. This base variation is a function of the system (i.e. assumptions and data sources used to define the estimate). Base variability is applied to the base estimate exclusive of risks. Contingencies that include risks are

removed from the base estimate to avoid double counting risks identified in the risk register. Allowances and expected construction change order costs typically remain in the base estimate.

Market conditions at the time of advertisement, bid, and award are modeled to reflect the future competitive bidding environment. Three scenarios are evaluated including worse than planned, as-planned, and better than planned. Each scenario is assigned a likelihood of occurrence and range of associated costs. In addition to market conditions, inflationary risk is also modeled and used to project current year dollars to year of expenditure.

A risk register is developed by interviewing the project team and its consultants to define the components of contingency and establish both cost and schedule risks. The risk register includes the event risk name, a description of the event, a probability measure of the likelihood the event will occur, as well as a probability distribution of costs if the event were to occur. The register also identifies if the risk event is a threat or opportunity for cost/schedule. Risk threats increase costs/schedule and opportunities decrease cost/schedule. A very important feature of the risk register is to establish the relationship of risk events. For example, some risks are mutually inclusive or mutually exclusive. Mutually inclusive means the risk event can only occur if the prior risk event occurs. Conversely, for a risk event to be mutually exclusive means that it can only occur if the prior risk event does not occur. Risk events can also be independent in which case the probability of occurrence is not dependent on any other risk event. Correlation determines how one risk event will sample relative to another risk event. Correlation should only be established when there is reason to suspect that a relationship exists and needs to be accounted for in the simulation.

After models are developed for market conditions, base variability, and risk events, the review team utilized a Monte Carlo simulation to generate a probability based estimate of YOE Total Project Costs. A simulation is essentially a rigorous extension of a “what-if” statement, or sensitivity analysis, which uses randomly selected sets of values from the probability distributions representing uncertainty to calculate separate and discrete results. A single iteration within a simulation is the process of sampling from all input distributions and performing a single calculation to produce a deterministic result. It is important that each iteration represent a scenario, or outcome, that is logically possible. It is for this reason that the simulation outcomes be reviewed to ensure accuracy. The process of sampling from a probability distribution is repeated until the specified number of computer iterations is completed or until the simulation process converges. Simulation convergence is that point at which additional iterations do not significantly change the shape of the output distribution. The results of the simulation are arrayed in the form of a distribution covering all possible outcomes. The key benefit of this process is that probability is associated with costs.

## Communicate Results

The last part of the review is to communicate the review results by providing a closeout presentation and final report. At the end of the review the review team provides a closeout presentation that summarizes the review findings. The presentation identifies the review objectives and agenda, discusses the methodology, and highlights the results of the review including the pre/post workshop estimate results and any estimate adjustments made during the review. The closeout presentation also identifies any significant cost and schedule risks, and provides a brief overview of recommendations by the review team. The close-out presentation for this review was held on February 11, 2016, and is included in the Appendices of this report.

The estimate review is a snapshot in time and as additional information becomes available it is expected that the estimate will change and be updated. Following the review if errors or omissions are identified and confirmed with the project sponsor these modifications will be incorporated into the final report. The final report communicates all findings of the review to the project sponsor and Division and serves as the official document for the cost estimate review. As noted earlier, the review results are used in the approval of the financial plan. Cost estimate review reports are maintained by the FHWA Office of Innovative Program Delivery's Project Delivery Team in Washington DC.

# CHAPTER 2– REVIEW SUMMARY

## PROJECT BACKGROUND & SCOPE

The purpose of this project is to improve traffic operations and safety along the I-81 corridor from the West Virginia state line to the Pennsylvania state line, a distance of approximately 12 miles. Traffic conditions along this segment of I-81 have deteriorated over time. Deficiencies in interchange ramp configurations and lengths of merge lanes, as well as increasing truck traffic, have created operational problems that will be addressed by this project.

The project is currently separated into five Phases. Phase 1 and 1A are currently funded, and Phases 2, 3 and 4 are unfunded. In MSHA's contract documents for Phase 1, it will include improvements in West Virginia from the Potomac River Bridge crossing south to merge with previous West Virginia improvements at US 11 (not part of MSHA's Major Project - NEPA document). The following describes the currently funded portions of the I-81 Improvement project.

**Phase I**: I-81 Improvements from South of US11 in WV to North of MD 63/68 in MD-project going forward with federal funds.

This project, located in Washington County, Maryland and Berkley County, West Virginia, is for improvements along I-81 from South of US Rte. 11 in West Virginia to North of Maryland Rte. 63/68 in Maryland including Widening and Superstructure Replacement for Dual Bridges No. 21078 on I-81 over Potomac River and Widening and Superstructure Replacement for Dual Bridges No. 21077 on I-81 over Maryland Rte. 63/68.

The work will consist of the following:

(a) Widening, paving, and resurfacing on the approach roadways along I-81.

(b) Permanent widening of the existing dual bridges in the median area of I -81 at the crossing of the Potomac River and MD Rte. 63/68.

(c) Removal and replacement of the bridge deck and structural steel for-the existing portions of each bridge. ·

(d) Replacement and Widening of the existing abutments, and Widening. of the bridge piers at the dual bridges on I-81 over the Potomac River.

(e) Widening and Rehabilitation of the existing abutments and bridge piers at the dual bridges on I-81 over MD 63/68.

(f) Construction of drainage and storm water management measures throughout the limits of the project.

(g) Placement of w-beam traffic barriers, signing, and pavement markings.

(h) Landscaping along I-81 within the project limits.

**Phase 1A**: I-81 SB from MD 58 to US 40 Acceleration/Deceleration Lane Widening-this construction project is using 100% state funds

This project will provide a continuous southbound lane in I-81 between MD 58 (Salem Ave.) and US40 (National Pike) by extending and connecting the existing entry from MD 58 and the exit to US40. The purpose of this improvement is to improve safety and mobility along southbound I-81 while requiring minimal changes to existing Interstate Access.

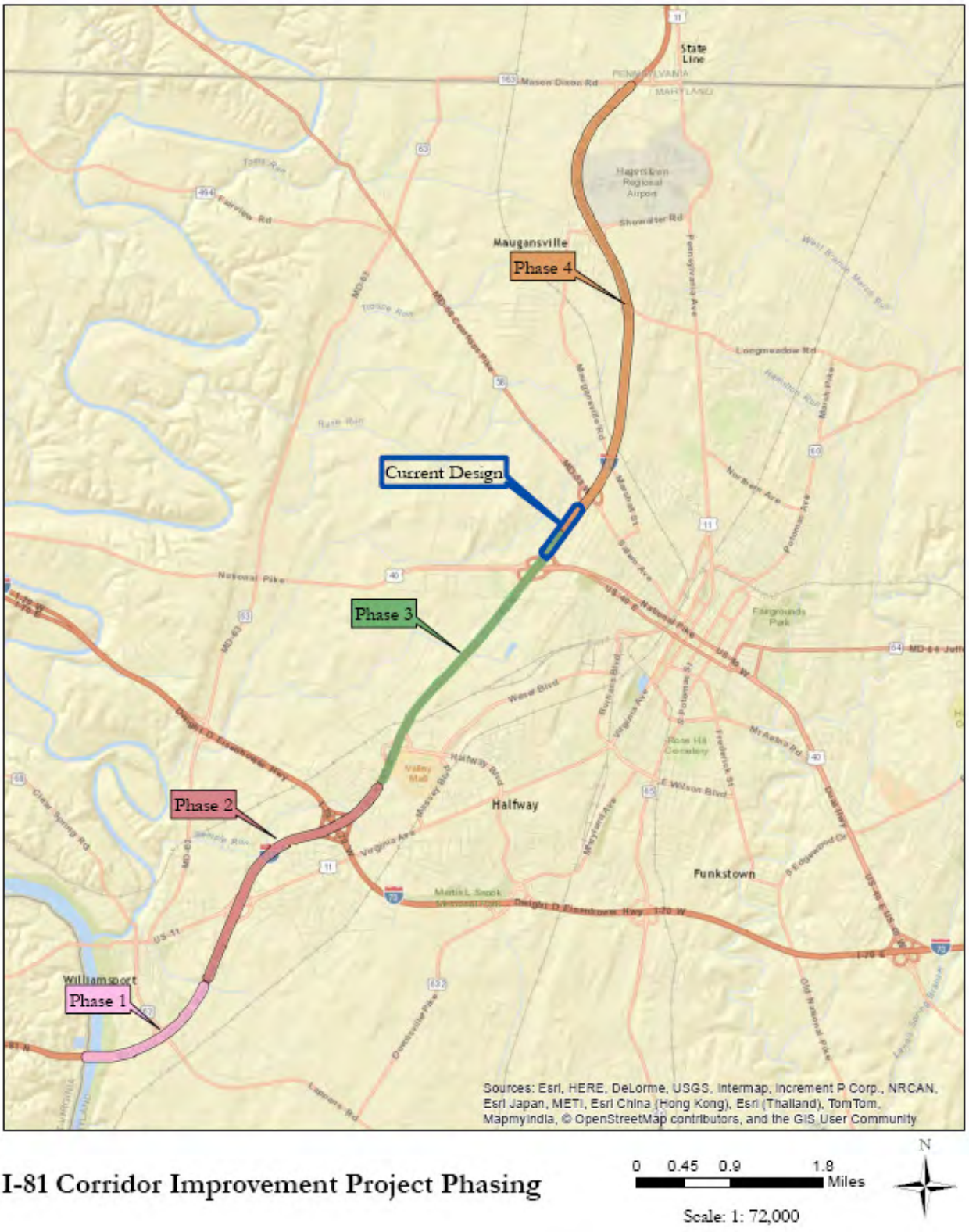
The unfunded phases of the project consist of the elements of improvements discussed in Phase I. The limits of these phases are the following:

**Phase 2**: South of I-70 to North of US 11

**Phase 3**: South of US 40 to North of I-70

**Phase 4**: South of US40 to North of PA163

The following Figure 1 depicts these phases on the corridor map. Note that the portion labeled "Current Design" in the figure is the funded Phase 1A portion of the project.




I-81 Corridor Improvement Project Phasing

0 0.45 0.9 1.8 Miles

N

Scale: 1: 72,000

**Figure 1: I-81 Corridor**

## ENVIRONMENTAL PROCESS

MSHA's Finding of No Significant Impact / 4(f) Evaluation document for the Major Project was issued in February 2010. A reevaluation document is currently in development for the MD portion of the funded Phase 1. The reevaluation is scheduled to be complete in the spring of 2016 that will allow Phase 1 to be advertised for construction with a scheduled construction start in July 2016. The West Virginia environmental document is proceeding concurrently with the Maryland's document for their portion of the funded Phase 1 and is not expected to have any impact on the construction advertisement.

## PROJECT PROCUREMENT

The funded phases of the I-81 Improvements Project are at the 95% design stage. Once design is complete, permits & other required documentation are in place, two separate construction projects for Phases 1 and 1A will be advertised using the Design-Bid-Build procurement method.

With the unfunded Phases 2-4 in the future, the project procurement method has not yet been determined for these Phases. The schedules for the projects have been set up with the assumption of using Design-Bid-Build.

## PROJECT SCHEDULE

Table 1 outlines overall schedule dates for the project. The funded Phases 1 and 1A are currently being managed toward the construction dates in Table 1. The dates for the unfunded Phases 2 – 4 are currently the best estimate each phase shown from start of design through completion of construction, with the assumption that the funding would be in a series beginning with Phase 2 in 2017, Phase 3 in 2023 and Phase 4 in 2029.

| Phase | Start Date | Completion Date |
|---|---|---|
| 1 – Construction | 7/18/2016 | 6/1/2019 |
| 1A – Construction | 6/1/2016 | 7/1/2017 |
| 2 – Design through Construction | 7/1/2017 | 6/30/2022 |
| 3 – Design through Construction | 7/1/2023 | 6/30/2028 |
| 4 – Design through Construction | 7/1/2029 | 6/30/2034 |

**Table 1 Project Milestones**

## COST ESTIMATE

Prior to the CER, the project team submitted a project estimate of $560 million in current year (CY) dollars, plus $9 million in previously expended costs equaling a total CY project amount of $569 million. This cost included environmental, engineering, right-of-way (ROW), utilities, construction costs and contingency. The breakdown of this cost estimate is as follows:

| Project Phase | Costs-to-Date | Costs-to-Complete | Total Costs |
|---|---|---|---|
| 1 | $8,738,000 (1) | $90,548,304(2) | $99,286,304 |
| 1A | $400,000 | $10,540,623 | $10,940,623 |
| **Subtotal Funded** | **$9,138,000** | **$101,088,927** | **$110,226,927** |
| 2 | | $114,305,825 | $114,305,825 |
| 3 | | $131,571,905 | $131,571,905 |
| 4 | | $212,875,475 | $212,875,475 |
| **Total** | **$9,138,000** | **$559,842,132** | **$568,980,132** |

**Table 2: Pre-CER Cost Estimate**

(1): Phase 1 Costs-to-Date = $3,514,000 for MD NEPA; $5,099,000 for Phase 1 Design; and $125,000 for WV NEPA. Note that NEPA costs were included in Phase 1 to keep to-date costs in funded portion of evaluation. A correction was noted to the Phase 1 costs-to-date following completion of the CER study. The corrected amount for the MD NEPA is $3,517,000 in lieu of the $3,514,000 used in the CER, and for Phase 1 Design the corrected amount is as follows in lieu of the $5,099,000 included in the CER results:

- Phase 1 design: $4,410,000
  - WV: $1,000,000
  - MD: $3,410,000

These corrected cost-to-date values are noted and should be used in any future analysis. However, the CER result was not changed for these corrections.

(2): Phase 1 Costs-to-Complete = approximately $55.7 million for MD Work and $34.9 for WV Work of the $90.5 million based prior to Adjustments. With adjustments, the values are approximately $57.9 million for MD Work and $36.4 for WV Work of the $94.3 million Phase I costs-to-complete.

During the CER, the project team agreed that adjustments to the originally submitted estimate before running the model and analysis. These adjustments are summarized below, with the revised “Revised Costs-to-Complete” being used as the base amount for the probability model:

| Project Phase | Costs-to-Complete | Adjustments | Total Costs-to-Complete |
|---|---|---|---|
| 1 | $90,548,304 | $3,731,132(2) | $94,279,436 |
| 1A | $10,540,623 | $421,625 | $10,962,248 |
| **Subtotal Funded** | **$101,088,927** | **$4,152,757** | **$105,241,684** |
| 2 | $114,305,825 | $4,572,233 | $118,878,058 |
| 3 | $131,571,905 | $5,262,876 | $136,834,781 |
| 4 | $212,875,475 | $8,515,019 | $221,390,494 |
| **Total** | **$559,842,132** | **$22,502,885** | **$582,345,017** |

**Table 3: CER Cost Estimate Adjustments**

The "Adjustments" of approximately $22.5 million shown in Table 3 is nearly all related to adding an allowance for changes during construction. The team was able to confirm this type of allowance is typically not included directly in MSHA cost estimates, and is budgeted at a higher level. It was agreed that a 4% allowance would be included. An additional adjustment for utility relocations was also included for Phase 1. This adjustment was $105,000, which includes $45,000 for a Verizon relocation and $60,000 for an electrical relocation by Allegheny Power.

The "Total Costs-to-Complete" columns in Table 3 are the base costs that were utilized in the Monte Carlo cost model before applying base variation, market conditions, risk and inflation.

## REVIEW FINDINGS / OBSERVATIONS

Findings and observations noted during the CER include the following:

- This project has 5 phases; Phases 1 and 1A are funded while Phase 2, 3, and 4 are the unfunded phases.
- MSHA is the lead agency in administrating the funded Phases 1 and 1A of this project. West Virginia is the partner agency for Phase 1 due to that WVDOH is contributing to portion of the bridge work in MD and to all of the work in WV included in Phase 1.
- The NEPA decision (WVDOH)/Reevaluation (for MSHA) documents for both states have not been approved.
- The Phase 1 will be advertised as one contract including all the work in Maryland and West Virginia.
- Some of the additional Risks (Drainage, Permits, Noise Walls, Landscaping , In stream Work and some of West Virginia-funded work items) were added/modified to the Risk register which was not included in the original risks register list submitted for the purpose of the CER.

- MSHA provided a basic schedule for funded and unfunded phases for the CER workshop. The schedule for the unfunded phases is at conceptual stage.
- There are only two Utility relocations identified in Phase 1.
- Positive Market conditions are identified for Phase 1.
- The Funded phases of the project will be delivered using Design-Bid-Build method.
- Level of design for the funded phases used for the estimate and workshop was (+/-95%).
- Estimate was updated in Current Year (CY) dollars, using conservative unit costs based on bid history and modified with current unit item cost.
- Project team and subject matter experts were familiar with project and estimate
- Planning level base estimates (including the 35% contingencies) were provided for the unfunded phases of the project.

## REVIEW RECOMMENDATIONS

During the workshop the review team developed the following recommendations:

- Complete the NEPA /Reevaluation process in Maryland and West Virginia.
- Should develop more detailed Schedule for funded phase of the project up to project award.
- Work proactively with Permitting Agencies to avoid delays.
- Work proactively with West Virginia to finalize the MOU addressing roles and responsibilities.
- Work proactively to finalize the Utility Agreements.
- Work proactively with West Virginia to establish Contract Administration activities.
- Continue to work with FHWA Maryland Division office liaison to make sure all necessary. project requirements are met.

# CHAPTER 3 – RISK ANALYSIS

Cost estimates, especially those for Major Projects, contain a degree of uncertainty due to unknowns and risks associated with the level of detail design completed. For this reason, it is logical to use a probabilistic approach and express the estimate as a range rather than a point value. During the cost estimate review, uncertainties in the project estimate such as base variability, inflation, market conditions, and risk events were modeled by the review team to reflect the opinions of the subject matter experts interviewed. Then a Monte-Carlo simulation was used to incorporate the uncertainties into forecast curves that represent a range of costs and completion dates for the Project.

## FORECAST RESULTS FOR TOTAL PROJECT COSTS

With the project having funded and unfunded phases, the Monte Carlo forecasts were run for the funded phases of the project only, and then for the total project, including both the funded and unfunded phases.

Funded Phases of the Project

The funded Phases 1 and 1A were combined, including the costs-to-date, and the results are demonstrated in Figures 2 and 3.

Figure 2 shows the results in 2016 or CY dollars. This forecast includes construction costs, environmental studies, utilities, construction support, construction inspection, ROW, and project uncertainty. The graphic shows the range of potential cost results, with 70% of the results being at or below $116.6 million. Figure 3 depicts the forecast curve for the Total Project Cost in YOE dollars. In addition to the cost included in the current year forecast (Figure 2), Figure 3 accounts for inflation. The 70$^{th}$ percentile level of confidence that the estimate will not exceed $125.2 million (YOE) in total project cost is shown by the blue shaded area. Alternatively, these results predict a 30% probability that total project costs will exceed this value based on the underlying variation within the estimate. It should be noted that the prior and fixed costs that have been expended or have contracts that are locked in and will remain constant for costs such as environmental studies and procurement activities are included in the analysis and in Figures 2 and 3. Financing and operation and maintenance costs and/or associated risks are not included in this analysis.

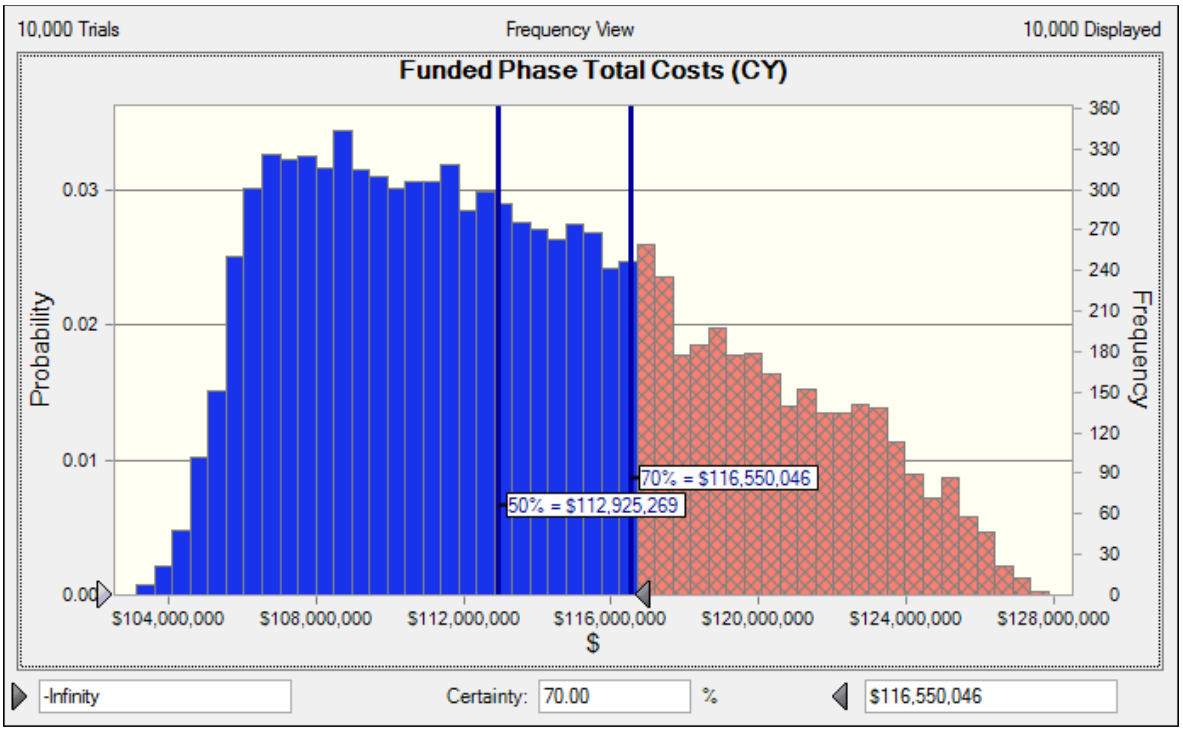



**Figure 2: Probable Range of Total Project Funded Costs Current Year (CY - 2016 dollars)**

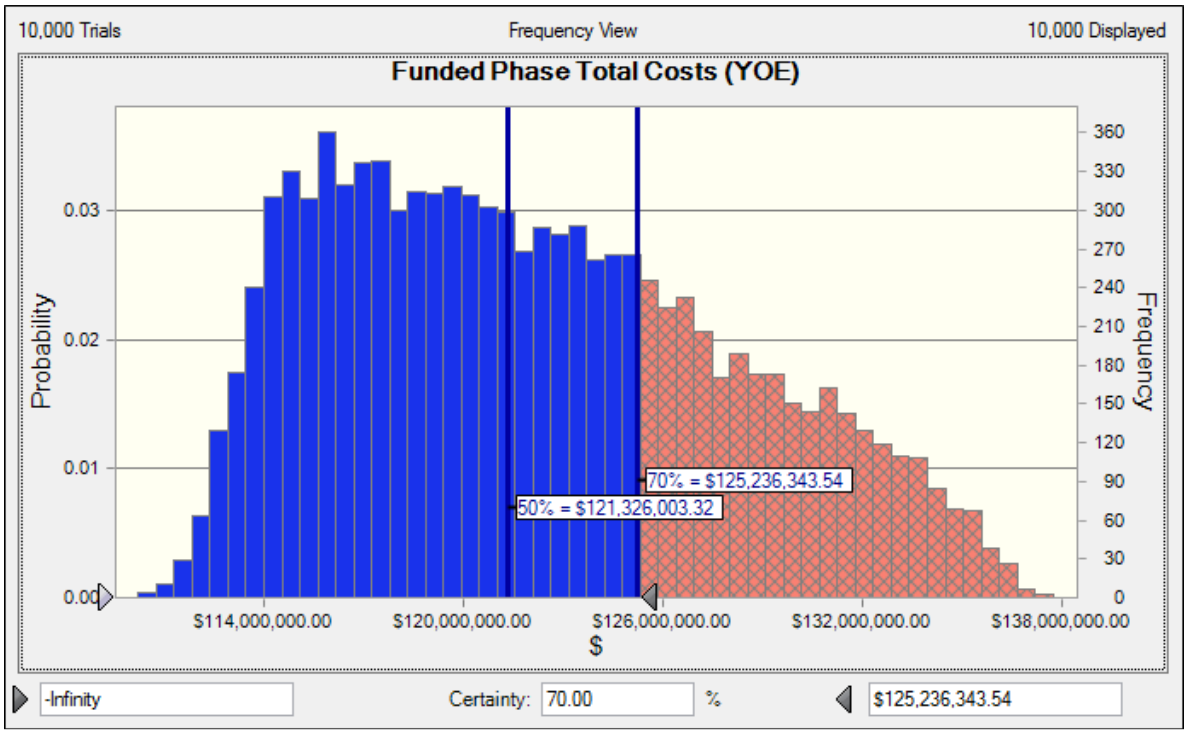



**Figure 3: Probable Range of Total Project Funded Costs (YOE dollars)**

Table 4 demonstrates the YOE results for the funded phases in a tabular range, showing that the project cost could range from $110 million to $138 million. The lower and higher ends of the variance are unlikely. The higher end at the 100% percentile reflects an occurrence where all significant risks identified during the review will be realized, including those with a relatively low likelihood. The estimate at the 70% percentile of $125.2 million should be used as the baseline cost in the initial financial plan.

| Percentile | Forecast values |
|---|---|
| 0% | $110,203,468.18 |
| 10% | $114,602,947.29 |
| 20% | $116,196,415.26 |
| 30% | $117,830,041.08 |
| 40% | $119,577,578.77 |
| 50% | $121,326,003.32 |
| 60% | $123,260,207.29 |
| 70% | $125,236,343.54 |
| 80% | $127,681,657.04 |
| 90% | $130,918,652.20 |
| 100% | $137,714,235.54 |

**Table 4: Percentile Rankings of Total Project Costs in YOE Dollars**

Total Project (both funded and unfunded phases)

The following figures 4 and 5 demonstrate the results of the probability analysis for the total project. Table 4 is in CY dollars, and Table 5 is in YOE dollars, using the assumed schedule for the unfunded phases with funding initiating in 2017 for Phase 2, 2023 for Phase 3 and 2029 for Phase 4. Figure 4 shows the 70% probability for CY at $617 million and for YOE at $811 million, demonstrating the impact of inflation for the future unfunded phases.

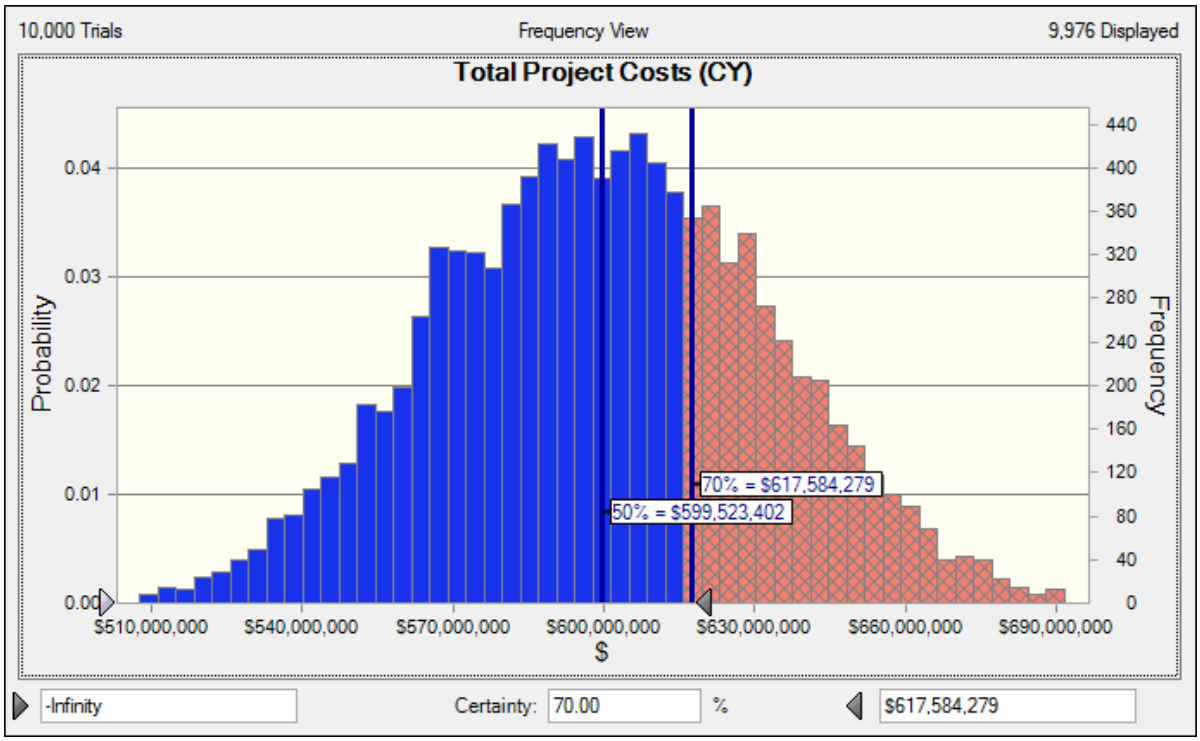



**Figure 4: Probable Range of Total Project Costs Current Year (CY - 2016 dollars)**

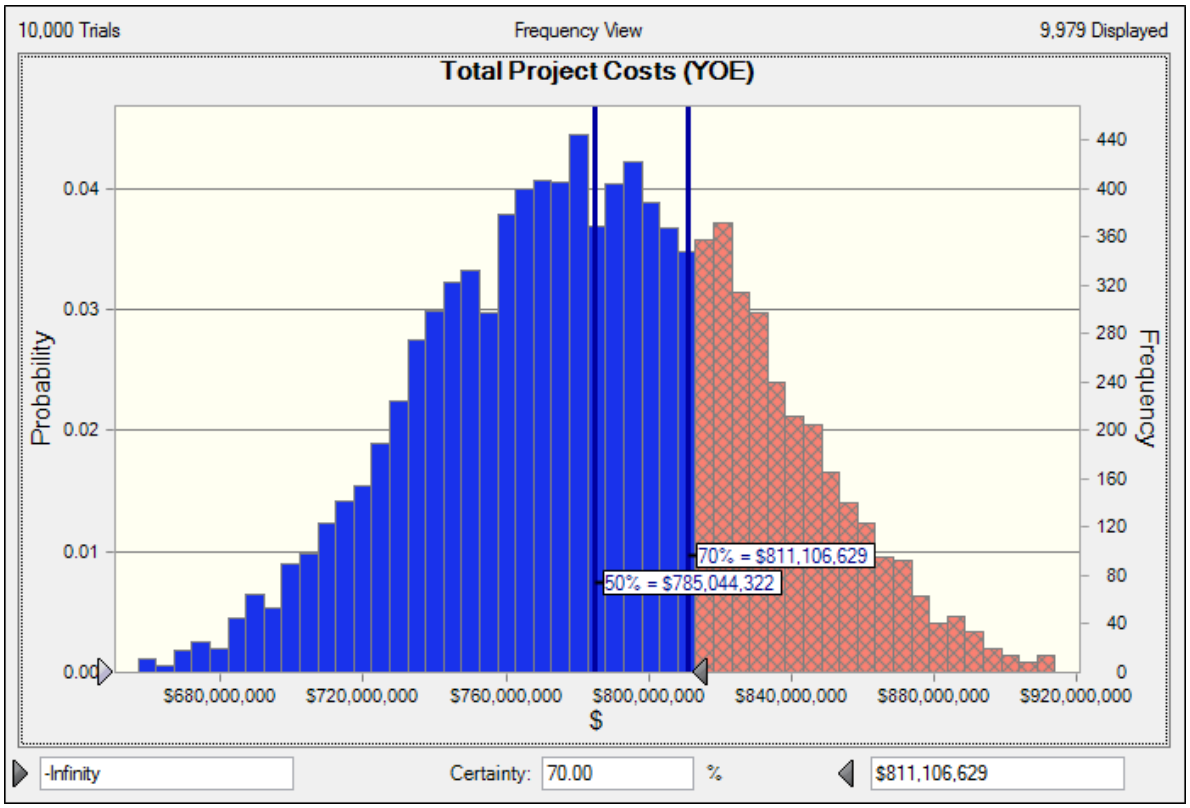



**Figure 5: Probable Range of Total Project Costs (YOE dollars)**

The resulting range of potential total project costs is shown in Table 5, demonstrating a broad range from approximately $631 million to $935 million.

| Percentile | Forecast values |
|---|---|
| 0% | $630,736,432 |
| 10% | $726,169,453 |
| 20% | $744,886,082 |
| 30% | $760,314,680 |
| 40% | $772,973,398 |
| 50% | $785,044,322 |
| 60% | $797,552,925 |
| 70% | $811,106,629 |
| 80% | $825,262,188 |
| 90% | $845,105,364 |
| 100% | $934,720,450 |

**Table 5: Percentile Rankings of Total Project Costs in YOE Dollars**

## PROBABILITY ASSUMPTIONS

The assumptions discussed below describe how the review team modeled the risk events, base variability, inflation, and market conditions that served as inputs for the results shown in the previous section of the report. As discussed in Chapter 1, the Monte Carlo analysis selects random inputs from these distributions to determine discrete values for a given number of iterations. The model runs the simulation through 10,000 iterations and ranks the results to determine the likely range of cost and schedule for the project.

## Risk - Threats and Opportunities

In a traditional cost estimate, risks are often accounted for using estimates of contingency. The review team identified that the contingency defined in the current estimate is designated as a 3% allowance for changes during construction. The review team considered this as an estimate allowance to be retained in the base estimate and decided during the review to increase the allowance to 5%. It was also agreed that by using the cost information from the current Phase 1 bids, the Project Team was able to minimize risk and the need for additional contingency within the cost estimate. During the review, a risk register was created and risk events were identified for the project. The purpose of the risk register is to identify significant cost and schedule risks in the estimate. The review team identified and discussed risks to the project in terms of threats and opportunities. For purposes of this review, a threat is a risk event that can add to the cost and/or schedule of the project and an opportunity is an event that can reduce the cost and/or shorten the schedule.

Risk events are quantified by likelihood of the occurrence and impact if it occurs. For example, review team identified that there is risk for Phase 1 of the project to potentially encounter karst related voids that would need to be addressed during construction. The review team determined a 20% likelihood that this condition could be encountered. Additionally, if the risk event occurred there would be a most likely cost increase to the project of $200,000 and a minimum and maximum range from $100,000 to $300,000, respectively. Figure 5 shows the binomial distribution used to model the likelihood of occurrence and Figure 6 shows the triangular distribution used to define how the cost impact was modeled in the simulation.

All risk events identified and modeled during the review involving cost threats and opportunities are reported in Table 6. There were other potential risks identified during the discussion, however when the team discussed them they were found to be minor and were not modeled.

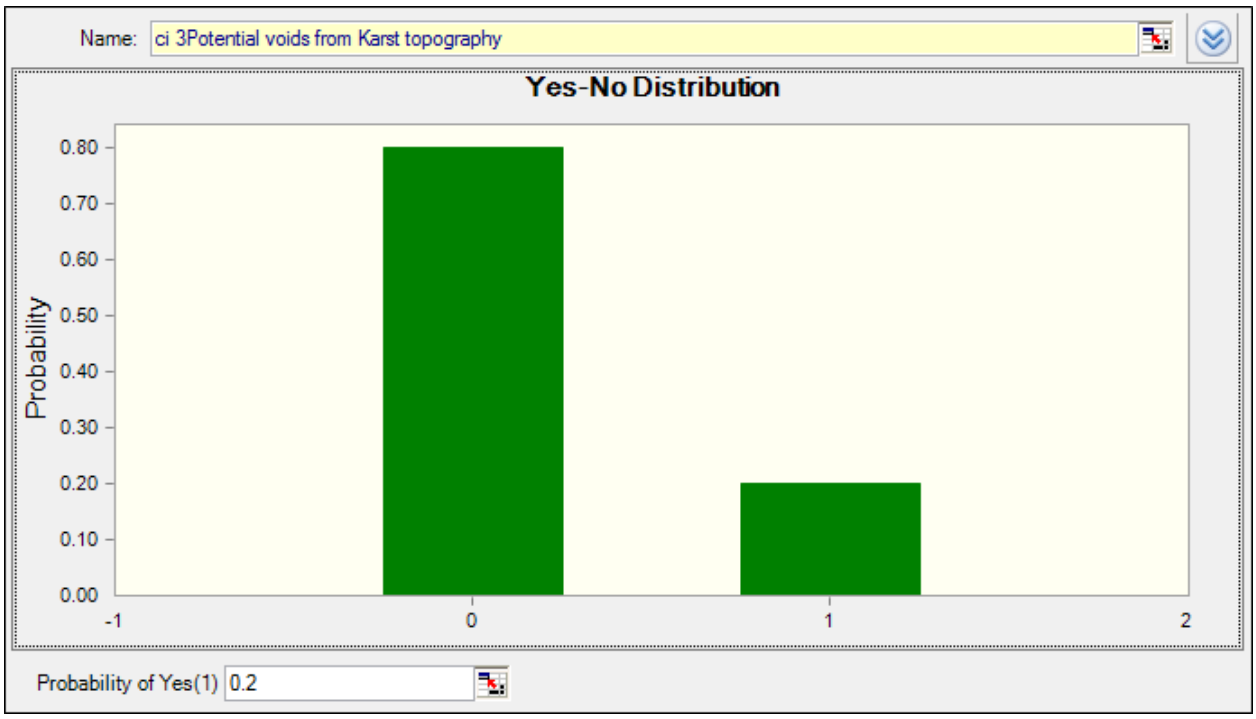



**Figure 6: Example of Binomial Distribution for a Project Risk's Likelihood of Occurrence**

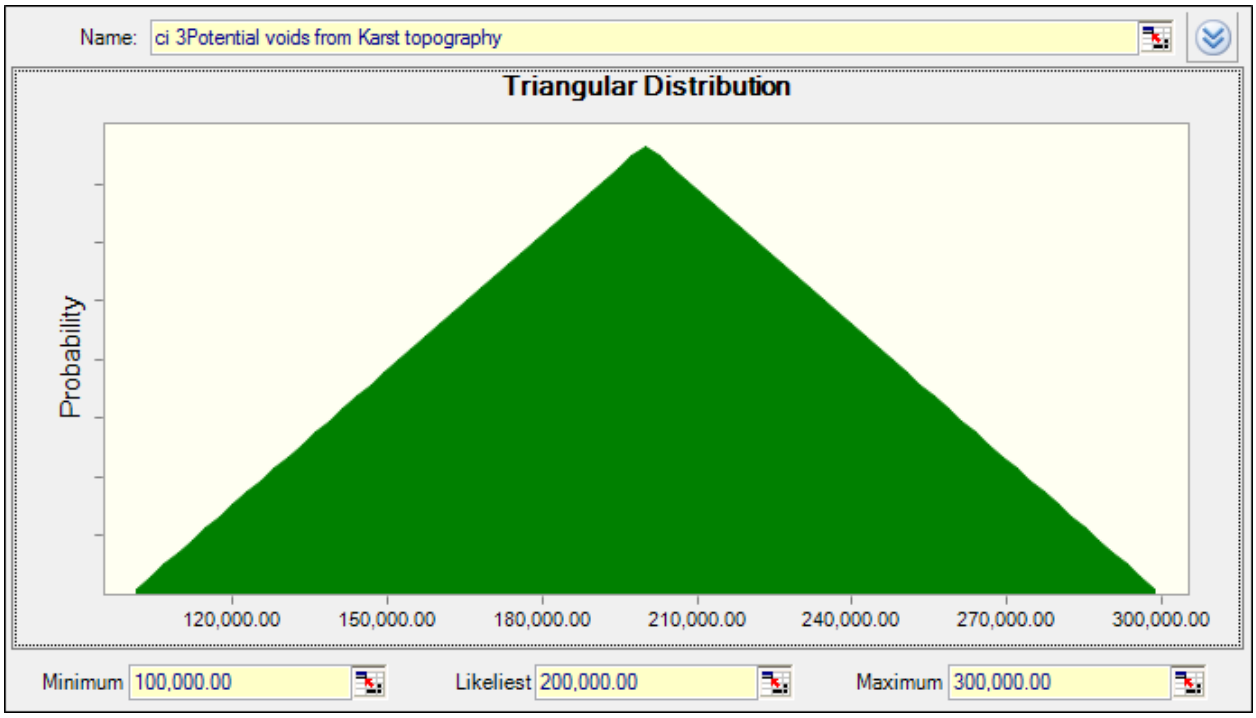



**Figure 7: Example of Triangular Distribution for a Project Risk's Cost Impact**

| Phase | Event Risk Name | Description of Risk Event | Probability | Min Cost | Most Likely Cost | Max Cost | Threat/ Opportunity |
|---|---|---|---|---|---|---|---|
| Phase 1 | Construction Change Orders | Changes during construction resulting in change orders could include bid item omissions, overrun or underrun in quantities, unforeseen conditions, or minor construction delays. This covers elements that are considered to vary from the 4% for changes included as an allowance adjustment in the base estimate. The team considered that this would vary from 4% up to 6%. | 100% | $0 | $906,533 | $1,813,066 | Threat |
| Phase 1 | Potential voids from Karst topography | Potential to encounter voids in Karst rock areas. Have not encountered any in bridge area, but some has been found away from the river (although not in the ROW). These are typically outside of the active roadway. | 20% | $100,000 | $200,000 | $300,000 | Threat |
| Phase 1 | Addition of Noise Barriers on West Virginia side of the bridge | WV has to address the Noise Barriers in their current CE. There is a high probability that the noise barriers could be added. | 90% | $800,000 | $1,000,000 | $1,200,000 | Threat |
| Phase 1A | Construction Change Orders | Changes during construction resulting in change orders could include bid item omissions, overrun or underrun in quantities, unforeseen conditions, or minor construction delays. This covers elements that are considered to vary from the 4% for changes included as an allowance adjustment in the base estimate. The team considered that this would vary from the base of 4% up to 6%. | 100% | $0 | $105,406 | $210,812 | Threat |
| Phase 1A | Potential voids from Karst topography | Potential to encounter voids in Karst rock areas. Risk notes this is prevalent in Washington County, although no voids have been identified despite efforts to locate. | 20% | $100,000 | $200,000 | $300,000 | Threat |
| Phase 2 | Construction Change Orders | Change order allowance for future construction included in base at 4%, with this risk to include additional amount up to 8% | 100% | $0 | $2,286,117 | $4,572,233 | Threat |
| Phase 2 | Design Contingency Variance | Design Contingency included in the base estimate as 35% of project costs. Team agreed to vary this contingency from 25% to 45% of project costs. | 100% | $11,430,583 | $0 | $11,430,583 | Threat |
| Phase 3 | Construction Change Orders | Change order allowance for future construction included in base at 4%, with this risk to include additional amount up to 8% | 100% | $0 | $2,631,438 | $5,262,876 | Threat |

**Table 6: Cost Threats/Opportunities**

## Schedule Analysis

During the CER workshop, potential schedule threats were discussed that might have an impact on project costs. The scheduling risks that were modeled include the following:

| Phase | Event Risk Name | Event Risk Description | Probability | Min Delay (Months) | Most Likely Delay (Months) | Max Delay (Months) | Threat / Opportunity |
|---|---|---|---|---|---|---|---|
| Phase 1 | MD Stormwater Management Permit | Some concern with getting the MD Stormwater Management Permit in time for construction | 30% | 1.0 | 1.3 | 1.5 | Threat |
| Phase 1 | WV Median Barrier | Constructing the WV median barrier (due to volume) has the potential to impact the schedule | 30% | 3.0 | 4.5 | 6.0 | Threat |
| Phase 1 | Pavement timely completion impacting project closeout | Potential for project completion ending 6 months later than scheduled due to delay in paving | 50% | 2.0 | 4.0 | 6.0 | Threat |
| Phase 1 | Addition of Noise Barriers on West Virginia side of the bridge | WV has to address the Noise Barriers in their current CE. There is a high probability that the noise barriers could be added. | 10% | 1.0 | 1.5 | 2.0 | Threat |

**Table 7: Cost Threats/Opportunities**

Although there is also potential schedule risk on the unfunded Phases 2 – 4, there were no specific risks modeled due to the uncertainty of the current schedule. The result of the Table 6 risks modeled is shown in the Figure 8 Funded Phases Completion, with the 70% result being 11/18/2019. Comparing this to the 6/1/2019 scheduled completion demonstrates an approximate 5-1/2 month risk delay impact at the 70% confidence level.

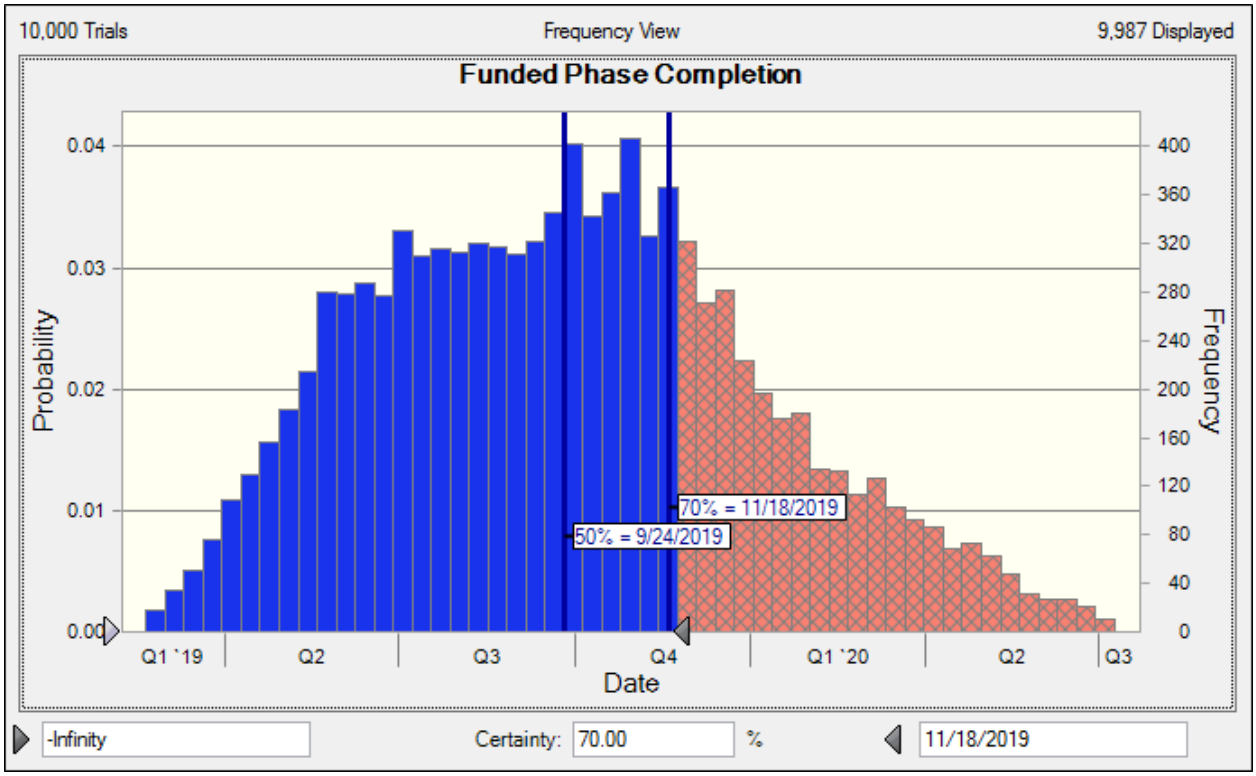



**Figure 8: Schedule Completion for Funded Phases**

To evaluate the potential cost of a delay in the delivery of the project, if Phases 2 through 4 were deferred for any reason, a "what-if" simulation was run for information on the potential cost impact of this deferral. The table below shows this potential impact of a 1 year deferral of these phases.

| Years of Delay | CER Result YOE (millions) | Delay YOE (millions) | Price of Delay (millions) | % Increase (from base) |
|---|---|---|---|---|
| 1 | $811.1 | $825.5 | $14.4 | 1.8% |

**Table 8: Price of 1 year Deferral / Delay (what-if analysis)**

## Base Variability

Base variability captures the variability and uncertainty inherently associated with the cost estimating process. Based on feedback from the project team and subject matter experts about the level of design completed for each of the phases, the base variability for the estimate was determined to be as shown in Table 9 below.

| Project Phase | Base Variability |
|---|---|
| Phase 1 and 1A | +/-2% |
| Phases 2 through 4 | +/-15% |

**Table 9: Base Variability**

### Market Conditions

The primary reason for modeling market conditions are to reflect the uncertainty associated with the bidding environment. These discussions consider the potential number of bidders on project contracts and the large amount of resources that will be required to deliver the project. Other factors considered were labor and material availability and the influence of other large projects scheduled to be advertised in the same timeframe.

The CER team discussed market conditions and came up with the following probabilities and impacts as shown in Table 10 below. The probability denotes the likelihood of occurrence, and the impact denotes the magnitude as a percent of planned value for better than planned (decrease from planned value) and worse than planned (increase from planned value).

| Phase | Likelihood (probability of occurrence) | | | Impact (% offset from base value) | |
|---|---|---|---|---|---|
| | Better Than Planned | As Planned | Worse Than Planned | Better Than Planned | Worse Than Planned |
| Phase 1 | 40% | 50% | 10% | 10% | 10% |
| Phase 1A | 10% | 50% | 40% | 10% | 10% |
| Phase 2 | 33% | 34% | 33% | 10% | 10% |
| Phase 3 | 33% | 34% | 33% | 10% | 10% |
| Phase 4 | 33% | 34% | 33% | 10% | 10% |

**Table 10: Market Conditions**

As demonstrated by the Market Conditions modeled, the Review Team considered that there is a higher likelihood (40%) that the construction costs will be lower than estimated than the likelihood (10%) that they would be higher than estimated for Phase 1, planned for construction start in July 2016. This is the result of the team considering a strong bidding environment for the Phase 1 project. The smaller size of Phase 1A and potential limited bidder interest resulted in the higher worse than planned (40%) for this phase.

### Inflation

The inflation for the CER was based on the table below for the project. The MSHA provided input for these rates. The future years beyond 2022 were all included at 2%.

| Year | Inflation Percentage |
|---|---|
| 2016 | 4.00% |
| 2017 | 4.00% |
| 2018 | 3.50% |
| 2019 | 3.25% |
| 2020 | 3.00% |
| 2021 | 3.00% |
| 2022 & beyond | 2.00% |

**Table 11: Inflation Percentages**

## CONCLUSION

Based on the assumptions and risks discussed during this review, the cost estimate at the 70% confidence level was $125.2 million (YOE) for the total funded project cost and $811 million (YOE) for the total project costs. This baseline is typically identified in the project's initial financial plan to show that adequate funding is available to construct the project. However, this estimate is a snapshot in time and is expected that through further project development the estimate will change. The initial financial plan should detail any changes in the project estimate. It is highly recommended that the costs for the funded phases be used in any project information conveyed to the public. For the unfunded phases, the CER team considered the results of the CER to be preliminary and there are concerns with reporting these costs knowing that these costs will likely change in the future. Appendix C includes the entire report of inputs and results of this probability analysis.

# APPENDICES

A – Cost Estimate Review Opening Presentation

B – Cost Estimate Review Closing Presentation

C – Crystal Ball Probability Analysis

D – Cost Estimate Review Agenda

E – Cost Estimate Review Sign-In Sheets

# Appendix A

## Cost Estimate Review Opening Presentation

# I-81 Improvement Project

***Washington County, Maryland***

# Cost Estimate Review

**February 09-11, 2016**

## Opening Presentation

# Cost Estimate Review
# Objective

Conduct an unbiased risk-based review to verify the accuracy and reasonableness of the current total cost estimate to complete the

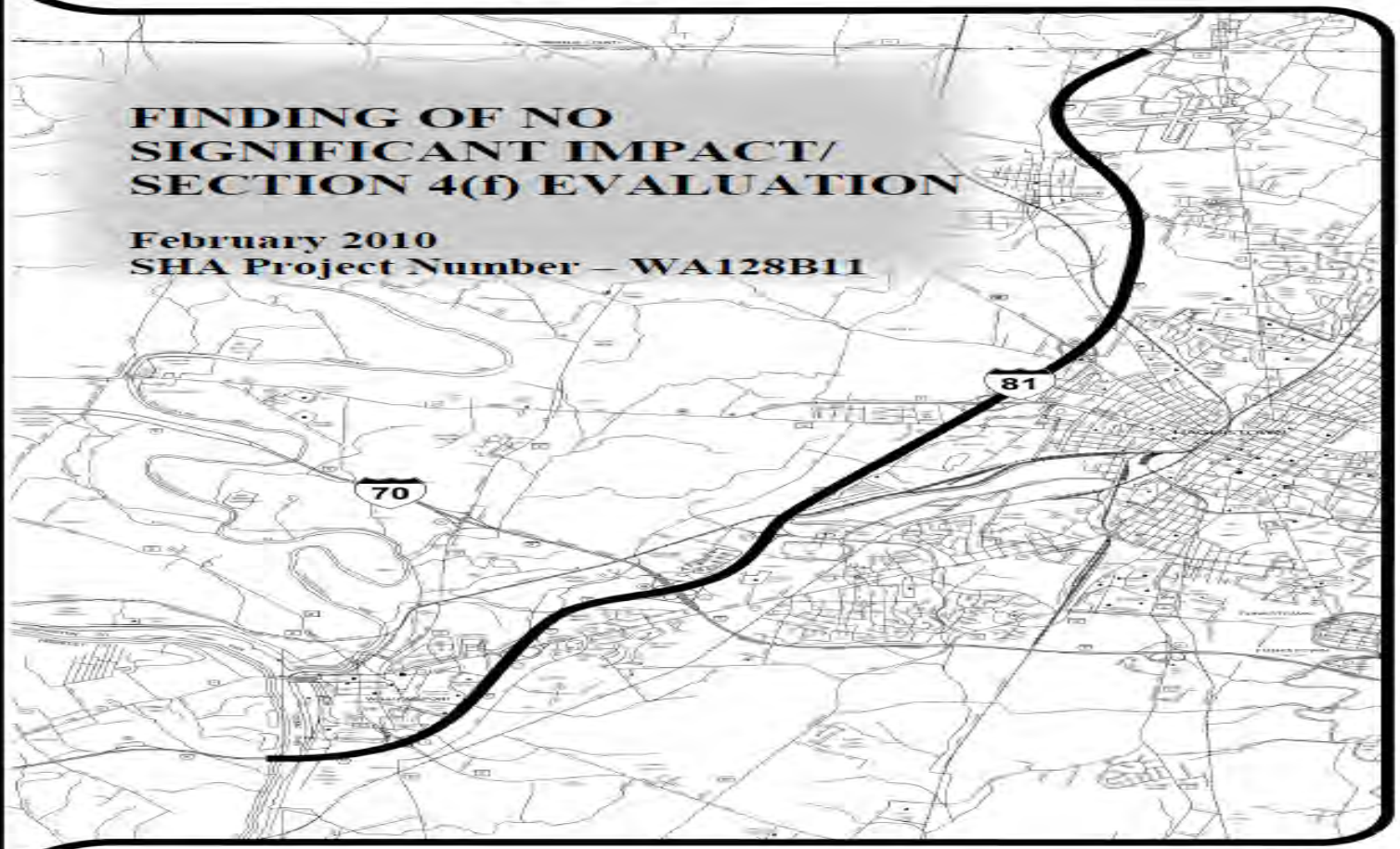
***I-81 Improvement Project***

and to develop a probability range for the cost estimate that represents the project's current stage of design.

# Project Location

## I-81 Improvement Project

From the West Virginia State Line to the
Pennsylvania State Line
Washington County, Maryland




**FINDING OF NO SIGNIFICANT IMPACT/ SECTION 4(f) EVALUATION**

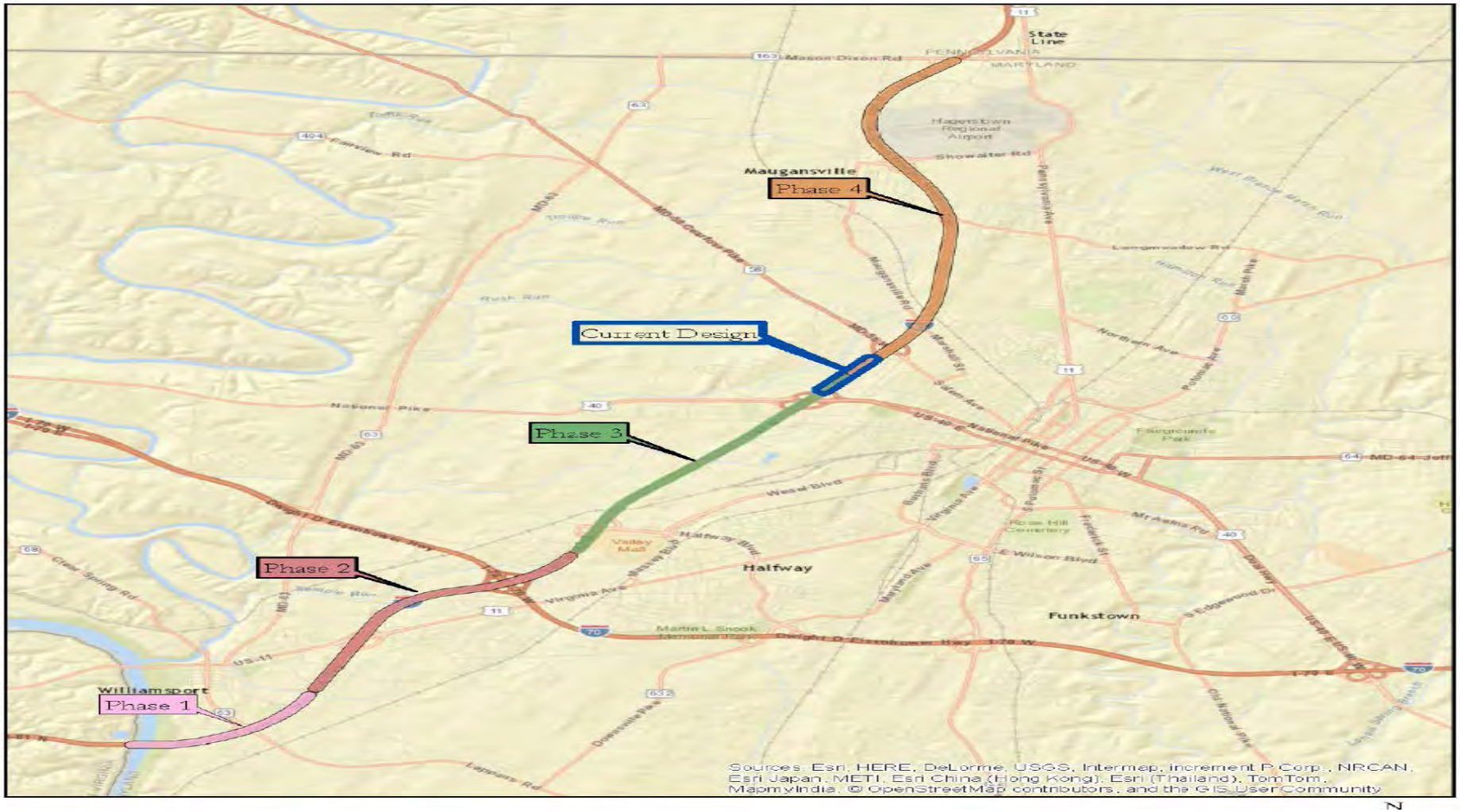
**February 2010**
**SHA Project Number – WA128B11**

SHA State Highway Administration

***Maryland Department of Transportation***
State Highway Administration
in cooperation with the National Park Service

DEPARTMENT OF TRANSPORTATION UNITED STATES OF AMERICA

# Project Location / Phasing




# I-81 Improvement Project

## Washington County, Maryland

# Policy Directives

- First enacted by TEA-21
- Title 23 U.S.C §106(h)(3)(B)

  …based on reasonable assumptions, as determined by the Secretary, of future increases in the cost to complete the project…"

  - Secretary = FHWA
  - Reasonable assumptions = Risk based probabilistic approach

# CERs & Financial Plans

- Consider all costs – Engineering, Construction, ROW, Utilities…
  - *In Year of Expenditure (YOE) Dollars inflated to the mid-point of construction*
- Required at the following thresholds:
  - **$500 Million or higher**
    Major Project – Requires concurrence from FHWA HQ
  - **$100 Million to $500 Million**
    Required, however review is at FHWA Division's discretion

# CERs & MAP-21

- Phasing Plans
  - Is funding available to construct the entire project as defined in the NEPA document?
  - MAP-21 allows project sponsors to show full funding in the financial plan for portions of the project that can be opened to public and effectively operate without having full funding for the entire project, i.e. fundable incremental improvements
  - CERs should evaluate the cost estimate and schedule for each phase to be identified in the financial plan

# CERs & MAP-21 (cont.)

P3 Assessment

- All financial plans must assess the appropriateness of a P3 to deliver the project
- All CERs should include discussions as to whether:
  1. P3 or traditional procurement could more effectively leverage the revenue stream
  2. Current state-level legislative authority for P3s
- For projects being procured as P3s, CERs must include an analysis of the allocation of risks with respect to delivering the project through a P3
- For projects with phasing plans, an assessment must be included for each funded phase

## Project Scope

- I-81 Improvements from South of US11 in WV to North of MD 63/68 in MD

The work will consist of the following:

(a) **Widening, paving, and resurfacing** on the approach roadways along I-81.
(b) **Permanent widening of the existing dual bridges in the median** area of I -81 at the crossing of the Potomac River and MD Rte. 63/68.
(c**) Removal and replacement of the bridge deck and structural steel** for-the existing portions of each bridge. ·
(d) Replacement and **Widening of the existing abutments,** and **Widening. of the bridge piers at the dual bridges** on I-81 over the Potomac River.
(e) Widening and Rehabilitation of the existing abutments and **bridge piers at the dual bridges** on I-81 over MD 63/68.
(f) Construction of **drainage and storm water management** measures throughout the limits of the project.
(g) Placement of w-beam **traffic barriers, signing, and pavement markings**.
(h) **Landscaping** along I-81 within the project limits.

# Review Participants

- FHWA
  - Sajid Aftab- Major Projects Engineer- FHWA- CER Lead
  - Dave Carter- Consultant- Crystal Ball/Model Developer
  - Peter Clogston- Advisor to CER Team
  - Daniel Suarez – Area Engineer- Maryland Division- FHWA- CER Team
- State Highway Administration SHA
- Interactive Workshop
- Everyone's input is Important

# Documentation Submitted

- Project Cost Estimate
- Project Schedule
- Project Risk Register
- Project Draft Environmental Document Link
- Other Documents

# Basis of Review

- Review based on estimates provided by the Project Team in advance
- Review to determine the reasonableness of assumptions used in the estimate
- Not an independent FHWA estimate
  - Did not verify quantities and unit prices
  - Goal is to verify accuracy and reasonableness of the estimate using a

**Probabilistic Risk-based Approach**

# Review Methodology

**Verify**

- Major cost elements
- Allowances/contingencies
- Adjust estimate as necessary

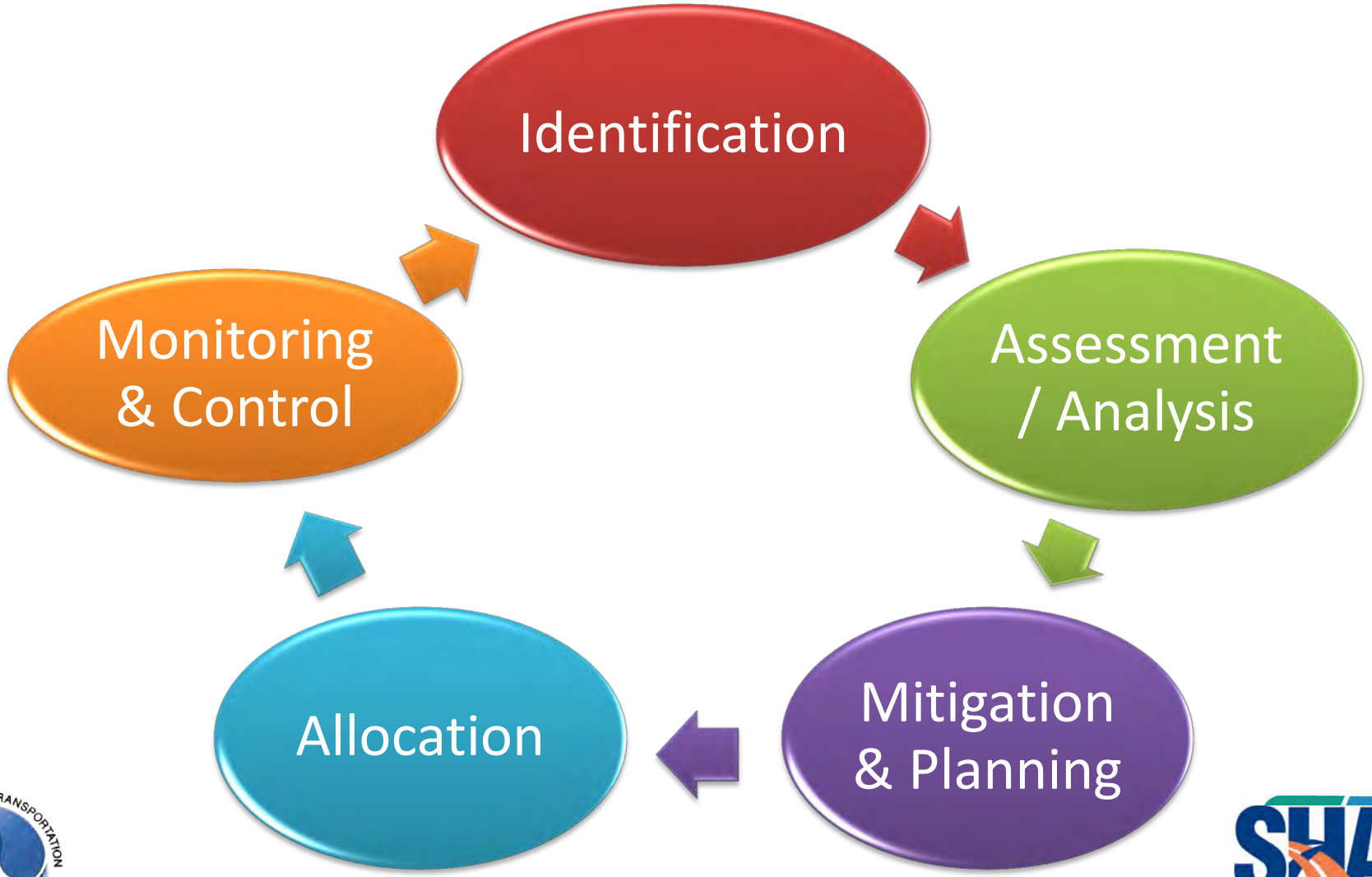
**Model**

- Base variability
- Market conditions and inflation
- Risk events (cost, schedule, probability, impact)
- Monte Carlo simulation

**Communicate**

- Closeout Presentation (preliminary results)
- Final report (within 60 days)
- Approval of finance plan

# Risk Management Process



# CER Concepts – Uncertainty

*"We know it is going to happen"*

**Known Knowns**

*"We expect it to happen, but do not have enough information to quantify it yet."*

**Known Unknowns**

(ALLOWANCES)

**Unknown Knowns**

(RISK REGISTER/CONTINGENCY)

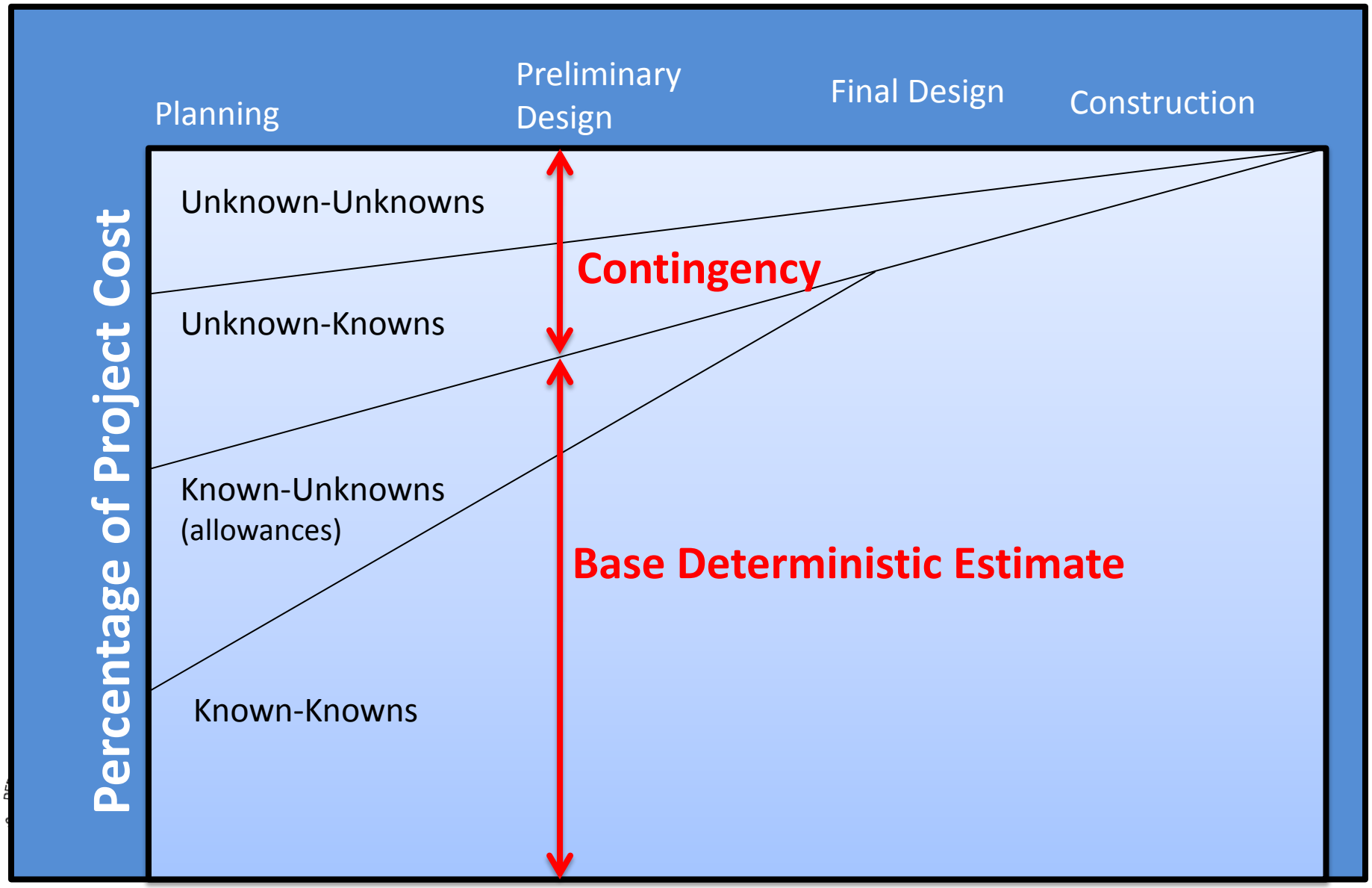
*"It might happen, but at least we know about it"*

**Unknown Unknowns**

*"We didn't see that coming!"*

# CER Concepts – Uncertainty (cont.)

## Principle 1 - Components of Cost Uncertainty

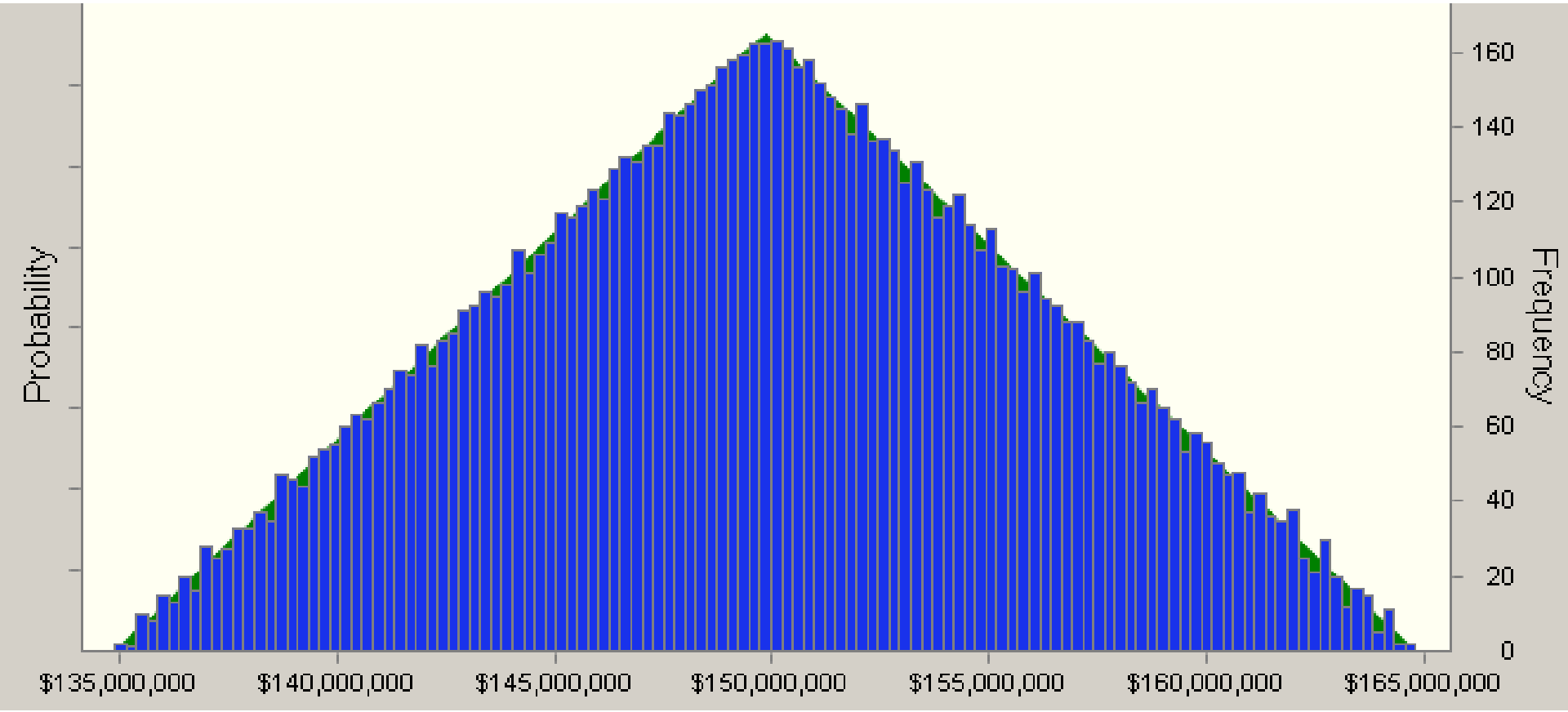


# CER Concepts

**Uncertainty = Base Variability + Risks + Market Conditions + Inflation Variability**

- Base Variability – inherent uncertainty not caused by risk events
  - Function of level of design & estimation process
- Risks – an uncertain event or condition that if it occurs has a negative or positive effect on project's objectives
  - Threats – negative impacts
  - Opportunities – positive impacts
  - Impacts project cost and/or schedule

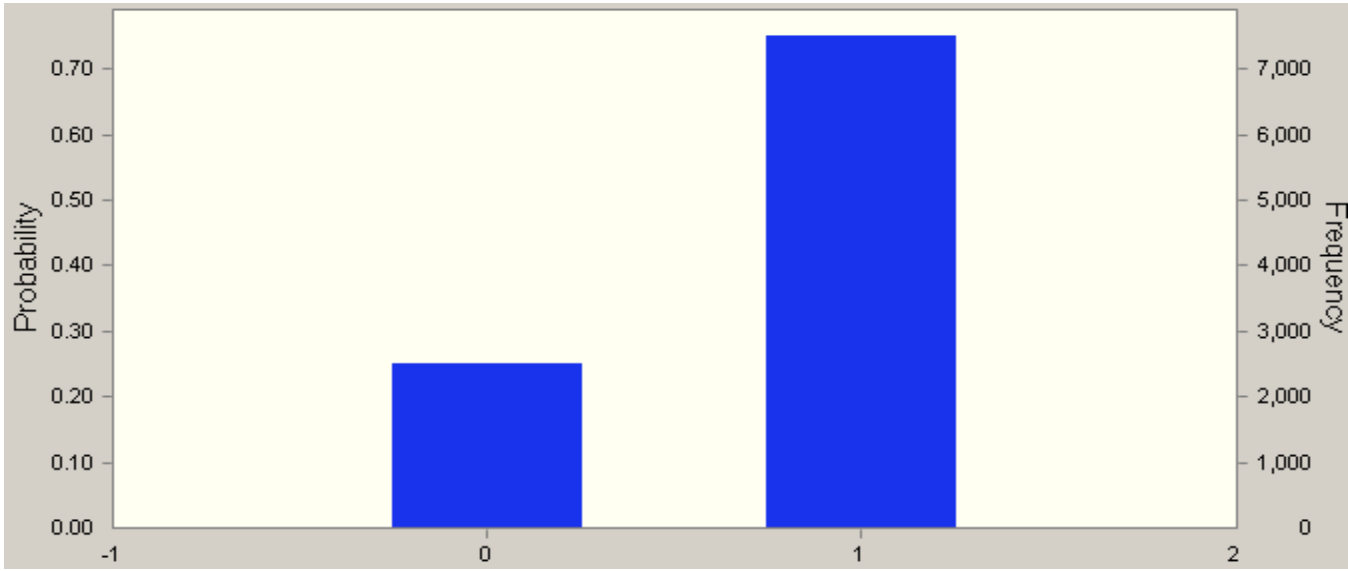
# CER Inputs – Base Variability Example



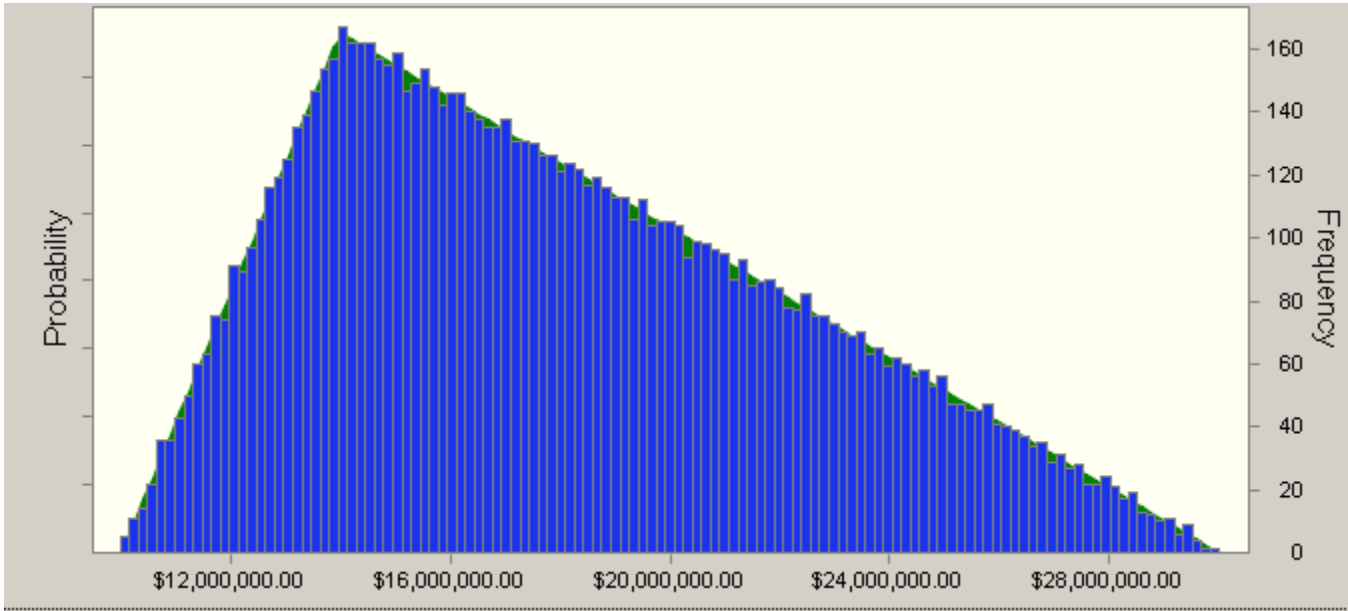

Triangular Distribution
Most Likely - $150 M
Minimum – $135 M
Maximum - $165 M

# CER Inputs – Risk Example

**Likelihood of Occurrence**
75%




**Impact of Occurrence**
Triangular Distribution
Most Likely - $14 M
Minimum - $13 M
Maximum - $30 M



# How do we Model Uncertainty in a Risk-Based Estimate?

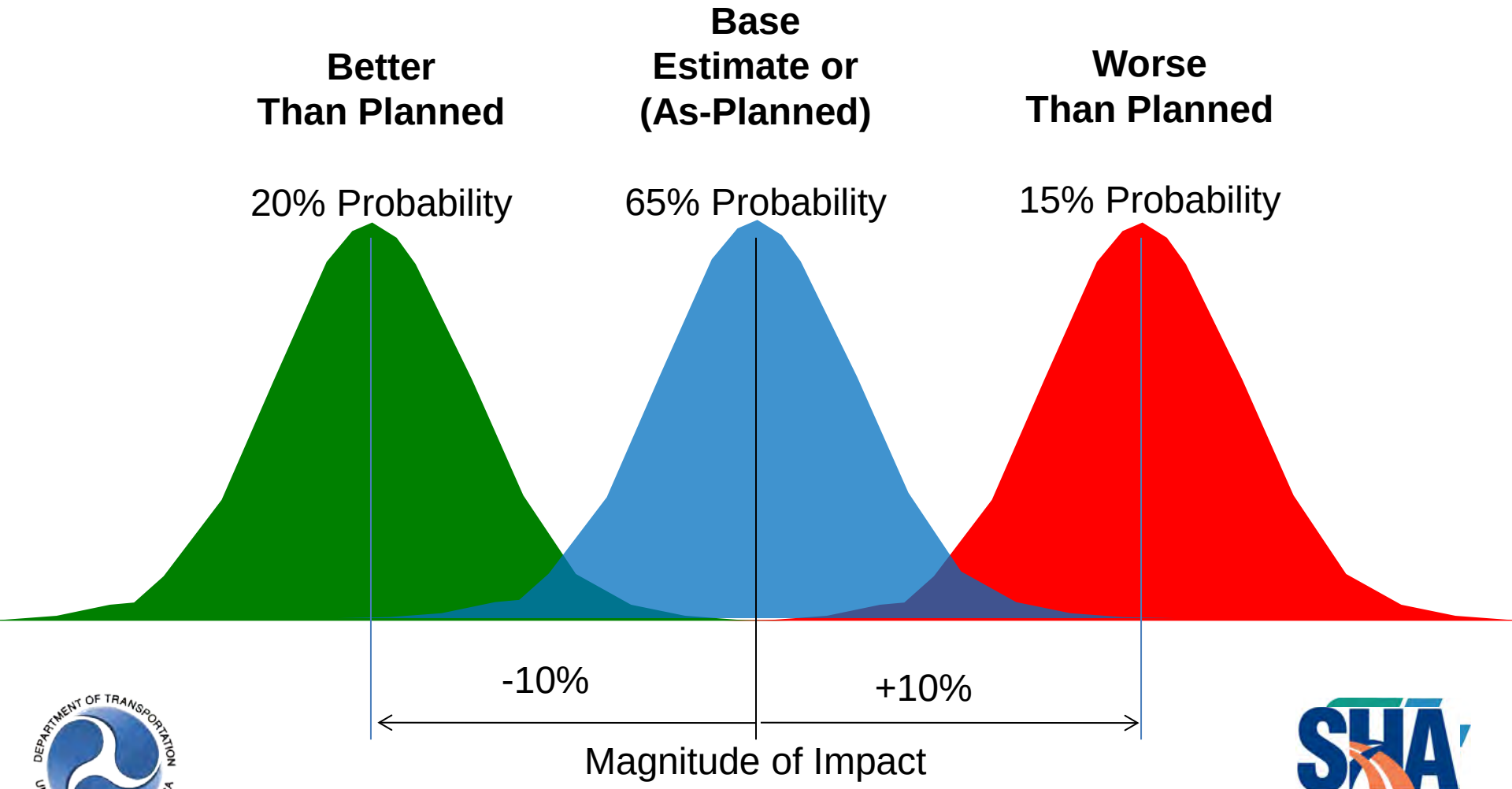
- Base Estimate
  - Base variability
  - Allowances
  - Allowance for Changes during Construction
- Risk Register
  - Risk Events (Threats and Opportunities)
  - Aggregate Minor Risks
  - Aggregate Unidentified Risks
  - Global (Projectwide) Project risks

# CER Concepts

- Inflation – increase in price over time
- Market Conditions – consequence of supply and demand factors which determine prices in a market economy (local)
  - bidding environment at time of letting, i.e. number of bidders, available labor

**The base estimate is adjusted to account for inflation and market conditions at the time of letting**

# Market Conditions



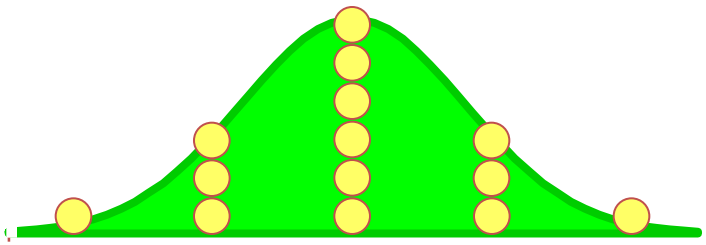
# Monte-Carlo Simulation

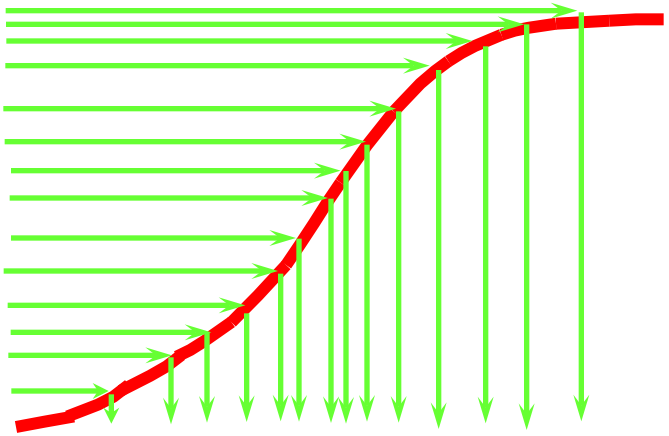
## Random Numbers and Outputs

y = f(x)  *or*  y is a function of x

Outputs

Frequency, %

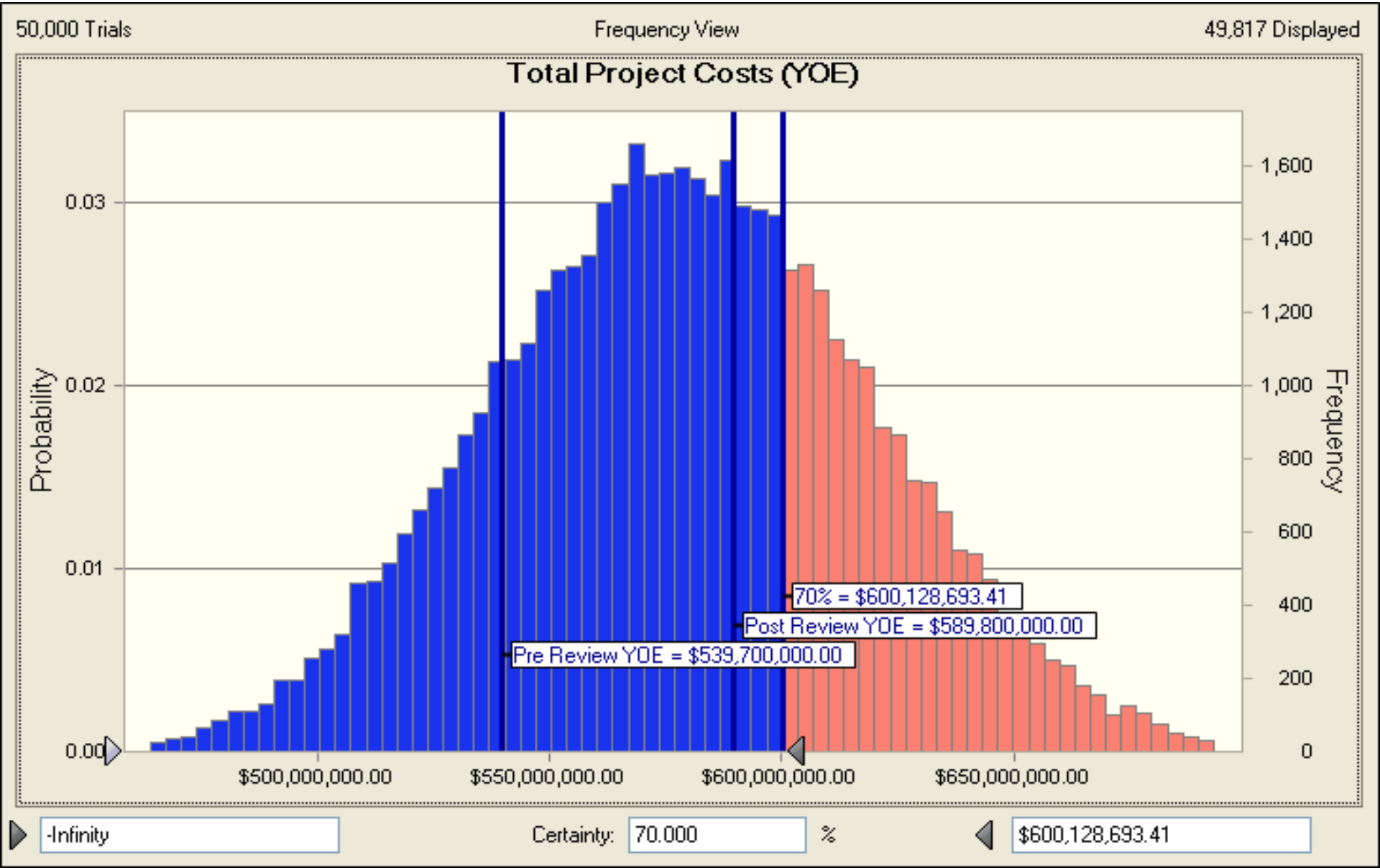




# CER Outputs

- Review findings/recommendations
- Adjustments made to estimate during review
- Project cost estimate at 70% level of confidence
- Project cost schedule at 70% level of confidence
- Risk Register – Threats/Opportunities

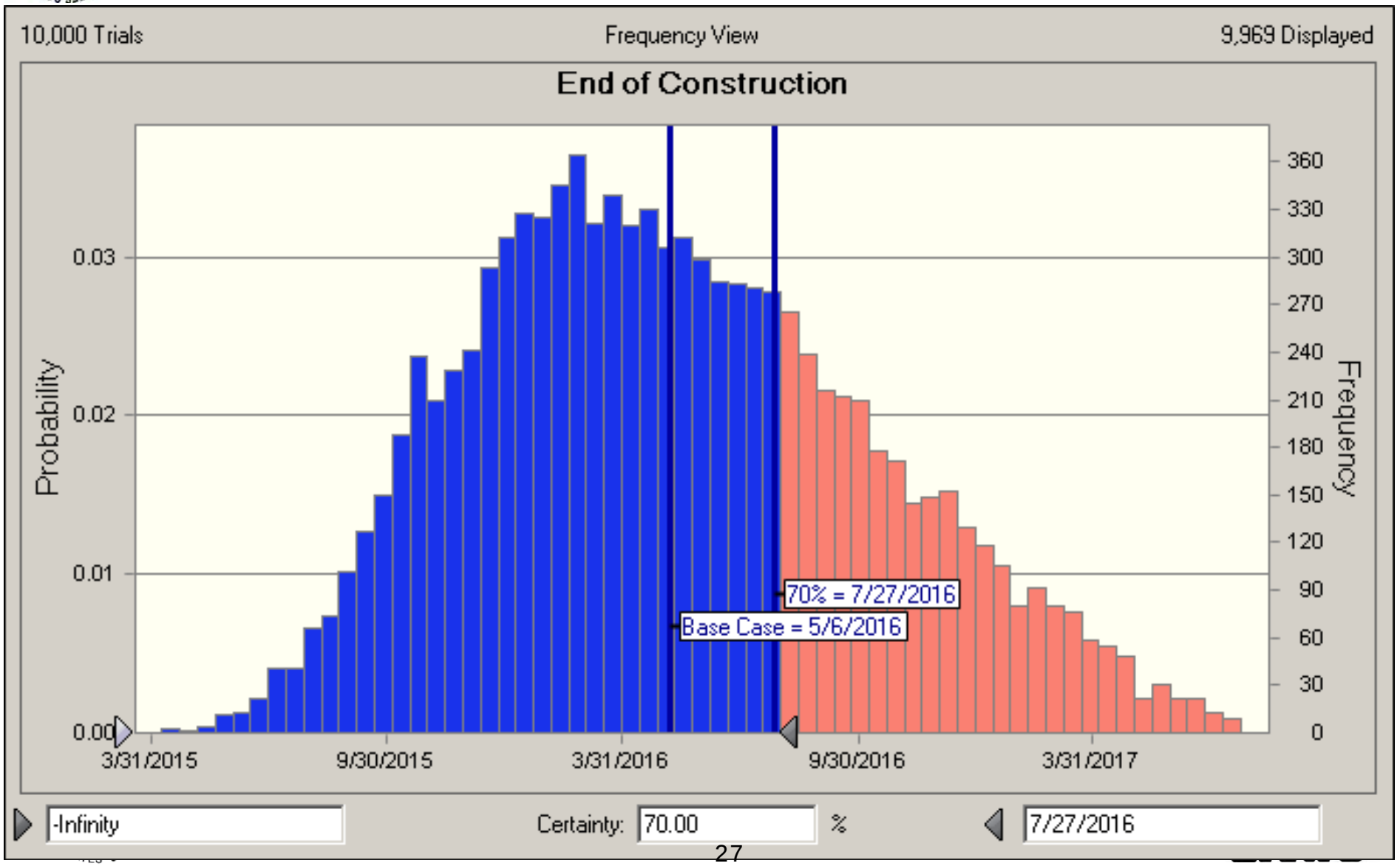
# **CER Outputs -** Cost Forecast Example



# CER Outputs – Total Project Cost (YOE) Percentile Ranking

| Percentile | Total Project Costs Forecast values |
|---|---|
| 0% | $622,045,165 |
| 10% | $642,051,331 |
| 20% | $648,556,174 |
| 30% | $653,448,838 |
| 40% | $657,845,556 |
| 50% | $661,753,712 |
| 60% | $665,305,814 |
| 70% | $668,813,224 |
| 80% | $672,868,683 |
| 90% | $678,086,378 |
| 100% | $926,597,262 |

# **CER Outputs -** Schedule Forecast Example



# **CER Outputs** - Risk Register

| 9 | Risk # | Risk Status | Risk Dependency | Guidance for Discrete Probability | Project Phase | Risk Location | Event Risk Name | Risk Type | Detailed Description of Risk Event (Specific, Measurable, Attributable, Relevant, Timebound) [SMART] | Risk Trigger | Probability (Bernoulli distribution) | Impact Cost | Correlation Prior Cost Risk | Cost Risk (Threat/ Opportunity) | Probable Cost Impact ($$$) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 10 | 1 | | | | Pre-CN | | Undetermined | Cost | Test | Bridge Type | 1 | $ 14,000,000 | Nil | Threat | $ - |
| 11 | 2 | Active | Independent | Prob<1 | CN+UT | | Market | Cost | Market Conditions | Procurement | 0.5 | $ - | Nil | Threat | $ - |
| 12 | 3 | Active | ME | <=0.5 | CN+UT | | Market | Cost | Market | Procurement | 0.5 | $ - | Nil | Opportunity | $ - |
| 13 | 3 | Active | Independent | Prob<1 | CN+UT | | MS4 Stormwater | Cost | Storm sewer | Approved | 0.2 | $ 750,000 | Nil | Threat | $ 150,000 |
| 14 | 4 | Active | Independent | Prob<1 | CN+UT | | Design speed | Cost | Design and | FHWA | 1 | $ 20,000,000 | Nil | Threat | $ 20,000,000 |
| 15 | 5 | Active | Independent | Prob<1 | CN+UT | | Below 75 575 split | Cost | Design and | FHWA | 0.4 | $ 55,000,000 | Nil | Threat | $ 22,000,000 |
| 16 | 6 | Active | Independent | Prob<1 | CN+UT | | Geotech Bridge | Cost | Final geotech | Final Geotech | 0.1 | $ - | Nil | Opportunity | $ - |
| 17 | 7 | Active | ME | <=0.9 | CN+UT | | Geotech Bridge | Cost | Final geotech | Final Geotech | 0.25 | $ - | Nil | Threat | $ - |
| 18 | 8 | Active | Independent | Prob<1 | CN+UT | | ATC Innovation | Cost | ATC Innovtion in | Developer | 1 | $ - | Nil | Opportunity | $ - |
| 19 | 9 | Active | Independent | Prob<1 | CN+UT | | Design level | Cost | Currently at 30% | Develo | .6 | $ - | Nil | Opportunity | $ - |
| 20 | 10 | Active | ME | <=0.4 | CN+UT | | Design level | Cost | Currently at 30% | Develo | .4 | $ - | Nil | Threat | $ - |
| 21 | 11 | Active | Independent | Prob<1 | CN+UT | | Limited resources | Cost | Due to high volume | Develo | .7 | $ - | Nil | Threat | $ - |
| 22 | 12 | Active | Independent | Prob<1 | CN+UT | | Roadway Design | Cost | Currently at 30% | Develo | .6 | $ - | Nil | Threat | $ - |
| 23 | 13 | Active | ME | <=0.4 | CN+UT | | Roadway Design | Cost | Currently at 30% | Develo | .4 | $ - | Nil | Opportunity | $ - |
| 24 | 14 | Active | Independent | Prob<1 | CN+UT | | Utility risk | Cost | Underground | Developer | 1 | $ 9,379,843 | Nil | Threat | $ 9,379,843 |
| 25 | 15 | Active | Independent | Prob<1 | Pre-CN | | Delays due to | Schedule | Project is not | Lack of | 0.5 | $ - | Nil | | $ - |
| 26 | 16 | Active | Independent | Prob<1 | Pre-CN | | PM 2.5 Air Quality | Schedule | EPA cannot take an | Project not in | 0.5 | $ - | Nil | | $ - |
| 27 | 17 | Active | Independent | Prob<1 | Pre-CN | | Completion of | Schedule | Policy update will | New Policy | 0.25 | $ - | Nil | | $ - |
| 28 | 18 | Active | Independent | Prob<1 | Pre-CN | | Potential | Schedule | | Lawsuit | | | Nil | | $ - |
| 29 | 18 | Active | Independent | Prob<1 | CN+UT | | Acceleration of | Schedule | Opportunity to | Developer | 0.8 | | Nil | | $ - |
| 30 | 19 | | | | | | | | | | | | | | $ - |

**Risk Trigger**
Event that indicates the risk is likely to occur. Used to determine when to implement the risk response strategy

# Cost Estimate Review Agenda:

**Location:** MDSHA, Calvert Street, Baltimore, Maryland

**Day 1 - Tuesday**

| | |
|---|---|
| 8:00 am – 8:45 am | - Introductions/FHWA Opening Presentation by **FHWA** |
| 8:45 am – 11:30 am | - Project Overview & Detailed Scope - by Project Team |
| | - Project Segments/Phasing- by Project Team |
| | - Overview of Project Cost Estimation– by Project Team |
| | - Project Schedule Estimate (High-level) – Verify |
| | - Project Risks(High-level-) by Project Team |
| 11:30 am – 12:30 pm | -Lunch |
| 12:30 am – 1:30 pm | - Overview of ROW/UT - by Project Team, ROW,& UT |
| | - Roadway – Environmental, Hazardous Material |
| | - Storm Water, Erosion Control, Landscape Architecture |
| 1:30 – 3:50 pm | - **Roadway**–Drainage, Excavation, Pavement |
| | - **Roadway**-Traffic Control, Lighting, Signing and signals |
| g | - Any outstanding items –related to PM, PE, OE, etc. |

# Cost Estimate Review Agenda:

**Location:** MDSHA, Calvert Street, Baltimore, Maryland

**Day 2 – Wednesday**

| | |
|---|---|
| 8:00 am – 10:00 am | - FHWA CER Model Overview – Risk Register<br>- Structures Risks (Bridges, Retaining/Sound Walls, etc.)<br>- Geotechnical, and Construction Risks |
| 10:00 am – 12:00 PM | - Public Private Partnerships<br>- Funding Schedule and Commitments, Support and Administrative Costs<br>- Contingency, Allowances or Supplemental Work<br>- Base Variability, Market Condition, Inflation Rates |
| 1:00 PM – 2:00 PM | - Revisit risks Items |
| 2:00 PM- 4:00 PM | - Closing presentation and Recommendations - **FHWA** |

# Cost Estimate Review Agenda: (cont.)

**Day 3 - Thursday**

| | |
|---|---|
| 8:00 am – 9:00 am | Preparation for Final Presentation (FHWA only) |
| 9:30 am – 10:30 am | Final Closing Presentation by FHWA and Q&A |
| 10:30 am – 11:00 am | Presentation by FHWA Major project Manager – Finance / Project Management Plan |
| | Adjourn |

# Questions?

# Appendix B

## Cost Estimate Review Closing Presentation

I-81 Improvement Project

***Washington County, Maryland***

# Cost Estimate Review

**February 11, 2016**

## Closing Presentation

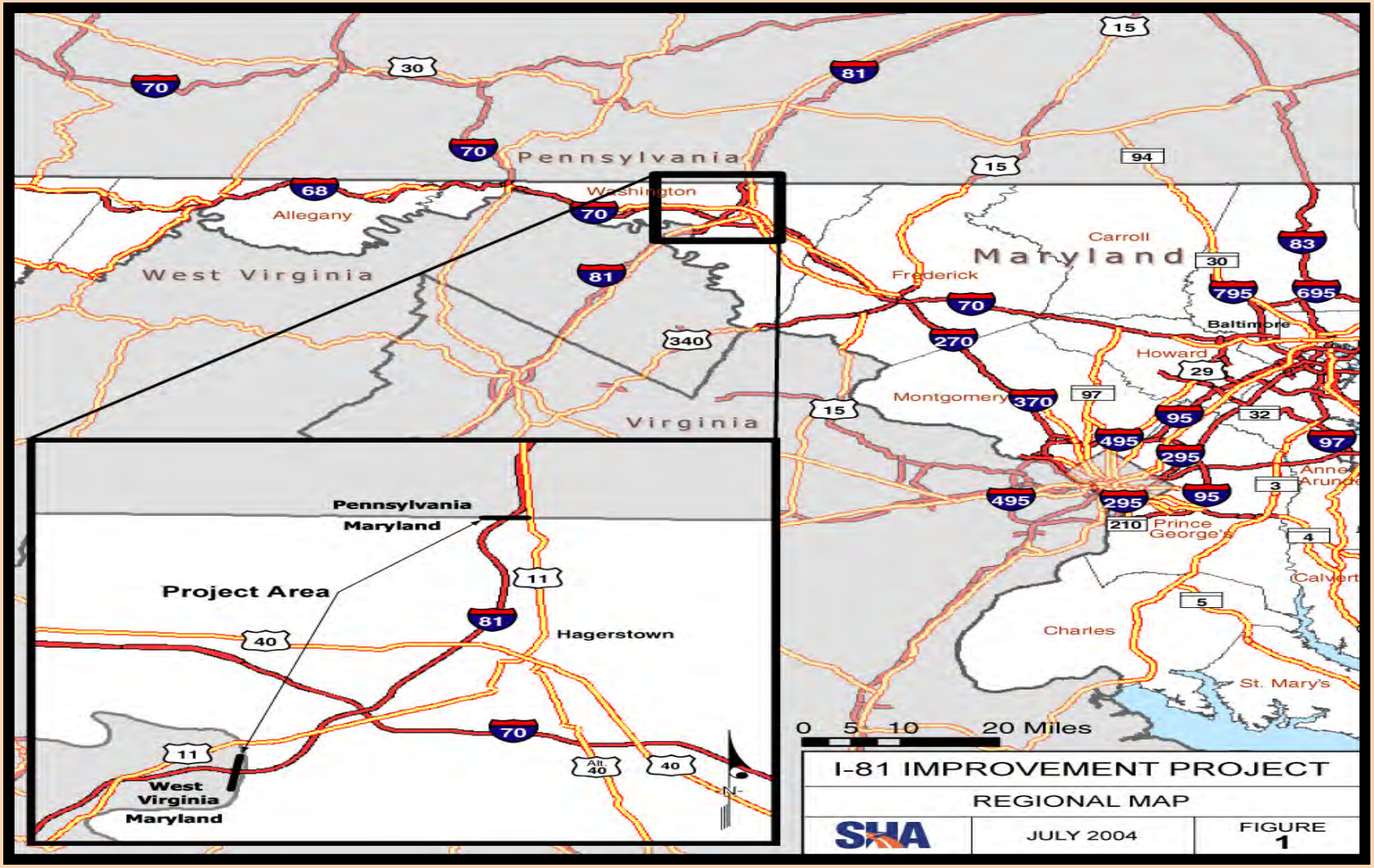
# Cost Estimate Review
# Objective

Conduct an unbiased risk-based review to verify the accuracy and reasonableness of the current total cost estimate to complete the

***I-81 Improvement Project***

and to develop a probability range for the cost estimate that represents the project's current stage of design.

# Project Location




## I-81 Improvement Project

### Washington County, Maryland

# Policy Directives

- First enacted by TEA-21
- Title 23 U.S.C §106(h)(3)(B)

  …based on reasonable assumptions, as determined by the Secretary, of future increases in the cost to complete the project…"

  - Secretary = FHWA
  - Reasonable assumptions = Risk based probabilistic approach

# CERs & Financial Plans

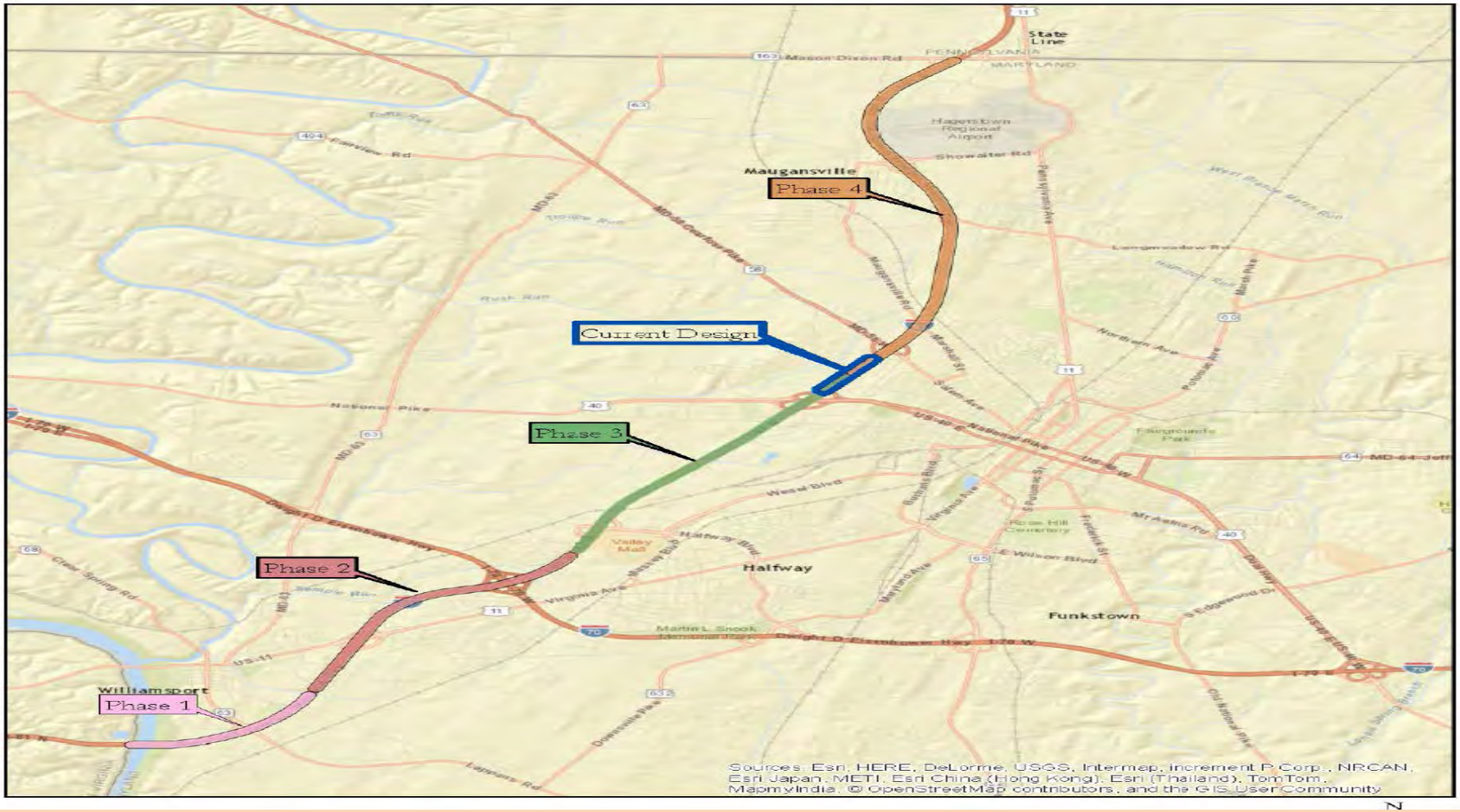
- Consider all costs – Engineering, Construction, ROW, Utilities…
  - *In Year of Expenditure (YOE) Dollars inflated to the mid-point of construction*
- Required at the following thresholds:
  - **$500 Million or higher**
    Major Project – Requires concurrence from FHWA HQ
  - **$100 Million to $500 Million**
    Required, however review is at FHWA Division's discretion

# CERs & MAP-21 (cont.)

P3 Assessment

- All financial plans must assess the appropriateness of a P3 to deliver the project
- All CERs should include discussions as to whether:
  1. P3 or traditional procurement could more effectively leverage the revenue stream
  2. Current state-level legislative authority for P3s
- For projects being procured as P3s, CERs must include an analysis of the allocation of risks with respect to delivering the project through a P3
- For projects with phasing plans, an assessment must be included for each funded phase

# Project Location / Phasing




# I-81 Improvement Project

## Washington County, Maryland

# Cost Estimate Review Agenda:

**Location:** MDSHA, Calvert Street, Baltimore, Maryland

**Day 1 – Tuesday**

- ✓ Project Overview & Detailed Scope - by Project Team
- ✓ Project Segments/Phasing- by Project Team
- ✓ Overview of Project Cost Estimation– by Project Team
- ✓ Project Schedule Estimate (High-level) – Verify
- ✓ Project Risks(High-level-) by Project Team
- ✓ Overview of ROW/UT - by Project Team, ROW,& UT
  Public Private Partnerships
- ✓ Funding Schedule and Commitments, Support and Administrative Costs
- ✓ Contingency, Allowances or Supplemental Work , Base Variability Market Condition, Inflation Rates, Escalation

# Cost Estimate Review Agenda:

**Location:** MDSHA, 707 Calvert Street, Baltimore, Maryland

**Day 2 – Wednesday**

Structures Risks (Bridges, Retaining/Sound Walls, etc.)
- Geotechnical, and Construction Risks

Roadway – Environmental, Hazardous Material

Storm Water, Erosion Control, Landscape Architecture

Roadway–Drainage, Excavation, Pavement

Roadway-Traffic Control, Lighting, Signing and signals

Any outstanding items –related to PM, PE, OE, etc.

Risk Register-FHWA CER Model Overview

Revisit risks Items-

Closing presentation and Recommendations

# Cost Estimate Review Agenda: (cont.)

**Day 3 - Thursday**

| | |
|---|---|
| 8:00 am – 9:00 am | Preparation for Final Presentation |
| 9:30 am – 10:30 am | Final Closing Presentation by FHWA and Q&A |
| 10:30 am – 11:00 am | Presentation by FHWA Major project Manager – Finance / Project Management Plan |
| | Adjourn |

# Review Participants

- **FHWA**
  - Sajid Aftab- Major Projects Engineer- FHWA- CER Lead
  - Dave Carter- Consultant- Crystal Ball/Model Developer
  - Peter Clogston- Advisor to CER Team
  - Daniel Suarez – Area Engineer-Maryland Division- FHWA- CER Team
- **State Highway Administration SHA**
  - John Narer- Office of Structure
  - Jason Harris- Project Management Division
  - Puskar Kar- Project Management Division
  - Barry Kiedrowski- Project Management Division
  - ROW/Utilities- District 6 Staff- Dave DeMaine and Dave Felker
  - Railgul Obul- Project Manager
- **RKK**- Dennis McMahon
- **McCormick& Taylor-** Bob Maimone- Environmental Planning

# Documentation Submitted

- Project Cost Estimate
- Project Schedule
- Project Risk Register
- Project Draft Environmental Document Link

# Basis of Review

- Review based on estimates provided by the Project Team in advance
- Review to determine the reasonableness of assumptions used in the estimate
- Not an independent FHWA estimate
  - Did not verify quantities and unit prices
  - Goal is to verify accuracy and reasonableness of the estimate using a

**Probabilistic Risk-based Approach**

# Review Methodology

**Verify**

- Major cost elements
- Allowances/contingencies
- Adjust estimate as necessary

**Model**

- Base variability
- Market conditions and inflation
- Risk events (cost, schedule, probability, impact)
- Monte Carlo simulation

**Communicate**

- Closeout Presentation (preliminary results)
- Final report (within 60 days)
- Approval of finance plan

# Base Estimate Adjustments

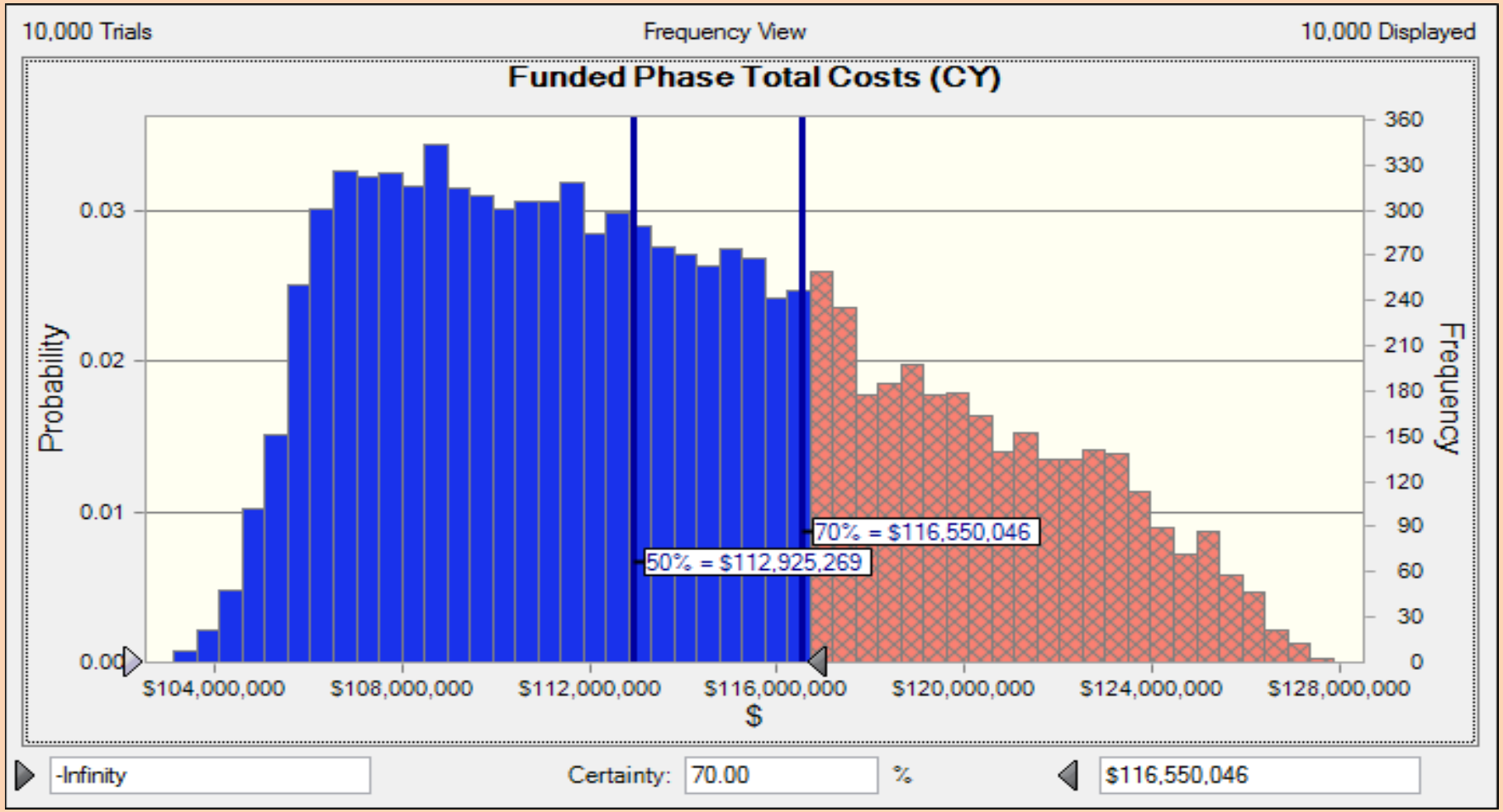
| | |
|---|---|
| $ 559,842,132 | Pre-Review Estimate (Current Year) |
| $ 9,138,000 | Prior Cost |

| Adjustment | Segment | Description of Adjustment | Original Cost | Adjusted Cost |
|---|---|---|---|---|
| $ 3,626,132 | Phase 1 | Change Order Allowance of 4% | $ 90,653,304 | $ 94,279,436 |
| $ 105,000 | Phase 1 | Added Utility Relocates ($45K for Verizon; | $ - | $ 105,000 |
| $ 421,625 | Phase 1A | Change Order Allowance of 4% | $ 10,540,623.00 | $ 10,962,247.92 |
| $ 4,572,233 | Phase 2 | Change Order Allowance of 4% | $ 114,305,825.00 | $ 118,878,058.00 |
| $ 5,262,876 | Phase 3 | Change Order Allowance of 4% | $ 131,571,905.00 | $ 136,834,781.20 |
| $ 8,515,019 | Phase 4 | Change Order Allowance of 4% | $ 212,875,475.00 | $ 221,390,494.00 |
| $ 22,502,885 | Total Net Adjustments | | $ 559,947,132 | $ 582,450,017 |

| Pre-Review Estimates | |
|---|---|
| Phase 1 | $90,548,304 |
| Phase 1A | $10,540,623 |
| Phase 2 | $114,305,825 |
| Phase 3 | $131,571,905 |
| Phase 4 | $212,875,475 |
| Total | $559,842,132 |

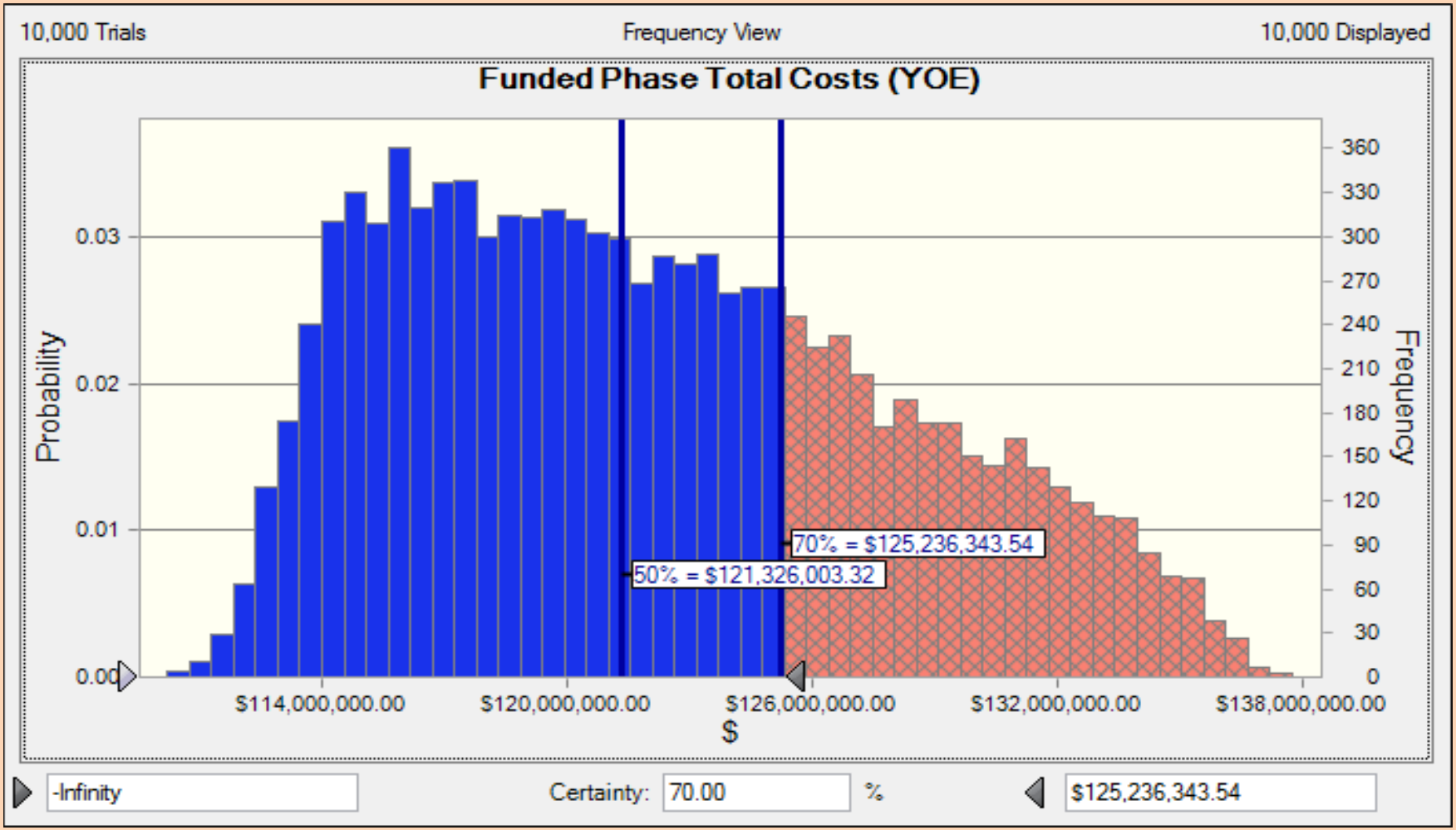
| | |
|---|---|
| $ 591,483,017 | Post Review Estimate (Current Year) |

# Total Funded Phase Project Cost in (CY)




**Pre- CER Estimate = $110.2 million**

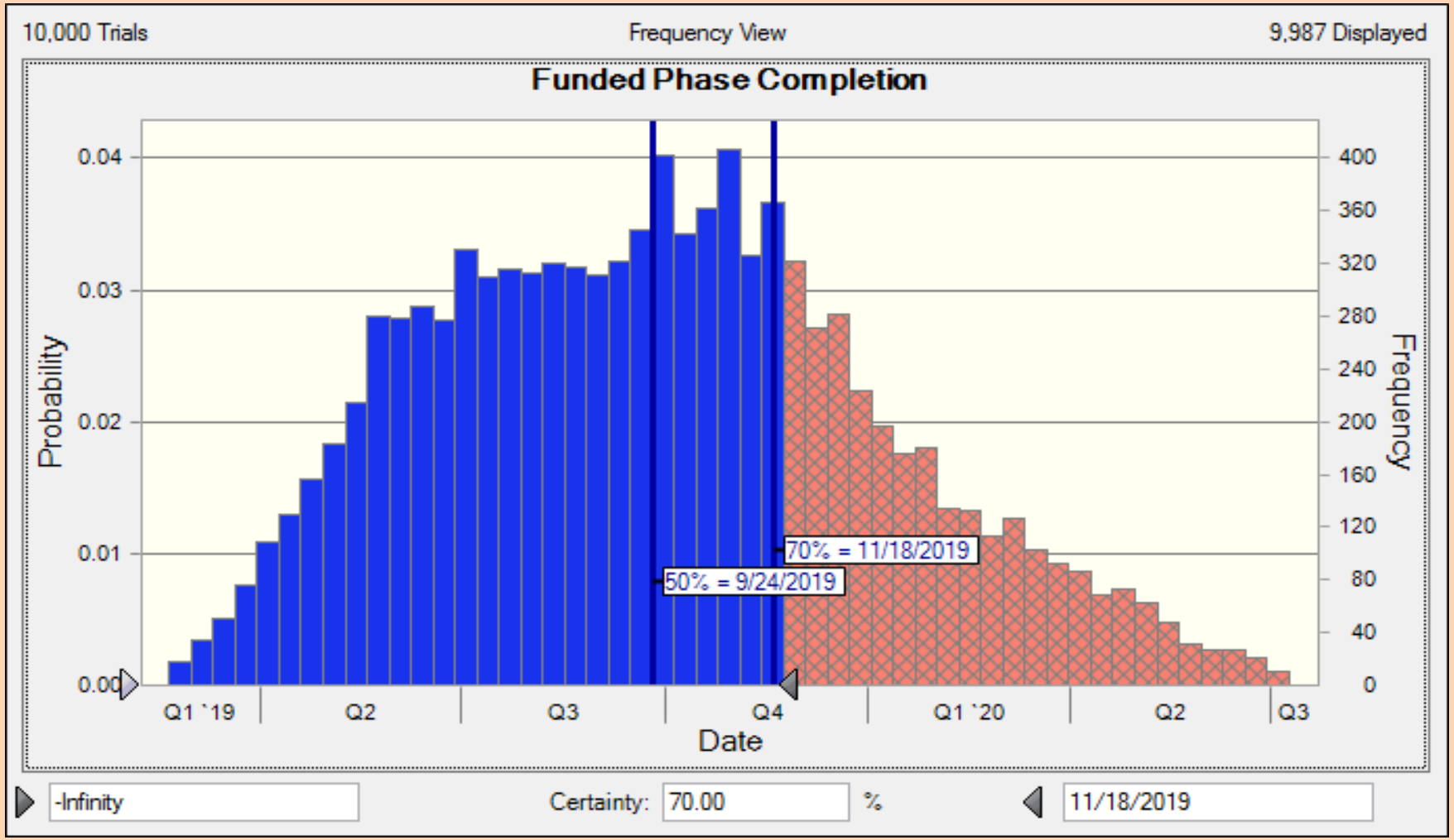
# Total Funded Phase Project Cost in (YOE)



# Total Funded Project Cost (YOE) Percentile Ranking

| Forecast Percentile | Forecast values |
|---|---|
| 0% | $110,203,468.18 |
| 10% | $114,602,947.29 |
| 20% | $116,196,415.26 |
| 30% | $117,830,041.08 |
| 40% | $119,577,578.77 |
| 50% | $121,326,003.32 |
| 60% | $123,260,207.29 |
| 70% | $125,236,343.54 |
| 80% | $127,681,657.04 |
| 90% | $130,918,652.20 |
| 100% | $137,714,235.54 |

# Date of Construction Completion ( Funded)

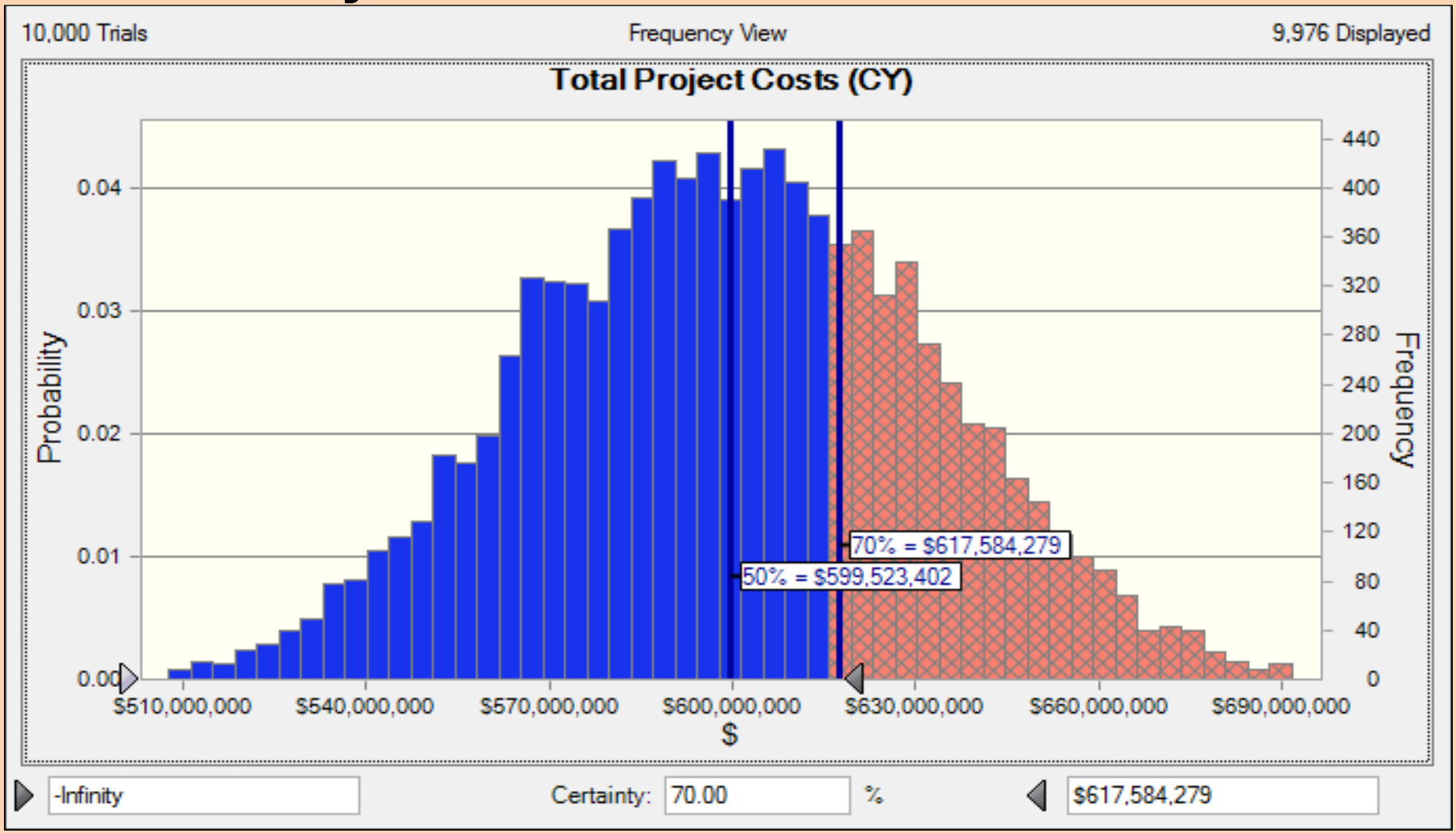



**Pre- CER Completion date = June 1, 2019**
**Post- CER Completion date= Nov 18, 2019**

# All Phases

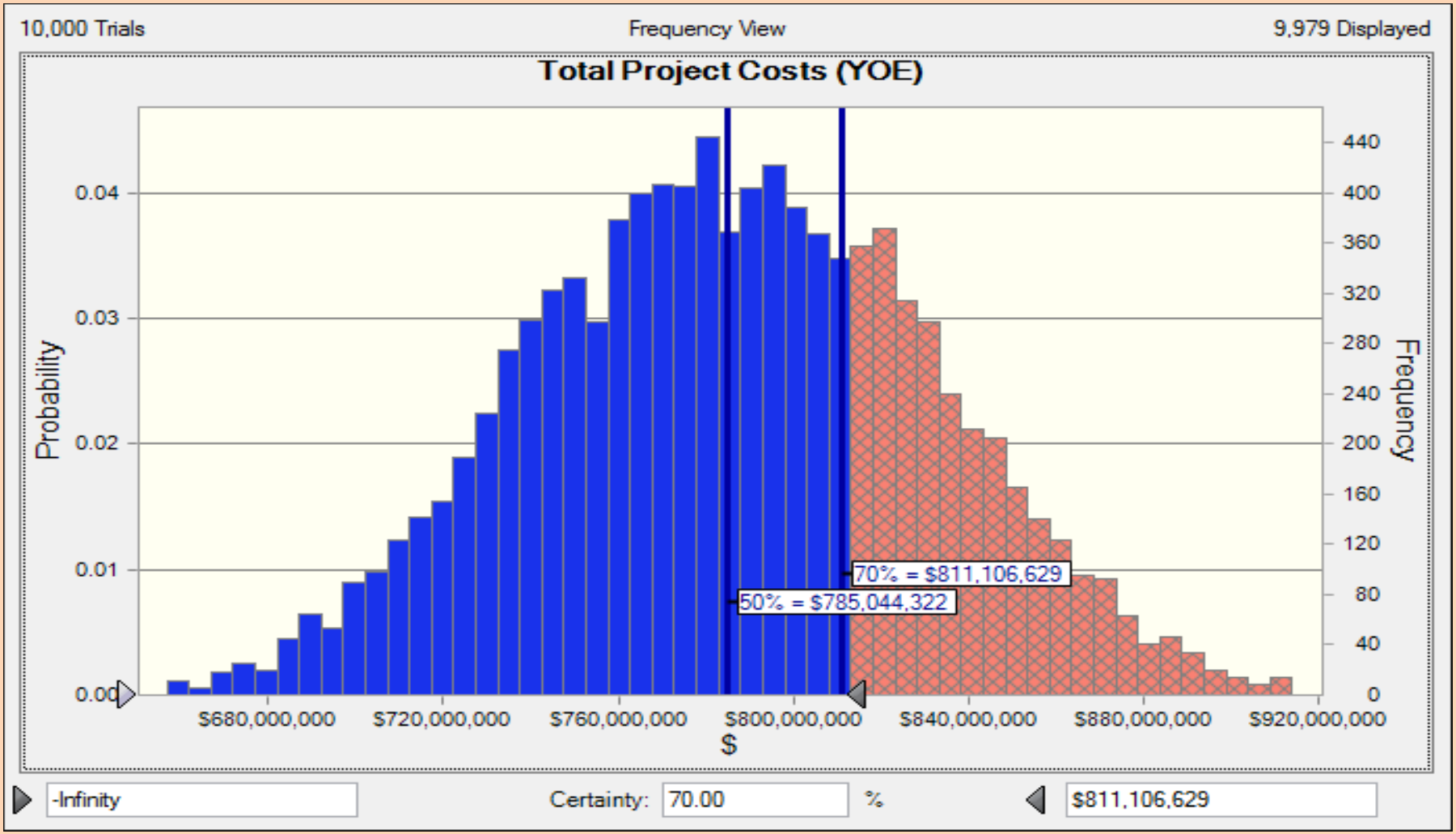
- ✓ Total Project Costs In Current Year (CY)
- ✓ Total Project Costs in Year Of Expenditure(YOE)
- ✓ Project Completion Date

# Total Project Costs in Current Year (CY)




**Pre- CER Estimate = $569.1million**

# Total Project Costs in Year of Expenditure (YOE)

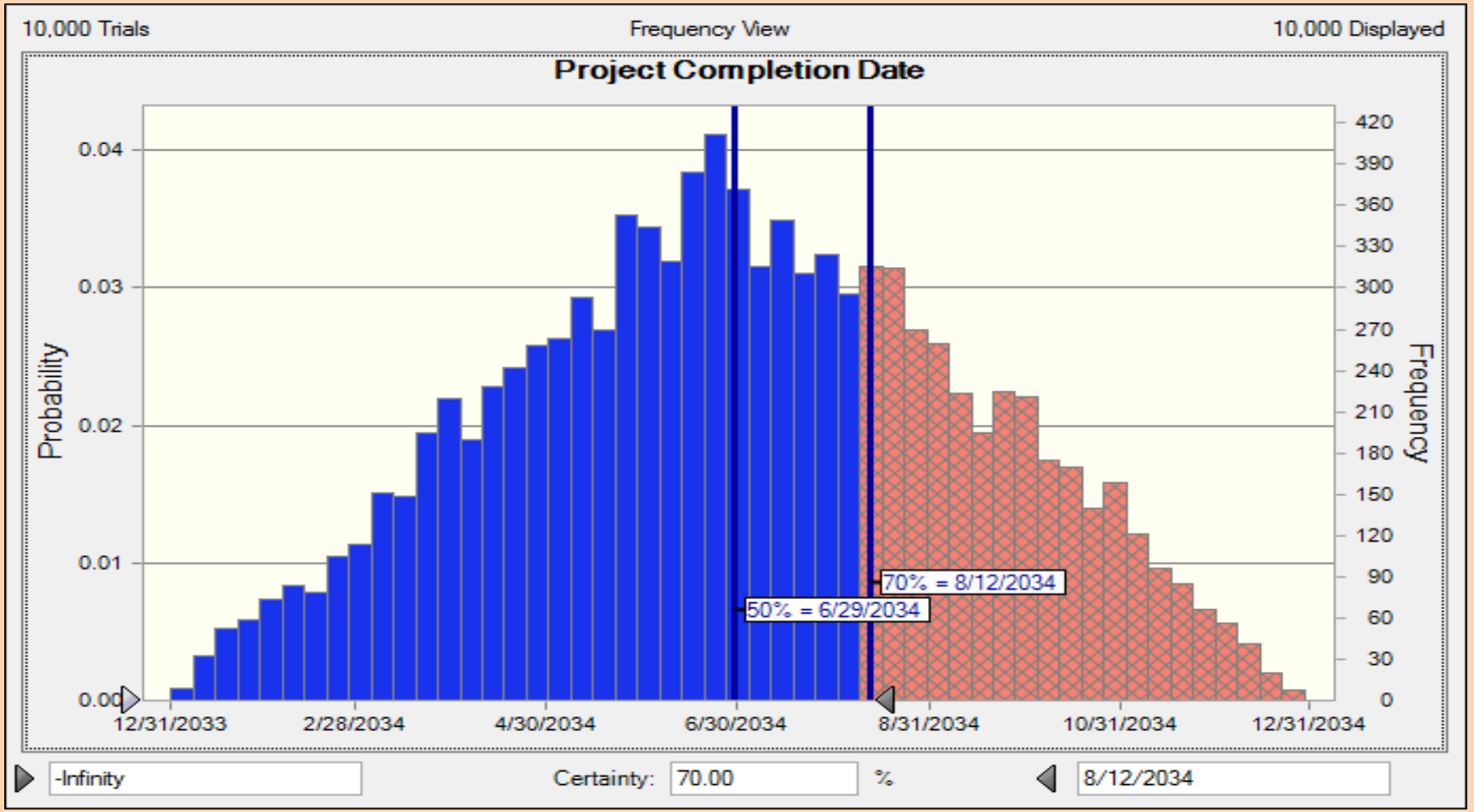



**Post- CER Estimate = $811.1 million**

# Total Project Cost (YOE) Percentile Ranking

| Forecast Percentile | Forecast values |
|---|---|
| 0% | $630,736,432 |
| 10% | $726,169,453 |
| 20% | $744,886,082 |
| 30% | $760,314,680 |
| 40% | $772,973,398 |
| 50% | $785,044,322 |
| 60% | $797,552,925 |
| 70% | $811,106,629 |
| 80% | $825,262,188 |
| 90% | $845,105,364 |
| 100% | $934,720,450 |

# Date of Construction Completion




**Post- CER Completion date = August 12, 2034**

**Pre- CER Completion date = June 30, 2034**

# Review Findings/Observations

- This project has 5 phases ; Phase 1 and 1-A are funded while Phase 2, 3, and 4 are the unfunded phases
- Maryland State Highway Administration is the lead agency in administrating the funded phases (1 and 1A) of this project. West Virginia is the partner agency for phase 1
- The NEPA decision/Reevaluation documents for both states have not been finalized/approved.
- The Phase I will be advertised as one contract including all the work in Maryland and West Virginia.
- Some of the additional Risks (Drainage, Permits, Noise Walls, Landscaping , In stream Work and some of West Virginia-funded work items) were added/modified to the Risk register which was not included in the original risks register list submitted for the purpose of the CER.

# Review Findings/Observations

- SHA provided basic schedule for funded and unfunded phases for the CER workshop. The schedule for the unfunded phases is at conceptual stage.
- There are only two Utilities relocation has been identified in phase 1.
- Positive Market conditions are identified for Phase 1
- The Funded phases of the project will delivered using Design-Bid-Build method
- Level of design used for estimate funded) and workshop was at level (+/- 95%)
- Estimate was updated in Current Year ( CY) dollars
  - Use of conservative unit cost based on bid history and modified with current unit item cost
  - Project team and subject matter experts were familiar with project and estimate
- Planning level base estimates ( including the 35% contingencies) were provided for the unfunded phases of the project

# Recommendations

- Complete the NEPA/Reevaluation process in Maryland and West Virginia
- Should develop more detailed Schedule for **funded phase** of the project up to project award.
- Work proactively with Permitting Agencies to avoid delays
- Work proactively with the West Virginia to finalize the MOU addressing roles and responsibilities.
- Work proactively to finalize the Utility Agreements
- Work proactively with West Virginia to establish Contract Administration activities.
- Continue to work with FHWA Maryland Division office liaison to make sure all necessary project requirements are met

# Recommendations

- Look for opportunities to accelerate schedule to minimize inflation cost for unfunded phases
- Consideration should be given to add schedule contingency to the current project schedule (Funded).
- SHA should update the current CER when funding is available for phases 2, 3, or 4.
- A P3 assessment must be completed and included in the FP for each funded phase.
- The 70% YOE amount for the funded phase should be included as the baseline project cost in the IFP
- Finalize and submit PMP and FP
- Manage threats and opportunities through a risk management plan

# CER Results

## Model Forecast Estimates

(70% confidence level)

### Funded Phase

**Total Escalated Cost in YOE : $125.2 million**

**Project Completion Date : November 2019**

### All Phases – Funded +Unfunded

**Total Escalated Cost in YOE : $811.1 million**

**Project Completion Date : August 2034**

# CER Next Steps

- FHWA will prepare a final report documenting review findings.
  - Draft report for review within 30 days
  - Draft report will be e-mailed to FHWA Maryland Division Office
  - Division Office will review the draft and forward it to the Project Team for comments
  - Final report issued within 30 days after receipt of comments
  - Final report forwarded to the Division Office for distribution to the Project Team and sent to FHWA Headquarters
- FHWA uses the results as the official cost estimate for the project (NEPA, IFP, reporting)
- Estimate review is a snapshot of the estimate at current time

# Questions?

# Appendix C

## Crystal Ball Probability Analysis

**Crystal Ball Report - Full**
Simulation started on 2/10/2016 at 2:08 PM
Simulation stopped on 2/10/2016 at 2:10 PM

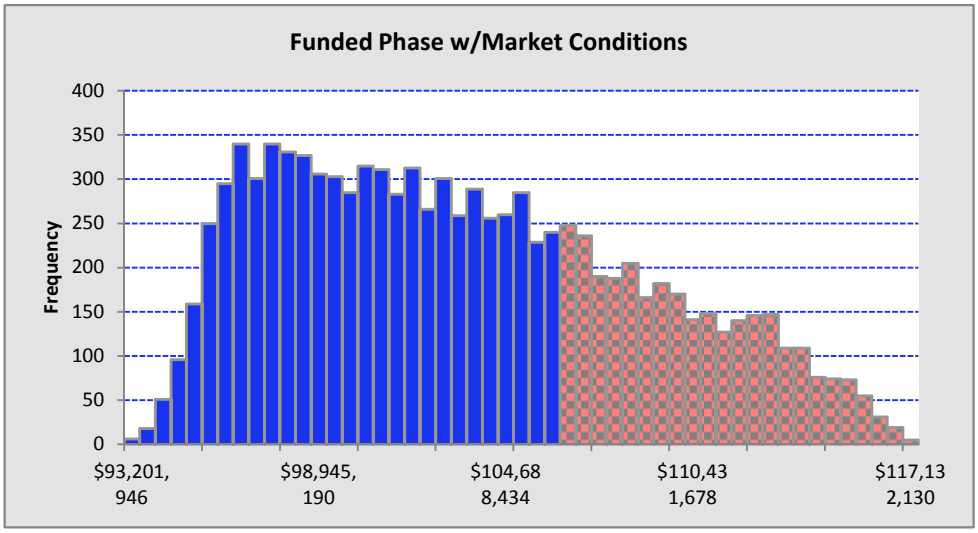
| | |
|---|---|
| Run preferences: | |
| Number of trials run | 10,000 |
| Monte Carlo | |
| Random seed | |
| Precision control on | |
| Confidence level | 95.00% |
| Run statistics: | |
| Total running time (sec) | 87.59 |
| Trials/second (average) | 114 |
| Random numbers per sec | 0 |
| Crystal Ball data: | |
| Assumptions | 0 |
| Correlations | 0 |
| Correlated groups | 0 |
| Decision variables | 0 |
| Forecasts | 11 |

## Forecasts

**Worksheet: [Copy of CERv66 4_MySite_FINAL_Maryland_I-81_2-10-16.xlsm]BaseSchedule&Cost**

**Forecast: Funded Phase w/Market Conditions** **Cell: R62**

Summary:
Certainty level is 70.00%
Certainty range is from -Infinity to $106,335,970
Entire range is from $92,962,644 to $117,371,431
Base case is $98,271,233
After 10,000 trials, the std. error of the mean is $55,148




| Statistics: | Forecast values |
|---|---|
| Trials | 10,000 |
| Base Case | $98,271,233 |
| Mean | $103,339,534 |
| Median | $102,691,475 |
| Mode | --- |
| Standard Deviation | $5,514,778 |
| Variance | $30,412,773,840,521 |
| Skewness | 0.3872 |
| Kurtosis | 2.20 |
| Coeff. of Variability | 0.0534 |
| Minimum | $92,962,644 |
| Maximum | $117,371,431 |
| Range Width | $24,408,788 |
| Mean Std. Error | $55,148 |

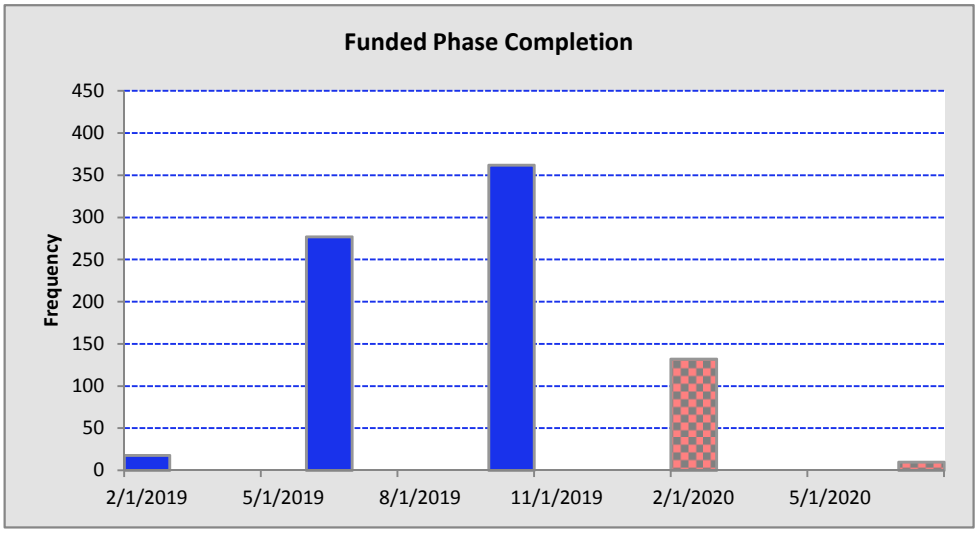
**Forecast: Funded Phase w/Market Conditions (cont'd)** **Cell: R62**

| Percentiles: | Forecast values |
|---|---|
| 0% | $92,962,644 |
| 10% | $96,473,187 |
| 20% | $97,968,434 |
| 30% | $99,490,570 |
| 40% | $101,043,433 |
| 50% | $102,691,248 |
| 60% | $104,444,431 |
| 70% | $106,335,970 |
| 80% | $108,561,799 |
| 90% | $111,554,671 |
| 100% | $117,371,431 |

**Worksheet: [Copy of CERv66 4_MySite_FINAL_Maryland_I-81_2-10-16.xlsm]YOE**

**Forecast: Funded Phase Completion** **Cell: E35**

Summary:
Certainty level is 70.00%
Certainty range is from -Infinity to 11/18/2019
Entire range is from 2/18/2019 to 9/5/2020
Base case is 6/6/2020
After 10,000 trials, the std. error of the mean is 1.02



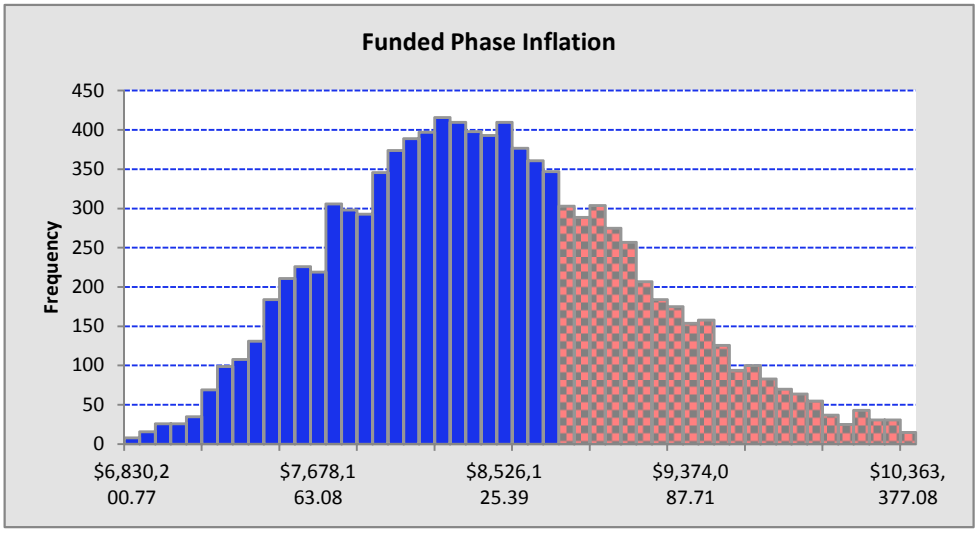

| Statistics: | Forecast values |
|---|---|
| Trials | 10,000 |
| Base Case | 6/6/2020 |
| Mean | 9/26/2019 |
| Median | 9/24/2019 |
| Mode | --- |
| Standard Deviation | 101.80 |
| Variance | 10,364.18 |
| Skewness | 0.2872 |
| Kurtosis | 2.57 |
| Coeff. of Variability | 0.0023 |
| Minimum | 2/18/2019 |
| Maximum | 9/5/2020 |
| Range Width | 565.80 |
| Mean Std. Error | 1.02 |

**Forecast: Funded Phase Completion (cont'd)** **Cell: E35**

| Percentiles: | Forecast values |
|---|---|
| 0% | 2/18/2019 |
| 10% | 5/19/2019 |
| 20% | 6/24/2019 |
| 30% | 7/24/2019 |
| 40% | 8/25/2019 |
| 50% | 9/24/2019 |
| 60% | 10/21/2019 |
| 70% | 11/18/2019 |
| 80% | 12/20/2019 |
| 90% | 2/12/2020 |
| 100% | 9/5/2020 |

**Forecast: Funded Phase Inflation** **Cell: E34**

Summary:
Certainty level is 70.00%
Certainty range is from -Infinity to $8,803,260.42
Entire range is from $6,794,869.00 to $11,113,738.23
Base case is $9,175,874.40
After 10,000 trials, the std. error of the mean is $6,889.17



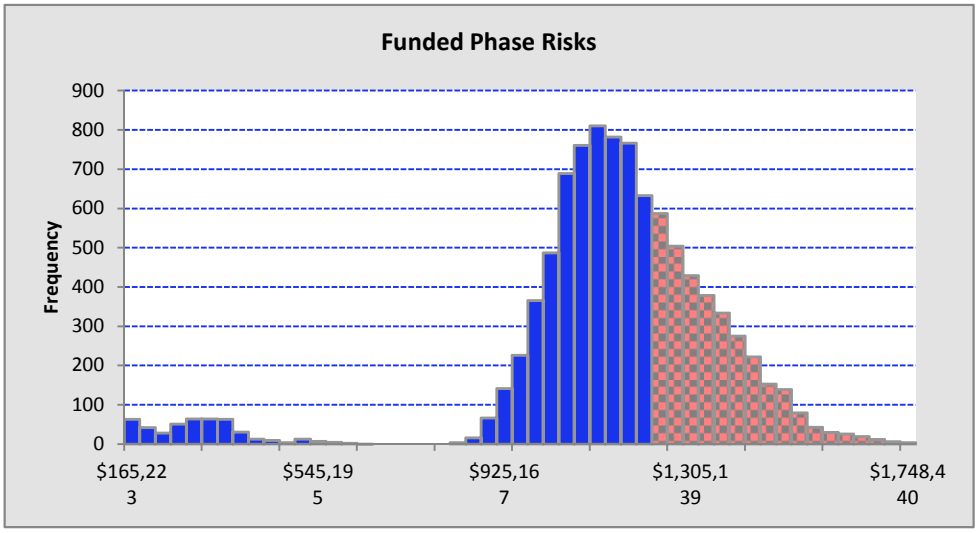

| Statistics: | Forecast values |
|---|---|
| Trials | 10,000 |
| Base Case | $9,175,874.40 |
| Mean | $8,469,739.93 |
| Median | $8,422,934.20 |
| Mode | --- |
| Standard Deviation | $688,917.47 |
| Variance | $474,607,278,532.45 |
| Skewness | 0.3625 |
| Kurtosis | 2.88 |
| Coeff. of Variability | 0.0813 |
| Minimum | $6,794,869.00 |
| Maximum | $11,113,738.23 |
| Range Width | $4,318,869.23 |
| Mean Std. Error | $6,889.17 |

**Forecast: Funded Phase Inflation (cont'd)** **Cell: E34**

| Percentiles: | Forecast values |
|---|---|
| 0% | $6,794,869.00 |
| 10% | $7,597,092.64 |
| 20% | $7,864,891.88 |
| 30% | $8,071,549.70 |
| 40% | $8,250,330.06 |
| 50% | $8,422,908.49 |
| 60% | $8,598,127.12 |
| 70% | $8,803,260.42 |
| 80% | $9,046,549.91 |
| 90% | $9,400,178.71 |
| 100% | $11,113,738.23 |

**Forecast: Funded Phase Risks** **Cell: E31**

Summary:
Certainty level is 70.00%
Certainty range is from -Infinity to $1,238,462
Entire range is from $5,668 to $1,764,272
Base case is $1,123,270
After 10,000 trials, the std. error of the mean is $3,349



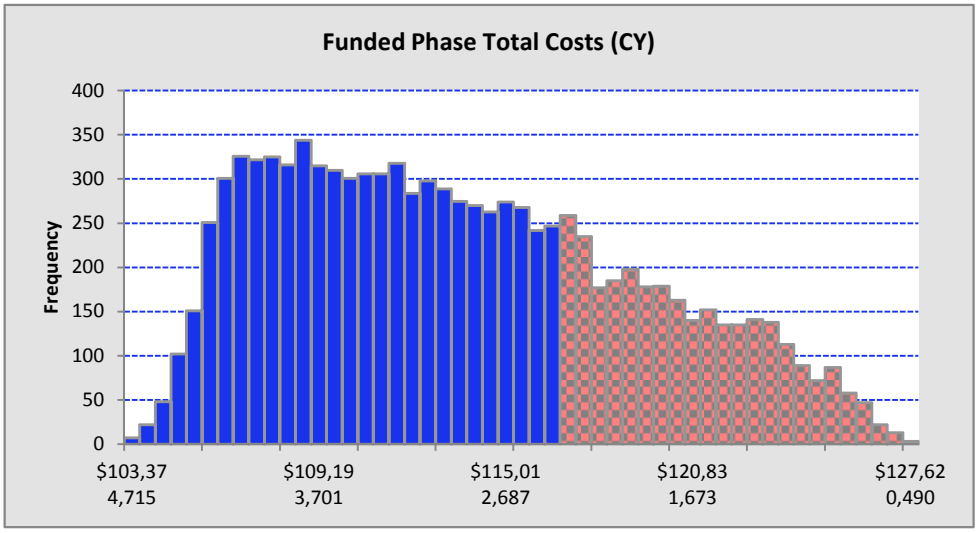

| Statistics: | Forecast values |
|---|---|
| Trials | 10,000 |
| Base Case | $1,123,270 |
| Mean | $1,087,086 |
| Median | $1,147,785 |
| Mode | --- |
| Standard Deviation | $334,891 |
| Variance | $112,152,133,197 |
| Skewness | -1.83 |
| Kurtosis | 6.07 |
| Coeff. of Variability | 0.3081 |
| Minimum | $5,668 |
| Maximum | $1,764,272 |
| Range Width | $1,758,604 |
| Mean Std. Error | $3,349 |

**Forecast: Funded Phase Risks (cont'd)** **Cell: E31**

| Percentiles: | Forecast values |
|---|---|
| 0% | $5,668 |
| 10% | $562,733 |
| 20% | $1,017,210 |
| 30% | $1,067,518 |
| 40% | $1,109,051 |
| 50% | $1,147,783 |
| 60% | $1,188,936 |
| 70% | $1,238,462 |
| 80% | $1,300,401 |
| 90% | $1,385,587 |
| 100% | $1,764,272 |

**Forecast: Funded Phase Total Costs (CY)** **Cell: E32**

Summary:
Certainty level is 70.00%
Certainty range is from -Infinity to $116,550,046
Entire range is from $103,132,258 to $127,862,947
Base case is $108,532,503
After 10,000 trials, the std. error of the mean is $55,202



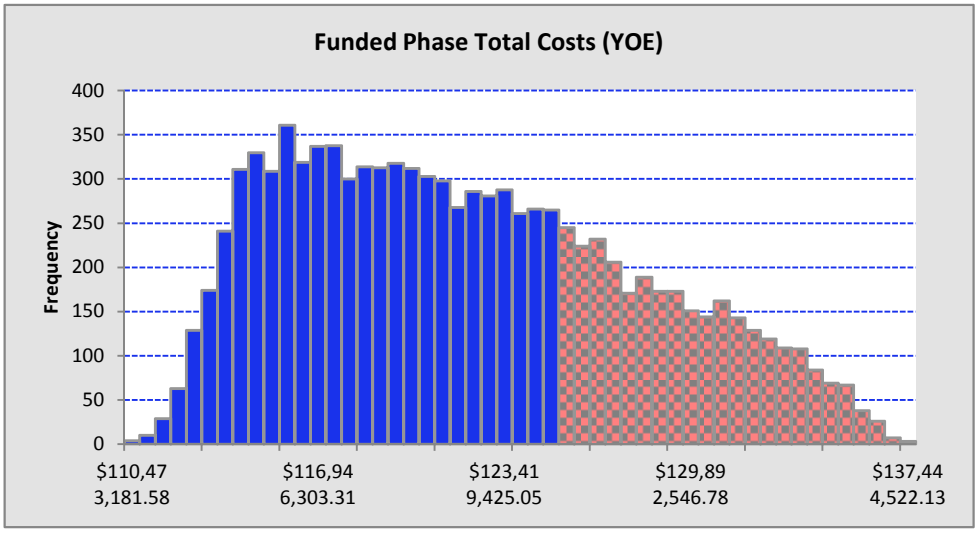

| Statistics: | Forecast values |
|---|---|
| Trials | 10,000 |
| Base Case | $108,532,503 |
| Mean | $113,564,620 |
| Median | $112,926,851 |
| Mode | --- |
| Standard Deviation | $5,520,196 |
| Variance | $30,472,559,439,277 |
| Skewness | 0.3861 |
| Kurtosis | 2.21 |
| Coeff. of Variability | 0.0486 |
| Minimum | $103,132,258 |
| Maximum | $127,862,947 |
| Range Width | $24,730,690 |
| Mean Std. Error | $55,202 |

**Forecast: Funded Phase Total Costs (CY) (cont'd)** **Cell: E32**

| Percentiles: | Forecast values |
|---|---|
| 0% | $103,132,258 |
| 10% | $106,689,103 |
| 20% | $108,202,768 |
| 30% | $109,699,990 |
| 40% | $111,295,338 |
| 50% | $112,925,269 |
| 60% | $114,662,682 |
| 70% | $116,550,046 |
| 80% | $118,794,932 |
| 90% | $121,773,997 |
| 100% | $127,862,947 |

**Forecast: Funded Phase Total Costs (YOE)** **Cell: E33**

Summary:
Certainty level is 70.00%
Certainty range is from -Infinity to $125,236,343.54
Entire range is from $110,203,468.18 to $137,714,235.54
Base case is $117,708,377.37
After 10,000 trials, the std. error of the mean is $60,026.13



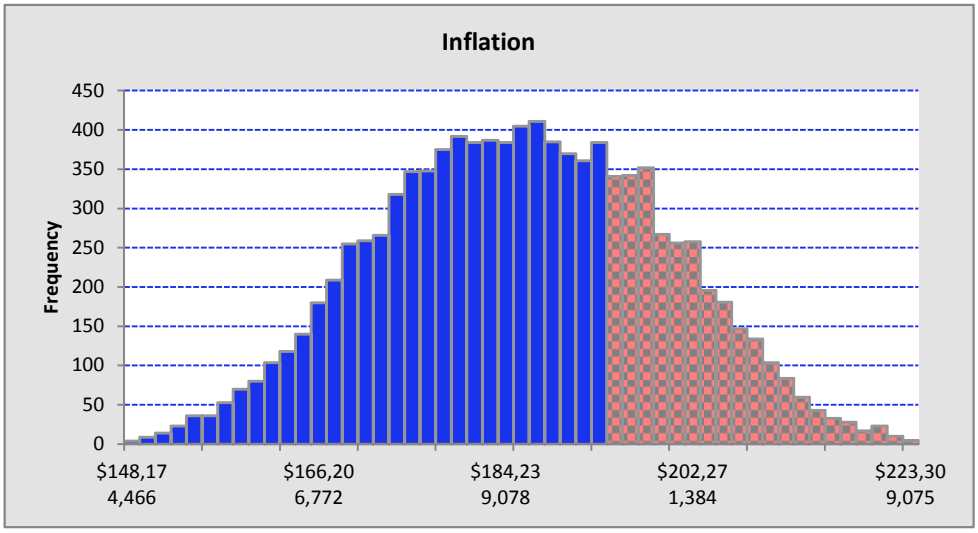

| Statistics: | Forecast values |
|---|---|
| Trials | 10,000 |
| Base Case | $117,708,377.37 |
| Mean | $122,034,359.86 |
| Median | $121,326,683.58 |
| Mode | --- |
| Standard Deviation | $6,002,613.39 |
| Variance | ################## |
| Skewness | 0.3810 |
| Kurtosis | 2.22 |
| Coeff. of Variability | 0.0492 |
| Minimum | $110,203,468.18 |
| Maximum | $137,714,235.54 |
| Range Width | $27,510,767.36 |
| Mean Std. Error | $60,026.13 |

**Forecast: Funded Phase Total Costs (YOE) (cont'd)** **Cell: E33**

| Percentiles: | Forecast values |
|---|---|
| 0% | $110,203,468.18 |
| 10% | $114,602,947.29 |
| 20% | $116,196,415.26 |
| 30% | $117,830,041.08 |
| 40% | $119,577,578.77 |
| 50% | $121,326,003.32 |
| 60% | $123,260,207.29 |
| 70% | $125,236,343.54 |
| 80% | $127,681,657.04 |
| 90% | $130,918,652.20 |
| 100% | $137,714,235.54 |

**Forecast: Inflation** **Cell: E27**

Summary:
Certainty level is 70.00%
Certainty range is from -Infinity to $193,606,978
Entire range is from $140,659,462 to $227,536,664
Base case is $214,724,904
After 10,000 trials, the std. error of the mean is $136,852



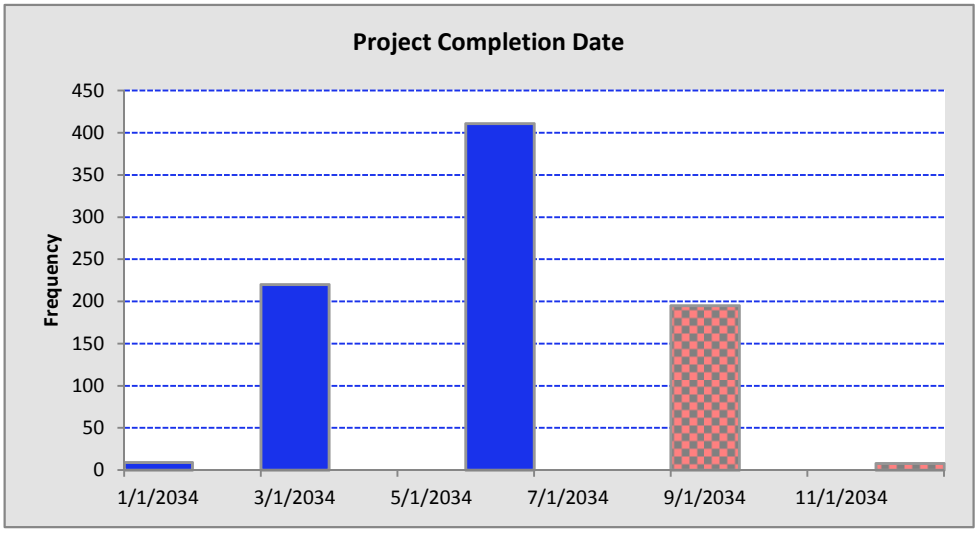

| Statistics: | Forecast values |
|---|---|
| Trials | 10,000 |
| Base Case | $214,724,904 |
| Mean | $185,741,770 |
| Median | $185,708,067 |
| Mode | --- |
| Standard Deviation | $13,685,232 |
| Variance | $187,285,584,461,069 |
| Skewness | 0.0013 |
| Kurtosis | 2.58 |
| Coeff. of Variability | 0.0737 |
| Minimum | $140,659,462 |
| Maximum | $227,536,664 |
| Range Width | $86,877,203 |
| Mean Std. Error | $136,852 |

**Forecast: Inflation (cont'd)** **Cell: E27**

| Percentiles: | Forecast values |
|---|---|
| 0% | $140,659,462 |
| 10% | $167,877,296 |
| 20% | $173,610,283 |
| 30% | $177,932,394 |
| 40% | $181,904,200 |
| 50% | $185,704,512 |
| 60% | $189,527,567 |
| 70% | $193,606,978 |
| 80% | $197,963,471 |
| 90% | $203,541,003 |
| 100% | $227,536,664 |

**Forecast: Project Completion Date** **Cell: E28**

Summary:
Certainty level is 70.00%
Certainty range is from -Infinity to 8/12/2034
Entire range is from 12/30/2033 to 12/29/2034
Base case is 7/29/2034
After 10,000 trials, the std. error of the mean is 0.7481



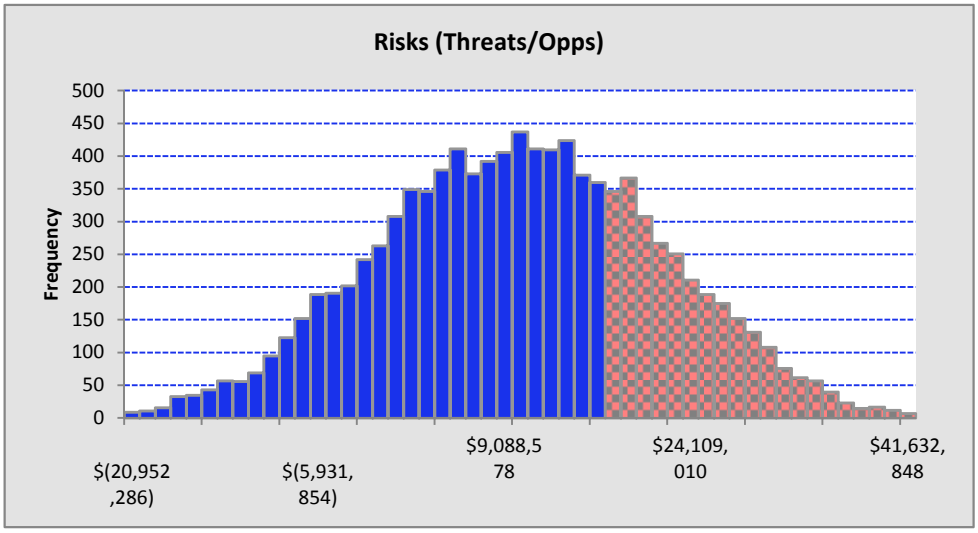

| Statistics: | Forecast values |
|---|---|
| Trials | 10,000 |
| Base Case | 7/29/2034 |
| Mean | 6/30/2034 |
| Median | 6/29/2034 |
| Mode | --- |
| Standard Deviation | 74.81 |
| Variance | 5,596.12 |
| Skewness | -0.0073 |
| Kurtosis | 2.39 |
| Coeff. of Variability | 0.0015 |
| Minimum | 12/30/2033 |
| Maximum | 12/29/2034 |
| Range Width | 363.22 |
| Mean Std. Error | 0.7481 |

**Forecast: Project Completion Date (cont'd)** **Cell: E28**

| Percentiles: | Forecast values |
|---|---|
| 0% | 12/30/2033 |
| 10% | 3/22/2034 |
| 20% | 4/24/2034 |
| 30% | 5/20/2034 |
| 40% | 6/11/2034 |
| 50% | 6/29/2034 |
| 60% | 7/20/2034 |
| 70% | 8/12/2034 |
| 80% | 9/6/2034 |
| 90% | 10/10/2034 |
| 100% | 12/29/2034 |

**Forecast: Risks (Threats/Opps)** **Cell: E24**

Summary:
Certainty level is 70.00%
Certainty range is from -Infinity to $16,600,363
Entire range is from $(23,917,230) to $48,921,003
Base case is $10,728,144
After 10,000 trials, the std. error of the mean is $113,994




| Statistics: | Forecast values |
|---|---|
| Trials | 10,000 |
| Base Case | $10,728,144 |
| Mean | $10,340,281 |
| Median | $10,399,734 |
| Mode | --- |
| Standard Deviation | $11,399,435 |
| Variance | $129,947,122,070,832 |
| Skewness | -0.0108 |
| Kurtosis | 2.71 |
| Coeff. of Variability | 1.10 |
| Minimum | $(23,917,230) |
| Maximum | $48,921,003 |
| Range Width | $72,838,233 |
| Mean Std. Error | $113,994 |

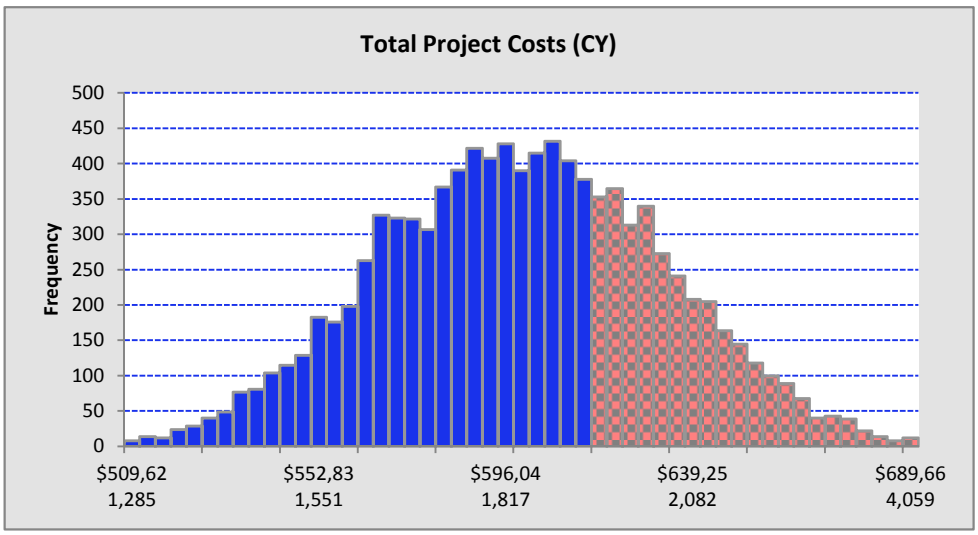
**Forecast: Risks (Threats/Opps) (cont'd)** **Cell: E24**

| Percentiles: | Forecast values |
|---|---|
| 0% | $(23,917,230) |
| 10% | $(4,680,484) |
| 20% | $438,701 |
| 30% | $4,134,478 |
| 40% | $7,318,030 |
| 50% | $10,397,385 |
| 60% | $13,388,159 |
| 70% | $16,600,363 |
| 80% | $20,234,316 |
| 90% | $25,238,196 |
| 100% | $48,921,003 |

**Forecast: Total Project Costs (CY)** **Cell: E25**

Includes base costs, prior costs, fixed costs, and risks

Summary:
Certainty level is 70.00%
Certainty range is from -Infinity to $617,584,279
Entire range is from $489,024,843 to $707,183,786
Base case is $638,348,522
After 10,000 trials, the std. error of the mean is $327,935




| Statistics: | Forecast values |
|---|---|
| Trials | 10,000 |
| Base Case | $638,348,522 |
| Mean | $599,642,672 |
| Median | $599,526,002 |
| Mode | --- |
| Standard Deviation | $32,793,505 |
| Variance | ################## |
| Skewness | 0.0037 |
| Kurtosis | 2.74 |
| Coeff. of Variability | 0.0547 |
| Minimum | $489,024,843 |
| Maximum | $707,183,786 |
| Range Width | $218,158,943 |
| Mean Std. Error | $327,935 |

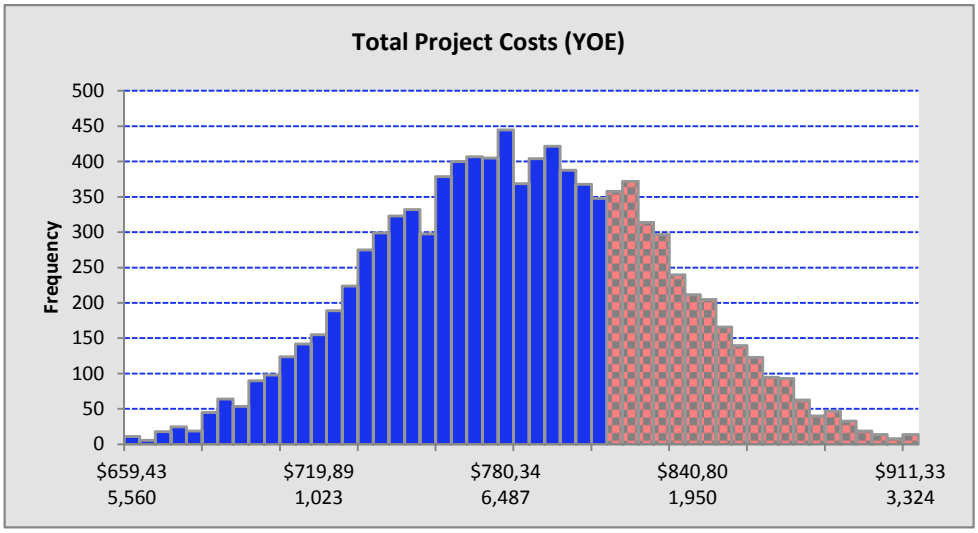
**Forecast: Total Project Costs (CY) (cont'd)** **Cell: E25**

| Percentiles: | Forecast values |
|---|---|
| 0% | $489,024,843 |
| 10% | $557,069,122 |
| 20% | $570,951,744 |
| 30% | $581,771,744 |
| 40% | $590,777,925 |
| 50% | $599,523,402 |
| 60% | $608,226,131 |
| 70% | $617,584,279 |
| 80% | $628,136,546 |
| 90% | $642,402,443 |
| 100% | $707,183,786 |

**Forecast: Total Project Costs (YOE)** **Cell: E26**

Includes base costs, prior costs, fixed costs, and YOE Costs (base costs adjusted for market conditions and risks) inflated to YOE.

Summary:
Certainty level is 70.00%
Certainty range is from -Infinity to $811,106,629
Entire range is from $630,736,432 to $934,720,450
Base case is $853,073,426
After 10,000 trials, the std. error of the mean is $458,814




| Statistics: | Forecast values |
|---|---|
| Trials | 10,000 |
| Base Case | $853,073,426 |
| Mean | $785,384,442 |
| Median | $785,047,631 |
| Mode | --- |
| Standard Deviation | $45,881,378 |
| Variance | ################## |
| Skewness | 0.0020 |
| Kurtosis | 2.69 |
| Coeff. of Variability | 0.0584 |
| Minimum | $630,736,432 |
| Maximum | $934,720,450 |
| Range Width | $303,984,018 |
| Mean Std. Error | $458,814 |

**Forecast: Total Project Costs (YOE) (cont'd)** **Cell: E26**

| Percentiles: | Forecast values |
|---|---|
| 0% | $630,736,432 |
| 10% | $726,169,453 |
| 20% | $744,886,082 |
| 30% | $760,314,680 |
| 40% | $772,973,398 |
| 50% | $785,044,322 |
| 60% | $797,552,925 |
| 70% | $811,106,629 |
| 80% | $825,262,188 |
| 90% | $845,105,364 |
| 100% | $934,720,450 |

# Appendix D

## Cost Estimate Review Agenda

# I-81-Improvement Project

**Cost Estimate Review (CER) Agenda**

**Date: February 9- February 11, 2016**

**Meeting Location:** MDSHA, Calvert Street, Baltimore, Maryland,

**Day 1-TUESDAY**

**8:00 am – 8:45 am** - Introductions/FHWA Opening Presentation by FHWA
**8:45 am – 11:30 am** - Project Overview & Detailed Scope - by Project Team
- Project Segments/Phasing- by Project Team
- Overview of Project Cost Estimation– by Project Team
- Project Schedule Estimate (High-level) – Verify
- Project Risks (High-level-) by Project Team

**11:30 am – 12:30 pm** - Lunch

**12:30 pm – 1:30 pm** - Overview of ROW/UT - by Project Team, ROW, & UT
- Roadway – Environmental, Hazardous Material
- Storm Water, Erosion Control, Landscape Architecture

**1:30 pm – 3:50 pm** - Roadway–Drainage, Excavation, Pavement
- Roadway-Traffic Control, Lighting, Signing and signals
- Any outstanding items –related to PM, PE, OE, etc.

# I-81-Improvement Project Cost Estimate Review (CER) Agenda (Continued)

**Day 2 – Wednesday**

| | |
|---|---|
| **8:00 are – 10:00 are** | - FHWA CER Model Overview – Risk Register<br>- Structures Risks (Bridges, Retaining/Sound Walls, etc.)<br>- Geotechnical, and Construction Risks |
| **10:00 am – 12:00 PM** | - Public Private Partnerships<br>- Funding Schedule and Commitments, Support and<br>- Administrative Costs<br>- Contingency, Allowances or Supplemental Work<br>- Base Variability, Market Condition, Inflation Rates |
| **1:00 PM – 2:00 PM** | - Revisit risks Items |
| **2:00 PM - 4:00 PM** | - Closing presentation and Recommendations – FHWA |

**Day 3 – Thursday**

| | |
|---|---|
| **8:00 am – 9:00 am** | - Preparation for Final Presentation (FHWA only) |
| **9:30 am – 10:30 am** | - Final Closing Presentation by FHWA and Q&A |
| **10:30 am – 11:00 am** | - Presentation by FHWA Major Projects |

**Adjourn**

# Appendix E

## Cost Estimate Review Sign-In Sheets

## COST ESTIMATE REVIEW SIGN-IN SHEET

**Project:** I-81 Corridor-Project

2/11/16

**State:** Maryland

**Date:** 02/09/16-02/11/16

| Name | Agency | Title | E-Mail |
|---|---|---|---|
| JOY LIANG | FHWA | ENVIRONMENTAL SPECIALIST | joy.liang@dot.gov |
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| Daniel Suarez | FHWA | Area Engineer | daniel.suarez@dot.gov |
| SAJID AFTAB | FHWA | Major Project | Sajid.Aftab@dot.gov |
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| JOHN MARCH | SHA-BRIDGE | PROJECT MANAGER | JMARCH@SHA.STATE.MD.US |
| Bob Maimone | SHA-EPLD | Environmental Manager | BMaimone@sha.state.md.us |
| G VAUGHAN | SHA BRIDGE | Dep Dir | GVAUGHAN |
| DENNIS McMAHON | RKK | PM. | Dmcmahon@RKK.com |
| Barry Kiedrowski | SHA-OPPE | Chief, Prog. Mgmt Div. | bkiedrowski@sha.state.md.us |
| JASON HARRIS | SHA-OPPE | LEAD DESIGN ENGINEER PMP | jharris@sha.state.md.us |
| Puskar Kar | SHA-OPPE | Asst. Div. Chief | pkar@sha.state.md.us |
| GUY TALERICO | SHA-OOF | Chief Fed. Aid | gtalerico@sha.stat.md.us |
| SAJID AFTAB | FHWA | MAJOR P Engr | Sajid.Aftab@dot.gov |
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# COST ESTIMATE REVIEW SIGN-IN SHEET

**Project:** I-81 Corridor-Project 2/10/16

**State:** Maryland

**Date:** 02/09/16-02/11/16

| Name | Agency | Title | E-Mail |
|---|---|---|---|
| Daniel Suarez | FHWA | Area Engineer | daniel.suarez@dot.gov |
| PETE CLOGSTON | FHWA | MAJOR PROJECT ENGINEER | peter.clogston@dot.gov |
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| SAJID AFTAB | FHWA | Major Project Coord. | Sajid.Aftab@dot.gov |
| DENNIS MCMAHON | RK&K | CONSTRUCTION MANAGER | DMCMAHON@RKK.COM |
| MT Chaudhry | FHWA | Bridge Engineer | MT.CHAUDHRY@DOT.GOV |
| JOHN NAGER | SHA - BRIDGE | PROJECT ENG. | JNAGER@SHA.STATE.MD.US |
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| MATT BAKER | SHA-RIPD | REG. PLANNER | mbaker4@sha.state.md.us |
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# COST ESTIMATE REVIEW SIGN-IN SHEET

**Project:** I-81 Corridor-Project

2/9/16

**State:** Maryland

**Date:** 02/09/16-02/11/16

| Name | Agency | Title | E-Mail |
|---|---|---|---|
| Daniel Suarez | FHWA | Area Engineer | daniel.suarez@dot.gov |
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| JASON HARRIS | SHA-Planning | Design Engineer | |
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| JOHN NAGEN | SHA - BRIDGE | PROJ. ENGR. | JNAGEN@SHA.STATE.MD.US |
| Bob Maimone | SHA - EPLD | Environmental Manager | BMaimone@sha.state.md.us |
| SAJID AFTAB | FHWA | Maj Projects | Sajid.Aftab@dot.g |
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