ATTACHMENT 1

COST ESTIMATE (MII V4.4.2)/TPCS/CSRA

Estimated by	Chester Hedderman, GBA
Designed by	GBA/AECOM/POH
Prepared by	G. Dale Williams, USACE
Preparation Date	12/4/2019
Effective Date of Pricing	12/4/2019
Estimated Construction Time	1,363 Days

[redacted]

Description	Quantity	UOM	DirectCost	ContractCost	ProjectCost
Project Cost Summary Report			**414,300,046**	**432,928,241**	**432,928,241**
Construction General - NED	**1.00**	**EA**	**414,300,046**	**432,928,241**	**432,928,241**
Segment 1	**1.00**	**EA**	**87,325,320**	**90,171,471**	**90,171,471**
01 Construction Year 01-02	**1.00**	**EA**	**75,565,813**	**78,180,986**	**78,180,986**
02 Construction Year 02-03	**1.00**	**EA**	**11,759,507**	**11,990,485**	**11,990,485**
Segment 2	**1.00**	**EA**	**104,936,094**	**112,082,953**	**112,082,953**
02 Construction Year 02-03	**1.00**	**EA**	**104,936,094**	**112,082,953**	**112,082,953**
Segment 3	**1.00**	**EA**	**97,414,396**	**99,743,251**	**99,743,251**
03 Construction Year 03-04	**1.00**	**EA**	**97,414,396**	**99,743,251**	**99,743,251**
Segment 4	**1.00**	**EA**	**91,295,165**	**95,415,294**	**95,415,294**
01 Construction Year 01-02	**1.00**	**EA**	**91,295,165**	**95,415,294**	**95,415,294**
Segment 5	**1.00**	**EA**	**3,981,995**	**4,216,305**	**4,216,305**
04 Construction Year 04-05	**1.00**	**EA**	**3,981,995**	**4,216,305**	**4,216,305**
Segment 6	**1.00**	**EA**	**29,347,076**	**31,298,967**	**31,298,967**
04 Construction Year 04-05	**1.00**	**EA**	**29,347,076**	**31,298,967**	**31,298,967**

Currency in US dollars

Estimated by	Chester Hedderman, GBA
Designed by	GBA/AECOM/POH
Prepared by	G. Dale Williams, USACE
Preparation Date	12/5/2019
Effective Date of Pricing	10/1/2019
Estimated Construction Time	1,830 Days

[redacted]

Description	Quantity	UOM	DirectCost	ContractCost	ProjectCost
Project Cost Summary Report			**532,842,750**	**557,028,037**	**557,028,037**
Construction General - LPP	**1.00**	**EA**	**532,842,750**	**557,028,037**	**557,028,037**
Segment 1	**1.00**	**EA**	**261,176,466**	**274,487,624**	**274,487,624**
01 Construction Year 01-02	**1.00**	**EA**	**77,132,593**	**79,747,766**	**79,747,766**
02 Construction Year 02-03	**1.00**	**EA**	**102,841,061**	**106,131,096**	**106,131,096**
03 Construction Year 03-05	**1.00**	**EA**	**81,202,813**	**88,608,762**	**88,608,762**
Segment 2	**1.00**	**EA**	**51,709,961**	**53,948,906**	**53,948,906**
02 Construction Year 02-03	**1.00**	**EA**	**51,709,961**	**53,948,906**	**53,948,906**
Segment 3	**1.00**	**EA**	**95,323,718**	**97,652,572**	**97,652,572**
03 Construction Year 03-05	**1.00**	**EA**	**95,323,718**	**97,652,572**	**97,652,572**
Segment 4	**1.00**	**EA**	**91,303,533**	**95,423,662**	**95,423,662**
01 Construction Year 01-02	**1.00**	**EA**	**91,303,533**	**95,423,662**	**95,423,662**
Segment 5	**1.00**	**EA**	**3,981,996**	**4,216,305**	**4,216,305**
04 Construction Year 05-06	**1.00**	**EA**	**3,981,996**	**4,216,305**	**4,216,305**
Segment 6	**1.00**	**EA**	**29,347,076**	**31,298,967**	**31,298,967**
04 Construction Year 05-06	**1.00**	**EA**	**29,347,076**	**31,298,967**	**31,298,967**

Currency in US dollars

WALLA WALLA COST ENGINEERING MANDATORY CENTER OF EXPERTISE

COST AGENCY TECHNICAL REVIEW

CERTIFICATION STATEMENT

For Project No. 451902

SWG – Houston Ship Channel Expansion Channel Improvement Project, Harris, Chambers and Galveston Counties

The Houston Ship Channel Expansion Channel Improvement Project, as presented by Galveston 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 December 6, 2019, the Cost MCX certifies the estimated total project cost:

National Economic Development (NED)

FY20 Project First Cost:	$666,265,000
Fully Funded Amount:	$767,138,000

Locally Preferred Plan (LPP)

FY20 Project First Cost:	$876,848,000
Fully Funded Amount:	$996,912,000

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.

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

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

PROJECT: Houston Ship Channel Improvement Project (NED Plan)
PROJECT NO: P2 451902
LOCATION: Houston Ship Channel, Texas

DISTRICT: Galveston District PREPARED: 12/5/2019
POC: CHIEF, COST ENGINEERING, Martin Regner, P.E.

This Estimate reflects the scope and schedule in report; HSC Feasibility

Civil Works Work Breakdown Structure		ESTIMATED COST				PROJECT FIRST COST (Constant Dollar Basis)						TOTAL PROJECT COST (FULLY FUNDED)			
						Program Year (Budget EC): 2020									
						Effective Price Level Date: 1 OCT 19									
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-19 ($K)	TOTAL FIRST COST ($K)	NFLATEC (%)	COST ($K)	CNTG ($K)	FULL ($K)
A	B	C	D	E	F	G	H	I	J		K	L	M	N	O
02	RELOCATIONS	$25,420	$9,151	36.0%	$34,571	0.0%	$25,420	$9,151	$34,571	$0	$34,571	9.5%	$27,832	$10,019	$37,851
06	FISH & WILDLIFE FACILITIES	$39,858	$14,349	36.0%	$54,207	0.0%	$39,858	$14,349	$54,207	$0	$54,207	12.5%	$44,823	$16,136	$60,960
12	NAVIGATION PORTS & HARBORS	$355,951	$128,142	36.0%	$484,094	0.0%	$355,951	$128,142	$484,094	$0	$484,094	15.8%	$412,191	$148,389	$560,580
	CONSTRUCTION ESTIMATE TOTALS:	$421,229	$151,642		$572,871	0.0%	$421,229	$151,642	$572,871	$0	$572,871	15.1%	$484,846	$174,545	$659,391
01	LANDS AND DAMAGES	$11,699	$2,925	25.0%	$14,624	0.0%	$11,699	$2,925	$14,624	$0	$14,624	9.7%	$12,832	$3,208	$16,040
30	PLANNING, ENGINEERING & DESIGN	$36,857.537	$13,269	36.0%	$50,126	0.0%	$36,858	$13,269	$50,126	$0	$50,126	15.1%	$42,430	$15,275	$57,704
31	CONSTRUCTION MANAGEMENT	$21,061	$7,582	36.0%	$28,644	0.0%	$21,061	$7,582	$28,644	$0	$28,644	18.7%	$25,002	$9,001	$34,003
	PROJECT COST TOTALS:	$490,847	$175,418	35.7%	$666,265		$490,847	$175,418	$666,265	$0	$666,265	15.1%	$565,110	$202,028	$767,138

REGNER.MARTIN.B.13 67377794 Digitally signed by REGNER.MARTIN.B.1367377794 Date: 2019.12.09 10:48:02 -06'00'

CHIEF, COST ENGINEERING, Martin Regner, P.E.

PROJECT MANAGER, Andrea Catanzaro

CHIEF, REAL ESTATE, Timothy Nelson

CHIEF, PLANNING, Robert Newman

CHIEF, ENGINEERING, Willie J. Honza, P.E.

CHIEF, OPERATIONS, Joe Hrametz. P.E.

CHIEF, CONSTRUCTION, Donald Carelock, P.E.

CHIEF, CONTRACTING,Jeffrey Neill

CHIEF, PM-PB, Valerie Miller

CHIEF, DPM, Edmund P. Russo, Jr., PHD, P.E., D.CE, D.NE.

ESTIMATED TOTAL PROJECT COST: $767,138

ASSOCIATED COST: $ 90,016

ESTIMATED TOTAL 50-Yr O&M COST: $ 9,981,513

ESTIMATED TOTAL INCREASE IN 50-Yr O&M COST: $ 1,883,123

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

****** CONTRACT COST SUMMARY ******

PROJECT: Houston Ship Channel Improvement Project (NED Plan)
LOCATION: Houston Ship Channel, Texas
This Estimate reflects the scope and schedule in report; HSC Feasibility

DISTRICT: Galveston District PREPARED: 12/5/2019
POC: CHIEF, COST ENGINEERING, Martin Regner, P.E.

Civil Works Work Breakdown Structure		ESTIMATED COST				PROJECT FIRST COST (Constant Dollar Basis)				TOTAL PROJECT COST (FULLY FUNDED)				
		Estimate Prepared: / Effective Price Level:			4-Dec-19 / 1-Oct-19	Program Year (Budget EC): / Effective Price Level Date:			2020 / 1 OCT 19					
WBS NUMBER A	Civil Works Feature & Sub-Feature Description B	COST ($K) C	CNTG ($K) D	RISK BASED CNTG (%) E	TOTAL ($K) F	ESC (%) G	COST ($K) H	CNTG ($K) I	TOTAL ($K) J	Mid-Point Date P	INFLATED (%) L	COST ($K) M	CNTG ($K) N	FULL ($K) O
	Segment 1													
02	RELOCATIONS	$0	$0	36.0%	$0	0.0%	$0	$0	$0	0	0.0%	$0	$0	$0
06	FISH & WILDLIFE FACILITIES	$22,010	$7,923	36.0%	$29,933	0.0%	$22,010	$7,923	$29,933	2023Q2	10.3%	$24,281	$8,741	$33,022
12	NAVIGATION PORTS & HARBORS	$68,106	$24,518	36.0%	$92,624	0.0%	$68,106	$24,518	$92,624	2023Q3	11.1%	$75,699	$27,252	$102,951
	CONSTRUCTION ESTIMATE TOTALS:	$90,115	$32,441	36.0%	**$122,557**		$90,115	$32,441	$122,557			$99,980	$35,993	$135,973
01	LANDS AND DAMAGES	$56	$14	25.0%	$70	0.0%	$56	$14	$70	2023Q3	11.1%	$63	$16	$78
30	PLANNING, ENGINEERING & DESIGN													
0.8%	Project Management	$676	$243	36.0%	$919	0.0%	$676	$243	$919	2022Q3	9.9%	$743	$267	$1,010
0.5%	Planning & Environmental Compliance	$451	$162	36.0%	$613	0.0%	$451	$162	$613	2022Q3	9.9%	$495	$178	$673
3.0%	Engineering & Design	$2,703	$973	36.0%	$3,677	0.0%	$2,703	$973	$3,677	2022Q3	9.9%	$2,971	$1,070	$4,041
0.5%	Reviews, ATRs, IEPRs, VE	$451	$162	36.0%	$613	0.0%	$451	$162	$613	2022Q3	9.9%	$495	$178	$673
0.5%	Life Cycle Updates (cost, schedule, risks)	$451	$162	36.0%	$613	0.0%	$451	$162	$613	2022Q3	9.9%	$495	$178	$673
0.5%	Contracting & Reprographics	$451	$162	36.0%	$613	0.0%	$451	$162	$613	2022Q3	9.9%	$495	$178	$673
1.0%	Engineering During Construction	$901	$324	36.0%	$1,226	0.0%	$901	$324	$1,226	2022Q3	9.9%	$990	$357	$1,347
0.5%	Planning During Construction	$451	$162	36.0%	$613	0.0%	$451	$162	$613	2022Q3	9.9%	$495	$178	$673
0.5%	Adaptive Management & Monitoring	$451	$162	36.0%	$613	0.0%	$451	$162	$613	2023Q1	12.0%	$505	$182	$686
1.0%	Project Operations	$901	$324	36.0%	$1,226	0.0%	$901	$324	$1,226	2022Q3	9.9%	$990	$357	$1,347
31	CONSTRUCTION MANAGEMENT													
3.0%	Construction Management	$2,703	$973	36.0%	$3,677	0.0%	$2,703	$973	$3,677	2022Q3	9.9%	$2,971	$1,070	$4,041
1.0%	Project Operation:	$901	$324	36.0%	$1,226	0.0%	$901	$324	$1,226	2022Q3	9.9%	$990	$357	$1,347
1.0%	Project Management	$901	$324	36.0%	$1,226	0.0%	$901	$324	$1,226	2022Q3	9.9%	$990	$357	$1,347
	CONTRACT COST TOTALS:	$102,562	$36,916		$139,479		$102,562	$36,916	**$139,479**			$113,670	$40,914	**$154,584**

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

****** CONTRACT COST SUMMARY ******

PROJECT: Houston Ship Channel Improvement Project (NED Plan)
LOCATION: Houston Ship Channel, Texas
This Estimate reflects the scope and schedule in report; HSC Feasibility

DISTRICT: Galveston District PREPARED: 12/5/2019
POC: CHIEF, COST ENGINEERING, Martin Regner, P.E.

Civil Works Work Breakdown Structure		ESTIMATED COST				PROJECT FIRST COST (Constant Dollar Basis)				TOTAL PROJECT COST (FULLY FUNDED)				
		Estimate Prepared: / Effective Price Level:			4-Dec-19 / 1-Oct-19	Program Year (Budget EC): / Effective Price Level Date:			2020 / 1 OCT 19					
WBS NUMBER	Civil Works Feature & Sub-Feature Description	COST ($K)	CNTG ($K)	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
	Segment 2													
02	RELOCATIONS	$0	$0	36.0%	$0	0.0%	$0	$0	$0	0	0.0%	$0	$0	$0
06	FISH & WILDLIFE FACILITIES	$3,718	$1,339	36.0%	$5,057	0.0%	$3,718	$1,339	$5,057	2024Q3	14.5%	$4,257	$1,532	$5,789
12	NAVIGATION PORTS & HARBORS	$108,327	$38,998	36.0%	$147,325	0.0%	$108,327	$38,998	$147,325	2025Q1	16.2%	$125,829	$45,299	$171,128
	CONSTRUCTION ESTIMATE TOTALS:	$112,045	$40,336	36.0%	**$152,382**		$112,045	$40,336	$152,382			$130,086	$46,831	$176,917
01	LANDS AND DAMAGES	$38	$9	25.0%	$47	0.0%	$38	$9	$47	2024Q3	14.5%	$43	$11	$54
30	PLANNING, ENGINEERING & DESIGN													
0.8%	Project Management	$840	$303	36.0%	$1,143	0.0%	$840	$303	$1,143	2023Q3	14.1%	$959	$345	$1,304
0.5%	Planning & Environmental Compliance	$560	$202	36.0%	$762	0.0%	$560	$202	$762	2023Q3	14.1%	$639	$230	$869
3.0%	Engineering & Design	$3,361	$1,210	36.0%	$4,571	0.0%	$3,361	$1,210	$4,571	2023Q3	14.1%	$3,835	$1,380	$5,215
0.5%	Reviews, ATRs, IEPRs, VE	$560	$202	36.0%	$762	0.0%	$560	$202	$762	2023Q3	14.1%	$639	$230	$869
0.5%	Life Cycle Updates (cost, schedule, risks)	$560	$202	36.0%	$762	0.0%	$560	$202	$762	2023Q3	14.1%	$639	$230	$869
0.5%	Contracting & Reprographics	$560	$202	36.0%	$762	0.0%	$560	$202	$762	2023Q3	14.1%	$639	$230	$869
1.0%	Engineering During Construction	$1,120	$403	36.0%	$1,524	0.0%	$1,120	$403	$1,524	2024Q3	18.4%	$1,327	$478	$1,805
0.5%	Planning During Construction	$560	$202	36.0%	$762	0.0%	$560	$202	$762	2024Q3	18.4%	$664	$239	$902
0.5%	Adaptive Management & Monitoring	$560	$202	36.0%	$762	0.0%	$560	$202	$762	2023Q3	14.1%	$639	$230	$869
1.0%	Project Operations	$1,120	$403	36.0%	$1,524	0.0%	$1,120	$403	$1,524	2023Q3	14.1%	$1,278	$460	$1,738
31	CONSTRUCTION MANAGEMENT													
3.0%	Construction Management	$3,361	$1,210	36.0%	$4,571	0.0%	$3,361	$1,210	$4,571	2024Q3	18.4%	$3,981	$1,433	$5,415
1.0%	Project Operation:	$1,120	$403	36.0%	$1,524	0.0%	$1,120	$403	$1,524	2024Q3	18.4%	$1,327	$478	$1,805
1.0%	Project Management	$1,120	$403	36.0%	$1,524	0.0%	$1,120	$403	$1,524	2024Q3	18.4%	$1,327	$478	$1,805
	CONTRACT COST TOTALS:	$127,489	$45,892		$173,381		$127,489	$45,892	**$173,381**			$148,022	$53,283	**$201,306**

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

****** CONTRACT COST SUMMARY ******

PROJECT: Houston Ship Channel Improvement Project (NED Plan)
LOCATION: Houston Ship Channel, Texas
This Estimate reflects the scope and schedule in report; HSC Feasibility

DISTRICT: Galveston District PREPARED: 12/5/2019
POC: CHIEF, COST ENGINEERING, Martin Regner, P.E.

Civil Works Work Breakdown Structure		ESTIMATED COST				PROJECT FIRST COST (Constant Dollar Basis)				TOTAL PROJECT COST (FULLY FUNDED)				
		Estimate Prepared: / Effective Price Level:			4-Dec-19 / 1-Oct-19		Program Year (Budget EC): / Effective Price Level Date:		2020 / 1 OCT 19					
WBS NUMBER	Civil Works Feature & Sub-Feature Description	COST ($K)	CNTG ($K)	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
	Segment 3													
02	RELOCATIONS	$0	$0	36.0%	$0	0.0%	$0	$0	$0	0	0.0%	$0	$0	$0
06	FISH & WILDLIFE FACILITIES	$5,520	$1,987	36.0%	$7,507	0.0%	$5,520	$1,987	$7,507	2025Q3	17.9%	$6,509	$2,343	$8,852
12	NAVIGATION PORTS & HARBORS	$94,186	$33,907	36.0%	$128,093	0.0%	$94,186	$33,907	$128,093	2025Q4	18.8%	$111,893	$40,281	$152,174
	CONSTRUCTION ESTIMATE TOTALS:	$99,706	$35,894	36.0%	**$135,600**		$99,706	$35,894	$135,600			$118,402	$42,625	$161,026
01	LANDS AND DAMAGES	$38	$9	25.0%	$47	0.0%	$38	$9	$47	2025Q1	16.2%	$44	$11	$54
30	PLANNING, ENGINEERING & DESIGN													
0.8%	Project Management	$748	$269	36.0%	$1,017	0.0%	$748	$269	$1,017	2024Q3	18.4%	$886	$319	$1,205
0.5%	Planning & Environmental Compliance	$499	$179	36.0%	$678	0.0%	$499	$179	$678	2024Q3	18.4%	$590	$213	$803
3.0%	Engineering & Design	$2,991	$1,077	36.0%	$4,068	0.0%	$2,991	$1,077	$4,068	2024Q3	18.4%	$3,543	$1,275	$4,818
0.5%	Reviews, ATRs, IEPRs, VE	$499	$179	36.0%	$678	0.0%	$499	$179	$678	2024Q3	18.4%	$590	$213	$803
0.5%	Life Cycle Updates (cost, schedule, risks)	$499	$179	36.0%	$678	0.0%	$499	$179	$678	2024Q3	18.4%	$590	$213	$803
0.5%	Contracting & Reprographics	$499	$179	36.0%	$678	0.0%	$499	$179	$678	2024Q3	18.4%	$590	$213	$803
1.0%	Engineering During Construction	$997	$359	36.0%	$1,356	0.0%	$997	$359	$1,356	2025Q3	23.0%	$1,227	$442	$1,668
0.5%	Planning During Construction	$499	$179	36.0%	$678	0.0%	$499	$179	$678	2025Q3	23.0%	$613	$221	$834
0.5%	Adaptive Management & Monitoring	$499	$179	36.0%	$678	0.0%	$499	$179	$678	2024Q3	18.4%	$590	$213	$803
1.0%	Project Operations	$997	$359	36.0%	$1,356	0.0%	$997	$359	$1,356	2024Q3	18.4%	$1,181	$425	$1,606
31	CONSTRUCTION MANAGEMENT													
3.0%	Construction Management	$2,991	$1,077	36.0%	$4,068	0.0%	$2,991	$1,077	$4,068	2025Q3	23.0%	$3,680	$1,325	$5,005
1.0%	Project Operation:	$997	$359	36.0%	$1,356	0.0%	$997	$359	$1,356	2025Q3	23.0%	$1,227	$442	$1,668
1.0%	Project Management	$997	$359	36.0%	$1,356	0.0%	$997	$359	$1,356	2025Q3	23.0%	$1,227	$442	$1,668
	CONTRACT COST TOTALS:	$113,453	$40,839		**$154,292**		$113,453	$40,839	**$154,292**			$134,981	$48,588	**$183,569**

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

**** CONTRACT COST SUMMARY ****

PROJECT: Houston Ship Channel Improvement Project (NED Plan)
LOCATION: Houston Ship Channel, Texas
This Estimate reflects the scope and schedule in report; HSC Feasibility

DISTRICT: Galveston District PREPARED: 12/5/2019
POC: CHIEF, COST ENGINEERING, Martin Regner, P.E.

Civil Works Work Breakdown Structure		ESTIMATED COST				PROJECT FIRST COST (Constant Dollar Basis)				TOTAL PROJECT COST (FULLY FUNDED)				
		Estimate Prepared:			4-Dec-19	Program Year (Budget EC):			2020					
		Effective Price Level:			1-Oct-19	Effective Price Level Date:			1 OCT 19	FULLY FUNDED PROJECT ESTIMATE				
WBS NUMBER	Civil Works Feature & Sub-Feature Description	COST ($K)	CNTG ($K)	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
	Segment 4													
02	RELOCATIONS	$25,420	$9,151	36.0%	$34,571	0.0%	$25,420	$9,151	$34,571	2023Q1	9.5%	$27,832	$10,019	$37,851
06	FISH & WILDLIFE FACILITIES	$7,184	$2,586	36.0%	$9,771	0.0%	$7,184	$2,586	$9,771	2023Q4	12.0%	$8,045	$2,896	$10,941
12	NAVIGATION PORTS & HARBORS	$51,415	$18,509	36.0%	$69,924	0.0%	$51,415	$18,509	$69,924	2023Q4	12.0%	$57,574	$20,727	$78,301
	CONSTRUCTION ESTIMATE TOTALS:	$84,019	$30,247	36.0%	**$114,266**		$84,019	$30,247	$114,266			$93,451	$33,642	$127,094
01	LANDS AND DAMAGES	$11,396	$2,849	25.0%	$14,245	0.0%	$11,396	$2,849	$14,245	2023Q1	9.5%	$12,478	$3,119	$15,597
30	PLANNING, ENGINEERING & DESIGN													
0.8%	Project Management	$630	$227	36.0%	$857	0.0%	$630	$227	$857	2022Q4	10.9%	$699	$252	$951
0.5%	Planning & Environmental Compliance	$420	$151	36.0%	$571	0.0%	$420	$151	$571	2022Q4	10.9%	$466	$168	$634
3.0%	Engineering & Design	$2,521	$907	36.0%	$3,428	0.0%	$2,521	$907	$3,428	2022Q4	10.9%	$2,796	$1,007	$3,803
0.5%	Reviews, ATRs, IEPRs, VE	$420	$151	36.0%	$571	0.0%	$420	$151	$571	2022Q4	10.9%	$466	$168	$634
0.5%	Life Cycle Updates (cost, schedule, risks)	$420	$151	36.0%	$571	0.0%	$420	$151	$571	2022Q4	10.9%	$466	$168	$634
0.5%	Contracting & Reprographics	$420	$151	36.0%	$571	0.0%	$420	$151	$571	2022Q4	10.9%	$466	$168	$634
1.0%	Engineering During Construction	$840	$302	36.0%	$1,143	0.0%	$840	$302	$1,143	2024Q4	19.6%	$1,005	$362	$1,366
0.5%	Planning During Construction	$420	$151	36.0%	$571	0.0%	$420	$151	$571	2024Q4	19.6%	$502	$181	$683
0.5%	Adaptive Management & Monitoring	$420	$151	36.0%	$571	0.0%	$420	$151	$571	2022Q4	10.9%	$466	$168	$634
1.0%	Project Operations	$840	$302	36.0%	$1,143	0.0%	$840	$302	$1,143	2022Q4	10.9%	$932	$336	$1,268
31	CONSTRUCTION MANAGEMENT													
3.0%	Construction Management	$2,521	$907	36.0%	$3,428	0.0%	$2,521	$907	$3,428	2024Q4	19.6%	$3,014	$1,085	$4,099
1.0%	Project Operation:	$840	$302	36.0%	$1,143	0.0%	$840	$302	$1,143	2024Q4	19.6%	$1,005	$362	$1,366
1.0%	Project Management	$840	$302	36.0%	$1,143	0.0%	$840	$302	$1,143	2024Q4	19.6%	$1,005	$362	$1,366
	CONTRACT COST TOTALS:	$106,968	$37,255		**$144,223**		$106,968	$37,255	**$144,223**			$119,218	$41,546	**$160,764**

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

****** CONTRACT COST SUMMARY ******

PROJECT: Houston Ship Channel Improvement Project (NED Plan)
LOCATION: Houston Ship Channel, Texas
This Estimate reflects the scope and schedule in report; HSC Feasibility

DISTRICT: Galveston District PREPARED: 12/5/2019
POC: CHIEF, COST ENGINEERING, Martin Regner, P.E.

Civil Works Work Breakdown Structure		ESTIMATED COST				PROJECT FIRST COST (Constant Dollar Basis)				TOTAL PROJECT COST (FULLY FUNDED)				
		Estimate Prepared: / Effective Price Level:			4-Dec-19 / 1-Oct-19	Program Year (Budget EC): / Effective Price Level Date:			2020 / 1 OCT 19	FULLY FUNDED PROJECT ESTIMATE				
WBS NUMBER	Civil Works Feature & Sub-Feature Description	COST ($K)	CNTG ($K)	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*
	Segment 5													
02	RELOCATIONS	$0	$0	36.0%	$0	0.0%	$0	$0	$0	0	0.0%	$0	$0	$0
06	FISH & WILDLIFE FACILITIES	$370	$133	36.0%	$503	0.0%	$370	$133	$503	2026Q3	21.5%	$450	$162	$611
12	NAVIGATION PORTS & HARBORS	$3,827	$1,378	36.0%	$5,205	0.0%	$3,827	$1,378	$5,205	2026Q3	21.5%	$4,649	$1,673	$6,322
	CONSTRUCTION ESTIMATE TOTALS:	$4,198	$1,511	36.0%	**$5,709**		$4,198	$1,511	$5,709			$5,098	$1,835	$6,934
01	LANDS AND DAMAGES	$19	$5	25.0%	$23	0.0%	$19	$5	$23	2026Q1	19.6%	$22	$6	$28
30	PLANNING, ENGINEERING & DESIGN													
0.8%	Project Management	$31	$11	36.0%	$43	0.0%	$31	$11	$43	2025Q3	23.0%	$39	$14	$53
0.5%	Planning & Environmental Compliance	$21	$8	36.0%	$29	0.0%	$21	$8	$29	2025Q3	23.0%	$26	$9	$35
3.0%	Engineering & Design	$126	$45	36.0%	$171	0.0%	$126	$45	$171	2025Q3	23.0%	$155	$56	$211
0.5%	Reviews, ATRs, IEPRs, VE	$21	$8	36.0%	$29	0.0%	$21	$8	$29	2025Q3	23.0%	$26	$9	$35
0.5%	Life Cycle Updates (cost, schedule, risks)	$21	$8	36.0%	$29	0.0%	$21	$8	$29	2025Q3	23.0%	$26	$9	$35
0.5%	Contracting & Reprographics	$21	$8	36.0%	$29	0.0%	$21	$8	$29	2025Q3	23.0%	$26	$9	$35
1.0%	Engineering During Construction	$42	$15	36.0%	$57	0.0%	$42	$15	$57	2026Q3	27.7%	$54	$19	$73
0.5%	Planning During Construction	$21	$8	36.0%	$29	0.0%	$21	$8	$29	2026Q3	27.7%	$27	$10	$36
0.5%	Adaptive Management & Monitoring	$21	$8	36.0%	$29	0.0%	$21	$8	$29	2025Q3	23.0%	$26	$9	$35
1.0%	Project Operations	$42	$15	36.0%	$57	0.0%	$42	$15	$57	2025Q3	23.0%	$52	$19	$70
31	CONSTRUCTION MANAGEMENT													
3.0%	Construction Management	$126	$45	36.0%	$171	0.0%	$126	$45	$171	2026Q3	27.7%	$161	$58	$219
1.0%	Project Operation:	$42	$15	36.0%	$57	0.0%	$42	$15	$57	2026Q3	27.7%	$54	$19	$73
1.0%	Project Management	$42	$15	36.0%	$57	0.0%	$42	$15	$57	2026Q3	27.7%	$54	$19	$73
	CONTRACT COST TOTALS:	$4,793	$1,724		**$6,517**		$4,793	$1,724	**$6,517**			$5,843	$2,101	**$7,945**

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

**** CONTRACT COST SUMMARY ****

PROJECT: Houston Ship Channel Improvement Project (NED Plan)
LOCATION: Houston Ship Channel, Texas
This Estimate reflects the scope and schedule in report; HSC Feasibility

DISTRICT: Galveston District PREPARED: 12/5/2019
POC: CHIEF, COST ENGINEERING, Martin Regner, P.E.

Civil Works Work Breakdown Structure		ESTIMATED COST				PROJECT FIRST COST (Constant Dollar Basis)				TOTAL PROJECT COST (FULLY FUNDED)				
		Estimate Prepared: / Effective Price Level:			4-Dec-19 / 1-Oct-19		Program Year (Budget EC): / Effective Price Level Date:		2020 / 1 OCT 19	FULLY FUNDED PROJECT ESTIMATE				
WBS NUMBER	Civil Works Feature & Sub-Feature Description	COST ($K)	CNTG ($K)	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
	Segment 6													
02	RELOCATIONS	$0	$0	36.0%	$0	0.0%	$0	$0	$0	0	0.0%	$0	$0	$0
06	FISH & WILDLIFE FACILITIES	$1,056	$380	36.0%	$1,436	0.0%	$1,056	$380	$1,436	2026Q3	21.5%	$1,282	$462	$1,744
12	NAVIGATION PORTS & HARBORS	$30,090	$10,833	36.0%	$40,923	0.0%	$30,090	$10,833	$40,923	2026Q3	21.5%	$36,547	$13,157	$49,704
	CONSTRUCTION ESTIMATE TOTALS:	$31,146	$11,213	36.0%	**$42,359**		$31,146	$11,213	$42,359			$37,829	$13,618	$51,447
01	LANDS AND DAMAGES	$153	$38	25.0%	$191	0.0%	$153	$38	$191	2026Q1	19.6%	$183	$46	$229
30	PLANNING, ENGINEERING & DESIGN													
0.8%	Project Management	$234	$84	36.0%	$318	0.0%	$234	$84	$318	2025Q3	23.0%	$287	$103	$391
0.5%	Planning & Environmental Compliance	$156	$56	36.0%	$212	0.0%	$156	$56	$212	2025Q3	23.0%	$192	$69	$261
3.0%	Engineering & Design	$934	$336	36.0%	$1,271	0.0%	$934	$336	$1,271	2025Q3	23.0%	$1,150	$414	$1,563
0.5%	Reviews, ATRs, IEPRs, VE	$156	$56	36.0%	$212	0.0%	$156	$56	$212	2025Q3	23.0%	$192	$69	$261
0.5%	Life Cycle Updates (cost, schedule, risks)	$156	$56	36.0%	$212	0.0%	$156	$56	$212	2025Q3	23.0%	$192	$69	$261
0.5%	Contracting & Reprographics	$156	$56	36.0%	$212	0.0%	$156	$56	$212	2025Q3	23.0%	$192	$69	$261
1.0%	Engineering During Construction	$311	$112	36.0%	$424	0.0%	$311	$112	$424	2026Q3	27.7%	$398	$143	$541
0.5%	Planning During Construction	$156	$56	36.0%	$212	0.0%	$156	$56	$212	2026Q3	27.7%	$199	$72	$270
0.5%	Adaptive Management & Monitoring	$156	$56	36.0%	$212	0.0%	$156	$56	$212	2025Q3	23.0%	$192	$69	$261
1.0%	Project Operations	$311	$112	36.0%	$424	0.0%	$311	$112	$424	2025Q3	23.0%	$383	$138	$521
31	CONSTRUCTION MANAGEMENT													
3.0%	Construction Management	$934	$336	36.0%	$1,271	0.0%	$934	$336	$1,271	2026Q3	27.7%	$1,193	$430	$1,623
1.0%	Project Operation:	$311	$112	36.0%	$424	0.0%	$311	$112	$424	2026Q3	27.7%	$398	$143	$541
1.0%	Project Management	$311	$112	36.0%	$424	0.0%	$311	$112	$424	2026Q3	27.7%	$398	$143	$541
	CONTRACT COST TOTALS:	$35,582	$12,793		**$48,374**		$35,582	$12,793	**$48,374**			$43,376	$15,595	**$58,971**

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

**** CONTRACT COST SUMMARY ****

PROJECT: Houston Ship Channel Improvement Project (NED Plan)
LOCATION: Houston Ship Channel, Texas
This Estimate reflects the scope and schedule in report; HSC Feasibility

DISTRICT: Galveston District PREPARED: 12/5/2019
POC: CHIEF, COST ENGINEERING, Martin Regner, P.E.

Civil Works Work Breakdown Structure		ESTIMATED COST				PROJECT FIRST COST (Constant Dollar Basis)				TOTAL PROJECT COST (FULLY FUNDED)				
		Estimate Prepared:			4-Dec-19	Program Year (Budget EC):			2020	FULLY FUNDED PROJECT ESTIMATE				
		Effective Price Level:			1-Oct-19	Effective Price Level Date:			1 OCT 19					
WBS NUMBER	Civil Works Feature & Sub-Feature Description	COST ($K)	CNTG ($K)	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
	Associated Costs													
12	NAVIGATION PORTS & HARBORS (Aids to Navigation)	$2,845	$1,024	36.0%	$3,869	0.0%	$2,845	$1,024	$3,869	2023Q4	12.0%	$3,186	$1,147	$4,332
12	NAVIGATION PORTS & HARBORS (Local Service Facilities)	$56,262	$20,254	36.0%	$76,516	0.0%	$56,262	$20,254	$76,516	2023Q4	12.0%	$63,002	$22,681	$85,683
	CONSTRUCTION ESTIMATE TOTALS:	$59,107	$21,278	36.0%	**$80,385**		$59,107	$21,278	$80,385			$66,188	$23,828	$90,016
01	LANDS AND DAMAGES	$0	$0	0.0%	$0	0.0%	$0	$0	$0	0	0.0%	$0	$0	$0
30	PLANNING, ENGINEERING & DESIGN													
0.0%	Project Management	$0	$0	0.0%	$0	0.0%	$0	$0	$0	0	0.0%	$0	$0	$0
0.0%	Planning & Environmental Compliance	$0	$0	0.0%	$0	0.0%	$0	$0	$0	0	0.0%	$0	$0	$0
0.0%	Engineering & Design	$0	$0	0.0%	$0	0.0%	$0	$0	$0	0	0.0%	$0	$0	$0
0.0%	Reviews, ATRs, IEPRs, VE	$0	$0	0.0%	$0	0.0%	$0	$0	$0	0	0.0%	$0	$0	$0
0.0%	Life Cycle Updates (cost, schedule, risks)	$0	$0	0.0%	$0	0.0%	$0	$0	$0	0	0.0%	$0	$0	$0
0.0%	Contracting & Reprographics	$0	$0	0.0%	$0	0.0%	$0	$0	$0	0	0.0%	$0	$0	$0
0.0%	Engineering During Construction	$0	$0	0.0%	$0	0.0%	$0	$0	$0	0	0.0%	$0	$0	$0
0.0%	Planning During Construction	$0	$0	0.0%	$0	0.0%	$0	$0	$0	0	0.0%	$0	$0	$0
0.0%	Adaptive Management & Monitoring	$0	$0	0.0%	$0	0.0%	$0	$0	$0	0	0.0%	$0	$0	$0
0.0%	Project Operations	$0	$0	0.0%	$0	0.0%	$0	$0	$0	0	0.0%	$0	$0	$0
31	CONSTRUCTION MANAGEMENT													
0.0%	Construction Management	$0	$0	0.0%	$0	0.0%	$0	$0	$0	0	0.0%	$0	$0	$0
0.0%	Project Operation:	$0	$0	0.0%	$0	0.0%	$0	$0	$0	0	0.0%	$0	$0	$0
0.0%	Project Management	$0	$0	0.0%	$0	0.0%	$0	$0	$0	0	0.0%	$0	$0	$0
	CONTRACT COST TOTALS:	$59,107	$21,278		**$80,385**		$59,107	$21,278	**$80,385**			$66,188	$23,828	**$90,016**

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

****** CONTRACT COST SUMMARY ******

PROJECT: Houston Ship Channel Improvement Project (NED Plan)
LOCATION: Houston Ship Channel, Texas
This Estimate reflects the scope and schedule in report; HSC Feasibility

DISTRICT: Galveston District PREPARED: 12/5/2019
POC: CHIEF, COST ENGINEERING, Martin Regner, P.E.

Civil Works Work Breakdown Structure		ESTIMATED COST				PROJECT FIRST COST (Constant Dollar Basis)				TOTAL PROJECT COST (FULLY FUNDED)				
		Estimate Prepared: / Effective Price Level:			4-Dec-19 / 1-Oct-19		Program Year (Budget EC): / Effective Price Level Date:		2020 / 1 OCT 19	FULLY FUNDED PROJECT ESTIMATE				
WBS NUMBER	Civil Works Feature & Sub-Feature Description	COST ($K)	CNTG ($K)	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
	O&M Costs													
12	NAVIGATION PORTS & HARBORS Total 50-Yr O&M Costs	$3,121,567	$0	0.0%	$3,121,567	0.0%	$3,121,567	$0	$3,121,567	2054Q1	173.7%	$8,544,692	$0	$8,544,692
	CONSTRUCTION ESTIMATE TOTALS:	$3,121,567	$0	0.0%	**3,121,567**		$3,121,567	$0	$3,121,567			$8,544,692	$0	$8,544,692
01	LANDS AND DAMAGES	$0	$0	0.0%	$ -	0.0%	$0	$0	$0	0	0.0%	$0	$0	$0
30	PLANNING, ENGINEERING & DESIGN													
0.5%	Project Management	$16,321	$3,427	21.0%	$19,749	0.0%	$16,321	$3,427	$19,749	2053Q3	280.1%	$62,038	$13,028	$75,066
0.3%	Planning & Environmental Compliance	$10,881	$2,285	21.0%	$13,166	0.0%	$10,881	$2,285	$13,166	2053Q3	280.1%	$41,358	$8,685	$50,044
2.1%	Engineering & Design	$65,285	$13,710	21.0%	$78,995	0.0%	$65,285	$13,710	$78,995	2053Q3	280.1%	$248,151	$52,112	$300,262
0.3%	Reviews, ATRs, IEPRs, VE	$10,881	$2,285	21.0%	$13,166	0.0%	$10,881	$2,285	$13,166	2053Q3	280.1%	$41,358	$8,685	$50,044
0.3%	Life Cycle Updates (cost, schedule, risks)	$10,881	$2,285	21.0%	$13,166	0.0%	$10,881	$2,285	$13,166	2053Q3	280.1%	$41,358	$8,685	$50,044
0.3%	Contracting & Reprographics	$10,881	$2,285	21.0%	$13,166	0.0%	$10,881	$2,285	$13,166	2053Q3	280.1%	$41,358	$8,685	$50,044
0.7%	Engineering During Construction	$21,762	$4,570	21.0%	$26,332	0.0%	$21,762	$4,570	$26,332	2054Q1	288.0%	$84,436	$17,732	$102,167
0.3%	Planning During Construction	$10,881	$2,285	21.0%	$13,166	0.0%	$10,881	$2,285	$13,166	2054Q1	288.0%	$42,218	$8,866	$51,084
0.3%	Adaptive Management & Monitoring	$10,881	$2,285	21.0%	$13,166	0.0%	$10,881	$2,285	$13,166	2054Q1	288.0%	$42,218	$8,866	$51,084
0.7%	Project Operations	$21,762	$4,570	21.0%	$26,332	0.0%	$21,762	$4,570	$26,332	2053Q3	280.1%	$82,717	$17,371	$100,087
31	CONSTRUCTION MANAGEMENT													
2.3%	Construction Management	$71,172	$14,946	21.0%	86,118	0.0%	$71,172	$14,946	$86,118	2054Q1	288.0%	$276,147	$57,991	$334,138
0.8%	Project Operation:	$23,724	$4,982	21.0%	28,706	0.0%	$23,724	$4,982	$28,706	2054Q1	288.0%	$92,049	$19,330	$111,379
0.8%	Project Management	$23,724	$4,982	21.0%	28,706	0.0%	$23,724	$4,982	$28,706	2054Q1	288.0%	$92,049	$19,330	$111,379
	CONTRACT COST TOTALS:	$3,430,602	$64,897		**3,495,500**		$3,430,602	$64,897	**$3,495,500**			$9,732,148	$249,366	**$9,981,513**

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

****** CONTRACT COST SUMMARY ******

PROJECT: Houston Ship Channel Improvement Project (NED Plan)
LOCATION: Houston Ship Channel, Texas
This Estimate reflects the scope and schedule in report; HSC Feasibility

DISTRICT: Galveston District PREPARED: 12/5/2019
POC: CHIEF, COST ENGINEERING, Martin Regner, P.E.

Civil Works Work Breakdown Structure		ESTIMATED COST				PROJECT FIRST COST (Constant Dollar Basis)				TOTAL PROJECT COST (FULLY FUNDED)				
		Estimate Prepared:			4-Dec-19	Program Year (Budget EC):			2020					
		Effective Price Level:			1-Oct-19	Effective Price Level Date:			1 OCT 19	FULLY FUNDED PROJECT ESTIMATE				
WBS NUMBER	Civil Works Feature & Sub-Feature Description	COST ($K)	CNTG ($K)	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
	O&M COSTS													
12	NAVIGATION PORTS & HARBORS Increase in 50-Yr O&M Costs	$499,180	$104,828	21.0%	$604,008	0.0%	$499,180	$104,828	$604,008	2054Q1	173.7%	$1,366,410	$286,946	$1,653,356
	CONSTRUCTION ESTIMATE TOTALS:	$499,180	$104,828	21.0%	**$604,008**		$499,180	$104,828	$604,008			$1,366,410	$286,946	$1,653,356
01	LANDS AND DAMAGES	$0	$0	0.0%	$0	0.0%	$0	$0	$0	0	0.0%	$0	$0	$0
30	PLANNING, ENGINEERING & DESIGN													
0.5%	Project Management	$2,610	$548	21.0%	$3,158	0.0%	$2,610	$548	$3,158	2053Q3	280.1%	$9,921	$2,083	$12,004
0.3%	Planning & Environmental Compliance	$1,740	$365	21.0%	$2,105	0.0%	$1,740	$365	$2,105	2053Q3	280.1%	$6,614	$1,389	$8,003
2.1%	Engineering & Design	$10,440	$2,192	21.0%	$12,632	0.0%	$10,440	$2,192	$12,632	2053Q3	280.1%	$39,683	$8,333	$48,016
0.3%	Reviews, ATRs, IEPRs, VE	$1,740	$365	21.0%	$2,105	0.0%	$1,740	$365	$2,105	2053Q3	280.1%	$6,614	$1,389	$8,003
0.3%	Life Cycle Updates (cost, schedule, risks)	$1,740	$365	21.0%	$2,105	0.0%	$1,740	$365	$2,105	2053Q3	280.1%	$6,614	$1,389	$8,003
0.3%	Contracting & Reprographics	$1,740	$365	21.0%	$2,105	0.0%	$1,740	$365	$2,105	2053Q3	280.1%	$6,614	$1,389	$8,003
0.7%	Engineering During Construction	$3,480	$731	21.0%	$4,211	0.0%	$3,480	$731	$4,211	2054Q1	288.0%	$13,502	$2,836	$16,338
0.3%	Planning During Construction	$1,740	$365	21.0%	$2,105	0.0%	$1,740	$365	$2,105	2054Q1	288.0%	$6,751	$1,418	$8,169
0.3%	Adaptive Management & Monitoring	$1,740	$365	21.0%	$2,105	0.0%	$1,740	$365	$2,105	2054Q1	288.0%	$6,751	$1,418	$8,169
0.7%	Project Operations	$3,480	$731	21.0%	$4,211	0.0%	$3,480	$731	$4,211	2053Q3	280.1%	$13,228	$2,778	$16,005
31	CONSTRUCTION MANAGEMENT													
2.3%	Construction Management	$11,381	$2,390	21.0%	$13,771	0.0%	$11,381	$2,390	$13,771	2054Q1	288.0%	$44,160	$9,274	$53,433
0.8%	Project Operation:	$3,794	$797	21.0%	$4,590	0.0%	$3,794	$797	$4,590	2054Q1	288.0%	$14,720	$3,091	$17,811
0.8%	Project Management	$3,794	$797	21.0%	$4,590	0.0%	$3,794	$797	$4,590	2054Q1	288.0%	$14,720	$3,091	$17,811
	CONTRACT COST TOTALS:	$548,599	$115,206		**$663,805**		$548,599	$115,206	**$663,805**			$1,556,300	$326,823	**$1,883,123**

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

PROJECT: Houston Ship Channel Improvement Project (LPP Plan)
PROJECT NO: P2 451902
LOCATION: Houston Ship Channel, Texas

DISTRICT: Galveston District **PREPARED:** **12/5/2019**
POC: CHIEF, COST ENGINEERING, Martin Regner, P.E.

This Estimate reflects the scope and schedule in report; HSC Feasibility

Civil Works Work Breakdown Structure		ESTIMATED COST				PROJECT FIRST COST (Constant Dollar Basis)						TOTAL PROJECT COST (FULLY FUNDED)			
						Program Year (Budget EC): 2020									
						Effective Price Level Date: 1 OCT 19									
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-19 ($K)	TOTAL FIRST COST ($K)	INFLATED (%)	COST ($K)	CNTG ($K)	FULL ($K)
A	B	C	D	E	F	G	H	I	J		K	L	M	N	O
02	RELOCATIONS	$26,870	$10,479	39.0%	$37,350	0.0%	$26,870	$10,479	$37,350	$0	$37,350	9.6%	$29,444	$11,483	$40,927
06	FISH & WILDLIFE FACILITIES	$58,819	$22,939	39.0%	$81,758	0.0%	$58,819	$22,939	$81,758	$0	$81,758	11.9%	$65,835	$25,676	$91,511
12	NAVIGATION PORTS & HARBORS	$459,613	$179,249	39.0%	$638,862	0.0%	$459,613	$179,249	$638,862	$0	$638,862	14.2%	$524,657	$204,616	$729,274
	CONSTRUCTION ESTIMATE TOTALS:	$545,302	$212,668		$757,969	0.0%	$545,302	$212,668	$757,969	$0	$757,969	13.7%	$619,937	$241,775	$861,712
01	LANDS AND DAMAGES	$11,726	$2,932	25.0%	$14,658	0.0%	$11,726	$2,932	$14,658	$0	$14,658	9.7%	$12,861	$3,215	$16,077
30	PLANNING, ENGINEERING & DESIGN	$47,714	$18,608	39.0%	$66,322	0.0%	$47,714	$18,608	$66,322	$0	$66,322	13.5%	$54,142	$21,115	$75,257
31	CONSTRUCTION MANAGEMENT	$27,265	$10,633	39.0%	$37,898	0.0%	$27,265	$10,633	$37,898	$0	$37,898	15.7%	$31,558	$12,308	$43,866
	PROJECT COST TOTALS:	$632,007	$244,841	38.7%	$876,848		$632,007	$244,841	**$876,848**	$0	**$876,848**	13.7%	$718,498	$278,414	$996,912

REGNER.MARTIN.B.13673 77794 Digitally signed by REGNER.MARTIN.B.1367377794 Date: 2019.12.09 10:48:34 -06'00'

CHIEF, COST ENGINEERING, Martin Regner, P.E.

PROJECT MANAGER, Andrea Catanzaro

CHIEF, REAL ESTATE, Timothy Nelson

CHIEF, PLANNING, Robert Newman

CHIEF, ENGINEERING, Willie J. Honza, P.E.

CHIEF, OPERATIONS, Joe Hrametz. P.E.

CHIEF, CONSTRUCTION, Donald Carelock, P.E.

CHIEF, CONTRACTING,Jeffrey Neill

CHIEF, PM-PB, Valerie Miller

CHIEF, DPM, Edmund P. Russo, Jr., PHD, P.E., D.CE, D.NE.

ESTIMATED TOTAL PROJECT COST: **$996,912**

ASSOCIATED COSTS: **$92,696**

ESTIMATED TOTAL 50 YR O&M Costs: **$10,331,048**
Beginning 2029 and includes 21% contingency

ESTIMATED TOTAL 50 YR O&M INCREASE : **$2,204,310**
Beginning 2029 and includes 21% contingency

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

****** CONTRACT COST SUMMARY ******

PROJECT: Houston Ship Channel Improvement Project (LPP Plan)
LOCATION: Houston Ship Channel, Texas
This Estimate reflects the scope and schedule in report; HSC Feasibility

DISTRICT: Galveston District PREPARED: 12/5/2019
POC: CHIEF, COST ENGINEERING, Martin Regner, P.E.

Civil Works Work Breakdown Structure		ESTIMATED COST				PROJECT FIRST COST (Constant Dollar Basis)				TOTAL PROJECT COST (FULLY FUNDED)				
		Estimate Prepared: / Effective Price Level:			4-Dec-19 / 1-Oct-19	Program Year (Budget EC): / Effective Price Level Date:			2020 / 1 OCT 19					
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
	Segment 1													
02	RELOCATIONS	$1,451	$566	39.0%	$2,017	0.0%	$1,451	$566	$2,017	2023Q3	11.1%	$1,612	$629	$2,241
06	FISH & WILDLIFE FACILITIES	$46,172	$18,007	39.0%	$64,179	0.0%	$46,172	$18,007	$64,179	2023Q3	11.1%	$51,320	$20,015	$71,334
12	NAVIGATION PORTS & HARBORS	$226,763	$88,438	39.0%	$315,201	0.0%	$226,763	$88,438	$315,201	2023Q3	11.1%	$252,047	$98,298	$350,345
	CONSTRUCTION ESTIMATE TOTALS:	$274,386	$107,010	39.0%	**$381,396**		$274,386	$107,010	$381,396			$304,979	$118,942	$423,921
01	LANDS AND DAMAGES	$102	$26	25.0%	$128	0.0%	$102	$26	$128	2023Q3	11.1%	$113	$28	$142
30	PLANNING, ENGINEERING & DESIGN													
0.8%	Project Management	$2,058	$803	39.0%	$2,860	0.0%	$2,058	$803	$2,860	2022Q3	9.9%	$2,262	$882	$3,144
0.5%	Planning & Environmental Compliance	$1,372	$535	39.0%	$1,907	0.0%	$1,372	$535	$1,907	2022Q3	9.9%	$1,508	$588	$2,096
3.0%	Engineering & Design	$8,232	$3,210	39.0%	$11,442	0.0%	$8,232	$3,210	$11,442	2022Q3	9.9%	$9,047	$3,528	$12,575
0.5%	Reviews, ATRs, IEPRs, VE	$1,372	$535	39.0%	$1,907	0.0%	$1,372	$535	$1,907	2022Q3	9.9%	$1,508	$588	$2,096
0.5%	Life Cycle Updates (cost, schedule, risks)	$1,372	$535	39.0%	$1,907	0.0%	$1,372	$535	$1,907	2022Q3	9.9%	$1,508	$588	$2,096
0.5%	Contracting & Reprographics	$1,372	$535	39.0%	$1,907	0.0%	$1,372	$535	$1,907	2022Q3	9.9%	$1,508	$588	$2,096
1.0%	Engineering During Construction	$2,744	$1,070	39.0%	$3,814	0.0%	$2,744	$1,070	$3,814	2022Q3	9.9%	$3,016	$1,176	$4,192
0.5%	Planning During Construction	$1,372	$535	39.0%	$1,907	0.0%	$1,372	$535	$1,907	2022Q3	9.9%	$1,508	$588	$2,096
0.5%	Adaptive Management & Monitoring	$1,372	$535	39.0%	$1,907	0.0%	$1,372	$535	$1,907	2023Q3	14.1%	$1,565	$610	$2,175
1.0%	Project Operations	$2,744	$1,070	39.0%	$3,814	0.0%	$2,744	$1,070	$3,814	2022Q3	9.9%	$3,016	$1,176	$4,192
31	CONSTRUCTION MANAGEMENT													
3.0%	Construction Management	$8,232	$3,210	39.0%	$11,442	0.0%	$8,232	$3,210	$11,442	2022Q3	9.9%	$9,047	$3,528	$12,575
1.0%	Project Operation:	$2,744	$1,070	39.0%	$3,814	0.0%	$2,744	$1,070	$3,814	2022Q3	9.9%	$3,016	$1,176	$4,192
1.0%	Project Management	$2,744	$1,070	39.0%	$3,814	0.0%	$2,744	$1,070	$3,814	2022Q3	9.9%	$3,016	$1,176	$4,192
	CONTRACT COST TOTALS:	$312,216	$121,750		$433,965		$312,216	$121,750	**$433,965**			$346,615	$135,164	**$481,778**

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

****** CONTRACT COST SUMMARY ******

PROJECT: Houston Ship Channel Improvement Project (LPP Plan)
LOCATION: Houston Ship Channel, Texas
This Estimate reflects the scope and schedule in report; HSC Feasibility

DISTRICT: Galveston District PREPARED: 12/5/2019
POC: CHIEF, COST ENGINEERING, Martin Regner, P.E.

Civil Works Work Breakdown Structure		ESTIMATED COST				PROJECT FIRST COST (Constant Dollar Basis)				TOTAL PROJECT COST (FULLY FUNDED)				
		Estimate Prepared: / Effective Price Level:			4-Dec-19 / 1-Oct-19	Program Year (Budget EC): / Effective Price Level Date:			2020 / 1 OCT 19					
WBS NUMBER	Civil Works Feature & Sub-Feature Description	COST ($K)	CNTG ($K)	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
	Segment 2													
02	RELOCATIONS	$0	$0	39.0%	$0	0.0%	$0	$0	$0	0	0.0%	$0	$0	$0
06	FISH & WILDLIFE FACILITIES	$599	$234	39.0%	$833	0.0%	$599	$234	$833	2024Q3	14.5%	$686	$267	$953
12	NAVIGATION PORTS & HARBORS	$53,331	$20,799	39.0%	$74,130	0.0%	$53,331	$20,799	$74,130	2025Q1	16.2%	$61,948	$24,160	$86,107
	CONSTRUCTION ESTIMATE TOTALS:	$53,930	$21,033	39.0%	**$74,963**		$53,930	$21,033	$74,963			$62,633	$24,427	$87,061
01	LANDS AND DAMAGES	$19	$5	25.0%	$23	0.0%	$19	$5	$23	2024Q3	14.5%	$21	$5	$27
30	PLANNING, ENGINEERING & DESIGN													
0.8%	Project Management	$404	$158	39.0%	$562	0.0%	$404	$158	$562	2023Q3	14.1%	$461	$180	$641
0.5%	Planning & Environmental Compliance	$270	$105	39.0%	$375	0.0%	$270	$105	$375	2023Q3	14.1%	$308	$120	$428
3.0%	Engineering & Design	$1,618	$631	39.0%	$2,249	0.0%	$1,618	$631	$2,249	2023Q3	14.1%	$1,846	$720	$2,566
0.5%	Reviews, ATRs, IEPRs, VE	$270	$105	39.0%	$375	0.0%	$270	$105	$375	2023Q3	14.1%	$308	$120	$428
0.5%	Life Cycle Updates (cost, schedule, risks)	$270	$105	39.0%	$375	0.0%	$270	$105	$375	2023Q3	14.1%	$308	$120	$428
0.5%	Contracting & Reprographics	$270	$105	39.0%	$375	0.0%	$270	$105	$375	2023Q3	14.1%	$308	$120	$428
1.0%	Engineering During Construction	$539	$210	39.0%	$750	0.0%	$539	$210	$750	2024Q3	18.4%	$639	$249	$888
0.5%	Planning During Construction	$270	$105	39.0%	$375	0.0%	$270	$105	$375	2024Q3	18.4%	$319	$125	$444
0.5%	Adaptive Management & Monitoring	$270	$105	39.0%	$375	0.0%	$270	$105	$375	2023Q3	14.1%	$308	$120	$428
1.0%	Project Operations	$539	$210	39.0%	$750	0.0%	$539	$210	$750	2023Q3	14.1%	$615	$240	$855
31	CONSTRUCTION MANAGEMENT													
3.0%	Construction Management	$1,618	$631	39.0%	$2,249	0.0%	$1,618	$631	$2,249	2024Q3	18.4%	$1,916	$747	$2,664
1.0%	Project Operation:	$539	$210	39.0%	$750	0.0%	$539	$210	$750	2024Q3	18.4%	$639	$249	$888
1.0%	Project Management	$539	$210	39.0%	$750	0.0%	$539	$210	$750	2024Q3	18.4%	$639	$249	$888
	CONTRACT COST TOTALS:	$61,364	$23,929		$85,294		$61,364	$23,929	**$85,294**			$71,267	$27,791	**$99,059**

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

****** CONTRACT COST SUMMARY ******

PROJECT: Houston Ship Channel Improvement Project (LPP Plan)
LOCATION: Houston Ship Channel, Texas
This Estimate reflects the scope and schedule in report; HSC Feasibility

DISTRICT: Galveston District
POC: CHIEF, COST ENGINEERING, Martin Regner, P.E.
PREPARED: 12/5/2019

Civil Works Work Breakdown Structure		ESTIMATED COST				PROJECT FIRST COST (Constant Dollar Basis)				TOTAL PROJECT COST (FULLY FUNDED)				
		Estimate Prepared: / Effective Price Level:			4-Dec-19 / 1-Oct-19	Program Year (Budget EC): / Effective Price Level Date:			2020 / 1 OCT 19					
WBS NUMBER	Civil Works Feature & Sub-Feature Description	COST ($K)	CNTG ($K)	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
	Segment 3													
02	RELOCATIONS	$0	$0	39.0%	$0	0.0%	$0	$0	$0	0	0.0%	$0	$0	$0
06	FISH & WILDLIFE FACILITIES	$3,429	$1,337	39.0%	$4,767	0.0%	$3,429	$1,337	$4,767	2025Q3	17.9%	$4,044	$1,577	$5,621
12	NAVIGATION PORTS & HARBORS	$94,186	$36,732	39.0%	$130,918	0.0%	$94,186	$36,732	$130,918	2025Q4	18.8%	$111,893	$43,638	$155,531
	CONSTRUCTION ESTIMATE TOTALS:	$97,615	$38,070	39.0%	**$135,685**		$97,615	$38,070	$135,685			$115,936	$45,215	$161,152
01	LANDS AND DAMAGES	$38	$9	25.0%	$47	0.0%	$38	$9	$47	2025Q1	16.2%	$44	$11	$54
30	PLANNING, ENGINEERING & DESIGN													
0.8%	Project Management	$732	$286	39.0%	$1,018	0.0%	$732	$286	$1,018	2024Q3	18.4%	$867	$338	$1,205
0.5%	Planning & Environmental Compliance	$488	$190	39.0%	$678	0.0%	$488	$190	$678	2024Q3	18.4%	$578	$225	$804
3.0%	Engineering & Design	$2,928	$1,142	39.0%	$4,071	0.0%	$2,928	$1,142	$4,071	2024Q3	18.4%	$3,469	$1,353	$4,821
0.5%	Reviews, ATRs, IEPRs, VE	$488	$190	39.0%	$678	0.0%	$488	$190	$678	2024Q3	18.4%	$578	$225	$804
0.5%	Life Cycle Updates (cost, schedule, risks)	$488	$190	39.0%	$678	0.0%	$488	$190	$678	2024Q3	18.4%	$578	$225	$804
0.5%	Contracting & Reprographics	$488	$190	39.0%	$678	0.0%	$488	$190	$678	2024Q3	18.4%	$578	$225	$804
1.0%	Engineering During Construction	$976	$381	39.0%	$1,357	0.0%	$976	$381	$1,357	2025Q3	23.0%	$1,201	$468	$1,669
0.5%	Planning During Construction	$488	$190	39.0%	$678	0.0%	$488	$190	$678	2025Q3	23.0%	$600	$234	$835
0.5%	Adaptive Management & Monitoring	$488	$190	39.0%	$678	0.0%	$488	$190	$678	2024Q3	18.4%	$578	$225	$804
1.0%	Project Operations	$976	$381	39.0%	$1,357	0.0%	$976	$381	$1,357	2024Q3	18.4%	$1,156	$451	$1,607
31	CONSTRUCTION MANAGEMENT													
3.0%	Construction Management	$2,928	$1,142	39.0%	$4,071	0.0%	$2,928	$1,142	$4,071	2025Q3	23.0%	$3,603	$1,405	$5,008
1.0%	Project Operation:	$976	$381	39.0%	$1,357	0.0%	$976	$381	$1,357	2025Q3	23.0%	$1,201	$468	$1,669
1.0%	Project Management	$976	$381	39.0%	$1,357	0.0%	$976	$381	$1,357	2025Q3	23.0%	$1,201	$468	$1,669
	CONTRACT COST TOTALS:	$111,075	$43,314		**$154,389**		$111,075	$43,314	**$154,389**			$132,169	$51,540	**$183,709**

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

**** CONTRACT COST SUMMARY ****

PROJECT: Houston Ship Channel Improvement Project (LPP Plan)
LOCATION: Houston Ship Channel, Texas
This Estimate reflects the scope and schedule in report; HSC Feasibility

DISTRICT: Galveston District PREPARED: 12/5/2019
POC: CHIEF, COST ENGINEERING, Martin Regner, P.E.

Civil Works Work Breakdown Structure		ESTIMATED COST				PROJECT FIRST COST (Constant Dollar Basis)				TOTAL PROJECT COST (FULLY FUNDED)				
		Estimate Prepared:			4-Dec-19	Program Year (Budget EC):			2020	FULLY FUNDED PROJECT ESTIMATE				
		Effective Price Level:			1-Oct-19	Effective Price Level Date:			1 OCT 19					
WBS NUMBER	Civil Works Feature & Sub-Feature Description	COST ($K)	CNTG ($K)	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
	Segment 4													
02	RELOCATIONS	$25,420	$9,914	39.0%	$35,333	0.0%	$25,420	$9,914	$35,333	2023Q1	9.5%	$27,832	$10,854	$38,686
06	FISH & WILDLIFE FACILITIES	$7,193	$2,805	39.0%	$9,998	0.0%	$7,193	$2,805	$9,998	2023Q4	12.0%	$8,055	$3,141	$11,196
12	NAVIGATION PORTS & HARBORS	$51,415	$20,052	39.0%	$71,467	0.0%	$51,415	$20,052	$71,467	2023Q4	12.0%	$57,574	$22,454	$80,028
	CONSTRUCTION ESTIMATE TOTALS:	$84,027	$32,771	39.0%	**$116,798**		$84,027	$32,771	$116,798			$93,461	$36,450	$129,910
01	LANDS AND DAMAGES	$11,396	$2,849	25.0%	$14,245	0.0%	$11,396	$2,849	$14,245	2023Q1	9.5%	$12,478	$3,119	$15,597
30	PLANNING, ENGINEERING & DESIGN													
0.8%	Project Management	$630	$246	39.0%	$876	0.0%	$630	$246	$876	2022Q4	10.9%	$699	$273	$972
0.5%	Planning & Environmental Compliance	$420	$164	39.0%	$584	0.0%	$420	$164	$584	2022Q4	10.9%	$466	$182	$648
3.0%	Engineering & Design	$2,521	$983	39.0%	$3,504	0.0%	$2,521	$983	$3,504	2022Q4	10.9%	$2,797	$1,091	$3,887
0.5%	Reviews, ATRs, IEPRs, VE	$420	$164	39.0%	$584	0.0%	$420	$164	$584	2022Q4	10.9%	$466	$182	$648
0.5%	Life Cycle Updates (cost, schedule, risks)	$420	$164	39.0%	$584	0.0%	$420	$164	$584	2022Q4	10.9%	$466	$182	$648
0.5%	Contracting & Reprographics	$420	$164	39.0%	$584	0.0%	$420	$164	$584	2022Q4	10.9%	$466	$182	$648
1.0%	Engineering During Construction	$840	$328	39.0%	$1,168	0.0%	$840	$328	$1,168	2024Q4	19.6%	$1,005	$392	$1,397
0.5%	Planning During Construction	$420	$164	39.0%	$584	0.0%	$420	$164	$584	2024Q4	19.6%	$502	$196	$698
0.5%	Adaptive Management & Monitoring	$420	$164	39.0%	$584	0.0%	$420	$164	$584	2022Q4	10.9%	$466	$182	$648
1.0%	Project Operations	$840	$328	39.0%	$1,168	0.0%	$840	$328	$1,168	2022Q4	10.9%	$932	$364	$1,296
31	CONSTRUCTION MANAGEMENT													
3.0%	Construction Management	$2,521	$983	39.0%	$3,504	0.0%	$2,521	$983	$3,504	2024Q4	19.6%	$3,015	$1,176	$4,190
1.0%	Project Operation:	$840	$328	39.0%	$1,168	0.0%	$840	$328	$1,168	2024Q4	19.6%	$1,005	$392	$1,397
1.0%	Project Management	$840	$328	39.0%	$1,168	0.0%	$840	$328	$1,168	2024Q4	19.6%	$1,005	$392	$1,397
	CONTRACT COST TOTALS:	$106,977	$40,126		**$147,103**		$106,977	$40,126	**$147,103**			$119,228	$44,752	**$163,981**

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

**** CONTRACT COST SUMMARY ****

PROJECT: Houston Ship Channel Improvement Project (LPP Plan)
LOCATION: Houston Ship Channel, Texas
This Estimate reflects the scope and schedule in report; HSC Feasibility

DISTRICT: Galveston District PREPARED: 12/5/2019
POC: CHIEF, COST ENGINEERING, Martin Regner, P.E.

Civil Works Work Breakdown Structure		ESTIMATED COST				PROJECT FIRST COST (Constant Dollar Basis)				TOTAL PROJECT COST (FULLY FUNDED)				
		Estimate Prepared: / Effective Price Level:			4-Dec-19 / 1-Oct-19	Program Year (Budget EC): / Effective Price Level Date:			2020 / 1 OCT 19	FULLY FUNDED PROJECT ESTIMATE				
WBS NUMBER	Civil Works Feature & Sub-Feature Description	COST ($K)	CNTG ($K)	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
	Segment 5													
02	RELOCATIONS	$0	$0	39.0%	$0	0.0%	$0	$0	$0	0	0.0%	$0	$0	$0
06	FISH & WILDLIFE FACILITIES	$370	$144	39.0%	$515	0.0%	$370	$144	$515	2026Q3	21.5%	$450	$175	$625
12	NAVIGATION PORTS & HARBORS	$3,827	$1,493	39.0%	$5,320	0.0%	$3,827	$1,493	$5,320	2026Q3	21.5%	$4,649	$1,813	$6,462
	CONSTRUCTION ESTIMATE TOTALS:	$4,198	$1,637	39.0%	**$5,835**		$4,198	$1,637	$5,835			$5,098	$1,988	$7,086
01	LANDS AND DAMAGES	$19	$5	25.0%	$23	0.0%	$19	$5	$23	2026Q1	19.6%	$22	$6	$28
30	PLANNING, ENGINEERING & DESIGN													
0.8%	Project Management	$31	$12	39.0%	$44	0.0%	$31	$12	$44	2025Q3	23.0%	$39	$15	$54
0.5%	Planning & Environmental Compliance	$21	$8	39.0%	$29	0.0%	$21	$8	$29	2025Q3	23.0%	$26	$10	$36
3.0%	Engineering & Design	$126	$49	39.0%	$175	0.0%	$126	$49	$175	2025Q3	23.0%	$155	$60	$215
0.5%	Reviews, ATRs, IEPRs, VE	$21	$8	39.0%	$29	0.0%	$21	$8	$29	2025Q3	23.0%	$26	$10	$36
0.5%	Life Cycle Updates (cost, schedule, risks)	$21	$8	39.0%	$29	0.0%	$21	$8	$29	2025Q3	23.0%	$26	$10	$36
0.5%	Contracting & Reprographics	$21	$8	39.0%	$29	0.0%	$21	$8	$29	2025Q3	23.0%	$26	$10	$36
1.0%	Engineering During Construction	$42	$16	39.0%	$58	0.0%	$42	$16	$58	2026Q3	27.7%	$54	$21	$75
0.5%	Planning During Construction	$21	$8	39.0%	$29	0.0%	$21	$8	$29	2026Q3	27.7%	$27	$10	$37
0.5%	Adaptive Management & Monitoring	$21	$8	39.0%	$29	0.0%	$21	$8	$29	2025Q3	23.0%	$26	$10	$36
1.0%	Project Operations	$42	$16	39.0%	$58	0.0%	$42	$16	$58	2025Q3	23.0%	$52	$20	$72
31	CONSTRUCTION MANAGEMENT													
3.0%	Construction Management	$126	$49	39.0%	$175	0.0%	$126	$49	$175	2026Q3	27.7%	$161	$63	$224
1.0%	Project Operation:	$42	$16	39.0%	$58	0.0%	$42	$16	$58	2026Q3	27.7%	$54	$21	$75
1.0%	Project Management	$42	$16	39.0%	$58	0.0%	$42	$16	$58	2026Q3	27.7%	$54	$21	$75
	CONTRACT COST TOTALS:	$4,793	$1,867		**$6,660**		$4,793	$1,867	**$6,660**			$5,843	$2,276	**$8,119**

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

****** CONTRACT COST SUMMARY ******

PROJECT: Houston Ship Channel Improvement Project (LPP Plan)
LOCATION: Houston Ship Channel, Texas
This Estimate reflects the scope and schedule in report; HSC Feasibility

DISTRICT: Galveston District PREPARED: 12/5/2019
POC: CHIEF, COST ENGINEERING, Martin Regner, P.E.

Civil Works Work Breakdown Structure		ESTIMATED COST				PROJECT FIRST COST (Constant Dollar Basis)				TOTAL PROJECT COST (FULLY FUNDED)				
		Estimate Prepared:			4-Dec-19	Program Year (Budget EC):			2020					
		Effective Price Level:			1-Oct-19	Effective Price Level Date:			1 OCT 19	FULLY FUNDED PROJECT ESTIMATE				
WBS NUMBER	Civil Works Feature & Sub-Feature Description	COST ($K)	CNTG ($K)	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
	Segment 6													
02	RELOCATIONS	$0	$0	39.0%	$0	0.0%	$0	$0	$0	0	0.0%	$0	$0	$0
06	FISH & WILDLIFE FACILITIES	$1,056	$412	39.0%	$1,467	0.0%	$1,056	$412	$1,467	2026Q3	21.5%	$1,282	$500	$1,782
12	NAVIGATION PORTS & HARBORS	$30,090	$11,735	39.0%	$41,826	0.0%	$30,090	$11,735	$41,826	2026Q3	21.5%	$36,547	$14,253	$50,800
	CONSTRUCTION ESTIMATE TOTALS:	$31,146	$12,147	39.0%	**$43,293**		$31,146	$12,147	$43,293			$37,829	$14,753	$52,582
01	LANDS AND DAMAGES	$153	$38	25.0%	$191	0.0%	$153	$38	$191	2026Q1	19.6%	$183	$46	$229
30	PLANNING, ENGINEERING & DESIGN													
0.8%	Project Management	$234	$91	39.0%	$325	0.0%	$234	$91	$325	2025Q3	23.0%	$287	$112	$399
0.5%	Planning & Environmental Compliance	$156	$61	39.0%	$216	0.0%	$156	$61	$216	2025Q3	23.0%	$192	$75	$266
3.0%	Engineering & Design	$934	$364	39.0%	$1,299	0.0%	$934	$364	$1,299	2025Q3	23.0%	$1,150	$448	$1,598
0.5%	Reviews, ATRs, IEPRs, VE	$156	$61	39.0%	$216	0.0%	$156	$61	$216	2025Q3	23.0%	$192	$75	$266
0.5%	Life Cycle Updates (cost, schedule, risks)	$156	$61	39.0%	$216	0.0%	$156	$61	$216	2025Q3	23.0%	$192	$75	$266
0.5%	Contracting & Reprographics	$156	$61	39.0%	$216	0.0%	$156	$61	$216	2025Q3	23.0%	$192	$75	$266
1.0%	Engineering During Construction	$311	$121	39.0%	$433	0.0%	$311	$121	$433	2026Q3	27.7%	$398	$155	$553
0.5%	Planning During Construction	$156	$61	39.0%	$216	0.0%	$156	$61	$216	2026Q3	27.7%	$199	$78	$276
0.5%	Adaptive Management & Monitoring	$156	$61	39.0%	$216	0.0%	$156	$61	$216	2025Q3	23.0%	$192	$75	$266
1.0%	Project Operations	$311	$121	39.0%	$433	0.0%	$311	$121	$433	2025Q3	23.0%	$383	$149	$533
31	CONSTRUCTION MANAGEMENT													
3.0%	Construction Management	$934	$364	39.0%	$1,299	0.0%	$934	$364	$1,299	2026Q3	27.7%	$1,193	$465	$1,659
1.0%	Project Operation:	$311	$121	39.0%	$433	0.0%	$311	$121	$433	2026Q3	27.7%	$398	$155	$553
1.0%	Project Management	$311	$121	39.0%	$433	0.0%	$311	$121	$433	2026Q3	27.7%	$398	$155	$553
	CONTRACT COST TOTALS:	$35,582	$13,855		**$49,437**		$35,582	$13,855	**$49,437**			$43,376	$16,891	**$60,266**

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

****** CONTRACT COST SUMMARY ******

PROJECT: Houston Ship Channel Improvement Project (LPP Plan)
LOCATION: Houston Ship Channel, Texas
This Estimate reflects the scope and schedule in report; HSC Feasibility

DISTRICT: Galveston District PREPARED: 12/5/2019
POC: CHIEF, COST ENGINEERING, Martin Regner, P.E.

Civil Works Work Breakdown Structure		ESTIMATED COST				PROJECT FIRST COST (Constant Dollar Basis)				TOTAL PROJECT COST (FULLY FUNDED)				
		Estimate Prepared:			4-Dec-19	Program Year (Budget EC):			2020					
		Effective Price Level:			1-Oct-19	Effective Price Level Date:			1 OCT 19	FULLY FUNDED PROJECT ESTIMATE				
WBS NUMBER	Civil Works Feature & Sub-Feature Description	COST ($K)	CNTG ($K)	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
	Associated Costs													
12	NAVIGATION PORTS & HARBORS (Aids to Navigation)	$3,316	$1,293	39.0%	$4,609	0.0%	$3,316	$1,293	$4,609	2023Q3	11.1%	$3,685	$1,437	$5,122
12	NAVIGATION PORTS & HARBORS (Local Service Facilities)	$56,262	$21,942	39.0%	$78,204	0.0%	$56,262	$21,942	$78,204	2023Q4	12.0%	$63,002	$24,571	$87,573
	CONSTRUCTION ESTIMATE TOTALS:	$59,578	$23,235	39.0%	**$82,813**		$59,578	$23,235	$82,813			$66,688	$26,008	$92,696
01	LANDS AND DAMAGES	$0	$0	0.0%	$0	0.0%	$0	$0	$0	0	0.0%	$0	$0	$0
30	PLANNING, ENGINEERING & DESIGN													
0.0%	Project Management	$0	$0	0.0%	$0	0.0%	$0	$0	$0	0	0.0%	$0	$0	$0
0.0%	Planning & Environmental Compliance	$0	$0	0.0%	$0	0.0%	$0	$0	$0	0	0.0%	$0	$0	$0
0.0%	Engineering & Design	$0	$0	0.0%	$0	0.0%	$0	$0	$0	0	0.0%	$0	$0	$0
0.0%	Reviews, ATRs, IEPRs, VE	$0	$0	0.0%	$0	0.0%	$0	$0	$0	0	0.0%	$0	$0	$0
0.0%	Life Cycle Updates (cost, schedule, risks)	$0	$0	0.0%	$0	0.0%	$0	$0	$0	0	0.0%	$0	$0	$0
0.0%	Contracting & Reprographics	$0	$0	0.0%	$0	0.0%	$0	$0	$0	0	0.0%	$0	$0	$0
0.0%	Engineering During Construction	$0	$0	0.0%	$0	0.0%	$0	$0	$0	0	0.0%	$0	$0	$0
0.0%	Planning During Construction	$0	$0	0.0%	$0	0.0%	$0	$0	$0	0	0.0%	$0	$0	$0
0.0%	Adaptive Management & Monitoring	$0	$0	0.0%	$0	0.0%	$0	$0	$0	0	0.0%	$0	$0	$0
0.0%	Project Operations	$0	$0	0.0%	$0	0.0%	$0	$0	$0	0	0.0%	$0	$0	$0
31	CONSTRUCTION MANAGEMENT													
0.0%	Construction Management	$0	$0	0.0%	$0	0.0%	$0	$0	$0	0	0.0%	$0	$0	$0
0.0%	Project Operation:	$0	$0	0.0%	$0	0.0%	$0	$0	$0	0	0.0%	$0	$0	$0
0.0%	Project Management	$0	$0	0.0%	$0	0.0%	$0	$0	$0	0	0.0%	$0	$0	$0
	CONTRACT COST TOTALS:	$59,578	$23,235		**$82,813**		$59,578	$23,235	**$82,813**			$66,688	$26,008	**$92,696**

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

****** CONTRACT COST SUMMARY ******

PROJECT: Houston Ship Channel Improvement Project (LPP Plan)
LOCATION: Houston Ship Channel, Texas
This Estimate reflects the scope and schedule in report; HSC Feasibility

DISTRICT: Galveston District PREPARED: 12/5/2019
POC: CHIEF, COST ENGINEERING, Martin Regner, P.E.

Civil Works Work Breakdown Structure		ESTIMATED COST				PROJECT FIRST COST (Constant Dollar Basis)				TOTAL PROJECT COST (FULLY FUNDED)				
		Estimate Prepared:			4-Dec-19	Program Year (Budget EC):			2020					
		Effective Price Level:			1-Oct-19	Effective Price Level Date:			1 OCT 19	FULLY FUNDED PROJECT ESTIMATE				
WBS NUMBER A	Civil Works Feature & Sub-Feature Description B	COST ($K) C	CNTG ($K) D	CNTG (%) E	TOTAL ($K) F	ESC (%) G	COST ($K) H	CNTG ($K) I	TOTAL ($K) J	Mid-Point Date P	INFLATED (%) L	COST ($K) M	CNTG ($K) N	FULL ($K) O
	O&M COSTS													
12	NAVIGATION PORTS & HARBORS Total O&M for 50 Years	$2,735,545	$574,464	21.0%	$3,310,009	0.0%	$2,735,545	$574,464	$3,310,009	2054Q1	173.7%	$7,488,030	$1,572,486	$9,060,516
	CONSTRUCTION ESTIMATE TOTALS:	$2,735,545	$574,464	21.0%	**3,310,009**		$2,735,545	$574,464	$3,310,009			$7,488,030	$1,572,486	$9,060,516
01	LANDS AND DAMAGES	$0	$0	0.0%	$ -	0.0%	$0	$0	$0	0	0.0%	$0	$0	$0
30	PLANNING, ENGINEERING & DESIGN													
0.5%	Project Management	$14,303	$3,004	21.0%	$17,307	0.0%	$14,303	$3,004	$17,307	2054Q1	288.0%	$55,496	$11,654	$67,150
0.3%	Planning & Environmental Compliance	$9,535	$2,002	21.0%	$11,538	0.0%	$9,535	$2,002	$11,538	2054Q1	288.0%	$36,997	$7,769	$44,767
2.1%	Engineering & Design	$57,212	$12,015	21.0%	$69,226	0.0%	$57,212	$12,015	$69,226	2054Q1	288.0%	$221,983	$46,616	$268,599
0.3%	Reviews, ATRs, IEPRs, VE	$9,535	$2,002	21.0%	$11,538	0.0%	$9,535	$2,002	$11,538	2054Q1	288.0%	$36,997	$7,769	$44,767
0.3%	Life Cycle Updates (cost, schedule, risks)	$9,535	$2,002	21.0%	$11,538	0.0%	$9,535	$2,002	$11,538	2054Q1	288.0%	$36,997	$7,769	$44,767
0.3%	Contracting & Reprographics	$9,535	$2,002	21.0%	$11,538	0.0%	$9,535	$2,002	$11,538	2054Q1	288.0%	$36,997	$7,769	$44,767
0.7%	Engineering During Construction	$19,071	$4,005	21.0%	$23,075	0.0%	$19,071	$4,005	$23,075	2054Q1	288.0%	$73,994	$15,539	$89,533
0.3%	Planning During Construction	$9,535	$2,002	21.0%	$11,538	0.0%	$9,535	$2,002	$11,538	2054Q1	288.0%	$36,997	$7,769	$44,767
0.3%	Adaptive Management & Monitoring	$9,535	$2,002	21.0%	$11,538	0.0%	$9,535	$2,002	$11,538	2053Q3	280.1%	$36,244	$7,611	$43,855
0.7%	Project Operations	$19,071	$4,005	21.0%	$23,075	0.0%	$19,071	$4,005	$23,075	2054Q1	288.0%	$73,994	$15,539	$89,533
31	CONSTRUCTION MANAGEMENT													
2.3%	Construction Management	$62,370	$13,098	21.0%	75,468	0.0%	$62,370	$13,098	$75,468	2054Q1	288.0%	$241,998	$50,820	$292,817
0.8%	Project Operation:	$20,790	$4,366	21.0%	25,156	0.0%	$20,790	$4,366	$25,156	2054Q1	288.0%	$80,666	$16,940	$97,606
0.8%	Project Management	$20,790	$4,366	21.0%	25,156	0.0%	$20,790	$4,366	$25,156	2054Q1	288.0%	$80,666	$16,940	$97,606
3.8%														
	CONTRACT COST TOTALS:	$3,006,364	$631,336		**3,637,700**		$3,006,364	$631,336	**$3,637,700**			$8,538,056	$1,792,992	**$10,331,048**

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

**** CONTRACT COST SUMMARY ****

PROJECT: Houston Ship Channel Improvement Project (LPP Plan)
LOCATION: Houston Ship Channel, Texas
This Estimate reflects the scope and schedule in report; HSC Feasibility

DISTRICT: Galveston District PREPARED: 12/5/2019
POC: CHIEF, COST ENGINEERING, Martin Regner, P.E.

Civil Works Work Breakdown Structure		ESTIMATED COST				PROJECT FIRST COST (Constant Dollar Basis)				TOTAL PROJECT COST (FULLY FUNDED)				
		Estimate Prepared: / Effective Price Level:			4-Dec-19 / 1-Oct-19	Program Year (Budget EC): / Effective Price Level Date:			2020 / 1 OCT 19	FULLY FUNDED PROJECT ESTIMATE				
WBS NUMBER	Civil Works Feature & Sub-Feature Description	COST ($K)	CNTG ($K)	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*
	O&M COSTS													
12	NAVIGATION PORTS & HARBORS Increase in O&M for 50 Years	$613,620	$128,860	21.0%	$742,480	0.0%	$613,620	$128,860	$742,480	2054Q1	173.7%	$1,679,666	$352,730	$2,032,396
	CONSTRUCTION ESTIMATE TOTALS:	$613,620	$128,860	21.0%	**$742,480**		$613,620	$128,860	$742,480			$1,679,666	$352,730	$2,032,396
01	LANDS AND DAMAGES	$0	$0	0.0%	$0	0.0%	$0	$0	$0	0	0.0%	$0	$0	$0
30	PLANNING, ENGINEERING & DESIGN													
0.5%	Project Management	$3,208	$674	21.0%	$3,882	0.0%	$3,208	$674	$3,882	2053Q3	280.1%	$12,195	$2,561	$14,756
0.3%	Planning & Environmental Compliance	$2,139	$449	21.0%	$2,588	0.0%	$2,139	$449	$2,588	2053Q3	280.1%	$8,130	$1,707	$9,837
2.1%	Engineering & Design	$12,833	$2,695	21.0%	$15,528	0.0%	$12,833	$2,695	$15,528	2053Q3	280.1%	$48,780	$10,244	$59,024
0.3%	Reviews, ATRs, IEPRs, VE	$2,139	$449	21.0%	$2,588	0.0%	$2,139	$449	$2,588	2053Q3	280.1%	$8,130	$1,707	$9,837
0.3%	Life Cycle Updates (cost, schedule, risks)	$2,139	$449	21.0%	$2,588	0.0%	$2,139	$449	$2,588	2053Q3	280.1%	$8,130	$1,707	$9,837
0.3%	Contracting & Reprographics	$2,139	$449	21.0%	$2,588	0.0%	$2,139	$449	$2,588	2053Q3	280.1%	$8,130	$1,707	$9,837
0.7%	Engineering During Construction	$4,278	$898	21.0%	$5,176	0.0%	$4,278	$898	$5,176	2053Q3	280.1%	$8,130	$1,707	$9,837
0.3%	Planning During Construction	$2,139	$449	21.0%	$2,588	0.0%	$2,139	$449	$2,588	2020Q2	0.9%	$4,318	$907	$5,225
0.3%	Adaptive Management & Monitoring	$2,139	$449	21.0%	$2,588	0.0%	$2,139	$449	$2,588	2020Q2	0.9%	$2,159	$453	$2,613
0.7%	Project Operations	$4,278	$898	21.0%	$5,176	0.0%	$4,278	$898	$5,176	2022Q1	7.8%	$2,307	$484	$2,791
										2053Q3	280.1%	$16,260	$3,415	$19,675
31	CONSTRUCTION MANAGEMENT													
2.3%	Construction Management	$13,991	$2,938	21.0%	$16,929	0.0%	$13,991	$2,938	$16,929	2020Q2	0.9%	$14,123	$2,966	$17,089
0.8%	Project Operation:	$4,664	$979	21.0%	$5,643	0.0%	$4,664	$979	$5,643	2020Q2	0.9%	$4,708	$989	$5,696
0.8%	Project Management	$4,664	$979	21.0%	$5,643	0.0%	$4,664	$979	$5,643	2020Q2	0.9%	$4,708	$989	$5,696
	CONTRACT COST TOTALS:	$674,368	$141,617		**$815,985**		$674,368	$141,617	**$815,985**			$1,821,744	$382,566	**$2,204,310**

US Army Corps
of Engineers®

Houston Ship Channel DMMP
45’ Expansion Channel Improvement
Project Cost and Schedule Risk Analysis Report
NED Plan

Prepared for:

U.S. Army Corps of Engineers,
Galveston District

Prepared by:

U.S. Army Corps of Engineers, Walla Walla District
Engineering and Construction Division, Cost Engineering Branch

November 20, 2019

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EXECUTIVE SUMMARY

The US Army Corps of Engineers (USACE), Galveston District, presents this cost and schedule risk analysis (CSRA) report regarding the risk findings and recommended contingencies for the Galveston District, Houston Ship Channel DMMP. In compliance with Engineer Regulation (ER) 1110-2-1302 CIVIL WORKS COST ENGINEERING, dated September 15, 2008, a *Monte-Carlo* based risk analysis 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.

The Houston Ship Channel (HSC) project purpose is to reduce transportation costs and address navigation safety issues on the Houston Ship Channel (HSC) system. The HSC consists of an existing 52 mile long deep-draft navigation channel, three deep-draft tributary channels and one shallow draft tributary channel. The primary HSC deep-draft channel has authorized depths ranging from 36 feet to 45 feet and widths ranging generally from 300 feet to 530 feet.

The DMMP documents the dredging and placement needs for the Federal project and associated non- Federal facilities, as feasible, for the next 50-years for the Houston Ship Channel complex, which includes: HSC main stem from Bolivar Roads to the Upper Turning Basin, Bayport Ship Channel, Barbour's Terminal Cut, Greens Bayou, Jacintoport, the light-draft channel, Turkey Bend, Turkey Bend Cut off, boater cuts, and barge lanes. The DMMP is developed as a stand-alone document for operations and management of future dredged material for the federal project.

The current and future placement plan for continued operation and maintenance of the existing HSC complex is outlined in the December 5, 2017 Preliminary Assessment (HSCPA) and conceptual 50-year DMMP dated December 18, 2018. This is considered the Future Without Project (FWOP) condition for the HSC ECIP Study. The study integrates changes to the FWOP conditions by identifying the base plan for placement needs for the increment of new work and maintenance dredging from the recommended modification which includes dredged material originating from the Federal channel for a period of 50-years. This is considered the Future With Project (FWP) condition for the HSC ECIP Study.

Specific to the Houston Ship Channel DMMP, the current project base cost estimate, pre-contingency, approximates $411M. This CSRA included study of estimated base construction, engineering and design and construction management. There are no spent costs and real estate costs are accounted for in the real estate appendix. Based

on the results of the analysis, the Cost Engineering Mandatory Center of Expertise for Civil Works (Cost MCX located in Walla Walla District) recommends a contingency value of $148M or approximately 36% of base project cost at an 80% confidence level of successful execution.

Cost estimates fluctuate over time. During this period of study, minor cost fluctuations can and have occurred. For this reason, contingency reporting is based in cost and percent values. Should cost vary to a slight degree with similar scope and risks, contingency per cent values will be reported, cost values rounded.

Table ES-1. Construction Contingency Results

Base Case Estimate	**$410,607,000**	
Confidence Level	**Construction Value ($) w/ Contingencies**	**Contingency (%)**
50%	$542,001,000	32%
80%	**$558,425,000**	**36%**
90%	$570,744,000	39%

KEY FINDINGS/OBSERVATIONS RECOMMENDATIONS

A formal Cost Risk Analysis was performed on Houston Ship Channel Improvement Project with the cooperation of the PDT and Cost Engineering Mandatory Center of Expertise for Civil Works. The risks were quantified and a cost risk model developed to determine a contingency at 80% confidence level (CL). The key risk drivers identified through sensitivity analysis suggest a cost contingency of $148M at an 80% confidence level.

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

- CO-8: Bird Island Marsh Construction – The PDT is concerned the long pumping distance will decrease the retainage and not allow the dike to be shaped as designed. The contractor may have to not just widen but dig deeper to get material with more stiff clay.
- CA-2: Market Conditions and Bidding Competition – Corps studies have resulted in an expected dredge shortage as compared to the many anticipated projects in the Gulf region. Generally there are 2 bidders for the 30” hydraulic dredges. A third hydraulic dredge is anticipated to be ready at the time of this construction.

There is the possibility of many dredging projects and less competition is possible, resulting in higher bids.

- PM-5: Scope Changes – Scope changes could add cost and delay the project. Moderate scope changes could occur during ship simulations in PED. Additional pipelines could be identified and be added at the time of construction.
- CO-1: Modification and Claims – Technical complexities and site conditions could result in increased risk of contract modifications. This does not include scope growth and cover the "Unknown-Unknowns" for items such as plan omissions, delays, etc.
- TR-11: Sheetpile Wall Design – Quantity of steel required could change with final design. Length is conservative and the quantity is possible to change. This is likely a design/build scope of work and the costs are possible to change,
- EX-2: Fuel Price – Fuel could increase or decrease altering the cost. Estimate assumes $3/gallon and the current price is $2.25/gallon for fuel and is conservative. We assume an increase of $.50/gal based on price fluctuations in the past years.

Lesser project risks can be referenced in the cost sensitivity forecast data.

Schedule Risks: The high value of schedule risk indicates a significant uncertainty of key risk items that can translate into added costs within the schedule. From the sensitivity chart, the key or greater Cost Risk items of include:

- PM-4: BCR Delays – Multiple separable elements that need to compete. The PDT feels the BCR will be competitive. Lengthy delays would require an economic update.
- CO-7: Inefficient Contractor – Inefficient contractor may delay the project and affect the quantities.
- PM-1: Federal Funding – Due to the priority of the project it is likely that the project may not receive adequate funding annually. The PHA (Port of Houston Authority) could advance funds which would mitigate the cost and schedule risk.
- PM-5: Scope Changes – Scope changes could add cost and delay the project.
- ES-5: Schedule Detail – Estimate and schedule assume 12 separate contracts and likely to change.

Recommendations: 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

Within the authority of the US Army Corps of Engineers (USACE), Galveston District, this report presents the efforts and results of the cost and schedule risk analysis for the Houston Ship Channel DMMP. The report includes risk methodology, discussions, findings and recommendations regarding the identified risks and the necessary contingencies to confidently administer the project, presenting a cost contingency value with an 80% confidence level of successful execution.

2.0 BACKGROUND

The NED cost estimate of the project is divided into six segments, or reaches, each with a separate placement plan and placement areas. All dredging was assumed to be performed by a 30-inch cutter-head pipeline dredge, except for portions of Bolivar Roads to Redfish Reef segment and Redfish to BSC, for which a mechanical dredge will be used. Reaches include:
The NED plan includes widening the channel from 530 feet wide to 700 feet wide from Bolivar Roads to Redfish, four bend easings, and easing the Bayport Flare from a 4,000 foot to a 5,300 foot radius in Segment 1; widening the Bayport Ship Channel from 350 and 400 feet to 455 feet in Segment 2; widening the Barbour's Cut Ship Channel from 300 to 455 feet wide and extending the turning radius flare to 1,800 feet in Segment 3; widening from 400 to 530 feet and deepening from 41.5 to 46.5 feet Boggy Bayou to Greens Bayou and deepening from 41.5 to 46.5 from Greens Bayou to the Washburn Tunnel in Segment 4; deepening from Sims to 610 from 37.5 to 41.5 in Segment 5; and deepening from 37.5 to 41.5 from 610 to the Turning Basin in Segment 6.

Detailed descriptions of the various HSC segments and tributary channels included in this DMMP are presented in the Integrated Dredged Material Management Plan and Environmental Assessment Report.

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 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 the 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

The Cost Engineering MCX performed the Cost and Schedule Risk Analysis, relying on local Galveston District staff to provide expertise and information gathering. The Galveston PDT conducted initial risk identification in March 2015. The initial risk identification meeting also included qualitative analysis to produce a risk register that served as the draft framework for the risk analysis.

A Risk meeting occurred in March 2015 with an update in December of 2015, resulting in a revision of the identified risks and the current known impacts. The cost and schedule risk analysis and cost certification was completed in January 2016. The project scope was changed and a cost and schedule risk analysis update was again completed in June 2019. Key PDT members included:

Attendance	Name	Office	Representing
Full	Dale Williams	CESWG-ECE-P	Cost Engineering
Full	T. Cheryl Jaynes	CESWF-PEC-PF	Plan Formulation
Full	Nancy C. Young	CESWF-EC-G	Civil Engineer
Full	David B. Boothby	CESWF-EC-S	Geotech Engineer
Full	Harmon Brown	CESWF-PEC-CC	Environmental
Full	Kenny Pablo	CESWG-RE	Real Estate
Full	Nichole Schlund	CESWG-RE	Real Estate
Full	A. Rashid Ali	CESWG-ECE-P	Cost Engineering
Full	Chester Hedderman	GBA/JV	PHA
Full	Richard Ruchoeft	PHA	PHA
Full	Ryan Harbor	CESWG-ECE-P	Cost Engineering
Full	Stephanie Nieves	CESWG-ECE-P	Cost Engineering
Full	Dana Cheney	GBA/JV	PHA
Full	Carl Sepulveda	AECOM/JV	Environmental

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 with the Galveston District office for the purposes of identifying and assessing risk factors. The meeting conducted June 2019 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. 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 (putting it to numbers of cost and time) 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 cost 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 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 project.

a. The Galveston District provided MII MCACES (Micro-Computer Aided Cost Estimating Software) and CEDEP (Corps of Engineers Dredge Estimating Program) files electronically. The MII files transmitted and downloaded June 2019 were the basis for the initial cost and schedule risk analyses. These files were again updated in November 2019.

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 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.

d. Per the CWCCIS Historical State Adjustment Factors in EM 1110-2-1304. 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. 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.

f. 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 and P90 confidence levels are also provided for illustrative purposes only.

Cost contingency for the Construction risks was quantified as approximately $148 Million at the P80 confidence.

Table 1. Construction Cost Contingency Summary

Base Case Estimate	**$411,070,000**	
Confidence Level	**Construction Value ($) w/ Contingencies**	**Contingency (%)**
50%	$542,001,000	32%
80%	**$558,425,000**	**36%**
90%	$570,744,000	39%

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.

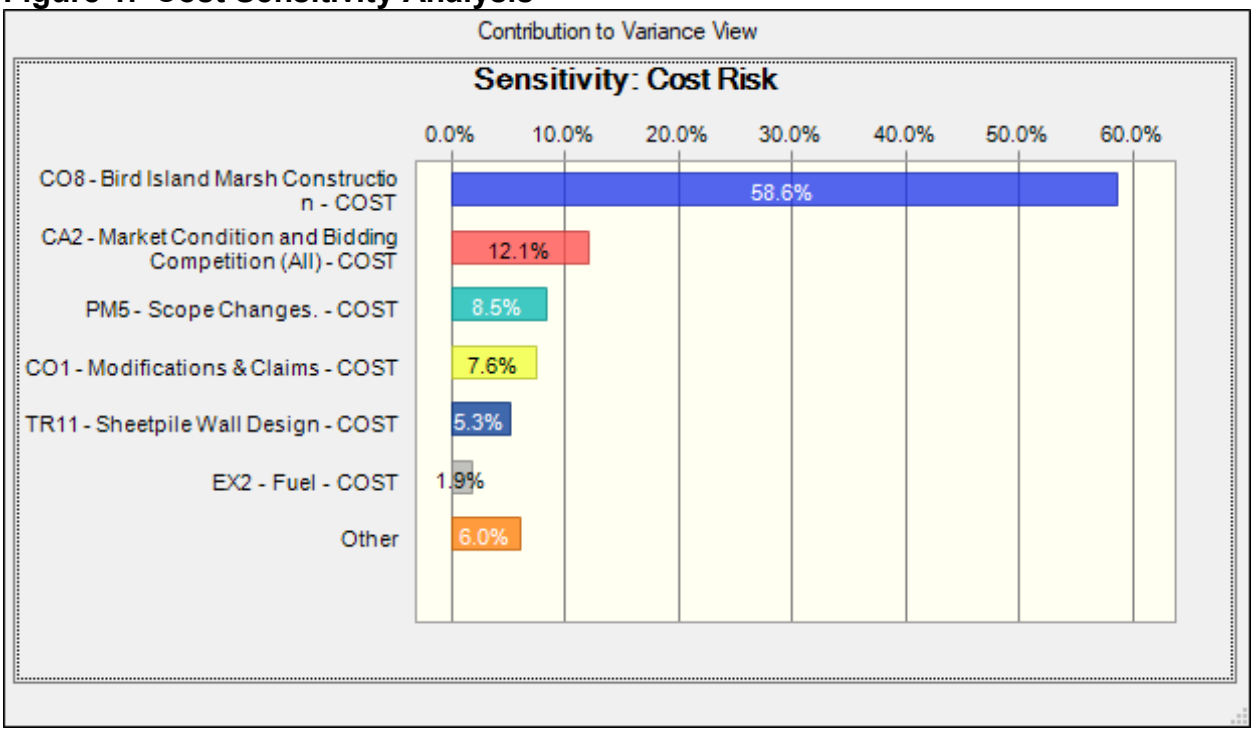
Key cost drivers identified in the sensitivity analysis can be used to support development of a risk management plan that will facilitate control of risk factors and their potential impacts throughout the project lifecycle. Together with the risk register, sensitivity analysis results can also be used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

Figure 1. Cost Sensitivity Analysis



6.3 Schedule 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 P90 confidence levels are also provided for illustrative purposes.

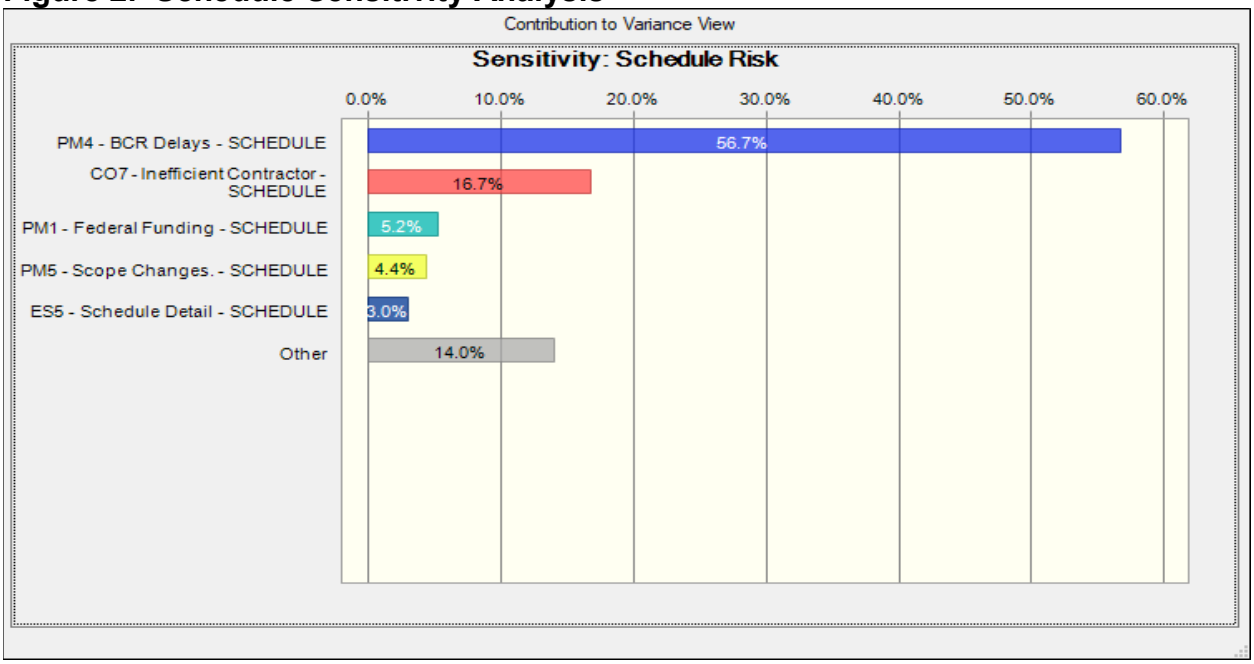
Schedule duration contingency was quantified as 22 months based on the P80 level of confidence. The schedule contingencies were calculated by applying the high level schedule risks identified in the risk register for each option to the durations of critical path and near critical path tasks.

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.

Table 2. Schedule Duration Contingency Summary

Risk Analysis Forecast (base schedule of 40 months)	Duration w/ Contingencies (months)	Contingency[1] (months)
50% Confidence	58	18
80% Confidence	62	22
90% Confidence	64	24

Figure 2. Schedule Sensitivity Analysis



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 comparison summaries are provided in Table 1. Additional major findings and observations of the risk analysis are listed below.

The Cost Engineering MCX performed the Cost and Schedule Risk Analysis, relying on local Galveston District staff to provide expertise and information gathering. The Galveston PDT conducted initial risk identification in 2015. The cost and schedule risk analysis and cost certification was completed January 2016 and updated in August 2019. The key risk drivers identified through sensitivity analysis suggest a cost contingency of $148M at an 80% confidence level.

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

- CO-8: Bird Island Marsh Construction – The PDT is concerned the long pumping distance will decrease the retainage and not allow the dike to be shaped as designed. The contractor may have to not just widen but dig deeper to get material with more stiff clay.
- CA-2: Market Conditions and Bidding Competition – Corps studies have resulted in an expected dredge shortage as compared to the many anticipated projects in the Gulf region. Generally there are 2 bidders for the 30” hydraulic dredges. A third hydraulic dredge is anticipated to be ready at the time of this construction. There is the possibility of many dredging projects and less competition is possible, resulting in higher bids.
- PM-5: Scope Changes – Scope changes could add cost and delay the project. Moderate scope changes could occur during ship simulations in PED. Additional pipelines could be identified and be added at the time of construction.
- CO-1: Modification and Claims – Technical complexities and site conditions could result in increased risk of contract modifications. This does not include scope growth and cover the "Unknown-Unknowns" for items such as plan omissions, delays, etc.
- TR-11: Sheetpile Wall Design – Quantity of steel required could change with final design. Length is conservative and the quantity is possible to change. This is likely a design/build scope of work and the costs are possible to change,
- EX-2: Fuel Price – Fuel could increase or decrease altering the cost. Estimate assumes $3/gallon and the current price is $2.25/gallon for fuel and is

conservative. We assume an increase of $.50/gal based on price fluctuations in the past years.

Lesser project risks can be referenced in the cost sensitivity forecast data.

Schedule Risks: The high value of schedule risk indicates a significant uncertainty of key risk items that can translate into added costs within the schedule. From the sensitivity chart, the key or greater Cost Risk items of include:

- PM-4: BCR Delays – Multiple separable elements that need to compete. The PDT feels the BCR will be competitive. Lengthy delays would require an economic update.
- CO-7: Inefficient Contractor – Inefficient contractor may delay the project and affect the quantities.
- PM-1: Federal Funding – Due to the priority of the project it is likely that the project may not receive adequate funding annually. The PHA (Port of Houston Authority) could advance funds which would mitigate the cost and schedule risk.
- PM-5: Scope Changes – Scope changes could add cost and delay the project.
- ES-5: Schedule Detail – Estimate and schedule assume 12 separate contracts and likely to change.

Table 2. Construction Cost Comparison Summary (Uncertainty Analysis)

PROJECT CONTINGENCY (BASELINE ESTIMATE)	Percentile	Baseline TPC	Baseline w/ Contingency	Contingency %
	0%	$410,606,921	**$476,304,028**	**16%**
	10%	$410,606,921	**$509,152,582**	**24%**
	20%	$410,606,921	**$521,470,789**	**27%**
	30%	$410,606,921	**$529,682,928**	**29%**
	40%	$410,606,921	**$533,788,997**	**30%**
	50%	$410,606,921	**$542,001,135**	**32%**
	60%	$410,606,921	**$546,107,205**	**33%**
	70%	$410,606,921	**$554,319,343**	**35%**
	80%	$410,606,921	**$558,425,412**	**36%**
	90%	$410,606,921	**$570,743,620**	**39%**
	100%	$410,606,921	**$632,334,658**	**54%**

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, mobile home relocations, 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).

APPENDIX A

CREF	Risk/Opportunity Event	Risk Event Description	PDT Discussions on Impact and Likelihood	Likelihood ©	Impact ©	Risk Level ©	Likelihood (S)	Impact (S)	Risk Level (S)
Organizational and Project Management Risks (PM)									
PM1	Federal Funding	Annual appropriations for Design and Construction could be delayed.	Due to the priority of the project it is likely that the project may not receive adequate funding annually. The PHA (Port of Houston Authority) could advance funds which would mitigate the cost and schedule risk.	Possible	Negligible	**Low**	Possible	Significant	**Medium**
PM2	Non Federal Funding	Non federal sponsor may not have the funds to cost share.	The port if committed to having the funding. The PPA is anticipated to be signed and the funding will be in place.	Unlikely	Negligible	**Low**	Unlikely	Marginal	**Low**
PM3	Labor Availability	There may be a shortage of manpower for the design of this project.	We expect to have enough people to work on this project with the Galveston district. The PHA will supplement any shortages with work in kind.	Unlikely	Negligible	**Low**	Unlikely	Negligible	**Low**
PM4	BCR Delays	A low BCR ratio may delay a new start decision.	Multiple separable elements that need to compete. The PDT feels the BCR will be competitive. Lengthy delays would require an economic update.	Unlikely	Negligible	**Low**	Likely	Marginal	**Medium**
PM5	Scope Changes.	Scope changes could add cost and delay the project.	Moderate scope changes could occur during ship simulations in PED. Additional pipelines could be identified and be added at the time of construction.	Possible	Moderate	**Medium**	Possible	Marginal	**Low**
PM6	Coordination between Construction and Operations	O&M needs could impact new work dredging schedule.	O&M dredging could cause individual contract schedule coordination between construction and operations. This coordination could cause new work schedule changes. The total duration is not expected to change.	Possible	Marginal	**Low**	Unlikely	Negligible	**Low**
Contract Acquisition Risks (CA)									

CA1	Acquisition Strategy	Acquisition Strategy could change.	Contracts are generally separated by contract year and the team does not feel there is a risk of the acquisition changing. The order of the contracts could change but would not add to cost or delay the overall construction schedule.	Unlikely	Marginal	**Low**	Unlikely	Negligible	**Low**
CA2	Market Condition and Bidding Competition (All)	There is the possibility of having a limited number of contractors bid which would increase the cost.	Having limited competition would likely increase the cost. Corps studies have resulted in an expected dredge shortage as compared to the many anticipated projects in the Gulf region. Generally there are 2 bidders for the hydraulic dredging. A third hydraulic dredge is anticipated to be ready at the time of this construction. There is the possibility of many dredging projects and less competition is possible, resulting in higher bids.	Likely	Moderate	**Medium**	Unlikely	Negligible	**Low**
CA3	Small Business Goals	Small Business goals could add subcontracting costs.	Majority of dredging and placement area work is assumed for IFB large business. Small business could be added for PA site prep at Segment 4 , 5 and 6 adding marginal cost and schedule delays.	Possible	Marginal	**Low**	Unlikely	Marginal	**Low**
General Technical Risks (TR)									
TR1	Mechanical Dredging Quantities	If dredging quantities increase it could lead to additional costs.	Quantities are conservative and not likely to change. Quantities included over depth dredging and advanced maintenance. The design assumes 3:1 slopes and the existing slopes are "flatter" and will require less dredging quantity due to the soft material. (Sta 57+000 to 100+000)	Unlikely	Negligible	**Low**	Unlikely	Negligible	**Low**
TR2	Hydraulic Dredging Quantities - Bay	If dredging quantities increase it could lead to additional costs.	Quantities are conservative and not likely to change. Quantities included over depth dredging and advanced maintenance. The design assumes advanced and over depth with 3:1 side slopes but does not include additional over depth of side slopes due to hard material. Additional side slopes quantities may be required. Final geo data during PED will allow final quantity determination.	Likely	Moderate	**Medium**	Likely	Marginal	**Medium**

TR3	Hydraulic Dredging Quantities - Bayou	If dredging quantities increase it could lead to additional costs.	Quantities are conservative and not likely to change. There is less Geo information for the Bayou than the bay. Quantities included over depth dredging and advanced maintenance. The design assumes advanced and over depth with 3:1 side slopes but does not include additional over depth of side slopes due to hard material. Additional side slopes quantities may be required. Final geo data during PED will allow final quantity determination.	Very Likely	Marginal	**Medium**	Very Likely	Marginal	**Medium**
TR4	Long bird Island and 8 Acre Bird Island PA Retainage	Conceptual Level Design and could change.	If less material is retained the island decreases and your costs decrease. If you have an overrun the island increases in size and increases the shaping, grading and rock costs.	Possible	Marginal	**Low**	Possible	Marginal	**Low**
TR5	3 Bird Island Marsh PA Design	Conceptual Level Design and could change.	There is potential for a soft foundation and could require additional material. If less material is retained the island decreases and your costs decrease. If you have an overrun the island increases in size and increases the shaping, grading and rock costs.	Likely	Marginal	**Medium**	Possible	Marginal	**Low**
TR7	M12 PA (NED) Design	Conceptual Level Design and could change.	There is potential for a soft foundation and could require additional material. (M12 is significantly better foundation than M11) If less material is retained the island decreases and your costs decrease. If you have an overrun the island increases in size and increases the shaping, grading and rock costs. Sweeping of Cedar Bayou navigation channel material could increase.	Possible	Marginal	**Low**	Possible	Marginal	**Low**
TR9	Oyster Mitigation Design (NED)	Conceptual Level Design and could change.	NED design is an established practice. 31.7 acre oyster reef mitigation for Boliver Roads to Redfish does not rely on berm. 30-inch layer of cultch is sufficient to account for settling.	Unlikely	Negligible	**Low**	Unlikely	Negligible	**Low**

TR11	Sheetpile Wall Design	Initial Sheetpile Wall Design and could change.	Quantity of steel required could change with final design. Length is conservative and the quantity is possible to change. This is likely a design/build scope of work and the costs are possible to change,	Possible	Moderate	**Medium**	Possible	Negligible	**Low**
TR12	Beltway 8 Upland PA Design	The Beltway 8 Design could change.	Exact parameters of onsite borrow material have been estimated and likely to change during PED.	Possible	Negligible	**Low**	Possible	Marginal	**Low**
TR13	E2 Clinton Upland PA Design	The E2 Clinton Design could change.	Exact parameters of onsite borrow material have been estimated and likely to change during PED.	Possible	Negligible	**Low**	Possible	Marginal	**Low**
TR14	Glendale and Filter bed Upland PA Design	Conceptual Level Design and could change.	The estimate assumes onsite borrow but may require offsite import material.	Likely	Moderate	**Medium**	Possible	Marginal	**Low**
TR15	Revetment Rock Sizing	Revetment Rock Sizing could change.	Revetment rock sizing could change during PED. Sizing currently to 1500# stone and is conservative. If stone sizing decreased the total tonnage could increase. This risk is independent of the shoaling attenuation feature.	Possible	Marginal	**Low**	Possible	Marginal	**Low**
Lands and Damages (LD)									
LD1	LERRDS	Additional LERRDS may be required.	ALL upland PA's owned by the Port of Houston. Bay PA's are on submerged lands. Oyster Mitigation reefs avoid tracts under 3rd party leases.	Unlikely	Negligible	**Low**	Unlikely	Negligible	**Low**
LD2	Pipeline Relocations	Utility Relocation numbers and construction may change.	8 assumed in estimate and quantities could change. Actual depth are unknown.	Likely	Negligible	**Low**	Possible	Negligible	**Low**
Regulatory Environmental Risks (RG)									
RG1	Historical/Cultural Significance	Historical/Cultural Significance	No historical or cultural sites expected.	Unlikely	Negligible	**Low**	Unlikely	Negligible	**Low**

RG2	Endangered Species	Bird avoidance and minimization	There is no beach disposal on this project. No endangered species concerns with the new work.	Unlikely	Negligible	**Low**	Unlikely	Negligible	**Low**
RG3	Unexploded Ordinance	Beltway 8 was former army munitions depot facility.	Sweeps did not find any UXO's with 95% confidence.	Unlikely	Marginal	**Low**	Unlikely	Moderate	**Low**
RG4	Sea Level Rise	The implementation of estimating sea level rise in the design life of all ACOE projects could affect the project cost.	This risk could be eliminated during the design phase. This could decrease the project cost due to less required dredging. Less dredging would also decrease the project schedule.	Unlikely	Negligible	**Low**	Unlikely	Negligible	**Low**
RG5	Oyster Mitigation	Oyster mitigation quantity could change.	Oyster mitigation based on updated survey. The Bird island size cannot change and therefore the oyster mitigation acreage not anticipated to change. Additional quantity changes are captured in the technical risks (ADD Risk #). There could be a schedule delay to coordinate with other agencies.	Unlikely	Negligible	**Low**	Possible	Marginal	**Low**
RG6	Air Quality	Construction could be delayed to minimize air quality impacts.	Do not foresee having any issue with EPA. Could require Tier 2 equipment and lower fuel efficiency but it is possible.	Unlikely	Marginal	**Low**	Possible	Marginal	**Low**
RG7	Contaminated Dredge Material	Contamination could lead to changing disposal location.	Segment 5 and 6 has the potential for contaminated material. Sediment testing has been done and no contamination was present in levels of significant concern. Current sediment sampling indicates this is a very low risk but if it occurred it could be a moderate cost. The design may require drainage of dredge effluent with onsite management. This would reduce the dredge production requiring the dredge to reduce time for 14 hours/day to 12 hours/day. The PDT feels this a possible risk for the project but has moderate cost risks.	Possible	Significant	**Medium**	Possible	Marginal	**Low**
RG8	Agency Reviews	Agency reviews could lead to delays.	There has been ongoing coordination with beneficial use group (BUG) and there are no delays anticipated. Sediment sampling and section 103 has been coordinated with the EPA.	Unlikely	Negligible	**Low**	Unlikely	Negligible	**Low**

Construction Risks (CO)									
CO1	Modifications & Claims	Construction contract modifications can impact construction cost and schedule growth.	Technical complexities and site conditions could result in increased risk of contract modifications. This does not include scope growth and cover the "Unknown-Unknowns" for items such as plan omissions, delays, etc. Will impact costs, but little overall impact to larger project timeline.	Possible	Marginal	**Low**	Unlikely	Marginal	**Low**
CO2	Labor Availability/Pricing	Gulf Labor rates are relatively low and estimate labor rate are conservative.	Gulf region labor rates are fairly low when compared to national rates. Busy economy may require paying extra for skilled labor. Estimate labor (Union Rates) conservative and typically higher than actual costs.	Unlikely	Marginal	**Low**	Unlikely	Negligible	**Low**
CO3	Navigation Traffic Conflicts	Traffic within the shipping channel could delay or halt construction.	Submerged pipeline required to mitigate navigation traffic interference. Estimate assumes decreased productivity to account for navigation channel traffic. 14 hours/day in Bayou and 16 hrs/day in the bay assumed in estimate. EWT accounted for in CEDEP estimate and is based on historical productivity. Additional cost and schedule risks are minimal.	Possible	Marginal	**Low**	Possible	Marginal	**Low**
CO4	New Dredging	New work dredging could be lower productivity than estimated.	New work dredging estimates based on historical boring information and production estimate reflect the new work materials seen per segment.	Possible	Marginal	**Low**	Possible	Marginal	**Low**
CO5	Material Availability	Rock material pricing is a concern.	Imported rock is assumed to be imported from Missouri. Rock and rip rap is readily available and conservatively priced based on common practice for the area.	Unlikely	Marginal	**Low**	Unlikely	Marginal	**Low**
CO6	Sheetpile Wall Construction	Specialized Equipment may not be available	Giken "press in" method may be required for pile installation and require specialized equipment that may not be available	Possible	Marginal	**Low**	Possible	Marginal	**Low**

			(segment 2 only). This could add to the cost for the segment 2 pile installation.						
CO7	Inefficient Contractor	Inefficient contractor may delay the project and affect the quantities.	Additional quantities could add to direct costs, additional oversight and management. Inefficiencies could delays future contracts and add costs to expedite future contracts.	Possible	Moderate	**Medium**	Possible	Moderate	**Medium**
CO8	Bird Island Marsh Construction	Low retainage may require 3 materials in order to construct Bird Island Marsh as designed.	The PDT is concerned the long pumping distance will decrease the retainage and not allow the dike to be shaped as designed. The contractor may have to not just widen but dig deeper to get material with more stiff clay.	Likely	Moderate	**Medium**	Possible	Moderate	**Medium**
Estimate and Schedule Risks (ES)									
ES1	Dredging Productivity	The types and classifications of materials for the purposes of estimating could present a risk to the project costs and schedule. Since future dredging in new work areas, there is some uncertainty about the types of material that will be encountered.	Material types affect dredging efficiency which drives the costs. Limited Geotechnical data of the dredged material may result in encountering unanticipated materials that could be more difficult to dredge that would impact productivity. Productivity was applied for individual segments utilizing existing boring logs. The PDT has strong confidence in the Bay productivity rates. Segment 5 and 6 has the possibility of decreased productivity.	Possible	Moderate	**Medium**	Unlikely	Moderate	**Low**
ES2	Dredge Mob/Demob	Actual Mob/Demob cost could vary	Mob/demob costs are based on average actual pricing. Actual mob costs could vary based on actual dredge plant location.	Possible	Marginal	**Low**	Unlikely	Moderate	**Low**

ES3	Relocation Pricing	Relocation costs may change.	Relocation costs based on historical costs. Actual costs may vary from escalated price included in estimate. Relocations based on land based equipment. Relocations need to be completed prior to work and could delay the contract. Relocation pricing modeled in LD2.	Unlikely	Negligible	**Low**	Unlikely	Negligible	**Low**
ES4	Equip rates	The equipment rates are outdated	Equipment pricing is outdated in the properties but the rates were manually updated based on current data.	Unlikely	Negligible	**Low**	Unlikely	Negligible	**Low**
ES5	Schedule Detail	Construction Schedule could change.	Estimate and schedule assume 12 separate contracts. Total dredging time, based on quantities, is 40 months. Schedule based on fiscal years but total schedule is unlikely to extend more than 3-6 months.	Unlikely	Marginal	**Low**	Possible	Marginal	**Low**
ES6	Sheetpile Pricing	Sheetpile Pricing Parametric and may change.	Sheetpile pricing is parametric and could vary from the actual pricing. There is updated material pricing but the labor and equipment is likely to change. The labor and equipment risk is modeled in TR11.	Unlikely	Marginal	**Low**	Possible	Marginal	**Low**
External Risks (EX)									
EX1	Adverse Weather	Location is subject to hurricanes.	Storms/hurricanes in other regions could limit number of dredges available close to project site during performance period, increasing distance to mobilize. This would be paid by another contract but could cause a schedule delay. A local storm could bring additional dredging quantities. Storms could damage existing placement area work.	Possible	Marginal	**Low**	Likely	Negligible	**Low**

EX2	Fuel	Fuel is a volatile cost and can greatly affect the cost of this project.	Fuel could increase or decrease altering the cost. Estimate assumes $3/gallon and the current price is $2.25/gallon for fuel and is conservative. We assume an increase of $.50/gal based on price fluctuations in the past years.	Possible	Moderate	**Medium**	Unlikely	Negligible	**Low**
EX3	Dredge Availability	The availability and number of quality dredges for this particular project is a potential concern.	There is concern in needing more dredges to complete dredging in a required timeframe. Dredges must be spaced a minimum distance, as per USCG (5 nautical miles). PDT feels this is not likely to be an issue. There is always a chance of a disaster response that would occupy the available dredge fleet. Historically this has not been a problem.	Unlikely	Moderate	**Low**	Possible	Marginal	**Low**
EX4	Inflation	Inflation could exceed CWCCIS	Project is for 2023-2027 (2028 for LPP) and inflation could exceed CWCCIS tables. Since this is dredging the risks for fuel and labor have already been accounted and therefore this risk is not modeled.	Possible	Marginal	**Low**	Unlikely	Marginal	**Low**
EX5	Upland Mitigation	Upland Mitigation	Bank credits are being used and if the project is delayed the credits could change (37 ac assumed). Bank credit cost could change. The bank credit costs covered in the estimate is conservative and therefore the cost risk has not been modeled.	Likely	Negligible	**Low**	Unlikely	Marginal	**Low**
EX6	Ship Accident/Oil Spill	Possible accident or oil spill in the channel.	A ship accident or oil spill within the channel could lead to standby costs and schedule delays.	Possible	Marginal	**Low**	Possible	Marginal	**Low**

US Army Corps
of Engineers®

Houston Ship Channel DMMP
45’ Expansion Channel Improvement
Project Cost and Schedule Risk Analysis Report
LPP Plan

Prepared for:

U.S. Army Corps of Engineers,
Galveston District

Prepared by:

U.S. Army Corps of Engineers, Walla Walla District
Engineering and Construction Division, Cost Engineering Branch

November 20, 2019

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EXECUTIVE SUMMARY

The US Army Corps of Engineers (USACE), Galveston District, presents this cost and schedule risk analysis (CSRA) report regarding the risk findings and recommended contingencies for the Galveston District, Houston Ship Channel DMMP. In compliance with Engineer Regulation (ER) 1110-2-1302 CIVIL WORKS COST ENGINEERING, dated September 15, 2008, a *Monte-Carlo* based risk analysis 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.

The Houston Ship Channel (HSC) project purpose is to reduce transportation costs and address navigation safety issues on the Houston Ship Channel (HSC) system. The HSC consists of an existing 52 mile long deep-draft navigation channel, three deep-draft tributary channels and one shallow draft tributary channel. The primary HSC deep-draft channel has authorized depths ranging from 36 feet to 45 feet and widths ranging generally from 300 feet to 530 feet.

The DMMP documents the dredging and placement needs for the Federal project and associated non- Federal facilities, as feasible, for the next 50-years for the Houston Ship Channel complex, which includes: HSC main stem from Bolivar Roads to the Upper Turning Basin, Bayport Ship Channel, Barbour's Terminal Cut, Greens Bayou, Jacinto Port, the light-draft channel, Turkey Bend, Turkey Bend Cut off, boater cuts, and barge lanes. The DMMP is developed as a stand-alone document for operations and management of future dredged material for the federal project.

The current and future placement plan for continued operation and maintenance of the existing HSC complex is outlined in the December 5, 2017 Preliminary Assessment (HSCPA) and conceptual 50-year DMMP dated December 18, 2018. This is considered the Future Without Project (FWOP) condition for the HSC ECIP Study. The study integrates changes to the FWOP conditions by identifying the base plan for placement needs for the increment of new work and maintenance dredging from the recommended modification which includes dredged material originating from the Federal channel for a period of 50-years. This is considered the Future With Project (FWP) condition for the HSC ECIP Study.

Specific to the Houston Ship Channel DMMP, the current project base cost estimate, pre-contingency, approximates $531M. This CSRA included study of estimated base construction, engineering and design and construction management. There are no spent costs and real estate costs are accounted for in the real estate appendix. Based

on the results of the analysis, the Cost Engineering Mandatory Center of Expertise for Civil Works (Cost MCX located in Walla Walla District) recommends a contingency value of $209M or approximately 39% of base project cost at an 80% confidence level of successful execution.

Cost estimates fluctuate over time. During this period of study, minor cost fluctuations can and have occurred. For this reason, contingency reporting is based in cost and percent values. Should cost vary to a slight degree with similar scope and risks, contingency per cent values will be reported, cost values rounded.

Table ES-1. Construction Contingency Results

Base Case Estimate	**$531,384,000**	
Confidence Level	**Construction Value ($) w/ Contingencies**	**Contingency (%)**
50%	$712,054,000	34%
80%	**$738,623,000**	**39%**
90%	$754,565,000	42%

KEY FINDINGS/OBSERVATIONS RECOMMENDATIONS

A formal Cost Risk Analysis was performed on Houston Ship Channel Improvement Project with the cooperation of the PDT and Cost Engineering Mandatory Center of Expertise for Civil Works. The risks were quantified and a cost risk model developed to determine a contingency at 80% confidence level (CL). The key risk drivers identified through sensitivity analysis suggest a cost contingency of $207M at an 80% confidence level.

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

- PM-5: Scope Changes – Additional ship simulations could result in wider channel recommended in Bay. Pilots contend that 725-ft width is the minimum to ensure safety, and 750-ft desired.
- CO-8: Bird Island Marsh Construction – The PDT is concerned the long pumping distance will decrease the retainage and not allow the dike to be shaped as designed. The contractor may have to not just widen but dig deeper to get material with more stiff clay.
- CO-1: Modification and Claims – Technical complexities and site conditions could result in increased risk of contract modifications. This does not include scope

growth and cover the "Unknown-Unknowns" for items such as plan omissions, delays, etc.

- CA-2: Market Conditions and Bidding Competition – Corps studies have resulted in an expected dredge shortage as compared to the many anticipated projects in the Gulf region. Generally there are 2 bidders for the 30" hydraulic dredges. A third hydraulic dredge is anticipated to be ready at the time of this construction. There is the possibility of many dredging projects and less competition is possible, resulting in higher bids.
- EX-2: Fuel Price – Fuel could increase or decrease altering the cost. Estimate assumes $3/gallon and the current price is $2.25/gallon for fuel and is conservative. We assume an increase of $.50/gal based on price fluctuations in the past years.
- TR-11: Sheetpile Wall Design – Quantity of steel required could change with final design. Length is conservative and the quantity is possible to change. This is likely a design/build scope of work and the costs are possible to change,
- ES-1: Dredging Productivity – Material types affect dredging efficiency which drives the costs. Limited Geotechnical data of the dredged material may result in encountering unanticipated materials that could be more difficult to dredge that would impact productivity. Productivity was applied for individual segments utilizing existing boring logs. The PDT has strong confidence in the Bay productivity rates. Segment 5 and 6 has the possibility of decreased productivity. Lesser project risks can be referenced in the cost sensitivity forecast data.

Schedule Risks: The high value of schedule risk indicates a significant uncertainty of key risk items that can translate into added costs within the schedule. From the sensitivity chart, the key or greater Cost Risk items of include:

- CO-8: Bird Island Marsh Construction – Low retainage may require additional time in order to construct Bird Island Marsh as designed.
- PM-4: BCR Delays – Multiple separable elements that need to compete. The PDT feels the BCR will be competitive. Lengthy delays would require an economic update.
- CO-7: Inefficient Contractor - Additional quantities could add to direct costs, additional oversight and management. Inefficiencies could delays future contracts and add costs to expedite future contracts.
- PM-5: Scope Changes – Additional ship simulations could result in wider channel recommended in Bay with a longer construction schedule. Pilots contend that 725-ft width is the minimum to ensure safety, and 750-ft desired
- ES-6: Schedule Detail: Estimate and schedule assume 12 separate contracts and likely to change.
- PM-1: Federal Funding – Due to the priority of the project it is likely that the project may not receive adequate funding annually. The PHA (Port of Houston Authority) could advance funds which would mitigate the cost and schedule risk.

Recommendations: 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

Within the authority of the US Army Corps of Engineers (USACE), Galveston District, this report presents the efforts and results of the cost and schedule risk analysis for the Houston Ship Channel DMMP. The report includes risk methodology, discussions, findings and recommendations regarding the identified risks and the necessary contingencies to confidently administer the project, presenting a cost contingency value with an 80% confidence level of successful execution.

2.0 BACKGROUND

The LPP cost estimate of the project is divided into six segments, or reaches, each with a separate placement plan and placement areas. All dredging was assumed to be performed by a 30-inch cutter-head pipeline dredge, except for portions of Boliver Roads to Redfish Reef segment and Redfish to BSC, for which a mechanical dredge will be used.

The NED plan includes widening the channel from 530 feet wide to 700 feet wide from Bolivar Roads to Redfish, four bend easings, and easing the Bayport Flare from a 4,000 foot to a 5,300 foot radius in Segment 1; widening the Bayport Ship Channel from 350 and 400 feet to 455 feet in Segment 2; widening the Barbour's Cut Ship Channel from 300 to 455 feet wide and extending the turning radius flare to 1,800 feet in Segment 3; widening from 400 to 530 feet and deepening from 41.5 to 46.5 feet Boggy Bayou to Greens Bayou and deepening from 41.5 to 46.5 from Greens Bayou to the Washburn Tunnel in Segment 4; deepening from Sims to 610 from 37.5 to 41.5 in Segment 5; and deepening from 37.5 to 41.5 from 610 to the Turning Basin in Segment 6.

The apparent LPP includes widening the channel from 530 feet to 700 feet wide from Redfish to Bayport and from Bayport to Barbour's Cut.

Detailed descriptions of the various HSC segments and tributary channels included in this DMMP are presented in the Integrated Dredged Material Management Plan and Environmental Assessment Report.

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 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 the 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

The Cost Engineering MCX performed the Cost and Schedule Risk Analysis, relying on local Galveston District staff to provide expertise and information gathering. The Galveston PDT conducted initial risk identification in March 2015. The initial risk identification meeting also included qualitative analysis to produce a risk register that served as the draft framework for the risk analysis.

A Risk meeting occurred in March 2015 with an update in December of 2015, resulting in a revision of the identified risks and the current known impacts. The cost and schedule risk analysis and cost certification was completed in January 2016. The project scope was changed and a cost and schedule risk analysis update was again completed in June 2019. Key PDT members included:

Attendance	Name	Office	Representing
Full	Dale Williams	CESWG-ECE-P	Cost Engineering
Full	T. Cheryl Jaynes	CESWF-PEC-PF	Plan Formulation
Full	Nancy C. Young	CESWF-EC-G	Civil Engineer
Full	David B. Boothby	CESWF-EC-S	Geotech Engineer
Full	Harmon Brown	CESWF-PEC-CC	Environmental
Full	Kenny Pablo	CESWG-RE	Real Estate
Full	Nichole Schlund	CESWG-RE	Real Estate
Full	A. Rashid Ali	CESWG-ECE-P	Cost Engineering
Full	Chester Hedderman	GBA/JV	PHA
Full	Richard Ruchoeft	PHA	PHA
Full	Ryan Harbor	CESWG-ECE-P	Cost Engineering
Full	Stephanie Nieves	CESWG-ECE-P	Cost Engineering
Full	Dana Cheney	GBA/JV	PHA
Full	Carl Sepulveda	AECOM/JV	Environmental

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 with the Galveston District office for the purposes of identifying and assessing risk factors. The meeting conducted June 2019 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. 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 (putting it to numbers of cost and time) 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 cost 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 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 project.

a. The Galveston District provided MII MCACES (Micro-Computer Aided Cost Estimating Software) and CEDEP (Corps of Engineers Dredge Estimating Program) files electronically. The MII files transmitted and downloaded June 2019 were the basis for the initial cost and schedule risk analyses. These files were again updated in November 2019.

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 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.

d. Per the CWCCIS Historical State Adjustment Factors in EM 1110-2-1304. 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. 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.

f. 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 and P90 confidence levels are also provided for illustrative purposes only.

Cost contingency for the Construction risks was quantified as approximately $93.5 Million at the P80 confidence.

Table 1. Construction Cost Contingency Summary

Base Case Estimate	**$531,384,000**	
Confidence Level	**Construction Value ($) w/ Contingencies**	**Contingency (%)**
50%	$712,054,000	34%
80%	**$738,623,000**	**39%**
90%	$754,565,000	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.

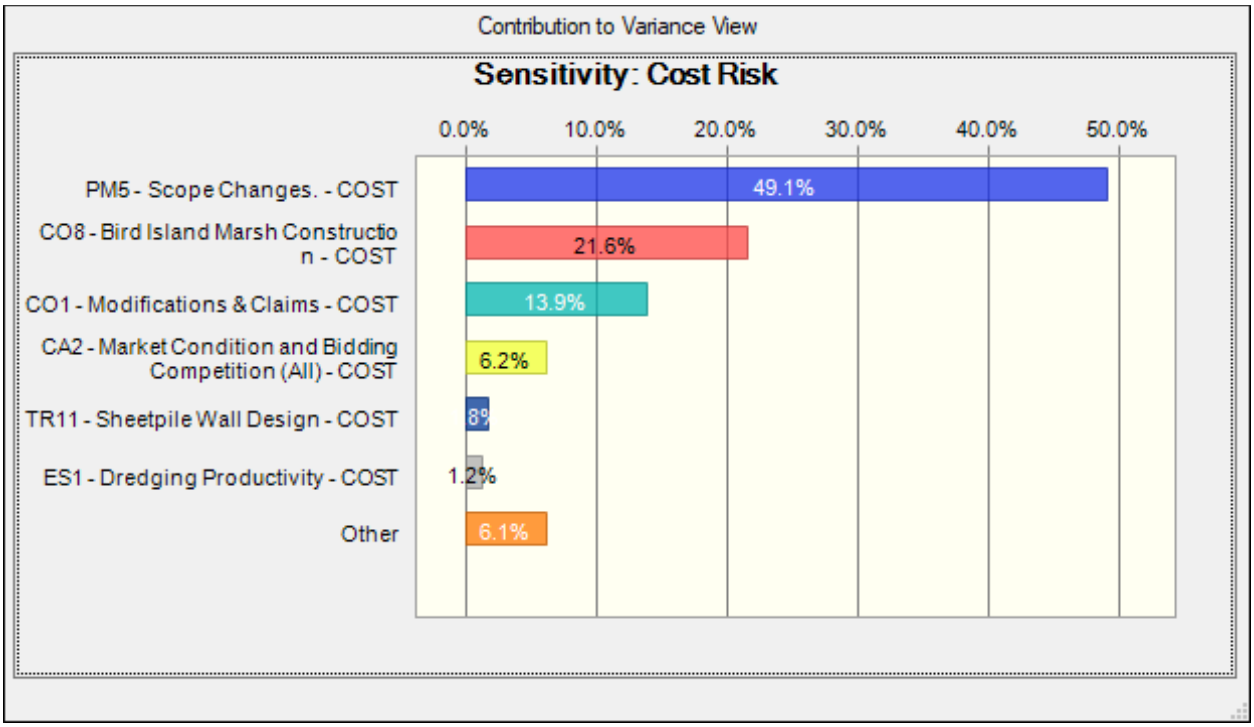
Key cost drivers identified in the sensitivity analysis can be used to support development of a risk management plan that will facilitate control of risk factors and their potential impacts throughout the project lifecycle. Together with the risk register, sensitivity analysis results can also be used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

Figure 1. Cost Sensitivity Analysis



6.3 Schedule 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 P90 confidence levels are also provided for illustrative purposes.

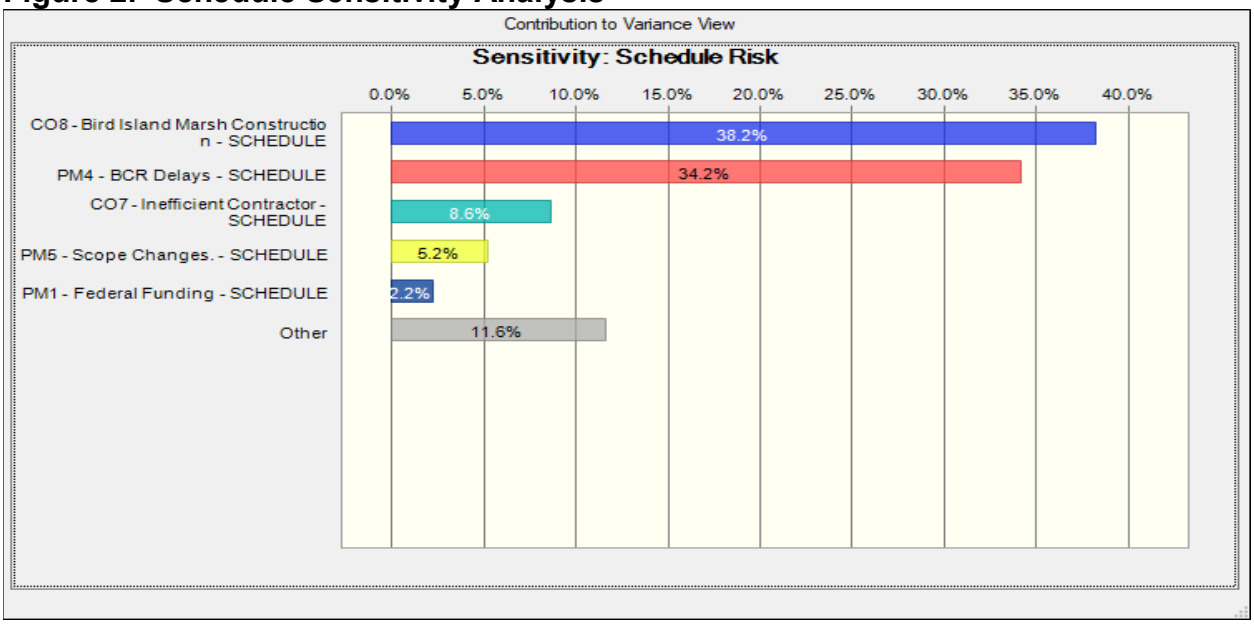
Schedule duration contingency was quantified as 23 months based on the P80 level of confidence. The schedule contingencies were calculated by applying the high level schedule risks identified in the risk register for each option to the durations of critical path and near critical path tasks.

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.

Table 2. Schedule Duration Contingency Summary

Risk Analysis Forecast (base schedule of 52 months)	Duration w/ Contingencies (months)	Contingency[1] (months)
50% Confidence	71	19
80% Confidence	75	23
90% Confidence	78	26

Figure 2. Schedule Sensitivity Analysis



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 comparison summaries are provided in Table 1. Additional major findings and observations of the risk analysis are listed below.

The Cost Engineering MCX performed the Cost and Schedule Risk Analysis, relying on local Galveston District staff to provide expertise and information gathering. The Galveston PDT conducted initial risk identification in 2015. The cost and schedule risk analysis and cost certification was completed January 2016 and updated in August 2019. The key risk drivers identified through sensitivity analysis suggest a cost contingency of $207M at an 80% confidence level.

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

- PM-5: Scope Changes – Additional ship simulations could result in wider channel recommended in the Bay. Pilots contend that 725-ft width is the minimum to ensure safety, and 750-ft desired.
- CO-8: Bird Island Marsh Construction – The PDT is concerned the long pumping distance will decrease the retainage and not allow the dike to be shaped as designed. The contractor may have to not just widen but dig deeper to get material with more stiff clay.
- CO-1: Modification and Claims – Technical complexities and site conditions could result in increased risk of contract modifications. This does not include scope growth and cover the "Unknown-Unknowns" for items such as plan omissions, delays, etc.
- CA-2: Market Conditions and Bidding Competition – Corps studies have resulted in an expected dredge shortage as compared to the many anticipated projects in the Gulf region. Generally there are 2 bidders for the 30” hydraulic dredges. A third hydraulic dredge is anticipated to be ready at the time of this construction. There is the possibility of many dredging projects and less competition is possible, resulting in higher bids.
- EX-2: Fuel Price – Fuel could increase or decrease altering the cost. Estimate assumes $3/gallon and the current price is $2.25/gallon for fuel and is conservative. We assume an increase of $.50/gal based on price fluctuations in the past years.
- TR-11: Sheetpile Wall Design – Quantity of steel required could change with final design. Length is conservative and the quantity is possible to change. This is likely a design/build scope of work and the costs are possible to change,
- ES-1: Dredging Productivity – Material types affect dredging efficiency which drives the costs. Limited Geotechnical data of the dredged material may result in encountering unanticipated materials that could be more difficult to dredge that would impact productivity. Productivity was applied for individual segments utilizing existing boring logs. The PDT has strong confidence in the Bay productivity rates. Segment 5 and 6 has the possibility of decreased productivity. Lesser project risks can be referenced in the cost sensitivity forecast data.

Lesser project risks can be referenced in the cost sensitivity forecast data.

Schedule Risks: The high value of schedule risk indicates a significant uncertainty of key risk items that can translate into added costs within the schedule. From the sensitivity chart, the key or greater Cost Risk items of include:

- CO-8: Bird Island Marsh Construction – Low retainage may require additional time in order to construct Bird Island Marsh as designed.
- PM-4: BCR Delays – Multiple separable elements that need to compete. The PDT feels the BCR will be competitive. Lengthy delays would require an economic update.
- CO-7: Inefficient Contractor - Additional quantities could add to direct costs, additional oversight and management. Inefficiencies could delays future contracts and add costs to expedite future contracts.
- PM-5: Scope Changes – Additional ship simulations could result in wider channel recommended in the Bay with a longer construction schedule. Pilots contend that 725-ft width is the minimum to ensure safety, and 750-ft desired
- ES-6: Schedule Detail: Estimate and schedule assume 12 separate contracts and likely to change.
- PM-1: Federal Funding – Due to the priority of the project it is likely that the project may not receive adequate funding annually. The PHA (Port of Houston Authority) could advance funds which would mitigate the cost and schedule risk.

Table 2. Construction Cost Comparison Summary (Uncertainty Analysis)

	Percentile	Baseline TPC	Baseline w/ Contingency	Contingency %
PROJECT CONTINGENCY (BASELINE ESTIMATE)	0%	$531,384,000	**$627,032,838**	**18%**
	10%	$531,384,000	**$669,543,539**	**26%**
	20%	$531,384,000	**$680,171,215**	**28%**
	30%	$531,384,000	**$690,798,890**	**30%**
	40%	$531,384,000	**$701,426,565**	**32%**
	50%	$531,384,000	**$712,054,240**	**34%**
	60%	$531,384,000	**$717,368,078**	**35%**
	70%	$531,384,000	**$727,995,753**	**37%**
	80%	$531,384,000	**$738,623,428**	**39%**
	90%	$531,384,000	**$754,564,941**	**42%**
	100%	$531,384,000	**$807,703,317**	**52%**

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, mobile home relocations, 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).

APPENDIX A

CREF	Risk/Opportunity Event	Risk Event Description	PDT Discussions on Impact and Likelihood	Likelihood ©	Impact ©	Risk Level ©	Likelihood (S)	Impact (S)	Risk Level (S)
Organizational and Project Management Risks (PM)									
PM1	Federal Funding	Annual appropriations for Design and Construction could be delayed.	Due to the priority of the project it is likely that the project may not receive adequate funding annually. The PHA (Port of Houston Authority) could advance funds which would mitigate the cost and schedule risk.	Possible	Negligible	**Low**	Possible	Significant	**Medium**
PM2	Non Federal Funding	Non federal sponsor may not have the funds to cost share.	The port if committed to having the funding. The PPA is anticipated to be signed and the funding will be in place.	Unlikely	Negligible	**Low**	Unlikely	Marginal	**Low**
PM3	Labor Availability	There may be a shortage of manpower for the design of this project.	We expect to have enough people to work on this project with the Galveston district. The PHA will supplement any shortages with work in kind.	Unlikely	Negligible	**Low**	Unlikely	Negligible	**Low**
PM4	BCR Delays	A low BCR ratio may delay a new start decision.	Multiple separable element that need to compete. The PDT feels the BCR will be competitive. Lengthy delays would require an economic update.	Unlikely	Negligible	**Low**	Likely	Marginal	**Medium**
PM5	Scope Changes.	Scope changes could add cost and delay the project.	Additional ship simulations could result in wider channel recommended in Bay. Pilots contend that 725-ft width is the minimum to ensure safety, and 750-ft desired. Additional pipelines could be identified and be added at the time of construction.	Possible	Significant	**Medium**	Unlikely	Negligible	**Low**
PM6	Coordination between Construction and Operations	O&M needs could impact new work dredging schedule.	O&M dredging could cause individual contract schedule coordination between construction and operations. This coordination could cause new work schedule changes. The total duration is not expected to change.	Possible	Marginal	**Low**	Unlikely	Negligible	**Low**
Contract Acquisition Risks (CA)									

CA1	Acquisition Strategy	Acquisition Strategy could change.	Contracts are generally separated by contract year and the team does not feel there is a risk of the acquisition changing. The order of the contracts could change but would not add to cost or delay the overall construction schedule.	Unlikely	Marginal	**Low**	Unlikely	Negligible	**Low**
CA2	Market Condition and Bidding Competition (All)	There is the possibility of having a limited number of contractors bid, due to increased work advertised, which would increase the cost.	Having limited competition would likely increase the cost. Corps studies have resulted in an expected dredge shortage as compared to the many anticipated projects in the Gulf region. Generally there are 2 bidders for the hydraulic dredging. A third hydraulic dredge is anticipated to be ready at the time of this construction. There is the possibility of many dredging projects and less competition is possible, resulting in higher bids.	Likely	Moderate	**Medium**	Unlikely	Negligible	**Low**
CA3	Small Business Goals	Small Business goals could add subcontracting costs.	Majority of dredging and placement area work is assumed for IFB large business. Small business could be added for PA site prep at Segment 4 , 5 and 6 adding marginal cost and schedule delays.	Possible	Marginal	**Low**	Unlikely	Marginal	**Low**
General Technical Risks (TR)									
TR1	Mechanical Dredging Quantities	If dredging quantities increase it could lead to additional costs.	Quantities are conservative and not likely to change. Quantities included over depth dredging and advanced maintenance. The design assumes 3:1 slopes and the existing slopes are "flatter" and will require less dredging quantity due to the soft material. (Sta 57+000 to 100+000)	Unlikely	Negligible	**Low**	Unlikely	Negligible	**Low**
TR2	Hydraulic Dredging Quantities - Bay	If dredging quantities increase it could lead to additional costs.	Quantities are conservative and not likely to change. Quantities included over depth dredging and advanced maintenance. The design assumes advanced and over depth with 3:1 side slopes but does not include additional over depth of side slopes due to hard material. Additional side slopes quantities may be required. Final geo data during PED will allow final quantity determination.	Likely	Moderate	**Medium**	Likely	Marginal	**Medium**

TR3	Hydraulic Dredging Quantities - Bayou	If dredging quantities increase it could lead to additional costs.	Quantities are conservative and not likely to change. There is less Geo information for the Bayou than the bay. Quantities included over depth dredging and advanced maintenance. The design assumes advanced and over depth with 3:1 side slopes but does not include additional over depth of side slopes due to hard material. Additional side slopes quantities may be required. Final geo data during PED will allow final quantity determination.	Very Likely	Marginal	**Medium**	Very Likely	Marginal	**Medium**
TR4	Long bird Island and 8 Acre Bird Island PA Retainage	Conceptual Level Design and could change.	If less material is retained the island decreases and your costs decrease. If you have an overrun the island increases in size and increases the shaping, grading and rock costs.	Possible	Marginal	**Low**	Possible	Marginal	**Low**
TR5	3 Bird Island Marsh PA Design	Conceptual Level Design and could change.	There is potential for a soft foundation and could require additional material. If less material is retained the island decreases and your costs decrease. If you have an overrun the island increases in size and increases the shaping, grading and rock costs.	Likely	Marginal	**Medium**	Possible	Marginal	**Low**
TR6	M7/8/9 and M11 PA (LPP) Design	Conceptual Level Design and could change.	There is potential for a soft foundation and could require additional material. If less material is retained the island decreases and your costs decrease. If you have an overrun the island increases in size and increases the shaping and grading. Oil and gas stakeholders may require access to the site.	Likely	Marginal	**Medium**	Possible	Marginal	**Low**
TR7	M12 PA (NED) Design	Conceptual Level Design and could change.	There is potential for a soft foundation and could require additional material. (M12 is significantly better foundation than M11) If less material is retained the island decreases and your costs decrease. If you have an overrun the island increases in size and increases the shaping, grading and rock costs. Sweeping of Cedar Bayou navigation channel material could increase.	Possible	Marginal	**Low**	Possible	Marginal	**Low**

TR8	Shoaling Attenuation Feature Design (LPP Only)	Conceptual Level Design and could change.	Highly conceptual level design will change after hydrodynamic modeling in PED. Size, length, position and orientation anticipated to change.	Very Likely	Moderate	**High**	Possible	Marginal	**Low**
TR9	Oyster Mitigation Design (NED)	Conceptual Level Design and could change.	NED design is an established practice.	Unlikely	Negligible	**Low**	Unlikely	Negligible	**Low**
TR10	Oyster Mitigation Design (LPP)	Conceptual Level Design and could change.	LPP Oyster design is new in Galveston Bay (357.9 AC for the LPP vs. 88 AC for the NED). Berm for San Leon oyster reef may require additional cultch if berm does not provide firm foundation. 2,030,000 CY hydraulically dredged to San Leon oyster reef (177 acres) to construct berm. If berm aborted, some material would be mechanically dredged.	Likely	Moderate	**Medium**	Possible	Marginal	**Low**
TR11	Sheetpile Wall Design	Initial Sheetpile Wall Design and could change.	Quantity of steel required could change with final design. Length is conservative and the quantity is possible to change. This is likely a design/build scope of work and the costs are possible to change,	Possible	Moderate	**Medium**	Possible	Negligible	**Low**
TR12	Beltway 8 Upland PA Design	The Beltway 8 Design could change.	Exact parameters of onsite borrow material have been estimated and likely to change during PED.	Possible	Negligible	**Low**	Possible	Marginal	**Low**
TR13	E2 Clinton Upland PA Design	The E2 Clinton Design could change.	Exact parameters of onsite borrow material have been estimated and likely to change during PED.	Possible	Negligible	**Low**	Possible	Marginal	**Low**
TR14	Glendale and Filter bed Upland PA Design	Conceptual Level Design and could change.	The estimate assumes onsite borrow but may require offsite import material.	Likely	Moderate	**Medium**	Possible	Marginal	**Low**
TR15	Revetment Rock Sizing	Revetment Rock Sizing could change.	Revetment rock sizing could change during PED. Sizing currently to 1500# stone and is conservative. If stone sizing decreased the total tonnage could increase. This risk is independent of the shoaling attenuation feature.	Possible	Marginal	**Low**	Possible	Marginal	**Low**
Lands and Damages (LD)									

LD1	LERRDS	Additional LERRDS may be required.	ALL upland PA's owned by the Port of Houston. Bay PA's are on submerged lands. Oyster Mitigation reefs avoid tracts under 3rd party leases.	Unlikely	Negligible	**Low**	Unlikely	Negligible	**Low**
LD2	Pipeline Relocations	Utility Relocation numbers and construction may change.	8 assumed in estimate and quantities could change. Actual depth are unknown.	Likely	Negligible	**Low**	Possible	Negligible	**Low**
Regulatory Environmental Risks (RG)									
RG1	Historical/Cultural Significance	Historical/Cultural Significance	No historical or cultural sites expected.	Unlikely	Negligible	**Low**	Unlikely	Negligible	**Low**
RG2	Endangered Species	Bird avoidance and minimization	There is no beach disposal on this project. No endangered species concerns with the new work.	Unlikely	Negligible	**Low**	Unlikely	Negligible	**Low**
RG3	Unexploded Ordinance	Beltway 8 was former army munitions depot facility.	Sweeps did not find any UXO's with 95% confidence.	Unlikely	Marginal	**Low**	Unlikely	Moderate	**Low**
RG4	Sea Level Rise	The implementation of estimating sea level rise in the design life of all ACOE projects could affect the project cost.	This risk could be eliminated during the design phase. This could decrease the project cost due to less required dredging. Less dredging would also decrease the project schedule.	Unlikely	Negligible	**Low**	Unlikely	Negligible	**Low**
RG5	Oyster Mitigation	Oyster mitigation quantity could change.	Oyster mitigation based on updated survey. The Bird island size cannot change and therefore the oyster mitigation acreage not anticipated to change. Additional quantity changes are captured in the technical risks (ADD Risk #). There could be a schedule delay to coordinate with other agencies.	Unlikely	Negligible	**Low**	Possible	Marginal	**Low**
RG6	Air Quality	Construction could be delayed to minimize air quality impacts.	Do not foresee having any issue with EPA. Could require Tier 2 equipment and lower fuel efficiency but it is possible.	Unlikely	Marginal	**Low**	Possible	Marginal	**Low**

RG7	Contaminated Dredge Material	Contamination could lead to changing disposal location.	Segment 5 and 6 has the potential for contaminated material. Sediment testing has been done and no contamination was present in levels of significant concern. Current sediment sampling indicates this is a very low risk but if it occurred it could be a moderate cost. The design may require drainage of dredge effluent with onsite management. This would reduce the dredge production requiring the dredge to reduce time for 14 hours/day to 12 hours/day. The PDT feels this a possible risk for the project but has moderate cost risks.	Possible	Significant	**Medium**	Possible	Marginal	**Low**
RG8	Agency Reviews	Agency reviews could lead to delays.	There has been ongoing coordination with beneficial use group (BUG) and there are no delays anticipated. Sediment sampling and section 103 has been coordinated with the EPA.	Unlikely	Negligible	**Low**	Unlikely	Negligible	**Low**
Construction Risks (CO)									
CO1	Modifications & Claims	Construction contract modifications can impact construction cost and schedule growth.	Technical complexities and site conditions could result in increased risk of contract modifications. This does not include scope growth and cover the "Unknown-Unknowns" for items such as plan omissions, delays, etc. Will impact costs, but little overall impact to larger project timeline.	Possible	Moderate	**Medium**	Unlikely	Marginal	**Low**
CO2	Labor Availability/Pricing	Gulf Labor rates are relatively low and estimate labor rate are conservative.	Gulf region labor rates are fairly low when compared to national rates. Busy economy may require paying extra for skilled labor. Estimate labor (Union Rates) conservative and typically higher than actual costs.	Unlikely	Marginal	**Low**	Unlikely	Negligible	**Low**
CO3	Navigation Traffic Conflicts	Traffic within the shipping channel could delay or halt construction.	Submerged pipeline required to mitigate navigation traffic interference. Estimate assumes decreased productivity to account for navigation channel traffic. 14 hours/day in Bayou and 16 hrs/day in the bay assumed in estimate. EWT accounted for in CEDEP estimate and is based on historical productivity. Additional cost and schedule risks are minimal.	Possible	Marginal	**Low**	Possible	Marginal	**Low**

CO4	New Dredging	New work dredging could be lower productivity than estimated.	New work dredging estimates based on historical boring information and production estimate reflect the new work materials seen per segment.	Possible	Marginal	**Low**	Possible	Marginal	**Low**
CO5	Material Availability	Rock material pricing is a concern.	Imported rock is assumed to be imported from Missouri. Rock and rip rap is readily available and conservatively priced based on common practice for the area.	Unlikely	Marginal	**Low**	Unlikely	Marginal	**Low**
CO6	Sheetpile Wall Construction	Specialized Equipment may not be available	Giken "press in" method may be required for pile installation and require specialized equipment that may not be available (segment 2 only). This could add to the cost for the segment 2 pile installation.	Possible	Marginal	**Low**	Possible	Marginal	**Low**
CO7	Inefficient Contractor	Inefficient contractor may delay the project and affect the quantities.	Additional quantities could add to direct costs, additional oversight and management. Inefficiencies could delays future contracts and add costs to expedite future contracts.	Possible	Moderate	**Medium**	Possible	Moderate	**Medium**
CO8	Bird Island Marsh Construction	Low retainage may require additional material in order to construct Bird Island Marsh as designed.	The PDT is concerned the long pumping distance will decrease the retainage and not allow the dike to be shaped as designed. The contractor may have to not just widen but dig deeper to get material with more stiff clay.	Likely	Moderate	**Medium**	Possible	Moderate	**Medium**
Estimate and Schedule Risks (ES)										

ES1	Dredging Productivity	The types and classifications of materials for the purposes of estimating could present a risk to the project costs and schedule. Since future dredging in new work areas, there is some uncertainty about the types of material that will be encountered.	Material types affect dredging efficiency which drives the costs. Limited Geotechnical data of the dredged material may result in encountering unanticipated materials that could be more difficult to dredge that would impact productivity. Productivity was applied for individual segments utilizing existing boring logs. The PDT has strong confidence in the Bay productivity rates. Segment 5 and 6 has the possibility of decreased productivity.	Possible	Moderate	**Medium**	Unlikely	Moderate	**Low**
ES2	Dredge Mob/Demob	Actual Mob/Demob cost could vary	Mob/demob costs are based on average actual pricing. Actual mob costs could vary based on actual dredge plant location.	Possible	Marginal	**Low**	Unlikely	Moderate	**Low**
ES3	Relocation Pricing	Relocation costs may change.	Relocation costs based on historical costs. Actual costs may vary from escalated price included in estimate. Relocations based on land based equipment. Relocations need to be completed prior to work and could delay the contract. Relocation pricing modeled in LD2.	Unlikely	Negligible	**Low**	Unlikely	Negligible	**Low**
ES4	Equip rates	The equipment rates are outdated	Equipment pricing is outdated in the properties but the rates were manually updated based on current data.	Unlikely	Negligible	**Low**	Unlikely	Negligible	**Low**
ES5	Schedule Detail	Construction Schedule could change.	Estimate and schedule assume 12 separate contracts. Total dredging time, based on quantities, is 40 months. Schedule based on fiscal years but total schedule is unlikely to extend more than 3-6 months.	Unlikely	Marginal	**Low**	Possible	Marginal	**Low**
ES6	Sheetpile Pricing	Sheetpile Pricing Parametric and may change.	Sheetpile pricing is parametric and could vary from the actual pricing. There is updated material pricing but the labor and equipment is likely to change. The labor and equipment risk is modeled in TR11.	Unlikely	Marginal	**Low**	Possible	Marginal	**Low**

External Risks (EX)									
EX1	Adverse Weather	Location is subject to hurricanes.	Storms/hurricanes in other regions could limit number of dredges available close to project site during performance period, increasing distance to mobilize. This would be paid by another contract but could cause a schedule delay. A local storm could bring additional dredging quantities. Storms could damage existing placement area work.	Possible	Marginal	**Low**	Likely	Negligible	**Low**
EX2	Fuel	Fuel is a volatile cost and can greatly affect the cost of this project.	Fuel could increase or decrease altering the cost. Estimate assumes $3/gallon and the current price is $2.25/gallon for fuel and is conservative. We assume an increase of $.50/gal or a decrease of $0.50/gal based price fluctuation in the past years.	Possible	Moderate	**Medium**	Unlikely	Negligible	**Low**
EX3	Dredge Availability	The availability and number of quality dredges for this particular project is a potential concern.	There is concern in needing more dredges to complete dredging in a required timeframe. Dredges must be spaced a minimum distance, as per USCG (5 nautical miles). PDT feels this is not likely to be an issue. There is always a chance of a disaster response that would occupy the available dredge fleet. Historically this has not been a problem.	Unlikely	Moderate	**Low**	Possible	Marginal	**Low**
EX4	Inflation	Inflation could exceed CWCCIS	Project is for 2023-2027 (2028 for LPP) and inflation could exceed CWCCIS tables. Since this is dredging the risks for fuel and labor have already been accounted and therefore this risk is not modeled.	Possible	Marginal	**Low**	Unlikely	Marginal	**Low**
EX5	Upland Mitigation	Upland Mitigation	Bank credits are being used and if the project is delayed the credits could change (37 ac assumed). Bank credit cost could change. The bank credit costs covered in the estimate is conservative and therefore the cost risk has not been modeled.	Likely	Negligible	**Low**	Unlikely	Marginal	**Low**

EX6	Ship Accident/Oil Spill	Possible accident or oil spill in the channel.	A ship accident or oil spill within the channel could lead to standby costs and schedule delays.	Possible	Marginal	**Low**	Possible	Marginal	**Low**