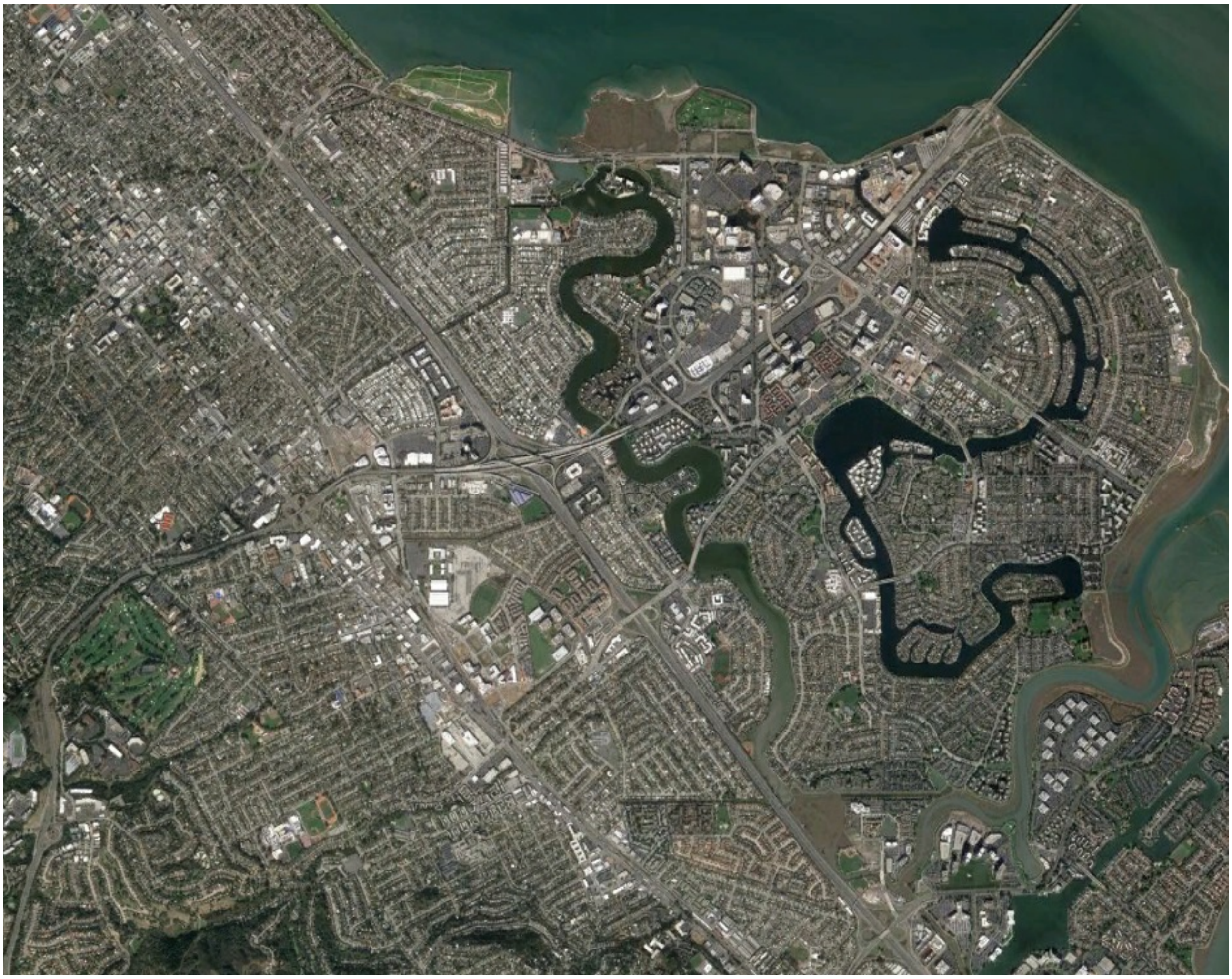
MARINA LAGOON PRELIMINARY DREDGING ASSESSMENT

CITY OF SAN MATEO



Prepared For:

Department of Public Works

City of San Mateo

moffatt & nichol

Document Verification

Client	City of San Mateo
Project name	Marina Lagoon Dredging Assessment
Document title	Marina Lagoon Dredging Assessment Report
Document sub-title	
Status	Final
Date	Thursday, May 03, 2018
Project number	9825
File reference	Q:\\mne.net\projects\WC\9825 Marina Lagoon Dredging Assessment

Revision	Description	Issued by	Date	Checked
01	DRAFT	Anna Johnson	1/18/2018	Dilip Trivedi
02	DRAFT Final	Anna Johnson	2/20/2018	Dilip Trivedi
03	Final	Anna Johnson	4/5/2018	Dilip Trivedi
04	Final – Revision 1	Anna Johnson	5/3/2018	Jack Fink

Prepared by:
Moffatt & Nichol
2185 N. California Blvd. Suite 500
94596. Walnut Creek, CA
(925)-944-5411
www.moffattnichol.com

Table of Contents

List of Figures

List of Tables

Glossary

AF	Acre-feet
BCDC	Bay Conservation and Development Commission
CDFW	California Department of Fish and Wildlife
CEQA	California Environmental Quality Act
CY	Cubic Yards
DBAW	California Department of Boating and Waterways
EPA	Environmental Protection Agency
gpm	gallons per minute
LSA	Lake and Streambed Alteration
MLLW	Mean Lower Low Water
M&N	Moffatt & Nichol
NAVD88	North American Vertical Datum 1988
NMFS	National Marine Fisheries Service
NTS	Not To Scale
RWQCB	Regional Water Quality Control Board
SMD	City of San Mateo Datum + 100
TMDL	Total Maximum Daily Loads
USACE	U.S. Army Corps of Engineers
USFWS	U.S. Fish and Wildlife Service

1. Introduction

Marina Lagoon is an approximate four mile long brackish water body that meanders through the City of San Mateo. Since its original construction in 1964, the primary functions of the Lagoon have been storm water retention and recreation. Though flows within the Lagoon are controlled by tide gates along the southern end and a pump station at the northern end, Bay water entering the tide gates has deposited sediments along the length of the Lagoon, lessening its storm water retention capacity and water depths for recreational vessels. The City of San Mateo has recognized the need to dredge the sediment to regain the original water depths and retention capacity.

1.1. Background

Originally known as Seal Slough, Marina Lagoon was a tidal slough hydrologically connected to San Francisco Bay. The Lagoon was constructed in the 1960's when both the northern and southern end were diked to control flows within the Lagoon. The pump station consisting of four active pumps and one stand-by pump has a total rated capacity of 600,000 gpm (150,000 gpm each) to transfer excess water collected in the Lagoon. The Lagoon receives water from the tide gates at the southern end, which convey Bay water from Belmont and O'Neill Slough, as well as three discharge channels and numerous storm drains. During the summer, water levels are maintained at an elevation of +97 feet San Mateo Datum (SMD) [1] and lowered to +95 feet SMD during the winter months to capture storm water runoff. Elevations within the Lagoon are operated as shown in Table 1-1.

TABLE 1-1: OPERATING WATER LEVELS OF MARINA LAGOON
(adapted from cityofsanmateo.org)

Period	Level Adjustment	Elevation	Comments
May 1 - October 31	--	+97.0 feet	Summer Operating Level
November 1 - November 30	-1 foot	+96.0 feet	Preparing for Winter Rains
December 1 - January 14	-1 foot	+95.0 feet	Winter Operating Level
January 15 - February 15	-1.5 foot	+93.5 feet	Dock Maintenance Period
February 16 - March 31	+1.5 foot	+95.0 feet	Winter Operating Level
April 1 - April 30	+1 foot	+96.0 feet	Spring Intermediate Level
May 1	+1 foot	+97.0 feet	Summer Operating Level

The tide gates at the southern end of the Lagoon consist of four sluice gates, each two feet square. Water enters the gates from Belmont and O'Neill Slough, both tidal sloughs of San Francisco Bay. Sediment enters the system with the flow through the tide gates, which are only closed occasionally during the summer months to maintain the summer operating water level. Therefore, flow in the Lagoon is from South to North, as can be seen by the sedimentation patterns. The largest amount of deposition has occurred in the southern reaches of the Lagoon, with the northern reaches maintaining water depths of approximately six feet.

[1] SMD = City of San Mateo Datum +100
[0' SMD = +2.36' NGVD29 = +5' NAVD88 = City of San Mateo Datum +100]

FIGURE 1-1 : VICINITY MAP

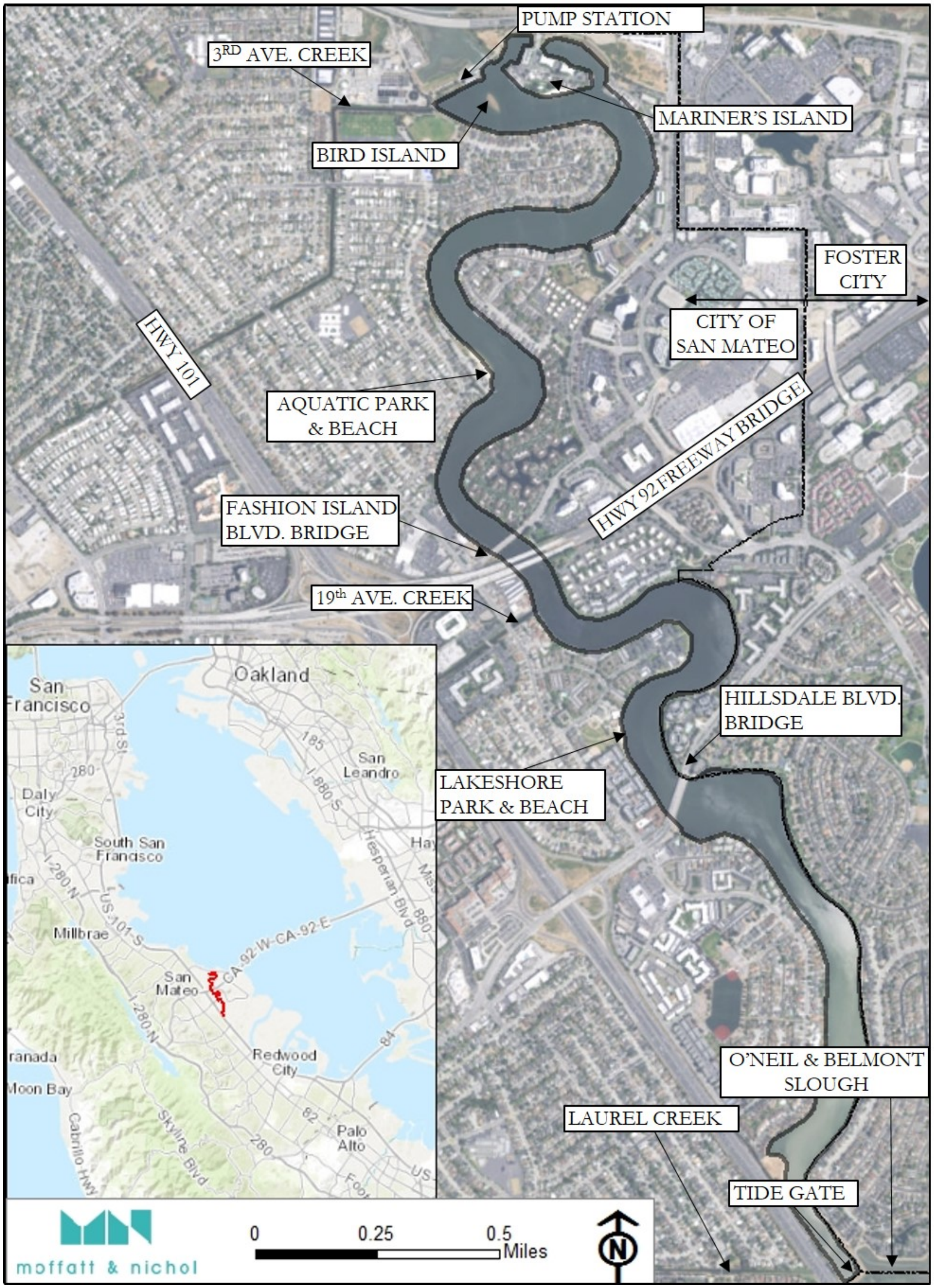


FIGURE 1-2: RECREATION ZONES WITHIN MARINA LAGOON

Multiple structures have been implemented along the shoreline of the Lagoon. Both private and public docks and launch ramps are present, riprap shoreline protection, stone and wooden bulkheads as well as vegetated slope and sandy beaches. Since many of these projects were constructed on an individual basis by adjacent landowners, the design and condition of each is not uniform. However, the permit from the US Army Corps of Engineers (USACE) did require all shoreline structures not to exceed 25 feet from the summer high water level (+97 contour) except in the Mariner's Island subdivision where this restriction was increased to 40 feet from the summer high water level.

1.2. Purpose

Since the last dredging episode to remove siltation performed in the 1980's, sedimentation has been on-going within the Lagoon and is threatening the storm water retention capacity and recreational uses. To help establish a dredging plan, The City of San Mateo has retained Moffatt & Nichol (M&N) to develop a feasibility analysis of dredging options for the Lagoon. Work associated with this objective is presented in the following section.

1.3. Scope

The Scope of Work for the Marina Lagoon Dredging Feasibility Assessment includes the following tasks:

1. A hydrographic survey of Marina Lagoon to capture all potential limits of dredging and to aid in determining the amount of siltation that has occurred since the last readily available hydrographic survey performed in 1996).
2. Exploratory Sediment Characterization was performed by Pacific EcoRisk. This task included performing preliminary laboratory testing of potential dredged material to determine general sediment chemistry as well as decant water properties associated with beneficial reuse and upland disposal sites. The Exploratory Sediment Characterization followed protocol developed by the Dredged Material Management Office (DMMO) so that the results of the analysis could be used as background information in the future when seeking permit approvals. The protocol includes the following phases:
    a. Sediment Analysis Plan (SAP) - Develop a plan for sample collection, laboratory testing, physical and chemical analysis.
    b. Sediment Sampling and Testing - All sediment sampling and testing procedures to follow the protocol developed by the DMMO.
    c. Sediment Analysis Results (SAR) - Develop a report that summarizes the collection, testing, and results of the analysis.
3. A Maintenance Dredging Assessment Report that is made up of the following components:
    a. Review Existing Data & Site Walk - Available data from the City including historical surveys, operation documents, dredging records and sediment testing results was reviewed and summarized. A site walk was conducted to identify relevant site conditions and potential construction related options.
    b. Volume Estimate- Dredging areas and volumes were identified.

c. Sediment Suitability - Based on the SAR, a recommended strategy for disposal has been prepared.

d. Identify Disposal Options - Three feasible option for dredged material disposal have been identified and evaluated.

e. Regulatory Considerations - Anticipated required permits are discussed, including the DMMO process and California Environmental Quality Act (CEQA).

f. Cost Estimates - Planning level cost estimates for the selected disposal options have been prepared. Costs include estimated sediment testing costs, permitting fees, engineering design and construction costs.

g. Schedules - Conceptual schedules for each phase of work have been developed.

h. Recommendations - Based on the assessment, recommendations for subsequent action have been provided.

4. Project Management responsibilities including conference calls, biweekly project updates, and three meetings with City officials.

2. Existing Conditions

The existing conditions at Marina Lagoon were assessed by conducting two site visits, performing a hydrographic survey, and conducting an exploratory sediment characterization. The following paragraphs summarize the present conditions existing along Marina Lagoon.

2.1. Site Description

The centerline of Marina Lagoon stretches approximately 3.85 miles from San Francisco Bay to the confluence of O'Neill Slough, Belmont Slough, and Laurel Creek (see Figure 1-1). The Lagoon is lined with docks and ramps belonging to private owners as well as public parks, beaches, launch ramps, and walking or bike paths. Approximately 39 storm drain outfalls line the length of the Lagoon. It is crossed by three bridge structures.

Site conditions were observed during the field reconnaissance surveys conducted on June 29, 2017 and September 14, 2017. Both onshore and in-water observations were recorded. Weather condition were similar for both days, with average temperatures of approximately 65°F, sunny conditions with average winds of 15 mph from the West-Southwest direction (as measured at the San Francisco International Airport wind gauge- KSFO). During the initial field visit, algae and other vegetation was observed within the Lagoon, indicating poor water circulation. During the second reconnaissance survey, the amount of vegetation observed was significantly less. Deeper portions experienced small, choppy wind-waves while shallower areas, especially in the southern reaches, contained stagnant water.

The western shoreline of the Lagoon looks to be almost entirely privately owned areas. Of the 3.85 miles of shoreline on the west, a public walking path is only evident in the northern most reach (approximately 250 feet long) and the southern-most area (approximately 2,000 feet long). Aquatic Park and Beach and Lakeshore Park and Beach also contain areas for public access. The majority of the western shoreline contains docks and ramps lining the Lagoon are in various conditions. In most areas, the shoreline itself looks to be protected by riprap or wood, stone or concrete bulkheads. A long, privately owned section of Lagoon contains a naturally vegetated shoreline. Measurements were taken of randomly selected docks and ramps and none were observed to exceed the 25 feet from the summer water line as dictated by the USACE permit.

The northern approximately 2.6 miles of the eastern shoreline (including Mariner's Island) is located in the City of San Mateo. The remaining portion is the border with Foster City. The portion within the City of San Mateo resembles the western shoreline in that the majority is privately owned docks and ramps. However, unlike the western shoreline, the homes along this shoreline extend over the edge of the bank and are supported on piles. Therefore, many of the docks in this reach extended farther than 25 feet from the summer water level.

Approximately one mile before the end of the City of San Mateo city limits, the Foster City Levee Pedestrian Pathway begins and runs the remaining length of the eastern shoreline. Unlike the western shoreline, private properties do not extend to the water's edge but, instead, stop approximately 20-50 feet landward of the summer water line.

2.2. Elevation Data

The hydrographic survey was conducted by Meridian Surveying and Engineers LLC (Meridian) in June and July 2017, shown in Figure 2-1. The vertical datum used in the survey was NAVD88, where 0 feet

NAVD88 is equivalent to 95 feet SMD. Bottom elevations within the Lagoon vary between 89 and 102 feet SMD and decrease moving north to south. The northern portion of the Lagoon and the channels surrounding Mariner's Island Subdivision contain bottom elevations between 91 and 93 feet SMD. Just south of this area is the deepest segment of Lagoon, where bottom elevations reach as low as 89 feet SMD. Bottom elevations along the middle portion of the Lagoon range between 91 and 93 feet SMD. The shallowest water depths are found along the southern reaches of the Lagoon, where bottom elevations range between 93 and 97 feet SMD.

The southern-most 600 feet of the Lagoon has been closed to boat traffic, therefore, water depths there could not be measured during the hydrographic survey. During the site visit, pole sounding were taken at the tide gate leading to O'Neill and Belmont Slough. Water depths in this area were estimated at just over 4 feet. Though the center of the Lagoon in this region was not measured, photos from the site visit show birds walking along the water bottom, indicating that water depths are as low as a few inches. Aerial images confirm that a channel connecting the outfall pipes at the southwestern tip of the Lagoon, the tide gates, and the Laurel Creek culvert meanders through a mudflat in this reach.

2.3. Sediment Characterization

Sediment sampling was completed within Marina Lagoon between November 13th and 16th, 2017. For sampling purposes, the Lagoon was divided into five Dredging Units (DU). Four (4) samples were taken within each DU for a total of 20 samples. The 4 samples within each DU were then combined to create 1 composite sample per DU for a total of 5 composites for testing purposes. The grain size distribution, shown in Table 2-1, is based on these 5 composites. Results from the testing is described in Section 4.3 of this report.

TABLE 2-1: GRAIN SIZE DISTRIBUTION OF SEDIMENT IN MARINA LAGOON

Grain Size (%, dry wt)	**ML-DU5-Comp**	**ML-DU4-Comp**	**ML-DU3-Comp**	**ML-DU2-Comp**	**ML-DU1-Comp**
Gravel	0.00	0.00	0.00	0.00	0.00
Sand	13.12	10.11	31.99	18.76	23.77
Silt	60.63	64.89	50.38	61.44	57.74
Clay	26.25	25.00	17.63	19.80	18.49

FIGURE 2-1: 2017 WATER BOTTOM ELEVATIONS

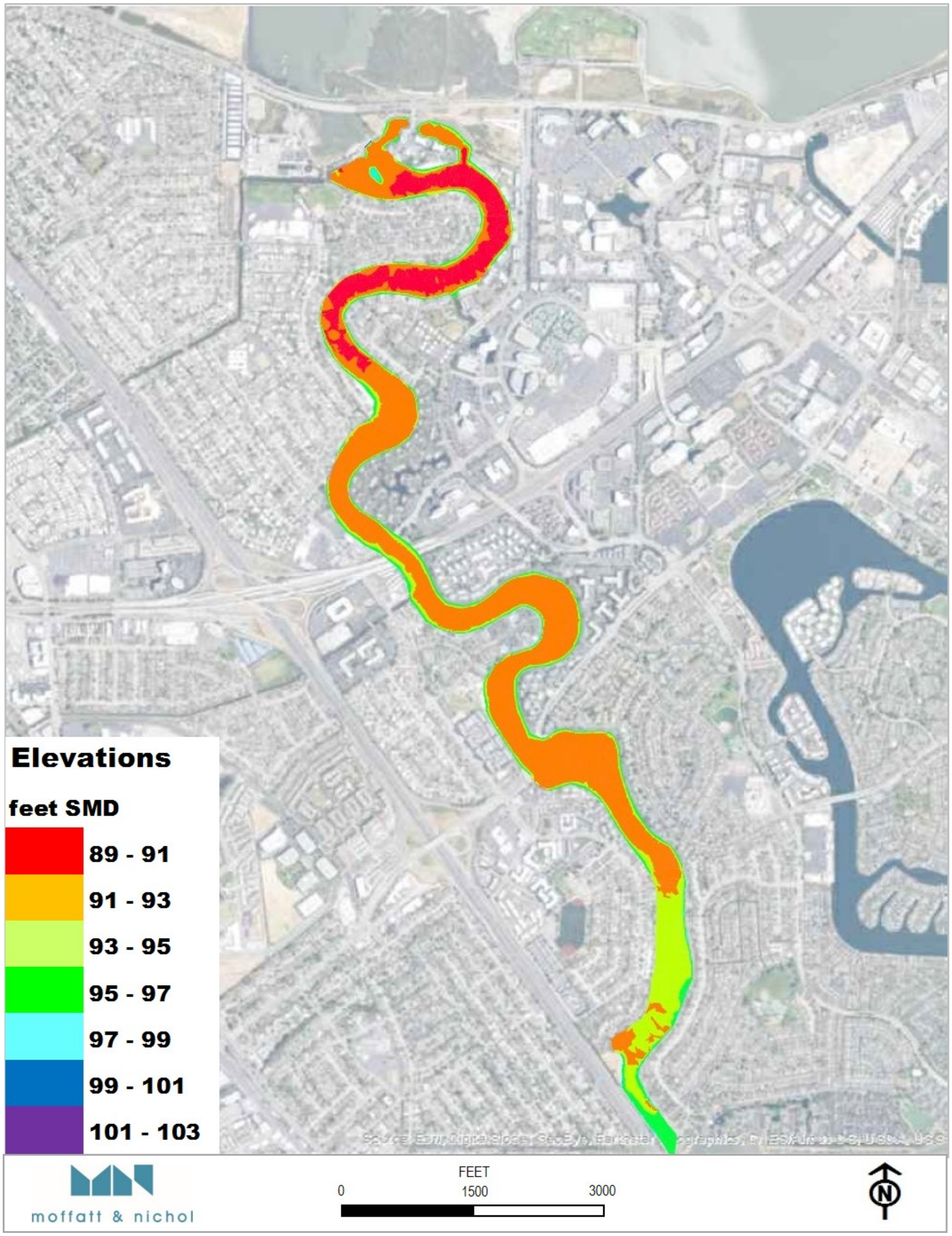


FIGURE 2-2: DRAFT DURING SUMMER WATER LEVEL

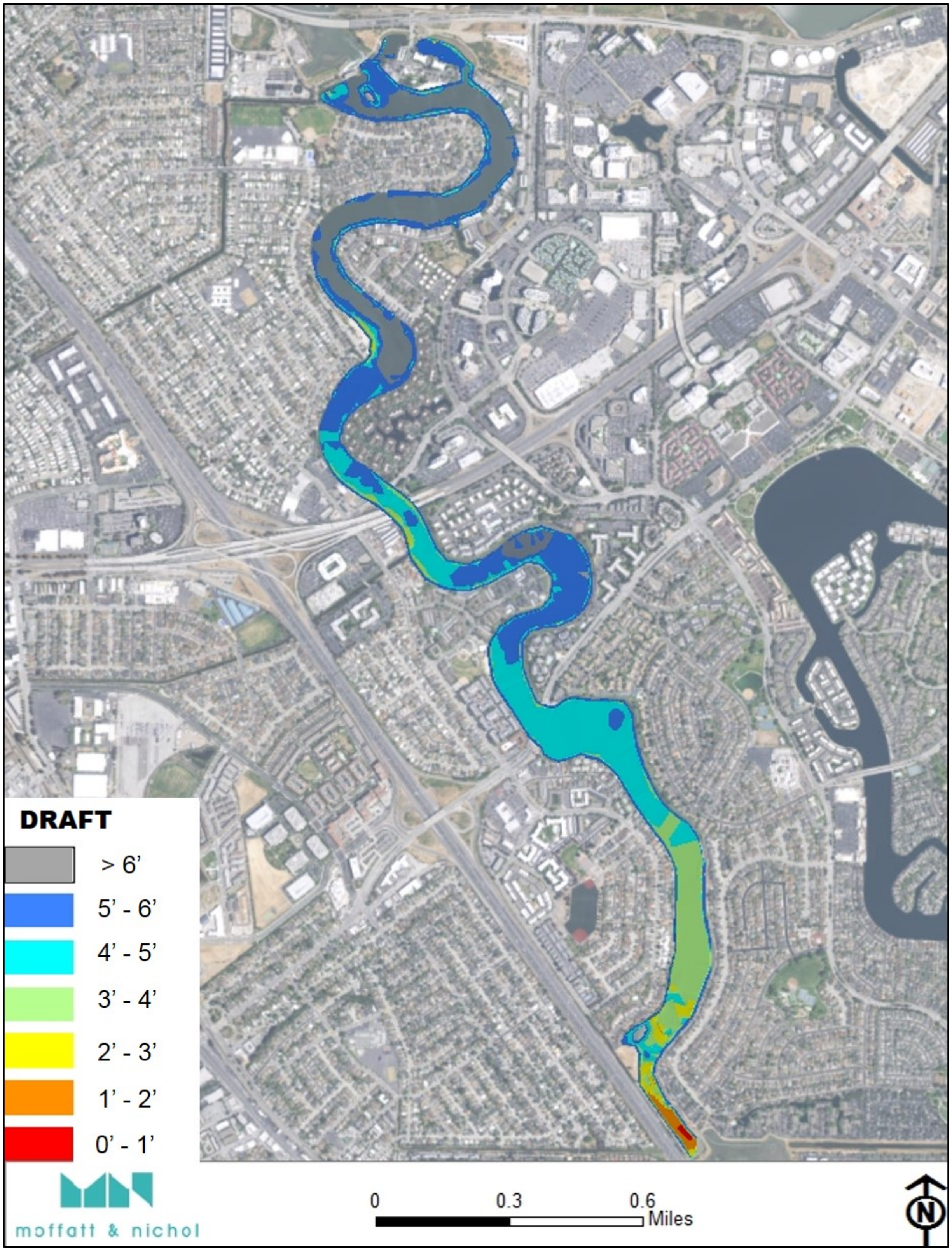
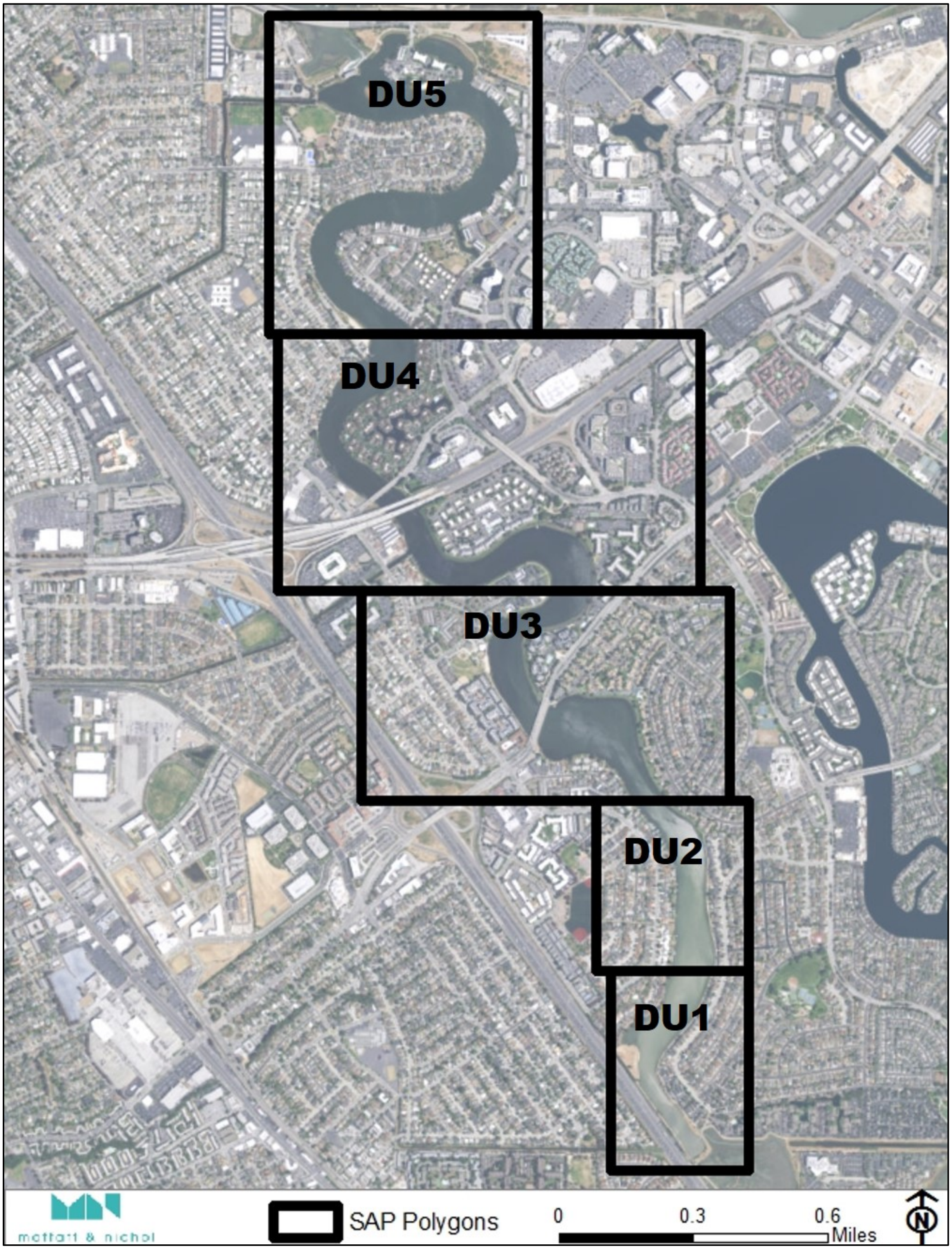


FIGURE 2-3: DREDGING UNITS (DU) FOR SEDIMENT CHARACTERIZATION



3. Sedimentation and Change in Retention Capacity

The Preliminary Dredging Assessment conducted by Moffatt & Nichol in 1998 was reviewed for this study. The assessment includes a review of existing data dating back to the original construction of Marina Lagoon. Additionally, a dredging analysis was conducted to establish a dredging template, estimate quantities of dredged volume, and determine changes in storm water retention capacity. Relevant information obtained from the previous assessment is presented in subsequent paragraphs.

3.1. Historical Conditions

The Preliminary Dredging Assessment (M&N 1998) reviewed design drawings from the construction of the Lagoon in 1965. Figure 3-1 depicts dredging limits and typical sections of the dredged template and proposed dock construction. The top-of-cut of the original dredging template corresponded to the property line in most areas along the Lagoon. Side slopes were generally kept at 5 (Horizontal):1 (Vertical), though the design drawings showed some variation (M&N 2008). The bottom elevation of the dredging template was presumably held at +91 feet SMD along the entire Lagoon. Water levels within the Lagoon were controlled by tide gates located at the northern limit of the Lagoon. Also, based on the US Army Corps of Engineers Permit 213561S, individual boat docks and ramps were not to exceed 25 feet into the Lagoon from the intersection of the summer water line and the shoreline, except within Mariner's Island, where this limitation was extended to 40 feet.

The original template did not include Bird Island or Mariner's Island, which were presumably added at a later date. The canal separating Mariner's Island was diked off from Marina Lagoon at the northern entrance near the historic tide gates. For the purposes of this study, it was assumed that this area was dredged to the same template as the rest of Marina Lagoon. Bird Island was also not present in the initial proposed dredging template. This area was either dredged around during the initial dredging event or was created by placement of material.

3.2. Elevations

For the Preliminary Dredging Assessment, a hydrographic survey conducted in 1996 by Aquatics Habitat Management was compared to the original dredged template to determine the amount of shoaling and loss of retention within Marina Lagoon. Because the exact template of the original dredging of Marina Lagoon is unknown, some qualifying assumptions were made to develop the template to compare it to the 1996 survey. Information provided indicates that the 1965 template was initiated at the property line, which has an approximate elevation of 100 feet SMD. From this elevation, the template was dredged down at a 5(H):1(V) side slope to the 91 contour.

To determine sedimentation below the summer water level of 97' within Marina Lagoon, the 1996 and 2017 surveys were compared to the original template as presented in Table 3-1.

FIGURE 3-1: ORIGINAL LIMITS AND DREDGED TEMPLATE

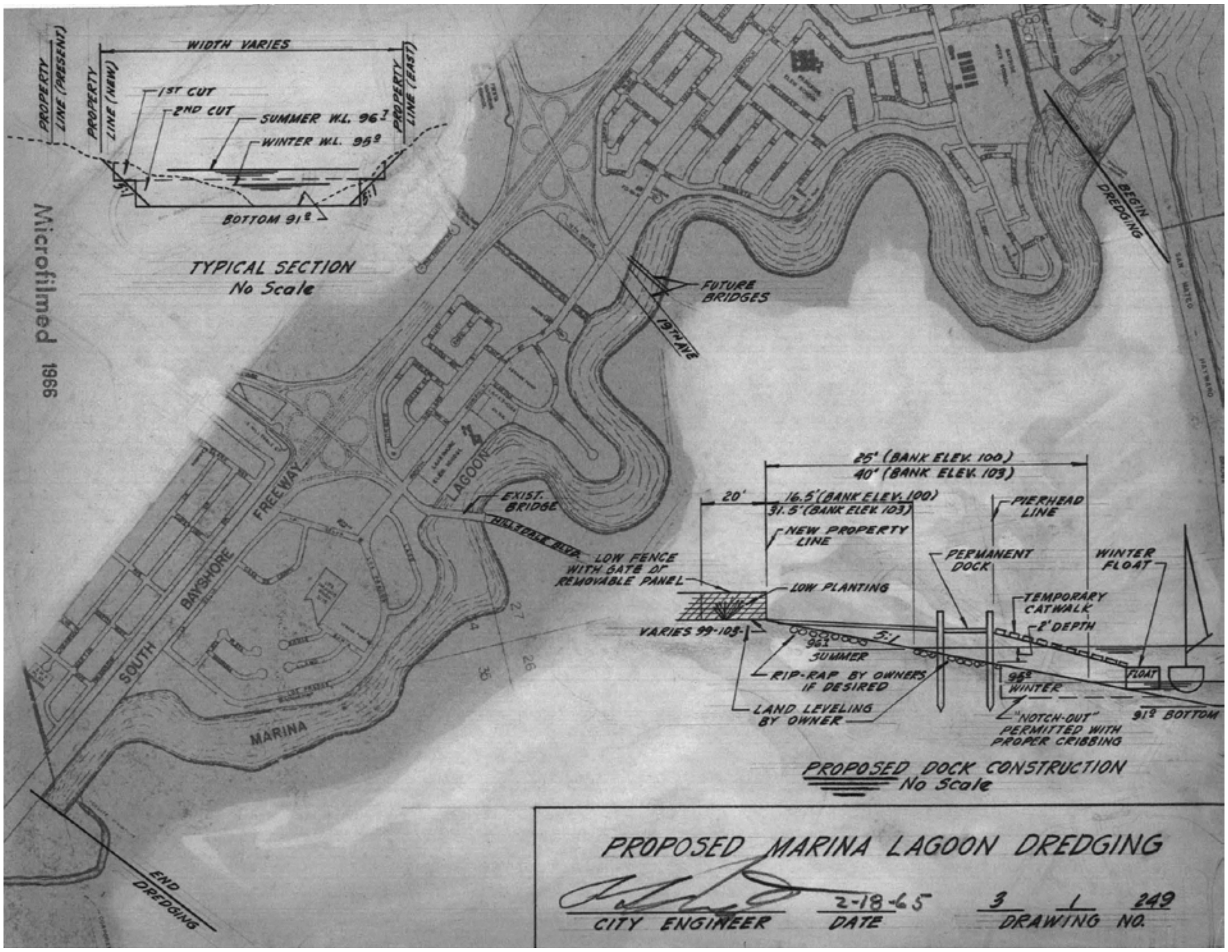


TABLE 3-1: SEDIMENTATION WITHIN MARINA LAGOON

Comparison	Total Shoaling (cubic yards)	Yearly Average (cubic yards/yr)	Sedimentation Rate (inches/year)
1996 Survey vs. 1965 Template	200,600	6,470	0.27
2017 Survey vs. 1965 Template	314,190	6,040	0.25
2017 Survey vs. 1996 Survey	113,587	5,410	0.22

The comparison shows that shoaling was greatest during the first 30 years of the project life and has slowed in the following 20 years. This is expected as sedimentation often declines once a dredged area begins to reach its natural depth. The decrease in shoaling rate may also be attributed to sedimentation in O'Neil Slough, which has decreased the amount of sediment-laden flow entering Marina Lagoon. Currently, the majority of flow enters Marina Lagoon during high tides.

Examining the approximate 50 years between the original dredging and the latest survey conducted in Summer of 2017, the average unit shoaling rate within the Lagoon is approximately ¼ inch per year.

Both surveys indicate that this is greatest in the southern portions of the Lagoon, with the northern portions experiencing little to no sedimentation.

3.3. Lagoon Capacity and Depth

Sedimentation within Marina Lagoon will reduce the Lagoon capacity and water depth. The following subsections quantify this loss in capacity and water depth based on the assumed original template and surveys conducted in 1996 and 2017.

3.3.1. Stormwater Capacity

One of the primary functions of the Lagoon is to collect stormwater runoff from the surrounding areas. A decrease in Lagoon storage volume will affect how much runoff can be collected. Table 3-2 summarizes the Lagoon storage volumes for the original template and the 1996 and 2017 surveys.

TABLE 3-2: LAGOON STORAGE VOLUMES

Period	Summer Volume (to 97')		Winter Volume (to 95')		Storm Water Retention	
	CY	AF	CY	AF	CY	AF
1965 (Original)	1,693,590	1,050	1,096,806	680	596,784	370
1996 Survey	1,649,299	1,022	1,028,633	638	620,665	385
2017 Survey	1,286,458	797	753,082	467	533,376	331

During the winter months, the water is pumped out of the Lagoon to lower the water level to 95 feet SMD to allow for the collection of stormwater runoff. The stormwater capacity (storage volume between the 95-feet water level and the 97-feet water level) is therefore the difference between the summer volume and the winter volume in the table above.

The 1996 survey indicates although there was sedimentation in the Lagoon there was an increase in storm water retention by 15 acre-feet. This is due to the addition of the two channels encompassing Mariner's Island, referred to as the 'Rabbit Ears'. However, sedimentation within the original template can be seen in the decrease in summer and winter volume, 28 acre-feet and 42 acre-feet, respectively. Therefore, though sedimentation within the Lagoon occurred between the original Lagoon dredging in 1965 and the survey in 1996, it was offset by the additional volume added by the inclusion of the Rabbit Ears.

Shoaling within the Lagoon is evident when comparing the 2017 survey to the previous surveys. However, because storm water retention is between the 95' and 97' water levels, the decrease in storm water retention capacity has not been significant. Less than 40 acre-feet has been lost since the original dredging occurred in 1965.

3.3.2. Depth for Recreational Use

In addition to stormwater runoff retention, the other primary function of the Lagoon is recreation, including boaters, water skiers, and swimmers. The California Department of Boating and Waterways (DBAW) provides recommendations for minimum depth requirements in areas with boat traffic. For fairways, defined as a watercourse by which boats travel between interior channels and berths, the recommended water depth for a boat less than 40 feet long is 6 feet deep with a minimum of 4 feet. During the summer months, when the water level is maintained at approximately 97 feet SMD, a bottom elevation of 91 feet SMD will achieve the recommended water depth. During the winter months, the water elevation is 95 feet SMD, resulting in 4 feet of water depth at a bottom elevation of 91 feet SMD.

Areas that meet the above requirement based on both the 1996 and 2017 surveys are shown in Figure 3-2. Table 3-3 provides the acreage and loss of water depth due to sedimentation.

TABLE 3-3: AREAS WITH WATER DEPTHS > 6 FEET DURING SUMMER WATER LEVEL

Template	Area (acres)	Percentage Lost
Original	160	-
1996	51	68%
2017	37	77%

Currently, only 33% of the original 160 acres meets the DBAW requirements for recommended water depths of 6 feet during the summer months. 85% meet the minimum water depth of 4 feet during the summer months. Only 25% meet the minimum water depth of 4 feet during the winter water level of 95 feet SMD. The area in the northern portion of the Lagoon with acceptable depths is used for power boating and water skiing, however, power boating and water skiing area in the southern reaches do not meet the minimum depth requirement.

FIGURE 3-2: WATER DEPTHS IN MARINA LAGOON

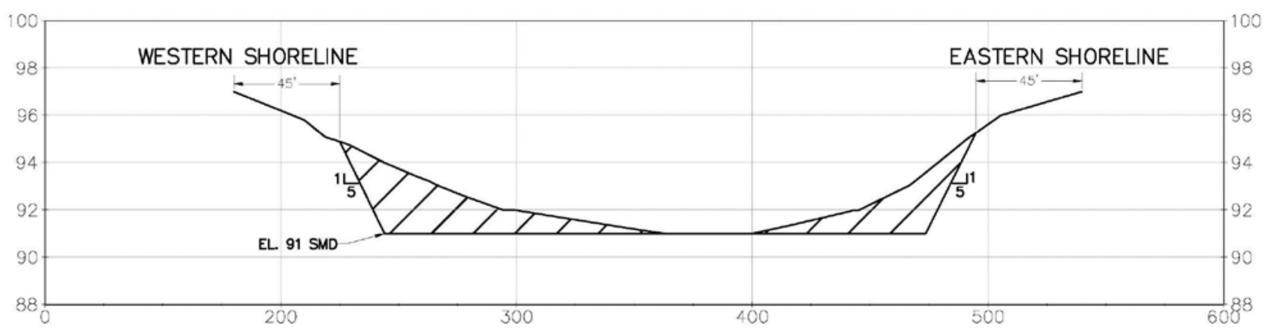
4. Project Design Criteria

Lost capacity and water depth within Marina Lagoon could be regained by performing maintenance dredging. The following conditions were considered in developing the dredging template for the maintenance dredging event:

- Dredging depths should be no deeper than the original dredged template. A deeper dredging template would result in the dredge encountering unknown soil conditions and/or rock beneath the shoaled sediment.
- Since the initial dredging event, structures such as docks and boat ramps as well as shoreline protection have been placed along the shoreline and must be avoided.
- The property easement of which the original dredged template was based is no longer operational. A new limit of dredging should be established.

Based on these requirements, the dredging template shown in Figure 4-1 was developed. The dredging cut is initiated at 45 feet inward from the summer high water line, as surveyed by Meridian in June/July 2017. This 45 foot buffer is meant to provide sufficient clearance for the docks, ramps, piles and shore protection along the shoreline. There are areas, especially along the eastern shoreline and at the public launch ramp near Aquatic Beach and Park, where structures would encroach into this 45 foot buffer. These few areas will be delineated and avoided prior to dredging.

FIGURE 4-1: TYPICAL SECTION (NTS)



4.1. Dredged Material Volumes

The template shown in Figure 4-1 will result in approximately 275,000 cubic yards of material to be dredged from the Lagoon. Figure 4-2 shows the distribution of dredged volume throughout the channel.

As shown in Figure 4-2, the majority of the material will be dredged from the southern reaches of Lagoon where the required depth-of-cut range between 2 and 6 feet. The northern portion of the Lagoon has bottom elevations at or below the dredging template shown in Figure 4-1. The middle of the Lagoon requires dredging cuts of between 0 and 2 feet.

Table 4-1 provides the breakdown of dredged areas and volumes within the Lagoon.

TABLE 4-1: DREDGED VOLUMES DISTRIBUTION

Cut Depth (feet)		Area (acres)	Volume (CY)
Min	Max		
No Cut		42.0	37,338
0	1	59.5	48,028
1	2	45.3	109,670
2	3	20.0	80,797
3	4	3.4	18,939
4	5	1.4	10,305
5	6	0.5	4,559
Total to be Dredged:		130.1	272,298

4.2. 'With Project' Capacity and Depth

Implementation of the template shown in Figure 4-1 would increase the capacity and the navigable water depths within the Lagoon. Table 4-2 depicts the increase in capacity the dredging project would produce. The "With Project" Capacity is less than the original capacity because of the applied 45 foot offset in order to avoid the docks, ramps, and shore protection.

TABLE 4-2: "WITH PROJECT" CAPACITY

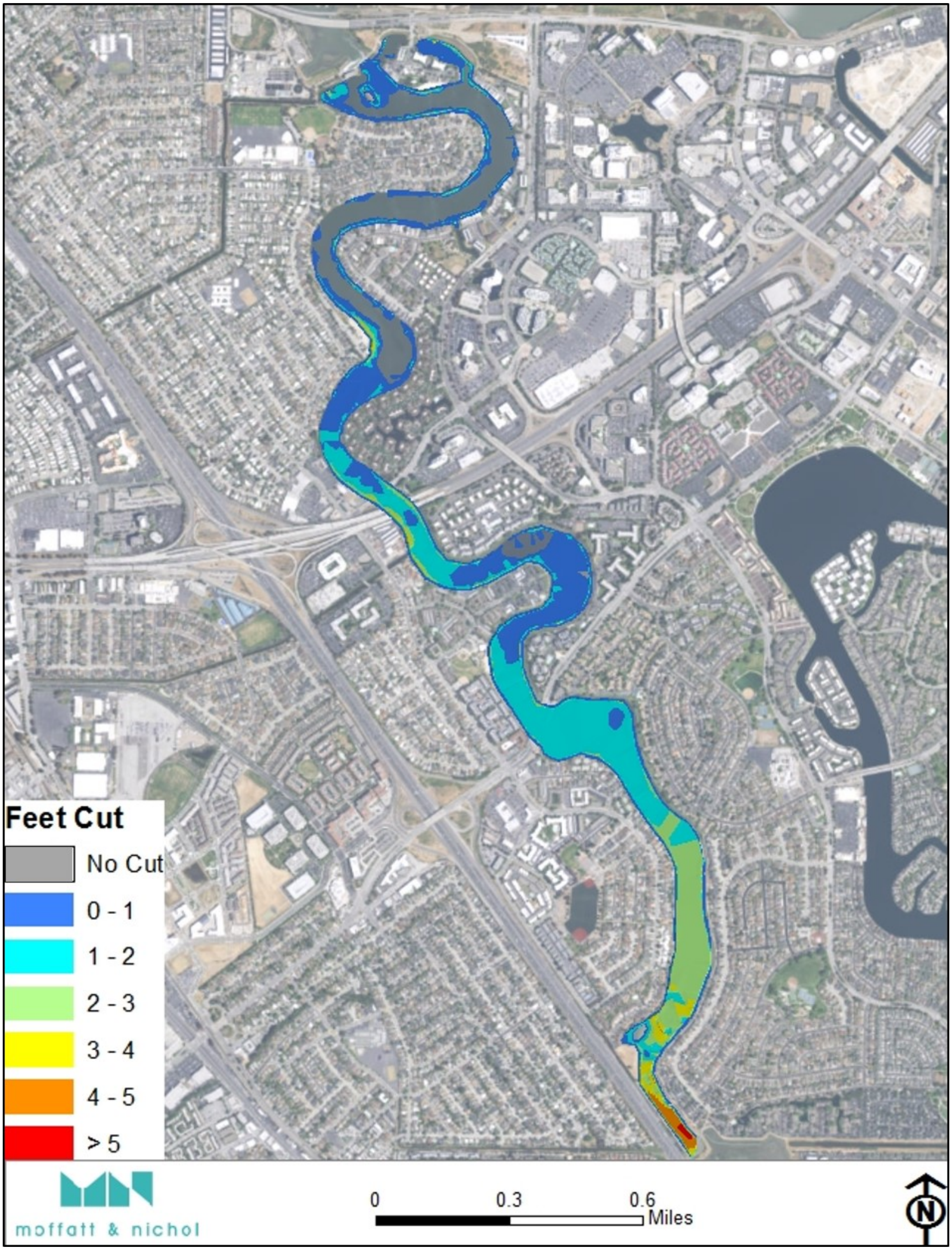
	Summer Capacity (to 97')		Winter Capacity (to 95')		Storm Water Retention	
Template	CY	AF	CY	AF	CY	AF
Original Template	1,693,590	1,050	1,096,806	680	596,784	370
2017 Survey	1,286,458	797	753,082	467	533,376	331
With Project	1,558,275	966	984,413	610	573,862	356

Similarly, the area with navigable water depths will change as shown in Table 4-3.

TABLE 4-3: "WITH PROJECT" AREAS WITH WATER DEPTHS > 6 FEET

Template	Area (acres)	Percentage Change
Original	160	-
2017	37	-77%
With Project	155	+76%

FIGURE 4-2: DREDGE CUT REQUIRED TO REACH ORIGINAL DEPTH



4.3. Sediment Suitability

Analytical chemistry testing was performed on the five composite samples described in Section 2.3 to assess the suitability of the material for a wide range of disposal options. Disposal options included in-water placement (within the lagoon or in the Bay), beneficial reuse in a wetlands environment, and disposal in an upland environment.

Sediment sampling and testing was conducted per San Francisco Bay standards and protocols put forth the Dredged Material Management Office (DMMO), discussed in Section 7. Sample concentrations from the testing program were compared against San Francisco Bay background levels (to assess suitability for in-water disposal) as well as established standards for reuse of material in a wetlands or upland environment (to assess beneficial reuse potential). Wetland beneficial reuse standards typically classify acceptable material into two categories, 'Foundation' and 'Cover'. Higher concentrations of certain analytes are permitted for the Foundation category because this zone is typically not exposed to the environment and will, therefore, not have any direct interface with tides, vegetation, wildlife, etc. The Cover category refers to material that is in direct contact with the environment, and allowable concentrations of analytes are lower than for Foundation material. More information on sampling and testing is given in the *Sediment Testing and Analysis Plan (Pacific EcoRisk 2017a).*

The analytical chemistry testing indicated that several of the constituents which were analyzed exceeded regulatory thresholds. The samples showed exceedances in concentration of certain metals, polychlorinated biphenyls (PCB), polycyclic aromatic hydrocarbons (PAH), and Dichlorodiphenyltrichloroethane (DDT). A summary of analytes that exceeded thresholds is provided in Table 4-4. Toxicity was not tested for during this exploratory characterization phase.

The presence and concentrations of the contaminants can be found in increasing quantities moving north along the Lagoon, with highest contamination at the northern reach. Results indicate that the material proposed to be dredged cannot be placed unconfined in the lagoon or in SF Bay, nor can it be used for beneficial reuse in wetlands because every composite sample contains levels of Chlordane above the screening values. Upland disposal of this material would also be restricted because of the potential for leaching into the ground and for storm water runoff exceedances; it would require a bottom liner as well as a cap for separation. Therefore, the only viable option for offsite disposal is taking the material to a landfill. Additional testing would be required for disposal at a landfill, which is specific to each landfill.

Testing of sample elutriates (dissolved form of the analytes) was also conducted, to compare the concentration of analytes in the return water for the in-Lagoon disposal or high-speed dewatering options (discussed in Section 5) to receiving water criteria. The results of the tests show elevated levels of dissolved copper that are above the allowable San Francisco Bay bioaccumulation levels. This implies that if the dredged material is disposed within the Lagoon, the return water from the hydraulically transported slurry will be above trigger levels for San Francisco Bay waters. However, since the receiving water body would be the Lagoon, it will necessitate further coordination with regulatory agencies to assess the potential for in-Lagoon disposal. More information is provided in the Sediment Sampling and Analysis Report *(Pacific EcoRisk 2017b).*

TABLE 4-4: MATERIAL CONTAMINANTS CONCENTRATIONS

Analyte	Sample ID					Bay Background[1]	Wetland Screening Criteria[2]	
	ML-DU5-Comp	ML-DU4-Comp	ML-DU3-Comp	ML-DU2-Comp	ML-DU1-Comp	<100% fines	Cover	Foundation
Metals (mg/kg, dry wt)								
Cadmium	0.645[A]	1.00[A]	1.15[A]	1.47[A]	2.31[A]	0.33	0.33	9.6
Copper	54.7	67.9	59.1	84.3[A]	109[A]	68.1	68.1	270
Lead	36	73.2[A]	99.2[A]	163[A]	193[A]	43.2	43.2	218
Mercury	0.292	0.502[A]	0.341	0.334	0.523[A]	0.43 (0.47[a])	0.43	1.3
Nickel	99.6	120[A]	97.1	112	137[A]	112	112	200
Selenium	0.418	0.676[A]	0.982[A]	1.46[A]	0.955[A]	0.64	0.64	1.4
Silver	0.495	0.54	0.384	0.581[A]	0.716[A]	0.58	0.58	3.7
Zinc	170[A]	205[A]	205[A]	281[A]	395[A]	158	158	410
PCBs (µg/kg, dry wt)								
∑ detected PCBs	11.26	24.23[A, B]	41.4[A, B]	60.5[A, B]	81.9[A, B]	21.6, 18[a], 29.6[b]	22.7	180
PAHs (µg/kg, dry wt)								
∑ detected PAHs	2738	2517	3,833[A]	3326	3,892[A]	3,390 (4,500[a])	3390	44792
Organochlorine Pesticides (µg/kg, dry wt)								
Chlordane	20[A, C, J]	14[A, C, J]	71[A, B, C]	41[A, B, C]	95[A, B, C]	1.1 (37[a])	2.3	4.8
Dieldrin	<0.91	<1.1	<0.98	<1.0	2.0[A, B]	0.44 (1.9[a])	0.72	4.3
∑ detected DDTs	15.5[A, J]	17.0[A, J]	50.2[A, B, J]	49.3[A, J]	62.0[A, B, J]	7.0, (50[a])	7	100

[1] San Francisco Regional Water Quality Control Board (1998) Staff Report: Ambient Concentrations of Toxic Chemicals in San Francisco Bay Sediments. May 1998.

[2] Montezuma Wetlands Restoration Project Waste Discharge Requirements Order No. R2-2012-0087 (SFRWQCB 2012).

a - Mercury concentration SF Bay TMDL threshold (= 99th percentile for San Francisco Bay [SFEI 2017]).

[b] - Total PCB concentration SF Bay TMDL threshold (= 99 percentile for San Francisco Bay [SFEI 2017]).

[J] - Analyte detected below the method reporting limit (MRL) and the reported value is therefore an estimate. All concentrations reported as being below the laboratory MDL are reported above as < the MDL.

[A] - Values exceeds Bay Background (RWQCB 1998), SF-DODS Database, or MWRP wetland cover screening value.

[B] - Value exceeds SF-Bay Bioaccumulation Trigger, or SF-Bay TMDL Threshold.

[C] - Value exceeds MWRP wetland foundation screening values

TABLE 4-5: MODIFIED ELUTRIATE TEST RESULTS

Analyte	Sample ID					Surface Water Discharge Screening Criteria[a]
	ML-DU1-Comp	**ML-DU2-Comp**	**ML-DU3-Comp**	**ML-DU4-Comp**	**ML-DU5-Comp**	
Dissolved Arsenic	7.31 J	14.0	19.9	15.7	17.4	69
Dissolved Cadmium	<1.28	<1.28	<1.28	<1.28	<1.28	42
Dissolved Chromium	<4.02	4.13 J	<4.02	4.09	<4.02	1100[b]
Dissolved Copper	11.7[A]	12.1[A]	11.8[A]	11.8[A]	11.0[A]	9.4[c]
Dissolved Lead	<0.90	<0.90	<0.90	<0.90	<0.90	210
Total Mercury	0.005	0.004	0.003	0.002	0.002	2.1
Dissolved Nickel	21.6	21.2	20.2	20.0	19.8	74
Total Selenium	32.4[A]	38.7[A]	37.8[A]	39.6[A]	39.9[A]	20[d]
Total Selenium**	<0.2	0.2 J	0.2 J	0.2 J	<0.2	20[d]
Dissolved Silver	<1.1	<1.1	<1.1	<1.1	<1.1	1.9
Dissolved Zinc	12.3 J	21.9 J	23.4 J	24.8 J	21.9 J	90
TSS	23	18	28	28	32	100

a - SFBRWQCB Basin Plan Water Quality Objective 1-hour Average. Source: 40 CFR Part 131.38 (California Toxics Rule or CTR), May 18, 2000, unless otherwise noted.

b - WQO is for Chromium VI; however, it may be met as total Chromium.

c - SFBRWQCB Basin Plan Amendment 2009. Applies to segments of the San Francisco Estuary north of the Hayward Shoals (line connecting Little Coyote Point and the Oakland Airport as shown in attached Figure 7.2.1-1 from the Basin Plan). South of this line, the 4-day continuous and 1-hr maximum objectives are 6.9 µg/L and 10.8 µg/L, respectively.

d - National Toxics Rule (NTR).

J - Analyte detected below the method reporting limit (MRL) and the reported value is therefore an estimate. All concentrations reported as being below the laboratory MDL are reported above as < the MDL.

A - Value exceeds surface water discharge screening value

** - Results of the follow-up test performed on 4/11/2018 to test the level of Selenium.

5. Dredging, Material Transfer, and Disposal Operation Options

There are three components that make up any dredging project: *1) Dredging, 2) Material Transport, a*nd *3) Disposal*. *Dredging* refers to the equipment and technique used to remove the sediment from the water bottom. With the material removed from the bed, the *Material Transport* component describes the method of transporting the dredged material from the dredging location to the disposal site. Finally, the *Disposal* component describes how the material is placed at the disposal site. The following paragraphs discuss the available options for each component for the dredging of Marina Lagoon.

5.1. Dredging Methodology

Dredging methodologies differ in equipment, technique, and material transportation. For dredging of Marina Lagoon, there exists two dredging options: hydraulic dredging and mechanical dredging. A description and analysis of how each can be used for Marina Lagoon is given in the subsequent paragraphs.

5.1.1. Hydraulic Dredging

Hydraulic Dredging involves the loosening of in-situ material and lifting it into suspension through a pipe system connected to a centrifugal pump. The sediment is pumped as a slurry consisting of approximately 75-85% water and 15-25% solids. The most common form of hydraulic dredging is using a cutterhead dredge, which includes a rotating cutter that excavates material. The material is then transported with a high velocity water flow using the dredge pump into a floating discharge line. Hydraulic dredge pumps can typically transport material for 8,000 to 10,000 feet. If the discharge location is located farther, booster pumps can be added along the discharge pipeline. Production rates for a small hydraulic dredge (as would be required for Marina Lagoon due to draft restrictions) is usually approximately 200-300 cubic yards/hour. An advantage to hydraulic dredging is that dredging only stops to move the dredge, resulting in a more time and cost efficient operation. Additionally, dredging accuracy is typically increased with hydraulic dredging. Concerns surrounding hydraulic dredging are due to fish, other water species, or debris potentially becoming entrained in the suction apparatus as well as water quality concerns from turbidity in the vicinity of the cutterhead.

The following options exist for the Material Transfer of hydraulically dredged material:

<u>5.1.1.1 Pump Directly to Disposal Site</u>

If the disposal site is located in close proximity to the hydraulic dredge, the slurry can be pumped directly into the site and decanted using water control structures. This option allows for the material to forgo being ‘rehandled’, or transported more than once. Containment structures would have to be constructed to contain the slurry until the water is decanted. This is typically the most cost effective option since the material is placed in its final destination directly after dredging. However, this option requires that the discharge pipeline have an unobstructed path to the disposal site, which, in highly developed areas such as the City of San Mateo and Foster City, may not be possible. It also required that the disposal site be in close proximity to the dredging area. Finally, since the material is transported as a slurry, there must be containment dikes constructed around the perimeter of the disposal site to contain the material. These dikes must be built with at least a 2 foot freeboard, which is defined as the distance between the top of the material placed within the disposal site and the levee crest elevation. Water control structures are also necessary to direct the water out of the disposal site.

5.1.1.2 Conventional Dewatering for Later Transport

If the disposal site of the material cannot be reached via discharge pipeline, an alternative is to create a settling pond where the material will be pumped and left to dewater. This option will also require containment dikes to contain the slurry and water control structures to guide the water out of the settling pond. The material would then be left to dry, with dozers turning the material periodically. The material will be left in the settling pond for months, or even years, until it has dried enough for the crew to return and loaded it into trucks for transport to the final disposal site.

5.1.1.3 High-Speed Dewatering System

A High-Speed Dewatering System receives slurry pumped from a hydraulic dredge into a dewatering unit that is capable of dewatering the sediment at the time of dredging. The end result is sediment that is ready for transport by trucks to its final disposal site and clean return water. The system utilizes a screen for coarse debris removal, a de-sanding unit for separation of sand, a flocculent control system which injects a polymer into the slurry to achieve flocculation, and fines recovery unit which allows the water to drain away from the flocculated, fine-grain sediment. Advantages of the dewatering unit include a quick dewatering system that produces transport-ready sediment significantly sooner than conventional dewatering, resulting in a faster dredging operation. After the material is dried in the dewatering unit, it is then either stockpiled for a few days to dry more or loaded directly into trucks and driven to the final disposal site.

A benefit of this system is that it requires much less space than would a settling pond, beneficial for highly urbanized areas, and the staging area requires minimal improvements since no dikes or water control structures are necessary. A disadvantage of the system is that it operates best with a constant stream of influent solids, therefore it is most efficient with a continuous operation. Because of the many homes surrounding the Lagoon, operating hours may be limited to daytime work and weekend work may be restricted. Another disadvantage is that mobilization and operating costs tend to be higher for this system than more traditional methods.

5.1.2. Mechanical Dredging

Mechanical dredging involves excavating material using a bucket connected to a clamshell dredge or small excavator mounted on a shallow draft barge. The material is dug from the bottom and placed on small scows, shallow draft barges, or a nearby site on land. The placement location must be within the length of the boom, usually no more than 120 feet away. Bucket sizes for removal of mud typically range from 10 to 54 cubic yards. Depending on the bucket size used, production rates for mechanical dredging range from approximately 350 to 800 cubic yards/hour. However, since mechanical dredges often place material on scows or barges that need to be transported and unloaded elsewhere, dredging is not continuous. Production rates, therefore, are dependent on the size and number of scows and barges used as well as the distance to the offloading site, but are generally slower than hydraulic dredging. Advantages of mechanical dredging include less water retention during dredging, ability to handle debris within dredged material, and maintaining soil benches so as not to compromise the integrity of bulkheads and other structures. Water quality issues also arise near the excavation site, but use of a removable silt curtain can contain the suspended solids.

Mechanically dredged material will need to be rehandled. Disposal options for mechanically dredged material include:

5.1.2.1 Offloaded from Scow to Disposal Site

If the final disposal site is in close proximity to the Lagoon, the material can be dredged and loaded onto scows or shallow draft barges. The scows or barges can then be transported by tugs to the disposal site where it will be offloaded using a crane. Containment dikes and water control structures would be necessary within the disposal site. An advantage of this method is that material will only need to be rehandled once between dredging and disposal. Disadvantages include a slow operating time since the scows will need to travel to the disposal site to be offloaded.

5.1.2.2 Offloaded into Rehandling Site and Dewatered, and Transport to End Use Site

The next option would also involve the dredged material being loaded onto scows or shall draft barges and pushed by tugs to a re-handling area. There, the material would be offloaded using a crane. The water would be directed to flow through filters to removed sediment before flowing back into the Lagoon. Once the material is stockpiled, cement or fly ash can be added to expedite the dewatering process. After sufficient dewatering, the sediment will be dry enough to be loaded onto trucks and transported to its final disposal site. A disadvantage to this alternative is that the material will be handled twice, once from the dredging site to the rehandling area, and then again via trucks from there to its final location. Each handling event will require more time, labor and equipment which will translate into a higher cost for dredging the material.

5.1.3. Mechanical Excavation 'In-the-Dry'

Mechanical excavation 'in-the-dry' refers to lowering the lagoon water level, building a haul road to allow for equipment to transverse the bottom, and utilizing a low-pressure excavator to remove the material. Since there are multiple storm drains, culverts and flow inlets located located along the perimeter of the Lagoon, it is not feasible to remove all water from the Lagoon. Therefore, a 'road' or elevated pathway would need to be constructed within the limits of the Lagoon to allow the mechanical excavator and trucks to reach the portions of the Lagoon to be dredged.

A portion of the operation could be conducted via long-reach excavators from the shoreline, but the road within the Lagoon would be required for the wider regions of the Lagoon. This technique has the advantage of producing nearly dry material immediately after dredging. Additionally, dredging precision is the highest for this option.

Material excavated with this option would be transported (see below) to a landfill via dump trucks.

5.1.3.1 Hauling Dredged Material by Truck

The only way to transfer dredged material from the lagoon with this option is to load into trucks and haul it to the disposal site or the re-handling area. For excavation done from the shoreline, the material would be stockpiled and loaded onto trucks for hauling. The trucks used for this portion of the work can carry about 12 cubic yards of material per load.

For excavators traversing the lagoon bottom, special low ground pressure trucks would transfer approximately 4-6 cubic yards of material per load to the re-handling area. It will require a large number of trucks to keep up with dredging production, which typically translates to higher costs.

6. Disposal Site Options

Multiple sites were initially identified for potential disposal of dredged material from Marina Lagoon. Options investigated include upland disposal sites, landfills, beneficial reuse areas, and in-lagoon disposal.

Ultimately, the results of the sediment testing dictate that the only two disposal options for the material are offsite landfill disposal or in-lagoon disposal. The in-Lagoon option will result in a small loss of recreational area but it provides a feasible and affordable placement option.

6.1. In-Lagoon Disposal

Potential areas identified within the Lagoon to deposit the dredged material are presented below:

- *Bird Island* – Bird Island is located within Marina Lagoon, approximately 225 feet south of the pump station and 250 feet west of Mariner's Island. The island is currently approximately 15,000 sq. feet (0.3 acres). It is not shown on the original dredging template (Figure 3-1), therefore, it is believed that the Island was created some time after the original dredging was performed. Presently, it is the location of Lagoon Island Park and serves for recreation and preservation of natural resources. Material could be placed here to increase the size of the Island for recreational purpose.
- *Creating a 'Wetland' along the Foster City Levee* – In this scenario, material would be dredged from within the center of the Lagoon and placed along the Foster City levee. A steel sheet pile wall would be built to contain the material. Since the dredged material contains contaminants above the San Francisco Bay trigger values, the material would be covered with an impermeable liner for separation and topped with clean material so as to completely 'cover' the dredged material. Marsh vegetation and wildlife would be allowed to inhabit the area and recreational traffic would be limited.
- *'Rabbit Ears' Surrounding Mariner's Island* – The benefit on placing material within the Rabbit Ear's is that very little steel sheet pile would be necessary to close off this area from the rest of the Lagoon. However, this area, similarly to Bird Island, is far from the majority of the dredging, which will require booster pumps or longer sail distances to reach. Additionally, it would remove the waterfront from the property owners living within Mariner's Island.
- *Creating an Upland Area near Laguna Vista Community* – The Laguna Vista Community is located along a bend in the southern reach of the Lagoon. The area just south of the community, enclosed by Hwy 101 and the walking trail, is an approximate 1.5 acre area of open space. Filling and capping the area directly next to it to create a larger area of open space is proposed as a potential in-lagoon disposal site. Advantaged of utilizing this area is the close proximity to the majority of the dredging. Disadvantages include the limited amount of capacity and the loss of waterfront property for a portion of the Laguna Vista Community.

After further evaluation and discussions with the City, only the Fringe Marsh, eastern 'Rabbit Ear', and the area near Laguna Vista remained as potential in-Lagoon disposal options. The locations of these areas as well as potential volume capacity is presented in Figure 6-1. The potential volume capacity is based on the elevation to which the infill is placed. For the Rabbit's Ear, potential fill elevations range from 97 feet SMD to 103 feet SMD. The volumes depicted are for fill elevations of

97 feet SMD and 98 feet SMD as building higher than this could impact the Foster City Levee. The maximum disposal at the southern upland area near Laguna Vista is for a fill elevation similar to that of the surrounding areas, approximated as 104 feet SMD.

6.2. Off-Site Disposal

The results of the sediment testing and analysis imply that the material is only suitable for disposal at a landfill. There are potential upland uses if that material is properly contained and capped, however, no such uses are known in close proximity to the project at this time. For this exercise, it is assumed the material is taken to Ox Mountain Sanitary Landfill in Half Moon Bay, approximately 12 miles from the project area.

FIGURE 6-1: POTENTIAL IN-LAGOON DISPOSAL AREAS AND VOLUMES

7. Regulatory Considerations

Dredging and disposal within the San Francisco Bay Area is regulated by the Dredged Material Management Office (DMMO), a joint program between the San Francisco Bay Conservation and Development Commission (BCDC), San Francisco Bay Regional Water Quality Control Board (RWQCB), State Lands Commission (SLC), the San Francisco District U.S. Army Corps of Engineers (USACE), and the U.S. Environmental Protection Agency (EPA). Additionally, consultation with the California Department of Fish and Wildlife (CDFW), National Marine Fisheries Service (NMFS), and the U.S. Fish and Wildlife Service (USFWS) is performed through the DMMO process. This interagency group was created to streamline the process of obtaining authorization for dredging and disposal projects from each member agency.

Additionally, dredging and disposal projects are regulated under the California Environmental Quality Act (CEQA), which requires that state and local agencies identify the significant environmental impacts and, if feasible, avoid or mitigate those impacts. The anticipated process of obtaining these authorizations as well as the potential implications of these regulatory considerations are discussed in the subsequent paragraphs.

7.1. Regulatory Considerations for Dredging

All dredging activity within the San Francisco Bay Area must undergo the DMMO process. The first step of the process involves developing a Sediment Analysis Plan (SAP) to be approved by the DMMO committee. The SAP will outline the proposed sampling and testing of the sediment to be dredged. The extent of sampling and testing will be based on factors such as area and volume quantity as well as the proposed disposal site. This plan must be approved by the DMMO prior to initiating the work. Once the plan has been approved, the sampling and testing may be conducted and summarized in the Sediment Analysis Results (SAR) Report. Depending on whether or not there are significant findings in the sediment testing, the DMMO will approve the report, request additional testing, or deny the request for use of a particular disposal site or methodology. In addition to the sediment characterization and analysis, the following information must be submitted to the DMMO for authorization:

1. Dredged Volume Calculations;
2. Project Drawings and Maps;
3. Proof of Legal Interest;
4. Statement of Consistency;
5. Environmental Document (CEQA Notice of Exemption);
6. Organizational Document;
7. Small Dredger Programmatic Alternatives Analysis (SPDAA);
8. List of Adjacent Landowners;
9. Location of State Lands Parcels within Project Footprint (if any).

Because the template of the proposed dredging is within the template originally dredged, this dredging event would be considered 'maintenance' dredging. Since this area was permitted for dredging before, the DMMO would additionally request a copy of all past permits issued for the previous dredging event.

Additionally, this project would fall under the CEQA Categorical Exemption § 15304 for Minor Alterations of Land. Therefore, for the dredging portion of this work, no additional CEQA documentation will be required.

The dredging work will also need to obtain a Lake and Streambed Alteration Agreement (LSA) from CDFW which requires a project description, project maps and drawings, and information on the effects on sensitive species. A fee is also associated with this application which is determined based on the cost of the project and project life.

7.2. Regulatory Considerations for Disposal

Disposal sites are typically included in the DMMO and LSA applications as described in Section 7.1. However, the location of the disposal site will influence the CEQA documentation necessary. If the material is taken to a landfill, no permits for disposal will be necessary.

8. Alternatives Analysis

An alternatives analysis was conducted to examine different options for the City to meet its objectives of improving water quality, stormwater retention capacity, and recreational use of the Lagoon. The alternatives encompass a range of dredging volumes, dredging methods, transport and processing options, and disposal locations. Criteria used to formulate alternatives consisted of the following:

a) Prioritize dredging of areas where deeper water depths would benefit navigation and water quality;

b) Consider land ownership, presence of docks, and material quality to identify disposal sites;

c) To determine minimum dredging volume, consider the high mobilization costs that are typical of such an operation and spread the costs over a large enough volume;

d) Assume dredging would be performed in the summer season when the water level is high (to allow floating equipment to operate);

e) Consider production rates of dredging such that work can be accomplished in one summer season (except for the full lagoon alternative, which will require two seasons);

f) Consider the high costs of double-handling dredged material to take it to an offsite landfill, and maximize in-lagoon disposal.

The goal of the analysis presented in this section was to identify potential 'projects' that can be implemented by the City, which achieves the primary objectives of increasing water depths within Marina Lagoon. The following alternatives have been evaluated:

TABLE 8-1: PROJECT ALTERNATIVES EVALUATED

Alternative	Name	Description	Volume Removed
Alternative 1	No Action	Allow sedimentation to continue within the Lagoon	-
Alternative 2	**Large Project**	Entire Lagoon is dredged to 91 SMD	275,000 CY
Alternative 3	**Medium Project**	Only the problem areas that are of immediate concern are dredged	100,000 CY
Alternative 4	**Small Project**	Only the area south of Lakeshore Park, near the intakes from Belmont Slough, is dredged	77,500 CY
Alternative 5	**Scalable Project**	Portions of the lagoon are incrementally dredged over several years funding, and to limit environmental impacts associated with a large dredging project	Up to 275,000 CY

For each of these project alternatives, dredging methodology, material transfer, and disposal location and operations, as described in Sections 5 and 6, were evaluated. Details of construction activity were assumed to determine high level cost estimates for implementation of each project alternative and dredging and disposal methodology combination. Each alternative was compared based on performance criteria which includes stormwater retention capacity, water depth, and reduction of treatment area.

8.1. Alternative 1: No Action

This alternative examines the benefits and consequences of taking 'No Action' to remove the sedimentation that has occurred within the Lagoon. Sedimentation has resulted in a loss of approximately 30 acre-feet of stormwater retention capacity and 77% of the recreational areas with water depths at or greater than 6 feet since the original construction in 1965. The decreased water depths have also resulted in poorer water quality, with approximately 70 acres of the original 172 has less than 3 feet of water depth during the winter months. This corresponds to approximately 41% of the Lagoon no longer having the depths to achieve good water quality.

Sedimentation of the Lagoon is expected to continue. If 'No Action' is taken, then the Lagoon will continue to shoal at an approximate rate of 0.25 inches/year. This corresponds to approximately 5,781 cubic yards of sediment entering the Lagoon. Based on this rate and assuming the material is dispersed evenly within the Lagoon, the entire Lagoon will experience loss of water depths at approximately 1 foot every 48 years.

Continued shoaling will lower the Lagoons stormwater retention capacity. Additionally, sedimentation will decrease recreational depths and increase areas needing water quality treatment further. Similarly to the southern-most reach of the Lagoon, more areas will have to be cordoned off from recreational activity due to shallow depths and more area will need to be treated annually. Indirect effects of this could lead to the Lagoon being considered a less desirable place to live and spend time around.

Benefits of the 'No Action' Alternative 1 would be no financial burden on the City of San Mateo or the residents. Recreation would not need to be suspended for any period of time for construction.

8.2. Alternative 2: Large Project – Dredge Entire Lagoon to 91'

Alternative 2 restores the Lagoon to similar conditions as the original design template. This alternative includes dredging the entire Lagoon to its design depth of 91 SMD, which requires the largest footprint, largest dredged material volume, largest dredging area, and provides the most benefit to the City. The template proposed for this alternative is slightly different from that originally constructed. An offset of 45 feet from the summer high water line (97 SMD) was added so that no dredging would occur in the vicinity of the dock piles or boat ramps built by adjacent land owners.

This alternative, shown in , has a total dredged material volume of 275,000 cubic yards and a dredging footprint of 131 acres. Reduction of treatment areas, stormwater retention capacity, and water depth for recreation will all benefit from this alternative.

8.2.1. Dredging and Disposal Options

This volume of sediment would require a 10-acre area to be filled to approximately 17 feet. Because this area is not available in close proximity to the Lagoon, this alternative examines hydraulically dredging and pumping into a High-Speed Dewatering System before trucking the material to a landfill as the only available dredging and disposal option. Table 8-2 presents the cost estimate for this alternative. Due to the large volume of dredging and trucking, the project duration is two summer seasons.

TABLE 8-2: COST ESTIMATE FOR ALTERNATIVE 2

(275,000 CY, hydraulic dredging + high-speed dewatering + landfill disposal)

Item	Description	Quantity	Units	Unit Price	Bid Total
1	Mobilization & Demobilization	2*	Lump Sum	$1,700,00.00	$3,400,000.00
2	Dredge and Dry Material	275,000	Cubic Yards	$65.00	$17,875,000
3	Load, Haul, Dispose of Material	275,000	Cubic Yards	$77.00 – $230.00**	$21,175,000 – $63,250,000
				Total Bid:	**$42,450,000 – $84,525,000**
				Project Duration:	**Two Summers**

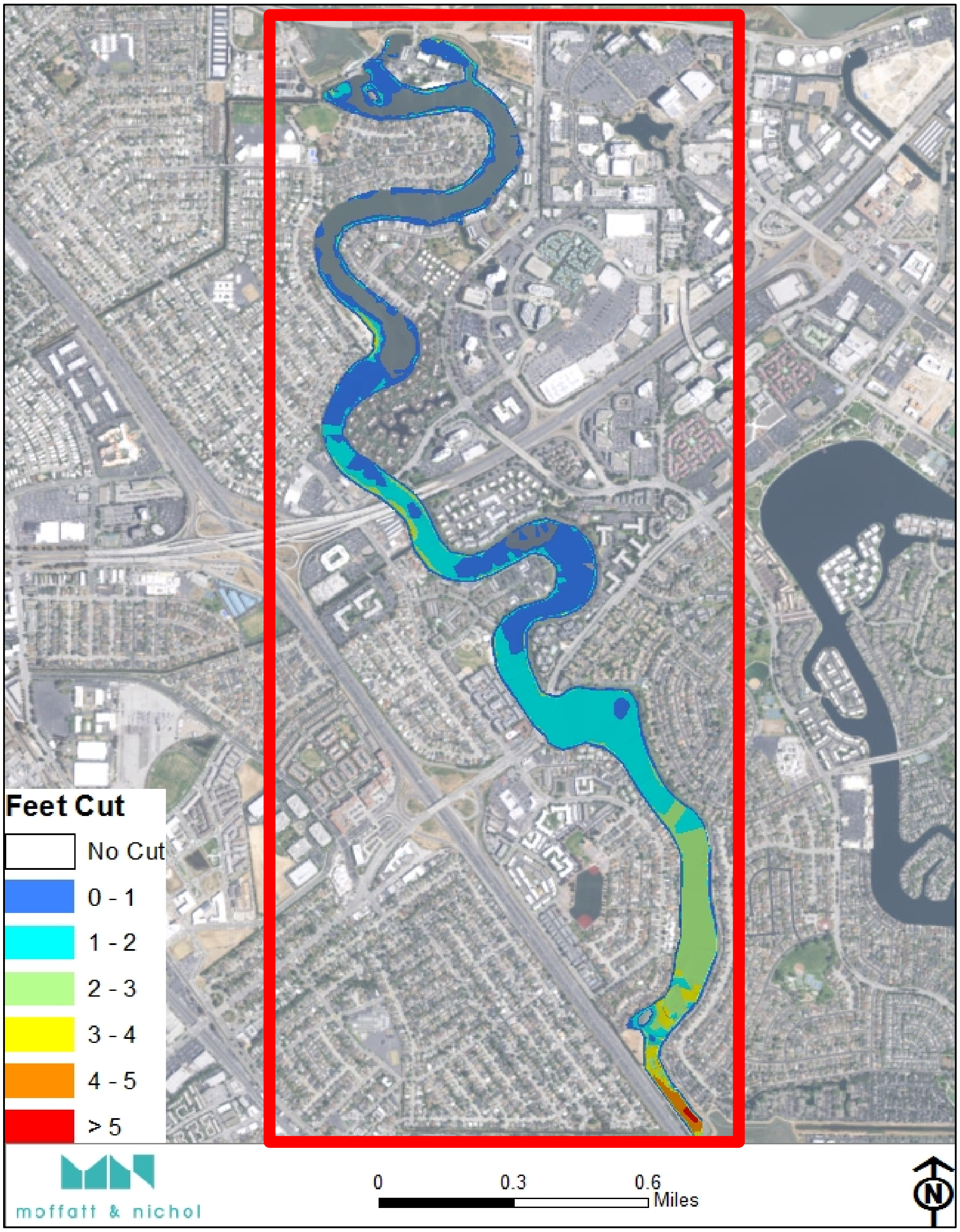
* Total cost based on 2 mobilization and demobilization events since work will be done in 2 summer seasons.

** Minimum unit price based on acceptance of material at Ox Mountain Sanitary Landfill. Maximum price based on railing material to alternative landfill.

A dredging and drying production rate of 100 CY/hr was assumed for an 8 hour work day. It was also assumed that loading and hauling the material could operate at the same speed as the production rate. The unit cost of $65 per cubic yard incorporates the additional operation to clarify the return water from the Dewatering Unit given the contaminants found in the material. The Load, Haul, and Dispose of Material unit cost of $77.00 per cubic yard includes the increased tipping fee associated with Ox Mountain Landfill when accepting contaminated material. Since it is unknown at the time of this study if the material is acceptable for disposal at Ox Mountain, a unit cost of $230.00 per cubic yard was used as the maximum estimated cost per cubic yard if the material would have to be railed or hauled to a distant landfill. To determine acceptance of material, Ox Mountain will need to be provided with the sediment chemistry conducted for this project. Additionally, they may require additional tests to assess the leaching potential of the material.

In-Lagoon placement of material is not feasible for this alternative given the large volume of sediment to be removed. Mechanical dredging cannot be used in conjunction with a high-speed dewatering system since the dewatering system requires a continuous flow of slurry into the system. Mechanically dredging the entire Lagoon in-the-dry is also not feasible given that the construction would take years to complete.

FIGURE 8-1: ALTERNATIVE 2 DREDGING AREA



8.3. Alternative 3: Medium Project – Dredge 'Problem Areas' and Place In-Lagoon

Alternative 3 is proposed to decrease the size and scope of the project. Many areas within the Lagoon have been identified as needing water quality treatment and having insufficient water depths to meet the needs of the City and Lagoon users. Therefore, Alternative 3 was developed to address just these areas.

The alternative combines different areas and dredged templates to achieve a dredged material volume of approximately 100,000 cubic yards. This quantity allows consideration of different dredging methodology and options for disposal locations. The areas that are considered as problematic in the Lagoon, shown in Figure 8-2, and the proposed templates for dredging them are:

- Area South of Lakeshore Park – Dredge Area to 92 feet SMD;
- Area near Pump Station – Dredge Area to 91 feet SMD;
- Area under Hwy 92 Bridge – Dredge Area to 91 feet SMD

Though not as significant as Alternative 2, this project would provide both reduction in treatment areas and recreational depth benefits. Depths in the southern reaches of the Lagoon would be increased to 5 feet during the summer and 3 feet during the winter months. The area under the Hwy 92 bridge would be increased to 6 feet in the summer and 4 feet in winter. The deeper water depths near Lakeshore Park would reduce the need for water quality treatment in those areas.

The volume of material removed for this alternatives is approximately 102,400 CY, with 77,500 CY being removed south of Lakeshore Park, 5,100 CY dredged near the pump station, and 19,800 CY dredged from under the Hwy 92 Bridge. The dredging footprint is approximately 83 acres.

8.3.1. Dredging and Disposal Options

For disposal of the 100,000 CY of material, a 10-acre site would require fill to approximately 6 feet. This area is available within the Lagoon. At least two of the In-Lagoon disposal areas described in Section 6.1 would be utilized for this alternative. It is anticipated that the most likely areas would be the 'Rabbit's Ear' disposal site and the 'Wetland' along the eastern shoreline. Two methods for dredging and disposal have been evaluated as part of this alternative.

8.3.1.1. Alternative 3A: Hydraulically Dredge and Pump to Disposal

The first alternative involves using a hydraulic dredge and pumping the material to the disposal site. Since pumping long distances (usually greater than one mile) requires the use of booster pumps, it was assumed that the material dredged near the pump station and under the Hwy 92 bridge would be pumped to the Rabbit's Ear disposal site. The material from the southern reach of the Lagoon would be pumped to the Wetland disposal site. Alternatively, if the area near the pump station is not dredged, the material dredged from the Hwy 92 Bridge crossing and the southern reach of the Lagoon could be placed within the Wetland disposal site and the 'Upland' area. No booster pumps would be needed for this alternative.

The estimated construction costs for this alternative is presented in Table 8-3. A steel sheetpile wall is required to contain the material within the disposal site. Because of the contamination of the material, the material within the disposal site must be capped with a layer of clean soil. Crews and equipment are assumed to operate for 8 hours per day.

TABLE 8-3: COST ESTIMATE FOR ALTERNATIVE 3A

(100,000 CY, hydraulic dredging + conventional dewatering + in-Lagoon disposal)

Item	Description	Quantity	Units	Unit Price	Bid Total
1	Mobilization & Demobilization	1	Lump Sum	$448,000.00	$448,000
2	Furnish and Install Containment Structures	89,400	Square Foot	$55.00	$4,917,000
3	Dredge & Pump Material to Disposal	100,000	Cubic Yards	$41.00	$4,100,000
				Total Bid:	**$9,465,000**
				Project Duration:	**One Summer**

8.3.1.2. Alternative 3B: Mechanically Dredge and Transport Material in Barges

Another option for dredging the Lagoon is to use a mechanical dredge mounted on a flexi-float and shallow draft barges to transport the material to the In-Lagoon disposal sites. Dredging would begin in deeper water so that the dredge could dig the appropriate draft for the barges when working in the shallower regions. The barges would then be transported along the Lagoon pushed by a tug to the designated disposal site, where another mechanical dredge mounted on a barge would be positioned to offload the material from the barge into the disposal site.

The estimated construction costs for this alternative are presented in Table 8-4.

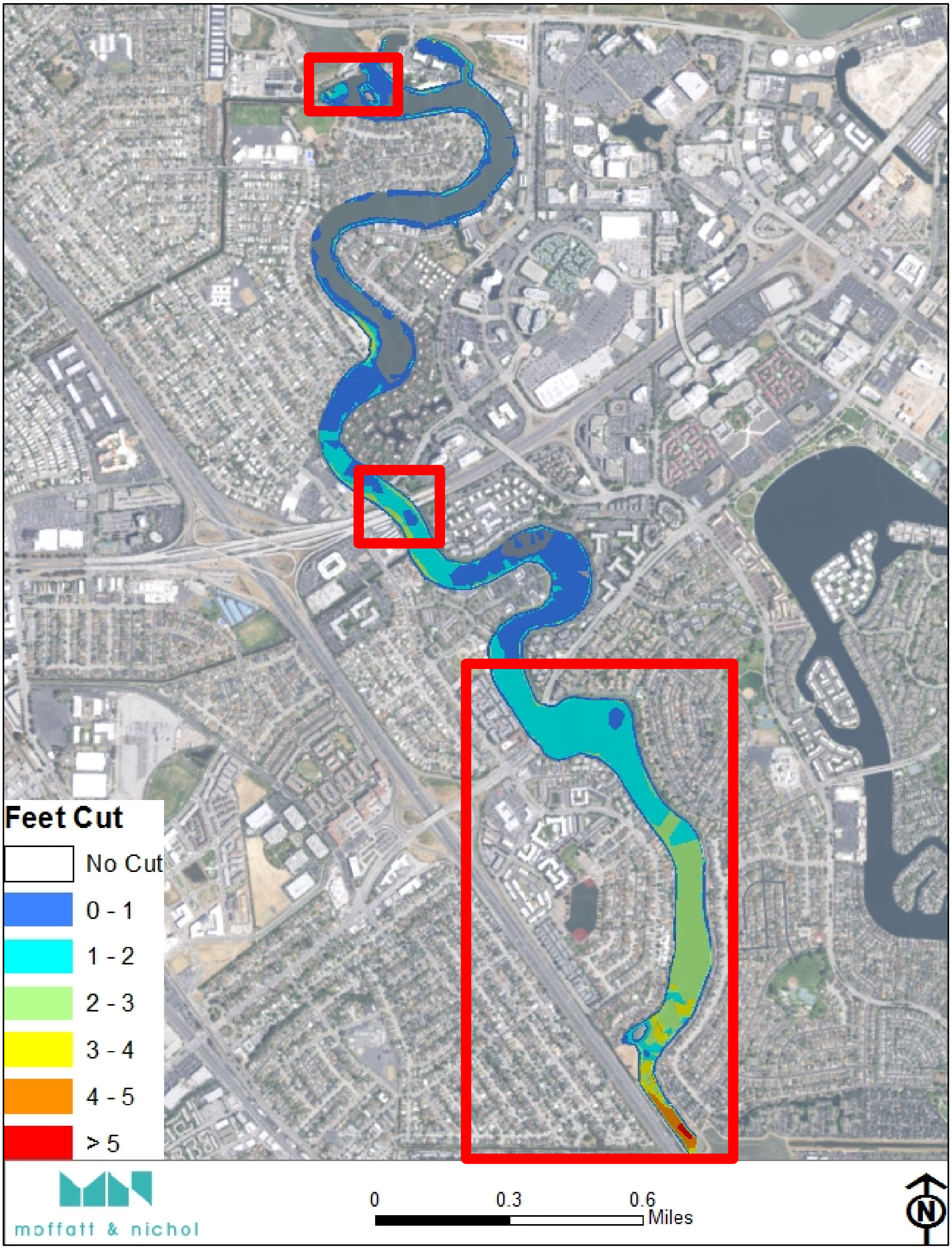
TABLE 8-4: COST ESTIMATE FOR ALTERNATIVE 3B

(100,000 CY, mechanical dredging + conventional dewatering + in-Lagoon disposal)

Item	Description	Quantity	Units	Unit Price	Bid Total
1	Mobilization & Demobilization	1	Lump Sum	$448,000.00	$448,000
2	Furnish and Install Containment Structures	89,400	Square Foot	$55.00	$4,917,000
3	Dredge, Haul, and Unload	100,000	Cubic Yards	$43.00	$4,300,000
				Total Bid:	**$9,665,000**
				Project Duration:	**One Summer**

Assumptions for this estimate are similar to those for Alternative 3A.

FIGURE 8-2: ALTERNATIVE 3 DREDGING AREA



8.4. Alternative 4: Dredge Area South of Lakeshore Park to 92'

Alternative 4 proposes only dredging the southern reach of the Lagoon to a bottom depth of 92 feet SMD. This alternative not only has the lowest volume quantity but also concentrates the work to a small, localized footprint. Since dredging costs quickly escalate when material must be pumped or transported by barge long distances, this alternative is designed to reduce costs by keeping the work in one area within the Lagoon.

This alternative, shown in Figure 8-3, will provide recreational benefits and reduce treatment areas in the southern reach of the Lagoon, where the majority of the siltation has occurred. The volume of dredged material to remove from this reach is approximately 77,500 CY with a footprint of 67 acres.

8.4.1. Dredging and Disposal Options

Disposal of 77,500 CY of material would require a 10-acre site to be filled with approximately 5 feet of dredged material. Because this area is not available, the following sections discuss the dredging and disposal of the material utilizing three potential methodologies and available disposal sites.

8.4.1.1. Alternative 4A: Mechanically Excavate 'Dry' Lagoon, Rehandling, Landfill Disposal

Unlike the other project alternatives, Alternative 4 has all the dredging occurring in one local area. This makes mechanically excavating the Lagoon 'in-the-dry' a feasible option. If the water was initially pumped out of the Lagoon, a road for which an excavator and trucks to haul off the material could be constructed along the bottom of the Lagoon. It is anticipated that the road would be constructed on one side of the Lagoon while the excavator removed material from the other side. A filter fabric would be placed along the bottom of the Lagoon to prevent the vehicles from getting stuck in the soft mud. The cost estimated to perform this alternative is presented in Table 8-5:

TABLE 8-5: COST ESTIMATE FOR ALTERNATIVE 4A

(77,500 CY, mechanical dredging + conventional dewatering + landfill disposal)

Item	Description	Quantity	Units	Unit Price	Bid Total
1	Mobilization & Demobilization	1	Lump Sum	$952,000.00	$ 952,000
2	Dredge, Haul and Unload	77,500	Cubic Yards	$90.00	$ 6,975,000
3	Load, Haul, Dispose of Material	77,500	Cubic Yards	$77.00 - $230.00*	$ 1,890,000 – $17,670,000
				Total Bid:	**$13,875,000 – $25,597,000**
				Project Duration:	**One Summer**

* Minimum unit price based on acceptance of material at Ox Mountain Sanitary Landfill. Maximum price based on railing material to alternative landfill.

Trucks would drive up to the dredge and be loaded. However, given that the material would still be too wet for transport to the landfill, the material would then be taken to another location where it would be left for a short time to dry before being loaded into the trucks for final transport to the landfill. Since the material requires approximately two days of drying, it was assumed that approximately one third of an acre would be required if the material was stacked to four feet high. This would require approximately four low ground pressure vehicles making four trips an hour from the dredge to the drying area. The approximate 1.5 acre area south of Laguna Vista Community could be utilized for this drying area.

8.4.1.2. Alternative 4B: Hydraulically Dredge and Dewater with a High Speed Dewatering System, Landfill Disposal

Similar to Alternative 2, this reach of Lagoon would be hydraulically dredged and the material pumped to a High-Speed Dewatering System to dry before hauling to a landfill. The dewatering unit would be staged in the area enclosed by the Bay Trail and Hwy 101 (south of Laguna Vista Community) so as to minimize pumping distance. Conversation with high-speed dewatering system contractors indicated that the unit requires approximately 1 acre for staging. If the 1.5 acre area south of Laguna Vista Community is used as the staging area, this would leave approximately ½ an acre for storage and loading of the material onto the truck and driven to the landfill. The schedule assumes an average production rate of 100 cy/hour and 40 truck trips per day. The cost estimate for this alternative is presented in Table 8-6.

TABLE 8-6: COST ESTIMATE FOR ALTERNATIVE 4B

(77,500 CY, hydraulic dredging + high speed dewatering + landfill disposal)

Item	Description	Quantity	Units	Unit Price	Bid Total
1	Mobilization & Demobilization	1	Lump Sum	$1,585,000.00	$1,585,000
2	Dredge, Haul and Unload	77,500	Cubic Yards	$65.00	$5,037,500
3	Load, Haul, Dispose of Material	77,500	Cubic Yards	$77.00 – $230.00*	$5,890,000 – $17,670,000
				Total Bid:	**$ 12,512,500 – $24,292,500**
				Project Duration:	**One Summer**

* Minimum unit price based on acceptance of material at Ox Mountain Sanitary Landfill. Maximum price based on railing material to alternative landfill.

8.4.1.3. Alternative 4C: Hydraulically Dredge and Place in the Lagoon

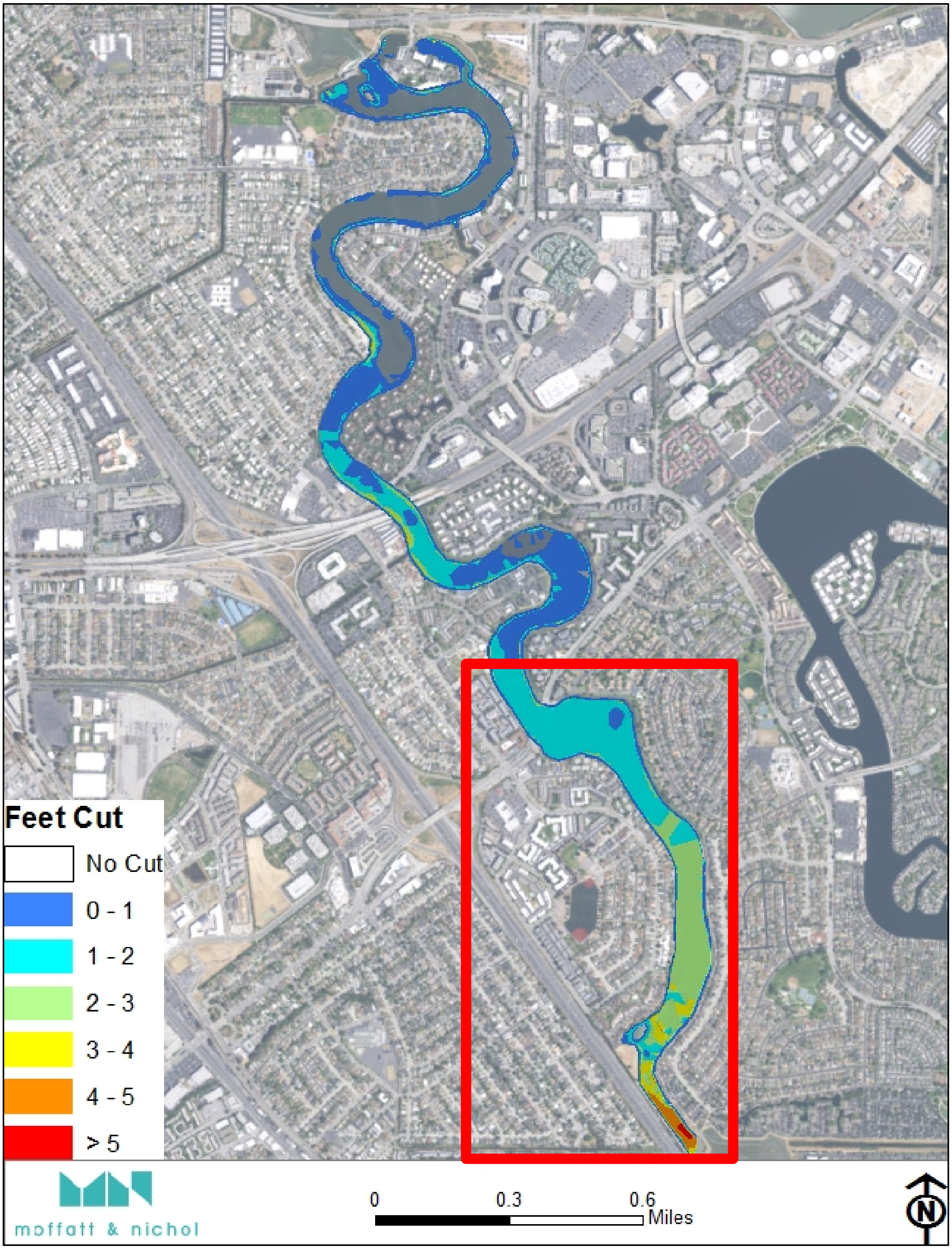
Since this alternative is a subset of Alternative 3, hydraulically dredging and placing the material within the Lagoon is also a viable option. Construction activities would be similar to those described in Alternative 3A. The cost estimate for this alternative is presented in Table 8-7.

TABLE 8-7: COST ESTIMATE FOR ALTERNATIVE 4C

(77,500 CY, hydraulic dredging + conventional dewatering + in-Lagoon disposal)

Item	Description	Quantity	Units	Unit Price	Bid Total
1	Mobilization & Demobilization	1	Lump Sum	$448,000.00	$448,000
2	Furnish and Install Containment Structures	89,400	Square Foot	$55.00	$4,917,000
3	Dredge & Pump Material to Disposal	77,500	Cubic Yards	$42.00	$3,255,000
				Total Bid:	**$8,620,000**
				Project Duration:	**One Summer**

FIGURE 8-3: ALTERNATIVE 4 DREDGING AREA



8.5. Alternative 5: Dredge Material and Place in Rehandling Site within the Lagoon

Alternative 5 was developed as a multi-year approach to achieve the objectives of the project. Over the course of several years, the Lagoon would be dredged and material placed within 'Rehandling' sites. Once in the rehandling site, the material would be left to dry until it can be loaded and hauled to a landfill at a later date.

The benefits, along with the project size and total costs, is scalable. It is estimated that the maximum dredged material in one year would be approximately 55,000 yd^3. This option may not decrease total project cost, however, it would eliminate a very large initial cost. Additionally, the areas used for rehandling could be reconnected to the Lagoon system once the dredging is over or they could serve as future disposal/rehandling sites for maintenance events.

8.5.1. Dredging and Disposal Options

Dredging and disposal options for this alternative are similar to those of Alternative 3.

8.5.1.1. Alternative 5A: Hydraulically Dredge and Place for Rehandling within the Lagoon

This option would function similarly to the Alternative 3A. However, once the material has been given an opportunity to dry (approximately one year), it would be dug again and placed in trucks for disposal offsite. The City could alternate each year between dredging and hauling the material, thereby phasing the project over many years until the desired template is reached.

Costs for this alternative can be estimated based on the item costs developed for Alternatives 3A and 3C.

8.5.1.2. Alternative 5B: Mechanically Dredge and Place for Rehandling within the Lagoon

All dredging operation for this option would be conducted similarly to the Alternative 3B described in Section 8.3.1.2. Since mechanically dredged material is usually much dryer than hydraulically dredged material, which must be mixed with water into a slurry for pumping, it will not require the amount of time to dry as would be necessary for the hydraulically dredged material. Therefore, rehandling and transport to its final destination can occur sooner for this option.

Costs for this alternative can be estimated based on the item costs developed for Alternatives 3B and 4B.

Mechanically excavating the Lagoon in-the-dry was not investigated for this alternative because the cost and regulatory considerations of pumping out the Lagoon and building a road multiple times over the course of several years would make this option infeasible. Additionally, the large mobilization and demobilization cost of the High-Speed Dewatering System would not be viable to incur several times over the course of many years.

8.6. Alternatives Comparison

The following alternatives matrix compares the alternatives and dredging and disposal options based on three performance criteria, which determine how well each project reaches the objectives of the City and is used to gauge how well the alternative performs. Table 8-8 summarizes how each alternative compares for reduction in treatment area, recreational depth, and stormwater retention capacity. The values presented for each alternatives depict the improvement in acres or acre-feet that can be anticipated with implementation of the alternative.

The table shows that each alternative either meets or exceeds the performance criteria for water quality and recreational depth. Alternative 2 provides the greatest water quality, recreational depth benefits, and stormwater retention capacity, however, at a significant increase in project cost. Since stormwater retention capacity has not been significantly affected by the sedimentation that has occurred with the Lagoon, Alternative 2 will only slightly improve stormwater retention capacity. For Alternatives 3a and 3b, a small amount of stormwater retention capacity will be lost due to in-lagoon disposal. For Alternative 4a and 4b, the location and limits of dredging are small enough that it does not result in any stormwater retention capacity benefit. For Alternative 4c, a small amount of stormwater retention capacity will be lost due to in-lagoon disposal.

Alternative 2 has the largest construction cost for the project. Hauling the sediment to a landfill will present less permitting challenges but uses of the Lagoon will be disrupted for a period of two summer seasons, and there will be a significant amount of truck trips through City streets over those two seasons. The significant costs associated with this alternative may deem it impractical.

Alternative 3 provides cost savings by disposing the material very close to the dredging area. Permitting issues may arise given the contamination of the material. Additionally, the residents along the Lagoon may object to the loss of Lagoon area and waterfront property.

Alternative 4a and 4b would present fewer environmental and landowner concerns as the material will be hauled away. However, this typically accompanies an increase in price. Disposal in-lagoon for 4c will present similar challenges as Alternative 3.

Since Alternative 5 is a scalable project, there are not enough details defined to quantify the benefits to reduction in treatment area, recreation depth or stormwater retention capacity. However, since rehandling will take place in the rehandling sites, both the environmental concerns and public perception challenges are anticipated to be similar to Alternatives 3 and 4c. Unit cost are anticipated to be increased for the entire completion of the project since phasing the work will require multiple mobilization and demobilization events, however, this increased cost will be distributed over the course of several years.

TABLE 8-8: ALTERNATIVES MATRIX

Project				**Performance Criteria**		
Alternative	Dredging Method	Transport Method	Disposal Site	Water Quality Improvement	Recreation Benefits	Stormwater Retention
Alternative 1: No Action Volume - 0 CY	N/A	N/A	N/A	No Change	No Change	No Change
Alternative 2: Large Project Volume - 275,000 CY	Hydraulically Dredge	Dewatering System and Hauling	Landfill	71 Acres	118 Acres	50 Acre-Ft
Alternative 3: Medium Project Volume - 100,000 CY	3.a) Hydraulically Dredge	Pumping to Disposal	In-Lagoon	67 Acres	83 Acres	-20 Acre-Ft
	3.b) Mechanically Dredge	Barge Transport to Disposal	In-Lagoon	67 Acres	83 Acres	-20 Acre-Ft
Alternative 4: Small Project Volume - 77,500 CY	4.a) Mechanically Dredge 'Dry' Lake	Hauling to Disposal	Landfill	25 Acres	45 Acres	No Change
	4.b) Hydraulically Dredge	Dewatering System and Hauling	Landfill	25 Acres	45 Acres	No Change
	4.c) Hydraulically Dredge	Pumping to Disposal	In-Lagoon	25 Acres	45 Acres	-20 Acre-Ft
Alternative 5: Phased Project Scalable	5.a) Hydraulically Dredge & Rehandle	Pump to Storage; Haul to Disposal	Storage In-Lagoon; Disposal in Landfill		*Scalable*	
	5.b) Mechanically Dredge & Rehandle	Barge Transport to Storage; Haul to Disposal	Storage In-Lagoon; Disposal in Landfill		*Scalable*	

9. Summary and Conclusions

The sediment analysis resulted in only two viable disposal options for the material dredged from Marina Lagoon – in-Lagoon disposal or hauling the material to a landfill. The benefits of in-Lagoon placement include disposing of the material in close proximity to the dredging site, which reduces transportation cost, does not require material drying prior to disposal, and allows for lesser re-handling of the material, which also translates to lower costs. The material may be dredged either hydraulically or mechanically for this disposal option. Some consequences for disposal of material within the Lagoon are a slight decrease in stormwater retention capacity, potential negative public perception due to loss of water bottom and shoreline, and the construction of permanent structures within the Lagoon to contain the material in the designated disposal areas.

If the material is to be removed from the Lagoon, the only current option for disposal is a landfill. This disposal option will likely result in fewer environmental impacts which will facilitate obtaining regulatory permits, provide an increase in stormwater retention capacity (albeit small), water quality benefits associated with deeper water depths, and no loss of lagoon areas for recreation. However, the material needs to be dewatered and loaded onto trucks for landfill disposal, which will entail approximately 40-50 trucks/day through City streets in the summer season. Since the Lagoon is located in a highly-urbanized area with no available parcels of land large enough to accommodate conventional dewatering, a high-speed dewatering system will be necessary for drying of the material. Though the high-speed dewatering system requires less space than conventional dewatering, it will still require 1-2 acres of land for staging of the equipment along with queuing and loading of trucks. The use of the high-speed dewatering system is substantially more expensive than conventional dewatering and requires a hydraulic connection to the Lagoon for return of treated effluent.

Given these high costs for all alternatives, it may be prudent for the City to focus their efforts on strategic dredging of areas where water quality concerns due to shallow depths are high. This could be, for example, a small amount of dredging prior to water quality treatments performed each year. If this is coupled with operational changes in lagoon water management, where pumps are operated more frequently to reduce the residence time of the lagoon waters, it is possible that some of the water quality concerns could be mitigated.

10. References

1. CA Department of Boating and Waterways (1991). *Layout and Design Guidelines for Small Craft Berthing Facilities*.

2. Moffatt & Nichol (1998). *Marina Lagoon Preliminary Dredging Assessment*. Prepared for the Department of Public Works, City of San Mateo.

3. Moffatt & Nichol (2015). *South Bay Salt Pond Restoration Project – Beneficial Reuse Feasibility Study*. Prepared for the Coastal Conservancy. January 2015.

APPENDIX A
Dredging Plan Cross Sections

NOTES:

1. FOR DETAILED INFORMATION NOT SHOWN ON THIS DRAWING, SEE XX.
2. CROSS SECTIONS ARE SHOWN LOOKING TOWARDS INCREASING STATION.

LEGEND:

XX

XX

20' 0' XX' XX

SCALE: 1"=XX'

IF SHEET IS LESS THAN 22" x 34" IT IS A REDUCED PRINT – SCALE REDUCED ACCORDINGLY.

REVISION	DESCRIPTION	BY	DATE

moffatt & nichol

2185 N. California Blvd., Suite 500
Walnut Creek, CA 94596

DSGN JAF/AJ | DR AJ | CHK XX

JOB NO. 9825 | Plans Reviewed and Approved by: /s/, City Engineer

MARINA LAGOON DREDGING ASSESSMENT

DATE 09/14/17

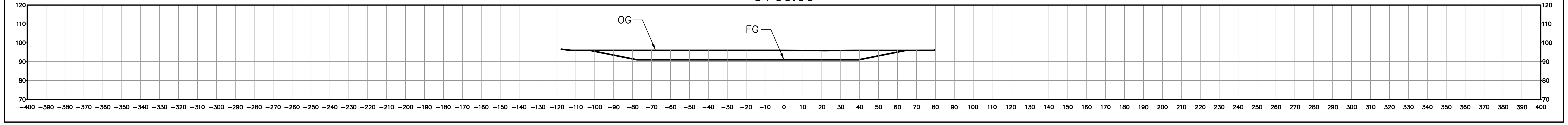
SHEET 1 OF 8

MARINA LAGOON CROSS SECTIONS

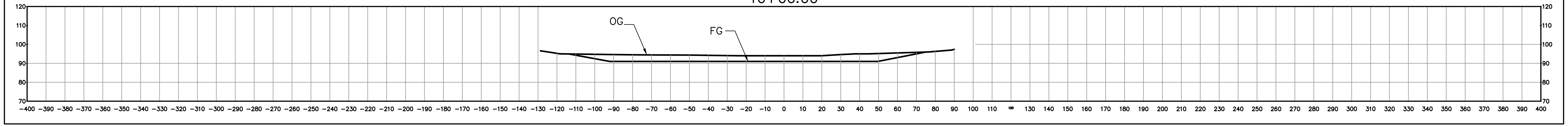
01

\\mne.net\projects\WC\9825 Marina Lagoon Dredging Assessment\4_CADD\Working\982500_Csheets_REV.dwg Sep 14, 2017 - 7:48am

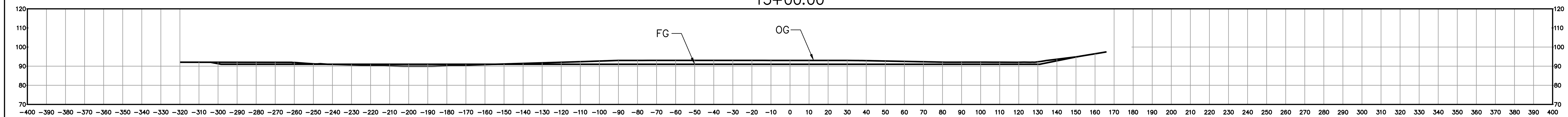
5+00.00



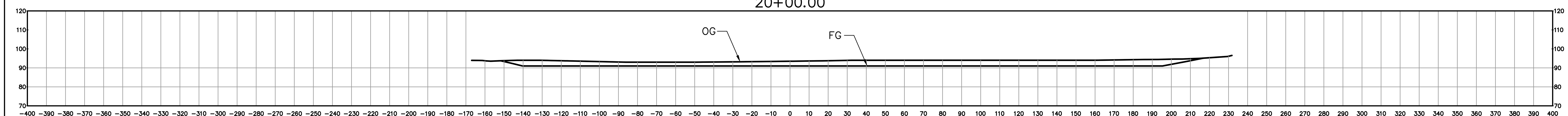
10+00.00



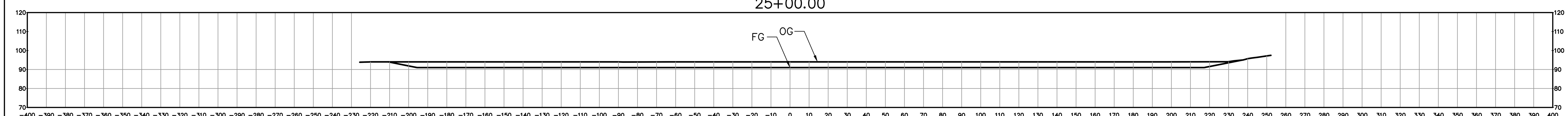
15+00.00



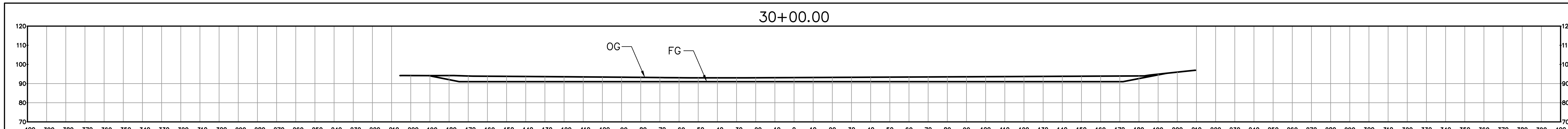
20+00.00



25+00.00



30+00.00



NOTES:

1. FOR DETAILED INFORMATION NOT SHOWN ON THIS DRAWING, SEE C12.
2. CROSS SECTIONS ARE SHOWN LOOKING TOWARDS INCREASING STATION.

LEGEND:

XX

XX

30' 0' 30' 60'

SCALE: 1"=30'

IF SHEET IS LESS THAN 22" x 34" IT IS A REDUCED PRINT – SCALE REDUCED ACCORDINGLY.

REVISION	DESCRIPTION	BY	DATE

moffatt & nichol

2185 N. California Blvd., Suite 500
Walnut Creek, CA 94596

DSGN JAF/AJ | DR AJ | CHK XX

JOB NO. 9825 | Plans Reviewed and Approved by: /s/, City Engineer

MARINA LAGOON DREDGING ASSESSMENT

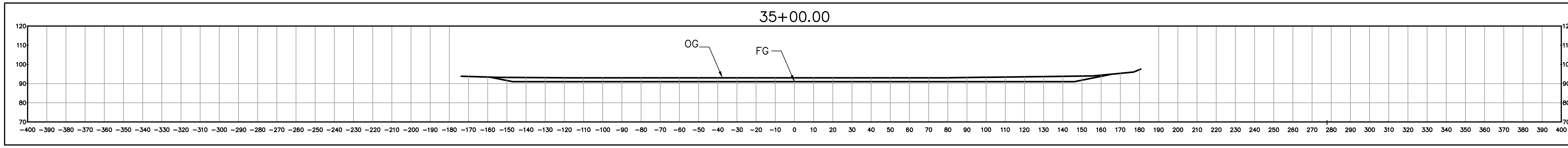
MARINA LAGOON CROSS SECTIONS

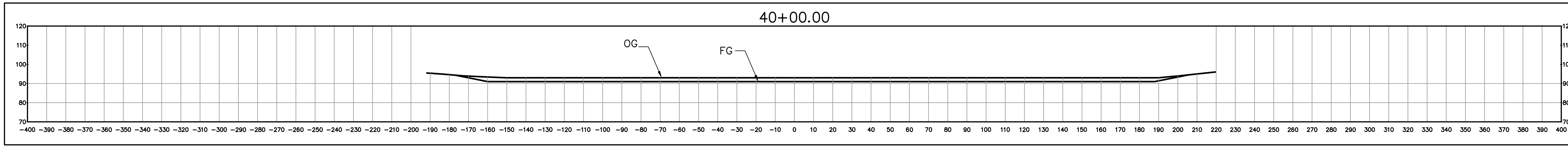
DATE 09/14/17

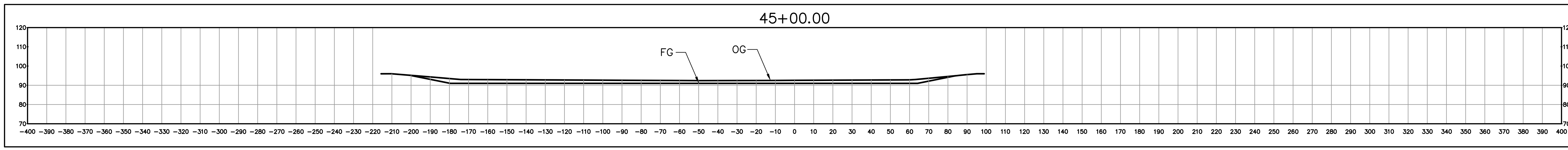
SHEET 2 OF 8

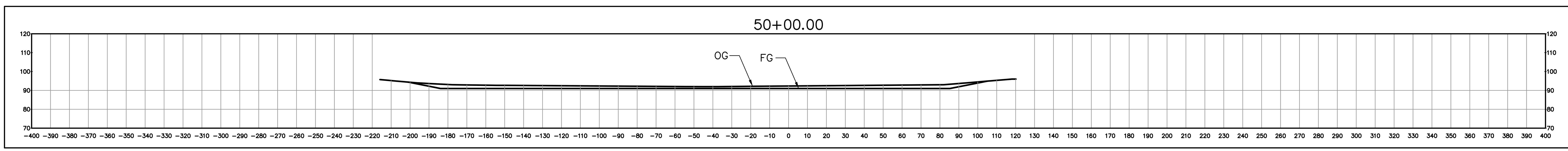
02

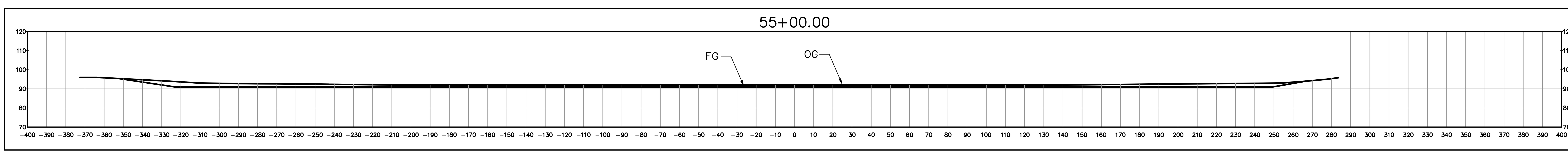
\\mne.net\projects\WC\9825 Marina Lagoon Dredging Assessment\4_CADD\Working\982500_Csheets_REV.dwg Sep 14, 2017 – 8:07am

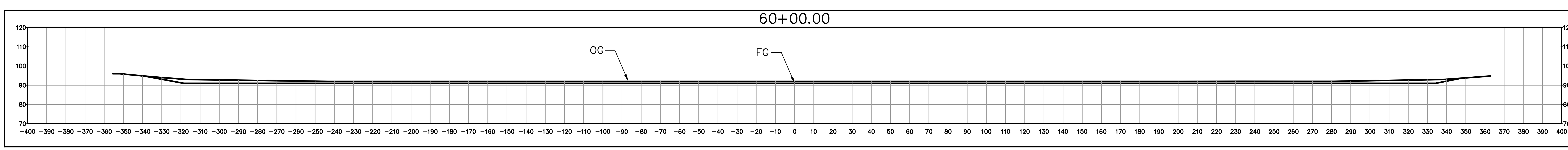












NOTES:

1. FOR DETAILED INFORMATION NOT SHOWN ON THIS DRAWING, SEE C12.
2. CROSS SECTIONS ARE SHOWN LOOKING TOWARDS INCREASING STATION.

LEGEND:

XX

XX

20' 0' 30' 60'

SCALE: 1"=30'

IF SHEET IS LESS THAN 22" x 34" IT IS A REDUCED PRINT – SCALE REDUCED ACCORDINGLY.

REVISION	DESCRIPTION	BY	DATE

moffatt & nichol
2185 N. California Blvd., Suite 500
Walnut Creek, CA 94596

DSGN JAF/AJ | DR AJ | CHK XX
JOB NO. 9825 | Plans Reviewed and Approved by: /s/, City Engineer

MARINA LAGOON DREDGING ASSESSMENT

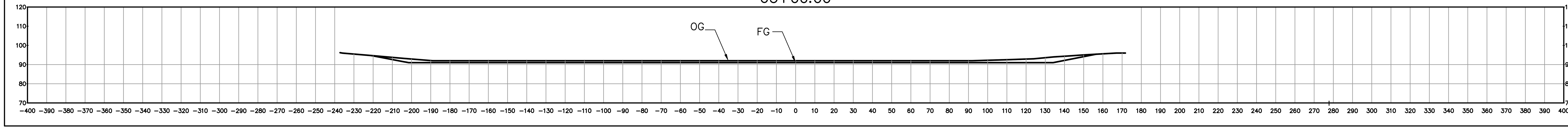
MARINA LAGOON CROSS SECTIONS

DATE 09/14/17

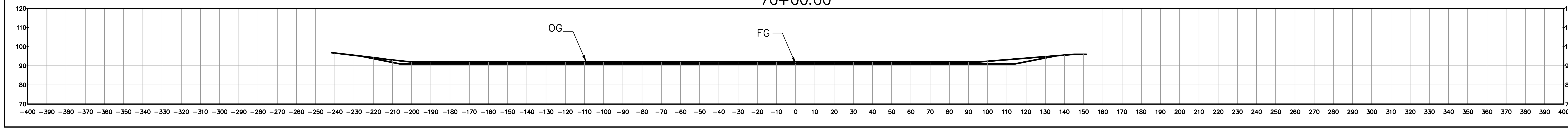
SHEET 3 OF 8

03

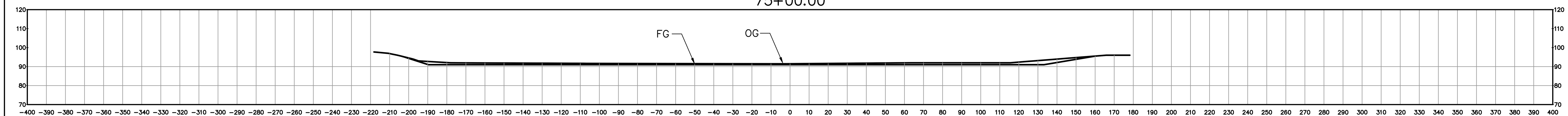
65+00.00



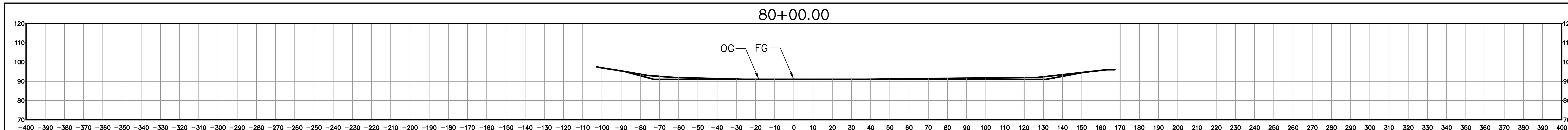
70+00.00



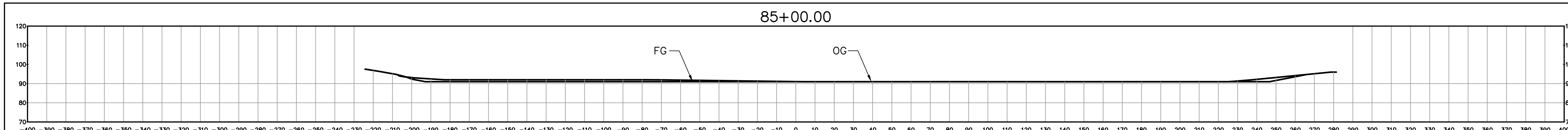
75+00.00



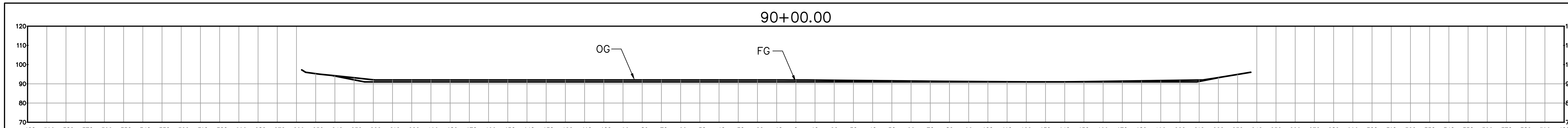
80+00.00



85+00.00



90+00.00



NOTES:

1. FOR DETAILED INFORMATION NOT SHOWN ON THIS DRAWING, SEE C12.
2. CROSS SECTIONS ARE SHOWN LOOKING TOWARDS INCREASING STATION.

LEGEND:

XX

XX

20' 0' 30' 60'
SCALE: 1"=30'

IF SHEET IS LESS THAN 22" x 34" IT IS A REDUCED PRINT – SCALE REDUCED ACCORDINGLY.

REVISION	DESCRIPTION	BY	DATE

moffatt & nichol
2185 N. California Blvd., Suite 500
Walnut Creek, CA 94596

DSGN JAF/AJ | DR AJ | CHK XX
JOB NO. 9825 | Plans Reviewed and Approved by: /s/, City Engineer

MARINA LAGOON DREDGING ASSESSMENT

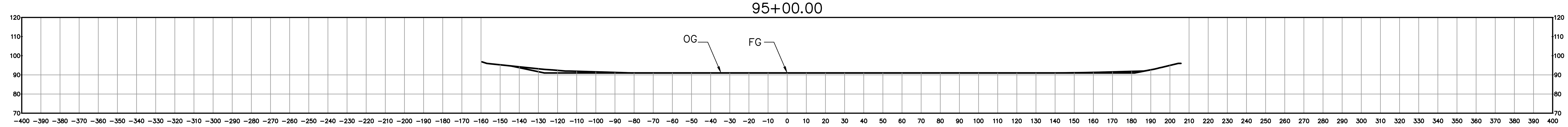
MARINA LAGOON CROSS SECTIONS

DATE 09/14/17

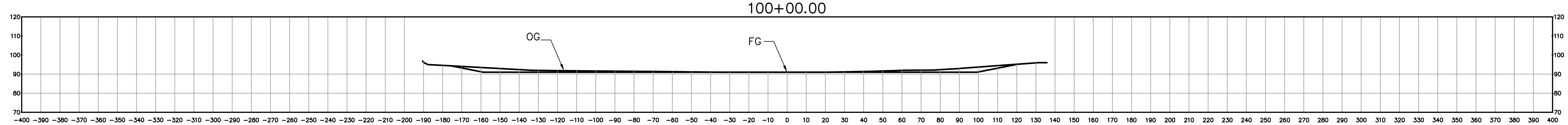
SHEET 4 OF 8

04

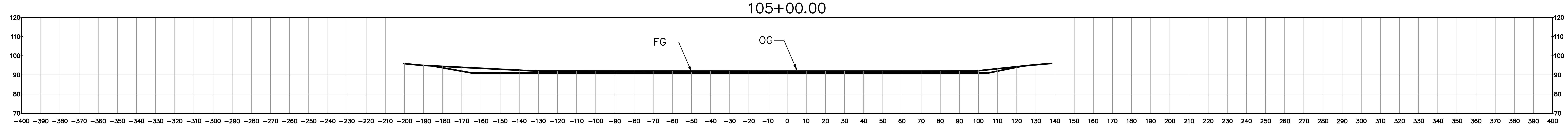
95+00.00



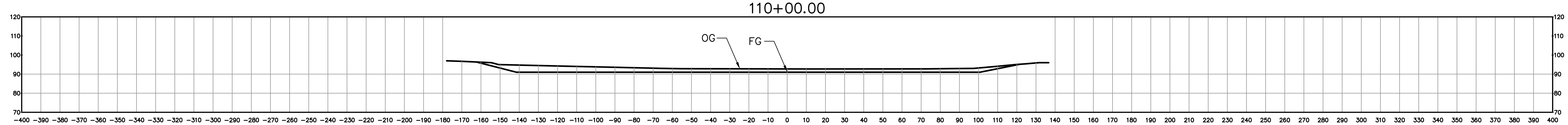
100+00.00



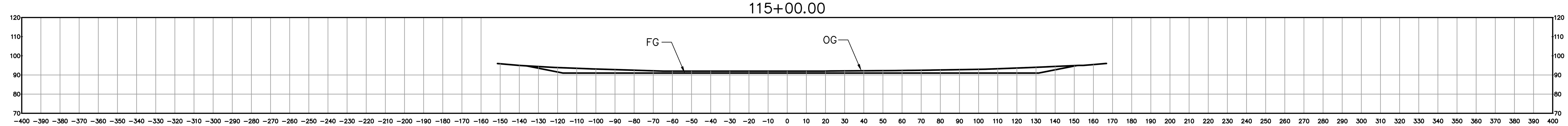
105+00.00



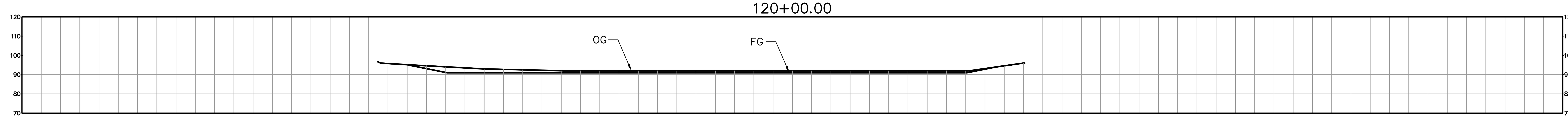
110+00.00



115+00.00



120+00.00



NOTES:

1. FOR DETAILED INFORMATION NOT SHOWN ON THIS DRAWING, SEE C12.
2. CROSS SECTIONS ARE SHOWN LOOKING TOWARDS INCREASING STATION.

LEGEND:

XX

XX

20' 0' 30' 60'

SCALE: 1"=30'

IF SHEET IS LESS THAN 22" x 34" IT IS A REDUCED PRINT – SCALE REDUCED ACCORDINGLY.

REVISION	DESCRIPTION	BY	DATE

moffatt & nichol

2185 N. California Blvd., Suite 500
Walnut Creek, CA 94596

DSGN JAF/AJ | DR AJ | CHK XX

JOB NO. 9825 | Plans Reviewed and Approved by: /s/, City Engineer

MARINA LAGOON DREDGING ASSESSMENT

MARINA LAGOON CROSS SECTIONS

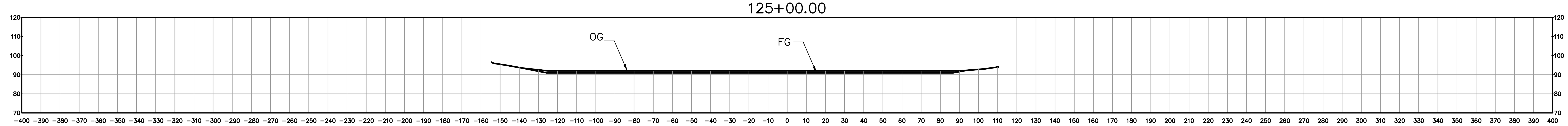
DATE 09/14/17

SHEET 5 OF 8

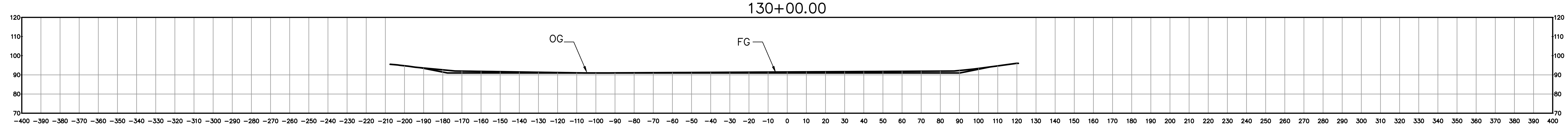
05

\\mne.net\projects\WC\9825 Marina Lagoon Dredging Assessment\4_CADD\Working\982500_Csheets_REV.dwg Sep 14, 2017 – 8:16am

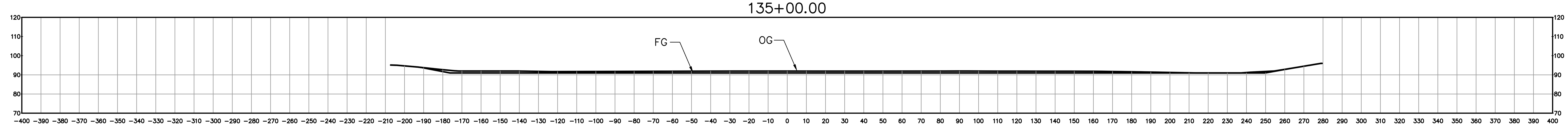
125+00.00



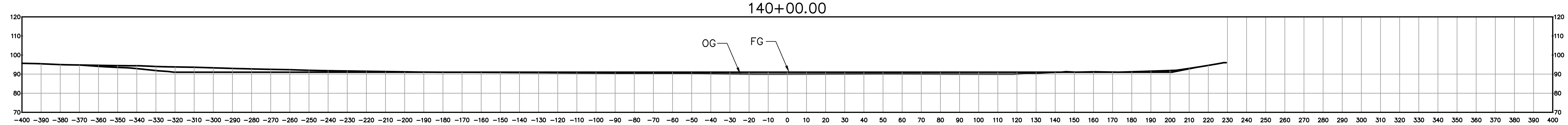
130+00.00



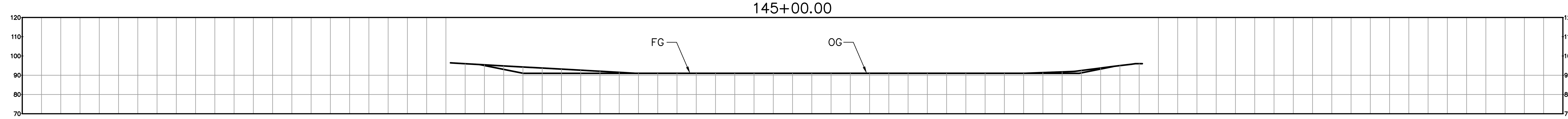
135+00.00



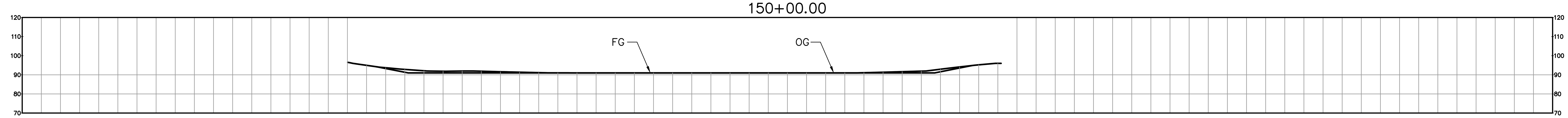
140+00.00



145+00.00



150+00.00



NOTES:

1. FOR DETAILED INFORMATION NOT SHOWN ON THIS DRAWING, SEE C12.
2. CROSS SECTIONS ARE SHOWN LOOKING TOWARDS INCREASING STATION.

LEGEND:

XX

XX

SCALE: 1"=30'

IF SHEET IS LESS THAN 22" x 34" IT IS A REDUCED PRINT – SCALE REDUCED ACCORDINGLY.

REVISION	DESCRIPTION	BY	DATE

moffatt & nichol
2185 N. California Blvd., Suite 500
Walnut Creek, CA 94596

DSGN JAF/AJ | DR AJ | CHK XX
JOB NO. 9825 | Plans Reviewed and Approved by: /s/, City Engineer

MARINA LAGOON DREDGING ASSESSMENT

MARINA LAGOON CROSS SECTIONS

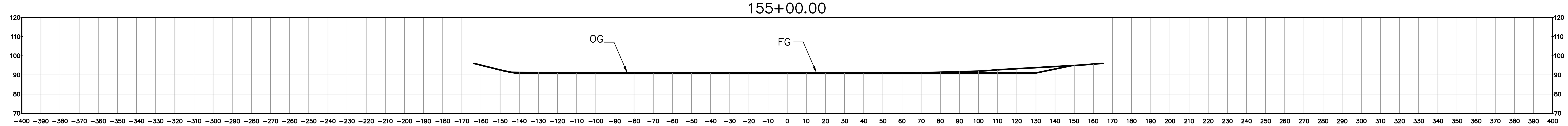
DATE 09/14/17

SHEET 6 OF 9

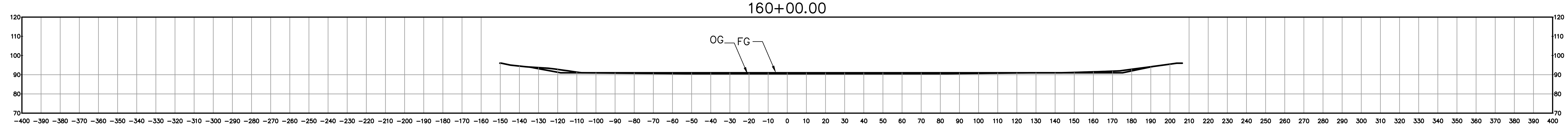
06

\\mne.net\projects\WC\9825 Marina Lagoon Dredging Assessment\4_CADD\Working\982500_Csheets_REV.dwg Sep 14, 2017 - 7:35am

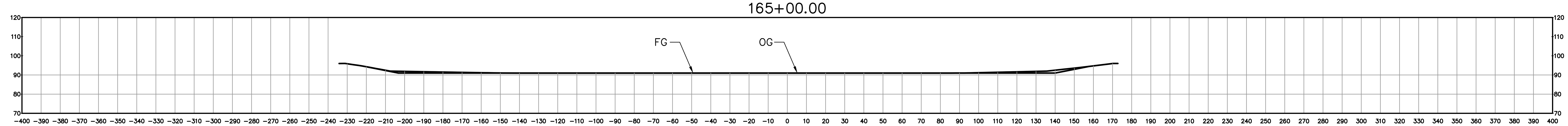
155+00.00



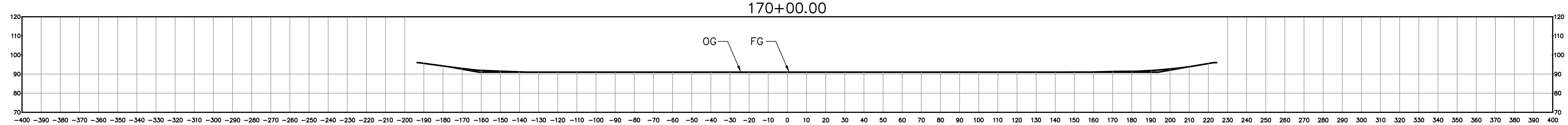
160+00.00



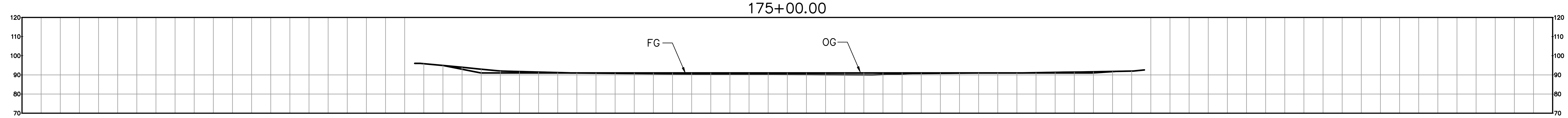
165+00.00



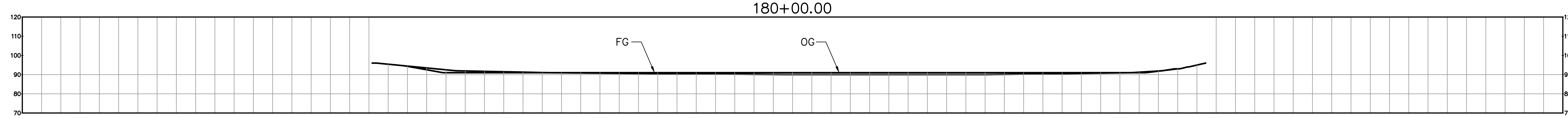
170+00.00



175+00.00



180+00.00



NOTES:

1. FOR DETAILED INFORMATION NOT SHOWN ON THIS DRAWING, SEE C12.
2. CROSS SECTIONS ARE SHOWN LOOKING TOWARDS INCREASING STATION.

LEGEND:

XX

XX

30' 0' 30' 60'

SCALE: 1"=30'

IF SHEET IS LESS THAN 22" x 34" IT IS A REDUCED PRINT – SCALE REDUCED ACCORDINGLY.

REVISION	DESCRIPTION	BY	DATE

moffatt & nichol

2185 N. California Blvd., Suite 500
Walnut Creek, CA 94596

DSGN JAF/AJ | DR AJ | CHK XX

JOB NO. 9825 | Plans Reviewed and Approved by: /s/, City Engineer

MARINA LAGOON DREDGING ASSESSMENT

MARINA LAGOON CROSS SECTIONS

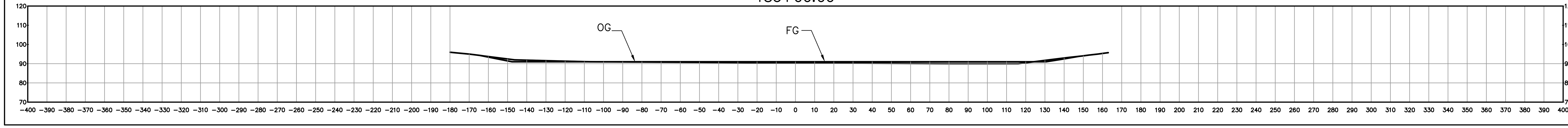
DATE 09/14/17

SHEET 7 OF 8

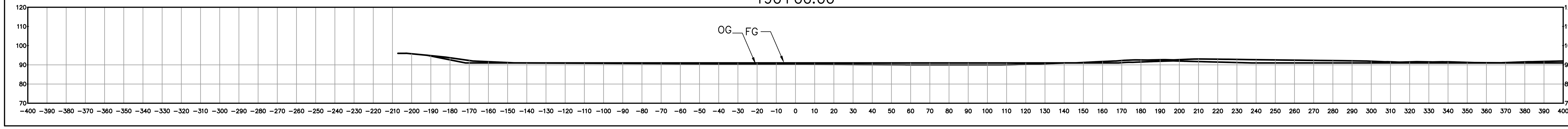
07

\\mne.net\projects\WC\9825 Marina Lagoon Dredging Assessment\4_CADD\Working\982500_Csheets_REV.dwg Sep 14, 2017 - 8:22am

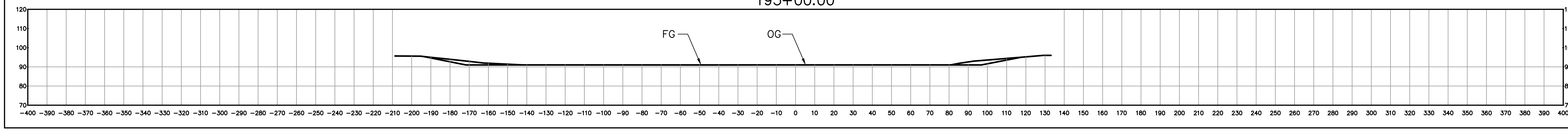
185+00.00



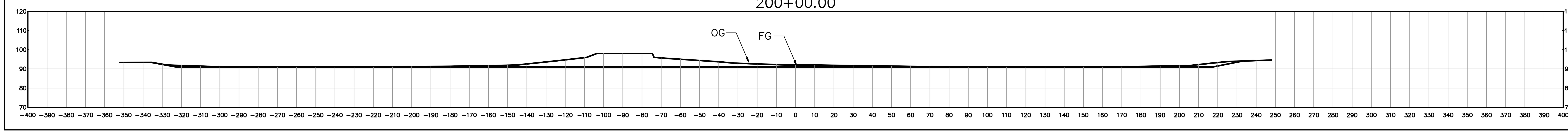
190+00.00



195+00.00



200+00.00



NOTES:

1. FOR DETAILED INFORMATION NOT SHOWN ON THIS DRAWING, SEE C12.
2. CROSS SECTIONS ARE SHOWN LOOKING TOWARDS INCREASING STATION.

LEGEND:

XX

XX

30' 0' 30' 60'

SCALE: 1"=30'

IF SHEET IS LESS THAN 22" x 34" IT IS A REDUCED PRINT – SCALE REDUCED ACCORDINGLY.

REVISION	DESCRIPTION	BY	DATE

moffatt & nichol

2185 N. California Blvd., Suite 500
Walnut Creek, CA 94596

DSGN JAF/AJ	DR AJ	CHK XX
JOB NO. 9825	Plans Reviewed and Approved by: /s/, City Engineer	

MARINA LAGOON DREDGING ASSESSMENT

MARINA LAGOON CROSS SECTIONS

DATE 09/14/17

SHEET 8 OF 8

08