ST. LUCIE COUNTY, FLORIDA

COASTAL STORM RISK MANAGEMENT PROJECT

DRAFT INTEGRATED FEASIBILITY STUDY AND ENVIRONMENTAL ASSESSMENT

APPENDIX B

Cost Engineering and Risk Analysis

APRIL 2016

US Army Corps
of Engineers
Jacksonville District

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ATTACHMENT TO APPENDIX B

B. COST ESTIMATES

B1. GENERAL INFORMATION

Corps of Engineers cost estimates for planning purposes are prepared in accordance with the following guidance:

- Engineer Technical Letter (ETL) 1110-2-573, Construction Cost Estimating Guide for Civil Works, 30 September 2008
- Engineer Regulation (ER) 1110-1-1300, Cost Engineering Policy and General Requirements, 26 March 1993
- ER 1110-2-1302, Civil Works Cost Engineering, 15 September 2008
- ER 1110-2-1150, Engineering and Design for Civil Works Projects, 31 August 1999
- ER 1105-2-100, Planning Guidance Notebook, 22 April 2000, as amended
- Engineer Manual (EM) 1110-2-1304 (Tables Revised 31 March 2009), Civil Works Construction Cost Index System, 31 March 2000
- CECW-CP Memorandum for Distribution, Subject: Initiatives to Improve the Accuracy of Total Project Costs in Civil Works Feasibility Studies Requiring Congressional Authorization, 19 September 2007
- CECW-CE Memorandum for Distribution, Subject: Application of Cost Risk Analysis Methods to Develop Contingencies for Civil Works Total Project Costs, 3 July 2007
- Cost and Schedule Risk Analysis Process, March 2008

The goal of the cost estimates for the St. Lucie County CSRM Project Draft Feasibility Study and Integrated EA are to present a Total Project Cost (construction and non-construction costs) for the Tentatively Selected Plan (TSP) at the current price level to be used for project justification/authorization and to escalate costs for budgeting purposes. In addition, the costing efforts are intended to produce a final product (cost estimate) that is reliable and accurate, and that supports the definition of the Government's and the non-Federal sponsor's obligations.

The cost estimating effort for the study also yielded a series of alternative plan formulation cost estimates for decision making. The final set of plan formulation cost estimates used for plan selection rely on construction feature unit pricing and are prepared in Civil Works Work Breakdown Structure (CWWBS) format to the sub-feature level. The cost estimate supporting the National Economic Development (NED) plan (Tentatively Selected Plan) is prepared in MCACES/MII (Microcomputer Aided Cost Estimating System) format to the CWWBS sub-feature level. This estimate is supported by the preferred labor, equipment, materials and crew/production breakdown. A fully funded (escalated for inflation through project completion) cost estimate, the Baseline Cost Estimate or Total Project Cost Summary, has also been developed.

A full cost and schedule risk analysis was performed to establish the project contingency for the TSP's cost items.

B.1.1 Plan Formulation Cost Estimates

For the plan formulation cost estimates, unit prices for dredging related work were developed in CEDEP and then entered into MCACES/MII. Unit prices for the remaining major or variable construction elements were developed in MCACES/MII based on input from the PDT. Design details, information and assumptions were provided in the Engineering Appendix. Plan formulation alternatives were run through Beach-Fx for calculation of the Benefit-to-Cost Ratio (BCR). Cost Engineering provided estimates for the initial construction on all alternatives that were input into Beach-Fx. Non-construction costs were included as percentages of the total construction contract cost for this level of comparison and screening.

Refer to Economics Section in the main report for final plan formulation cost tables.

B.1.2 Tentatively Selected Plan(s)

The TSP was chosen by the Project Delivery Team (PDT) according to the plan formulation described above. The Economics Appendix fully describes the plan selection. The scope of work for the TSP is found in the Engineering Appendix. The MCACES/MII cost estimate for the TSP is based on that scope and is formatted in the CWWBS. The notes provided in the body of the estimate detail the estimate parameters and assumptions. These include pricing at the Fiscal Year 2016 price level (1 October 2015-30 September 2016). For project justification purposes, the estimate costs are categorized under the appropriate CWWBS code and include both construction and non-construction costs.

The construction costs fall under the following feature codes:

- 17 Beach Replenishment

The non-construction costs fall under the following feature codes:

- 01 Lands and Damages
- 30 Planning, Engineering and Design
- 31 Construction Management

B.1.3 Construction Cost

For the construction costs, unit prices for dredging related work were developed in the Cost Engineeing Dredge Estimating Program (CEDEP) and then entered into MCACES/MII. These costs include all major project components categorized under the appropriate CWWBS to the sub-feature level. The Total Project Cost Summary (TPCS) on the TSP contains contingencies that were determined as a result of the cost and schedule risk analysis, which is covered under another paragraph.

B.1.4 Non-construction Costs

Non-construction costs typically include Lands and Damages (Real Estate), Planning Engineering & Design (PED) and Construction Management Costs (Supervision & Administration, S&A). These costs were provided by the PDT either as a lump sum cost or as a percentage of the total Construction Contract Cost. Lands and Damages are provided by Real Estate and are best described in the Real Estate Appendix. PED costs are for the preparation of contract plans and specifications (P&S) and include itemized costs that were provided by the project manager, as well as costs for Post-Construction Monitoring, Life Cycle Updates, Planning During Construction (PDC), and Engineering During Construction (EDC). Construction Management costs are for the supervision and administration of a contract. This cost was provided by the project manager and is included as a percentage of the total construction contract cost.

The main report details both cost allocation and cost apportionment for the Federal Government and the non-Federal Sponsor. Also included in the main report are the non-Federal Sponsor's obligations (items of local cooperation).

B.1.5 Construction Schedule

A construction schedule was prepared utilizing input from the PDT and reflects all project construction components. The schedule considers not only durations of construction, but also the timing of construction contracts based on funding and construction windows. The construction schedule was combined with the project schedule to create an overall schedule that was used for the generation of the TPCS. The construction schedule will change as the project moves through the various project lifecycle phases.

B.1.6 Total Project Cost Summary

The cost estimate for the TSP is prepared with an identified price level date and inflation factors are used to adjust the pricing to the project schedule. This estimate is known as the Fully Funded Cost Estimate or Total Project Cost Summary. It includes all Federal and non-Federal costs: Lands, Easements, Rights of Way and Relocations; construction features; Planning Engineering and Design; Construction Management; Contingency; and Inflation.

B2. PLAN FORMULATION COST ESTIMATES

There were several alternatives the PDT evaluated during plan formulation in order to identify the TSP. All alternatives that were evaluated at various stages in the study can be found in the Economics Appendix and are also outlined in the Main Report.

The Final Array of Alternatives looked at the initial construction costs for one (1) reach, South Hutchison Island (R-98 to Martin County Line, or R-001), as described in the Main Report and Engineering Appendix. The final array considered five (5) separate conditions (varying beach widths); altogether there were five beach replenishment alternatives estimated, evaluated, and compared in the final array to determine the TSP.

The alternatives in the final array considered varying dune or beach widths constructed via dredging and hydraulic pumpout and truck haul; costs for dune plantings were also included where applicable. All fill densities and volumes were provided in spreadsheet format by Engineering. The volumes were calculated by BeachFx. Average distances to borrow sites were estimated using GoogleEarth (truck haul) or were provided by Engineering (dredging). Quantities for dune plantings were calculated based on acreages and FDEP planting requirement information.

The various alternatives were as follows:

- Dune10 (Truck Haul)
  - This alternative is a 10-foot extension of the existing dune with vegetation.
- ABerm10DuneEx (Truck Haul)

    - This alternative is a 10-foot extension of the existing berm constructed with the existing dune.
- ABerm20DuneEx (Hopper Dredging)
    - This alternative is a 20-foot extension of the existing berm constructed with the existing dune.
- ABerm30DuneEx (Hopper Dredging)
    - This alternative is a 30-foot extension of the existing berm constructed with the existing dune.
- ABerm40DuneEx (Hopper Dredging)
    - This alternative is a 40-foot extension of the existing berm constructed with the existing dune.

All dredging unit costs were calculated in CEDEP and transferred to MII to determine the total initial construction costs for each alternative. All truck haul unit costs were based upon input from various permitted sand mine vendors. A contingency was applied to each alternative based upon design level.

Once the total initial construction costs for each alternative were developed in MII, the costs were broken down into a spreadsheet provided by the PDT.

See also the Economics Section in the Main Report.

B3. TENTATIVELY SELECTED PLAN (NED) COST ESTIMATE

The recommended design, ABerm20DuneEx covers approximately 3.4 miles of shoreline between FDEP monuments R-98 and the Martin County line (R-001). The construction template consists of a variable width berm with a 1 on 100 slope and foreshore fill extending to approximately -5.0 ft-NAVD88 with a slope of 1 on 5. This template, dimensioned for constructability, will then equilibrate into the project (20 foot berm and profile extension) template. It should be noted that modification of this design may occur during the detailed design phase of the study.

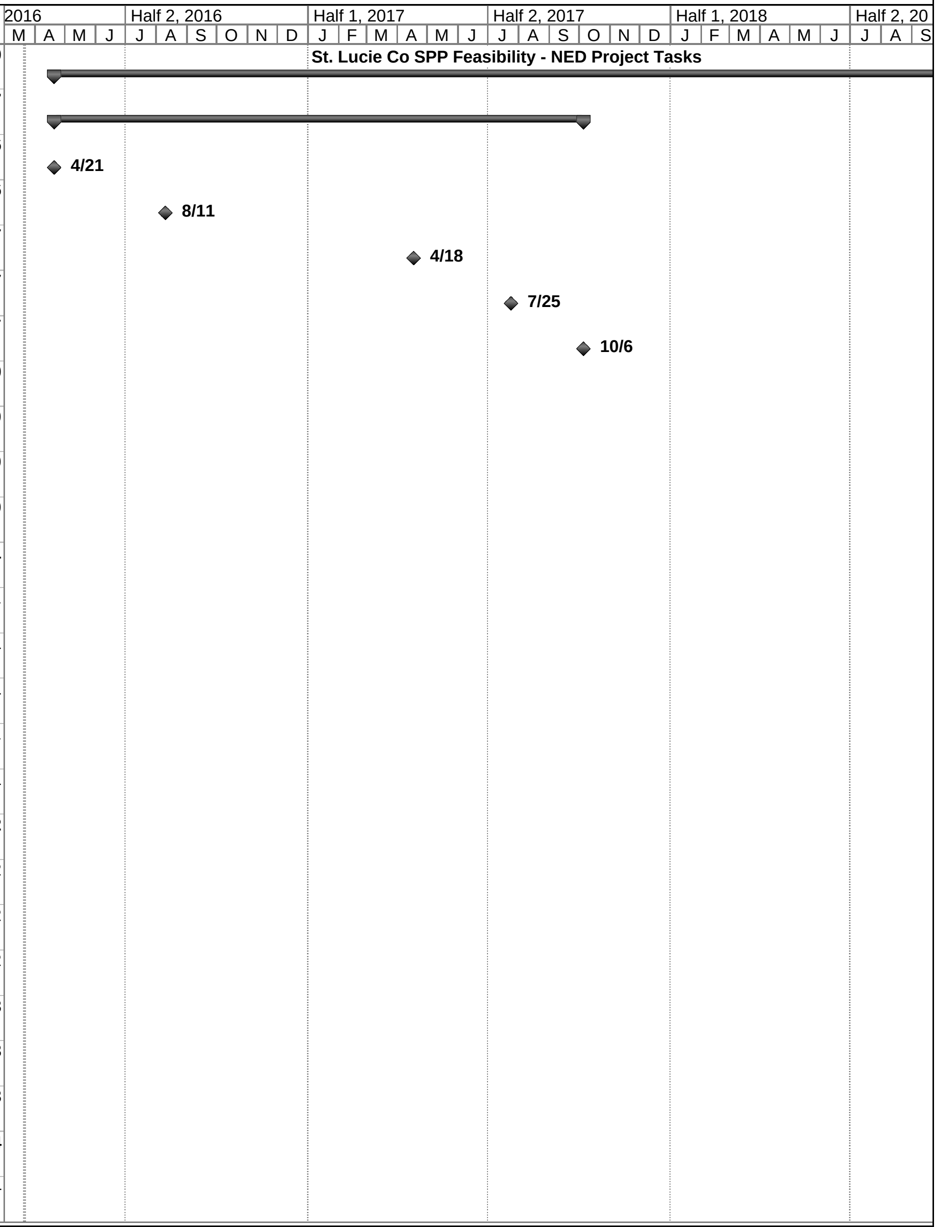
The Recommended Plan estimate was prepared for the Total Project Cost, not just the initial construction costs.

B4. SCHEDULE

The project schedule covers the lifecycle phases of the recommended plan (Planning Phase, Preconstruction, Engineering and Design (PED) Phase and the Construction Phase). Refer to the Schedule on the next page.

St. Lucie Co. Feasibility

ID	ℹ	Task Name	Duration	Start	Finish
1		**St. Lucie Co SPP Feasibility - NED Project Tasks**	**12237 days**	**Thu 4/21/16**	**Fri 10/22/49**
2		**Report Milestones**	**533 days**	**Thu 4/21/16**	**Fri 10/6/17**
3	▦	Tentatively Selected Plan (TSP) Milestone	0 days	Thu 4/21/16	Thu 4/21/16
4	▦	Agency Decision Milestone (ADM)	0 days	Thu 8/11/16	Thu 8/11/16
5	▦	Civil Works Review Board (CWRB) Milestone	0 days	Tue 4/18/17	Tue 4/18/17
6	▦	Chief of Engineer's Report Milestone	0 days	Tue 7/25/17	Tue 7/25/17
7	▦	Final Approval through ASA	0 days	Fri 10/6/17	Fri 10/6/17
8		**2019 - P&S, PED Mapping, Update**	**365 days**	**Tue 10/1/19**	**Wed 9/30/20**
9	▦	Lands & Damages	365 days	Tue 10/1/19	Wed 9/30/20
10	▦	PED	365 days	Tue 10/1/19	Wed 9/30/20
11	▦	Physical/Environmental Monitoring	365 days	Tue 10/1/19	Wed 9/30/20
12		**2020 - Initial Construction, Update**	**364 days**	**Thu 10/1/20**	**Thu 9/30/21**
13	▦	Beach Replenishment	111 days	Thu 10/1/20	Wed 1/20/21
14		Lands & Damages	364 days	Thu 10/1/20	Thu 9/30/21
15	▦	PED	364 days	Thu 10/1/20	Thu 9/30/21
16		Construction Management	111 days	Thu 10/1/20	Wed 1/20/21
17		Physical/Environmental Monitoring	364 days	Thu 10/1/20	Thu 9/30/21
18		**2021 - Update, Monitoring**	**364 days**	**Fri 10/1/21**	**Fri 9/30/22**
19		Lands & Damages	364 days	Fri 10/1/21	Fri 9/30/22
20		PED	364 days	Fri 10/1/21	Fri 9/30/22
21		Physical/Environmental Monitoring	364 days	Fri 10/1/21	Fri 9/30/22
22		**2022 - Update, Monitoring**	**364 days**	**Sat 10/1/22**	**Sat 9/30/23**
23		PED	364 days	Sat 10/1/22	Sat 9/30/23
24		Physical/Environmental Monitoring	364 days	Sat 10/1/22	Sat 9/30/23
25		**2023 - Update, Monitoring**	**365 days**	**Sun 10/1/23**	**Mon 9/30/24**
26		PED	365 days	Sun 10/1/23	Mon 9/30/24



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Task	🟦	Rolled Up Task	🟦	Split	┈	Progress	▬
Critical Task	🟥	Rolled Up Critical Task	🟥	External Tasks	▬	Deadline	⇩
Milestone	◆	Rolled Up Milestone	◇	Project Summary	▬		
Summary	▬	Rolled Up Progress	▬	Group By Summary	▬		

St. Lucie Co. Feasibility

ID	ℹ	Task Name	Duration	Start	Finish
27		Physical/Environmental Monitoring	365 days	Sun 10/1/23	Mon 9/30/24
28		**2024 - Update**	**364 days**	**Tue 10/1/24**	**Tue 9/30/25**
29		PED	364 days	Tue 10/1/24	Tue 9/30/25
30		**2025 - Update, Monitoring**	**364 days**	**Wed 10/1/25**	**Wed 9/30/26**
31		PED	364 days	Wed 10/1/25	Wed 9/30/26
32		Physical/Environmental Monitoring	364 days	Wed 10/1/25	Wed 9/30/26
33		**2026 - Update**	**364 days**	**Thu 10/1/26**	**Thu 9/30/27**
34		PED	364 days	Thu 10/1/26	Thu 9/30/27
35		**2027 - Update, Monitoring**	**365 days**	**Fri 10/1/27**	**Sat 9/30/28**
36		PED	365 days	Fri 10/1/27	Sat 9/30/28
37		Physical/Environmental Monitoring	365 days	Fri 10/1/27	Sat 9/30/28
38		**2028 - Update**	**364 days**	**Sun 10/1/28**	**Sun 9/30/29**
39		PED	364 days	Sun 10/1/28	Sun 9/30/29
40		**2029 - Update, Monitoring**	**364 days**	**Mon 10/1/29**	**Mon 9/30/30**
41		PED	364 days	Mon 10/1/29	Mon 9/30/30
42		Physical/Environmental Monitoring	364 days	Mon 10/1/29	Mon 9/30/30
43		**2030 - Update**	**364 days**	**Tue 10/1/30**	**Tue 9/30/31**
44		PED	364 days	Tue 10/1/30	Tue 9/30/31
45		**2031 - Update, Monitoring**	**365 days**	**Wed 10/1/31**	**Thu 9/30/32**
46		PED	365 days	Wed 10/1/31	Thu 9/30/32
47		Physical/Environmental Monitoring	365 days	Wed 10/1/31	Thu 9/30/32
48		**2032 - Update**	**364 days**	**Fri 10/1/32**	**Fri 9/30/33**
49		PED	364 days	Fri 10/1/32	Fri 9/30/33
50		**2033 - Update, Monitoring**	**364 days**	**Sat 10/1/33**	**Sat 9/30/34**
51		PED	364 days	Sat 10/1/33	Sat 9/30/34
52		Physical/Environmental Monitoring	364 days	Sat 10/1/33	Sat 9/30/34

2016 | Half 2, 2016 | Half 1, 2017 | Half 2, 2017 | Half 1, 2018 | Half 2, 20

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Task	🟦	Rolled Up Task	🟦	Split	┈	Progress	▬
Critical Task	🟥	Rolled Up Critical Task	🟥	External Tasks	▬	Deadline	⇩
Milestone	◆	Rolled Up Milestone	◇	Project Summary	▬		
Summary	▬	Rolled Up Progress	▬	Group By Summary	▬		

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St. Lucie Co. Feasibility

2016 | Half 2, 2016 | Half 1, 2017 | Half 2, 2017 | Half 1, 2018 | Half 2, 20
M A M J | J A S O N D | J F M A M J | J A S O N D | J F M A M J | J A S

ID	ℹ	Task Name	Duration	Start	Finish
53		**2034 - Update**	**364 days**	**Sun 10/1/34**	**Sun 9/30/35**
54		PED	364 days	Sun 10/1/34	Sun 9/30/35
55		**2035 - Update, Monitoring**	**365 days**	**Mon 10/1/35**	**Tue 9/30/36**
56		PED	365 days	Mon 10/1/35	Tue 9/30/36
57		Physical/Environmental Monitoring	365 days	Mon 10/1/35	Tue 9/30/36
58		**2036 - Update**	**364 days**	**Wed 10/1/36**	**Wed 9/30/37**
59		PED	364 days	Wed 10/1/36	Wed 9/30/37
60		**2037 - P&S, PED Mapping, Update**	**364 days**	**Thu 10/1/37**	**Thu 9/30/38**
61		Lands & Damages	364 days	Thu 10/1/37	Thu 9/30/38
62		PED	364 days	Thu 10/1/37	Thu 9/30/38
63		Physical/Environmental Monitoring	364 days	Thu 10/1/37	Thu 9/30/38
64		**2038 - 1st Renourishment, Update**	**364 days**	**Fri 10/1/38**	**Fri 9/30/39**
65		Beach Replenishment	88 days	Fri 10/1/38	Tue 12/28/38
66		Lands & Damages	364 days	Fri 10/1/38	Fri 9/30/39
67		PED	364 days	Fri 10/1/38	Fri 9/30/39
68		Construction Management	88 days	Fri 10/1/38	Tue 12/28/38
69		Physical/Environmental Monitoring	364 days	Fri 10/1/38	Fri 9/30/39
70		**2039 - Update, Monitoring**	**365 days**	**Sat 10/1/39**	**Sun 9/30/40**
71		PED	365 days	Sat 10/1/39	Sun 9/30/40
72		Physical/Environmental Monitoring	365 days	Sat 10/1/39	Sun 9/30/40
73		**2040 - Update, Monitoring**	**364 days**	**Mon 10/1/40**	**Mon 9/30/41**
74		PED	364 days	Mon 10/1/40	Mon 9/30/41
75		Physical/Environmental Monitoring	364 days	Mon 10/1/40	Mon 9/30/41
76		**2041 - Update, Monitoring**	**364 days**	**Tue 10/1/41**	**Tue 9/30/42**
77		PED	364 days	Tue 10/1/41	Tue 9/30/42
78		Physical/Environmental Monitoring	364 days	Tue 10/1/41	Tue 9/30/42

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Task	▬	Rolled Up Task	▬	Split	┈	Progress	▬
Critical Task	▬	Rolled Up Critical Task	▬	External Tasks	▬	Deadline	⇩
Milestone	◆	Rolled Up Milestone	◇	Project Summary	▬		
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St. Lucie Co. Feasibility

ID	ℹ	Task Name	Duration	Start	Finish
79		**2042 - Update**	**364 days**	**Wed 10/1/42**	**Wed 9/30/43**
80		PED	364 days	Wed 10/1/42	Wed 9/30/43
81		**2043 - Update, Monitoring**	**365 days**	**Thu 10/1/43**	**Fri 9/30/44**
82		PED	365 days	Thu 10/1/43	Fri 9/30/44
83		Physical/Environmental Monitoring	365 days	Thu 10/1/43	Fri 9/30/44
84		**2044 - Update**	**364 days**	**Sat 10/1/44**	**Sat 9/30/45**
85		PED	364 days	Sat 10/1/44	Sat 9/30/45
86		**2045 - Update, Monitoring**	**364 days**	**Sun 10/1/45**	**Sun 9/30/46**
87		PED	364 days	Sun 10/1/45	Sun 9/30/46
88		Physical/Environmental Monitoring	364 days	Sun 10/1/45	Sun 9/30/46
89		**2046 - Update**	**364 days**	**Mon 10/1/46**	**Mon 9/30/47**
90		PED	364 days	Mon 10/1/46	Mon 9/30/47
91		**2047 - Update, Monitoring**	**365 days**	**Tue 10/1/47**	**Wed 9/30/48**
92		PED	365 days	Tue 10/1/47	Wed 9/30/48
93		Physical/Environmental Monitoring	365 days	Tue 10/1/47	Wed 9/30/48
94		**2048 - Update**	**364 days**	**Thu 10/1/48**	**Thu 9/30/49**
95		PED	364 days	Thu 10/1/48	Thu 9/30/49
96		**2049 - Update, Monitoring**	**364 days**	**Fri 10/1/49**	**Fri 9/30/50**
97		PED	364 days	Fri 10/1/49	Fri 9/30/50
98		Physical/Environmental Monitoring	364 days	Fri 10/1/49	Fri 9/30/50
99		**2050 - Update**	**364 days**	**Sat 10/1/50**	**Sat 9/30/51**
100		PED	364 days	Sat 10/1/50	Sat 9/30/51
101		**2051 - Update, Monitoring**	**365 days**	**Sun 10/1/51**	**Mon 9/30/52**
102		PED	365 days	Sun 10/1/51	Mon 9/30/52
103		Physical/Environmental Monitoring	365 days	Sun 10/1/51	Mon 9/30/52
104		**2052 - Update**	**364 days**	**Tue 10/1/52**	**Tue 9/30/53**

2016 | Half 2, 2016 | Half 1, 2017 | Half 2, 2017 | Half 1, 2018 | Half 2, 20

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Summary	▬	Rolled Up Progress	▬	Group By Summary	▬		

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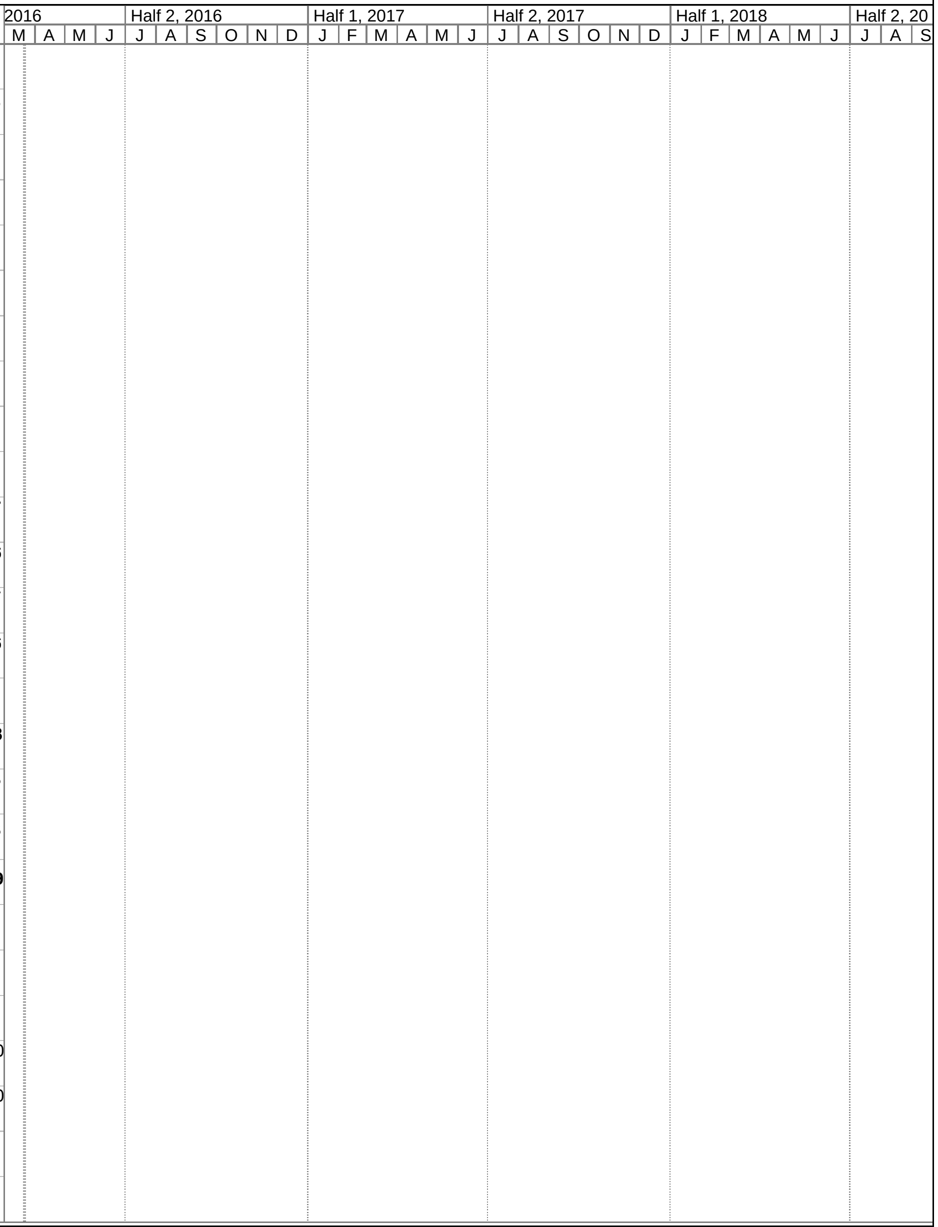
St. Lucie Co. Feasibility

ID	ℹ	Task Name	Duration	Start	Finish
105		PED	364 days	Tue 10/1/52	Tue 9/30/53
106		**2053 - Update, Monitoring**	**364 days**	**Wed 10/1/53**	**Wed 9/30/54**
107		PED	364 days	Wed 10/1/53	Wed 9/30/54
108		Physical/Environmental Monitoring	364 days	Wed 10/1/53	Wed 9/30/54
109		**2054 - Update**	**364 days**	**Thu 10/1/54**	**Thu 9/30/55**
110		PED	364 days	Thu 10/1/54	Thu 9/30/55
111		**2055 - P&S, PED Mapping, Update**	**365 days**	**Fri 10/1/55**	**Sat 9/30/56**
112		Lands & Damages	365 days	Fri 10/1/55	Sat 9/30/56
113		PED	365 days	Fri 10/1/55	Sat 9/30/56
114		Physical/Environmental Monitoring	365 days	Fri 10/1/55	Sat 9/30/56
115		**2056 - 2nd Renourishment, Update**	**364 days**	**Sun 10/1/56**	**Sun 9/30/57**
116		Beach Replenishment	88 days	Sun 10/1/56	Thu 12/28/56
117		PED	364 days	Fri 10/1/56	Sun 9/30/57
118		Construction Management	88 days	Fri 10/1/56	Thu 12/28/56
119		Physical/Environmental Monitoring	364 days	Fri 10/1/56	Sun 9/30/57
120		**2057 - Update, Monitoring**	**364 days**	**Mon 10/1/57**	**Mon 9/30/58**
121		PED	364 days	Mon 10/1/57	Mon 9/30/58
122		Physical/Environmental Monitoring	364 days	Mon 10/1/57	Mon 9/30/58
123		**2058 - Update, Monitoring**	**364 days**	**Tue 10/1/58**	**Tue 9/30/59**
124		PED	364 days	Tue 10/1/58	Tue 9/30/59
125		Physical/Environmental Monitoring	364 days	Tue 10/1/58	Tue 9/30/59
126		**2059 - Update, Monitoring**	**365 days**	**Wed 10/1/59**	**Thu 9/30/60**
127		PED	365 days	Wed 10/1/59	Thu 9/30/60
128		Physical/Environmental Monitoring	365 days	Wed 10/1/59	Thu 9/30/60
129		**2060 - Update**	**364 days**	**Fri 10/1/60**	**Fri 9/30/61**
130		PED	364 days	Fri 10/1/60	Fri 9/30/61



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Task	🟦	Rolled Up Task	🟦	Split	┈	Progress	▬
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Milestone	◆	Rolled Up Milestone	◇	Project Summary	▬		
Summary	▬	Rolled Up Progress	▬	Group By Summary	▬		

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St. Lucie Co. Feasibility

ID	ℹ	Task Name	Duration	Start	Finish
131		**2061 - Update, Monitoring**	**364 days**	**Sat 10/1/61**	**Sat 9/30/62**
132		PED	364 days	Sat 10/1/61	Sat 9/30/62
133		Physical/Environmental Monitoring	364 days	Sat 10/1/61	Sat 9/30/62
134		**2062 - Update**	**364 days**	**Sun 10/1/62**	**Sun 9/30/63**
135		PED	364 days	Sun 10/1/62	Sun 9/30/63
136		**2063 - Update, Monitoring**	**365 days**	**Mon 10/1/63**	**Tue 9/30/64**
137		PED	365 days	Mon 10/1/63	Tue 9/30/64
138		Physical/Environmental Monitoring	365 days	Mon 10/1/63	Tue 9/30/64
139		**2064 - Update**	**364 days**	**Wed 10/1/64**	**Wed 9/30/65**
140		PED	364 days	Wed 10/1/64	Wed 9/30/65
141		**2065 - Update, Monitoring**	**364 days**	**Thu 10/1/65**	**Thu 9/30/66**
142		PED	364 days	Thu 10/1/65	Thu 9/30/66
143		Physical/Environmental Monitoring	364 days	Thu 10/1/65	Thu 9/30/66
144		**2066 - Update**	**364 days**	**Fri 10/1/66**	**Fri 9/30/67**
145		PED	364 days	Fri 10/1/66	Fri 9/30/67
146		**2067 - Update, Monitoring**	**365 days**	**Sat 10/1/67**	**Sun 9/30/68**
147		PED	365 days	Sat 10/1/67	Sun 9/30/68
148		Physical/Environmental Monitoring	365 days	Sat 10/1/67	Sun 9/30/68
149		**2068 - Update**	**364 days**	**Mon 10/1/68**	**Mon 9/30/69**
150		PED	364 days	Mon 10/1/68	Mon 9/30/69
151		**2069 - Update, Monitoring**	**364 days**	**Tue 10/1/69**	**Tue 9/30/70**
152		PED	364 days	Tue 10/1/69	Tue 9/30/70
153		Physical/Environmental Monitoring	364 days	Tue 10/1/69	Tue 9/30/70
154		**2070 - Update**	**364 days**	**Wed 10/1/70**	**Wed 9/30/71**
155		PED	364 days	Wed 10/1/70	Wed 9/30/71

2016 | Half 2, 2016 | Half 1, 2017 | Half 2, 2017 | Half 1, 2018 | Half 2, 20

M | A | M | J | J | A | S | O | N | D | J | F | M | A | M | J | J | A | S | O | N | D | J | F | M | A | M | J | J | A | S

Project: Ft Pierce FY17 Econ Update
Date: Mon 3/21/16

Task	▬	Rolled Up Task	▬	Split	┈┈┈	Progress	▬
Critical Task	▬	Rolled Up Critical Task	▬	External Tasks	▬	Deadline	⇩
Milestone	◆	Rolled Up Milestone	◇	Project Summary	▬		
Summary	▬	Rolled Up Progress	▬	Group By Summary	▬		

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B5. RISK AND UNCERTAINTY ANALYSIS

A Cost and Schedule Risk Analysis was conducted according to the procedures outlined in 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.

B.5.1 Risk Analysis Methods

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.

The entire PDT participated in a risk analysis brainstorming session to identify risks associated with the Recommended Plan. The risks were listed in the risk register, which is a tool commonly used in project planning and risk analysis, and evaluated by the PDT. The actual risk register is provided in Attachment A. Assumptions were made as to the likelihood and impact of each risk item, as well as the probability of occurrence and magnitude of the impact if it were to occur. A risk model was then developed in order to establish a contingency to apply to the project costs.

After the model was run, the results were reviewed and all parameters were re-evaluated by the PDT as a sanity check of assumptions and inputs. Adjustments were made to the analysis accordingly and the final contingency was established. The contingency was applied to the Recommended Plan estimate in the Total Project Cost Summary in order to obtain the Fully Funded Cost.

B.5.2 Risk Analysis Results

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.

Based on the risks that were assessed for the project, the resultant contingency was 20%. The complete breakdown of results can be viewed in the Cost and Schedule Risk Analysis report provided in Attachment A.

B6. TOTAL PROJECT COST SUMMARY

The Total Project Cost Summary (TPCS) addresses inflation through project completion (accomplished by escalation to mid-point of construction per ER 1110-2-1302, Appendix C, Page C-2). It is based on the scope of the Recommended Plan and the official project schedule. The TPCS includes Federal and non-Federal costs for Lands and Damages, all construction features, PED, S&A, along with the appropriate contingencies and escalation associated with each of these activities. The TPCS is formatted according to the CWWBS and uses Civil Works Construction Cost Indexing System (CWCCIS) factors for escalation (EM 1110-2-1304) of construction costs and Office of Management and Budget (EC 11-2-18X, 20 Feb 2008) factors for escalation of PED and S&A costs.

The Total Project Cost Summary was prepared using the MCACES/MII cost estimate on the Recommended Plan, as well as the contingencies set by the risk analysis and the official project schedule.

B.6.1 Total Project Cost Summary Spreadsheet

Refer to the Total Project Cost Summary Spreadsheet on the next page.

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

PROJECT: **St. Lucie County CSRM**
PROJECT NO: P2 112339
LOCATION: St. Lucie County, FL

DISTRICT: SAJ District
POC: CHIEF, COST ENGINEERING, MATTHEW CUNNINGHAM

PREPARED: 3/31/2016

This Estimate reflects the scope and schedule in the report. St Lucie County CSRM Draft Feasibility Study and Integrated EA Report

Civil Works Work Breakdown Structure		**ESTIMATED COST**				**PROJECT FIRST COST (Constant Dollar Basis)**						**TOTAL PROJECT COST (FULLY FUNDED)**			
		Estimate Prepared:			**31-Mar-16**			Program Year (Budget EC):		2019					
		Effective Price Level:			1-Oct-15			Effective Price Level Date:		1 OCT 18					
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*	Spent Thru: **10/1/2015** ($K)	**TOTAL FIRST COST** ($K) *K*	INFLATED (%) *L*	COST ($K) *M*	CNTG ($K) *N*	FULL ($K) *O*
17	BEACH REPLENISHMENT	$49,048	$9,810	20.0%	$58,858	5.7%	$51,841	$10,368	$62,209	$0	$62,209	49.3%	$77,410	$15,482	$92,893
	CONSTRUCTION ESTIMATE TOTALS:	$49,048	$9,810		$58,858	5.7%	$51,841	$10,368	$62,209	$0	$62,209	49.3%	$77,410	$15,482	$92,893
01	LANDS AND DAMAGES	$1,390	$278	20.0%	$1,668	5.7%	$1,469	$294	$1,763	$0	$1,763	7.7%	$1,583	$317	$1,899
30	PLANNING, ENGINEERING & DESIGN	$6,075	$1,215	20.0%	$7,290	12.1%	$6,808	$1,362	$8,169	$0	$8,169	334.7%	$29,592	$5,918	$35,510
31	CONSTRUCTION MANAGEMENT	$3,728	$746	20.0%	$4,473	12.1%	$4,177	$835	$5,013	$0	$5,013	195.6%	$12,349	$2,470	$14,818
	PROJECT COST TOTALS:	$60,241	$12,048	20.0%	$72,289		$64,295	$12,859	**$77,154**	$0	**$77,154**	88.1%	$120,934	$24,187	$145,121

______________________ **CHIEF, COST ENGINEERING, MATTHEW CUNNINGHAM**

______________________ **PROJECT MANAGER, SHELLEY TRULOCK**

______________________ **CHIEF, REAL ESTATE, AUDREY OMI**

______________________ **CHIEF, PLANNING, ERIC BUSH**

______________________ **CHIEF, ENGINEERING, LAUREEN BOROCHANER**

______________________ **CHIEF, OPERATIONS, JIM JEFFORDS**

______________________ **CHIEF, CONSTRUCTION, STEPHEN DUBA**

______________________ **CHIEF, CONTRACTING, CARLOS CLARKE**

______________________ **CHIEF, PM-PB, GERALD GRUBB**

______________________ **CHIEF, DPM, TIM MURPHY**

ESTIMATED FEDERAL COST:	**23%**	**$33,378**
ESTIMATED NON-FEDERAL COST:	**77%**	**$111,743**
ESTIMATED TOTAL PROJECT COST:		**$145,121**

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

**** CONTRACT COST SUMMARY ****

PROJECT: St. Lucie County CSRM
LOCATION: St. Lucie County, FL
This Estimate reflects the scope and schedule in report; St Lucie County CSRM Draft Feasibility Study and Integrated EA Report

DISTRICT: SAJ District
PREPARED: 3/31/2016
POC: CHIEF, COST ENGINEERING, MATTHEW CUNNINGHAM

Civil Works Work Breakdown Structure		**ESTIMATED COST**				**PROJECT FIRST COST (Constant Dollar Basis)**				**TOTAL PROJECT COST (FULLY FUNDED)**				
		Estimate Prepared:			**31-Mar-16**	Program Year (Budget EC):			2019					
		Effective Price Level:			1-Oct-15	Effective Price Level Date:			1 OCT 18					
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***
	Initial Construction													
17	BEACH REPLENISHMENT	$19,966	$3,993	20%	$23,959	5.7%	$21,103	$4,221	$25,324	2021Q1	4.0%	$21,955	$4,391	$26,346
	CONSTRUCTION ESTIMATE TOTALS:	$19,966	$3,993	20%	**$23,959**		$21,103	$4,221	$25,324			$21,955	$4,391	$26,346
01	LANDS AND DAMAGES	$1,330	$266	20%	$1,596	5.7%	$1,406	$281	$1,687	2021Q2	4.6%	$1,470	$294	$1,764
30	PLANNING, ENGINEERING & DESIGN													
1.3%	Project Management	$220	$44	20%	$264	12.1%	$247	$49	$296	2028Q4	49.7%	$369	$74	$443
0.1%	Planning & Environmental Compliance	$15	$3	20%	$18	12.1%	$17	$3	$20	2028Q4	49.7%	$25	$5	$30
1.9%	Engineering & Design	$300	$60	20%	$360	12.1%	$336	$67	$403	2028Q4	49.7%	$503	$101	$604
0.3%	Contracting & Reprographics	$40	$8	20%	$48	12.1%	$45	$9	$54	2028Q4	49.7%	$67	$13	$81
3.3%	Life Cycle Updates (cost, schedule, risks)	$540	$108	20%	$648	12.1%	$605	$121	$726	2028Q4	49.7%	$906	$181	$1,087
0.1%	Engineering During Construction	$20	$4	20%	$24	12.1%	$22	$4	$27	2021Q1	8.2%	$24	$5	$29
0.1%	Planning During Construction	$20	$4	20%	$24	12.1%	$22	$4	$27	2021Q1	8.2%	$24	$5	$29
2.9%	Physical Monitoring	$480	$96	20%	$576	12.1%	$538	$108	$645	2028Q2	46.4%	$787	$157	$945
2.7%	Environmental Monitoring:	$450	$90	20%	$540	12.1%	$504	$101	$605	2028Q2	46.4%	$738	$148	$886
31	CONSTRUCTION MANAGEMENT													
7.6%	Construction Management	$1,517	$303	20%	$1,821	12.1%	$1,700	$340	$2,041	2021Q1	8.2%	$1,839	$368	$2,207
	CONTRACT COST TOTALS:	$24,898	$4,980		$29,878		$26,546	$5,309	$31,855			$28,709	$5,742	$34,451

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

**** CONTRACT COST SUMMARY ****

PROJECT: St. Lucie County CSRM
LOCATION: St. Lucie County, FL
This Estimate reflects the scope and schedule in report; St Lucie County CSRM Draft Feasibility Study and Integrated EA Report

DISTRICT: SAJ District
POC: CHIEF, COST ENGINEERING, MATTHEW CUNNINGHAM
PREPARED: 3/31/2016

Civil Works Work Breakdown Structure		**ESTIMATED COST**				**PROJECT FIRST COST (Constant Dollar Basis)**				**TOTAL PROJECT COST (FULLY FUNDED)**				
		Estimate Prepared:			**31-Mar-16**	Program Year (Budget EC):			2019					
		Effective Price Level:			1-Oct-15	Effective Price Level Date:			1 OCT 18					
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***
	1st Renourishment													
17	BEACH REPLENISHMENT	$14,541	$2,908	20.0%	$17,449	5.7%	$15,369	$3,074	$18,443	2039Q1	48.6%	$22,837	$4,567	$27,405
							$0							
	CONSTRUCTION ESTIMATE TOTALS:	$14,541	$2,908	20.0%	**$17,449**		$15,369	$3,074	$18,443			$22,837	$4,567	$27,405
01	LANDS AND DAMAGES	$30	$6	20.0%	$36	5.7%	$32	$6	$38	2038Q3	47.1%	$47	$9	$56
30	PLANNING, ENGINEERING & DESIGN													
1.3%	Project Management	$220	$44	20.0%	$264	12.1%	$247	$49	$296	2046Q4	261.9%	$892	$178	$1,071
0.1%	Planning & Environmental Compliance	$15	$3	20.0%	$18	12.1%	$17	$3	$20	2046Q4	261.9%	$61	$12	$73
1.9%	Engineering & Design	$300	$60	20.0%	$360	12.1%	$336	$67	$403	2046Q4	261.9%	$1,217	$243	$1,460
0.3%	Contracting & Reprographics	$40	$8	20.0%	$48	12.1%	$45	$9	$54	2046Q4	261.9%	$162	$32	$195
3.3%	Life Cycle Updates (cost, schedule, risks)	$540	$108	20.0%	$648	12.1%	$605	$121	$726	2046Q4	261.9%	$2,190	$438	$2,628
0.1%	Engineering During Construction	$20	$4	20.0%	$24	12.1%	$22	$4	$27	2039Q1	146.1%	$55	$11	$66
0.1%	Planning During Construction	$20	$4	20.0%	$24	12.1%	$22	$4	$27	2039Q1	146.1%	$55	$11	$66
2.9%	Physical Monitoring	$480	$96	20.0%	$576	12.1%	$538	$108	$645	2046Q3	257.4%	$1,922	$384	$2,307
2.7%	Environmental Monitoring:	$450	$90	20.0%	$540	12.1%	$504	$101	$605	2046Q3	257.4%	$1,802	$360	$2,163
31	CONSTRUCTION MANAGEMENT													
7.6%	Construction Management	$1,105	$221	20.0%	$1,326	12.1%	$1,238	$248	$1,486	2039Q1	146.1%	$3,048	$610	$3,657
	CONTRACT COST TOTALS:	$17,761	$3,552		$21,313		$18,976	$3,795	$22,771			$34,289	$6,858	$41,146

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

**** CONTRACT COST SUMMARY ****

PROJECT: St. Lucie County CSRM
LOCATION: St. Lucie County, FL
This Estimate reflects the scope and schedule in report; St Lucie County CSRM Draft Feasibility Study and Integrated EA Report

DISTRICT: SAJ District
POC: CHIEF, COST ENGINEERING, MATTHEW CUNNINGHAM
PREPARED: 3/31/2016

Civil Works Work Breakdown Structure		**ESTIMATED COST**				**PROJECT FIRST COST (Constant Dollar Basis)**				**TOTAL PROJECT COST (FULLY FUNDED)**				
		Estimate Prepared: Effective Price Level:			**31-Mar-16** 1-Oct-15	Program Year (Budget EC): Effective Price Level Date:			2019 1 OCT 18					
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***
	2nd Renourishment													
17	BEACH REPLENISHMENT	$14,541	$2,908	20.0%	$17,449	5.7%	$15,369 $0	$3,074	$18,443	2057Q1	112.2%	$32,618	$6,524	$39,141
	CONSTRUCTION ESTIMATE TOTALS:	$14,541	$2,908	20.0%	**$17,449**		$15,369	$3,074	$18,443			$32,618	$6,524	$39,141
01	LANDS AND DAMAGES	$30	$6	20.0%	$36	5.7%	$32	$6	$38	2056Q2	109.1%	$66	$13	$80
30	PLANNING, ENGINEERING & DESIGN													
1.3%	Project Management	$200	$40	20.0%	$240	12.1%	$224	$45	$269	2063Q4	743.0%	$1,889	$378	$2,267
0.1%	Planning & Environmental Compliance	$15	$3	20.0%	$18	12.1%	$17	$3	$20	2063Q4	743.0%	$142	$28	$170
1.9%	Engineering & Design	$300	$60	20.0%	$360	12.1%	$336	$67	$403	2063Q4	743.0%	$2,834	$567	$3,401
0.3%	Contracting & Reprographics	$40	$8	20.0%	$48	12.1%	$45	$9	$54	2063Q4	743.0%	$378	$76	$453
3.3%	Life Cycle Updates (cost, schedule, risks)	$480	$96	20.0%	$576	12.1%	$538	$108	$645	2063Q4	743.0%	$4,534	$907	$5,441
0.1%	Engineering During Construction	$20	$4	20.0%	$24	12.1%	$22	$4	$27	2057Q1	502.5%	$135	$27	$162
0.1%	Planning During Construction	$20	$4	20.0%	$24	12.1%	$22	$4	$27	2057Q1	502.5%	$135	$27	$162
2.9%	Physical Monitoring	$430	$86	20.0%	$516	12.1%	$482	$96	$578	2063Q3	732.5%	$4,012	$802	$4,814
2.7%	Environmental Monitoring:	$400	$80	20.0%	$480	12.1%	$448	$90	$538	2063Q3	732.5%	$3,732	$746	$4,478
31	CONSTRUCTION MANAGEMENT													
7.6%	Construction Management	$1,105	$221	20.0%	$1,326	12.1%	$1,238	$248	$1,486	2057Q1	502.5%	$7,462	$1,492	$8,954
	CONTRACT COST TOTALS:	$17,581	$3,516		**$21,097**		$18,774	$3,755	$22,529			$57,936	$11,587	**$69,524**

B7. DISTRICT QUALITY CONTROL CERTIFICATION

The recommended plan estimate, formal cost and schedule risk analysis and total project cost summary spreadsheet underwent internal cost review and will be certified by the Walla Walla Mandatory Center of Expertise before final report approval.

DISCIPLINE QUALITY CHECK & REVIEW CERTIFICATION

The Cost Engineering Section of the Jacksonville District Engineering Division has completed the Discipline Quality Checks and and Reviews for:

St. Lucie County Coastal Storm Risk Management
(CSRM) Draft Feasibility Study and Integrated
Environmental Assessment (EA)
St. Lucie County, Florida

This review was conducted in compliance with EC 1165-2-209, Civil Works Review Policy dated 31 January 2010, ER 1110-1-12, Quality Management dated 30 September 2006 and 02611-SAJ Quality Management of In-House Products: Civil Works PED.

The review considered the current design effort and how the design would influence the preparation of estimated construction costs, considering especially conformance with the design parameters, assumptions, and cost estimate accuracy. All comments and/or issues raised during the Discipline Quality Checks and Review of **St. Lucie County CSRM Draft Feasibility Report and Integrated EA Cost Appendix** have been resolved.

Discipline Specific Quality Control Team Authorization

BRYANT.SOPHIA.LEEANN.1112150958

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Date: 2016.04.05 12:38:35 -04'00'

Cost Engineering Section Team Member — Date

BLAKE.BRIAN.CURTIS.1230023740

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Date: 2016.04.05 12:46:16 -04'00'

Reviewer, Cost Engineering Section Team Lead — Date

CUNNINGHAM.MATTHEW.W.1265406722

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Date: 2016.04.05 12:53:05 -04'00'

Chief, Cost Engineering Section — Date

BROOKSHALL.KIMBERLY.DIANE.1232245898

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Date: 2016.04.06 15:20:30 -04'00'

Chief, Technical Services Branch — Date

ATTACHMENT A
COST AND SCHEDULE RISK ANALYSIS

US Army Corps
of Engineers®

St. Lucie County Coastal Storm Risk Management (CSRM)
St. Lucie County, Florida
Draft Feasibility Study and Integrated Environmental Assessment (EA)
Project Cost and Schedule Risk Analysis (CSRA) Report

Prepared by:

U.S. Army Corps of Engineers
Jacksonville District
Cost Engineering Section

April 2016

TABLE OF CONTENTS

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EXECUTIVE SUMMARY

The CSRA was developed with support by the Cost Engineering Mandatory Center of Expertise (MCX) for Civil Works. The CSRA will be reviewed by the MCX during Agency Technical Review (ATR) and during subsequent coordination between the MCX and Jacksonville District Cost Engineering. This report presents a recommendation for the total project cost and schedule contingencies for the St. Lucie County CSRM's Draft Feasibility Study and Integrated Environmental Assessment. In compliance with Engineer Regulation (ER) 1110-2-1302 CIVIL WORKS COST ENGINEERING, dated September 15, 2008, a formal risk analysis study was conducted for the development of contingency on the total project cost. The purpose of this risk analysis study was to establish project contingencies by identifying and measuring the cost and schedule impact of project uncertainties with respect to the estimated total project cost.

Specific to the St. Lucie County CSRM project, the project base cost for the remaining work is approximately $58.9 Million. Based on the results of the analysis, the Jacksonville District recommends a contingency value of $11.8 Million, or 20%. This contingency includes $11.5 Million (19.5%) for risks related to cost and $0.3 Million (0.5%) for the effect of schedule delay on overall project costs.

The Jacksonville District performed the risk analysis using the *Monte Carlo* technique, producing the aforementioned contingencies and identifying key risk drivers. This has been reviewed, as required, by the MCX, Walla Walla District.

The following table portrays the development of contingencies (20% overall). The contingency is based on an 80% confidence level, as per USACE Civil Works guidance.

Table ES-1. Contingency Analysis Table

Base Cost Estimate	**$58,851,000**	
Confidence Level	**Value ($$)**	**Contingency (%)**
5%	$61,793,550	5%
50%	$67,090,140	14%
80%	**$70,621,200**	**20%**
95%	$74,152,260	26%

KEY FINDINGS/OBSERVATIONS RECOMMENDATIONS

The key cost risk drivers identified through sensitivity analysis are PR-1 (Fuel Prices), TL1 (Volume Variations), ET3 (Quantity Estimates), and REG2 (Environmental Monitoring & Mitigation) which together contribute over 86 percent of the statistical cost variance.

- Fuel Prices refers to the potential impacts to the cost due to fluctuations in fuel costs during various phases of the project, both in and out of construction.
- Volume Variations captures the risk to the cost caused by fluctuations in erosion rates between modeling and, later, dredging surveys.
- Quantity Estimates captures the risk that projected bid volumes increase or decrease between design and pre-construction surveys.
- Environmental Monitoring & Mitigation addresses the risk of triggering mitigation of some kind, or new and/or more stringent environmental requirements being developed.

An additional moderate cost risk that should be closely monitored is TL2 (Renourishment Interval).

- Renourishment intervals captures the risk to the cost due to the events not occurring at the projected intervals.

The key schedule risk drivers identified through sensitivity analysis are REG5 (Permit Delays), PR1 (Bidding Climate and Competition), and LD3 (Easements), which together contribute over 81 percent of the statistical schedule variance.

- Permit Delays captures the risk to the schedule due to complications that may arise during permit coordination.
- Bidding Climate and Competition captures the risk that the bidding pool is impacted by such things as economic swings and scheduling.
- Easements captures the risk to schedule that unexpected problems/delays occur during the process of obtaining easements/land certifications.

An additional moderate schedule risk that should be closely monitored is PM4 (Review & Authorization Delays).

- Review and Authorization Delays captures the impacts to the schedule due to delayed authorization and/or reviews.

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

MAIN REPORT

1.0 PURPOSE

This report presents a recommendation for the total project cost and schedule contingencies for the St. Lucie County CSRM's Draft Feasibility Study and IntegratedEnvironmental Assessment.

2.0 BACKGROUND

St. Lucie County is located on the south-central east coast of Florida (Figure 1-1). The county is bounded to the north by Indian River County and to the south by Martin County. St. Lucie County has approximately 22 miles of sandy shoreline located on a coastal barrier island that varies in width from approximately 400 feet to 1.5 miles. The St. Lucie County shoreline is subject to erosion caused by both tropical and extra-tropical storms as well as other natural shoreline processes. The purpose of this study is to assess the feasibility of providing Federal Coastal Flood Risk Management (CFRM) measures to the southern portion of the St. Lucie County shoreline.

Based on Beach-fx model results and economic evaluation, project alternative ABerm20DuneEx (a 20 foot berm template designed to maintain the existing (2008) dune between renourishments) was identified as the National Economic Development (NED) Plan for nourishment of St. Lucie County. However, the local Sponsor has identified ABerm30DuneEx (a 30 foot berm template designed to maintain the existing dune) as the Locally Preferred Plan (LPP). The LPP is not economically justified. Therefore, the NED is considered to be the Tentatively Selected Plan (TSP).

The full study area (7.4 miles), extending from FDEP monument R-77 to the Martin County line, was initially considered during project evaluation using Beach-fx. The TSP, ABerm20DuneEx, covers approximately 3.4 miles of the study area. The beach fill will be placed from R-98 to the Martin County line with tapers extending approximately 1,000 feet to the north of R-98 and approximately 1,000 feet to the south. As Martin County, south of St. Lucie is part of an authorized Federal project, future nourishment events may be timed to tie into the southern project, negating the need for a taper.

The design beach fill template is characterized by a 20 foot berm extension (+7 ft-NAVD88 to Depth of Closure) from the existing dune. Beach fill material required under the Base SLR case includes an average of 530,400 cubic yards for initial construction of the design beach profile and two to three renourishment events averaging 380,000 cubic yards each. Dune planting is expected for initial construction only, with responsibility falling to the Local Sponsor during renourishments. Periodic nourishment, after initial construction, is expected at approximately 18 year intervals.

It is likely that the contracts will be acquired using a Request for Proposal (RFP). The expected construction schedule is about 4 months for initial construction in 2020, and approximately 3 months for the subsequent renourishments in 2038 and 2056.

As a part of this effort, Jacksonville District will request that the USACE Cost Engineering MCX provide an ATR of the CSRA.

3.0 REPORT SCOPE

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

3.1 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 baseline Micro Computer Aided Cost Estimating System (MCACES) cost estimate, schedule, and funding profiles using Crystal Ball software to conduct a *Monte Carlo* simulation and statistical sensitivity analysis, per the guidance in Engineer Technical Letter (ETL) CONSTRUCTION COST ESTIMATING GUIDE FOR CIVIL WORKS, dated September 30, 2008.

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

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

3.2 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

As part of the Draft Feasibility Study and Integrated EA, the Jacksonville District performed the Cost and Schedule Risk Analysis, conducting a risk identification meeting on November 19, 2015 with the Project Delivery Team (PDT) to produce a risk register that served as the framework for the risk analysis. The cost engineer solicited updates from the PDT on 24 February 2016, as part of the current CSRA. Additional comments were solicited from Contracting, on 22 March 2016. Participants in the risk identification process included the following:

Section	Title
PM-WN	Project Manager
PD-PN	Planning Technical Lead
PD-D	Economics
RE-A	Real Estate
EN-WC	Water Resources
EN-GG	Geotech
PD-ES	Archaelogy/Cultural Resources
OC	Legal
EN-TC	Cost Estimating
CT	Frances Jones

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 and follow up discussions were held for the purposes of identifying and assessing risk factors. The meeting included capable and qualified representatives from multiple project team disciplines and functions, including project management, cost engineering, design, geology, and coastal engineering.

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

4.2 Quantify Risk Factor Impacts

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

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

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

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

4.3 Analyze Cost Estimate and Schedule Contingency

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

For the cost estimate, the contingency is calculated as the difference between the P80 cost forecast and the baseline cost estimate. Each option-specific contingency is then allocated on a civil works feature level based on the dollar-weighted relative risk of each feature as quantified by *Monte Carlo* simulation. Standard deviation is used as the feature-specific measure of risk for contingency allocation purposes. This approach results in a 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 St. Lucie County CSRM.

a. The Jacksonville District completed the MII MCACES (Micro-Computer Aided Cost Estimating Software), serving as the basis for the cost and schedule risk analyses, on March 31, 2016.

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 for the remaining work.

c. Schedules are analyzed for impact to the project cost in terms of both uncaptured escalation (variance from OMB factors and the local market) and unavoidable fixed contract costs and/or languishing federal administration costs incurred throughout delay. Specific to the St. Lucie County CSRM, the schedule was analyzed only for impacts due to residual fixed costs.

d. Per the CWCCIS Historical State Adjustment Factors in EM 1110-2-1304, State Adjustment Factor for the State of Florida is 0.92, meaning that the average inflation for the project area is assumed to be 8% lower than the national average for inflation. Therefore, it is assumed that the project inflations experienced are similar to OMB inflation factors for future construction. Based on this information, the risk analysis accounted for a slight escalation adjustment over and above the national average.

e. The assumed residual fixed cost rate for this project is 7.6%. This rate has been used to calculate impacts to the P80 schedule and cost contingencies within the risk model. This is based upon the standard Planning, Engineering, and Design (PED) and Supervision & Administration (S&A) percentage for the Jacksonville District CSRM projects. The majority of schedule risk is assumed to occur during the early stages of PED.

f. The Cost MCX guidance generally focuses on the eighty-percent level of confidence (P80) for cost contingency calculation. For this risk analysis, the eighty-percent level of confidence (P80) was used. It should be noted that the use of P80 as a decision criteria is a moderately risk averse approach, generally resulting in higher cost contingencies. However, the P80 level of confidence also assumes a small degree of risk that the recommended contingencies may be inadequate to capture actual project costs.

g. Only high and moderate risk level impacts, as identified in the risk register, were considered for the purposes of calculating cost contingency. Low level risk impacts should be maintained in project management documentation, and reviewed at each project milestone to determine if they should be placed on the risk “watch list”.

6.0 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 P100 confidence levels are also provided for illustrative purposes only.

Contingency was quantified as approximately $11.8 Million at the P80 confidence level (20% of the baseline cost estimate). For comparison, the cost contingencies at the P50 and P100 confidence levels were quantified as 14% and 46% of the baseline cost estimate, respectively.

Table 1. Project Cost Contingency Summary

Risk Analysis Forecast	Baseline Estimate	Total Contingency[1,2] ($)	Total Contingency (%)
50% Confidence Level			
Project Cost	$58,851,000	$8,239,140	14%
80% Confidence Level			
Project Cost	$58,851,000	$11,770,200	20%
100% Confidence Level			
Project Cost	$58,851,000	$27,071,460	46%

Notes:
1) These figures combine uncertainty in the baseline cost estimates and schedule.
2) A P100 confidence level is an abstract concept for illustration only, as the nature of risk and uncertainty (specifically the presence of “unknown unknowns”) makes 100% confidence a theoretical impossibility.

6.2.1 Sensitivity Analysis

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

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

6.2.2 Sensitivity Analysis Results

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

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

6.3 Schedule and Contingency Risk Analysis

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

Schedule duration contingency was quantified as 31.0 months based on the P80 level of confidence. These contingencies were used to calculate the projected residual fixed cost impact of project delays that are included in the Table 1 presentation of total cost contingency. The schedule contingencies were calculated by applying the high level schedule risks identified in the risk register for each option to the durations of critical path and near critical path tasks.

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

Table 2. Schedule Duration Contingency Summary

Risk Analysis Forecast	Baseline Schedule Duration (months)	Contingency[1] (months)
50% Confidence Level		
Project Duration	620.0	24.8
80% Confidence Level		
Project Duration	620.0	31.0
100% Confidence Level		
Project Duration	620.0	49.6

Notes:
1) The schedule was not resource loaded and contained open-ended tasks and non-zero lags (gaps in the logic between tasks) that limit the overall utility of the schedule risk analysis. These issues should be considered as limitations in the utility of the schedule contingency data presented in Table 2.
2) A P100 confidence level is an abstract concept for illustration only, as the nature of risk and uncertainty (specifically the presence of “unknown unknowns”) makes 100% confidence a theoretical impossibility.

Figure 1. Cost Sensitivity Analysis

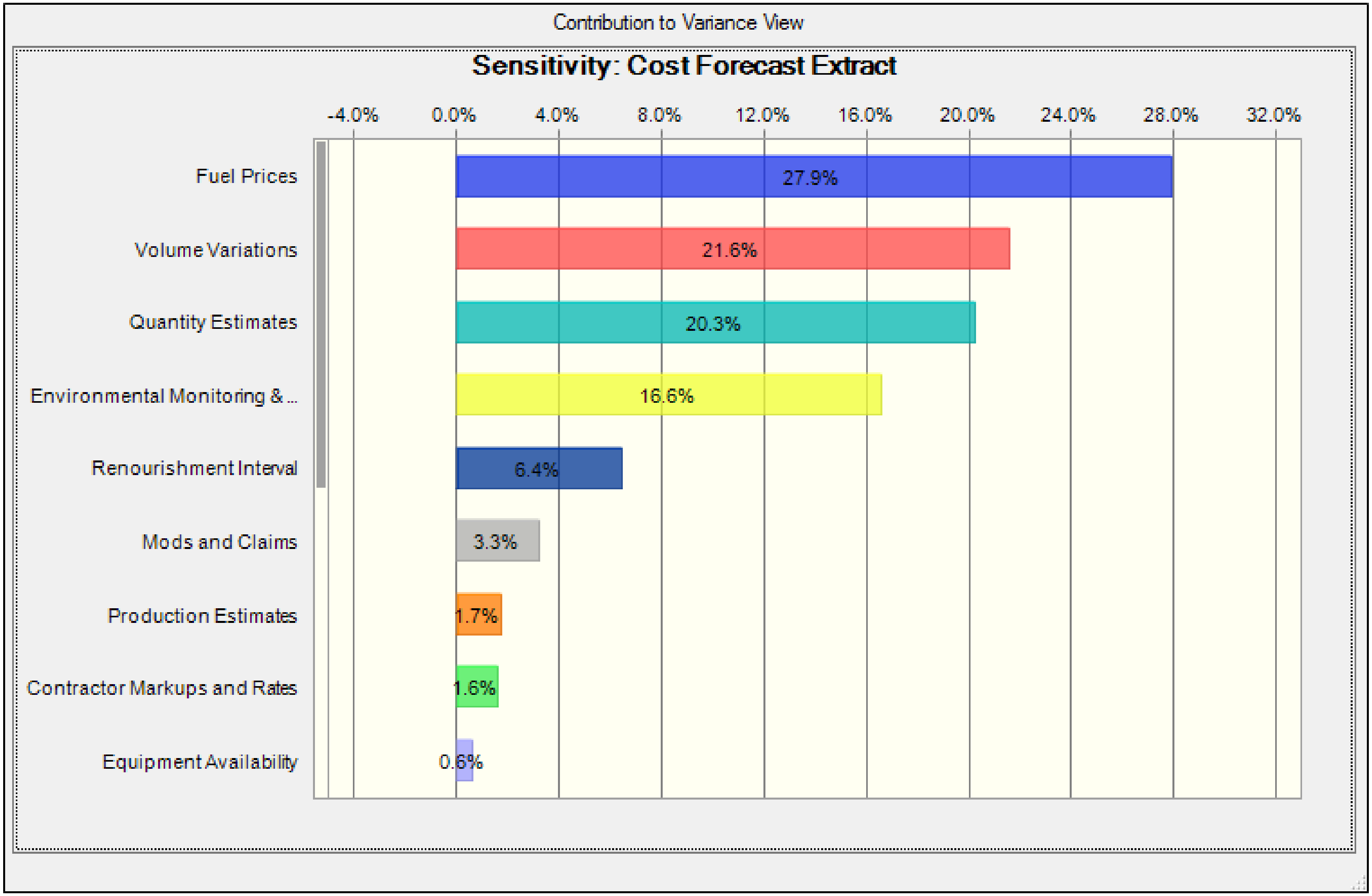
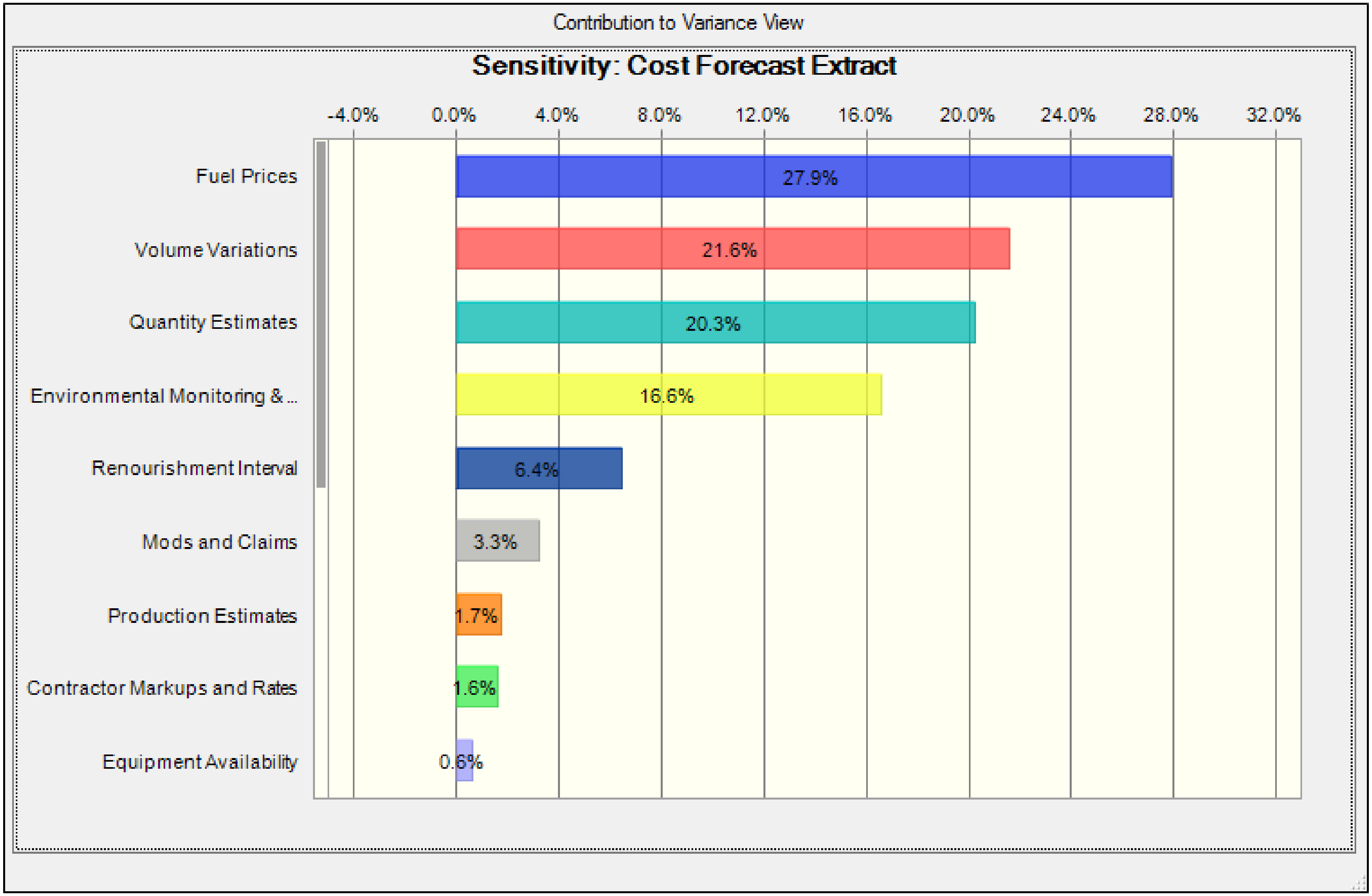


Figure 2. Schedule Sensitivity Analysis



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 3 and Figure 3. Additional major findings and observations of the risk analysis are listed below.

1. The key cost risk drivers identified through sensitivity analysis are PR-1 (Fuel Prices), TL1 (Volume Variations), ET3 (Quantity Estimates), and REG2 (Environmental Monitoring & Mitigation) which together contribute over 86 percent of the statistical cost variance.

2. An additional moderate cost risk that should be closely monitored is TL2 (Renourishment Interval).

3. The key schedule risk drivers identified through sensitivity analysis are REG5 (Permit Delays), PR1 (Bidding Climate and Competition), and LD3 (Easements), which together contribute over 81 percent of the statistical schedule variance.

4. An additional moderate schedule risk that should be closely monitored is PM4 (Review & Authorization Delays).

Table 3. Project Cost Comparison Summary (Uncertainty Analysis)

Confidence Level	Project Cost ($)	Contingency ($)	Contingency (%)
0%	$54,142,920	-$4,708,080	-8%
5%	$61,793,550	$2,942,550	5%
10%	$62,970,570	$4,119,570	7%
15%	$63,559,080	$4,708,080	8%
20%	$64,147,590	$5,296,590	9%
25%	$64,736,100	$5,885,100	10%
30%	$65,324,610	$6,473,610	11%
35%	$65,913,120	$7,062,120	12%
40%	$66,501,630	$7,650,630	13%
45%	$66,501,630	$7,650,630	13%
50%	$67,090,140	$8,239,140	14%
55%	$67,678,650	$8,827,650	15%
60%	$68,267,160	$9,416,160	16%
65%	$68,855,670	$10,004,670	17%
70%	$69,444,180	$10,593,180	18%
75%	$70,032,690	$11,181,690	19%
80%	**$70,621,200**	**$11,770,200**	**20%**
85%	$71,209,710	$12,358,710	21%
90%	$72,386,730	$13,535,730	23%
95%	$74,152,260	$15,301,260	26%
100%	$85,922,460	$27,071,460	46%

Figure 3. Project Cost Summary (Uncertainty Analysis)

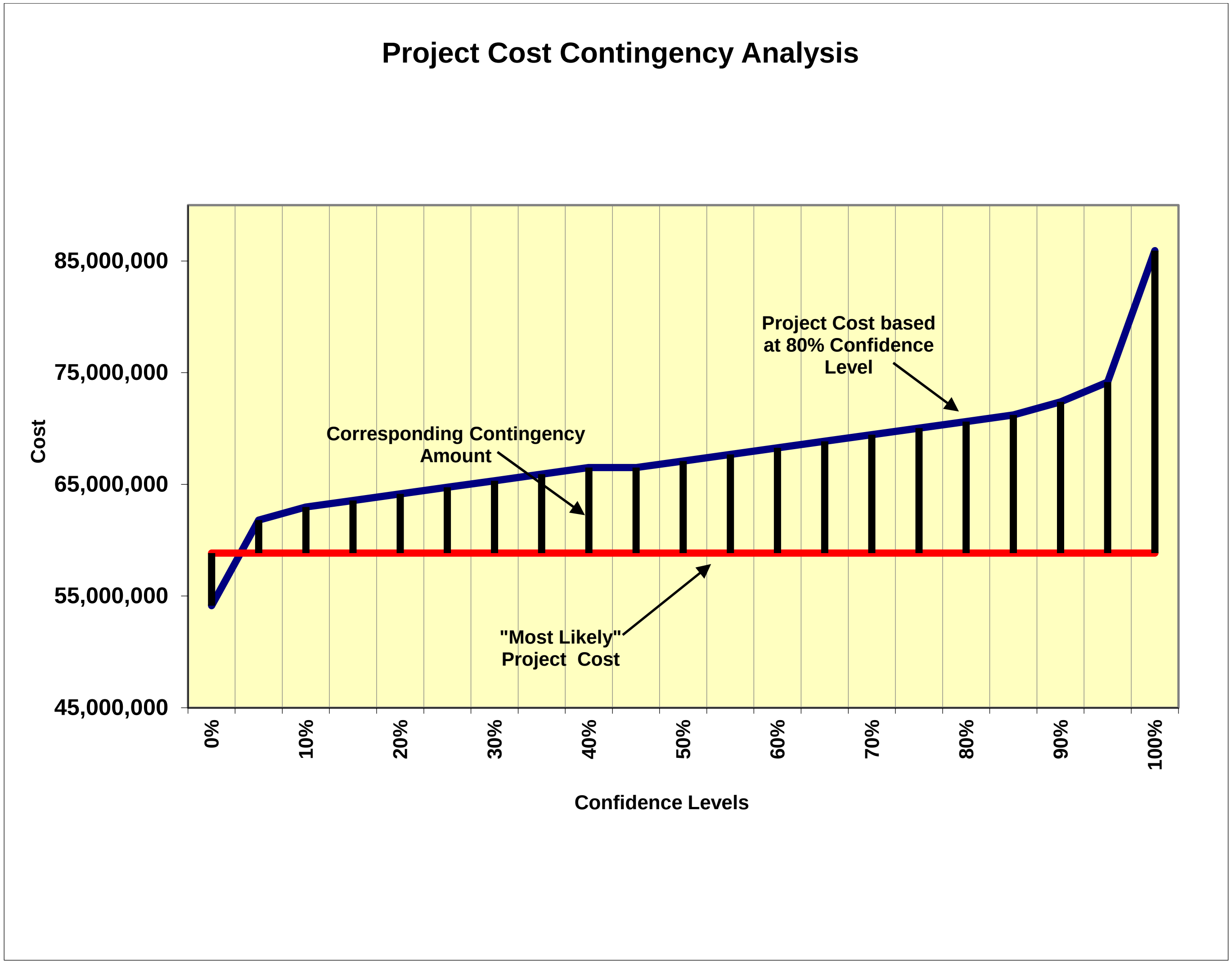
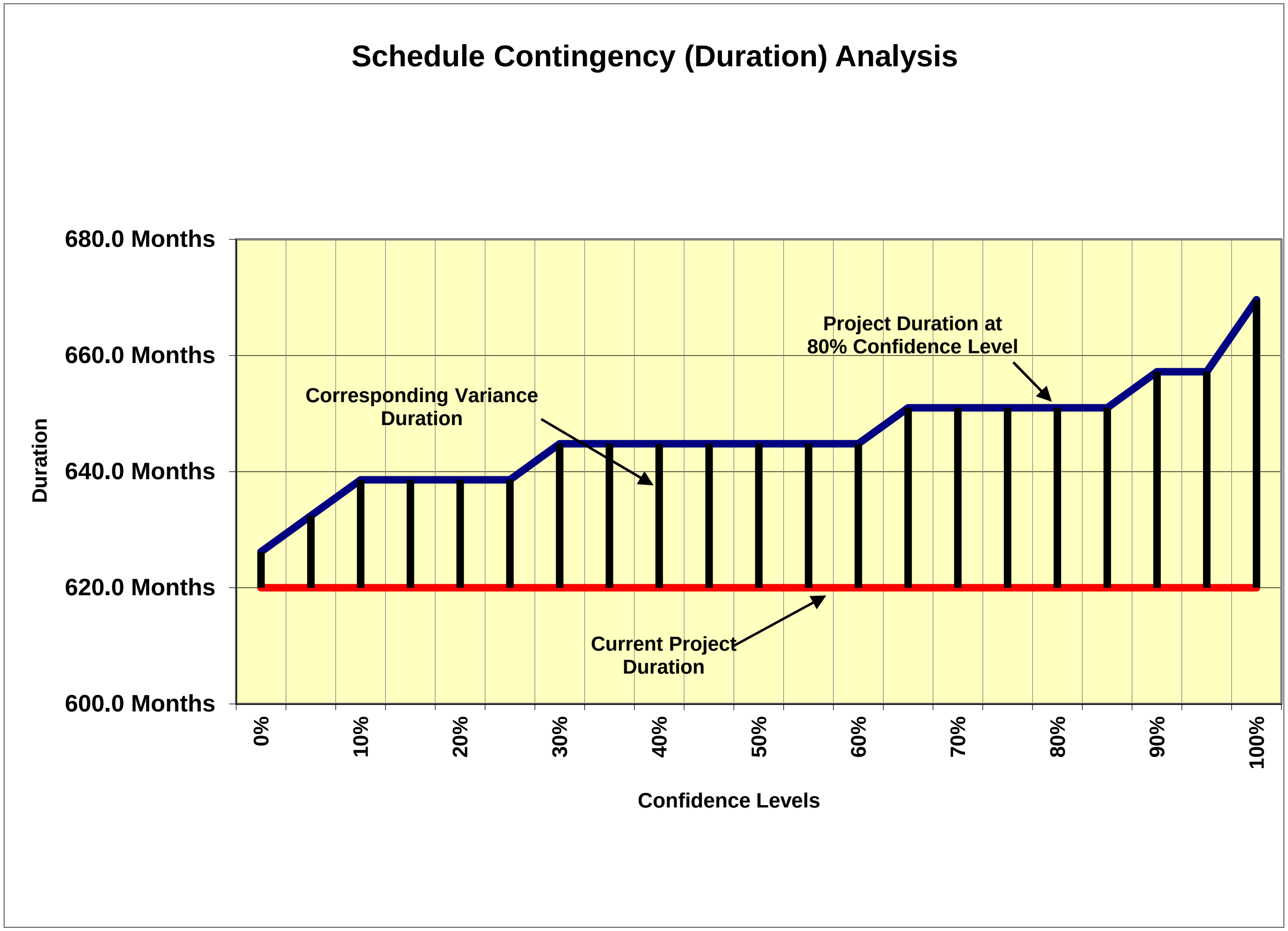


Figure 4. Project Duration Summary (Uncertainty Analysis)



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 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.

1. Key Cost Risk Drivers: The key cost risk drivers identified through sensitivity analysis are PR-1 (Fuel Prices), TL1 (Volume Variations), ET3 (Quantity Estimates), and REG2 (Environmental Monitoring & Mitigation) which together contribute over 86 percent of the statistical cost variance.

  a) Fuel Prices: Naturally, fuel is an ever-fluctuating cost, and a big factor in dredging projects. While contract estimates for each nourishment would use the most-recent rates, the budget submission estimate attempts to mitigate risks by considering a 5-year average. Recently, fuel costs have been quite low, so the average does well to counter the risk of fuel rising beyond current rates between now and the end of the project life. There is not much that the team can do about fuel costs, other than keep an eye on the trends.

  b) Volume Variations: Erosion rates vary. The team accounts for this through historical data, averages, storm data, and modeling software like Beach-Fx. Factors like heavy storms could cause variations beyond team control. The PDT will keep variation potential in mind as the project, post-authorization, progresses in order to maintain accurate volume calculations. This would be accomplished most readily via up-to-date surveys. The estimate uses the average volumes as presented in the draft Engineering Appendix.

  c) Quantity Estimates: Quantities can vary between design and pre-construction surveys. The project's erosion rate is high, so volumes could easily change between design and construction. This could lead to a modification. This is best mitigated by ensuring quality surveys are as current as possible during development of plans and specifications. Quantity projections can also be impacted by storm events. Weather impacts are covered under PR8 Weather in the risk register.

d) Environmental Monitoring & Mitigation: Monitoring and mitigation requirements as a result of hardbottom impacts could impact cost and schedule. The PDT is not expecting to trigger mitigation for this project; however, costs for mitigation have already been explored in the alternative screenings for this project (mimicking Local Sponsor mitigation project). For monitoring, such requirements already well-known and would be incorporated into the contract. No surprises are either front are expected. Regardless, the impacts would be notable, if they occurred. The team can counter this by ensuring that mitigation is not triggered or, at least, ensure that the team is prepared to take appropriate measures are taken if mitigation is triggered.

2. Key Schedule Risk Drivers: The key schedule risk drivers identified through sensitivity analysis are REG5 (Permit Delays), PR1 (Bidding Climate and Competition), and LD3 (Easements), which together contribute over 63 percent of the statistical schedule variance.

a) Permit Delays: Predictably, delays in permitting actions can lead to delays in the advertisement process. It is possible that a lengthy delay on future permit mods/extensions could push the construction into the following environmental window. Permitting conditions have been fairly consistent, as this is a routine project, and the team usually has advance notice of new requirements that may impact the project. As long as the team keeps abreast of requirements and executes things in a timely fashion, problems here should be minimal, if any.

b) Bidding Climate and Competition: Bidder interest is fairly consistent for these types of projects, especially in this area (vicinity of Ft. Pierce and Martin Co, which are well-established SAJ projects). Bidder availability is always considered in advance. The PDT will try to time construction as favorably as possible. Historically, there hasn't been a problem with projects in this area. The small size of the project may impact bidder interest, but that is something the team can better predict with pre-proposal meetings. Poor turnout could cause bidders to artificially drive up costs. Receiving no bids, though extremely unlikely, would delay the project. Competition requirements only call for two (2) bidders in order to make award and the PDT is confident that this is something that can be accomplished. Bidder availability as impacted by weather is captured under PR8 Weather.

c) Easements: The project does require easements/land certifications. Eminent domain, condemnation, unwillingness of property owners, etc. could cause delays for easements west of the erosion control line. However, the county has already paved a path for this project by completing their own in the recent past

(2012/2013), so problems following in the established trail are not expected. Again, while easement acquisition is not anticipated to be problematic, if issues occur, there will be notable impacts.

3. Risk Management: Project leadership should use 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.

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

ATTACHMENT A

St. Lucie County Coastal Storm Risk Management (CSRM)

Risk Matrix

Likelihood of Occurrence	Negligible	Marginal	Significant	Critical	Crisis
	Impact or Consequence of Occurrence				
Certain	Moderate	Moderate	High	High	High
Very Likely	Low	Moderate	High	High	High
Likely	Low	Moderate	High	High	High
Unlikely	Low	Low	Moderate	Moderate	High
Very Unlikely	Low	Low	Low	Low	Moderate

Overall Project Scope

Per Draft Feasibility Report, the purpose of this study is to assess the feasibility of providing Federal Coastal Flood Risk Management (CFRM) measures to the southern portion of the St. Lucie County shoreline. This appendix summarizes the engineering design of a shore protection project proposed for construction in St. Lucie County, Florida. The project consists of beach nourishment/renourishment along approximately 3.4 miles of shoreline between FDEP monuments R-98 and the Martin County line. TSP/LPP: The design beach fill template is characterized by a 30 foot berm extension (+7 ft-NAVD88 to Depth of Closure) from the existing dune. Beach fill material required under the Base SLR case includes an average of 713,000 cubic yards for initial construction of the design beach profile and two to three renourishment events averaging 570,000 cubic yards each. Per a separate document from EN, the NED has a design beach fill template is characterized by a 20 foot berm extension (+7 ft-NAVD88 to Depth of Closure) from the existing dune. Beach fill material required under the Base SLR case includes an average of 530,000 cubic yards for initial construction of the design beach profile and two to three renourishment events averaging 380,000 cubic yards each.

SEE ASSUMPTIONS TAB FOR COST VALUE RANGES DEVELOPMNENT

Negligible--- *Less than*		**$294,255**		**19 Months**
Marginal ---*between*	**$294,256**	**and $1,177,020**	**19 Months**	**and 31 Months**
Significant ---*between*	**$1,177,021**	**and $1,765,530**	**31 Months**	**and 62 Months**
Critical--- *between*	**$1,765,531**	**and $2,942,550**	**62 Months**	**and 124 Months**
Crisis ---*Over*	**$2,942,551**		**124 Months**	

LINKED	PROJECT CONTINGENCY TAB	FORECAST EXTRACTS TAB	COST RISK MODEL TAB	Project Cost				Project Schedule					
Risk No.	**Risk/Opportunity Event**	**Concerns**	**PDT Risk Conclusions, Justification**	**Likelihood***	**Impact***	**Risk Level***	**Rough Order Impact ($)**	**Likelihood***	**Impact***	**Risk Level***	**Order Impact (mo)**	**Variance Distribution**	**Correlation to Other(s)**
Contract Risks (Internal Risk Items are those that are generated, caused, or controlled within the PDT's sphere of influence.)													
PROJECT & PROGRAM MGMT													
PM1	Scope Definition, Scope Changes	Poorly defined scope could lead to higher costs and impacts to the schedule. Poor definition could also lead to changes later on, which could impact cost and schedule.	The scope is well-defined. The PDT has maintained excellent coordination with all necessary agencies to ensure that all bases are covered. The project also mimics existing projects and their mitigation plans. The planned project is quite routine for the district as well. The PDT considers the probability of scope definition issues or potential for changes to be a unlikely.	Unlikely	Marginal	LOW		Unlikely	Negligible	LOW			
PM2	Funding Stream Issues	Not receiving of funding in a timely manner, for any reason, could affect the cost and schedule	This could be problematic if, after authorization, there is a delay in construction funding. This could delay the start of construction, which could cause impacts to predicted construction quantities. However, it should be noted that FY17 Funding was provided ahead of schedule.	Very Unlikely	Marginal	LOW		Very Unlikely	Significant	LOW			
PM3	PPA Issues	Delay in an agreement could delay the project	The PPA for construction has not been obtained yet, as the PDT is still working on authorization at this time. Delays to obtaining the PPA agreement, post-authorization, would cause schedule impacts.	Unlikely	Negligible	LOW		Unlikely	Significant	MODERATE			
PM4	Review & Authorization Delays	Delayed reviews and authorization would impact the schedule	Delays in the review process and/or authorization would impact timing for receipt of construction funds. Risks related to funding stream delay covered under PPM-2 Funding Stream.	Unlikely	Negligible	LOW		Unlikely	Significant	MODERATE			
CONTRACT ACQUISITION RISKS													

CA1	Acquisition Strategy	If the route of multiple contracts is chosen, it could increase costs.	The project will not be split into multiple contracts. This is illogical, cost-prohibitive, and would be highly difficult due to its small size (20-foot berm) and environmental restrictions (the windows would place too much time in between).	Very Unlikely	Significant	LOW		Very Unlikely	Significant	LOW			
CA2	Acquisition Plan	Multiple CT methods available (IFB, RFP, IDIQ, 8A), which represents uncertainty in contract cost and schedule. Impacts effort in award; some contract vehicles more conducive to lower cost	The PDT is expecting to use RFP (large business) as it suits this project type and size the best. Special conditions or requirements which would require alteration from this choice are not expected. A suitable MATOC will NOT be available at the time of CT method selection. Altering the CT method to something like IFB or 8A would impact the schedule, but only if that change is made after establishing RFP as the official CT method for the project. The team is not expecting any special requirements that would mandate Lowest Price, Technically Acceptable (LPTA). There are several other projects in the area under similar circumstances, procurement issues are not anticipated.	Unlikely	Marginal	LOW		Unlikely	Marginal	LOW			
CA3	Acquisition Delays	Bid opening could be delayed due to amendments, permit receipt, etc. which could affect schedule	There are similar, ongoing CSRM projects nearby (within the same county and adjacent to the county line) with sufficient lessons learned to prevent impacting delays. Again, there are no conditions that indicate that the PDT may run into complications later on. This is a small, straightforward project in an area that is not unfamiliar to the industry. Amendments that would result in schedule impacts to the bid schedule opening date are considered unlikely. A pre-bid conference call will help minimize risk of surprises. Delays, if any, would be minimal.	Unlikely	Negligible	LOW		Unlikely	Negligible	LOW			
	TECHNICAL RISKS												
TL1	Volume Variations	Erosion rates may vary throughout the project life as monitoring information is collected and shorelines stabilize	Erosion rates, naturally, do vary. This is accounted for through historical data, averages, storm data, and modeling software like Beach-Fx. Factors like heavy storms could cause variations beyond team control. Risk related to storm impacts is captured under PR-8 Weather. The PDT will keep variation potential in mind as the project, post-authorization, progresses in order to maintain accurate volume calculations. This would be accomplished most readily via up-to-date surveys. The estimate uses the average volumes as presented in the draft Engineering Appendix.	Likely	Crisis	HIGH		Likely	Negligible	LOW			

TL2	Renourishment Interval	Renourishment intervals could change (from the range predicted by Beach-Fx) based on storm events, sea level rise, and timing of funding	The risk purely related to a change to the renourishment interval, once established, is not considered likely to change from the range of possibilities provided via Beach-Fx. Such a change would impact the number of renourishments within the project life and, from there, the total project cost. The project life, conversely, is fixed, so there would be no schedule impact. Risk related to storm impacts is captured under PR-8 Weather, sea level rise under PR-9 Sea Level Rise, and funding delays captured under PPM-2 Funding Stream.	Unlikely	Crisis	HIGH		Unlikely	Negligible	LOW			
TL3	Availability of Borrow Area/Sand	Could be a shortage in the amount of borrow material available for the life of the project	A report by Coastal Tech (for the LS) was completed in 2012. The report indicates that availability should not be a problem for this borrow area and use of the potential borrow area will not hurt current projects in area.	Very Unlikely	Significant	LOW		Very Unlikely	Marginal	LOW			
TL4	Character of Materials	Lack of geotech investigations or presence of rock leads to uncertainity regarding the yield of suitable material from the borrow site	The character of materials is not expected to be problematic. Any undesired material can be handled by screening if necessary. The district also has other standard contract language (remediation, etc.) for such issues. The PDT feels that the investigations are for this are solid.	Very Unlikely	Significant	LOW		Very Unlikely	Marginal	LOW			
	LANDS AND DAMAGES RISKS												
LD1	Site Access	Availability of access areas	Availability assumptions based upon data from county permits (2012/2013). Requires validation for this particular project. However, this project is mimicking the county project and mitigation (if needed). Design would determine need for additional staging/access areas.	Unlikely	Negligible	LOW		Unlikely	Negligible	LOW			
LD2	Staging Areas	Availability of staging areas	For this type of project, staging areas and site access for beach fill tend to be adjacent to one another. The highly close proximity means that problems for one translates to problems for the other. Therefore, the PDT considers this risk to be covered under LD-1 Site Access.	Unlikely	Negligible	LOW		Unlikely	Negligible	LOW			
LD3	Easements	Need to obtain perpetual easements	The project does require easements/land certifications. Eminent domain, condemnation, unwillingness of property owners, etc. could cause delays for easements west of the erosion control line. However, the county has already paved a path for this project by completing their own in the recent past (2012/2013), so problems following in the established trail are not expected.	Unlikely	Negligible	LOW		Unlikely	Significant	MODERATE			
	REGULATORY AND ENVIRONMENTAL RISKS												

REG1	Environmental Impacts	Could be impacts to hardbottoms, reefs and cultural resources at the project site or borrow area which would require additional investigation, coordination and permitting	All cultural resource surveys are complete and of excellent quality. Unexpected discoveries are not anticipated. Sufficient detailing of cultural resources and provision of surveys to bidders should prevent impacts during construction. Additionally, our project footprint is expected to be smaller than that of the Local Sponsor's, reducing impact chances further. Risk of triggering mitigation is captured under REG-2 Environmental Monitoring & Mitigation.	Very Unlikely	Significant	LOW		Very Unlikely	Marginal	LOW			
REG2	Environmental Monitoring & Mitigation	Monitoring and mitigation requirements as a result of hardbottom or reef impacts could impact cost and schedule	The PDT is not expecting to trigger mitigation for this project; however, costs for mitigation have already been explored in the alternative screenings for this project (mimicking Local Sponsor mitigation project). For monitoring, such requirements already well-known and would be incorporated into the contract. No surprises are either front are expected.	Unlikely	Crisis	HIGH		Unlikely	Marginal	LOW			
REG3	Environmental Restrictions	Required dredging windows and environmental restrictions could impact project cost and schedule. This is addressing likelihood of being caught off guard by such restrictions/windows	The project area is a high turtle nesting area. The PDT is already aware of potential restrictions and has ongoing coordination with the appropriate agencies. All restrictions/windows will be incorporated accordingly. No new or otherwise unanticipated window/restriction impositions are expected.	Very Unlikely	Significant	LOW		Very Unlikely	Marginal	LOW			
REG4	Environmental Delays	Turtle takes and other wildlife impacts could delay the contract	The project area is a high turtle nesting area. The PDT is already aware of potential restrictions and has ongoing coordination with the appropriate agencies. All restrictions/windows will be incorporated into the contract accordingly for contractor awareness. No surprises are expected for this project, but contingency plans are standard inclusions in district contracts (environmental standby time, reporting processes, etc).	Very Unlikely	Marginal	LOW	(standby time avg)	Very Unlikely	Negligible	LOW			
REG5	Permit Delays	Permit coordination	The PDT is maintaining excellent communication channels with the appropriate agencies. The Local Sponsor has already paved a path by completing a project here, which we are mimicking. New requirements and other complications are not expected.	Unlikely	Negligible	LOW		Unlikely	Significant	MODERATE			

REG6	NEPA	Project changes could require changes to NEPA document	Changes post-authorization are not expected by the team. The PDT has the LS Environmental Impact Statement, which was accepted in 2012. The plan is to reference that approved existing document in order to satisfy requirements. The worst case scenario is having to create a document similar to what the LS submitted.. This would, however, open things up for comments, revisions, and schedule impacts.	Very Unlikely	Negligible	LOW		Very Unlikely	Significant	LOW			
	CONSTRUCTION RISKS												
CO1	Mods and Claims	Could be modifications and claims that impact cost and schedule	There is an inherent risk of this, but it isn't a problem for this area historically. The small size of this project and its routine nature (beach fill is fairly typical) leads the PDT to feel that there will not be a large problem. Mods could impact cost and schedule positively or negatively. Claims would be more of a post-construction issue and wouldn't affect schedule so much as cost.	Unlikely	Significant	MODERATE		Unlikely	Marginal	LOW			
CO2	Staging Areas	Accessibility and location of staging areas could pose a risk to contractor	The PDT feels that this is a low risk. Staging areas for these types of projects are usually on the beach (fill area) or adjacent to the beach. Contract includes language for barring/re-routing public, access, clearing, and restoration. The team considers ease of use and safety when designating potential site access and staging areas. This is a dredging project, so mobilizing/demobilizing landside equipment shouldn't cause much of an issue. If the contractors feel differently, this could impact how they price their bids.	Very Unlikely	Significant	LOW	% of mob/demob	Very Unlikely	Negligible	LOW			
CO3	Safety Issues	Certain project requirements and existing features could pose a safety risk	There are no unique requirements or conditions anticipated for completion of this project. Beach fill (dune/berm) is a common project for the area and the industry is well-versed. Safety language is always present in permits and contract language. QA/QC and SSHO requirements should also minimize issues/impacts.	Very Unlikely	Negligible	LOW		Very Unlikely	Negligible	LOW			

CO4	Contractor/Subcontractor Issues	Contractor/Subcontractor inefficiency, error, negligence, inexperience, etc may impact construction time and cost	Even experienced contractors experience slip-ups and mishaps. The team will try to mitigate with rapid, thorough, and appropriate responses to contractor concerns. The quality assurance team will monitor the contractor carefully in order to gauge progress and potential concerns. The Corps cannot 100% make up for contractor issues, but precautions and damage control is within the realm of our legal and contractual abilities. The risk of such issues resulting in a modification or claim is covered under CO-1 Mods and Claims. The team will work to ensure that the Government does not pay for Contractor-caused problems. The team will also be sure to request recovery schedules, if the contractor falls behind, in order to minimize schedule impacts.	Likely	Negligible	LOW		Likely	Negligible	LOW			
	ESTIMATE AND SCHEDULE RISKS												
ET1	Production Estimates	Actual production can vary from what was assumed	This project will be new for SAJ, thus there is no historical production specific to the dredging area for the estimate to draw upon. Instead, the estimate uses comarable projects. As time progresses and historical data is established, this risk should decline in likelihood.	Likely	Significant	HIGH		Likely	Marginal	MODERATE			
ET2	Pipeline Corridors	Use of corridors could affect project cost	The estimate is assuming use of corridors already shown in the county's permit drawings. The county has conducted contracts using these corridors and necessary considerations are included within the estimate and discussed within the report.	Likely	Negligible	LOW		Likely	Negligible	LOW			
ET3	Quantity Estimates	Quantities can vary between design survey and construction	The project's erosion rate is high, so volumes can change between design and construction. This could lead to a modification.	Likely	Critical	HIGH		Likely	Negligible	LOW			

ET4	Contractor Markups and Rates	Actual contractor markups and labor rates can vary from what was estimated	This project is set to be completed by one of the large dredging contractors, so markups should fall within a typical range of historical markups used by big business dredging contractors. Mark-ups in the estimate are "historic average contractor markups from past SAJ contracts and audits for large dredging contractors". Additionally, while the rates in the estimate and CEDEP are historical and valid for the area, it is still possible that these vary as well. The Contractor could use a higher rate due to business choice, because the laborer in question has higher-than-normal credentials, or their personal requirements are more stringent than ours and the pay must match accordingly. There may also be fluctuations (increase or decrease) in rates over time.	Likely	Significant	HIGH		Likely	Negligible	LOW			
ET5	Subcontracting Plan	Subcontracting plan can vary	It is assumed the Contractor would subcontract all environmental and vibration monitoring work based upon typical industry choices. Other associated general work could be subcontracted as well, but sub-markups on other work would result in very negligible cost increases.	Likely	Negligible	LOW		Likely	Negligible	LOW			
ET6	Dredge Size/Type	Actual dredge size/type could vary from what was assumed	The estimate assumes a large hopper, which would be most practical due to environmental restrictions and borrow area depths.	Unlikely	Marginal	LOW		Unlikely	Marginal	LOW			
ET7	Haul/Pumping Distance	Could be some variation in hauling and pumping distance that may affect the cost and schedule	There is no room for variation in haul or pump distance. The borrow area will not change, which limits the hauling distance. Additionally, the contractor has to use corridors. This limits options for routing pipeline, which limits pumpout distance variation.	Very Unlikely	Significant	LOW		Very Unlikely	Negligible	LOW			
	Programmatic Risks	(External Risk Items are those that are generated, caused, or controlled exclusively outside the PDT's sphere of influence.)											

PR1	Bidding Climate and Competition	Severe economic swings can increase / decrease number of potential bidders.	Bidder interest is fairly consistent for these types of projects, especially in this area (vicinity of Ft. Pierce and Martin Co, which are well-established SAJ projects). Bidder availability is considered in advance. The PDT will try to time construction as favorably as possible. Historically, there hasn't been a problem with projects in this area. The small size of the project may impact bidder interest, but that is something the team can predict with a pre-proposal meeting. Poor turnout could cause bidders to artificially drive up costs. Receiving no bids, though extremely unlikely, would delay the project. Competition requirements only call for two (2) bidders in order to make award and the PDT is confident that this is something that can be accomplished. Bidder availability as impacted by weather is captured under PR8 Weather.	Unlikely	Marginal	LOW		Unlikely	Significant	MODERATE			
PR2	Bid Protests	There is inherent risk of protests from the industry	Historically, there hasn't been an issue for this area. The PDT can reduce risk by remaining firm on acquisition strategy and keeping to the standards of the advertisement-award process. Problems are not expected. A protest does not necessarily equate to re-advertisement. Impact time would also be affected by a decision to fight the protest versus corrective action.	Unlikely	Negligible	LOW		Unlikely	Marginal	LOW			
PR3	Court Injunctions	Could cause schedule delays	An injunction is something resultant from a bidding protest scenario, with a worst case impact of 4 months per Legal. This has been captured under PR2 Bid Protests.	Very Unlikely	Negligible	LOW		Very Unlikely	Negligible	LOW			
PR4	Political Support/Opposition	Delays due to political ramifications are possible and could delay the work.	Interest from politicians is considered very low. The Local Sponsor is favorable towards the project. The project area has an active community, so problems could arise if residents feel slighted by exclusion and won't easily accept the Corps' technical explanations and reasoning (more likely prior to authorization). Public meetings/workshops could help in this area, if determined to be necessary. However, without movement from the Local Sponsor or politicians, the residents will not be able to impede the project legally.	Unlikely	Negligible	LOW		Unlikely	Negligible	LOW			

PR5	Fuel Prices	Fluctuation in fuel costs could impact the contract cost	Fuel is always fluctuating and is a big factor in dredging projects. While contract estimates for each nourishment would use the most-recent rates, the budget submission estimate attempts to mitigate risks here by considering a 5-year average. Fluctuations are likely, but fluctuations beyond the 5-year average are Unlikely. Therefore, the Likelihood will be Unlikely. Recently, fuel costs have been quite low, so the average does well to counter the risk of fuel rising beyond current rates between now and the end of the project life.	Unlikely	Critical	MODERATE		Unlikely	Negligible	LOW			
PR6	Labor Availability	Labor Prices are fixed by Davis Bacon wage rates. Labor availability is subject to bidding climate.	For SAJ beach projects, this is not a common problem. It has not been an issue for the projects on either side of this one (Ft. Piece, Martin County), and the PDT does not predict that it will be a problem for this project either.	Very Unlikely	Marginal	LOW		Very Unlikely	Significant	LOW			
PR7	Equipment Availability	Industry demand can have an effect on the available equipment; Dredge may have to come from further away, increasing mobilization costs; size/type of equipment available may vary	The PDT is planning for use of a hopper dredge, so there is an inherent risk that a hopper will not be available to perform the work in the specified timeframe. The project could see impacting costs in the form of inflated proposals from the contractors who do happen to be available at the time. The project is subject to strict environmental windows, making it a little more susceptible to adverse market forces. SAJ has seen up to an additional $1M per contract during times of heavy workload due to equipment shortage.	Likely	Marginal	MODERATE		Likely	Negligible	LOW			
PR8	Weather	Severe weather causing damage to project during construction could cause schedule delays	The project has to observe a strict environmental window, so it would be completed within the same timeframe, seasonally. Looking at projects on either side of it (Ft. Pierce, Martin County), issues with severe weather delays beyond what is built into the contract are not expected.	Unlikely	Marginal	LOW		Unlikely	Marginal	LOW			
PR9	Sea Level Rise	Sea Level Rise could impact the scope and schedule	Per the Feasibility Report, considerations for sea level rise are incorporated into the modeling. Though we are directed to follow the Base Scenario, the report does present scenarios for intermediate and high sea level rise as well. This leaves the team with some idea of what the need would be, should it later be proven that the base scenario is insufficient. Such a decision is programmatic and beyond the control of the PDT. As it pertains to the estimate, these considerations are reflected in the quantities for intial construction and the subsequent renourishments.	Very Unlikely	Negligible	LOW		Very Unlikely	Negligible	LOW			

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

1. Risk/Opportunity identified with reference to the Risk Identification Checklist and through deliberation and study of the PDT.
2. Discussions and Concerns elaborates on Risk/Opportunity Events and includes any assumptions or findings (should contain information pertinent to eventual study and analysis of event's impact to project).

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