APPENDIX E
COST ENGINEERING AND RISK ANALYSIS

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ACRONYMS AND ABBREVIATIONS

C&SF	Central and Southern Florida
O&M	operations and maintenance
ROM	rough order of magnitude
SFWMD	South Florida Water Management District
C&SF Section 203 Study	Central and Southern Florida Flood Resiliency (Section 203) Study for Broward Basins
CM	construction management
FWOP	Future Without Project
MCACES/MII	Micro-Computer Aided Cost Estimating System Second Generation
O&M	operations and maintenance
ROM	rough order of magnitude
TPCS	total project cost summary
TSP	Tentatively Selected Plan
USACE	U.S. Army Corps of Engineers
USD	U.S. dollars

E COST ESTIMATES

E.1 Cost Estimating Standards

U.S. Army Corps of Engineers (USACE) cost estimates for planning purposes are prepared in accordance with the following guidance:

- ER 1110-1-1300, Cost Engineering Policy and General Requirements (March 26, 1993);
- ER 1110-2-1302, Civil Works Cost Engineering (June 30, 2016);
- ER 1110-2-1150, Engineering and Design for Civil Works Projects (August 31, 1999);
- ER 1105-2-100, Planning Guidance Notebook (April 22, 2000, as amended);
- EM 1110-2-1304 (Tables revised September 30, 2018), *Civil Works Construction Cost Index System* (September 30, 2025);
- CECW-CP Memorandum for Distribution, Subject: Initiatives to Improve the Accuracy of Total Project Costs in Civil Works Feasibility Studies Requiring Congressional Authorization (September 19, 2007);
- CECW-CE Memorandum for Distribution, Subject: Application of Cost Risk Analysis Methods to Develop Contingencies for Civil Works Total Project Costs (July 3, 2007); and
- USACE Recommended Best Practices, Cost & Schedule Risk Analysis (March 2024).

Cost estimates completed for the Central and Southern Florida (C&SF) Flood Resiliency (Section 203) Study for Broward Basins (C&SF Section 203 Study) Integrated Feasibility Study/Environmental Assessment report, described in **Appendix E**, are in accordance with the above listed standards.

E.2 Class 4 Cost Estimates to Support Plan Formulation

The plan formulation process for the C&SF Section 203 Study, leading to the identification of the Tentatively Selected Plan (TSP), which was later referred to as the Recommended Plan, is described in the main report, **Appendix C** and **Appendix D**. The TSP/Recommended Plan is described in **Section 6** of the main report and in **Section A.1** of **Appendix A**.

As part of the plan formulation process, Class 4 cost estimates, as defined in ER 1110-2-1302, were prepared for the purpose of comparing alternatives. These cost estimates included Class 4 construction cost estimates and Class 4 annual operations and maintenance (O&M) cost estimates prepared for the final array of alternatives and the TSP, as described in **Sections E.2.1** and **E.2.2**. These cost estimates are also referred to as rough order of magnitude (ROM) cost estimates in the main report and **Appendix A**.

E.2.1 Class 4 Construction Cost Estimates for Plan Formulation

The Class 4/ROM construction cost estimates for the final array of alternatives and the TSP were developed using the following considerations.

Existing structures were evaluated using available information taken from as-built drawings. From these drawings, we were able to establish the items of work that would be required to deconstruct the existing facilities and estimate quantities of materials that would need to be demolished and removed

from the site. These items included (but were not limited to) upland vegetation removal, excavation of dredged material, and demolishing/removal of rip rap, sheet pile and concrete caps, tie-rods, walers, base slabs, needle beams, abutments, service bridges, liquid propane tanks, fuel tanks, control buildings, control panels, pumps, motors/power units, antennas, stilling wells, staff gauges, fencing, walkways, paving and signage.

For the ROM construction cost estimates, it was assumed that all excavated or demolished miscellaneous materials would be hauled off site and disposed of at the nearest local landfill.

Proposed structures were evaluated based on their proposed footprint and how the construction would need to be sequenced to maintain full functionality of the flood control system. In most cases, this meant that portions of existing structures would need to be partially demolished and false work constructed to provide workarounds that would allow for continuous operation during construction.

For the ROM construction cost estimates, it was necessary to estimate the size of the cofferdams and excavations that would be required; temporary and permanent sheet pile needed; tie-back systems; reinforced concrete base slabs; abutments; piers; service bridges; operating platforms; retaining walls; access; and grading, paving, and drainage of the parking areas. The ROM construction cost estimates also include assumptions for the control buildings, antenna poles, pumping systems, instrumentation and controls, mechanical systems, structurally connected upland systems, rip rap scour protection, water safety devices, weed and debris barriers, and fencing and signage.

For the development of these ROM cost estimates, the base cost was assumed to be based on the project developed site plans, which were reviewed for the purpose of approximating the quantities to be constructed. The steps below were taken to develop the ROM construction cost estimates:

1. Prepare general construction sequence plan.
2. Take off quantities from the site plans for each phase of the sequence plan.
3. Estimate quantities for structures using historical information for most likely structural configurations. At the time the ROM was developed, no quantitative information was available for the structures themselves, so assumptions were made for these features.
4. Determine the unit rate cost of each activity on the sequence plan phases.
5. Sum up the total cost.
6. Estimate the midpoint cost.
7. Estimate contingency cost percentage.
8. Sum up the total ROM cost.

E.2.1.1 Preparation of General Construction Sequence Plan

Proposed structures were evaluated based on their site plan footprint and the construction sequencing required to maintain full flood control system functionality. This approach involves phased construction, with the following steps outlining the process for typical projects:

For a new spillway:

- Two or more bays of the new structure are built while the canal flow is temporarily diverted.
- Once the new bays are complete and operational, the old spillway is demolished.
- Flow is then rerouted through the newly constructed bays, allowing for the completion of the remaining features.

For combined spillway and pump station sites:

- The same phased strategy is used as for the new spillway.
- One new structure (e.g., the pump station) is constructed first.
- The existing structure is then demolished.
- Construction then proceeds on the remaining new structure (e.g., the spillway).

This phased approach provides a continuous workaround, ensuring the flood control system remains fully operational during construction.

E.2.1.2 Take Off Quantities for Each Phase of the Sequence Plan

Conceptual design drawings were used to perform a detailed quantity takeoff for each construction phase. Activities were broken down into individual tasks, including mobilization and laydown area preparation, cofferdam installation, bypass channel construction, and the building of the new spillway and pump station. Other components accounted for were asphalt pavement; various types of fences, riprap, sod; the new control building; fuel tanks; a generator room; an antenna pole; staff gauges; stilling wells; etc.

E.2.1.3 Estimation of Unit Rates Cost of Each Activity on the Sequence Plan Phases

The proposed unit rates for the project's structures were estimated using historical data from the South Florida Water Management District's (SFWMD) current and past projects. This includes an analysis of actual costs for similar or equivalently sized project activities.

Pump Stations

Unit rates for pump stations were determined by incorporating SFWMD’s cost-curve assumptions that compare pump station total project cost to its design flow rate (cost per cubic foot per second). After the total pump station costs were estimated using this chart, the pricing for internal items of work was estimated based on percentages of total cost seen for similar items of work on other SFWMD pump stations.

Spillways

The same strategy was used to estimate the cost of the spillways, which involved consideration of cost based on the size of the bays and gates. Historical cost data based on these gate sizes was then interpolated and used to estimate the total overall cost.

E.2.1.4 Total Structure Cost

The total project cost was derived from a comprehensive analysis of all unit costs, which included a rough estimate and breakdown of materials, labor, and equipment.

E.2.1.5 Estimation of the Midpoint Cost

An estimation of the midpoint cost was prepared using the current Inflation rate and forecasted future inflation rates. The future midpoint costs were estimated to be 20 percent. This was an across-the-board estimate that will be refined from structure to structure in future revisions of this cost model.

E.2.1.6 Estimation of the Contingency Cost Percentage

The contingency cost was estimated to be between 30 percent and 50 percent, depending on the complexity of the project. For example, a minor construction without phasing would use a 30 percent contingency, a gated spillway would use 40 percent, and a combination spillway/pump station structure that requires a complex phasing plan, access management issues, and real estate availability issues would use 50 percent.

E.2.1.7 Summation of the Total ROM Cost

A summation of the total unit cost, midpoint cost, and contingency cost was completed to determine the total ROM cost for each proposed project.

E.2.2 Class 4 Estimate of Annual O&M Costs for Plan Formulation

The Class 4/ROM estimate of annual O&M costs for the Final Array of Alternatives and the TSP, shown in **Table E.2-1**, was prepared using the Microsoft Access-based SFWMD O&M Cost Estimating Tool software (September 28, 2010 version), developed by Stanley Consultants, Inc. and RADISE International, LC. for SFWMD. This SFWMD cost estimating tool, released in 2010, estimates O&M costs in 2010 U.S. dollars (USD), for typical SFWMD infrastructure, such as pump stations, gated spillways, gated culverts, canals, stormwater treatment areas, flow ways and levees, based on historical records of SFWMD annual field operations O&M costs. Since this cost estimating tool provides estimated annual O&M costs in 2010 USD, these costs were converted into estimated annual O&M costs in 2025 USD based on an average escalation rate from 2010 to 2025 of 2.43 percent. The estimated net annual O&M cost in the table is the net increase in annual O&M cost for the alternative compared to the Future Without Project (FWOP) alternative.

Table E.2-1. Class 4 Estimate of Annual O&M Costs for Plan Formulation.

Alternative	Estimated Annual O&M Cost (2010 USD)	Estimated Annual O&M Cost (2025 USD)	Estimated Net Annual O&M Cost (2025 USD)
FWOP	$1,125,000	$1,610,009	N/A
Alt A	$2,050,000	$2,933,976	$1,323,867
Alt B	$2,740,000	$3,921,509	$2,311,400
Alt C	$4,166,000	$5,962,411	$4,352,302
Alt C Enhanced	$4,166,000	$5,962,411	$4,352,302
TSP	$2,808,000	$4,018,831	$2,408,722

Notes: O&M = operations and maintenance; USD = U.S. dollars; FWOP = Future Without Project; N/A = not applicable; Alt = Alternative; TSP = Tentatively Selected Plan

E.3 Class 3 Cost Estimate for the Tentatively Selected Plan/Recommended Plan

This section discusses the preparation and development of a Class 3 cost estimate for the TSP.

E.3.1 Cost Estimate

E.3.1.1 Project Scope for TSP

The TSP includes thirteen separate features from the ROM estimates. Eight of these included reconstructing spillways and pump stations within existing canals. The remaining features include a large diameter culvert project, three canal excavation projects and the last is installation of stage monitoring stations within the Study Area. The proposed features are listed below according to the construction contract they are assigned to with the primary construction/demolition activity at each site listed. Additional details on these Project features are provided in **Appendix A**.

- Contract 1: G-56 Improvements
    - Construction of new G-56 Gated Spillway and ancillary structures
    - Demolition of existing G-56 Gated Spillway and ancillary structures

- Contract 2A: G-57 Improvements
    - Construction of new G-57 Gated Spillway and ancillary structures
    - Demolition of existing G-57 Gated Spillway and ancillary structures

- Contract 2B: G-16 (Pompano) Canal Culvert Improvements
    - Construction of two parallel Pompano Canal culverts upstream of G-57

- Contract 3: S-37B Improvements
    - Construction of new S-37B Gated Spillway and ancillary structures
    - Demolition of existing S-37B Gated Spillway and ancillary structures

- Contract 4: S-37A Improvements
    - Construction of new S-37A Pump Station and Gated Spillway with ancillary structures
    - Demolition of existing S-37A Gated Spillway and ancillary structures

- Contract 5: S-36 Improvements
    - Construction of new S-36 Pump Station and Gated Spillway with ancillary structures
    - Demolition of existing S-36 Gated Spillway and ancillary structures

- Contract 6: S-33 Improvements
    - Construction of new S-33 Pump Station and Gated Spillway with ancillary structures
    - Demolition of existing S-33 Gated Spillway and ancillary structures

- Contract 7: G-54 Improvements
    - Construction of new G-54 Pump Station and Gated Spillway with ancillary structures
    - Demolition of existing G-54 Gated Spillway, ancillary structures, and boat lock structure

- Contract 8: S-13 Improvements
    - Construction of new S-13 Pump Station and Gated Spillway with ancillary structures
    - Demolition of existing S-13 Pump Station and Gated Spillway and ancillary structures

- Contract 9: G-08 (Hillsboro) Canal Improvements
    - Dredging of approximately 1.1 miles of the G-08 (Hillsboro) Canal

- Contract 10: C-14 (Cypress Creek) Canal Improvements
    - Dredging of approximately 1.2 miles of the C-14 Canal

- Contract 11: C-11 (south New River) Canal Improvements
    - Dredging of approximately 2.0 miles of the C-11 Canal
    - Lining with riprap the dredged side slopes of an approximately 1.5-mile reach of the C-11 Canal

- Contract 12: Canal Stage Monitoring Improvements for Downstream Watersheds
    - Construction of six canal stage monitoring stations

E.3.1.2 Estimating Methodology

The Micro-Computer Aided Cost Estimating System (MCACES)/Second Generation (MII) cost estimate for the TSP is based on the preliminary design of these TSP features presented in **Appendix A** (including the preliminary design drawings in **Annex F-1** of **Appendix A**). The estimate is formatted following the Contract Work Breakdown Structure.

E.3.1.3 Quantities

Detailed quantity take-offs have been prepared for each of the primary features of the Project and are consistent with the current level of design. **Annex 1** of **Appendix E** includes all quantity calculations currently developed for use in the estimate, sorted by proposed construction contract. These quantities include assumptions and sources of data used for the quantity development.

E.3.1.4 Work Breakdown Structure

The estimate includes both construction and non-construction costs. The construction costs, developed in MCACES, fall under the following feature codes:

- 09 – Channels and Canals (for canal excavation and stage monitoring station projects)
- 15 – Floodway Control and Diversion Structures (for spillway and pump station projects)

The other construction and non-construction costs, included in the total project cost summary, fall under the following feature codes:

- 01 Lands and Damages
- 19 Buildings, Grounds and Utilities (accounts for Florida Power and Light infrastructure upgrades)
- 30 Planning, Engineering, and Design
- 31 Construction Management (CM)

E.3.1.5 MCACES Cost Item Development

The direct cost for Project elements identified in the plans and scope of work were developed in the MCACES/MII estimate using detailed labor, equipment, and materials for most of the cost items. Some cost items are priced using recent bids and quotes received on other similar projects in the area. The database line item productivities have been used where possible, with productivity adjustments made, as necessary. Where required, new crews have been created using the appropriate number of equipment, size of equipment, and labor trades to fit the work activity, and detailed production rate durations have been estimated. A majority of the costs have been compared with contractor bid prices from other similar projects in the area for reasonableness of use in this estimate.

E.3.1.6 Labor Rates

Federal wage determination rates have been used in the estimate. The wage rates for Broward County were used in the estimate. Additionally, a separate value of $12.50 an hour has been added to account for potential incentivization that may be required, as well as for lodging costs that the labor would need. Recommended values for these issues ranged from $5 to $15 dollars per hour beyond the current wage and fringe values.

E.3.1.7 Contracting Plan

Due to the size of the Project, the estimate assumes this work would be broken out into thirteen separate construction contracts as described in **Section A.3** of **Appendix A**, which represent each of the Project elements referenced above. The prime contractors for each would be a civil-site/structural contractor and would self-perform primary earthwork components. Primary subcontractor work in each contract has been assumed to include dewatering, landscaping, reinforced concrete, pile driving, asphalt, electrical and pump installation.

E.3.1.8 Cost Estimate Productivities and Markups

Crew productivities were adjusted as necessary to be consistent with other ongoing and completed projects in the area, as well as to account for efficiency factors/weather delays. In addition, a 7.5 percent material sales tax and a 16.67 percent overtime markup have been included in the estimate.

The following prime contractor's markups were applied to the direct and subcontractor's costs:

- Job Office Overhead – Prime contractor job office overhead (JOOH) values are based on calculated values for each of the proposed construction contracts. Subcontractor JOOH is assumed to be 10 percent.
- Home Office Overhead – 12.5 percent prime contractor and 12.5 percent subcontractor.
- Profit – All contractors' profit, including subcontractors, is currently assumed to be 10 percent.
- Performance Bond – These have been calculated in MCACES for each of the proposed contracts.

E.3.1.9 Non-Construction Costs

Non-construction costs include real estate, planning, engineering, and design, construction management (CM) (or supervision and administration). Real estate costs are discussed in **Appendix F**.

Planning, engineering and design cost was calculated based upon a percentage of 15 percent of construction costs, which is based upon a preconstruction engineering and design cost of 10 percent of construction costs and an engineering during construction cost of 5 percent of construction costs. CM cost was calculated based upon a percentage of 8.5 percent of construction costs.

E.3.1.10 Tentative Project Schedule

A tentative project schedule has been prepared to present a reasonable schedule for the work that could be used in estimating durations for job office overhead calculations within the cost estimate (see **Annex 2** for the proposed project schedule). The construction durations and sequencing were established based on productivities from recent and ongoing projects in the area in coordination with the MCACES cost estimate.

E.3.1.11 MCASES Summary

A detailed printout of the MCACES cost estimate is provided in **Annex 3**. This summary presents the current construction costs of the project based on the assumptions and information discussed above. This estimate of total project and/or construction costs prepared by J-Tech represents its professional judgment at the time of this submittal and is supplied for the guidance of SFWMD. J-Tech has developed the current construction cost estimate per USACE cost estimating guidance, along with the best available information, and J-Tech's cost estimating experience. J-Tech does not have control over the cost of contractor labor and material, or overcompetitive bidding or market conditions. As such, J-Tech is not able to guarantee the accuracy of such estimates as compared to contractor bids or actual costs to SFWMD at some future date.

E.3.2 Class 3 Estimate of Annual O&M Costs

The Class 3 estimate of annual O&M costs for the FWOP and TSP alternatives, shown in **Table E.3-1**, was prepared using the historical annual O&M costs for SFWMD structures G-56, G-57, S-37B, S-37A, S-36, S-33, G-54 and S-13 from the year 2015 to 2025, which were obtained from a report of annual O&M costs generated by SFWMD's SAP enterprise management system. To calculate the estimated annual O&M costs shown in **Table E.3-1**, the first step was to convert each structure's historical annual O&M cost for each year from 2015 to 2024 into 2025 USD. Next, those annual O&M costs from 2015 to 2024 in 2025 USD along with the 2025 annual O&M cost for each structure were averaged, resulting in an average annual O&M cost for each structure from 2015 to 2025 in 2025 USD. Then the average annual O&M costs for these structures were totaled to yield the FWOP estimated annual O&M cost in 2025 USD. To produce the TSP estimated annual O&M cost in 2025 USD, the FWOP estimated annual O&M cost in 2025 USD for each structure was adjusted based on the increase in the number of gates and/or pumping capacity for each structure under the TSP. The estimated net annual O&M cost in the table is the net increase in annual O&M cost for the alternative compared to the FWOP alternative.

Table E.3-1. Class 3 Estimate of Annual O&M Costs.

Alternative	Estimated Annual O&M Cost (2025 USD)	Estimated Net Annual O&M Cost (2025 USD)
FWOP	$299,113	N/A
TSP	$1,164,315	$865,201

Notes: O&M = operations and maintenance; USD = U.S. dollars; FWOP = Future Without Project; TSP = Tentatively Selected Plan

E.3.3 Risk Analysis

E.3.3.1 Risk Analysis Methods

The risk analysis process for this study followed the USACE requirements as well as the guidance provided by the USACE Walla Walla Cost Engineering Center of Expertise. The risk analysis process reflected within this report uses probabilistic cost and schedule risk analysis methods within the framework of the Oracle Crystal Ball software application. First, members of the Project Delivery Team met to identify risk items for both the construction cost estimate and the construction schedule. Then, the risk register was completed (see **Annex 4**). After that, the risk model was customized using commercially available Oracle Crystal Ball software. The most likely "high" and "low" values were assigned to estimate items using the software's "Assumption" function and the triangular distribution. "Forecasts" were then defined and the model was run.

After the model was run, the results were extracted from the sensitivity chart, the forecast chart, and the percentiles table for major items. The percentiles were then used to determine the contingency at the 80 percent confidence level. The appropriate contingency was then input in the total project cost summary spreadsheet.

E.3.3.2 Risk Analysis Results

The current risk analysis calculated a 23 percent contingency for costs and a 26 percent contingency on the schedule, which is based on the 80 percent confidence level. The current sensitivity charts, which provide an assessment of the contribution to the contingency calculation, are presented in **Figure E.3-1** and **Figure E.3-2** below.

Figure E.3-1. Top Cost Risks.

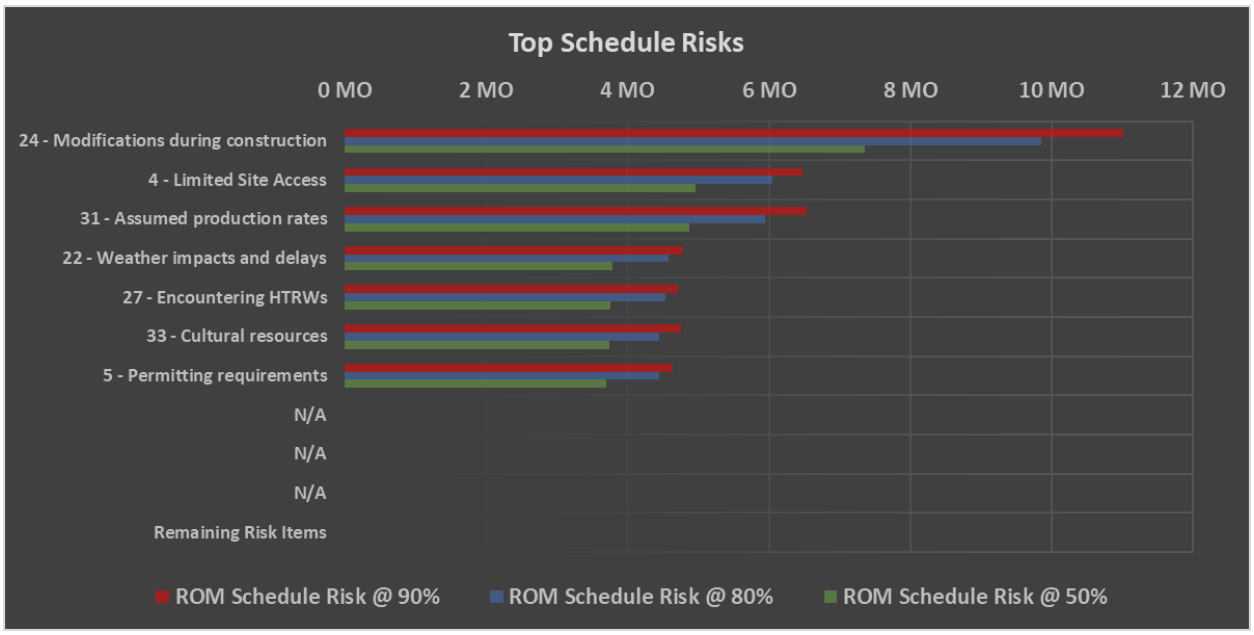

Figure E.3-2. Top Schedule Risks.

E.3.4 Total Project Cost Summary

The total project cost summary (TPCS) addresses inflation through Project completion (accomplished by escalation to midpoint of construction per ER 1110-2-1302, Appendix C). It is based on the scope of the TSP and the Project schedule. The TPCS includes federal and non-federal costs for lands and damages, all construction features, Florida Power and Light infrastructure upgrades, planning, engineering, and design and CM, along with the appropriate contingencies and escalation associated with each of these activities as discussed above. The current TPCS is provided in **Annex 5**.

E.3.4.1 Cost Agency Technical Review Certification Statement

The Cost Agency Technical Review Certification Statement, received from the USACE Walla Walla Cost Engineering Center of Expertise on April 23, 2026, is attached.