U.S. Army Corps of Engineers

Galveston District
Southwestern Division

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

Dredged Material Management Plan
Appendix R

November 2019

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Executive Summary HSC Expansion Channel Improvement Project (ECIP)

Final Integrated Feasibility Report – Environmental Impact Statement (FIFR-EIS)

This Dredged Material Management Plan (DMMP) documents the dredging and placement needs for the Federal project and associated non-Federal facilities, as feasible, for the next 50-years for the Houston Ship Channel (HSC) complex, which includes: HSC main stem from Bolivar Roads to the Upper Turning Basin, Bayport Ship Channel (BSC), Barbours Cut Channel (BCC), Greens Bayou, Jacintoport Channel, the Buffalo Bayou Light-Draft Channel, Turkey Bend Channel, boater cuts, and barge lanes. This DMMP is developed to be used as a stand-alone document for operations and management of dredged material for the federal project and included as an appendix to the ECIP Study.

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

The authorization of the HSC ECIP Study would result in changes to the currently authorized dimensions as highlighted in blue in Table ES-1. The existing dimensions of the BSC, BCC, Jacintoport and Greens Bayou channels were previously constructed by the NFS and maintenance was assumed by United States Army Corps of Engineers (USACE). Their dimensions are authorized for maintenance through assumption of maintenance granted by ASACW and/or WRDA. These channels would become Federally authorized upon completion and authorization of the HSC ECIP Study and noted below.

Table Es-1 describes the existing and proposed channel dimensions resulting from the HSC ECIP recommended plan (RP). Figure ES-1 shows the existing and planned placement areas (PAs). Table ES-2 indicates the 50-year shoaling rates for the HSC System and Table ES-3 provides the 50-year conceptual DMMP.

Table ES-1: Authorized and Planned Dimensions

Houston Ship Channel Section of Waterway	Channel Dimensions					
	Authorized			Planned		
	Depth (feet)		Width (feet)	Depth (feet)	Width (feet)	Length (miles)
	(-) MLT	(-) MLLW		(-) MLLW		
Segment 1 – HSC-Bay Reach Safety and Efficiency Enhancements						
-Bolivar Roads (Mile 0) to Morgans Point (Mile 26.2)[1]	45	46/46.5	530	46/46.5	700	26.2
-Barge Lanes (adjacent to and on each side from Mile 0 to Mile 26.2)	12	13	125	-	-	26
-Morgans Point (Mile 26.2) to Boggy Bayou (Mile 38.5)	45	46.5	530-600	-	-	12.3
-South Boaters Cut @ Mile 15.3	8	9	300	-	-	1.9
-North Boaters Cut @ Mile 18.7	8	9	100	-	-	2.1
-Five Mile Cut Channel @ Mile 20.9	8	9	125	-	-	1.9
Segment 2 – Bayport Ship Channel						
-Bayport Ship Channel (Mile 21.4 at intersection with HSC)[3]	40	41.5	300	46.5	455	3.8
Turning Basin	40	41.5	300-1,600	46.5	300-1,600	0.3
Segment 3 – Barbours Cut Channel						
-Barbours Cut Channel (Miles 26.3 at intersection with HSC)[3]	40	41.5	300	46.5	455	1.1
Turning Basin	40	41.5	300-1,600	46.5	300-1,600	0.3
Segment 4 –Boggy Bayou to Sims Bayou						
-Boggy Bayou (Mile 38.5) to Greens Bayou (Mile 42.0)	40	41.5	300	46.5	530	3.5
-Jacintoport Channel	40	41.5	200		-	0.7
-Greens Bayou (Mile 42.0) to Sims Bayou (Mile 47.5)[4]	40	41.5	300	46.5	300	5.5
Hunting Bayou Turning Basin	40	41.5	948-1,000[2]	-	-	0.3
Clinton Island Turning Basin	40	41.5	965-1,070[2]	-	-	0.3
-Greens Bayou Channel Mile 0.0 to Mile 0.36	40	41.5	175	-	-	0.4
-Greens Bayou Channel Mile 0.36 to Mile 1.65	15	16.5	100	-	-	1.3
Segment 5 –Sims Bayou to I-610 Bridge						
-Sims Bayou (Mile 47.5) to I-610 Bridge (Mile 48.3)	36	37.5	300	41.5	300	0.8
Segment 6 –I-610 Bridge to Main Turning Basin						
-I-610 Bridge (Mile 48.3) to Houston (Main) Turning Basin (Mile 50.2)	36	37.5	300	41.5	300	1.9
Houston (Main) Turning Basin	36	37.5	400-932	-	-	0.6
Upper Turning Basin	36	37.5	150-527	-	-	0.2
Brady Island Channel	10	11	60	-	-	0.9
Brady Island Turning Basin	36	37.5	900	41.5	900	0.2
Buffalo Bayou Light Draft Channel	10	11	60	-	-	4.1
Turkey Bend Channel	10	11	60	-	-	0.8

[1] Per the MLT to MLLW Datum Conversion, the split occurs at Beacon 76
[2] Includes 300-foot channel width
[3]PHA received approval to deepen channel to 46.5 feet MLLW and subsequent Federal Assumption of Maintenance (AOM) under Section 408/204(f). BSC deepening was completed in Fall of 2016 and BCC was completed in August 2015. Additionally, the BSC was widened from 300 feet to 400 feet from the BSC Flare to the land cut and from 300 feet to 350 feet from the land cut to the BSC Turning Basin.
[4] Greens Bayou to Sims Bayou deepening stops short of Washburn Tunnel at Station 974+007

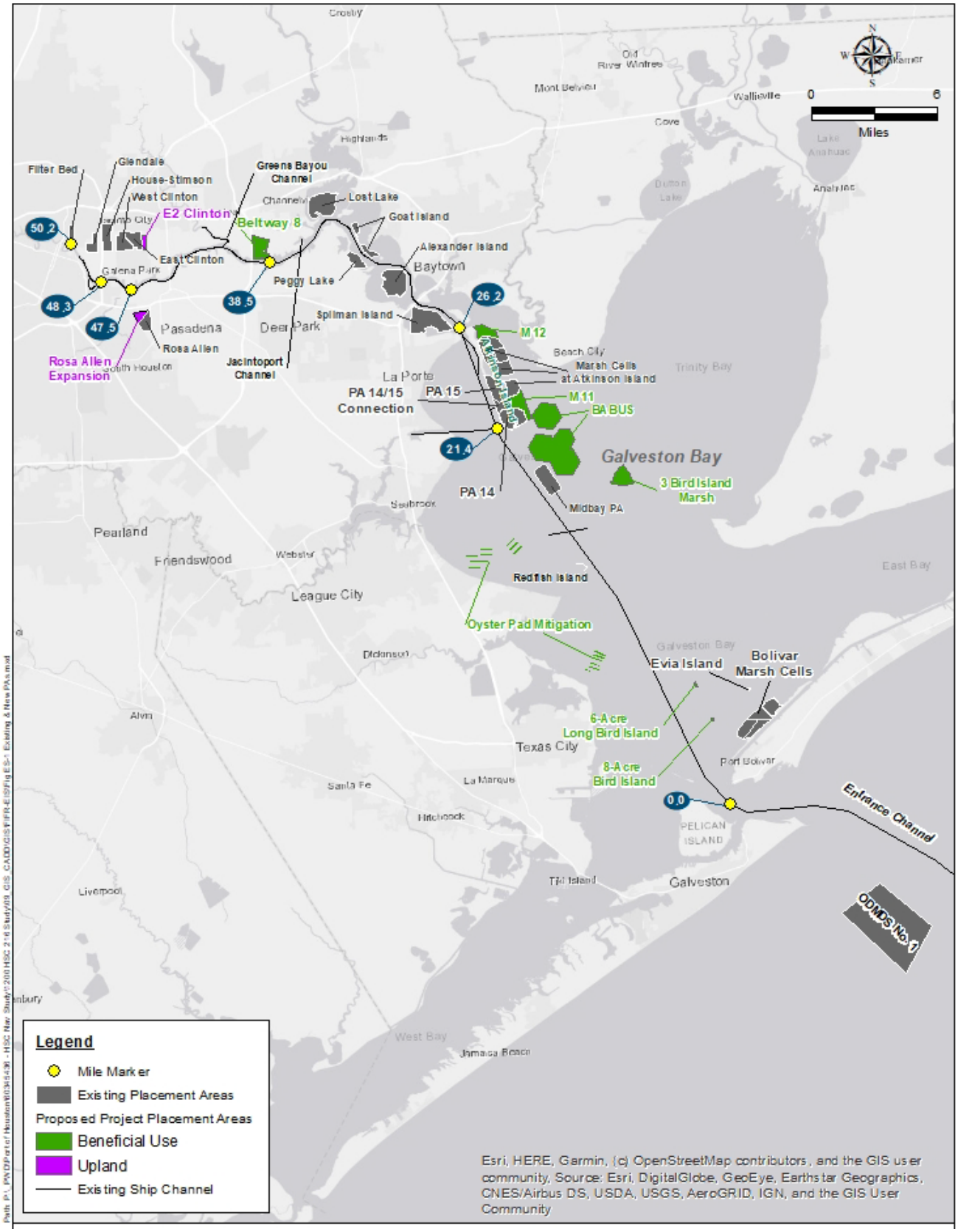

Figure ES-1: Existing and Planned Placement Areas

Table ES-2: 50- Yr Shoaling Rate

Reach Description	Federal Channel Annual Shoaling Rate (Total Volume) CY	Non-Federal Annual Shoaling Rate (Gross Volume) CY	Total Federal and Non-Federal Annual Shoaling Rate CY	Average Dredging Frequency YR	Total Shoaling Rate per Cycle CY	No. of Cycles in 50-Yr Analysis Period	Total 50-Yr Shoaling Volume CY
HSC Bolivar Roads to Redfish Reef	142,391	0	142,391	4	569,564	13	7,119,550
HSC Redfish Reef to BSC	2,021,615	0	2,021,615	3	6,064,845	17	101,080,750
HSC BSC to Morgans Point	142,391	0	142,391	4	569,564	13	7,119,550
BSC & Turning Basin	582,970	24,139	607,109	2	1,214,218	25	30,355,450
BSC Flare	831,814	0	831,814	1	831,814	50	41,590,700
HSC Morgans Point to Exxon	1,288,052	47,250	1,335,302	3	4,005,906	17	66,765,100
BCC	493,749	109,310	603,059	3	1,809,177	17	30,152,950
HSC Exxon to Carpenters Bayou	454,759	13,607	468,366	3	1,405,098	17	23,418,300
HSC Carpenters Bayou to Boggy Bayou (includes Jacintoport Channel)	194,478	137,625	332,103	4	1,328,412	13	17,269,000
HSC Boggy Bayou to Greens Bayou	208,000	22,230	230,230	4	920,920	13	11,511,500
HSC Greens Bayou to Sims Bayou	229,000	8,127	237,127	5	1,185,635	10	11,856,350
Greens Bayou	52,748	50,826	103,574	6	621,441	8	4,972,000
HSC Sims Bayou to Turning Basin	134,000	43,205	177,205	6	1,063,230	9	8,860,250
HSC Main Turning Basin	116,000	0	116,000	3	348,000	17	5,800,000
HSC Upper Turning Basin	35,228	0	35,228	3	105,684	17	1,797,000
Buffalo Bayou Light Draft Channel	16,769	0	16,769	6	100,614	9	905,000
Turkey Bend Channel	2,519	0	2,519	6	15,114	9	136,000
		Total Federal and Non-Federal Gross Volume:					**347,036,000**

Table ES-3: FWP 50-Year Conceptual DMMP

Placement Area	Study Seg.	Dredging Reach	Total 50-Yr OM Dredging Volume KCY	Available Capacity in PA KCY	PA Life, YR	Year Full	Alternate Placement Location After End of PA Life	Volume Placed in Alt. Location KCY
ODMDS	1	HSC Bolivar Roads to Redfish Reef	7,120	NEL	50	NA	NA	0
Mid Bay	1	HSC Redfish Reef to Bayport	45,922	11,406	7	2035	ODMDS	34,516
B.I.M.	1	HSC Redfish Reef to Bayport	55,158	13,700	10	2038	ODMDS	41,458
PA14	2	Bayport Ship Channel	26,296	9,031	17	2045	ODMDS	17,265
PA14/15 Conn.	2	Bayport Ship Channel	29,292	10,060	19	2047	ODMDS	19,232
PA15	1	HSC Bayport to Morgans Point	34,302	11,386	19	2047	ODMDS	22,916
M7/8/9	1,2	Bayport Ship Channel	2,527	868	4	2032	ODMDS	3,406
		HSC Bayport to Morgans Point	2,615	868	4	2032	ODMDS	
M11	1,2	Bayport Ship Channel	13,831	4,750	18	2046	ODMDS	18,641
		HSC Bayport to Morgans Point	14,310	4,750	18	2046	ODMDS	
M12	3	Barbours Cut Channel	15,466	6,000	16	2044	ODMDS/ BABUS	9,466
Spilman Is.	1,3	Barbours Cut Channel	14,687	5,698	13	2041	BABUS	22,049
		HSC Morgans Point to Exxon	21,606	8,546	16	2044	BABUS	
Alexander Is.	1	HSC Morgans Point to Exxon	43,159	17,862	22	2050	BABUS	27,297
Peggy Lake	1	HSC Exxon to Carpenters Bayou	23,418	6,296	26	2054	BABUS	17,122
Lost Lake	1,4	HSC Carpenters Bayou to Boggy Bayou	16,605	4,607	6	2034	BABUS	21,892
		Boggy Bayou to Greens Bayou	11,512	1,619	1	2029	BABUS	
Rosa Allen	4	HSC Greens Bayou to Sims Bayou	2,462	2,934	6	2034	NA	0
Rosa Allen Exp	4	HSC Greens Bayou to Sims Bayou	9,395	11,198	46	2074	NA	0
East Clinton	4, 6	Greens Bayou, HSC Upper Turning Basin, Light Draft Channel, Turkey Bend Channel, Turkey Bend Cut-off Channel	7,905	6,290	50	2050	BABUS	1,615
West Clinton	5,6	HSC Sims Bayou to Turning Basin	8,137	5,651	25	2053	BABUS	2,486
House Tract	5,6	HSC Sims Bayou to Turning Basin	6,523	4,530	37	2065	BABUS	1,993
Glendale	6	NA	NA	NA	NA	NA	NA	0
Filterbed	6	NA	NA	NA	NA	NA	NA	0
FWP Totals:			**411,884**	**148,049**	-	-	-	**256,716**

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List of Acronyms

$/CY	Cost per cubic yard
AC	acres
AOM	Assumption of Maintenance
BABUS	Bay Area Beneficial Use Site
BCC	Barbours Cut Channel
BCCT	Barbours Cut Container Terminal
BSC	Bayport Ship Channel
BU	beneficial use
BUG	Beneficial Uses Group
CAD	confined aquatic disposal
CDF	confined disposal facility
CPP	conceptual third-party placement
CWBS	Civil Works Breakdown Structure
CY	cubic yards
CY/YR	cubic yards per year
DAMP	Disposal Area Management Plan
DMDF	dredge material disposal facility
DMMP	Dredged Material Management Plan
EIS	Environmental Impact Statement
EPA	U.S. Environmental Protection Agency
ER	Engineer Regulation
ERDC	Engineer Research and Design Center
ERDC-CHL	Engineer Research and Design Center Coastal and Hydraulics Laboratory
FFR-EIS	Final Feasibility Report and Environmental Impact Statement
FWOP	future without project
FWP	future with project
FY	fiscal year
GBANS	Galveston Bay Area Navigation System
GIWW	Gulf Intracoastal Waterway
GNF	General Navigation Feature
HCAD	Harris County Appraisal District
HGNC	Houston Galveston Navigation Channel
HP	Houston Pilots
HSC	Houston Ship Channel

HSC ECIP	Houston Ship Channel Expansion Channel Improvement Project
HSCPA	Houston Ship Channel Preliminary Assessment
HTRW	Hazardous, Toxic and Radioactive Waste
JV	Joint Venture
LERRD	Lands, easements, removals, relocations, and damages
LPP	Locally Preferred Plan
LRR	Limited Reevaluation Report
LSF	local service facility
MCY	million cubic yards
MLLW	mean lower low water
MLT	mean low tide
NAD83	North American Datum of 1983
NED	National Economic Development
NEPA	National Environmental Policy Act
NFS	Non-Federal Sponsor
NMFS	National Marine Fisheries Service
NOAA	National Oceanic and Atmospheric Administration
NRCS	National Resources Conservation Service
O&M	operations and maintenance
ODMDS	Ocean Dredged Material Disposal Site
PA	placement area
PCA	Project Cooperation Agreement
PDR	Project Deficiency Report
PDT	Project Delivery Team
PED	Preconstruction Engineering and Design
P&G	Principles and Guidance
PGN	Policy Guidance Notebook
PHA	Port of Houston Authority
PPA	Project Partnership Agreement
PTM	particle tracking model
ROW	right-of-way
RSLC	relative sea level change
SMMP	Site Management and Monitoring Plan
SSPEED	Severe Storm Prediction, Education, and Evacuation from Disaster
TCEQ	Texas Commission on Environmental Quality
TGLO	Texas General Land Office
TPCS	total project cost summary

TPWD	Texas Parks and Wildlife Department
USACE	United States Army Corps of Engineers
USACE-HQ	United States Army Corps of Engineers Head Quarters
USACE-SWG	United States Army Corps of Engineers Southwestern Division Galveston District
UCPA	upland confined placement area
USCG	United States Coast Guard
USFWS	United States Fish and Wildlife Service
VTS	Vessel traffic service
WIIN Act	Water Infrastructure Improvements for the Nation Act of 2016
WRDA	Water Resources Developmental Act

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1 Introduction

This Dredged Material Management Plan (DMMP) documents the dredging and placement needs for the Federal project and associated non-Federal facilities, as feasible, for the next 50-years for the Houston Ship Channel (HSC) complex, which includes: HSC main stem from Bolivar Roads to the Upper Turning Basin, Bayport Ship Channel (BSC), Barbours Cut Channel (BCC), Greens Bayou, Jacintoport Channel, the Buffalo Bayou Light-Draft Channel, Turkey Bend Channel, boater cuts, and barge lanes. This DMMP is prepared in accordance with ER 1105-2-100, Appendix E and serves as a comprehensive placement plan for continued operation and maintenance (O&M) of the HSC and associated channels and will serve as a decision document for any modifications of the existing placement areas (PAs), creation of new PAs, and offshore placement as necessary to accommodate maintenance material dredged from the HSC and tributaries over the 50-year study period of the HSC ECIP. This DMMP is developed as a stand-alone document for O&M of future dredged material for the federal project and included as an appendix to the HSC ECIP Study.

1.1 DMMP Scope

This DMMP integrates the Future Without Project (FWOP) dredging and placement needs for the HSC system as outlined in the December 5, 2017 Houston Ship Channel Preliminary Assessment (HSCPA) and conceptual 50-year DMMP dated December 18, 2018 with the placement needs associated with recommended modifications proposed in the HSC Expansion Channel Improvement Project (ECIP) Final Integrated Feasibility Report and Environmental Impact Statement (FIFR-EIS) of which this document is an appendix. This DMMP identifies the base plan placement needs for the increment of new work and maintenance dredging from the recommended modification as documented in the FIFR-EIS, including dredged material originating from the Federal channel and associated benefitting non-Federal local service facilities (LSFs), for a period of 50-years. This resulting DMMP is, therefore, considered the Future With Project (FWP) condition for the HSC ECIP feasibility study.

Placement alternatives in the FWP condition analyzed capacity needs for new work dredged material from the recommended channel modifications and improvements to associated LSFs, and the associated incremental maintenance over the FWOP. Those areas of the channels within the HSC system that are not recommended for improvements would continue to follow the FWOP conditions for 50-year maintenance of the existing HSC system. Implementation of the Recommended Plan (RP) outlined in FIFR-EIS would result in one new single Project Partnership Agreement (PPA) that encompasses the entire HSC System. This PPA along with this FIFR-EIS would outline how the HSC will be maintained in the future.

Following USACE Head Quarters (HQ) approval of the HSC ECIP FIFR-EIS, all dredged material identified under this study would be eligible for placement into the Federal dredge material disposal facilities (DMDFs) (subject to Federal appropriations). Conversely, if placement

requirements for dredged material quantities have not been identified/planned for under the FWOP or FWP DMMP for this FIFR-EIS, such quantities may not be eligible for placement into the Federal DMDFs until such time as the DMMP is updated or another study provides justification and authorization.

For channel reaches not recommended for modification under the HSC ECIP Study (i.e. Morgans Point to Boggy Bayou, Greens Bayou, Jacintoport Channel, the Buffalo Bayou Light-Draft Channel, Turkey Bend Channel), the continued operation, maintenance and placement options outlined in FWOP will remain valid. Specific cost estimates, environmental, or engineering for these sections of channel would consist of a short discussion of their planned maintenance. Constraints and assumptions for this DMMP are further listed below.

1. A placement plan for new work dredged material from construction of the Recommended Plan (RP) has been developed that does not utilize existing upland confined placement areas (UCPAs) planned and identified for use in the conceptual FWOP conditions. The exceptions to this are Glendale and Filterbed PAs. These sites would be utilized for new work as they are not planned for use in the FWOP condition.
2. New work materials resulting from the upgrade of the 21 LSFs identified as directly benefiting from the HSC ECIP improvements would be placed into Bay Area Beneficial Use Sites (BABUS) or existing private facilities.
3. The 50-year FWOP DMMP has been updated to reflect the change in life span and capacities of the PAs due to the incremental maintenance from the HSC ECIP improvements. Costs have been developed for specific improvements to PAs necessary to accommodate the incremental change in O&M from these improvements, and these changes have been captured in the project costs.
4. O&M of the recommended HSC ECIP improvements and existing channel features below Morgans Point would utilize new PAs constructed using new work dredged material from channel improvements, existing PAs and the Ocean Dredged Material Disposal Sites (ODMDS). The 50-year FWOP tables have beenupdated to reflect the change in PA life span resulting from placement of the incremental maintenance as well as the additional PAs and their capacities . Costs have been developed for specific improvements to accommodate the incremental maintenance and the incremental costs have been indicated in the project costs.
5. FWOP and FWP non-Federal new work may not be allowed in existing or proposed PAs unless documented and accounted for in the integrated DMMP for the HSC system.
6. FWOP non-Federal new work associated with the 21 LSFs benefitting from the proposed modifications documented in the FIFR-EIS may be designated to go to BABUS at sole non-Federal associated costs where feasible and available.
7. Unplanned non-Federal FWP new work material beyond the scope of these 21 LSFs would not be accommodated by existing or planned PAs unless provided by this FWP DMMP or another study.

8. FWOP non-Federal maintenance material will be managed and placed as documented in the FWOP condition along with the channel at sole non-Federal cost where feasible and available.

1.2 Assumptions

General assumptions regarding the integrated DMMP include the following:

1. The costs for continued maintenance dredging of of the existing Federal channel and the associated costs to maintain the LSF are referenced in the 2017 PA. Costs for existing and continued operations and maintenance, including placement needs, of the federal channel for the FWOP condition have been provided in a summary table in this integrated DMMP (Section 2).
2. The costs for the base plan for placement of new work dredged material, incremental maintenance dredged material and the associated costs of the LSF improvements and their incremental maintenance have been developed and provided in Section 5.
3. FWP non-Federal new work and maintenance dredging is estimated at1.7 MCY for the known 21 LSF currently benefitting from the proposed modifications. An additional 25% of material should be targeted for placement in the BABUS which would need to be adjusted in size during future preconstruction engineering and design (PED) activities. Costs will not be identified for this effort.

1.3 Study Area

The study area for this DMMP encompasses the entire HSC and associated channels, property directly adjacent to and near the channel(s), including upland, confined PAs, beneficial use (BU) sites, and ODMDS, within Galveston, Chambers, and Harris Counties, Texas. An overview of the study area is shown in FIGURE 1-1 below. The study area is comprised of six segments which were evaluated for channel modifications in the FIFR-EIS.

The HSC provides access to various private and public docks and berthing areas associated with the PHA. At 52 miles in length, the HSC is the longest major navigation channel in the Galveston Bay area. Associated channels (or cuts) are listed in Section 1.4.

1.4 HSC Study Area Segment Descriptions

An overview of the study area is show on Figure 1-1 below. This DMMP covers both the channel improvements as well as the existing channel where improvements are not made as described in the sections below.

1.4.1 Segment 1: Bay Reach

Segment 1, the 46.5-Foot Project, extends from Bolivar Roads to Boggy Bayou. Segment 1 is separated into two sections, each divided further into three reaches with an authorized depth of -46feet Mean Lower Low Water (MLLW) from Bolivar Roads to Beacon 76 and -46.5 feet MLLW for the remainder of Segment 1 .

1.4.1.1 The Bay Section –

This section begins at Station 138+369 (Mile 0.0) at Bolivar Roads and extends to Station 0+00 (Mile 26.2) at Morgans Point and is generally 530 feet wide with 125-foot-wide barge lanes at -13 feet MLLW on either side of the channel. This section is divided into three reaches at each channel bend.

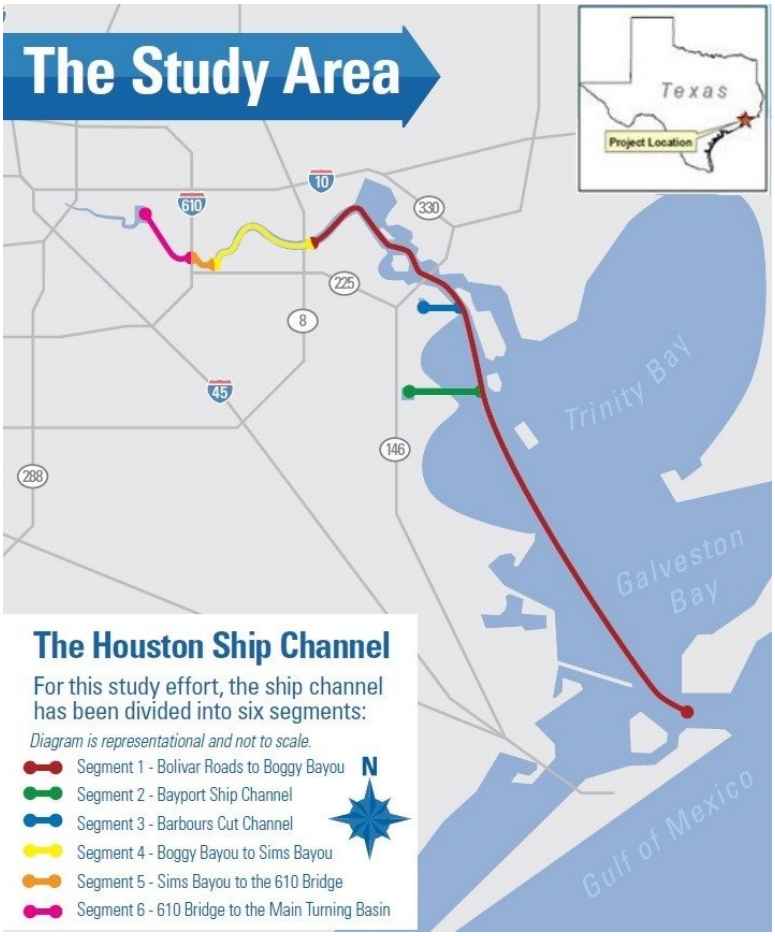


Figure 1-1: Study Segments

Opportunities evaluated in the HSC study include channel widening up to a 700-foot width and easing the channel bends to 328 feet. The barge lanes would be relocated in-kind at their current dimensions. The current authorized depth would remain the same.

A. Bolivar Roads to Redfish (1a) – Extends from Station 138+369 (Mile 0.0) near Buoy 18 to Station 78+844 (Mile 11.2) at Redfish Light 1.
B. Redfish to BSC (1b) – Extends from Station 78+844 (Mile 11.2) to Beacon 75/76 at Station 28+605 (Mile 21.4).
C. BSC to BCC (1c) – Extends from Station 28+605 (Mile 21.4) to lower end Morgans Point Cut at Station 0+00 (Mile 26.2).

The Bay section also includes minor tributary channels described below.

- South Boat Cut - This existing 10,000-foot long cut, small boater's cut intersects the HSC between Redfish Reef and Mid Bay PA (HSC Station 57+600), was constructed as part of the Houston Galveston Navigation Channel (HGNC) 45-foot project.

- North Boat Cut - This existing 11,000-foot small boater's cut intersects the HSC between Mid Bay PA and PA 14 (HSC Station 39+600).
- Five Mile Cut - This existing 10,000-foot long shallow draft channel connects to the HSC just south of the BSC (HSC Station 28+000) and runs eastward. This was an existing shallow-draft channel prior to construction of the HGNC 45-foot project. Maintenance dredging was performed on this channel during the 45-foot project new work construction (FY 2001 contract). Maintenance dredging was performed concurrently in 2016 with the adjacent HSC dredging reach from Redfish to Morgan's Point removing approximately 190,000 CY.

1.4.1.2 The Bayou Section – (No changes in the FWP Condition)

This section begins at Station 0+05 (Mile 26.2) at Morgans Point and extends to the end of Boggy Bayou at Station 684+03 (Mile 38.5). The existing channel is approximately 530 feet wide and greater in the turns. The channel narrows to 400 feet for the last approximate 1.3 miles, west of the San Jacinto Monument to Boggy Bayou. No significant changes will be made to this section/reaches other than potential minor safety modifications to be analyzed in PED ship simulations as discussed in Section 4 of the Engineering Appendix. This section is divided into three reaches.

A. Morgans Point to Exxon (Lower Bayou) – Extends from Station 0+05 to Station 295+00.
B. Exxon to Carpenter Bayou (Mid Bayou) – Extends from Station 295+00 to 520+00.
C. Carpenters to Boggy Bayou (Upper Bayou) – Extends from Station 520+00 to 684+03. (Part of Existing Condition HSC Carpenters Bayou to Greens Bayou)

1.4.2 Segment 2: Bayport Ship Channel

The 4.1-mile-long BSC was originally constructed to a 300-foot width and a depth of -41.5 feet MLLW with a 3,000-foot radius flare at the southern mouth of the intersection of the BSC and the HSC by the PHA. Maintenance was assumed by USACE via WRDA86. The PHA with authority under Section 408 and Regulatory Permit # SWG-2011-1183 deepened the channel to -46.5 feet MLLW and widened the bay portions of the channel by 100 feet and widened the constricted portion of the channel within the land cut by 50 feet. The USACE assumed maintenance of the PHA improvements to the BSC Improvement Projects under Section 204 (f) of WRDA 86, as amended as well as extended the 3,000-foot radius flare to 4,000 feet under the PDR. The HSC ECIP Study RP includes widening the channel to 455 feet wide and a bend at the intersection of Mid Bay and Upper Bay at Station 28+605.

1.4.3 Segment 3: Barbours Cut Channel

The 1.6-mile-long BCC is was originally constructed by the PHA to a depth of -41.5 feet MLLW and a width of 300 feet with a 1,600 turning basin at its terminus and was assumed by USACE via WRDA 86. The PHA with authority under Section 408 (Regulatory Permit #SWG-1999-02499) deepened the channel to -46.5 feet MLLW and shifted the channel 75 feet north to accommodate a wider berthing area. To accommodate the shift, the channel was excavated 75 feet to the north between Station 20+13 and 65+43 to maintain a 300-foot channel bottom width. The USACE

recently assumed maintenance of the PHA improvements to the BCC Improvement Projects under Section 204 (f) of the Water Resources Development Ace (WRDA) 86, as amended. The HSC ECIP RP includes widening the channel to 455 feet and extending the flare to an 1,800-foot radius.

1.4.4 Segment 4: Boggy Bayou to Sims Bayou

This segment consists of two reaches. Boggy Bayou to Greens Bayou extends from channel Station 684+03 to Station 833+05. Greens Bayou to Sims Bayou extends from Station 833+05 to 1110+77. The channel is generally 300 feet wide in this reach. HSC Station 1110+77 marks the transition from the existing -41-foot MLLW channel downstream to the -37.5-foot MLLW channel upstream. The Washburn Tunnel crosses beneath the HSC in this dredging reach at about HSC Station 976+00. Due to the shallow depth of the tunnel, the dredged depth over the tunnel is limited to an elevation of -41 feet MLLW plus one foot overdepth; dredging depth on either side of the tunnel is -43 feet plus one foot overdepth. The portion of the channel between Boggy Bayou and Sims Bayou is a narrow, highly industrialized area that is closely bordered on both sides by berths, docking facilities and other PHA infrastructure. The HSC ECIP Study RP includes deepening the 8-mile portion of the HSC from Boggy Bayou to the Hunting TB at station 930+00 to a depth -46.5 feet MLLW and widening between Boggy Bayou to Greens Bayou to a width up to 530 feet, where feasible.

1.4.5 Greens Bayou – (No changes in the FWP Condition)

The Greens Bayou Channel is a deep and shallow draft tributary of the HSC that extends from the north side of the HSC generally northward into Greens Bayou in the vicinity of Houston and Channelview, Texas. Greens Bayou Channel Station numbers are preceded by "GBC" to differentiate between stationing for the HSC. Greens Bayou Channel has both deep-draft and shallow draft channel components. The channel stationing begins at GBC Station 0+00 located at the intersection with HSC Station 810+42. The deep-draft channel is a -41.5-foot MLLWproject and extends from GBC Station 0+00 to GBC Station 19+40. The shallow draft channel is a -16.5-foot MLLW project extending from GBC Station 19+40 to GBC Station 108+24. Federal maintenance dredging has not been performed in the shallow draft channel for at least 20 years. If maintenance dredging is required for the shallow draft channel in the future, the material would most likely be placed in East Clinton PA or BABUS.

1.4.6 Jacintoport Channel – (No changes in the FWOP Condition)

This deep-draft tributary channel is located on the north side of the HSC at about HSC Station 570+00 in Channelview, Harris County, Texas. The USACE assumed the maintenance of Jacintoport Channel on April 29, 2016 after the execution of a Memorandum of Agreement (MOA).

1.4.7 Segment 5: Sims Bayou to I-610 Bridge

Segment 5 extends from station 1110+77 to station 1160+62 is approximately 300-foot wide with an authorized depth of -37.5 feet MLLW. The HSC ECIP RP includes deepening the 1-mile portion of the HSC from Sims Bayou to the I-610 Bridge to a depth of -41.5 feet MLLW. The portion of

the channel between Sims Bayou and the I-610 Bridge is a narrow, highly industrialized area that is closely bordered on both sides by berths, docking facilities and other Port of Houston infrastructure. Study Segment 5 lies within the HSC reach known as Sims Bayou to Turning Basin from Station 110+77 to 1266+48.

1.4.8 Segment 6: I-610 Bridge to Turning

Segment 6 extends from station 1160+62 through the turning basin and is approximately 300-foot wide with an authorized depth of -37.5 feet MLLW. The HSC ECIP RP includes deepening the 2.5-mile portion of the HSC from the I-610 Bridge through the Main Turning Basin to -41.5 feet MLLW. Widening of the channel was not ultimately considered due to apparent constrictions from surrounding structures and industry. The HSC ECIP also includes expanding the Brady Island turning basin to 900 feet. Study Segments 6 lies within the HSC reach known as Sims Bayou to Turning Basin from Station 1110+77 to 1266+48.

1.4.9 Brady Island Channel

This is a shallow-draft tributary channel (-10-foot MLT authorized depth) located just upstream of the I-610 bridge and connects to the HSC channel on the downstream and upstream sides of Brady Island. The channel is divided into an upstream and downstream portion, being bisected by the Cypress Street bridge which is too low to allow navigation traffic to pass.

1.4.10 Buffalo Bayou Light Draft Channel

This is a shallow draft channel (-11-foot MLLW authorized depth) located within the Buffalo Bayou, just upstream of the HSC Upper Turning Basin. The channel extends from Station 0+00 beginning at the west end of the HSC Upper Turning Basin to the terminus at Station 212+00 just east of the Jensen Drive bridge (about 4 miles) and has a channel width of 60 feet. The latest channel alignment includes what was known as the Turkey Bend Cut-off Channel authorized in 1958 to improve navigation past the oxbow Turkey Bend Channel.

1.4.11 Turkey Bend Channel

The 0.8-mile long Turkey Bend Channel (TBC) branches off the Buffalo Bayou Light Draft Channel at about Station 103+11 (TBC Station 0+00) and dead ends at TBC Station 40+66.21. This channel has an authorized width of 60 feet and depth of -11 feet MLLW. The Turkey Bend Channel is an old river oxbow near the midpoint of the Buffalo Bayou Light Draft Channel.

Table 1-1: Existing Channel Dimensions for HSC and Tributaries

Houston Ship Channel Section of Waterway	Existing Dimensions			
	Depth (feet)		Width (feet)	Length (miles)
	(-) MLT	(-) MLLW		
SEGMENT 1 – HSC-BAY REACH SAFETY AND EFFICIENCY ENHANCEMENTS				
-Bolivar Roads (Mile 0) to Morgans Point (Mile 26.2)[1]	45	46/46.5	530	26.2
-Barge Lanes (adjacent to and on each side from Mile 0 to Mile 26.2)	12	13	125	26
-Morgans Point (Mile 26.2) to Boggy Bayou (Mile 38.5)	45	46.5	530-600	12.3
-South Boaters Cut @ Mile 15.3	8	9	300	1.9
-North Boaters Cut @ Mile 18.7	8	9	100	2.1
-Five Mile Cut Channel @ Mile 20.9	8	9	125	1.9
SEGMENT 2 – BAYPORT SHIP CHANNEL				
-Bayport Ship Channel (Mile 21.4 at intersection with HSC)[3]	40	41.5	350-400	3.8
Turning Basin	40	41.5	300-1,600	0.3
SEGMENT 3 – BARBOURS CUT CHANNEL				
-Barbours Cut Channel (Miles 26.3 at intersection with HSC)[3]	40	41.5	300	1.1
Turning Basin	40	41.5	300-1,600	0.3
SEGMENT 4 –BOGGY BAYOU TO SIMS BAYOU				
-Boggy Bayou (Mile 38.5) to Greens Bayou (Mile 42.0)	40	41.5	300	3.5
-Jacintoport Channel	40	41.5	200	0.7
-Greens Bayou (Mile 42.0) to Sims Bayou (Mile 47.5)	40	41.5	300	5.5
Hunting Bayou Turning Basin	40	41.5	948-1,000[2]	0.3
Clinton Island Turning Basin	40	41.5	965-1,070[2]	0.3
-Greens Bayou Channel Mile 0.0 to Mile 0.36	40	41.5	175	0.4
-Greens Bayou Channel Mile 0.36 to Mile 1.65	15	16.5	100	1.3
SEGMENT 5 –SIMS BAYOU TO I-610 BRIDGE				
-Sims Bayou (Mile 47.5) to I-610 Bridge (Mile 48.3)	36	37.5	300	0.8
SEGMENT 6 –I-610 BRIDGE TO MAIN TURNING BASIN				
-I-610 Bridge (Mile 48.3) to Houston (Main) Turning Basin (Mile 50.2)	36	37.5	300	1.9
Houston (Main) Turning Basin	36	37.5	400-932	0.6
Upper Turning Basin	36	37.5	150-527	0.2
Brady Island Channel	10	11	60	0.9
Brady Island Turning Basin	36	37.5	300-722	0.2
Buffalo Bayou Light Draft Channel	10	11	60	4.1
Turkey Bend Channel	10	11	60	0.8

[1] Per the MLT to MLLW Datum Conversion, the split occurs at Beacon 76.
[2] Includes 300-foot channel width
[3]PHA received approval to deepen channel to 46.5 feet MLLW and subsequent Federal Assumption of Maintenance (AOM) under Section 408/204(f). BSC deepening was completed in Fall of 2016 and BCC was completed in August 2015. Additionally, the BSC was widened from 300 feet to 400 feet from the BSC Flare to the land cut and from 300 feet to 350 feet from the land cut to the BSC Turning Basin.

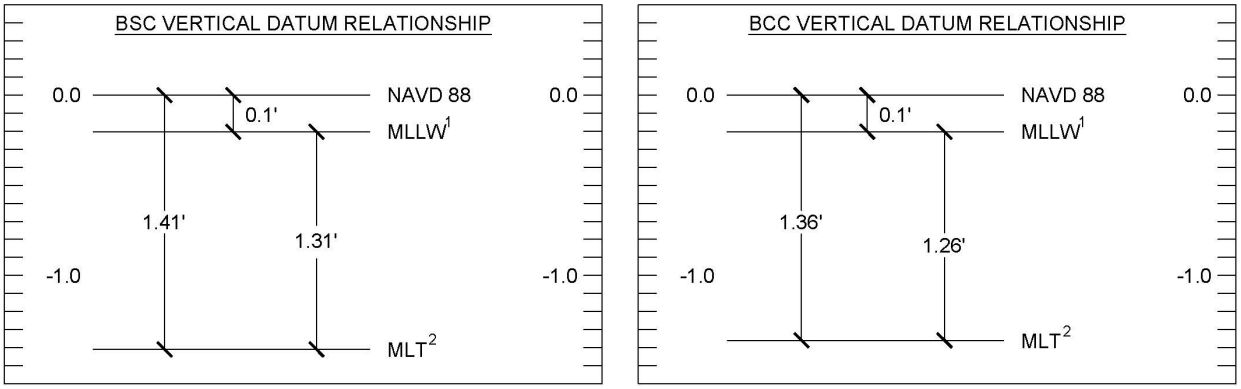
1.5 Datum

The horizontal datum for the project is based on the Texas State Plane Coordinate System, South Central Zone 4204, North American Datum of 1983 (NAD83). The vertical datum is MLLW.

All prior projects in the Galveston District have used the USACE vertical datum MLT. The USACE has completed the process of converting the vertical datum for all navigation projects from MLT to MLLW (USACE, 2015a). From Bolivar Roads Station 138+369.011 to Beacon 76 at Station 28+605.055, MLLW is 1 foot above MLT, converting the -45-foot MLT project to -46 feet MLLW. From Station 28+605.055 to the termination of the HSC at the end of Main Turning

Basin the conversion is 1.5 feet. The depths of the channels at -45, -40, -37 and -36 feet MLT are now -46.5, -41.5, -38.5 and -37.5 feet MLLW, respectively.

To convert the survey data to MLLW the vertical datum relationships in Figure 1-2 were used.



NAVD 88 = NORTH AMERICAN VERTICAL DATUM 1988
MLLW = MEAN LOWER LOW WATER
MLT = MEAN LOW TIDE

NOTES:
[1] RELATIONSHIP BETWEEN MLLW AND NAVD88 IS FROM THE MORGANS POINT STATION 8770613
[2] RELATIONSHIP BETWEEN MLT AND NAVD88 PROVIDED BY THE USACE (MAY 2013)

Figure 1-2: BSC and BCC vertical datum relationship for converting survey data

1.6 Related DMMP Documents

This integrated HSC FFR and Environmental Impact Statement (EIS) report includes National Environmental Protection Act (NEPA) documentation of the proposed action. Other DMMP related documents prepared by the USACE for the HSC area include:

- 1987. Final feasibility Report and Environmental Impact Statement, Galveston Bay Area Navigation Study. Volume 1, Main Report. U.S. Army Corps of Engineers, Galveston District, Galveston, Texas.
- 1995. Houston-Galveston Navigation Channels, Texas. Limited Reevaluation Report and Final Environmental Impact Statement. U.S. Army Corps of Engineers, Galveston District, Galveston, Texas.
- 1999. Environmental Assessment for Changes in Bolivar Beneficial Use Placement Area, Safety Zone Construction, Changes in the Offshore Placement Area, and Centerline Offset-Lower Bayou Reach, Houston-Galveston Navigation Channels, Texas, Project. U.S. Army Corps of Engineers, Galveston District, Galveston, Texas.
- 2001. Record of Environmental Considerations for Environmental Restoration of Redfish Reef and San Jacinto State Park Shoreline Protection, Houston-Galveston Navigation Channels, Texas, Project. U.S. Army Corps of Engineers, Galveston District, Galveston, Texas.
- 2003. Final Environmental Assessment, Houston-Galveston Navigation Channels, Texas, Project, Upper Bay Barge Lanes.

- 2005. Record of Environmental Considerations for Houston-Galveston Navigation Channels, Texas Project - Upper Bay Barge Lanes. U.S. Army Corps of Engineers, Galveston District, Galveston, Texas.
- 2006. Final Environmental Assessment, Houston-Galveston Navigation Channels, Texas, Project -Mining Barbours Terminal Channel for Dike Repair and Construction. U.S. Army Corps of Engineers, Galveston District, Galveston, Texas.
- 2010. Final Environmental Assessment, Expansion of Placement Areas 14 and 15, Houston Ship Channel Chambers County, Texas.
- 2014. Final Environmental Assessment for 33 U.S.C Section 408 Approval Request and Section 204(F) Assumption of Maintenance Report Bayport Ship Channel Improvements, Harris and Chambers Counties, Texas. U.S. Army Corps of Engineers, Galveston District, Galveston, Texas.
- 2014. Final Environmental Assessment for 33 U.S.C Section 408 Approval Request and Section 204(F) Assumption of Maintenance Report Barbours Cut Channel Improvement Project, Harris County, Texas. U.S. Army Corps of Engineers, Galveston District, Galveston, Texas.
- 2017. Houston Ship Channel, Texas Preliminary Assessment, 05 December 2017.
- 2018. Houston Ship Channel, Texas 50-Year Conceptual DMMP, 18 December 2018.

2 Existing Conditions

2.1 General

This section describes the existing conditions in the FWOP condition to include shoaling rates, PA/BU sites, potential FWOP PAs, the conceptual FWOP 50-year DMMP, and FWOP non-Federal placement of materials. Channel dimensions are shown in Table 1-1 above. Channel reaches are described in Section 1.4 above.

2.2 Material Types

Geotechnical properties of the maintenance materials are discussed in Section 6.4 of the Engineering Appendix.

2.3 Existing Shoaling Rates

The Federal and non-Federal operations and maintenance (O&M) shoaling data, dredging reaches, dredging practices, and placement of dredged material used for this DMMP analysis were referenced from the HSCPA, dated 5 December 2017 (2017 HSCPA). The FWOP plan assumes the O&M shoaling volumes (and thus dredging volumes) will remain the same as reported in the 2017 HSCPA for the duration of the 50-year project life beginning in the year 2029 and ending in 2078. It also assumes that no new upland PAs will be available after the existing placement areas have reached capacity. Table 2-1presents the 50-year shoaling volumes by reach. The volumes shown in the table include estimated non-pay as presented in the documents referred herein.

The annual shoaling rates, dredging frequencies, and PAs used for each dredging reach represent average values for existing maintenance practices as reported in the 2017 HSCPA. The shoaling rates as presented in the 2017 HSCPA were derived from multiple data sources, including the USACE Dredging Histories Database, and the Draft Houston Ship Channel Sedimentation Study, dated November 2008 (Rev 2012), prepared by the Turner Collie & Braden, Inc./Gahagan & Bryant Associates J.V. for the Port of Houston Authority.

Table 2-1: FWOP 50-Year DMMP by Dredging Reach

Reach Description	Federal Channel Annual Shoaling Rate (Total Volume) CY	Non-Federal Annual Shoaling Rate (Gross Volume) CY	Total Federal and Non-Federal Annual Shoaling Rate CY	Average Dredging Frequency YR	Total Shoaling Rate per Cycle CY	No. of Cycles in 50-Yr Analysis Period	Total 50-Yr Shoaling Volume CY
HSC Bolivar Roads to Redfish Reef	99,194	0	99,194	4	396,784	12	4,761,000
HSC Redfish Reef to BSC	1,468,925	844	1,469,769	3	4,409,307	17	74,958,000
HSC BSC to Morgans Point	771,433	0	771,433	3	2,314,299	17	39,343,000
BSC & Turning Basin	498,500	24,139	522,639	2	1,045,278	25	26,132,000
BSC Flare	788,415	0	788,415	1	788,415	50	39,421,000
HSC Morgans Point to Exxon	509,844	0	509,844	3	1,529,532	17	26,002,000
BCC	234,824	109,310	344,134	3	1,032,402	17	17,551,000
HSC Morgans Point (BCC) to Exxon	730,958	47,250	778,208	3	2,334,624	17	39,689,000
HSC Exxon to Carpenters Bayou	454,759	0	454,759	3	1,364,277	17	23,193,000
HSC Exxon to Carpenters Bayou	0	13,607	13,607	6	81,642	9	735,000
HSC Carpenters Bayou to Boggy Bayou	194,478	88,625	83,103	4	1,132,412	13	14,721,000
Jacintoport Channel	26,000	23,000	49,000	4	196,000	13	2,548,000
HSC Boggy Bayou to Greens Bayou	113,709	0	113,709	4	454,837	13	5,913,000
HSC Greens Bayou to Sims Bayou	215,662	1,709	217,371	5	1,086,857	10	10,869,000
Greens Bayou	52,748	50,826	103,574	6	621,441	8	4,972,000
HSC Sims Bayou to Turning Basin	114,078	9,073	123,151	3	369,453	17	6,281,000
HSC Sims Bayou to Turning Basin	0	34,115	34,115	6	204,690	9	1,842,000
HSC Main Turning Basin	105,089	0	105,089	3	315,267	17	5,360,000
HSC Upper Turning Basin	35,228	0	35,228	3	105,684	17	1,797,000
Buffalo Bayou Light Draft Channel	16,769	0	16,769	6	100,614	9	905,000
Turkey Bend Channel	2,519	0	2,519	6	15,114	9	136,000
Total Federal and Non-Federal Gross Volume:							**347,036,000**

2.4 Advance Maintenance

The current advanced maintenance practices are shown in Table 2-2 below.

Table 2-2: FWOP Advanced Maintenance by Dredging Reach

Houston Ship Channel Section of Waterway	Existing Dimensions					
	Authorized Depth (feet)		Advanced Maintenance	Over Depth	Width (feet)	Length (miles)
	(-) MLT	(-) MLLW				
Segment 1 – HSC-Bay Reach Safety and Efficiency Enhancements						
-Bolivar Roads (Mile 0) to Morgans Point (Mile 26.2)[1]	45	46/46.5	48/48.5	50/50.5	530	26.2
-Barge Lanes (adjacent to and on each side from Mile 0 to Mile 26.2)	12	13	-	14	125	26
-Morgans Point (Mile 26.2) to Boggy Bayou (Mile 38.5)	45	46.5	48.5/50.5	49.5/51.5	530-600	12.3
Morgans Point (Mile26.2) to Exxon (Mile 31.8)	45	46.5	50.5	51.5	530-600	5.6
Exxon (Mile 31.8) to Boggy Bayou (Mile 38.5)	45	46.5	48.5	49.5	530-600	7.4
-South Boaters Cut @ Mile 15.3	8	9	11	12	300	1.9
-North Boaters Cut @ Mile 18.7	8	9	11	12	100	2.1
-Five Mile Cut Channel @ Mile 20.9	8	9	11	12	125	1.9
Segment 2 – Bayport Ship Channel						
-Bayport Ship Channel (Mile 21.4 at intersection with HSC)[3]	45	46.5	48.5	50.5	350-455	3.8
Flare	45	46.5	48.5	50.5	455-4,783	0.7
Turning Basin	45	46.5	48.5	50.5	300-1,600	0.3
Segment 3 – Barbours Cut Channel						
-Barbours Cut Channel (Miles 26.3 at intersection with HSC)[3]	45	46.5	48.5	50.5	300	1.1
Flare	45	46.5	48.5	50.5	455-2,495	0.4
Turning Basin	45	46.5	48.5	50.5	300-1,600	0.3
Segment 4 –Boggy Bayou to Sims Bayou						
-Boggy Bayou (Mile 38.5) to Greens Bayou (Mile 42.0)	45	46.5	48.5	49.5	530	3.5
-Jacintoport Channel*	40	41.5	43.5	45.5	200	0.7
-Greens Bayou (Mile 42.0) to Sims Bayou (Mile 47.5)3	45	46.5	43.5/48.5	44.5/49.5	300	5.5
Greens Bayou (Mile 42.0) to Washburn Tunnel (Mile XX)	45	46.5	48.5	49.5	300	2.7
Washburn Tunnel (Mile XX)	37	38.5	40.5	41.5	300	-
Washburn Tunnel (Mile XX) to Sims Bayou (Mile 47.5)	40	41.5	43.5	44.5	300	2.6
Hunting Bayou Turning Basin	40	41.5	43.5	44.5	948-1,000[2]	0.3
Clinton Island Turning Basin	40	41.5	42.5	43.5	965-1,070[2]	0.3
-Greens Bayou Channel Mile 0.0 to Mile 0.36	40	41.5			175	0.4
-Greens Bayou Channel Mile 0.36 to Mile 1.65	15	16.5			100	1.3
Segment 5 –Sims Bayou to I-610 Bridge						
-Sims Bayou (Mile 47.5) to I-610 Bridge (Mile 48.3)	36	37.5	39.5	40.5	300	0.8
Segment 6 –I-610 Bridge to Main Turning Basin						
-I-610 Bridge (Mile 48.3) to Houston (Main) Turning Basin (Mile 50.2)	36	37.5	39.5	40.5	300	1.9
Houston (Main) Turning Basin	36	37.5	39.5	40.5	400-932	0.6
Upper Turning Basin	36	37.5	39.5	40.5	150-527	0.2
Brady Island Channel	10	11	13	14	60	0.9
Brady Island Turning Basin	45	46.5	48.5	49.5	900	0.2
Buffalo Bayou Light Draft Channel	10	11	13	14	60	4.1
Turkey Bend Channel	10	11	13	14	60	0.8

[1] *Per the MLT to MLLW Datum Conversion, the split occurs at Beacon 76.*

[2] *Includes 300-foot channel width*

[3] *PHA received approval to deepen channel to 46.5 feet MLLW and subsequent Federal Assumption of Maintenance (AOM) under Section 408/204(f). BSC deepening was completed in Fall of 2016 and BCC was completed in August 2015. Additionally, the BSC was widened from 300 feet to 400 feet from the BSC Flare to the land cut and from 300 feet to 350 feet from the land cut to the BSC Turning Basin.*

2.5 Existing PAs and BU sites

Figure 2-1 shows the PAs and BU sites currently associated with the HSC. Table 2-3 shows 1) the existing HSC PAs and BU sites; 2) their approximate size, 3) which study reach the PAs and BU sites are located within; and 4) whether the site is feasible for continued use. Although the PA(s) and BU sites are described by reach, emergency repairs, natural events, and other reasons may require the use of different PA by a particular reach. These sites are described as "typically" used; not assigned or restricted to. For the 2017 HSCPA, limited geotechnical exploration was performed for the upland confined PAs. The geotechnical data collected was analyzed and used to perform slope stability analyses for assumed ultimate dike elevations for each PA. Descriptions of the geotechnical exploration and stability analyses performed for the upland confined PAs are included in Attachment 7 of the Engineering Appendix. PA plans and typical dike sections are discussed in Section 4.8.2 of the Engineering Appendix.

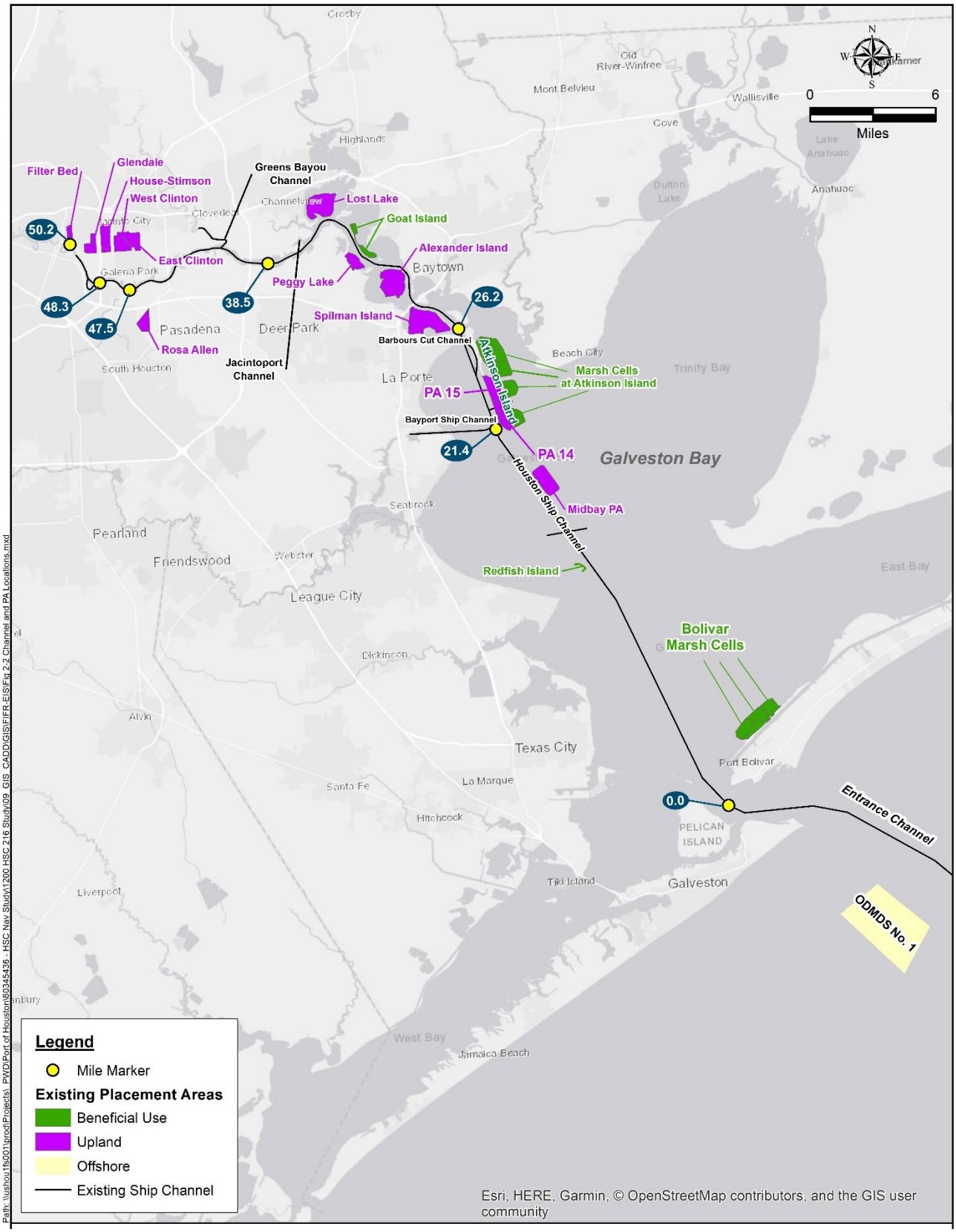


Figure 2-1 Existing HSC PAs and BU Sites

Table 2-3: Existing HSC PAs and BU sites

PA/BU Name	PA Type[1]	Approximate Size	Associated Study Reach (*beginning at Seaward end*)	Future Use Feasible (Y/N)
ODMDS	OW	6.6 square nautical miles (M^2) (about 5,550 acres)	Bolivar Roads to Redfish Reef	Y
Bolivar Marsh BU	BU	1,078 acres	Bolivar Roads to Redfish Reef	N
Evia Island BU	BU	6 acres	Bolivar Roads to Redfish Reef	N
Mid Bay PA	BC	600 acres	Redfish to BSC/BSC	Y
PA 14	UC	325 acres	Redfish to BSC/BSC/BSC to BCC	Y
PA 15	UC	395 acres	Redfish to BSC/BSC/BSC to BCC	Y
PA 14/15 Connection	UC	160 acres	Redfish to BSC/BSC/BSC to BCC	Y
Atkinson Island BU Marsh Site	BU	1,842 acres	BSC/BSC to BCC	Y
PA 16	UC	80 acres	BSC/BSC to BCC	N
Spilman Island PA	UC	890 acres	Morgans Point to Exxon	Y
Alexander Island PA	UC	650 acres	Morgans Point to Exxon	Y
Peggy Lake PA	UC	240 acres	Exxon to Carpenters, Carpenters to Boggy Bayou, Boggy Bayou to Greens Bayou	Y
Goat Island BU	BU	320 acres	Exxon to Carpenters, Carpenters to Boggy Bayou, Boggy Bayou to Greens Bayou, Jacintoport Channel	N
Lost Lake PA	UC	600 acres	Exxon to Carpenters, Carpenters to Boggy Bayou, Boggy Bayou to Greens Bayou, Jacintoport Channel	Y
Rosa Allen PA	UC	223 acres	Upstream of Greens Bayou	Y
East Clinton PA	UC	290 acres	Upstream of Greens Bayou	Y
West Clinton PA	UC	317 acres	Upstream of Greens Bayou	Y
House Tract PA	UC	312 acres	Upstream of Greens Bayou	Y
Glendale PA	UC	177 acres	Upstream of Greens Bayou	Y
Filterbed PA	UC	90 acres	Upstream of Greens Bayou	Y

[1] *OW-Open Water; UC – Upland Confined; BC – Bay Confined*

2.5.1 Future PA 50-Year Life in the FWOP Condition

Table 2-4 shows a summary of the projected FWOP 50-year DMMP by PA with dredging reaches and study segments identified, along with PA life, and estimated volumes for the BABUS and ODMDS after the existing PAs have reached capacity. Future PAs are discussed in Section 2.6 below. This table assumes the projected condition in year 2029, the beginning of the O&M period of analysis for the HSC ECIP Study.

Table 2-4: FWOP 50-Year Conceptual DMMP

Placement Area	Study Segment	Dredging Reach	Total 50-YR OM Dredging Volume, CY[2]	Available Capacity in PA, CY[2]	PA Life, YR[3]	Year Full	Alternate Placement Location After End of PA Life	Volume Placed in Alternate Location, CY[2]
ODMDS	1	HSC Bolivar Roads to Redfish Reef	4,761,000	NEL	50	NA	NA	0
Mid Bay	1	HSC Redfish Reef to BSC	75,494,000	11,406,000	7	2035	ODMDS	64,088,000
PA 14	2	BSC	45,843,000	9,031,000	10	2038	ODMDS	36,812,000
PA 14/PA 15 Conn.	2	BSC	19,710,000	10,060,000	25	2053	ODMDS	9,650,000
PA 15	1	HSC BSC to Morgans Point	38,714,000	11,386,000	17	2045	ODMDS	27,328,000
Spilman Is.	1,3	HSC Morgans Point to Exxon and BCC	43,553,000	14,244,000	16	2044	BABUS	29,309,000
Alexander Is.	1	HSC Morgans Point (BCC) to Exxon	39,689,000	17,862,000	22	2050	BABUS	21,827,000
Peggy Lake	1	HSC Exxon to Carpenters Bayou	12,195,000	6,296,000	26	2054	BABUS	5,899,000
Lost Lake	1,4	HSC Carpenters Bayou to Boggy Bayou, Boggy Bayou to Greens Bayou, and Jacintoport Channel	34,915,000	6,225,000	6	2034	BABUS	28,690,000
Rosa Allen	4	HSC Greens Bayou to Sims Bayou	5,477,000	2,934,000	19	2047	BABUS	2,543,000
East Clinton	4	HSC Greens Bayou to Sims Bayou and Greens Bayou	10,364,000	6,290,000	29	2057	BABUS	4,074,000
West Clinton	5,6	HSC Sims Bayou to Turning Basin	8,711,000	5,651,000	31	2059	BABUS	3,060,000
House Tract	5,6	HSC Sims Bayou to Turning Basin & Light Draft	7,610,000	4,530,000	28	2056	BABUS	3,080,000
Glendale	6	HSC Sims Bayou to Turning Basin & Light Draft	Not Used	3,926,000	-	-	-	-
Filterbed	6	HSC Sims Bayou to Turning Basin & Light Draft	Not Used	-	-	-	-	-
Totals	-	-	347,036,000	109,841,000	-		-	236,360,000

Notes:
[1]Includes non-pay volumes.
[2]In-Situ Dredging Volumes, including Federal and non-Federal Maintenance.
[3]Beginning in 2029.

Table 2-5 summarizes the FWOP DMMP by study segment, presents estimated 50-year O&M volumes by study segment and identifies the portions of those volumes which exceed the existing PA capacities, and finally, where those excess volumes would be placed. Based on this table, of the estimated 236.4 Million cubic yards (MCY) volume of maintenance material over and above existing PA capacity, approximately 137.9 MCY would be placed into the ODMDS and 98.5 MCY would be placed into BABUS sites. BABUS sites are discussed further in Section 2.6.2 below.

Table 2-5: FWOP 50-Year by Study Segment

Study Segment	Total 50-YR OM Dredging Volume, CY	Total 50-YR OM Dredging Volume over PA Capacity, CY	OM Dredging Volume to ODMDS, CY	OM Dredging Volume to BABUS, CY
1	225,857,000	159,294,000	91,416,000	67,878,000
2	65,553,000	46,462,000	46,462,000	0
3	17,551,000	12,389,000	0	12,389,000
4	21,754,000	12,075,000	0	12,075,000
5	2,599,000	978,000	0	978,000
6	13,722,000	5,162,000	0	5,162,000
Totals	347,036,000	236,360,000	137,878,000	98,482,000

2.6 Future Placement Areas

2.6.1 Lynchburg PA

The Lynchburg PA is a new UCPA that would be constructed at a site located about 6 miles north northeast of the existing Lost Lake PA in Highlands, Texas. This site was previously evaluated in the 2017 HSCPA (the Farmland Tract) but dropped from further consideration due to costs and operability issues. This PA was dropped from further consideration for this study for the same reasons it was dropped from the 2017 HSPA. The following is a description of the PA.

The new PA would include one new drop-outlet (weir) discharge structure having the capability to regulate ponding levels in the PA, and to discharge dredge water while maintaining required water quality. Construction of the new PA would be expected to impact existing wetland habitat and pipelines.

The location of the new PA would require about 10 to 15 miles of hydraulic pumping distance to transport new work and maintenance material from the HSC to the PA; this distance is over 8 miles longer than that required to pump material into the existing Lost Lake PA. Two to three booster pumps would be required to transport dredged maintenance material from the HSC to the new PA. Depending on the dredging reach, this measure would require an estimated 10-15 miles of pipeline (8 miles of additional dredge pipe beyond Lost Lake PA) which would consist of a combination of temporary floating, submerged, and/or land pipe and some length of permanent dredge pipe.

There are a number of operability issues associated with this PA alternative. These include limitations on vessel speed and movements through long reaches of the federal channel during ongoing dredging as a result of the presence of the cutter head dredge plant and miles of floating pipeline that would be in the channel. The pipeline route from the HSC to the Lynchburg PA would follow the suggested route identified in the Value Engineering Report prepared for the HSCPA. This pipeline route would begin in the HSC at the point of dredging and then follow the HSC to Lost Lake PA. The route continues from Lost Lake PA across the San Jacinto River, and then follows the right-of-way (ROW) on N. Main Street to just north of Commerce Street in a permanent conduit. Temporary dredge pipe would then continue on to the discharge point at the PA. Real estate (land and easements) would have to be purchased by the non-Federal Sponsor (NFS). The Lynchburg PA site would provide new work PA capacity and extend the capacity for the maintenance material for bayou reaches of the project beyond 20 years.

2.6.2 Bay Aquatic Beneficial Use Sites (BABUS)

The BABUS concept is a combination traditional confined aquatic disposal (CAD) cell excavated below existing bay bottom with an emergent dike constructed around the CAD cell using the excavated soils placed hydraulically to create BU or habitat areas. The estimated interior excavation elevation would be -70 feet MLLW and the dike crest elevation would be +6 feet MLLW for the purposes of this study. Actual elevations will be determined during design. The BABUS concept includes establishing submerged, intertidal, and emergent habitat on the dikes, with the interior area of each site raised to create intertidal marsh habitat once filled to capacity. The interior excavation will be performed using hydraulic cutter head dredge with the excavated material used to build the exterior dikes and the resulting habitat. The dikes will have 7H:1V inside side slopes. The exterior side slopes will be compound with 7H:1V from the dike crest to elevation +3 feet, then about 30H:1V side slopes below elevation +3 feet down to bay bottom to provide more habitat area and protection against erosion from the bay wave and current environment. Table 2-6lists the general habitat types and area of each estimated to be created for the BABUS.

The BABUS sites would be constructed in Galveston Bay, south of Atkinson Island, north of Midbay PA, and east of the HSC, with the intent to avoid oyster impacts and impacts to existing pipelines. Design and placement of the BABUS sites will take into consideration minimization of bay bottom area impacts by overlapping the outside toes of adjacent sites.

The BABUS sites would be utilized to provide storage for O&M dredged material once the existing confined PAs have reached capacity. They would also be able to accept new work from expansion of either Federal channels or non-Federal facilities. The O&M dredged material would be placed in the BABUS using bottom-dump scows and/or hopper dredges that would access the interior of the sites using the existing Five Mile Cut (widened and deepened as required) and then through access channels excavated into the bay bottom and extending through gaps in the exterior dikes. Once the BABUS fill elevation prevents floatation inside each site, the exterior dike would be

closed, and the interior would be filled to final marsh elevation using &OM material dredged and hydraulically pumped into the sites.

For the FWOP DMMP, an estimated four (three 325-acre and one 200-acre) BABUS sites would be required to provide capacity for O&M (Federal and non-Federal) material dredged over the 50-year analysis period. The acreages shown for the BABUS sites are as measured at the dike centerlines for the purposes of these descriptions, although the outside toes of the dikes will extend over greater areas due to the very flat outside side slopes. Estimated O&M dredged material capacities for the BABUS sites are 29 MCY and 15 MCY for the 325-acre and 200-acre sites, respectively. The total capacity provided by the three 325-acre and one 200-acre BABUS would be about 102 MCY which exceeds the estimated required capacity of about 98.5 MCY shown in Table 2-5.

Once each BABUS is constructed, it is estimated it will take about five years (325-acre) and three years (200-acre) to fill each site considering their respective capacities and depending upon actual maintenance dredging tempos. BABUS sizes presented here were selected for the purposes of this study and may vary during design in PED. A discussion of the timing for beginning construction and use of the BABUS is presented in following sections of this document.

Table 2-6: BUBUS Habitat

Habitat Description	Area per BABUS, Ac	
	325-Ac Site	200-Ac Site
Upland on Dike Slopes	59	39
Emergent Marsh on Dike Slopes	66	46
Oyster Reef on Dike Slopes	50	33
Emergent Marsh Interior of Site	347	218
Total Habitat Area	522	336

2.6.2.1 BABUS Environmental Features

Multiple habitat types can be created on the sides of the BABUS cells. The height of the BABUS cell crest would be approximately 6 feet above MLLW. To estimate the amount of each habitat that would be created we created a template for where each habitat type would be established. Oyster (*Crassostrea virginica*) habitat would be established from approximately -2 feet to -10 feet MLLW on the outer slope of the cells. This would provide 50 acres of reef on the larger cells and 33 acres on the smaller cells. Emergent marsh habitat, dominated by smooth cordgrass (*Spartina alterniflora*), could be established from 0 to 3 feet on both the inner and outer slops of the cells, providing 66 acres on the larger cells and 46 acres on the smaller cell. After the BABUS cell has been filled the interior of the cell can then be utilized to establish another 290 acres of emergent marsh in each of the larger cells and 175 acres in the smaller cell. Upland/bird island habitat, dominated by marsh elder (*Iva frutescens*) and saltbush (*Baccharis halmifolia*), could be established from 3 feet to the top of the crest of the cell, covering both the inner and outer slopes. This habitat would provide 59 acres of habitat on each of the larger cells and 39 acres on the

smaller cell. Conceptual drawings of the BABUS environmental habitat features are shown in Section 4.8.1.5 of the Engineering Appendix.

HEP models were used to estimate impacts from the placement of the BABUS cells to the bay bottom. Two models were used to estimate the impacts to different species groups. Red drum was selected as the proxy for finfish, while brown shrimp was chosen as the proxy for invertebrates. The AAHUs for each model were averaged to give a representative impact to the community utilizing the bay bottom. When the succession of four BABUS cells were included in the model over a 50-year project horizon the average AAHUs are estimated to be 495. The American Oyster HSI model estimated the benefits of the oyster reefs over the project life to be 124 AAHUs. The Brackish Marsh WVA V 2.0 model estimated the benefits of the fringing emergent marshes over the project life to be 315 AAHUs. The Roseate spoonbill HSI model estimated the benefits of the upland/bird island habitat at 149 AAHUs. While the impacts to the bay bottom of over the 50-year project life will total an estimated 495 AAHUs, the benefits returned by the ecological habitats created would total an estimated 588 AAHUs.

2.7 Future Without Project -Year Plan (Beginning in 2029)

The total projected FWOP 50-year maintenance dredging volume for the HSC and tributary channels is about 347 MCY. The system currently has capacity for about 105.9 MCY, leaving an estimated capacity shortfall of about 236.4 MCY. The system capacity volumes described do not include the ODMDS which is considered to have no engineering limit because it is a dispersive open water site. BABUS located in Galveston Bay are proposed to provide storage for maintenance material volumes that exceed existing confined PA capacities generally above Morgans Point and supplemented with ODMDS in generally Galveston Bay. Table 2-7 shows the placement plan by dredging reach in general accordance with the 2017 HSCPA and projected out over the 50-year period of analysis.

Table 2-7: FWOP 50-Year Mainenance

Reach Description	Placement Area Used	Federal Channel Annual Shoaling Rate (Total Volume) CY	Non-Federal Annual Shoaling Rate (Gross Volume) CY	Total Federal and Non-Federal Annual Shoaling Rate CY	Average Dredging Frequency YR	Total Shoaling Rate per Cycle CY	No. of Cycles in 50-Yr Analysis Period	Total 50-Yr Shoaling Volume CY
HSC Bolivar Roads to Redfish Reef	ODMDS (PA1)	99,194	0	99,194	4	396,776	12	4,960,000
HSC Redfish Reef to BSC	Mid Bay/ODMDS	1,468,925	0	1,468,925	3	4,406,775	17	73,446,000
HSC BSC to Morgans Point (BCC)	PA15/ODMDS	771,433	0	771,433	3	2,314,299	17	38,572,000
BSC & Turning Basin	PA14/Connection/ODMDS	498,500	24,139	522,639	2	1,045,278	25	26,132,000
BSC Flare	PA14/Connection/ODMDS	788,415	0	788,415	1	788,415	50	39,421,000
BCC	Spilman Island/BABUS	282,144	109,310	391,454	3	1,174,362	17	19,573,000
HSC Morgans Point to Exxon	Spilman/Alexander Island/BABUS	1,240,802	47,250	1,288,052	3	3,864,156	17	64,403,000
HSC Exxon to Carpenters Bayou	Peggy Lake/Lost Lake/BABUS	454,759	13,607	468,366	3	1,405,098	17	23,418,000
HSC Carpenters Bayou to Boggy Bayou	Lost Lake/BABUS	194,478	137,625	332,103	4	1,328,412	13	16,605,000
HSC Boggy Bayou to Greens Bayou	Lost Lake/BABUS	113,709	0	113,709	4	454,837	13	5,685,000
HSC Greens Bayou to Sims Bayou	Rosa Allen/East Clinton/BABUS	215,662	1,709	217,371	5	1,086,857	10	10,869,000
Greens Bayou	East Clinton/BABUS	52,748	50,826	103,574	6	621,441	8	5,179,000
HSC Sims Bayou to Turning Basin	House Tract/West Clinton/BABUS	114,078	43,188	157,266	3	471,798	17	7,863,000
HSC Main Turning Basin	House Tract/BABUS	105,089	0	105,089	3	315,267	17	5,254,000
HSC Upper Turning Basin	House Tract/BABUS	35,228	0	35,228	3	105,684	17	1,761,000
Light Draft Channel	House Tract/BABUS	12,650	0	12,650	6	75,900	9	633,000
Turkey Bend Channel	House Tract/BABUS	2,519	0	2,519	6	15,114	9	126,000
Turkey Bend Cut-off Channel	House Tract/BABUS	4,119	0	4,119	6	24,714	8	206,000
Total Federal and Non-Federal Gross Volume:								**344,106,000**

2.8 FWOP Dredging Operations

The FWOP DMMP assumes that existing maintenance dredging and placement practices, as described in the 2017 HSCPA, would continue until each of the existing PAs reach capacity. The existing practice of maintenance dredging for the HSC and tributary channels is cutter head dredging with the material conveyed and placed into upland and bay confined PAs by hydraulic pipeline, with the exception of the Bolivar Roads to Redfish reach and occasionally the Redfish to BSC reach which is dredged using a hopper dredge and placed into the ODMDS. For the HSC dredging reaches north of Morgans Point (including BCC), once each individual existing PA has reached capacity, the maintenance material that is normally placed in that PA would then be dredged using mechanical dredging and placed into bottom-dump barges/scows, or by hopper, then transported and placed into the proposed BABUS. For the HSC reaches south of Morgans Point to Bolivar Roads (including BSC), the channel will be maintained using hopper dredges and the dredged material placed into the ODMDS.

2.8.1 BABUS

Transitioning to BABUS use with mechanical dredging with bottom-dump scows and/or hopper dredges to move the OM material to BUBAS sites will need to occur prior to the first exiting PA reaching capacity in order to provide uninterrupted maintenance of the HSC. Lost Lake PA is the first existing PA projected to reach capacity in the year 2034 or about 6 years into the period of analysis; therefore, a BABUS would be constructed and fully operational sometime prior to that time. This approach would also allow the dredging industry to develop the necessary plant for use in the area and provide competitive bidding and thus cost for the O&M dredging in the future. It has been suggested that a test-case BABUS be constructed early in the period of analysis as a proof of concept.

2.8.2 Hopper Dredging

As described above, the FWOP assumes using hopper dredging and placement into the ODMDS for the HSC from Bolivar Roads to Morgans Point, and BSC. Although it may be possible to receive environmental clearance from the Environmental Protection Agency (EPA) to hopper dredge and place maintenance material from the HSC upstream of Morgans Point (bayou reach) into the ODMDS, there are a number of constraints on that operation that make it less desirable than the planned mechanical dredging and placement into BABUS. Those constraints are listed below:

- Hopper dredging of the bayou reach (existing 400-foot wide or less) channel is not an optimum solution for FWOP due to limited channel width, maneuverability within a congested channel, and long distance to ODMDS;
- Hopper dredge of non-federal material within the berths/docks is limited to areas outside of the required dock offset of 50 feet (minimum); this offset requirement will not change with proposed widening or deepening of the bayou channel;

- A secondary mechanical or pipeline dredge would be required to dredge dock space within the offset performed under an additional separate contract, to include an additional dredge plant mobilization/demobilization to separate nearby PA;
- Sail distance from the bayou reach to the ODMDS can be up to about 114 miles round trip. With an average hopper dredge capacity of about 14,000 CY of material, the relatively small capacity combined with the long sail distance to the ODMDS site make hopper dredging an inefficient method of dredging and placement for material. The production rate would be slow, on the order of 1 cycle per day. This slow of a production rate would result in extremely long contract durations for the bayou dredging reaches;
- There is also the risk that industry would not be interested in contracting a job that would have inherent slow production rates; and therefore, tie up their hopper dredges for extended periods. Because of this, contract costs would likely be higher than expected, or contractors may not bid on jobs thus reducing competition. Additionally, other USACE projects (beach placement, jetty channel jobs) across the nation are dependent on the availability of hopper dredges. Taking a dredge out of competition for other USACE work in order to dredge the HSC upstream of Morgan's Point adversely impacts the overall USACE navigation mission.

2.9 FWOP DMMP Costs

FWOP O&M dredging costs for the DMMP would not change from the current practice until the existing confined PAs are nearing capacity. This assumes that the current practice of using hydraulic cutter head dredges to maintain the HSC and tributary channels upstream of Redfish Reef and placement into confined PAs, and hopper dredging of the HSC from Bolivar Roads to Redfish Reef and placement into the ODMDS would continue. Costs for the existing practices, as well as hopper dredging of the HSC up to Morgans Point and the BSC, have been developed and are presented and discussed in the FWP planning formulation sections of this report. Once the existing confined PAs begin to reach capacity and the dredging and placement practices begin to change as described above for the FWOP DMMP, the dredging, transporting, and placement costs will change. For the purposes of the FWOP DMMP, per cubic yard unit costs were developed for each dredging reach for mechanical dredging and bottom-dump scow transportation to the BABUS locations and placement of the dredged material into the sites by dumping directly from the scows. In addition, estimated construction costs to build the BABUS were developed. Table 2-8 presents the total dredging costs by dredging reach and are based on an average travel distance to the BABUS for each reach.

Table 2-8: FWOP OM Mechanical Dredging to BABUS Unit Costs

Dredging Reach	Dredging Volume per Cycle, CY	Total Placement Cost
Morgans Point to Exxon, Sta 0+00 to Sta 150+00	1,530,000	$12,454,200.00
Morgans Point to Exxon, Sta 150+00 to Sta 300+00	2,335,000	$15,924,700.00
Exxon to Carpenters Bayou, Sta 300+00 to Sta 530+00	1,446,000	$13,751,460.00
Carpenters Bayou to Boggy Bayou, Sta 530+00 to Sta 684.03	1,328,000	$16,772,640.00
Boggy Bayou to Greens Bayou, Sta 684+03 to Sta 833+06	455,000	$8,185,450.00
Greens Bayou	622,000	$7,775,000.00
Greens Bayou to Sims Bayou, Sta 833+05 to Sta 1110+78	1,087,000	$13,467,930.00
Sims Bayou to Turning Basin, Sta 1110+78 to Sta 1266+49	574,000	$10,773,980.00
Main and Upper Turning Basins	421,000	$7,999,000.00

Once the elevation of fill within the BABUS has reached the point where floatation of the bottom-dump scows is not possible (above about +17 feet MLLW) within the area, the dredged O&M material must be hydraulically placed to raise the interior to the required elevation to create marsh habitat. As a result, it was estimated that about sixty percent of the dredge material placement volumes would be placed in the BABUS using the bottom-dump scow method. The remaining forty percent of the dredged material would be placed using the hydraulic method described below. An additional $3.75 per CY cost must be added to the bottom-dump scow unit costs if a material handler and slurry barge is used to hydraulically place the dredge material. Alternately, the final marsh fill may be constructed using O&M material dredged from nearby HSC channel reaches using conventional hydraulic cutter head dredging methods.

Initial BABUS construction costs were developed for each of the different size BABUS proposed. In addition, costs for deepening and widening the existing Five Mile Cut channel and to provide access channels from Five Mile Cut to the BABUS' were developed. Table 2-9 presents these costs.

Table 2-9: BABUS and Channel Construction Costs

Item Description	Five Mile Cut Deepening & Widening Dredging	BABUS 325-Acre Cost Each (3 Required)	BABUS 200-Acre Cost Each (1 Required)	Total Construction Costs All BABUS
Mobilization/Demobilization	-[1]	$1,500,000	$1,500,000	$6,000,000
Excavate Cell & Place on Dike Alignment		$71,591,000	$35,426,000	$250,199,000
Shape Dike Fill		$10,542,000	$8,391,000	$40,017,000
Oyster Reef Construction		$5,260,000	$3,610,000	$19,390,000
Emergent Marsh Spartina Planting		$56,000	$47,000	$215,000
Upland Marsh Shrub Planting		$3,369,000	$2,248,000	$12,355,000
Hydraulic Cutter Head Dredge Access Channel		$1,006,000	$1,006,000	$4,024,000
Hydraulic Cutter Head Dredging	$1,890,000	-	-	$1,890,000
Total Costs	$1,890,000	$93,324,000	$52,228,000	$334,090,000

Note: [1]Mobilization/Demobilization cost for dredging Five Mile Cut assumed included in first BABUS construction costs.

The total capacity provided by the three 325-Acre and one 200-Acre BABUS would be about 102 MCY.

2.10 Future Non-Federal New Work from Local Service Facilities

Due to capacity limitations of the existing Federal PAs for maintenance of the existing HSC and tributary channels, non-Federal LSF needing to modify and/or maintain their berthing facilities would need to identify other placement opportunities for their new work and maintenance material. The BABUS constructed by USACE would offer additional capacity that could be made available to non-federal users, at a fee to compensate for federal costs of planning, engineering, construction and maintenance.

Existing privately-owned PAs known as East and West Jones are located south of the HSC near Station 875+00. Placement into these sites has occurred as recently as 2018. However, these PAs pose a high risk for future containment dike failures. The East Jones PA experienced a major dike failure during the summer of 2018 while placing dredged material from private sources located in the HSC.

There are at least twelve know private DMPAs as indicted on Figure 2-5. Because the USACE doesn't own or operate these PAs, the government cannot direct the availability of these sites for non-Federal placement of dredged material.

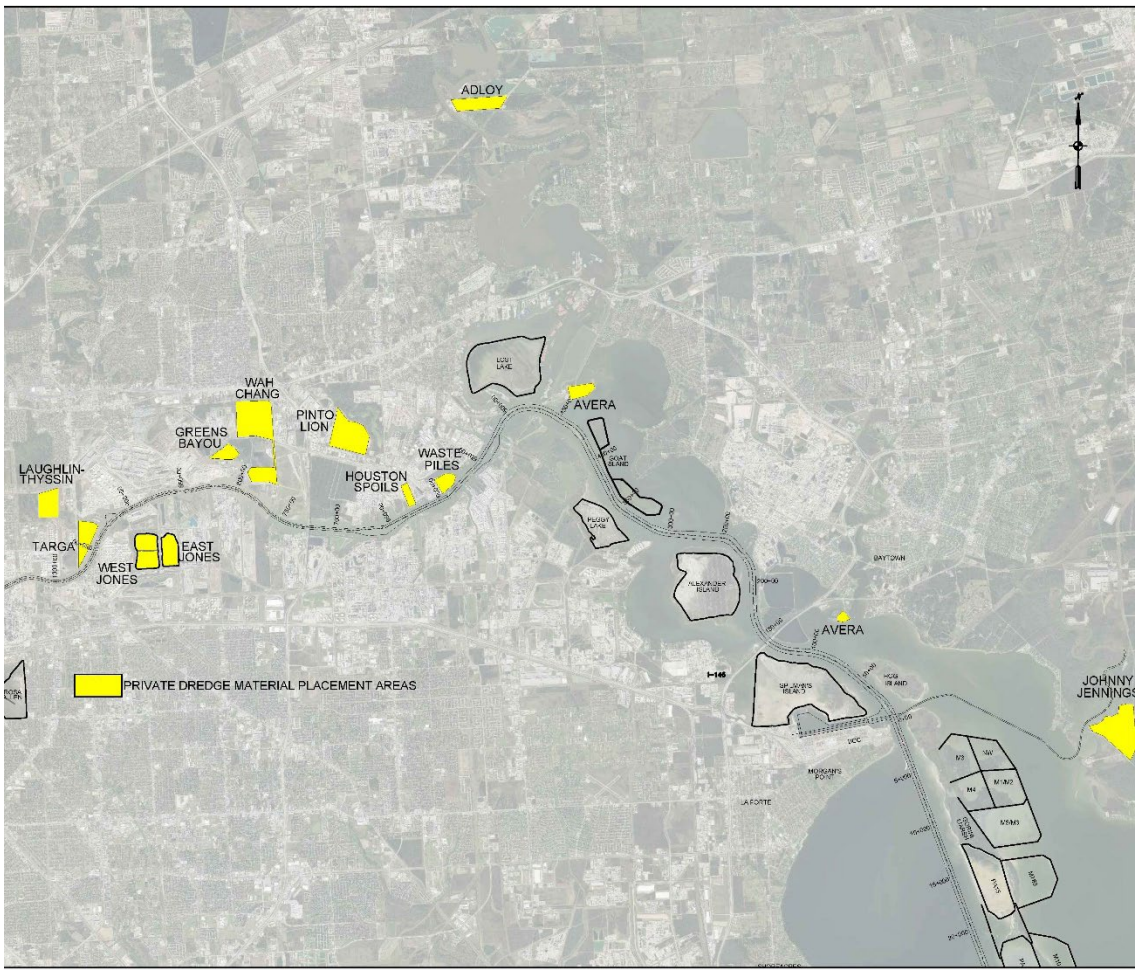


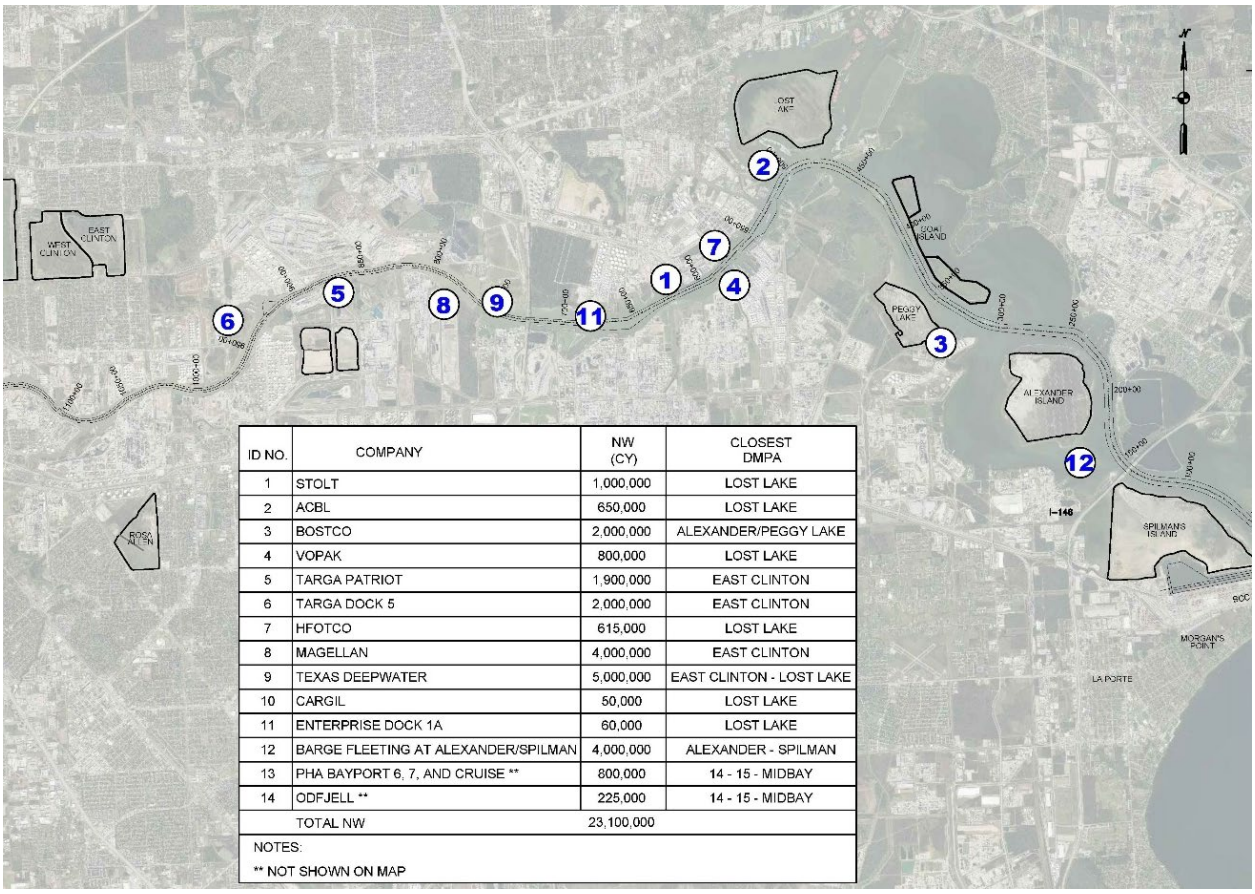
Figure 2-2: Location of Private DMPAs

The PHA provided a list of known planned dock expansion projects along the HSC expected in the next 5 years as part of the 2017 HSCPA. Details are shown in Table 2-10 and approximate locations are shown in Figure 2-3.

Table 2-10: Planned Dock Expansions

No.	Company	New Work (CY)	Closest DMPA	Status	Comment
1	Stolt	1,000,000	Lost Lake	permit pending	
2	ACBL	650,000	Lost Lake	permit pending	
3	BOSTCO	2,000,000	Alexander Island or Peggy Lake	permitted	Complete
4	Vopak	800,000	Lost Lake	permit pending	
5	Targa Patriot	1,900,000	Clinton East	not permitted	East-West Jones/Banana Bend
6	Targa Dock 5	2,000,000	Clinton East	not permitted	East-West Jones/Banana Bend
7	HFOTCO	615,000	Lost Lake	permit pending	going East-West Jones
8	Magellan	4,000,000	Clinton East	permit pending	going on-site/private
9	Texas Deepwater	5,000,000	Clinton East or Lost Lake	permitted	going on-site/private

10	Cargil	50,000	Lost Lake	not permitted	on hold
11	Enterprise Dock 1A	60,000	Lost Lake	not permitted	going on-site/private
12	Barge Fleeting at Alexander/Spilman Islands	4,000,000	Alexander or Spilman	not permitted	
13	PHA Bayport 6, 7 and Cruise*	800,000	14, 15, Midbay	permitted	not shown on map
14	Odfjell*	225,000	14, 15, Midbay	permitted	not shown on map
Total		23,100,000			



ID NO.	COMPANY	NW (CY)	CLOSEST DMPA
1	STOLT	1,000,000	LOST LAKE
2	ACBL	650,000	LOST LAKE
3	BOSTCO	2,000,000	ALEXANDER/PEGGY LAKE
4	VOPAK	800,000	LOST LAKE
5	TARGA PATRIOT	1,900,000	EAST CLINTON
6	TARGA DOCK 5	2,000,000	EAST CLINTON
7	HFOTCO	615,000	LOST LAKE
8	MAGELLAN	4,000,000	EAST CLINTON
9	TEXAS DEEPWATER	5,000,000	EAST CLINTON - LOST LAKE
10	CARGIL	50,000	LOST LAKE
11	ENTERPRISE DOCK 1A	60,000	LOST LAKE
12	BARGE FLEETING AT ALEXANDER/SPILMAN	4,000,000	ALEXANDER - SPILMAN
13	PHA BAYPORT 6, 7, AND CRUISE **	800,000	14 - 15 - MIDBAY
14	ODFJELL **	225,000	14 - 15 - MIDBAY
	TOTAL NW	23,100,000	

NOTES:
** NOT SHOWN ON MAP

Figure 2-3: FWOP LSF New Work Dock Locations

The table below provided by PHA lists the approximate CY of dredged materials placed by third parties in Federal UCPAs in the last 10-years. This does not fully express the need for placement as new processes for the acceptance of materials such as testing and funding agreements evolved over the time period and third parties had to place their materials in alternate sites.

Table 2-11: Third Party Placement over Last 10 Years

Year	Company	Quantity (CY)	PA	Material Type	Approx. HSC Station
2009	Sneed Shipbuilding	53,000	Lost Lake	new work	490+00
	Kinder Morgan Petcoke	15,000	Lost Lake	maintenance	715+00
	Texas Terminals	42,000	Lost Lake	maintenance	625+00
2010	ExxonMobil	190,000	Alex Is.	maintenance	230+00
	Westway	9,000	House	maintenance	1260+00
	HFOTCO dock 4	250,000	Peggy Lake	new work	540+00
	Houston Cement	20,000	House	maintenance	1105+00
2011	City of Baytown	57,000		maintenance	90+00
	ExxonMobil	120,000	Spilman	maintenance	230+00
	BOSTCO	2,200,000	Alexander	new work	330+00
2012	ExxonMobil	80,000	Spilman	maintenance	230+00
	Manchester Terminal	20,000	Rosa Allen	maintenance	1090+00
2013	Linde LLC	29,000	Spilman	maintenance	150+00
	ExxonMobil	80,000	Spilman	maintenance	230+00
	BOSTCO	150,000	Lost Lake	maintenance	330+00
	ExxonMobil	38,000	Spilman	maintenance	230+00
2014	ExxonMobil	75,000	Spilman	maintenance	230+00
	Cemex	140,000	Lost Lake	maintenance	500+00
	Westway	9,000	House or Clinton	maintenance	1260+00
2015	ExxonMobil	70,000	Spilman	maintenance	230+00
	HFOTCO	130,000	Lost Lake	maintenance	565+00
	Vopak Deer Park	105,000	Lost Lake	maintenance	550+00
2016	Manchester Terminal	21,000	Housetract/Clinton	maintenance	1090+00
	Odfjell	28,000	cell 14 /15	maintenance	2600+00
2017	ExxonMobil	91,000	Alex. Island	maintenance	230+00
2018	ExxonMobil	100,000	Peggy Lake	maintenance	230+00
	BOSTCO	75,000	Peggy Lake	maintenance	330+00
	MARMAC	63,000	Lost Lake	maintenance	490+00
	City of Baytown	115,000	Spilman	maintenance	90+00
	ITC	122,000	Lost Lake	maintenance	570+00

The FWOP DMMP is constrained by the scope of the project as set forth in the HGNC, Texas, Limited Reevaluation Report (LRR) and Final Supplemental EIS that was completed in November 1995. The LRR identifies 7 specific LSF on the HSC necessary to achieve the benefits of the project, and 10 PAs which are also referenced by the Project Cooperation Agreement (PCA). Specifically, the LRR lists the LSF for the HSC as "the berthing areas for the private docks at Exxon, Shell, Oiltanking, Paktank, Houston Fuel Oil, and Cargil and the public dock at

International Terminals." Therefore, O&M funding may be used to study and plan for capacity issues, including loss of capacity caused by the placement of non-Federal material from LSFs in the HSC, provided that planning is limited to the 7 LSFs and 10 PAs described in the LRR. Placement of the approximately 23 MCY of material from LSFs not contemplated by the LRR or Chief's Report falls outside the scope of the Congressionally authorized project.

The use of O&M funds to plan for non-Federal new work material, the accommodation of which would necessitate expansion or modification of the Federal project, is limited to conceptual-level planning, per Office of Counsel Galveston District's reading of ER 1105-2-100.

The costs of DMMP studies for continued maintenance of existing Federal navigation projects are Federally funded O&M costs. However, ER 1105-2-100 Appendix E-15 (f)(1)(a) states that study activities related to dredged material management which are not required for continued maintenance may not be included in the study unless funded by others. The DMMP should consider, among other things, placement of non-Federal material to the extent it will affect size and capacity for the Federal project. However, O&M-funded planning must be limited to the original Congressionally authorized scope of the project. Any planning related to expansion, enlargement, or modification of the project may not be funded with O&M dollars.

2.10.1 Impacts to the Federal Project

Placement of 23 MCY of non-Federal new work material into Federal PAs would reduce the capacity to less than 20 years and significantly increase O&M costs. Loss of confined disposal capacity and associated increased distances/costs will specifically require:

- Over 10 miles of pipeline instead of the current average of 3 to 5 miles.
- Booster pumps, which are not currently required.
- Large-sized dredges instead of the current medium sized.

Loss of Federal PA capacity would result in an estimated tripling of costs from approximately $10 to approximately$30 per cubic yard.

2.10.2 50-Year Conceptual Non-Federal Placement Plan New Work

The FWOP condition assumes that none of the non-Federal new work material would be placed in Federal placement areas and that it be placed into permitted third-party PAs (either land based or in the bay) or used for new BU applications. However, it may be possible on a case-by-case basis that the USACE would accept third-party new work placement into a Federal PA, if the material is acceptable for dike construction, placement can be performed in such a manner to minimize loss of capacity and disruption of maintenance of the Federal channel, and the cost of the capacity used is paid for by the non-Federal entity. The FWOP DMMP does not preclude evaluation and potential implementation of opportunities for use or incorporation of non-Federal new work material, provided placement is in accordance with applicable rules and regulations.

The FWOP conceptual third-party placement (CPP) includes accommodation of maintenance increments resulting from third-party facility expansions (for new and existing facilities) along the HSC and anticipated during the 50-year period of analysis. New and expanded facilities may include, but not be limited to, vessel berthing areas and turning basins, with associated docks, wharves, mooring facilities, and bulkheads. The PHA provided a list of potential third-party facility expansions that are assumed to occur for a total of about 23 MCY of new work material in the next 5 years. Beyond the initial 5 years, it was assumed that between 1 MCY and 1.25 MCY of third-party new work for facility expansion would be dredged each year for the next twenty years, ending in year twenty-five. It is also assumed that between 1 MCY and 1.25 MCY of third-party new work would be dredged every 5 years for the remaining 25 years. The total assumed estimated new work and maintenance volume resulting from the third-party facility work is approximately 50 MCY. The existing HSC System PA capacity cannot sustain the accommodation of this volume of new work, which represents approximately half of the current capacity capability over the 50-year period without the construction or addition of new sites.

2.10.3 50-Year Conceptual NF Placement Plan Maintenance

Third-party maintenance volume along the HSC is about 428,000 CY per year for the existing condition for a total of about 21.4 MCY over the 50-year plan. Maintenance increments (that volume of additional maintenance over and above current volumes) resulting from the assumed third-party facility expansions were estimated at 0.45 percent of the associated new work volumes for each facility. The maintenance increments were assumed to be placed in nearby Federal PAs located within the same geographical area as the new work during the period of analysis at typical average third-party dredging frequencies currently being performed. The estimated maintenance increment for the assumed facility expansions will add increasing volumes throughout the 50-year period of analysis, ultimately adding about 225,000 CY per year after all facility expansions are constructed. It is estimated that a total third-party maintenance increment of about 8 MCY would be placed into Federal PAs over the 50-year plan. The resulting estimated total third-party maintenance volume over the 50-year plan is therefore about 29.4 MCY. The maintenance of the third-party expansions is minimal and is not expected to significantly alter or reduce capacity of the system and may be allowable on a case by case basis if the cost of capacity is paid for by the third parties. See Table 2-13 below for a breakout of estimated maintenance increment volumes by geographic area.

Table 2-12: Estimated Maintenance Increment Volumes by Geographic Area

HSC Geographic Area	Estimated 50-Year Incremental Volume (CY)
Downstream of Morgans Point	1,450,000
Morgans Point to Beltway 8 Bridge	3,160,000
Upstream of Beltway 8 Bridge	3,370,000
Total	**7,980,000**

2.10.4 Recommendations for Accommodation of Non-Federal Dredging

Many opportunities exist for non-Federal new work placement outside existing Federal placement areas. USACE has considered a few potential opportunities as listed below, however industry may choose to proceed, coordinating with resource agencies, to develop their own placement opportunities to accommodate their dredged material. Potential placement opportunities include the NF entity coordinating for its own permitted BU, permitted offshore placement, use of existing private PAs, development of a new non-Federal PA, or any other opportunities able to be coordinated with the required resource agencies.

2.10.4.1 Contributed Funds Agreement

The PHA and USACE could enter into a contributed funds agreement as a mechanism to provide funds for the USACE to provide a detailed analysis for the design and incorporation of non-Federal dredged material placement in Federal PAs and resulting construction.

2.10.4.2 Construct a New PA

Should private placement or BU sites not be available, an alternative would be to construct a BABUS as discussed in Section 2.6.2 above. Construction would require the applicant to comply with all regulatory and environmental requirements, to include environmental mitigation.

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3 Future With Project Quantities

3.1 General

Based on screening level costs and benefits, the study is broken into two components, the NED and the Locally Preferred Plan (LPP). Channel measures are fully described in Section 5 of the FFR-EIS Report and Section 4 of the Engineering Appendix. The dredged materials resulting from the NED plan and the LPP Plan are described by Segment and Reach below. A geographic map indicating the study reaches and channel improvement measures for NED plan is included in Figure 3-1 and the LPP in Figure 3-2.

3.2 New Work Quantities by Segment and Reach

The new work that would be generated from the channel improvements in the NED and LPP are summarized by segment proximity below and are inclusive of all the channel measures in that segment. Material types and properties are discussed in Section 6.3 of the Engineering Appendix.

Table 3-1: New Work Quantities

SEGMENT	REACH	NED NW (CY)	LPP NW (CY)
1	BR-REDFISH	3,922,000	3,922,000
	REDFISH-BSC	1,109,000	8,794,000
	BSC-BCC	425,000	5,341,000
2	BSC CHANNEL	2,108,000	2,108,000
	BSC FLARE	1,925,000	-
3	BCC CHANNEL	1,202,000	1,202,000
	BCC FLARE	1,623,000	1,623,000
4	BOGGY BAYOU-GREENS BAYOU	2,412,000	2,412,000
	GREENS BAYOU-SIMS BAYOU	860,000	860,000
5	SIMS BAYOU-I-610	176,000	176,000
6	I-610-TURNING BASIN	1,001,000	1,001,000
	TOTAL	16,763,000	27,439,000

Note:
The NED plan widens the HSC to 700 feet from Bolivar Roads to Redfish and requires a transition at Station 78+844 to the existing 530-foot channel. Limiting the 700-foot channel widening to Redfish will require additional measures upstream including the BSC Flare widening to 5,375 feet and the HSC bend easing at Station 28+605. Under the LPP the entire bay reach from Bolivar to BCC would be widened to 700 feet and would eliminate the need for those additional measures of the NED plan.

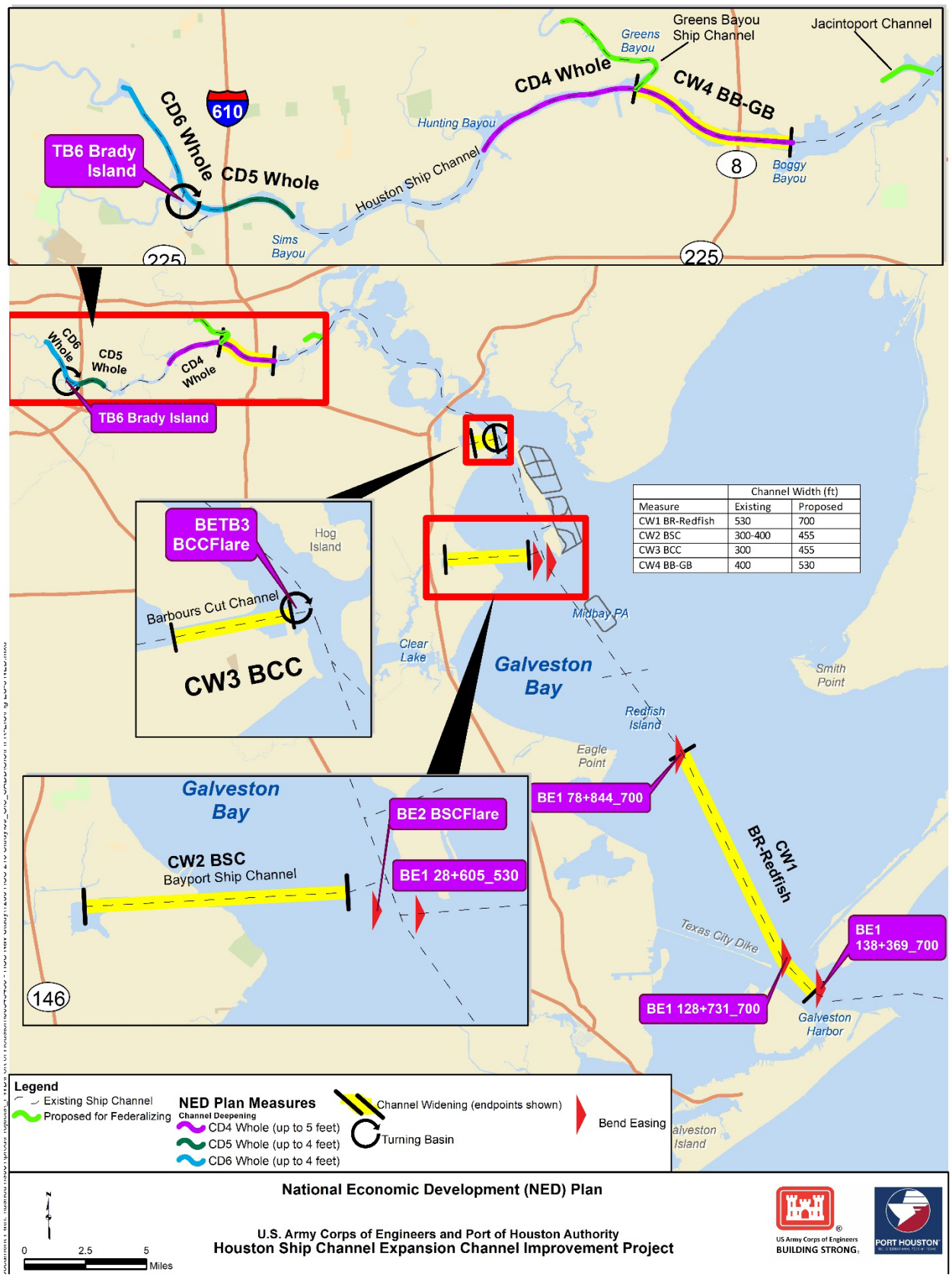


Figure 3-1: NED Channel Measures Overview

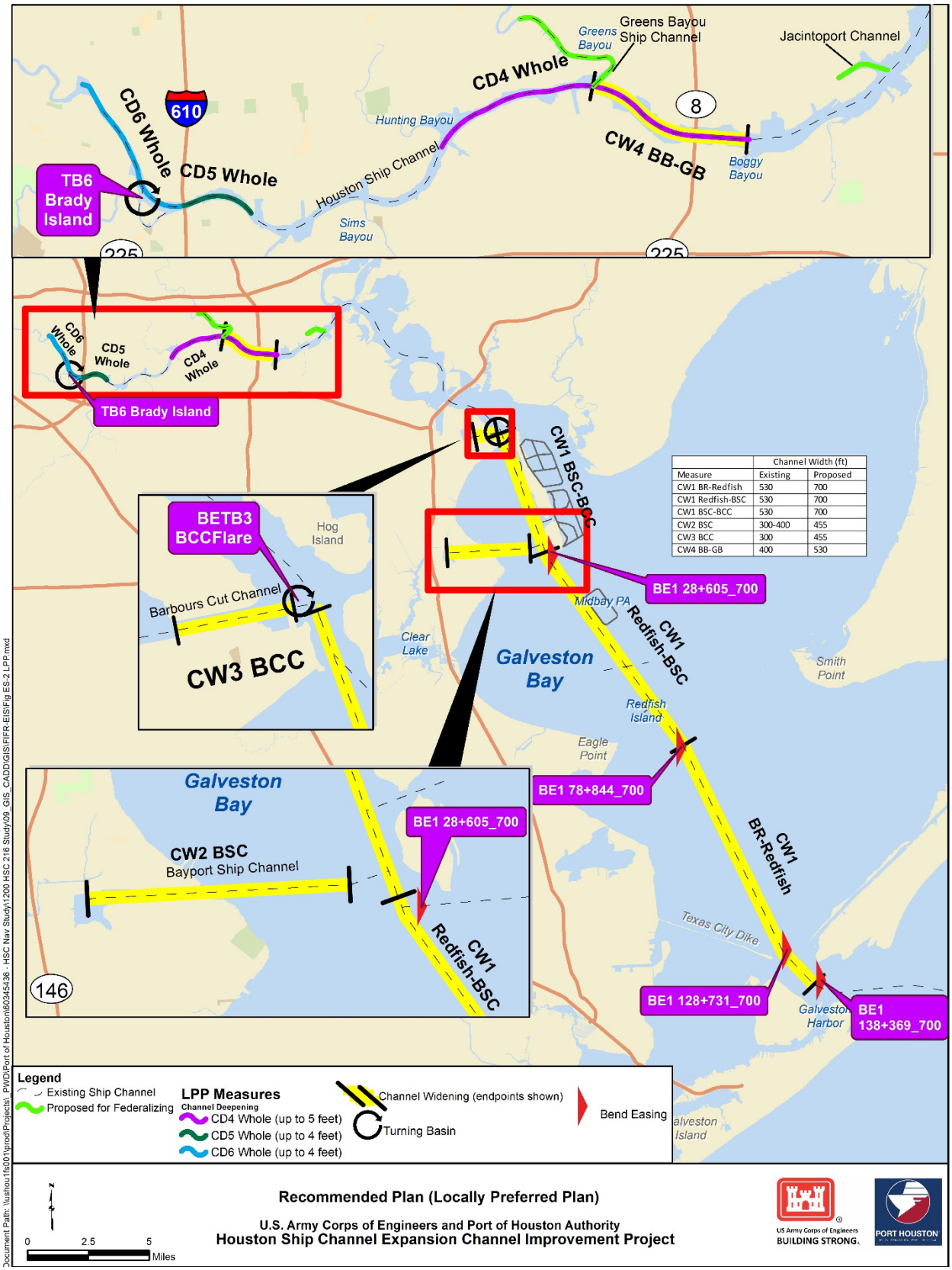


Figure 3-2: LPP Channel Measures Overview

3.3 Incremental Shoaling Increase

The existing, incremental, and total shoaling that would be generated from the channel improvements in the NED and LPP are summarized by segment proximity below and are inclusive of all the channel measures in that segment. Additionally, the shoaling rate of the existing LSFs and the 21 projected facilities that would be benefiting and improved as a result of the channel improvements are included in Table 3-2 below.

Table 3-2: Increased Shoaling

SEG.	REACH	NED NEW WORK (CY)	LPP NEW WORK (CY)	EXISTING CY/YR	NED INC. CY/YR	LPP INC. CY/YR	EXST LSF CY/YR	INCR.LSF CY/YR
1	BR-REDFISH	3,922,000	3,922,000	99,194	43,197	43,197	-	-
	REDFISH-BSC	1,109,000	8,794,000	1,468,925	75,543	552,690	-	-
	BSC-BCC	425,000	5,341,000	771,433	25,860	253,094	-	-
2	BSC CHANNEL	2,108,000	2,108,000	498,500	84,470	84,470	24,139	-
	BSC FLARE	1,925,000	-	788,415	350,767	43,399	-	-
3	BCC CHANNEL	1,202,000	1,202,000	113,152	21,885	21,885	109,310	-
	BCC FLARE	1,623,000	1,623,000	168,992	189,720	189,720	-	-
4	BOGGY BAYOU-GREENS BAYOU	2,412,000	2,412,000	113,709	94,291	94,291	0	22,230
	GREENS BAYOU - SIMS BAYOU	860,000	860,000	215,662	13,338	13,338	1,709	6,418
5	SIMS BAYOU-I610	176,000	176,000	38,751	4,249	4,249	9,073	-
6	I610-TURNING BASIN	1,000,000	1,000,000	180,416	26,584	26,584	34,115	17
TOTAL		16,971,000	27,647,000	4,234,688	844,629	1,308,982	341,529	28,665

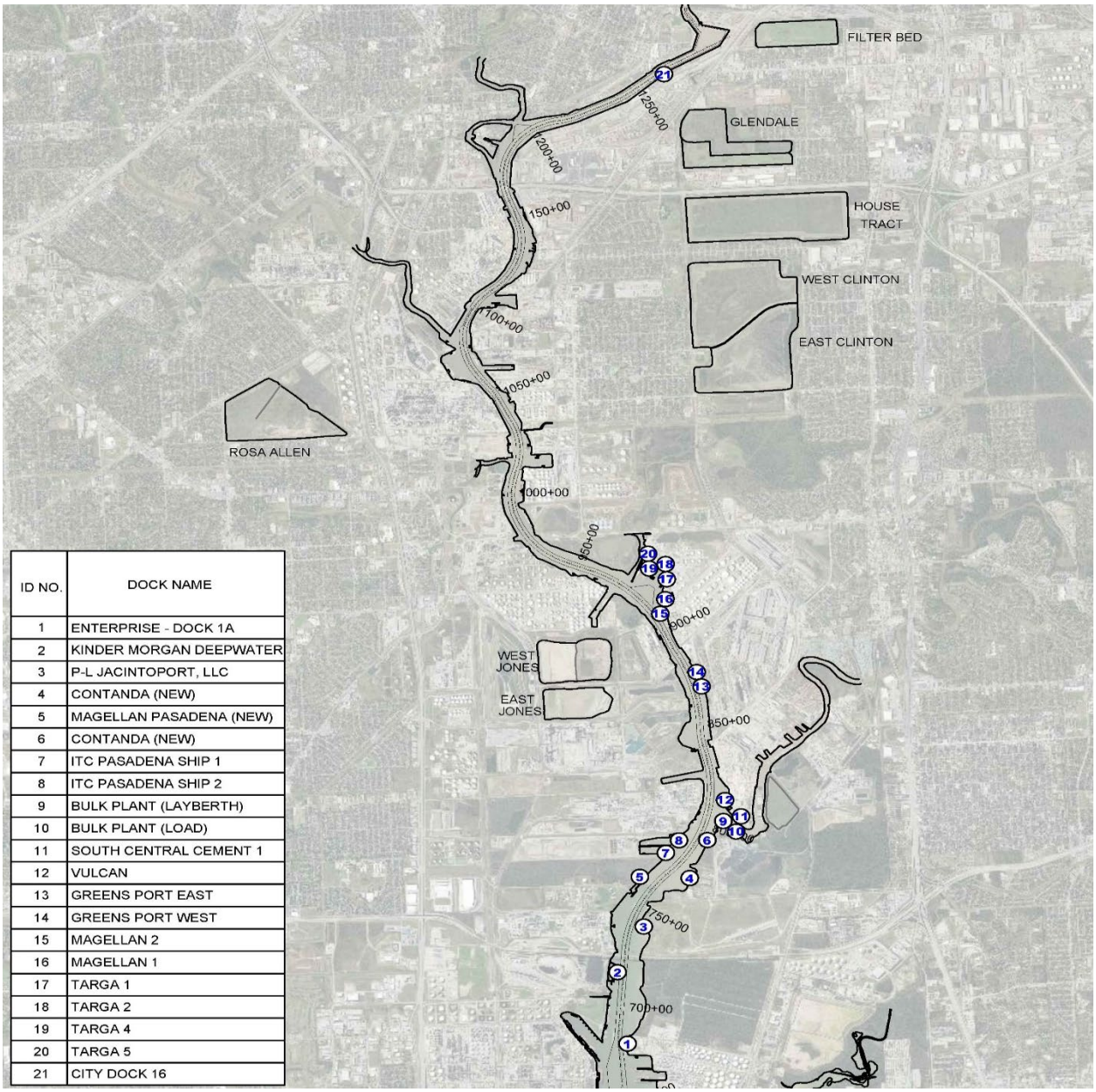
3.4 LSF Improvements

A total of 21 LSFs are projected to benefit from the channel improvements. The facilities, their projected new work and incremental shoaling are included in Table 3-3 and their approximate locations are shown on Figure 3-3.

A meeting was held in June 6, 2018 with representatives of several LSFs as discussed in Section 5.4 of the Engineering Appendix. These LSFs stated at that time that they planned to utilize private facilities or their own property for placement of their new work dredged materials.

Table 3-3: LSFs to Benefit from HSC ECIP

SEG.	NAME	APPROX. STATION	NW (CY)	MAINT (CY/YEAR)	50-YR O&M
4	ENTERPRISE - DOCK 1A	675+00-685+00	36,000	4,517	226,000
4	Kinder Morgan Deepwater	712+00-721+00	23,000	2,824	141,000
4	P-L Jacintoport, LLC	725+00-760+00	287,000	35,938	1,797,000
4	CONTANDA (NEW)	763+00-774+00	230,000	28,765	1,438,000
4	MAGELLAN PASADENA (NEW)	759+00-777+00	321,000	40,232	2,012,000
4	CONTANDA (NEW)	778+00-807+00	143,000	17,924	96,000
4	ITC Pasadena Ship 1 (INCLUDES EXPANSION)	778+00-796+00	132,000	16,567	828,000
4	ITC Pasadena Ship 2	780+00-788+00	62,000	7,777	89,000
4	Bulk Plant (Lay Berth)	810+00	7,000	925	46,000
4	Bulk Plant (Load)	810+00	7,000	900	45,000
4	South Central Cement 1	810+00	30,000	3,708	185,000
4	Vulcan	820+00	54,000	6,781	339,000
4	Greens Port East	863+00-870+00	44,000	4,594	30,000
4	Greens Port West	870+00-880+00	71,000	6,346	317,000
4	Magellan 2	905+00-911+00	37,000	4,682	234,000
4	Magellan 1	911+00-915+00	74,000	9,253	463,000
4	Targa 1	914+00	35,000	4,397	220,000
4	Targa 2	916+00	29,000	3,660	183,000
4	Targa 4	922+00	62,000	7,772	389,000
4	Targa 5	924+00	87,000	10,959	548,000
6	City Dock 16	1260+00-1266+00	1,000	1,351	68,000
			1,772,000	**219,872**	**10,994,000**



ID NO.	DOCK NAME
1	ENTERPRISE - DOCK 1A
2	KINDER MORGAN DEEPWATER
3	P-L JACINTOPORT, LLC
4	CONTANDA (NEW)
5	MAGELLAN PASADENA (NEW)
6	CONTANDA (NEW)
7	ITC PASADENA SHIP 1
8	ITC PASADENA SHIP 2
9	BULK PLANT (LAYBERTH)
10	BULK PLANT (LOAD)
11	SOUTH CENTRAL CEMENT 1
12	VULCAN
13	GREENS PORT EAST
14	GREENS PORT WEST
15	MAGELLAN 2
16	MAGELLAN 1
17	TARGA 1
18	TARGA 2
19	TARGA 4
20	TARGA 5
21	CITY DOCK 16

Figure 3-3: LSF to benefit from channel improvements

4 Problems and Opportunities

The following water resources problems and opportunities have been defined, to date, as part of this DMMP for the HSC ECIP study in the FWP condition. These problems and opportunities were also generally evaluated in the development of the FWOP condition in the HSCPA in areas that channel modifications are not occurring. They are considered in the integrated DMMP discussed in Section 7.0 of this appendix and include the following:

4.1 Problems

- The USACE annually removes over 5 MCY of material with maintenance dredging (Federal project and non-Federal O&M historically dredged) from the HSC and associated channels. Current maintenance placement practices, without modification, will result in the need for "new" or expanded PAs or modified placement options, by 2034.
- Identifying environmentally acceptable dredged material placement (PA/BU) with capacity to serve the channel improvement construction and maintenance as well as capacity to serve the HSC system.
- Third party (non-Federal) requests for placement of new work material into the Federal PAs cannot currently be accommodated as there is not sufficient capacity for the Federal and non-Federal O&M in the 20 or 50-year analysis.

A new DMMP that maximizes dredged material management would result in budget efficiencies that would result in accomplishing:

1. More effective and timely dike raises and repairs;
2. Better scheduling of dredging jobs to maximize PA storage capacity;
3. Ensures PAs would not become obsolete prior to reaching design life;
4. Allows for more accurate estimates of need for new PAs. New PAs take a long time to coordinate, budget, and approve, so an accurate schedule of need will facilitate bringing new PAs on-line in a timely manner;
5. PA availability improves ability to respond to storm or flood conditions.

When a navigation project has an overall lack of O&M funding, the maintenance and upkeep of the PAs is often deferred. Available funds are used to patchwork dewatering, dike raises and spill box maintenance. Post storm conditions normally produce the largest quantity of dredged material and PAs that have been neglected may: 1) be difficult to get into shape to receive sediments and/or 2) may not have enough capacity to receive sediments to open the channel. Lack of funding to regain capacity can also result in more costly pumping of dredge material to other PAs located farther away.

When dike raising or dredging jobs get out of sequence due to limited funding or unforeseen requirements, it creates difficulties due to dredge spacing requirements (agreement between USACE, Pilots and Vessel Traffic Service (VTS) for five nautical miles between dredges).

Historically the District receives requests from both the NFS and private entities for placement of both new work and maintenance material into the Federal PAs. Not all of these requests can be

accommodated as there is not sufficient capacity for the Federal and non-Federal O&M. Past attempts to accurately assess the non-Federal quantities was difficult. Because of the proprietary nature of the plans for those facilities they are unwilling to make that information available to the District and NFS. The District has been directed to address placement capacity for Federal maintenance material, non-Federal maintenance material the District has historically placed, and the new work for the remaining facility (Cargil) used for benefits in the 1995 LRR. Requests for non-Federal capacity in the future are to be addressed only through processes such as the Section 217(b) agreement.

4.2 Opportunities

Opportunities associated with the HSC ECIP Study area are:

- Establish environmentally suitable PA/BU sites for new work dredged material as well as maintenance dredged material;
- Reduce the risk of adverse environmental impacts from a new project, or protect or improve environmentally sensitive areas in the vicinity of the Federal project through BU.
- Placement of material from private dredging
- Enhance recreation through creation of marsh and estuarine habitat amenable to hunting, fishing, and wildlife viewing.

4.3 Planning Goals and Objectives

4.3.1 Planning Goals

The goal of this study is to develop a DMMP that would accommodate at least 20 years of Federal dredged maintenance material placement associated with maintenance of the HSC and the non-Federal maintenance material historically allowed in the PAs with a conceptual plan that provides for budgeting and consideration over the remaining 50-year study period of analysis.

4.3.2 Planning Objectives

The following planning objective was used in the formulation and evaluation of alternative plans:

- Identify the least cost, environmentally acceptable plan that is consistent with sound engineering practice over the 50-year period of analysis for placement of dredged material associated with the construction and maintenance dredging of the HSC ECIP channel modifications as well as integration of the existing Federal channel and historical non-Federal maintenance volumes (Base Plan).
- Maintain the navigation channel system to authorized dimensions.
- Place the dredged material in the most cost-effective location consistent with environmental and engineering requirements.
- Optimize BU of dredged materials where feasible.
- Maintain dredged material placement sites in a manner to optimize capacities and comply with sound economic and environmental principles.
- Provide for the placement of material dredged by non-Federal interests, within certain parameters.

4.4 Planning Constraints

The final DMMP must be environmentally acceptable, economically feasible and use sound engineering practices and methodologies. As such, the project must have minimal negative impacts on the environment and utilize efficient means for construction of the site(s) and for placement of the dredged material. More specific study area constraints include the following:

1. The study process and plans must comply with Federal and State laws and policies.
2. Measures considered must not have an adverse impact to fish and wildlife habitat.
3. Unconfined open water placement in the bay is not considered acceptable at this time.
4. Must not adversely impact or interfere with operations of other Federal channels or their DMMPs.
5. The minimum required distance between operating dredges is five nautical miles so as to not impact shipping or result in interference between the dredging operations. This complicates the scheduling of dredging in the system.
6. Existing soils at any site considered for placement must be able to provide adequate foundation support for the purpose analyzed and/or meet acceptable borrow quality for containment dike construction as required to provide required capacity.
7. Property not available or for which a Section 10/404 Regulatory permit application by another party other than the NFS or for another purpose is under review will be eliminated from further study.
8. Material placed in the ODMDS must meet EPA requirements for ocean placement in compliance with Section 103 of the Marine Protection, Research, and Sanctuaries Act.

In reference to number 3 above, open water placement in the bay was used in the HSC 40-foot project, was proposed in the Galveston Bay Area Navigation System (GBANS) report, and was included in the NED Plan presented in the 1995 Draft LRR. However, this method of placement was met with disapproval from state and Federal environmental agencies and the public; hence, a locally preferred BU plan was developed in the Final 1995 LRR that used material beneficial for marsh construction. As a result, open water placement in the bay has not been used for HSC dredged material placement since before construction of the 45-foot project.

4.5 Key Assumptions

The DMMP assumes that:

1. No new work materials will be placed in an existing viable UCPA with remaining capacity beyond one or two cycles may be placed in viable PAs. Construction of the channel improvements shall not deplete the ability to maintain the existing system.
2. HSC will be maintained to the fully authorized dimensions with advanced maintenance and allowable overdepth quantities to allow efficient channel management and minimize the risk of draft restriction. See Tables 1-1 and 7-1 for HSC authorized and planned dimensions.
3. Formulation of alternatives is only necessary for the areas of channel improvements in Segments 1-6. Formulation of alternatives is not necessary for areas where no channel

improvements are made. Where no channel improvements are made, the FWOP DMMP/Preliminary Assessment will be used.

4. A Site Management and Monitoring Plan (SMMP) has been developed with EPA to allow offshore placement of all dredged material to Morgans Point in ODMDS so long as sediment testing continues to meet required standards. This study assumes that maintenance material from offshore to Morgans Point would be placed in ODMDS.
5. This DMMP accounts for only Federal O&M, non-Federal O&M (maintenance material from the berthing areas and other private facilities) historically dredged as part of the current operations plan, and Cargil Facility new work (anticipated deepening of berthing areas for facilities identified as local service facilities in the 1995 LRR). Cargil is the only facility identified in the 1995 LRR that remains to be deepened.
6. This study assumes constant dredged material quantities estimated from historic quantities database by reach in the DMMP calculations and the estimated incremental shoaling resulting from the channel improvements as shown in Section 6.4 of the Engineering Appendix. These calculations do not include potential storm or epic flood event quantities.
7. This DMMP assumes there would be no chemical contamination from spills and vessel accidents that would preclude the use of ODMDS or placement of material into the PA/BU sites.
8. USACE must consider long-term sustainability of the project beyond a 20-year time limit. The DMMP is a living document and would be updated as necessary, ideally every five years. Each update would review and reevaluate the needs for each subsequent 20-year period, serving as a mechanism for extending the life of the DMMP. Subsequent studies and adaptive management employed during the implementation of the DMMP would help to address sustainability issues as the plan moves into the future.

5 Formulation and Evaluation of Alternative Plans

5.1 Overview and Plan Formulation Rationale

In order to formulate alternatives for placement of the dredged materials from construction of the channel improvements, various placement strategies were formulated for the construction of new PAs, both upland and BU, (marshes, bird islands, oyster mitigation pads, etc.) as well as offshore placement. Generally, features were sized based upon the needs of the required new work dredging.

5.2 Typical Dredging Equipment

The type of dredging equipment considered depends on the type of material, the depth of the channel, the depth of access to the PA, the amount of material, the distance to the PA, and the wave-energy environment, etc. A detailed description of types of dredging equipment, which includes mechanical-clamshell, hydraulic hopper, cutter-suction pipeline dredges and cutter suction dredges with barges for transportation of dredged material to designated PAs, can be found in EM 1110-2-5025, *Dredging and Dredged Material Management* (USACE, 2015b). A brief synopsis of the types of dredging employed and evaluated are included in the subsections below.

5.2.1 Mechanical – Clamshell Dredging

Mechanical dredges are classified by how the bucket is connected to the dredge. The three standard classifications are structurally connected (backhoe), wire rope connected (clamshell), and chain and structurally connected (bucket ladder). The advantage of mechanical dredging systems is that very little water is added to the dredged material by the dredging process and the dredging unit is not used to transport the dredged material. This is important when the placement location is remote from the dredging site. The disadvantage is that mechanical dredges require sufficient dredge cut thickness to fill the bucket to be efficient and greater re-suspended sediment is possible when the bucket impacts the bottom and as fine-grained sediment washes from the bucket as it travels through the water column to the surface. These dredges can work in confined areas, can pick up large material, and are less sensitive to sea conditions than other dredges.

Mechanical dredging operations would be employed for measures reviewed for this study. Areas previously mechanically dredged between Station 57+000 to 100+000 during the new work dredging of the previous HSC expansion project would most likely be mechanically dredged as well for this project. This is due to the fact that materials in this area are of generally unsuitable types for new PA or BU construction. These materials would be mechanically excavated by a clamshell dredge and hauled to ODMDS via bottom dump scow. Additionally, mechanical dredging would be employed above Morgans Point for maintenance dredging after existing/new PAs have reached maximum capacity. These materials would be transported to BABUS sites. Other mechanical dredging operations may include ancillary tasks to major construction

features, such as side channel sweeping or relocations, if applicable, and in sensitive structural areas or areas where debris or old structures need to be removed.

5.2.2 Hydraulic – Hopper Dredging

Hopper dredges include self-propelled ocean-going vessels that hydraulically lift dredged material from the bottom surface. Since hopper dredges are self-propelled, they are more maneuverable than dredges that rely upon tugboats to move. One or more suction tubes equipped with a drag head or other suspension apparatus are dragged along the channel bottom. A pump system sucks up a mixture of materials such as sand, gravel, silt or clay, and water and discharges it in the "hopper" or hold of the vessel. Once the vessel is fully loaded, it sails to the unloading site. The material can be deposited on the seabed through bottom doors, reclaimed using a rainbow technique, or discharged through a floating pipeline to the shore.

Hopper dredges for long term maintenance of the channel may be conducted along with cutter head suction dredging in the Bay reaches of the HSC, BSC and BCC. Material would be transported to the ODMDS and disposed of according to the SMMP that is approved by the EPA.

5.2.3 Hydraulic – Cutter Suction Dredge

Large cutter suction dredges, or cutterhead dredges, are mounted on barges. The cutter suction dredge is equipped with a rotating cutterhead used for cutting and fragmenting the soils to be removed. It mobilizes the dredged material as it rotates. The mobilized material is hydraulically moved into the suction pipe for transport. The cutter suction head is located at the end of a ladder structure that raises and lowers it to and from the bottom surface. The cutter suction dredge moves by means of a series of anchors, wires, and spuds. The cutter suction dredges as it moves across the dredge area in an arc as the dredge barge swings on the anchor wires. The discharge pipeline connects the cutter suction dredge to the PA. The dredged material is hydraulically pumped from the bottom, through the dredge, and out through the discharge pipeline to the placement location. Booster pumps can also be added along the discharge pipeline to move the material greater distances. Additionally, the cutter suction dredge can pump the dredged material into a series of barges that can be transported to a PA and pumped out or bottom dumped. Three types of barges are generally used to transport dredged material to the placement sites, which include a split hull barge/scow, bottom dump barge/scow, or a flat top barge/scow. All three barge types are typically pushed or pulled to the placement site by a tug. This is the least efficient option for cutterhead dredging. Cutterhead suction dredging is the predominant dredging practice currently employed in the study area and this is the anticipated primary practice for construction, operation and maintenance of the measures considered under this study.

5.3 Typical Dredged Material Placement Options

5.3.1 Ocean Dredged Material Disposal Site

This ODMDS, also referred to as PA 1, is an open water dispersive site located approximately 3.7 nautical miles offshore from Galveston Island and covers an area of about 5,550 acres as shown in Figure 2-1. Surveys of the ODMDS prior to and following placement of dredged material indicate little to no accumulation within its boundaries; therefore, it is considered to be a dispersive site with unlimited future capacity. A Particle Tracking Model (PTM) was done for this site and showed that material placed in the ODMDS does move out of the area through the process of littoral drift and does not return to the channel. This site was coordinated for the Galveston Harbor and Channel project with the SMMP for the ODMDS being signed in 2008 by the EPA and USACE, Galveston. The current SMMP is dated May 31, 2016 and is valid for ten years and allows for material from any reach of the HSC or Galveston Harbor and Channel project, including potential third-party users, to be deposited in the ODMDS provided their results of the required testing are within acceptable limits. USACE-SWG continues to coordinate use of the ODMDS with EPA for each upcoming dredging project. The ODMDS has six zones (A-E), which allows the potential for different contracts to use different zones of the ODMDS concurrently. Contactors must provide post-placement bathymetric surveys of the ODMDS zones in order to ensure material has not mounded.

5.3.2 Upland Confined Placement Areas

An UCPA (also known as a confined disposal facility [CDF]) is an engineered structure for the containment of dredged material. UCPAs are bound by confinement dikes or structures to enclose the PA, thereby isolating the dredged material from its surrounding environment as shown in Figure 5-1. The material is placed into the UCPA either hydraulically or mechanically. Placing the material directly into the UCPA hydraulically via pipeline connected to the dredge is the most economical method in this region. Material may also be dredged mechanically and then transferred to the UCPA via barge and placed into the facility using a hydraulic unloader. Dredged material placement within a UCPA has several benefits:

- Prevent or substantially reduce the amount of sediment material re-entering the environment when properly designed, operated, and maintained;
- Provide a permanent storage location for dredged material that would naturally vegetate when left undisturbed;
- Be mined or processed for construction materials for BU both ecologically or otherwise used for another purpose.

Hydraulically placed dredged material contains a large amount of additional water when it is introduced into the facility, causing it to occupy several times its original volume. To maximize the UCPA capacity, management measures for dewatering the sites must be followed, including

ditching, drying, and draining of materials to allow for consolidation and increased capacity. Following these measures allows the dredged material to consolidate to 65-70 percent of its gross volume.

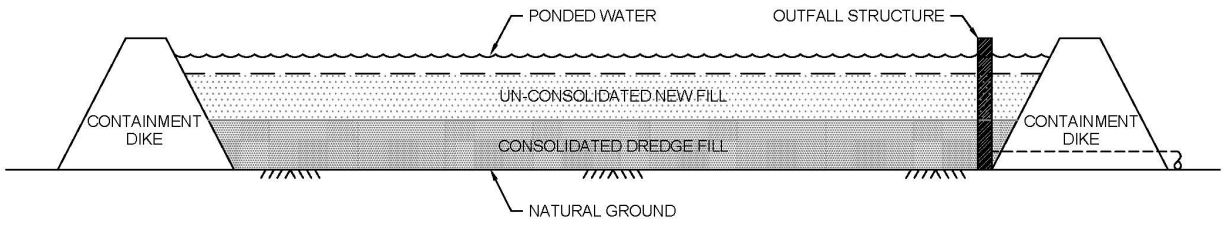


Figure 5-1: Typical Section of Hydraulic Fill at an Existing UCPA

During the preliminary assessment, NEPA scoping process, resource agencies, and the general public expressed interest in the following options:

- Expansion of the Mid Bay PA to the north, south, or east.
- Creation of a UCPA in the Bay
- Develop the Beltway 8 (BW-8) site
- Expand PAs on existing non-Federal Sponsor owned lands (E2 Clinton, E3 Clinton, Rosa Allen, Wah Chang)
- Obtain and develop the Lynchburg site (formerly known as Farm Tract)
- Goat Island expansion
- Relocate existing PA materials to another site such as Lynchburg
- Raise dikes on existing PAs
- Focus new work material placement on existing PAs nearing final life as a cap for closure

5.3.3 Beneficial Use

The Federal Government has placed considerable emphasis on using dredged material in a beneficial manner. Statutes such as the Water Resources Development Acts of 1992, 1996, 2000, and 2007 demonstrate that BU has been a Congressional priority. The USACE has emphasized the use of dredged material for BU through such regulations as 33 CFR Part 335, ER 1105-2-100, and ER 1130-2-520 and by Policy Guidance Letter No. 56. ER 1105-2-100 states that "all dredged material management studies include an assessment of potential BUs for environmental purposes including fish and wildlife habitat creation, ecosystem restoration and enhancement and/or hurricane and storm damage reduction" (USACE, 2000, E-69). Opportunities for BU of dredged material exist in the project vicinity. In accordance with ER 1105-2-100, the USACE is considering BU of dredged material as a part of the project. During the PED phase, additional options for BUs that are cost-effective and meet regulatory and environmental protection requirements may be pursued. The additional cost, above the least cost environmentally and

engineeringly acceptable option for dredged material placement would need to be paid by a willing partner. Many BU options were identified in previous studies and meetings with the resource agencies. The Beneficial Uses Group (BUG), consisting of Federal and state resource agencies (EPA, NMFS, NRCS, USFWS, TCEQ, TGLO, and TPWD) would be coordinated with regularly throughout the execution of the DMMP. During the NEPA scoping process, resource agencies, and the general public expressed interest in the following options:

- Creation of intertidal marsh
    - Expansion of the existing BU marsh placement sites at Bolivar, Mid-Bay and Atkinson Island as shown in Figure 5-2.
    - Creation of marsh features along the Texas City Dike.
    - BSC dike and marsh creation
    - BSC RoRo Terminal marsh
    - Semi-confined discharge to create sand fans/tidal mudflats
    - Restoration of the Trinity River Delta through borrow from existing Bay upland PAs to restore capacity (MidBay, PA 14, PA 15)
    - Placement of materials and expansion of Redfish Island
    - Eagle Point marsh restoration
    - Smith Point marsh restoration
    - BU in Burnett Bay
    - BU in Scott Bay
    - Expansion of Goat Island
    - San Jacinto marsh nourishment
    - Marsh behind Spilmans Island
    - Marsh behind Alexander Island
    - Marsh behind Hogg Island
- Creation of additional bird islands in Galveston and Trinity Bay (Figure 5-2)
- Benthic habitat creation
- Oyster reef pad construction
- Oyster mining hole reclamation
- Capping of San Jacinto waste pits
- Stockpiling of materials for use in other projects for use in coastal protection and hurricane risk reduction
- Refilling salt domes
- Provide opportunities for mining of existing upland PAs by third parties for construction, fill, BU, or other actions
- Storm damage abatement

Figure 5-2: Examples of BU currently in the HGNC; Evia Island (left) (Source: Houston Audubon, 2017) and Bolivar Marsh (right)

5.4 DMMP Placement Area Design Considerations

5.4.1 Ocean Dredged Material Disposal Sites

USACE-SWG coordinates with the EPA for each use of the ODMDS in accordance with the SMMP. Bioassay testing must be performed at a minimum of every 5 years for reaches utilizing the ODMDS. There are no special design considerations for the use of the ODMDS. ODMDS placement is considered for all reaches of the HSC if another viable placement option does not exist.

5.4.2 Upland Confined Placement Area

The design of UCPAs shall follow EM 1110-2-5027, *Confined Disposal of Dredged Material* (USACE, 1987). Steps to design the UCPAs in more detail during PED would generally include the following steps.

- Hydrographic and topographic surveys of the project areas to develop bay bottom and upland elevation contour data. These surfaces were used during the design of the dredging templates and the dike templates. Hydrographic data is used to estimate material quantities to be dredged.
- Analyze existing geotechnical data, including boring logs and material test results, and evaluate the need for additional investigations
- Geotechnical field investigations including borings and probings at candidate sites to determine the subsurface conditions of the existing foundations. Material testing of samples to include strength tests, sieve analysis, settling tests, Atterberg Limits and consolidation tests. Analysis of material testing results will identify material characteristics needed for the design of the of the proposed dikes.
- Classification of dredge material and quantity calculations of each material type available within the proposed dredge areas

- Perform slope stability analysis for dike template design
- Calculate material quantities required to construct containment dikes
- Determine corresponding required dredging quantities based upon expected cut/fill ratios
- Wind, tide and current data for the area should be collected and analyzed to evaluate design wave conditions for the design of the shore protection elements, and to consider future sea level change into the design process.
- Identify project constraints and existing features that must be protected, e.g., gas and oil wells, pipelines, and other utilities

5.4.3 Beneficial Use

Typically, design of BU projects requires a grain size/compatibility analysis and potentially modeling of sediment transport and fate to be completed for these types of projects. To meet the goals of accelerating the schedule and reducing study costs, this work is scheduled for the PED phase. As a result, the measures are discussed in the FIFR-EIS without detailed analysis, but with a commitment to perform additional analysis during the PED phase and re-coordinate all decisions with resource agencies to ensure environmental acceptability. Final designs, decisions to implement, and environmental considerations/clearances would take place during the PED phase. Some of the engineering considerations and analyses to be conducted during the PED phase include but are not limited to:

- Grain size analysis and PSDDF consolidation testing of materials to be dredged by reach considered for BU marsh construction to determine the bulking and consolidation characteristics of the materials to be dredged and placed.
- Geotechnical probings and borings to determine foundation characteristics for stability and consolidation to determine construction and maintenance elevations.
- Site specific wind and wave analysis to determine optimal dike heights and shore protection features.
- Intertidal marsh elevation surveys would be conducted on neighboring marshes to the site selection to determine the optimal tidal elevation target range with consideration of relative sea level change (RSLC).
- Natural and artificial reef surveys to determine optimal design elevations, contours, and monitoring strategies.
- Ground truthing of assumptions made for planting marshes and bird islands during the HGNC deepening and widening construction and maintenance.
- BU site elevations should reference NAVD88.

5.4.4 Hazardous, Toxic and Radioactive Waste Concerns

Hazardous, Toxic and Radioactive Waste (HTRW) concers were addressed under various NEPA documents for the construction or modification of the channels covered under this DMMP. HTRW issues were not found to be a concern. The sediments dredged during construction and or

maintenance of the authorized footprints of the HSC, BSC, BCC and Greens Bayou Channels are regularly tested by the Galveston District for a range of chemical compounds of concern to the EPA as well as the Texas Commission on Environmental Quality (TCEQ). Specific information regarding HTRW concerns can be found in Appendix G of the main FIFR-EIS.

5.4.4.1 San Jacinto River Waste Pits Superfund Site

A portion of the HSC near its confluence with the San Jacinto River, lies within the southern boundary of the Area of Concern for the EPA designated superfund site known as the San Jacinto River Waste Pits. The results of the routine water quality and sediment testing of dredged material from this segment of the HSC are evaluated in accordance with the requirements established by the EPA, TCEQ and USACE (2009) to ensure that maintenance dredging within this area would not have an impact on the EPA's investigation and cleanup of this superfund site.

5.4.4.2 Patrick Bayou Superfund Site

Patrick Bayou is one of several small bayous of the HSC located within the lower portion of the San Jacinto River Basin. This 3-mile tidal bayou is on the south side of the HSC about 2 miles upstream of its confluence with the San Jacinto River. The site consists of contaminated sediments within Patrick Bayou, a portion of the East Fork tributary, and associated wetlands. Patrick Bayou is bounded by Occidental Chemical, Shell Refinery, Shell Chemical, and Lubrizol Corporation. The bayou also receives effluent via ditches from the City of Deer Park wastewater treatment plant and an air separation plant, Praxair, Inc. (EPA, 2015). The authorized and maintained footprint of the HSC project at its confluence with Patrick Bayou is located outside the area of concern for this superfund site (TCEQ, 2014).

To date, the maintenance material dredged from these channels, including the segments located near these superfund sites, has been determined to be acceptable for placement, as appropriate, in the UCPAs, BU sites, or ODMDS designated for use in this DMMP.

5.5 Operations and Maintenance Considerations

1. Dredging contracts would continue to be planned to maintain 5 nautical miles between dredges, per agreement with U.S. Coast Guard (USCG) VTS and local pilots.
2. Deviations from the plan should be expected on occasion due to unforeseen shoaling events, lack of availability of a PA, and the like.
3. The DMMP should not prevent the use of other sites for placement of dredge material, should the opportunity arise.
4. UCPA containment dike raises would ideally increase dike heights adequately to provide capacity for more than one dredge cycle due to the operational tempo of maintenance dredging on the HSC; however, it is understood that lower dike raises (less than about 5 feet) to accommodate fewer dredge cycles may be performed should funding, geotechnical,

scheduling, and/or construction constraints preclude a higher dike raising in any particular instance.

5. Dredging reaches listed are those generally used, although variations should be expected as the need arises.
6. A combination of dredged material placement strategies in any given reach should be used that maximizes the capacity available or assigned to any given reach. Considerations should be made to:
    a. rotation between UCPAs to allow time for material decant and settlement if possible
    b. limit fill to 4 feet in UCPAs at a time to maximize capacity regains and material drying for future dike raises that may be afforded from DAMP activities if possible
    c. allow time for construction activities such as dike raises or new PA construction to occur if possible
7. The RP does not account for additional non-Federal new work or maintenance volumes not included in the capacity analyses and described above. Placement of additional non-Federal new work and/or maintenance volumes in the existing PAs may be possible and should be evaluated to ensure that it would not impact the 20-year capacity.
8. The approved DMMP should be periodically updated approximately every five years to confirm adequate capacity of the system for a 20-year period of analysis to validate the dredging needs and PA capacities forecast and to capture future changed conditions over the 50-year study period.

5.6 Plan Formulation Rationale

The planning process for the DMMP includes two components. The first being the development of a placement plan for material from construction of the project modification and increments of new maintenance attributable from the project modification for the 50-year period of analysis. The second component being the integration of current and future placement plan for continued operation and maintenance of the existing HSC complex as outlined in the FWOP condition. The resulting FWP condition DMMP for operation and maintenance of the project modification and remaining HSC system components will follow the conceptual 50-year FWOP plan and utilize any additional capacity created by the FWP construction.

The planning process for this study is driven by the requirement to develop a DMMP that would provide 50-years of capacity for the placement of dredged material, associated with the maintenance dredging of the HSC, in the least costly manner consistent with sound engineering practice and which meets all Federal environmental standards including those established by Section 404 of the Clean Water Act of 1972 or Section 103 of the Marine Protection, Research and Sanctuaries Act of 1972, as amended.

Plan formulation is the process of building alternative plans from one or more management measures that meet the planning objective(s) and avoid planning constraints. A management measure is a feature (structural) or activity (nonstructural) that can be implemented at a specific

geographic site to address one or more planning objectives. Management measures are the building blocks of alternative plans.

The Project Delivery Team (PDT) first identified a wide array of management measures. Following preliminary evaluation, a number of the dredged material management measures were eliminated from further consideration while others were carried forward. Additional measures identified in later phases of the formulation process were also developed and analyzed. Measures that did not address one or more of the DMMP study objectives were eliminated. The following screening criteria were used to evaluate the preliminary measures:

1. Environmental Considerations;
2. Agency and Public Consideration;
3. Engineering Considerations;
4. Site Access;
5. Construction Costs for New Sites or Cost to Perform;
6. Cultural Resource Concerns;
7. HTRW Concerns;
8. Real Estate Issues;
9. Infringement on Another Federal Project or Proposed Action;
10. Capacity Limitations

Preliminary plans were formulated by combining management measures. Each plan was formulated in consideration of the following four criteria described in the Principles and Guidelines (P&G).

- Completeness: Extent to which the plan provides and accounts for all necessary investments or actions to ensure realization of the planning objectives.
- Effectiveness: Extent to which the plan contributes to achieving the planning objectives.
- Efficiency: Extent to which the plan is the most cost-effective means of addressing the specified problems and realizing the specified opportunities, consistent with protecting the nation's environment.
- Acceptability: Workability and viability of the alternative plan with respect to acceptance by Federal and non-federal entities and the public, and compatibility with existing laws, regulations, and public policies.

The USACE is required to consider the option of "No Action" as one of the study alternatives in order to comply with the requirements of the NEPA. With the No Action Plan (i.e., the FWOP Condition), it is assumed that no project would be implemented by the Federal Government or by local interests to achieve these particular planning objectives. However, normal operation and maintenance activities, along with other probable channel improvements, are assumed to be performed over the period of analysis. The No Action Plan, therefore, forms the basis against which all other alternative plans are measured. Details of the No Action Plan are included in

Section 2.0 and would entail continued maintenance dredging and placement under the existing FWOP DMMP.

5.7 Management Measures

Management measures were introduced throughout plan formulation and evaluation in an iterative process. Nonstructural and structural measures were considered in the study analysis and were developed to address the study objectives presented in Section 4.3.2, and to avoid or minimize impacts from the planning constraints identified in Section 4.4.

This section will present a compilation of the management measures (structural and non-structural) identified by the PDT, of which the NFS is a member. A wide array of measures was initially identified; subsequently, those measures that did not adequately address the study objectives were eliminated. The evaluation and screening process utilized in this study is described below:

- Initial Identification – The initial identification of potential measures;
- First Iteration/Initial Screening – Refinement of measures previously identified, elimination of those measures that were without merit, and introduction of new measures;
- Second Iteration/Secondary Screening - Refinement of measures previously identified, elimination of those measures that were without merit, and introduction of new measures; and
- Final Iteration/Final Screening – Refinement of measures previously identified and elimination of those measures that were without merit.

In order to evaluate the remaining preliminary measures, screening criteria that would likely have the most influence in determining the viability of the measures were identified.

The following criteria were used to evaluate and initially screen the measures proposed for placement and/or containment of the new work dredged material resulting from the channel improvements:

1. Environmental Considerations – a measure that increases (or causes) adverse impact on sensitive habitats or species that cannot be mitigated in a cost-effective way will be eliminated from further study.
2. Agency and Public Consideration – measures resulting from the construction of channel improvements (known as new work materials) as coordinated with the BUG resulted in an agreed request that all usable and viable dredged materials be kept within the system to construct general navigation features and not wasted. These materials were requested to be used for BU where practicable, environmentally acceptable, engineeringly feasible, and economically justified. Soft new work materials that will not viably construct features may be placed offshore or within the interior of new or existing PAs. Open bay placement of materials without benefit of creating capacity or features of demonstrated environmental benefit are not acceptable. Final selection of the placement of materials must be the least cost environmentally acceptable plan unless there is a willing party to pay the incremental cost over a lower cost plan.

3. Engineering Considerations – measures that contemplate construction of a new PA must consider the existing soil conditions. The approximate site locations must be able to provide adequate foundation support and/or meet acceptable borrow quality for containment dike or levee construction as required to provide the required end use. Additionally, the required end use must be known to make engineering assumptions.
4. Site Access - accessible for entry of construction equipment and crews for dredged pipe entry either by direct access from the Federal channel, via pipeline easement(s) less than 5-7 miles, or access channels for scow placement. New PA sites must be situated such that dredging effluent water can be drained from the site in a manner that minimizes impacts to the environment and that allows for proper management of water quality.
5. Construction Costs for New Sites or Cost to Perform – measures that are very expensive due to construction cost, environmental impacts, and resultant mitigation costs that do not provide high value relative to cost will be eliminated from further study. These costs would be in addition to the cost to maximize efficient placement and/or storage capacity as well as the method of dredging and/or construction.
6. Cultural Resource Concerns - a measure that increases (or causes) adverse impact on cultural resource sites that cannot be mitigated in a cost-effective way will be eliminated from further study.
7. HTRW Concerns – any measure for a new PA on a site with unmanageable HTRW concerns/restrictions will be eliminated from further study.
8. Real Estate Issues – real estate examines ownership issues related to the site of the measure. Property not available, developed, or for which a 10/404 regulatory permit application by another party other than the NFS or for another purpose is under review will be eliminated from further study.
9. Infringement on another Federal Project or Proposed Action – any measure that would impact or overlap another Federal project's DMMP or BU plan will be eliminated from further study. The HSC is adjacent to the Texas City Ship Channel, Cedar Bayou Navigation Channel, the Gulf Intracoastal Waterway (GIWW), and the Galveston Harbor and Channels. Any proposed action under another Federal study is not studied further under the HSC ECIP study. However, synergies may be found between various other flood control and storm abatement projects as discussed in Section 8.0 of this DMMP that should be considered during various updates to the DMMP in the future.
10. Capacity Limitations – any measure that contemplates the placement of new work materials in an existing viable UCPA with remaining capacity beyond one or two cycles will be eliminated from further study. Construction of the channel improvements shall not deplete the ability to maintain the existing system.

5.7.1 Nonstructural Measures

The nonstructural measures considered included:

1. Optimization of reaches; and
2. PA management practices (Disposal Area Management Plan (DAMP) activities, containment dike raises, etc.). Dredging measures are considered as nonstructural in this

context because different methods are better suited for geographical and environmental reasons. Dredging itself occurs regardless of method.

5.7.2 Structural Measures

Table 5-1 through Table 5-2 are a compilation of the dredged material management measures identified by the PDT for the 6 study segments and their respective sub reaches (where applicable). Figure 5-3 shows the general locations of measures in Galveston Bay and Figure 5-4 shows the general location of measures in the Bayou section of the HSC above Morgans Point.

Table 5-1: Measures Carried Forward in Galveston Bay

#	Name of Measure	Segments	NW	O&M	Iteration of Screening Measure was Dropped	Screening Criteria Number for Reason Dropped
Measures Carried Forward in Galveston Bay						
B1	Creation of New Upland PA in the Bay	1b, 1c, 2,3	X		Carried Forward	
B2	Relocate existing PA materials	1b, 1c, 2,3		X	1st	3, 4,5
B3	Raise existing dikes with NW	1b, 1c, 2,3	X		2nd	10
B4	Raise existing dikes during O&M	1b, 1c, 2,3		X	SOP	
B5	Focus NW material placement on existing PAs nearing final life as a cap for closure	1,2,3	X		N/A	
B6	Expansion of existing BU marshes at Atkinson Island	1c, 2,3	X		Carried Forward	
B7	Expansion of existing BU marshes at Bolivar Mash	1a	X		Carried Forward	
B8	Expansion of Mid Bay PA	1b, 1c,	X		Carried Forward	
B9	Creation of marsh features along the Texas City Dike	1a, 1b	X	X	1st	9
B10	BSC Dike and Marsh Creation	2	X		Carried Forward	
B11	BSC RoRo Terminal Marsh	2	X		1st	8
B12	Semi-Confined discharge to create sand fans/tidal mudflats	1,2,3	X		2nd	3, 5
B13	Restoration of the Trinity River Delta through borrow from existing Bay Upland PAs to restore capacity (MidBay, PA 14, PA 15)	1b, 1c		X	1st	3, 4, 5,8,9
B14	Placement of materials and expansion of Redfish Island	1b	X		1st	1,5
B15	Eagle Point marsh restoration	1a,1b	X		1st	4,5,8
B16	Smith Point marsh restoration	1a,1b	X		1st	4,5,8
B17	Marsh behind Hogg Island	3	X		2nd	3, 5,8,9
B18	Creation of additional bird islands in Galveston and Trinity Bay	1a, 1b,1c, 2	X		Carried Forward	
B19	Benthic habitat creation	1a, 1b,1c, 2,3	X	X	1st	1,2,3
B20	Oyster reef pad construction	1a, 1b,1c, 2,3	X		Carried Forward	
B21	Oyster mining hole reclamation	1a, 1b,1c, 2	X	X	1st	1,2,3
B22	Stockpiling of materials for use in other projects for use in coastal protection and hurricane risk reduction	1a, 1b,1c, 2,3	X	X	2nd	3, 8,9
B23	Refilling salt domes	1a, 1b,1c, 2,3		X	2nd	3, 8,9
B24	Provide opportunities for mining of existing upland PAs by third parties for construction, fill, BU, or other actions	1b,1c, 2,3		X	2nd	8,9
B25	Storm damage abatement	1a, 1b,1c, 2,3	X	X	2nd	3, 8,9
B26	Renourishment of existing marshes	1a, 1b,1c, 2,3		X	SOP	
B27	Creation of BABUS cells	1a, 1b,1c, 2,3	X		2nd	1,2

List of Criteria: 1) Environmental Considerations, 2) Agency and Public Consideration, 3) Engineering Considerations, 4) Site Access, 5) Construction Costs for New Sites or Cost to Perform, 6) Cultural Resource Concerns, 7) HTRW Concerns, 8) Real Estate Issues, 9) Infringement on another Federal Project or Proposed Action, 10) Capacity Limitations

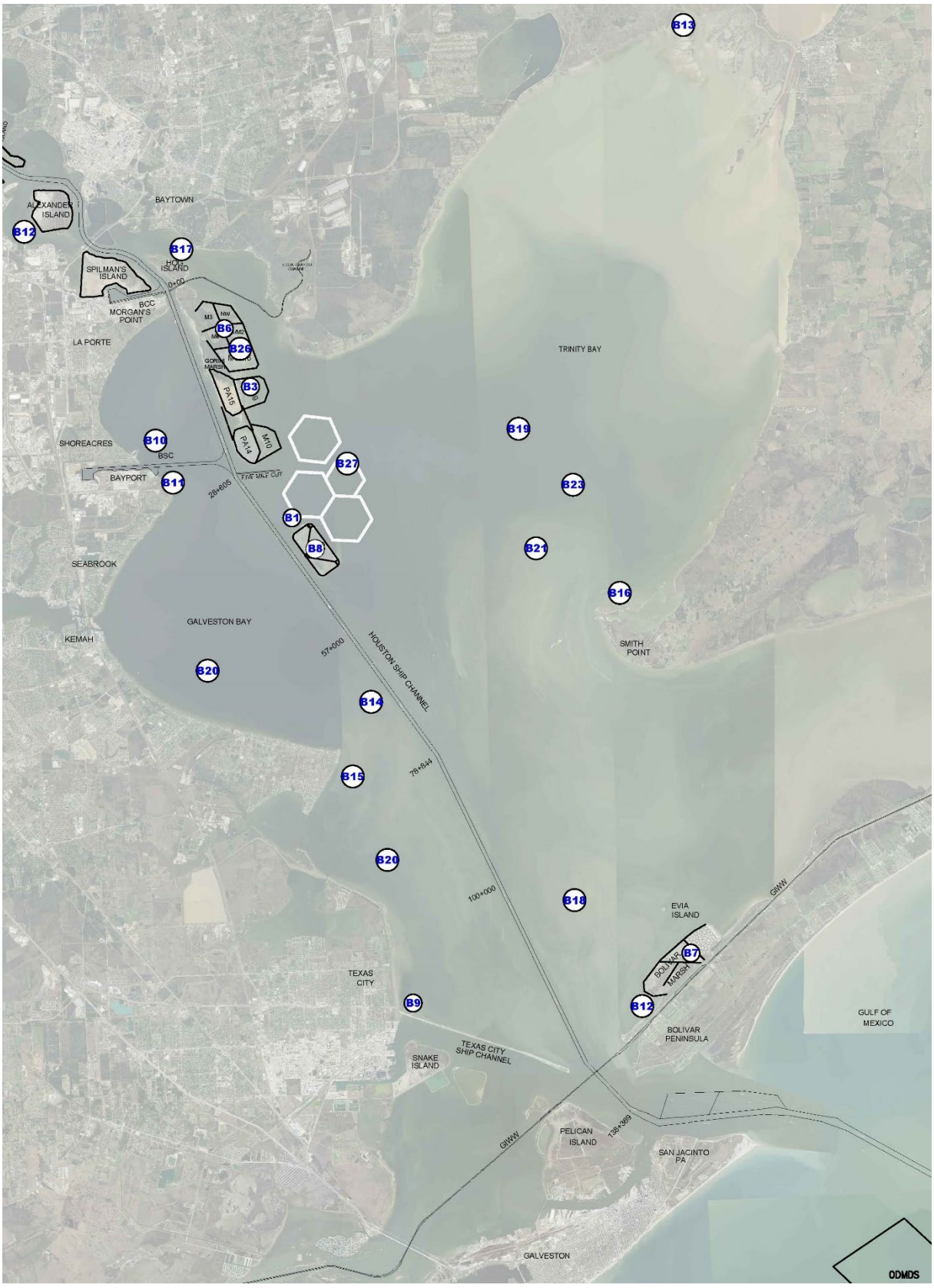


Figure 5-3: Measures Carried Forward in Galveston Bay

Table 5-2: Measures Carried Forward in Boggy Bayou (above Morgans Point)

#	Name of Measure	Segments	NW	O&M	Iteration of Screening Measure was Dropped	Screening Criteria Number for Reason Dropped
Measures Carried Forward in Boggy Bayou (above Morgans Point)						
BB1	Develop BW 8 Site	4	X		Carried Forward	
BB2	Expand existing PHA Property E2 Clinton	4,5	X		Carried Forward	
BB3	Expand existing PHA Property E3 Clinton	4,5,6	X	X	2nd	1,5,8,9
BB4	Expand existing PHA Property Rosa Allen	4,5	X	X	Carried Forward	
BB5	Lynchburg Site	4,5	X	X	2nd	1,4,8
BB6	Relocate existing PA materials	4,5,6		X	2nd	1,5,7,8
BB7 *	Raise existing dikes with NW	4,5,6	X		2nd	10
BB8	Raise existing dikes for O&M	4,5,6		X	SOP	
BB9	Focus NW material placement on existing PAs nearing final life as a cap for closure	4,5,6	X		Carried Forward	
BB10	Semi-Confined discharge to create sand fans/tidal mudflats	4,5,6	X		1st	1,7,8
BB11	BU in Scott Bay	4	X	X	1st	1,5
BB12	Expansion of Goat Island	4	X	X	1st	1,5
BB13	San Jacinto marsh nourishment	4		X	1st	5
BB14	Marsh behind Spilmans Island	3	X		1st	1,5,8
BB15	Marsh behind Alexander Island	3	X		Carried Forward	
BB16	Benthic habitat creation	4,5,6	X	X	1st	1,2,7,8
BB17	Stockpiling of materials for use in other projects for use in coastal protection and hurricane risk reduction	4,5,6	X	X	2nd	8,9
BB18	Refilling salt domes	4,5,6		X	2nd	8,9
BB19	Provide opportunities for mining of existing upland PAs by third parties for construction, fill, BU, or other actions	4,5,6		X	2nd	8,9
BB20	Storm damage abatement	4,5,6	X	X	2nd	8,9
BB21	ODMDS placement for private facilities	4,5,6	X	X	Carried Forward	
BB22	Creation of BABUS cells	4,5,6		X	Carried Forward	

* Some NW clays may be necessary to fortify existing dikes to be evaluated in PED

List of Criteria: 1) Environmental Considerations, 2) Agency and Public Consideration, 3) Engineering Considerations, 4) Site Access, 5) Construction Costs for New Sites or Cost to Perform, 6) Cultural Resource Concerns, 7) HTRW Concerns, 8) Real Estate Issues, 9) Infringement on another Federal Project or Proposed Action, 10) Capacity Limitations

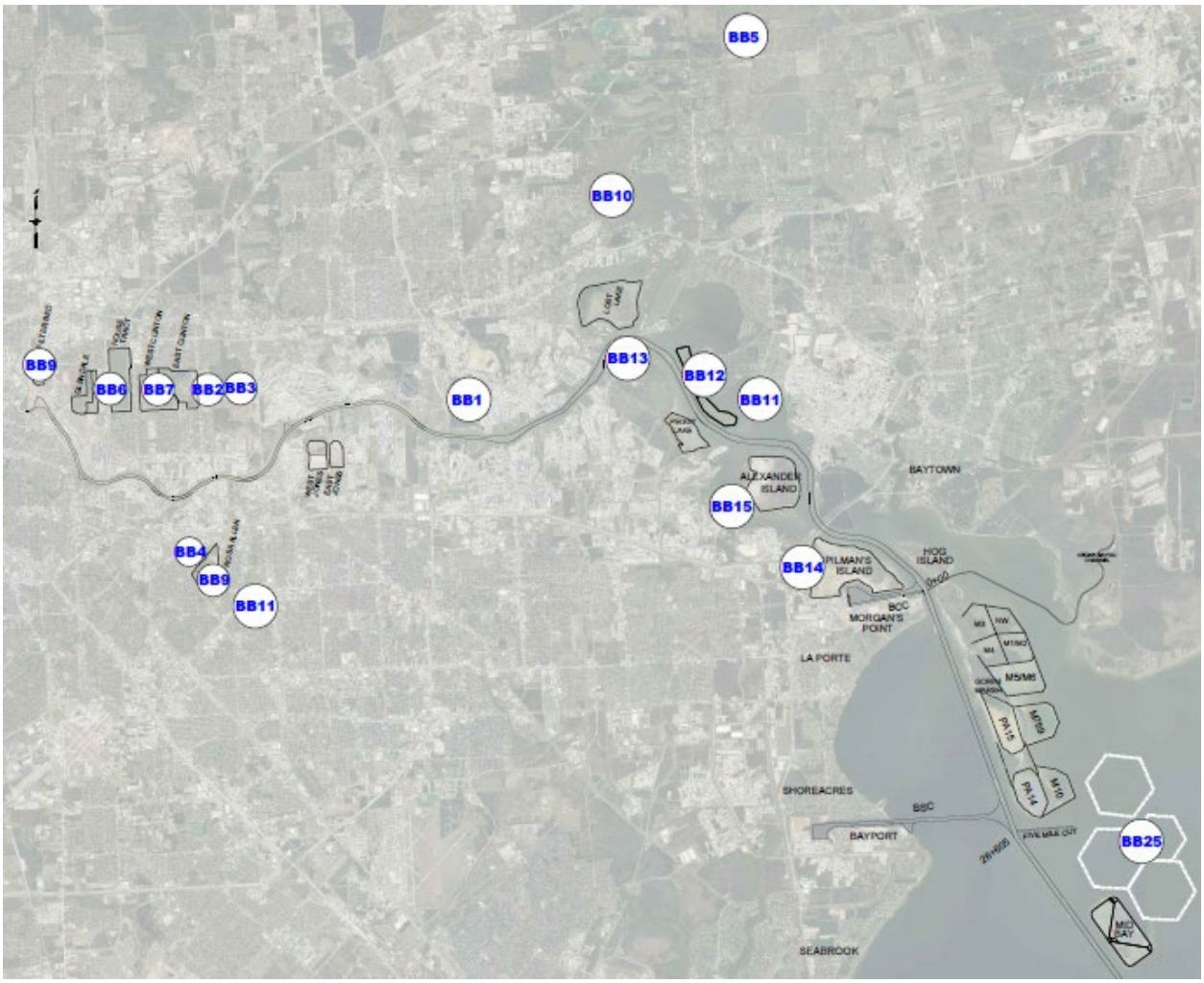


Figure 5-4: Measures Carried Forward in Boggy Bayou (above Morgans Point)

Table 5-3: Non-Structural Measures Considered

#	Name of Measure	Segments	NW	O&M	Iteration of Screening Measure was Dropped	Screening Criteria Number for Reason Dropped
Non-Structural Measures Considered						
NS-1	Optimization of Reaches	1-6	X	X	Carried Forward	
NS-2	PA Management Practices (DAMP Activities, etc.)	1-6		X	Carried Forward	
NS-3	ODMDS placement for private facilities	2,3,4,5,6	X	X	Carried Forward	
NS-4	ODMDS placement for viable NW from the channel	1,2,3,4,5,6	X		1st	2
NS-5	ODMDS placement for soft NW from the channel	1	X		Carried Forward	
NS-6	ODMDS placement for O&M	1,2,3		X	Carried Forward	
NS-8	Cutterhead Dredging	1,2,3,4,5,6	X	X	Carried Forward	
NS-9	Mechanical Dredging (Bay)	1	X		Carried Forward	
NS-10	Mechanical Dredging (Bayou)	4,5,6		X	Carried Forward	
NS-11	Hopper Dredging	4,5,6		X	1st	5

5.7.3 Measures Eliminated During First and Second Screenings

The measures considered in Galveston Bay and Boggy Bayou were subjected to two initial screenings in order to reduce the number of measures prior to pursuing more detailed engineering, cost and NEPA analysis. The tables above (Table 5-1 through 5-3) list the preliminary measures that were considered for each of the sections, segments, and sub reaches, the iteration of screening (1st or 2nd) during which measures were dropped (if it was dropped) and the reason(s) based on the criteria described in Section 5.6 for which the measure was dropped from further consideration. The majority of the measures that were screened out with in the first two screenings for multiple reasons. If a measure was not dropped from consideration during the initial screenings it is noted in the table as being carried forward for additional analysis.

- Galveston Bay – of the 27 measures in Galveston Bay, four measures were eliminated for environmental or agency and public considerations, four were eliminated because of real estate or infringement on another Federal project or proposed action alone, and nine more were screened out for a combination of several criteria. Seven measures were carried forward. Two were considered as standard operating procedure such as raising existing dikes, and one was not applicable as there are no PAs near complete capacity or private facilities to go offshore.

- Boggy Bayou – of the 23 measures in Boggy Bayou, one measure was eliminated for environmental or agency and public considerations, four were eliminated because of real estate or infringement on another Federal project or proposed action alone, one was eliminated for capacity reasons, two were eliminated for costs to perform, and seven more were screened out for a combination of several criteria. Seven measures were carried forward, and one was considered as standard operating procedure such as raising existing dikes.
- All non-structural measures were carried forward except NS-4 as viable new work materials from the channel improvements may not be placed offshore and hopper dredging is not evaluated above Morgans Point as discussed in Section 2.8.2.

5.8 Measures Carried Forward for Final Screening

The measures considered in Galveston Bay and Boggy Bayou were further developed into more definable features by segment and reach. Since one of the project constraints involves not placing new work in viable existing PAs (with the exception of measure BB9), the first task was to develop scenarios for the construction of new sites to either contain the new work materials as a result of the construction of the channel modifications and/or to create additional future O&M capacity where feasible. The placement measures for new work were generally sized to hydraulically construct dikes for the measure with the new work in Galveston Bay. There are no new non-Federal facility improvements in Galveston Bay. In Boggy Bayou in-situ earthen dikes were sized on the various PAs to contain the new work. The Boggy Bayou area of the channel is heavily constrained by existing industrial and residential developed property. Therefore, few opportunities for new dredged material placement options are available within reasonable proximity to the channel. Non-Federal facilities expected to be improved as a result of this project are discussed in Section 3.4 and are not considered in the formulation of channel construction placement alternatives.

Measures carried forward and defined by segment and reach for new work are described below. O&M of the channel improvements along with the existing HSC complex are described in Section 7.0. Specific descriptions of aspects of measures requiring mitigation, that are self-mitigating, or provide mitigation credits are discussed in Appendix P of the FIFR-EIS.

5.8.1 Segment 1A – Bolivar to Redfish (Lower Bay)

Of the measures carried forward, the following measures apply to this reach of Segment 1.

- B1 - Creation of New UCPA in the Bay - Use the available stiff clays from Station 138+369 to 100+00 to create a new PA and place the softer materials for fill. This was immediately screened out in this reach because there is not sufficient new work to create dikes with sufficient capacity to contain the softer materials.
- B7 - Expansion of existing BU marshes at Bolivar Marsh – Space for large expansion at Bolivar Marsh is limited due to the surrounding open water PAs for the GIWW. Therefore, a plan to create an instamarsh with new work materials on the southern side of the existing Bolivar Marsh as shown in Figure 5-5 was developed. This would be created by pumping

a fan shaped pad from the shoreline and shaping it with circulation channels to entirely be constructed from the channel improvements from station 138+369 to 100+000 that contain stiff clays. This measure does not require mitigation as discussed in Appendix P.

Figure 5-5: Measure B7 Bolivar Marsh

- B18 - Creation of additional bird islands in Trinity and Galveston Bay. Two separate bird island concepts were favored by the BUG. The previously constructed Evia Island has been a great success and provides habitat for several species of birds. However, habitat for skimmers and ground nesting birds in Galveston Bay is dwindling and the BUG felt that this was a habitat that needed attention. Therefore, two types of Bird Islands are presented and detailed in Figure 5-6 and Figure 5-7. These measures do not require mitigation as discussed in Appendix P of the FIFR EIS..
  - B18 a, Long Bird Island
  - B18 b, 8-Acre Bird Island
- B20 – Oyster reef pad construction - Utilize a portion of the stiff new work materials to construct elevated pads on the bay bottom as BU to reduce rock costs for the oyster mitigation required as a result of the channel improvements. These materials would be hydraulically dredged and placed via spill barge evenly across the bay bottom with a 6-inch veneer of limestone cultch as shown in Figure 5-8. Due to the low acreage of oyster reef mitigation in this section and the separation of NED and LPP plans discussed in Section 4.2.1.1 of the Engineering Appendix, this alternative was eliminated for BU of dredged material placement for Segment 1a.

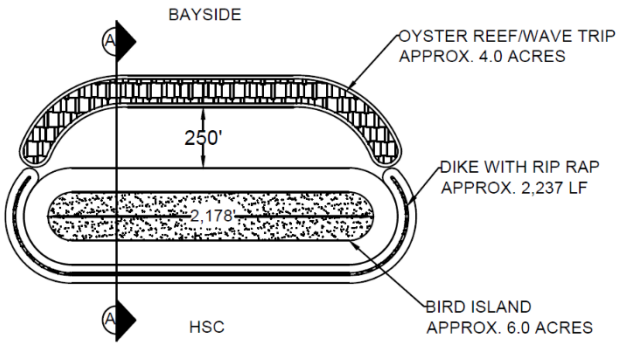


Figure 5-6: Measure B18a Long Bird Island

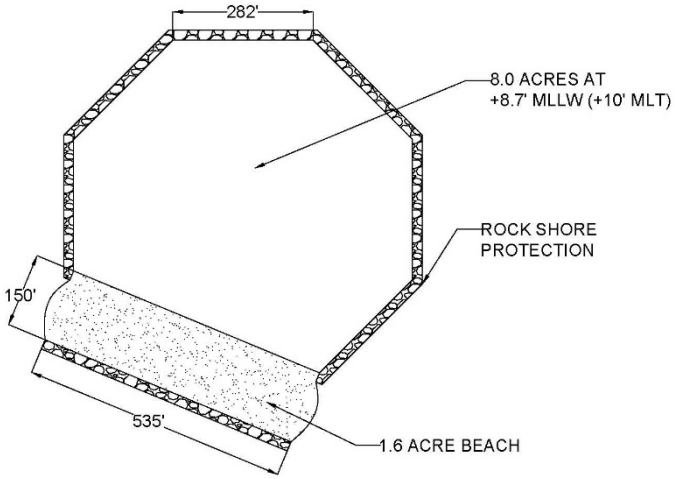


Figure 5-7: Measure B18b 8-Acre Bird Island

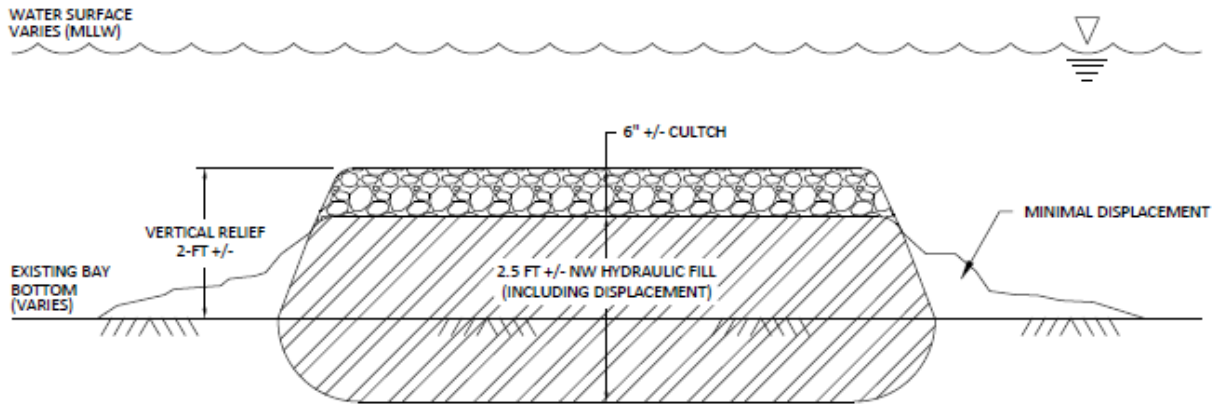


Figure 5-8: Measure B20 Oyster Pad Construction

- B29 ODMDS placement for soft new work from the channel – Very soft new work materials exist in the channel improvement template from station 100+000 to 78+000 and are selected to go to the ODMDS as shown in Figure 2-1.

5.8.1.1 Segment 1B – Redfish to Bayport (Mid Bay)

Segment 1B (Mid Bay), Segment 1C (Upper Bay) and Segment 2 (BSC) are all managed as a system. Therefore, materials from either of these three areas may and do utilize existing and planned PAs, UCPA or BU, as well as ODMDS placement at any given time materials for construction or O&M may be interchanged and therefore some of the same measures are developed into varying alternatives going forward.

Of the measures carried forward, the following measures apply to this reach of Segment 1.

- B1 -Creation of New Upland PA in the Bay - Create an entirely new approximate 500-acre UCPA site to north east of the existing Mid Bay (Upland Concept 1) as shown in Figure 5-9. This would require 373 acres of mitigation for bay bottom conversion and 0.4 acres for oyster impacts as described in Appendix P of the FIFR EIS.
- B8 – Expansion of Mid Bay PA - Use available new work materials to expand the existing Mid Bay PA to the north and south by 292 acres respectively as shown in Figure 5-9. This would require mitigation of 336 acres for bay bottom conversion and 7.3 acres of oyster habitat as described in Appendix P of the FIFR EIS.
    - B8 a – Mid Bay expansion north
    - B8 b – Mid Bay expansion south

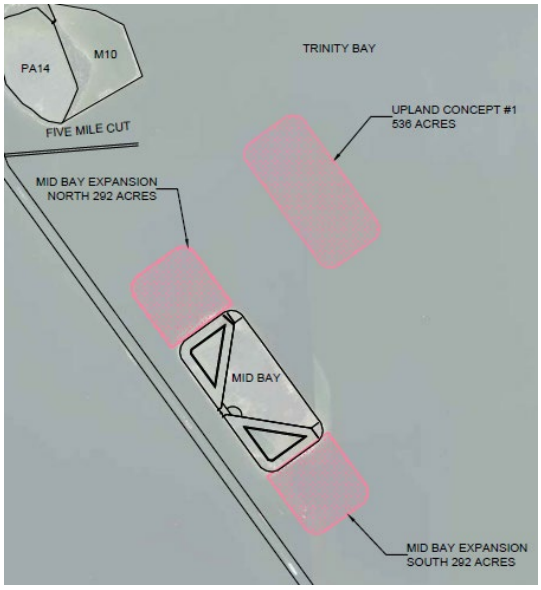


Figure 5-9: Measure B1 Upland Concept 1; Measure B8a and B8b Mid Bay PA Expansion

- B18 - Creation of additional bird islands in Trinity and Galveston Bay - Construct an approximate 400-acre triangularly shaped marsh with 3 approximate 2-acre bird islands that are surrounded by a wave trip to provide wading and foraging habitat at each corner as shown in Figure 5-10, becoming measure B18 c, 3 Bird Island Marsh. This measure does not require mitigation as discussed in Appendix P of the FIFR EIS.
    - B18 c – 3 Bird Island Marsh

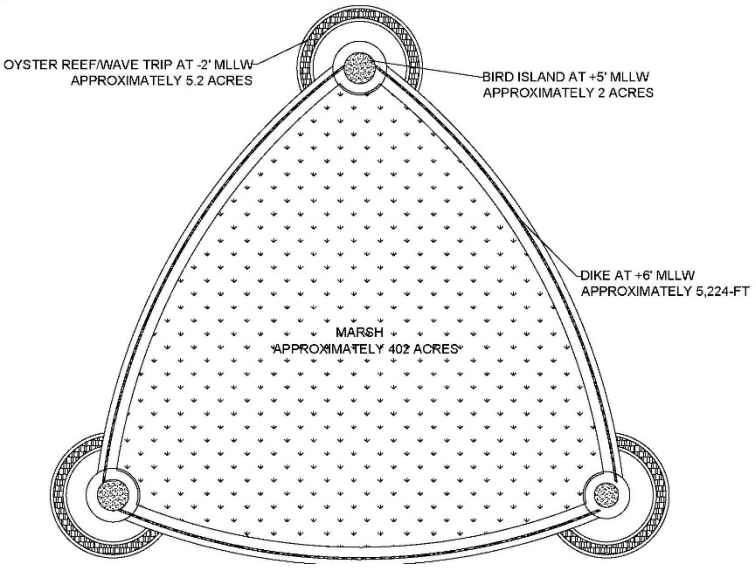


Figure 5-10: Measure B18c Bird Island Marsh

- B20 – Oyster reef pad construction - Utilize a portion of the stiff new work materials to construct elevated pads on the bay bottom as BU to reduce rock costs for the oyster mitigation required as a result of the channel improvements. These materials would be hydraulically dredged and placed via spill barge evenly across the bay bottom with a 6-inch veneer of limestone cultch as shown in Figure 5-8.
- B29 -ODMDS placement for soft new work from the channel – Very soft new work materials exist in the channel improvement template from station 78+000 to 57+000 and are selected to go to the ODMDS as shown in Figure 2-1.

5.8.1.2 Segment 1c – Bayport to Barbours Cut (Upper Bay)

Of the measures carried forward, the following measures apply to this reach of Segment 1.

- B1- Creation of New UCPA in the Bay - Create an entirely new 500-acre upland site to north east of the existing Mid Bay (Upland Concept 1) as shown in Figure 5-9. This would require 373 acres of mitigation for bay bottom conversion and 0.4 acres for oyster impacts as described in Appendix P of the FIFR EIS.
- B6 – Expansion of Atkinson Island Marshes - Construct new marsh BU cells M11 between M7/8/9 and M10 on the southern end of Atkinson Island and M12 on the north end of Atkinson Island as shown in Figure 5-11. This could include repair and fortification of marsh dikes on 7/8/9. These measures do not require

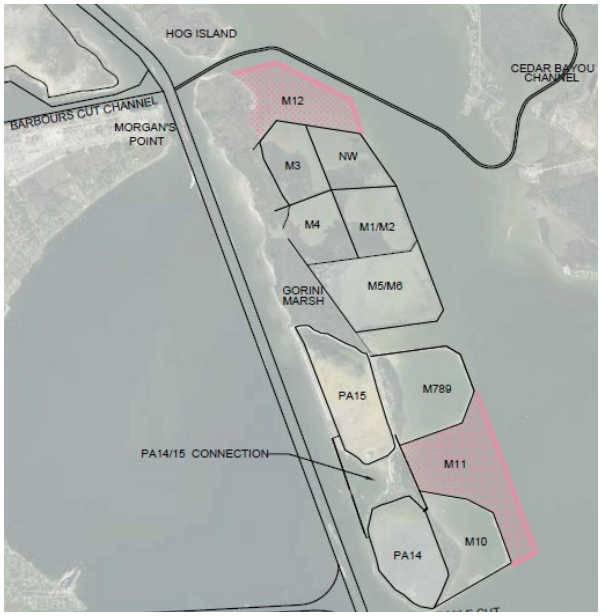


Figure 5-11: Measure B6a M11, B6b M12, and B6c M7/8/9 Rehab

mitigation as discussed in Appendix P of the FIFR EIS..

- B6 a – M11
- B6b – M12
- B6c – Repair M 7/8/9

- B8 – Expansion of Mid Bay PA - Use available new work materials to expand the existing Mid Bay PA to the north and south by 292 acres respectively as shown in Figure 5-9. This would require mitigation of 336 acres for bay bottom conversion and 7.3 acres of oyster habitat as described in Appendix P of the FIFR EIS.
  - B8 a – Mid Bay expansion north
  - B8 b – Mid Bay expansion south
- B10 – BSC Dike and Marsh Creation – This feature began as a shoaling attenuation feature on the north side of the BSC in order to reduce shoaling of the BSC Flare as well as to create a marsh and recreational feature in northern Galveston Bay. However, due to public comment opposition, it was reduced to only a shoaling attenuation feature consisting of an earthen dike from available new work materials to construct a base of a shoaling attenuation feature with a riprap cap on the north side of the BSC Flare as shown in Figure 5-12. These measures do not require mitigation as discussed in Appendix P of the FIFR EIS.

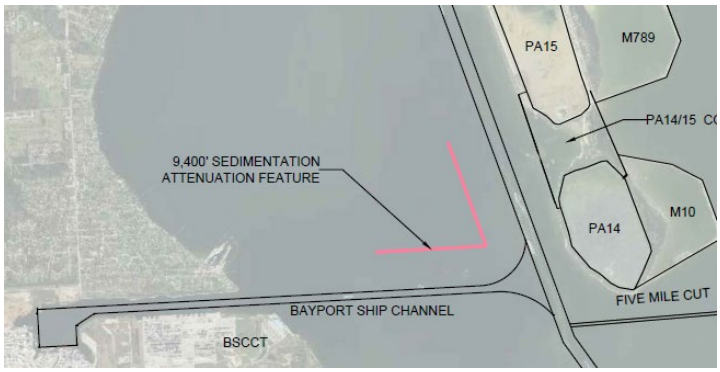


Figure 5-12: Measure B10 Bayport Shoaling Attenuation Feature

- B18 - Creation of additional bird islands in Trinity and Galveston Bay - Construct an approximate 400-acre triangularly shaped marsh with 3 approximate 2-acre bird islands that are surrounded by a wave trip to provide wading and foraging habitat at each corner as shown in Figure 5-10. This measure does not require mitigation as discussed in Appendix P of the FIFR EIS.
  - B18 c – 3 Bird Island Marsh
- B20 – Oyster reef pad construction - Utilize a portion of the stiff new work materials to construct elevated pads on the bay bottom as BU to reduce rock costs for the oyster mitigation required as a result of the channel improvements. These materials would be hydraulically dredged and placed via spill barge evenly across the bay bottom with a 6-inch veneer of limestone cultch as shown in Figure 5-8.

5.8.1.3 Segment 2 – Bayport Ship Channel

Of the measures carried forward, the following measures apply to Segment 2.

- B1- Creation of New UCPA in the Bay - Create an entirely new 500-acre upland site to north east of the existing Mid Bay (Upland Concept 1) as shown in Figure 5-9. This would require 373 acres of mitigation for bay bottom conversion and 0.4 acres for oyster impacts as described in Appendix P of the FIFR EIS.

- B6 – Expansion of Atkinson Island Marshes - Construct new marsh BU cells M11 between M7/8/9 and M10 on the southern end of Atkinson Island and M12 on the north end of Atkinson Island as shown in Figure 5-11. This could include repair and fortification of marsh dikes on 7/8/9. These measures do not require mitigation as discussed in Appendix P of the FIFR EIS.
    - B6 a – M11
    - B6b – M12
    - B6c – Repair M 7/8/9
- B8 – Expansion of Mid Bay PA - Use available new work materials to expand the existing Mid Bay PA to the north and south by 292 acres respectively as shown in Figure 5-9. This would require mitigation of 336 acres for bay bottom conversion and 7.3 acres of oyster habitat as described in Appendix P of the FIFR EIS.
    - B8 a – Mid Bay expansion north
    - B8 b – Mid Bay expansion south .
- B10 – BSC Dike and Marsh Creation – This feature began as a shoaling attenuation feature on the north side of the BSC in order to reduce shoaling of the BSC Flare as well as to create a marsh and recreational feature in northern Galveston Bay. However, due to public comment opposition, it was reduced to only a shoaling attenuation feature consisting of an earthen dike from available new work materials to construct a base of a shoaling attenuation feature with a riprap cap on the north side of the BSC Flare as shown in Figure 5-12. This measure does not require mitigation as discussed in Appendix P of the FIFR EIS.
- B18 - Creation of additional bird islands in Trinity and Galveston Bay - Construct an approximate 400-acre triangularly shaped marsh with 3 approximate 2-acre bird islands that are surrounded by a wave trip to provide wading and foraging habitat at each corner as shown in Figure 5-10. This measure does not require mitigation as discussed in Appendix P of the FIFR EIS.
    - B18 c – 3 Bird Island Marsh
- B20 – Oyster reef pad construction - Utilize a portion of the stiff new work materials to construct elevated pads on the bay bottom as BU to reduce rock costs for the oyster mitigation required as a result of the channel improvements. These materials would be hydraulically dredged and placed via spill barge evenly across the bay bottom with a 6-inch veneer of limestone cultch as shown in Figure 5-8.

5.8.1.4 Segment 3 – Barbours Cut Channel

Of the measures carried forward, the following measures apply to Segment 3.

- B6 – Expansion of Atkinson Island Marshes - Construct new marsh BU cell M12 on the north end of Atkinson Island as shown in Figure 5-11. This could include repair and fortification of marsh dikes on 7/8/9. These measures does not require mitigation as discussed in Appendix P of the FIFR EIS.
    - B6b – M12
    - B6c – Repair M 7/8/9

- BB7 – Raise existing dikes with new work – Hydraulically raise dikes on Spilman Island with new work from BCC directly adjacent.
- BB15 – Create marsh behind Alexander Island – Hydraulically pump new work materials into a marsh behind Alexander Island as shown in Figure 5-13.

Figure 5-13: Alexander Island Marsh

5.8.1.5 Segment 4 – Boggy to Sims Bayou

During the first and second screenings, the majority of the sites in proximity of Segment 4 such as the use of existing PAs for new work, removal of materials from existing PAs, the Lynchburg site, E3 Clinton, and habitat creation were screened out for several reasons, but primary importance was environmental considerations. This area of the channel is heavily constrained by existing industrial and residential developed property. Therefore, few opportunities for new dredged material placement options are available within reasonable proximity to the channel. Of the measures carried forward, the following measures apply to Segment 4.

- BB1 – Develop BW-8 Site – Place new work materials beneficially in the BW-8 property for site leveling and raising. This will require approximately 30 acres of forested/shrub wetland to be mitigated at a mitigation bank. An earthen dike approximately 9 feet high will be constructed from onsite materials, two spill boxes, and drainage of effluent will occur in the adjacent drainage ditch back to the HSC. Real estate interest has already been obtained by the PHA and an easement will be granted for one-time use to the Federal Government for new work material.
- BB2 – Expand existing PHA Property E2 Clinton - Place new work materials at E2 Clinton located adjacent to the existing East Clinton PA. This will require approximately 1.49 acres of herbaceous and 4.76 acres of forested/shrub wetland to be mitigated at a mitigation bank. An earthen dike approximately 9 feet high will be constructed from onsite materials, two spill boxes will be installed, and effluent drainage will connect to the existing drainage at East Clinton. Real estate interest has already been obtained by the PHA and will be granted for one-time use to the Federal Government.

5.8.1.6 Segment 5 – Sims to I-610 Bridge

During the first and second screenings, the majority of the sites in proximity of Segment 5 such as the use of existing PAs for new work, removal of materials from existing PAs, the Lynchburg site, E3 Clinton, and habitat creation were screened out for several reasons, but primary importance was environmental considerations. This area of the channel is heavily constrained by existing

industrial and residential developed property. Therefore, few opportunities for new dredged material placement options are available within reasonable proximity to the channel. Of the measures carried forward, the following measures apply to Segment 5.

- BB4 – Expand existing PHA Property Rosa Allen - Expand the existing Rosa Allen PA by 138 acres with the mechanical construction of a 9-foot dike with on-site and adjacent materials, and two spill boxes. Drainage would be the same as for the existing Rosa Allen PA. PHA owns the real estate interest.
- BB9 – Focus new work material placement on existing sites nearing final life as a cap - Both the Glendale and Filterbed PAs are at or near final capacity. Public comment and coordination indicate that the neighboring residential areas desire that these sites be capped and closed. This measure contemplates construction earthen dikes and filling and capping the site with new work materials from construction of the channel improvements.
    - BB9a - Cap and close Glendale
    - BB9b – Cap and close Filterbed

5.8.1.7 Segment 6 – I-610 to Turning Basin

Both Segments 5 and 6 are short sections of channel and are typically maintained together and utilize the same PAs. Therefore, their measures are the same.

5.9 Alternative Plans and Screening

As discussed in Section 5 of the FIFR-EIS the channel improvement measures are divided into the NED Plan and the LPP Plan to come to a recommended channel improvement plan. The channel improvement measures in conjunction with the DMMP measures are evaluated and screened by study segment and reach(s) below. Several DMMP measures are combined by Segment and/or reach to develop alternative options. The least cost option for each Segment and sub-reach(s) of segments where applicable are selected to formulate the NED or the LPP alternatives.

There are no new non-Federal facility improvements in Galveston Bay. Non-Federal facilities expected to be improved as a result of this project are discussed in Section 3.4 of this DMMP and Section 5.4 of the Engineering Appendix. The non-Federal facilities that are currently planned for construction and existing facilities expected to be deepened as a result of this project, are accounted for in the FWP condition as an associated cost based upon placement of those materials at the current private PA CY costs as described in the 10.2.7 of the Engineering Appendix and are not considered in the formulation of channel construction alternatives. The FWOP DMMP is presented in Section 7 and accounts for capacity needed for the Federal and non-Federal dredging needs. Quantities and costs listed in this section account for the construction of the channel improvements and the incremental maintenance of those improvements above the FWOP condition. Costs shown herein are categorized into the Civil Works Breakdown Structure (CWBS) Feature codes to include:

- 02 – Lands and Damages – real estate costs
- 03 – Relocations – pipeline relocation

- 06 – Fish & Wildlife – mitigation (costs include mitigation for channel and dredged material measures)
- 12 – Navigation – dredging, placement, PA construction, O&M

Real estate costs for screening utilized Harris County Appraisal District (HCAD) values. Contingencies used are based on the abbreviated risk assessment in November 2018 as described in Section 6.2. They do not include costs for engineering, design, supervision, and administration for screening purposes.

Alternative plans were formulated in order of Segment and reach from Bolivar to the Main TB. Segment 1B (Mid Bay), Segment 1C (Upper Bay) and Segment 2 (BSC) are all managed as a system. Therefore, materials from either of these three areas may and do utilize existing and planned PAs, UPCA or BU, as well as ODMDS placement. At any given time, materials for construction or O&M may be interchanged and therefore some of the same measures are developed into varying alternatives going forward.

This section is divided into three parts, the No Action Plan, the NED Plan and the LPP. Table 5-4 and Table 5-5 provides the description of the segment, reach, channel measure, DMMP measure and costs for each option evaluated by Segment and reach(s). Table 5-6 and Table 5-7 evaluate the plans based on least cost plan selection, provides mitigation acreages for each placement measure (channel measures are evaluated separately), P&G evaluation criteria (acceptability, completeness, efficiency, effectiveness), planning objectives, and screening criteria for the NED and LPP Plans.

5.9.1 Alternative A - No Action Plan

The No Action Plan means status quo and no channel improvements will be made that necessitate a change from the FWOP. This alternative provides a baseline against which the benefits and impacts of the action alternatives are measured, and it is required by NEPA to be included among the alternative plans in the final array of alternatives. It is described in Section 2 of this DMMP. No action is acceptable but is an incomplete solution to all planning objectives. It is not effective because it doesn't address the planning objective. It is ineffective for the 50-year placement of dredged materials.

5.9.2 Alternative B - NED Plan

Table 5-4 provides the description of the segment, reach, channel measure, DMMP measure and costs for each alternative evaluated. The NED does not widen the HSC above Redfish. Coordination with the Houston Pilots (HP) and preliminary ship simulation indicate that without the 700-foot HSC widening north of Redfish, the channel turn from Redfish to BSC at Station 028+605 would require a 328-foot bend easing in addition to widening the BSC flare from the existing 4,000 feet to a 5,375-foot radius.

Channel measures included in the NED plan consist of the following:

- BE1_138+369_700*
- BE1_128+731_700*
- BE1_78+844_700*
- CW1_BR-Redfish_700
- BE1_028+605_530
- BE2_BSCFlare
- CW2_BSC_455
- BETB3_BCCFlare
- CW3_BCC_455
- CW4_BB-GB
- CD4_Whole
- CD5_Whole
- CD6_Whole
- TB6_Brady 900

*These measures are combined into the CW1_BR-Redfish_700

5.9.3 Alternative C - LPP Plan

Table 5-5 provides the description of the segment, reach, channel measure, DMMP measure and costs for each alternative evaluated. The LPP is generally the same as the NED in all areas except Segment 1 from Redfish to BSC, BSC to BCC, and Segment 2. The LPP will widen the HSC to 700-feet from Redfish to BCC. Coordination with the HP and preliminary ship simulation indicate that the current 4,000-foot radius of the BSC Flare would not need modification if the HSC is widened to 700-feet with 328-foot bends. Measure BE1_028+605 was a 328-foot bend on the existing 530-foot channel at Station 028+605. This measure will no longer be needed as the project footprint falls within the 700-foot channel widening. Removal of this quantity of material, and the use of some of the construction materials from Redfish to BSC being used for oyster mitigation to construct base pads for cultch placement, reduces the construction materials remaining from both Redfish to BSC and BSC. The resulting combined new work material remaining from Segment 1B and Segment 2 is relatively the same as Segment 2 for the NED. Therefore, these two channel features were combined for DMMP Planning.

Channel measures included in the LPP plan consist of the following:

- BE1_138+369_700*
- BE1_128+731_700*
- BE1_78+844_700*
- CW1_BR-Redfish_700
- CW1_Redfish-BSC_700
- BE1_028+605_700*
- CW1_BSC-BCC_700
- CW2_BSC_455
- BETB3_BCCFlare
- CW3_BCC_455
- CW4_BB-GB
- CD4_Whole
- CD5_Whole
- CD6_Whole
- TB6_Brady 900

*These measures are combined into the channel widening features

Table 5-4: Screened Options for the HSC ECIP NED Plan

Segment and Features		PA/BU Site	Stations	NW Plan Description	NW Req. (KCY)	NW Avail. (KCY)	01 ($K's)	02 ($K's)	06 ($K's)	12 ($K's)	First Cost ($K's)	O&M Plan Description	50-YR Total Incremental Cost ($K's)	SUMMARY		
														Total NW Req. (KCY)	Total NW Avail. (KCY)	Total Cost ($K's)
1A	BE1_138+369_700 BE1_128+731_700 BE1_078+844_700 CW1_BR-Redfish_700	B18a B18b B29	138+369 - 100+00	NW channel widening to Long Bird Island	1,172 [1]	1,994	$48	$0	$20,200	$74,200	$94,400	BR-RF: B29	$19,400	5,120	5,032	$113,800
				NW channel widening to 8-AC Bird Island	910 [1]											
			100+000 - 073+934	NW channel widening to ODMDS	3,038	3,038										
	BE1_138+369* BE 128+731* BE78+844* CW1_BR-Redfish_700	B7 B29	138+369 - 100+00	NW channel widening to new Bolivar Marsh	1,989 [1]	1,994	$48	$0	$21,800	$72,700	$94,500	BR-RF: B29	$19,400	5,027	5,032	$113,900
			100+000 - 073+934	NW channel widening to ODMDS	3,038	3,038										
1B/C, 2	BE1_028+605_530	B18c B29	031+171 - 028+605	NW bend easing to Bird Island Marsh	4,500 [1]	260	$23	$23	$3,900	$10,700	$122,400	RF-BSC: B18c, Mid Bay PA, B29	$264,300	4,500	4,458	$386,700
			028+605 - 026+028			165						BSC-BCC: PA15, B29				
	CW2_BSC_455		25+58 - 221+00	NW channel widening to Bird Island Marsh		2,108	$24	$0	$0	$68,900		BSC: PA14, Connection, B29				
	BE2_BSCFlare		203+66 - 239+00	NW flare widening to Bird Island Marsh		1,925	$24	$0	$1,900	$36,900		BSC Flare: PA14, Connection, B29				
	BE1_028+605	B1 B29	031+171 - 028+605	NW bend easing to Upland Concept 1	4,500 [1]	260	$23	$0	$5,700	$9,600	$125,100	RF-BSC: B1, Mid Bay PA, B29	$264,700	4,500	4,458	$389,800
			028+605 - 026+028			165						BSC-BCC: PA15, B29				
	CW2_BSC_455		25+58 - 221+00	NW channel widening to Upland Concept 1		2,108	$24	$0	$7,600	$60,500		BSC: PA14, Connection, B29				
	BE2_BSCFlare		203+66 - 239+00	NW flare widening to Upland Concept 1		1,925	$24	$0	$9,800	$31,800		BSC Flare: PA14, Connection, B29				
	BE1_028+605	B8a B6c B10	031+171 - 028+605	NW bend easing to MB Exp. N	2,800 [1]	260	$23	$0	$5,800	$9,700	$155,200	RF-BSC: B8a, Mid Bay PA, B29	$263,300	4,200	4,458	$418,500
			028+605 - 026+028			165						BSC-BCC: B6c, PA15, B29				
	CW2_BSC_455		25+58 - 221+00	NW channel widening to MB Exp. N		2,108	$24	$0	$8,200	$57,900		BSC: PA14, Connection, B29				
	BE2_BSCFlare		203+66 - 239+00	NW flare widening to MB Exp N		267	$24	$0	$9,900	$63,600		BSC Flare: B6c, PA14, Connection, B29				
				NW flare widening to M7/8/9	600 [1]	700										
				NW flare widening to Sed. Attenuation	800 [1]	958										
	BE1_028+605	B6a B6c B10	031+171 - 028+605	NW bend easing to M11	2,800 [1]	260	$23	$0	$4,400	$9,500	$129,400	RF-BSC: Mid Bay PA, B29	$262,400	4,200	4,458	$391,800
			028+605 - 026+028			165						BSC-BCC: B6a, B6c, PA15, B29				
	CW2_BSC_455		25+58 - 221+00	NW channel widening to M11		2,108	$24	$0	$1,600	$45,400		BSC: PA14, Connection, B29				
	BE2_BSCFlare		203+66 - 239+00	NW flare widening to M11		267	$24	$0	$5,100	$63,300		BSC Flare:B6c, B6a, PA14, Connection, B29				
				NW flare widening to M7/8/9	600 [1]	700										
				NW flare widening to Sed. Attenuation	800 [1]	958										

3	CW3_BCC_455 BETB3_BCCFlare	B6b	08+78 - 67+11	NW channel/flare widening to Atkinson Marsh Cell M12	2,300 [1]	2,825	$47	$0	$1,200	$107,400	$108,600	BCC & Flare: Spilman, BABUS, B6b, B29	$96,900	2,300	2,825	$205,500
	CW3_BCC_455 BETB3_BCCFlare	BB7	08+78 - 67+11	NW channel/flare widening to Spilman Island PA	2,400 [1]	2,825	$47	$0	$1,200	$94,000	$95,200	BCC: O&M to Spilman, ODMDS, & BABUS	$106,800	2,400	2,825	$202,000
	CW3_BCC_455 BETB3_BCCFlare	BB15	08+78 - 67+11	NW channel/flare widening to Alexander Marsh	2,400 [1]	2,825	$47	$0	$1,200	$109,800	$111,000	BCC: O&M to Spilman, ODMDS, & BABUS	$106,800	2,400	2,825	$217,800
4	CW4_BB-GB CD4_Whole	BB1	684+03 - 850+00	NW widening/deepening to even lift on BW8	2,920	3,272	$14,200	$9,300	$6,400	$85,600	$115,500	BB-GB: Lost Lake, BABUS	$129,800	3,272	3,272	$245,300
		BB2	850+00 - 930+00	NW deepening to even lift on E2 Clinton	352							GB-SB: Rosa Allen, Rosa Allen Exp., East Clinton				
5	CD5_Whole	BB9a	1110+78 - 1160+62	NW deepening to even lift on Glendale PA.	176	176	$24	$0	$0	$6,500	$6,500	Sims to 610: West Clinton, BABUS	$4,500	176	176	$11,000
6	CD6_Whole TB6_Brady_900	BB9a	1160+62 - 1266+49	NW deepening to even lift on Glendale PA.	734	734	$191	$0	$0	$38,600	$38,800	610 to Main TB:West Clinton, House Tract, BABUS	$27,200	1,001	1,001	$66,000
		BB9b	00+00 - 30+95	NW deepening to even lift on Filterbed PA	267	267										

TABLE LEGEND
BE=Bend Easing
CW=Channel Widening
CD=Channel Deepening

NW=New Work
BR-RF=Bolivar Roads to Redfish
BABUS=Bay Aquatic BU Site
B18a=Long Bird Island
B10=Sedimentation Attenuation Feature

B18b=8-Ac Bird Island
B18c=Bird Island Marsh
B6b=Atkinson Marsh Cell M12
BB1=BW8 site
B7=Bolivar New Marsh

BB2=E2 Clinton Site
BB9a=Glendale PA
BB9b=Filterbed PA
B29 is used in DMMP Appendix for Existing ODMDS

Note 1) All material is dredged and costs are accounted for in the estimate. Final PA sizes to be determined through additional geotechnical and engineering evaluations in PED

Table 5-5: Screened Options for the HSC-ECIP LPP (Recommended Plan)

Segment and Features		PA/BU Site	Stations	NW Plan Description	NW Req. (KCY)	NW Avail. (KCY)	02 ($K's)	03 ($K's)	06 ($K's)	12 ($K's)	First Cost ($K's)	O&M Plan Description	50-YR Total Incremental Cost ($K's)	SUMMARY		
														Total NW Req. (KCY)	Total NW Avail. (KCY)	Total Cost ($K's)
1A	BE1_138+369_700 BE1_128+731_700 BE1_078+844_700 CW1_BR-Redfish_700	B18a B18b B29	138+369 - 100+00	NW channel widening to Long Bird Island	1,172 [1]	1,994	$48	$0	$20,200	$74,200	$94,400	BR-RF: B29	$19,400	5,120	5,032	$113,800
				NW channel widening to 8-AC Bird Island	910 [1]											
			100+000 - 073+934	NW channel widening to ODMDS	3,038	3,038										
	BE1_138+369* BE 128+731* BE78+844* CW1_BR-Redfish_700	B7 B29	138+369 - 100+00	NW channel widening to new Bolivar Marsh	1,989 [1]	1,994	$48	$0	$21,800	$72,700	$94,500	BR-RF: B29	$19,400	5,027	5,032	$113,900
			100+000 - 073+934	NW channel widening to ODMDS	3,038	3,038										
1B, 2	CW1_Redfish-BSC_700	B18c B20 B29	073+794 - 028+605	NW channel widening to ODMDS	2,474	2,474	$35	$0	$14,300	$108,600	$172,800	RF-BSC: B18c, B29, Mid Bay PA	$291,100	9,004	9,793	$463,900
				NW channel widening to Oyster Mitigation	2,030 [2]	2,030										
				NW channel widening to Bird Island Marsh	4,500 [1]	3,181										
	CW2_BSC_455		25+58 - 221+000	NW channel widening to Bird Island Marsh		2,108	$24	$0	$0	$49,800		BSC & Flare: B6a, B6c, PA14, Connection, B29				
	CW1_Redfish-BSC_700	B1 B20 B29	073+794 - 028+605	NW channel widening to ODMDS	2,474	2,474	$35	$0	$22,400	$107,300	$179,300	RF-BSC: B1, B18, B29, Mid Bay PA	$295,100	9,006	9,793	$474,400
				NW channel widening to Oyster Mitigation	2,032 [2]	2,032										
				NW channel widening to Upland Concept 1	4,500 [1]	3,179										
	CW2_BSC_455		25+58 - 221+000	NW channel widening to Upland Concept 1		2,108	$24	$0	$5,300	$44,200		BSC: O&M to PA14, Connection, B29				
	CW1_Redfish-BSC_700	B8a B6c B20 B29	073+794 - 028+605	NW channel widening to ODMDS	2,474	2,474	$35	$0	$25,900	$98,000	$193,800	RF-BSC: B1, B8a, Mid Bay PA, B29 *Note: Also uses Upland Concept 1 built from BSC to BCC	$298,100	8,817	9,793	$491,900
				NW channel widening to Oyster Mitigation	2,143 [2]	2,143										
				NW channel widening to MB Exp. N	2,800 [1]	3,068										
	CW2_BSC_455		25+58 - 221+000	NW channel widening to M7/8/9	600 [1]	850	$24	$0	$1,100	$68,700		BSC & Flare: B6c, PA14, Connection, B29				
				NW channel widening to Sed. Attn. Feature	800 [1]	1,258										
	CW1_Redfish-BSC_700	B6a B20 B29	073+794 - 028+605	NW channel widening to ODMDS	2,474	2,474	$35	$0	$14,900	$91,700	$176,500	RF-BSC: B8a, B8b, Mid Bay PA, B29 *Note: Also uses MB Exp. N & S built from BSC-BCC	$294,600	9,029	9,793	$471,100
				NW channel widening to Oyster Mitigation	2,355 [2]	2,355										
				NW channel widening to M11	2,800 [1]	2,856										
	CW2_BSC_455		25+58 - 221+000	NW channel widening to M7/8/9	600 [1]	850	$24	$0	$1,100	$68,700		BSC: B6a, B6c, PA14, Connection, B29 *Note: Also uses M11 built from Redfish to BSC				
				NW channel widening to Sed. Attn. Feature	800 [1]	1,258										
1C	CW1_BSC-BCC_700	B6c	-3.94 - 28+605	NW channel widening to Atkinson Marsh Cell M11	2,800 [1]	2,800	$45	$4,300	$11,200	$103,000	$118,500	BSC-BCC: B6a, B6c, PA15, B29	$115,700	4,200	5,341	$234,200

		B6a		NW channel widening to Atkinson Marsh Cell M7/8/9	600 [1]	1,000										
		B10		NW channel widening to Sed. Attn. Feature	800 [1]	1,541										
	CW1_BSC-BCC_700	B18c	-3.94 - 28+605	NW channel widening to Bird Island Marsh	4,270 [1]	5,341	$45	$4,300	$9,500	$111,200	$125,000	BSC to BCC: O&M to PA15 & ODMDS	$119,600	4,270	5,341	$244,600
	CW1_BSC-BCC_700	B1	-3.94 - 28+605	NW channel widening to Upland Concept 1	4,500 [1]	5,341	$45	$4,300	$22,900	$105,100	$132,300	BSC to BCC: B6c, PA15 B29 *Note: Also uses M7/8/9 built from BSC	$119,000	4,500	5,341	$251,300
	CW1_BSC-BCC_700	B8a B8b	-3.94 - 28+605	NW channel widening to MB Exp. N	2,800 [1]	2,800	$45	$4,300	$34,400	$110,500	$149,200	BSC to BCC: B6a, B6c, PA15, B29 *Note: Also uses M7/8/9 built from BSC & M11 built from Redfish to BSC	$115,700	5,600	5,341	$264,900
				NW channel widening to MB Exp. S	2,800 [1]	2,541										
3	CW3_BCC_455 BETB3_BCCFlare	B6b	08+78 - 67+11	NW channel/flare widening to Atkinson Marsh Cell M12	2,300 [1]	2,825	$47	$0	$1,200	$107,400	$108,600	BCC & Flare: Spilman, BABUS, B6b, B29	$96,900	2,300	2,825	$205,500
	CW3_BCC_455 BETB3_BCCFlare	BB7	08+78 - 67+11	NW channel/flare widening to Spilman Island PA	2,400 [1]	2,825	$47	$0	$1,200	$94,000	$95,200	BCC: O&M to Spilman, ODMDS, & BABUS	$106,800	2,400	2,825	$202,000
	CW3_BCC_455 BETB3_BCCFlare	BB15	08+78 - 67+11	NW channel/flare widening to Alexander Marsh	2,400 [1]	2,825	$47	$0	$1,200	$109,800	$111,000	BCC: O&M to Spilman, ODMDS, & BABUS	$106,800	2,400	2,825	$217,800
4	CW4_BB-GB CD4_Whole	BB1	684+03 - 850+00	NW widening/deepening to even lift on BW8	2,920	3,272	$14,200	$9,300	$6,400	$85,600	$115,500	BB-GB: Lost Lake, BABUS	$129,800	3,272	3,272	$245,300
		BB2	850+00 - 930+00	NW deepening to even lift on E2 Clinton	352							GB-SB: Rosa Allen, Rosa Allen Exp., East Clinton				
5	CD5_Whole	BB9a	1110+78 - 1160+62	NW deepening to even lift on Glendale PA.	176	176	$24	$0	$0	$6,500	$6,500	Sims to 610: West Clinton, BABUS	$4,500	176	176	$11,000
6	CD6_Whole TB6_Brady_900	BB9a	1160+62 - 1266+49	NW deepening to even lift on Glendale PA.	734	734	$191	$0	$0	$38,600	$38,800	610 to Main TB:West Clinton, House Tract, BABUS	$27,200	1,001	1,001	$66,000
		BB9b	00+00 - 30+95	NW deepening to even lift on Filterbed PA	267	267										

TABLE LEGEND
BE=Bend Easing
CW=Channel Widening
CD=Channel Deepening
TB=Turning Basin

NW=New Work
BR-RF=Bolivar Roads to Redfish
RF-BSC=Redfish to Bayport Ship Channel
BSC-BCC=BSC to Barbours Cut Channel
BABUS=Bay Aquatic BU Site

B18a=Long Bird Island
B18b=8-Ac Bird Island
B18c=Bird Island Marsh
B20=Oyster mitigation sites
B6a=Atkinson Marsh Cell M7/8/9

B6c=Atkinson Marsh Cell M11
B10=Sedimentation Attenuation Feature
B6b=Atkinson Marsh Cell M12
BB1=BW8 site
BB2=E2 Clinton Site

BB9a=Glendale PA
BB9b=Filterbed PA
B29 is used in DMMP Appendix for Existing ODMDS
B7=Bolivar New Marsh

Note 1) All material is dredged and costs are accounted for in the estimate. Final PA sizes to be determined through additional geotechnical and engineering evaluations in PED
Note 2) Oyster mitigation varies by PA/BU type

5.10 Identification of Recommended Plan for NED and LPP

In the comparison of the plans by cost and planning evaluation criteria alternative options were screened out to develop the RP for the NED and LPP alternatives. The RP for both the NED and LPP plans is shown in Table 5-6 and Table 5-7 below. The costs are still based on screening level estimates discussed in Section 5.9. Option 1 for each Segment and applicable reach(s) was chosen.

Table 5-6: Least Cost Dredge Material Management Plan for the HSC ECIP NED Plan

Segment and Features		PA/BU Site	Stations	NW Plan Description	NW Req. (KCY)	NW Avail. (KCY)	01 ($K's)	02 ($K's)	06 ($K's)	12 ($K's)	First Cost ($K's)	O&M Plan Description	50-YR Total Incremental Cost ($K's)	SUMMARY		
														Total NW Req. (KCY)	Total NW Avail. (KCY)	Total Cost ($K's)
1A	BE1_138+369_700 BE1_128+731_700 BE1_078+844_700 CW1_BR-Redfish_700	B18a B18b B29	138+369 - 100+00	NW channel widening to Long Bird Island	1,172 [1]	1,994	$48	$0	$20,200	$74,200	$94,400	BR-RF: B29	$19,400	5,120	5,032	$113,800
				NW channel widening to 8-AC Bird Island	910 [1]											
			100+000 - 073+934	NW channel widening to ODMDS	3,038	3,038										
1B/C, 2	BE1_028+605_530	B18c B29	031+171 - 028+605	NW bend easing to Bird Island Marsh	4,500 [1]	260	$23	$23	$3,900	$10,700	$122,400	RF-BSC: B18c, Mid Bay PA, B29	$264,300	4,500	4,458	$386,700
			028+605 - 026+028			165						BSC-BCC: PA15, B29				
	CW2_BSC_455		25+58 - 221+00	NW channel widening to Bird Island Marsh		2,108	$24	$0	$0	$68,900		BSC: PA14, Connection, B29				
	BE2_BSCFlare		203+66 - 239+00	NW flare widening to Bird Island Marsh		1,925	$24	$0	$1,900	$36,900		BSC Flare: PA14, Connection, B29				
3	CW3_BCC_455 BETB3_BCCFlare	B6b	08+78 - 67+11	NW channel/flare widening to Atkinson Marsh Cell M12	2,300 [1]	2,825	$47	$0	$1,200	$107,400	$108,600	BCC & Flare: Spilman, BABUS, B6b, B29	$96,900	2,300	2,825	$205,500
4	CW4_BB-GB CD4_Whole	BB1	684+03 - 850+00	NW widening/deepening to even lift on BW8	2,920	3,272	$14,200	$9,300	$6,400	$85,600	$115,500	BB-GB: Lost Lake, BABUS	$129,800	3,272	3,272	$245,300
		BB2	850+00 - 930+00	NW deepening to even lift on E2 Clinton	352							GB-SB: Rosa Allen, Rosa Allen Exp., East Clinton				
5	CD5_Whole	BB9a	1110+78 - 1160+62	NW deepening to even lift on Glendale PA.	176	176	$24	$0	$0	$6,500	$6,500	Sims to 610: West Clinton, BABUS	$4,500	176	176	$11,000
6	CD6_Whole TB6_Brady_900	BB9a	1160+62 - 1266+49	NW deepening to even lift on Glendale PA.	734	734	$191	$0	$0	$38,600	$38,800	610 to Main TB:West Clinton, House Tract, BABUS	$27,200	1,001	1,001	$66,000
		BB9b	00+00 - 30+95	NW deepening to even lift on Filterbed PA	267	267										

Table 5-7: Least Cost Dredge Material Management Plan for the HSC ECIP LPP Plan (Recommended Plan)

Segment and Features		PA/BU Site	Stations	NW Plan Description	NW Req. (KCY)	NW Avail. (KCY)	02 ($K's)	03 ($K's)	06 ($K's)	12 ($K's)	First Cost ($K's)	O&M Plan Description	50-YR Total Incremental Cost ($K's)	SUMMARY		
														Total NW Req. (KCY)	Total NW Avail. (KCY)	Total Cost ($K's)
1A	BE1_138+369_700 BE1_128+731_700 BE1_078+844_700 CW1_BR-Redfish_700	B18a B18b B29	138+369 - 100+00	NW channel widening to Long Bird Island	1,172 [1]	1,994	$48	$0	$20,200	$74,200	$94,400	BR-RF: B29	$19,400	5,120	5,032	$113,800
				NW channel widening to 8-AC Bird Island	910 [1]											
			100+000 - 073+934	NW channel widening to ODMDS	3,038	3,038										
1B, 2	CW1_Redfish-BSC_700	B18c B20 B29	073+794 - 028+605	NW channel widening to ODMDS	2,474	2,474	$35	$0	$14,300	$108,600	$172,800	RF-BSC: B18c, B29, Mid Bay PA	$291,100	9,004	9,793	$463,900
				NW channel widening to Oyster Mitigation	2,030 [2]	2,030										
				NW channel widening to Bird Island Marsh	4,500 [1]	3,181										
	CW2_BSC_455		25+58 - 221+000	NW channel widening to Bird Island Marsh		2,108	$24	$0	$0	$49,800		BSC & Flare: B6a, B6c, PA14, Connection, B29				
1C	CW1_BSC-BCC_700	B6c	-3.94 - 28+605	NW channel widening to Atkinson Marsh Cell M11	2,800 [1]	2,800	$45	$4,300	$11,200	$103,000	$118,500	BSC-BCC: B6a, B6c, PA15, B29	$115,700	4,200	5,341	$234,200
		B6a		NW channel widening to Atkinson Marsh Cell M7/8/9	600 [1]	1,000										
		B10		NW channel widening to Sed. Attn. Feature	800 [1]	1,541										
3	CW3_BCC_455 BETB3_BCCFlare	B6b	08+78 - 67+11	NW channel/flare widening to Atkinson Marsh Cell M12	2,300 [1]	2,825	$47	$0	$1,200	$107,400	$108,600	BCC & Flare: Spilman, BABUS, B6b, B29	$96,900	2,300	2,825	$205,500
4	CW4_BB-GB CD4_Whole	BB1	684+03 - 850+00	NW widening/deepening to even lift on BW8	2,920	3,272	$14,200	$9,300	$6,400	$85,600	$115,500	BB-GB: Lost Lake, BABUS	$129,800	3,272	3,272	$245,300
		BB2	850+00 - 930+00	NW deepening to even lift on E2 Clinton	352							GB-SB: Rosa Allen, Rosa Allen Exp., East Clinton				
5	CD5_Whole	BB9a	1110+78 - 1160+62	NW deepening to even lift on Glendale PA.	176	176	$24	$0	$0	$6,500	$6,500	Sims to 610: West Clinton, BABUS	$4,500	176	176	$11,000
6	CD6_Whole TB6_Brady_900	BB9a	1160+62 - 1266+49	NW deepening to even lift on Glendale PA.	734	734	$191	$0	$0	$38,600	$38,800	610 to Main TB:West Clinton, House Tract, BABUS	$27,200	1,001	1,001	$66,000
		BB9b	00+00 - 30+95	NW deepening to even lift on Filterbed PA	267	267										

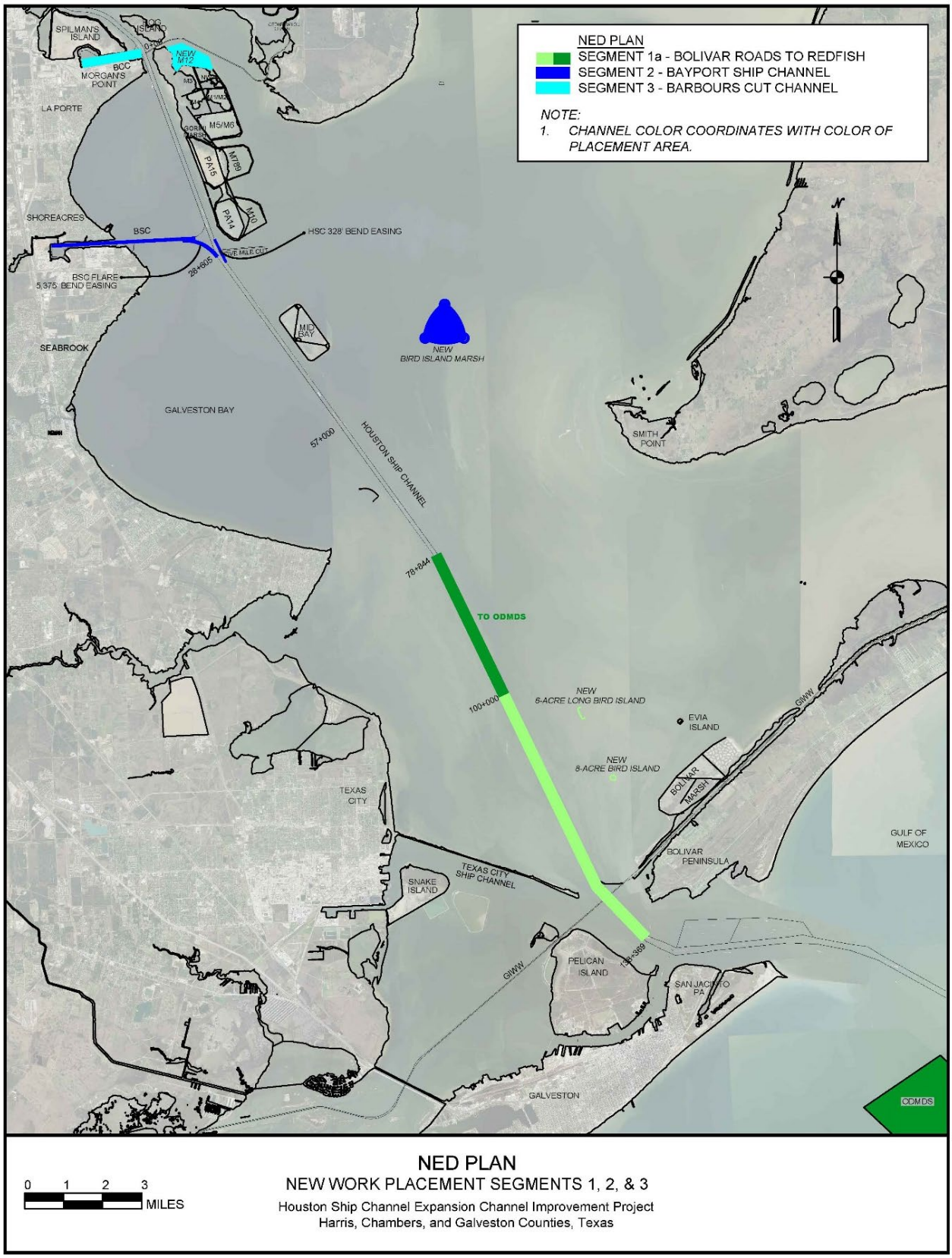


Figure 5-14: NED Plan New Work Proposed Placement Segment 1, 2, & 3

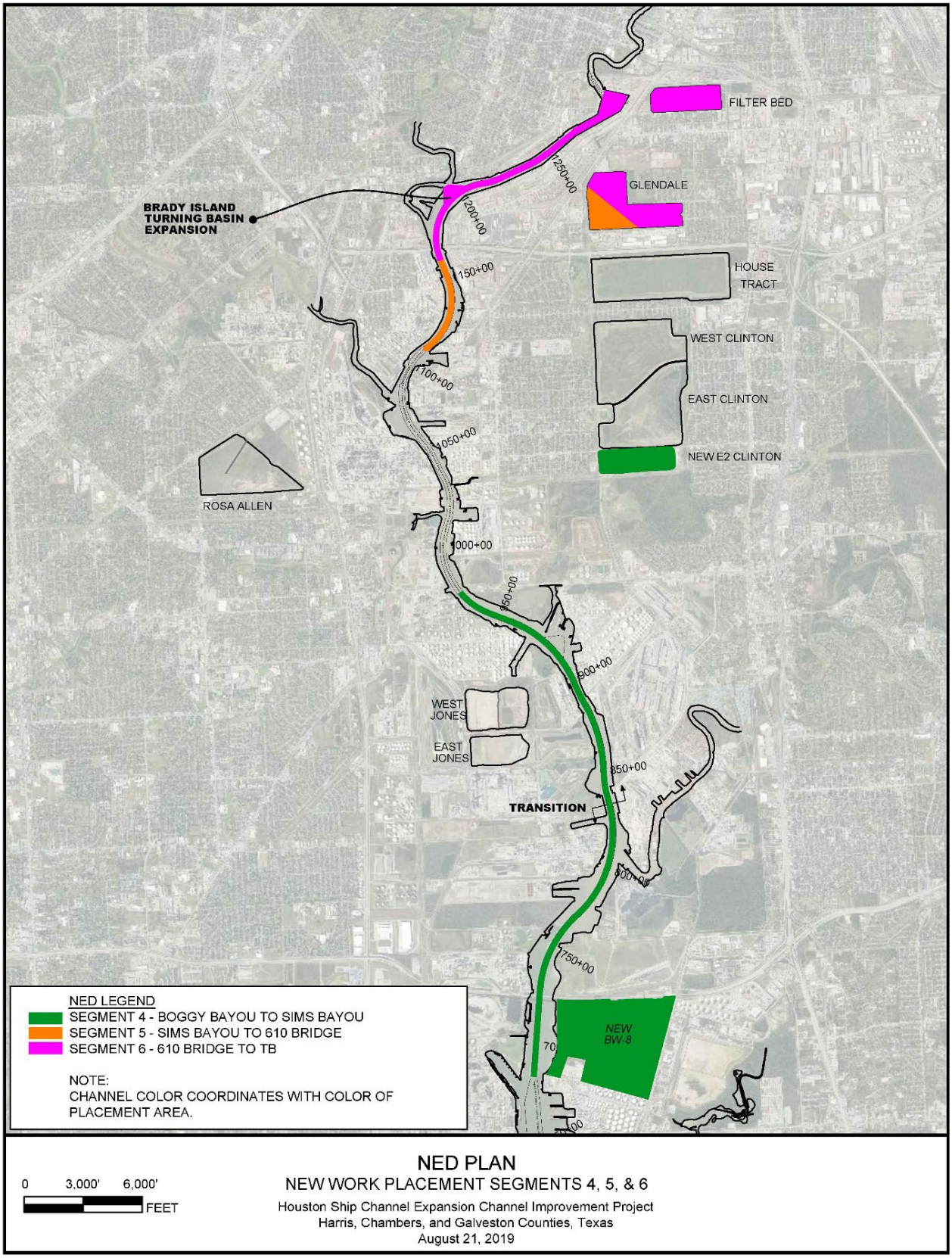


Figure 5-15: NED New Work Proposed Placement Segments 4, 5, & 6

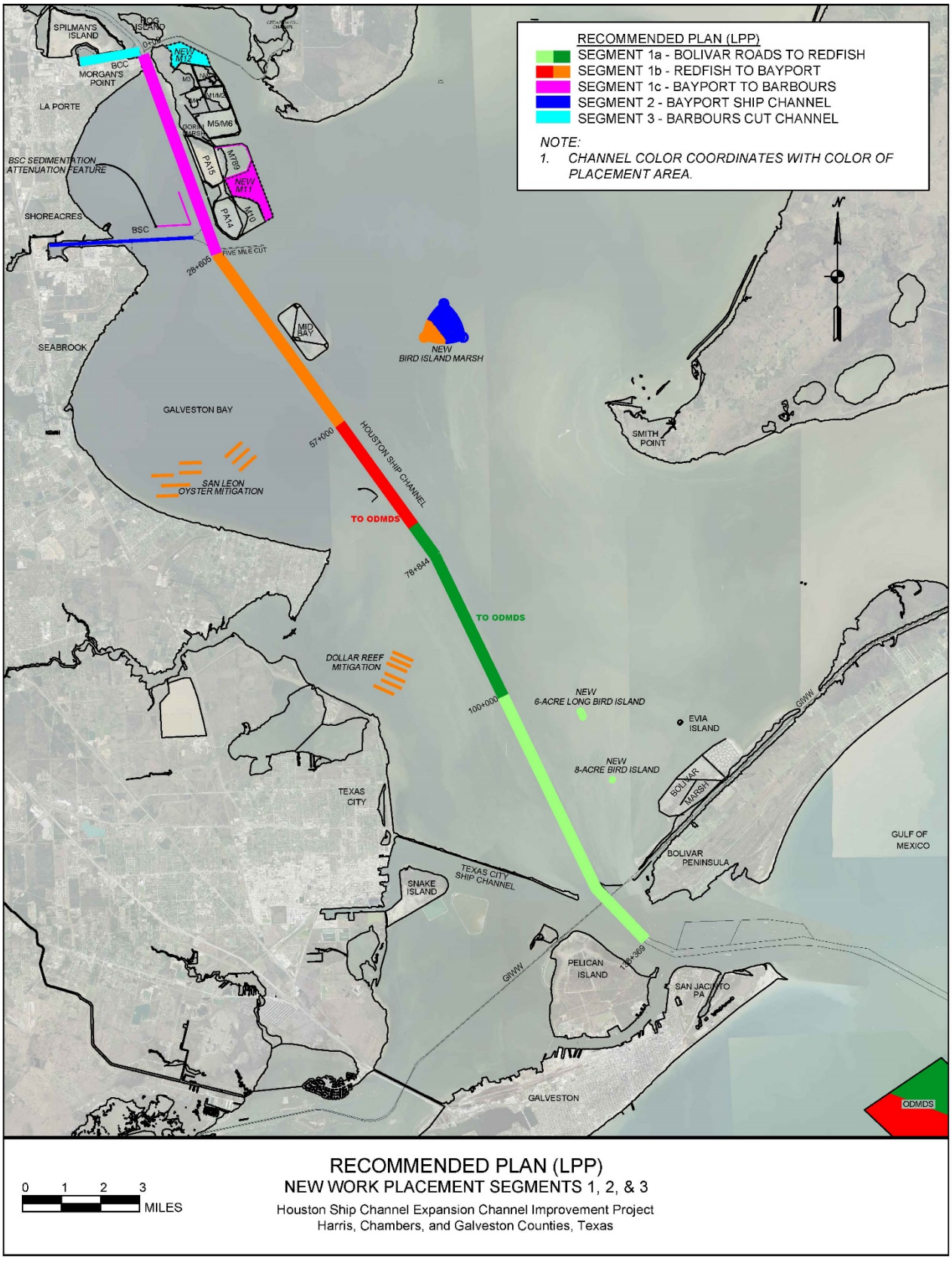


Figure 5-16: Recommended Plan (LPP) New Work Proposed Placement Segements 1, 2 & 3

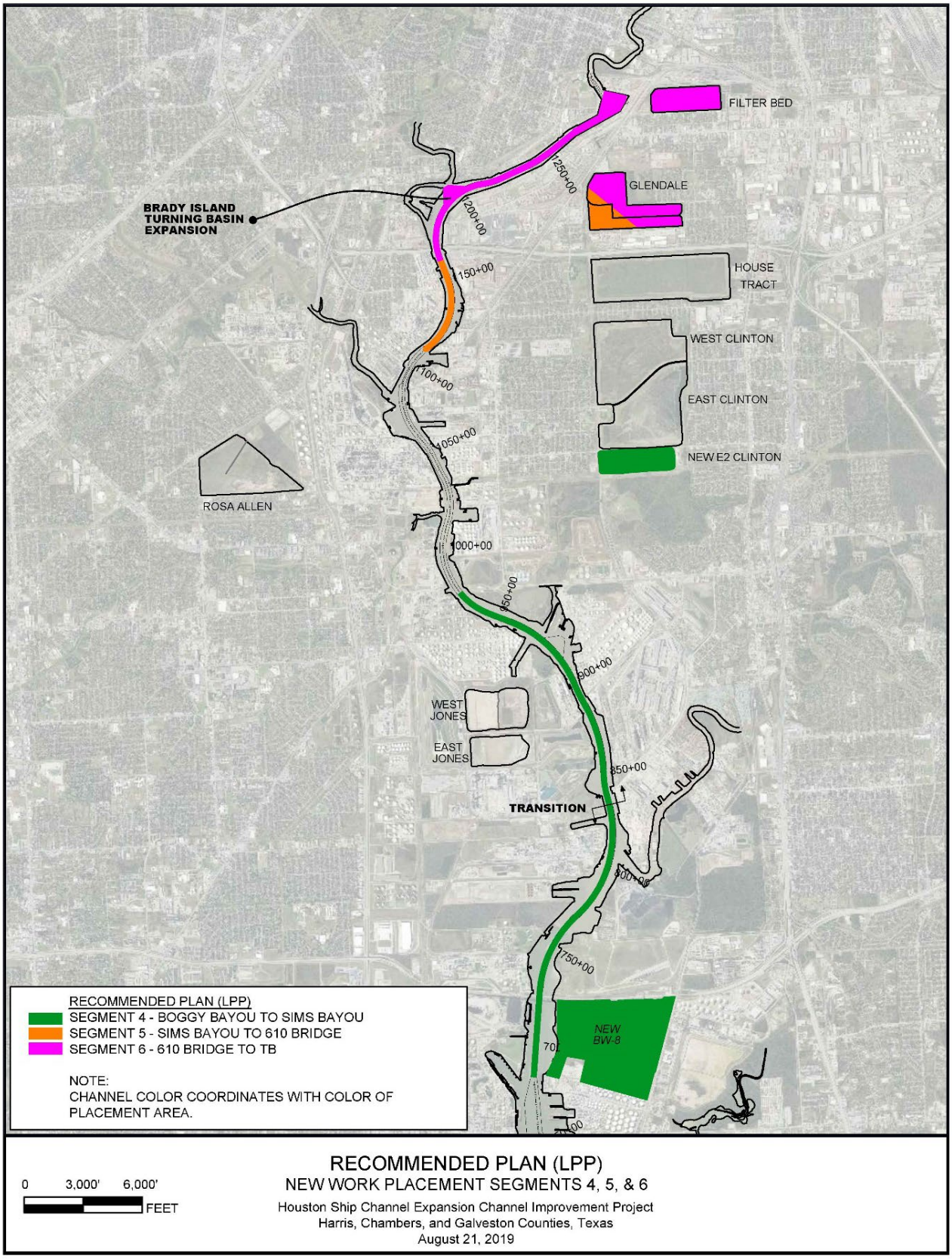


Figure 5-17: Recommended Plan (LPP) New Work Placement Segments 4, 5 &6

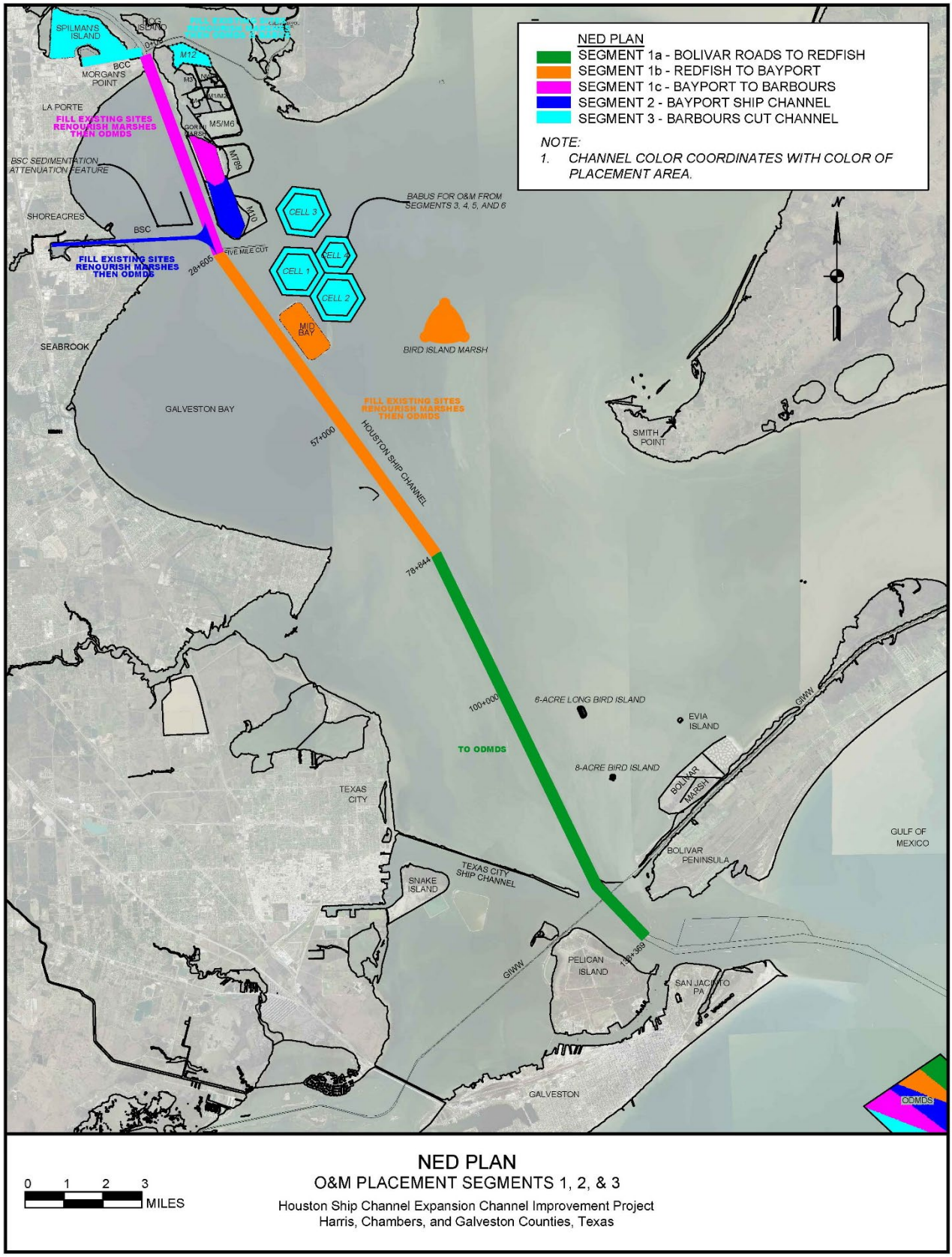


Figure 5-18: NED Plan O&M Placement Segments 1, 2 & 3

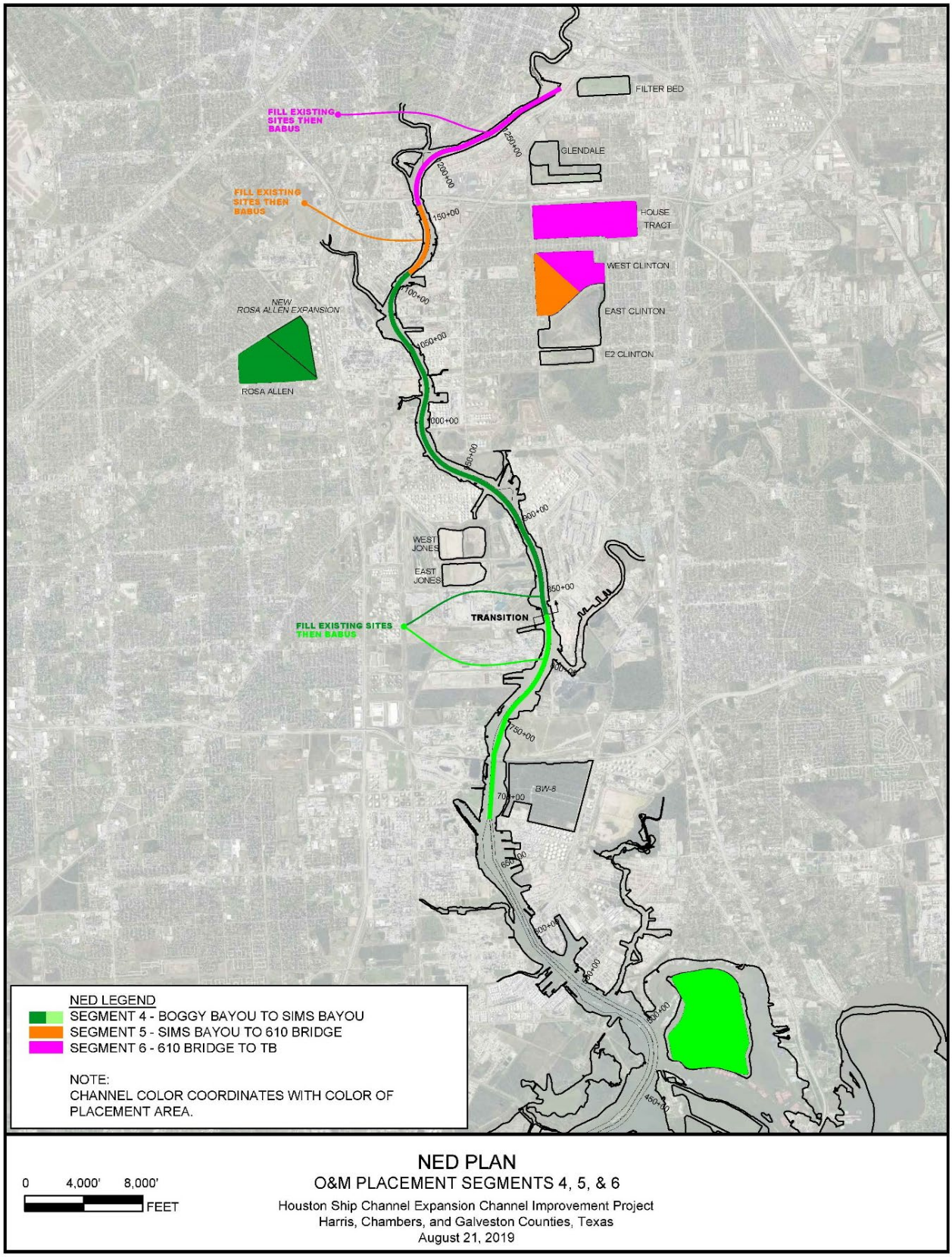


Figure 5-19: NED Plan O&M Placement Segments 4, 5 & 6

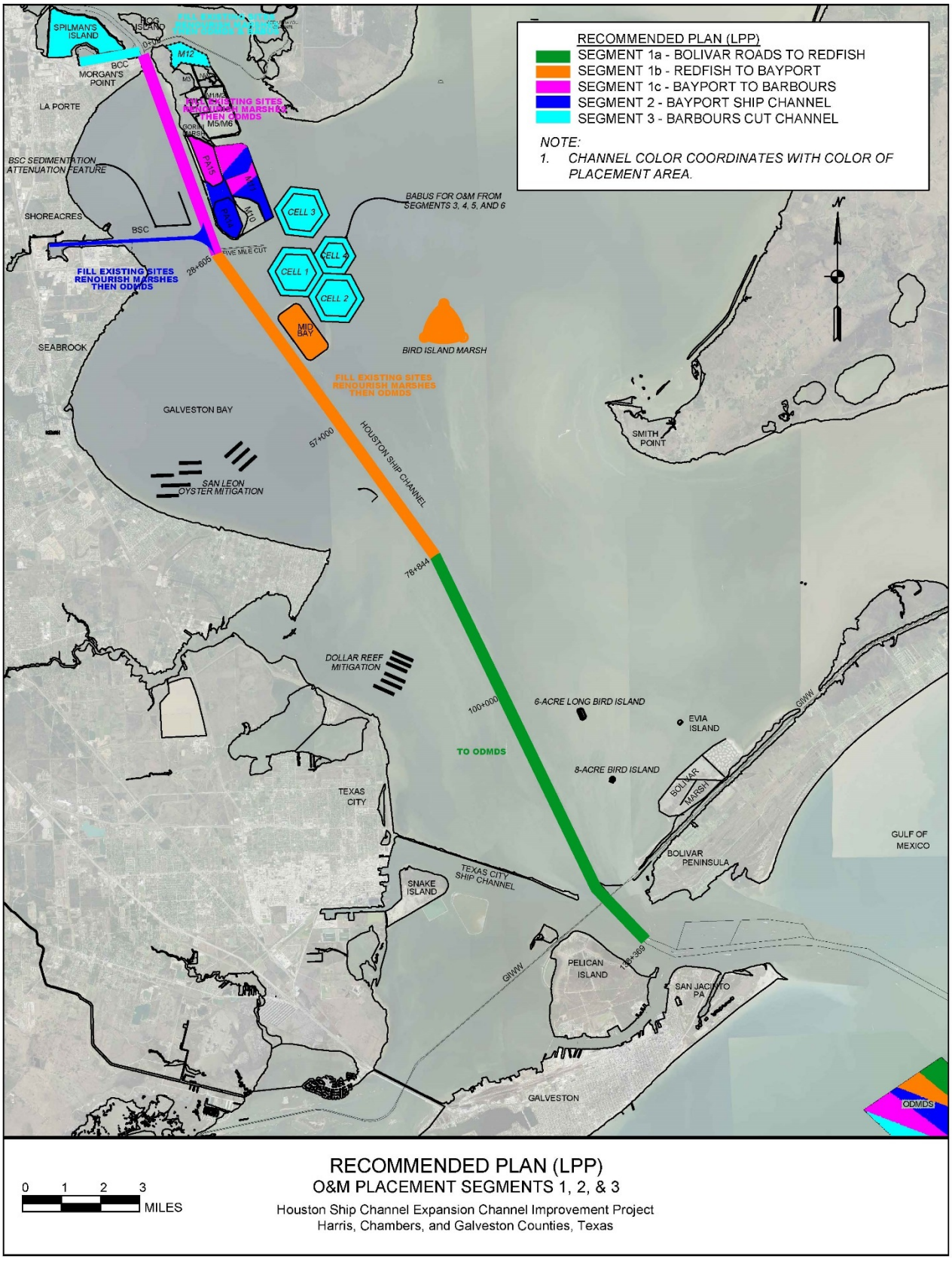


Figure 5-20: Recommended Plan (LPP) O&M Placement Segments 1, 2 & 3

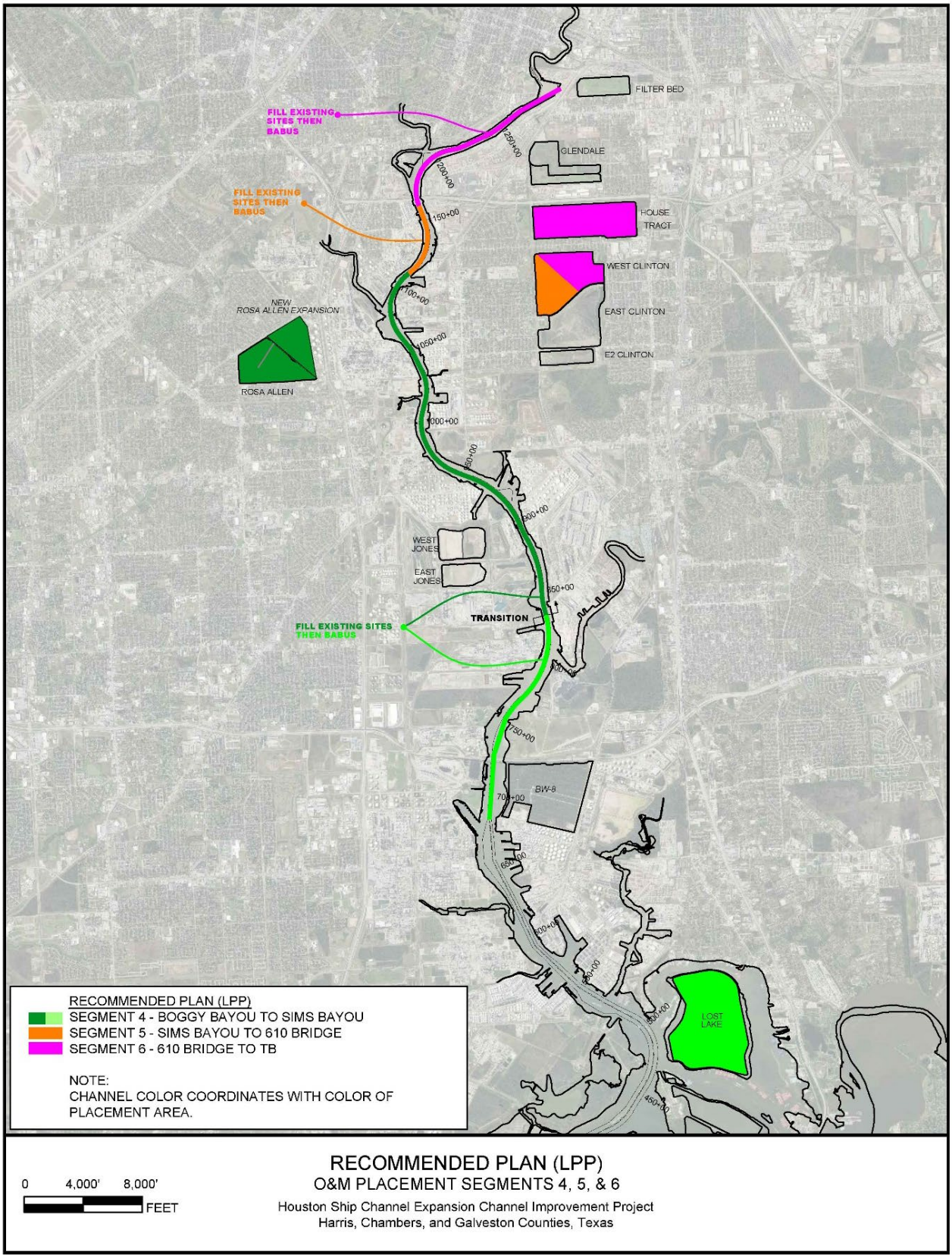


Figure 5-21:Recommended Plan (LPP) O&M Placement Segments 4, 5 & 6

6 The Recommended Plan

The RP is the LPP combined with the FWOP DMMP components for areas of the HSC System that are not being improved/modified. The comprehensive DMMP to include the channel improvements and the FWOP condition unimproved areas is discussed in Section 7.

6.1 Detailed Cost Estimate (MCACES)

The MCACES estimate for the construction of the channel improvements is provided in Appendix C, Attachment A. A summary of total costs is provided in Table 6-1, below.

Table 6-1: Total Cost Summary MCACES

Segment	1s Cost	50-Year O&M Increment
1	$423,929,000	$401,198,000
2	$84,953,000	$80,228,000
3	$151,592,000	$119,025,000
4	$146,846,000	$180,611,000
5	$6,477,000	$5,219,000
6	$49,191,000	$29,704,000
Total	$862,988,000	$815,985,000

6.2 Risk and Uncertainty

6.2.1 Abbreviated Risk Analysis

An abbreviated Risk Analysis was conducted for screening purposes in November 2018. The resulting contingencies are shown in Table 6-2 below.

Table 6-2: Abbreviated Risk Analysis

Project Contingencies (From 12/18/18 Abbreviated Risk Analysis)			
Code	**Description**	**Item**	**% Cntg.**
01	Lands & Damages	Real Estate	25%
06	Fish & Wildlife Facilities	Oyster Reef On Top of new work Material	21%
12	Navigation, Ports, & Harbors	Bayou Pipeline Dredging (NW & OM)	24%
		Bay Pipeline Dredging Contracts (NW & OM)	14%
		ODMDS Hopper in Bay O&M	21%
		ODMDS Hopper in Bayou O&M	34%
		CAD Cell Mech Scow O&M	19%
		ODMDS Mech Scow in Bay NW	14%
		CAD Cell Construction	46%

		Beltway 8 PA Construction	48%
		Bay Upland PA Construction (Upland Concept 1, MB Expansion north and south)	27%
		Lynchburg Road PA	58%
		Upland PA's (Clinton, Rosa Allen Exp, Glendale, Filter Bed)	16%
		Bay BU Sites (Bird Island with Marsh)	27%
		E3 Clinton	110%

6.2.2 Cost, Schedule, and Risk Analysis

An abbreviated risk analysis (ARA) was first performed with the cooperation of the PDT in March 2015. Since several of the O&M yearly events will exceed a total project cost of over 40 million dollars, it was necessary to perform a formal Cost and Schedule Risk Analysis (CSRA). An updated abbreviated risk analysis was submitted, as part of a November 2015 ATR report, with a resultant total risk assessment of 22%. That period of time allowed improved project scope definition, investigations, and design. In January 2016 a formal CSRA was performed with the cooperation of the PDT and Cost Engineering Mandatory Center of Expertise for Civil Works with a resultant total risk assessment of 21%.

In June 2019 the project was split between O&M (FWOP) and deepening. A formal Cost Risk Analysis was performed on the remaining scope (FWP) with the cooperation of the PDT and Cost Engineering Mandatory Center of Expertise for Civil Works. The risks were quantified, and a cost risk model developed to determine a contingency at 80% confidence level. The key risk drivers identified through sensitivity analysis suggest a cost contingency of $93.5M at an 80% confidence level.

In October 2019 the CSRA was revisited. The risks were re-quantified, and a cost risk model developed to determine a contingency at 80% confidence level. The key risk drivers identified through sensitivity analysis suggest a cost contingency of $209 M at an 80% confidence level. The CSRA report can be found in Appendix C, Attachment 1.

6.3 Conclusions

Based on the comparisons and the evaluations of the alternatives, the PDT has determined that Alternative C, the LPP, is the RP. It is consistent with environmental and engineering requirements.

Planning Objectives. The RP would comply with each of the planning objectives:

- Place the dredged material in the most cost-effective location consistent with environmental and engineering requirements.
- Optimize BU of dredged materials where feasible.

- Maintain dredged material placement sites in a manner to optimize capacities and comply with sound economic and environmental principles.

Screening Criteria. The RP would be compatible with Constraints, Considerations, and Opportunities identified in the plan formulation process.

Considerations:

- Costs. The RP is economically sound.
- Real Estate Acquisitions. The RP would account for all necessary real estate.
- Public Use Enhancement. The RP would enhance public use through the BU of dredge material for habitat restoration and enhancement.
- Long-Term Facilities Operation and Maintenance Costs. The RP accounts for long term O&M costs.

Opportunities:

- The RP establishes environmentally suitable PA/BU sites for new work dredged material as well as maintenance dredged material;
- Reduces the risk of adverse environmental impacts from a new project, or protect or improve environmentally sensitive areas in the vicinity of the Federal project through BU.
- Provides for placement of material from existing private maintenance dredging and incremental maintenance from the 21 benefiting LSFs.
- Enhances recreation through creation of marsh and estuarine habitat amenable to hunting, fishing, and wildlife viewing.

Planning Criteria. The RP would comply with each of the four P&G planning criteria:

- Acceptability. The RP is anticipated to be workable and viable with respect to acceptance by state and local entities and the public, and compatibility with existing laws, regulations, and public policies. The RP is feasible and achievable in the context of technical, environmental, economic, and social considerations.
- Completeness. The RP would include and account for all necessary financial investments, long-term operation and maintenance costs, or other actions.
- Effectiveness. The RP provides attainment of the planning objectives.
- Efficiency. The RP provides for the continued operation of the HSC. It is technically and environmentally sound and provides both monetary and non-monetary cost effectiveness. It provides for the realization of opportunities and considers constraints and other considerations.

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7 FWP and FWOP O&M DMMP

This section provides a 50-year schedule of activities and annual costs for executing the DMMP for the HSC. This section also discusses initial plans and recommendations for the engineering, design, construction, and management of dredged material placement sites. Descriptions of recommended dredged material PAs include planning-level technical assumptions. Geotechnical considerations and engineering designs of specific sites, configurations, and parameters would be accomplished during follow-up studies in PED.

7.1 New Channel Dimensions

The authorization of the HSC ECIP Study would result in changes to the currently authorized dimensions as highlighted in blue below. The BSC, BCC, Jacintoport and Greens Bayou channels were previously constructed by the NFS and maintenance was assumed by USACE. They would become Federally authorized upon completion and authorization of the HSC ECIP Study and noted below.

Table 7-1: Authorized and Planned Dimensions

Houston Ship Channel Section of Waterway	Channel Dimensions					
	Authorized			Planned		Length (miles)
	Depth (feet)		Width (feet)	Depth (feet)	Width (feet)	
	(-) MLT	(-) MLLW		(-) MLLW		
Segment 1 – HSC-Bay Reach Safety and Efficiency Enhancements						
-Bolivar Roads (Mile 0) to Morgans Point (Mile 26.2)[1]	45	46/46.5	530	46/46.5	700	26.2
-Barge Lanes (adjacent to and on each side from Mile 0 to Mile 26.2)	12	13	125	-	-	26
-Morgans Point (Mile 26.2) to Boggy Bayou (Mile 38.5)	45	46.5	530-600	-	-	12.3
-South Boaters Cut @ Mile 15.3	8	9	300	-	-	1.9
-North Boaters Cut @ Mile 18.7	8	9	100	-	-	2.1
-Five Mile Cut Channel @ Mile 20.9	8	9	125	-	-	1.9
Segment 2 – Bayport Ship Channel						
-Bayport Ship Channel (Mile 21.4 at intersection with HSC)[3]	40	41.5	300	46.5	455	3.8
Turning Basin	40	41.5	300-1,600	46.5	300-1,600	0.3
Segment 3 – Barbours Cut Channel						
-Barbours Cut Channel (Miles 26.3 at intersection with HSC)[3]	40	41.5	300	46.5	455	1.1
Turning Basin	40	41.5	300-1,600	46.5	300-1,600	0.3
Segment 4 –Boggy Bayou to Sims Bayou						
-Boggy Bayou (Mile 38.5) to Greens Bayou (Mile 42.0)	40	41.5	300	46.5	530	3.5
-Jacintoport Channel	40	41.5	200		-	0.7
-Greens Bayou (Mile 42.0) to Sims Bayou (Mile 47.5)[4]	40	41.5	300	46.5	300	5.5
Hunting Bayou Turning Basin	40	41.5	948-1,000[2]	-	-	0.3
Clinton Island Turning Basin	40	41.5	965-1,070[2]	-	-	0.3
-Greens Bayou Channel Mile 0.0 to Mile 0.36	40	41.5	175	-	-	0.4
-Greens Bayou Channel Mile 0.36 to Mile 1.65	15	16.5	100	-	-	1.3

Segment 5 –Sims Bayou to I-610 Bridge						
-Sims Bayou (Mile 47.5) to I-610 Bridge (Mile 48.3)	36	37.5	300	41.5	300	0.8
Segment 6 –I-610 Bridge to Main Turning Basin						
-I-610 Bridge (Mile 48.3) to Houston (Main) Turning Basin (Mile 50.2)	36	37.5	300	41.5	300	1.9
Houston (Main) Turning Basin	36	37.5	400-932	-	-	0.6
Upper Turning Basin	36	37.5	150-527	-	-	0.2
Brady Island Channel	10	11	60	-	-	0.9
Brady Island Turning Basin	36	37.5	900	41.5	900	0.2
Buffalo Bayou Light Draft Channel	10	11	60	-	-	4.1
Turkey Bend Channel	10	11	60	-	-	0.8

[1] Per the MLT to MLLW Datum Conversion, the split occurs at Beacon 76
[2] Includes 300-foot channel width
[3]PHA received approval to deepen channel to 46.5 feet MLLW and subsequent Federal Assumption of Maintenance (AOM) under Section 408/204(f). BSC deepening was completed in Fall of 2016 and BCC was completed in August 2015. Additionally, the BSC was widened from 300 feet to 400 feet from the BSC Flare to the land cut and from 300 feet to 350 feet from the land cut to the BSC Turning Basin.
[4] Greens Bayou to Sims Bayou deepening stops short of Washburn Tunnel at Station 974+007

7.2 HSC Channel Reaches

The channel reaches would remain as described in Section 1.3.

7.3 Shoaling

Table 7-2 below depicts the existing shoaling rates for the HSC System along with the projected incremental increase in shoaling for the six channel segments and their respective reaches over the 50-year period of analysis as highlighted. A description of how the new shoaling rates were derived can be found in Section 5.2.2 of the Engineering Appendix.

7.4 PAs and BU sites

Figure 7-1 shows the locations of all the PA/BU sites. Table 7-3 provides a list of all of the PA/BU sites in the system with their respective acreages. Table 7-4 provides the conceptual 50-year DMMP by reach. Table 7-5 provides the future with project 50-year PA/BU life and estimated quantities placed therein. The life of two PAs are impacted by the FWP DMMP condition; Spilman Island and Lost Lake. The life of Spilman Island would be reduced by three years and be full in 2041 instead of 2044. Lost Lake would have one remaining cycle left. The future use of Lost Lake is limited in both the FWOP and FWP conditions. In either case, the reach from Carpenters to Boggy Bayou and Boggy Bayou to Greens Bayou would have to transition from cutterhead dredging with placement in UCPA to mechanical dredging with placement in BABUS cells in 2029.

Specific information regarding the engineering properties, construction, quantities, and design considerations of the new PA/BU sites is included in Section 4.8 of the Engineering Appendix.

Table 7-2: Existing and Proposed Shoaling Rates

Reach Description	Existing				Proposed				Total Increased Shoaling (KCY)
	Federal Channel Annual Shoaling Rate Total (KCY/YR)	Non-Fed Channel Annual Shoaling Rate Total (KCY/YR)	Total Channel Annual Shoaling Rate (KCY/YR)	Total 50-Year Shoaling (KCY)	Federal Channel Annual Shoaling Rate Total (KCY/YR)	Non-Fed Channel Annual Shoaling Rate Total (KCY/YR)	Total Channel Annual Shoaling Rate (KCY/YR)	Total 50-Year Shoaling (KCY)	
HSC Bolivar Roads to Redfish Reef	99	0	99	4,960	142	0	142	7,120	2,160
HSC Redfish Reef to Bayport	1,469	0	1,469	73,446	2,022	0	2,022	101,081	27,635
HSC Bayport to Morgans Point	771	0	771	38,572	1,025	0	1,025	51,226	12,655
Bayport Ship Channel & Turning Basin	499	24	523	26,132	583	24	607	30,355	4,224
Bayport Ship Channel Flare	788	0	788	39,421	832	0	832	41,591	2,170
Barbours Cut Channel	282	109	391	19,573	494	109	603	30,153	10,580
HSC Morgans Point to Exxon	1,241	47	1,288	64,403	1,241	47	1,288	64,403	0
HSC Exxon to to Carpenters Bayou	455	14	468	23,418	455	14	468	23,418	0
HSC Carpenters Bayou to Boggy Bayou	194	138	332	16,605	194	138	332	16,605	0
HSC Boggy Bayou to Greens Bayou	114	0	114	5,685	208	22	230	11,512	5,826
HSC Greens Bayou to Sims Bayou	216	2	217	10,869	229	8	237	11,856	988
Greens Bayou	53	51	104	5,179	53	51	104	5,179	0
HSC Sims Bayou to Turning Basin	114	43	157	7,863	134	43	177	8,860	997
HSC Main Turning Basin	105	0	105	5,254	116	0	116	5,800	546
HSC Upper Turning Basin	35	0	35	1,761	35	0	35	1,761	0
Light Draft Channel	13	0	13	633	13	0	13	633	0
Turkey Bend Channel	3	0	3	126	3	0	3	126	0
Turkey Bend Cut-off Channel	4	0	4	206	4	0	4	206	0
Totals	**6,454**	**428**	**6,882**	**344,105**	**7,781**	**456**	**8,238**	**411,884**	***67,779***

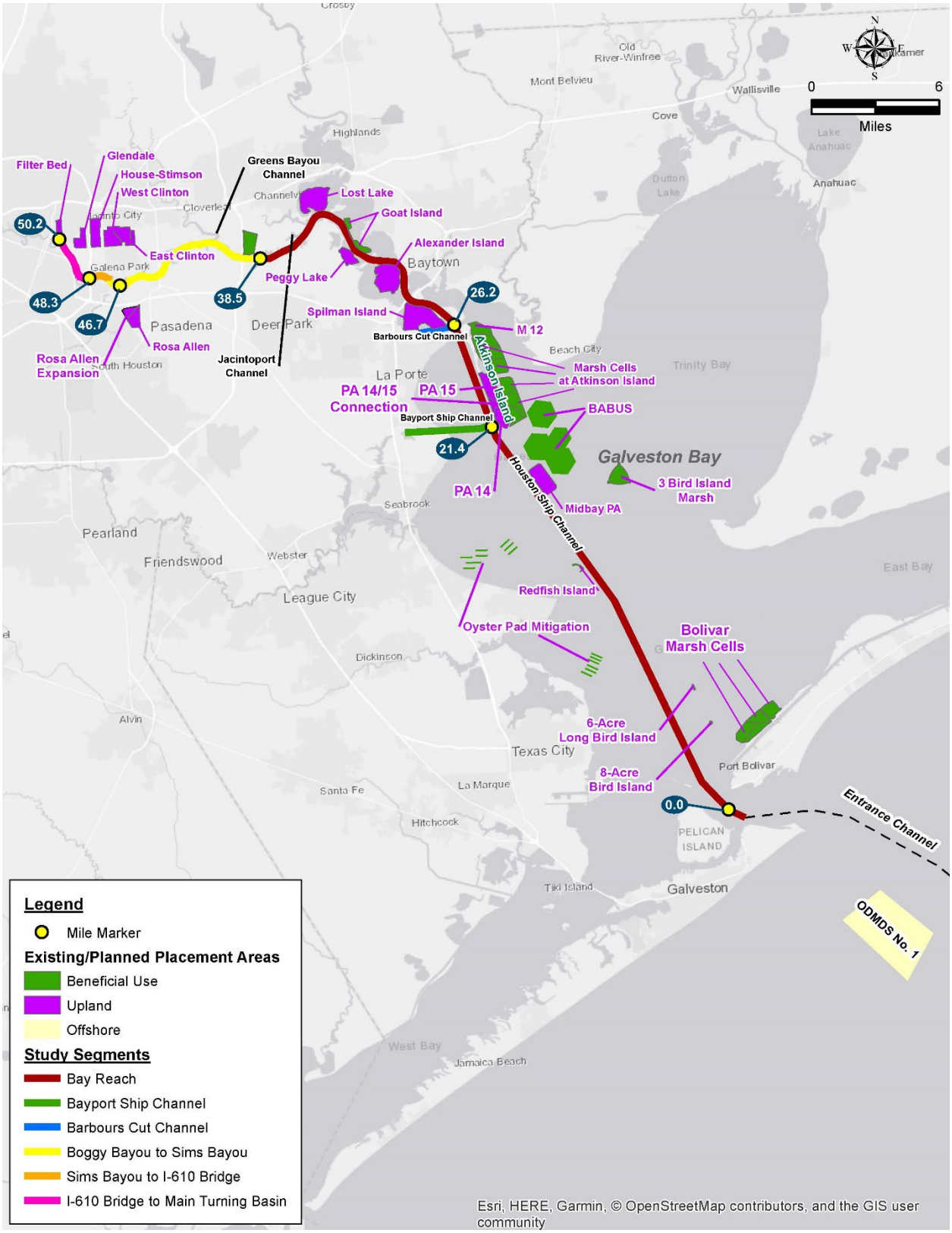

Figure 7-1: Locations of all PA/BU Sites

Table 7-3: PA/BU Sites

PA/BU Name	PA Type[1]	Approximate Size	Associated Study Reach (*beginning at Seaward end)*	Future Use Feasible (Y/N)
ODMDS	OW	6.6 square nautical miles (M^2) (about 5,550 acres)	Bolivar Roads to Redfish Reef, Redfish to BSC, BSC to BCC, BSC, BCC	Y
BABUS	BU		All Reaches	Y
Bolivar Marsh BU	BU	1,078 acres	Bolivar Roads to Redfish Reef	N
Evia Island BU	BU	6 acres	Bolivar Roads to Redfish Reef	N
Long Bird Island	BU	6 acres	Bolivar Roads to Redfish Reef	N
Bird Island	BU	8 acres	Bolivar Roads to Redfish Reef	N
Mid Bay PA	BC	600 acres	Redfish to BSC/BSC	Y
Bird Island Marsh	BU	402 acres	Redfish to BSC/BSC	Y
PA 14	UC	325 acres	Redfish to BSC/BSC/BSC to BCC	Y
PA 15	UC	395 acres	Redfish to BSC/BSC/BSC to BCC	Y
PA 14/15 Connection	UC	160 acres	Redfish to BSC/BSC/BSC to BCC	Y
Atkinson Island BU Marsh Site	BU	1,842 acres	BSC/BSC to BCC	Y
M11	BU	445 acres	BSC/BSC to BCC	Y
M12		273 acres	BCC	Y
PA 16	UC	80 acres	BSC/BSC to BCC	N
Spilman Island PA	UC	890 acres	Morgans Point to Exxon	Y
Alexander Island PA	UC	650 acres	Morgans Point to Exxon	Y
Peggy Lake PA	UC	240 acres	Exxon to Carpenters, Carpenters to Boggy Bayou, Boggy Bayou to Greens Bayou	Y
Goat Island BU	BU	320 acres	Exxon to Carpenters, Carpenters to Boggy Bayou, Boggy Bayou to Greens Bayou	N
Lost Lake PA	UC	600 acres	Exxon to Carpenters, Carpenters to Boggy Bayou, Boggy Bayou to Greens Bayou	Y
BW8	UC	355 acres	Boggy Bayou to Greens Bayou	N
E2 Clinton	UC	70 acres	Boggy Bayou to Greens Bayou	N
Rosa Allen PA	UC	223 acres	Upstream of Greens Bayou	Y
Rosa Allen Expansion PA2	UC	138 acres	Upstream of Greens Bayou	Y
East Clinton PA	UC	290 acres	Upstream of Greens Bayou	Y
West Clinton PA	UC	317 acres	Upstream of Greens Bayou	Y
House Tract PA	UC	312 acres	Upstream of Greens Bayou	Y
Glendale PA	UC	177 acres	Upstream of Greens Bayou	N
Filterbed PA	UC	90 acres	Upstream of Greens Bayou	N

[1] OW-Open Water; UC – Upland Confined; BC – Bay Confined
2 To be constructed in the future

Table 7-4: FWP 50-Year DMMP By Dredging Reach

Reach Description	Placement Area Used	Federal Channel Annual Shoaling Rate KCY	Non-Fed Annual Shoaling Rate KCY	Total Fed & Non-Fed Annual Shoaling Rate KCY	Average Dredging Frequency YR	Total Shoaling Rate per Cycle KCY	No. of Cycles in 50-Yr Analysis Period	Total 50-Yr Shoaling Volume KCY
HSC Bolivar Roads to Redfish Reef	ODMDS	142	0	142	4	570	13	7,120
HSC Redfish Reef to Bayport	Mid Bay/B.I.M./ ODMDS	2,022	0	2,022	3	6,065	17	101,081
HSC Bayport to Morgans Point	PA15/M789/ M11/ODMDS	1,025	0	1,025	3	3,074	17	51,226
Bayport Ship Channel & Turning Basin	PA14/Connection/ ODMDS	583	24	607	2	1,214	25	30,355
Bayport Ship Channel Flare	PA14/Connection/ M789/M11/ODMDS	832	0	832	1	832	50	41,591
Barbours Cut Channel	Spilman/M12/ BABUS/ODMDS	494	109	603	3	1,809	17	30,153
HSC Morgans Point to Exxon	Spilman/Alexander/ BABUS	1,241	47	1,288	3	3,864	17	64,403
HSC Exxon to Carpenters Bayou	Peggy Lake/Lost Lake/BABUS	455	14	468	3	1,405	17	23,418
HSC Carpenters Bayou to Boggy Bayou	Lost Lake/BABUS	194	138	332	4	1,328	13	16,605
HSC Boggy Bayou to Greens Bayou	Lost Lake/BABUS	208	22	230	4	921	13	11,512
HSC Greens Bayou to Sims Bayou	Rosa Allen/Rosa Allen Expansion/BABUS	229	8	237	5	1,186	10	11,856
Greens Bayou	East Clinton/BABUS	53	51	104	6	621	8	5,179
HSC Sims Bayou to Turning Basin	House Tract/West Clinton/BABUS	134	43	177	6	1,063	9	8,860
HSC Main Turning Basin	House Tract/BABUS	116	0	116	3	348	17	5,800
HSC Upper Turning Basin	BABUS	35	0	35	3	106	17	1,761
Light Draft Channel	BABUS	13	0	13	6	76	8	633
Turkey Bend Channel	BABUS	3	0	3	6	15	8	126
Turkey Bend Cut-off Channel	BABUS	4	0	4	6	25	8	206
TOTALS		**7,781**	**456**	**8,238**	**-**	**-**	**-**	**411,884**

Table 7-5: FWP 50-Year by Placement Area

Placement Area	Study Segment	Dredging Reach	New Work Material (KCY)	Total 50-Year OM Dredging Volume (KCY)	Available Capacity in PA (KCY)	PA Life YR	Year Full	Alternate Placement Location after End of PA Life	Volume Placed in Alt Location (KCY)
ODMDS	1	HSC Bolivar Roads to Redfish Reef	3,038	7,120	NEL	50	NA	NA	0
Long Bird Island	1	HSC Bolivar Roads to Redfish Reef	1,172		0	0	NA	NA	0
8-AC Bird Island	1	HSC Bolivar Roads to Redfish Reef	910		0	0	NA	NA	0
Mid Bay	1	HSC Redfish Reef to Bayport	0	45,922	11,406	7	2032	ODMDS	34,516
ODMDS	1	HSC Redfish Reef to Bayport	2,474		NEL	50	NA	NA	0
Oyster Mitigation	1	HSC Redfish Reef to Bayport	2,030		0	0	NA	NA	0
B.I.M.	1,2	Bayport Ship Channel	2,108		0	0	NA	NA	0
		HSC Redfish Reef to Bayport	3,181	55,158	13,700	4	2038	ODMDS	41,458
PA14	2	Bayport Ship Channel	0	26,296	9,031	17	2045	ODMDS	17,265
PA14/15 Conn.	2	Bayport Ship Channel	0	29,292	10,060	19	2047	ODMDS	19,232
PA15	1	HSC Bayport to Morgans Point	0	34,302	11,386	19	2047	ODMDS	22,916
M7/8/9	1,2	Bayport Ship Channel	0	2,527	868	4	2032	ODMDS	3,406
		HSC Bayport to Morgans Point	1,000	2,615	868	4	2032	ODMDS	
M11	1,2	Bayport Ship Channel	0	13,831	4,750	18	2046	ODMDS	18,641
		HSC Bayport to Morgans Point	2,800	14,310	4,750	18	2046	ODMDS	
Shoaling Attenuation Feature	1	HSC Bayport to Morgans Point	1,541		0	0	NA	NA	
M12	3	Barbours Cut Channel	2,825	15,466	6,000	16	2044	ODMDS/ BABUS	9,466
Spilman Is.	1,3	Barbours Cut Channel	0	14,687	5,698	13	2041	BABUS	21,285
		HSC Morgans Point to Exxon	0	20,842	8,546	16	2044	BABUS	
Alexander Is.	1	HSC Morgans Point to Exxon	0	43,561	17,862	22	2050	BABUS	25,699
Peggy Lake	1	HSC Exxon to Carpenters Bayou	0	23,418	6,296	26	2054	BABUS	17,122
Lost Lake	1,4	HSC Carpenters Bayou to Boggy Bayou	0	16,605	4,607	6	2034	BABUS	21,892
		Boggy Bayou to Greens Bayou	0	11,512	1,619	1	2029	BABUS	
BW8	4	Boggy Bayou to Greens Bayou	2,920		0	0	NA	NA	0
E2 Clinton	4	HSC Greens Bayou to Sims Bayou	352		0	0	NA	NA	0
Rosa Allen	4	HSC Greens Bayou to Sims Bayou	0	2,462	2,934	6	2034	NA	0
Rosa Allen Exp	4	HSC Greens Bayou to Sims Bayou	0	9,395	11,198	46	2074	NA	0
East Clinton	4, 6	HSC Greens Bayou to Sims Bayou & Greens Bayou, HSC Upper Turning Basin, Light Draft Channel, Turkey Bend Channel, Turkey Bend Cut-off Channel	0	7,905	6,290	50	2050	BABUS	1,615
West Clinton	5,6	HSC Sims Bayou to Turning Basin	0	8,137	5,651	25	2053	BABUS	2,486
House Tract	5,6	HSC Sims Bayou to Turning Basin	0	6,523	4,530	37	2065	BABUS	1,993
Glendale	5,6	HSC Sims Bayou to Turning Basin	910	NA	NA	NA	NA	NA	0
Filterbed	5,6	HSC Sims Bayou to Turning Basin	267	NA	NA	NA	NA	NA	0
		FWP Totals:	**27,528**	**411,884**	**148,049**	**-**	**-**	**-**	**258,992**

7.5 Alternate PAs and Impact on FWOP DMMP

As can be seen from Table 7-6, the FWP condition would create an additional 77,182,000 CY of maintenance materials to be removed during the 50-year study period. The FWP condition would additionally however create 34,734,000 CY of new capacity. Therefore, the remaining 42,447,000 CY of increased maintenance materials will need to be placed into alternate non-PA sites ODMDS or BABUS.

The quantity from the FWOP condition that would go to ODMDS would be 140,647,000 CY and the quantity that would go to BABUS would be 97,543,000 CY. Under the FWP condition, the quantities to non-PA sites are offset in that incremental materials from BCC Flare would be taken to ODMDS, rather than to a BABUS like in the FWOP. Incremental materials from the BCC and docks would continue to go to BABUS in the FWP like in the FWOP. This ultimately results in a small net decrease of materials that would require placement into a BABUS under the FWP condition. Essentially, impacts to the FWOP BABUS requirement in the FWP are negligible, while increases in the materials going to ODMDS are roughly 50% of total increased O&M requirement. These quantities are summarized in Table 7-6 below.

Table 7-6: Alternate PA Use and Impact on FWOP DMMP

DESC.	FWOP (KCY)	FWP (KCY)	DIFF (KCY)
Total 50-Yr O&M, CY	344,105	411,884	67,779
PA Capacity, CY	105,915	140,649	34,734
Qty. to Non-PA, CY	238,190	273,511	35,321
-To ODMDS	140,647	184,040	43,392
-To BABUS	97,543	89,472	-8,072
Total CY to Alternate PAs	238,190	273,511	35,321

7.6 Dredging

Table 7-7 below indicates the transition from historic dredging practice on the HSC and tributaries to new practices of hopper or mechanical dredging.

Table 7-7: Dredging Method

Reach	Dredge Type:	Transitions To:	In Cycle Year:
HSC Bolivar Roads to Redfish	Hopper	NA	NA
HSC Redfish to BSC	30” Cutter Suction	Hopper to ODMDS	2038
BSC to BCC	30” Cutter Suction	Hopper to ODMDS	2044/2050
BSC	30” Cutter Suction	Hopper to ODMDS	2048
BCC	30” Cutter Suction	Hopper to ODMDS (Flare)	2047
		Clamshell to BABUS (Channel)	2050
HSC Morgans to Exxon	30” Cutter Suction	Clamshell to BABUS (Channel)	2041
HSC Exxon to Carpenters	30” Cutter Suction	Clamshell to BABUS (Channel)	2050
HSC Carpenters to Boggy Bayou	30” Cutter Suction	Clamshell to BABUS (Channel)	2029
HSC Boggy to Greens	24” Cutter Suction	Clamshell to BABUS	2033
HSC Greens to Sims	24” Cutter Suction	NA	NA
Greens Bayou	24” Cutter Suction	Clamshell to BABUS (Channel)	2034
Jacinto Port	24” Cutter Suction	Clamshell to BABUS (Channel)	2034
HSC Sims to Turning Basin	24” Cutter Suction	Clamshell to BABUS	2059
HSC Main Turning Basin	24” Cutter Suction	Clamshell to BABUS	2068
Brady Island	24” Cutter Suction	Clamshell to BABUS (Channel)	2053
Buffalo Bayou Light Draft Channel	24” Cutter Suction	Clamshell to BABUS (Channel)	2053
Turkey Bend Channel	24” Cutter Suction	Clamshell to BABUS (Channel)	2053

7.7 Advanced Maintenance

O&M costs over the 50-year period are the most significant costs to the project. Incremental measure O&M costs equate to approximately 50% of the total study costs (construction costs plus incremental O&M costs). For two key areas, advance maintenance dredging was considered at the construction phase, to lower O&M costs over the 50-year period. These areas are the BCC Flare and BSC Flare. The BSC Flare has a high shoaling rate, requiring yearly maintenance cycles. It is typically dredged on a bi-yearly basis with the greater BSC (channel to turning basin), and then again on off years, either as a standalone contract or as part of or an option to adjacent HSC maintenance dredging. The BCC is typically dredged every three years and generally on the same cycle timing as the HSC Morgan’s to Exxon reach. However, due to high shoaling volumes at BCC, the cycle period currently implemented can at times be limiting to the available draft of the channel as this flare shoals heavily. Due to these factors, advance maintenance dredging at each flare was considered.

The shoaling rates were held constant per square foot of area within the flare toes. These rates were then applied to the increased footprint area for the modified toes to determine the new shoaling rate. Advance maintenance applies to increasing the channel depth in order to decrease the number cycles required over the 50-year analysis period, by allowing for dredging more material per cycle. The current channels are maintained at -46.5 feet MLLW with 2 feet of advance maintenance. Therefore, increments of additional advance maintenance are what is considered

here. For the purpose of this exercise, the actual dredging cost was held constant as dredging a smaller quantity over an increased frequency is directly proportional to dredging a larger quantity over a decreased frequency (at an assumed constant dredging unit cost in 2018 dollars). The cost savings from advance maintenance are therefore limited to a decreased number of mobilization costs due to the increase in time between cycles. This savings is offset by the increased first cost to dredge the additional new work materials. The difference is the cost savings.

The added new work cost was derived from the screening estimates for the least cost alternatives. For the BSC Flare advance maintenance, this was in the option of the new Bird Island Marsh from measures CW1_Redfish-BSC and CW2_BSC_455 (i.e. widening of HSC Redfish to BSC and widening of BSC channel to turning basin). The advance maintenance dredging of the flare would be assumed to occur in concert with these measures' dredging. The average unit cost for this new work dredging, inclusive of all dredging, placement, site work, and applicable contingencies, is $18.68/CY.

For the BCC Flare advance maintenance, the new work dredging cost was taken from the screened option to construct the new Atkinson Marsh Cell M12. The advance maintenance dredging would be assumed to be performed at the same time as that for measures CW3_BCC_455 and BETB3_BCCFlare_1800 (i.e. widening of BCC channel and expanding the flare to create a large turning basin). The full unit cost for this inclusive of all screening cost components is $18.60/CY.

The O&M portion of the analysis was performed by first dividing the cycle CY by the area within the toes. This gave a depth of cut (assumed homogenous across the limits) under the existing condition of channel depth plus advance maintenance per cycle. In one-foot increments, the increased shoaling cycle quantity and years between cycles was determined proportionally. With the new cycle years, a reduced total of 50-year O&M mobilization costs was determined. For the mobilization costs, since the flare portions are typically dredged in concert with adjacent channel reaches, one half of the full spread mobilization costs used in the screening estimates, $1.2M, was used. (It should be noted that if the full mobilization cost of $2.4M was used under the assumption that the flares would be dredged independently, then the provided cost savings from mobilization would be considerably more.)

For the base case scenario, the proposed channel dredging of -46.5 feet MLLW plus 2 feet of advance maintenance is provided in Table 7-8.

Table 7-8: Advanced Maintence BSC and BCC Shoaling Rates

Channel Flare	Existing Shoaling CY/YR	Increment Shoaling CY/YR	Total Shoaling CY/YR	Existing Adv. Maint. (AM), FT	Vert. Ft Per Cyc. FT/Cyc.	Years Per Cycle YR/Cyc.	Qty. Per Cyc. CY/Cyc.	No. of Cycles EA	50-Yr Mob. $
BSC	788,415	43,399	831,814	2	5	1	831,814	50	$ 60,000,000
BCC	168,992	189,720	358,712	2	11	3	1,076,136	17	$ 20,400,000

The BSC Flare and BCC Flare incremental advance maintenance cost savings are provided in Table 7-9 and Table 7-10.

Table 7-9: BSC Advanced Maintence Cost Reduction

AM	Grade	NW Qty. CY	NW Cost $	Years Per Cyc. YR/Cyc.	Vert. Ft Per Cyc. FT/Cyc.	O&M Qty. Per Cyc. CY/Cyc.	50-Yr Mob. $	50-Yr Savings $	Cost Adj. From Adv. Maint., $
0	-46.5	(See screening measure)		1.0	4	649,576	$ 60,000,000	$ -	$ -
1	-47.5								
2	-48.5								
3	-49.5	65,269	$ 1,218,931	1.2	6	993,119	$ 50,300,000	$ 9,700,000	$ 8,500,000
4	-50.5	154,654	$ 2,888,244	1.4	7	1,154,424	$ 43,200,000	$ 16,800,000	$ 13,900,000
5	-51.5	261,428	$ 4,882,302	1.6	8	1,315,729	$ 37,900,000	$ 22,100,000	$ 17,200,000
6	-52.5	375,491	$ 7,012,492	1.8	9	1,477,033	$ 33,800,000	$ 26,200,000	$ 19,200,000
7	-53.5	493,078	$ 9,208,495	2.0	10	1,638,338	$ 30,500,000	$ 29,500000	$ 20,300,000

Table 7-10: BCC Advanced Maintence Cost Reduction

AM	Grade	Cmmu. NW Qty. CY	Cmmu. NW Cost $	Years Per Cyc. YR/Cyc.	Vert. Ft Per Cyc. FT/Cyc.	O&M Qty. Per Cyc. CY/Cyc.	50-Yr Mob. $	50-Yr Savings $	Cost Adj. From Adv. Maint., $
0	-46.5	(See screening measure)		3.0	11	1,076,136	$ 20,400,000	$ -	$ -
1	-47.5								
2	-48.5								
3	-49.5	32,620	$ 606,832	3.3	12	1,170,789	$ 18,400,000	$ 2,000,000	$ 1,400,000
4	-50.5	67,264	$1,251,327	3.5	13	1,265,441	$ 17,000,000	$ 3,400,000	$ 2,100,000
5	-51.5	113,859	$ 2,118,135	3.8	14	1,360,094	$ 15,800,000	$ 4,600,000	$ 2,500,000
6	-52.5	182,700	$ 3,398,798	4.1	15	1,454,746	$ 14,800,000	$ 5,600,000	$ 2,200,000
7	-53.5	268,053	$ 4,986,638	4.3	16	1,549,399	$ 13,900,000	$ 6,500,000	$ 1,500,000

As can be seen, advance maintenance dredging offers a cost savings to both locations. The cost savings is most pronounced at the BSC Flare due to the high frequency of dredging. The cycle can conceivably be reduced from 1 year per cycle to 2 years per cycle. At the BCC Flare, the cost savings is less as the cycle can only be reduced from the current 3 years per cycle to approximately 4 years per cycle. These cost savings represent a tabletop level analysis using geometric constants in terms of shoaling rates per foot of area. They are for consideration purposes only to be further

evaluated in PED. The current FWP RP does not include these cost savings but rather holds the existing dredging frequencies and dredging depths used in the FWOP for the 50-year O&M.

Additionally, a shoaling attenuation feature is currently part of the RP that will be evaluated and modeled further in PED. A combination of both the shoaling attenuation feature and some advanced maintenance of the BSC Flare may be required and will be adjusted upon completion of the analysis.

7.8 General Engineering

Table 7-4 and Table 7-5 were prepared using 50-year gross dredging quantities and do not take into account UCPA capacity gains from active site management and fill consolidation. The actual UCPA capacities would increase by implementing site management. Additional UCPA capacity is necessary to provide needed freeboard and to allow ponding during the dredging process. As generally described in the following subsections and outlined in the Engineering Appendix, a thorough topographic and/or hydrographic survey, subsurface geotechnical investigations, and site-specific engineering would be part of the implementation process conducted during PED. Geotechnical surveys, including soil borings, would provide an accurate characterization of the foundation materials. Incorporation of that information into final designs would enable adjustments to be made in the estimated site capacities.

For the preparation of the DMMP, historical geotechnical data were evaluated and used to determine the consolidation factors of the dredged material in both upland and open water settings. The estimated cut-to-fill ratio of managed materials within a UCPA is 0.6. The estimated cut-to-fill ratio of managed materials placed at BU sites is 0.65. The cut-to-fill ratio would be used as a tool along with site-specific foundation consolidation factors during preparation of final designs of the placement areas.

Slope stability calculations for dike raising at existing PAs were based on data gathered during previous investigations and during the HSCPA and are included as Attachment 7 to the Engineering Appendix. The initial analysis indicated that the configurations proposed for construction and raising of dikes is feasible from a geotechnical perspective. The conceptual dike designs for the proposed beneficial use sites are based on the designs of BU dikes previously constructed in on the HSC and are discussed in Section 4.8 of the Engineering Appendix.

The height, width, and slopes of the dikes at each of the PAs and BUs would be decided on a site-by-site basis with updated geotechnical data collected during implementation of this plan.

7.9 UCPA Management

The principle features of this program are:

- Directing the quantity and location of placement for each site
- Maximizing the drainage of each site
- Installing and maintaining spillboxes, weirs, and dewatering structures

- Crust management
- Managing non-pay excess dredging quantities

7.9.1 Directing the Placement of Material

Heavier clays and sands deposit at or near the discharge location, while the finer silts, clays, and muds deposit farther away from the discharge location at the rear of the site. Proper UCPA management would involve dredge pipe discharge locations that vary for each dredging event in an effort to prevent stacking on one side of the UCPA (short-circuiting) and to fill low areas of ponds to promote proper drainage. Depending on the volume and characteristics of the material to be placed, the discharge pipe should be relocated one or more times during the dredging event. Because relocating the discharge pipe can increase costs, careful consideration would be given to relocations. Flexibility should be considered in dredging and water quality permits to allow for discharges from more than one weir location.

7.9.2 Maximizing Drainage of Each Site

The level of boards in the spillway determines the water level in the PA after dredging is complete. During and immediately after the dredging cycle, the boards would be kept at the lowest possible level that meets water quality requirements. After decanting, the boards would be removed to the lowest level that would prevent sediment from flowing through the spillway. This would facilitate drainage of the site and reduce ponding due to precipitation. The boards would be monitored at regular intervals to ensure that they are lowered to account for the settlement and consolidation of dredged material. An additional factor in maximizing the drainage of UCPAs in the Bay is the alteration of cutterhead placement of materials in the UCPA with hopper dredging and placement of materials in the ODMDS.

7.9.3 Crust Management

Crust management also known as DAMP is a method for increasing available site capacity by improving surface drainage and thereby maximizing the desiccation, shrinkage, and consolidation of dredged material within the site. This is accomplished by constructing an extensive network of shallow ditches that lowers the water table within the UCPA. Crust management should be conducted after every dredged material placement event to ensure and prolong the life of the upland PAs.

Water control and surface ditching promote evaporative drying of fine-grained dredged materials. Under appropriate conditions, the drying and desiccation of fine-grained materials gives two important results:

- It reduces the occupied volume in the placement site to as much as one-half or less of the volume of cut in the channel. It creates dried material in the site suitable for constructing dikes, thus eliminating the need for transporting material for dike construction.
- Both results lower costs by maximizing the life of placement sites, reducing the need for additional real estate, and reducing the cost of periodic dike raising.

A crust management program promotes the shrinkage of dredged material by providing drainage for precipitation and water released by excess pore water pressure. Shrinkage of the contained material would be achieved by:

- Constructing a Perimeter Ditch. The first step is to create a ditch along the inside of the dikes. This would be done after the water has completely drained from the interior and a skin has formed on the surface with evidence of desiccation cracking (usually three to six months after the dredging event). The perimeter ditch would be placed a sufficient distance inside the dikes not to create foundation and borrow area problems that may affect future dike raising. Construction would generally involve excavating the ditch by casting excavated material onto the inside of the dike where it would dry and consolidate to become available for dike raising.
- Constructing Interior Ditches. The expense of using a dragline for trenching the interior of most UCPAs is cost prohibitive. A low-ground-pressure vehicle equipped with a plow or rotary ditcher is generally the most practical means for ditch construction. The ditcher creates a small trench of sufficient width and depth to provide drainage and promote formation of desiccation cracks, which expose more surface area to evaporative drying. The procedure to be used would be for the ditcher to begin work at a weir or some point of the perimeter trench and proceed along the alignment of the drainage pattern. The drainage pattern is governed by spillbox and weir location, topography, and management budget.

Once evaporation and shrinkage have reached the point where the material has dried to the bottom of the trenches, the dragline and ditcher would repeat the above procedure and deepen the trenches created in the first pass. This procedure is repeated until the thickness being managed has dried entirely and formed crust.

At the end of the drying season, a survey would be performed to document the shrinkage and settlement. Surveys and calculations of the levee and interior site conditions would be performed to determine the need and amount, if any, of dike raising that may be required for future dredging operations. The resulting volume computations would generate cost and performance indices used to design and manage future crust management activities and levee raisings and provide information that may be useful for managing other UCPAs.

7.9.4 Installing and Maintaining Spillboxes, Weirs, and Dewatering Structures

Spillboxes, weirs, and other dewatering structures would be placed strategically within each UCPA in a manner that provides the most efficient dewatering and consolidation. In some instances, it may be necessary to relocate or add spillway, weir boxes, and/or other dewatering structures. This would be determined on a site-by-site basis during the engineering and design phase of implementation.

Prior to placing materials into the UCPA, spillways would be inspected for structural integrity, corrosion, quantity of spillway boards available, and sediment buildup. Small sumps or depressions would be created at the entrances of the spillways to prevent excessive sediment

buildup, which forms barriers and causes ponding. This process would increase UCPA capacity by allowing the site to drain, dry, and consolidate.

7.9.5 Managing Non-pay Excess Dredging Quantities

For estimating quantities for a dredging project, an allowance for 10 percent non-pay overdepth dredging is typically used. In order to properly design the UCPAs and plan for required capacities, the amount of dredged material must be managed. Incentives or disincentives to limit a contractor's non-pay overdepth dredging would be included as part of the management plan. Among the guidelines for planning, engineering and design, and maintenance of projects are the following:

- Contracts should contain appropriate incentives and disincentives to limit over-depth-dredging while assuring that the design profile is achieved. This is normally achieved by defining an allowable or paid over-depth and not providing payment beyond this depth and/or width. Environmental compliance documents and permits also provide an upper limit on the dredging and placement quantities and dredging beyond these quantity limits are subject to environmental compliance enforcement.
- Reference to the dredging process contained in environmental documentation should be included in project specifications.
- The pre-construction conference should address the dredging process, and the expectations and limitations contained in the environmental documentation.

7.10 Construction and Maintenance of Dikes for UCPAs

Dike construction and maintenance should be planned and carried out with sufficient lead time to allow newly constructed dikes to reach their maximum strength before dredged material is introduced into the UCPA.

Crowns of the dikes would be used for the transport of equipment; therefore, the crown would be kept smooth and sufficiently wide to allow for safe passage. Interior and exterior equipment access ramps to the crowns of the dikes would also be maintained. Because of the anticipated use of the dikes for transporting equipment, special consideration must be given to the design and construction of dike foundations, which must provide adequate support.

Site-specific engineering and geotechnical analyses would be necessary to confirm and or revise the dike sections on a site-by-site basis prior to construction.

Vegetation control at the UCPAs is an important maintenance activity. Dikes must be kept free of woody-stemmed vegetation with large root structures that may affect dike structural integrity. Maintenance activities may include tree and stump removal, brush removal, weed control, and clearing and grubbing. Dikes would be planted with low-lying herbaceous vegetation to reduce erosion.

7.10.1 Erosion Control

Rock or riprap are be placed along the channel edges of the dikes along the HSC. As wave energy increases through the passage of larger vessels and the increased intensity of storms, the shore protection on the existing sites should be examined and improved in areas of erosion. Although rock and/or riprap shore protection and bulkheading was evaluated as part of this DMMP, other cost-effective methods of shore protection may be considered during follow-up site-specific engineering and geotechnical evaluations, as well as possible value engineering studies during implementation.

Grasses or other low-lying, herbaceous, drought-resistant vegetation should be planted along the levee crowns and upper slopes to reduce erosion and subsequent channel shoaling. In low lying areas along water bodies outside of the high energy environment directly adjacent to the ship channel, marsh grasses, such as smooth cordgrass, should be planted to reduce erosion and wave energy.

7.11 Construction

The schedule and sequence for construction of various UCPAs, UCPA dike raises, DAMP, BU sites and their respective filling, and site expansions are shown in Table 7-11.

Table 7-11: Construction Schedule for UCPAs and BU

Placement Area	Construction Year	First Use	Last Use	DAMP	Dike Raise
Mid Bay	NA-Existing	2029	2035	2031, 2037	2029, 2034
Bird Island Marsh	2024	2032	2032	NA	NA
PA14	NA-Existing	2029	2045	2031, 2035, 2039, 2043	2032, 2036, 2040
PA14/15 Conn.	2029	2031	2047	2032, 2034, 2036, 2038, 2040, 2042, 2044, 2046, 2048	2033, 2037, 2041, 2045
PA15	NA-Existing	2029	2047	2031, 2037, 2043, 2049	2029, 2038, 2044
M7/8/9	2026	2030	2032	NA	NA
M11	2026	2030	2046	NA	NA
M12	2025	2032	2044	NA	NA
Spilman Is.	NA-Existing	2029	2041	2038	NA
Lost Lake	NA-Existing	2029	2029	2031	NA
Rosa Allen	NA-Existing	2029	2034	2031	2033
Rosa Allen Exp	2037	2039	2074	2041, 2046, 2051, 2056 2061, 2066, 2071, 2077	2042, 2047, 2052, 2057 2062, 2067, 2072
West Clinton	NA-Existing	2029	2053	2038, 2050	2044
House Tract	NA-Existing	2029	2065	2039, 2057	2052
Glendale*	NA-Existing	2027	2027	NA	NA
Filterbed*	NA-Existing	2027	2027	NA	NA
*NW placement only, during construction of project Segments 5 & 6					

7.12 Beneficial Use

Design considerations were provided by the BUG for the BU sites; Long Bird Island, 8-acre Bird Island, Bird Island Marsh, M11, M12, and BABUS are detailed in Section 4.8 of the Engineering Appendix. General considerations include the following.

- Target Elevations: The target elevations of placed and consolidated fill at each BU site would be determined through geotechnical analyses. These analyses would consider long-term settlement of the dredged materials and PA foundations, as well as elevation surveys of the nearby planned wetland or bird island habitat to determine the appropriate target range and consider RSLC. These elevation targets would be coordinated with resource agencies prior to construction. For marsh creation, it is anticipated that the final result of the dredged material placement would be a combination of wetlands and shallow open water habitat within the placement site. Dredged material slurry would be allowed to overflow over existing emergent marsh vegetation within the proposed PAs where applicable such as the existing Atkinson Marsh cells but would not be allowed to exceed a height of about one foot above the existing marsh elevation.
- Vegetation: The establishment of vegetation on marsh areas would provide stability and reduce erosion. The vegetation of marsh areas would rely on natural recruitment and the spreading of seeds once the dredge materials have decanted and subsided. However, marsh vegetation, such as smooth cordgrass, may be planted by other agencies and organizations as desired

- Dike Degradation: The dikes around BU sites and cells would be designed to slowly deteriorate and subside in areas of desired circulation to the level of the adjacent marsh substrate, thereby promoting the tidal exchange of water. Earthen dikes may require mechanical degradation to the settled elevations of the PA if natural erosive processes do not degrade them sufficiently to meet fish and tidal access needs. Such breaches would be undertaken after consolidation of the dredged sediments and vegetation has become established on the exposed soil surface.
- Flotation Access Corridors: Channels would be excavated as needed in shallow open water areas to allow construction equipment to access sites. If necessary, flotation access channels would be excavated by a mechanical dredge to maximum dimensions of approximately 80 feet wide and 10 feet deep. Flotation access channel material would be used in dike/closure construction or refurbishment, to backfill flotation access channels, or be placed adjacent to and behind the dikes and closures in shallow open water to an elevation conducive to wetlands development following consolidation of the material. Flotation access channel material used to backfill the flotation access channels following completion of placement work would be temporarily stockpiled on water bottoms adjacent to the flotation access channels.
- Dike Degradation or Refurbishment: Dikes surrounding BU sites may be degraded as necessary to provide access into the PA. If dikes are degraded for construction access, they may be rebuilt following completion of placement activities. Degraded dike material would be placed/stockpiled either in shallow open water adjacent to the degraded levee sections or on adjacent levees. Material degraded from dikes may be used to rebuild degraded dikes sections. If borrow material is required to rebuild degraded dike sections, borrow material would be excavated from adjacent shallow water. If dikes are not to be rebuilt using material removed during dike degradation activities, any dike material that was placed in shallow open water would be degraded, if necessary, to a height conducive to wetlands development.
- Staging Areas: The construction or designation of staging areas may be necessary for construction equipment and for the unloading of pipeline and other equipment necessary to perform placement operations. Staging areas would be a maximum of about 300 feet by 300 feet in area. If necessary, materials such as gravel, sand, dirt, shell, or some combination of materials would be permanently placed over existing upland, wetland, and shallow open water habitat to construct staging areas.
- Board Roads: Temporary board roads may be constructed along access corridor alignments and staging areas wherever emergent marsh exists. Board roads would be removed when work is completed. Fill material may be deposited where the board road would be located to offset damage to the underlying marsh caused by soil compression. Board road fill material may be degraded to adjacent marsh elevations following completion of placement activities either by placing excess material into nearby shallow open water to elevations conducive to wetlands development, by placing material on existing uplands/dikes, or by removing material from the project vicinity.

- Shore Protection: Consideration of varying types of shore protection should be made and include; riprap, long sloping containment, various natural vegetation, wave trips that may serve as secondary oyster habitat, oyster castles, and natural living shorelines.

Minimal site-specific data exist for the majority of the proposed BU sites. An interactive approach would be taken with resource agencies, as necessary, to verify the type of beneficial use at each site.

A collaborative, adaptive management strategy that involves engineers, scientists, and resource agencies would be employed throughout the life of the DMMP to improve design, construction, and post-construction procedures to promote circulation, establish vegetation, and manage beneficial use sites. The intent of adaptive management for this project is to account for uncertainties and allow decision-making and implementation to proceed while acknowledging that some structural or operational changes may be necessary (EC 1105-2-409 [31 May 2005; expired 30 September 2007]. Although this project is not an ecosystem restoration project, it would comply with the adaptive management guidance of ER 1105-2-100, paragraph 3-5b(8), which states:

"For complex specifically authorized projects that have high levels of risk and uncertainty of obtaining the proposed outputs, adaptive management may be recommended."

As dredged material placement sites are constructed and completed, the adaptive management process would be used to adjust and improve the DMMP and the placement of dredged material. During construction of the beneficial use sites the agencies would be advisors but final decision-making will rest with the USACE and the local sponsor.

7.13 Non-Federal Dredged Material Placement

As shown in Section 3.4, the 21 identified LSFs that would provide benefits of the channel modifications would generate an approximate 1,772,000 CY of new work materials and 10,994,000 CY of incremental shoaling. This is in addition to the approximate 50 MCY of new work materials estimated in the FWOP Condition over the 50-year period of analysis. As noted in Section 2, the current HSC system cannot sustain the placement of the new work materials in either the FWOP or FWP condition and effectively be able to maintain the Federal channel. Alternatives for new work include: the private facilities listed in Section 2.10; additional BU opportunities that could be explored with the resource agencies; ODMDS placement; and additional BABUS cells. The HSC system can, however, potentially handle the existing and incremental identified maintenance of the LSFs in either the FWOP or FWP case. Facilities not identified in this DMMP will not be eligible for maintenance material placement in existing PA facilities, they may however be eligible for placement in BABUS cells in the future on a case by case basis.

Per Galveston Districts Counsel review of ER 1105-2-100 Appendix E-15 (f)(1)(a), O&M funded studies for DMMPs may not study items outside the current authorization as noted in Section 2.10. Additionally, SMART Planning principles and ER 1105-2-100 Appendix E-15 (f)(1)(a), preclude

the study of issues in the FWOP condition outside of the scope of the study such as existing LSF improvements happening regardless of the channel improvements. Therefore, study of additional improvements to be made to plan, engineer, construct and maintain additional capacity outside of the Federal requirements would have to be funded by a third party. The potential for this to occur is through a contributed funds agreement such as a 401C or 217b. Capacity would have to be paid for and constructed up front prior to use.

While the non-Federal maintenance capacity need was identified and considered in this DMMP, the actual timeframes and dredging needs for permitted non-Federal dredging may not be consistent with the Federal interests at the time the non-Federal dredging placement is requested because they may occur during an active Federal dredging cycle during construction activities or operation and maintenance of a UCPA(s), or there may be limited capacity. Hence, non-Federal entities should consider and plan for alternative placement of dredged materials. The placement of permitted non-Federal dredging will require the approval of and direct coordination with USACE-SWG and the PHA, shall be consistent with all Federal and state laws and regulations, as well as sediment testing requirements. **Requests for the placement of permitted non-Federal dredging shall be evaluated in accordance with the provisions of WRDA 1996 (217b), PGL 47, the Project PPA, and subsequent Laws, Regulations, and Policy at the time requested.**

7.14 Cost

Table 7-12 and Table 7-13 provide the costs for the 50-Year DMMP in the FWOP and FWP Condition respectively for the period of analysis from 2029 to 2078. The FWOP and FWP costs provided in this section are for the O&M period of analysis only and do not include first costs of construction of the channel and the resulting PAs. However, it does include the expansion of the Rosa Allen site in 2038. The cost of the FWOP DMMP over the 50-year period of analysis is $3.7 Billion. The resulting FWP DMMP will require a total of approximately $779 Million more.

7.14.1 FWOP DMMP 50- Year Costs

The total cost of the existing 50-Year FWOP is described in Table 7-12 below.

Table 7-12: FWOP DMMP Costs

TOTAL FWOP DMMP COSTS		
Reach Description	**Placement Area Used**	**TOTAL $**
HSC Bolivar Roads to Redfish Reef	ODMDS	$65,855,111
HSC Redfish Reef to Bayport	Mid Bay/ODMDS	$744,827,021
HSC Bayport to Morgans Point	PA15/ODMDS	$382,330,159
Bayport Ship Channel & Turning Basin	PA14/PA14/15 Connection/ODMDS	$361,079,698
Bayport Ship Channel Flare	PA14/PA14/15 Connection/ODMDS	$310,312,427
Barbours Cut Channel	Spilman/BABUS	$145,852,866
HSC Morgans Point to Exxon	Spilman/Alexander/BABUS	$553,924,020
HSC Exxon to to Carpenters Bayou	Peggy Lake/Lost Lake/BABUS	$245,248,484
HSC Carpenters Bayou to Boggy Bayou	Lost Lake/BABUS	$153,926,502
HSC Boggy Bayou to Greens Bayou	Lost Lake/BABUS	$264,592,931
HSC Greens Bayou to Sims Bayou	Rosa Allen/East Clinton/BABUS	$180,703,878
Greens Bayou	East Clinton/BABUS	$39,984,135.00
HSC Sims Bayou to Turning Basin	House Tract/West Clinton/BABUS	$122,106,046
HSC Main Turning Basin	House Tract/BABUS	$106,168,863
HSC Upper Turning Basin	House Tract/BABUS	$51,277,993.0
Light Draft Channel	House Tract/BABUS	$23,349,444.00
Turkey Bend Channel	House Tract/BABUS	$14,101,962.00
Turkey Bend Cut-off Channel	House Tract/BABUS	$15,455,043.00
TOTALS		**$3,781,096,583**
Costs shown include Existing Federa & Federal Increment. Non-Federal costs not shown.		
Cost total of just study segments		$2,683,829,000

7.14.2 FWP DMMP 50-Year Costs

The total cost of the 50-Year FWP DMMP is described in Table 7-13 below.

Table 7-13: FWP DMMP Costs/LPP Recommended Plan

TOTAL FWP DMMP COSTS / LPP Recommended Plan		
Reach Description	**Placement Area Used**	**TOTAL**
HSC Bolivar Roads to Redfish Reef	ODMDS	$70,088,000
HSC Redfish Reef to Bayport	Mid Bay/B.I.M./ODMDS	$913,688,000
HSC Bayport to Morgans Point	PA15/M789/M11/ODMDS	$526,816,000
Bayport Ship Channel & Turning Basin	PA14/Connection/ODMDS	$519,310,000
Bayport Ship Channel Flare	PA14/Connection/M789/M11/ODMDS	$355,759,000
Barbours Cut Channel	Spilman/M12/M789/M11/ODMDS	$285,984,000
HSC Morgans Point to Exxon	Spilman/Alexander/BABUS	$553,924,020
HSC Exxon to to Carpenters Bayou	Peggy Lake/Lost Lake/BABUS	$245,248,484
HSC Carpenters Bayou to Boggy Bayou	Lost Lake/BABUS	$153,926,502
HSC Boggy Bayou to Greens Bayou	Lost Lake/BABUS	$288,347,000
HSC Greens Bayou to Sims Bayou	Rosa Allen/East Clinton/BABUS	$221,162,000
Greens Bayou	East Clinton/BABUS	$39,984,135
HSC Sims Bayou to Turning Basin	House Tract/West Clinton/BABUS	$155,144,000
HSC Main Turning Basin	House Tract/BABUS	$126,481,000
HSC Upper Turning Basin	House Tract/BABUS	$51,277,993
Light Draft Channel	House Tract/BABUS	$23,349,444
Turkey Bend Channel	House Tract/BABUS	$14,101,962
Turkey Bend Cut-off Channel	House Tract/BABUS	$15,455,043
TOTALS		**$4,560,046,583**
Costs shown include Existing Federa & Federal Increment. Non-Federal costs not shown.		
Cost total of just study segments		$3,462,779,000

7.15 Cost Sharing

The total costs of construction and operation and maintenance of the HSC are included in Section 8 of the FIFR-EIS. In general cost sharing ER-1105-2-100 (Page E-62) states under 2(a) Harbors, General Navigation Features (GNF), Section 101 specifies cost shares for GNF that vary according to the channel depth: (20 feet or less, greater than 20 feet but not more than 45 feet, and greater than 45 feet). For GNF features not changing depths, such as breakwaters, locks, channel widening, etc., cost sharing shall be at the percentage applicable to the authorized or existing depth, whichever is greater. The percentage also applies to mitigation and other work cost shared the same as GNF. The cost share is paid during construction. Section 101 also requires the project sponsor to pay an additional amount equal to 10 percent of the total construction cost for GNF. This may be paid over a period not to exceed thirty years, and lands, easements, removals, relocations, and damages (LERRDs) acquired for this project may be credited against it. The Water Infrastructure Improvements for the Nation Act of 2016, Section 1111 (WIIN Act) modifies the cost share percentages for new work, originally stated in WRDA 1986.

7.16 Agreements

For the HSC ECIP a new PPA that encompasses the entire HSC and tributaries system will be prepared and negotiated. Some of the pertinent previous resolutions and agreements that will require consideration are shown below.

1. In 1909, the voters of Harris County approved the port as the Harris County Houston Ship Channel Navigation District. The Texas Legislature changed the name to the PHA in 1971. Agreements in regard to the HSC that have been made between the NFS and government are listed below with a short description. In some cases, these documents are quite lengthy and included exhibits delineating the feature discussed. The following descriptions are not meant to be all inclusive.
2. September 17, 1948 Resolution – Harris County Houston Ship Channel Navigation District agreement to comply with requirement to (1) furnish without cost to the United States (U.S.) all lands, easements and rights-of-way necessary for construction of the improvement and subsequent maintenance when and as required and (2) hold and save the U.S. free from claims for damages due to the construction and maintenance of the improvements.
3. August 6, 1959 Resolution – Harris County Houston Ship Channel Navigation District agreement to 1) furnish free of cost to the U.S. all lands, easements, rights-of-way, and suitable spoil-PAs necessary for construction and subsequent maintenance of the project, when and as required; 2) accomplish without expense to the U.S. all necessary alterations of pipelines, power lines, telephone and telegraph lines, bulkheads, revetments, wharves, and other structures and utilities; 3) hold and save the U.S. free from damages due to construction and maintenance of the project; 4) provided assurance of sufficient funding; and 5) stated power to submit bond issues and levy taxes to secure additional funds as may be needed.
4. April 6, 1993 Local Cooperation Agreement (LCA) between the Department of the Army (DA) and the PHA in reference to the O&M of the HSC, Texas Project, Bayport Ship Channel. Originally constructed at 40 feet in depth by the PHA pursuant to DA Permit 6140, the channel was to be perpetually maintained by the Government at a depth of 40 feet and width of 300 feet, from the HSC at mile 20.5 to the Bayport Turning Basin, approximately 22,000 feet west; and the turning basin, to be perpetually maintained by the Government at a depth of 40 feet, a width of 1,600 feet and a length of 1,600 feet.
5. February 8, 1994 LCA between the DA and PHA for O&M of the HSC, Texas, Project, Greens Bayou Channel. The project features assigned to commercial navigation included a channel 36 feet by 175 feet between Mile 0.0 to Mile 0.34, exclusive of berthing areas. The channel was constructed by the USACE under agreement with the PHA and subsequently deepened to a 40-foot depth by the PHA pursuant to DA Permit 8445. The channel was to be perpetually maintained by the Government at a project depth of 40 feet and width of 175 feet, from the Mouth of Greens Bayou to Mile 0.34, approximately 2,000 feet upstream.
6. February 8, 1994, LCA between the DA and PHA for O&M of the HSC, Texas Project, Barbour Terminal Channel. The project features assigned to commercial navigation

included the channel, exclusive of berthing areas, originally constructed and maintained by the DA at 16 feet in depth, subsequently deepened to a 40-foot depth by the PHA, pursuant to DA Permit 8726. To be perpetually maintained by the Government at a depth of 40 feet and width of 300 feet, from the HSC at Mile 26.0 to the Barbour Terminal Turning Basin, approximately 8,400 feet west. Also included was the turning basin, to be perpetually maintained by the Government at a depth of 40 feet, a width of 2,000 feet and a length of 1,900 feet.

7. June 10, 1998 Project Cooperation Agreement (PCA) between DA and PHA for modification of the HSC and the Entrance Channel portion of the Galveston Harbor and Channels, Texas, Project of the HGNC, Texas. Features in this agreement included:
    a. The deepening of the existing Entrance Channel to 47 feet. Deepening to include two feet of advance maintenance and two feet of allowable overdepth.
    b. Deepening and widening the HSC from Morgans Point to Bolivar Roads (approximately 26 miles) to 45 feet and a bottom width of 530 feet, including boater access channels to a depth of 8 feet with varying bottom widths. Deepening to include two feet of advance maintenance and two feet of allowable overdepth.
    c. Deepening and widening the HSC from Boggy Bayou to Morgans Point (approximately 13 miles) to the authorized project depth of 45 feet and a bottom width of 530 feet. Deepening to include advance maintenance (which varies from two to four feet) and an allowable overdepth of two feet.
    d. Dredged or excavated material PAs at Lost Lake, Goat Island, Peggy Lake, Alexander Island, Spilman Island, Cell 15, Cell 14, Offshore Berm, and Offshore Disposal Facility, and reconstruction of Redfish Island (subject to final design considerations and acceptance thereof, and
    e. Creation of approximately 118 acres of artificial oyster reef in Galveston Bay for mitigation of environmental impacts associated with the recommended general navigation features.
8. January 9, 2013 Memorandum of Agreement between DA and PHA for goods and services (e.g., furnishing technical expertise, oversight reviews of the design requirements, studies, economic analysis, and environmental considerations) activities to meet guidelines for Federal assumption of O&M of the non-Federal improvements of the portions of the BSC and BCC, and such other related goods or services as may be agreed upon in the future.
9. May 7, 2014 Memorandum of Agreement between DA and PHA for Federal Assumption of O&M of improvements to the Bayport Ship Channel and Barbours Cut Channels, Texas, Navigation Projects. The project improvements undertaken by the NFS consist of a) for BSC: deepening the channel from the Turning Basin through the entrance flare to 45 feet with 2 feet advanced maintenance and 2 feet of overdepth, widening the channel to 400 feet in the Bay and 350 feet in the landside cut, placing dredged material at PA 15 to improve dikes, and b) for BCC: deepening the channel and turning basin to 45 feet with 2 feet of advanced maintenance and 2 feet of overdepth, dredging an area approximately 4,500 feet long shifting the channel 75 feet to the north, and placing dredged material at the Spilman Island PA, as generally described in the *Bayport Ship Channel Improvement and Barbours Cut Channel Improvement Projects Section 204(f)*

Assumption of Maintenance Assessment Report for Harris and Chambers Counties, Texas Report dated December 23, 2013, approved by the Assistant Secretary of the Army (Civil Works) on May 5, 2014 and the Section 408 Review, dated December 2013.

8 Future Considerations for the Living DMMP

8.1 Future DMMP Updates

ER 1105-2-100 states that DMMPs shall be updated periodically to identify potentially changed conditions. Conditions that shall be addressed include dredging needs, placement capabilities, capacities of PAs, environmental compliance requirements, potential for beneficial use, and indicators of continued economic justification. This DMMP would be updated when changes occur that would require new approvals.

8.2 Beneficial Use and the Base Plan/Federal Standard

As provided in ER 1105-2-100, when determining an acceptable method of dredged material placement, USACE districts are encouraged to consider options that provide opportunities for aquatic ecosystem restoration. BU sites included in the RP of this DMMP are components of the least-cost, environmentally acceptable alternative for disposing dredged material from the HSC and are therefore part of the base plan/Federal standard.

BU sites not included as components of the RP may be reevaluated during future updating of the DMMP. If it is determined that placing dredged material at these BU sites is a least-cost, environmentally acceptable method of placement, the sites may become part of the base plan/Federal standard for the project and the dredged material could be placed in accordance with the prescribed navigation cost share. If it is determined that placing dredged material at these new BU sites is not the least-cost, environmentally acceptable method of placement, the additional costs of placement above the base plan would have to be borne by the responsible third party.

8.3 Ongoing Interagency Coordination

The USACE-SWG plans to conduct annual coordination meetings with interested Federal and state agencies. The meetings are anticipated to provide an opportunity for the USACE-SWG to present dredging plans for the upcoming year and provide a forum for discussion. Through these meetings, USACE-SWG will keep agencies involved and notified of the project's ongoing compliance with environmental laws and requirements related to future dredging operations. Other considerations for discussion may include proposed changes to the DMMP, newly identified BU opportunities, changed environmental conditions, anticipated problems, and other topics related to dredging and dredged material placement. Additionally, USACE-SWG and the local sponsor will regularly coordinate design of the BU features with the BUG during PED.

8.4 Uncertainties

It must be emphasized that this DMMP is a planning-level document. While the USACE-SWG has every intention of implementing the DMMP in its entirety, the DMMP is subject to the uncertainties that are inherent in the planning process when unknown conditions must be considered. Potential items that could affect the implementation of the DMMP include physical conditions that were modeled or inferred based on currently existing information, but the exact nature of which must await detailed surveys and engineering. Examples of physical uncertainties

include forecasted dredging quantities, erosion rates, hydrodynamics, and geotechnical characteristics. Sociopolitical uncertainties include such examples as availability of Congressional, state, or local funding and the possibility of legal actions taken by third parties. In addition, there are catastrophic uncertainties that could affect the DMMP; these include hurricanes, chemical contamination from spills, and vessel accidents.

Such unforeseen events or conditions may result in the shifting of priorities for the placement of dredged material for BU or the rehabilitation of UCPAs, but it is not expected that these actions would affect the overall DMMP. In the event that it becomes necessary for the USACE-SWG to alter the RP, the DMMP would be updated and the alterations would be fully coordinated with state and Federal agencies, and the public would be advised of the changes.

8.5 Adaptive Management

A collaborative, adaptive management strategy that involves engineers, scientists, and resource agencies would be employed throughout the life of the DMMP to improve design, construction, and post-construction procedures to promote circulation, establish vegetation, and manage BU sites. The intent of adaptive management for this project is to account for uncertainties and allow decision-making and implementation to proceed while acknowledging that some structural or operational changes may be necessary (EC 1105-2-409 [31 May 2005; expired 30 September 2007]). Although this project is not an ecosystem restoration project, it would comply with the adaptive management guidance of ER 1105-2-100, paragraph 3-5b(8), which states:

"For complex specifically authorized projects that have high levels of risk and uncertainty of obtaining the proposed outputs, adaptive management may be recommended."

As dredged material placement sites are constructed and completed, the adaptive management process would be used to adjust and improve the DMMP and the placement of dredged material. During construction of the BU sites, agencies would be advisors, but final decision-making will rest with the USACE and the local sponsor.

8.6 Potential Synergy with Other Foreseeable Projects

While this DMMP provides a systems approach for the construction and future O&M of the entire HSC system that considers regional sediment management (RSM), several Federal and private ecosystem and flood control projects are under study in the project vicinity that could potentially utilize dredged materials from the HSC and tributaries. As these studies progress, synergies between these projects may be found. As these projects have not completed study, are not authorized/permitted, they cannot be directly considered under the HSC ECIP study at this time due to their uncertainty. However, these projects may provide alternative placement of dredged material for the HSC and tributaries. Materials could be provided to these projects, if authorized/permitted, as long as they do not impede the navigability of the HSC and tributaries, and costs to place and transport the dredged materials above the base plan defined herein are paid

for by a third party per the laws, regulations, and funding agreements available at the time of the action. A brief summary of potential projects are noted below.

8.6.1 Texas Coastal

The Coastal TX study has proposed a comprehensive plan to reduce storm surge risks and restore ecosystems coast wide. In the Houston/Galveston area, the plan focuses on keeping storm surge from entering the Galveston Bay by deploying a multiple lines of defense. The Coastal TX Barrier system includes an estimated 42 miles of Gulf-side beach and dune complexes in conjunction with two sets of navigation sector gates, 15 vertical lift gates and 16 shallow water environmental gates (SWEGs) at the Bolivar Roads Inlet. Improvements to the existing Galveston Seawall and 18 miles of ring barrier around the bay-side of the City of Galveston and four large pumping stations are included in the plan as a second line of defense. The third line of defense includes a series of flood gates (and accompanying pumping stations) at Dickinson Bayou and Clear Creek in combination with on-structural measures (buildings being raised & flood-proofed) on the upper west side of Galveston Bay. The plan also includes 6,000 acres of habitat restoration in the form of marsh creation, bird island development, oyster reef recovery and dune/beach improvements using thin layer placement of beneficial use dredge materials and 100MCY of sand sourced from near-shore locations. The estimated cost of the Coastal TX Barrier plan ranges from $23B-$32B (40% of which is attributed to ecosystem restoration). The study is scheduled to submit a Chief's Report to Congress in the spring of 2021, and construction is estimated to begin as early as 2025 if authority and appropriations are received from Congress. The cost-share sponsor for the current study is the Texas General Land Office. A cost-share sponsor will need to be identified in advance of the next phase of the project (Preliminary Engineering and Design, or PED). The Texas Legislature will take this cost-sharing proposition under consideration in their next session (i.e., 2021).

8.6.2 Galveston Bay Park

Complimentary to the Texas Coastal feasibility study underway, Rice University's Severe Storm Prediction, Education and Evacuation from Disaster (SSPEED) Center proposes various structural elements in and around Galveston Bay to reduce impacts from major hurricanes to residents and industry in Harris, Chambers, and Galveston counties. The proposed features include creation of a ring levee around the older portion of the City of Galveston, a barrier levee to protect the island of Galveston, beach nourishment along Bolivar, and raising the main egress for Bolivar. In addition, the SSPEED Center proposes adding nearly 10,000 acres to the existing PAs and BUs along the HSC to develop the Galveston Bay Park. The park extends from Houston Point in Chambers County, to the existing Texas City Dike in Galveston County. The project includes a gate structure across the HSC. The park will include marsh, upland recreational space and habitat and a minimum 25-foot high levee along its entire length. The SSPEED Center, in its 23 April 2019 presentation to the PHA Commissioners, expressed their desire to source the material from the HSC. The estimated 50 to 200 MCY of material would be sourced from the LPP portion of the HSC to limit costs. The SSPEED Center estimates dredging and park construction at $1.4B to $1.7B without the cost of a gate structure.

8.6.3 Additional Studies

Multiple additional studies with regards to flood risk management that could reduce shoaling in the HSC and tributaries are on-going. Additionally, several resource agencies and private industry are conducting their own evaluation of beneficial use that could be utilized in future DMMP updates.

9 References

ASTM International. 2013. *Standard Practice for Environmental Site Assessment: Phase 1 Environmental Site Assessment Process*. (Publication No. E1527-13). West Conshohocken, PA: ASTM International.

Houston Audubon. (2017). *Evia Island*. Retrieved from http://houstonaudubon.org/conservation/evia-island.html.

Joint Venture: Turner Collie & Braden Inc. & Gahagan & Bryant Associates, Inc. 2012. *Draft Report Houston Ship Channel Sedimentation Study*. Houston, Texas.

Joint Venture: Turner Collie & Braden Inc. and Gahagan & Bryant Associates, Inc. 2013. *Environmental Assessment in Support of Department of the Army Permit Application SWG-2011-01183 for Bayport Ship Channel Improvements, Harris and Chambers Counties, Texas*. Houston, TX.

Powell, E. N., J. Song, and M. Ellis. 1994. *The status of oyster reefs in Galveston Bay, Texas*. Webster, Texas: Galveston Bay National Estuary Program Publication GBNEP-37.

U. S. Army Corps of Engineers. 1987. *Confined Disposal of Dredged Material*. EM 1110-2-5027. Washington, DC: Department of the Army.

U. S. Army Corps of Engineers. 1992. *Hazardous, Toxic and Radioactive Waste (HTRW) Guidance for Civil Works Projects*. ER 1165-2-132. Washington, DC: Department of the Army.

U.S. Army Corps of Engineers. 1995. *Houston-Galveston Navigation Channels, Texas, Limited Reevaluation Report and Final Supplemental Environmental Impact Statement*. Galveston, TX: Galveston District, Southwestern Division.

U.S. Army Corps of Engineers. 1996. *Navigation and Dredging Operations and Maintenance Policies*. ER 1130-2-520. Washington, DC: Department of the Army.

U.S. Army Corps of Engineers. 1997. *Life Cycle Design and Performance*. ER 1110-2-8159. Washington, DC: Department of the Army.

U.S. Army Corps of Engineers. 2000. *Planning Guidance Notebook*. ER 1105-2-100. Washington, DC: Department of the Army.

U.S. Army Corps of Engineers. 2000. Houston Ship Channel, Texas Preliminary Assessment. Galveston District, Southwester Division, Texas.

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