US Army Corps of Engineers®

Middle Brazos System Assessment – Phase 2 Aquilla Project Cost and Schedule Risk Analysis Report Appendix E

Prepared for:

U.S. Army Corps of Engineers, Ft. Worth District

Prepared by:

U.S. Army Corps of Engineers Ft. Worth District with

Walla Walla Cost Engineering MCX

June 23, 2017

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EXECUTIVE SUMMARY

The US Army Corps of Engineers (USACE), Ft. Worth District, presents this cost and schedule risk analysis (CSRA) report regarding the risk findings and recommended contingencies for the Middle Brazos System Assessment – Phase 2 Aquilla Feasibility Report. In compliance with Engineer Regulation (ER) 1110-2-1302 CIVIL WORKS COST ENGINEERING, dated September 15, 2008, a formal risk analysis, *Monte-Carlo* based-study was conducted by the Project Development Team (PDT) on remaining costs. The purpose of this risk analysis study is to present the cost and schedule risks considered, those determined and respective project contingencies at a recommended 80% confidence level of successful execution to project completion.

Specific to the Phase 2 Aquilla project, the best case project cost for the Tentatively Selected Plan is estimated at approximately $10.1 Million. Based on the results of the analysis, the Cost Engineering Mandatory Center of Expertise for Civil Works (Walla Walla District) recommends a contingency value of $2.3 Million, or 30.1%. This contingency includes $2. Million (25.7%) for risks related to cost and $370 Thousand (4.4%) for the effect of schedule delay on overall project costs.

Walla Walla Cost MCX performed risk analysis using the *Monte Carlo* technique, producing the aforementioned contingencies and identifying key risk drivers.

The following table ES-1 portray the development of contingencies (30.1% overall). The contingency is based on an 80% confidence level, as per USACE Civil Works guidance.

Table ES-1. Contingency Analysis Table

Base Cost Estimate	**$7,800,000**	
	Value ($$)	**Contingency (%)**
5%	$8,700,000	11.1%
50%	$9,600,000	23.1%
80%	**$10,100,000**	**30.1 %**
95%	$10,600,000	36.6%

KEY FINDINGS/OBSERVATIONS RECOMMENDATIONS

Cost Risks: From the CSRA, the key or greater Cost Risk items include:

- CA-2 (Undefined acquisition plan) – There is no detailed acquisition plan, which could affect cost, depending on funding and procurement method.
- PR-3 (Market Conditions /Bidding Climate/) - bidding climate in the area may be at a premium due to the number of contracts that are planned for execution in the area during this time.

- CA-1 (Multiple Separate Contracts) - The assumption is this project could be broken out into 2-4 contracts. If there ends up being more contracts the project cost and schedule would be impacted.
- RE-1 (Mitigation Uncertainty) – Based on the current assumptions and what is known about the project area it is assumed the mitigation costs shown are adequate, but if in-stream mitigation is required it could increase the costs.

Schedule Risks: The high value of schedule risk indicates a significant uncertainty of key risk items, time duration growth that can translate into added costs. Over time, risks increase on those out-year contracts where there is greater potential for change in new scope requirements, uncertain market conditions, and unexpected high inflation. The greatest risks are:

- PR-2 (Opposition regarding mitigation) - Various local groups or special interests may take exception to the plans for mitigation leading to have to use actual mitigation rather than banking credits, if it is then cost and schedule will be strongly affected.
- PPM-1 – Project Scope is Incomplete – Where the purpose has been defined the project features are conceptual and not fully designed. This affects the project details and quantities.
- TL-1 (Dam Safety Conditions and Use Limitations) - There is need for more detailed evaluation of H&H to ensure reduction in flood control storage, potential for overtopping and to ensure the DSAC rating is where it needs to be. Changes to plan implementation could affect cost and schedule.
- CA-1 (Multiple Separate Contracts) – There could be multiple contracts for the various pieces of the project such as the mitigation, recreation and floodwall and levee. It could affect the schedule by either lengthening or shortening the duration.

Recommendations: As detailed within the main report, include the implementation of cost and schedule contingencies, further iterative study of risks throughout the project life-cycle, potential mitigation throughout the PED phase, and proactive monitoring and control of risk identified in this study.

MAIN
REPORT

1.0 PURPOSE

Under the auspices of the US Army Corps of Engineers (USACE), Ft. Worth District, this report presents a recommendation for the total project cost and schedule contingencies for the Dallas Floodway IDP/FRM Inlet Navigation Pilot Study Project.

2.0 BACKGROUND

The Middle Brazos System Assessment – Phase 2 Aquilla project is comprised of relocations, mitigation, levees and floodways and recreation components. The goal is to provide an economical flood control project that can protect property located at Aquilla Lake. The objectives include (1) raising the pool and increasing water storage. (2) Determine recreation components affected by the pool rise and relocate and replace affected items to current conditions. Cost estimating activities support this by providing deliverables required to prepare life cycle project cost estimates needed to support the Integrated Interim Feasibility Report and Environmental Assessment, and to prepare the baseline project cost estimate.

As a part of this effort, Ft. Worth District requested that the USACE Cost Engineering Mandatory Center of Expertise for Civil Works (Cost Engineering MCX) provide an agency technical review (ATR) of the cost estimate and schedule for Recommended Project Plan. That tasking also included providing a risk analysis study to establish the resulting contingencies.

3.1 REPORT SCOPE

The scope of the risk analysis report is to calculate and present the cost and schedule contingencies at the 80 percent confidence level using the risk analysis processes, as mandated by U.S. Army Corps of Engineers (USACE) Engineer Regulation (ER) 1110- 2-1150, Engineering and Design for Civil Works, ER 1110-2-1302, Civil Works Cost Engineering, and Engineer Technical Letter 1110-2-573, Construction Cost Estimating Guide for Civil Works. The report presents the contingency results for cost risks for all project features. The study and presentation does not include consideration for life cycle costs.

3.2 Project Scope

The formal process included extensive involvement of the PDT for risk identification and the development of the risk register. The analysis process evaluated the base case Micro Computer Aided Cost Estimating System (MCACES) cost estimate, schedule, and funding profiles using Crystal Ball software to conduct a *Monte Carlo* simulation and statistical sensitivity analysis, per the guidance in Engineer Technical Letter (ETL) CONSTRUCTION COST ESTIMATING GUIDE FOR CIVIL WORKS, dated September 30, 2008.

The project technical scope, estimates and schedules were developed and presented by the Ft. Worth District. Consequently, these documents serve as the basis for the risk analysis.

The scope of this study addresses the identification of problems, needs, opportunities and potential solutions that are viable from an economic, environmental, and engineering viewpoint.

3.3 USACE Risk Analysis Process

The risk analysis process for this study follows the USACE Headquarters requirements as well as the guidance provided by the Cost Engineering MCX. The risk analysis process reflected within this report uses probabilistic cost and schedule risk analysis methods within the framework of the Crystal Ball software. Furthermore, the scope of the report includes the identification and communication of important steps, logic, key assumptions, limitations, and decisions to help ensure that risk analysis results can be appropriately interpreted.

Risk analysis results are also intended to provide project leadership with contingency information for scheduling, budgeting, and project control purposes, as well as to provide tools to support decision making and risk management as the project progresses through planning and implementation. To fully recognize its benefits, cost and schedule risk analysis should be considered as an ongoing process conducted concurrent to, and iteratively with, other important project processes such as scope and execution plan development, resource planning, procurement planning, cost estimating, budgeting and scheduling.

In addition to broadly defined risk analysis standards and recommended practices, this risk analysis was performed to meet the requirements and recommendations of the following documents and sources:

- Cost and Schedule Risk Analysis Process guidance prepared by the USACE Cost Engineering MCX.

- Engineer Regulation (ER) 1110-2-1302 CIVIL WORKS COST ENGINEERING, dated September 15, 2008.
- Engineer Technical Letter (ETL) CONSTRUCTION COST ESTIMATING GUIDE FOR CIVIL WORKS, dated September 30, 2008.

4.1 METHODOLOGY / PROCESS

The Walla Walla Cost Engineering MCX performed the Cost and Schedule Risk Analysis, relying on local Ft. Worth District staff to provide information gathering. The Walla Walla Cost Engineering MCX facilitated an on-site risk identification meeting on May 1, 2013 with the Ft. Worth District PDT to produce a risk register that served as the framework for the risk analysis. Participants in risk identification meeting included the following:

Name	Organization
Ninfa Taggart	SWF-EC
Glenn Matlock	NWW-EC-C
Kathy Gately	SWF-PM-C
Norm Lewis	SWF-PEC-PE
Nancy Parrish	SWF-PEC-PF

The first cost risk model was completed June 05, 2014. However, scope and estimate updates since then. Also, a PDT sanity check review necessitated a rerun of the original model. The final results were reported to Ft. Worth on July 14, 2014 to account for changes in cost and mitigation.

The risk analysis process for this study is intended to determine the probability of various cost outcomes and quantify the required contingency needed in the cost estimate to achieve the desired level of cost confidence. Per regulation and guidance, the P80 confidence level (80% confidence level) is the normal and accepted cost confidence level. District Management has the prerogative to select different confidence levels, pending approval from Headquarters, USACE.

In simple terms, contingency is an amount added to an estimate to allow for items, conditions or events for which the occurrence or impact is uncertain and that experience suggests will likely result in additional costs being incurred or additional time being required. The amount of contingency included in project control plans depends, at least in part, on the project leadership's willingness to accept risk of project overruns. The less risk that project leadership is willing to accept the more contingency should be applied in the project control plans. The risk of overrun is expressed, in a probabilistic context, using confidence levels.

The Cost MCX guidance for cost and schedule risk analysis generally focuses on the 80-percent level of confidence (P80) for cost contingency calculation. It should be noted that use of P80 as a decision criteria is a risk averse approach (whereas the use of P50 would be a risk neutral approach, and use of levels less than 50 percent would be risk seeking). Thus, a P80 confidence level results in greater contingency as compared to a P50 confidence level. The selection of contingency at a particular confidence level is ultimately the decision and responsibility of the project's District and/or Division management.

The risk analysis process uses *Monte Carlo* techniques to determine probabilities and contingency. The *Monte Carlo* techniques are facilitated computationally by a commercially available risk analysis software package (Crystal Ball) that is an add-in to Microsoft Excel. Cost estimates are packaged into an Excel format and used directly for cost risk analysis purposes. The level of detail recreated in the Excel-format schedule is sufficient for risk analysis purposes that reflect the established risk register, but generally less than that of the native format.

The primary steps, in functional terms, of the risk analysis process are described in the following subsections. Risk analysis results are provided in Section 6.

4.2 Identify and Assess Risk Factors

Identifying the risk factors via the PDT is considered a qualitative process that results in establishing a risk register that serves as the document for the quantitative study using the Crystal Ball risk software. Risk factors are events and conditions that may influence or drive uncertainty in project performance. They may be inherent characteristics or conditions of the project or external influences, events, or conditions such as weather or economic conditions. Risk factors may have either favorable or unfavorable impacts on project cost and schedule.

A formal PDT meeting was held with the Ft. Worth District office for the purposes of identifying and assessing risk factors. The meeting included capable and qualified representatives from multiple project team disciplines and functions, including project management, cost engineering, design, environmental compliance, and real estate.

The initial formal meetings focused primarily on risk factor identification using brainstorming techniques, but also included some facilitated discussions based on risk factors common to projects of similar scope and geographic location. Subsequent meetings focused primarily on risk factor assessment and quantification.

Additionally, numerous conference calls and informal meetings were conducted throughout the risk analysis process on an as-needed basis to further facilitate risk factor identification, market analysis, and risk assessment.

4.3 Quantify Risk Factor Impacts

The quantitative impacts of risk factors on project plans were analyzed using a combination of professional judgment, empirical data and analytical techniques. Risk factor impacts were quantified using probability distributions (density functions) because risk factors are entered into the Crystal Ball software in the form of probability density functions.

Similar to the identification and assessment process, risk factor quantification involved multiple project team disciplines and functions. However, the quantification process relied more extensively on collaboration between cost engineering and risk analysis team members with lesser inputs from other functions and disciplines. This process used an iterative approach to estimate the following elements of each risk factor:

- Maximum possible value for the risk factor
- Minimum possible value for the risk factor
- Most likely value (the statistical mode), if applicable
- Nature of the probability density function used to approximate risk factor uncertainty
- Mathematical correlations between risk factors
- Affected cost estimate and schedule elements

The resulting product from the PDT discussions is captured within a risk register as presented in section 6 for both cost and schedule risk concerns. Note that the risk register records the PDT's risk concerns, discussions related to those concerns, and potential impacts to the current cost and schedule estimates. The concerns and discussions support the team's decisions related to event likelihood, impact, and the resulting risk levels for each risk event.

4.4 Analyze Cost Estimate and Schedule Contingency

Contingency is analyzed using the Crystal Ball software, an add-in to the Microsoft Excel format of the cost estimate and schedule. *Monte Carlo* simulations are performed by applying the risk factors (quantified as probability density functions) to the appropriate estimated cost and schedule elements identified by the PDT. Contingencies are calculated by applying only the moderate and high level risks identified for each option (i.e., low-level risks are typically not considered, but remain within the risk register to serve historical purposes as well as support follow-on risk studies as the project and risks evolve).

For the cost estimate, the contingency is calculated as the difference between the P80 cost forecast and the baseline cost estimate. Each option-specific contingency is then allocated on a civil works feature level based on the dollar-weighted relative risk of each feature as quantified by *Monte Carlo* simulation. Standard deviation is used as the feature-specific measure of risk for contingency allocation purposes. This approach results in a relatively larger portion of all the project feature cost contingency being allocated to features with relatively higher estimated cost uncertainty.

5.0 PROJECT ASSUMPTIONS

The following data sources and assumptions were used in quantifying the costs associated with the Phase 2 – Aquilla project.

a. The Ft. Worth District provided MII MCACES (Micro-Computer Aided Cost Estimating Software) files electronically. The MII and CWE files transmitted and downloaded on July 05, 2014 was the basis for the updated cost and schedule risk analyses.
b. The cost comparisons and risk analyses performed and reflected within this report are based on design scope and estimates that are at the feasibility level.
c. Schedules are analyzed for impact to the project cost in terms of both uncaptured escalation (variance from OMB factors and the local market) and unavoidable fixed contract costs and/or languishing federal administration costs incurred throughout delay. Specific to the Dallas Floodway IDP/FRM project, the schedule was analyzed only for impacts due to residual fixed costs.
d. Per the CWCCIS Historical State Adjustment Factors in EM 1110-2-1304, State Adjustment Factor for the State of Texas is 0.87, meaning that the average inflation for the project area is assumed to be 13% lower than the national average for inflation. Therefore, it is assumed that the project inflations experienced are similar (or better) to OMB inflation factors for future construction. Thus, the risk analyses accounted for no escalation over and above the national average.
e. Per the data in the estimate, the Overhead percentage for the Prime Contractor is 23%, and 15-16% for the Subcontractors. Thus, the assumed residual fixed cost rate for this project is 18%. For the P80 schedule, this comprises approximately 28.24% of the total contingency and 3.37% of the base cost estimate. This is due to the accrual of residual fixed costs associated with delay associated with the implementation schedule.

f. The Cost MCX guidance generally focuses on the eighty-percent level of confidence (P80) for cost contingency calculation. For this risk analysis, the eighty-percent level of confidence (P80) was used. It should be noted that the use of P80 as a decision criteria is a moderately risk averse approach, generally resulting in higher cost contingencies. However, the P80 level of confidence also assumes a small degree of risk that the recommended contingencies may be inadequate to capture actual project costs.
g. Only high and moderate risk level impacts, as identified in the risk register, were considered for the purposes of calculating cost contingency. Low level risk impacts should be maintained in project management documentation, and reviewed at each project milestone to determine if they should be placed on the risk "watch list".

6.1 RESULTS

The cost and schedule risk analysis results are provided in the following sections. In addition to contingency calculation results, sensitivity analyses are presented to provide decision makers with an understanding of variability and the key contributors to the cause of this variability.

6.2 Risk Register

A risk register is a tool commonly used in project planning and risk analysis. The actual risk register is provided in Appendix A. The complete risk register includes low level risks, as well as additional information regarding the nature and impacts of each risk.

It is important to note that a risk register can be an effective tool for managing identified risks throughout the project life cycle. As such, it is generally recommended that risk registers be updated as the designs, cost estimates, and schedule are further refined, especially on large projects with extended schedules. Recommended uses of the risk register going forward include:

- Documenting risk mitigation strategies being pursued in response to the identified risks and their assessment in terms of probability and impact.
- Providing project sponsors, stakeholders, and leadership/management with a documented framework from which risk status can be reported in the context of project controls.
- Communicating risk management issues.
- Providing a mechanism for eliciting feedback and project control input.
- Identifying risk transfer, elimination, or mitigation actions required for implementation of risk management plans.

6.3 Cost Contingency and Sensitivity Analysis

The result of risk or uncertainty analysis is quantification of the cumulative impact of all analyzed risks or uncertainties as compared to probability of occurrence. These results, as applied to the analysis herein, depict the overall project cost at intervals of confidence (probability).

Table 1 provides the construction cost contingencies calculated for the P80 confidence level and rounded to the nearest thousand. The construction cost contingencies for the P50 and P100 confidence levels are also provided for illustrative purposes only.

Contingency was quantified as approximately $2.1 Million at the P80 confidence level (25.6% of the baseline cost estimate). For comparison, the cost contingency at the P50 and P100 confidence levels was quantified as 19.8% and 44.3% of the baseline cost estimate, respectively.

Table 1. Construction Cost Contingency Summary

Base Case Construction Cost Estimate	**$7,800,000**	
Confidence Level	**Construction Value ($$)**	**Contingency (%)**
5%	$8,500,000	9.7%
50%	$9,300,000	19.8%
80%	**$9,800,000**	**25.74%**
90%	$10,100,000	28.98%

6.2.1 Sensitivity Analysis

Sensitivity analysis generally ranks the relative impact of each risk/opportunity as a percentage of total cost uncertainty. The Crystal Ball software uses a statistical measure (contribution to variance) that approximates the impact of each risk/opportunity contributing to variability of cost outcomes during *Monte Carlo* simulation.

Key cost drivers identified in the sensitivity analysis can be used to support development of a risk management plan that will facilitate control of risk factors and their potential impacts throughout the project lifecycle. Together with the risk register, sensitivity analysis results can also be used to support development of strategies to eliminate, mitigate, accept or transfer key risks.

6.2.2 Sensitivity Analysis Results

The risks/opportunities considered as key or primary cost drivers are ranked in order of importance in contribution to variance bar charts. Opportunities that have a potential to reduce project cost and are shown with a negative sign; risks are shown with a positive sign to reflect the potential to increase project cost. A longer bar in the sensitivity analysis chart represents a greater potential impact to project cost.

Figure 1 presents a sensitivity analysis for cost growth risk from the high level cost risks identified in the risk register. Likewise, Figure 2 presents a sensitivity analysis for schedule growth risk from the high level schedule risks identified in the risk register.

6.3 Schedule and Contingency Risk Analysis

Table 2 provides the schedule duration contingencies calculated for the P80 confidence level. The schedule duration contingencies for the P50 and P100 confidence levels are also provided for illustrative purposes.

Schedule duration contingency was quantified as 18 months based on the P80 level of confidence. These contingencies were used to calculate the projected residual fixed cost impact of project delays that are included in the Table 1 presentation of total cost contingency. The schedule contingencies were calculated by applying the high level schedule risks identified in the risk register for each option to the durations of critical path and near critical path tasks.

The schedule was not resource loaded and contained open-ended tasks and non-zero lags (gaps in the logic between tasks) that limit the overall utility of the schedule risk analysis. These issues should be considered as limitations in the utility of the schedule contingency data presented. Schedule contingency impacts presented in this analysis are based solely on projected residual fixed costs.

Figure 1. Cost Sensitivity Analysis

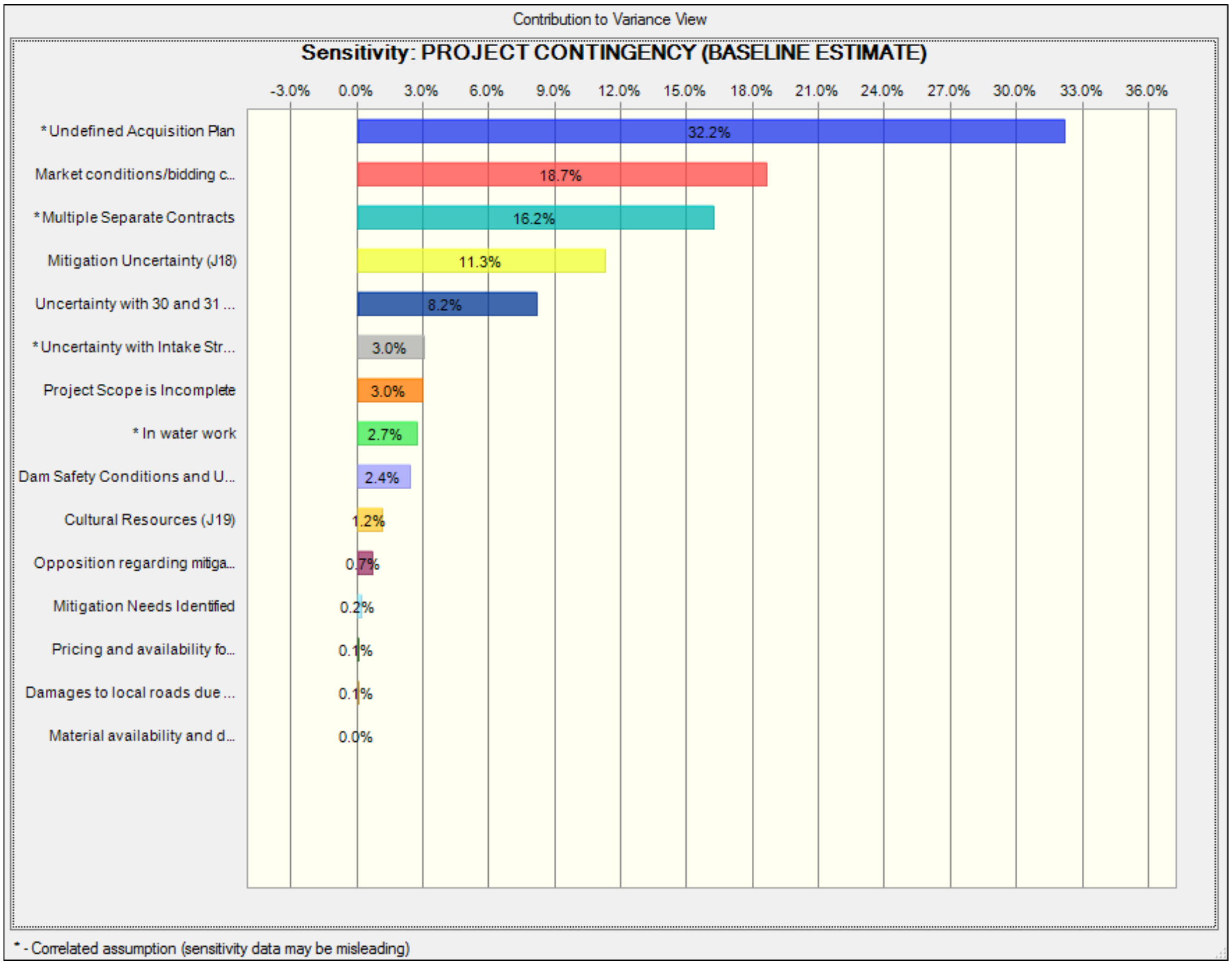
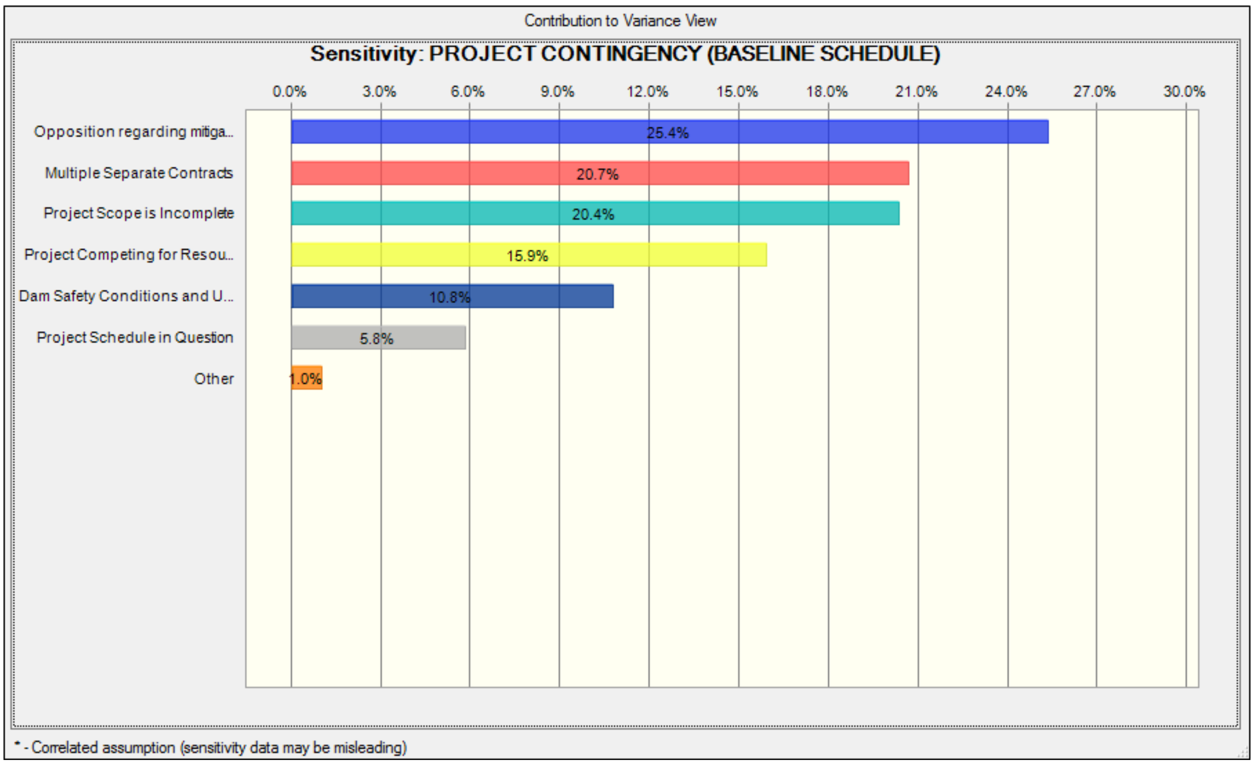


Table 2. Schedule Duration Contingency Summary

Risk Analysis Forecast	Baseline Schedule Duration (months)	Contingency[1] (months)
50% Confidence Level		
Project Duration	35	13
80% Confidence Level		
Project Duration	35	17
100% Confidence Level		
Project Duration	35	31

Figure 2. Schedule Sensitivity Analysis



7.1 MAJOR FINDINGS/OBSERVATIONS/RECOMMENDATIONS

This section provides a summary of significant risk analysis results that are identified in the preceding sections of the report. Risk analysis results are intended to provide project leadership with contingency information for scheduling, budgeting, and project control purposes, as well as to provide tools to support decision making and risk management as projects progress through planning and implementation. Because of the potential for use of risk analysis results for such diverse purposes, this section also reiterates and highlights important steps, logic, key assumptions, limitations, and decisions to help ensure that the risk analysis results are appropriately interpreted.

7.2 Major Findings/Observations

Project cost comparison summaries are provided in Table 3. Additional major findings and observations of the risk analysis are listed below.

Cost Risks: From the CSRA, the key or greater Cost Risk items of include:

- CA-2 (Undefined acquisition plan) – There is no detailed acquisition plan, which could affect cost, depending on funding and procurement method.
- PR-3 (Market Conditions /Bidding Climate/) - bidding climate in the area may be at a premium due to the number of contracts that are planned for execution in the area during this time.
- CA-1 (Multiple Separate Contracts) - The assumption is this project could be broken out into 2-4 contracts. If there ends up being more contracts the project cost and schedule would be impacted.
- RE-1 (Mitigation Uncertainty) – Based on the current assumptions and what is known about the project area it is assumed the mitigation costs shown are adequate, but if in-stream mitigation is required it could increase the costs.

Schedule Risks: The high value of schedule risk indicates a significant uncertainty of key risk items, time duration growth that can translate into added costs. Over time, risks increase on those out-year contracts where there is greater potential for change in new scope requirements, uncertain market conditions, and unexpected high inflation. The greatest risk is:

- PR-2 (Opposition regarding mitigation) - Various local groups or special interests may take exception to the plans for mitigation leading to have to use actual mitigation rather than banking credits, if it is then cost and schedule will be strongly affected.

- PPM-1 – Project Scope is Incomplete – Where the purpose has been defined the project features are conceptual and not fully designed. This affects the project details and quantities.

- TL-1 (Dam Safety Conditions and Use Limitations) - There is need for more detailed evaluation of H&H to ensure reduction in flood control storage, potential for overtopping and to ensure the DSAC rating is where it needs to be. Changes to plan implementation could affect cost and schedule.
- CA-1 (Multiple Separate Contracts) – There could be multiple contracts for the various pieces of the project such as the mitigation, recreation and floodwall and levee. It could affect the schedule by either lengthening or shortening the duration.

Table 3. Construction Cost Comparison Summary (Uncertainty Analysis)

Most Likely Cost Estimate	**$7,800,000**		
Confidence Level	**Project Cost**	**Contingency**	**Contingency %**
0%	**$8,045,208**	**$251,376.02**	**3.23%**
5%	**$8,548,668**	**$754,835.69**	**9.69%**
10%	**$8,728,760**	**$934,927.79**	**12.00%**
15%	**$8,848,721**	**$1,054,889.21**	**13.53%**
20%	**$8,935,692**	**$1,141,860.01**	**14.65%**
25%	**$9,027,358**	**$1,233,526.01**	**15.83%**
30%	**$9,089,646**	**$1,295,814.09**	**16.63%**
35%	**$9,166,123**	**$1,372,291.05**	**17.61%**
40%	**$9,227,301**	**$1,433,469.10**	**18.39%**
45%	**$9,274,780**	**$1,480,947.78**	**19.00%**
50%	**$9,336,798**	**$1,542,966.12**	**19.80%**
55%	**$9,420,878**	**$1,627,045.29**	**20.88%**
60%	**$9,493,008**	**$1,699,175.39**	**21.80%**
65%	**$9,569,102**	**$1,775,270.07**	**22.78%**
70%	**$9,629,139**	**$1,835,306.52**	**23.55%**
75%	**$9,714,291**	**$1,920,458.97**	**24.64%**
80%	**$9,800,157**	**$2,006,324.56**	**25.74%**
85%	**$9,889,689**	**$2,095,856.40**	**26.89%**
90%	**$10,052,141**	**$2,258,308.72**	**28.98%**
95%	**$10,227,112**	**$2,433,280.08**	**31.22%**
100%	**$11,106,433**	**$3,312,601.12**	**42.50%**

Table 4. Construction Schedule Comparison Summary (Uncertainty Analysis)

Most Likely Schedule Duration	35.0 Months		
Confidence Level	**Project Duration**	**Contingency**	**Contingency %**
0%	**36.0 Months**	**1.0 Months**	**2.98%**
5%	**40.7 Months**	**5.7 Months**	**16.22%**
10%	**42.1 Months**	**7.2 Months**	**20.46%**
15%	**43.1 Months**	**8.2 Months**	**23.35%**
20%	**44.1 Months**	**9.1 Months**	**26.07%**
25%	**44.9 Months**	**9.9 Months**	**28.32%**
30%	**45.5 Months**	**10.6 Months**	**30.21%**
35%	**46.3 Months**	**11.3 Months**	**32.34%**
40%	**46.9 Months**	**11.9 Months**	**34.14%**
45%	**47.5 Months**	**12.5 Months**	**35.74%**
50%	**48.0 Months**	**13.0 Months**	**37.13%**
55%	**48.5 Months**	**13.5 Months**	**38.73%**
60%	**49.1 Months**	**14.1 Months**	**40.27%**
65%	**49.8 Months**	**14.8 Months**	**42.31%**
70%	**50.4 Months**	**15.5 Months**	**44.20%**
75%	**51.2 Months**	**16.3 Months**	**46.49%**
80%	**51.9 Months**	**17.0 Months**	**48.50%**
85%	**53.1 Months**	**18.1 Months**	**51.87%**
90%	**54.1 Months**	**19.1 Months**	**54.71%**
95%	**55.9 Months**	**20.9 Months**	**59.76%**
100%	**66.4 Months**	**31.4 Months**	**89.88%**

7.3 Recommendations

Risk Management is an all-encompassing, iterative, and life-cycle process of project management. The Project Management Institute's (PMI) *A Guide to the Project Management Body of Knowledge (PMBOK® Guide), 4th edition,* states that "project risk management includes the processes concerned with conducting risk management planning, identification, analysis, responses, and monitoring and control on a project." Risk identification and analysis are processes within the knowledge area of risk management. Its outputs pertinent to this effort include the risk register, risk quantification (risk analysis model), contingency report, and the sensitivity analysis.

The intended use of these outputs is implementation by the project leadership with respect to risk responses (such as mitigation) and risk monitoring and control. In short, the effectiveness of the project risk management effort requires that the proactive management of risks not conclude with the study completed in this report.

The Cost and Schedule Risk Analysis (CSRA) produced by the PDT identifies issues that require the development of subsequent risk response and mitigation plans. This section provides a list of recommendations for continued management of the risks identified and analyzed in this study. Note that this list is not all inclusive and should not substitute a formal risk management and response plan.

Risk Drivers:

1. Cost Risk: The project does not have a developed acquisition plan and the estimate is based on one the assumption that it will be one contract, there could be multiple contracts before it is complete. The mitigation for the project has been developed and it was determined there would be no need for in-stream mitigation, if mitigation requirements change the cost will be affected. Pricing is based on previous costs in the area, if market conditions change from where they are currently it could change the project costs.

2. Schedule Risk: Incomplete project scope, opposition regarding mitigation, multiple separate contracts and possibility of a change in schedule could affect the project duration. The incomplete scope could lead to changes in the current assumptions during the design phase which could affect the project schedule. Multiple contracts could lead to multiple solicitations and phasing, especially regarding mitigation. The PDT will have to monitor these issues closely as the project moves forward to ensure the risks do not become issues that could hinder the progression.

3. Risk Management: Accurate representation of estimates and risks throughout the development of the in the project is critical, and the risk analysis study and technical review of said estimate is a critical mitigation strategy. Cost Engineering and ATR MCX recommends continuous, proactive, and timely updates to estimates in conjunction with proactive contract

placement and phasing planning and execution. It is recommended for the outputs created during the initial risk analysis effort serve as tools in future risk management processes. The risk register should be updated at each major project milestone and estimate update. The results of the sensitivity analysis may also be used for response planning strategy and development. These tools should be used in conjunction with regular risk review meetings. As an example, recommended uses of the risk register include:

- Documenting risk mitigation strategies being pursued in response to the identified risks and their assessment in terms of probability and impact.
- Providing project sponsors, stakeholders and leadership/management with a documented framework from which risk status can be reported in the context of project controls.
- Communicating risk management issues.
- Providing a mechanism for eliciting risk analysis feedback and project control input.
- Identifying risk transfer, elimination or mitigation actions required for implementation of risk management plans.

4. Risk Analysis Updates: Project leadership should review risk items identified in the original risk register and add others, as required, throughout the project life-cycle. Risks should be reviewed for status and reevaluation (using qualitative measure, at a minimum) and placed on risk management watch lists if any risk's likelihood or impact significantly increases. Project leadership should also be mindful of the potential for secondary (new risks created specifically by the response to an original risk) and residual risks (risks that remain and have unintended impact following response).

APPENDIX A

Risk No.	Risk/Opportunity Event	Concerns	PDT Discussions & Conclusions	Project Cost			Project Schedule		
				Likelihood*	Impact*	Risk Level*	Likelihood*	Impact*	Risk Level*
	Contract Risks (Internal Risk Items are those that are generated, caused, or controlled within the PDT's sphere of influence.)								
	PROJECT & PROGRAM MGMT								
PPM-1	Project Scope is Incomplete	The requirements and purpose have been defined, and the features are well-established. However, most of the project features are conceptual at this point. The exact characterization and details for the features are not fully defined.	For example, there is concern regarding the quantity calculations for riprap, rock, and other features. Some methods and activities are also not fully defined. This risk will impact the cost and schedule. However, these issues will be captured in specific detail through other risks.	Very Likely	Marginal	MODERATE	Likely	Significant	HIGH
PPM-2	Project Schedule in Question	There were estimates provided by others and there is not a detailed schedule that matches up with the estimate. The estimate provided by others has been developed in MII to help determine a likely schedule, however there are a couple of items where costs were based on historical data and does not provide a duration.	This will impact the overall project schedule slightly.	N/A	N/A	N/A	Likely	Marginal	MODERATE
PPM-3	Project Competing for Resources	The project is 100% non-federal funded. It is not competing for funding, but it may lose resources to other projects.	This could impact the engineering and design effort during PED.	N/A	N/A	N/A	Likely	Marginal	MODERATE
	CONTRACT ACQUISITION RISKS								
CA-1	Multiple Separate Contracts	There could be as many as 3-5 contracts to accomplish the project. The sponsor may accomplish the contracting.	Multiple contract actions would require multiple mobilizations, and varying indirect costs.	Likely	Marginal	MODERATE	Likely	Marginal	MODERATE
CA-2	Undefined Acquisition Plan	At present, there is not a detailed acquisition plan. There could be as many as 5 contracts (or even one single contract). The other factors are increments of funding as well as different procurement methods (IFB, IDIQ, 8(a), etc.). Another consideration is the requirements imposed by internal regulations within the Contracting community.	This could impact the ultimate contract costs.	Very Likely	Significant	HIGH	N/A	N/A	N/A
	TECHNICAL RISKS								
TL-1	Dam Safety Conditions and Use Limitations	Dam safety must be on the critical path of all decisions regarding water supply storage in USACE reservoirs. When water supply is requested by non-Federal customers, USACE decision makers at all levels must fully consider the condition of the dam, DSAC of the dam, associated risks, and their impacts on inspection, operation and maintenance of the project. Uncertainties exist regarding the hydraulic loading and potential impacts with respect to dam safety and flood storage.	Need for more detailed evaluation of; H&H to effective criteria, Reduction in flood control storage, potential for overtopping and potential consequences to support Periodic Assessment in 2016 as well as Independent technical review effort of Decision Document. Variable impacts to cost and schedule throughout all phases of the plan implementation with potential for storage restrictions to maintain structural integrity of dam throughout the life of the Federal Project.	Likely	Significant	HIGH	Likely	Significant	HIGH
	LANDS AND DAMAGES RISKS								
LD-1	County Bridge May Be Impacted	There may be some repairs and reinforcement necessary on the bridge.	The costs would be incidental to the construction.	Likely	Negligible	LOW	N/A	N/A	N/A
LD-2	Mitigation Needs Identified	There is no current plan for the land acquisition for the purposes of in-stream mitigation. The plan is currently to use banking credits for in-stream mitigation. If this is not possible, or a combination is required, real estate would need to be required.	If mitigation features are necessary, requiring real estate acquisition, it would significantly impact the costs.	Unlikely	Significant	MODERATE	N/A	N/A	N/A
	REGULATORY AND ENVIRONMENTAL RISKS								

Risk No.	Risk/Opportunity Event	Concerns	PDT Discussions & Conclusions	Project Cost Likelihood*	Project Cost Impact*	Project Cost Risk Level*	Project Schedule Likelihood*	Project Schedule Impact*	Project Schedule Risk Level*
	Contract Risks (Internal Risk Items are those that are generated, caused, or controlled within the PDT's sphere of influence.)								
RE-1	Mitigation Uncertainty	The extent of in-stream mitigation is uncertain. It is very volatile, as there is uncertainty as to whether or not it is required. The amount and availability of mitigation banking credits available will also greatly impact the costs associated with this risk.	This is a critical issue for the cost if something comes up during design, but additional information makes the estimated costs to be accurate. This is not seen as an issue for schedule.	Likely	Critical	HIGH	N/A	N/A	N/A
RE-2	Adaptive Management Features	There will be a requirement to do adaptive management. However, the extent and scope of the features are unknown. This is contingent upon whether or not banking credits are possible as well as the ultimate elevation.	The costs would likely be negligible.	Very Likely	Negligible	LOW	N/A	N/A	N/A
RE-3	Cultural Resources	There are 3 sites that require investigation. It is unknown if there are any measures (mitigation) required in relation to these sites. This is contingent upon whether or not the sites are determined to be "significant" sites.	If the sites are determined to be significant, it could introduce significant costs.	Likely	Significant	HIGH	Likely	Marginal	MODERATE
	CONSTRUCTION RISKS								
CON-1	Damages to local roads due to equipment traffic	Although the road is currently supporting farm machinery and trucks, increased traffic may produce damage that the County may seek reimbursement/repair.	If road repair or reimbursement is required, it could increase the costs of the project.	Likely	Marginal	MODERATE	N/A	N/A	N/A
CON-2	Material availability and delivery	The rural location of the lake will probably make the cost of riprap delivery higher due to transportation costs. The condition and suitability of roads may also force contractors to use less than efficient loading.	Transportation costs will increase the overall contract costs.	Likely	Negligible	LOW	N/A	N/A	N/A
CON-3	In water work	There will be in water work related to modification of the existing intake tower. This will also require expertise that may be in high demand.	There are no costs programmed for this issue to date. This is captured by EST-3 below.	Likely	Marginal	MODERATE	Unlikely	Negligible	LOW
CON-4	Consideration for Low and Unknown Internal/External Risk and Modifications	There is inherent risk in all projects that could contribute to cost and schedule variance due to unknowns or modifications that may arise during construction.	There is always the possibility for modifications and other unknowns to arise during the project, the biggest impact will be cost. Schedule could be affected but it will be a negligible impact.	Likely	Marginal	MODERATE	Likely	Negligible	LOW
	ESTIMATE AND SCHEDULE RISKS								
EST-1	Uncertainty with Source for Fill	The estimate currently assumes that fill will be comprised of material on site. However, if fill must be imported, it will impact cost.	Could impact costs.	Unlikely	Marginal	LOW	N/A	N/A	N/A
EST-2	Estimate Not Matching Likely Acquisition Scenario	The estimate currently assumes that the project will be accomplished under one contract. It seems likely that it will be at least 3 contracts, if not more.	This will impact the mobilization and indirect costs. This is already captured by Risks CA-1 and CA-2.	Very Likely	Significant	HIGH	Unlikely	Negligible	LOW
EST-3	Uncertainty with Intake Structure	There is uncertainty with the details for the intake structure. There is nothing in the estimate for the modifications to the intake structure. Will involve in water work (i.e. off of a boat).	The PDT had assumed that this was captured in the contingency. However, the CSRA has not been finalized to capture and include this cost.	Very Likely	Marginal	MODERATE	Unlikely	Marginal	LOW
EST-4	Uncertainty with 30 and 31 Account Costs	The estimate currently has 10% for the 30 account and 6% for the 31 account. Whereas the 30 account may be adequate, the 31 account was calculated assuming that a significant amount of the project cost was non-construction activity. However, there is no one in a field office proximate to the project site.	This may have a marginal impact on costs.	Likely	Marginal	MODERATE	N/A	N/A	N/A
	Programmatic Risks	(External Risk Items are those that are generated, caused, or controlled exclusively outside the PDT's sphere of influence.)							

Risk No.	Risk/Opportunity Event	Concerns	PDT Discussions & Conclusions	Project Cost			Project Schedule		
				Likelihood*	Impact*	Risk Level*	Likelihood*	Impact*	Risk Level*
	Contract Risks (Internal Risk Items are those that are generated, caused, or controlled within the PDT's sphere of influence.)								
PR-1	Severe Weather Impact	A major flood event require suspension of construction. It could also necessitate major rework, depending on timing.	A 25-year flood event could cause a substantial impact.	Unlikely	Marginal	LOW	Unlikely	Marginal	LOW
PR-2	Opposition regarding mitigation	Various local groups or special interests may take exception to the plans for mitigation, which may force the PDT to utilize actual mitigation features for in-stream mitigation rather than banking credits.	This is strongly correlated to the mitigation risks detailed elsewhere.	Likely	Marginal	MODERATE	Likely	Significant	HIGH
PR-3	Market conditions/bidding climate	There is uncertainty regarding the ultimate bidding climate and market conditions. Whereas economic conditions have produced more attractive pricing, there is a great deal of construction occurring in the region which may attract contractors and affect the pricing here.	Contractors who can perform the riprap requirements that the Corps has are also in a niche market. This may impact the ultimate contract costs.	Likely	Significant	HIGH	Unlikely	Negligible	LOW
PR-4	Pricing and availability for riprap material	There may be a variance in the ultimate cost of riprap and rock material.	Would not have a significant impact on costs.	Likely	Marginal	MODERATE	Unlikely	Negligible	LOW

*Likelihood, Impact, and Risk Level to be verified through market research and analysis (conducted by cost engineer).

1. Risk/Opportunity identified with reference to the Risk Identification Checklist and through deliberation and study of the PDT.
2. Discussions and Concerns elaborates on Risk/Opportunity Events and includes any assumptions or findings (should contain information pertinent to eventual study and analysis of event's impact to project).
3. Likelihood is a measure of the probability of the event occurring -- **Very Unlikely**, **Unlikely**, **Moderately Likely**, **Likely**, **Very Likely.** The likelihood of the event will be the same for both Cost and Schedule, regardless of impact.
4. Impact is a measure of the event's effect on project objectives with relation to scope, cost, and/or schedule -- **Negligible**, **Marginal**, **Significant**, **Critical**, or **Crisis.** Impacts on Project Cost may vary in severity from impacts on Project Schedule.
5. Risk Level is the resultant of Likelihood and Impact **Low**, **Moderate**, or **High**. Refer to the matrix located at top of page.
6. Variance Distribution refers to the behavior of the individual risk item with respect to its potential effects on Project Cost and Schedule. For example, an item with clearly defined parameters and a solid most likely scenario would probably follow a triangular or normal distribution. A risk item for which the PDT has little data or probability of modeling with respect to effects on cost or schedule (i.e. "anyone's guess") would probably follow a uniform or discrete uniform distribution.
7. The responsibility or POC is the entity responsible as the Subject Matter Expert (SME) for action, monitoring, or information on the PDT for the identified risk or opportunity.
8. Correlation recognizes those risk events that may be related to one another. Care should be given to ensure the risks are handled correctly without a "double counting."
9. Affected Project Component identifies the specific item of the project to which the risk directly or strongly correlates.
10. Project Implications identifies whether or not the risk item affects project cost, project schedule, or both. The PDT is responsible for conducting studies for both Project Cost and for Project Schedule.
11. Results of the risk identification process are studied and further developed by the Cost Engineer, then analyzed through the Monte Carlo Analysis Method for Cost (Contingency) and Schedule (Escalation) Growth.