Encinitas-Solana Beach Coastal Storm Damage Reduction Project

San Diego County, California

Appendix F

Cost Estimate

U.S. Army Corps of Engineers
Los Angeles District

December 2012

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1 Overview

This paper discusses the cost assumptions and construction methodology utilized in the Encinitas and Solana Beach Shoreline Feasibility Study.

The Solana Beach-Encinitas shoreline study area is located along the Pacific Ocean in the Cities of Solana Beach and Encinitas, San Diego County, California. The City of Encinitas is approximately 10 miles (mi) south of Oceanside Harbor, and 17 mi north of Point La Jolla. The Encinitas shoreline is about 6 mi long. It is bounded on the north by Batiquitos Lagoon and on the south by San Elijo Lagoon. Immediately south of the City of Encinitas is the City of Solana Beach. Solana Beach is bounded by San Elijo Lagoon to the north and by the City of Del Mar on the south. It is approximately 17 mi south of Oceanside Harbor, and 10 mi north of Point La Jolla. Solana Beach's shoreline is about 2 mi long.

The project area consists of two segments. Segment 1 (Reaches 3, 4, and 5) exists within the City of Encinitas and is approximately 2.0 mi in length; Segment 2 (Reaches 8 and 9) exists within the City of Solana Beach and is approximately 1.4 mi in length.

The non-Federal sponsors are the City of Encinitas and the City of Solana Beach.

Project purpose is to reduce coastal storm damage and shoreline erosion at Encinitas and Solana Beach. Recommended plan involves the use of a hopper dredge to excavate sand from offshore borrow sites and pumping it to Encinitas and Solana Beach.

The Cost Engineering Dredge Estimating Program (CEDEP) program was used to compute hopper dredging unit costs for Encinitas (Segment 1) and Solana Beach (Segment 2). The dredging unit costs were transferred to the Micro-Computer Aided Cost Engineering System, Second Generation (Mii) software program. Current Working Estimate (CWE) meets the Standard USACE Civil Works Work Breakdown Structure (WBS).

2 Direct Cost

Unit costs for mob/demob and hopper dredge operations were calculated using the Hopper Dredge CEDEP program. The CEDEP dredging units cost accounts for the dredging operation of a single event. Unit costs for the pump-out pipelines were calculated on a separate CEDEP run from a division of the Pipeline Dredge CEDEP program. Unit costs for the hopper dredge, pump-out pipeline, mob/demob and shore crews were integrated in MCACES (MII). There are a total of three MCACES (MII) estimates. One MII estimate for the initial event, a second MII estimate for subsequent Solana Beach events (one contract) and a third MII estimate for subsequent Encinitas Beach events (one contract).

The total project cost is broken down into three estimates. One estimate was prepared for the initial dredging event where the Solana and Encinitas segments are assumed to be awarded under contract. The initial combined Solana-Encinitas estimate includes associated mitigation and monitoring cost incurred within the first 5 years for the Encinitas reach and the first 13 years for the Solana reach. The other two estimates were prepared, individually, for Solana and Encinitas subsequent dredging events including associated mitigation and monitoring costs lapsing through the remaining years of the 50-yr project.

Labor rates used to develop the estimate were provided from latest Davis-Bacon Wage Rates for San Diego County, Heavy and Dredging.

Equipment rates are based on the US Army Corps of Engineers EP 1110-1-8 “Construction Equipment Ownership and Expense Schedule”, Region 7 and CEDEP.

Crews were developed for project specific application and are listed in the crew database.

3 Dredge Quantity and Material Analysis

In Encinitas (Segment 1), approximately 820,000 CY of beach quality sand would be initially placed along 1.5 mi of shoreline providing a nourishment width of 100 ft. The beach fill would then naturally slope seaward at a slope of 10:1. Beach replenishment of an additional sand volume of 336,469 CY would occur on average every 5 years within the 50-year project lifetime.

In Solana (Segment 2), approximately 1,180,000 CY of beach quality sand would be initially placed along 1.4 mi of the shoreline, providing a nourishment width of 200 ft. The beach fill would then naturally slope seaward at a slope of 10:1. Beach replenishment of an additional sand volume of 499,299 CY would occur on average every 13 years within the 50-year project lifetime.

Dredging area within the CEDEP program is based on the given volumes for each segment and a bank height of 3-feet.

Material classification assumed: 6% fines, 92% sand and 2% gravel. Material classification is directly linked to the excavating or pumping rate of the dredge.

4 Dredge Equipment Selection

Equipment selection and sizing were developed through construction cost estimator experience and consultation with the designer and study manager.

A medium-sized hopper dredge with pump-out capabilities is selected due to the long haul from the sand source to the receiver beach. Selected hopper maximum safe load capacity is 2,500 CY; however the effective capacity is 1,750 CY for sandy material. The hopper pump-out capabilities permit reverse pumping the dredge material via a pipeline.

The dredge and construction equipment are expected to operate on a 24/7 basis. Construction is planned to occur during a period of seasonably mild wave climate between April and September. And two (2) beach access/temporary staging areas will be required for the term of construction.

5 Fuel Adjustments

Of all the dredging equipment available, hopper dredges are the most sensitive to fuel price fluctuations. Out-in-the-ocean delivery marine diesel fuel cost was estimated from a quote from a local supplier.

6 Quantity Analysis

Quantities are based on dredged volumes instead of placement volumes. Dredge quantities assume 20% loss by volume. Placement quantities are based on shoreline modeling and erosion rates.

Take-off and hauling distances were provided by Noble Consultants (Chia Chi Lu, PE). Given volumes were used to run the CEDEP estimates and develop dredging unit costs.

7 Dredging Construction Methodology

Dredging operation mirrors the beach nourishment work that took place at San Diego, in 2001. The selected hopper is equipped with an installation at the bow of the ship, which makes it possible to connect to a moored floating/sunken pipeline in the open sea.

The first step in beginning the beach replenishment process involves transporting and installing the sunken/floating beach access pipeline. The dredge is attached to a floating section of the pipeline which is connected to the submerged pipeline section.

The hopper dredge is filled at the designated S0-6 borrow site and hauled 2.5 miles to Encinitas (Segment 1) and 1.9 miles to Solana (Segment 2). At the receiver beach, the dredge is attached to a moored floating section of pipeline extending 2,640 feet to the shoreline. The material is re-suspended and discharged through its on-board pumping system to the receiver site.

Total pump-out pipeline length consists of 2,640 LF of submerged/floating pipeline, in addition to the shore pipeline. Shore pipeline length amounts to 1,500 lf for the Encinitas segment and 3,500 lf for the Solana segment.

For the Encinitas segment the mooring site where the hopper dredge connects to pump-out the slurry to the shore will be relocated 3 times.

The Solana segment allows for only one central pump out slurry location, therefore pump-out mooring site once established will not be relocated.

Remove submerged and shore pipeline upon completion.

The shore crew was broken down in two parts: morning crew and night (skeleton) crew. The morning crew consists of a loader (severe conditions), a dozer (severe conditions), fill placer, shoremen and a superintendent. The morning crew will build berms, contain the slurry, and build a gigantic hole for the night pumping. The beach is graded so that a basin is created by the morning crew to contain the slurry pumped at night.

8 Dredge Mobilization and Demobilization

Includes hopper dredge and moored/sunken pipeline transfer, setup and dismantle. Since there is very little hopper dredge work on the west coast, a more likely scenario is that a hopper dredge would mob/demob from the Gulf of Mexico or from the east coast. The distance from New Orleans to Los Angeles is approximately 4,300 nautical miles (5,000 statute miles).

9 Dredging Schedule

Dredging operation is performed 24-hours a day, 7 days a week. Dredging shore crew operation is performed 12-hours a day, 7 days a week. Contract restrictions limit our operating time on the beach to meet noise ordinances. Dredging contracts limit heavy equipment

operations on the beach between 7:00 am and 7:00 pm, but marine equipment is allowed to work 24-hours a day.

The shore crew was broken down in two parts: morning crew and night (skeleton) crew. The morning crew consists of a loader (severe conditions), a dozer (severe conditions), fill placer, shoremen and a superintendent. The morning crew will build berms, contain the slurry, and build a gigantic hole for the night pumping if needed. The shore night crew is for safety.

Estimated initial dredging duration amounts to 7 months, excluding mob/demob. Project duration per nourishment event is approximately 2 months for the Encinitas beach replenishment and an additional 2 months for the Solana beach replenishment, excluding mob/demob.

10 Mitigation Costs

Habitat mitigation costs consist of kelp mitigation, and kelp transplanting.

10.1 Kelp Reef Mitigation

The overall purpose is to create a reef kelp habitat to offset lost habitat. Costs are associated only with Solana Beach reef mitigation. Encinitas beach nourishment does not result into kelp habitat loss.

The profile of the reef consists of a single rock layer rising no more than 1.5 feet off the existing sand seafloor. Quarry boulders are the exclusive construction material used to build reefs, specifically quarter-ton rock. Assume quarry boulders are transported to the placement site utilizing tugboats towing either 1 or 2 flat deck barges. Boulders are mined from quarries at Santa Catalina Island. As a reference, the project by Southern California Edison on the Wheeler North Reef at San Clemente (2008) had a variation of boulder deposition ranging from 743 to 987 tons per acre with an average of 865 tons/acre. Based on the Wheeler North Reef at San Clemente assume an overall average tonnage per acre of 685 with a coverage of 42% to 66% (average of 54% coverage).

Initially a derrick barge is positioned by tugboat above the designated dumping area. Motorized winch anchor lines moor the derrick barge within the boundary. During boulder deposition, the derrick barge is guided into the designated position by winching in or out on anchor cables connected to their respective anchors. Each anchor is connected by a cable to a concrete anchor block and then cabled to the derrick-barge. The locations of the anchors are routinely monitored by an attending tugboat and by the derrick barge winch operator. After securely tethering the supply-barge to the derrick-barge, the derrick-barge winch operator maneuvers the edge of the flat deck barge to the required position. The derrick-barge winch operator assists in locating the edge of the supply barge at the exact line of deployment. The stone is pushed in a windrows by a track dozer over the edge of the supply barge. Assume stone is allowed to be placed during day light hours, only. No placement is done at night, except for hauling.

Assume contract allows lead time for the quarry to fabricate the stone ahead of time.
Work schedule is 12 hr/day, 7 day/week.

10.2 Kelp Transplant Mitigation

The purpose is to transplant reef kelp habitat to offset lost habitat. Costs are associated only with Solana Beach reef mitigation since Encinitas beach nourishment does not result into kelp habitat loss. Mitigation involves transplanting adult plants and sporophylls. Assume kelp is harvested from around the project site. Kelp transplant will take place in deep waters. A pre-survey of the planting area will determine the planting grid. Harvesting and transplanting occurs within a 24-hr period. Divers harvest the kelps and hand them over to the boat crew for planting preparation. The kelp is attached to a CMU block and lowered to the mitigation site sea floor by a small crane.

Work schedule is 5 days/wk, 10 hr/day.
Assume work is subcontracted by the prime marine contractor.

10.3 Environmental Monitoring

Environmental monitoring takes places before, during and after dredging for each event. It starts with an Environmental Impact Assessment (EIA) to establish the environmental status of the project and predict how it would change after the project. During the project the environmental monitoring is conducted to confirm that management plan is having the desired effect. Continuation of the monitoring after the project's completion guarantees no long-term negative impacts. Work will be contracted out. Cost obtained from Planning Division, including markups.

10.4 Physical Monitoring

Physical monitoring involves measuring changes is elevation and volume through successive bathymetric surveys; taking sand samples; and measuring beach profiles. Physical monitoring is needed to quantify the benefits of the sand replenishment project. Work will be contracted out. Costs obtained from Coastal Design and include markups.

Additional lagoon sedimentation maintenance costs for San Dieguito, San Elijo and Batiquitos were provided by lagoon managers. Costs are based on on-going lagoon maintenance costs for their dredging cost maintenance.

11 Dredging Contractor Markups

The CWE is based on performing the work using the “Invitation for Bid” contract mechanism.

12 Planning, Engineering and Design (PED) and Construction Management

Planning, Engineering and Design (PED) and Construction Management estimates were based on labor-hour estimates provided by section chiefs. Associated burdened hourly rates were extracted from CEFMS.

13 Contingency

Contingency was derived from the Cost and Schedule Risk Analysis (CSRA). Please refer to the risk analysis study.

14 Escalation

Construction Escalation is based on the Civil Works Construction Cost Index System (CWCCIS) EM 1110-2-1304, dated 30 September 2012.

PED and Construction Management Escalation is based on EC 11-2-202 Table 1, Class 1 (Government Personnel)

Real Estate escalation is based on the Construction Price Yearly Index (CPI)

Estimate was inflated to mid-point of construction for the initial and subsequent nourishment events starting on 2015.

Please refer to the Total Project Cost Summary (TPCS) for breakdown.

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

PROJECT: Solana - Encinitas Coastal Storm Damage Reduction (LOW SLR)
LOCATION: San Diego, CA

DISTRICT: Los Angeles District PREPARED: December 4, 2012
POC: Juan Dominguez, Cost Engineering

Public Draft Report (PDR)

		ESTIMATED COST				PROJECT FIRST COST (Constant Dollar Basis)				TOTAL PROJECT COST (FULLY FUNDED)			
		Mii Estimate Prepared: October 20, 2012				Program Year: 2015 Effective Price Level Date: 1 Oct 2014							
WBS NUMBER	Civil Works Feature & Sub-Feature Description	COST ($K)	CNTG ($K)	CNTG (%)	TOTAL ($K)	ESC (%)	COST ($K)	CNTG ($K)	TOTAL ($K)	Spent Thru: 1 Oct 2014 ($K)	COST ($K)	CNTG ($K)	FULL ($K)
17	BEACH REPLENISHMENT	82,972	25,642	31%	108,614	3.9%	86,186	26,639	112,825		126,765	39,180	165,945
06	FISH & WILDLIFE FACILITIES MITIGATION	2,047	921	45%	2,968	3.9%	2,127	956	3,083		2,234	1,005	3,239
	CONSTRUCTION ESTIMATE TOTALS:	85,019	26,563		111,582		88,313	27,595	115,908		128,999	40,185	169,184
06	FISH & WILDLIFE FACILITIES MITIGATION - NFS	14,370	6,467	45%	20,837	3.9%	14,927	6,718	21,645		22,696	10,212	32,908
01	LANDS AND DAMAGES	189	28	15%	217	9.5%	207	30	237		314	46	360
30	PLANNING, ENGINEERING & DESIGN	26,009	3,902	15%	29,911	3.7%	26,969	4,045	31,014		37,323	5,597	42,920
31	CONSTRUCTION MANAGEMENT	6,974	1,046	15%	8,020	3.7%	7,232	1,085	8,317		9,278	1,392	10,670
	PROJECT COST TOTALS:	132,561	38,006	29%	170,567		137,648	39,473	177,121		198,610	57,432	**256,042**

CHIEF, COST ENGINEERING, Mike Newnam

Project Management, Susie Ming

CHIEF, REAL ESTATE, Theresa Kaplan

CHIEF, ENGINEERING, Richard Leifield

ESTIMATED FEDERAL COST:	**116,347**
ESTIMATED NON-FEDERAL COST:	**139,695**
ESTIMATED TOTAL PROJECT COST:	**256,042**

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

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

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WBS NUMBER	Civil Works Feature & Sub-Feature Description	COST ($K)	CNTG ($K)	CNTG (%)	TOTAL ($K)	ESC (%)	COST ($K)	CNTG ($K)	TOTAL ($K)	Mid-Point Date	ESC (%)	COST ($K)	CNTG ($K)	FULL ($K)
	ENCINITAS & SONATA BEACH NOURISHMENT INITIAL EVENT													
17	Solana - Encinitas Initial Beach Nourishment (Yr 2015)	17,362	5,365	31%	22,727	3.9%	18,035	5,573	23,608	2015Q4	1.4%	18,280	5,649	23,929
06	Solana - Reef Mitigation (Yr 2017)	1,847	831	45%	2,678	3.9%	1,919	863	2,782	2017Q4	5.0%	2,016	907	2,923
06	Solana - Kelp Transplant Mitigation (Yr 2017)	200	90	45%	290	3.9%	208	93	301	2017Q4	5.0%	218	98	316
	CONSTRUCTION ESTIMATE TOTALS:	19,409	6,286	32%	25,695		20,162	6,529	26,691			20,514	6,654	27,168
06	Solana - Table Tops Reef Mitigation (Yr 2017) - NFS	250	113	45%	363	3.9%	260	117	377	2017Q2	4.1%	271	122	393
06	Encinitas Post-Construction Bio Survey (Monitoring)-NFS (Yr 2014 and Yr 2016)	129	58	45%	187	3.9%	134	60	194	2015Q2	0.5%	135	60	195
06	Solana Post-Construction Bio Survey (Monitoring) - NFS (Yr 2014 and Yr 2016)	129	58	45%	187	3.9%	134	60	194	2015Q2	0.5%	135	60	195
06	Encinitas - Physical Monitoring - NFS (Yearly - Yr 2015 thru Yr 2019)	477	215	45%	692	3.9%	495	223	718	2017Q2	4.1%	515	232	747
06	Solana - Physical Monitoring - NFS (Yearly - Yr 2015 thru Yr 2027)	1,240	558	45%	1,798	3.9%	1,288	580	1,868	2021Q2	11.8%	1,440	648	2,088
06	Solana - Environmental Monitoring - NFS (Yearly - Yr 2017 thru Yr 2022)	90	41	45%	131	3.9%	93	43	136	2020Q2	9.8%	102	47	149
06	Encinitas - Lagoon Sedimentation: San Elijo and Batiquitos - NFS (Yearly - Yr 2015 thru Yr 2019) - NFS	336	151	45%	487	3.9%	349	157	506	2017Q2	4.1%	363	163	526
06	Solana - Lagoon Sedimentation: San Dieguito and San Elijo - NFS (Yearly - Yr 2015 thru Yr 2027) - NFS	1,365	614	45%	1,979	3.9%	1,418	638	2,056	2021Q2	11.8%	1,585	713	2,298
01	LANDS AND DAMAGES	33	5	15%	38	9.3%	36	5	41	2014Q4		36	5	41
30	PLANNING, ENGINEERING & DESIGN													
	Project Management	79	12	15%	91	3.7%	82	12	94	2014Q2		82	12	94
	Planning & Environmental Compliance	12	2	15%	14	3.7%	12	2	14	2014Q2		12	2	14
	Engineering & Design	1,306	196	15%	1,502	3.7%	1,354	203	1,557	2014Q2		1,354	203	1,557
	Engineering Tech Review ITR & VE	350	53	15%	403	3.7%	363	55	418	2014Q2		363	55	418
	Contracting	40	6	15%	46	3.7%	41	6	47	2014Q2		41	6	47
	Engineering During Construction	532	80	15%	612	3.7%	552	83	635	2015Q4	1.2%	559	84	643
	Planning During Construction	65	10	15%	75	3.7%	67	10	77	2015Q4	1.2%	68	10	78
	Project Operation													
			PED Subtotal:		2,743		PED Subtotal:		2,842			PED Subtotal:		2,851
31	CONSTRUCTION MANAGEMENT													
	Construction Management	2,526	379	15%	2,905	3.7%	2,619	393	3,012	2015Q4	1.2%	2,651	398	3,049
	Project Operation:													
	Project Management													
	CONTRACT COST TOTALS:	28,368	8,837		37,205		29,459	9,176	38,635			30,226	9,474	**39,700**
COST SPLIT														
65.0%	**FEDERAL COST TOTALS:**				20,373				21,154					21,494
35.0%	**NON-FEDERAL COSTS TOTALS:**				16,832				17,481					18,206

Filename: Solana-Encinitas (TPCS) Updated with Sept CWICCS -- Revised.xlsx
TPCS

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**** CONTRACT COST SUMMARY ****

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DISTRICT: Los Angeles District PREPARED: December 4, 2012
POC: Juan Dominguez, Cost Engineering

Public Draft Report (PDR)

		ESTIMATED COST				PROJECT FIRST COST (Constant Dollar Basis)				TOTAL PROJECT COST (FULLY FUNDED)				
		Mii Estimate Prepared: 2012(Jul - Sep)				Program Year: 2015 Effective Price Level Date: 1 Oct 2014								
WBS NUMBER	Civil Works Feature & Sub-Feature Description	COST ($K)	CNTG ($K)	CNTG (%)	TOTAL ($K)	ESC (%)	COST ($K)	CNTG ($K)	TOTAL ($K)	Mid-Point Date	ESC (%)	COST ($K)	CNTG ($K)	FULL ($K)
	ENCINITAS - 9 PERIODIC BEACH NOURISHMENTS ON 5-YR CYCLES (100-FT beach width)													
17	Encinitas - Subsequent Beach Nourishment (Yr 2020)	5,319	1,644	31%	6,963	3.9%	5,525	1,708	7,233	2020Q3	10.3%	6,095	1,884	7,979
17	Encinitas - Subsequent Beach Nourishment (Yr 2025)	5,319	1,644	31%	6,963	3.9%	5,525	1,708	7,233	2025Q3	20.6%	6,664	2,060	8,724
17	Encinitas - Subsequent Beach Nourishment (Yr 2030)	5,319	1,644	31%	6,963	3.9%	5,525	1,708	7,233	2030Q3	31.9%	7,286	2,252	9,538
17	Encinitas - Subsequent Beach Nourishment (Yr 2035)	5,319	1,644	31%	6,963	3.9%	5,525	1,708	7,233	2035Q3	44.2%	7,965	2,462	10,427
17	Encinitas - Subsequent Beach Nourishment (Yr 2040)	5,319	1,644	31%	6,963	3.9%	5,525	1,708	7,233	2040Q3	57.6%	8,709	2,692	11,401
17	Encinitas - Subsequent Beach Nourishment (Yr 2045)	5,319	1,644	31%	6,963	3.9%	5,525	1,708	7,233	2045Q3	70.8%	9,436	2,917	12,353
17	Encinitas - Subsequent Beach Nourishment (Yr 2050)	5,319	1,644	31%	6,963	3.9%	5,525	1,708	7,233	2050Q3	84.1%	10,171	3,144	13,315
17	Encinitas - Subsequent Beach Nourishment (Yr 2055)	5,319	1,644	31%	6,963	3.9%	5,525	1,708	7,233	2055Q3	97.4%	10,906	3,371	14,277
17	Encinitas - Subsequent Beach Nourishment (Yr 2060)	5,319	1,644	31%	6,963	3.9%	5,525	1,708	7,233	2060Q3	110.7%	11,641	3,599	15,240
	CONSTRUCTION ESTIMATE TOTALS:	47,871	14,796	31%	62,667		49,725	15,372	65,097			78,873	24,381	103,254
06	Encinitas - Physical Monitoring - NFS (Yearly - Yr 2020 thru Yr 2064)	2,167	975	45%	3,142	3.9%	2,251	1,013	3,264	2042Q3	62.8%	3,665	1,649	5,314
06	Encinitas - Lagoon Sedimentation: San Elijo & Batiquitos - NFS (Yearly - Yr 2020 thru Yr 2064)	2,520	1,134	45%	3,654	3.9%	2,618	1,178	3,796	2043Q2	64.8%	4,314	1,941	6,255
01	LANDS AND DAMAGES	117	18	15%	135	9.3%	128	19	147	2042Q3	63.1%	209	31	240
30	PLANNING, ENGINEERING & DESIGN													
	Project Management	549	82	15%	631	3.7%	569	85	654	2039Q3	41.5%	805	120	925
	Planning & Environmental Compliance	108	16	15%	124	3.7%	112	17	129	2039Q3	41.5%	158	24	182
	Engineering & Design	10,333	1,550	15%	11,883	3.7%	10,715	1,607	12,322	2039Q3	41.5%	15,161	2,274	17,435
	Engineering Tech Review ITR & VE	3,073	461	15%	3,534	3.7%	3,187	478	3,665	2039Q3	41.5%	4,509	676	5,185
	Contracting	360	54	15%	414	3.7%	373	56	429	2039Q3	41.5%	528	79	607
	Engineering During Construction	2,756	413	15%	3,169	3.7%	2,858	428	3,286	2040Q3	43.2%	4,092	613	4,705
	Planning During Construction	540	81	15%	621	3.7%	560	84	644	2040Q3	43.2%	802	120	922
	Project Operation													
			PED Subtotal:		20,376		PED Subtotal:		21,129			PED Subtotal:		29,961
31	CONSTRUCTION MANAGEMENT													
	Construction Management	3,240	486	15%	3,726	3.7%	3,360	504	3,864	2040Q3	43.2%	4,811	722	5,533
	Project Operation:													
	Project Management													
	CONTRACT COST TOTALS:	73,634	20,066		93,700		76,456	20,841	97,297			117,927	32,630	**150,557**
COST SPLIT														
50.0%	**FEDERAL COST TOTALS:**				43,385				45,045					69,374
50.0%	**NON-FEDERAL COSTS TOTALS:**				50,315				52,252					81,183

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

**** CONTRACT COST SUMMARY ****

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LOCATION: San Diego, CA

DISTRICT: Los Angeles District PREPARED: December 4, 2012
POC: Juan Dominguez, Cost Engineering

Public Draft Report (PDR)

		ESTIMATED COST				PROJECT FIRST COST (Constant Dollar Basis)				TOTAL PROJECT COST (FULLY FUNDED)				
		Mii Estimate Prepared: 2012(Jul - Sep)				Program Year: 2015 Effective Price Level Date: 1 Oct 2014								
WBS NUMBER	Civil Works Feature & Sub-Feature Description	COST ($K)	CNTG ($K)	CNTG (%)	TOTAL ($K)	ESC (%)	COST ($K)	CNTG ($K)	TOTAL ($K)	Mid-Point Date	ESC (%)	COST ($K)	CNTG ($K)	FULL ($K)
	SOLANA - 3 PERIODIC BEACH NOURISHMENTS ON 13-YR CYCLES (200-FT beach width)													
17	Solana - Subsequent Beach Nourishment (Yr 2028)	5,913	1,827	31%	7,740	3.9%	6,142	1,898	8,040	2028Q3	27.2%	7,815	2,415	10,230
17	Solana - Subsequent Beach Nourishment (Yr 2041)	5,913	1,827	31%	7,740	3.9%	6,142	1,898	8,040	2041Q3	60.1%	9,836	3,039	12,875
17	Solana - Subsequent Beach Nourishment (Yr 2054)	5,913	1,827	31%	7,740	3.9%	6,142	1,898	8,040	2054Q3	94.7%	11,961	3,696	15,657
	CONSTRUCTION ESTIMATE TOTALS:	17,739	5,481	31%	23,220		18,426	5,694	24,120			29,612	9,150	38,762
06	Solana - Physical Monitoring - NFS (Yearly - Yr 2028 thru Yr 2064)	1,782	802	45%	2,584	3.9%	1,851	833	2,684	2046Q2	72.8%	3,198	1,439	4,637
06	Solana - Lagoon Sedimentation: San Dieguito & San Elijo - NFS (Yearly - Yr 2028 thru Yr 2064)	3,885	1,748	45%	5,633	3.9%	4,036	1,816	5,852	2046Q2	72.8%	6,973	3,138	10,111
01	LANDS AND DAMAGES	39	6	15%	45	9.3%	43	6	49	2041Q3	60.8%	69	10	79
30	PLANNING, ENGINEERING & DESIGN													
	Project Management	183	27	15%	210	3.7%	190	28	218	2040Q3	43.2%	272	40	312
	Planning & Environmental Compliance	36	5	15%	41	3.7%	37	5	42	2040Q3	43.2%	53	7	60
	Engineering & Design	3,444	517	15%	3,961	3.7%	3,571	536	4,107	2040Q3	43.2%	5,113	768	5,881
	Engineering Tech Review ITR & VE	1,024	154	15%	1,178	3.7%	1,062	160	1,222	2040Q3	43.2%	1,521	229	1,750
	Contracting	120	18	15%	138	3.7%	124	19	143	2040Q3	43.2%	178	27	205
	Engineering During Construction	919	138	15%	1,057	3.7%	953	143	1,096	2041Q3	44.9%	1,381	207	1,588
	Planning During Construction	180	27	15%	207	3.7%	187	28	215	2041Q3	44.9%	271	41	312
	Project Operation													
			PED Subtotal:		6,792		PED Subtotal:		7,043			PED Subtotal:		10,108
31	CONSTRUCTION MANAGEMENT													
	Construction Management	1,208	181	15%	1,389	3.7%	1,253	188	1,441	2041Q3	44.9%	1,816	272	2,088
	Project Operation:													
	Project Management													
	CONTRACT COST TOTALS:	30,559	9,104		39,663		31,733	9,456	41,189			50,457	15,328	**65,785**
COST SPLIT														
50.0%	**FEDERAL COST TOTALS:**				15,701				16,302					25,479
50.0%	**NON-FEDERAL COSTS TOTALS:**				23,962				24,887					40,306

Encinitas and Solana Beach Fill (Initial)

Estimated by	Juan Dominguez, PE, CCE
Designed by	Art Shak, PE
Prepared by	Los Angeles District
Preparation Date	7/2/2012
Effective Date of Pricing	10/1/2012
Estimated Construction Time	Days

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Description	Quantity	UOM	BareCost	DirectCost	CostToPrime	ProjectCost
Project Summary Report			**19,158,400**	**19,913,650**	**18,201,278**	**23,459,078**
1 Real Estate	**1.00**	**LS**	**33,000**	**33,000**	**0**	**33,000**
2 Solana-Encinitas Initial Beach Replenishment (awarded as one contract)	**1.00**	**LS**	**14,334,203**	**14,706,440**	**14,706,440**	**17,361,893**
2.1 Dredging - Mob/Demob (Initial) -- Assumed awarded as one contract	**1.00**	**LS**	**2,614,650**	**2,762,371**	**2,762,371**	**3,261,156**
2.2 Solana Beach Replenishment (One Cycle) - 200-ft Width, 13-Yr Cycles	**1,180,000.00**	**CY**	**6,785,869**	**6,916,286**	**6,916,286**	**8,165,118**
2.3 Encinitas Beach Replenishment (One Cycle) - 100-ft Width, 5-Yr Cycles	**820,000.00**	**CY**	**4,933,684**	**5,027,783**	**5,027,783**	**5,935,619**
3 Kelp Reef Construction (2:1 mitigation ratio for Solana 200-ft beach width)	**16.20**	**ACR**	**1,352,929**	**1,504,449**	**1,516,415**	**1,846,851**
3.1 Mob/Demob and Set-up	**1.00**	**LS**	**538,800**	**593,648**	**593,648**	**723,007**
3.2 Stone Placement in windrows on the sea floor	**14,000.00**	**TON**	**771,611**	**863,891**	**863,891**	**1,052,137**
3.3 Survey	**1.00**	**LS**	**42,517**	**46,910**	**58,877**	**71,706**
4 Kelp Transplant	**16.20**	**ACR**	**111,783**	**129,745**	**164,407**	**200,232**
4.1 Pre-survey area to establish planting grid	**30.00**	**HR**	**13,223**	**15,968**	**20,234**	**24,644**
4.2 Harvesting kelp	**650.00**	**EA**	**58,025**	**66,746**	**84,578**	**103,008**
4.3 Transport, prepare kelp for planting and placement	**650.00**	**EA**	**40,535**	**47,030**	**59,595**	**72,580**
5 Solana - Table Tops Reef Mitigation (Designed and Built by Others)	**1.00**	**LS**	**178,484**	**201,375**	**176,375**	**250,623**
5.1 Table Top Reef Mitigation	**0.80**	**ACR**	**153,484**	**176,375**	**176,375**	**225,623**
5.2 Design Fees	**1.00**	**LS**	**25,000**	**25,000**	**0**	**25,000**
6 Encinitas Monitoring - Post Construction Bio Survey (Work By Others)	**3.00**	**YR**	**87,907**	**102,600**	**102,600**	**129,405**
6.1 Number of Surveys	**6.00**	**EA**	**87,907**	**102,600**	**102,600**	**129,405**
7 Solana - Monitoring - Post Construction Bio Survey (Work By Others)	**3.00**	**YR**	**87,907**	**102,600**	**102,600**	**129,405**
7.1 Number of Surveys	**6.00**	**EA**	**87,907**	**102,600**	**102,600**	**129,405**
8 Encinitas - Physical Monitoring (Work by Others)	**5.00**	**YR**	**335,316**	**378,154**	**378,154**	**476,948**
8.1 Number of Separate Surveys	**10.00**	**EA**	**335,316**	**378,154**	**378,154**	**476,948**
9 Solana - Physical Monitoring (Work by Others)	**13.00**	**YR**	**871,821**	**983,201**	**983,201**	**1,240,064**
9.1 Number of Separate Surveys	**26.00**	**EA**	**871,821**	**983,201**	**983,201**	**1,240,064**
10 Solana - Environmental Monitoring - Mitigation (Work by Others)	**6.00**	**YR**	**64,050**	**71,086**	**71,086**	**89,657**

Description	Quantity	UOM	BareCost	DirectCost	CostToPrime	ProjectCost
10.1 Off-shore Survey (3 day survey)	**144.00**	**HR**	**64,050**	**71,086**	**71,086**	**89,657**
11 Encinitas - Lagoon Sedimentation - San Elijo & Batiquitos (Work By Others)	**6.00**	**YR**	**336,000**	**336,000**	**0**	**336,000**
12 Solana - Lagoon Sedimentation - San Dieguito & San Elijo (Work By Others)	**13.00**	**YR**	**1,365,000**	**1,365,000**	**0**	**1,365,000**

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2 Solana-Encinitas Initial Beach Replenishment (awarded as one contract) 1
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2.2 Solana Beach Replenishment (One Cycle) - 200-ft Width, 13-Yr Cycles 1
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3 Kelp Reef Construction (2:1 mitigation ratio for Solana 200-ft beach width) 1
3.1 Mob/Demob and Set-up 1
3.2 Stone Placement in windrows on the sea floor 1
3.3 Survey 1
4 Kelp Transplant 1
4.1 Pre-survey area to establish planting grid 1
4.2 Harvesting kelp 1
4.3 Transport, prepare kelp for planting and placement 1
5 Solana - Table Tops Reef Mitigation (Designed and Built by Others) 1
5.1 Table Top Reef Mitigation 1
5.2 Design Fees 1
6 Encinitas Monitoring - Post Construction Bio Survey (Work By Others) 1
6.1 Number of Surveys 1
7 Solana - Monitoring - Post Construction Bio Survey (Work By Others) 1
7.1 Number of Surveys 1
8 Encinitas - Physical Monitoring (Work by Others) 1
8.1 Number of Separate Surveys 1
9 Solana - Physical Monitoring (Work by Others) 1
9.1 Number of Separate Surveys 1
10 Solana - Environmental Monitoring - Mitigation (Work by Others) 1
10.1 Off-shore Survey (3 day survey) 1
10.1 Off-shore Survey (3 day survey) 2
11 Encinitas - Lagoon Sedimentation - San Elijo & Batiquitos (Work By Others) 2
12 Solana - Lagoon Sedimentation - San Dieguito & San Elijo (Work By Others) 2

Encinitas Beach Fill (Nine (9) Subsequent replenishments on 5-yr Cycles)

Estimated by	Juan Dominguez, PE, CCE
Designed by	Art Shak, PE
Prepared by	Los Angeles District
Preparation Date	7/2/2012
Effective Date of Pricing	10/1/2012
Estimated Construction Time	Days

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Description	Quantity	UOM	BareCost	DirectCost	CostToPrime	ProjectCost
Project Summary Report			**51,022,995**	**51,393,366**	**6,204,687**	**52,674,190**
1 Real Estate (9 Cycles)	**1.00**	**LS**	**117,000**	**117,000**	**0**	**117,000**
1.1 Real Estate (9 events)	**9.00**	**EA**	**117,000**	**117,000**	**0**	**117,000**
2 Encinitas Beach Replenishment (Yr 2020)	**1.00**	**LS**	**4,325,394**	**4,502,993**	**4,502,993**	**5,318,960**
2.1 Dredging - Mob/Demob to Encinitas	**1.00**	**LS**	**2,262,864**	**2,349,845**	**2,349,845**	**2,775,650**
2.2 Encinitas Beach Replenishment - Segment 1 (Qty of one replenishment cycle)	**336,469.00**	**CY**	**2,062,530**	**2,153,148**	**2,153,148**	**2,543,310**
3 Encinitas Beach Replenishment (Yr 2025)	**1.00**	**LS**	**5,318,960**	**5,318,960**	**0**	**5,318,960**
3.1 Dredging - Mob-Demob to Encinitas	**1.00**	**LS**	**2,775,650**	**2,775,650**	**0**	**2,775,650**
3.2 Encinitas Beach Replenishment - Segment 1	**1.00**	**LS**	**2,543,310**	**2,543,310**	**0**	**2,543,310**
4 Encinitas Beach Replenishment (Yr 2030)	**1.00**	**LS**	**5,318,960**	**5,318,960**	**0**	**5,318,960**
4.1 Dredging - Mob-Demob to Encinitas	**1.00**	**LS**	**2,775,650**	**2,775,650**	**0**	**2,775,650**
4.2 Encinitas Beach Replenishment - Segment 1	**1.00**	**LS**	**2,543,310**	**2,543,310**	**0**	**2,543,310**
5 Encinitas Beach Replenishment (Yr 2035)	**1.00**	**LS**	**5,318,960**	**5,318,960**	**0**	**5,318,960**
5.1 Dredging - Mob-Demob to Encinitas	**1.00**	**LS**	**2,775,650**	**2,775,650**	**0**	**2,775,650**
5.2 Encinitas Beach Replenishment - Segment 1	**1.00**	**LS**	**2,543,310**	**2,543,310**	**0**	**2,543,310**
6 Encinitas Beach Replenishment (Yr 2040)	**1.00**	**LS**	**5,318,960**	**5,318,960**	**0**	**5,318,960**
6.1 Dredging - Mob-Demob to Encinitas	**1.00**	**LS**	**2,775,650**	**2,775,650**	**0**	**2,775,650**
6.2 Encinitas Beach Replenishment - Segment 1	**1.00**	**LS**	**2,543,310**	**2,543,310**	**0**	**2,543,310**
7 Encinitas Beach Replenishment (Yr 2045)	**1.00**	**LS**	**5,318,960**	**5,318,960**	**0**	**5,318,960**
7.1 Dredging - Mob-Demob to Encinitas	**1.00**	**LS**	**2,775,650**	**2,775,650**	**0**	**2,775,650**
7.2 Encinitas Beach Replenishment - Segment 1	**1.00**	**LS**	**2,543,310**	**2,543,310**	**0**	**2,543,310**
8 Encinitas Beach Replenishment (Yr 2050)	**1.00**	**LS**	**5,318,960**	**5,318,960**	**0**	**5,318,960**
8.1 Dredging - Mob-Demob to Encinitas	**1.00**	**LS**	**2,775,650**	**2,775,650**	**0**	**2,775,650**
8.2 Encinitas Beach Replenishment - Segment 1	**1.00**	**LS**	**2,543,310**	**2,543,310**	**0**	**2,543,310**
9 Encinitas Beach Replenishment (Yr 2055)	**1.00**	**LS**	**5,318,960**	**5,318,960**	**0**	**5,318,960**
9.1 Dredging - Mob-Demob to Encinitas	**1.00**	**LS**	**2,775,650**	**2,775,650**	**0**	**2,775,650**

Description	Quantity	UOM	BareCost	DirectCost	CostToPrime	ProjectCost
9.2 Encinitas Beach Replenishment - Segment 1	**1.00**	**LS**	**2,543,310**	**2,543,310**	**0**	**2,543,310**
10 Encinitas Beach Replenishment (Yr 2060)	**1.00**	**LS**	**5,318,960**	**5,318,960**	**0**	**5,318,960**
10.1 Dredging - Mob-Demob to Encinitas	**1.00**	**LS**	**2,775,650**	**2,775,650**	**0**	**2,775,650**
10.2 Encinitas Beach Replenishment - Segment 1	**1.00**	**LS**	**2,543,310**	**2,543,310**	**0**	**2,543,310**
11 Physical Monitoring (NFS)	**45.00**	**YR**	**1,508,921**	**1,701,694**	**1,701,694**	**2,166,551**
11.1 Number of Separate Surveys	**45.00**	**EA**	**1,508,921**	**1,701,694**	**1,701,694**	**2,166,551**
12 Lagoon Sedimentation - San Elijo and Batiquitos (NFS)	**45.00**	**EA**	**2,520,000**	**2,520,000**	**0**	**2,520,000**
12.1 Lagoon Sedimentation - San Elijo (Construction to be done by other agencies)	**45.00**	**YR**	**45,000**	**45,000**	**0**	**45,000**
12.2 Lagoon Sedimentation - Batiquitos (Construction to be done by other agencies)	**45.00**	**YR**	**2,475,000**	**2,475,000**	**0**	**2,475,000**

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Project Summary Report	**1**
1 Real Estate (9 Cycles)	1
1.1 Real Estate (9 events)	1
2 Encinitas Beach Replenishment (Yr 2020)	1
2.1 Dredging - Mob/Demob to Encinitas	1
2.2 Encinitas Beach Replenishment - Segment 1 (Qty of one replenishment cycle)	1
3 Encinitas Beach Replenishment (Yr 2025)	1
3.1 Dredging - Mob-Demob to Encinitas	1
3.2 Encinitas Beach Replenishment - Segment 1	1
4 Encinitas Beach Replenishment (Yr 2030)	1
4.1 Dredging - Mob-Demob to Encinitas	1
4.2 Encinitas Beach Replenishment - Segment 1	1
5 Encinitas Beach Replenishment (Yr 2035)	1
5.1 Dredging - Mob-Demob to Encinitas	1
5.2 Encinitas Beach Replenishment - Segment 1	1
6 Encinitas Beach Replenishment (Yr 2040)	1
6.1 Dredging - Mob-Demob to Encinitas	1
6.2 Encinitas Beach Replenishment - Segment 1	1
7 Encinitas Beach Replenishment (Yr 2045)	1
7.1 Dredging - Mob-Demob to Encinitas	1
7.2 Encinitas Beach Replenishment - Segment 1	1
8 Encinitas Beach Replenishment (Yr 2050)	1
8.1 Dredging - Mob-Demob to Encinitas	1
8.2 Encinitas Beach Replenishment - Segment 1	1
9 Encinitas Beach Replenishment (Yr 2055)	1
9.1 Dredging - Mob-Demob to Encinitas	1
9.2 Encinitas Beach Replenishment - Segment 1	1
9.2 Encinitas Beach Replenishment - Segment 1	2
10 Encinitas Beach Replenishment (Yr 2060)	2
10.1 Dredging - Mob-Demob to Encinitas	2
10.2 Encinitas Beach Replenishment - Segment 1	2
11 Physical Monitoring (NFS)	2
11.1 Number of Separate Surveys	2
12 Lagoon Sedimentation - San Elijo and Batiquitos (NFS)	2
12.1 Lagoon Sedimentation - San Elijo (Construction to be done by other agencies)	2
12.2 Lagoon Sedimentation - Batiquitos (Construction to be done by other agencies)	2

Solana Beach Fill (Three (3) Subsequent replenishments on 13-yr Cycles)

Estimated by	Juan Dominguez, PE, CCE
Designed by	Art Shak, PE
Prepared by	Los Angeles District
Preparation Date	7/2/2012
Effective Date of Pricing	10/1/2012
Estimated Construction Time	Days

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Description	Quantity	UOM	BareCost	DirectCost	CostToPrime	ProjectCost
Project Summary Report			**21,940,282**	**22,175,996**	**6,425,204**	**23,446,131**
1 Real Estate (3 cycles)	**1.00**	**LS**	**39,000**	**39,000**	**0**	**39,000**
1.1 Real Estate (3 events)	**3.00**	**EA**	**39,000**	**39,000**	**0**	**39,000**
2 Solana Beach Replenishment (Yr 2028)	**1.00**	**LS**	**4,948,822**	**5,026,034**	**5,026,034**	**5,913,396**
2.1 Dredging - Mob/Demob to Solana	**1.00**	**LS**	**2,114,040**	**2,141,615**	**2,141,615**	**2,519,724**
2.2 Solana Beach Replenishment - Segment 2 (Qty of one replenishment cycle)	**499,299.00**	**CY**	**2,834,782**	**2,884,419**	**2,884,419**	**3,393,672**
3 Solana Beach Replenishment (Yr 2041)	**1.00**	**LS**	**5,913,396**	**5,913,396**	**0**	**5,913,396**
3.1 Dredging - Mob/Demob to Solana	**1.00**	**LS**	**2,519,724**	**2,519,724**	**0**	**2,519,724**
3.2 Solana Beach Replenishment	**1.00**	**LS**	**3,393,672**	**3,393,672**	**0**	**3,393,672**
4 Solana Beach Replenishment (Yr 2054)	**1.00**	**LS**	**5,913,396**	**5,913,396**	**0**	**5,913,396**
4.1 Dredging - Mob/Demob to Solana	**1.00**	**LS**	**2,519,724**	**2,519,724**	**0**	**2,519,724**
4.2 Solana Beach Replenishment	**1.00**	**LS**	**3,393,672**	**3,393,672**	**0**	**3,393,672**
5 Physical Monitoring (NFS)	**37.00**	**YR**	**1,240,669**	**1,399,170**	**1,399,170**	**1,781,944**
5.1 Number of Separate Surveys	**37.00**	**EA**	**1,240,669**	**1,399,170**	**1,399,170**	**1,781,944**
6 Lagoon Sedimentation - San Dieguito and San Elijo (NFS)	**37.00**	**YR**	**3,885,000**	**3,885,000**	**0**	**3,885,000**
6.1 Lagoon Sedimentation - San Dieguito (Construction to be done by other agencies)	**37.00**	**YR**	**3,848,000**	**3,848,000**	**0**	**3,848,000**
6.2 Lagoon Sedimentation - San Elijo (Construction to be done by other agencies)	**37.00**	**YR**	**37,000**	**37,000**	**0**	**37,000**

Description	Page

Project Summary Report **1**
1 Real Estate (3 cycles) 1
1.1 Real Estate (3 events) 1
2 Solana Beach Replenishment (Yr 2028) 1
2.1 Dredging - Mob/Demob to Solana 1
2.2 Solana Beach Replenishment - Segment 2 (Qty of one replenishment cycle) 1
3 Solana Beach Replenishment (Yr 2041) 1
3.1 Dredging - Mob/Demob to Solana 1
3.2 Solana Beach Replenishment 1
4 Solana Beach Replenishment (Yr 2054) 1
4.1 Dredging - Mob/Demob to Solana 1
4.2 Solana Beach Replenishment 1
5 Physical Monitoring (NFS) 1
5.1 Number of Separate Surveys 1
6 Lagoon Sedimentation - San Dieguito and San Elijo (NFS) 1
6.1 Lagoon Sedimentation - San Dieguito (Construction to be done by other agencies) 1
6.2 Lagoon Sedimentation - San Elijo (Construction to be done by other agencies) 1

US Army Corps
of Engineers®

Solana-Encinitas Coastal Storm Damage Reduction Project

Feasibility Study – Public Draft Report (PDR)

Project Cost and Schedule Risk Analysis Report

Prepared for:

U.S. Army Corps of Engineers,
Los Angeles District

Prepared by:

Juan Dominguez, PE, CCE
U.S. Army Corps of Engineers
Cost Engineering

November 26, 2012

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EXECUTIVE SUMMARY

Under the auspices of the US Army Corps of Engineers (USACE), Los Angeles District, this report presents a recommendation for the total project cost and schedule contingencies for the Encinitas-Solana Beach Coastal Storm Damage Reduction Project. In compliance with Engineer Regulation (ER) 1110-2-1302 CIVIL WORKS COST ENGINEERING, dated September 15, 2008, a formal risk analysis study was conducted for the development of contingency on the total project cost. The purpose of this risk analysis study was to establish project contingencies by identifying and measuring the cost and schedule impact of project uncertainties with respect to the estimated total project cost.

Specific to the Encinitas-Solana Beach Coastal Storm Damage Reduction Project, the most likely total project cost (at price level) is estimated at approximately $133 Million. Based on the results of the analysis, the Cost Engineering Section (Los Angeles District) recommends a contingency value of $38 Million, or 29%.

Executive Summary on the Cost Risk.

Contingency includes $37 Million (97%) for cost growth potential due to risk analyzed in the base cost estimate. The key cost risk drivers are volume variations, fuel prices, mitigation functional replacement, bidding climate, and scope definition which together contribute approximately 75 percent of the statistical cost variance.

Executive Summary on the Schedule Risk.

Contingency includes $1 Million (3%) for cost growth potential due to risk analyzed in the baseline schedule. The key schedule risk drivers are impact of hopper size, small business set-aside, and funding stream which together contribute over 50 percent of the statistical schedule variance. Since the project consists of an initial construction event followed by twelve short subsequent construction events within five and thirteen years intervals, the total project schedule (50 years) includes enough float time to absorb most of the schedule risk. Therefore, the total project risk unfolds mainly from the construction cost risk instead of the schedule risk.

Executive Summary on Risk Analysis procedure.

A separate contingency was calculated for each major project feature: beach nourishment; mitigation; real estate; planning, engineering and design; and construction management. Identified risks were distributed into three categories: risks associated with beach nourishment (dredging); risks directly connected with mitigation; and general project risks impacting all project items. General project risks encompass cited features; real estate; planning, engineering and design; and construction management.

The Los Angeles District performed the risk analysis using the *Monte Carlo* technique, producing the aforementioned contingencies and identifying key risk drivers.

The following table ES-1 portrays the development of contingencies. Contingencies are based on an 80% confidence level, as per USACE Civil Works guidance.

Table ES-1 Contingency Analysis Tables

Most Likely Cost Estimate for Beach Nourishment	**$82,972,000**	
Confidence Level	**Value ($$)**	**Contingency (%)**
50%	$13,817,762	16.7%
80%	**$25,481,467**	**30.7%**
100%	$106,641,805	128.5%

Most Likely Cost Estimate for Mitigation	**$16,417,000**	
Confidence Level	**Value ($$)**	**Contingency (%)**
50%	$4,376,677	26.7%
80%	**$7,448,751**	**45.4%**
100%	$15,221,286	92.7%

Most Likely Cost Estimate for Real Estate	**$189,000**	
Confidence Level	**Value ($$)**	**Contingency (%)**
50%	$18,721	9.9%
80%	**$28,648**	**15.2%**
100%	$53,152	28.1%

Most Likely Cost Estimate for PED	**$26,009,000**	
Confidence Level	**Value ($$)**	**Contingency (%)**
50%	$2,576,251	9.9%
80%	**$3,942,348**	**15.2%**
100%	$7,314,470	28.1%

Most Likely Cost Estimate for Construction Management	$6,974,000	
Confidence Level	**Value ($$)**	**Contingency (%)**
50%	$690,791	9.9%
80%	**$1,057,093**	**15.2%**
100%	$1,961,287	28.1%

The following table ES-2 portrays the full costs of the recommended alternative based on the anticipated contracts. The costs are intended to address the congressional request of estimates to implement the project. The contingency is based on an 80% confidence level, as per accepted USACE Civil Works guidance.

Table ES-2. Cost Summary

Encinitas-Solana		COST ($1,000)	CNTG ($1,000)	TOTAL ($1,000)
01	LANDS AND DAMAGES	189	28	217
06	FISH AND WILDLIFE FACILITIES (FED)	2,047	921	2,968
06	FISH AND WILDLIFE FACILITIES (NFS)	14,370	6,467	20,837
17	BEACH NOURISHMENT	82,972	25,642	108,614
30	PLANNING, ENGINEERING AND DESIGN	26,009	3,902	29,911
31	CONSTRUCTION MANAGEMENT	6,974	1,046	8,020
TOTAL PROJECT COSTS		**132,561**	**38,006**	**170,567**
Schedule Completion with Contingency		**1 Mar 2015**	**578 months**	**1 May 2063**

Notes:
1) All costs include recommended contingency..
2) Costs exclude O&M and Life Cycle Cost estimates.

KEY FINDINGS/OBSERVATIONS RECOMMENDATIONS

The key cost risk drivers identified through sensitivity analysis were volume variations (T-1), fuel prices (EST-3), mitigation functional replacement (ENV-6), bidding climate (PR-3), and scope definition (PPM-2) which together contribute approximately 75 percent of the statistical cost variance. Volume variations (T-1) represent concern on dredging volumes, quantities are based on projected beach profiles and quantity changes are likely. Fuel prices (EST-30) represent concern that rising fuel prices will cause significant cost growth. Mitigation functional replacement (ENV-6) represents concern that estimated ratio, if differ from that assumed in the estimate, could cause variance in costs. Bidding climate (PR-3) represents concern that market conditions

could impact project cost. Scope definition (PPM-2) represents concern that over the life of the project the scope may change.

The key schedule risk drivers identified through sensitivity analysis were impact of hopper size (EST-1), small business set-aside (CA-2) and funding stream (PPM-2) which together contribute over 50 percent of the statistical schedule variance. Hopper size (EST-1) represents concern that size of hopper dredges actually used, if they differ from that assumed in the estimate, could cause schedule variance. Small business set-aside (CA-2) represents concern that biological monitoring could cause project delays since there are monitoring services in the overall implementation. Funding stream (PPM-2) represents concern that federal and/or non-federal appropriations delays may impact the project schedule.

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

MAIN REPORT

1.0 PURPOSE

Under the auspices of the US Army Corps of Engineers (USACE), Los Angeles District, this report presents a recommendation for the total project cost and schedule contingencies for the Solana-Encinitas Coastal Storm Damage Reduction Project.

2.0 BACKGROUND

Project purpose is to reduce coastal storm damage and shoreline erosion at Encinitas and Solana Beach. Recommended plan consists of beach replenishment activities. On-shore placement involves a trailing suction hopper dredge excavating sand from an off-shore borrow site, hauling and pumping it to the receiver beaches.

The initial dredging event combines the Encinitas and Solana Beaches under one contract award. Initial dredge volume equals 820,000 CY for Encinitas and 1,180,000 CY for Solana Beach totaling 2,000,000 CY. Each subsequent nourishment cycle quantity amounts to 336,469 CY for Encinitas and 499,299 CY Solana Beach.

Encinitas (Segment 1) has an initial width addition of 100-feet and periodic replenishment intervals of 5-years; and Solana Beach (Segment 2) has an initial width addition of 300-feet and periodic replenishment intervals of 13-years. Encinitas replenishment cycles amount to a total of nine (9) events and Solana Beach replenishment events amount to three events (3) totaling twelve (12) subsequent sand nourishment events.

The Recommended Plan is the Locally Preferred Plan.

Costs are based on actual dredged volume in lieu of quantity placed on the receiver beach.

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

3.0 REPORT SCOPE

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

3.1 Project Scope

The formal process included extensive involvement of the PDT for risk identification and the development of the risk register. The analysis process evaluated the most likely Micro Computer Aided Cost Estimating System (MCACES) cost estimate, schedule, and funding profiles using Crystal Ball software to conduct a *Monte Carlo* simulation and statistical sensitivity analysis, per the guidance in Engineer Technical Letter (ETL) CONSTRUCTION COST ESTIMATING GUIDE FOR CIVIL WORKS, dated September 30, 2008.

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

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

3.2 USACE Risk Analysis Process

The risk analysis process for this study follows the USACE Headquarters requirements as well as the guidance provided by the Cost Engineering Dx. The risk analysis process reflected within this report uses probabilistic cost and schedule risk analysis methods within the framework of the Crystal Ball software. Furthermore, the scope of the report includes the identification and communication of important steps, logic, key assumptions, limitations, and decisions to help ensure that risk analysis results can be appropriately interpreted.

Risk analysis results are also intended to provide project leadership with contingency information for scheduling, budgeting, and project control purposes, as well as to provide tools to support decision making and risk management as the project progresses through planning and implementation. To fully recognize its benefits, cost and schedule risk analysis should be considered as an ongoing process conducted concurrent to, and iteratively with, other important project processes such as scope and

execution plan development, resource planning, procurement planning, cost estimating, budgeting and scheduling.

In addition to broadly defined risk analysis standards and recommended practices, this risk analysis was performed to meet the requirements and recommendations of the following documents and sources:

- Cost and Schedule Risk Analysis Process guidance prepared by the USACE Cost Engineering Dx.

- Engineer Regulation (ER) 1110-2-1302 CIVIL WORKS COST ENGINEERING, dated September 15, 2008.

- Engineer Technical Letter (ETL) CONSTRUCTION COST ESTIMATING GUIDE FOR CIVIL WORKS, dated September 30, 2008.

4.0 METHODOLOGY / PROCESS

Cost Engineering, Los Angeles District, facilitated a risk identification and qualitative analysis meeting with the PDT on October 18, 2012. The risk identification meeting also included qualitative analysis to produce a risk register that served as the framework for the risk analysis.

The initial cost and schedule risk models were completed and results reported on November 06, 2012. Revisions and iterations of the cost and schedule risk model took place between November 15, 2012 and November 27, 2012. The final results were completed and reported on November 28, 2012.

The risk analysis process for this study is intended to determine the probability of various cost outcomes and quantify the required contingency needed in the cost estimate to achieve any desired level of cost confidence.

In simple terms, contingency is an amount added to an estimate to allow for items, conditions or events for which the occurrence or impact is uncertain and that experience will likely result in additional costs being incurred or additional time being required. The amount of contingency included in project control plans depends, at least in part, on the project leadership's willingness to accept risk of project overruns. The less risk that project leadership is willing to accept the more contingency should be applied in the project control plans. The risk of overrun is expressed, in a probabilistic context, using confidence levels.

The Cost Dx guidance for cost and schedule risk analysis generally focuses on the 80-percent level of confidence (P80) for cost contingency calculation. It should be noted

that use of P80 as a decision criteria is a risk averse approach (whereas the use of P50 would be a risk neutral approach, and use of levels less than 50 percent would be risk seeking). Thus, a P80 confidence level results in greater contingency as compared to a P50 confidence level. The selection of contingency at a particular confidence level is ultimately the decision and responsibility of the project's District and/or Division management.

The risk analysis process uses *Monte Carlo* techniques to determine probabilities and contingency. The *Monte Carlo* techniques are facilitated computationally by a commercially available risk analysis software package (Crystal Ball) that is an add-in to Microsoft Excel. Cost estimates are packaged into an Excel format and used directly for cost risk analysis purposes. The level of detail recreated in the Excel-format schedule is sufficient for risk analysis purposes that reflect the established risk register, but generally less than that of the native format.

The primary steps, in functional terms, of the risk analysis process are described in the following subsections. Risk analysis results are provided in Section 6.

4.1 Identify and Assess Risk Factors

Identifying the risk factors via the PDT is considered a qualitative process that results in establishing a risk register that serves as the document for the quantitative study using the Crystal Ball risk software. Risk factors are events and conditions that may influence or drive uncertainty in project performance. They may be inherent characteristics or conditions of the project or external influences, events, or conditions such as weather or economic conditions. Risk factors may have either favorable or unfavorable impacts on project cost and schedule.

Checklists or historical databases of common risk factors are sometimes used to facilitate risk factor identification. However, key risk factors are often unique to a project and not readily derivable from historical information. Therefore, input from the entire PDT was obtained using creative processes such as brainstorming or other facilitated risk assessment meetings.

Formal PDT meetings were held for the purposes of identifying and assessing risk factors. The formal meeting conducted on October 18, 2012 included the following:

No.	Section	Title
1	CESPL-PM-N	Project Manager
2	CESPL-ED-DC	Coastal Engineering
3	CESPL-PD-RN	Environmental Specialist
4	CESPL-PD-WS	Planning
5	CESPL-PD-E	Economics
6	CESPD	Environmental
7	CESPL-ED-DD	Cost Engineering

8	CESPL-ED-GG	Geotechnical
9	CESPL-AM-A	Real Estate

The formal meeting focused primarily on risk factor identification using brainstorming techniques, but also included some discussions based on risk factors common to projects of similar scope and geographic location.

4.2 Quantify Risk Factor Impacts

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

Similar to the identification and assessment process, risk factor quantification involved multiple project team disciplines and functions. This process used an iterative approach to estimate the following elements of each risk factor:

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

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

4.3 Analyze Cost Estimate and Schedule Contingency

Contingency is analyzed using the Crystal Ball software, an add-in to the Microsoft Excel format of the cost estimate and schedule. *Monte Carlo* simulations are performed by applying the risk factors (quantified as probability density functions) to the appropriate estimated cost and schedule elements identified by the PDT. Contingencies are calculated by applying only the moderate and high level risks

identified for each option (i.e., low-level risks are typically not considered, but remain within the risk register to serve historical purposes as well as support follow-on risk studies as the project and risks evolve).

For the cost estimate, the contingency is calculated as the difference between the P80 cost forecast and the baseline cost estimate. Each option-specific contingency is then allocated on a civil works feature level based on the dollar-weighted relative risk of each feature as quantified by *Monte Carlo* simulation. Standard deviation is used as the feature-specific measure of risk for contingency allocation purposes. This approach results in a relatively larger portion of all the project feature cost contingency being allocated to features with relatively higher estimated cost uncertainty.

5.0 PROJECT ASSUMPTIONS

The following data sources and assumptions were used in quantifying the costs associated with the project conditions at Encinitas and Solana Beach.

a. The MII MCACES (Micro-Computer Aided Cost Estimating Software) files “Encinitas and Solana Beach fill (Initial).mlp”, “Encinitas Beach fill (Subsequent Cycles).mlp”, and “Solana Beach fill (Subsequent Cycles).mlp”” as well as accompanying CEDEP (Corps of Engineers Dredge Estimating Program) files were the basis for the cost and schedule risk analyses.

b. The cost comparisons and risk analyses performed and reflected within this report are based on design scope and estimates that are at the feasibility level.

c. The schedule was analyzed for impact to the project cost in terms of both uncaptured escalation (variance from OMB factors and the local market) and monthly recurring costs (unavoidable fixed contract costs and/or languishing federal administration costs incurred throughout delay).

d. Per the CWCCIS Historical State Adjustment Factors in EM 1110-2-1304, State Adjustment Factor for California is 1.17, meaning that historical inflation is up to 17% higher than the national average.

e. Per the data in the estimate, the Job Office Overhead (JOOH) amount for the Contract Cost comprises approximately 3.64% of the Project Cost at Baseline. However, the project includes twelve individual nourishment activities occurring intermittently over nearly 50 years. Thus, the assumed monthly recurring rate for this project is half of the approximate JOOH rate, or 1.82%. For the P80 schedule, this comprises less than 1% of the total contingency due to the accrual of residual fixed costs associated with delay.

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

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

6.0 RESULTS

The cost and schedule risk analysis results are provided in the following sections. In addition to contingency calculation results, sensitivity analyses are presented to provide decision makers with an understanding of variability and the key contributors to the cause of this variability.

6.1 Risk Register

A risk register is a tool commonly used in project planning and risk analysis. The actual risk register is provided in Appendix A. The complete risk register includes low level risks, as well as additional information regarding the nature and impacts of each risk.

It is important to note that a risk register can be an effective tool for managing identified risks throughout the project life cycle. As such, it is generally recommended that risk registers be updated as the designs, cost estimates, and schedule are further refined, especially on large projects with extended schedules. Recommended uses of the risk register going forward include:

- Documenting risk mitigation strategies being pursued in response to the identified risks and their assessment in terms of probability and impact.
- Providing project sponsors, stakeholders, and leadership/management with a documented framework from which risk status can be reported in the context of project controls.
- Communicating risk management issues.
- Providing a mechanism for eliciting feedback and project control input.
- Identifying risk transfer, elimination, or mitigation actions required for implementation of risk management plans.

6.2 Cost Contingency and Sensitivity Analysis

Identified risks were distributed into three major categories or among three major work features: risks associated with beach nourishment (dredging); risks directly connected with mitigation; and general project risks affecting all project civil work features, including cited risks, real estate, PED and construction management. In turn, a specific cost and schedule contingency was calculated for each category.

The baseline cost estimate was distributed by dollar weight: beach nourishment civil works features (WBS 17) represent 63% of the total project cost; mitigation features (WBS 06) represent 12% of the total project cost. Remaining civil work features such real estate (WBS 01); planning, engineering and design (WBS 30) and construction management (WBS 31) represent 25% of the total project cost. Calculated percent distribution of the total baseline estimate was used to distribute the general project cost risks by weight.

A dollar-weighted distribution of general project cost and schedule contingency amounts was apportioned over the beach nourishment and mitigation features. While general project features (i.e. real estate, PED and construction management) only carry the calculated general project contingency. Therefore, beach nourishment and mitigation contingencies result from the sum of their owned inherent risks and apportioned general risks from the total project. Real estate, PED and construction management cost and schedule contingencies result from the general project forecast.

Table 1 provides the raw construction cost contingencies calculated for the P80 confidence level and rounded to the nearest thousand. The construction cost contingencies for the P50 and P100 confidence levels are also provided for illustrative purposes only.

The combined contingency was quantified at approximately $38 Million at the P80 confidence level (29% of the baseline cost estimate).

Table 1. Project Cost Contingencies Summary

LANDS AND DAMAGES CONTINGENCY SUMMARY (WBS 01)

Risk Analysis Forecast	Base Cost Estimate	Base Cost Estimate Contingency	Weighted Total Project Cost Estimate Contingency	Schedule Estimate Contingency	Weighted Total Project Schedule Estimate Contingency	Real Estate Contingency ($)	Real Estate Contingency (%)
50% Confidence Level							
Total Project Cost	$189,000	$17,976	--	$745	--	$18,721	9.9%
80% Confidence Level							
Total Project Cost	$189,000	$27,509	--	$1,139	--	$28,648	**15.2%**
100% Confidence Level							
Total Project Cost	$189,000	$51,038	--	$2,114	--	$53,152	28.1%

MITIGATION CONTINGENCY SUMMARY (WBS 06)

Risk Analysis Forecast	Base Cost Estimate	Base Cost Estimate Contingency	Weighted Total Project Cost Estimate Contingency	Schedule Estimate Contingency	Weighted Total Project Schedule Estimate Contingency	Mitigation Nourishment Contingency ($)	Mitigation Contingency (%)
50% Confidence Level							
Total Project Cost	$16,417,000	$2,689,095	$1,561,465	$61,441	$64,677	$4,376,677	26.7%
80% Confidence Level							
Total Project Cost	$16,417,000	$4,893,437	$2,418,080	$66,886	$70,348	$7,448,751	**45.4%**
100% Confidence Level							
Total Project Cost	$16,417,000	$10,521,662	$4,530,027	$82,696	$86,900	$15,221,286	92.7%

BEACH NOURISHMENT CONTINGENCY SUMMARY (WBS 17)

Risk Analysis Forecast	Base Cost Estimate	Base Cost Estimate Contingency	Weighted Total Project Cost Estimate Contingency	Schedule Estimate Contingency	Weighted Total Project Schedule Estimate Contingency	Total Beach Nourishment Contingency ($)	Beach Nourishment Contingency (%)
50% Confidence Level							
Total Project Cost	$82,972,000	$5,348,553	$7,891,688	$250,643	$326,878	$13,817,762	16.7%
80% Confidence Level							
Total Project Cost	$82,972,000	$12,628,848	$12,221,049	$276,031	$355,538	$25,481,467	**30.7%**
100% Confidence Level							
Total Project Cost	$82,972,000	$82,972,000	$22,894,890	$335,720	$439,194	$106,641,805	128.5%

PLANNING, ENGINEERING AND DESIGN CONTINGENCY SUMMARY (WBS 30)

Risk Analysis Forecast	Base Cost Estimate	Base Cost Estimate Contingency	Weighted Total Project Cost Estimate Contingency	Schedule Estimate Contingency	Weighted Total Project Schedule Estimate Contingency	PED Contingency ($)	PED Contingency (%)
50% Confidence Level							
Total Project Cost	$26,009,000	$2,473,785	--	$102,465	--	$2,576,251	9.9%
80% Confidence Level							
Total Project Cost	$26,009,000	$3,785,548	--	$159,799	--	$3,942,348	**15.2%**
100% Confidence Level							
Total Project Cost	$26,009,000	$7,023,551	--	$290,919	--	$7,314,470	28.1%

CONSTRUCTION MANAGEMENT CONTINGENCY SUMMARY (WBS 31)

Risk Analysis Forecast	Base Cost Estimate	Base Cost Estimate Contingency	Weighted Total Project Cost Estimate Contingency	Schedule Estimate Contingency	Weighted Total Project Schedule Estimate Contingency	Construction Management Contingency ($)	Construction Management Contingency (%)
50% Confidence Level							
Total Project Cost	$6,974,000	$663,316	--	$27,475	--	$690,791	9.9%
80% Confidence Level							
Total Project Cost	$6,974,000	$1,015,049	--	$42,044	--	$1,057,093	**15.2%**
100% Confidence Level							
Total Project Cost	$6,974,000	$1,883,281	--	$78,006	--	$1,961,287	28.1%

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

6.2.1 Sensitivity Analysis

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

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

6.2.2 Sensitivity Analysis Results

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

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

6.3 Schedule and Contingency Risk Analysis

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

Schedule duration contingency was quantified as 36 months based on the P80 level of confidence. These contingencies were used to calculate the projected monthly recurring cost impact of project delays that are included in the Table 1 presentation of total cost contingency. The schedule contingencies were calculated by applying the high level schedule risks identified in the risk register for each option to the durations of critical path and near critical path tasks.

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

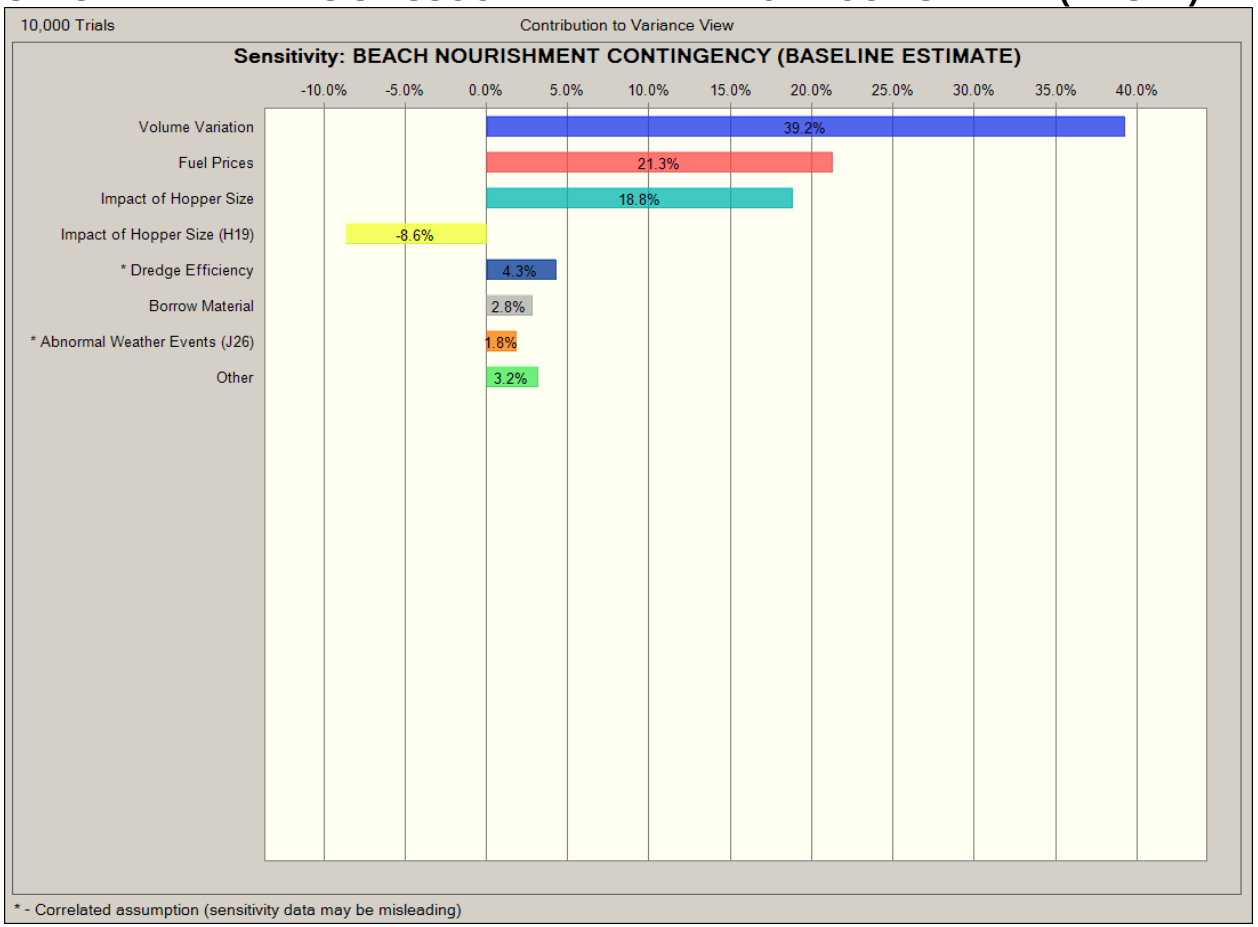
Table 2. Schedule Duration Contingency Summary

Risk Analysis Forecast	Baseline Schedule Duration (months)	Contingency[1] (months)	Contingency (%)
50% Confidence Level			
Total Project Duration	579	27	5%
80% Confidence Level			
Total Project Duration	579	36	7%
100% Confidence Level			
Total Project Duration	579	62	11%

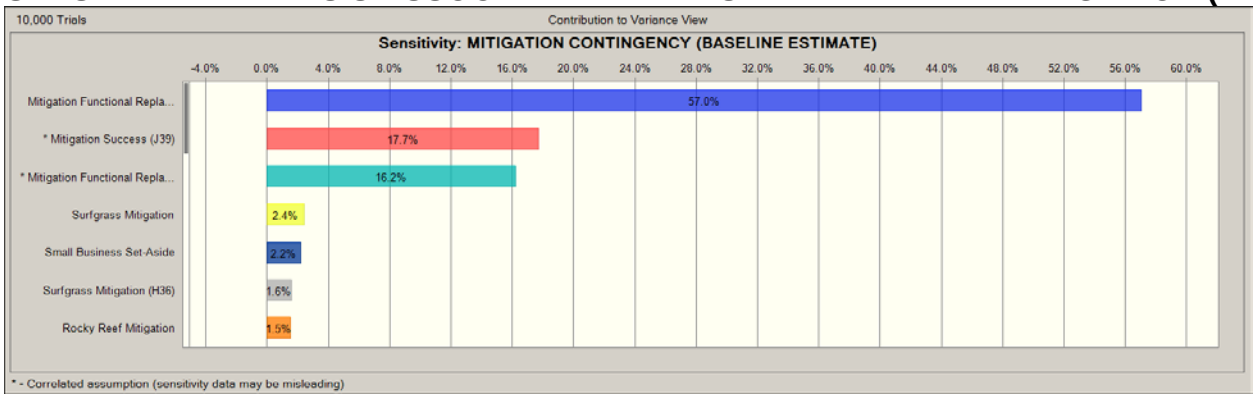
Notes:
1) The schedule was not resource loaded and contained open-ended tasks and non-zero lags (gaps in the logic between tasks) that limit the overall utility of the schedule risk analysis. These issues should be considered as limitations in the utility of the schedule contingency data presented in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

Figure 1. Cost Sensitivity Analyses

SENSITIVITY ANALYSIS ASSOCIATED WITH BEACH NOURISHMENT (WBS 17)



SENSITIVITY ANALYSIS ASSOCIATED WITH FISH AND WILDLIFE MITIGATION (WBS 06)



SENSITIVITY ANALYSIS ASSOCIATED WITH GENERAL RISKS (Impacting Beach Replenishment, Mitigation, Real Estate, PED and Construction Management Cost)

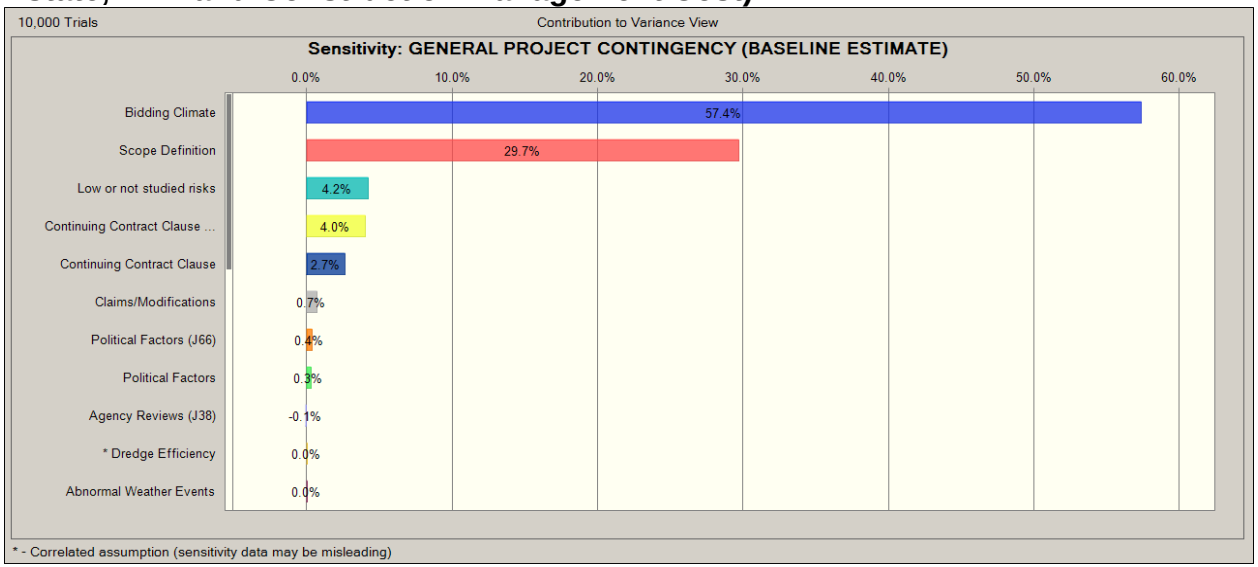
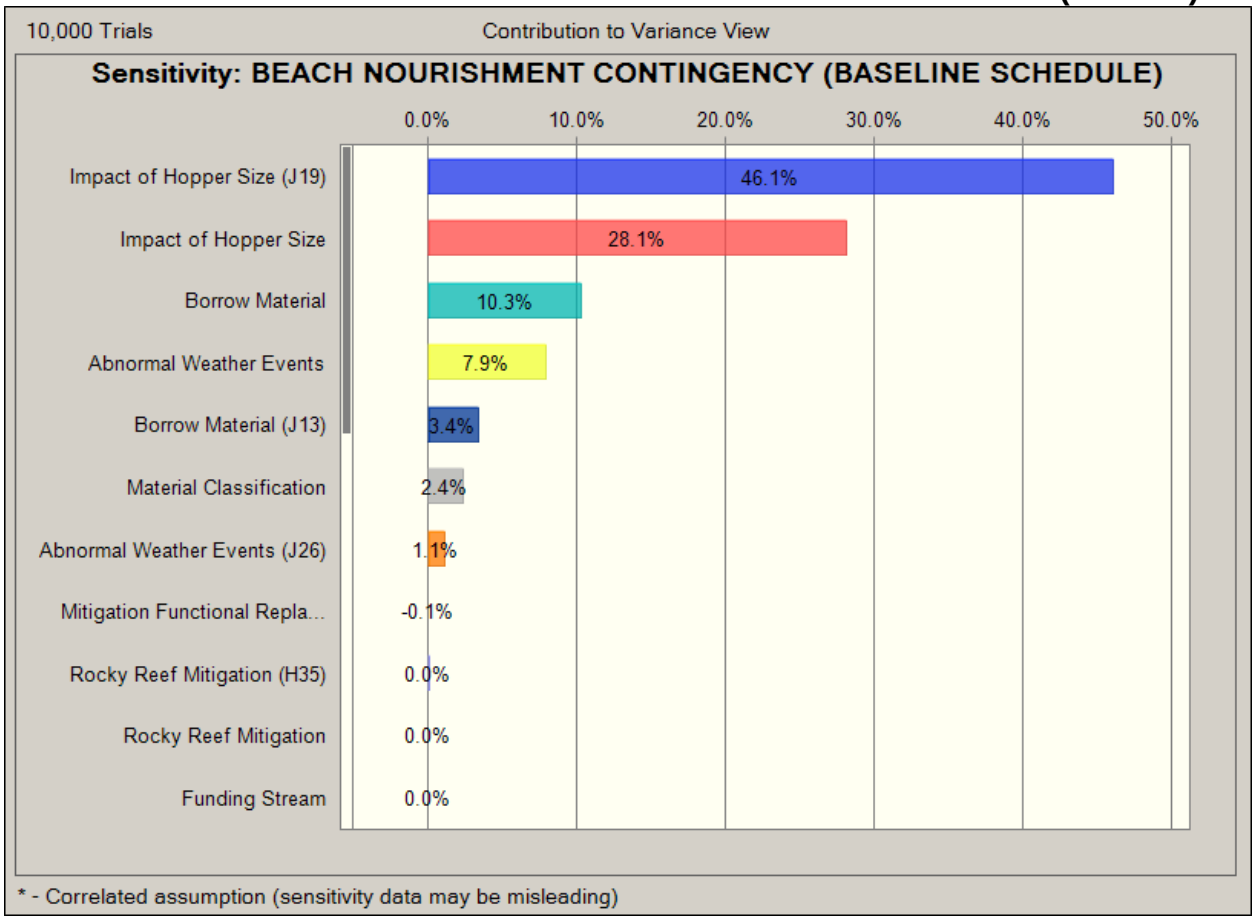
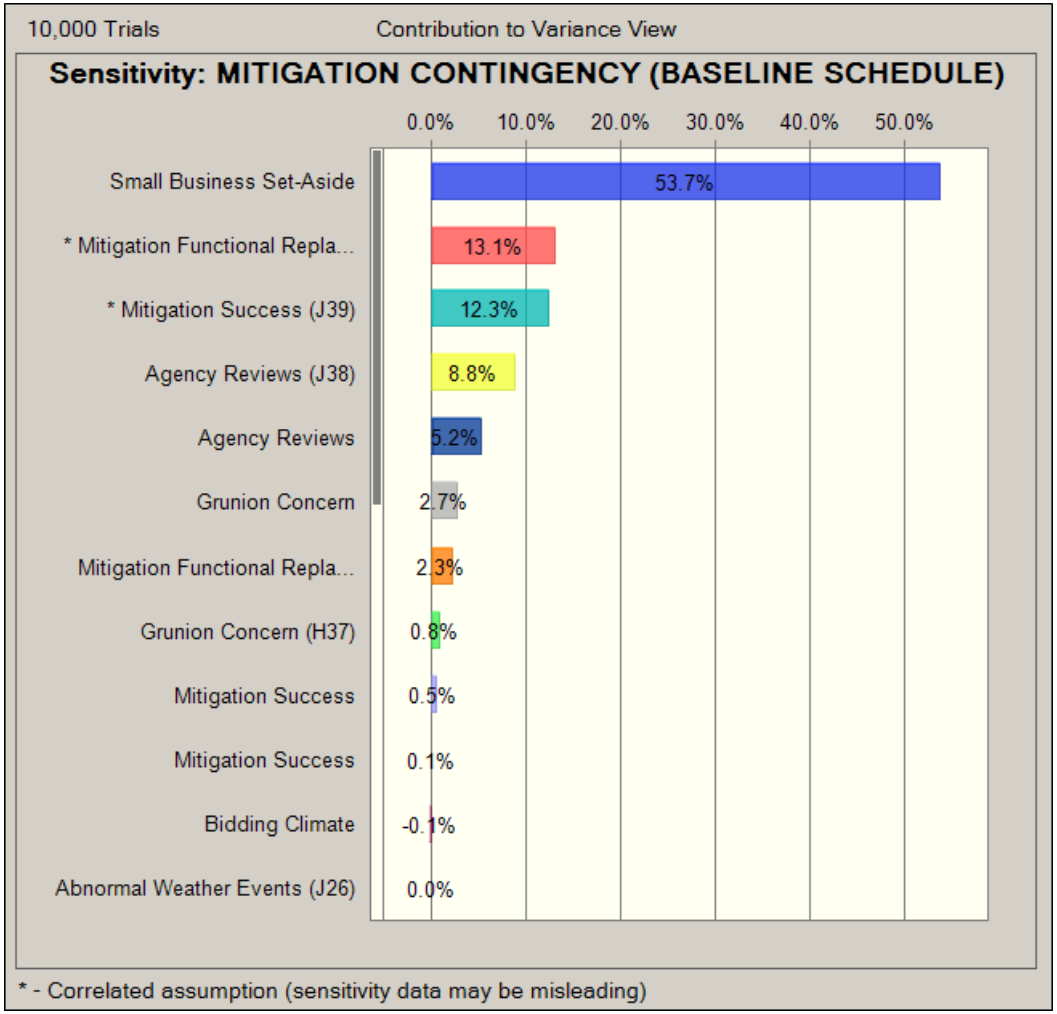


Figure 2. Schedule Sensitivity Analyses

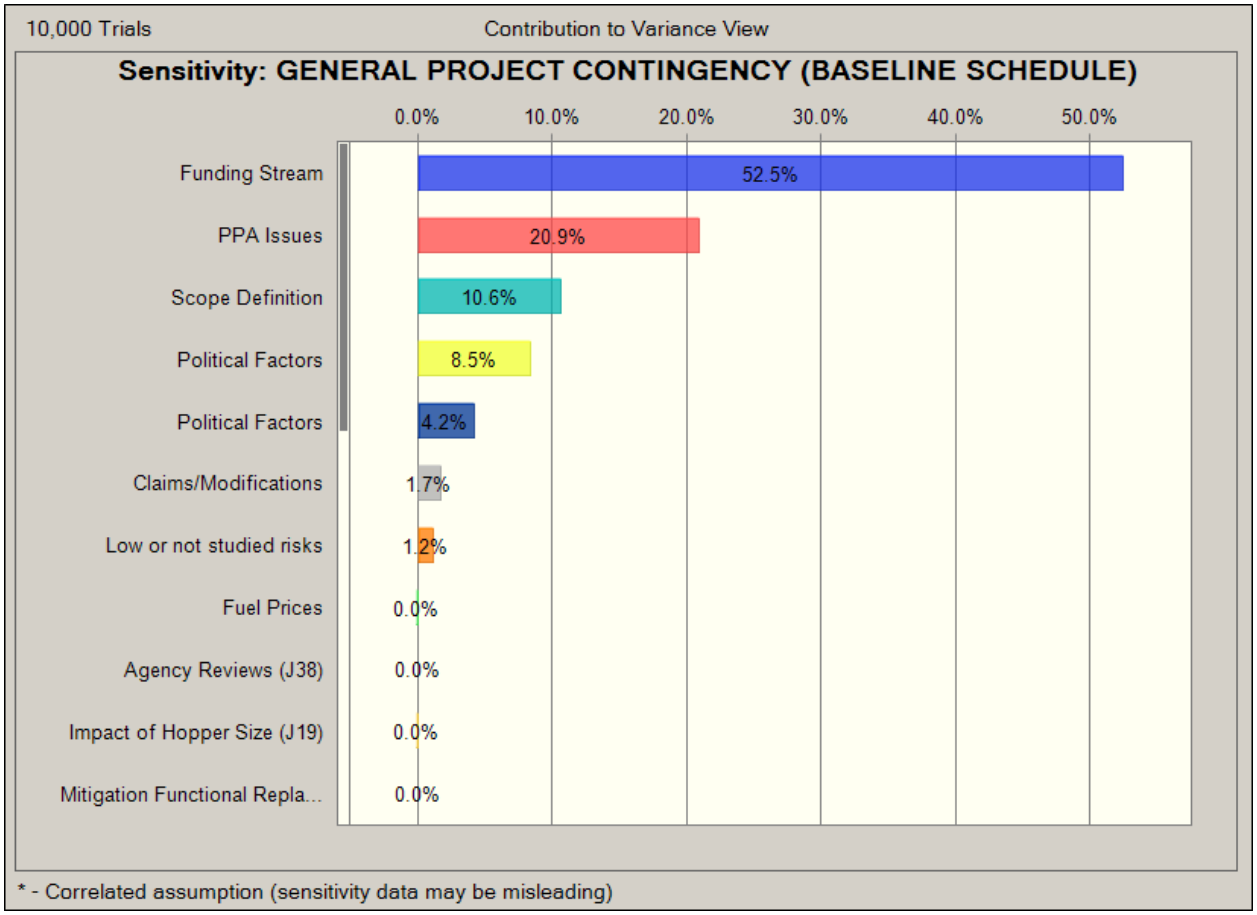
SENSITIVITY ANALYSIS ASSOCIATED WITH BEACH NOURISHMENT (WBS 17)



SENSITIVITY ANALYSIS ASSOCIATED WITH FISH AND WILDLIFE MITIGATION (WBS 06)



SENSITIVITY ANALYSIS ASSOCIATED WITH GENERAL RISKS (Impacting Beach Replenishment, Mitigation, Real Estate, PED and Construction Management Cost)



7.0 MAJOR FINDINGS/OBSERVATIONS/RECOMMENDATIONS

This section provides a summary of significant risk analysis results that are identified in the preceding sections of the report. Risk analysis results are intended to provide project leadership with contingency information for scheduling, budgeting, and project control purposes, as well as to provide tools to support decision making and risk management as projects progress through planning and implementation. Because of the potential for use of risk analysis results for such diverse purposes, this section also reiterates and highlights important steps, logic, key assumptions, limitations, and decisions to help ensure that the risk analysis results are appropriately interpreted.

7.1 Major Findings/Observations

Total project cost comparison summaries are provided in Table 3. Additional major findings and observations of the risk analysis are listed below.

Major Findings / Observations associated with the Cost

1. The greatest key cost risk drivers are associated with the base cost estimate since they represent 97% ($37 million) potential cost growth. Therefore, the total project risk unfolds mainly from the construction cost risk instead of the schedule risk.

2. The key cost risk drivers identified through sensitivity analysis were volume variations (T-1), fuel prices (EST-3), mitigation functional replacement (ENV-6), bidding climate (PR-3), and scope definition (PPM-2) which together contribute approximately 75 percent of the statistical cost variance.

Major Findings / Observations associated with the Schedule

1. Only, 3% ($1 million) cost growth potential is due to risk analyzed in the baseline schedule. Since the project consists of an initial construction event followed by twelve (12) short subsequent construction events within 5-year (Encinitas) and 13-year (Solana Beach) intervals, the total project schedule (50 years) includes enough float time to absorb most of the schedule risk.

2. The key schedule risk drivers identified through sensitivity analysis were impact of hopper size (EST-1), small business set-aside (CA-2) and funding stream (PPM-2) which together contribute over 50 percent of the statistical schedule variance.

3. The schedule was not resource loaded and contains open-ended tasks, and non-zero lags (gaps in the logic between tasks) that limit the overall utility of the schedule risk analysis. These issues should be considered as limitations in the utility of the schedule contingency data presented. Schedule contingency impacts

presented in this analysis are based solely on projected monthly recurring costs. Resource impacts related to potential schedule delays could not be evaluated.

Operation and maintenance activities were not included in the cost estimate or schedules. Therefore, a full lifecycle risk analysis could not be performed. Risk analysis results or conclusions could be significantly different if the necessary operation and maintenance activities were included.

Table 3. Project Cost Comparison Summary

REAL ESTATE COST SUMMARY

Confidence Level	Project Cost ($)	Contingency(%)
P0	174,738	-7.5%
P5	189,210	0.1%
P10	192,984	2.1%
P15	195,606	3.5%
P20	197,767	4.6%
P25	199,873	5.8%
P30	201,500	6.6%
P35	203,170	7.5%
P40	204,807	8.4%
P45	206,286	9.1%
P50	207,721	9.9%
P55	209,204	10.7%
P60	210,621	11.4%
P65	212,238	12.3%
P70	213,972	13.2%
P75	215,620	14.1%
P80	217,648	15.2%
P85	219,921	16.4%
P90	222,466	17.7%
P95	226,303	19.7%
P100	242,152	28.1%

BEACH NOURISHMENT COST SUMMARY

Confidence Level	Project Cost ($)	Contingency (%)
P0	46,243,970	-44.3%
P5	71,939,766	-13.3%
P10	77,437,195	-6.7%
P15	81,179,431	-2.2%
P20	84,139,540	1.4%
P25	86,822,433	4.6%
P30	89,074,441	7.4%
P35	91,193,480	9.9%
P40	93,207,485	12.3%
P45	95,019,953	14.5%
P50	96,789,762	16.7%
P55	98,590,382	18.8%
P60	100,364,844	21.0%
P65	102,112,096	23.1%
P70	104,069,816	25.4%
P75	106,038,646	27.8%
P80	108,453,467	30.7%
P85	111,018,378	33.8%
P90	114,203,576	37.6%
P95	119,029,218	43.5%
P100	146,707,652	76.8%

MITIGATION PROJECT COST SUMMARY

Confidence Level	Project Cost ($)	Contingency(%)
P0	13,064,073	-19.9%
P5	16,625,713	1.4%
P10	17,360,330	5.8%
P15	17,870,349	8.9%
P20	18,290,905	11.4%
P25	18,705,303	14.0%
P30	19,096,254	16.3%
P35	19,508,336	18.8%
P40	19,938,061	21.5%
P45	20,351,901	24.0%
P50	20,791,978	26.7%
P55	21,241,747	29.4%
P60	21,693,943	32.2%
P65	22,222,639	35.4%
P70	22,777,043	38.8%
P75	23,326,120	42.1%
P80	23,863,556	45.4%
P85	24,509,863	49.3%
P90	25,303,186	54.1%
P95	26,477,039	61.3%
P100	31,615,777	92.7%

PLANNING, ENGINEERING AND DESIGN COST SUMMARY

Confidence Level	Project Cost ($)	Contingency (%)
P0	24,046,338	-7.5%
P5	26,037,929	0.1%
P10	26,557,312	2.1%
P15	26,918,117	3.5%
P20	27,215,487	4.6%
P25	27,505,325	5.8%
P30	27,729,141	6.6%
P35	27,958,998	7.5%
P40	28,184,257	8.4%
P45	28,387,748	9.1%
P50	28,585,251	9.9%
P55	28,789,345	10.7%
P60	28,984,406	11.4%
P65	29,206,835	12.3%
P70	29,445,446	13.2%
P75	29,672,247	14.1%
P80	29,951,348	15.2%
P85	30,264,198	16.4%
P90	30,614,350	17.7%
P95	31,142,444	19.7%
P100	33,323,470	28.1%

CONSTRUCTION MANAGEMENT COST SUMMARY

Confidence Level	Project Cost ($)	Contingency (%)
P0	6,447,736	-7.5%
P5	6,981,757	0.1%
P10	7,121,023	2.1%
P15	7,217,769	3.5%
P20	7,297,505	4.6%
P25	7,375,222	5.8%
P30	7,435,235	6.6%
P35	7,496,869	7.5%
P40	7,557,269	8.4%
P45	7,611,833	9.1%
P50	7,664,791	9.9%
P55	7,719,516	10.7%
P60	7,771,819	11.4%
P65	7,831,461	12.3%
P70	7,895,442	13.2%
P75	7,956,256	14.1%
P80	8,031,093	15.2%
P85	8,114,980	16.4%
P90	8,208,869	17.7%
P95	8,350,471	19.7%
P100	8,935,287	28.1%

TOTAL PROJECT COST SUMMARY

Confidence Level	Project Cost ($)	Contingency (%)
P0	90,000,000	-32%
P5	121,800,000	-8%
P10	128,700,000	-3%
P15	133,400,000	1%
P20	137,100,000	3%
P25	140,600,000	6%
P30	143,500,000	8%
P35	146,400,000	10%
P40	149,100,000	12%
P45	151,600,000	14%
P50	154,000,000	16%
P55	156,600,000	18%
P60	159,000,000	20%
P65	161,600,000	22%
P70	164,400,000	24%
P75	167,200,000	26%
P80	170,500,000	29%
P85	174,100,000	31%
P90	178,600,000	35%
P95	185,200,000	40%
P100	220,800,000	67%

7.2 Recommendations

Risk Management is an all-encompassing, iterative, and life-cycle process of project management. The Project Management Institute's (PMI) *A Guide to the Project Management Body of Knowledge (PMBOK® Guide)*, *4th edition*, states that "project risk management includes the processes concerned with conducting risk management planning, identification, analysis, responses, and monitoring and control on a project." Risk identification and analysis are processes within the knowledge area of risk management. Its outputs pertinent to this effort include the risk register, risk quantification (risk analysis model), contingency report, and the sensitivity analysis.

The intended use of these outputs is implementation by the project leadership with respect to risk responses (such as mitigation) and risk monitoring and control. In short, the effectiveness of the project risk management effort requires that proactive management of risks does not conclude with the study completed in this report.

The Cost and Schedule Risk Analysis (CSRA) produced by the PDT identifies issues that require the development of subsequent risk response and mitigation plans. This section provides a list of recommendations for continued management of the risks identified and analyzed in this study. Note that this list is not all inclusive and should not substitute a formal risk management and response plan.

1. Key Cost Risk Drivers:

The key cost risk drivers identified through sensitivity analysis were volume variations (T-1), fuel prices (EST-3), mitigation functional replacement (ENV-6), bidding climate (PR-3), and scope definition (PPM-2) which together contribute approximately 75 percent of the statistical cost variance.

a) Volume Variations: Project leadership should attempt to finalize dredging quantities to the maximum extent possible.

b) Fuel Prices: Project leadership should ensure proactive market research to identify trends and their effect on the project cost. Ultimately, this is an external risk, and its impacts must be communicated to management, and funds should be maintained in project reserve for treatment of this risk.

c) Mitigation Functional Replacement: With respect to mitigation, Cost Engineering recommends further research into the variables that support that support mitigation functional replacement values. Changes in mitigation values should be controlled and reported to management for expeditious cost recovery efforts.

d) Bidding Climate: The PDT may consider changing the engineering requirements or methodologies to increase competition. Ultimately, this is an

external risk, and its impacts must be communicated to management, and funds should be maintained in project reserve for treatment of this risk.

e) Scope Definition: Project leadership should attempt to capture and finalize the scope of the project to the maximum extent possible. It is imperative to identify all features of work and probable methodologies prior to project authorization, continuing to refine scoping details during the Pre-Construction Engineering and Design (PED Phase).

2. Key Schedule Risk Drivers: The key schedule risk drivers identified through sensitivity analysis were impact of hopper size (EST-1), small business set-aside (CA-2) and funding stream (PPM-2) which together contribute over 50 percent of the statistical schedule variance.

a) Impact of Hopper Size: Project leadership should ensure that the PDT conducts market research to determine the regional trends regarding the availability of equipment to meet the requirements in parallel to the general market research being conducted. Ultimately, this is an external risk, and its impacts must be communicated to management, and funds should be maintained in project reserve for treatment of this risk.

b) Small Business set-aside: Changes to anticipated timeline with respect to biological monitoring schedule should be controlled and reported to management for expeditious schedule recovery efforts.

c) Funding Stream: Project leadership should take proactive measures with respect to the schedule and the timeline for budget approval and disbursement of project funds. Impacts must be communicated to management.

3. Risk Management: Project leadership should use of the outputs created during the risk analysis effort as tools in future risk management processes. The risk register should be updated at each major project milestone. The results of the sensitivity analysis may also be used for response planning strategy and development. These tools should be used in conjunction with regular risk review meetings.

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

APPENDIX A

Solana-Encinitas Coastal Storm Damage Reduction Project

Risk Level

Likelihood of Occurrence	Negligible	Marginal	Significant	Critical	Crisis
Very Likely	Low	Moderate	High	High	High
Likely	Low	Moderate	High	High	High
Unlikely	Low	Low	Moderate	Moderate	High
Very Unlikely	Low	Low	Low	Low	High

Impact or Consequence of Occurrence

Overall Project Scope
The purpose is to address coastal storm water damage within coastal region of the Cities of Encinitas and Solana Beach Work involves beach fill with the use of a hopper dredge to excavate sand from an off-shore borrow site and place it on the beach. There will be an initial dredging cycle followed by subsequent dredging cycles spread over 50 years. Mitigation costs are also incurred.

Cost Impacts
For the Solana-Encinitas Beach Replenishment Project Project, any cost impact of $2 Million or higher should be considered at least "Significant."
Anything over $1 Million should be considered at least "Marginal."

Schedule Impacts

For the Solana-Encinitas Beach Replenishment Project, any schedule impact of 6 months or greater should be considered at least "Significant."
Anything over 3 months should be considered at least "Marginal."

Risk No.	Risk/Opportunity Event	Concerns	PDT Discussions	Project Cost				Project Schedule				Variance Distribution	Correlation to Other(s)	Responsibility/POC	Affected Project Component
				Likelihood*	Impact*	Risk Level*	Rough Order Impact ($)	Likelihood*	Impact*	Risk Level*	Rough Order Impact (mo)				
	Contract Risks (Internal Risk Items are those that are generated, caused, or controlled within the PDT's sphere of influence.)														
	PROJECT & PROGRAM MGMT														
PPM-1	Funding Stream	Schedule developed with the assumption that sufficient funding would be received on a timely basis.	Design and construction phases will be entirely dependent on appropriations which are uncertain. This issue can have an effect on the overall performance of planning and engineering, as far as schedule is concerned. The local sponsors may not have their non-federal share of project funding at the right time to move forward on the project. Funding stream delays could impact the project schedule.	Unlikely	Marginal	LOW		Likely	Critical	HIGH		Uniform	PPM-4	Project Manager	Project Schedule
PPM-2	Scope Definition	The PDT discussed the possibility that over the life of the project the scope may change. The storm damage reduction project could add sand retention features.	If the scope changes a Postauthorization Change (PAC) would need to be drafted, the cost would increase and the project would be delayed.	Unlikely	Significant	MODERATE		Unlikely	Critical	MODERATE		Uniform		Project Manager	Project Cost & Schedule
PPM-3	PPA Issues	The execution and finalization of the PPA may cause some delay. Show-stopping issues are not anticipated, but it could have an impact if the final agreements are delayed.	This could have an impact on the overall implementation schedule, as the Government cannot advertise until the PPA is signed.	Very Unlikely	Negligible	LOW		Very Likely	Significant	HIGH		Yes-No/Uniform		Project Manager	Projec Schedule
PPM-4	Continuing Contract Clause	If the initial construction is not fully funded, the Continuing Contract Clause will need to be exercised to make a subsequent cycle award.	Standard Continuing Contract Clause increases the risk of contractors increasing their prices.	Likely	Marginal	MODERATE		Very Unlikely	Marginal	LOW		Yes-No/Uniform	PPM-1	Project Manager	Project Cost
	TECHNICAL RISKS														
T-1	Volume Variation	Dredging volumes are calculated on projected beach profiles which will change from cycle to cycle.	Year-to-year variation of beach profile is high. Volume changes significantly affect dredging cost.	Likely	Significant	HIGH		Unlikely	Marginal	LOW		Yes-No/Triangular		Technical Lead	Contract Cost & Schedule
T-2	Dredging cycles	Dredging cycles (schedule) could change as a result of higher than average storm events during El-Niño-Southern Oscillation (ENSO) periods of the Pacific Ocean's decadel cycle.	There is a chance for the replenishment schedule to change. It may accelerate or slow down, resulting in one more or one less dredge event over the project life.	Likely	Marginal	MODERATE		Likely	Significant	HIGH		Uniform		Technical Lead	Contract Cost & Schedule

T-3	Borrow Material	Uncertainty with the yield of suitable material from the borrow site. There is uncertainty as to the actual limits and location of the borrow site(s), and of the quality of borrow material within those site(s). Competing projects may use the finite borrow materials at the identified site(s).	The identified borrow site will likely be available for the inital dredging cycle. However, the likelihood of the identified borrow site availability decreases for subsequent nourishment events. If another site must be identified and utilized, then it could change the sailing distance from approximately 6 miles to up to 25 miles. This would have a significant impact on the costs and the schedule.	Unlikely	Significant	MODERATE		Unlikely	Significant	MODERATE		Custom/Triangular		Technical Lead	Contract Cost & Schedule
	LANDS AND DAMAGES RISKS														
LD-1	State Land Permits	The sponsors has to obtain a State Land Permit for the borrow sites and the placement sites. The risk would be that State Lands may not want to give the permit to the sponsors.	This risk is seen as highly unlikely. The worst case scenario is that this would require that the PDT select a different borrow site. There is the possibility that some additional surveys may be required, as it pertains to habitat and wildlife issues.	Very Unlikely	Significant	LOW		Very Unlikely	Marginal	LOW		Yes-No/Uniform		Real Estate	
	ACQUISITION STRATEGY														
CA-1	Initial Contract Award	The estimate is build under the assumption that the initial dredging event for the Solana Beach Replenishment and the Encinitas Beach replenishment will be awarded together under one contract.	If the initial dredging event is broken down into two contracts, mob/demob might double, but the life of the project is unlikely to be altered.	Unlikely	Significant	MODERATE		Unlikely	Negligible	LOW		Yes-No/Triangular		Contracting	Contract Cost
CA-2	Small Business Set-Aside	Small Business Set-Aside for Biological Monitoring Services.	There are biological monitoring services in the overall implementation. These could be set aside for small business or 8(a). The District has experienced several challenges with small business contracts in the past for these services. This issue would ca+D30use a cost impact, but it could also cause schedule delays, if qualified offerors are unavailable.	Likely	Marginal	MODERATE		Likely	Marginal	MODERATE		Uniform		Contracting	Contract Cost & Schedule
	ENVIRONMENTAL														
ENV-1	Rocky Reef Mitigation	Currently, the extent of the mitigation is undefined. Mitigation size will result from actual impacts.	The details of the mitigation reef and it's extents are not defined. The PDT's currently assumes no mitigation costs associated with the Encinitas segment. Mitigation costs could significantly increase or decrease. Overall schedule should not be affected.	Likely	Critical	HIGH		Likely	Negligible	LOW		Yes-No/Triangular		Environmental	Project Cost
ENV-2	Surfgrass Mitigation	Surfgrass mitigation is not predicted, may have to be built if it occurs.	Surfgrass mitigation is not proposed or included in estimated costs and schedule. If monitoring shows impacts, mitigation will have to be negotiated, designed, built, and monitored resulting in increased costs.	Unlikely	Significant	MODERATE	~$2M	Unlikely	Negligible	LOW		Yes-No/Triangular		Environmental	Project Cost
ENV-3	Grunion Concern	If the constructed protective beach becomes a spawning site for the California grunion (fish), the replenishment cycles schedule would be affected.	Schedule would be altered so that dredging cycles occur outside the grunion season. Pushes project into the rough season. Initial dredging cycle is unlikely to be affected, but the subsequent cycles are more likely to be affected.	Very Unlikely	Significant	LOW		Likely	Significant	HIGH	~6 months	Yes-No/Triangular		Environmental	Projec Schedule

ENV-4	Agency Reviews	Mitigation policy could be elevated to headquearter level by the Fish and Wildlife Services (FWS) and the National Marine Fishery Services (NMFS).	Review process from the draft to final report could affect the mitigation scope. This is a large and expensive project that could be elevated to headquarters for further review. Additional review processes could result into additional project restrictions and significant costs and schedule delays.	Likely	Significant	HIGH		Likely	Marginal	MODERATE		Yes-No/Uniform		Environmental	Project Cost & Schedule
ENV-5	Mitigation Success	This assumes that the mitigation will achieve a level of functional equivalence to the existing reefs.	If the reef does not achieve full functionality, additional work may be needed to achieve full functionality in coordination with state and federal resource agencies. Additional work translates into higher costs and extended schedule.	Likely	Significant	HIGH		Likely	Marginal	MODERATE		Yes-No/Uniform	ENV-6	Environmental	Project Cost & Schedule
ENV-6	Mitigation Functional Replacement	Mitigation quantities are based on a a 2:1 functional replacement, the ratio could go as high as 4:1.	There is some disagreement about what ratio to use in the baseline estimate. If other agencies approach headquarters, the variables that support the mitigation functional replacement may increase resulting in higher mitigation costs and delaying the schedule.	Likely	Significant	HIGH		Likely	Marginal	MODERATE		Yes-No/Custom	ENV-5	Environmental	Project Cost & Schedule
	CONSTRUCTION														
CON-1	Inefficient Contractor	There is a possibility that a new dredging contractor obtains one of the contracts and is unable to perform the work.	The nature of this type of work makes this unlikely. Capable remaining dredging contractors in the area are experienced and the work is not complex.	Very Unlikely	Significant	LOW		Very Unlikely	Significant	LOW		Yes-No/Triangular		Contracting	
CON-2	Misplacement Risk	If contractor misplaces the material (pipe leaks, misdumps, etc) it would result into additional mitigation costs.	Misplaced dredged material would create additional mitigation requirements, however the PDT team feels this event is very unlikely to happen, but the impact would be significant.	Very Unlikely	Significant	LOW		Very Unlikely	Significant	LOW		Yes-No/Triangular		Construction	
CON-3	Claims/Modifications	This item captures the risk that post-award construction modifications or claims may cause a variance to project cost and schedule.	Possible claims and modifications may rise affecting the cost and/or causing schedule delays.	Likely	Marginal	MODERATE		Likely	Significant	HIGH		Triangular		Construction	Contract Cost & Schedule
	ESTIMATE AND SCHEDULE														
EST-1	Impact of Hopper Size	Baseline estimate considered a medium size hopper, however, there is the possibility of a large or small hopper dredge bidding the job.	The use of a large size hopper will result in a lower dredging unit cost. The use of a small size hopper will result in a higher dredging unit cost.	Very Likely	Marginal	MODERATE		Very Likely	Marginal	MODERATE		Yes-No/Uniform		Cost Engineering	Contract Cost & Schedule
EST-2	Dredge Availability	Availability of hopper dredges on West Coast is scarse, however baseline estimate considered mob/demob from the East Coast.	The baseline estimate assumes mob/demob from the East Coast which is the worst case but highly likely scenario. It is unlikely that dredging equipment will mob/demob from a farther location.	Very Unlikely	Critical	LOW		Unlikely	Marginal	LOW		Yes-No/Uniform		Cost Engineering	Contract Cost
EST-3	Fuel Prices	Fuel prices are volatile.	Fluctuations in fuel prices affect the dredging unit cost.	Very Likely	Marginal	MODERATE		Unlikely	Marginal	LOW		BetaPERT		Cost Engineering	Contract Cost
EST-4	Dredge Efficiency	Unusual wave action and downtime related to dredge Effective Working Time (EWT).	Baseline estimate assumes a 90% effective working time. Efficiency could range from 70% to 90% affecting the dredging unit cost.	Likely	Marginal	MODERATE		Unlikely	Marginal	LOW		Triangular	PR-1	Cost Engineering	Contract Cost

EST-5	Material Classification	Dredging productivity may vary based on material classification.	Fine components range from 6% mud, 92% sand and 2% gravel. Current material classification resulted from average of 9 test holes in the area. However, sediment classification changes with time, currents, etc. Variation in gradations could affect the unit costs of dredging and the dredging time and the placement costs.	Likely	Marginal	MODERATE		Likely	Marginal	MODERATE		Triangular		Cost Engineering	Contract Cost & Schedule
EST-6	Dredge Haul Distance	This relates to longer or shorter hauls for the dredge within the identified borrow site.	Most likely haul distance from borrow site to receiver beach is estimated at 2.5 miles for Encinitas and 1.9 miles for Solana. Worst case scenario would be 3.0 miles. Best case scenario would be 1.8 miles.	Unlikely	Significant	MODERATE		Unlikely	Marginal	LOW		Yes-No/Triangular		Cost Engineering	Contract Cost
EST-7	Confidence on Est. and Sch.	Estimated costs are detailed and the schedule has gone through an extensive review process.	Confidence level in the current working estimate (CWE) and schedule are high.	Very Unlikely	Significant	LOW		Unlikely	Marginal	LOW		Triangular		Cost Engineering	
	REGULATORY AND ENVIRONMENTAL RISKS														
RE-1	Regulatory Agencies	Fish and Wildlife Services (FWS) and National Marine Fisheries Service (NMFS) reviews may cause changes to the current plan.	Regulatory agencies could impose additional studies, environmental windows or areas to be avoided. Additional restriction will impact the cost and significantly delay the project.	Likely	Marginal	MODERATE		Likely	Significant	HIGH	~ 1 Yr	Uniform		Project Manager	Contract Cost & Schedule
RE-2	State Regulation Changes	Coastal policy changes	Policy changes could alter the B/C ratio and the 902 limit . There is a chance that the project would not provide enough protection and the benefit value is insufficient. The PDT feels this risk is unilikely.	Very Unlikely	Significant	LOW		Very Unlikely	Significant	LOW		Uniform		Project Manager	
	CONSIDERATION FOR INTERNAL RISKS IDENTIFIED AS LOW OR NOT STUDIED ("UNKNOWN, UNKNOWNs")														
INT-1	Low or not studied risks	This item captures the risk that low or unknown internal risks may cause a variance to project cost and schedule.	Risk based on standard items not included in the formal cost and schedule risk analyses, such as sufficient studies.	Likely	Marginal	MODERATE		Likely	Marginal	MODERATE		Triangular		Project Manager	Contract Cost & Schedule
	Programmatic Risks	(External Risk Items are those that are generated, caused, or controlled exclusively outside the PDT's sphere of influence.)													
PR-1	Abnormal Weather Events	Abnormally excessive waves due to weather events could slow productivity of the hopper dredging.	The issue is that the contractor would not be able to complete in the dredging window, meaning that they would have to be remobilized the following year (additional mob and demob costs). This has happened before on previous jobs. The wave issue arises about every 15 years or so.	Likely	Marginal	MODERATE		Unlikely	Significant	MODERATE		Hypergeometric/Custom	EST-4	N/A	Contract Cost & Schedule
PR-2	Political Factors	There are local SIGs (i.e. Surf Rider Foundation) that are opposed to the nourishment activities. They could potentially attempt to file a suit against the project. There are also other groups that oppose nourishment activities.	There remains the possibility that political opposition could stop the project or any individual event. It could also create a delay in the activities as well.	Likely	Marginal	MODERATE		Likely	Marginal	MODERATE		Yes-No/Uniform		Project Manager	Projec Schedule
PR-3	Bidding Climate	Large dredging projects requiring hopper dredges has always being handled by a limited pool contractors.	Lack of competition may have a high impact on the construction cost.	Likely	Significant	HIGH		Unlikely	Marginal	LOW		Uniform		N/A	Contract Cost

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

1. Risk/Opportunity identified with reference to the Risk Identification Checklist and through deliberation and study of the PDT.
2. Discussions and Concerns elaborates on Risk/Opportunity Events and includes any assumptions or findings (should contain information pertinent to eventual study and analysis of event's impact to project).
3. Likelihood is a measure of the probability of the event occurring -- **Very Unlikely**, **Unlikely**, **Moderately Likely**, **Likely**, **Very Likely.** The likelihood of the event will be the same for both Cost and Schedule, regardless of impact.
4. Impact is a measure of the event's effect on project objectives with relation to scope, cost, and/or schedule -- **Negligible**, **Marginal**, **Significant**, **Critical**, or **Crisis.** Impacts on Project Cost may vary in severity from impacts on Project Schedule.
5. Risk Level is the resultant of Likelihood and Impact **Low**, **Moderate**, or **High**. Refer to the matrix located at top of page.

##

7. The responsibility or POC is the entity responsible as the Subject Matter Expert (SME) for action, monitoring, or information on the PDT for the identified risk or opportunity.
8. Correlation recognizes those risk events that may be related to one another. Care should be given to ensure the risks are handled correctly without a "double counting."
9. Affected Project Component identifies the specific item of the project to which the risk directly or strongly correlates.
10. Project Implications identifies whether or not the risk item affects project cost, project schedule, or both. The PDT is responsible for conducting studies for both Project Cost and for Project Schedule.
11. Results of the risk identification process are studied and further developed by the Cost Engineer, then analyzed through the Monte Carlo Analysis Method for Cost (Contingency) and Schedule (Escalation) Growth.