ARKANSAS RIVER CORRIDOR

Appendix E: Cost Estimate

ARKANSAS RIVER CORRIDOR, TULSA COUNTY, OKLAHOMA

Introduction

The Arkansas River is a water resource serving numerous nationally significant purposes. The river has historically served as a nationally significant resource for aquatic and terrestrial habitat of the nation's wildlife that live, breed, and migrate through the Arkansas River ecosystem. This includes federally endangered Interior Least Tern (Least Tern, *Sterna antillarum*), a nationally significant resource, and one federally threatened bird species, the Piping Plover (*Charadrius melodus*) as well as a plethora of native species and migratory waterfowl that support a healthy and functional riverine ecosystem. Keystone Lake and its dam located along the Arkansas River play vital roles in supporting the continued provision for these species, as well as many other purposes. In particular, the lake and dam provide flood risk management benefits, contribute to the eleven reservoir system operation of the McClellan-Kerr Arkansas River Navigation System, provide clean and efficient power through the associated hydropower plant, and provide a source of water for municipal and industrial uses. However, construction, operation, and maintenance of the Keystone Dam, lake, associated hydropower operations and other multi-purposes have significantly degraded the riverine ecosystem structure, function, and dynamic processes below Keystone Dam on the Arkansas River within Tulsa County, Oklahoma.

Purpose

This study is in response to the Section 3132 authorization of the 2007 WRDA. The purpose of this study is to evaluate the aquatic ecosystem restoration components of the October 2005 Arkansas River Corridor Master Plan (ARC Master Plan) and determine if there is a Federal Interest that aligns with the Corps of Engineers' ecosystem restoration mission.

Study Authority

The Arkansas River Corridor study is authorized in the Water Resources Development Act (WRDA) of 2007, Section 3132.

Section 3132. Arkansas River Corridor.

(a) IN GENERAL. – The Secretary is authorized to participate in the ecosystem restoration, recreation, and flood damage reduction components of the Arkansas River Corridor Master Plan dated October 2005. The Secretary shall coordinate with appropriate representatives in the vicinity of Tulsa, Oklahoma, including representatives of Tulsa County and surrounding communities and the Indian Nations Council of Governments.

(b) AUTHORIZATION OF APPROPRIATIONS. – There is authorized to be appropriated $50,000,000 to carry out this section.

Non-Federal Sponsor

Tulsa County is the non-federal sponsor for the Arkansas River Corridor feasibility study. An amended feasibility cost-sharing agreement was executed in May 2015.

Recommended Plan

Alternative 5 is the National Ecosystem Restoration (NER) Plan and includes construction of a pool structure at River Mile 530 to regulate flow in the Arkansas River, a rock riffle feature associated wetland plantings at Prattville Creek, and construction of a sandbar island near Broken Arrow, OK. With the implementation of the NER plan, more natural river flow would return to 42 river miles of the Arkansas River within the study area. The NER plan would provide approximately 2,144 acres of additional riverine habitat, nearly doubling the amount of currently available habitat under low flow conditions. Also five acres of restored wetlands, and three acres of reliable sandbar island habitat where none currently succeed, would be restored as part of the NER plan. Shoreline, river, backwater, slackwater, wetland, and sandbar island habitat quality would all be improved generating an overall increase in the ecosystem quality and carrying capacity of the corridor. Current operation of Keystone Dam would not be changed. Additional water and flow would remain within the existing banks of the river and would not increase the flood elevation, nor downstream or backwater flooding.

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ARKANSAS RIVER CORRIDOR – TSP (ALT 5) COST ESTIMATE

1.1 General

1.1.1 Project Location and Description

The Arkansas River is a water resource serving numerous nationally significant purposes. The river has historically served as a nationally significant resource for aquatic and terrestrial habitat of the nation's wildlife that live, breed, and migrate through the Arkansas River ecosystem. This includes federally endangered Interior Least Tern (Least Tern, *Sterna antillarum*), a nationally significant resource, and two federally threatened bird species, the Piping Plover (*Charadrius melodus*) and the Red Knot (*Calidris canutus rufa*) as well as a plethora of native species and migratory waterfowl that support a healthy and functional riverine ecosystem. Keystone Lake and its dam located along the Arkansas River also play vital roles in supporting the continued provision of many of those multi-purposes. In particular, the lake and dam provide flood risk management benefits, contribute to the eleven reservoir system operation of the McClellan-Kerr Arkansas River Navigation System, provide clean and efficient power through the associated hydropower plant, and provide a source of water for municipal and industrial uses. However, construction, operation, and maintenance of the Keystone Dam, lake, associated hydropower operations and other multi-purposes have significantly degraded the riverine ecosystem structure, function, and dynamic processes below Keystone Dam on the Arkansas River within Tulsa County, Oklahoma.

1.2 Scope of Work

1.2.1 Construction

Construction on the corridor will occur at three different areas designated as Pool Control Structure, Least Tern Island, and Prattville Rock Riffle/Wetlands Plantings.

1.2.1.1 WBS 04 – Dams

Scope of work for the pool control structure includes the following:

- River Diversion
- Dewatering
- Common Excavation
- Rock Blasting & Removal
- Mass Concrete Placement
- Gate Installation
- Maintenance Building
- Grouted Riprap
- Maintenance Bridge

1.2.1.2 WBS 06 – Fish & Wildlife Facilities

The Least Tern Island is a 5 acre island with structure dimensions of 43' x 10' x 3' (front) and 56' x 10' x 3' (back). The selected site is located east of S. 145th E. Ave. and south of E. 131st St. S, approximately 35 river miles downstream of the pool control structure. 30" riprap is assumed for the front and back structures. The island will be formed naturally as material is trapped between the structures.

1.2.1.3 WBS 08 – Roads, Railroads, & Bridges

The bridge will be constructed on top of the pool control structure with concrete columns and girders. The bridge will provide access to the maintenance facility and provide fishing areas to the public.

1.2.1.4 WBS 19 – Buildings, Grounds, & Utilities

The maintenance building is assumed to be a pre-fabricated metal building, 20 foot x 40 foot dimensions. The building will house the operating equipment for the gates. It is assumed that the utility tie-ins will be within 2,500 feet of the building.

1.2.2 Non-Construction

1.2.2.1 WBS 01 – Lands and Damages

Real estate acquisition costs were provide by the real state members of the PDT. Real estate assigned a 20% contingency factor.

1.2.2.2 WBS 30 – Planning, Engineering & Design (PED)

The work covered under this account includes project management, project planning, preparation of plans & specifications, instrumentation, engineering during construction, contract acquisition costs, review costs, completion reports, financial closeout, and contingencies. PED costs were developed using the estimated construction cost multiplied by percentages developed in the Total Project Cost Summary (TPCS) spreadsheet. PED costs are estimated based on starting in June 2018.

1.2.2.3 WBS 31 – Supervision & Administration (S&A)

The work covered under this account includes contract supervision, contract administration, construction administration, technical management activities, project management, and District office supervision and administration costs. S&A cost was estimated based on using the estimated construction cost multiplied by percentages developed in the Total Project Cost Summary (TPCS) spreadsheet.

1.3 Major Assumptions

- Utilities for operating the gates will be within 2,500 feet from the maintenance building.
- The common excavation material can be used for the construction of the cofferdam.
- The blasted rock material will be disposed of off-site.
- Concrete will be supplied from local commercial plants.
- No cost included in estimate for damages/time delays due to overtopping of cofferdam. (covered in CSRA)
- One construction contract required to complete the work.
- Construction contract will not be small business set-aside.

- Contractor will work 5 day 10 hours per day work week.

1.4 Cost Estimate Development

The Cost Estimate supporting The Selected Plan (TSP) is prepared using the latest HQ approved Micro-Computer Aided Cost Estimating System (MCACES) MII software and the established Civil Works Work Breakdown Structure to the sub-feature level of detail in accordance of ER 1110-2-1308. The estimate uses the feature Accounts Codes 01 – Lands & Damages, 06 – Fish & Wildlife Facilities, 04 – Dams, 08 – Roads, Railroads & Bridges, 19 – Buildings, Grounds, & Utilities, 30 – PED, and 31 – Construction Management. Costs were primarily developed from detail while some were developed using alternate methodologies as appropriate.

1.4.1 Price Level

The TSP cost is priced at the October 2017 price level. Estimated costs have been determined as accurately as possible, in as much detail as can be assumed, and are based on the best available information. Estimated construction costs include costs which a prudent, well-equipped, and experienced contractor would reasonably expect to incur.

1.4.2 Detailed MII Cost Estimate

The MII estimating software was used to develop a construction sequence for each item of work and applying detailed line items and crews to perform the work. Crews were developed in correspondence with the work being performed and estimated productivities. Material prices were obtained through telephone solicitations with vendors, internet suppliers, and MII Unit Cost Book 2015. Summary and detailed MII cost reports can be found in Attachment 1: MII Estimate.

1.4.3 Equipment Rates

Equipment rates are from the 2016 Construction Ownership/Operation Expense Schedule for Region 6. Fuel prices are based on a five year average of the listed prices by the U.S. Energy Information Administration (www.eia.gov/oog/info/gdu/gasdiesel.asp, Midwest [PADD2] and the current State Motor Fuel Tax Rates. Equipment usage costs are affected by fuel rates and therefore should also be adjusted and noted in each document submittal as the project progresses to contract award.

1.4.4 Labor Rates

The labor rates are based on Wage Decisions OK170053 (Building), OK1700238 (Heavy), and OK170017 (Highway). The hourly labor rates also include an average fringe benefit rate that is customarily applied by contractors for this type of work. The labor burden percentage include costs for unemployment insurance, social security, taxes, etc.

1.4.5 Sales Tax

Sales tax at 8.52% was applied to materials for Tulsa County, OK.

1.4.6 Overtime

Overtime is anticipated and is included in the costs. Work is assumed to occur Monday – Friday 50 hr work weeks.

1.4.7 Quantities

Quantities were developed by CH2M Hill during the alternative evaluation. The PDT independently performed quantity verification checks on major cost drivers. Quantities were checked or verified and adjusted to account for construction methodology, shrink, swell, waste, etc. Notes within the MII estimate and attached calculations are provided for clarification.

1.4.8 Indirect Costs

1.4.8.1 Field Office Overhead (FOOH)

For Field Office Overhead (FOOH), represents the anticipated prime contractor's field overhead costs for such items as project supervision, contractor quality control, contractor field office supplies, personal protective equipment, field engineering, and other incidental field overhead costs. Detailed FOOH cost was developed for the anticipated contract duration.

1.4.8.2 Home Office Overhead (HOOH)

For Home Office Overhead (HOOH) expense, the cost estimate includes an allowance applied as a percentage of direct cost plus FOOH. HOOH includes items such as office rental/ownership costs, utilities, office equipment ownership/maintenance, office staff (managers, accountants, clerical, etc.), insurance, and miscellaneous. In reality, the range of home office overhead can be quite broad and depends largely on the contractor's annual volume of work and the type of work that is generally performed by the contractor. HOOH for the prime contractor on the main contracts was assumed to be 12%.

1.4.8.3 Profit

For the prime contractor profit was assumed to be 10.6% on self-performed work and to subcontract work. Profit was applied as a running percentage of direct cost plus FOOH and HOOH. For subcontractors, profit was based on estimator judgment and applied as a running percentage of direct costs plus subcontractor's overhead.

1.4.8.4 Bond

Bond rate of 0.66 was calculated as a running percentage of direct cost plus FOOH, HOOH, and profit. Additional bond was not included for subcontracted work and is assumed to be covered by the prime contractor's bond cost.

1.4.9 Owner Costs

1.4.9.1 Contingency

Contingency for both the cost and schedule was established at the 80% confidence level using a risk based Monte Carlo simulation. Contingency costs are not included in the MII cost estimate but are instead included in the TPCS spreadsheet. See Section 1.7 for additional details regarding risk-based contingency development.

1.4.9.2 Escalation

Escalation is calculated using EM 1110-2-1304, Table A-1, September 2017 CWCCIS Index. Escalation for WBS 04 (construction) is based on Pricing Level Date (1st quarter, FY 18) and estimated mid-point of construction. Escalation for WBS 30 - PED is based on Pricing Level Date (1st quarter, FY 18) to estimated mid-point of design. Escalation for WBS 31 – Construction Management is based on Pricing Level Date (1st quarter, FY 18) to estimated mid-point of construction. Escalated costs are not included in the MII cost estimate but are included in the TPCS spreadsheet.

1.5 Acquisition Strategy

Through discussions with the PDT, the contract is assumed not to be small business set-aside contract. The contract is assumed to use the “Lowest Price Technically Acceptable” acquisition method. To complete the project only one contract action is anticipated.

1.6 Schedule

The total project schedule includes time for design, design reviews, procurement process, construction, and financial close-out. The schedule is developed with the assumption that there will only be one design package and one construction contract required to complete the total project. Time is included for real estate acquisitions, geotechnical investigation, 65%, 95% and Final design submittals, corresponding design reviews, construction, and financial closeout of the project. Major project milestones schedule is provided in Table 1.

1.6.1 80% Confidence Contract Duration

Schedule risk analysis was performed using Monte-Carlo simulation within Oracle Crystal Ball risk modeling software. This schedule risk analysis resulted in a recommended 6.6 MO extension to the base schedule to achieve the 80% Confidence Period of Performance duration for the contract. The analysis included the identification and quantification of risk events that could impact the overall contract duration. Schedule risk modeling was limited to risks owned by the performing and prudent contractor and reasonable to occur.

1.6.2 Schedule Development

The total project duration is supported by a network analysis schedule (NAS) developed within Oracle Primavera P6. Assumptions were made for durations based on past projects with similar complexity of design and construction and using production rates within the MII estimate. A detailed activity total project schedule can be found in Attachment 2.

1.6.3 Work Calendars Defined

The total project schedule includes application of the different defined work calendars within Primavera P6 as summarized in Table 2. The 7 day/week, 24 hour/day calendar, ARC01, which does not include any non-work days is applied to purely time dependent activities such as submittal preparation and reviews, and contract actions. The five-day workweek calendar, ARC02, includes non-work days for federal holidays and is applied to design type and design review activities. The construction calendar, ARC04, assumes the contractor will be working 5-10 hour days and includes anticipated weather days Table 3.

A planting season calendar, ARC03, is used for the vegetation planting activities at the Prattville and Least Tern Island. The planting season calendar has non-work days blocked from November 1 thru March 15. The Feasibility Report states that a two year maintenance period will be required to ensure planting survival. The current project schedule assumes that the vegetation planting at Prattville and Least Tern Island will occur early in the overall construction sequence which will allow the two year maintenance period fall within the overall construction duration. If the contractor's planting activities fall outside of the planting periods, the Contracting Officer will determine the job substantially complete in order not to access liquidated damages to the contractor. The contractor will return to plant during the specified periods. This will be at no additional cost to the Government.

1.6.4 Real Estate

The real estate activities have not been divided into separate activities. Real estate provided the overall duration of 300 cal-days to complete all real estate acquisition activities. It is assumed in the project schedule that real estate will start upon receiving PED cost sharing agreement and will be completed prior to construction contract award.

1.6.5 Design Phase

The design phase follows the guidance as stated in ER 1110-2-1150. The total design duration includes activities for geotechnical investigations, 35%, 65%, 95%, final design phases, ATR reviews, VE study, constructability review, and BCOE review. The design completion dates include time for reviews and review resolution meetings. See Attachment 2, activity backup for details.

1.6.6 Procurement Process

The procurement process includes activities for pre-solicitation, solicitation period, evaluation of proposals, and award. Procurement activities prior to pre-solicitation are assumed to be conducted concurrently with the design phase. See Attachment 2, activity backup for details.

1.6.7 Construction Period

The construction duration presented for the pool control structure is based on data from projects with similar activities and complexity. Currently the assumption is that one contract will be awarded for the work on the pool control structure, Least Tern Island and Prattville rock riffle/wetlands planting. The island work is approximately 35 river miles downstream of the pool control structure. Due to the distance between the construction sites, the work at the Least Tern island site and Prattville rock riffle/wetlands planting can be performed concurrently with the pool control structure without any interference or extending the total project completion date. The construction schedule includes non-construction activities for preparation of submittals, submittal review times, long lead time for materials, and site mobilization/demobilization.

The current schedule assumes the following phasing for the pool control structure; Phase 1- site setup and installation of temporary porta-dam/cofferdam. Phase 2 - includes South half of structure and gate installation, maintenance building, and bridge columns. Phase 3 – port-dam/cofferdam removal and rebuild on second half of structure. Phase 4 – includes North half of structure, gate installation, and bridge columns. Phase 5 – includes pedestrian bridge girders, bridge deck, and removal of porta-dam/cofferdam. See Attachment 2, activity backup for details.

1.6.8 Financial Closeout

The financial closeout period includes time for completion of as-built drawings and the Government receiving the release of claims from the contractor. Current schedule assumes this period will require a one year duration after construction completion.

1.7 Cost & Schedule Risk Analysis

1.7.1 Purpose

See attachment 4.

1.8 Total Project Cost Summary

The Estimated Total Project Cost is $140,971,000 at the current price level (October 2017). The Total Project Cost figure includes escalation calculated per CWCCIS as required by ER 1110-2-1302 and ETL 1110-2-573.

Table 1. Key Project Milestones

Arkansas River Corridor Total Project Schedule

Beginning FY
2018

Alternative/Detail	Start	Finish	FY18	FY19	FY20	FY21	FY22	FY23	FY24	FY25	FY26
Alternative #5											
Planning, Engineering, & Design	18-Jun-18	20-Aug-20									
Real Estate Acquistions	18-Jun-18	14-Apr-19									
Procurement Process	29-Jun-20	5-Jan-21									
Construction	19-Jan-21	2-Jul-24									
Financial Closeout	2-Jul-24	27-Jun-25									

Table 2. Project Work Calendars

P6 Calendar	Work Schedule	Notes
ARC01 - 7x24 Workweek Calendar (Non-Labor)	7 days per week 24 hrs per day 12 months	Typically applies to milestones, solicitation periods, etc that are independent of work schedules, holidays, weather, etc. (cal-days)
ARC02 - Standard 5 Day USACE Labor Calendar	5 days per week 8 hrs per day 12 months	Typical calendar for USACE labor activities such as design, plans & specs, etc. Includes non-work for all Federal holidays.
ARC03 - Planting Season Calendar (Non-Labor)	5 days per week 8 hrs per day 7.5 months	Typically applies to vegetative planting season. Planting not permitted from November 1 - March 15.
ARC04 - Construction Calendar	5 days per week 10 hrs per day 12 months	Typically applies to construction activities. Calendar includes non-work days for anticipated normal weather events.

Table 3. Anticipated Adverse Weather Days by Month

JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
3	4	4	3	4	4	3	2	4	3	4	4

ATTACHMENT 1: MII ESTIMATE

Arkansas River Corridor - Total Project Cost
PURPOSE OF ESTIMATE: Estimate cost for planning as part of the Arkansas River Corridor Study
ACQUISITION PLAN: Lowest Price Technically Acceptable, Open
PRIME HOOH = 12%, PROFIT = 10.6%, BOND = 0.66%,. PRODUCTIVITY = 85%
SALES TAX = 8.52%,

CONSTRUCTION CONTINGENCY = TBD by CSRA
ESTIMATE TYPE: Class 4, Feasibility Study

Estimated by	T Jones (CH2M Hill)
Designed by	TBD
Prepared by	Timothy Batson 918-669-7050
Preparation Date	1/17/2018
Effective Date of Pricing	10/1/2017
Estimated Construction Time	986 Days

Description	Quantity	UOM	ContractCost	Escalation	Contingency	SIOH	ProjectCost	C/O
Project Cost Summary Report			**94,051,235**	**0**	**0**	**0**	**94,051,235**	
Arkansas River Corridor	**1.00**	**LS**	**94,051,235**	**0**	**0**	**0**	**94,051,235**	
WBS 01 - Lands & Damages	**1.00**	**LS**	**12,392,000**	**0**	**0**	**0**	**12,392,000**	
Real Estate (POOL CONTROL STRUCTURE)	**1.00**	**EA**	*12,392,000.00* **12,392,000**	**0**	**0**	**0**	*12,392,000.00* **12,392,000**	
WBS 02 - Relocations	**1.00**	**EA**	*155,731.66* **155,732**	**0**	**0**	**0**	*155,731.66* **155,732**	
Sewer Outfall Relocation	**3.00**	**EA**	*51,910.55* **155,732**	**0**	**0**	**0**	*51,910.55* **155,732**	
WBS 04 - DAMS	**1.00**	**LS**	**49,613,622**	**0**	**0**	**0**	**49,613,622**	
Low Water Dam	**1.00**	**EA**	*49,613,622.30* **49,613,622**	**0**	**0**	**0**	*49,613,622.30* **49,613,622**	
WBS 06 - Fish & Wildlife Facilities	**1.00**	**LS**	**1,957,651**	**0**	**0**	**0**	**1,957,651**	
Sand Bar Island	**1.00**	**JOB**	*790,650.61* **790,651**	**0**	**0**	**0**	*790,650.61* **790,651**	
Prattville Creek Rock Riffle + Wetland Plantings	**1.00**	**JOB**	*1,167,000.44* **1,167,000**	**0**	**0**	**0**	*1,167,000.44* **1,167,000**	
WBS 08 - Roads, Railroads & Bridges	**1.00**	**EA**	*4,997,855.20* **4,997,855**	**0**	**0**	**0**	*4,997,855.20* **4,997,855**	
Access Bridge	**1.00**	**EA**	*4,997,855.20* **4,997,855**	**0**	**0**	**0**	*4,997,855.20* **4,997,855**	
WBS 19 - Buildings, Grounds, & Utilities	**1.00**	**LS**	**134,875**	**0**	**0**	**0**	**134,875**	
Maintenance Building	**800.00**	**SF**	*168.59* **134,875**	**0**	**0**	**0**	*168.59* **134,875**	
WBS 30 - Planning, Engineering, & Design	**1.00**	**LS**	**17,345,000**	**0**	**0**	**0**	**17,345,000**	
Project Management	**1.00**	**LS**	**1,422,000**	**0**	**0**	**0**	**1,422,000**	
Planning & Environmental Compliance	**1.00**	**LS**	**569,000**	**0**	**0**	**0**	**569,000**	
Engineering & Design	**1.00**	**LS**	**8,529,000**	**0**	**0**	**0**	**8,529,000**	
Reviews, ATRs, IEPRs, VE	**1.00**	**LS**	**569,000**	**0**	**0**	**0**	**569,000**	
Life Cycle Updates (cost, schedule, risks)	**1.00**	**LS**	**569,000**	**0**	**0**	**0**	**569,000**	

Description	Quantity	UOM	ContractCost	Escalation	Contingency	SIOH	ProjectCost	C/O
Contracting & Reprographics	**1.00**	**LS**	**569,000**	**0**	**0**	**0**	**569,000**	
Engineering During Construction	**1.00**	**LS**	**1,706,000**	**0**	**0**	**0**	**1,706,000**	
Planning During Construction	**1.00**	**LS**	**1,137,000**	**0**	**0**	**0**	**1,137,000**	
Adaptive Management & Monitoring	**1.00**	**LS**	**1,706,000**	**0**	**0**	**0**	**1,706,000**	
Project Operations	**1.00**	**LS**	**569,000**	**0**	**0**	**0**	**569,000**	
WBS 31 - Construction Management	**1.00**	**LS**	**7,454,500**	**0**	**0**	**0**	**7,454,500**	
Construction Management	**1.00**	**LS**	**5,686,000**	**0**	**0**	**0**	**5,686,000**	
Project Operation	**1.00**	**LS**	**346,500**	**0**	**0**	**0**	**346,500**	
Project Management	**1.00**	**LS**	**1,422,000**	**0**	**0**	**0**	**1,422,000**	

Contractor Markups Report

[18-AR001a] Arkansas River Corridor - Total Project Cost

W:\Cost Engineering\FY18 Cost Estimates\Arkansas River\18-AR001a Arkansas River Corridor\Cost Estimates\Feasibility Report\ARC Feasibility Total Project Cost 02-02-2018.mlp

Prime

Markup	Desc	Own Work	Weight	Sub Work
JOOH (Small Tools) [Small Tools]		2.00%		0.00%
JOOH [JOOH]		3.91%		3.91%
HOOH [Running %]		12.00%		12.00%
Profit [Profit]		10.60%		10.60%
	Desc	**Value**	**Weight**	**Percentage**
	Risk	0.12	20	2.40%
	Difficulty	0.12	15	1.80%
	Size	0.03	15	0.45%
	Period	0.12	15	1.80%
	Invest (Contractor's)	0.12	5	0.60%
	Assist (Assistance by)	0.12	5	0.60%
	SubContracting	0.118	25	2.95%
		Total	100	10.60%
Bond [Bond]	Class B 24 mo.	0.66%		0.66%

Sub Contractor

Markup	Desc	Own Work	Weight	Sub Work
HOOH [Running %]		12.00%		12.00%
Profit [Profit]		10.60%		10.60%
	Desc	**Value**	**Weight**	**Percentage**
	Risk	0.12	20	2.40%
	Difficulty	0.12	15	1.80%
	Size	0.03	15	0.45%
	Period	0.12	15	1.80%
	Invest (Contractor's)	0.12	5	0.60%
	Assist (Assistance by)	0.12	5	0.60%
	SubContracting	0.118	25	2.95%
		Total	100	10.60%

Annual O&M Costs

Markup	Own Work	Sub Work

Design

Markup	Own Work	Sub Work

Real Estate

Markup	Own Work	Sub Work

ATTACHMENT 2: TOTAL PROJECT SCHEDULE
ACTIVITY DETAIL

TWR-01 Classic Schedule Report - Sort by ES

WBS Name / Activity ID	Activity Name	Original Duration	Start	Finish
35% Design Phase				
A1000	Receive PED Cost Sharing Agreement	0	18-Jun-18*	
A1030	Technical Review Conference	16	18-Jun-18	19-Jun-18
A1020	35% Design	516	20-Jun-18	20-Sep-18
A1010	Geotechnical Inestigation	1032	20-Sep-18	29-Mar-19
A1050	ATR Review	344	20-Sep-18	23-Nov-18
A1070	Answer ATR Comments	80	23-Nov-18	07-Dec-18
Subtotal		**1564**	**18-Jun-18**	**29-Mar-19**
65% Design Phase				
A1060	Start 65% Design	0	07-Dec-18	
A1130	Gate/Structural Design	1032	07-Dec-18	13-Jun-19
A1150	Site/Civil Design	688	07-Dec-18	12-Apr-19
A1090	Mass Concrete 65% Design	344	07-Dec-18	12-Feb-19
A1100	Cofferdam Design	344	07-Dec-18	12-Feb-19
A1110	Dewatering Design	344	07-Dec-18	12-Feb-19
A1120	Building Design	172	07-Dec-18	09-Jan-19
A1140	Electrical Design	40	07-Dec-18	14-Dec-18
A1080	Rock Anchor 65% Design	516	29-Mar-19	28-Jun-19
A1160	65% DQC Design	172	01-Jul-19	31-Jul-19
A1170	Incorporate DQC Comments	80	31-Jul-19	14-Aug-19
A1340	Constructability Review Mtg	40	31-Jul-19	07-Aug-19
A1180	65% ITR	344	14-Aug-19	16-Oct-19
A1040	VE Study	516	14-Aug-19	15-Nov-19
A1190	65% ITR Comment Resolution Meeting	40	16-Oct-19	23-Oct-19
Subtotal		**1892**	**07-Dec-18**	**15-Nov-19**
95% Design Phase				
A1200	95% Design Start	0	23-Oct-19	
A1250	Gate/Structural Design P&S	1032	23-Oct-19	28-Apr-20
A1270	Site/Civil Design P&S	1032	23-Oct-19	28-Apr-20
A1260	Electrical Design P&S	516	23-Oct-19	27-Jan-20
A1280	Rock Anchor Design P&S	516	23-Oct-19	27-Jan-20
A1210	Mass Concrete P&S	344	23-Oct-19	26-Dec-19
A1220	Cofferdam Design P&S	344	23-Oct-19	26-Dec-19
A1230	Dewatering Design P&S	344	23-Oct-19	26-Dec-19

TWR-01 Classic Schedule Report - Sort by ES

WBS Name				
Activity ID	**Activity Name**	**Original Duration**	**Start**	**Finish**
A1240	Building Design P&S	172	23-Oct-19	25-Nov-19
A1290	95% ATR Review	344	28-Apr-20	29-Jun-20
A1300	95% ATR Comment Resolution Meeting	40	29-Jun-20	07-Jul-20
Subtotal		**1416**	**23-Oct-19**	**07-Jul-20**
Construction Contract				
A1650	Prepare Cofferdam Submittal	1440	05-Jan-21	06-Mar-21
A1520	Pre-Construction Submittals	172	05-Jan-21	03-Feb-21
A1450	NTP	0	19-Jan-21	
A1620	Gov't Approval of Pre-Construction submittals	172	03-Feb-21	08-Mar-21
A1660	Gov't Approval - Cofferdam Submittal	720	06-Mar-21	05-Apr-21
A1940	Demob	80	06-Dec-23	20-Dec-23
A1480	Construction Complete	0		20-Dec-23
Subtotal		**6096**	**05-Jan-21**	**20-Dec-23**
Final Desgin				
A1350	Fianalize P&S	258	07-Jul-20	20-Aug-20
A1360	BCOE Review	172	07-Jul-20	05-Aug-20
A1370	P&S Completed	0		20-Aug-20
Subtotal		**258**	**07-Jul-20**	**20-Aug-20**
Financial Closeout				
A1540	Receive As-Builts	4320	20-Dec-23	17-Jun-24
A1550	Receive Release of Claims/Final Payment	4320	17-Jun-24	14-Dec-24
A1560	Project Complete	0		14-Dec-24
Subtotal		**8640**	**20-Dec-23**	**14-Dec-24**
Least Tern Island				
A1590	Survey	40	08-Mar-21	15-Mar-21
A1570	Construct Access Road/Staging Area	75	08-Mar-21	17-Mar-21
A1580	Place Stone	197	17-Mar-21	21-Apr-21
A1600	Restore Area/Final Acceptance	80	21-Apr-21	05-May-21
Subtotal		**338**	**08-Mar-21**	**05-May-21**
Maintenance Bldg				

TWR-01 Classic Schedule Report - Sort by ES

WBS Name / Activity ID	Activity Name	Original Duration	Start	Finish
A1510	Maintenance Bldg	645	26-Oct-21	15-Feb-22
A1950	Install Gate Operating Equipment	400	15-Feb-22	22-Apr-22
Subtotal		**1045**	**26-Oct-21**	**22-Apr-22**
Phase 1 - Site Setup Construct Temp. Cofferdam				
A1670	Mobilize/Setup Staging Area	172	02-Feb-21	04-Mar-21
A1680	Construct Access Roads	80	04-Mar-21	18-Mar-21
A1690	Construct Porta-dam	120	05-Apr-21	23-Apr-21
Subtotal		**456**	**02-Feb-21**	**23-Apr-21**
Phase 2 - South Half				
A1770	Procurement/Fabrication of Gates	4320	08-Mar-21	04-Sep-21
A1700	Common Excavation	80	23-Apr-21	11-May-21
A1710	Rock Blasting/hauling	415	11-May-21	21-Jul-21
A1720	Foundation Mapping	80	21-Jul-21	04-Aug-21
A1730	Dental Conc Placement	195	04-Aug-21	07-Sep-21
A1750	Mass Concrete Placement	287	07-Sep-21	25-Oct-21
A1740	Rock Bolts	240	04-Oct-21	10-Nov-21
A1760	Grouted Riprap	420	18-Oct-21	22-Dec-21
A1780	Gate Installation	260	26-Oct-21	07-Dec-21
A1790	Bridge Conc. Columns	318	30-Nov-21	21-Jan-22
A1960	Gate Testing	80	22-Apr-22	06-May-22
Subtotal		**2370**	**08-Mar-21**	**06-May-22**
Phase 3 - Remove/rebuild Temp. Cofferdam				
A1830	Remove Temp. Cofferdam/porta-dam	100	09-May-22	27-May-22
A1840	Construct North Cofferdam/porta-dam	150	30-May-22	23-Jun-22
Subtotal		**270**	**09-May-22**	**23-Jun-22**
Phase 4 - North Half				
A1850	Common Excavation	80	23-Jun-22	08-Jul-22
A1860	Rock Blasting/hauling	415	08-Jul-22	16-Sep-22
A1870	Foundation Mapping	80	16-Sep-22	30-Sep-22
A1880	Dental Conc Placement	195	30-Sep-22	03-Nov-22
A1900	Mass Concrete Placement	287	03-Nov-22	19-Dec-22

TWR-01 Classic Schedule Report - Sort by ES

WBS Name / Activity ID	Activity Name	Original Duration	Start	Finish
A1920	Gate Installation	240	19-Dec-22	01-Feb-23
A1890	Rock Bolts	240	21-Dec-22	06-Feb-23
A1970	Bridge Conc. Columns	318	24-Jan-23	21-Mar-23
A1980	Gate Testing	80	01-Feb-23	15-Feb-23
A1910	Grouted Riprap	420	06-Feb-23	19-Apr-23
Subtotal		**1707**	**23-Jun-22**	**19-Apr-23**
Phase 5 - Bridge				
A1800	Bridge Girders	200	21-Mar-23	25-Apr-23
A1810	Bridge Surface	1200	25-Apr-23	20-Nov-23
A1930	Remove Cofferdam/porta-dam	100	20-Nov-23	06-Dec-23
Subtotal		**1500**	**21-Mar-23**	**06-Dec-23**
Prattville Creek				
A1610	Cut/Fill Area	131	06-May-21	01-Jun-21
A1500	Prattville Rock Riffle	48	01-Jun-21	09-Jun-21
A1630	Wetland Plantings	340	09-Jun-21	10-Aug-21
A1640	2 Yr Maintainance Period	20687	10-Aug-21	20-Dec-23
Subtotal		**5410**	**06-May-21**	**20-Dec-23**
WBS 01 - Real Estate Actions				
A1530	Real Estate Acquisitions (by Others)	7200	18-Jun-18	14-Apr-19
Subtotal		**7200**	**18-Jun-18**	**14-Apr-19**
WBS 30 - Procurement Process				
A1310	SWD Consolidation Approval	1032	14-Aug-19	20-Feb-20
A1320	Pre-Soliciation Period	720	29-Jun-20	29-Jul-20
A1380	Contracting Prepare Solicitation	80	20-Aug-20	03-Sep-20
A1330	Solicitation Period	1440	03-Sep-20	02-Nov-20
A1390	Receive Proposals	0		02-Nov-20
A1400	Contracting Review Proposals	40	02-Nov-20	10-Nov-20
A1410	Evaluation of Proposals	172	10-Nov-20	11-Dec-20
A1420	Prepare Evaluation Report	40	11-Dec-20	18-Dec-20
A1430	KO Prepare Award Notification	80	18-Dec-20	05-Jan-21
A1440	Contract Award	0		05-Jan-21

TWR-01 Classic Schedule Report - Sort by ES

WBS Name Activity ID	Activity Name	Original Duration	Start	Finish
A1460	KO Receive/Review Contract Bond	80	05-Jan-21	19-Jan-21
Subtotal		**2870**	**14-Aug-19**	**19-Jan-21**
WBS 31 - Construction Management				
A1470	S&A	6180	19-Jan-21	20-Dec-23
Subtotal		**6180**	**19-Jan-21**	**20-Dec-23**

ATTACHMENT 3: TOTAL PROJECT COST SUMMARY/COST CERTIFICATION

WALLA WALLA COST ENGINEERING MANDATORY CENTER OF EXPERTISE

COST AGENCY TECHNICAL REVIEW

CERTIFICATION STATEMENT

For Project No. 145827

SWT – Arkansas River Corridor

The Arkansas River Corridor, as presented by Tulsa District, has undergone a successful Cost Agency Technical Review (Cost ATR), performed by the Walla Walla District Cost Engineering Mandatory Center of Expertise (Cost MCX) team. The Cost ATR included study of the project scope, report, cost estimates, schedules, escalation, and risk-based contingencies. This certification signifies the products meet the quality standards as prescribed in ER 1110-2-1150 Engineering and Design for Civil Works Projects and ER 1110-2-1302 Civil Works Cost Engineering.

As of February 16, 2018, the Cost MCX certifies the estimated total project cost:

FY18 Project First Cost: $128,375,000
Fully Funded Amount: $140,971,000

It remains the responsibility of the District to correctly reflect these cost values within the Final Report and to implement effective project management controls and implementation procedures including risk management through the period of Federal Participation.

JACOBS.MICHAEL.PIERRE.1160569537

Digitally signed by JACOBS.MICHAEL.PIERRE.1160569537
DN: c=US, o=U.S. Government, ou=DoD, ou=PKI, ou=USA, cn=JACOBS.MICHAEL.PIERRE.1160569537
Date: 2018.02.16 08:51:44 -08'00'

Michael P Jacobs, PE, CCE
Chief, Cost Engineering MCX
Walla Walla District

**** TOTAL PROJECT COST SUMMARY ****

PROJECT: **Arkansas River Corridor**
PROJECT NO: P2 xxxxxx
LOCATION: Tulsa, OK

DISTRICT: Tulsa District
POC: CHIEF, COST ENGINEERING, xxx

PREPARED: 2/6/2018

This Estimate reflects the scope and schedule in report; Feasibility report dated December 2017

Civil Works Work Breakdown Structure		**ESTIMATED COST**				**PROJECT FIRST COST (Constant Dollar Basis)**						**TOTAL PROJECT COST (FULLY FUNDED)**			
						Program Year (Budget EC): 2018 Effective Price Level Date: 1 OCT 17									
WBS NUMBER	Civil Works Feature & Sub-Feature Description	COST ($K)	CNTG ($K)	CNTG (%)	TOTAL ($K)	ESC (%)	COST ($K)	CNTG ($K)	**TOTAL ($K)**	Spent Thru: **1-Oct-17** ($K)	**TOTAL FIRST COST** ($K)	INFLATED (%)	COST ($K)	CNTG ($K)	FULL ($K)
A	*B*	*C*	*D*	*E*	*F*	*G*	*H*	*I*	*J*		*K*	*L*	*M*	*N*	*O*
04	DAMS	$49,614	$19,349	39.0%	$68,963	0.0%	$49,614	$19,349	$68,963	$0	$68,963	9.9%	$54,544	$21,272	$75,816
06	FISH & WILDLIFE FACILITIES	$1,958	$764	39.0%	$2,722	0.0%	$1,958	$764	$2,722	$0	$2,722	9.9%	$2,153	$839	$2,992
08	ROADS, RAILROADS & BRIDGES	$4,998	$1,949	39.0%	$6,947	0.0%	$4,998	$1,949	$6,947	$0	$6,947	9.9%	$5,495	$2,143	$7,637
19	BUILDINGS, GROUNDS & UTILITIES	$135	$53	39.0%	$188	0.0%	$135	$53	$188	$0	$188	9.9%	$148	$58	$206
02	RELOCATIONS	$156	$61	39.0%	$217	0.0%	$156	$61	$217	$0	$217	9.9%	$171	$67	$238
	#N/A	$0	$0	-	$0	-	$0	$0	$0	$0	$0	-	$0	$0	$0
	#N/A	$0	$0	-	$0	-	$0	$0	$0	$0	$0	-	$0	$0	$0
	#N/A	$0	$0	-	$0	-	$0	$0	$0	$0	$0	-	$0	$0	$0
	CONSTRUCTION ESTIMATE TOTALS:	$56,861	$22,176		$79,037	0.0%	$56,861	$22,176	$79,037	$0	$79,037	9.9%	$62,511	$24,379	$86,890
01	LANDS AND DAMAGES	$12,392	$2,478	20.0%	$14,870	0.0%	$12,392	$2,478	$14,870	$0	$14,870	0.0%	$12,392	$2,478	$14,870
30	PLANNING, ENGINEERING & DESIGN	$17,343	$6,764	39.0%	$24,106	0.0%	$17,343	$6,764	$24,106	$0	$24,106	10.7%	$19,199	$7,488	$26,687
31	CONSTRUCTION MANAGEMENT	$7,455	$2,907	39.0%	$10,362	0.0%	$7,455	$2,907	$10,362	$0	$10,362	20.9%	$9,010	$3,514	$12,524
	PROJECT COST TOTALS:	$94,050	$34,325	36.5%	$128,375		$94,050	$34,325	**$128,375**	$0	**$128,375**	9.8%	$103,112	$37,859	$140,971

ESTIMATED TOTAL PROJECT COST: $140,971

______________________ **CHIEF, COST ENGINEERING, xxx**

______________________ **PROJECT MANAGER, xxx**

______________________ **CHIEF, REAL ESTATE, xxx**

______________________ **CHIEF, PLANNING, xxx**

______________________ **CHIEF, ENGINEERING, xxx**

______________________ **CHIEF, OPERATIONS, xxx**

______________________ **CHIEF, CONSTRUCTION, xxx**

______________________ **CHIEF, CONTRACTING,xxx**

______________________ **CHIEF, PM-PB, xxxx**

______________________ **CHIEF, DPM, xxx**

**** TOTAL PROJECT COST SUMMARY ****

**** CONTRACT COST SUMMARY ****

PROJECT: Arkansas River Corridor
LOCATION: Tulsa, OK
This Estimate reflects the scope and schedule in report; Feasibility report dated December 2017

DISTRICT: Tulsa District
POC: CHIEF, COST ENGINEERING, xxx

PREPARED: 2/6/2018

Civil Works Work Breakdown Structure		**ESTIMATED COST**				**PROJECT FIRST COST (Constant Dollar Basis)**				**TOTAL PROJECT COST (FULLY FUNDED)**				
		Estimate Prepared:			**5-Feb-18**	Program Year (Budget EC):			2018					
		Effective Price Level:			1-Oct-17	Effective Price Level Date:			1 OCT 17					
WBS NUMBER	Civil Works Feature & Sub-Feature Description	COST ($K)	CNTG ($K)	RISK BASED CNTG (%)	TOTAL ($K)	ESC (%)	COST ($K)	CNTG ($K)	TOTAL ($K)	Mid-Point Date	INFLATED (%)	COST ($K)	CNTG ($K)	FULL ($K)
A	*B*	*C*	*D*	*E*	*F*	*G*	*H*	*I*	*J*	*P*	*L*	*M*	*N*	*O*
	CONTRACT 1													
04	DAMS	$49,614	$19,349	39.0%	$68,963	0.0%	$49,614	$19,349	$68,963	2022Q4	9.9%	$54,544	$21,272	$75,816
06	FISH & WILDLIFE FACILITIES	$1,958	$764	39.0%	$2,722	0.0%	$1,958	$764	$2,722	2022Q4	9.9%	$2,153	$839	$2,992
08	ROADS, RAILROADS & BRIDGES	$4,998	$1,949	39.0%	$6,947	0.0%	$4,998	$1,949	$6,947	2022Q4	9.9%	$5,495	$2,143	$7,637
19	BUILDINGS, GROUNDS & UTILITIES	$135	$53	39.0%	$188	0.0%	$135	$53	$188	2022Q4	9.9%	$148	$58	$206
02	RELOCATIONS	$156	$61	39.0%	$217	0.0%	$156	$61	$217	2022Q4	9.9%	$171	$67	$238
	#N/A	$0	$0	39.0%	$0	0.0%	$0	$0	$0	0	0.0%	$0	$0	$0
	#N/A	$0	$0	39.0%	$0	0.0%	$0	$0	$0	0	0.0%	$0	$0	$0
	#N/A	$0	$0	39.0%	$0	0.0%	$0	$0	$0	0	0.0%	$0	$0	$0
	CONSTRUCTION ESTIMATE TOTALS:	$56,861	$22,176	39.0%	**$79,037**		$56,861	$22,176	$79,037			$62,511	$24,379	$86,890
01	LANDS AND DAMAGES	$12,392	$2,478	20.0%	$14,870	0.0%	$12,392	$2,478	$14,870	2018Q1	0.0%	$12,392	$2,478	$14,870
30	PLANNING, ENGINEERING & DESIGN													
2.5%	Project Management	$1,422	$554	39.0%	$1,976	0.0%	$1,422	$554	$1,976	2019Q4	7.1%	$1,522	$594	$2,116
1.0%	Planning & Environmental Compliance	$569	$222	39.0%	$790	0.0%	$569	$222	$790	2019Q4	7.1%	$609	$237	$846
15.0%	Engineering & Design	$8,529	$3,326	39.0%	$11,856	0.0%	$8,529	$3,326	$11,856	2019Q4	7.1%	$9,134	$3,562	$12,696
1.0%	Reviews, ATRs, IEPRs, VE	$569	$222	39.0%	$790	0.0%	$569	$222	$790	2019Q4	7.1%	$609	$237	$846
1.0%	Life Cycle Updates (cost, schedule, risks)	$569	$222	39.0%	$790	0.0%	$569	$222	$790	2019Q4	7.1%	$609	$237	$846
1.0%	Contracting & Reprographics	$569	$222	39.0%	$790	0.0%	$569	$222	$790	2019Q4	7.1%	$609	$237	$846
3.0%	Engineering During Construction	$1,706	$665	39.0%	$2,371	0.0%	$1,706	$665	$2,371	2022Q4	20.9%	$2,062	$804	$2,866
2.0%	Planning During Construction	$1,137	$444	39.0%	$1,581	0.0%	$1,137	$444	$1,581	2022Q4	20.9%	$1,375	$536	$1,911
3.0%	Adaptive Management & Monitoring	$1,706	$665	39.0%	$2,371	0.0%	$1,706	$665	$2,371	2022Q4	20.9%	$2,062	$804	$2,866
1.0%	Project Operations	$569	$222	39.0%	$790	0.0%	$569	$222	$790	2019Q4	7.1%	$609	$237	$846
31	CONSTRUCTION MANAGEMENT													
10.0%	Construction Management	$5,686	$2,218	39.0%	$7,904	0.0%	$5,686	$2,218	$7,904	2022Q4	20.9%	$6,873	$2,680	$9,553
	Project Operation:	$347	$135	39.0%	$482	0.0%	$347	$135	$482	2022Q4	20.9%	$419	$164	$583
2.5%	Project Management	$1,422	$554	39.0%	$1,976	0.0%	$1,422	$554	$1,976	2022Q4	20.9%	$1,718	$670	$2,388
	CONTRACT COST TOTALS:	$94,050	$34,325		$128,375		$94,050	$34,325	**$128,375**			$103,112	$37,859	**$140,971**

Filename: ARC TPCS 2-07-18.xlsx
TPCS

ATTACHMENT 4: COST & SCHEDULE RISK ASSESSMENT

US Army Corps of
Engineers®

Arkansas River Corridor, Tulsa County, Oklahoma
Feasibility Report
Project Cost and Schedule Risk Analysis Report

Prepared for:
U.S. Army Corps of Engineers,
Tulsa District

Prepared by:
Walla Walla District, U.S. Army Corps of Engineers

February 13, 1018

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EXECUTIVE SUMMARY

The US Army Corps of Engineers (USACE), Tulsa District, presents this cost and schedule risk analysis (CSRA) report regarding the risk findings and recommended contingencies for the Arkansas River Corridor Feasibility Report Project. 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 recommend 80% confidence level of successful execution to project completion.

This is a feasibility report and integrated environmental assessment completed by the United States Army Corps of Engineers (USACE), Tulsa District, presenting the results of study on the potential for ecosystem restoration (ER) opportunities along a 42-mile corridor of the Arkansas River in Tulsa County, Oklahoma (Figure 1). The Arkansas River is a water resource serving numerous purposes within the City of Tulsa and surrounding communities. The river is dammed at the western Tulsa County line creating Keystone Lake which, along with the dam, provide flood risk management benefits, contribute to the eleven-reservoir-system operation of the McClellan-Kerr Arkansas River Navigation System (MKARNS), provide clean and efficient power through the associated hydropower plant, and provide a source of water for municipal and industrial uses. Historically, the river has served as an important resource for aquatic and terrestrial habitat of the nation's wildlife that live, breed, and migrate through the Arkansas River ecosystem. Construction, operation, and maintenance of the Keystone Dam, lake, associated hydropower operations, and other multi-purposes have significantly degraded the riverine ecosystem structure, function, and dynamic processes along the Arkansas River within Tulsa County. In addition to the nationally significant purposes of flood risk management, inland navigation, hydropower, and water supply, the Arkansas River ecosystem is a nationally significant resource for the Federally-listed Interior Least Tern (Sterna antillarum), hereafter referred to as Least Tern, as well as a plethora of other native species that support a functional riverine ecosystem.

Specific to the Arkansas River Corridor Feasibility Report Project, the current fully funded estimate approximates $132M, including sunk costs, contingency and escalation. The estimated project base cost for the remaining work approximates $56.7M. However, the CSRA is calculated, only, on the estimated remaining construction, PED and construction management base cost of $95.0M expressed in FY2018 dollars. The CSRA base cost excludes lands and damages costs of $12.4M; relocation costs of $0.2M; escalation; contingencies and sunk costs. Cost Engineering performed study on the estimated remaining construction, PED and construction management costs since the Real Estate office provided a separate 5% contingency for its real estate and 15% contingency for its relocations requirements. Based on the results of the risk analysis, **Cost Engineering recommends a contingency value of $37.1M on the remaining work or approximately 39% of base project cost**. The project as a whole; including remaining construction features; given contingency for lands and damages; relocations; PED and construction management equates to a contingency value of $37.1M on the remaining work or approximately 39% of the base project cost as shown on the Total Project Cost (TPC) template.

Walla Walla District, Cost Engineering performed a risk analysis using the *Monte Carlo* technique for the estimated construction costs, supported by the district PDT input. The following table ES-1 portrays the development of the construction contingencies. The contingency is based on an 80% confidence level, as per USACE Civil Works guidance. Knowing that estimates can fluctuate to a certain degree over time with little to no change in risk, it is common to rely on the per cent of contingency applied against the costs under study. For example, the estimated construction cost of $56.7M was the basis for the risk model. The current construction estimate may have changed to a minor degree with no change in risks.

Table ES-1. Construction Contingency Results

Baseline Cost Estimate	$56,704,003.	
Confidence Level	Project Cost ($) w/ Contingency	Contingency (%)
50%	$18,145,281	32%
80%	$22,114,561	39%
90%	$23,815,681	42%

KEY FINDINGS/OBSERVATIONS RECOMMENDATIONS
The PDT worked through the risk register on two separate occasions: January 2018 and February 2018. That period of time allowed improved project scope definition, investigations, design and cost information, and resulted in reduced risks in certain project areas. The key risk drivers identified through sensitivity analysis suggest a cost contingency of $xxM and schedule risks adding another potential of $xxM, both at an 80% confidence level.

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

- ET4- Estimate confidence in large and critical quantities –
- TL1 – Scoping Documentation and Quantities –
- EX3 – Market Condition and Bidding Competition (All) –
- CO1 –Modifications and Claims –
- Et10 – jobsite Overhead –
- ET7 – Water Control Gate Pricing –
- ET6 – Downstream Grouted Rock –
- ET5 – Mob/Demob Costs –

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

- ET2 – Construction Schedule Level of Detail
- ET4 – Estimate Confidence in Large and Critical Quantities
- CO3 – Rock Excavation for Pool Structure
- CA5 – Lack of Contract Acquisition Plan

Recommendations: Timely coordination and risk resolution between the Sponsor and USACE is needed in areas of project scoping, design quantities and site investigations. The PDT must include the recommended cost and schedule contingencies and incorporate risk monitoring and mitigation on those identified risks. Further iterative study and update of the risk analysis throughout the project life-cycle is important in support of the remaining project work within an approved budget and appropriation.

MAIN REPORT

1.0 PURPOSE

Under the auspices of the US Army Corps of Engineers (USACE), Tulsa District, this report presents a recommendation for the total project cost and schedule contingencies for the Arkansas River Corridor Feasibility Report Project.

2.0 BACKGROUND

This is a feasibility report and integrated environmental assessment completed by the United States Army Corps of Engineers (USACE), Tulsa District, presenting the results of study on the potential for ecosystem restoration (ER) opportunities along a 42-mile corridor of the Arkansas River in Tulsa County, Oklahoma (Figure 1). The Arkansas River is a water resource serving numerous purposes within the City of Tulsa and surrounding communities. The river is dammed at the western Tulsa County line creating Keystone Lake which, along with the dam, provide flood risk management benefits, contribute to the eleven-reservoir-system operation of the McClellan-Kerr Arkansas River Navigation System (MKARNS), provide clean and efficient power through the associated hydropower plant, and provide a source of water for municipal and industrial uses. Historically, the river has served as an important resource for aquatic and terrestrial habitat of the nation’s wildlife that live, breed, and migrate through the Arkansas River ecosystem. Construction, operation, and maintenance of the Keystone Dam, lake, associated hydropower operations, and other multi-purposes have significantly degraded the riverine ecosystem structure, function, and dynamic processes along the Arkansas River within Tulsa County. In addition to the nationally significant purposes of flood risk management, inland navigation, hydropower, and water supply, the Arkansas River ecosystem is a nationally significant resource for the Federally-listed Interior Least Tern (Sterna antillarum), hereafter referred to as Least Tern, as well as a plethora of other native species that support a functional riverine ecosystem.

As a part of this effort, Tulsa District requested that the USACE Cost Engineering Directory of Expertise for Civil Works (Cost Engineering MCX) provide an agency technical review (ATR) of the cost estimate, schedule and risk analysis for Recommended Project Plan.

3.0 REPORT SCOPE

The scope of the risk analysis report is to identify cost and schedule risks with a resulting recommendation for 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 construction features. The CSRA excludes Real Estate costs, relocations and does not include consideration for life cycle costs.

3.1 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 Micro Computer Aided Cost Estimating System (MCACES) cost estimate, project 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 Tetra Tech and the Tulsa District. Consequently, these documents serve as the basis for the risk analysis.

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

3.2 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.

4.0 METHODOLOGY / PROCESS

Cost Engineering performed the Cost and Schedule Risk Analysis, relying on local Tulsa District staff to provide expertise and information gathering. The Tulsa PDT conducted initial risk identification via webinar/teleconference with the Walla Walla Cost Engineering MCX facilitator on January 4, 2018. The initial risk identification meeting also included qualitative analysis to produce a risk register that served as the draft framework for the risk analysis.

Risk Facilitator: Phillip C. Ohnstad — Arkansas River Corridor

Risk Register Meeting

Date: Thursday, January 4, 2018

Attendance	Name	Office	Representing
Full	Tim Batson	CESWT-EC-C	Cost Engineering
Full	Terry Rice	CESWT-DS-D	Dam Safety
Full	Michelle Lay	CESWT-EC-DD	Civil Design
Full	Brandon Wadington	CESWF-PEC-TN	Biologist
Full	Nancy Parish	CESWF-PEC-TN	Planner
Full	Heath Sand	CESWT-EC-HF	H&H
Full	David Blackmore	CESWT-EC-DI	Dam Safety
Full	Andrew Blakenship	CESWT-EC-DM	Civil Design
Full	David Clark	CESWF-PEC-TM	Environmental
Full	David Gade	CESWF-PEC-TN	NEPA/Cultrual Resources
Full	Kim Jackson	CESWT-RE-M	Real Estate
Full	Cynthia Kitchens	CESWT-PP-C	Project Management
Full	Pinc Gaylon	A/E	Environmental Program Manag.
Full	Mandy Mcguire	CESWF-PEC-TN	Environmental

The draft CSRA model was completed January 23, 2018. However, subsequent sanity checks and technical review of the base cost estimate, design package from CH2M Hill and quantity checks required revisions, necessitating a rerun of the original model. Results were furthered on February 7, 2018, and it's now ready for ATR.

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.

4.1 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 for the purposes of identifying and assessing risk factors. The meeting (conducted on January 4, 2018) included capable and qualified representatives from multiple project team disciplines and functions, including project management, cost engineering, design, and City of Flagstaff.

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. 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.

4.2 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.

4.3 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 larger portion of the project 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 Arkansas River Corridor project.

The Tulsa District provided MII MCACES (Micro-Computer Aided Cost Estimating Software) files electronically. The MII and CWE files prepared on December 15, 2017 were the basis for the initial cost and schedule risk analyses. The MII and CWE files dated February 5, 2018 (post ATR) served as the basis for the final CSRA.

b. The cost comparisons and risk analyses performed and reflected within this report are based on design scope and estimates that are at the preconstruction engineering and design (PED) level, approximating a 75%-90% design stage.

c. Schedules are analyzed for impact to the project cost in terms of delayed funding, uncaptured escalation (variance from OMB factors and the local market) and unavoidable fixed contract costs and/or languishing federal administration costs incurred throughout delay. The original schedule provided dated December 4, 2017 was a minimal top level 12 item schedule. The schedule dated February 5, 2018 was more comprehensive and was used as the basis for the final CSRA.

d. Per the CWCCIS Historical State Adjustment Factors in EM 1110-2-1304, State Adjustment Factor for the State of Arizona is 0.96, meaning that the average inflation for the project area is assumed to be 4% 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; however, recent experience in the past five years does indicate a construction inflation above the standard OMB rates published. This risk was considered with the delay impacts.

e. Per the data in the estimate, the Job Office Overhead (JOOH) amount for the Contract Cost comprises approximately 5% of the Project Cost at Baseline. The project includes up to 3 individual contracts occurring concurrently over two to three years. The assumed monthly recurring rate for this project is approximately 10%. For the P80 schedule, this comprises 3% of the total contingency due to the accrual of residual fixed costs associated with delay of the implementation schedule.

f. The Cost Engineering 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”.

6.0 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.

6.1 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.

6.2 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, P80 and P90 confidence levels are also provided for illustrative purposes only.

Cost contingency for the Construction risks (including schedule impacts converted to dollars) was quantified as approximately $9 Million at the P80 confidence level (20% of the baseline construction cost estimate).

Table ES-1. Construction Contingency Results

Baseline Cost Estimate	$56,704,003.	
Confidence Level	Project Cost ($) w/ Contingency	Contingency (%)
50%	$18,145,281	32%
80%	$22,114,561	39%
90%	$23,815,681	42%

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 and the respective value variance 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.

Figure 1. Cost Sensitivity Analysis

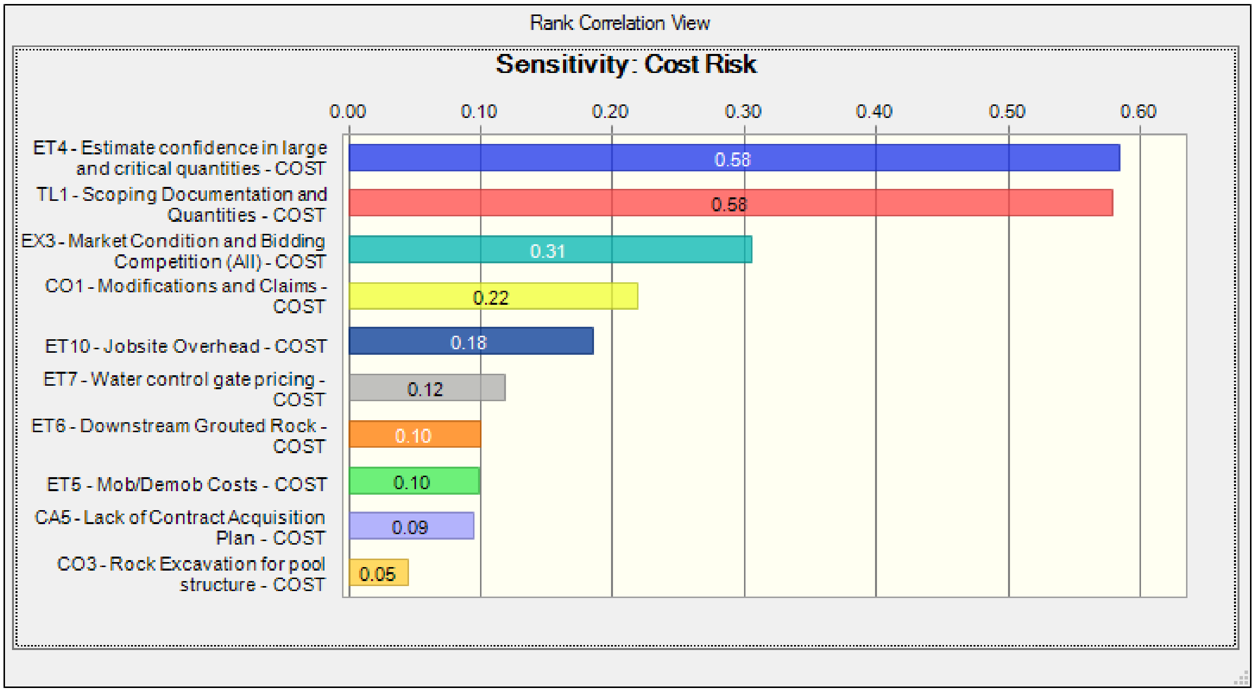
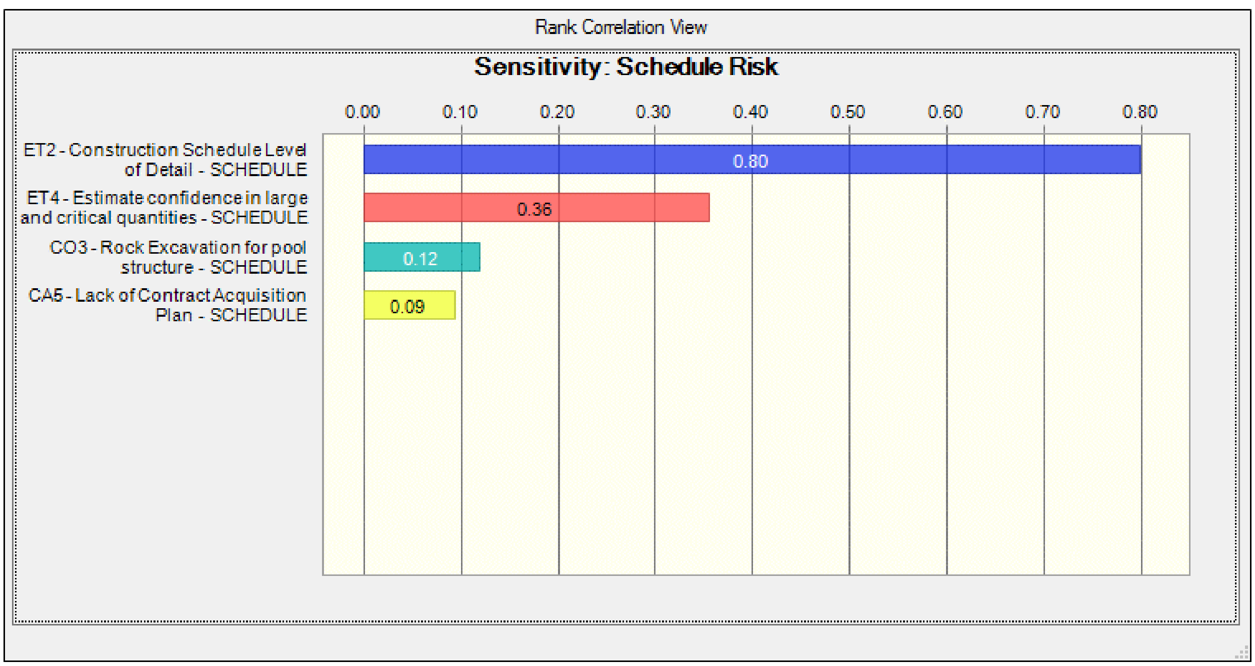


Figure 2 – Schedule Sensitivity Analysis



6.3 Schedule and Contingency Risk 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 duration at intervals of confidence (probability).

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 7 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.

Table 2. Schedule Duration Contingency Summary

Base Case Schedule	24 Months	
Confidence Level	Schedule Duration (months) w/ Contingency	Contingency (Months)
50%	4	6%
80%	7	10%
90%	8	12%

Notes:
1) 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 in Table 2.
2) A P100 confidence level is an abstract concept as the nature of risk and uncertainty (specifically the presence of "unknown unknowns") makes 100% confidence a theoretical impossibility.

7.0 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.

7.1 Major Findings/Observations

Project cost and schedule comparison summaries are provided in Table 3 and Table 4 respectively. Additional major findings and observations of the risk analysis are listed below.

The PDT worked through the risk register on two separate occasions: January 2018 and February 2018. That period of time allowed improved project scope definition, investigations, design and cost information, and resulted in reduced risks in certain project areas. The key risk drivers identified through sensitivity analysis suggest a cost contingency of $xxM and schedule risks adding another potential of $xxM, both at an 80% confidence level.

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

- ET4- Estimate confidence in large and critical quantities –
- TL1 – Scoping Documentation and Quantities –
- EX3 – Market Condition and Bidding Competition (All) –
- CO1 –Modifications and Claims –
- Et10 – jobsite Overhead –
- ET7 – Water Control Gate Pricing –
- ET6 – Downstream Grouted Rock –
- ET5 – Mob/Demob Costs –

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

- ET2 – Construction Schedule Level of Detail
- ET4 – Estimate Confidence in Large and Critical Quantities
- CO3 – Rock Excavation for Pool Structure
- CA5 – Lack of Contract Acquisition Plan

Table 3. Construction Cost Comparison Summary (Uncertainty Analysis)

INITIAL CONSTRUCTION

Contingency Analysis

Base Case Estimate (Excluding 01)	$56,704,003	
Confidence Level	**Contingency Value**	**Contingency**
0%	5,103,360	9%
10%	13,041,921	23%
20%	14,743,041	26%
30%	15,877,121	28%
40%	17,011,201	30%
50%	18,145,281	32%
60%	19,279,361	34%
70%	20,980,481	37%
80%	22,114,561	39%
90%	23,815,681	42%
100%	31,187,202	55%

Table 4. Construction Schedule Comparison Summary (Uncertainty Analysis)

Contingency Analysis

Base Case Schedule	66.1 Months	
Confidence Level	**Contingency Value**	**Contingency**
0%	-1 Months	-1%
10%	2 Months	3%
20%	3 Months	4%
30%	3 Months	5%
40%	4 Months	6%
50%	4 Months	6%
60%	5 Months	7%
70%	6 Months	9%
80%	7 Months	10%
90%	8 Months	12%
100%	14 Months	21%

7.2 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.

The CSRA study serves as a “road map” towards project improvements and reduced risks over time. Timely coordination and risk resolution between the Sponsor, Railroad, and USACE is needed in areas of ROW, site access and staging, and funding needs and updates as applicable. The PDT must include the recommended cost and schedule contingencies and incorporate risk monitoring and mitigation on those identified risks. Further iterative study and update of the risk analysis throughout the project life-cycle is important in support of remaining within an approved budget and appropriation.

Risk Management: Project leadership should use of the outputs created during the risk analysis effort as tools in future risk management processes. The risk register should be updated at each major project milestone. 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.

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).

Recommendations: Timely coordination and risk resolution between the Sponsor and USACE is needed in areas of project scoping, design quantities and site investigations. The PDT must include the recommended cost and schedule contingencies and incorporate risk monitoring and mitigation on those identified risks. Further iterative study and update of the risk analysis throughout the project life-cycle is important in support of the remaining project work within an approved budget and appropriation.

APPENDIX A