The GLMRIS Report

Appendix K - Cost Engineering

USACE
01/06/2014

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FIGURES

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K.1 INTRODUCTION

The purpose of this Appendix is to summarize the projected total project costs for the different proposed alternatives. These estimates are to give an idea of the order of magnitude for the costs for implementation of each alternative. All costs given are for all control and mitigation measures for aquatic nuisance species (ANS) described for each alternative in the main report. They also include operating and maintenance (O&M) costs on a yearly basis for each alternative.

The cost and schedule estimates are appropriately used in this report as a means to compare the alternatives presented. These cost and schedule estimates are not intended to support authorizing language, and will change with more detailed designs of an alternative.

K.2 COST METHODOLOGY

K.2.1 General

Due to the level of design for the alternatives (approximately 5% level), the estimate falls into a Class 4 estimate. Based on this, all costs were derived using corollary data from similar projects completed recently and scaled up or down to the projected design. For the corollary cost data, recent projects in close geographic proximity with similar scope were used when possible to give the most reasonable similar costs. Each of the projects and cost information used is presented below with the corresponding features.

The preparation of the cost estimate is in accordance with guidelines and policies included in:
“ER 1110-1-1300 - Cost Engineering Policy and General Requirements (26 March 1993)”;
“ER 1110-2-1302 - Civil Works Cost Engineering (15 Sept 2008)”; “EI 01D010, Construction Cost Estimates (1 Sept 1997)”; “EM 1110-1-8, Construction Equipment Ownership and Operating Expense Schedule, Region II (July 2007)”; “EM 1110-2-1304, Civil Works Construction Cost Index System (CWCCIS) (30 September 2010)”; and “ETL 1110-2-573, Construction Cost Estimating Guide for Civil Works (30 Sept 2008).” The estimate was completed using the latest guidance concerning implementation of the Civil Works Breakdown Structure (CWBS) and Chart of Accounts. MII estimating software from Project, Cost & Time, Inc. was used to compile and organize the costs for the final estimate.

K.2.2 Risk-Based Contingency Development

An abbreviated risk analysis was performed on this project to help to develop a contingency value. The results of the analysis produced a contingency related to each project feature. These contingencies were applied to each feature within each individual alternative to give an overall weighted contingency for each alternative. The results of this risk analysis as well as a detailed breakdown for the basis of contingency are included in Section K.4 of this Appendix.

K.2.3 Program Year Cost vs. Fully Funded Cost Estimate

The program year cost estimate is the estimated total construction cost marked up by the calculated contingency value. This number is then escalated to the program budget year, which is 2014 for this report.

The fully funded cost estimate includes inflation to the estimated mid-point of construction for each feature. The fully funded table distributes the base-level cost estimate across the appropriate years according to the schedule. Each feature account is inflated to the mid-point of expenditure activity using the Civil Works Construction Cost Index System (CWCCIS) factors. These inflated feature account totals are summed to yield a total fully funded project cost.

K.3 COST SUMMARY[1]

Culmination of the cost engineering efforts results in the following cost comparisons between the various alternatives. The 2014 program costs (Table K.1) include the calculated contingencies as discussed within the Risk Analysis, Section K.4. The fully funded amount includes the escalations through midpoint of construction, based on Office of Management and Budget (OMB) projections as of March 2013.

The following six scheduling figures (Figures K.1–K.6) depict rudimentary construction schedule activities for each measure for each alternative. The figures are rudimentary and theoretical. Construction schedule refinement would occur as more project information becomes available. There are numerous key and critical assumptions in the respective schedule executions--the greater assumptions being the preliminary scope and cost development, timely funding, real estate, and permitting resolution. As seen in the schedules, features are brought to construction completion as close to the finish of the project as possible to minimize unnecessary O&M costs before the features can be used. The risk discussions and risk register found in Section K.4 present these issues in more detail.

Figure K.7 combines the alternative project costs and schedules, depicting what might be an annual funding allocation or expenditure over time for each alternative. The presentation assumes favorable conditions relative to cost, real estate, and permitting and inclusion of the current risk contingencies. Note that earlier construction placement results in escalation savings, but increases the O&M costs for those same construction placements.

TABLE K.1 2014 Program Costs

ALTERNATIVE	PROGRAM YEAR COST (2014)	FULLY FUNDED COST	YEARLY O&M	YEARLY NON STRUCTURAL
Mid-System Control Technologies without a Buffer Zone	$15,543,000,000	$21,321,000,000	$145,500,000	$68,000,000
Technology Alternative with a Buffer Zone	$7,806,000,000	$9,100,000,000	$150,500,000	$68,000,000
Lakefront Hydrologic Separation	$18,389,000,000	$25,115,000,000	$87,000,000	$68,000,000
Mid-System Hydrologic Separation	$15,512,000,000	$20,805,000,000	$67,000,000	$68,000,000
Mid-System Separation Cal-Sag Open Control Technologies with a Buffer Zone	$15,097,000,000	$18,193,000,000	$110,200,000	$68,000,000
Mid-System Separation CSSC Open Control Technologies with a Buffer Zone	$8,332,000,000	$11,069,000,000	$96,500,000	$68,000,000

[1] The cost and schedule estimates are appropriately used in this report as a means to compare the alternatives presented. These cost and schedule estimates are not intended to support authorizing language, and will change with more detailed designs of an alternative.

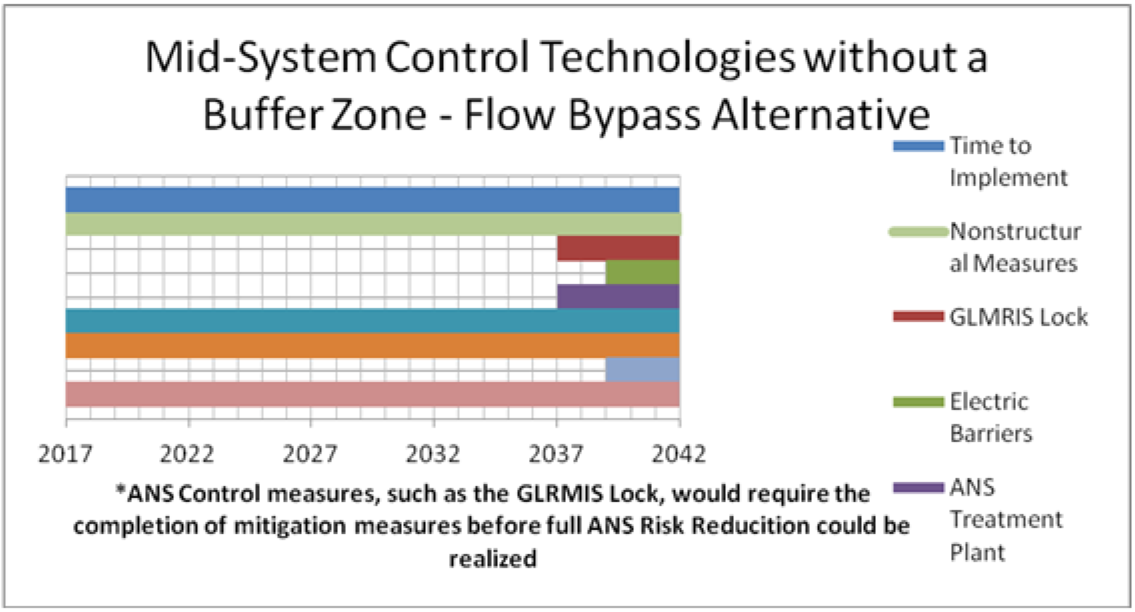

FIGURE K.1 Construction Schedule for Mid-System Technologies without a Buffer Zone Alternative

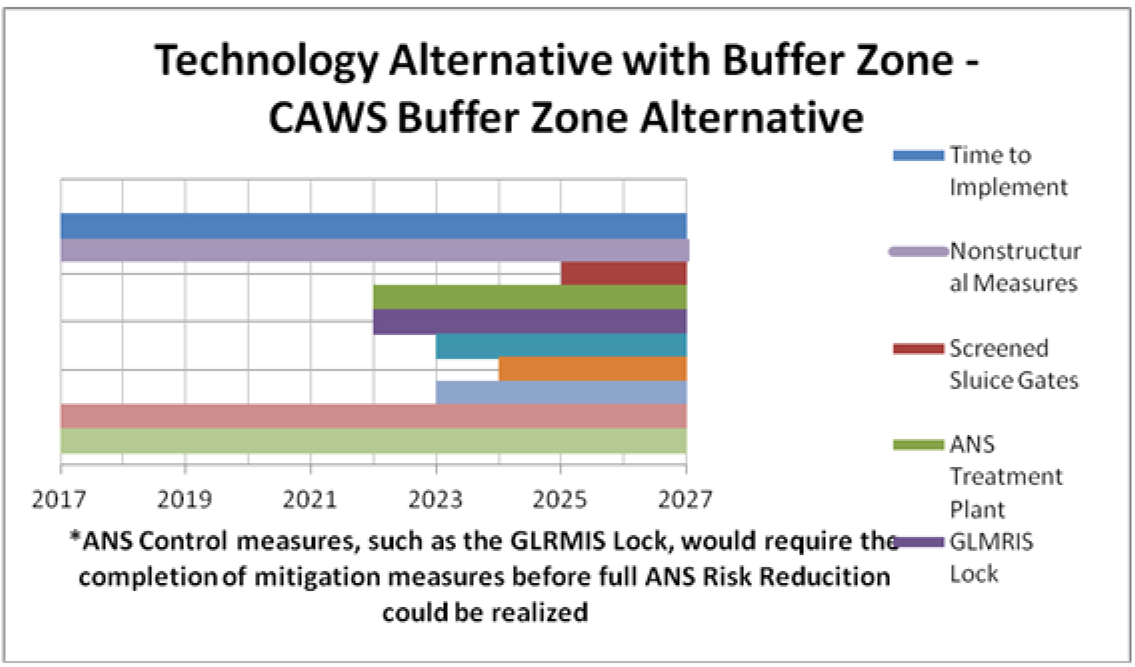

FIGURE K.2 Construction Schedule for Technical Alternative with Buffer Zone

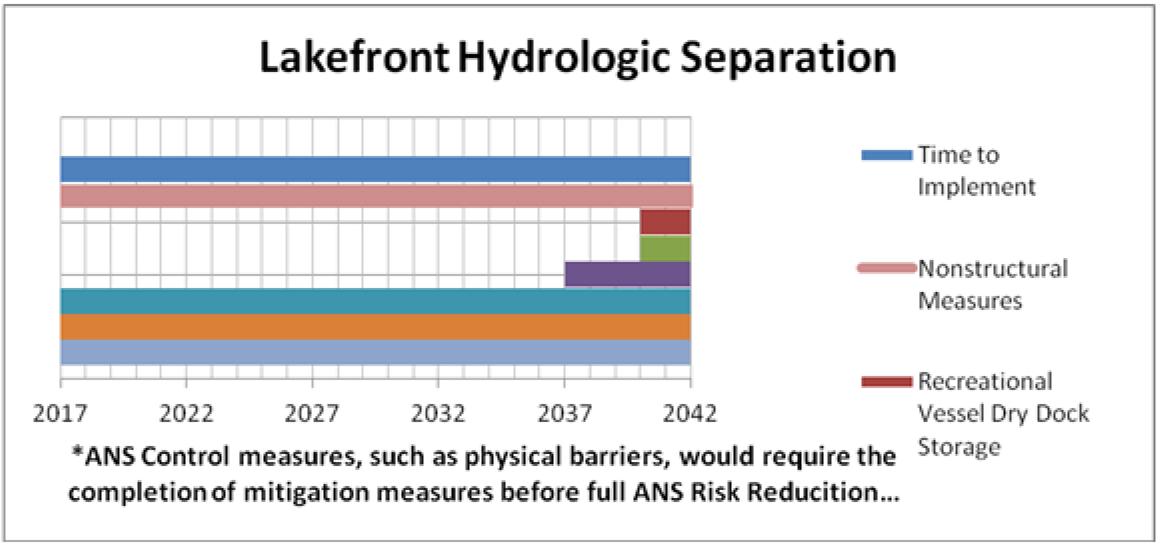

FIGURE K.3 Construction Schedule for Lakefront Hydrologic Separation Alternative

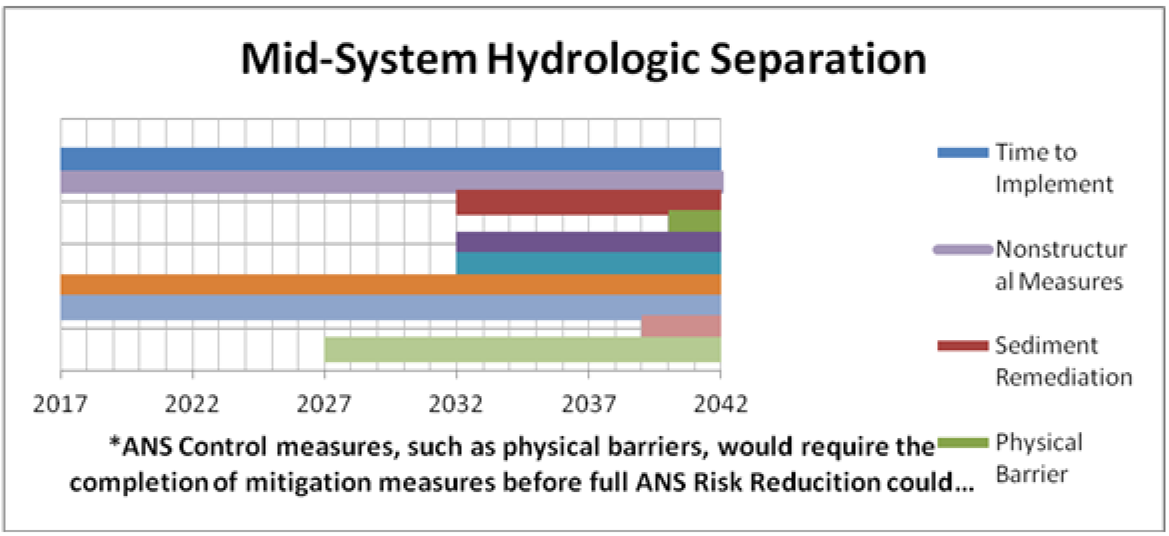

FIGURE K.4 Construction Schedule for Mid-System Hydrologic Separation Alternative

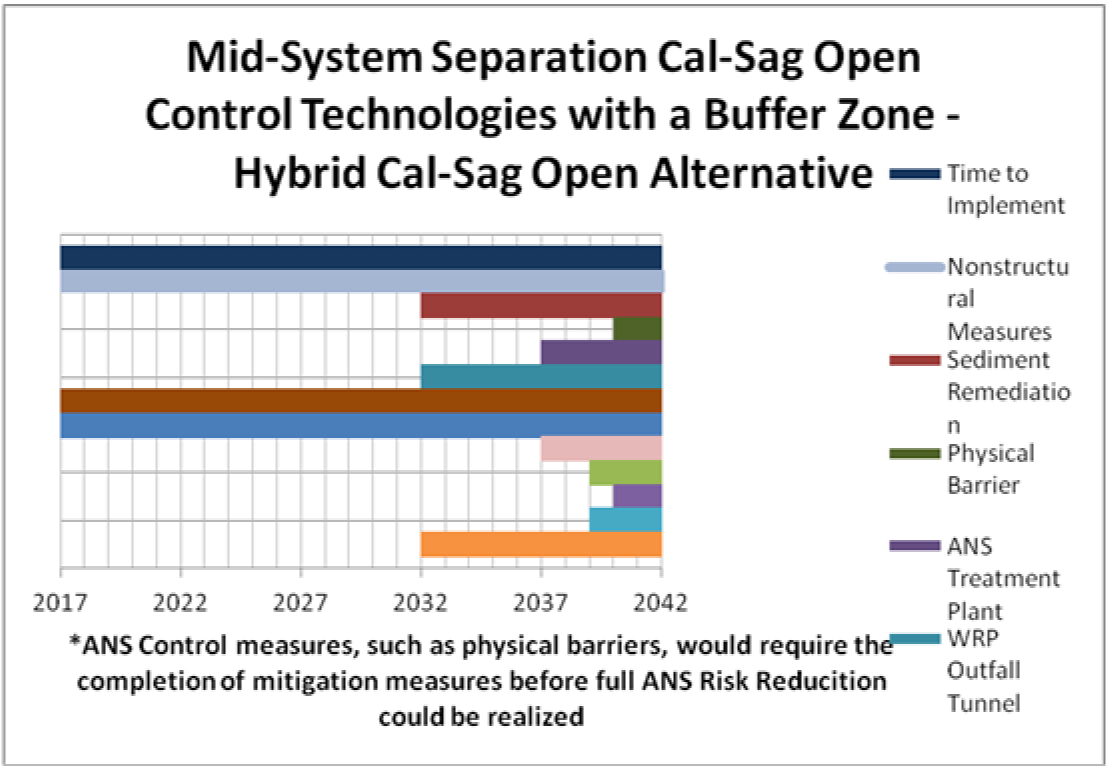

FIGURE K.5 Construction Schedule for Mid-System Separation Cal-Sag Open Control Technologies with a Buffer Zone Alternative

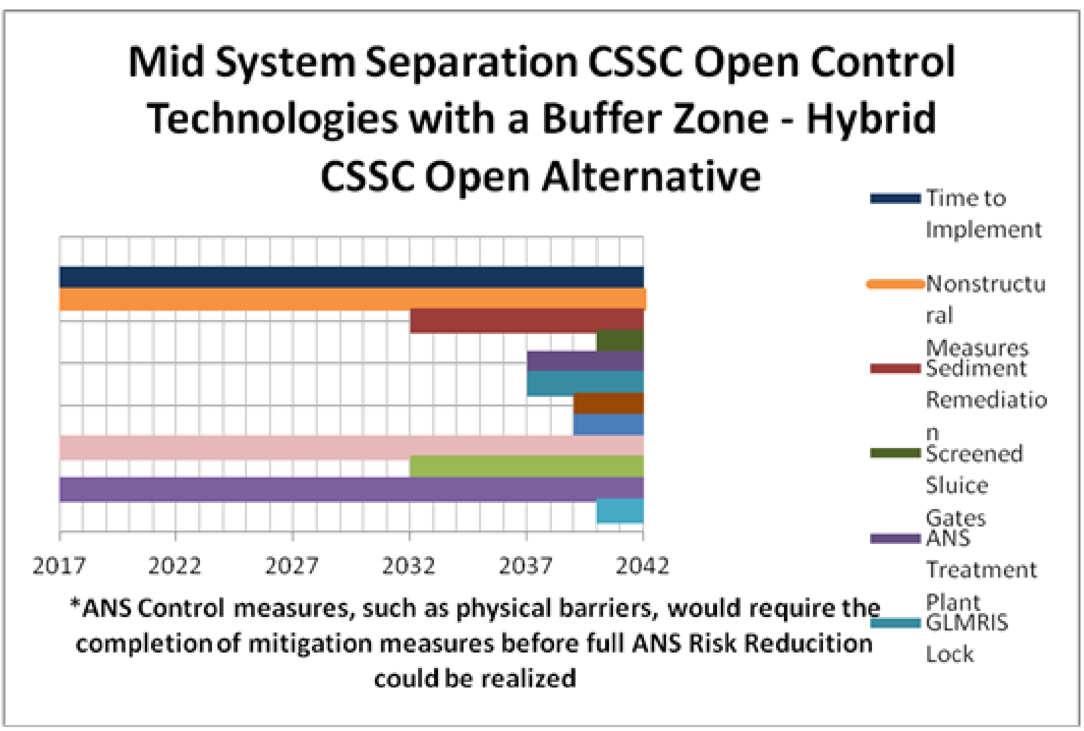

FIGURE K.6 Construction Schedule for Mid-System CSSC Open Control Technologies with Buffer Zone Alternative

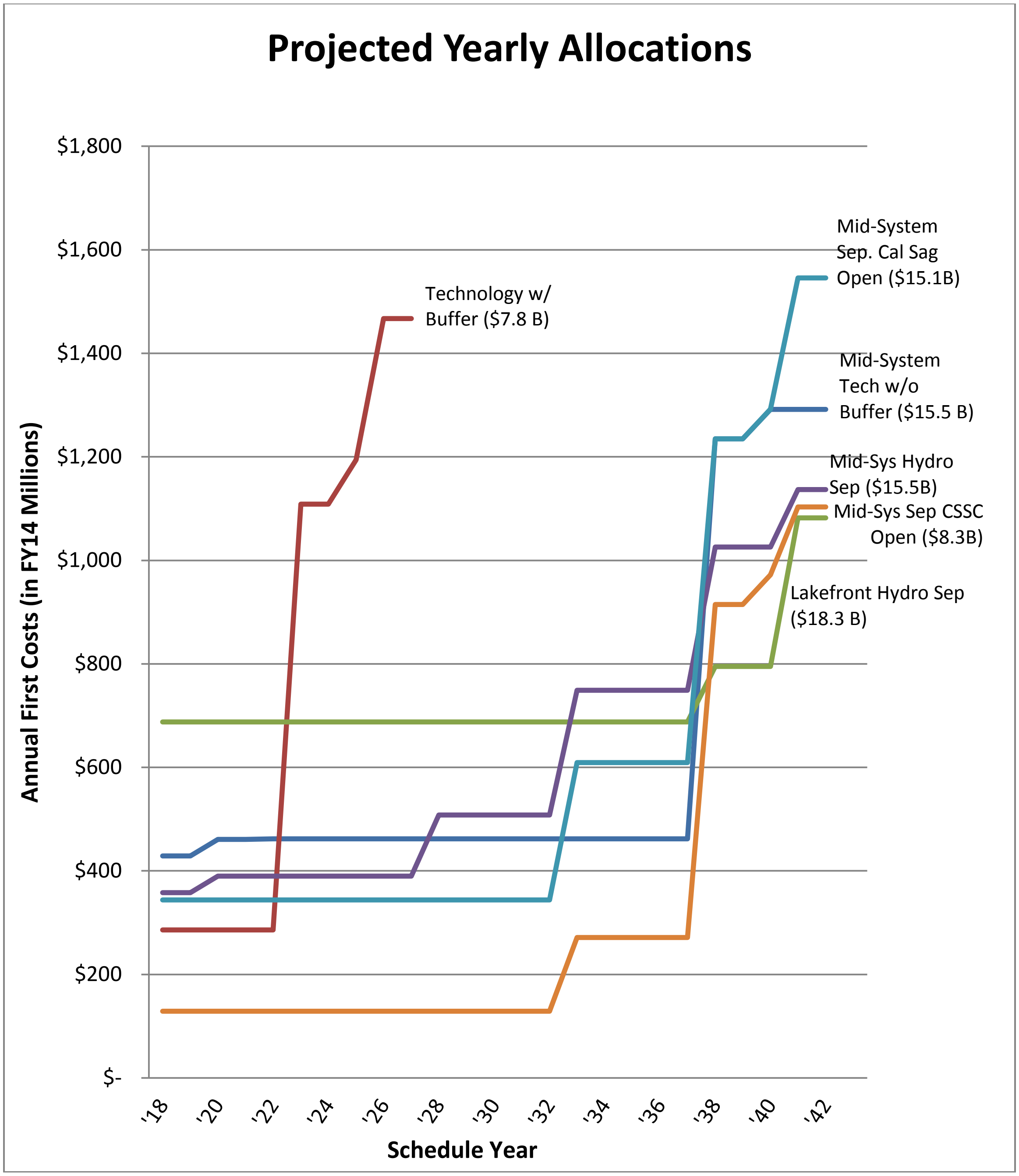

FIGURE K.7 Alternative Project Costs and Schedules

K.3.1 Total Project Cost Summaries

TABLE K.2 Total Project Costs for Mid-System Control Technologies without a Buffer Zone

Civil Works Work Breakdown Structure			**Estimated Cost**				**Project First Cost (Constant Dollar Basis)**				**Total Project Cost (Fully Funded)**			
							Program Year (Budget EC): 2014 Effective Price Level Date: 1 OCT 13							
WBS Number	Civil Works Feature & Sub-Feature Description		COST ($M)	CNTG ($M)	CNTG (%)	TOTAL ($M)	ESC (%)	COST ($M)	CNTG ($M)	TOTAL ($M)		COST ($M)	CNTG ($M)	FULL ($M)
A	***B***		***C***	***D***	***E***	***F***	***G***	***H***	***I***	***J***	***L***	***M***	***N***	***O***
20	PERMANENT OPERATING EQUIPMENT	Electrical Barrier	$104	$67	64%	$171	0.0%	$104	$67	$171		167	$107	$274
13	PUMPING PLANT	ANS Treatment Plant	$1,056	$1,098	104%	$2,154	0.0%	$1,056	$1,098	$2,154		$1,658	$1,724	$3,382
05	LOCKS	GLMRIS Lock	$858	$849	99%	$1,707	0.0%	$858	$849	$1,707		$1,373	$1,359	$2,732
03	RESERVOIRS	Reservoirs	$4,103	$1,928	47%	$6,031	0.0%	$4,103	$1,928	$6,031		$5,541	$2,604	$8,146
13	PUMPING PLANT	Pump Stations	$1,661	$1,229	74%	$2,890	0.0%	$1,661	$1,229	$2,890		$1,858	$1,375	$3,234
09	CHANNELS & CANALS	Tunnel System	$128	$91	71%	$218	0.0%	$128	$91	$218		$176	$125	$301
06	FISH & WILDLIFE FACILITIES	Ecosystem Mitigation	$34	$10	30%	$44	0.0%	$34	$10	$44		$47	$14	$61
	Construction Estimate Totals		$7,944	$5,273		$13,216	0.0%	$7,944	$5,273	$13,216		$10,820	$7,309	$8,129
01	Lands and Damages		$35	$35	100%	$70	0.0%	$35	$35	$70		$38	$38	$77
30	Planning, Engineering & Design		$1,073	$483	45%	$1,556	0.0%	$1,073	$483	$1,556		$1,495	$673	$2,168
31	Construction Management		$477	$224	47%	$701	0.0%	$477	$224	$701		$645	$303	$948
		Project Cost Totals	$9,529	$6,015	63%	$15,543		$9,529	$6,015	**$15,543**		$12,998	$8,323	$21,321

Estimated Total Project Cost (Program Year)	$15,543,400,000
Estimated Total Project Cost (Fully Funded)	$21,321,400,000

TABLE K.3 Total Project Costs for Technology Alternative with a Buffer Zone

Civil Works Work Breakdown Structure			Estimated Cost				Project First Cost (Constant Dollar Basis)				Total Project Cost (Fully Funded)			
							Program Year (Budget EC): 2014 Effective Price Level Date: 1 OCT 13							
WBS Number	Civil Works Feature & Sub-Feature Description		COST ($M)	CNTG ($M)	CNTG (%)	TOTAL ($M)	ESC (%)	COST ($M)	CNTG ($M)	TOTAL ($M)		COST ($M)	CNTG ($M)	FULL ($M)
A	***B***		***C***	***D***	***E***	***F***	***G***	***H***	***I***	***J***	***L***	***M***	***N***	***O***
20	PERMANENT OPERATING EQUIPMENT	Electrical Barrier	$156	$100	64%	$256	0.0%	$156	$100	$256		$172	$110	$282
13	PUMPING PLANT	ANS Treatment Plant	$764	$795	104%	$1,559	0.0%	$764	$795	$1,559		$888	$923	$1,811
05	LOCKS	GLMRIS Lock	$1,284	$1,271	99%	$2,555	0.0%	$1,284	$1,271	$2,555		$1,464	$1,449	$2,913
03	RESERVOIRS	Reservoirs	$688	$323	47%	$1,011	0.0%	$688	$323	$1,011		$814	$383	$1,197
13	PUMPING PLANT	Pump Stations	$269	$199	74%	$468	0.0%	$269	$199	$468		$301	$223	$524
09	CHANNELS & CANALS	Tunnel System	$187	$133	71%	$320	0.0%	$187	$133	$320		$221	$157	$379
04	DAMS	Physical Barrier	$198	$137	69%	$335	0.0%	$198	$137	$335		$253	$174	$427
10	BREAKWATER & SEAWALLS	Breakwater	$19	$10	52%	$29	0.0%	$19	$10	$29		$21	$11	$32
05	LOCKS	Sluice Gates and Screens	$75	$107	143%	$182	0.0%	$75	$107	$182		$89	$127	$216
06	FISH & WILDLIFE FACILITIES	Ecosystem Mitigation	$19	$6	30%	$25	0.0%	$19	$6	$25		$26	$8	$34
	Construction Estimate Totals		$3,659	$3,080		$6,739	0.0%	$3,659	$3,080	$6,739		$4,249	$3,565	$7,815
01	Lands and Damages		$15	$15	100%	$30	0.0%	$15	$15	$30		$15	$15	$31
30	Planning, Engineering & Design		$493	$222	45%	$715	0.0%	$493	$222	$715		$602	$271	$873
31	Construction Management		$219	$103	47%	$322	0.0%	$219	$103	$322		$259	$122	$381
		Project Cost Totals	$4,386	$3,420	78%	$7,806		$4,386	$3,420	**$7,806**		$5,126	$3,974	$9,100

Estimated Total Project Cost (Program Year)	$7,805,980,000
Estimated Total Project Cost (Fully Funded)	$9,099,900,000

TABLE K.4 Total Project Costs for Lakefront Hydrologic Separation Alternative

Civil Works Work Breakdown Structure			Estimated Cost				Project First Cost (Constant Dollar Basis)				Total Project Cost (Fully Funded)			
							Program Year (Budget EC): 2014 Effective Price Level Date: 1 OCT 13							
WBS Number	Civil Works Feature & Sub-Feature Description		COST ($M)	CNTG ($M)	CNTG (%)	TOTAL ($M)	ESC (%)	COST ($M)	CNTG ($M)	TOTAL ($M)		COST ($M)	CNTG ($M)	FULL ($M)
A	***B***		***C***	***D***	***E***	***F***	***G***	***H***	***I***	***J***	***L***	***M***	***N***	***O***
13	PUMPING PLANT	ANS Treatment Plant	$262	$272	104%	$534	0.0%	$262	$272	$534		$411	$428	$839
03	RESERVOIRS	Reservoirs	$3,011	$1,415	47%	$4,426	0.0%	$3,011	$1,415	$4,426		$4,066	$1,911	$5,978
13	PUMPING PLANT	Pump Stations	$1,222	$904	74%	$2,126	0.0%	$1,222	$904	$2,126		$1,650	$1,221	$2,872
09	CHANNELS & CANALS	Tunnel System	$4,619	$3,279	71%	$7,898	0.0%	$4,619	$3,279	$7,898		$6,238	$4,429	$10,667
04	DAMS	Physical Barrier	$264	$182	69%	$446	0.0%	$264	$182	$446		$439	$303	$741
12	NAVIGATION PORTS & HARBORS	Small Boat Harbor	$103	$26	35%	$129	0.0%	$103	$26	$129		$113	$28	$141
06	FISH & WILDLIFE FACILITIES	Ecosystem Mitigation	$36	$11	30%	$47	0.0%	$36	$11	$47		$50	$15	$64
	Construction Estimate Totals		$9,517	$6,090		$15,607	0.0%	$9,517	$6,090	$15,607		$12,968	$8,335	$21,303
01	Lands and Damages		$39	$39	100%	$78	0.0%	$39	$39	$78		$40	$40	$79
30	Planning, Engineering & Design		$1,285	$578	45%	$1,863	0.0%	$1,285	$578	$1,863		$1,791	$806	$2,597
31	Construction Management		$572	$269	47%	$841	0.0%	$572	$269	$841		$773	$363	$1,136
		Project Cost Totals	$11,413	$6,976	61%	$18,389		$11,413	$6,976	**$18,389**		$15,571	$9,544	25,115

Estimated Total Project Cost (Program Year)	$18,389,220,000
Estimated Total Project Cost (Fully Funded)	$25,115,300,000

TABLE K.5 Total Project Costs for Mid-System Hydrologic Separation Alternative

Civil Works Work Breakdown Structure			**Estimated Cost**				**Project First Cost (Constant Dollar Basis)**				**Total Project Cost (Fully Funded)**			
							Program Year (Budget EC): 2014 Effective Price Level Date: 1 OCT 13							
WBS Number	Civil Works Feature & Sub-Feature Description		COST ($M)	CNTG ($M)	CNTG (%)	TOTAL ($M)	ESC (%)	COST ($M)	CNTG ($M)	TOTAL ($M)		COST ($M)	CNTG ($M)	FULL ($M)
A	***B***		***C***	***D***	***E***	***F***	***G***	***H***	***I***	***J***	***L***	***M***	***N***	***O***
13	PUMPING PLANT	ANS Treatment Plant	$678	$705	104%	$1,383	0.0%	$678	$705	$1,383		$1,064	$1,107	$2,172
03	RESERVOIRS	Reservoirs	$2,022	$950	47%	$2,972	0.0%	$2,022	$950	$2,972		$2,731	$1,283	$4,014
13	PUMPING PLANT	Pump Stations	$816	$604	74%	$1,420	0.0%	$816	$604	$1,420		$1,102	$816	$1,918
09	CHANNELS & CANALS	Tunnel System	$2,760	$1,960	71%	$4,720	0.0%	$2,760	$1,960	$4,720		$3,728	$2,647	$6,374
04	DAMS	Physical Barrier	$132	$91	69%	$223	0.0%	$132	$91	$223		$219	$151	$371
16	BANK STABILIZATION	Sediment Remediation	$1,500	$915	61%	$2,415	0.0%	$1,500	$915	$2,415		$1,678	$1,024	$2,702
06	FISH & WILDLIFE FACILITIES	Ecosystem Mitigation	$32	$10	30%	$42	0.0%	$32	$10	$42		$44	$13	$57
	Construction Estimate Totals		7,940	$5,235		$13,175	0.0%	$7,940	$5,235	$13,175		$10,566	$7,041	$17,607
01	Lands and Damages		$40	$40	100%	$80	0.0%	$40	$40	$80		$41	$41	$81
30	Planning, Engineering & Design		$1,073	$483	45%	$1,556	0.0%	$1,073	$483	$1,556		$1,495	$673	$2,168
31	Construction Management		$477	$224	47%	$701	0.0%	$477	$224	$701		$645	$303	$948
		Project Cost Totals	$9,530	$5,982	63%	$15,512		$9,530	$5,968	**$15,512**		$12,747	$8,057	$20,805

Estimated Total Project Cost (Program Year)	$15,511,620,000
Estimated Total Project Cost (Fully Funded)	$20,804,600,000

TABLE K.6 Total Project Costs for Mid-System Separation Cal-Sag Open Control Technologies with a Buffer Zone Alternative

Civil Works Work Breakdown Structure			**Estimated Cost**				**Project First Cost (Constant Dollar Basis)**				**Total Project Cost (Fully Funded)**			
							Program Year (Budget EC): 2014 Effective Price Level Date: 1 OCT 13							
WBS Number	Civil Works Feature & Sub-Feature Description		COST ($M)	CNTG ($M)	CNTG (%)	TOTAL ($M)	ESC (%)	COST ($M)	CNTG ($M)	TOTAL ($M)		COST ($M)	CNTG ($M)	FULL ($M)
A	***B***		***C***	***D***	***E***	***F***	***G***	***H***	***I***	***J***	***L***	***M***	***N***	***O***
20	PERMANENT OPERATING EQUIPMENT	Electrical Barrier	$104	$67	64%	$171	0.0%	$104	$67	$171		$115	$73	$188
13	PUMPING PLANT	ANS Treatment Plant	$699	$727	104%	$1,426	0.0%	$699	$727	$1,426		$812	$845	$1,657
05	LOCKS	GLMRIS Lock	$856	$847	99%	$1,703	0.0%	$856	$847	$1,703		$976	$966	$1,942
03	RESERVOIRS	Reservoirs	$1,913	$899	47%	$2,812	0.0%	$1,913	$899	$2,812		$2,584	$1,214	$3,798
13	PUMPING PLANT	Pump Stations	$766	$567	74%	$1,333	0.0%	$766	$567	$1,333		$857	$634	$1,491
09	CHANNELS & CANALS	Tunnel System	$2,170	$1,541	71%	$3,711	0.0%	$2,170	$1,541	$3,711		$2,569	$1,824	$4,393
04	DAMS	Physical Barrier	$264	$182	69%	$446	0.0%	$264	$182	$446		$357	$246	$603
16	BANK STABILIZATION	Sediment Remediation	$743	$453	61%	$1,196	0.0%	$743	$453	$1,196		$831	$507	$1,338
05	LOCKS	Sluice Gates and Screens	$25	$36	143%	$61	0.0%	$25	$36	$61		$30	$42	$72
06	FISH & WILDLIFE FACILITIES	Ecosystem Mitigation	$34	$10	30%	$44	0.0%	$34	$10	$44		$47	$14	$61
	Construction Estimate Totals		$7,574	$5,329		$12,903	0.0%	$7,574	$5,329	$12,903		$9,176	$6,366	$15,543
01	Lands and Damages		$21	$21	100%	$42	0.0%	$21	$21	$42		$23	$23	$46
30	Planning, Engineering & Design		$1,023	$460	45%	$1,483	0.0%	$1,023	$460	$1,483		$1,250	$562	$1,812
31	Construction Management		$455	$214	47%	$669	0.0%	$455	$214	$669		$539	$253	$792
		Project Cost Totals	$9,073	$6,024	66%	$15,097		$9,073	$6,024	**$15,097**		$10,988	$7,205	$18,193

Estimated Total Project Cost (Program Year)	15,097,200,000
Estimated Total Project Cost (Fully Funded)	$18,193,100,000

TABLE K.7 Total Project Costs for Mid-System Separation CSSC Open Control Technologies with a Buffer Zone Alternative

Civil Works Work Breakdown Structure			Estimated Cost				Project First Cost (Constant Dollar Basis)				Total Project Cost (Fully Funded)			
							Program Year (Budget EC): 2014 Effective Price Level Date: 1 OCT 13							
WBS Number	Civil Works Feature & Sub-Feature Description		COST ($M)	CNTG ($M)	CNTG (%)	TOTAL ($M)	ESC (%)	COST ($M)	CNTG ($M)	TOTAL ($M)		COST ($M)	CNTG ($M)	FULL ($M)
A	***B***		***C***	***D***	***E***	***F***	***G***	***H***	***I***	***J***	***L***	***M***	***N***	***O***
20	PERMANENT OPERATING EQUIPMENT	Electrical Barrier	$104	$67	64%	$171	0.0%	$104	$67	$171		$157	$101	$258
13	PUMPING PLANT	ANS Treatment Plant	$743	$773	104%	$1,516	0.0%	$743	$773	$1,516		$863	$898	$1,761
05	LOCKS	GLMRIS Lock	$856	$847	99%	$1,703	0.0%	$856	$847	$1,703		$1,369	$1,356	$2,725
03	RESERVOIRS	Reservoirs	$798	$375	47%	$1,173	0.0%	$798	$375	$1,173		$1,119	$526	$1,645
13	PUMPING PLANT	Pump Stations	$319	$236	74%	$555	0.0%	$319	$236	$555		$357	$264	$621
09	CHANNELS & CANALS	Tunnel System	$188	$133	71%	$321	0.0%	$188	$133	$321		$264	$187	$451
04	DAMS	Physical Barrier	$66	$46	69%	$112	0.0%	$66	$46	$112		$84	$58	$142
10	BREAKWATER & SEAWALLS	Breakwater	$884	$539	61%	$1,423	0.0%	$884	$539	$1,423		$1,128	$688	$1,817
05	LOCKS	Sluice Gates and Screens	$50	$72	143%	$122	0.0%	$50	$72	$122		$59	$85	$144
10	BREAKWATER & SEAWALLS	Breakwater	$19	$10	52%	$29	0.0%	$19	$10	$29		$30	$16	$46
06	FISH & WILDLIFE FACILITIES	Ecosystem Mitigation	$20	$6	30%	$26	0.0%	$20	$6	$26		$28	$8	$36
	Construction Estimate Totals		$4,047	$3,103		$7,150	0.0%	$4,047	$3,103	$7,150		$5,459	$4,187	$9,646
01	Lands and Damages		$18	$18	100%	$36	0.0%	$18	$18	$36		$18	$18	$37
30	Planning, Engineering & Design		$545	$245	45%	$790	0.0%	$545	$245	$790		$666	$300	$965
31	Construction Management		$242	$114	47%	$356	0.0%	$242	$114	$356		$287	$135	$421
		Project Cost Totals	$4,852	$3,480	72%	$8,332		$4,852	$3,480	**$8,332**		$6,430	$4,639	$11,069

Estimated Total Project Cost (Program Year)	$8,332,470,000
Estimated Total Project Cost (Fully Funded)	$11,069,200,000

K.3.2 Cost Basis

Below is a description of the cost methodology for obtaining and developing the corollary cost data for each of the proposed features. For all measures, costs were derived from similar features or projects. Whenever possible, similar projects from the local area were used to account for local cost conditions (labor rates, suppliers, local regulations, etc.).

Some of the measures used final construction costs from actual projects that have been built. These include all costs for construction, including modifications, claims, and close-out costs.

When true cost data were not available, construction estimates for projects or from studies were used. While these cost estimates are based on real world data, the projects have not actually been constructed yet, so there is a slightly higher level of uncertainty in the costs. The uncertainty of the costs from studies or preliminary estimates, as opposed to after-construction costs, is reflected in the risk analysis and contingency calculations.

All costs from historical cost data have been escalated to fiscal year 2014 dollars using the CWCCIS, which is specifically designed for civil works construction and provides specific cost indexes for each major civil works feature. These indexes are used to escalate or inflate project features to a desired price level. The indexes are made up of historic escalation and simple projected indexes based on OMB inflation factors.

K.3.2.1 Electrical Barriers

The costs for the electrical barriers were based on preliminary costs for the Chicago Sanitary and Ship Canal Permanent Dispersal Barrier 1. This preliminary estimate of costs for construction is based on actual cost data from the three other fish barrier projects that the U.S. Army Corps of Engineers (USACE) operates and maintains. The current estimate for the project is $52 million, which includes three electrical arrays, a two-story building (including all building systems), backup power, in-water structures, utilities, and all associated site work. This $52,000,000 cost was used for every location that a new electrical barrier was proposed. While the final configuration will need to be tailored to the specific site, the overall in-water electrical equipment, building power and backup needs, and most of the building barrier-specific equipment will be the same regardless of location.

K.3.2.2 Physical Separations

For the actual hydro-separations, the proposed plans call for concrete dam structures. For this preliminary level of design, a similar structure was used for a cost basis. As the exact location of the dam is not defined, approximate dimensions were assumed using the bank-to-bank lengths in the approximate proposed location.

In order to find a comparable structure in size and scope that was built in river conditions (coffer dam in-water construction, water protection, slope stabilization, etc.), a recent similar USACE concept plan from another metro area was considered. That concept contains many additional items not needed for the structures in the Great Lakes and Mississippi River Interbasin Study (GLMRIS). Because this design and cost were developed by USACE, we had the MII estimate file and were able to remove the costs for items that were not a part of our scope. The remaining items were essentially concrete and sheet pile, where coffer-dam-phased construction was used to build the structure in the river. The cost of this work was $66,000,000. This cost was used for the hydraulic separations.

K.3.2.3 Reservoirs

The corollary costs for the reservoirs were based on historical costs for the McCook reservoir currently under construction in the Chicago area. The McCook Reservoir Project was authorized by Congress in 1988. The 10-billion gallon reservoir will be built out of a large rock quarry on the site of the project sponsor's solids processing lagoons. The Metropolitan Water Reclamation District of Greater Chicago (MWRD) is the local sponsor and will own and operate the reservoir when construction is completed. Major components include an overburden cutoff wall, distribution tunnels, a main tunnel, dewatering pumps, gates, valves, hydraulic structures, aquifer protection, and an aeration system.

The McCook reservoir is being mined out by a private company. Currently, they mine the stone as quickly as they can sell the material. For the purpose of this report, it is assumed the material will be mined and stored off site. No potential income from sale of the rock is considered here.

Both USACE and MWRD have done or will be doing other work needed to turn the mined limestone excavation into the final reservoir.

Table K.8 shows all of the completed current and future contracts for completion of the McCook Reservoir.

The total of the completed and under-construction costs is $743,128,000. The costs of the future work are estimated to be $107,568,000. The total cost of the finished reservoir will be $850,696,000 (in 2014 dollars). The final reservoir configuration will hold 10,032,000,000 gallons of water, which equates to a corollary unit cost of $0.085 per gallon of water.

Costs for mining (Table K.9) were based on the price that the mined material is being sold for, after backing out overhead and profit.

Based on these data, a cost of $10.14 per ton of stone being mined is used for the project. Only the reservoirs that are above 13,500 acre-feet are assumed to have rock blasting. For reservoirs smaller than 13,500 acre-feet, all of the cost is assumed to be for earth excavation, with no stone mining being needed.

Using the combined mining and auxiliary work for a completed McCook reservoir, the cost for a large, mined limestone reservoir is $0.15 per gallon. This is the corollary unit cost that was used for large reservoirs.

A study of other reservoirs performed by USACE in 2004 reported a slightly lower construction cost of approximately $0.11 per gallon (2014 dollars). This study included significantly smaller reservoirs, with the latest one being constructed in 1998. These reservoirs were primarily earth excavations with little to no rock excavation and had none of the water protection issues needed in building a reservoir that contains contaminated water (cutoff walls, grouting, etc.)

TABLE K.8 Completed Current and Future Contracts for McCook Reservoir

Project Name	Status
McCook Conveyance Tunnel	Completed
McCook Reservoir Site Preparation	Completed
McCook Reservoir Overburden Removal	Completed
Expanded Stage 2 Overburden Removal	Future
McCook Reservoir Excavation Hard Costs	On-going
Expanded Stage 2 Hard Costs	Future
Conveyance Systems and Maintenance Facilities	Completed
HOH Design/Post Award	Completed
Mobile Mining Equipment	Completed
Mining Equipment	Completed
Stage 2 Miscellaneous Overburden Removal	Completed
Furnish and Deliver Primary Crusher	Completed
Willow Springs Berm	Completed
73rd Street Tunnel Relocation	Completed
MWH Post Award	Completed
USACE Contracts	
Overburden Groundwater Cut-off Wall, Stage 1	Completed
Grout Test	Completed
Addition of Pumps and Motors	Completed
Distribution Tunnel System	Completed
Overburden Groundwater Cut-off Wall, Stage 2	Completed
Grout Curtain, Stage 1	Completed
Rock Wall Stabilization, Stage 1a	Completed
Distribution Tunnel Emergency Response IDIQ	Completed
Main Tunnel Gates	Under Construction
Grout Curtain, Stage 2	Completed
IDIQ Heavy Civil Miscellaneous (TOs 3&4 only)	Under Construction
Main Shaft	Completed
Main Tunnels System (MTS)	Under Construction
Rock Wall Stabilization, Stage 1b	Under Construction
Hydraulic Structures	Future
Tunnel C and D tie-ins	Future
Miscellaneous Surface Features, Stage 2	Future
Miscellaneous Floor Features, Stage 1	Future
Aeration Stage 1	Future
Miscellaneous Floor Features, Stage 2	Future
Aeration Stage 2	Future
Rock Wall Stabilization, Stage 2	Future
Slope Stabilization Stage 2	Future
Distribution Tunnels Completion	Future
Other Costs	
MWRDGC Engineering/PM	Ongoing
USACE Design & Planning	Ongoing
USACE Project Management	Ongoing
USACE Construction Management	Ongoing
USACE Engineering During Construction	Ongoing

TABLE K.9 Mining Costs for McCook Reservoir[a]

Name	F.O.B. Plant	COD Discount	Sales Mix[b]	Wtd Avg.[c]	Notes
Surge Stone	$14.00	$11.90	2%	$0.24	
CA-1	$16.30	$13.86	10%	$1.39	
RR #2	$16.30	$13.86	5%	$0.69	
3"-1" Stone	$13.50	$11.48	3%	$0.34	
CA-5	$14.85	$12.62	5%	$0.63	
CERT CM-06 STONE	$10.70	$9.10			Recycled concrete material CA-6.
CA-7	$15.25	$12.96	25%	$3.24	
FA-5/ Screenings	$10.60	$9.01	10%	$0.90	
FA-6	$10.85	$9.22			Imported material from gravel pits.
CA-18	$15.40	$13.09	40%	$5.24	75±25 on a #4 screen (3/8").
	$14.53	$12.35	100%		Average price (less CM stone and FA-6).
		$12.67			Weighted average based on product mix.
		-$2.53			Less OH&P at 20%.
		$10.14 / ton			Raw cost of product to mine.

[a] Pricing is based on quotes which were considered "C" level pricing. Pricing strategy is "A, B, C" with "A" getting the largest discounts. Discount for A pricing is 15%. All costs are per ton.

[b] Sales mix is based on aerial imagery of stockpiles of products. Primary customers are asphalt pavers and ready-mixed suppliers, which consume CA-7 and CA-18.

[c] Since the weighted average is a higher cost than the overall average, it is considered the basis for cost.

K.3.2.4 Pump Stations

The pump stations proposed for GLMRIS are at every proposed reservoir to empty the water. For reservoirs over 14,500 acre-feet, the Mainstream Pump Station at McCook Reservoir is being used as a cost basis. Per MWRD, the total cost for construction was $261,578,700, with a mid-stream construction date of 1984. Escalated to 2014 dollars, this construction cost would be $607,621,000. Because of the varying sizes of reservoirs and pumps needed, this cost was divided by the 10,032,000,000 gallons of water that McCook holds, yielding a unit cost of $0.061 per gallon for the relative cost for pump station construction.

For smaller pump stations (reservoirs smaller than 14,000 acre-feet), the large scale of the high head pumps of the larger reservoir is not a valid price basis. A more reasonable comparison is the pump station designed for the Bid Bend Reservoir designed by the Army Corps of Engineers in Chicago. This design was for a 10,000 acre-foot reservoir, and the cost estimate for construction is $712,000. A cost of $700,000 is used for the smaller pump stations for GLMRIS. Since there is a minimum cost for construction of a pump station and minimum number of pumps needed, this cost was used no matter the size of the small reservoirs.

K.3.2.5 ANS Treatment Plants

Costs for ANS treatment plants were received from the Metropolitan Water Reclamation District. Costs are based on "Cost Study Report Preliminary Cost Opinion for North Side WRP UV Disinfection" prepared by CTE AECOM Professional Design Consultant (dated January 31, 2008). Costs were based on screening plus ultraviolet (UV) treatment, which was chosen for the GLMRIS designs.

Estimated capital costs for screens, general site work, low lift pump station, and UV disinfection facility came to $234,730/MGD (million gallons per day). Estimated annual O&M costs came to $10,733/MGD. The O&M costs included energy costs and O&M labor costs.

For specific locations, due to water quality concerns, tertiary filtration systems (sand filters) need to be added. The estimated capital costs for these are $373,333/MGD, making the total for these types of ANS plants $608,063/MGD. See the Water Quality Appendix for locations and design of where sand filter filtration will be used.

K.3.2.6 Tunnels

Costs for the proposed tunnel system were difficult to determine. The only similar applicable project is the Tunnel and Reservoir Plan (TARP) of Chicago, of which the McCook Reservoir is a part. The project is also known as the "Deep Tunnel" system. "The Deep Tunnel" is the MWRD's solution to water pollution and sewer backup problems in 52 municipalities in Cook County. Begun in 1975, it involves the construction of 109 miles of tunnels (9 to 33 feet in diameter) excavated in dolomitic limestone bedrock as much as 350 feet below the surface. These tunnels will collect combined sanitary and storm sewer flows and convey them to surface reservoirs for storage until the area's water reclamation plants can treat and safely discharge the effluent.

Table K.10 lists of all of the contracts executed by MWRD in construction of the Deep Tunnel system. The contracts include the actual tunnels themselves along with all auxiliary cost related to the system.

Contracts in bold refer specifically to tunnel construction.

The present value on the construction costs for the system is $8,490,236,175. This cost would include full construction, modifications and additions, and any final claims. The tunnels included in this system vary in diameter and length, but the overall volume of the tunnels is 264,904,064 cubic feet. This leads to a unit cost for the Deep Tunnel system of $32.05 per cubic foot of tunnel. This unit cost was used for the proposed tunnels for GLMRIS.

K.3.2.7 Lock Structures

The proposed GLMRIS Locks only have a general size and function at this time. A similarly sized lock that was constructed by the Army Corps of Engineers in 2004 is the LaGrange Lock and Dam, designed by the Rock Island district of USACE. The cost of the construction was $366,000,000 in 2014 dollars. This lock was slightly smaller than that being proposed for the GLMRIS Report but has many similar factors, including location of construction and many design features.

TABLE K.10 Contracts Executed by MWRD for Deep Tunnel System

CONTRACT NUMBER	COMPLETION DATE	Present VALUE (2014)	Finished Tunnel Diameter(s) (feet)	Tunnel Length(s) (feet)
73-172-2H	03/10/76	$156,333.11		
72-049-2H	**04/07/83**	$386,933,369.55	**30 & 22**	**27269 & 24036**
73-317-2S	**08/21/80**	$194,739,512.70	**20**	**22061**
73-320-2S	**11/15/79**	$114,267,826.93	**16**	**10665**
73-319-2S	**06/23/78**	$14,837,836.79		
73-287-2H	**02/09/84**	$398,666,710.43	**9**	**4751**
73-160-2H	**12/01/83**	$399,304,361.59	**33**	**17744**
75-118-IH 9	03/03/80	$2,852,611.53		
75-119-AH 1	10/03/85	$21,143,692.73		
75-120-HH 8	11/15/79	$21,559,896.46		
75-118-AH 1	11/07/85	$6,116,162.54		
75-118-GH 7	11/04/82	$9,829,519.89		
75-126-2H	**11/07/85**	$455,965,617.11	**33**	**25345**
75-119-CH 3	07/09/81	$13,648,601.69		
75-120-DH 4	11/15/79	$4,238,655.64		
75-120-IH 9	03/26/81	$2,931,323.84		
75-125-2H	**03/08/84**	$496,934,231.14	**30**	**24692**
75-118-DH 4	04/10/80	$2,870,115.43		
75-118-EH 5	03/05/80	$1,100,098.28		
75-118-FH 6	04/10/80	$1,568,057.40		
75-119-DH 4	11/15/79	$3,083,618.73		
75-124-2H	**05/03/84**	**$469,941,482.58**	**30 & 13**	**13052 & 6889**
75-120-AH 1	02/07/85	$42,822,463.75		
73-318-2S	07/09/81	$22,496,466.95		
75-119-EH 5	06/18/81	$1,445,834.85		
75-120-FH 6	10/04/79	$2,135,280.17		
75-123-2H	**12/15/83**	**$403,411,144.06**	**30**	**21922**
75-120-BH 2	12/20/79	$2,225,199.82		
75-119-BH 2	10/18/84	$16,581,207.21		
75-120-GH 7	03/06/80	$3,144,500.39		
75-118-HH 2 & 8	06/05/80	$2,278,357.75		
75-119-IH 9	11/01/79	$5,543,227.48		
75-120-CH 3	03/26/81	$9,111,245.81		
75-118-JH 10	02/24/83	$14,660,206.67		
75-119-HH 8	05/08/80	$5,366,716.89		
75-119-JH 10	09/07/79	$4,950,732.55		
75-118-CH 3	11/21/85	$4,787,316.00		
75-120-EH 5	03/06/80	$3,470,252.62		
75-119-FH 6	12/18/80	$4,440,325.23		
75-118-KH 11	02/24/83	$9,800,209.92		
75-119-GH 7	06/05/80	$2,991,457.71		
75-120-JH 10	07/17/80	$2,888,000.15		
73-163-AH 1	06/16/83	$144,368,676.86		
73-163-BH 2	11/04/82	$689,113.46		
73-163-CH 3	02/10/83	$1,568,996.14		
73-162-BH	**11/07/85**	**$285,215,354.63**	**12**	**35412**
73-163-DH 4	12/04/80	$857,825.66		
73-163-EH 5	06/19/80	$1,349,627.17		
73-163-FH 6	05/02/81	$2,433,786.94		

TABLE K.10 (CONT.)

CONTRACT NUMBER	COMPLETION DATE	Present VALUE (2014)	Finished Tunnel Diameter(s) (feet)	Tunnel Length(s) (feet)
73-163-GH 7	02/11/81	$1,529,823.27		
73-163-IH 9	12/18/80	$1,997,184.71		
74-206-2H	03/24/88	$247,147,291.39		
73-162-CH	**02/23/84**	**$112,544,660.34**	**33**	**2931**
73-163-JH 10	03/12/81	$699,507.84		
73-163-KH 11	03/12/81	$731,921.48		
73-163-LH 12	02/11/81	$2,000,449.13		
73-273-2H	10/17/85	$83,159,047.02		
73-058-AH	01/19/84	$145,196,572.47		
73-162-AH	11/03/88	$671,315,920.49		
73-058-BH	11/03/83	$115,619,864.21		
73-058-CH	06/27/85	$79,568,401.88		
73-058-DH	05/09/85	$53,097,915.31		
75-120-KH 11	02/07/85	$894,690.39		
74-206-BH	05/09/85	$396,841.68		
73-162-DH	04/02/87	$2,074,097.31		
75-130-2H	**08/03/89**	**$74,586,343.45**	**10**	**17855**
82-178-2H	07/17/86	$9,260,204.00		
82-243-2H	06/12/86	$1,016,023.68		
85-113-AM	03/05/87	$729,781.86		
86-131-2H	10/20/88	$1,926,212.68		
73-164-2H	**10/21/93**	**$434,622,471.66**	**33 & 10**	**21174 & 14601**
75-132-2H	**12/16/93**	**$420,261,743.24**	**30 & 12**	**24024 & 12665**
85-122-2H	08/02/90	$1,330,282.36		
73-271-2H	**08/08/96**	**$508,433,974.81**	**30 & 15 & 10**	**37719 & 9274 & 13086**
73-060-2H	**08/13/98**	**$402,134,293.25**	**30 & 8.5**	**45753 & 6156**
75-131-2H	**01/18/01**	**$303,327,017.62**	**22**	**35575**
75-208-2H		**$275,110,323.10**	**25 & 15**	**34088 & 8067**
75-213-2H		**$298,902,245.35**	**16**	**39219**
68-211-2S	09/09/72	$64,027,491		
67-112-2S	06/30/71	$60,519,161		
68-136-2S	01/06/77	$43,298,944		
69-215-2S	10/29/77	$49,052,310		
Total:		**$8,490,236,175.55**		

Costs were also taken from feasibility-level costs for three lock structures from the Upper Ohio River Navigation Study by USACE. These locks (Emsworth, Dasheilds, and Montgomery Locks) are larger than any proposed for the GLMRIS project. Based on feasibility-level cost estimates done by the Pittsburgh district, the average cost for locks of similar size and scope as being recommended for GLMRIS is $550,000,000.

Because the locks on the Ohio River are larger than what is being proposed for GLMRIS, and the LaGrange lock is slightly smaller, the cost used for GLMRIS Locks would fall in the middle. $425,000,000 was used for the cost of each GLMRIS Lock proposed.

K.3.2.8 Sluice Gates and Screens

Rehabilitation of the existing sluice gates with new sluice gates and screens is a unique project. No similar indicial projects were found that would be comparable. Because it is conceptual work, there is no specific design to apply prices to. Therefore, the major features of the rehabilitation work were priced individually with comparative work and combined into a lump sum item for this work.

For the in-water replacement of the existing walls, the estimated costs from the Greenup Lock Extension project in Greenup, KY, were used. The applicable portion of the work consisted of a length of monolithic wall to be demolished and replaced, using coffer dam construction. The estimated construction cost of this work is $15,400,000.

Based on cost data from the current Chicago Lock for sluice gates and recent quotes from screen suppliers for these gates, $8,000,000 was added to the overall construction, for a total of $23,400,000. A cost of $25,000,000 was used for all of the locations that sluice gate rehabilitation and screens are called for.

K.3.2.9 Small Boat Harbor

The small boat harbor will be very similar to the recently completed Chicago Park District (CPD) beach harbor at 31st Street. Costs for the CPD boat harbor are based on information in the CPD website (http://www.chicagoparkdistrict.com/chicago-park-district-opens-newest-harbor-at-31st-st-offering-numerous-amenities-for-the-neighborhood/).

The actual completed construction costs for this boat harbor were $103,000,000.

K.3.2.10 Sediment Remediation

For the proposed sediment remediation, the material removal (dredging) and the sediment cap are very similar to the recently completed work done on the Grand Calumet River by the U.S. Environmental Protection Agency (EPA).

Costs for that project are summarized in “West Branch Grand Calumet River (Reach 3) Sediment Remediation Project Cost and Performance Report,” prepared for the U.S. EPA by SulTRAC.

In the report, historical and ongoing costs for all of the contractor tasks for the project are broken down, including mobilization, coffer dams, site prep and restoration, and erosion control. Applying the overall project costs to the unit items gives costs of $198 per cubic yard of dredged material and $91 per square foot of sediment cap.

K.3.2.11 Breakwater

The proposed breakwaters do not have quantities or design yet, but will be similar in size and scope to breakwaters built recently in the Chicagoland area, including the 31st Street Beach and Waukegan Harbor. Work has also been done recently on repairs to the Chicago Harbor breakwater. Based on very preliminary lengths and cross sections designed by USACE, the cost of the breakwaters used in this estimate is $19,000,000.

K.3.2.12 Nonstructural Measures

To develop general cost estimates for nonstructural approaches for addressing ANS concerns, a cost template was prepared that listed each of the non-structural approaches evaluated, except for "laws and regulations," together with six annual cost categories:

- $0–100,000;
- $100,000–$500,000;
- $500,000–$1,000,000;
- $1,000,000–$2,500,000;
- $2,500,000–$5,000,000; and
- > $5,000,000.

This cost template was sent to a number of state, federal, and international agencies and organizations, requesting recipients to mark the cost category they feel is appropriate for any of the nonstructural approaches in which their organizations are currently involved. It is these cost estimates that were used for the cost discussion in the nonstructural report.

Organizations from which information was requested (*asterisk indicates a response was received from that organization):

- Michigan Department of Environmental Quality*
- New York State Department of Environmental Conservation*
- Indiana Department of Natural Resources, Division of Fish and Wildlife
- Wisconsin Department of Natural Resources*
- Ohio Department of Natural Resources*
- Minnesota Department of Natural Resources
- Pennsylvania Department of Conservation and Natural Resources
- Illinois Wildlife Action Plan
- Animal and Plant Inspection Service, U.S. Department of Agriculture
- Great Lakes Center
- Great Lakes Restoration Initiative
- Great Lakes Fishery Commission*
- International Joint Commission*
- U.S. EPA*
- National Oceanic and Atmospheric Administration City of Chicago
- U.S. Geological Survey
- U.S. Coast Guard
- U.S. Fish and Wildlife Service

K.3.2.13 Operations and Maintenance

Operations and maintenance (O&M) costs for the proposed features include any operational labor needs, basic yearly maintenance, and any other regularly scheduled costs needed to operate and maintain the structures. They also include any lifecycle costs needed while looking at a 50-year time frame. These include any major components that will need replacing or updating over the 50 years. This cost is then amortized over the 50-year period so it can be included in a yearly cost.

ANS Treatment Plants
Per MWRD, estimated O&M costs are $10,733/MGD. Yearly O&M costs include energy costs, O&M labor costs, and replacement part costs. An added $5,111/MGD will be applied to ANS plants that require sand filtration. Estimates are based on “Cost Study Report Preliminary Cost Opinion for North Side WRP UV Disinfection,” prepared by CTE AECOM Professional Design Consultant, dated January 31, 2008.

Lock Structures
These O&M costs were based on current O&M costs for the Chicago Lock being operated by the Army Corps of Engineers. The O&M costs for the Chicago Lock are $2.3 million per year, with $30 million in expected repairs and upkeep over a 50-year timeframe.

Electric Barriers
These O&M costs were based on current O&M costs for the two electric barriers being operated by the Army Corps of Engineers. The O&M costs for the electric barriers are $8 million per year, with $45 million in expected repairs and upkeep over a 50-year timeframe.

Physical Barriers
The assumption for O&M for the physical barriers was that some maintenance, repairs, and basic checks will be needed. Based on discussions with other districts, these tasks for a simple concrete barrier will take a 2-person crew 3 weeks per year (120 hours). All other costs (small tools, etc.,) are incidental.

Sluice Gate and Screens
The assumption for O&M on the screens and sluice gates was that some maintenance, repairs, and basic checks will be needed. The screens and sluice gates will need frequent checks and maintenance. In all of the proposed locations for the sluice gates, there is already maintenance staff. A full time equivalent is assumed to be needed for the gates and screens, along with the cost of replacing screens and fixing mechanical problems. Based on estimates from screen manufacturers, replacement parts could cost as much as $50 million dollars over the 50-year life of the gates.

Reservoirs and Pump Stations
A full time staff would be needed for O&M of the pump station and reservoir system. MWRD’s estimate for McCook is $6,850,000 in annual operation and $2,700,000 in annual maintenance. This would include all pumps, valves and gates, aeration, and all other O&M required. It would also include air quality and water quality monitoring. Also expected is close to $200 million in replacement part costs over a 50-year time period.

K.3.2.14 Planning, Engineering and Design Costs, and Construction Management Costs

The USACE costs to perform pre-construction engineering and design (PED) and construction supervision and administration (S&A). With limited project development, PED and S&A costs are calculated as a percentage of construction costs. Given the large scale of these projects, percentages are based on guidance developed by the New Orleans District in preparation of its post-Katrina program budgets (“New Orleans Hurricane and Storm Damage Reduction System — Programmatic Cost Estimate,” July 2007) and on historical information. Such large costs consider the potential for private industry support for design and construction services.

(1) Pre-construction Engineering and Design (30 Account). The PED percentage rate includes such costs as project management, engineering, planning, designs, investigations, studies, reviews, and value engineering and engineering during construction (EDC). Historically, USACE civil works districts report values ranging from 10% to 15%. Based on guidance provided by New Orleans for a program of similar size, 30 Account costs of 13.5% are used for this estimate (a combination of 12% for PED and 1.5% for EDC).

(2) Construction Supervision and Administration (31 Account). The S&A percentage rate captures costs for review and coordination of the construction contract. USACE civil works districts report values ranging from 5% to 10%. Based on guidance provided by New Orleans for a construction project of similar size, 31 Account costs of 6% are used for this estimate.

K.4 ABBREVIATED COST RISK ANALYIS REPORT
(BASIS OF CONTINGENCY)

K.4.1 Risk Analysis Summary

This section of the appendix presents a preliminary risk analysis of the remaining construction measures as identified within GLMRIS. The following discussion expresses the major concerns and rough order contingencies for each of the remaining construction measures that, in various combinations, make up the remaining alternatives under study. The calculated contingencies for each of the remaining alternatives are used in calculating the total project costs presented in Section K.3 of this Appendix.

The scope of this risk analysis is to identify the major risk concerns accompanied with a rudimentary cost contingency value of the remaining structural measures, which are then combined in various combinations that result in the remaining alternatives under study. This report focuses on the measures, since the risks and contingencies are determined directly from these. These contingency values are considered elementary for comparison purposes of alternatives, and should not to be misinterpreted as a confident forecast for total cost and time growth.

A few key exclusions from this risk analysis have the potential to be showstoppers or increase the overall costs significantly, on an order of two/three fold. These risks cannot be reasonably measured:

a. **Funding**. Concern for sufficient or timely funding to support each alternative was excluded from the risk evaluations. The assumption is timely funding to support progress annually. Delays result in a construction inflationary impact of 3–4% annually compounded over several decades. The team felt that such an unknown and potential showstopper would create risks and add contingencies far beyond the goal of simple comparison between measures and alternatives.

b. **Real Estate**. The PDT excluded the risk of needed real estate for each measure, alternative, and site location. It is known that this risk is extremely high for certain locations, but any real estate formulation and denial have not yet occurred. No real contingency can be placed on a hypothetical no-go situation.

c. **Permitting**. The PDT also excluded the risk of obtaining the necessary permits for construction of various measures at various locations. It is known that this risk is extremely high for certain locations, but no formal request or formal permitting denial has yet occurred. No real contingency can be placed on a hypothetical no-go situation.

There are other project assumptions and qualifications noted in Section K.4.5, but these three comprise the largest risks that are being excluded from this analysis.

Current major construction measures fall into two major categories: ANS control measures and resulting mitigation measures needed to support those control measures:

ANS Control Measures

- Physical Barriers
- Breakwaters
- Electric Barriers
- Lock Structures

- ANSTP
- Sluice Gates and Screens

Mitigation Measures

- Tunnels
- Reservoirs
- Reservoir Pump Stations
- Sediment Remediation

The matrix approach utilized by USACE identifies seven major risk categories, each related to unique risks from design-contract solicitation and construction. These categories are more generic in nature and have been established over time through detailed study of the Monte Carlo-style risk analyses performed throughout USACE on many and varied large projects. The following were considered for each of the measures:

- Project Scope Maturity and Potential Growth
- Acquisition Strategy
- Quantities of Current Scope
- Construction Elements
- Specialty Fabrication and Equipment
- Cost Estimate Assumptions
- External Project Risks

Cost Engineering MCX recommends addressing the risks related to project development phases: early concept, post-appropriation plans and specifications, contract solicitation, construction, and closeout. These major risk categories are expanded upon in Section K.4.6.2.

The results of the cost risk analysis led to contingencies for each of the individual features, which were then applied to the individual plans. To see a summary of the weighted contingency based on features for each different alternative, see Section K.11.

K.4.2 Study Background

This study is considered high risk overall. The items that contribute to the high risk are:

- Significant natural resources such as ecosystems and threatened and endangered species;
- Commercial and recreational fisheries;
- Current recreational uses of lakes and waterways;
- ANS effects on water users;
- Effects of potential ANS Controls on current waterway uses such as flood risk management, commercial and recreational navigation, recreation, water supply, and hydropower and conveyance of effluent from wastewater treatment plants and other industries; and
- Statutory and legal responsibilities relative to the lakes and waterways.

K.4.3 Risk Analysis Scope

K.4.3.1 Measures and Alternatives

The scope of this risk analysis is to identify the major risk concerns accompanied with a rudimentary cost contingency percent value for the remaining construction measures. The contingency percents are then included per measure in the various combinations that result in the current alternatives under study. This study also incorporated consideration for the risks related to design and construction management. This study focuses on the measures since the risks and contingencies are determined directly from these. Current major construction measures fall into two major categories: ANS control measures and resulting mitigation measures needed to support those control measures:

ANS Control Measures

- Physical Barriers
- Breakwaters
- Electric Barriers
- Lock Structures
- ANS Treatment Plants
- Sluice Gates and Screens

Mitigation Measures

- Tunnels
- Reservoirs
- Reservoir Pump Stations
- Sediment Remediation

The above measures in various combinations and for various site locations result in the established alternatives. As mentioned previously, this risk study focuses on the measures that make up the alternatives:

- Mid-System Control Technologies without a Buffer Zone
- Technology Alternative with a Buffer Zone
- Lakefront Hydrologic Separation
- Mid-System Hydrologic Separation
- Mid-System Separation Cal-Sag Open Control Technologies with a Buffer Zone
- Mid-System Separation CSSC Open Control Technologies with a Buffer Zone

K.4.3.2 Measure Descriptions

For better understanding of risks determined by measure, the following descriptions are provided and are necessary in understanding some of the challenges within the study:

1. **Physical Barriers**: The purpose of the physical barriers is to prevent the transfer of untreated surface water in the Chicago Area Waterway System (CAWS), thus severing the aquatic pathway where the physical barrier is constructed.

2. **Breakwaters**: The breakwaters are in support of Chicago Lock to settle wave action for approaching vessels. It is a separate measure because of its differing risk considerations.

3. **Electric Barriers**: The purpose of an electric barrier is to reduce the risk to the maximum extent possible of fish transfer into an invading basin via operation of the GLRMIS Lock. The electrical barrier consists of steel electrodes mounted across the bed of the lock approach channel and on-land power generation and distribution equipment. The on-land equipment sends a pulsing DC current through the electrodes, creating an electric field in the water that repels and stuns fish, preventing them from entering the lock while allowing boats to freely pass.

4. **Lock Structures**: The purpose of the GLMRIS Lock is to allow for vessel transportation while reducing the risk to the maximum extent possible of passive drift GLMRIS species transferring during lockages. After a vessel enters the lock and the sector gates close, the GLMRIS Lock's pump-driven filling and emptying system removes the contained water from one end and, on the opposite end, fills the lock with water, maintaining a pool for vessels to float. This pumped water flushes and replaces the water originating in the lock.

   Special consideration would be given to the GLMRIS Lock located at the current location of the Chicago Lock and Controlling Works to prevent potential bypass of this control point. During high winds, Lake Michigan waves currently top the lakefront structures near the Chicago Lock and splash into the CAWS. Lakefront structures such as breakwaters and rubble mounds would be constructed to break the waves and address this bypass.

5. **ANS Treatment Plant**: The purpose of the Aquatic Nuisance Species Treatment Plant (ANSTP) is to reduce the risk to the maximum extent possible of ANS presence in Lake Michigan water prior to discharge into the CAWS.

   Treatment technology included in the ANSTP would include screening and disinfection to remove nine aquatic nuisance species that have been identified to pose a high- or medium-risk of transfer from Lake Michigan to the Mississippi River basin. Of the disinfection technologies available (chlorination/dechlorination, ultraviolet radiation, ozone, etc.), UV is selected for the conceptual ANSTP design because it is expected to be effective for Lake Michigan water, which has low turbidity. UV is the second most commonly used disinfection technology in the United States for wastewater treatment plants greater than 100 MGD.

6. **Sluice Gates and Screens**: The purpose of the Screened Sluice Gates is to allow for the passage of flood waters from the CAWS to Lake Michigan while still reducing the risk, to the maximum extent possible, of the transfer of Great Lakes ANS fish into the Mississippi River Basin. During large storm events, these gates may be opened at Wilmette Pumping Station, Chicago River Controlling Works, and T.J. O'Brien Lock and Dam.

7. **Tunnels**: The purpose of conveyance tunnels in GLMRIS Alternatives is to create a controlled environment for storm water or wastewater to be collected and then allowed to travel to a desired location such as a reservoir. The storm or wastewater that would be collected by the conveyance tunnels would otherwise be causing some negative Flood Risk Management *(*FRM) and/or water quality impacts on the CAWS.

8. **Reservoirs and Pump Stations**:

    a. Reservoirs: The purpose of reservoirs in GLMRIS Alternatives is to provide a controlled environment for storm and/or wastewater. By storing the storm and/or wastewater, negative impacts of the water can be avoided to the CAWS, and the water can be treated before it is released back into the CAWS, reducing its potential negative FRM and/or water quality impacts to the environment.

    b. Reservoir Pump Stations: To convey the water from the reservoirs, pump stations will be necessary. The risk study chose to make a separate distinction since the technologies vary in design scope and related risks.

9. **Sediment Remediation**: The purpose of sediment remediation is to prevent the heavy metals and persistent organic pollutants produced throughout the region's long industrial history, now residing in the CAWS river bottom, from negatively impacting the water quality of Lake Michigan. Under the mid-system hydrologic separation alternative, contaminated sediments in the Calumet and Chicago River systems will have greater potential to impact Lake Michigan.

K.4.4 Methodology/Process

K.4.4.1 PDT Strategy and Focus

In the standard USACE civil works feasibility process, study includes the consideration, study, and evaluation of a broad base of potential solutions to solve or reduce the impacts of identified challenges. For the sake of this report, these potentials are termed "measures and alternatives," where certain measures combine to form differing alternatives. The initial study, the sorting and sifting of potential measures and alternatives, can be found in Appendix A – Alternative Development Analysis. The results of that study produced the measures under risk study here.

For the sake of this risk study, a Project Development Team (PDT) was assembled, and the major, senior, and qualified Chicago District members were asked to continue measure and alternative evaluations by applying a risk-based approach. The initial and formal meetings took place the week of June 24, 2013. Sidebar meetings continued through to completion of this report. The PDT focused on the risk-related measures, considered the building blocks of the alternatives. Knowing that the various measures are in an early stage of concept development and rough cost development, the study included the major PDT members addressing the major identified risks. Those risks were then formulated into a rough contingency based on USACE qualitative exercises. PDT members included expertise in:

- Project and Program Management
- Planning
- Regulatory Economics
- Real Estate
- Office of Counsel
- Geotechnical
- Hydraulics and Hydrology
- Ecology
- Structural Engineering

- Environmental
- Civil Engineering
- Construction
- Cost Engineering

The formulation process includes identifying concept design scopes resulting in rudimentary costs and schedules. After initial sorting of measures and alternatives, the PDT became more focused on those that appear to have the greatest potential in addressing the study objectives. In the final cost evaluation, outcome is dependent upon identified scope, quality of estimates, risk-based contingencies, and cost escalation based on an assumed schedule. The challenges faced within this study itself are new or unusual technologies, very preliminary concept designs, and rudimentary quantities or comparison-based scopes, resulting in elementary cost and schedule estimates. All those factors carry greater risk, but lack of details compromises the ability to apply a Monte-Carlo style risk analysis, which requires sufficient data points to arrive at statistically based conclusions and recommend cost contingencies at a prescribed confidence level for successful execution to completion.

For this reason, the PDT, supported by the Cost Engineering MCX, has taken a matrix approach, focusing on and emphasizing the major risks per measure category, and arriving at a reasonable contingency based on experience from other challenging projects, with certain risk exclusions being considered. The risks are identified by construction measures and presented within a risk register structure, Section K.4.9 of this Appendix. A matrices development of the measures results in approximate contingencies per construction measure, which is then rolled into the featured costs per alternative. This results in a weighted comparison of costs and risks for each alternative (Figure K.9)

K4.4.2 Risk Categories

The matrix approach currently utilized by USACE identifies seven major risk categories, each related to unique risks from design-contract solicitation and construction. These categories are more generic in nature and have been established over time through detailed study of the Monte Carlo-style risk analyses performed throughout USACE on many and varied large projects. The following were considered for each of the measures:

- Project Scope Maturity and Potential Growth
- Acquisition Strategy
- Quantities of Current Scope
- Construction Elements
- Specialty Fabrication and Equipment
- Cost Estimate Assumptions
- External Project Risks

K.4.4.3 Qualitative Risks

Normally, risk studies begin with risk identification and a determination of subjective or speculative cost and time impacts. These are captured in a risk register as previously mentioned and presented in Section K.4.9 of this Appendix. This is referred to as a “qualitative study.” Those identified risks and respective variance potentials are then studied more thoroughly relative to cost and time variance (dollars and months, respectively). This is referred to as the “quantitative study phase” and is used for the Monte Carlo or statistical-based study.

In this study case, recognizing the very limited scope, limited cost, and schedule data at the detailed level that would normally support a thorough quantitative study, the Cost Engineering MCX recommended applying greater focus on the qualitative risk aspects, then applying an abbreviated risk approach that identifies the major risk concerns per feature, but this still arrives at an approximate contingency value.

Those contingency values can then be applied to the various construction measures and resulting alternatives, but it must be emphasized that those contingency values are for comparison purposes of alternatives, and not to be misinterpreted as a confident forecast for total cost and time growth. Note that schedule growth was not considered because of the rough schedules currently developed and the likelihood that any alternative could last for several decades.

K.4.5 Project Assumptions and Qualifications

Listed here are the major key assumptions supporting the PDT's identification of risks:

a. **Pre-concept Designs**. Rudimentary or pre-concept designs do not lend themselves to a more formal risk study based on Monte Carlo principles. There are insufficient data points and sufficient lack of confidence in the current data to support such a statistical approach. Any contingency output would be highly questionable. The PDT focused on qualitative risks and applied a hybrid process fashioned from the abbreviated risk analysis developed by Cost Engineering MCX. The process results in identified risks per measure and a cost contingency, but confidence in the contingency values is limited. The contingencies do serve as a means for alternative comparisons.

b. **High Level Risks**. The PDT focused on high risks, knowing that the limited study and design do not well support detailed project items that have not yet been conceived.

c. **Funding**. Concern for sufficient or timely funding to support each alternative was excluded from the risk evaluations. The assumption is timely funding to support progress annually. Delays result in a construction inflationary impact of 3–4% annually compounded over several decades. The team felt that such an unknown and potential showstopper would create risks and add contingencies far beyond the goal of simple comparison between measures and alternatives.

d. **Real Estate**. The PDT excluded the risk of needed real estate for each measure, alternative, and site location. It is known that this risk is extremely high for certain locations, but any real estate formulation and denial have not yet occurred. No real contingency can be placed on a hypothetical no-go situation.

e. **Permitting**. The PDT also excluded the risk of obtaining the necessary permits for construction of various measures at various locations. It is known that this risk is extremely high for certain locations, but no formal request or formal permitting denial has yet occurred. No real contingency can be placed on a hypothetical no-go situation.

f. **Design and Construction Management**. This risk study included construction cost, design, and construction management. Design and construction management could be as high as 20% of construction costs to a project.

g. **Measure Locations**. It is known that the same measure can be applied at several locations, and site-specific risks can impact the same measure. Knowing that the risk assessment is focused on the higher level risks, it was assumed that site-specific risks will be of a lower magnitude and were excluded from this early risk assessment study.

h. **Sponsor Support**. Project development is very preliminary. The risks exclude any relationship of sponsor(s) support related to permitting, real estate, funding, etc. The PDT felt it was too early to move forward for sponsorship in any long-term coordinated process on the speculative alternatives.

i. **Higher Contingencies**. Construction measures are very preliminary relative to scoping, design, sizing, quantities, cost, and schedule. Contingencies will likely vary based on those qualifying factors. Some contingencies will likely be high for those categories deemed overly complex and lacking sufficient scoping and design.

j. **O&M Costs**. The risk study excludes O&M costs. The standard procedure is to compare the project first costs and exclude the O&M. With the large projected costs, O&M would likely be very small by comparison.

k. **Project Schedule**. Project schedules were excluded from the measures and alternatives studies. It is known that design and construction could go many years, but there is insufficient data to place a reliable contingency on such occurrences as long-term schedule delays.

l. **Cost and Time Estimates.** Cost and schedule estimates are greatly influenced over time and are a reflection of the project management controls and cost and schedule management practices implemented. The estimate assumptions assume sound management practices.

K.4.6 Results

The qualitative risk results are provided in the following sections. The presentations include the risk register, matrix of measures to the seven risk categories, and a corresponding contingency value. These products are meant to provide decision makers with an understanding of the variability of various measures and alternatives as well as the key contributors to the cause of this variability.

K.4.6.1 Risk Register

A risk register is a tool commonly used in project planning and risk analysis. It identifies the key risks per each measure and serves as the basis for establishing concerns, documenting discussions, and establishing risk values per risk category for each measure. The actual risk register is provided in Section K.4.9.

K.4.6.2 Category Risks

The Cost Engineering MCX recommends addressing the risks related to project development phases: early concept, post-appropriation plans and specifications, contract solicitation, construction, and closeout. As PDT discussions progressed, common themes were recognized based on general risk categories.

a. **Project Scope and Maturity Growth**. The ten measures studied are very dependent upon the known site locations and site information. Pre-concept designs vary in technical complexity and available design information. Greater complexity with limited design equals greater scoping risks.

b. **Acquisition Strategy**. The type of contracting strategy will likely be based on project size, district experience, quality and completeness of plans and specifications, and schedule for construction implementation. Project size and contract strategies can affect ability to bond contractors, bidding competition, and government-assumed risks versus contractor risks. These are likely to impact overall project costs, larger projects even more so. Contract strategy can greatly influence a final project cost from least risk to greatest: funding availability, contract value, competitive bids, firm-fixed lowest price, best value, design/build, and cost plus incentive fee.

c. **Construction Risks**. Issues such as higher construction risks or complex structures, in-water work, weather impacts, unique construction methods, potential for modifications, claims, and litigation were considered. The greater the construction or design complexity is, the greater are the potential for construction cost growth in the form of contract modifications, claims, and litigation.

d. **Quantities for Current Scope**. Pre-final designs lack quantity confidence, complex projects even more so. The PDT recognized the potential of double counting these risks between the categories of project scope, quantities, and cost estimate assumptions. Lacking sufficient scope, most risk was placed in the scope maturity category, with residual risks placed in fluctuating quantities of a defined scope.

e. **Specialty Fabrication**. Consideration of this factor included unusual equipment, sole source potential, and complex or high risk items.

f. **Cost Estimate Assumptions**. Estimate development is highly reliant on the established scope, quantities, detailed costs for items such as prime and subcontractor markups and assignments, materials, crews, and productivity rates. The limited data and detail resulted in lesser confidence in estimate development, leaving greater reliance on similar projects, historical costs, escalation applications, high level parametrics, and limited detailed unit prices. Lesser cost confidence equals greater risk.

g. **External Project Risks**. The higher risks in this area are often forgotten but can result in major impacts. Protracted or long duration increases likelihood of scope change, as well as cost and time increases. Similarly, multiple interests, special interest, and political groups can result in unexpected changes and delays. Recent history indicates an annual national construction escalation rate of 3–4%. Compounded annually over a significant period, this factor greatly increases final project costs. For those projects occurring near the end of the timeline, there is greater risk potential.

K.4.6.3 Risk Matrix Presentation

Presented in this section is a portrayal of the team's risk assessment per construction measure per risk category. The potential weighting is from zero to five, five being the greatest risk, as shown in Figure K.8.

Risk Level

	Negligible	Marginal	Significant	Critical	Crisis
Very Likely	2	3	4	5	5
Likely	1	2	3	4	5
Possible	0	1	2	3	4
Unlikely	0	0	1	2	3

FIGURE K.8 Risk Level Matrix

The outcome of the likelihood and impact level assessment as processed through the risk register and risk discussions resulted in Figure K.9.

Typical Risk Elements	Potential Risk Areas											
	Physical Barriers	Breakwaters	Electric Barriers	Lock Structures	ANS Treatment Plants	Sluice Gates and Screens	Tunnels	Reservoirs	Reservoir Pump Stations	Sediment Remediation	Preconstruction Engineering, & Design	Construction Management
Project Scope Maturity and Growth	1	0	2	3	3	4	3	2	1	2	3	2
Acquisition Strategy	2	1	1	2	3	1	3	1	3	1	1	3
Construction Elements	2	1	2	2	3	2	2	2	2	1	1	2
Quantities for Current Scope	1	2	1	1	1	1	1	2	1	2	1	2
Specialty Fabrication or Equipment	0	0	1	3	2	3	1	0	2	0	2	1
Cost Estimate Assumptions	3	0	1	3	3	4	2	2	1	1	0	0
External Project Risks	4	4	4	4	4	4	3	3	4	4	2	1
Contingency	69%	52%	64%	99%	104%	143%	71%	47%	74%	61%	45%	47%

FIGURE K.9 Measure Risk Outcome and Contingency

The above figure is an indication of the cost confidence related to each measure as compared with the seven risk factors. The relative weights of 0–5 (5 being worst case) and green to red (red being worst case) are correlated to contingency values for each risk category. The weights and resulting contingencies reflect the PDT's current confidence relative to the measures and indicate where greater study may be warranted to resolve or lessen certain concerns. When the various measures are combined to form differing alternatives, weighted contingencies that include all features roughly range from 60% to 75%, excluding the major show-stopping risks found within the Key Assumptions section. More detailed discussions of the risk concerns for each measure per each risk category are presented in the risk register (Section K.4.9).

K.4.7 Major Findings and Observations

Section K.4.6.2 discussed the major risk categories as they relate to each construction measure. Figure K.9 highlights the greater areas of concern for each construction measure relative to the seven major risk categories. The contingencies presented in Figure K.9 are meant to convey what one might expect for potential cost growth with consideration of the key assumptions of the study. While the contingency values vary significantly between 30 and over 100%, one must remember that those contingency values are then applied against a certain estimate value for each measure, and then an established weighted contingency percent is assigned to each alternative. That results in the weighted contingencies in Table K.11.

For the contingencies associated with Preconstruction Engineering and Design and with Construction Management, 45% and 47% contingencies were established, respectively. These contingency values are for comparison purposes of alternatives, and not to be misinterpreted as a confident forecast for total cost and time growth. At this stage of project development relative to the challenging technical solutions, the higher contingencies should not come as a surprise. The many uncertainties, most specifically regarding project scope, acquisition strategy, construction complexity, cost estimate assumptions, and external project risks, are emphasized in lock structures, ANSTPs, and sluice gates and structures.

K.4.8 Recommendations

The risk analysis process is not a one-step measure. It is part of life-cycle project management. As planning decisions continue and concepts are honed into more likely measures and alternatives, there will be a natural refinement of scope and design. That refinement can more confidently support quantity development as well as cost estimates, schedules, and risk-based contingencies.

TABLE K.11 Weighted Contingencies per Alternative

ALTERNATIVE	Weighted Contingency
Mid-System Control Technologies without a Buffer Zone	63%
Technology Alternative with a Buffer Zone	78%
Lakefront Hydrologic Separation	61%
Mid-System Hydrologic Separation	63%
Mid-System Separation Cal-Sag Open Control Technologies with a Buffer Zone	66%
Mid-System Separation CSSC Open Control Technologies with a Buffer Zone	72%

K.4.9 Abbreviated Risk Analysis Summary

GLMRIS
Reconnaissance
Abbreviated Risk Analysis

Meeting Date: 24-Jun-13

Risk level

	Negligible	Marginal	Significant	Critical	Crisis
Very Likely	2	3	4	5	5
Likely	1	2	3	4	5
Possible	0	1	2	3	4
Unlikely	0	0	1	2	3

TABLE K.12 Abbreviated Risk Analysis Summary

Risk Element	Feature of Work	Concerns	PDT Discussions & Conclusions (includes logic & justification for choice of likelihood & impact)	Likelihood	Impact	Risk Level
Project Scope Maturity and Growth						
PS-1	Physical Barriers	Physical barriers were designed to current water conditions. The exact best locations may change, necessitating a change in size or design.	USACE has extensive experience with physical barriers such as concrete, earthen dams, levees, and floodwalls. Location changes could add some scoping changes, but significant cost impacts not expected.	Likely	Negligible	1
PS-2	Breakwaters	There has not been any detailed study of the wave climate and need for wave attenuation on the lakefront structures, which could change design/quantity.	USAGE is very experienced with design and construction of this type of facility and has built numerous breakwaters in the area. Additional protection measures or modification to proposed measures may need to be modified due to wave climate but should be reflected in current assumptions. Potential navigation issue, depending on alignment of breakwater, must be examined further, but technology is relatively simple. Quantity risk is considered below and is more likely to have greater impact.	Possible	Negligible	0
PS-3	Electric Barriers	Technology improvements for items such as stray electrical currents will need to be controlled for each specific location. Changing applications for each location results in some scoping uncertainty in terms of impacts to surrounding existing facilities/structures.	USAGE has designed/constructed this technology and has built electric barriers locally in past few years. Should be able to use much of what has been learned during design and construction to minimize scope growth. Further research may be needed to control stray current. Most likely this will involve different methods of construction than we have seen to date. Barriers will most likely have even greater safety concerns due to heavy recreational usage.	Likely	Marginal	2
PS-4	Lock Structures	Potential for resizing and re-orientating the proposed lock structures, most specifically with the Chicago Lock. The remote locks carry lesser risk, but the congested areas are of greater concern. Scope of filling and emptying systems at all locks could change due to unique first time applications for ANS treatment.	Additional modeling and testing will impact scope for scope growth depending on alignment maintaining navigation traffic, public traffic and impacts, and historical and other unanticipated impacts. Other concerns are pumping impact on structures and safety of vessels which are not seen in current Chicago Lock. Assuming retrofit of existing locks currently, may need additional aesthetic/recreational features for local buy in to plan. Rehabilitation of existing lock potentially more difficult/costly. Possible construction next to electric barrier may have unforeseen issues. Will need non-conductive elements in 400-ft area assumed for now.	Likely	Significant	3

Meeting Date: 24-Jun-13

Risk level

	Negligible	Marginal	Significant	Critical	Crisis
Very Likely	2	3	4	5	5
Likely	1	2	3	4	5
Possible	0	1	2	3	4
Unlikely	0	0	1	2	3

TABLE K.12 (CONT.)

Risk Element	Feature of Work	Concerns	PDT Discussions & Conclusions (includes logic & justification for choice of likelihood & impact)	Likelihood	Impact	Risk Level
PS-5	ANS Treatment Plants	Newer, evolving technologies and application to these specific needs may be challenging with respect to scope understanding, development, and resulting changes.	USACE lacks extensive experience with this type of technology, but has performed some research. Scope and cost are based on previous studies performed by others, but no plant has yet been constructed. Additional research, modeling, and testing may impact size of plant and complexity of treatment. Permitting could cause delays. Scope increases- UV treatment on this scale might not be be adequate. Scope based on most likely scenario may change pending further study.	Likely	Significant	3
PS-6	Sluice Gates and Screens	Scope of screen structures for sluice gates and backflow gates could change to accommodate cleaning/raking systems.	USAGE is experienced with gates and screens, but no design or experience similar to the gate and screening levels anticipated for this project. The scope for these features has not developed yet, resulting in higher risk of scope growth. There could be a series or multiple screens. Smaller screen sizes have O&M issues.	Very LIKELY	Significant	4
PS-7	Tunnels	Scope at this early stage is very unclear. Preliminary design may not capture all aspects for such a complex system (inlet structures, trash racks/rakes, air shafts, gates, backup gates, etc.).	USACE does not have experience with metropolitan tunneling on this scale, but some cities have been and are involved with major tunneling projects. Tunneling work has been performed by others in the recent past (MWRD Chicago deep tunnel system TARP). It is likely that with further study, design, and modeling additional items will be identified which would impact costs, but current tunnel diameter is conservative. Current scope is conservative. Real estate assumes we place new tunnels close to current TARP; metropolitan might not agree.	Likely	Significant	3
PS-8	Reservoirs	Current assumptions *may* not capture all aspects of complex system. Geotechnical data at final site locations may lead to additional needs (specialized stabilizations, etc.) compared to McCook on which the costs are based.	USACE has been involved in recent reservoir construction. Preliminary design and cost assumes worst case...best case possibly using reservoirs. After completion of further design and modeling, additional items may be identified. However, there is the potential that scope may increase due to assumptions regarding existing reservoirs.	Possible	Significant	2
PS-9	Reservoir Pump Stations	Current scope assumptions for the pump station may change after further investigation/design is completed.	Assumptions from the existing pump station at the McCook Reservoir were used and provide a solid basis for costs and scope. The scope is thought to be conservative based on anticipated sizing. Changes are possible but overall impact is not expected to be significant.	Possible	Marginal	1

Risk level

	Negligible	Marginal	Significant	Critical	Crisis
Very Likely	2	3	4	5	5
Likely	1	2	3	4	5
Possible	0	1	2	3	4
Unlikely	0	0	1	2	3

TABLE K.12 (CONT.)

Risk Element	Feature of Work	Concerns	PDT Discussions & Conclusions (includes logic & justification for choice of likelihood & impact)	Likelihood	Impact	Risk Level
PS-10	Sediment Remediation	If some alternatives were to go forward, the sediment remediation (which is a mitigation feature under GLMRIS) would require a feasibility study of its own.	USACE has very recent and ongoing experience with this type of work. This work is included in the mid-system hydro-separation alternatives. Project has used the EPA assumptions from the Grand Calumet River project for scope. It is possible that a cap solution will not be acceptable, resulting in deeper dredging. Dredging/capping could require extensive studies. There is potential for scope growth depending on what remediation would be required (depth of dredging), such as special handling of material. This could potentially result in additional time/scope.	Possible	Significant	2
PS-11	Preconstruction Engineering & Design	Scope growth or changes can cause further design and redesign.	The project seeping is dependent upon studies, investigations, and external scoping considerations. Additional investigations, new findings, and external changes are likely.	Likely	Significant	3
PS-12	Construction Management	Scope growth can result in more construction management due to added scope, longer contract durations.	Scope growth, based on above discussions, is likely. Construction management impacts would be considered less than the design impacts, because the management team is already mobilized. Changes could result in longer durations or added personnel to manage.	Likely	Marginal	2
Acquisition Strategy						
AS-1	Physical Barriers	Contracting plan is not established at this stage of development. Various technical challenges and related design and construction complexities can result in differing contract strategies that result in less or greater government risks and resulting project costs. Condensed project schedules could limit design and lean more heavily into design/build contracts, assuming more government risks.	Type of contracting strategy will likely be based on project size, district experience, completion of plans and specs, and schedule for construction implementation. Project size and contract strategies can affect ability to bond contractors, bidding competition, and government risks versus contractor risks. It is likely to impact overall project costs, larger projects even more so. Contract strategy can greatly influence a final project cost from least risk to greatest: funding availability, contract value, competitive bids, firm-fixed lowest price, best value, design/build, and cost plus incentive fee.	Likely	Marginal	2

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Risk level

	Negligible	Marginal	Significant	Critical	Crisis
Very Likely	2	3	4	5	5
Likely	1	2	3	4	5
Possible	0	1	2	3	4
Unlikely	0	0	1	2	3

TABLE K.12 (CONT.)

Risk Element	Feature of Work	Concerns	PDT Discussions & Conclusions (includes logic & justification for choice of likelihood & impact)	Likelihood	Impact	Risk Level
AS-2	Breakwaters	Contracting plan is not established at this stage of development. Various technical challenges and related design and construction complexities can result in differing contract strategies that result in less or greater government risks and resulting project costs. Condensed project schedules could limit design and lean more heavily into design/build contracts, assuming more government risks.	Type of contracting strategy will likely be based on project size, district experience, completion of plans and specs, and schedule for construction implementation. Project size and contract strategies can affect ability to bond contractors, bidding competition, and government risks versus contractor risks. It is likely to impact overall project costs, larger projects even more so. Contract strategy can greatly influence a final project cost from least risk to greatest: funding availability, contract value, competitive bids, firm-fixed lowest price, best value design/build, and cost plus incentive fee.	Possible	Marginal	1
AS-3	Electric Barriers	Contracting plan is not established at this stage of development. Various technical challenges and related design and construction complexities can result in differing contract strategies that result in less or greater government risks and resulting project costs. Condensed project schedules could limit design and lean more heavily into design/build contracts, assuming more government risks.	Type of contracting strategy will likely be based on project size, district experience, completion of plans and specs, and schedule for construction implementation. Project size and contract strategies can affect ability to bond contractors, bidding competition, and government risks versus contractor risks. It is likely to impact overall project costs, larger projects even more so. Contract strategy can greatly influence a final project cost from least risk to greatest: funding availability, contract value, competitive bids, firm-fixed lowest price, best value design/build, and cost plus incentive fee.	Likely	Marginal	1
AS-4	Lock Structures	Contracting plan is not established at this stage of development. Various technical challenges and related design and construction complexities can result in differing contract strategies that result in less or greater government risks and resulting project costs. Condensed project schedules could limit design and lean more heavily into design/build contracts, assuming more government risks, contract value, competitive bids, firm-fixed lowest price, best value, design/build, and cost plus incentive fee.	Type of contracting strategy will likely be based on project size, district experience, completion of plans and specs, and schedule for construction implementation. Project size and contract strategies can affect ability to bond contractors, bidding competition, and government risks versus contractor risks. It is likely to impact overall project costs, larger projects even more so. Contract strategy can greatly influence a final project cost from least risk to greatest: funding availability, contract value, competitive bids, firm-fixed lowest price, best value design/build, and cost plus incentive fee.	Likely	Marginal	2

Meeting Date: 24-Jun-13

Risk level

	Negligible	Marginal	Significant	Critical	Crisis
Very Likely	2	3	4	5	5
Likely	1	2	3	4	5
Possible	0	1	2	3	4
Unlikely	0	0	1	2	3

TABLE K.12 (CONT.)

Risk Element	Feature of Work	Concerns	PDT Discussions & Conclusions (includes logic & justification for choice of likelihood & impact)	Likelihood	Impact	Risk Level
AS-5	ANS Treatment Plants	This newer technology can carry greater risks. Contracting plan is not established at this stage of development. Various technical challenges and related design and construction complexities can result in differing contract strategies that result in less or greater government risks and resulting project costs. Condensed project schedules could limit design and lean more heavily into design/build contracts, assuming more government risks.	Type of contracting strategy will likely be based on project size, district experience, completion of plans and specs, and schedule for construction implementation. Project size and contract strategies can affect ability to bond contractors, bidding competition, and government risks versus contractor risks. It is likely to impact overall project costs, larger projects even more so. Contract strategy can greatly influence a final project cost from least risk to greatest: funding availability, contract value, competitive bids, firm-fixed lowest price, best value, design/build, and cost plus incentive fee.	Likely	Significant	3
AS-6	Sluice Gates and Screens	Contracting plan is not established at this stage of development. Various technical challenges and related design and construction complexities can result in differing contract strategies that result in less or greater government risks and resulting project costs. Condensed project schedules could limit design and lean more heavily into design/build contracts, assuming more government risks.	Type of contracting strategy will likely be based on project size, district experience, completion of plans and specs, and schedule for construction implementation. Project size and contract strategies can affect ability to bond contractors, bidding competition, and government risks versus contractor risks. It is likely to impact overall project costs, larger projects even more so. Contract strategy can greatly influence a final project cost from least risk to greatest: funding availability, contract value, competitive bids, firm-fixed lowest price, best value, design/build, and cost plus incentive fee.	Possible	Marginal	1
AS-7	Tunnels	This technology can carry greater risk. Contracting plan is not established at this stage of development. Various technical challenges established at this stage of development. Various technical challenges and contract strategies that result in less or greater government risks and resulting project costs. Condensed project schedules could limit design and lean more heavily into design/build contracts, assuming more government risks.	Type of contracting strategy will likely be based on project size, district experience, completion of plans and specs, and schedule for construction implementation. Project size and contract strategies can affect ability to bond contractors, bidding competition, and government risks versus contractor risks. It is likely to impact overall project costs, larger projects even more so. Contract strategy can greatly influence a final project cost from least risk to greatest: funding availability, contract value, competitive bids, firm-fixed lowest price, best value, design/build, and cost plus incentive fee.	Likely	Significant	3

Risk level

Very Likely	2	3	4	5	5
Likely	1	2	3	4	5
Possible	0	1	2	3	4
Unlikely	0	0	1	2	3
	Negligible	Marginal	Significant	Critical	Crisis

TABLE K.12 (CONT.)

Risk Element	Feature of Work	Concerns	PDT Discussions & Conclusions (includes logic & justification for choice of likelihood & impact)	Likelihood	Impact	Risk Level
AS-8	Reservoirs	Contracting plan is not established at this stage of development. Various technical challenges and related design and construction complexities can result in differing contract strategies that result in less or greater government risks and resulting project costs. Condensed project schedules could limit design and lean more heavily into design/build contracts, assuming more government risks.	Type of contracting strategy will likely be based on project size, district experience, completion of plans and specs, and schedule for construction implementation. Project size and contract strategies can affect ability to bond contractors, bidding competition, and government risks versus contractor risks. It is likely to impact overall project costs, larger projects even more so. Contract strategy can greatly influence a final project cost from least risk to greatest: funding availability, contract value, competitive bids, firm-fixed lowest price, best value, design/build, and cost plus incentive fee.	Possible	Marginal	1
AS-9	Reservoir Pump Stations	Contracting plan is not established at this stage of development. Various technical challenges and related design and construction complexities can result in differing contract strategies that result in less or greater government risks and resulting project costs. Condensed project schedules could limit design and lean more heavily into design/build contracts, assuming more government risks.	Type of contracting strategy will likely be based on project size, district experience, completion of plans and specs, and schedule for construction implementation. Project size and contract strategies can affect ability to bond contractors, bidding competition, and government risks versus contractor risks. It is likely to impact overall project costs, larger projects even more so. Contract strategy can greatly influence a final project cost from least risk to greatest: funding availability, contract value, competitive bids, firm-fixed lowest price, best value, design/build, and cost plus incentive fee. Pump and motors are specialty items, and this contract is likely to be best value or lowest cost technically acceptable	Likely	Significant	3
AS-10	Sediment Remediation	Contracting plan is not established at this stage of development. Various technical challenges and related design and construction complexities can result in differing contract strategies that result in less or greater government risks and resulting project costs. Condensed project schedules could limit design and lean more heavily into design/build contracts, assuming more government risks.	Type of contracting strategy will likely be based on project size, district experience, completion of plans and specs, and schedule for construction implementation. Project size and contract strategies can affect ability to bond contractors, bidding competition, and government risks versus contractor risks. It is likely to impact overall project costs, larger projects even more so. Contract strategy can greatly influence a final project cost from least risk to greatest: funding availability, contract value, competitive bids, firm-fixed lowest price, best value, design/build, and cost plus incentive fee.	Possible	Marginal	1

Risk level

	Negligible	Marginal	Significant	Critical	Crisis
Very Likely	2	3	4	5	5
Likely	1	2	3	4	5
Possible	0	1	2	3	4
Unlikely	0	0	1	2	3

TABLE K.12 (CONT.)

Risk Element	Feature of Work	Concerns	PDT Discussions & Conclusions (includes logic & justification for choice of likelihood & impact)	Likelihood	Impact	Risk Level
AS-11	Preconstruction Engineering & Design	Acquisition strategies will change the PED efforts. Design/build leaves major detailed design to the construction contractor.	Lesser impact is expected because design/build results in the cost increases in the construction contract. Design/build is considered likely.	Likely	Negligible	1
AS-12	Construction Management	Construction management is based on the acquisition strategy.	Certain acquisition requirements cause greater need for management related to design/build and cost plus projects. Design/build contracts are very likely.	Likely	Significant	3
Construction Elements						
CON-1	Physical Barriers	Greatest concerns are site access, congested areas, and schedule delays.	Concrete structure planned. Anticipated 100% Plans &Specs. Difficulty depending on locations is a known, and can be planned for. Very limited staging areas and access are available, and surrounding transportation, utilities, winter weather, etc., will need to be managed. Similarly on long lead times for projects. Some areas have limestone bottom. Additionally, Chicago barrier site will be a complex project due to the high density of population surrounding the project site. Since sites are solid barriers, other risks limited.	Likely	Marginal	2
CON-2	Breakwaters	In-water work, potential navigational influences and congestion, weather impacts, construction near heavily used recreational area.	Construction practices can manage these concerns.	Possible	Marginal	1
CON-3	Electric Barriers	Potential differing site conditions changes based on chosen final locations, utilities, etc.	In-water work, but USACE and contractor(s) have recent experience. USACE has done extensive research and design on electric barriers as well as construction of an existing barrier in the past few years. Water levels may impact in-water work. Site access and staging areas pose potential issues, but contractor experience should minimize extreme impacts.	Possible	Significant	2

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Risk level

	Negligible	Marginal	Significant	Critical	Crisis
Very Likely	2	3	4	5	5
Likely	1	2	3	4	5
Possible	0	1	2	3	4
Unlikely	0	0	1	2	3

TABLE K.12 (CONT.)

Risk Element	Feature of Work	Concerns	PDT Discussions & Conclusions (includes logic & justification for choice of likelihood & impact)	Likelihood	Impact	Risk Level
CON-4	Lock Structures	Work would need to be performed while the river is still open to navigation without disrupting	USACE and contractors have experience with this skill set. This includes in-water work. In-water work poses certain risks. Water levels and winter weather can result in impacts. Site access and staging are a concern in a metro area. Construction will have to accommodate traffic and be prepared for winter shutdown or slowdown. Phased construction can push schedule. Flood control must protect construction processes.	Possible	Significant	2
CON-5	ANS Treatment Plant	Complex designs are anticipated accompanied by heavy construction in congested construction areas.	USACE does not have extensive design and construction experience on facilities like this. There is potential for many unforeseen impacts that lead to construction modifications, claims, and litigation.	Likely	Significant	3
CON-6	Sluice Gates and Screens	Work would be performed at existing facilities, so it could result in phasing/staging issues. Existing facilities will need to stay in operation as work is being completed	Maintaining operations during construction could result in extended construction durations.	Likely	Marginal	2
CON-7	Tunnels	The complex excavation, related structures, impacts with metropolitan utilities, and traffic could require complex coordination, Management, and phasing.	Underground work and major user involvement can result in modifications, claims, litigation, and schedule delays. Impact of maintaining the current systems functionality during construction/transition may increase costs. Current preliminary planning can result in major impacts in all aspects. Since the base estimate already includes those considerations realized from previous MWRD work, impact should be relatively marginal.	Likely	Marginal	2
CON-8	Reservoirs	The large reservoirs will have a very long construction time if existing quarries cannot be modified, which will delay the implementation of the rest of the alternative.	Based on final locations, blasting restrictions likely will apply. There could also be construction impacts to adjacent roads and properties. There are some concerns regarding haul and disposal of the excavated materials causing potential negative impacts to local roads traffic and the public. Since the base estimate already includes those considerations realized from previous MWRD work, impact should be relatively marginal.	Likely	Marginal	2
CON-9	Reservoir Pump Stations	Construction will require coordination with multiple subcontractors and tie in with tunnel work. Limited access and working 300 ft below grade creates additional staging problems.	Since a similar size pump station was already constructed and used as a basis for this feature of work at the McCook Reservoir, these concerns should already be included in the costs. After further study, changes will likely be identified but impact should be relatively marginal.	Likely	Marginal	2

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Risk level

	Negligible	Marginal	Significant	Critical	Crisis
Very Likely	2	3	4	5	5
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Possible	0	1	2	3	4
Unlikely	0	0	1	2	3

TABLE K.12 (CONT.)

Risk Element	Feature of Work	Concerns	PDT Discussions & Conclusions (includes logic & justification for choice of likelihood & impact)	Likelihood	Impact	Risk Level
CON-10	Sediment Remediation	In-water work, maintenance of navigation during construction, potential for encountering contaminated wastes, and weather impacts.	This work has been performed in the recent past. No major impacts are expected. No significant contaminated wastes are expected. Risks are considered fairly low.	Possible	Marginal	1
CE-11	Preconstruction Engineering & Design	Some design is required during the construction contracts to support RFIs, submittal review, and design of construction modifications.	This effort is considered minimal compared to project costs in larger projects where scope has already been established.	Likely	Negligible	1
CE-12	Construction Management	Construction management can be challenged by coordinating the many subcontractors on large projects, monitoring progress, and processing of modifications and claims.	Large projects inherently bring many modifications, claims, and litigation because of the great sums of money involved. Construction would likely experience a greater impact than design.	Likely	Marginal	2
Quantities for Current Scope						
Q-1	Physical Barriers	Designs are not yet established, Quantities for this feature have not been developed to any level of detail.	Design and quantities have not been developed in any detail at this point, making it likely that the quantities will change to a degree as design progresses. Most risk is considered in establishing the initial scope.	Possible	Marginal	1
Q-2	Breakwaters	Breakwaters were estimated based on very rough quantities of stone. Size may increase or decrease based on true conditions, requirements, scope, etc.	Quantities likely to have some variation as design progresses but should not be significant. USACE has data from previous breakwater design in the area, but there is still variation potential based on location.	Likely	Marginal	2
Q-3	Electric Barriers	Building electric barriers in locations often traversed by people/passenger vessels may vary from barriers constructed in past.	Given USAGE's experience in this area, improvements will be included to make the barrier safer, along with restrictions and rules to keep passengers safe. Most concern is related to scope change, not any quantity change that would impact greatly.	Possible	Marginal	1
Q-4	Lock Structures	Features have not yet been designed. Quantities for this feature have hot been developed to any level of detail.	Design and quantities have not been developed in any detail at this point, making it likely that the quantities and estimate will change to a degree as design progresses. Most risk is considered in establishing the initial scope.	Possible	Marginal	1
Q-5	ANS Treatment Plants	May be difficult to place treatment plants near barriers in some locations. While a design may not vary in industry processes, quantities could vary based on sizing and utility distance.	If treatment plants cannot be placed adjacent to the barrier, they can be built further away but will require more extensive utility systems. System design can still cause a change in plant and equipment sizing.	Possible	Marginal	1

Risk level

	Negligible	Marginal	Significant	Critical	Crisis
Very Likely	2	3	4	5	5
Likely	1	2	3	4	5
Possible	0	1	2	3	4
Unlikely	0	0	1	2	3

TABLE K.12 (CONT.)

Risk Element	Feature of Work	Concerns	PDT Discussions & Conclusions (includes logic & justification for choice of likelihood & impact)	Likelihood	Impact	Risk Level
Q-6	Sluice Gates and Screens	Design and quantities are at a very early development stage. Quantities could still vary.	Design and quantities have not been developed in any detail at this point, making it likely that the quantities and estimate will change to a degree as design progresses. Most risk is considered in establishing the initial scope.	Possible	Marginal	1
Q-7	Tunnels	Quantities (sizing, length of tunnels, size and number of shafts required, etc.) will change after further modeling/design is finished. Tunnel sizing will also vary depending on area, locations, and depth of reservoirs.	Tunneling model based on hydraulic modeling and conservative assumptions in sizing were applied. Likelihood of quantity growth for excavation is low, but supporting infrastructure could increase.	Possible	Marginal	1
Q-8	Reservoirs	The stage-volume curves are not available at this point. The performance of the reservoir can only be determined and optimized once the site and size are known.	A calculated volume has been established. The volume is considered conservative, but may change based on assumptions of the completed Chicagoland Underflow Project (CUP) reservoirs.	Possible	Significant	2
Q-9	Reservoir Pump Stations	Quantities (sizing of pumps/motors, etc.) will change after further modeling/design is finished.	Conservative assumptions based on existing pump station were applied. Likelihood of changes is low and should be relatively small.	Possible	Marginal	1
Q-10	Sediment Remediation	Quantities are at an early stage of development. In-water and under-water work can influence quantities in dredging, then placement of sand and stone.	Depths are uncertain based on material types. Quantity fluctuations can be significant.	Possible	Significant	2
Q-11	Preconstruction Engineering & Design	Design quantities are likely to change, causing added design work to support those changes.	Designs address systems, supported by details. Quantity changes will have minimal effect on overall design.	Possible	Marginal	1
Q-12	Construction Management	Construction management efforts could increase due to project size and quantities.	Construction management is required to monitor and inspect installation, completion, and payment based on quantities. A variation results in more construction management than design work.	Likely	Marginal	2
Specialty Fabrication of Equipment						
FE-1	Physical Barriers	Numerous assumptions are made with respect to a conceptual design, but no special equipment or fabrications are anticipated.	Major construction is mass concrete, reinforcement, sheet pile. No impacts are expected.	Unlikely	Negligible	0
FE-2	Breakwaters	No specialized fabrication or equipment anticipated.	None at this time. Breakwaters consisting of readily available limestone or granite.	Unlikely	Negligible	0

GLMRIS
Reconnaissance
Abbreviated Risk Analysis

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Risk level

	Negligible	Marginal	Significant	Critical	Crisis
Very Likely	2	3	4	5	5
Likely	1	2	3	4	5
Possible	0	1	2	3	4
Unlikely	0	0	1	2	3

TABLE K.12 (CONT.)

Risk Element	Feature of Work	Concerns	PDT Discussions & Conclusions (includes logic & justification for choice of likelihood & impact)	Likelihood	Impact	Risk Level
FE-3	Electric Barriers	The specialized equipment is limited to a single source.	Pending quantities and orders, there could be inflation due to limited competition and fabrication delays. The estimates have considered the bulk of this risk, but there may be some residual risks.			
FE-4	Lock Structures	Lock structure layout, orientation, and chamber configuration are very preliminary and likely to change. Concerns relate to gate designs, high volume pumping, and sizing. Fabrication and delivery of the specialized equipment are still an unknown. Filling and emptying systems at all locks are unique 1st-time applications to satisfy ANS treatment requirements.	Currently lacking confident design, fabrication, and installation information. Filling and emptying system changes likely to result in significantly higher costs. Special composites may need to be used in approach channels. Sealing gates, positive pressure possible.	Likely	Significant	3
FE-5	ANS Treatment Plant	The treatment plants will require fabricated and specialty equipment; most concern for the UV technology. There could be a certain dependency on limited sources and availability.	Large amount of specialized equipment would be needed and coordinated, with USAGE having had no experience. Uncertain whether the special equipment is readily available. Critical equipment with limited availability could drive up processes and cause delays.	Possible	Significant	2
FE-6	Sluice Gates and Screens	Screen structures for sluice gates and backflow gates will be innovative designs and will require specialized cleaning/raking systems unknown at this time.	These features will require specialized clearing/raking systems unknown at this time. Fabrication and supply sources will likely be limited. Variance could be significant.	Likely	Significant	3
FE-7	Tunnels	Design not developed, but there is potential for a number of structural fabrications, control gates, etc.	Tunnel system is anticipated to be gravity or mostly passive flow. There will be some control structures. There is good historical information on what MWRD and USAGE have built to date. Specialty fabricated items are not expected to be a significant factor when compared to overall costs of tunnels.	Possible	Marginal	1
FE-8	Reservoirs	No significant specialty equipment is expected.	Major project feature is excavation. No impacts related to special fabrication or equipment are expected.	Unlikely	Negligible	0
FE-9	Reservoir Pump Stations	The pump stations will include high head pumps and motors that will require specialty fabrication and require long lead time.	The current pump station at McCook was used as basis and provides a solid basis for costs and scope. However, these are specialty items that could potentially vary from existing equipment, and further investigation/design and changes could be significant.	Possible	Significant	2
FE-10	Sediment Remediation	No specialty or fabricated equipment expected for this item.	No significant specialty equipment or fabrications expected. Estimate already makes consideration.	Unlikely	Marginal	0

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Risk level

Very Likely	2	3	4	5	5
Likely	1	2	3	4	5
Possible	0	1	2	3	4
Unlikely	0	0	1	2	3
	Negligible	Marginal	Significant	Critical	Crisis

TABLE K.12 (CONT.)

Risk Element	Feature of Work	Concerns	PDT Discussions & Conclusions (includes logic & justification for choice of likelihood & impact)	Likelihood	Impact	Risk Level
FE-11	Preconstruction Engineering & Design	Specialty equipment requires more design research and could include complex designs.	Designers are more challenged with special equipment requirements, joint testing, and inspection and installation.	Likely	Marginal	2
FE-12	Construction Management	Construction management can be challenged by special equipment installation and testing	The special equipment installation and testing will be a joint effort between designer and construction management. Designers will play a heavier role	Possible	Marginal	1
Cost Estimate Assumptions						
EST-1	Physical Barriers	Costs are based on a model from a different geographical area; sizing has not been adjusted for quantities or costs.	Preliminary design sketches exist. Design complexity is considered relatively simple. Estimate assumes a concrete structure. Cost is based on a lump sum costs from Sacramento. There are some other structure elements expected. Site-specific changes related to quantities and costs are likely and could be significant.	Likely	Significant	3
EST-2	Breakwaters	Most cost changes will be based on design scope and quantity changes, which are addressed elsewhere. Potential concern relates to availability of quality stone.	USACE has built several breakwaters in area so there is recent historical and on-going work information. Estimates are based on local historical costs. Design may change from current assumptions, but it is not expected to have any significant impact on cost. Verified availability of quality stone. Some changes possible but should be minor.	Possible	Negligible	0
EST-3	Electric Barriers	Electric barrier costs may differ from current design and cost estimate assumptions due to potential locations and possible site adjustments.	USACE has good scope/cost information for currently installed barriers, but new designs are forthcoming. Site conditions for this project at the different barrier sites may require different building requirements. Design will likely be refined but should be an improvement. Certain cost assumptions related to the design changes carry a potential risk.	Possible	Marginal	1
EST-4	Lock Structures	Estimate is a very parametric, high level comparison. It is unclear whether the GLMRIS Locks will be similar in cost to a new lock or a lock rehab. Cost estimate assumptions could easily be faulty.	USACE does perform this type of work. Most available cost data are based on rehab of existing locks. There are no current designs supporting detailed or unit-priced based costs. There are new lock structures under design in other Corps districts, but supporting markets related to materials and labor rates are likely different from those of the Chicago area. Cost is based on other site models. The cost difference potential is considered likely and possibly significant.	Likely	Significant	3

Risk level

	Negligible	Marginal	Significant	Critical	Crisis
Very Likely	2	3	4	5	5
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Possible	0	1	2	3	4
Unlikely	0	0	1	2	3

TABLE K.12 (CONT.)

Risk Element	Feature of Work	Concerns	PDT Discussions & Conclusions (include logic & justification for choice of likelihood & impact)	Likelihood	Impact	Risk Level
EST-5	ANS Treatment Plants	ANS cost estimates based on very general studies and parametric costs provided by MWRD.	No actual detailed estimates or construction costs available. Costs are based on gal/water treated per day. This number is all we have now based on level of design, but final design may have significantly differing costs than general assumptions used. Costs are also dependent upon site locations. Cost confidence is considered medium, but detailed information likely to change and could be significant.	Likely	Significant	3
EST-6	Sluice Gates and Screens	No detailed design information is available that supports cost estimates. Anticipated screens of this nature are not known to exist for this application.	USACE has used historical data from current projects in Chicago area. Sluice gates are fairly common, but screens with openings this small are an unknown. Changes are very likely and could be significant.	Very LIKELY	Significant	4
EST-7	Tunnels	The estimate data are aging (1970s-1990s).	MWRD Deep Tunnel costs were used as estimate basis. The actual contracts were from the 70s thru 90s and escalated to present day costs. Those tunnels are deep, approximately 300 feet in limestone. Estimate confidence is fair, but tunnel tie-ins and complexities are unclear. Without detailed design, cost assumptions can change and be significant.	Possible	Significant	2
EST-8	Reservoirs	Reservoir costs might vary based on changes from current cost assumptions. Costs used are based on ongoing work in the local area.	Reservoir pricing based on McCook reservoir. The reservoir sizing is conservative. McCook currently has a private company (Vulcan) mining the reservoir and selling the stone based on demand for product. For GLMRIS, the assumption is that USACE would have to get into the mining business, something it has never done before. Vulcan's cost for mining were used, but they are an established mining company with existing quarry and equipment. The estimate assumes that haul and disposal of excavated materials (conservative scope, quantities and estimate based on local data). The greater risk is in the haul distance.	Possible	Significant	2

Risk level

	Negligible	Marginal	Significant	Critical	Crisis
Very Likely	2	3	4	5	5
Likely	1	2	3	4	5
Possible	0	1	2	3	4
Unlikely	0	0	1	2	3

TABLE K.12 (CONT.)

Risk Element	Feature of Work	Concerns	PDT Discussions & Conclusions (includes logic & justification for choice of likelihood & impact)	Likelihood	Impact	Risk Level
EST-9	Reservoir Pump Stations	Actual cost data exist for this type of work, but construction was completed in 1984 plus an assumed escalation on a national level.	PDT is confident on type of pump station. Elevation change for pumps is several hundred feet, so no current models are known to be readily available and will require specialty fabrication (discussed above). Estimate assumptions are considered conservative since assumptions are based on larger station requirements. Estimate increases are not expected to be significant.	Possible	Marginal	1
EST-10	Sediment Remediation	This type of work is currently under construction locally in the same rivers.	USACE has detailed estimate data, with project information coming in part from EPA projects in Chicago area. Cost confidence is fairly high.	Possible	Marginal	1
EST-11	Preconstruction Engineering & Design	Design estimating will be based on quality and completeness of the designs.	Estimators can be challenged in developing costs for incomplete or challenging designs, but the associated labor costs are very small relative to overall efforts. Designers will have even less of an impact related to estimator assumptions.	Possible	Negligible	0
EST-12	Construction Management	Construction management will be impacted very little based on estimate assumptions.	No measureable impact expected.	Possible	Negligible	0
External Projects Risks						
EX-1	Physical Barriers	The external risk here excludes concerns related to permitting; hazardous, toxic, and radioactive waste (HTRW); real estate; and available funding. Those are addressed separately in the GLMRIS Report. External risks included in the risk register (and contingency) are extreme escalation and delays/impacts by others (outside organizations, municipalities, public interest groups, etc.).	Project delays increase likelihood of scope growth and cost increases. Similarly, multiple interest and political groups can result in unexpected changes and delays. Recent history indicates an annual national construction escalation rate of 3.5%. Compounding annually over a significant duration greatly increases final project costs. Physical barriers would occur toward the end of project duration; therefore, risks are greater for change and escalation.	Very LIKELY	Significant	4
EX-2	Breakwaters	The external risk here excludes concerns related to permitting, HTRW, real estate, and available funding. Those are addressed separately in the GLMRIS Report. External risks included in the risk register (and contingency) are extreme escalation and delays/impacts by others (outside organizations, municipalities, public interest groups, etc.).	Project delays increase likelihood of scope growth and cost increases. Similarly, multiple interest and political groups can result in unexpected changes and delays. Recent history indicates an annual national construction escalation rate of 3.5%. Compounding annually over a significant duration greatly increases final project costs. Breakwaters would occur near project end, resulting in greater risk potential.	Very LIKELY	Significant	4

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Risk level

	Negligible	Marginal	Significant	Critical	Crisis
Very Likely	2	3	4	5	5
Likely	1	2	3	4	5
Possible	0	1	2	3	4
Unlikely	0	0	1	2	3

TABLE K.12 (CONT.)

Risk Element	Feature of Work	Concerns	PDT Discussions & Conclusions (includes logic & justification for choice of likelihood & impact)	Likelihood	Impact	Risk Level
EX-3	Electric Barriers	The external risk here excludes concerns related to permitting, HTRW, real estate, and available funding. Those are addressed separately in the GLMRIS Report. External risks included in the risk register (and contingency) are extreme escalation and delays/impacts by others (outside organizations, municipalities, public interest groups, etc.).	Project delays increase likelihood of scope growth and cost increases. Similarly, multiple interest and political groups can result in unexpected changes and delays. Recent history indicates an annual national construction escalation rate of 3.5%. Compounding annually over a significant duration greatly increases final project costs. Electric barrier construction would occur near project end, resulting in greater risk potential.	Very LIKELY	Significant	4
EX-4	Lock Structures	The external risk here excludes concerns related to permitting, HTRW, real estate, and available funding. Those are addressed separately in the GLMRIS Report. External risks included in the risk register (and contingency) are extreme escalation and delays/impacts by others (outside organizations, municipalities, public interest groups, etc.).	Project delays increase likelihood of scope growth and cost increases. Similarly, multiple interest and political groups can result in unexpected changes and delays. Recent history indicates an annual national construction escalation rate of 3.5%. Compounding annually over a significant duration greatly increases final project costs. This work occurs near project end, resulting in greater risk potential.	Very LIKELY	Significant	4
EX-5	ANS Treatment Plants	The external risk here excludes concerns related to permitting, HTRW, real estate, and available funding. Those are addressed separately in the GLMRIS Report. External risks included in the risk register (and contingency) are extreme escalation and delays/impacts by others (outside organizations, municipalities, public interest groups, etc.).	Project delays increase likelihood of scope growth and cost increases. Similarly, multiple interest and political groups can result in unexpected changes and delays. Recent history indicates an annual national construction escalation rate of 3.5%. Compounding annually over a significant duration greatly increases final project costs. Treatment plants occur towards the end of project duration; therefore, risks are greater for change and escalation.	Very LIKELY	Significant	4
EX-6	Sluice Gates and Screens	The external risk here excludes concerns related to permitting, HTRW, real estate, and available funding. Those are addressed separately in the GLMRIS Report. External risks included in the risk register (and contingency) are extreme escalation and delays/impacts by others (outside organizations, municipalities, public interest groups, etc.).	Project delays increase likelihood of scope growth and cost increases. Similarly, multiple interest and political groups can result in unexpected changes and delays. Recent history indicates an annual national construction escalation rate of 3.5%. Compounding annually over a significant duration greatly increases final project costs. Sluice gates and screens would occur near project end, resulting in greater risk potential.	Very LIKELY	Significant	4

Risk level

	Negligible	Marginal	Significant	Critical	Crisis
Very Likely	2	3	4	5	5
Likely	1	2	3	4	5
Possible	0	1	2	3	4
Unlikely	0	0	1	2	3

TABLE K.12 (CONT.)

Risk Element	Feature of Work	Concerns	PDT Discussions & Conclusions (includes logic & justification for choice of likelihood & impact)	Likelihood	Impact	Risk Level
EX-7	Tunnels	The external risk here excludes concerns related to permitting, HTRW, real estate, and available funding. Those are addressed separately in the GLMRIS Report. External risks included in the risk register (and contingency) are extreme escalation and delays/impacts by others (outside organizations, municipalities, public interest groups, etc.).	Project delays increase likelihood of scope growth and cost increases. Similarly, multiple interest and political groups can result in unexpected changes and delays. Recent history indicates an annual national construction escalation rate of 3.5%. Compounding annually over a significant duration greatly increases final project costs. Tunnel construction starts earlier than some other features, reducing some of risk concerns. Public concerns remain high.	Likely	Significant	3
EX-8	Reservoirs	The external risk here excludes concerns related to permitting, HTRW, real estate, and available funding. Those are addressed separately in the GLMRIS Report. External risks included in the risk register (and contingency) are extreme escalation and delays/impacts by others (outside organizations, municipalities, public interest groups, etc.).	Project delays increase likelihood of scope growth and cost increases. Similarly, multiple interest and political groups can result in unexpected changes and delays. Recent history indicates an annual national construction escalation rate of 3.5%. Compounding annually over a significant duration greatly increases final project costs. Reservoirs are comprised mostly of excavation, and construction start is sooner.	Likely	Significant	3
EX-9	Reservoir Pump Stations	The external risk here excludes concerns related to permitting, HTRW, real estate, and available funding. Those are addressed separately in the GLMRIS Report. External risks included in the risk register (and contingency) are extreme escalation and delays/impacts by others (outside organizations, municipalities, public interest groups, etc.).	Project delays increase likelihood of scope growth and cost increases. Similarly, multiple interest and political groups can result in unexpected changes and delays. Recent history indicates an annual national construction escalation rate of 3.5%. Compounding annually over a significant duration greatly increases final project costs. The pump station work occurs near project end, resulting in greater risk potential.	Very LIKELY	Significant	4
EX-10	Sediment Remediation	The external risk here excludes concerns related to permitting, HTRW, real estate, and available funding. Those are addressed separately in the GLMRIS Report. External risks included in the risk register (and contingency) are extreme escalation and delays/impacts by others (outside organizations, municipalities, public interest groups, etc.).	Project delays increase likelihood of scope growth and cost increases. Similarly, multiple interest and political groups can result in unexpected changes and delays. Recent history indicates an annual national construction escalation rate of 3.5%. Compounding annually over a significant duration greatly increases final project costs. Sediment remediation work would occur near project end, resulting in greater risk potential.	Very LIKELY	Significant	4
EX-11	Preconstruction Engineering & Design	External changes related to scoping and redesign could cause new or redesign efforts.	Most of this risk was addressed in potential scope growth, but the lengthy schedules do open up the possibility for redesign.	Likely	Marginal	2

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Likely	1	2	3	4	5
Possible	0	1	2	3	4
Unlikely	0	0	1	2	3

TABLE K.12 (CONT.)

Risk Element	Feature of Work	Concerns	PDT Discussions & Conclusions (includes logic & justification for choice of likelihood & impact)	Likelihood	Impact	Risk Level
EX-12	Construction Management	Any design changes due to external would mostly impact design. External changes related to weather could impact management oversight.	The costs are already based on local costs; weather impacts should already have been included. No significant further impacts are anticipated.	Possible	Marginal	1