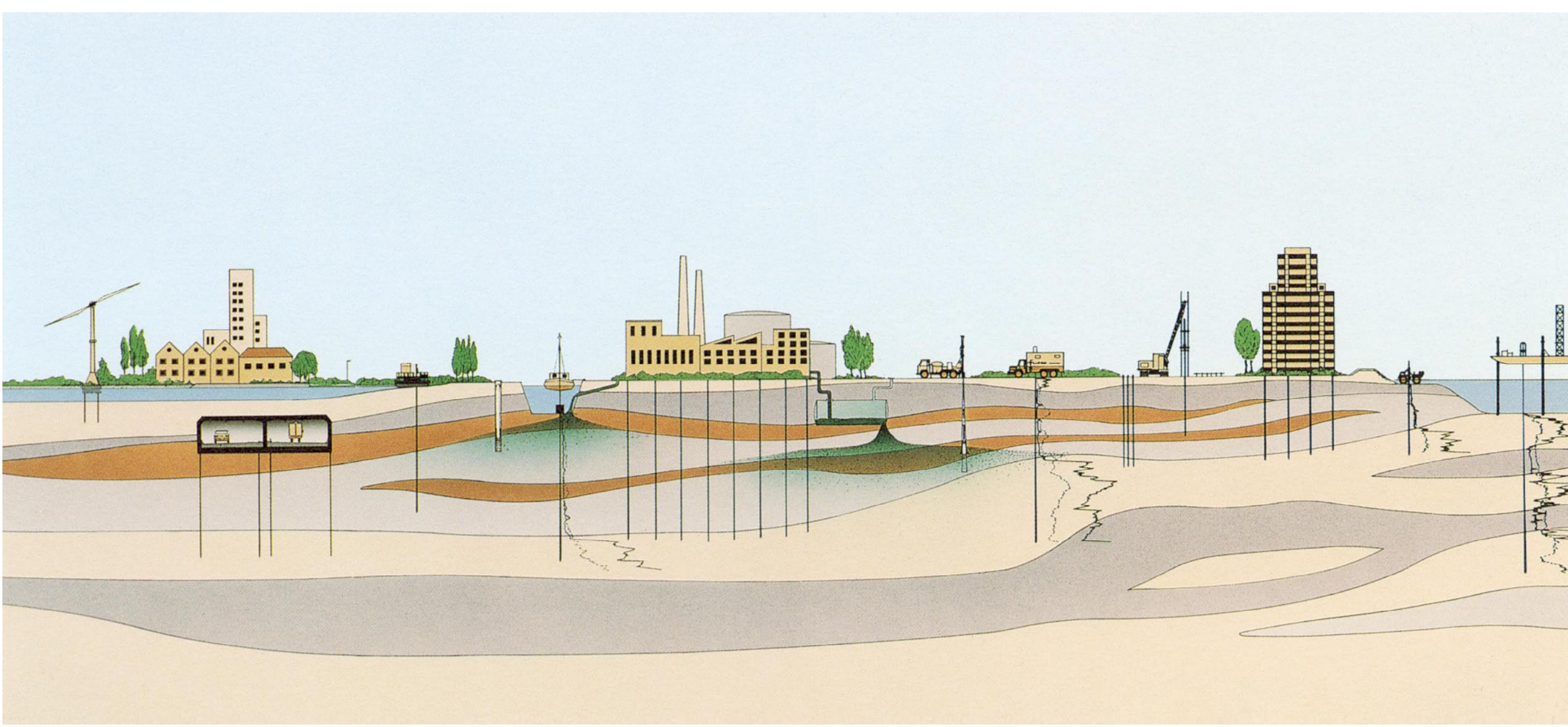
FUGRO WEST, INC.

FINAL
GEOTECHNICAL STUDY
CHANNEL DEEPENING PROJECT
PORT OF LOS ANGELES, CALIFORNIA

Prepared for:
UNITED STATES ARMY CORPS OF ENGINEERS

April 2002



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April 30, 2002
Project No. 01-32-0633

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Attention: Mr. Christopher Sands, G.E.

FINAL GEOTECHNICAL STUDY REPORT
CHANNEL DEEPENING PROJECT
PORT OF LOS ANGELES, CALIFORNIA

Dear Mr. Sands:

We are pleased to submit this final geotechnical study report for the proposed Channel Deepening Project. Task Order 0002 of Agreement DACW09-00-D-0023 between the U.S. Army Corps of Engineers and Fugro West, Inc., provided authorization for this geotechnical study. Work on the study included the review of existing data for the site, the integration of geotechnical and geophysical data, and dialogue with the project designer team to characterize the stratigraphic conditions that underlie the various waterways of the Inner Harbor.

On behalf of Fugro and the project team, we appreciate the opportunity to provide our services on this unique and interesting project, and look forward to our continued association with you and the Port of Los Angeles. Please contact us if you have questions or comments regarding this report and/or the Channel Deepening Project.

Sincerely,

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EXECUTIVE SUMMARY

Fugro West, Inc. (Fugro), has completed geophysical and geotechnical studies of the various waterways in the Inner Harbor of the Port of Los Angeles (POLA) to support the Channel Deepening Project. The studies were conducted to document and evaluate the types and in situ physical characteristics of geologic materials present beneath the waterways.

The first component of Fugro's study included a detailed review of existing geological and geotechnical data sources. Field and laboratory data, in combination with the geophysical results and factual information contained in various existing data sources (including Fugro's geotechnical evaluation report [1997c]), were used to re-evaluate and refine the interpreted shallow subsurface conditions throughout the Inner Harbor. The subsurface exploration data were integrated with the geophysical data gathered by Fugro in 2001. Based on the stratigraphic interpretation and anticipated material types, eight native dredge units have been established in the Inner Harbor for the Channel Deepening Project: CG-1 through CG-4, FG-1 through FG-3, and FM-1.

Four of the eight dredge units (i.e., CG-1 through CG-4) cover about 265 acres of the Inner Harbor and are underlain (within the planned dredge depths) primarily by native coarse-grained sediments that are considered desirable, from an engineering standpoint, for use in hydraulically placed landfills. These dredge units are located in the middle two-thirds of the Main Channel, northern West Basin, northeastern Turning Basin, and southwestern East Basin Channel areas of the Inner Harbor. Fine-grained sediments and formation materials that are considered undesirable for use in hydraulically placed landfills predominate in the other four dredge units (i.e., FG-1 through FG-3, and FM-1). Possible disposal options for these sediments could include ocean disposal, placement in the Cabrillo Shallow Water Habitat Expansion, and/or disposal onto upland Anchorage Road. Dredge units FG-1 through FG-3 are located in the: 1) northern Main Channel and southwestern Turning Basin areas; 2) southern and eastern West Basin Channel areas; and 3) northeastern East Basin Channel, East Basin, and Cerritos Channel areas.

The formation materials of dredge unit FM-1 consist of soft rock or hard, fine-grained soil with inclusions of hard rock. This formation dredge unit is present in the northern Glenn Anderson Ship Channel and extreme southern Main Channel areas. The numerous hard rock lenses and layers have created difficult dredging conditions, including low production rates and equipment damage during past dredging in these materials.

Throughout most of the Inner Harbor, non-native Harbor Bottom Sediments are present above the native sediments. These Harbor Bottom Sediments, which are of variable composition and thickness, but are typically fine-grained sediments. Although these Harbor Bottom Sediments are generally considered undesirable for use in hydraulically placed landfills, it is likely that they will be dredged as part of the individual dredge units.

1.0 INTRODUCTION

1.1 BACKGROUND

The Port of Los Angeles (POLA) is currently planning to deepen the Inner Harbor channels and turning basins to accommodate the most modern vessels in the commercial container fleet. In January 1998, POLA approved the Channel Deepening Program to deepen the Main Channel and associated channels and turning basins from the existing elevation (El.) -45 feet mean lower low water (MLLW) to El. -50 feet MLLW, a depth that will accommodate new container vessels with a 46-foot draft. Since approval of this project, new ships in the world container fleet and pending ship orders indicate that container vessels with a draft of 52 feet are being planned. The new deeper vessels will require a navigational channel as deep as El. -55 feet MLLW that includes a 2-foot-over-depth allowance (USACOE, 2000). Therefore, the deepening project is now planned to deepen the Inner Harbor channels and turning basins to El. -53 feet MLLW plus. It is our understanding that the Channel Deepening Project will be divided into three different components:

1. Channel and basin dredging
2. Utility deepening and/or relocation
3. Berth improvements

The first component is directed at deepening the various channels and basins within the Inner Harbor (e.g., the Main Channel, Turning Basin, West Basin, East Basin Channel, and East Basin) as shown on Plate 1.1. The dredged materials from the Channel Deepening Project will allow POLA to pursue future expansion and terminal development. The recommended plan envisions the use of dredged materials for the following development projects:

1. 35-acre Southwest Slip expansion
2. Berth improvements
3. Cabrillo Shallow Water Habitat (CSWH) expansion
4. Extension of the Pier 300 Terminal

Dredged materials unsuitable for in-water disposal may be encapsulated in the 35-acre Southwest Slip fill or deposited at the upland Anchorage Road disposal site.

At several locations, utility lines that cross beneath the various channels and basins are buried at various depths below the current harbor bottom (i.e., mudline). The current design burial depths were typically based on a harbor bottom that is no deeper than about El. -47 feet MLLW. Therefore, to deepen the Inner Harbor channels and turning basins, some or all of the existing utility lines will have to be relocated and/or reburied at greater depths. The redesign of utility crossings reportedly will be based on a top elevation of El. -65 feet MLLW.

The third component of the Channel Deepening Project is directed at improvements (i.e., deepening) along specific berthlines. It is our understanding that the following berths are currently being considered for improvement:

Berths	Tenant
121-126	Yang Ming (formerly APL) Container Terminal
136-139	Trans Pacific Container Service Corp. Terminal
212-221	NYK Container Terminal
226-232	Evergreen Container Terminal

The discussions, summaries, and conclusions provided within this report primarily address factors associated with the first component of the Channel Deepening Project (i.e., channel and basin dredging). The data contained herein also will be useful for the second (utility relocation) and third (berth improvement) components; however, a greater amount of site-specific evaluations will be required for those components.

This report describes the site and subsurface conditions that are present beneath the Inner Harbor channels and turning basin within the area to be deepened. Factual data developed during several phases of subsurface exploration completed since 1986 are provided in various reports, as described below.

1.2 COMPLETED INVESTIGATIONS

Extensive field investigations, including bathymetry and geophysical surveys, and geotechnical explorations have been previously conducted within the inner and outer harbors at POLA as part of the 2020 Plan, Pier 400 Landfill Project, and the Channel Deepening Project.

As part of the POLA 2020 Plan, Fugro completed geological and geotechnical studies within the Outer Harbor. The 2020 Plan Geotechnical Investigation consisted of a geophysical survey, 122 borings, downhole CPT soundings in 29 borings, and 86 vibracores. At the time, the 2020 investigation was one of the largest and most comprehensive geotechnical studies undertaken in United States' coastal waters. The main purpose of that investigation was to gain an understanding of the overall geologic structure of the Pier 400 Landfill Project area (Fugro-McClelland, 1992). In 1993, supplemental geotechnical investigations were performed in various areas to aid in the conceptual design of Pier 400. The 1993 explorations included 5 borings, 14 CPT soundings, and 27 vibracores (Fugro-McClelland, 1993).

Fugro West previously completed geological and geotechnical studies of the various waterways in the POLA Inner Harbor to support the Channel Deepening Program. Two phases of field exploration and laboratory testing were previously performed to evaluate stratigraphic (and environmental) conditions within the limits of the Channel Deepening Program project area. The Phase 1 field investigation was performed in August and September 1996, and the Phase 2 field investigation was performed in April 1997. A description of the fieldwork activities is provided in the Fugro field program assessment reports (Fugro, 1996a, 1996b, 1997c).

A total of 143 tethered cone penetration tests (CPTs) were performed throughout the Inner Harbor during those two phases of preliminary field exploration. All testing was performed using the tethered Seascout mini-CPT system designed and developed by Fugro. The two phases of exploration also included 153 vibracores performed primarily for evaluating sediment chemistry characteristics. Further description of the methods used to obtain those data and the testing results are provided in Fugro's geotechnical evaluation report (Fugro, 1997c).

Concurrent with the second phase of preliminary exploration, overwater and adjacent land borings were drilled for two potential pipeline crossings beneath the Inner Harbor. The relocation of the Fries Avenue force main across the East Channel between Berth 170 and Berths 221/222 (Fugro, 1997a) and a new reclaimed water line across the Turning Basin between Berth 150 and Berth 225 (Fugro, 1997b).

The Port of Los Angeles, in conjunction with the second phase of the post-fill investigation on the Pier 400 landfill, also took the opportunity on two occasions to perform overwater borings and other related activities within the Main Channel. The main purpose of the first set of investigations (in 2000) was to gain an understanding of the geologic structure along the proposed realignment route of two Los Angeles Department of Public Works (DPW) sewer lines. One sewer line crosses the Main Channel between Berths 84 and 234 (Fugro, 2001b), while the other crosses the Turning Basin to the south of the Vincent Thomas Bridge between Berths 94 and 226 (Fugro, 2001a).

The second set of investigations, in Winter 2000-2001, included overwater geotechnical borings and laboratory testing conducted for proposed future developments. The projects included: 1) the proposed future terminal development of the West Basin and Southwest Slip (Fugro, 2001d); 2) the Pier 300 Extension area (Fugro 2001c); 3) non-federal dredging south of the Pilot's Station; and 4) the planned expansion of the Cabrillo Shallow Water Habitat.

Explorations for the Channel Deepening Project, 2020 Plan, and other historical data (in the channels and turning basins and along the adjacent wharves) from various sources were used to supplement the data from the explorations for this project. The historical data sources are listed in Chapter 7.0 (References) and discussed in Chapter 3.0. Where relevant, data from those historical subsurface explorations have been added to Fugro's existing Underground Geographical Information System (UGIS). The geologic and subsurface models developed from these previous exploration programs have been used in conjunction with the field data collected as part of the current program to characterize the geologic conditions underlying the Channel Deepening Project area.

1.3 AUTHORIZATION AND SCOPE OF SERVICES

The purpose of this study is to evaluate the site and subsurface conditions for the Channel Deepening Project. Authorization for this geotechnical study was provided by Task Order 0002 of Agreement DACW09-00-D-0023 between the U.S. Army Corps of Engineers (USACOE) and Fugro West, Inc. The Water Resources Development Act of 1986 (PL99-662) Section 203 authorized the contract.

The scope of services authorized (by the second task order to Agreement DACW09-00-D-0023 paragraph f) for the site and subsurface conditions evaluation included the tasks listed below:

- Task 1 - Review and compile existing (including data collected under this scope of work) geotechnical information and confirm adequacy of data for design analyses and objectives.
- Task (2) - Site Characterization. Characterize geologic features and stratigraphic sequence foundation materials throughout the Channel Deepening Project area.
- Task (3) - Representative Properties. Determine characteristics and representative properties of foundation sediments for the design of: a) Pier 300 Extension rock dikes, and b) CSWH Expansion rock dikes.
- Task (4) - Reporting. Preparation of draft and final Main Channel Subsurface Characterization reports.

The characteristics and representative properties of foundation sediments for the Pier 300 Extension and CSWH Expansion rock dikes are included in the rock dike design reports for those two projects.

1.4 REPORT ORGANIZATION

This report includes the following sections:

- Chapter 1.0 - Introduction to the report and reference to previously published reports
- Chapter 2.0 - Relevant conditions within the Main Channel including bathymetric conditions, seafloor obstructions, and utility crossings with results of the marine geophysical survey performed by Fugro
- Chapter 3.0 - Review of marine and land site investigations including environmental and geotechnical studies
- Chapter 4.0 - Discussion on the refinement of the site characterization and subsurface conditions and description of the non-native Harbor Bottom Sediments and formation materials
- Chapter 5.0 - Discussion on the interpreted shallow stratigraphic conditions beneath Inner Harbor waterways including descriptions of the sediment properties and characteristics of the native sediments
- Chapter 6.0 - Discussion on the relevant engineering properties of the native sediments
- Chapter 7.0 - References

1.5 SOURCES OF FACTUAL DATA/RELATED REPORTS

In addition to this geotechnical study, there are several other reports that relate to the scope of work for the Channel Deepening Project. Factual data are included in the following reports:

- The results of 4 vibracores and 9 land borings completed for the West Basin Entrance Widening in 1987 are provided in McClelland Engineers (1987).
- Fugro's geotechnical report for the DPW relocation of the Fries Avenue force main under the East Basin Channel (Fugro, 1997a) includes the results of 3 overwater borings and 2 adjacent land borings.
- Fugro's geotechnical report for the Department of Water and Power (DWP) reclaimed water pipeline across the Turning Basin (Fugro, 1997b) includes the results of 4 overwater borings, 1 boring through the wharf, 2 adjacent land borings, and 7 vibracores.
- The results of 153 vibracores and 143 tethered mini-CPT soundings completed throughout the Inner Harbor in 1996 and 1997 are included in a Fugro (1997c) geotechnical evaluation report.
- Fugro's geotechnical report for the DPW siphon harbor crossing relocation across the Main Channel (Fugro, 2001b) includes the results of 3 overwater borings and 2 adjacent land borings.
- Fugro's geotechnical report for the DPW San Pedro force main crossing relocation across the Turning Basin (Fugro, 2001a) includes the results of 3 overwater borings and 2 adjacent land borings.
- Fugro's geotechnical report for the West Basin and Southwest slip development (Fugro, 2001d) includes the results of 14 overwater borings.
- Fugro's geotechnical report for the Channel Deepening Project [including the Pier 300 Extension, CSWH Expansion, and Non-Federal Dredge areas] (Fugro, 2001c) includes the results of 8 overwater borings.

In addition to the factual data developed throughout the Inner Harbor from overwater explorations, the data was augmented with historical land borings performed adjacent to the Main Channel. Chapter 3.0 of this report includes a summary of these historical explorations.

1.6 LIMITATIONS

This geotechnical report has been prepared for the U.S. Army Corps of Engineers and the City of Los Angeles Harbor Department solely for the planning of the proposed Channel Deepening Project, Port of Los Angeles. In performing our professional services, we have used that degree of care and skill ordinarily exercised, under similar circumstances, by reputable geotechnical engineers currently practicing in this or similar localities. No other warranty, express or implied, is made as to the professional advice included in this report. Fugro West, Inc., makes no claim or representation concerning any activity or conditions falling outside its specified purposes to which this report is directed.

The interpretation of general subsurface conditions is based on subsurface conditions observed at exploration locations only. The information interpreted from those explorations has been used as a basis for our interpretations. Conditions may vary at locations not investigated by our explorations. Subsurface conditions also may change with time due to either natural phenomena or people's activities. Any statements or absence of statements, in this geotechnical report regarding odors, unusual or suspicious items, or conditions observed are strictly for descriptive purposes and are not intended to convey engineering judgment regarding potential hazardous/toxic assessment.

Users of this report should recognize that the construction process is an integral design component with respect to the geotechnical aspects of a project, and that geotechnical engineering is an inexact science due to the variability of natural and man-induced processes that can produce unanticipated or changed conditions. Proper geotechnical observation and testing during construction thus are imperative in allowing the geotechnical engineer the opportunity to verify assumptions made during the design process. Therefore, we recommend that Fugro be retained during construction to observe compliance with the design concepts and geotechnical recommendations, and to allow design changes in the event that subsurface conditions or methods of construction differ from those anticipated.

2.0 BATHYMETRIC CONDITIONS AND GEOPHYSICAL SURVEY RESULTS

2.1 OVERVIEW OF BATHYMETRIC SURVEYS

In late March and early April 1996, the Port of Los Angeles performed a bathymetric survey of the Inner Harbor. The results from this survey were presented in a Fugro (1997c) geotechnical evaluation report. Following operation and maintenance (O&M) dredging and localized sand removal, the Port of Los Angeles took advantage of the existing contract with the USACOE and Gahagan & Bryant Associates (GBA) and gathered bathymetric data from 1999 through 2001. In the spring of 2001, the Port of Los Angeles performed a survey of the West Basin and Southwest Slip areas in preparation for the West Basin Development Program (WBDP).

2.2 BATHYMETRIC CONDITIONS

The combined bathymetric data are shown on Map 1 and have been filtered to show three major ranges of elevations: 1) higher than El. -45 feet MLLW (light blue); 2) between El. -45 and El. -55 feet MLLW (blue); and 3) deeper than El. -55 feet MLLW (dark blue). The El. -45-foot level was chosen because most of the areas to be deepened during the Channel Deepening Project were dredged to about El. -45 feet in 1981 to 1983 as part of the USACOE Harbor Deepening Project (USACOE, 1980a,b). The El. -55-foot level was specified because the Channel Deepening Program is being designed for El. -53 feet MLLW with a 2-foot-over-depth allowance. Bathymetric elevations between El. -45 and El. -55 feet MLLW are further filtered by 2-foot intervals in order to display relief within that interval.

As indicated on Map 1, much of the Inner Harbor bathymetry is between El. -45 and El. -55 feet MLLW, with shallower areas generally limited to the edges of the channels and basins. We note that the majority of the El. -45 to El. -55-foot area shown on Map 1 is at elevations lower than -48 feet. Several areas exist within the Inner Harbor where the current harbor bottom is at or below El. -55 feet MLLW. The larger areas are located:

1) In the middle of the Main Channel between Station (Sta.) 154+00 and Sta. 172+00;
2) In the southern and middle portions of the Turning Basin;
3) At the north end of the West Basin; and
4) South of Sta. 50+00.

At least two of those locations were used as borrow sources for materials to fill old slips (e.g., Slip 228) within the Inner Harbor. Additionally, in May 1997, a portion of the south Main Channel was dredged to about El. -50 feet MLLW to supply material for Pier 400 Stage 1. The area that was deepened corresponds to the eastern side of the Main Channel between Sta. 114+00 and Sta. 136+00. The area to the southeast of Sta. 50+00 also was dredged as part of the Pier 400 dredging and landfill project.

The bathymetric conditions within the Southwest Slip consist of a dipping surface elevation from the outlet of the Los Angeles County Flood Control culvert to towards the West

Basin. The majority of the Southwest Slip area is higher than about El. -45 feet MLLW, with the exception of two depressions ("bathtubs"). The two localized depressions are likely the remains of ship lifting mechanisms from the former Todd's Shipyard, which was demolished in the early 1990s.

2.3 PAST AND CONCURRENT BERTH DEVELOPMENTS

The Port of Los Angeles widened the entrance to the West Basin in 1997 by creating a new pierhead alignment that cuts diagonally from Berth 97 to Berth 101. The project included the demolition of Berths 97 to 101, removal of sediments in front and behind the current berthlines, and construction of a new pierhead alignment. Removal of the sediments was ongoing during the Phase 2 investigation for the Channel Deepening Program (Fugro, 1997c). The sediments from the West Basin Entrance Widening Project were reportedly placed in several locations, including: a) the Pier 400 Stage 2 landfill area, b) the LA-2 ocean disposal site, and/or c) the upland disposal in the backland areas directly behind the new pierhead alignment. Contracts have been let recently to construct new wharves for Berths 100 and 101 and their associated backlands.

The WBDP is concurrently under design and related to the Channel Deepening Project. The WBDP includes the creation of a 35-acre Southwest Slip landfill using dredged material from the Channel Deepening Project. The WBDP will eventually create 75 acres of backlands, and includes the construction of Berth 102 and bridges across the Los Angeles County Flood Control Channel to expand the existing China Shipping Terminal (EMI, 2001).

2.4 MARINE GEOPHYSICAL SCOPE OF WORK

In late July and early August 2001, Fugro conducted side scan, subbottom profiler, and single-beam hydrographic surveys for the Channel Deepening Project (Fugro, 2001e) while under contract to the U.S. Army Corps of Engineers (USACOE). The survey was conducted from July 26 to August 4, 2001, and included complete coverage of the Channel Deepening Project dredge area, the Pier 300 Extension footprint, and the CSWH Expansion area. The interpretation of the subbottom data for the Channel Deepening Project is included in this report. The interpretation of the data for the Pier 300 Extension and CSWH Expansion are included in their respective geotechnical study reports.

2.5 DESCRIPTION OF GEOPHYSICAL TECHNIQUES

The following paragraphs briefly describe the techniques used in the geophysical and side scan sonar surveys that were conducted as part of the Channel Deepening Project. The geophysical survey consisted of simultaneous collection of data from four systems: navigation, echo sounder, subbottom profiler, and side scan sonar.

The Fugro geophysical survey was conducted using a spread spectrum (CHIRP) subbottom profiling system to assist in the characterization of the shallow subsurface within the Channel Deepening Project area. The spread spectrum technology employs a swept frequency between 2.0 and 16.0 kilohertz (kHz). The subbottom data were recorded as both digital

(SEG-Y) data and as analog data on an EPC thermal plotter. Horizontal positioning was achieved using a STARFIX II Differential GPS positioning system integrated with a Hypack navigation package with navigation fixes taken at nominally 150-foot intervals. Map 2 shows the geophysical tracklines traveled during the hydrographic survey.

2.5.1 Subbottom Profiler Data

A geophysical (subbottom) survey is conducted by using an acoustic energy source to generate a pulse of sound that travels through the water column and penetrates into the sea bottom. The acoustic energy is reflected back to a receiver system that measures the travel time from transmission to reception. The media through which the acoustic energy passes affects the signal in various ways. The more dense a medium, the faster the pulse travels; therefore, as the wave passes through different media densities (i.e., from water to soil to rock), the wave velocity changes. At the interface between different media, the change in properties will cause some energy to be reflected (this is most prominent at the water-soil interface and between soil and rock strata).

The subbottom profile records on the film plots and the digital SEG-Y recordings were analyzed using Seismic Micro Technologies (SMT) Kingdom Suite software. Filters and settings were adjusted to enhance the upper sediments. The geotechnical data (borings, CPTs, and vibracores) were used to ground "truth" the geophysical data, thereby providing better confidence in the interpretation of the geophysical records. In addition to the subbottom data used in the interpretation of the shallow stratigraphy, the data were used to assist in locating the position and burial depths of existing pipelines.

2.5.2 Side Scan Sonar Data

Side scan sonar provides an oblique acoustic image of the seafloor. The side scan survey parameters were set to optimize resolution of the side scan sonar records to support interpretation of possible debris, hard-bottom features, and other anomalies.

The sonar was set up to acquire imagery at a slant range of about 150 feet per channel. Navigation fixes were taken about every 150 feet. A total of 72 nautical miles of tracklines were traveled during the geophysical and hydrographic surveys. These operating parameters provided 200-percent coverage of the required survey corridor area.

2.6 SEAFLOOR OBSTRUCTIONS

Side scan sonar records were analyzed in conjunction with the bathymetry and subbottom data for evidence of objects on the harbor bottom (note that the survey methods do not identify the presence of buried, non-ferrous objects) and other evidence of human activity. The seafloor features (which include debris, unidentified targets, and bedrock outcrops) were mapped and logged. The anomaly table included in the Fugro survey report (2001e) identifies 355 targets.

Clearly visible on the side scan sonar data are bedrock outcrops in the entrance to the Main Channel. Unidentified sonar targets were mapped throughout the Main Channel with the greatest concentrations being close to the pierheads. An area of what may possibly be several sunken boats was located along the northern edge of the Southwest Slip along Berths 116 to 118. Another area of what may possibly be several sunken boats was located along the north side of the East Turning Basin at about Berth 193.

2.7 UTILITY CROSSINGS

At several locations throughout the Inner Harbor, utility lines cross the channels and basins. The utilities include oil, water, sewer, fuel, power, and telephone lines. Based on a "Channel Deepening Program, Utility Crossings" draft drawing (dated May 3, 1996) provided by POLA, and using the drawings for the USACOE's Maintenance Dredging Project (USACOE, 1995) a list of utilities that require relocation are shown in the Channel Deepening Project Feasibility Study (USACOE, 2000). Listed in the table below are the locations of the utility lines (from south to north) that were studied during the geophysical and hydrographic surveys performed by Fugro. This list is not considered all inclusive and other utilities may exist.

Type of Utility	Number and Diameter (in.)	Elevation (feet MLLW)	Crossing Location (Berth Nos.)	Comments
Oil	1 (36)	-45 to -50	81 to 236	Located
Water	1 (20)	-45 to -48	83 to 235	Located and exposed
Sewer	2 (20)	-51 to-55	84 to 234	Located
Telephone	2 Cables	??	85 to 234	Not located
Telephone	Cable	??	92 to 230	Not located
Sewer	1 (30)	-50 to -65	94 to 227	Located
Fuel	3 (18)	??	97 to 226	Warrants further study
Sewer	1 (30)	-50	170 to 221	Located
Power	2 Cables	??	173 to 218	Not located
Oil	2 (10-24)	-50 to -56	176 to 215	Located
Oil	2 (10-16)	-50	176 to 215	Located
Water	1 (24)	-55	176 to 215	Located

The utility crossing survey provided burial positions and depths for most of the pipelines within the Main Channel and East Basin Channel. However, the survey was unsuccessful in locating the telephone and power cables (which are probably buried beneath the current harbor bottom) and the deep pipelines. Although the Navy fuel lines were not detected, a mound along the reported pipeline route (Fugro, 2001e) was detected in the survey.

2.8 HISTORICAL GEOPHYSICAL SURVEYS

Two geophysical surveys were performed in the 1990s that provide additional geophysical data that are useful for stratigraphic definition within the Main Channel. The first geophysical survey was performed in 1990 as part of the 2020 Plan Geotechnical Investigation (Fugro-McClelland, 1991 and 1992). Geophysical data were acquired along two tracklines in the Main Channel, two tracklines in the East Basin Channel, and one trackline in the southern

West Basin. The data consist of both shallow, analog boomer records and deeper, multichannel, digitally processed records. We note that the 1990 geophysical records were used by Fugro for the interpretation of shallow stratigraphic conditions throughout the Inner Harbor, as discussed and presented within our 1997 Geotechnical Evaluation report (Fugro, 1997c).

The California Division of Mines and Geology (CDMG) performed geophysical surveys in the Inner Harbor to further identify faulting for Caltrans' Vincent Thomas Bridge Seismic Retrofit project. Shallow boomer data were acquired during a March 1996 survey, and deeper multichannel data were reportedly acquired during a second geophysical survey performed in June 1996. Based on a preliminary trackline map provided to Fugro, the March 1996 survey included: a) four tracklines along the full length of the Main Channel that extend into the Turning Basin; b) two tracklines along the East Basin Channel that extend into the East Basin and Cerritos Channel; c) three tracklines in the West Basin; and d) several other shorter tracklines that extend into a few slips. The shallow boomer records acquired along those tracklines provided useful information for further interpretation of the sediment formation contact conditions within the Main Channel.

2.9 SUPPLEMENTAL GEOPHYSICAL SURVEY

The U.S. Geological Survey (USGS) performed geophysical surveys in both the Inner and Outer Harbors of the Port of Los Angeles and the Port of Long Beach for aquifer identification related to saltwater intrusion. High-resolution GeoPulse and multichannel mini-sparker data were acquired during a September 2000 survey (USGS, 2001). The quality of both types of data varies. Based on a preliminary trackline map provided to Fugro, the 2000 survey included: a) four tracklines along the full length of the Main Channel extending into the East Basin and Cerritos Channel; b) one trackline that extends into the West Basin; and c) several other tracklines that extend into a few slips. The records along those tracklines may provide useful information for further interpretation of the shallow stratigraphic conditions within the Main Channel. We requested the digital trackline data for the 2000 survey from the USGS, but have not received the data in time for preparation of this final report.

3.0 REVIEW OF EXISTING STRATIGRAPHIC DATA SOURCES

3.1 INTRODUCTION

Prior to developing and executing the field program for the 1996/1997 Channel Deepening Program, Fugro performed a detailed review of relevant existing data sources. The existing data sources were primarily related to: 1) geotechnical studies for specific berths; 2) sediment chemistry and bioassay studies for maintenance dredging adjacent to specific berths; 3) other studies addressing large areas of the channels and basins rather than individual berths; 4) geophysical surveys; and 5) pre-development morphology maps. Those existing data sources are discussed in the Channel Deepening Program report (Fugro, 1997c). Emphasis was placed on those data sources that provided information in the channels and basins, as compared to information along and close to specific berthlines.

Similarly, as part of this geotechnical study, the exploration and laboratory data from the historical geotechnical studies (those reviewed for the 1996/1997 Main Channel Deepening Program) together with the more recent exploration data (those performed since 1997) were reviewed and, when relevant, were added to Fugro's existing UGIS. The locations of historical and recent geotechnical and environmental explorations are shown on Map 3. Those data sources that provided information in the channels and basins were augmented with exploration data along and close to specific berthlines as shown on Map 3.

3.2 HISTORICAL GEOTECHNICAL STUDIES

In addition to the various Fugro studies for the Main Channel deepening and related studies, approximately 30 geotechnical reports were identified and reviewed. Most of the geotechnical reports were for proposed engineering improvements and/or modifications along specific berthlines and did not include environmental data (e.g., sediment chemistry or bioassay testing). The subsurface exploration data from the geotechnical studies provide detailed stratigraphic information to depths generally deeper than El. -100 feet MLLW. However, because most of the explorations were performed on land and/or over water within about 100 feet of the berthlines, the factual stratigraphic data typically do not extend into the main portions of the channels and basins. Therefore, the data contained in most of the existing geotechnical studies are only partially useful for subsurface characterization of the channels and basins, but should be extremely useful for when specific berthlines are improved.

Two geotechnical studies include extensive vibracore explorations within the channels and basins, and provide a significant quantity of subsurface data in several areas of the Inner Harbor. CH2M Hill (1984) performed 32 vibracores in the Turning Basin and northern portions of the Main Channel. The main objective of those vibracores was to identify desirable sediments (i.e., sands and silty sands) for dredging and filling of old Slip 228. Most of the CH2M Hill (1984) vibracores extended downward to elevations of about -55 to -65 feet MLLW.

The second geotechnical study that included extensive vibracores was executed by Harding Lawson Associates (HLA, 1987). For that study, about 50 vibracores were collected in the East Basin and Slip 5, and about 30 vibracores were collected in the West Basin. The main objective of those vibracores was to identify desirable sediments (i.e., sands and silty sands) for dredging and filling of several slips that existed at that time along Berths 212 through 215. The elevation data noted in the HLA (1987) report indicate that: a) the West Basin vibracores typically extended downward to elevations of about -50 to -55 feet MLLW; and b) the East Basin vibracores to elevations of about -60 to -65 feet MLLW.

A review of the vibracore data in HLA (1987) suggests that the associated elevation data may be questionable and may be erroneous for some of the vibracore locations. The elevation data for the West Basin vibracores appear to be reasonable and correct; however, for the East Basin vibracores, the noted elevations do not seem reasonable. Based on our evaluation, it appears that tide corrections may not have been incorporated in the elevation data for the East Basin vibracores. Incorporating an assumed 2- to 5-foot tide correction for the East Basin vibracores would suggest that those vibracores typically extended downward to elevations of about -55 to -60 feet MLLW.

3.3 SEDIMENT CHEMISTRY AND BIOASSAY STUDIES

In addition to the 1996 and 1997 Main Channel sediment chemistry program, approximately 20 reports that specifically address chemistry and bioassay characterization of sediments within the various channels and basins were identified and reviewed. A detailed review of the existing, pre-1996 environmental studies, including summaries of sediment chemistry and bioassay results, was performed by Kinnetic Laboratories, Incorporated (KLI) and was presented as an appendix to Fugro's Field Assessment Reports (1996a,c).

Most of the sediment chemistry and bioassay studies were performed for various maintenance dredging projects (along specific berthlines) that have been necessary since the completion of the 1981 to 1983 Harbor Deepening Project (USACOE, 1980a,b). Those maintenance dredging studies, which typically address Harbor Bottom Sediments within about 50 to 150 feet of the shoreline, often lack detailed stratigraphic data and provide limited data relative to the middle portions of the channels and basins.

The MEC Analytical Systems, Inc. (MEC, 1995) study was performed for the USACOE's proposed maintenance dredging throughout the Los Angeles Harbor (and at the Los Angeles River estuary). Sediment samples for chemistry/bioassay testing were collected in six large regions encompassing most of the Los Angeles Inner Harbor. The exploration locations used to collect sediment samples were generally located near the edges and did not extend into the middle portions of the channels and basins. It is noted that MEC (1995) environmental sampling is related to the USACOE (1995) stratigraphic sampling.

More recently, two series of environmental vibracores were performed in support of permitting issues for the Channel Deepening Project. The first series of environmental sampling is related to the sediment conditions adjacent to the former Kaiser site. The vibracores in this location were performed by AMEC (2001) and were used along with the geophysical data to interpret the thickness of non-native sediments overlying the formation material. The second series of environmental sampling was performed by MEC (2001) throughout the Main Channel to provide data for additional permitting requirements. The geotechnical data from those vibracores supplemented the various Fugro Main Channel explorations and the geophysical data to interpret the thickness of non-native materials overlying the native sediments.

3.4 U.S. ARMY CORPS OF ENGINEERS DREDGING PROJECTS

Two data sources related to previous USACOE dredging projects provide stratigraphic and/or limited chemistry testing data for sediments throughout the Los Angeles Inner Harbor. As part of the 1981 to 1983 Harbor Deepening Project (USACOE, 1980a,b), the USACOE performed explorations throughout the Inner Harbor from 1977 to 1979. Detailed stratigraphic data were obtained at about 100 locations down to elevations that typically ranged between about El. -45 to El. -55 feet MLLW. Limited sediment chemistry testing was performed on many discrete-depth sediment samples. Because the prior Harbor Deepening Project was primarily directed at dredging to El. -45 feet MLLW with 1.5-foot overdredge allowance, most of the chemistry testing was performed on samples from elevations typically no deeper than El. -48 feet MLLW. The stratigraphic and chemistry data were presented in a General Design Memorandum (USACOE, 1980a) and as project drawings (USACOE, 1980b).

In August 1993, the USACOE sampled 21 locations throughout the Inner Harbor to determine shallow stratigraphic conditions within the areas of their proposed maintenance dredging. Divers pushing tubes into the harbor bottom sampled the sediments. Therefore, limited penetration was achieved and most samples did not extend below about El. -48 to El. -49 feet MLLW. To our knowledge, the stratigraphic data were only presented in the project drawings (USACOE, 1995).

During May 1997, about 160,000 cubic yards of sand were removed to supply material for the Pier 400 dredging and landfill project. Based on the latest bathymetric data, an area to the eastern side of the main channel (between POLA Sta. 114+00 and Sta. 136+00) was deepened to an elevation of about -50 feet MLLW.

3.5 PRELIMINARY 1996/1997 MAIN CHANNEL DEEPENING PROGRAM EXPLORATIONS

Two phases of field exploration and laboratory testing were performed to evaluate stratigraphic (and environmental) conditions within the limits of the Channel Deepening Program project area. The Phase 1 field investigation was performed in August and September 1996, and the Phase 2 field investigation was performed in April 1997. Both phases of the stratigraphic investigations included cone penetration testing, vibracore explorations, and geotechnical laboratory testing. General summaries of those activities are provided in two Fugro (1996a,c) Field Program Assessment reports. The locations of the explorations are shown on Map 3.

A total of 143 tethered CPTs were performed throughout the Inner Harbor. All testing was performed using the tethered Seascout CPT system designed and developed by Fugro. During the Phase 1 investigation, 14 CPTs (CA-1 through CA-14) were located in the southern portion of the Main Channel and 38 CPTs (CB-15 through CB-52) were located throughout the remainder of the Inner Harbor. During the Phase 2 investigation, 91 CPTs were performed. Of those 91 CPTs, 41 (CPT-1 through CPT-38 and CPT-90 through CPT-92) were located in the middle portions of the various waterways in the northern two-thirds of the Inner Harbor. The remaining 50 CPTs were performed within about 20 to 40 feet of existing pierhead alignments along four specific berthlines, which include the following:

- Berths 122 through 127 - CPT-39 through CPT-49
- Berths 136 through 139 - CPT-50 through CPT-57
- Berths 212 through 221 - CPT-58 through CPT-74 (CPT-73 was not performed)
- Berths 226 through 232 - CPT-75 through CPT-89

In addition to using the berthline-specific CPTs for the stratigraphic interpretation presented in our 1997 report, Fugro also prepared four separate reports (Fugro, 1997d,e,f,g) that discuss general stratigraphic conditions along the specific berthlines. It is likely that the information contained within those four reports will be useful to the design of the future berth-deepening component of the Channel Deepening Project.

3.6 SCOPE OF 2000/2001 GEOTECHNICAL INVESTIGATIONS

The subsurface explorations conducted specifically for the Channel Deepening Project included the advancement of eight borings designated as MCD-1 through MCD-8. The borings were advanced at three separate locations: 1) to the south of the Pilot's Station, 2) the CSWH Expansion, and 3) Pier 300 Terminal Extension area.

In late 2000 and early 2001, Fugro conducted subsurface explorations within the West Basin and Southwest Slip area in preparation for the WBDP. The subsurface explorations included the advancement of 14 borings designated as MCD-9 through MCD-22 (Fugro, 2001b). The specific sequence of the borings was based on the requirements imposed by navigation access in the channels and terminal operations in the onshore areas. The borings were drilled in two phases:

- The first phase of borings (MCD-9 through MCD-15) were drilled between December 4 and 13, 2000. Borings MCD-9 through MCD-13 are located in the Southwest Slip area and are drilled to an elevation of -80 to -100 feet MLLW. As requested by POLA, Borings MCD-14 and MCD-15 were drilled to an elevation of -130 feet MLLW. These two borings were drilled to assist in the characterization of the subsurface conditions in front of Berth 100.

- The second phase of borings (MCD-16 through MCD-22) were drilled between January 22 and 30, 2001. These borings were terminated at an elevation of -80 to -120 feet MLLW.

The execution of the Channel Deepening Project and WBDP boring programs was conducted together with a study for the Department of Public Works sewerline relocations (Fugro, 2001c,d). The subsurface exploration conducted specifically for the siphon harbor crossing relocation included the advancement of five borings designated as DPW-1L and DPW-2L for land borings and DPW-1W through DPW-3W for overwater borings. The three overwater borings were drilled in the Main Channel and the two land borings were drilled at the planned siphon microtunnel jacking pit locations. The five borings drilled for the siphon harbor crossing relocation were drilled between November 9 and December 6, 2000.

The subsurface exploration conducted specifically for the force main crossing relocation included the advancement of five borings designated as DPW-3L and DPW-4L for land borings and DPW-4W through DPW-6W for overwater borings. The five borings drilled for the force main crossing relocation were drilled between November 7 and December 5, 2000. The locations of the explorations are shown on Map 3.

3.7 DESCRIPTION OF 2000/2001 PROGRAM EXPLORATION TECHNIQUES

The following paragraphs briefly describe the techniques used in the geotechnical borings that were conducted as part of the Channel Deepening Project and WBDP.

3.7.1 Geotechnical Borings

The drilling operation was conducted under the technical guidance and observation of a Fugro geologist who also described and packaged the recovered samples. Drilling services for these borings were provided by Pitcher Drilling of Palo Alto, California, who provided a truck-mounted Failing 1500 drill rig, personnel, and associated equipment. The borings were advanced using wet/rotary procedures using a drag bit attached to a drill string of NW-rod drill pipes, and resulted in hole diameters measuring about 5 inches. The borings were advanced using non-toxic, revert or bentonite-based drilling.

To advance the overwater borings, Pitcher Drilling's truck-mounted drill rig was mounted on a work barge (the *Hightide 18*) owned and operated by Connolly-Pacific. Borings were advanced through a 3-foot-diameter moon pool. The *Hightide 18* was tied up to Connolly-Pacific's derrick barge (DB) *Los Angeles*. The DB *Los Angeles* measures approximately 50 feet by 150 feet and has a four-point anchor system. The barges were positioned by Connolly-Pacific, who also supplied and operated a 40-foot, 65-ton, twin-screw tugboat (the *Durango*) to move the barges and handle the DB *Los Angeles'* anchors.

3.7.2 Soil Sampling and Field Testing

As requested by POLA, continuous sampling was performed within the "near-surface" zone and at about 5-foot intervals thereafter.

The sampling methods primarily included driven sampling using standard penetration test (SPT) and California liner (with rings) samplers (1-3/8-inch-ID [inside diameter] by 2-inch-OD [outside diameter] and 2.4-inch-ID by 3-inch-OD, respectively). These samplers were driven using a 140-pound hammer falling 30 inches. The hammer was lifted and dropped using a rope and cathead, with the rope looped twice around the cathead. The number of blows required to drive the samplers the last 12 inches of the 18-inch penetration are shown on the boring logs. Additionally, an Osterberg cell (hydraulic piston) sampler (2.7-inch-ID by 3-inch-OD) was used in the soft/loose sediments immediately below the harbor bottom.

3.8 CRITICAL EVALUATION OF AVAILABLE STRATIGRAPHIC DATA

Most of the useful stratigraphic information for the sediments beneath the channels and basins of the Inner Harbor is contained within only a handful of reports. The most extensive source of relevant data are the CPT and vibracore data acquired by Fugro during the Phase 1 and Phase 2 investigations for the Channel Deepening Program (Fugro, 1997c). At that time, Fugro also acquired a secondary source of data that provided useful stratigraphic information during the exploration programs for the DPW and DWP pipeline crossing relocations and the Main Channel Deepening borings (Fugro, 1997a,b). Similar supplemental data are the explorations for the two DPW pipeline crossings, south of the Pilot's Station, and the WBDP program (Fugro, 2001a,b,c,d).

The other older but relevant existing data sources include USACOE (1980a,b) vibracores and borings, CH2M Hill (1984) vibracores, HLA (1987) vibracores, Fugro-McClelland (1993) vibracores, and USACOE (1995) push samples. Approximate exploration locations for each of those references are shown on Map 3. We note that the pre-1996 exploration locations typically were digitized from various types and sizes of maps and, therefore, the locations shown may be in error up to about 100 or 200 feet.

To evaluate the relative vertical extent of the historic exploration data (excluding the recently acquired borings), we compared the top and bottom elevations of each exploration (shown on Map 3) with the current harbor bottom bathymetry data. The comparisons were then filtered to identify exploration locations that have associated stratigraphic data extending to specific elevation ranges below the current harbor bottom. Explorations where penetration depths were less than the current harbor bottom bathymetry were excluded and are not shown on Map 3.

3.9 GEOPHYSICAL AND GEOTECHNICAL INTEGRATION

As part of this geotechnical study, the relevant exploration and laboratory data from the historical and more recent explorations were added to the existing computerized subsurface database referred to as the UGIS. Once all the data were in the system in a standardized format and in the same coordinate system, the UGIS subsurface database provided a valuable tool for integrating the exploration data (both historic and more recent data) with the geophysical data collected for this study (Fugro, 2001e).

Subsurface conditions were generally interpreted from the geophysical data by correlating the seismic reflectors imaged in the geophysics with the stratigraphic breaks observed in the geotechnical borings, CPTs, and vibracores. Since the geophysical survey provided relatively continuous information over a wide area, it was possible to develop stratigraphic surfaces throughout the Main Channel Deepening area.

4.0 CHARACTERIZATION OF FORMATION AND NON-NATIVE MATERIALS

4.1 STRATIGRAPHIC INTERPRETATION

The first objective of this geotechnical study was to review the interpreted sediment types and stratigraphic conditions within proposed dredge depths throughout the Inner Harbor of POLA as determined in our 1997 report. Fugro's interpretation of shallow stratigraphic conditions, as presented in that report (Fugro, 1997c), was based on CPT and vibracore data and other relevant stratigraphic data contained in various older data sources. The final objective of this geotechnical study was to refine and augment the prior interpretation using additional post-1997 exploration data and the geophysical data from 2001.

4.2 DEFINITION OF NATIVE DREDGE UNITS

In our preliminary geotechnical report (Fugro, 1996c), we divided the Inner Harbor into eight native dredge units that were based on the interpreted stratigraphic conditions. The additional exploration and geophysical data gathered subsequent to the earlier preliminary study confirm the basic validity of the prior interpretation and definition of eight native dredge units. The added data have been used, where appropriate, to refine the boundaries of the eight native dredge units that are shown on Plate 4.1. The boundaries between adjacent native dredge units generally correlate to the locations of interpreted stratigraphic contacts (refer to Plates 4.1 and 4.2) and/or the locations of utility crossings.

Because potential disposal options partially depend on sediment types, we created an alphanumeric dredge unit designation scheme that is based on the anticipated predominant material types within the proposed dredge depth (i.e., El. -53 feet MLLW with 2-foot overdredge allowance) of each native dredge unit. The dredge unit designations are as follows:

Dredge Unit Designation	Description
CG-1, CG-2, CG-3, CG-4	Areas where **C**oarse-**G**rained sediments predominate
FG-1, FG-2, FG-3	Areas where **F**ine-**G**rained sediments predominate
FM-1	Areas where **F**ormation **M**aterials are present

Each of the above listed dredge units are discussed in the following sections of this report.

4.2.1 CG Dredge Units

The four CG dredge units are located in the middle Main Channel (CG-1), north Main Channel (CG-2), north West Basin (CG-3), and northeast Turning Basin/southwest East Basin Channel (CG-4) areas of the Inner Harbor, as shown on Plate 4.1. In general, deposits of primarily coarse-grained sediments (i.e., sand and silty sand) are present at shallow depths (i.e., above about El. -54 feet MLLW) within those four areas. The native sands are overlain by variable thicknesses of Harbor Bottom Sediments.

The CG dredge units contain the most desirable sediments in comparison to the other dredge units. Consideration also may be given to mining the CG dredge units below the planned navigational dredge depth to obtain a greater quantity of coarse-grained sediments for use in the hydraulically placed fills.

We note that, because of the presence of desirable sediments, portions of dredge units CG-2 and CG-3 previously were used as borrow sources for the filling of several old slips within the Inner Harbor. In addition, a portion of dredge unit CG-1 was dredged in May 1997 to obtain additional coarse-grained material for the Pier 400 Stage 1 landfill.

4.2.2 FG Dredge Units

As shown on Plate 4.1, the FG dredge units cover three relatively large regions of the Inner Harbor. Those dredge units are interpreted to contain significant deposits of fine-grained sediments (i.e., silt and clay) within the proposed dredge elevations. From an engineering standpoint, those sediments are considered undesirable for use in hydraulically placed fills. Although coarse-grained sediments are present in localized areas of the FG dredge units (especially in the northwestern portion of dredge unit FG-2), fine-grained sediments generally predominate. The native sediments are overlain by variable thicknesses of Harbor Bottom Sediments.

4.2.3 FM Dredge Unit

Dredge unit FM-1 represents the southernmost portion of the Channel Deepening Project area and includes the extreme northern segment of the Glenn Anderson Ship Channel and the southernmost segment of the Main Channel. The northern limit correlates to the sediment-formation contact that crosses the Main Channel in a northwesterly trend at about survey station 100+00 feet. Existing exploration and geophysical data suggest that formation materials are present throughout dredge unit FM-1. Those older formation materials are overlain by variable thicknesses of Harbor Bottom Sediments.

4.3 SEDIMENTS WITHIN NATIVE DREDGE DEPTHS

Using the relevant historical stratigraphic data discussed previously, the CPT and vibracore data acquired in 1996, two morphology maps (Fugro, 1997c), and the 2001 geophysical data (Fugro, 2001e), Fugro refined the interpreted shallow stratigraphic conditions throughout the Inner Harbor. Relative to the existing stratigraphic data, we note that emphasis was placed on the channel and basin boring, vibracore, and CPT data, and that the stratigraphic data included in the various berthline geotechnical reports were used to supplement the overwater data where relevant.

With the exception of the formation area (dredge unit FM-1), the sediments that underlie the Inner Harbor generally consist of a thin surface layer of non-native Harbor Bottom Sediments overlying disturbed and undisturbed native Holocene sediments that were naturally deposited throughout San Pedro Bay prior to the development of POLA. In the FM-1 dredge unit, the Holocene sediments are absent, and older "bedrock" formations underlie the non-native sediments, or are exposed locally on the channel bottom. Specific details relative to the general descriptions of stratigraphic conditions within each native dredge unit are discussed in Chapters 5.0 and 6.0.

Interpreted shallow stratigraphic conditions for the Inner Harbor are considered generally representative of stratigraphic conditions above an elevation of about -53 feet MLLW. The native materials present within the Inner Harbor have been divided into five stratigraphic units that include three Holocene sediment units and two older formation units. Those stratigraphic units are listed below:

- Primarily coarse-grained sediments (sand, silty sand)
- Interlayered deposits of coarse- and fine-grained sediments
- Primarily fine-grained sediments (silt, sandy silt, clay, sandy clay)
- Formation materials of the Timms Point Silt (silt, sandy silt, silty sand)
- Formation materials of the Malaga Mudstone (silt with hard rock lenses)

In addition to the five native sediment or formation types listed above, non-native Harbor Bottom Sediments are present throughout most of the Inner Harbor. The formation materials (present in the southern extent of the Channel Deepening Project area) and their contact with the Holocene sediments are discussed in detail in the following sections. The non-native Harbor Bottom Sediments, which overly the native sediments and are of variable thicknesses, are discussed in further detail towards the end of this chapter.

4.4 SEDIMENT-FORMATION CONTACT

4.4.1 General Description

The contact between older formation materials and Holocene sediments transects the southern Main Channel in a northwesterly trend between Reservation Point and the San Pedro (SP) Slip. The older, formation materials are present to the south-southwest of the contact and are primarily comprised of deposits associated with the Monterey and San Pedro formations. In this area, the Malaga Mudstone member represents the Monterey Formation, and the Timms Point Silt member primarily represents the San Pedro Formation. We note that while other members of the San Pedro Formation may be present and may overlie the Timms Point Silt member, the available data are inconclusive. Therefore, within this report, materials related to the San Pedro Formation are grouped together and referred to as the Timms Point Silt. Holocene-age, alluvial and marine sediments are located to the north-northeast of where the Timms Point Silt approaches the harbor bottom and onlap onto the formation material. Plate 4.1 shows the extent of the formation materials, and Map 4 shows the surface elevations of the Malaga Mudstone and Timms Point Silt.

4.4.2 Geophysical Interpretation

In the preliminary Main Channel Deepening site characterization (Fugro, 1997c) report, the location of the sediment-formation contact was determined using the data available at that time. The available data included: a) existing stratigraphic data from USACOE (1980a,b); b) geophysical data from Fugro-McClelland (1991, 1992); c) geophysical data from the California Department of Conservation Division of Mines and Geology (CDMG) March 1996 survey (CDMG, 1998); and d) stratigraphic data from the sediment-formation vibracores (i.e., VA-23 through VA-30) performed during the field exploration program for the Phase 1A investigation (Fugro, 1996a). Refer to Map 3 for vibracore locations.

Based on Fugro's stratigraphic evaluation of the sediment-formation vibracores (VA-23 through VA-30), materials possibly associated with the Malaga Mudstone were only recovered in Vibracore VA-23. Timms Point Silt deposits (or deposits associated with other members of the San Pedro Formation) were encountered and recovered at four vibracore locations (i.e., VA-24 through VA-27). In particular, the top of the Timms Point Silt deposits was encountered at about 3.5-foot depth in Vibracore VA-24, 1.7-foot depth in VA-25, 2-foot depth in VA-26, and 2.5-foot depth in VA-27. The materials encountered in Vibracores VA-24 and VA-27 were classical Timms Point Silt (as identified in the Outer Harbor by Fugro-McClelland [1992]) and consisted of very stiff to hard silt with almost no sand fraction. In the 1997 report, we noted that the materials encountered in Vibracores VA-25 and VA-26 may not be Timms Point Silt and possibly could be related to another member of the San Pedro Formation.

4.4.3 Geophysical Interpretation Refinement

The Fugro geophysical survey performed in July and August 2001 collected seismic reflection data throughout the Main Channel of the Port of Los Angeles and is discussed in detail in Fugro (2001e). The new data enables us to refine the location of the formation-sediment and formation-formation contacts. Geophysical records containing seismic reflection data were used to map the contacts, which appeared as dipping reflectors in the records. These records were augmented with the sediment-formation vibracores used for the earlier study (Fugro, 1997c), and other vibracores performed later that year. These vibracores provided important ground truthing for the geophysics.

The geophysical data were collected using a spread spectrum CHIRP Subbottom Profiling System, which provides information on the extent and thickness of surficial sedimentation. Measurements were recorded in milliseconds and then converted to feet for analysis. An assumed constant acoustic propagation velocity of 5,000 feet per second (ft/s) was used in all of the calculations to convert travel time in milliseconds to distances in feet.

These new data were used to map the top of the Malaga Mudstone and Timms Point Silt formations in the Main Channel. These "top of the bedrock reflector" picks are each generally accurate up to ±0.6 to ±0.8 millisecond. We note that natural velocity variations add an additional uncertainty to depth conversions. The accuracy of elevations estimated from the seismic reflection data is about ±1.5 to ±2.0 feet.

Plate 4.3 shows a sample subbottom profiling record with the tops of the Malaga Mudstone and Timms Point Silt reflectors as they were interpreted and subsequently mapped. Both contacts (appearing as reflectors in the record) are traceable to the surface and are indicated in red. Depth to the reflector was measured in milliseconds as shown with straight red lines at navigation fixes (shotpoints). The faint reflector visible along the bottom of the record is a multiple of the channel bottom.

The data from the 2001 subbottom profiling survey of the Main Channel were compared to a geophysical record contained in CDMG (1998). This record contains seismic reflection data down to 125 milliseconds (over twice as deep as the Fugro survey). A portion of the CDMG geophysical record is shown in Plate 4.3. The surface of the Malaga Mudstone and Timms Point Silt reflectors as they were interpreted is shown in red. The green lines indicate the approximate extent of the depth of geophysical penetration from the Fugro record on Plate 4.3. Note that the vertical exaggeration for Plates 4.3 and 4.4 is different, so the angles of the dipping reflectors corresponding to the contacts appear to be unequal. The CDMG geophysical record agrees with the interpreted contacts in the Fugro records used to determine the location of the formation-sediment contact.

4.4.4 Description of the Formation-Sediment Contact

The contacts (appearing as reflectors) between the Malaga Mudstone-Timms Point Silt, and the Timms Point Silt-Holocene Sediments were mapped and depths were converted to feet at each navigation fix as described in the previous section. The structural surfaces of both the Malaga Mudstone and Timms Point Silt are shown on Map 4.

Relative to the survey stations, the two contacts are approximately located as follows:

	Approximate Survey Stations (feet)	
	Malaga Mudstone-Timms Point Silt	**Timms Point Silt-Holocene Sediments**
Eastern Edge	93+50 to 94+00	98+50 to 99+00
Centerline	94+50 to 95+00	100+00 to 100+50
Western Edge	98+00 to 98+50	107+50 to 108+00

These contact locations reveal the extent of Malaga Mudstone and Timms Point Silt along the channel bottom since the contacts reach the surface as stated previously. However, we note that loose, unconsolidated Harbor Bottom Sediments overlie formation material in some areas of the channel bottom.

4.5 FORMATION MATERIALS

4.5.1 General Description

The formation materials located in the northern Glenn Anderson Ship Channel and extreme southern Main Channel areas appear to be the Malaga Mudstone member of the Monterey Formation, and the Timms Point Silt member of the San Pedro Formation. Both formations were extensively mapped and sampled in the Outer Harbor by Fugro-McClelland (1992) during the 2020 Plan Geotechnical Investigation. The database established during that investigation, in combination with data presented by USACOE (1980a,b), provides the primary basis for the following descriptions of the formation materials; however, data from the Channel Deepening Program (Fugro, 1997c) investigations also were used. Note that the deposits we have mapped in the southern Main Channel as Timms Point Silt also may contain sediments associated with other members of the San Pedro Formation.

4.5.2 Structural Surface

Within the Channel Deepening Project area limits, the surface of the Malaga Mudstone is at an elevation of about -50 to -55 feet MLLW. Beyond the edges of the previous dredged channels to the south of the Pilot's Station and Reservation Point, the formation material rises up to an elevation of about -24 to -26 feet MLLW.

For the Pier 400 Dredging and Landfill Project, Malaga Mudstone was dredged to the east of the Channel Deepening Project limits. Locally, however, the Malaga Mudstone has been dredged to an elevation of as deep as about El. -86 feet MLLW. Map 4 shows the structural surfaces of the formation materials within the southern Main Channel area.

4.6 ROCK ASSOCIATED WITH FORMATION MATERIALS

Although the matrix of the formation materials is predominately composed of hard clay and silt, the formation includes prevalent rock inclusions. The rock inclusions are believed to be limestone lenses and/or concretions that occur throughout the Malaga Mudstone as localized deposits and concentrated bands. Uniaxial compressive strengths measured on samples of the rock-like layers in the Malaga Mudstone underlying the Outer Harbor range from about 1,150 to 6,800 pounds per square inch (psi) (Fugro-McClelland, 1992). Higher strengths, however, were measured on some rocks encountered during prior construction dredging (i.e., Main Channel Deepening and Pier 400).

Dredging experience in the early 1980s (when the Inner Harbor channels were deepened from El. -35 to El. -45 feet MLLW) and the more recent experience during the Pier 400 dredging project provide a basis for anticipation of the problematic conditions that may be encountered when dredging the Malaga Mudstone materials. That experience indicates that a relatively significant quantity of the rock-like materials may be encountered within the clay matrix, especially at shallow depths in the northern Glenn Anderson Ship Channel and southern Main Channel. In addition, that experience suggests that rock may be encountered as both intact rock ledges within the predominantly hard clay formation or as isolated rocks.

Past experience also suggests that the overexcavation and burial of rock inclusions below the project dredge depth has been a relatively common dredging practice. Thus, subsequent dredging (e.g., dredge element D6 of the Pier 400 Stage 1 project) encountered an atypically large quantity of rock inclusions at the top exposure of the Malaga Mudstone. This has adversely impacted dredge production. We consider it likely that such a condition will be encountered in the formation area in the upcoming Main Channel deepening.

4.7 MISCELLANEOUS ROCK AND DEBRIS

The existing stratigraphic data, in combination with experience gained from recent dredging operations within the Inner Harbor, highlight the possibility that miscellaneous rock and debris may be present almost anywhere throughout the Inner Harbor. Some of the rock appears to be naturally occurring and associated with local geologic formations, while other rock appears to be non-native. Although neither rock nor debris were encountered in the overwater explorations conducted for the project, past dredging experience in the Los Angeles Harbor indicates that such materials may be encountered on the harbor bottom or embedded within the underlying sediments. Rock or debris could be associated with historic structures, adjacent slope protection, past construction or commerce activities, or could be redeposited material derived from sources outside the harbor area.

Not enough data exist to establish typical rock sizes, but Fugro has been shown rocks reportedly taken from the southern Main Channel that were as large as about 12 to 15 inches in rough diameter. We note that the rocks observed by Fugro were not related to the rock-like layers that are associated with the Malaga Mudstone.

Some of the debris and non-native rock are clearly remnants of old train trestles, pile foundations, wharves, breakwaters, dikes, groynes, and other structures that were built and demolished within POLA. Because much of the non-native rock and debris is likely related to old infrastructure, Fugro recommends that POLA compile and review existing data (e.g., maps, aerial photos, plans, etc.) to identify locations where old structures intersect the current channels and basins. That information should be provided in the dredging bid package for the Channel Deepening Project. In addition, the full-coverage side scan sonar survey of the entire Channel Deepening Project area provides data to potential dredging contractors for their evaluation of the potential presence of exposed surface rock and debris. The side scan sonar data is included in Fugro's Subbottom Profiling and Side Scan Sonar Survey report (Fugro, 2001e).

4.8 HARBOR BOTTOM SEDIMENTS

4.8.1 General Description

The materials that underlie the various channels and basins consist almost exclusively of sediments that were naturally deposited throughout San Pedro Bay prior to the development of POLA. A limited thickness of non-native Harbor Bottom Sediments (deposited or accumulated subsequent to Port development), however, overlies the native sediments throughout most of the Inner Harbor.

The CPT and vibracore data acquired in 1996 provide abundant information relative to the Harbor Bottom Sediments and allow "truthing" of geophysical data. At a majority of the exploration locations, the Harbor Bottom Sediments primarily consist of very soft to soft fine-grained sediments with a lesser amount of coarse-grained sediments. Based on the laboratory data, the fine-grained sediments typically are classified as sandy clays (CL) and sandy silts (ML).

In addition to the 2001 geophysical survey data and the post-1996 exploration and laboratory data, there are several historical data sources that also provide information relative to the occurrence and thickness of the non-native sediments (also referred to as Harbor Bottom Sediments, surface sediments, muck, or bay mud) within the Inner Harbor. The historical references include reports from the USACOE (USACOE, 1995 and 1980a,b) and consultants (CH2M Hill, 1984; HLA, 1987). For the 1981 to 1983 Harbor Deepening Project, the USACOE (1980a) noted that:

> *"These sediments* [surface sediments] *extend north from about the end of Reservation Point through all the waterways in thicknesses varying from zero to 8 feet. West Basin contains a layer of these sediments generally less than 3 feet thick, since the basin is the most recent to be dredged. In general, the deposit is thicker towards the waterway borders and thinner in the middle. This is apparently caused by ocean currents and moving ships spreading it towards the borders. The material is consistently a 'soupy' and very soft muck. It consists mostly of material classifying as clay or silt with varying amounts of fine sand . . . The origin of the muck is primarily from sources in the inner waterways such as sewage or coagulation of materials in suspension following prior dredging of silts, clays and the bedrock. Surface runoff from storms drainage has provided additional material including sand..."*

Much of the "surface sediments" identified by the USACOE (1980a) were subsequently removed when the Inner Harbor was deepened to El. -45 feet MLLW in 1981 to 1983. Thus, the current layer of Harbor Bottom Sediments in most of the Channel Deepening Project area has been deposited since 1981 to 1983. However, some of the Harbor Bottom Sediments along the edges of the waterways may pre-date the 1981 to 1983 dredging program.

The non-native Harbor Bottom Sediments are composed of a mixed assemblage of materials that include sand, silt, clay, and organic matter or debris. Silt- and clay-sized particles appear to be the primary components, with varying amounts of sand-sized particles. Grain size testing indicates that the percentage of sand is typically less than about 20 to 45 percent, but occasionally is in excess of 60 to 70 percent.

Using the grain size and plasticity data, the Harbor Bottom Sediments are primarily classified as sandy clay (CL), clay with sand (CL), and clay (CL) throughout most of the Inner Harbor. In dredge unit FG-3, the Harbor Bottom Sediments are classified as silt (ML) to sandy silt (ML), while in dredge unit FM-1 they are classified as elastic silt (MH).

4.8.2 Geophysical Interpretation

The measured thickness of Harbor Bottom Sediments at the various exploration locations and the 2001 geophysical data (Fugro, 2001e) were used to construct an isopach map estimating non-native Harbor Bottom Sediment (HBS) thickness within the Channel Deepening Project area. A sequence of refinements (including statistical averaging) was performed on the data to prepare the final isopach shown on Map 5. No statistical averaging was performed on the data to prepare the isopach for the southern section of the Channel Deepening Project area shown on Map 6.

HBS thickness was determined at each exploration location in the Main Channel (see Map 3). Seismic reflection survey records were used to provide the necessary additional data throughout the Channel Deepening Project area and were integrated with the geotechnical exploration data. An assumed acoustic velocity of 5,000 ft/s was used to convert the reflection time between the mudline and the top of the native sediment surface to a thickness in feet. True velocities may vary from the assumed value, thereby affecting the thickness estimates. Vertical resolution of subbottom reflectors on geophysical data is ±0.5 to ±1.0 millisecond, which represents about 1.2 to 2.5 feet.

An isopach (thickness) measured in feet was estimated from the geophysical records at each shotpoint (navigation fix) along the trackline using the above information. The geophysics were integrated with the exploration data (which provided ground truthing), to provide a large data set covering the entire Channel Deepening Project area. A preliminary HBS isopach grid was made using this data set.

4.8.3 Geophysical Interpretation Refinement

Following the initial interpretation, the preliminary isopach grid was statistically refined several times before the final HBS isopach was determined. Explorations in some areas indicated a thicker HBS layer than that interpreted from the geophysical records. This difference in HBS thickness was quantified by creating a TIN (Triangular Irregular Network) surface in the UGIS database using the geophysical data.

The HBS thickness on this TIN surface at each exploration was subtracted from the thickness taken from the exploration logs (exploration minus geophysics). This process produced a difference (in feet) between the HBS thickness in the explorations and the interpreted HBS thickness from the geophysics throughout the Main Channel. After systematic verification of the HBS thickness interpreted from the exploration logs throughout the Main Channel, two areas showed consistently higher HBS thickness values as interpreted from the geophysics. The West Turning Basin and the East Turning Basin had average thickness differences of about 0.5 foot and 0.3 foot, respectively.

An adjustment was made at each shotpoint in the West and East Turning Basin areas by adding a correction factor. Then, as before, the HBS thickness values from the explorations and the geophysics were combined into a data set of about 2,200 data points and used to create a surface of the HBS sediment isopach. The surface was converted to a grid with a cell size of 50 feet (about one-third of the average spacing of the data points). The final mapping of the isopach of the Harbor Bottom Sediments that included the statistical approach described above is provided as Map 5.

4.8.4 Thickness and Distribution

As shown on Maps 5 and 6, Harbor Bottom Sediments are present and variable in thickness throughout the entire Channel Deepening Project area. The Harbor Bottom Sediments range in thickness from less than 0.5 foot to greater than about 8 feet (with localized areas with thicknesses greater than 12 feet). Although the data suggest that the thickness is quite variable throughout the Inner Harbor, a few trends were identified:

- Harbor Bottom Sediments tend to be thicker along the edges as compared to the middle portions of the channels and basins.
- The difference in sediment thickness between the middle portions and the edges generally appears to be greater in the "narrow" channels (e.g., Main Channel, East Basin Channel) as compared to the "wide" basins (e.g., West Basin, Turning Basin, and East Basin).
- There is an apparent absence of HBS within the portion of the south Main Channel that was dredged to about El. -50 feet MLLW to supply material for Pier 400 Stage 1.
- The average HBS thickness appears to slightly increase to the north, moving up the Main Channel towards the West and East Basins.
- The thickest accumulations of HBS generally correspond to the edges of the West Turning Basin and West Basin, northern reaches of the East Basin Channel, and the edges of the East Basin.
- In the West Basin, there is an apparent absence of HBS within localized dredged areas.

Although the thickness is variable, we conclude that the typical range of Harbor Bottom Sediment thickness is: a) about 0 to 1 foot thick along the middle and deepest sections of the waterways, b) generally greater than about 2.5 to 3 feet thick along the edges of the waterways, and c) about 1 to 3 feet thick between the deepest sections and the edges. Average thickness throughout the entire Channel Deepening Project area is estimated to be about 1.5 feet.

4.9 DISTURBED VERSUS UNDISTURBED NATIVE DEPOSITS

At the harbor bottom and/or beneath a thin layer of non-native Harbor Bottom Sediments, both disturbed and undisturbed native Holocene deposits are present within the Inner Harbor. The native sediments, which generally were deposited throughout San Pedro Bay prior to the development of POLA, consist of Holocene-age marine, alluvial, lagoonal, and localized slope-wash deposits.

Based on the 1996 CPT and vibracore data, the native Holocene sediments may be divided into two distinct deposits: disturbed and undisturbed. The disturbed deposits (encountered at the harbor bottom or directly beneath the Harbor Bottom Sediments) consist of native sediments that were agitated, suspended, and/or redeposited during the dredging operations for the 1981 to 1983 Harbor Deepening Project. The disturbed deposits generally consist of the same sediment types as the underlying undisturbed deposits. Our interpretation of the available data indicates that the disturbed deposits are generally thicker and more extensive in areas underlain by coarse-grained sediments (i.e., sand) as compared to areas underlain by fine-grained sediments (i.e., silt and clay). Typical thicknesses range from about 1 to 3 feet for areas underlain by fine-grained sediments and about 2 to 4 feet for areas underlain by coarse-grained sediments.

In comparison to the underlying undisturbed deposits, the disturbed deposits typically: a) are a slightly darker color, b) have a distinctly lower cone point resistance, c) contain more shells and shell fragments, and d) where underlain by fine-grained sediments, contain intact chunks of native sediments. The interface between the disturbed and undisturbed sediments, which is occasionally marked by a shell hash layer and/or a significant increase in cone point resistance, typically correlates to elevations of between about -48 and -53 feet MLLW. We note that identification of the interface generally was more obvious in the CPT data than in the vibracore data, and in areas underlain by native coarse-grained deposits as compared to areas underlain by native fine-grained deposits.

5.0 SITE CHARACTERIZATION AND SUBSURFACE CONDITIONS

5.1 INTRODUCTION

As discussed previously, based on anticipated material types, eight "native" dredge units are delineated within the Inner Harbor for the Channel Deepening Project. The eight dredge units are shown on Map 7. The locations and shapes of the interpreted contacts between different stratigraphic units (on Map 7) are approximate and were partially influenced by the shapes and general trends of paleochannels and other features depicted on morphology maps. Our examination of the stratigraphic data suggests that at least a few of the paleochannels, especially those in the vicinity of the Vincent Thomas Bridge, are filled with a relatively thick sequence of silts and clays. The locations and shapes of the interpreted contacts between different stratigraphic units have been refined based on the additional explorations performed since 1996 and the geophysical data collected in 2001.

As noted previously, delineation of the preliminary dredge units was based primarily on Fugro's stratigraphic interpretation. Therefore, in the following paragraphs, the native sediments that are present at shallow depths throughout the Inner Harbor will be discussed on a dredge unit by dredge unit basis (refer to Plate 4.1 and Map 7 for dredge unit locations) in the following order: CG dredge units, FG dredge units, and then the FM dredge unit. Properties and engineering characteristics of the sediments are discussed in the Chapter 6.0 of this report. We note that, because the Harbor Bottom Sediments are present in all of the dredge units, only the native sediments will be discussed in the following paragraphs.

5.2 INTERPRETED SHALLOW STRATIGRAPHIC CONDITIONS

5.2.1 Native Dredge Unit CG-1

The native sediments within dredge unit CG-1 (i.e., middle Main Channel) consist of: a) alluvial- and marine-deposited, coarse-grained sediments associated with a sweeping paleochannel system; and b) localized slope-wash sediments apparently derived from the Palos Verdes Hills. Based on the existing data, it appears that the slope-wash deposits primarily exist as 1- to 4-foot-thick interlayers within the coarse-grained paleochannel deposits. At shallow depths, the coarse-grained paleochannel deposits spatially predominate in the southern and eastern one-third of dredge unit CG-1, while the slope-wash deposits apparently are more prevalent throughout the western and northern two-thirds of the dredge unit. As indicated on Plate 5.1, a semi-linear deposit of interlayered sediments (which is not related to the slope-wash deposits) crosses the middle portion of the dredge unit. We note that additional specific stratigraphic details for dredge unit CG-1 are provided by Fugro (1996b).

The paleochannel deposits primarily consist of light gray to gray, fine sands (SP) and fine sands with silt (SP-SM). The slope-wash sediments are typically light brown to reddish brown, silty fine sands (SM) and sandy silts (ML) that contain inclusions of dissimilar sediments and yellowish-red (oxidized) zones.

5.2.2 Native Dredge Unit CG-2

The native sediments within dredge unit CG-2 (i.e., middle and northern Main Channel) are generally the same and likely related to those present in dredge unit CG-1 (refer to Plate 5.2). As indicated on Plate 5.2, the coarse-grained paleochannel deposits predominate throughout dredge unit CG-2, with the exception of: a) interlayered slope-wash deposits; b) a localized fine-grained deposit along the western edge of the Main Channel in the middle section of dredge unit CG-2; and interlayered deposits in the extreme northeastern corner of the dredge unit. We note that the fine-grained deposits in the northeastern corner are related to a distinct U-shaped paleochannel that generally defines the limits of dredge unit FG-1, as will be discussed in a following section.

The predominant coarse-grained sediments within this dredge unit consist of fine sands (SP) and fine sands with silt (SP-SM) that have a median grain size (D_{50}) of between about 0.2 and 0.45 millimeters (mm). CH2M Hill (1984) identified those sediments as "preferred" borrow sediments for the filling of old Slip 228. We note that the middle section of dredge unit CG-2 has been used as a borrow source and, as indicated on Map 1, current harbor bottom elevations are lower than El. -50 feet MLLW over much of the area. Therefore, much of the "preferred" borrow sediments have already been removed, but additional coarse-grained sediments are present at greater depths. The fine-grained deposits encountered within dredge unit CG-2 consist primarily of low to medium plasticity clays (CL).

5.2.3 Native Dredge Unit CG-3

Most of dredge unit CG-3 (i.e., West Basin) is underlain by coarse-grained sediments that extend well below the project dredge elevation. Because of the existence of abundant coarse-grained sediments, the middle portion of dredge unit CG-3 previously has been used as a borrow source and, as indicated on Map 1, has current bottom elevations typically lower than about El. -50 feet MLLW. The coarse-grained sediments within dredge unit CG-3 consist of fine sands with silt (SP-SM) and silty fine sands (SM) that have a median grain size (D_{50}) of between about 0.1 and 0.2 mm.

In addition to the predominant coarse-grained deposits, interlayered deposits are present in the northwestern corner of the dredge unit, while fine-grained sediments are present along the southwestern edge and the extreme southern portion of dredge unit CG-3 (refer to Plate 5.3). The interlayered deposits appear to consist primarily of coarse-grained sediments; however, localized layers of fine-grained sediments are present. The fine-grained layers typically consist of low to medium plasticity, normally consolidated clays (CL).

In addition to the sediments mentioned above, an apparently localized, shallow deposit of fine-grained sediments was encountered at CPT-21 in the middle of the dredge unit along the southern portion of the existing borrow pit. That localized fine-grained deposit is interpreted to be non-typical for the area and may actually be dredge spoil that was placed in the existing borrow pit.

5.2.4 Native Dredge Unit CG-4

The native sediments within dredge unit CG-4 (i.e., northeastern Turning Basin and southwestern East Basin Channel) are similar and likely related to those present within dredge unit CG-3. Consisting predominantly of fine sands with silt (SP-SM) and silty fine sands (SM), the coarse-grained sediments are present throughout the dredge unit, except for fine-grained sediments at the extreme northeastern end of the dredge unit (refer to Plate 5.4). The predominant sands and silty sands within dredge unit CG-4 have a median grain size (D_{50}) of between about 0.1 and 0.3 mm.

Within the predominantly coarse-grained sediments of dredge unit CG-4, a few fine-grained layers were encountered that appear to be overconsolidated (possibly desiccated) and apparently consist of fat clays (CH). As will be discussed in a following paragraph, those overconsolidated layers also were encountered in dredge units FG-1 and FG-2.

5.2.5 Native Dredge Unit FG-1

This dredge unit, which covers the extreme northern Main Channel and southwestern Turning Basin areas of the Inner Harbor, is underlain almost entirely by predominantly fine-grained sediments that apparently have infilled at least one major paleochannel (refer to Plate 5.5). In addition, interlayered deposits, which also appear to infill another paleochannel, are present along the northeastern boundary of the dredge unit. The interlayered deposits and fine-grained sediments (and the paleochannels) appear to extend northwesterly towards, and are present within, the more southern reaches of dredge unit FG-2. We note that the northwesterly extension of those deposits (and the paleochannels) generally follows the trend of, and were likely controlled by, the Palos Verdes fault within the Inner Harbor. Fugro (1994) and McNeilan et al. (1996) provide details relative to the Palos Verdes fault. A recent study by Earth Mechanics, Inc., discusses the Palos Verdes fault within the West Basin area of the Channel Deepening Project (EMI, 2001b).

The fine-grained sediments within dredge unit FG-1 consist primarily of normally consolidated, low to medium plasticity clays (CL) that extend to depths exceeding about El. -70 feet MLLW. Localized layers of overconsolidated (possibly desiccated) fat clay (CH) were encountered at a few locations within the dredge unit. The overconsolidated layers within dredge unit FG-1 are similar and likely related to the overconsolidated clay layers that are present within dredge units CG-4 and FG-2.

5.2.6 Native Dredge Unit FG-2

Dredge unit FG-2 (i.e., West Basin Channel) contains some of the most complex geologic and stratigraphic conditions encountered throughout the Inner Harbor. The complexity appears to be primarily related to movement along the Palos Verdes fault. As indicated on Plate 5.6, units of coarse-grained, interlayered, and fine-grained deposits are present within the dredge unit. The interlayered and fine-grained deposits predominate, with the coarse-grained deposits generally limited to the southwestern portions of the dredge unit. As noted above, the interlayered and fine-grained deposits within dredge unit FG-2 appear to be an extension of the same deposits present in dredge unit FG-1. We note that subdivision of the dredge unit may be possible, thus permitting selective dredging of the limited coarse-grained deposits within the area.

The fine-grained sediments consist primarily of normally consolidated clays (CL) with a few localized layers of overconsolidated (desiccated) fat clays (CH). The coarse-grained sediments consist of fine sands with silt (SP-SM) and silty fine sands (SM) that are similar to the coarse-grained sediments present within dredge unit CG-4.

5.2.7 Native Dredge Unit FG-3

Within the depths of interest for the Channel Deepening Program, fine-grained deposits predominate throughout dredge unit FG-3 (i.e., Cerritos Channel, East Basin, and northeastern East Basin Channel). The fine-grained sediments, which extend downward to elevations of about -55 to -60 feet MLLW, consist primarily of normally consolidated to slightly overconsolidated, low to medium plasticity silts (ML) with silty sand layers that were likely deposited in a lagoonal or backwater environment. As indicated on Plate 5.7, the northern corner of the East Basin contains some interlayered deposits at shallow depths.

The predominant fine-grained sediments appear to be underlain by coarse-grained sediments. Consisting of silty fine sands (SM), the top of those deeper coarse-grained sediments was encountered at about El. -50 to -60 feet MLLW. The existing data are insufficient to determine the thickness of the deeper coarse-grained sediments.

5.2.8 Native Dredge Unit FM-1

Native dredge unit FM-1 is underlain by geologic deposits associated with two specific formations: 1) the Timms Point Silt member of the San Pedro Formation, and 2) the Malaga Mudstone member of the Monterey Formation. The Malaga Mudstone deposits consist of elastic silts (MH), while the Timms Point Silt deposits consist of silts (ML), sandy silts (ML), and some silty fine sands (SM).

The extreme northern portion of the Glenn Anderson Ship Channel contains Malaga Mudstone deposits. We note that Fugro-McClelland (1992) explored and partially mapped that portion of POLA during the 2020 Plan Geotechnical Investigation. Northerly from the Glenn Anderson Ship Channel, the Malaga Mudstone deposits extend into the extreme southern portion of the Main Channel, as indicated on Plate 5.8. Malaga Mudstone deposits extend westerly to the Non-Federal Dredge Area, which is south of the Pilot's Station. Farther north, Timms Point Silt deposits are present within the Main Channel. The northern boundary of the formation materials (i.e., Timms Point Silt) crosses the Main Channel at about Sta. 100+00, roughly corresponding to a line connecting the U.S. Coast Guard slip on Reservation Point to the San Pedro (SP) slip. We note that additional details relative to the sediment-formation contact are presented in Chapter 4.0 of this report.

Furthermore, the data collected from side scan sonar surveys (Fugro, 1997d and 2001e) performed in dredge unit FM-1 provide additional information relative to rock inclusions within and on top of the formation materials.

5.3 POTENTIAL SUBSURFACE VARIABILITY

Fugro's interpretation of general stratigraphic conditions is based on sediment conditions that were: a) observed at boring locations, b) observed at the environmental and stratigraphic vibracore locations, c) interpreted from the mini-CPT data, d) depicted on the stratigraphic logs for the various historical explorations, and e) interpreted from the available geophysical data. Conditions may vary at locations not sampled by the vibracores or probed by the CPTs. We note that, within certain areas of the Inner Harbor, Fugro relied significantly on the existing data that have been acquired over the last 15 to 20 years by various agencies and consultants.

Maps 8a and 8b include several cross sections that were created from the UGIS database developed by Fugro. The cross sections, which include borings, CPT soundings, and vibracores, have been color coded to identify stratigraphic breaks and material types. Several of the cross sections were developed specifically for the Channel Deepening Project, while others were compiled from existing cross sections drawn for proposed utility line relocations. Map 8a is a compilation of previously presented cross sections, while Map 8b provides new cross sections drawn along the centerline of the Channel Deepening Project from about Sta. 50+00 to the East Channel. Along the widest section of the Main Channel to about Sta. 145+00, subsurface explorations (marine and land) within 300 feet of the centerline have been included in the cross sections. From Sta. 145+00 to Sta. 185+00, the width of subsurface exploration narrowed to within 250 feet of the channel centerline. Subsurface explorations within 150 feet of the channel centerline were included in cross sections drawn beyond Sta. 185+00. The cross sections were drawn with vertical to horizontal exaggerations that depend upon the extent of the cross section. The vertical to horizontal exaggeration is noted for each cross section on Maps 8a and 8b. The cross sections provide insight into the general stratigraphic conditions within the Channel Deepening Project area and the inherent variability of the native sediments.

5.4 RELEVANT PROPERTIES AND CHARACTERISTICS

5.4.1 General Properties

There are several sediment properties and conditions relevant to the Channel Deepening Project. Of particular interest are the defining sediment types and in situ conditions. Sediment types, which are commonly evaluated using typical geotechnical classification tests, are important for evaluating dredge spoil disposal options and dredge production rates. In situ conditions, such as undrained shear strength, also are important for determining dredge production rates and the degree of difficulty in excavating dredged materials.

Relevant sediment properties for the various geologic materials present within the Inner Harbor are discussed in the following paragraphs. The native sediments are divided into three groups: coarse-grained, fine-grained, and formation materials. The Harbor Bottom Sediments, formation materials, and disturbed native sediments are discussed separately.

Additional detail relative to the properties of the native sediments in each dredge unit is provided in Chapter 6.0.

5.4.2 Classification

Overview. The classification of sediments was evaluated by performing grain size analyses and plasticity determinations using the methods established by the American Society for Testing and Materials (ASTM). The following tests were performed on various samples retrieved from the vibracores: a) sieve, hydrometer, and percent passing the No. 200 sieve (ASTM D422 and D1140); and b) Atterberg limits (ASTM D4318). Relevant data provided by those tests include percent fines, median grain size (D_{50}), liquid limit, and plasticity index.

Coarse-Grained Sediments. On Plate 5.9, the percentage of soil passing the No. 200 sieve is plotted versus elevation for the coarse-grained sediments throughout the Channel Deepening Project area. A layer between about El. -45 and El. -50 feet MLLW coincides with the Harbor Bottom Sediments and has a much higher percentage of fines material. Below the Harbor Bottom Sediments, the coarse-grained sediments typically have a fines content of less than about 40 percent.

Fine-Grained Sediments. On Plate 5.10, the percentage of soil passing the No. 200 sieve is plotted versus elevation for the fine-grained sediments throughout the Channel Deepening Project area. The fines content of the fine-grained sediments are variable but indicate an increased coarseness with depth.

Interlayered Sediments. On Plate 5.11, the percentage of soil passing the No. 200 sieve is plotted versus elevation for the interlayered sediments throughout the Channel Deepening Project area. The fines content of the interlayered sediments are variable throughout the depth of exploration.

Formation Materials. On Plate 5.12, the percentage of soil passing the No. 200 sieve is plotted versus elevation for the formation materials within the southern limits of the Channel Deepening Project area. The formation materials typically have a fines content of greater than about 80 percent and are commonly in excess of about 90 percent.

5.4.3 Undrained Shear Strength

In addition, undrained shear strengths (S_u) also can be used to anticipate the degree of difficulty in excavating (dredging) fine-grained sediments. Laboratory and field test measurements of the undrained shear strength of fine-grained sediments have been recorded.

This report discusses the geotechnical engineering property of undrained shear strength. It should be noted that for shallow, high quality samples, the unconfined compressive strength is twice the undrained shear strength. Often, when selecting the type and size of a dredge cutter, the unconfined compressive strength is used rather than the undrained shear strength. Therefore, the undrained shear strength will need to be doubled if estimates of soil unconfined compressive strength are needed. In this report, the unconfined compressive strength is presented in discussions of rock strength.

5.4.4 Cone Point Resistance

Overview. As previously noted, CPTs were performed throughout the Inner Harbor. Details relative to the CPTs performed in 1996 are provided in our report (Fugro, 1997c). Particularly relevant is the measured cone point resistance (q_c). In addition to evaluating stratigraphic conditions, the cone point resistance also provides a means to estimate relative density, inferred N-values, and undrained shear strengths when direct measurement of those properties is not possible.

We note that the Seascout system uses a miniature cone (about 0.38 inch in diameter), which is significantly smaller than the typical cone (about 1.4 inches in diameter) used on land. The measured cone point resistances may have been influenced by the cone size. Based on Fugro's past experience and evaluation of the new CPT data, it appears that the cone point resistances measured by the miniature cone, as compared to the typical on-land cone, are or may be: a) similar in magnitude in medium dense to very dense coarse-grained deposits; b) lower in magnitude in very loose to loose coarse-grained deposits; and c) similar in magnitude in most fine-grained deposits. The possibility of lower measured cone point resistances in very loose to loose coarse-grained deposits is important to remember when considering the properties for the disturbed native coarse-grained deposits.

Interpretation. The general characteristics of the three Holocene sediment units have been interpreted using cumulative frequency plots of cone tip resistance. For classification purposes, cone tip resistance is considered to be a logarithmically distributed parameter (Robertson and Campanella, 1988), so the cumulative frequency plot has been plotted on a log scale. Generally, soil classification based on CPT parameters requires knowledge of cone tip resistance, friction ratio or pore pressure parameter. With site-specific knowledge, cone tip resistance may give a good indication of stratigraphy and subsurface conditions.

Using the UGIS database, CPT soundings were characterized by the Holocene sediment unit into which they were performed. The cumulative frequency plots of cone tip resistance (refer to Plate 5.13) have been prepared for each of the geologic unit.

Coarse-Grained Sediments. The coarse-grained deposits are most desirable for landfill construction, and generally should have a higher cone tip resistance value as compared to the other Holocene sediment units. Typically, the median cone tip resistance ($q_{c,50}$) is about 100 tons per square foot (tsf) for the coarse-grained sediments.

Fine-Grained Sediments. The fine-grained deposits are the least desirable for landfill construction, and generally should have a lower cone tip resistance value as compared to the other Holocene sediment units. Typically, the median cone tip resistance ($q_{c,50}$) is about 20 tsf.

Interlayered Sediments. The interlayered deposits consist of both coarse- and fine-grained materials and have a moderate desirability with respect to landfill construction. The cone tip resistance profile in interlayered deposits will include both high and low values. On average, the cone tip resistance in interlayered materials should be greater than fine-grained deposits and less than coarse-grained deposits. The median cone tip resistance ($q_{c,50}$) is about 68 tsf for the interlayered deposits.

5.5 MINING OPTIONS FOR COARSE-GRAINED SEDIMENTS

5.5.1 Background

It is Fugro's understanding that POLA is considering options for mining additional coarse-grained sediments that are present within the Inner Harbor below the Channel Deepening Project elevation of -53 feet MLLW. The possible mining option was discussed during the development of the preliminary Phase 2 investigation. The recommended scope of the Phase 2 investigation, as presented by Fugro (1996c), was modified to include: a) deeper vibracore sampling in areas (i.e., CG dredge units) anticipated to be underlain by coarse-grained sediments; and b) geotechnical laboratory and bulk sediment chemistry testing on samples obtained from the deeper vibracores between El. -52 and El. -65 feet MLLW. Therefore, in addition to testing the primary dredge interval (i.e., existing harbor bottom down to El. -52 feet MLLW) during the Phase 2 investigation, sediment samples from the El. -52 to El. -65-foot interval also were tested for bulk sediment chemistry and to determine pertinent geotechnical properties.

5.5.2 Interpretation of Deeper Stratigraphy

During Fugro's 1997 interpretation of shallow stratigraphic conditions, the available data also were used to evaluate deeper stratigraphic conditions within the CG dredge units. Most of the available and useful data are related to the vibracore sampling performed specifically for the Channel Deepening Project. However, some of the existing data sources (e.g., CH2M Hill, 1984; HLA, 1987) do provide useful but limited stratigraphic data below El. -55 feet MLLW. Additional detailed information is locally available where borings have been drilled for pipeline and utility crossings.

The deeper stratigraphic interpretation was directed primarily towards identifying significant deposits of coarse-grained sediments that exist below El. -55 feet MLLW and that extend downward to at least El. -65 to El. -70 feet MLLW. Those areas are shown on Map 9.

5.5.3 Evaluation of Potential Mining Areas

As shown on Map 9, Fugro has identified three general areas within the Inner Harbor that could be considered for mining of coarse-grained sediments:

- The middle two-thirds of the Main Channel (dredge units CG-1 and CG-2)
- Most of the northern West Basin (dredge unit CG-3)
- A portion of the Turning Basin and East Channel (dredge unit CG-4)

Each of those areas apparently contains significant deposits of coarse-grained sediments below El. -53 feet MLLW. From the standpoint of engineering characteristics, the deeper sediments within the Main Channel are more desirable than those within the West Basin, northeast Turning Basin, and southwest East Basin Channel.

6.0 ENGINEERING PROPERTIES OF NATIVE SEDIMENTS

6.1 NATIVE DREDGE UNITS

Based on anticipated material types, eight "native" dredge units are delineated within the Inner Harbor for the Channel Deepening Project. A summary of relevant information for each dredge unit is presented in Chapter 5.0. The eight native dredge units are shown on Map 7.

The native sediments beneath the Harbor Bottom Sediments in four of the dredge units (CG-1 through CG-4, which cover about 265 acres of the Inner Harbor) appear to be comprised primarily of coarse-grained sediments that, from an engineering standpoint, are considered desirable for use in a landfill. Fine-grained sediments, which are considered undesirable for use in an "engineered" landfill, predominate in the three FG and one FM dredge units. Other possible disposal options for these sediments could include ocean disposal at LA-3, placement in the Cabrillo Shallow Water Habitat Expansion (USACOE, 2000), placement into the 35-acre Southwest Slip fill area, and/or upland disposal. As described in Chapter 4.0, the native sediments are generally overlain by a variable thickness of soft, recent, primarily fine-grained Harbor Bottom Sediments.

6.2 DREDGE UNIT CG-1

6.2.1 General Characteristics

This area correlates to an approximately 3,800-foot-long by 800-foot-wide section in the middle of the Main Channel that covers about 70 acres. The southern limit generally corresponds to the sediment-formation contact that crosses the Main Channel in a northwesterly trend. A portion of this unit was dredged during the Pier 400, Stage 1 construction.

Based on existing data, it appears that dredge unit CG-1 is underlain primarily by coarse-grained sediments. However, fine-grained deposits may be present in localized areas or as lenses interbedded with the coarse-grained sediments. Furthermore, non-native Harbor Bottom Sediments generally overlie the native coarse-grained sediments. We note that about 160,000 cubic yards were removed from dredge unit CG-1 in May 1997 for borrow material for the Pier 400 Stage 1 landfill. This material was used to heighten the Stage 1 surcharge. These coarse-grained sediments were the coarsest sand deposited in Stage 1. A significant quantity of fines from the CG-1 deposit accumulated behind the surcharge outlet weir.

Several sediment properties and conditions are relevant to the proposed Channel Deepening Project and associated dredging. The defining sediment types and in situ conditions are of particular interest. Sediment types, which are commonly evaluated using typical geotechnical classification tests, are important for evaluating dredge spoil disposal options and dredge production rates. The laboratory test data were augmented with results from testing performed on samples from borings drilled in and adjacent to the dredge unit CG-1. The historical data were from work performed for other geotechnical studies (L.T. Evans, 1971;

HLA, 1982; Diaz-Yourman & Associates, 1998). The following section summarizes the results of pertinent laboratory tests.

6.2.2 Classification Properties

Water Content. A plot of water content versus elevation for the dredge unit CG-1 is shown on Plate 6.1a. The water content in depth interval of the Harbor Bottom Sediments (from about El. -45 to El. -50 feet MLLW) ranges from about 30 to 80 percent. In the predominantly granular soils below the Harbor Bottom Sediments, the majority of water contents are between 23 and 28 percent.

Fines Content. On Plate 6.1b, minus Sieve No. 200 values are plotted versus elevation for the dredge unit CG-1 area. Between El. -45 and El. -50 feet MLLW, some of the data coincides with the Harbor Bottom Sediments that have a much higher percentage of fines material. Below the Harbor Bottom Sediments, the native sand has a fines content of typically 3 to 15 percent. The samples with a higher percentage of fines correlate to the interlayered deposits and slope-wash sediments.

Median Grain Size. On Plate 6.1c, median grain size values are plotted versus elevation for the dredge unit CG-1 area. The values of D_{50} generally range from 0.1 to 0.4 mm. Values greater than about 0.2 mm are consistent with coarse-grained sediments associated with the granular paleochannel system. The laboratory test results with a D_{50} value between 0.1 and 0.2 generally correlate to the slope-wash sediments. Two D_{50} values of about 0.01 mm correlate to the Harbor Bottom Sediment samples.

Plasticity. The native dredge unit CG-1 sediments are generally non-plastic. In contrast, the Harbor Bottom Sediments consist of silts and clays in the range of low to medium plasticity. Although these soils contain various degrees of plasticity, most plot along the A-line of the Atterberg plasticity chart presented on Plate 6.1d.

6.2.3 In Situ Conditions

Total Unit Weight. Measured total unit weight versus elevation for the dredge unit CG-1 is given on Plate 6.1e. The total unit weight of the Harbor Bottom Sediments ranges from about 90 to 120 pounds per cubic foot (pcf). Below the Harbor Bottom Sediments, the native material has total unit weights ranging from about 122 to 128 pcf.

Measured Cone Tip Resistances. There were 14 CPTs analyzed in native dredge unit CG-1. Nine of these were in geologic units classified as coarse-grained deposits, and five were in geologic units classified as interlayered. Plate 6.1f shows the cumulative frequency plot for the cone tip resistance of the 14 CPT soundings analyzed. The median cone tip resistance ($q_{c,50}$) is about 53 tsf. The cumulative frequency curve for CG-1 lies to the left of the typical curve for coarse-grained sediments, which indicates a greater presence of sediments with lower cone tip resistance (i.e., fine-grained sediments). The lower than average values of q_c may be due to the presence of fine-grained slope wash deposits and the interlayered area of CG-1.

The majority of cone tip resistance values in native dredge unit CG-1 are greater than 40 tsf, which is generally associated with sands, silty sands, and sandy silts.

6.3 DREDGE UNIT CG-2

6.3.1 General Characteristics

Dredge unit CG-2 correlates to an approximately 3,000-foot-long by 900-foot-wide section of the north Main Channel and covers about 65 acres (refer to Map 7). The Evergreen Container Terminal, Los Angeles World Cruise Center, and Pasha/Honda Auto Terminal generally define the lateral limits of the area. A cluster of utilities crossing the Main Channel between about Berths 84/85 and 234/235 defines the southern limit of dredge unit CG-2. The northern limit generally corresponds to the southern side of Slip 93. In the northern portion of dredge unit CG-2, a utility (i.e., telephone) line crosses the Main Channel between about Berths 91/92 and 229/230.

The stratigraphic data suggest that primarily coarse-grained deposits are present in this area. Much of dredge unit CG-2 was previously used as a borrow source for the filling of several old slips. Some data, including the old morphology maps, suggest that fine-grained deposits may be locally present in the middle portion of the dredge unit.

The laboratory test data were augmented with previous results from testing performed on samples from borings drilled in and adjacent to dredge unit CG-2. The historical data were added from work performed for other geotechnical studies (CH2M Hill, 1984; Dames & Moore, 1968 and 1984; Diaz-Yourman & Associates, 1998; L.T. Evans, 1958 and 1971). The following section summarizes the results of pertinent laboratory tests.

6.3.2 Classification Properties

Water Content. A plot of water content versus elevation for dredge unit CG-2 is given on Plate 6.2a. In predominantly granular soils below the Harbor Bottom Sediments, the majority of the water contents are between about 20 and 30 percent.

Fines Content. On Plate 6.2b, the percentage of soil passing the No. 200 sieve is plotted versus elevation for the dredge unit CG-2 area. A layer between about El. -45 and El. -50 feet MLLW coincides with the Harbor Bottom Sediments and has a much higher percentage of fines material. Below the Harbor Bottom Sediments, the native material typically has a fines content of less than about 12 percent and is commonly about 2 to 5 percent. Some silty areas exist with fines content values ranging from 20 to 40 percent. A higher percentage of fines within the native material may indicate the presence of slope-wash sediments (silty fine sands and sandy silts).

Median Grain Size. On Plate 6.2c, median grain size values are plotted versus elevation for the dredge unit CG-2 area. Mean grain size values from sieve analyses performed typically lie between 0.2 and 0.45. The values of D_{50} greater than about 0.2 mm are consistent with typical coarse-grained sediments within the Channel Deepening Project limits.

Plasticity. The CG-2 sands are non-plastic. The Harbor Bottom Sediments consist of silts and clays in the range of low to medium plasticity. Additionally, fine-grained materials in the northeastern portion of the dredge unit consist of silts and clays with low to medium plasticity. Although these soils contain various degrees of plasticity, most plot along the A-line of the Atterberg plasticity chart presented on Plate 6.2d.

6.3.3 In Situ Conditions

Total Unit Weight. Measured total unit weight versus elevation for dredge unit CG-2 is given on Plate 6.2e. The total unit weight of the Harbor Bottom Sediments ranges from about 100 to 120 pcf. Below the Harbor Bottom Sediments, the native material has total unit weight measurements typically ranging from about 120 to 128 pcf.

Measured Cone Tip Resistances. There were 16 CPTs analyzed in native dredge unit CG-2 (12 in coarse-grained deposits, 1 in interlayered deposits, and 3 in fine-grained deposits). Plate 6.2f shows the cumulative frequency plot for the cone tip resistance of the 16 CPT soundings analyzed. It should be noted that less than about 5 percent of the CG-2 area contains geologic units classified as fine grained, but nearly 20 percent of the CPT data is from CPTs conducted in fine-grained units. The median cone tip resistance ($q_{c,50}$) is about 58 tsf. The cumulative frequency curve for CG-2 typically lies close to the typical curve for coarse-grained sediments, with the exception of lower than average cone tip resistance values in the middle of the curve. The lower than anticipated values of q_c may be due to the higher proportion of CPT soundings advanced within the predominantly fine-grained area of the dredge unit.

6.4 DREDGE UNIT CG-3

6.4.1 General Characteristics

The northern West Basin area has been designated dredge unit CG-3 and covers about 70 acres. This area extends from the narrow point of the West Basin near Berth 124 to the northern limit of the basin, in front of the Trans Pacific Container Terminal, which is a distance of about 2,100 feet (refer to Map 7). Dredge unit CG-3 extends across the full east-west width of the West Basin, which varies in width from about 650 feet near Berth 124 to about 2,300 feet in front of the Trans Pacific Container Terminal.

Stratigraphic data suggest that dredge unit CG-3 is underlain primarily by coarse-grained deposits. There are localized, interlayered deposits in the western and northwestern portions of the basin and fine-grained deposits in localized bathymetric depressions in the middle of the West Basin.

The laboratory test data were augmented with previous results from testing performed on samples from borings drilled in and adjacent to dredge unit CG-3. The historical data were added from work performed for other geotechnical studies (Dames & Moore, 1982; Earth Technology, 1983; Geotechnical Professionals, 1994; ToxScan, 1994). The following section summarizes the results of pertinent laboratory tests.

6.4.2 Classification Properties

Water Content. A plot of water content versus elevation for dredge unit CG-3 is given on Plate 6.3a. The water content in the depth interval of the Harbor Bottom Sediments (from about El. -45 to El. -50 feet MLLW) ranges from about 30 to 60 percent. In the predominantly granular soils below the Harbor Bottom Sediments, the majority of water content values are between 20 and 30 percent. Between El. -45 and El. -55 feet MLLW, water contents of about 50 percent represent localized layers of fine-grained deposits.

Fines Content. On Plate 6.3b, the percentage of soil passing the No. 200 sieve is plotted versus elevation for the dredge unit CG-3 area. A layer between about El. -45 and El. -50 feet MLLW coincides with the Harbor Bottom Sediments and has a higher percentage of fines material. Below the Harbor Bottom Sediments, the native material typically has a fines content of less than 12 percent, with some silty and clayey areas containing fines content values ranging from 25 to 40 percent. Some fine-grained layers within the other deposits have fines content values in excess of 50 percent.

Median Grain Size. On Plate 6.3c, median grain size values are plotted versus elevation for the dredge unit CG-3 area. Median grain size values from sieve analyses were typically between 0.1 and 0.2 mm.

Plasticity. Dredge unit CG-3 sands are non-plastic. The Harbor Bottom Sediments consist of silts and clays in the range of low to medium plasticity. Although these soils contain various degrees of plasticity, most plot along the A-line of the plasticity chart(Plate 6.3d). Fine-grained layers located below the Harbor Bottom Sediments consist of silts and clays of low to high plasticity and generally plot above the A-line. Liquid limit (LL) values greater than 50 are consistent with the presence of localized areas of clay within the interlayered deposits.

6.4.3 In Situ Conditions

Total Unit Weight. Measured total unit weight versus elevation for dredge unit CG-3 is given on Plate 6.3e. The total unit weight of the Harbor Bottom Sediments ranges from about 100 to 115 pcf. Below the Harbor Bottom Sediments, the coarse-grained native material has total unit weight measurements typically ranging from about 120 to 125 pcf, and the total unit weight of the clay layers is between 105 and 115 pcf. The variability of total unit weight in dredge unit CG-3 is greater than that observed in other primarily granular areas (CG-1, CG-2, and CG-4).

Measured Cone Tip Resistances. There were 25 CPTs analyzed in native dredge unit CG-3 (14 in coarse-grained deposits, 4 in interlayered deposits, and 7 in fine-grained deposits). Plate 6.3f shows the cumulative frequency plot for the cone tip resistance of the 25 CPT soundings analyzed. The median cone tip resistance ($q_{c,50}$) is about 97 tsf. The cumulative frequency curve for CG-3 typically lies close to the curve for coarse-grained sediments. About 50 percent of the CPT q_c data are greater than about 100 tsf, which is generally associated with sands and silty sands.

6.5 DREDGE UNIT CG-4

6.5.1 General Characteristics

Dredge unit CG-4 includes the northeastern one-half of the western Turning Basin and the southwestern 1,800 feet of the East Basin Channel. The dredge unit extends northeasterly from about Berth 224 to about Berth 218. The southwestern boundary, which trends northwesterly from about Berth 224 to about Berth 150, generally corresponds to our interpreted contact (refer to Map 7) between apparently significant deposits of fine- and coarse-grained sediments. The northeastern limit corresponds to a utility (i.e., power cables) line that crosses the East Basin Channel between about Berths 173 and 218.

The materials underlying dredge unit CG-4 consist primarily of coarse-grained sediments; however, interlayered deposits are locally present and fine-grained sediments are present within the northeastern corner of the dredge unit. Non-native Harbor Bottom Sediments overlie the native sediments throughout dredge unit CG-4.

The laboratory test data were augmented with previous results from testing performed on samples from borings drilled in and adjacent to dredge unit CG-4. The historical data were added from work performed for other geotechnical studies (CH2M Hill, 1984; EMI, 1996; L.T. Evans, 1961; Woodward-Clyde, 1984). The following section summarizes the results of pertinent laboratory tests.

6.5.2 Classification Properties

Water Content. A plot of water content versus elevation for dredge unit CG-4 is given on Plate 6.4a. The water content in the depth interval of Harbor Bottom Sediments (from about El. -45 to El. -50 feet MLLW) ranges from about 35 to 55 percent. In predominantly granular soils below the Harbor Bottom Sediments, the majority of water content values are between 20 and 30 percent. Fine-grained layers existing below the Harbor Bottom Sediments typically have water content values between 30 and 50 percent.

Fines Content. On Plate 6.4b, the percentage of soil passing the No. 200 sieve is plotted versus elevation for the dredge unit CG-4 area. A layer between about El. -45 and El. -50 feet MLLW coincides with the Harbor Bottom Sediments and has a higher percentage of fines material. Below the Harbor Bottom Sediments, the native materials typically have a fines content of less than about 30 percent. Some silty areas exist with fines content values ranging up to 50 percent, and a few silt and clay layers with a fines content of over 50 percent exist below El. -50 feet MLLW.

Median Grain Size. On Plate 6.4c, median grain size values are plotted versus elevation for the dredge unit CG-4 area. The median grain size values from sieve analyses performed typically lie between 0.1 and 0.2 mm. Below El. -58 feet MLLW, there are a few samples with a mean grain size between 0.2 and 0.4 mm.

Plasticity. Dredge unit CG-4 sands are non-plastic. The Harbor Bottom Sediments consist of silts and clays in the range of low to medium plasticity. Clay layers below the Harbor Bottom Sediments generally have slightly higher plasticity indices (PI), with PI values above 20. Although these soils contain various degrees of plasticity, most plot along the A-line of the Atterberg plasticity chart presented on Plate 6.4d. LL values greater than 50 are consistent with the presence of fat clays (CH) within the fine-grained layers. Those overconsolidated layers have additionally been observed in dredge units FG-1 and FG-2.

6.5.3 In Situ Conditions

Total Unit Weight. Measured total unit weight versus elevation for dredge unit CG-4 is given in Plate 6.4e. The total unit weight of the Harbor Bottom Sediments ranges from about 105 to 115 pcf. Below the Harbor Bottom Sediments, the coarse-grained native materials have total unit weights ranging from about 120 to 132 pcf, with the fine-grained native materials having total unit weight values ranging from about 105 to 120 pcf.

Measured Cone Tip Resistances. There were 21 CPTs analyzed in dredge unit CG-4 (20 in coarse-grained deposits and 1 in fine-grained deposits). Plate 6.4f shows the cumulative frequency plot for the cone tip resistance of the 21 CPT soundings analyzed. The median cone tip resistance ($q_{c,50}$) is about 71 tsf. The cumulative frequency curve for CG-4 typically lies close to the typical curve for coarse-grained sediments, with the exception of lower than average cone tip resistance values in the middle of the curve. The lower than anticipated values of q_c may be due to the higher proportion of fine sands and silty sands within the dredge unit (refer to Plate 6.4b). Plate 6.4b indicates that laboratory test results measured the value of fines content as being typically greater than about 5 percent (sand with silt and silty sands).

6.6 DREDGE UNIT FG-1

6.6.1 General Characteristics

Dredge unit FG-1 extends northwesterly from the north Main Channel area into the southwestern portion of the Turning Basin (refer to Map 7). Two utility (i.e., sewer and fuel) lines cross dredge unit FG-1 beneath or adjacent to the Vincent Thomas Bridge between about Berths 94/97 and 226.

Additional historical stratigraphic data and supplemental laboratory test results were included from work performed for other geotechnical studies (CH2M Hill, 1984; EMI, 2001a; Geotechnical Professionals, 1993; L.T. Evans, 1958; McClelland Engineers, 1987). The following section summarizes the results of pertinent laboratory tests.

6.6.2 Classification Properties

Water Content. A plot of water content versus elevation for the dredge unit FG-1 area is provided on Plate 6.5a. The water content in the depth interval of the FG-1 Harbor Bottom Sediments (from about El. -45 to El. -50 feet MLLW) ranges from about 30 to 65 percent. In the native fine-grained FG-1 materials below the Harbor Bottom Sediments, the majority of water content values are between 20 and 50 percent; however, in the native interlayered sediments, the water content values are typically between 20 and 30 percent.

Fines Content. On Plate 6.5b, the percentage of soil passing the No. 200 sieve is plotted versus elevation for the dredge unit FG-1 area. The plot indicates the inherent variability of the materials within the FG-1 area. Silty, clayey, and sandy layers are present in the predominantly fine-grained and interlayered deposits.

Median Grain Size. On Plate 6.5c, median grain size values are plotted versus elevation for the dredge unit FG-1 area. The median grain size of the fine-grained sediments is typically less than 0.02 mm. The median grain size values from sieve analyses on sand layers were typically between 0.1 and 0.25 mm.

Plasticity. The Harbor Bottom Sediments consist of medium to high plasticity silts and clays. Although these soils contain various degrees of plasticity, most plot along or slightly above the A-line of the plasticity chart presented on Plate 6.5d. The native fine-grained sediments below the Harbor Bottom Sediments consist of low to high plasticity silts and clays and generally plot along the A-line.

6.6.3 In Situ Conditions

Total Unit Weight. A plot of total unit weight versus elevation for dredge unit FG-1 is given on Plate 6.5e. The total unit weight in the depth interval of the FG-1 Harbor Bottom Sediments (from about El. -45 to El. -50 feet MLLW) ranges from about 95 to 115 pcf. Below the Harbor Bottom Sediments, the fine-grained native materials have a total unit weight typically ranging from about 110 to 135 pcf.

Measured Cone Tip Resistance. There were 21 CPTs analyzed in native dredge unit FG-1 (15 in fine-grained deposits and 6 in interlayered deposits). Plate 6.5f shows the cumulative frequency plot for the cone tip resistance of the 21 CPT soundings analyzed. The median cone tip resistance ($q_{c,50}$) is about 25 tsf. The cumulative frequency curve for FG-1 lies slightly to the right of the typical curve for fine-grained sediments. The higher than anticipated values of q_c may be due to the presence of interlayered deposits in the northeast part of the unit.

Undrained Shear Strength. On Plate 6.5g, laboratory test results of undrained shear strength are plotted versus elevation for the dredge unit FG-1 area. Typically, the fine-grained layers within FG-1 have undrained shear strengths of about 1 to 2 kips per square foot (ksf).

6.7 DREDGE UNIT FG-2

6.7.1 General Characteristics

The West Basin Channel area, which covers about 65 acres, has been designated as dredge unit FG-2. As shown on Map 7, the dredge unit extends northwesterly from the West Basin entrance (at about Berths 100 and 150) to the narrow point of the West Basin near Berth

124. Our interpretation suggests that the materials to be encountered in this dredge element are variable, but consist of primarily fine-grained sediments within the dredge elevation. Because of the variability in this area, relatively significant deposits of coarse-grained sediments may be locally present, especially in the western portion of dredge unit FG-2.

Additional historical stratigraphic data and supplemental laboratory test results were included from work performed for other geotechnical studies (Dames & Moore, 1982; EMI, 2001c; Earth Technology, 1983; McClelland Engineers, 1987; MEC, 2001; ToxScan, 1994). The following section summarizes the results of pertinent laboratory tests.

6.7.2 Classification Properties

Water Content. A plot of water content versus elevation for the dredge unit FG-2 area is given on Plate 6.6a. Water content in the depth interval of the FG-2 Harbor Bottom Sediments (from about El. -45 to El. -50 feet MLLW) ranges from about 30 to 55 percent. In the native FG-2 materials below the Harbor Bottom Sediments, the water content for coarse-grained sediments and interlayered deposits is typically between 20 and 40 percent and about 30 to 45 percent for fine-grained deposits.

Fines Content. On Plate 6.6b, the percentage of soil passing the No. 200 sieve is plotted versus elevation for the dredge unit FG-2 area. The plot indicates the inherent variability of the materials within the FG-2 area.

Median Grain Size. On Plate 6.6c, median grain size values are plotted versus elevation for the dredge unit FG-2 area. The median grain size of the fine-grained sediments is typically less than 0.02 mm. The median grain size values from sieve analyses on sand layers were typically between 0.1 and 0.3 mm.

Plasticity. The Harbor Bottom Sediments consist of medium to high plasticity silts and clays. Although these soils contain various degrees of plasticity, most plot along or slightly above the A-line of the plasticity chart presented on Plate 6.6d. Fine-grained layers located below the Harbor Bottom Sediments consist of silts and clays of low to high plasticity and generally plot above the A-line.

6.7.3 In Situ Conditions

Total Unit Weight. A plot of total unit weight versus elevation for dredge unit FG-2 is given on Plate 6.6e. Total unit weight in the depth interval of the FG-2 Harbor Bottom Sediments (from about El. -45 to El. -50 feet MLLW) ranges from about 105 to 115 pcf. Below the Harbor Bottom Sediments, the native predominantly fine-grained materials have a total unit weight typically ranging from about 110 to 130 pcf within the proposed dredged elevations. The coarse-grained deposits have a total unit weight ranging from about 120 to 130 pcf.

Measured Cone Tip Resistance. There were 20 CPTs analyzed in native dredge unit FG-2 (7 in fine-grained deposits, 11 in interlayered deposits, and 2 in coarse-grained deposits). Plate 6.6f shows the cumulative frequency plot for the cone tip resistance of the 20 CPT soundings analyzed. The median cone tip resistance ($q_{c,50}$) is about 95 tsf. The cumulative frequency curve for FG-2 lies close to the typical curve for coarse-grained sediments. The much higher than anticipated values of q_c may be due to the presence of both interlayered deposits and coarse-grained sediments within the dredge unit.

Undrained Shear Strength. On Plate 6.6g, laboratory test results of undrained shear strength are plotted versus elevation for the dredge unit FG-2 area. Typically, the fine-grained layers within FG-2 have an undrained shear strength of between 0.5 and 1.5 ksf. Typically, the interlayered deposits within FG-2 have an undrained shear strength of between 2 and 3 ksf.

6.8 DREDGE UNIT FG-3

6.8.1 General Characteristics

Dredge unit FG-3, which covers about 120 acres of the Inner Harbor (see Map 7), corresponds to the northeastern one-third of the East Basin Channel, the entire East Basin, and about 1,800 feet of the Cerritos Channel. The southwestern limit corresponds to a utility (i.e., power cables) line that crosses the East Basin Channel between about Berth 173 and Berth 218. The northeastern limit of the dredge unit correlates to the northeastern boundary of the East Basin and the westernmost portion of the Cerritos Channel. In the southwestern reaches of the dredge unit, several utility (i.e., oil and water) lines cross between about Berths 176 and 215/216. Within the proposed dredge depths, primarily fine-grained deposits are present along with some interlayered coarse-grained sediments. Significant deposits of fine-grained Harbor Bottom Sediments are apparently present in the East Basin.

The laboratory test data were augmented with results from testing performed on samples from borings drilled in and adjacent to dredge unit FG-3. Additional historical stratigraphic data and supplemental laboratory test results were included from work performed for other geotechnical studies (Dames & Moore, 1971; HLA, 1982; EMI, 1996; L.T. Evans, 1969; Woodward-Clyde, 1983). The following section summarizes the results of pertinent laboratory tests.

6.8.2 Classification Properties

Water Content. A plot of water content versus elevation for the dredge unit FG-3 area is given on Plate 6.7a. The water content in the depth interval of the FG-3 Harbor Bottom Sediments (from about El. -45 to El. -50 feet MLLW) ranges from about 30 to 55 percent. In the underlying native FG-3 sediments, the water contents are between 25 and 40 percent.

Fines Content. On Plate 6.7b, the percentage of soil passing the No. 200 sieve is plotted versus elevation for the dredge unit FG-3 area. The plot indicates the inherent variability of the materials within the FG-3 area, although there is a predominance of fine-grained sediments.

Median Grain Size. On Plate 6.7c, median grain size values are plotted versus elevation for the dredge unit FG-3 area. The median grain size of the fine-grained sediments is typically less than 0.02 mm. The median grain size values from sieve analyses were typically less than 0.1 mm within the planned dredge depth. At greater depths, the mean grain size ranges from 0.1 to 0.4 mm.

Plasticity. The Harbor Bottom Sediments consist of low to medium plasticity silts and clays. Although these soils contain various degrees of plasticity, most plot along or slightly below the A-line of the plasticity chart presented on Plate 6.7d. The underlying native fine-grained sediments consist of silts and clays of low to medium plasticity and generally plot along the A-line.

6.8.3 In Situ Conditions

Total Unit Weight. A plot of total unit weight versus elevation for dredge unit FG-3 is given on Plate 6.7e. The total unit weight in the depth interval of the FG-3 Harbor Bottom Sediments (from about El. -45 to El. -50 feet MLLW) ranges from about 105 to 115 pcf. Below the Harbor Bottom Sediments, the fine-grained native material has total unit weight measurements typically ranging from about 115 to 125 pcf.

Measured Cone Tip Resistance. There were 23 CPTs analyzed in native dredge unit FG-3 (20 in fine-grained deposits and 3 in interlayered deposits). Plate 6.7f shows the cumulative frequency plot for the cone tip resistance of the 23 CPT soundings analyzed. The median cone tip resistance ($q_{c,50}$) is about 26 tsf. The cumulative frequency curve plots very close to that of the typical fine-grained deposits.

Undrained Shear Strength. Within the native dredge unit FG-3, there are an insufficient number of laboratory test results from which to draw conclusions on the measured undrained shear strength of the fine-grained layers.

6.9 DREDGE UNIT FM-1

6.9.1 General Characteristics

Dredge unit FM-1 covers about 135 acres at the southernmost portion of the Channel Deepening Project area. Dredge unit FM-1 includes the extreme northern segment of the Glenn Anderson Ship Channel and the extreme southern segment of the Main Channel (refer to Map 7). The southern portion of this dredge unit has been modified to reflect the Federal Channel Limits (USACOE, 2000), and now extends farther to the east and southeast below Reservation Point, corresponding to where the Glenn Anderson Ship Channel intersects the dredge limits from the Pier 400 borrow area. The northern limit correlates to the sediment-formation contact that crosses the main channel in a northwesterly trend. This sediment-formation contact has been refined since the Fugro (1997c) report, which was based on the geophysical survey performed by Fugro and additional investigations.

During previous dredging projects, dredging contractors have reported problematic conditions while excavating the formation materials. The problematic conditions are attributed to the in situ characteristics of the formation materials and, in particular, the presence of hard rock inclusions, layers, and lenses. The rock inclusions include both local inclusions of various sizes and ledges that may extend for several hundred feet. The thickness of the inclusions and ledges is commonly on the order of several feet. Uniaxial compressive strengths for the rock-like layers in the Malaga Mudstone range from about 1,150 to 6,800 psi (Fugro-McClelland, 1992). More recent data obtained by the Pier 400 Constructors reportedly indicate that the rock-like layers may, within localized areas, have uniaxial compressive strengths that exceed 6,800 psi.

The Non-Federal Dredge Area (designated on attached plates as NFDA) to the west of dredge unit FM-1 includes similar subsurface characteristics and is included in this discussion. This area extends approximately 1,500 feet south of Pilot Point and adds approximately 25 acres to the dredge unit size, increasing it to 160 acres. The formation materials are overlain by silty sands and up to about 12 feet of Harbor Bottom Sediments. The top of the formation material typically ranges from about El. -25 to El. -35 feet MLLW within the Non-Federal Dredge Area.

The northern portion of the Glenn Anderson Ship Channel in potential dredge unit FM-1 and the Non-Federal Dredge Area are both underlain by Malaga Mudstone. Farther north of the Glenn Anderson Ship Channel, the Malaga Mudstone deposits extend about 2,800 feet into the extreme southern portion of the Main Channel, as indicated on Map 7. Farther north, Timms Point Silt deposits are present within the Main Channel up to the interface with dredge unit CG-1. Additional historical stratigraphic data were assessed from work performed for other geotechnical studies (AMEC, 2001; MEC, 2001), but no supplemental laboratory data were available. The following section summarizes the results of pertinent laboratory tests.

6.9.2 Classification Properties

Water Content. A plot of water content versus elevation for dredge unit FM-1 and the Non-Federal Dredge Area is shown on Plate 6.8a. The water content in the depth interval of the FM-1 Harbor Bottom Sediments (from about El. -45 to El. -50 feet MLLW) ranges from about 50 to 95 percent. In the FM-1 formation materials below the Harbor Bottom Sediments, the majority of water content values are between 30 and 70 percent with several values greater than 80 percent. The water content in the formation materials is influenced by the frequently diatomaceous characteristic of the Malaga Mudstone. The silty sands below the Harbor Bottom Sediments within the Non-Federal Dredge Area have water content values between 25 and 35 percent.

Fines Content. On Plate 6.8b, the percentage of soil passing the No. 200 sieve is plotted versus elevation for the dredge unit FM-1 area and the Non-Federal Dredge Area. For the Harbor Bottom Sediments and formation materials, the fines content values generally were greater than 80 percent. Two samples from granular soils south of the Pilot's Station have a fines content of about 25 and 40 percent.

Median Grain Size. On Plate 6.8c, median grain size values are plotted versus elevation for dredge unit FM-1. Median grain size values from hydrometer analyses performed are typically less than 0.02 mm, indicating predominantly fine-grained materials.

Plasticity. The Harbor Bottom Sediments consist of medium to high plasticity silts and clays. Although these soils contain various degrees of plasticity, most plot along or slightly below the A-line of the plasticity chart presented on Plate 6.8d. The formation materials encountered in FM-1 tend to have medium to high plasticity and plot on or below the A-line of the plasticity chart.

6.9.3 In Situ Condition

Total Unit Weight. A plot of total unit weight versus elevation for dredge unit FM-1 is given on Plate 6.8e. The total unit weight in the depth interval of the FM-1 Harbor Bottom Sediments (from about El. -45 to El. -50 feet MLLW) ranges from about 90 to 100 pcf. In the underlying FM-1 formation materials, the unit weights typically range between 95 and 125 pcf. The sands that are present between the Harbor Bottom Sediments and formation materials in the Non-Federal Dredge Area have a total unit weight between 115 and 125 pcf.

Measured Cone Tip Resistance. Within native dredge unit FM-1, there are no CPT soundings from which to draw conclusions on the measured cone tip resistance (Plate 6.8f).

Undrained Shear Strength. On Plate 6.8g, laboratory test results of undrained shear strength are plotted versus elevation for the dredge unit FM-1 area. Typically, the fine-grained matrix of the formation materials within FM-1 have an undrained shear strength that ranges between about 2 and 5 ksf. Uniaxial compressive strengths measured on samples of the rock-like inclusions in the Malaga Mudstone underlying the Outer Harbor range from about 1,150 to 6,800 psi (Fugro-McClelland, 1992).

7.0 REFERENCES

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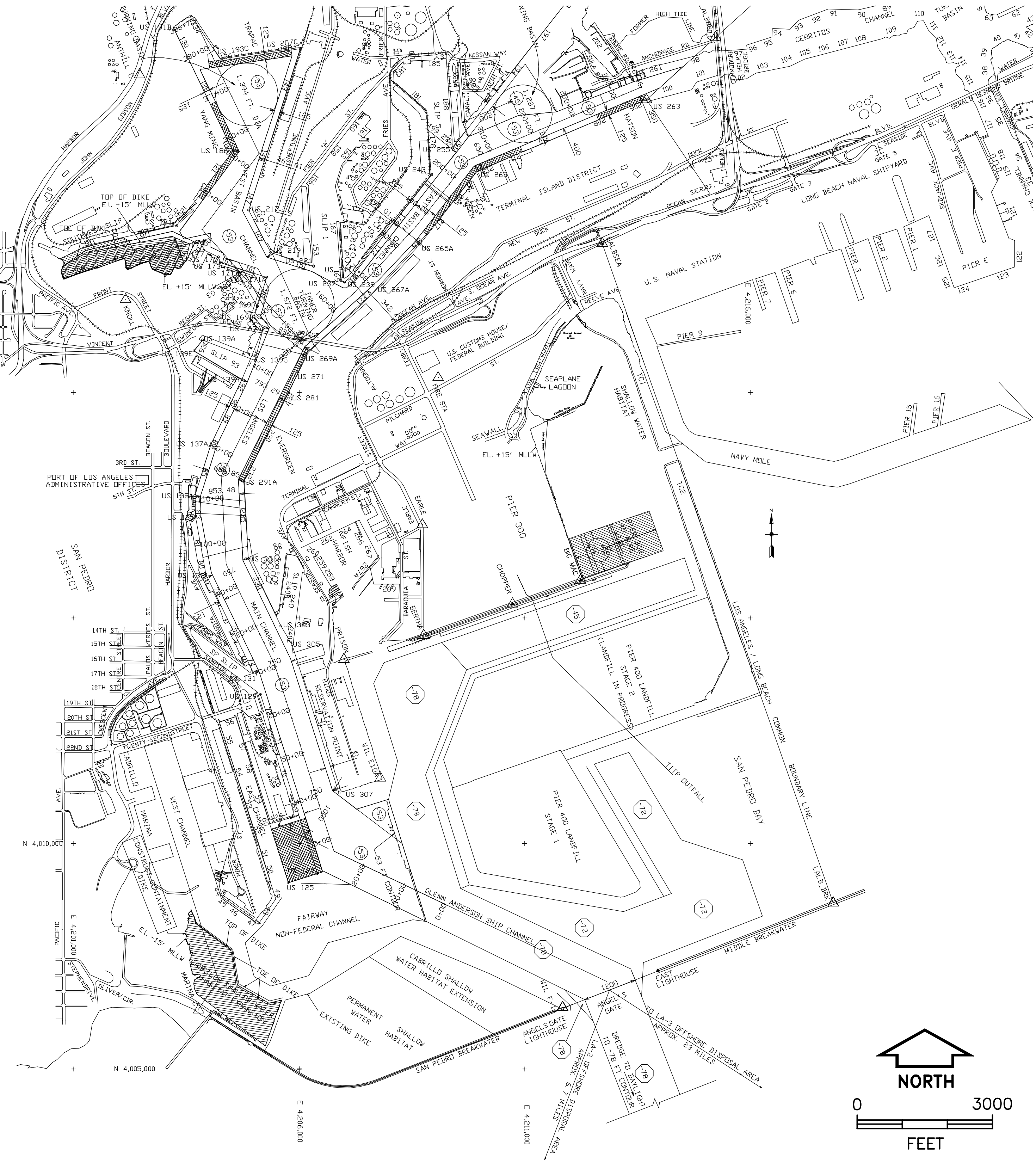
PLATES



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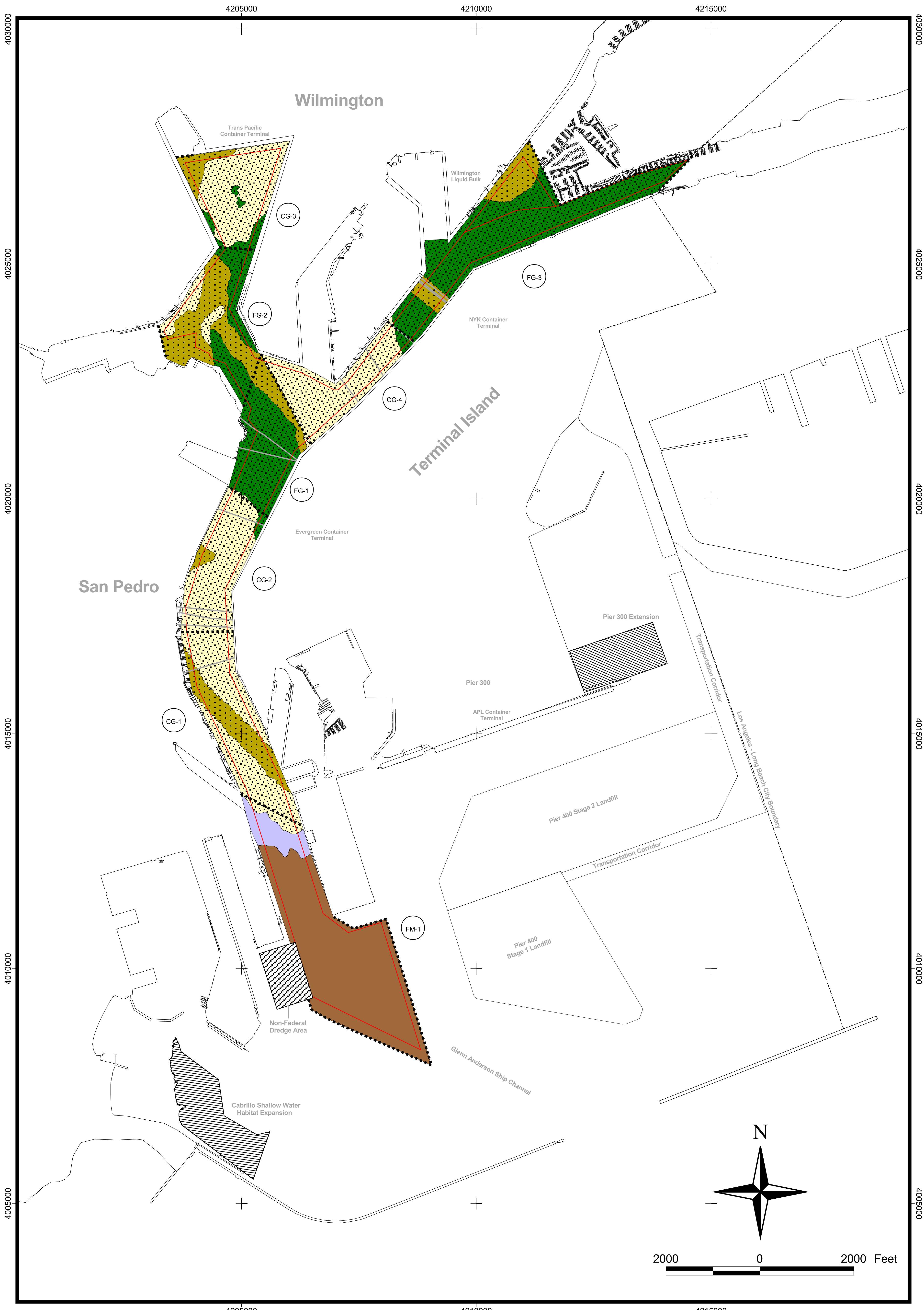
VICINITY MAP

Channel Deepening Project
Port of Los Angeles, California

PLATE 1.1



NOTE: Refer to Plate 4.2 for Map Legend and Notes

FUGRO

NATIVE DREDGE UNITS
Channel Deepening Project
Port of Los Angeles, California

01-32-0633

PLATE 4.1

FUGRO

Landfill Use Desirability	Material Types
High	Primarily coarse-grained sediments (sand and silty sand).
Low-Moderate	Interlayered deposits of coarse- and fine-grained sediments.
Very Low	Primarily fine-grained sediments (silt, sandy silt, and clay).
Low-Very Low	Intact and/or weathered Timms Point Silt (silt, sandy silt, silty sand) (Approximate location of contact between Holocene sediments and Timms Point Silt as projected vertically from an elevation of -60 ft MLLW.)
Very Low	Intact and/or weathered Malaga Mudstone (elastic silts) (Approximate location of contact between Malaga Mudstone and Timms Point Silt as projected vertically from an elevation of -60 ft MLLW.)

Legend

- Native Dredge Unit Boundary
- Utility Crossing Location (refer to notes)

Coordinate System is California State Plane, Zone 7, NAD 27, Feet.

CG-1 Native Dredge Unit Designation

Federal Channel Dredging Limit

Notes

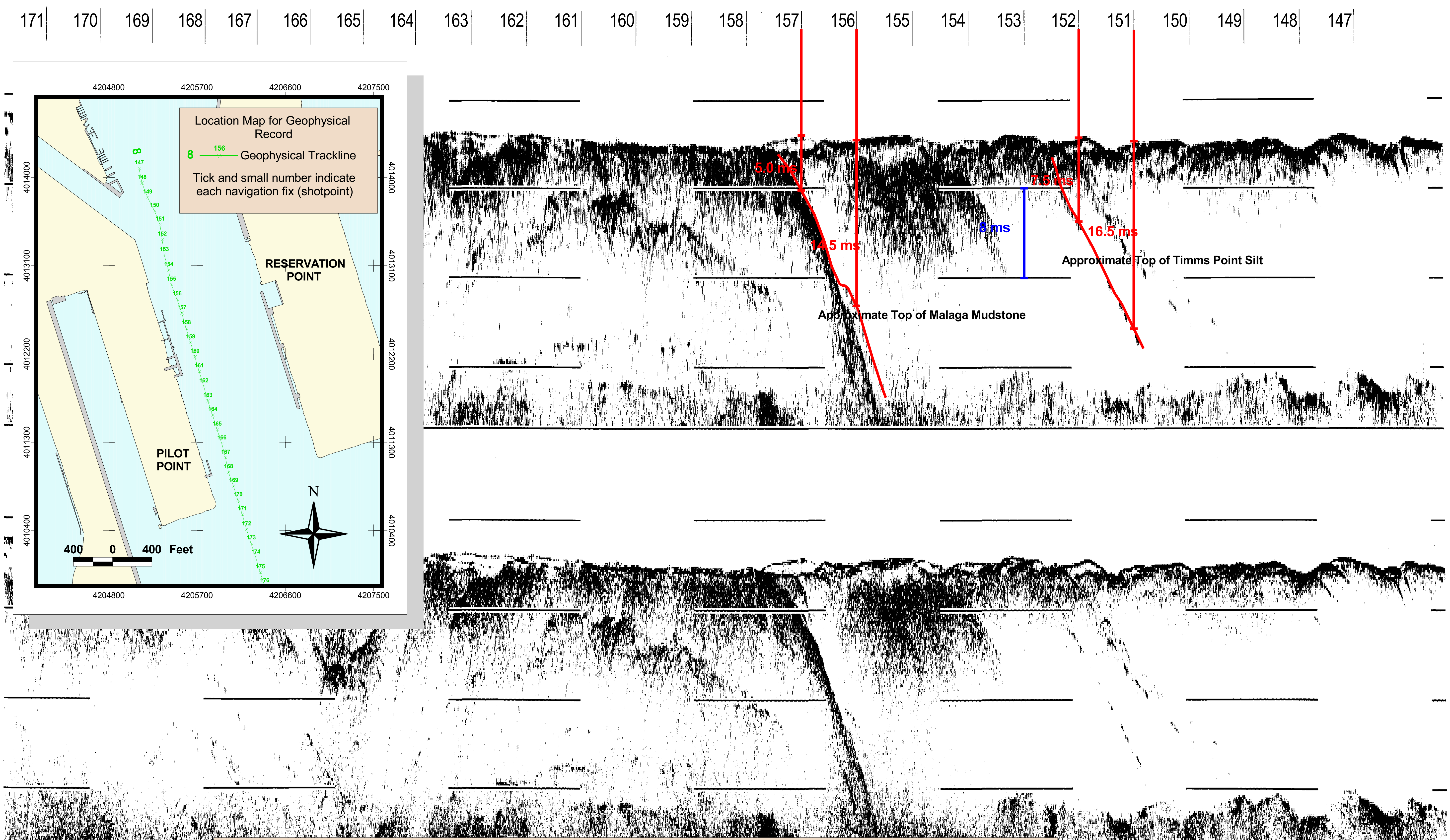
1. The interpreted shallow stratigraphic conditions shown on this map are generally representative of native sediments present above an elevation of about -55 feet MLLW. Non-native Harbor Bottom Sediments overlie the native sediments throughout much of the Inner Harbor. The presence of those Harbor Bottom Sediments did not influence delineation of the different stratigraphic deposits. Contact locations are approximate.

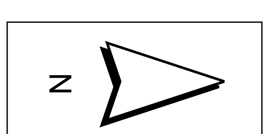
2. Utility locations are based on a geophysical survey performed by Fugro (2001e).

3. Vertical resolution of subbottom reflectors on geophysical data is +/- 0.5 to 1 millisecond, which represents 1.25 to 2.5 feet.

KEY TO INTERPRETED SHALLOW SUBSURFACE CONDITIONS (PLATES 4.1, 5.1 - 5.8)

Channel Deepening Project
Port of Los Angeles, California





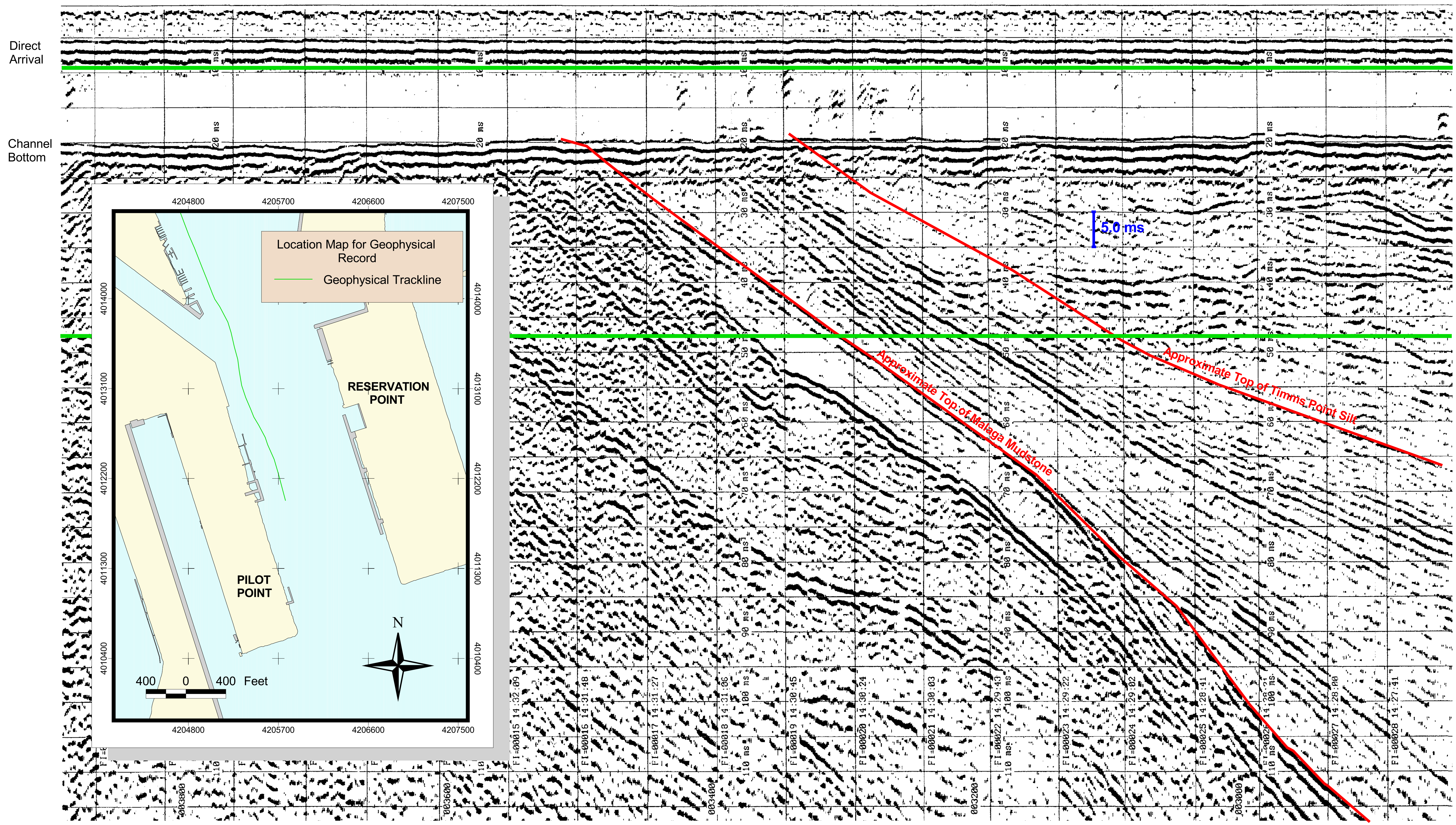
Notes

1. Lines in red indicate interpretations discussed in the text.
2. Record obtained from a geophysical survey performed by Fugro (2001e)
3. Distance between each navigation fix shown along the top is 150 feet.
4. Sediment thicknesses above the "top of the reflector" are calculated from CHIRP Subbottom Profiler data using an assumed constant acoustic propagation velocity of 5000 ft/sec.
5. The "top of the bedrock reflector" picks are generally accurate to +/- 0.6 to +/- 0.8 millisecond.
6. Vertical exaggeration for this record is approximately 12:1.
7. Top record is collected at a frequency of 2.0-6.0 kHz. Bottom record is collected at a frequency of 2.0-10.0 kHz.
8. Vessel trackline is shown with north to the right for comparison with Plate 4.4.

FUGRO

SAMPLE GEOPHYSICAL RECORD
Sediment-Formation Contact
Channel Deepening Project
Port of Los Angeles, California

01-32-0633 PLATE 4.3



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Notes

1. Lines in red indicate interpretations discussed in the text.
2. Record collected with the GeoPulse system at a frequency of 1.0 kHz.
3. Vertical exaggeration is approximately 5.5:1
4. Green lines show approximate extent of record presented in Plate 4.3
5. Record taken from report entitled "Analysis of Late Quaternary Faulting in the Los Angeles Area and Hazard to the Vincent Thomas Bridge", California Department of Conservation (Division of Mines and Geology) (1998).
6. South end of trackline shown in the inset corresponds to left (south) edge of geophysical record. North is to the right.

FUGRO

CDMG DEEP GEOPHYSICAL RECORD
Sediment-Formation Contact
Channel Deepening Project
Port of Los Angeles, California

01-32-0633 PLATE 4.4

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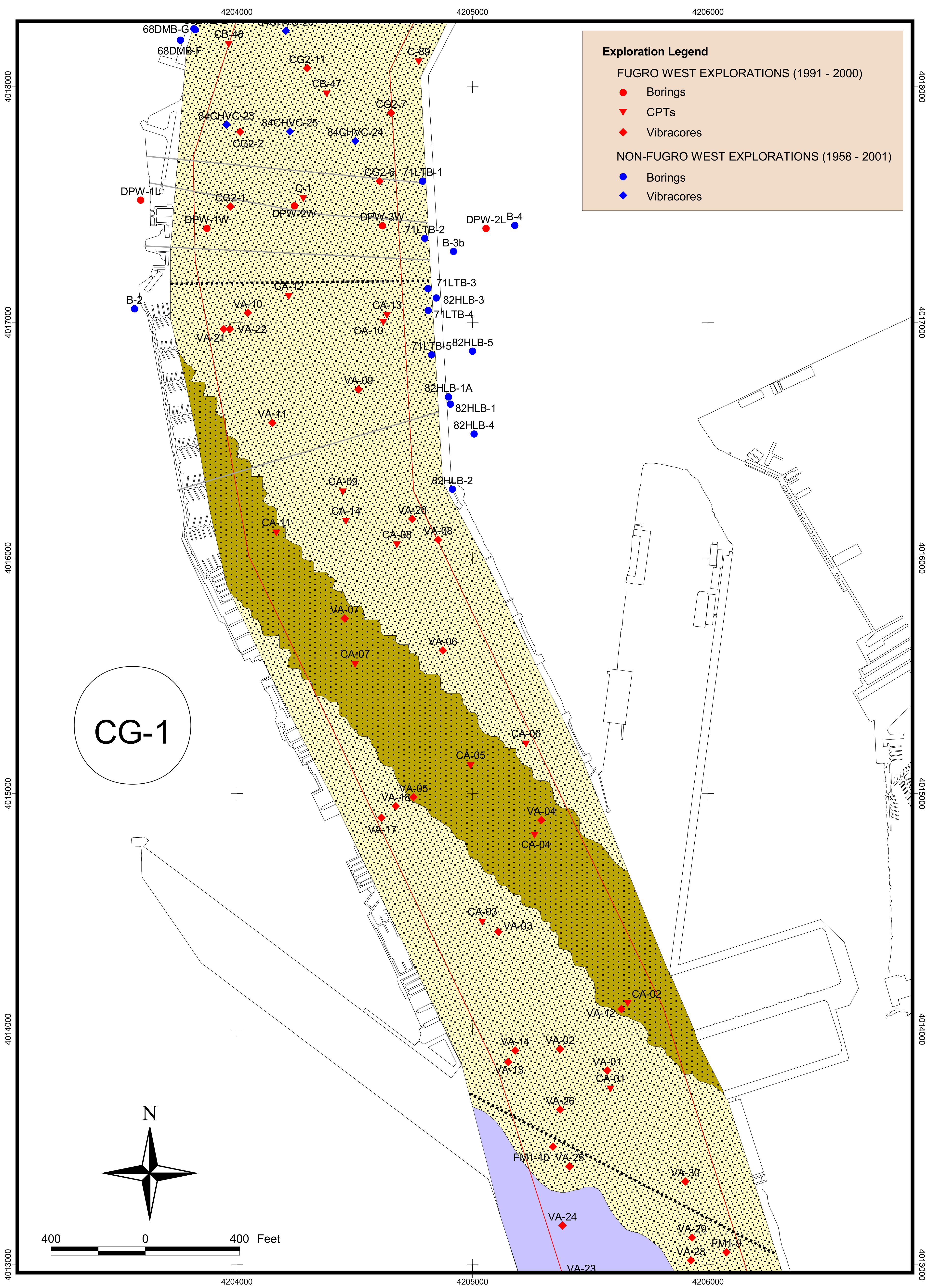

NOTE: Refer to Plate 4.2 for Map Legend and Notes

INTERPRETED SHALLOW SUBSURFACE CONDITIONS
Native Dredge Unit CG-1
Channel Deepening Project
Port of Los Angeles, California

01-32-0633 PLATE 5.1

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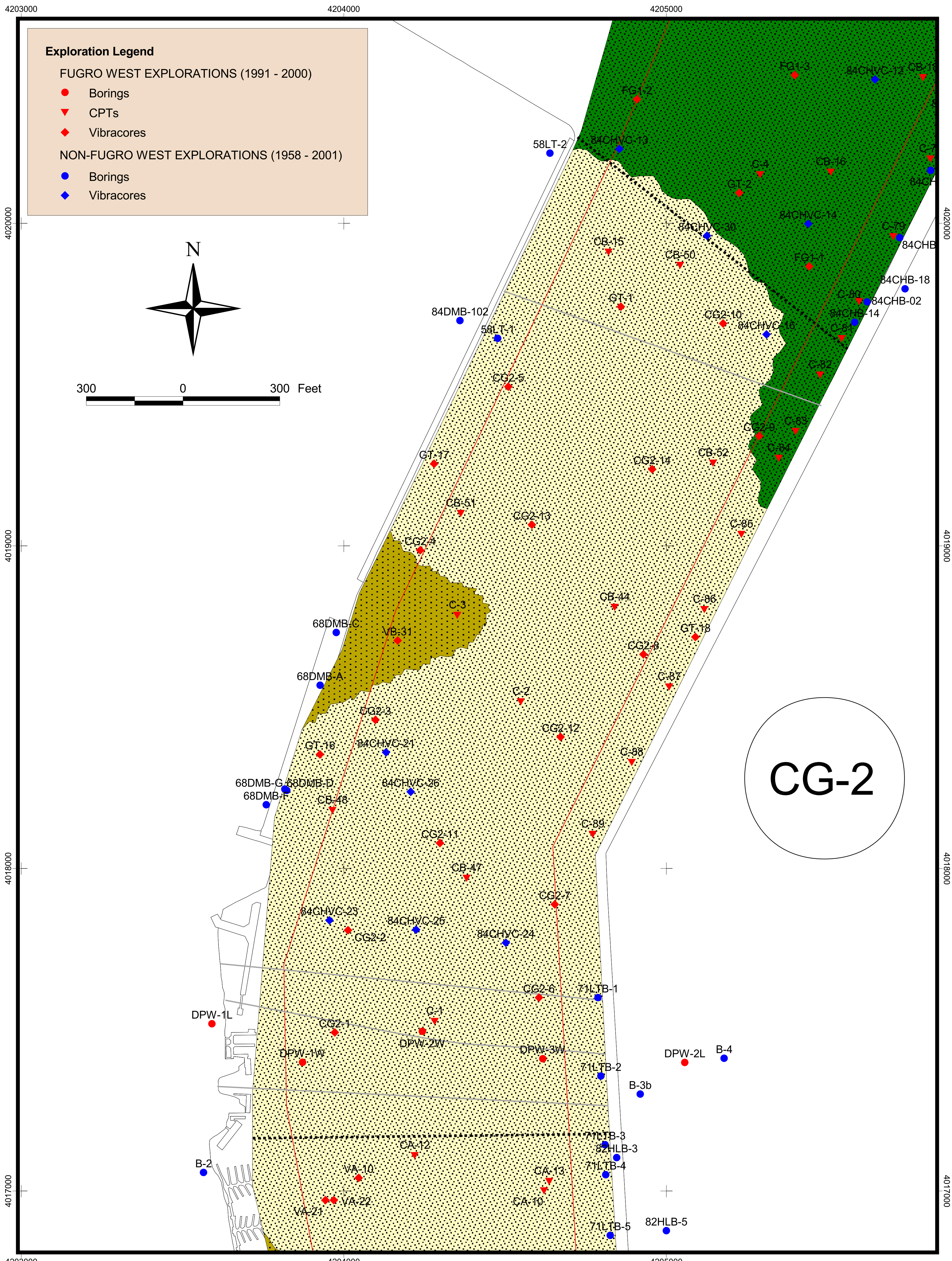
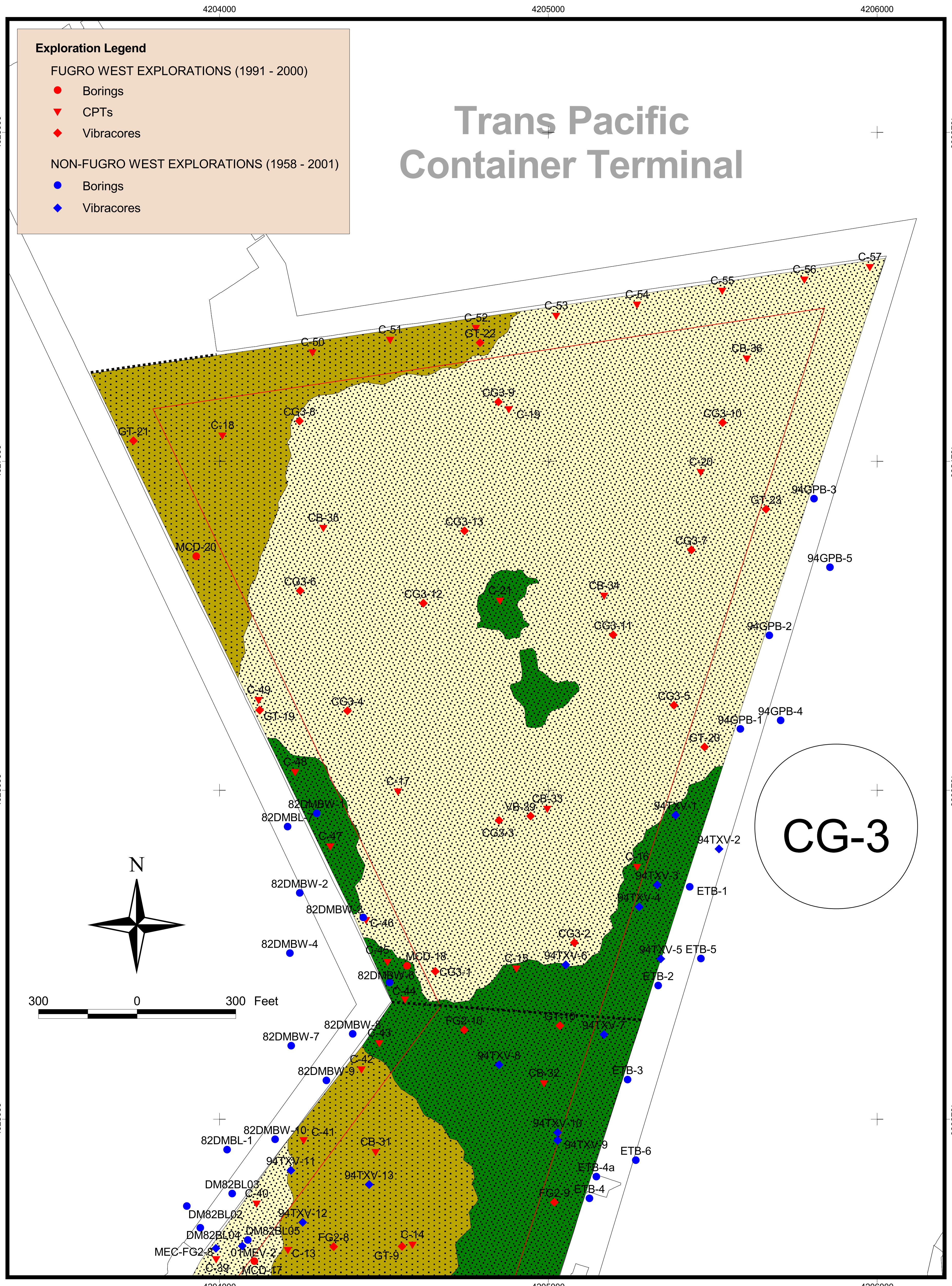


NOTE: Refer to Plate 4.2 for Map Legend and Notes

FUGRO

INTERPRETED SHALLOW SUBSURFACE CONDITIONS
Native Dredge Unit CG-2
Channel Deepening Project
Port of Los Angeles, California

01-32-0633 PLATE 5.2

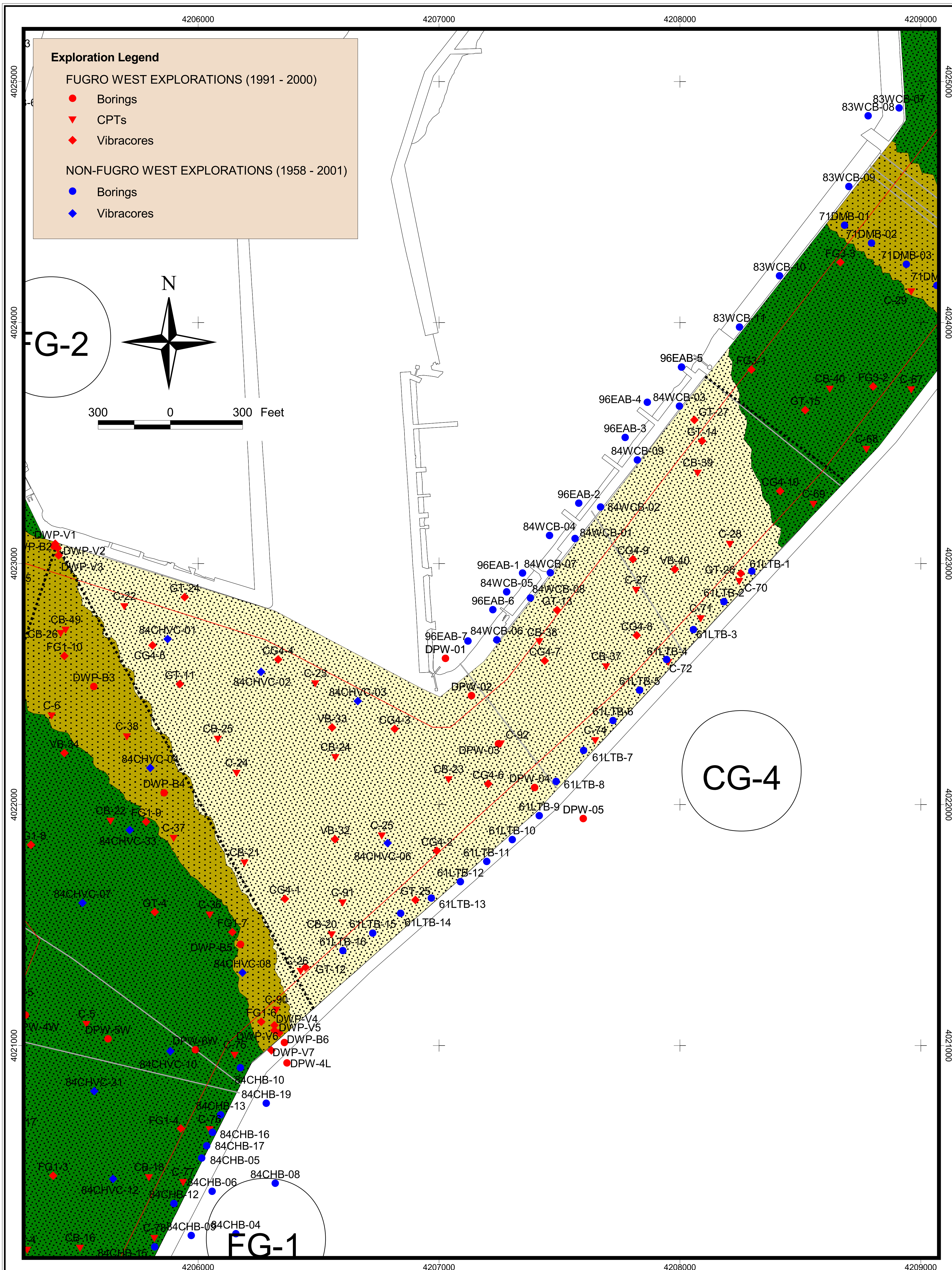


NOTE: Refer to Plate 4.2 for Map Legend and Notes

FUGRO

INTERPRETED SHALLOW SUBSURFACE CONDITIONS
Native Dredge Unit CG-3
Channel Deepening Project
Port of Los Angeles, California

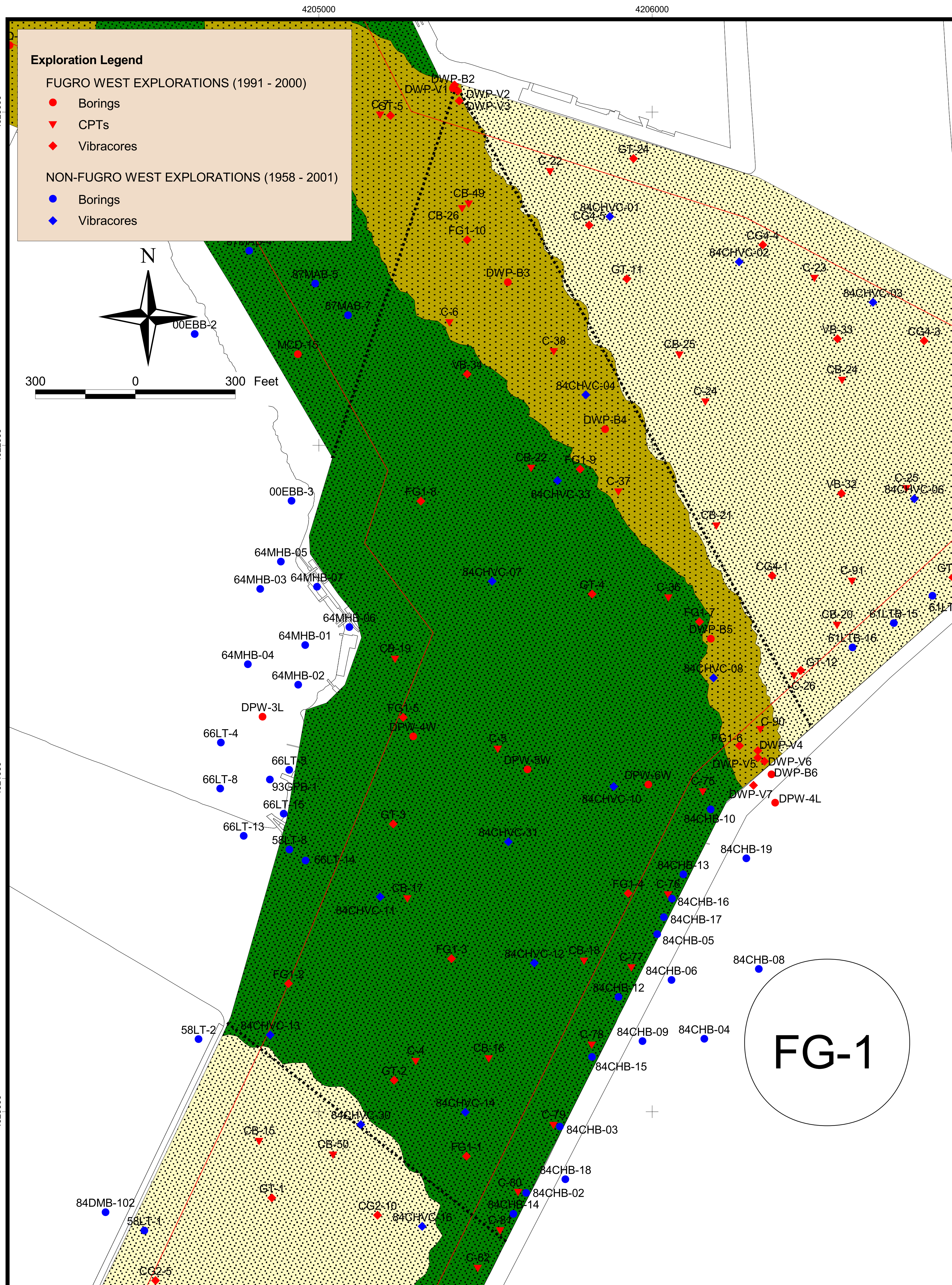
01-32-0633 | PLATE 5.3



NOTE: Refer to Plate 4.2 for Map Legend and Notes

INTERPRETED SHALLOW SUBSURFACE CONDITIONS
Native Dredge Unit CG-4
Channel Deepening Project
Port of Los Angeles, California

01-32-0633 PLATE 5.4



NOTE: Refer to Plate 4.2 for Map Legend and Notes

FUGRO

INTERPRETED SHALLOW SUBSURFACE CONDITIONS
Native Dredge Unit FG-1
Channel Deepening Project
Port of Los Angeles, California

01-32-0633 | PLATE 5.5

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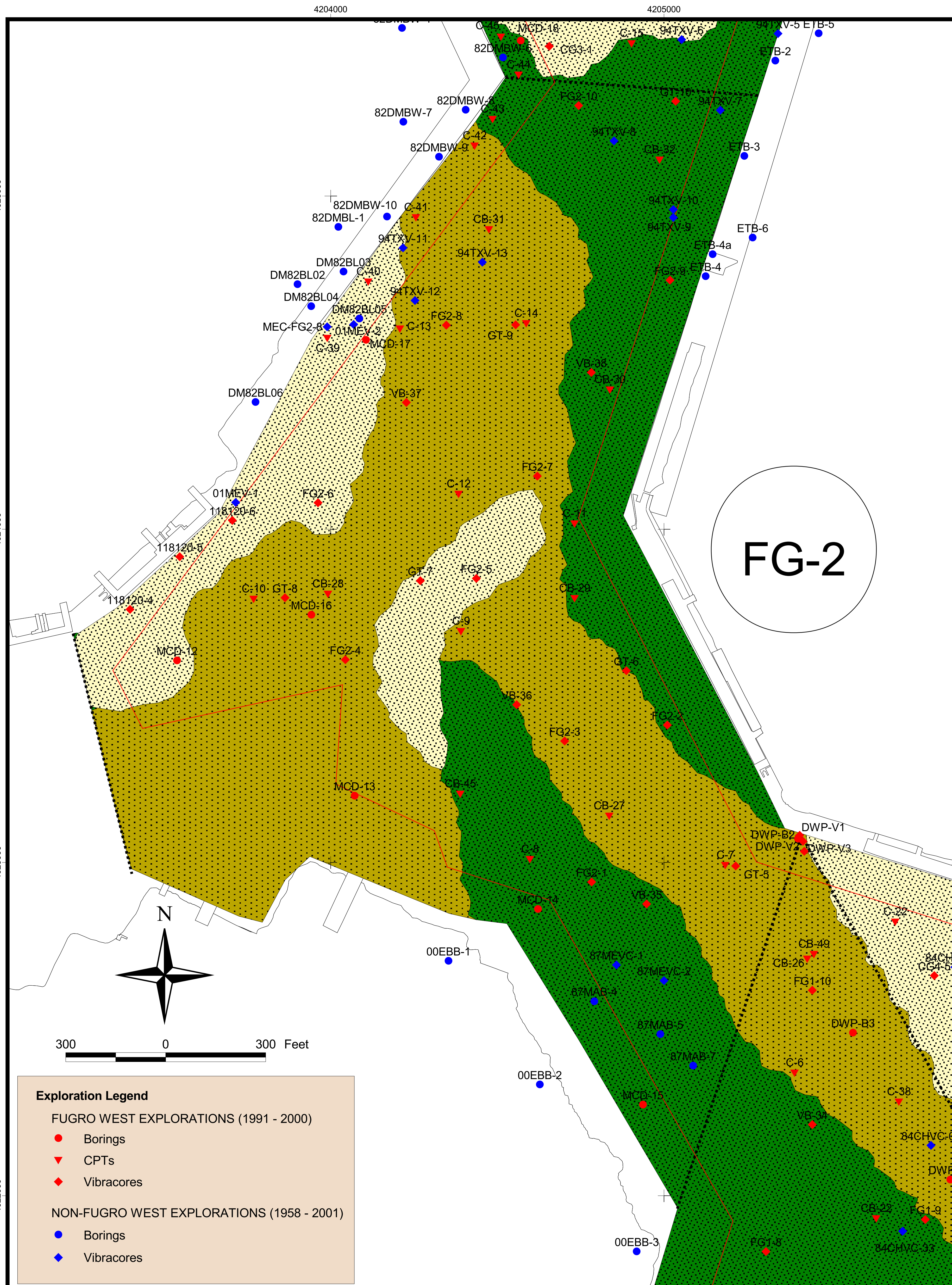
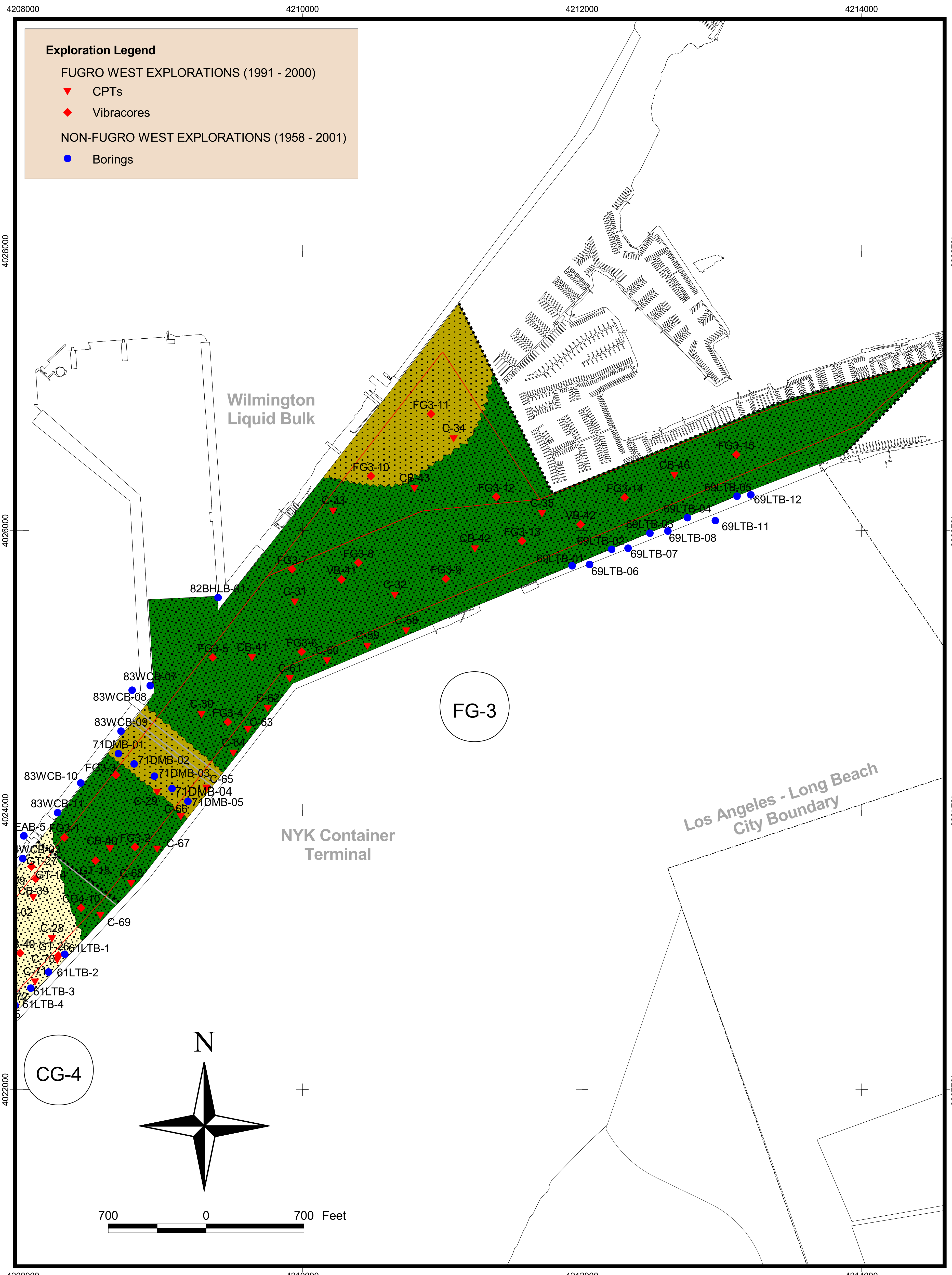


NOTE: Refer to Plate 4.2 for Map Legend and Notes

INTERPRETED SHALLOW SUBSURFACE CONDITIONS
Native Dredge Unit FG-2
Channel Deepening Project
Port of Los Angeles, California

01-32-0633 PLATE 5.6



NOTE: Refer to Plate 4.2 for Map Legend and Notes

INTERPRETED SHALLOW SUBSURFACE CONDITIONS
Native Dredge Unit FG-3
Channel Deepening Project
Port of Los Angeles, California

01-32-0633 PLATE 5.7

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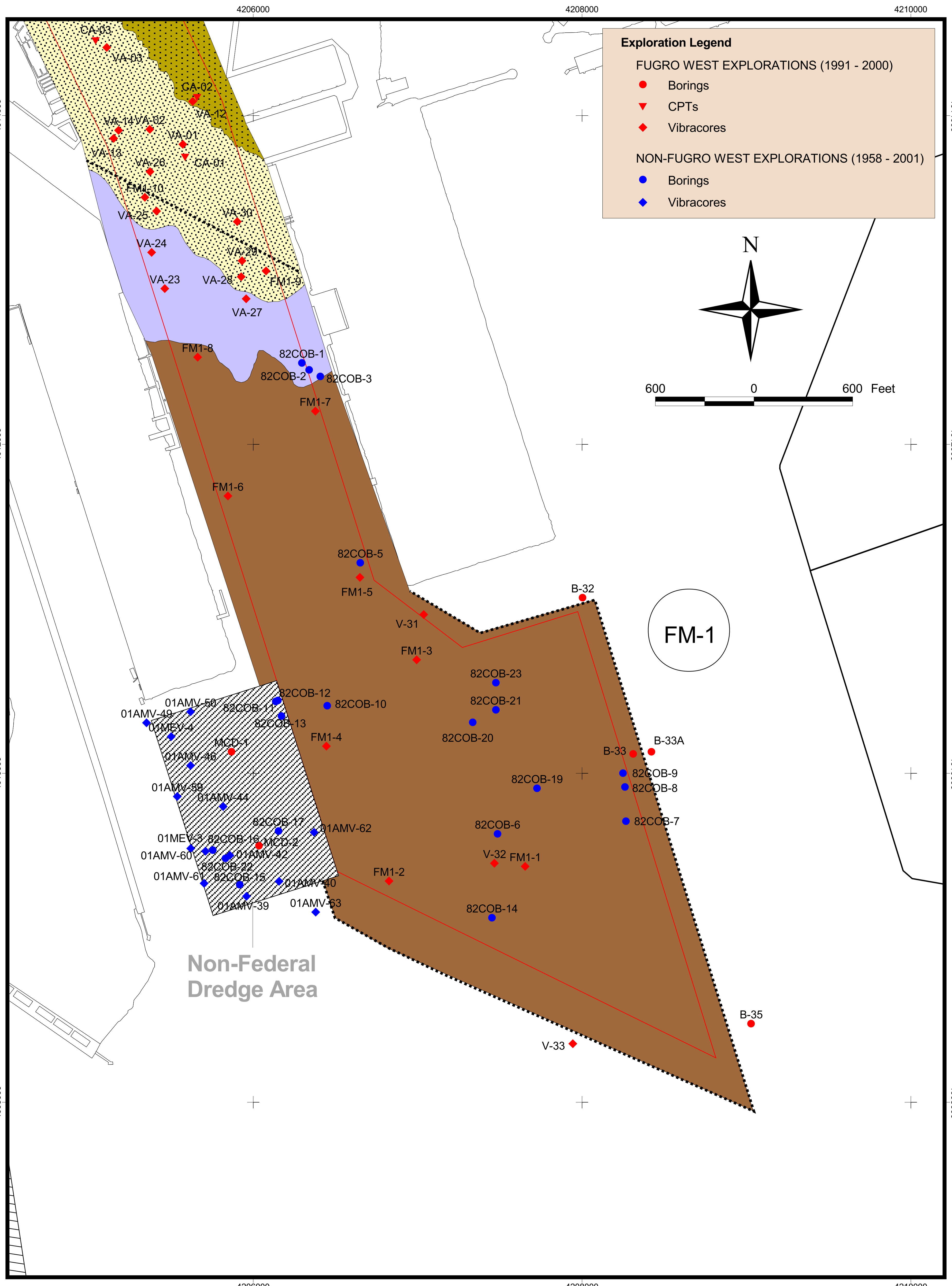
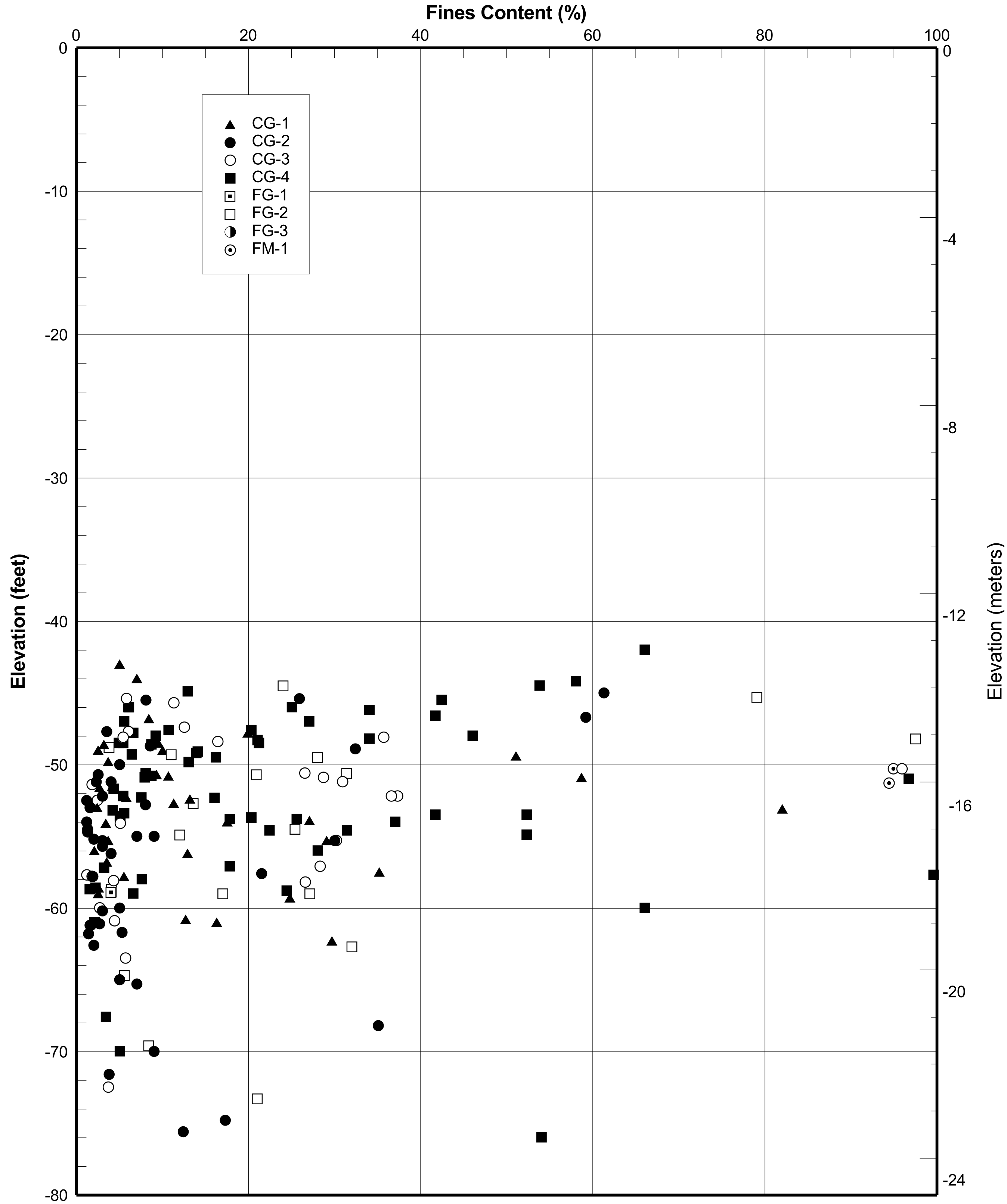


NOTE: Refer to Plate 4.2 for Map Legend and Notes

FUGRO

INTERPRETED SHALLOW SUBSURFACE CONDITIONS
Native Dredge Unit FM-1
Channel Deepening Project
Port of Los Angeles, California

01-32-0633 PLATE 5.8



FINES CONTENT PROFILE
Coarse-Grained Sediments
Channel Deepening Project
Port of Los Angeles, California

PLATE 5.9

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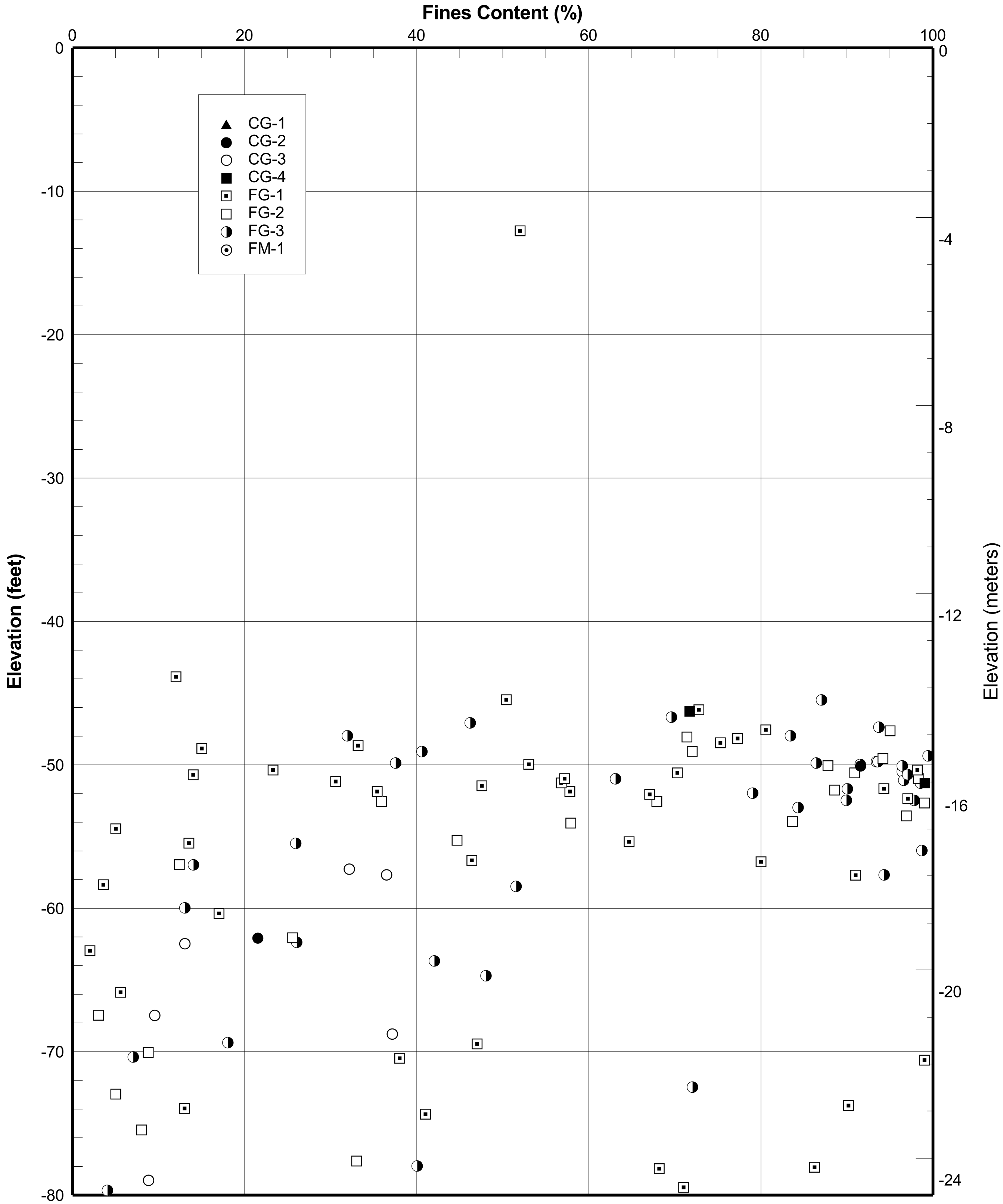

FINES CONTENT PROFILE
Fine-Grained Sediments
Channel Deepening Project
Port of Los Angeles, California

PLATE 5.10

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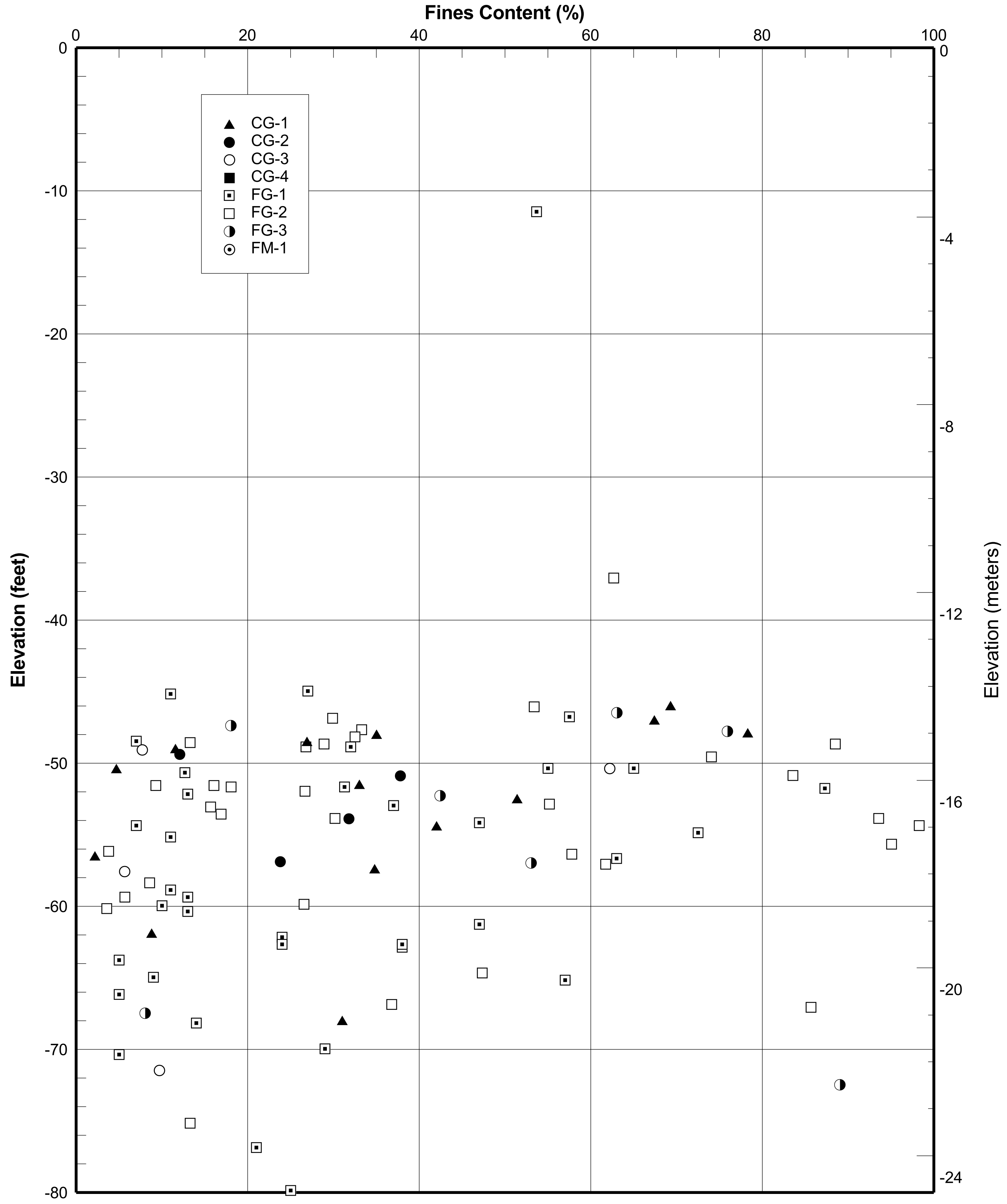
U.S. Army Corps of Engineers
Project No. 01-32-0633



FINES CONTENT PROFILE
Interlayered Sediments
Channel Deepening Project
Port of Los Angeles, California

PLATE 5.11

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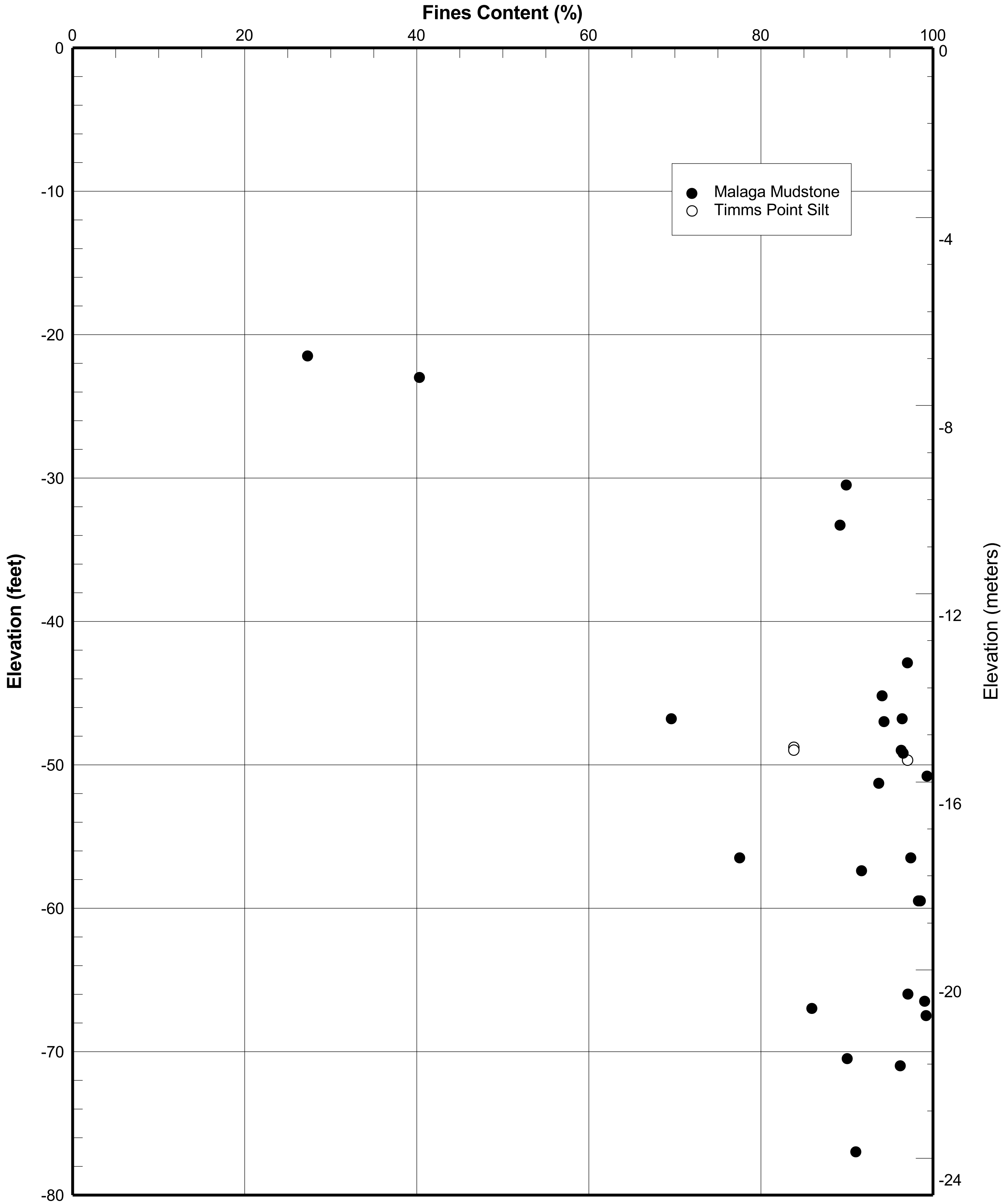
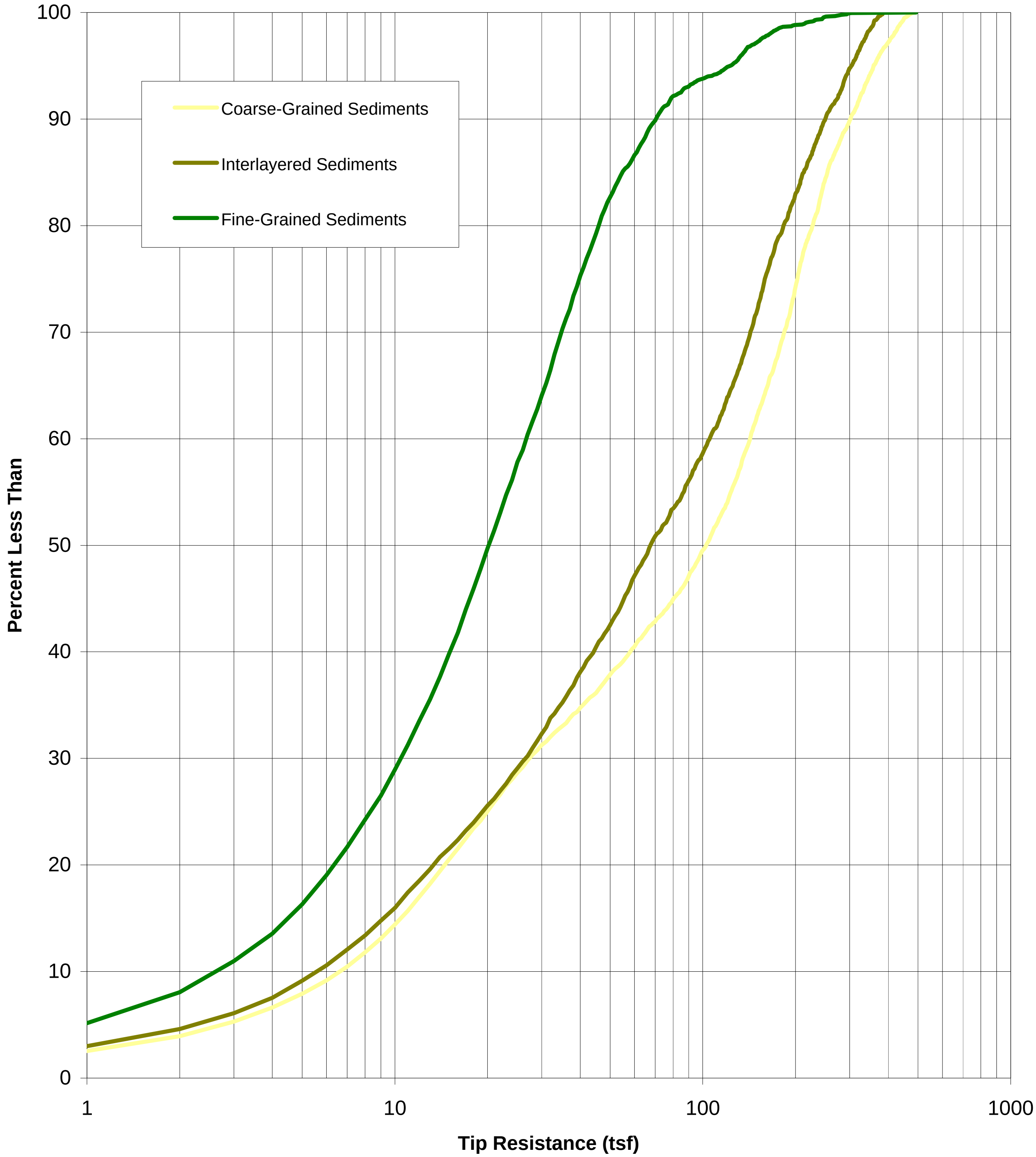
FUGRO



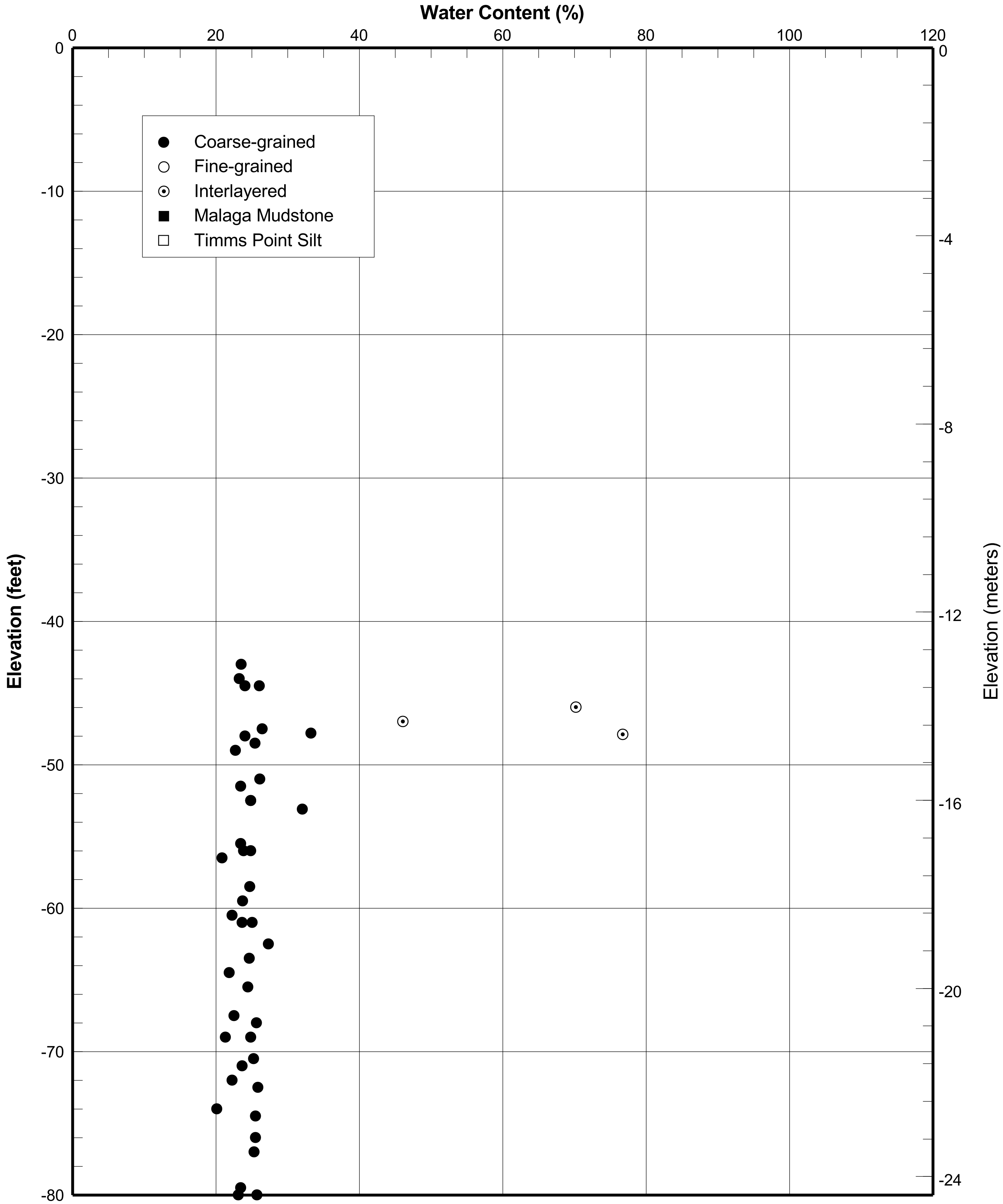
FINES CONTENT PROFILE
Formation Materials
Channel Deepening Project
Port of Los Angeles, California

PLATE 5.12



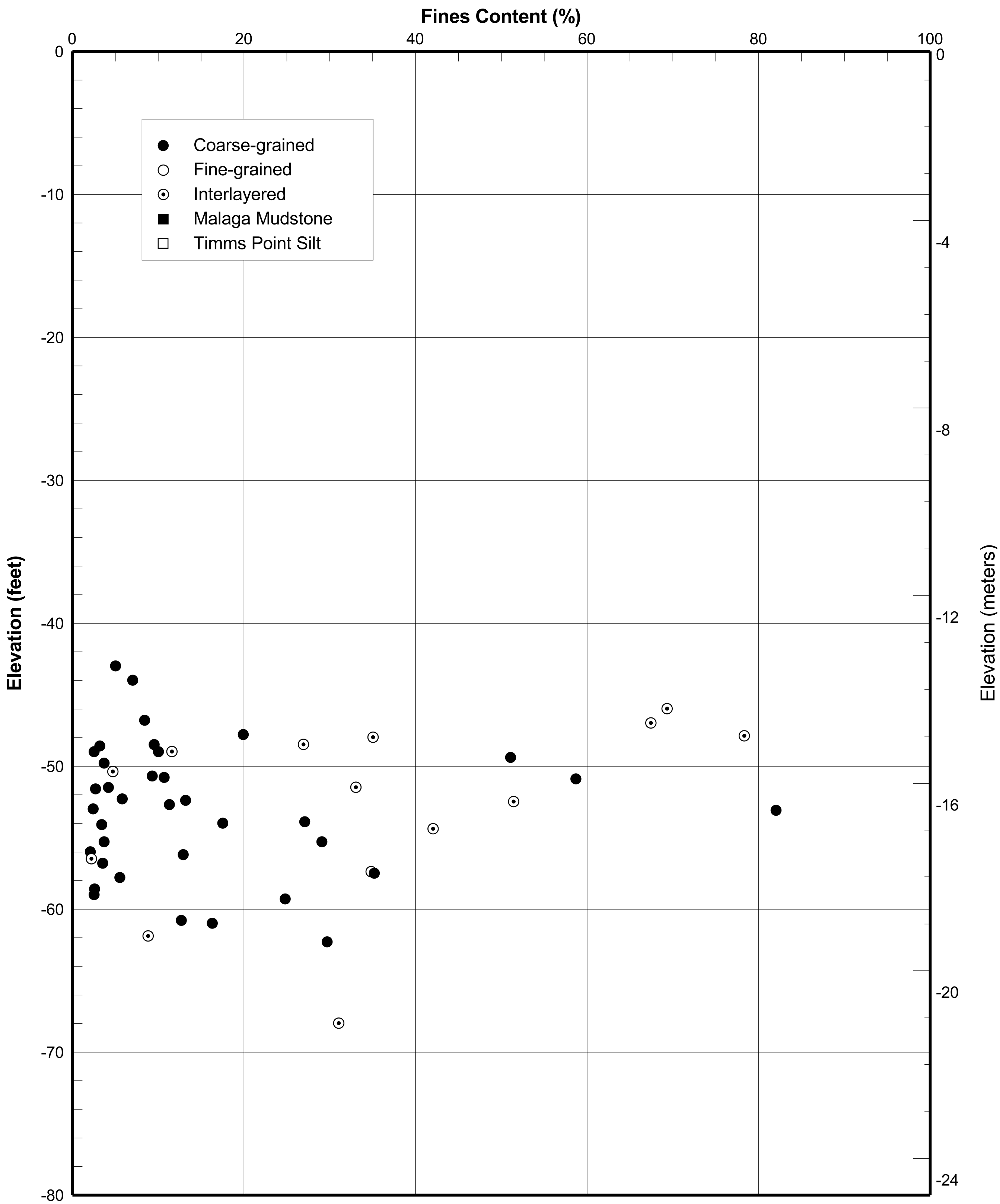
CUMULATIVE FREQUENCY DISTRIBUTION
Channel Deepening Project
Port of Los Angeles, California

PLATE 5.13



WATER CONTENT PROFILE
Native Dredge Unit CG-1
Channel Deepening Project
Port of Los Angeles, California

PLATE 6.1a



FINES CONTENT PROFILE
Native Dredge Unit CG-1
Channel Deepening Project
Port of Los Angeles, California

PLATE 6.1b

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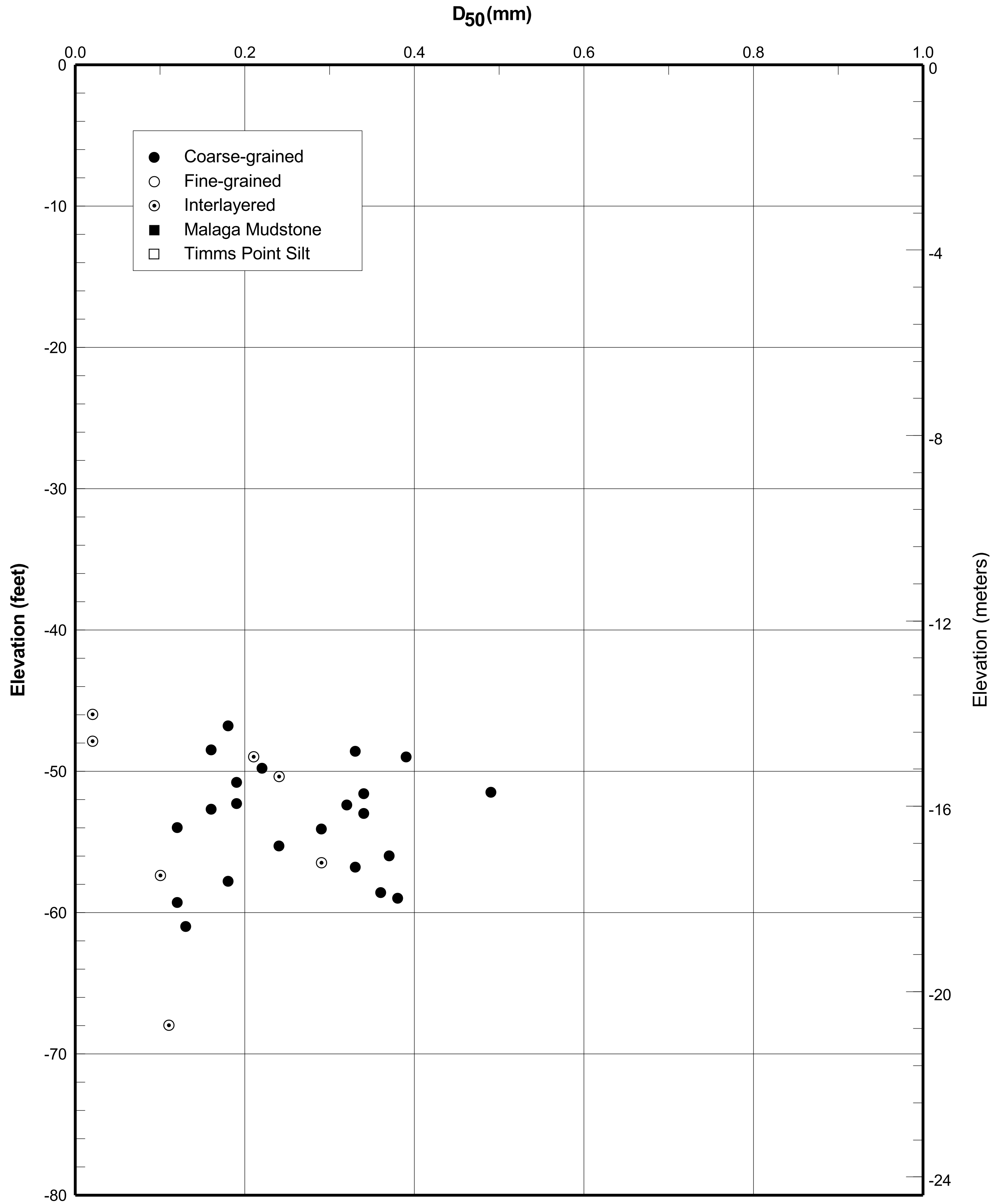
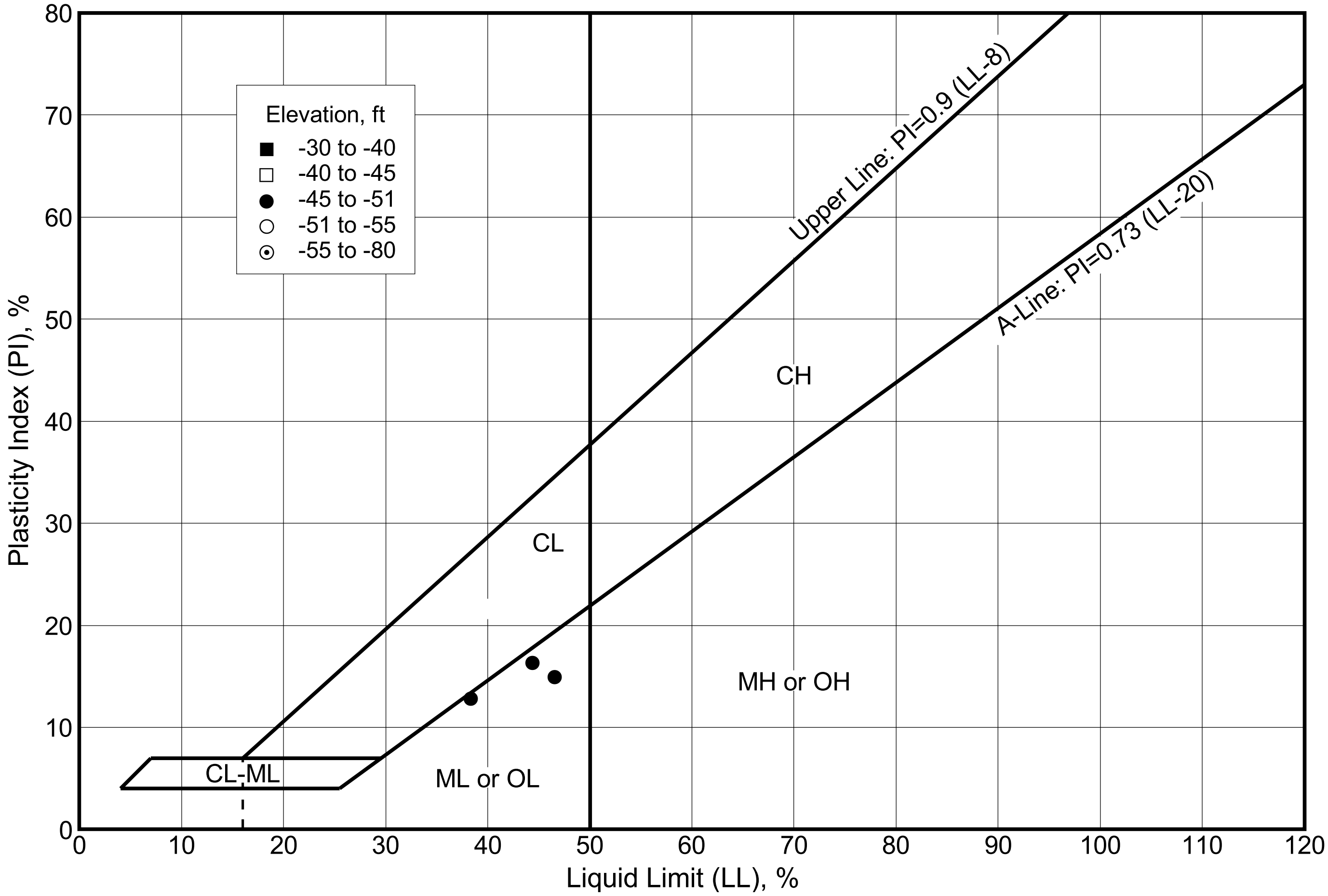
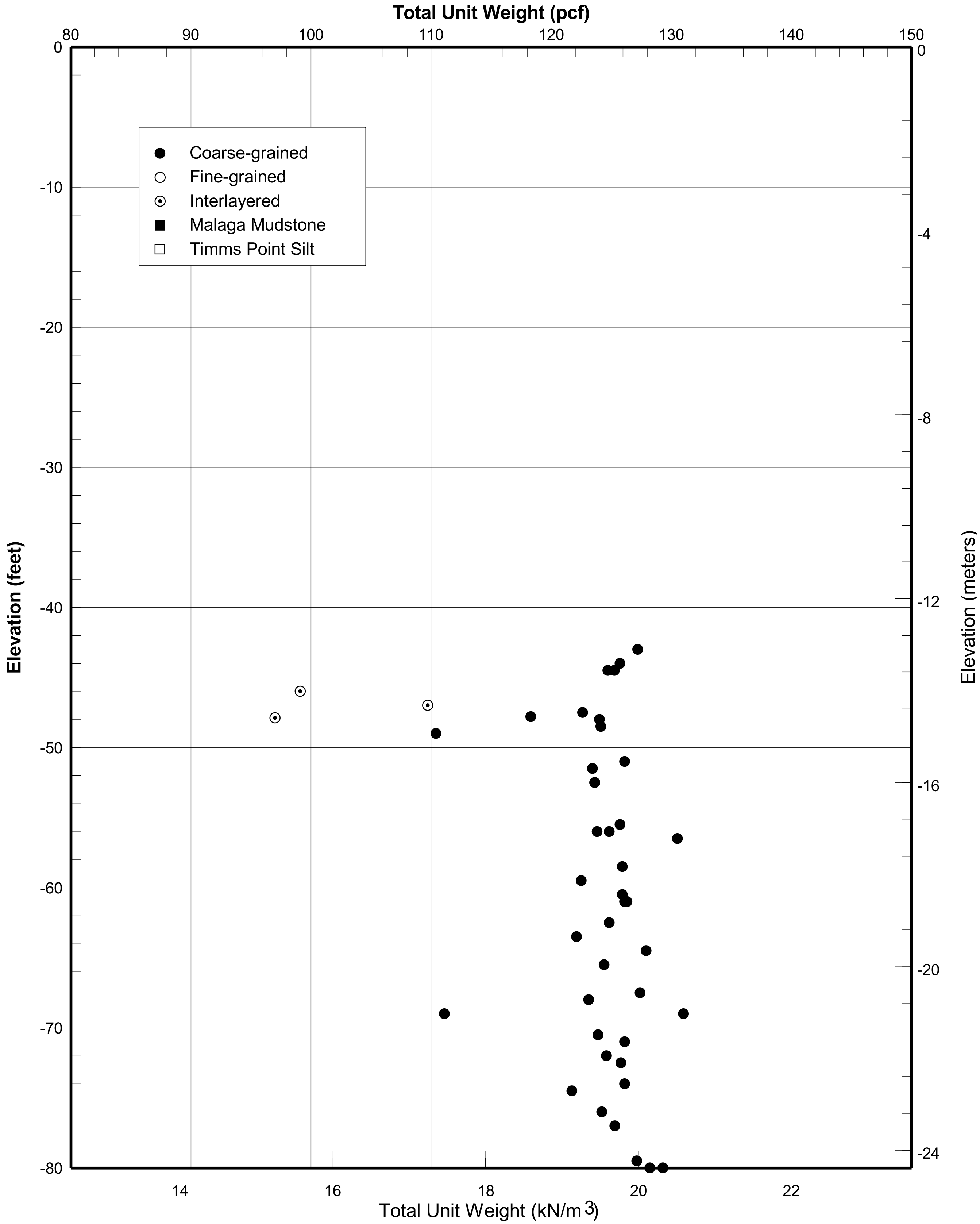


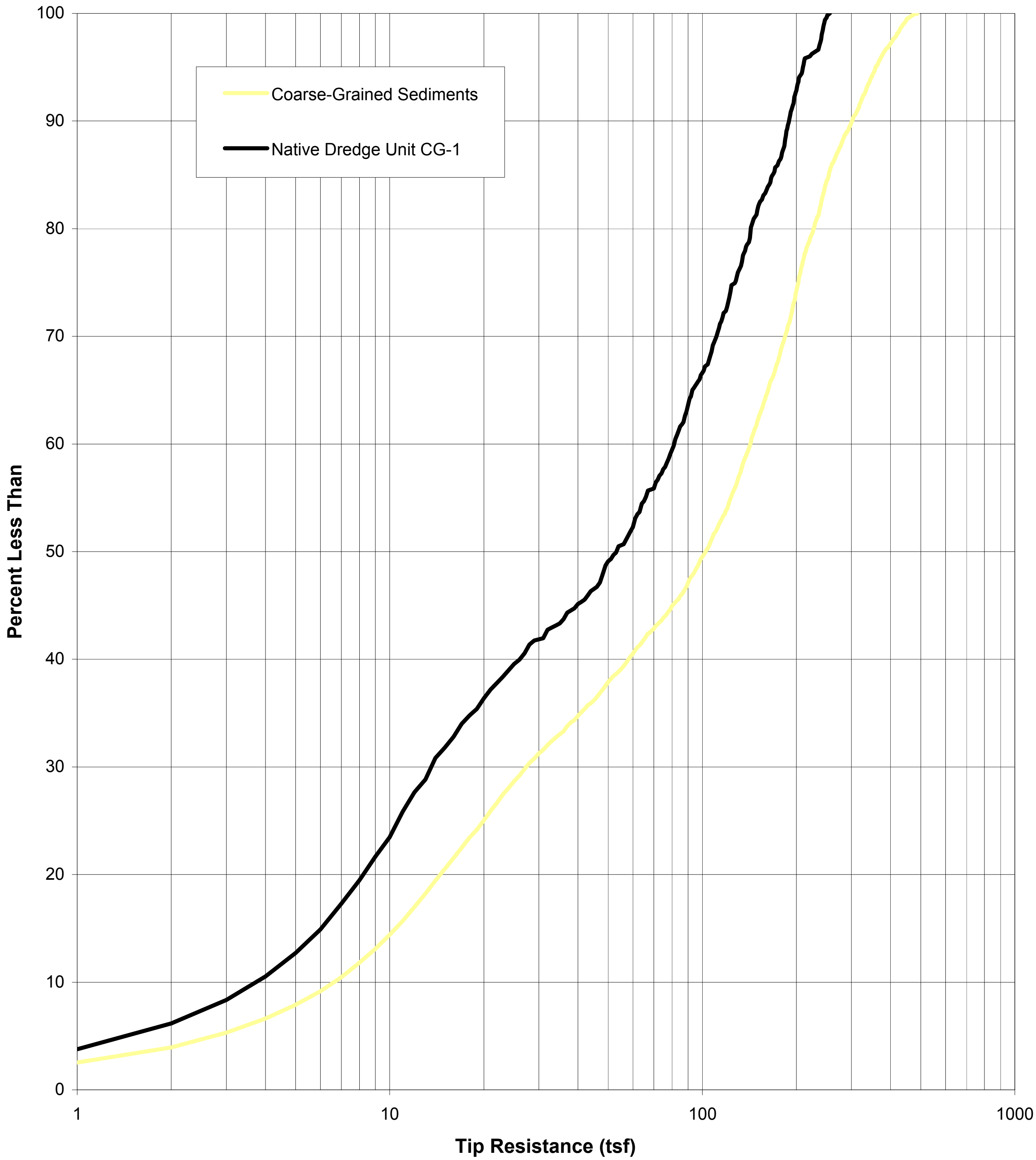
D_{50} PROFILE
Native Dredge Unit CG-1
Channel Deepening Project
Port of Los Angeles, California



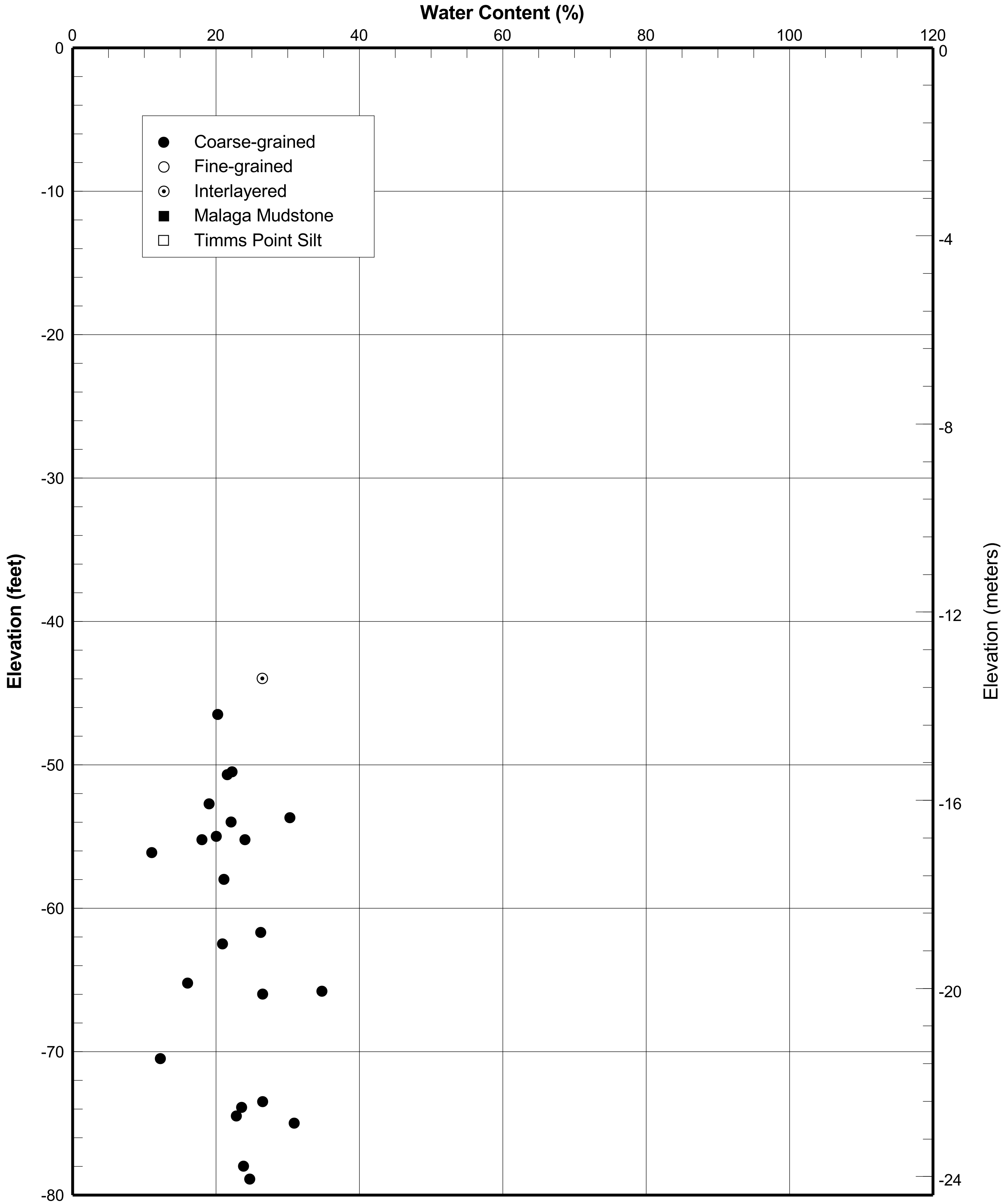
PLASTICITY CHART
Native Dredge Unit CG-1
Channel Deepening Project
Port of Los Angeles, California



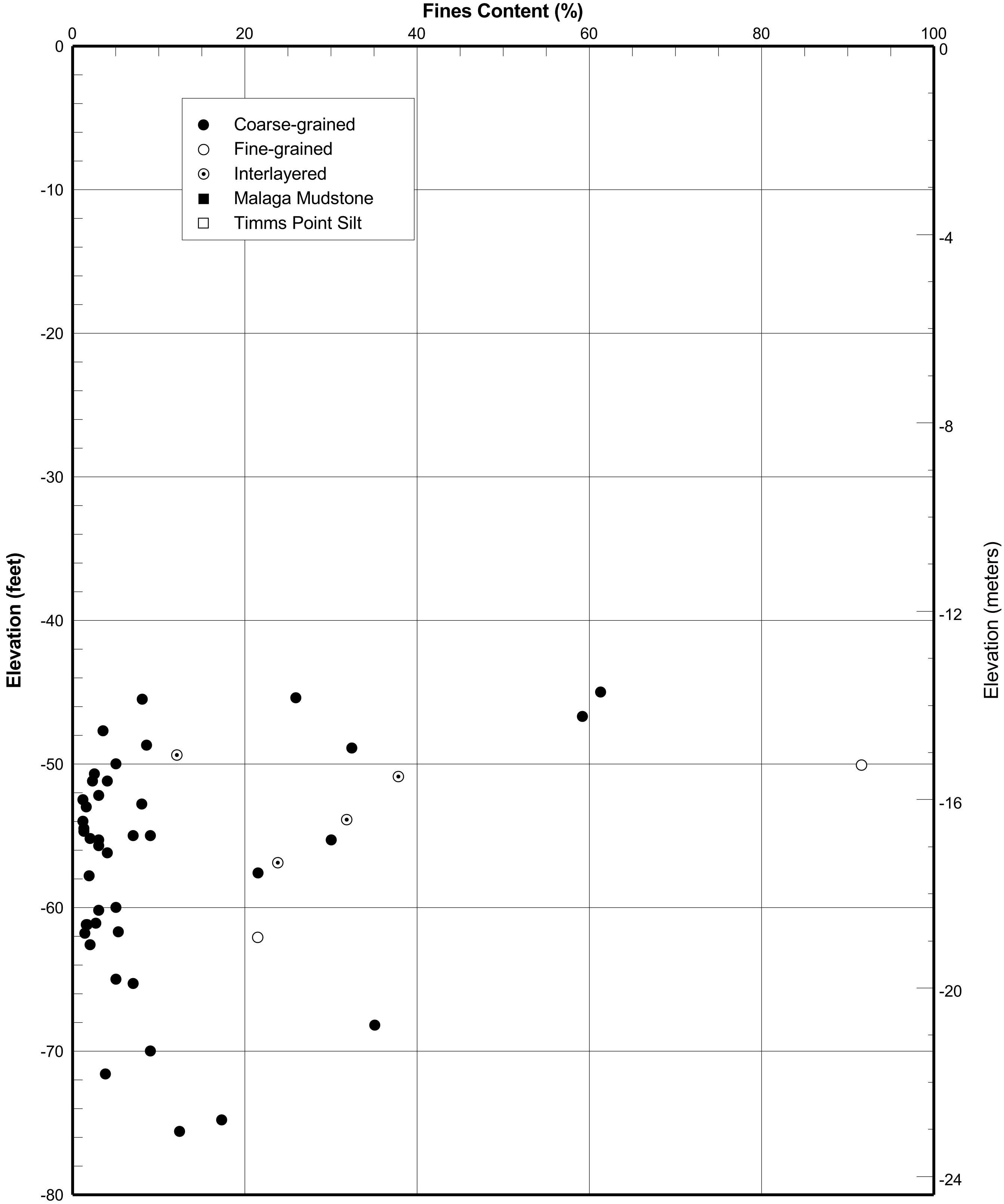
TOTAL UNIT WEIGHT PROFILE
Native Dredge Unit CG-1
Channel Deepening Project
Port of Los Angeles, California



CUMULATIVE FREQUENCY DISTRIBUTION
Native Dredge Unit CG-1
Channel Deepening Project
Port of Los Angeles, California



WATER CONTENT PROFILE
Native Dredge Unit CG-2
Channel Deepening Project
Port of Los Angeles, California



FINES CONTENT PROFILE
Native Dredge Unit CG-2
Channel Deepening Project
Port of Los Angeles, California

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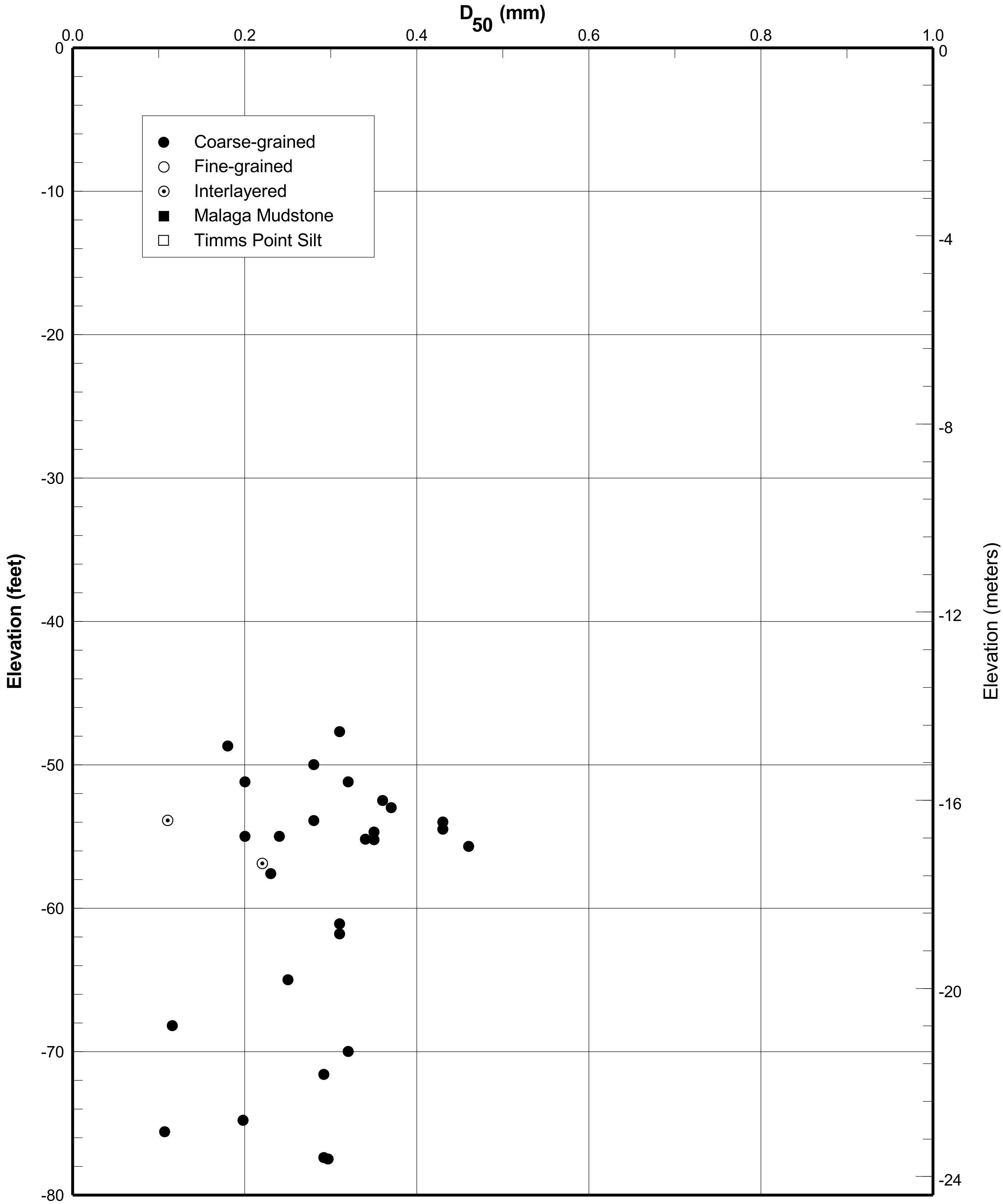
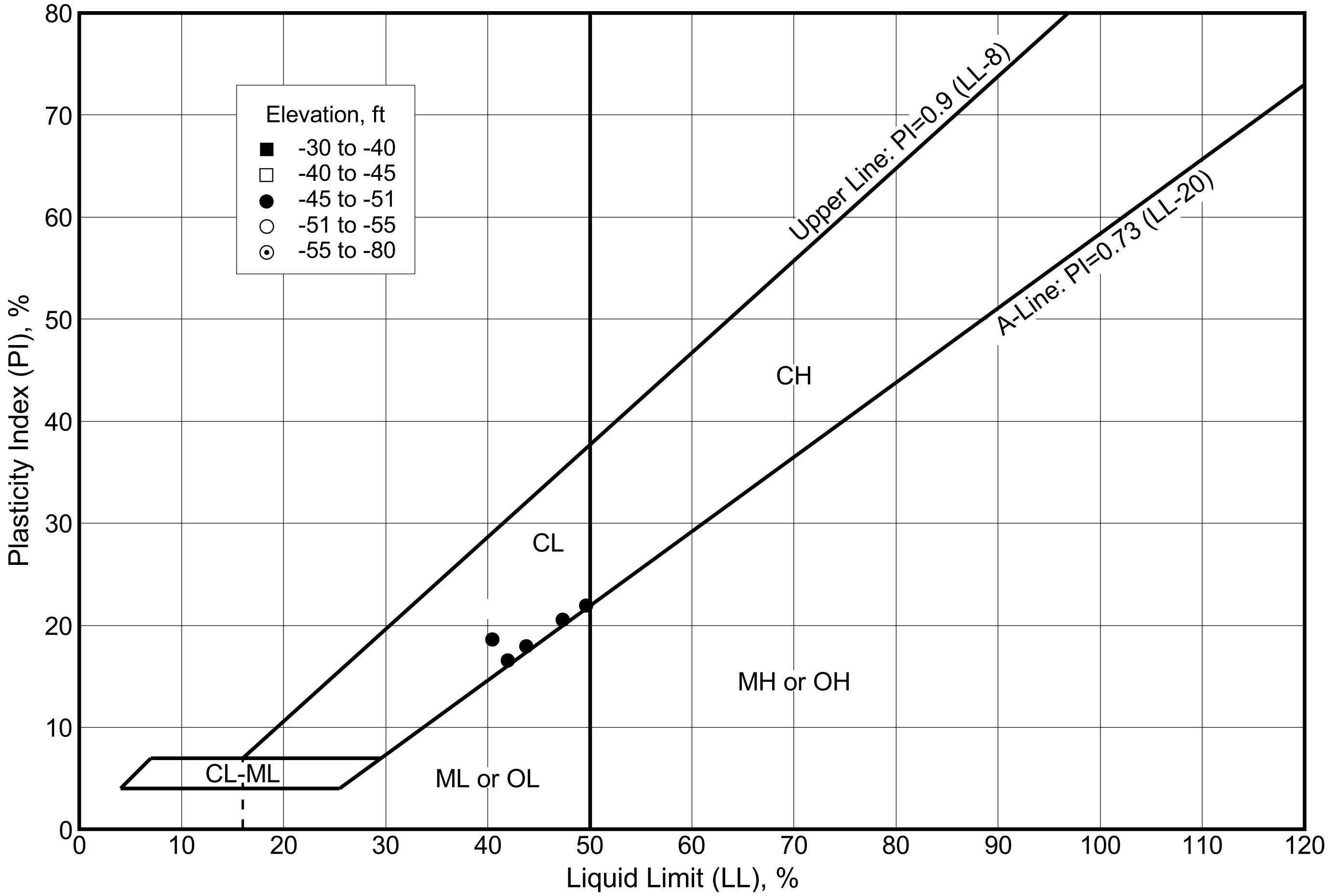
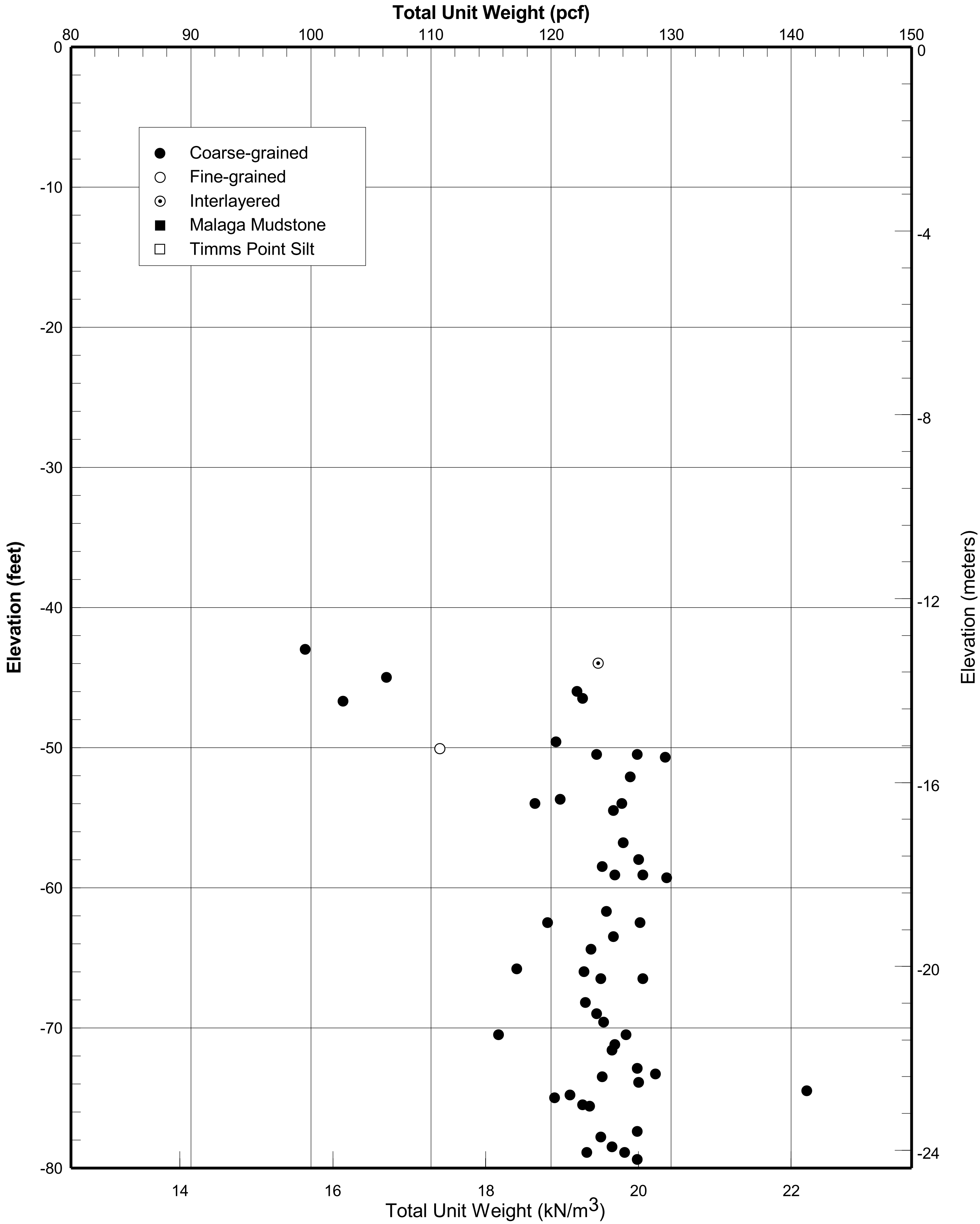


D_{50} PROFILE
Native Dredge Unit CG-2
Channel Deepening Project
Port of Los Angeles, California

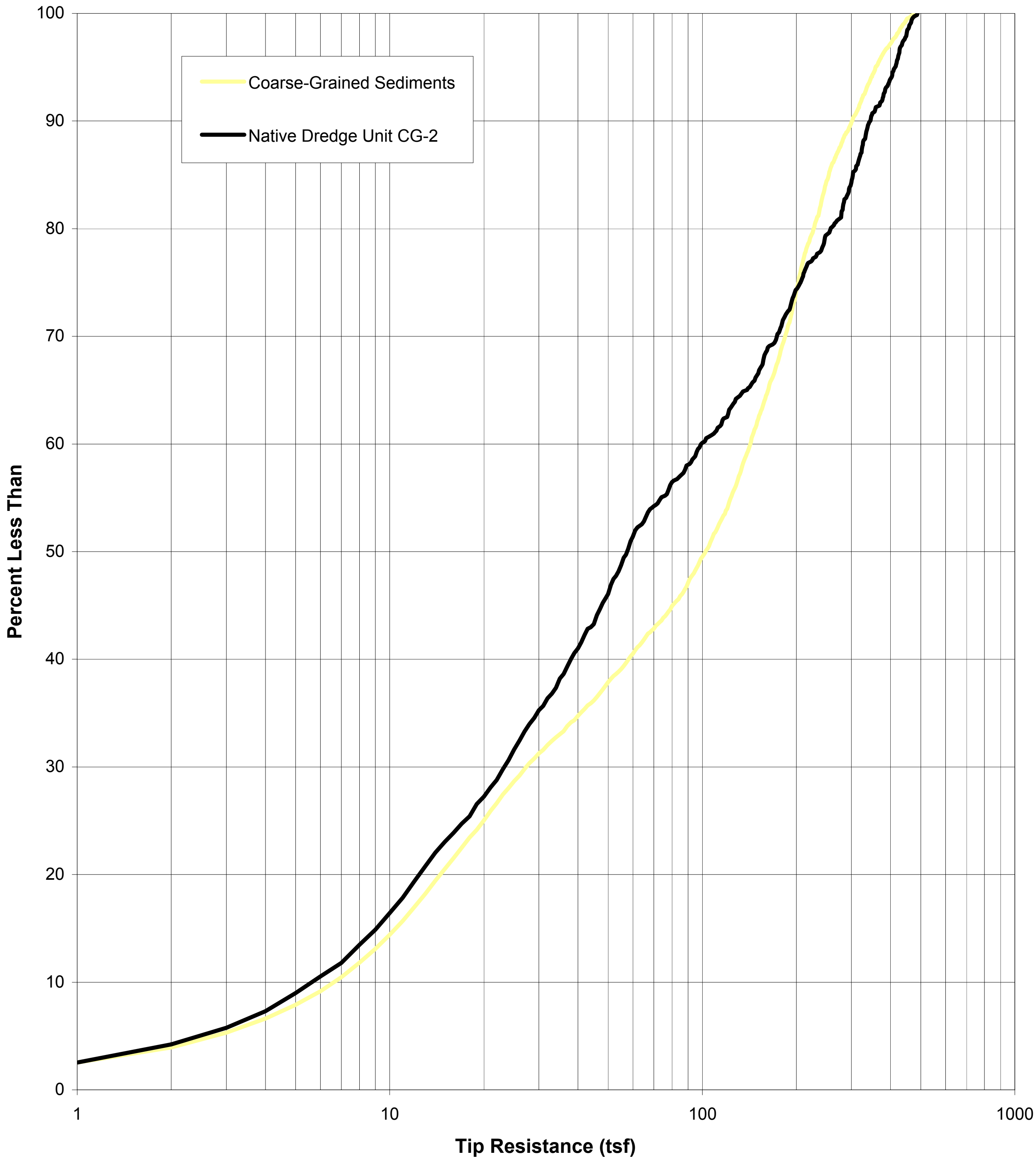


PLASTICITY CHART
Native Dredge Unit CG-2
Channel Deepening Project
Port of Los Angeles, California

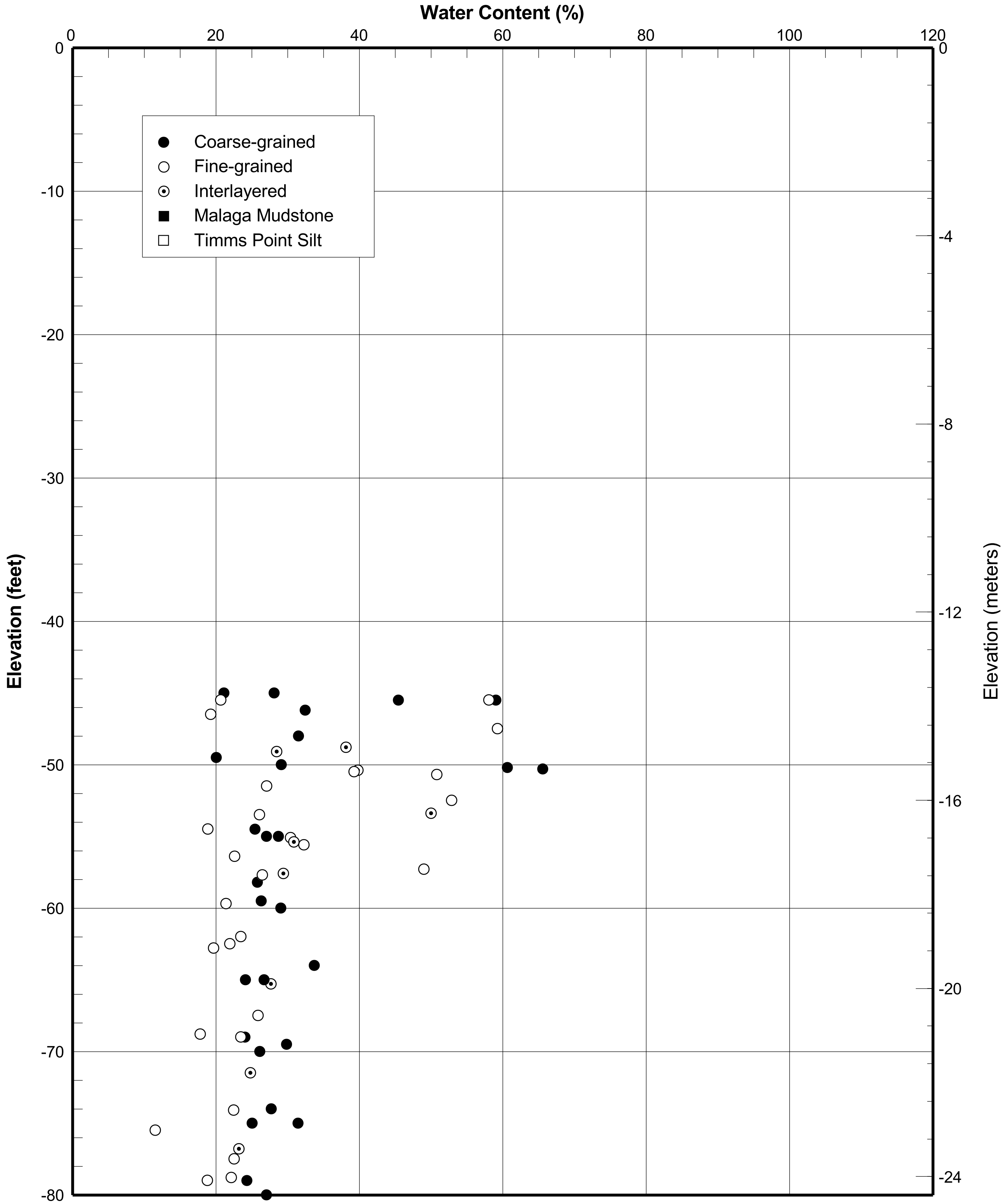


TOTAL UNIT WEIGHT PROFILE
Native Dredge Unit CG-2
Channel Deepening Project
Port of Los Angeles, California

PLATE 6.2e

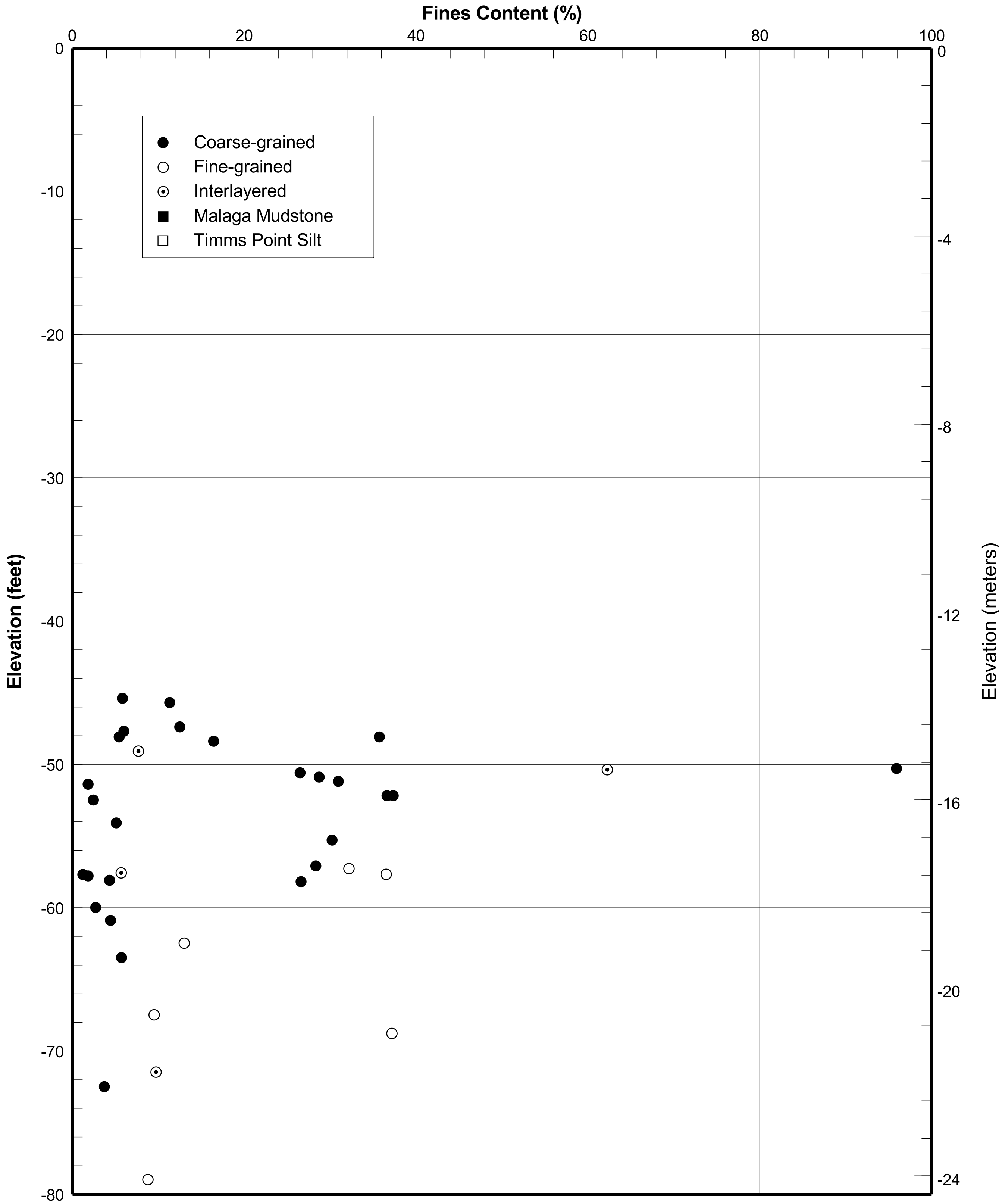


CUMULATIVE FREQUENCY DISTRIBUTION
Native Dredge Unit CG-2
Channel Deepening Project
Port of Los Angeles, California



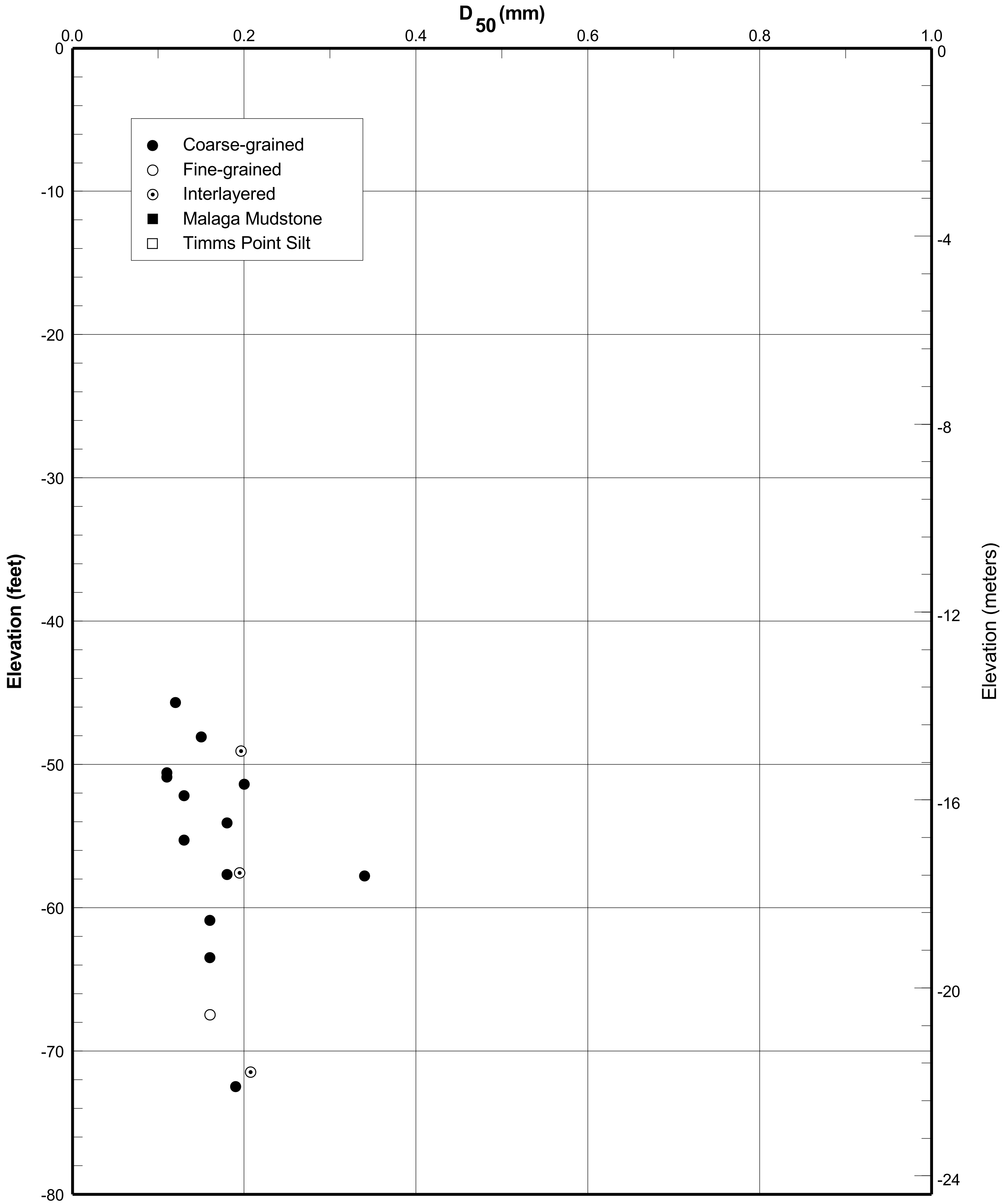
WATER CONTENT PROFILE
Native Dredge Unit CG-3
Channel Deepening Project
Port of Los Angeles, California

PLATE 6.3a



FINES CONTENT PROFILE
Native Dredge Unit CG-3
Channel Deepening Project
Port of Los Angeles, California

PLATE 6.3b

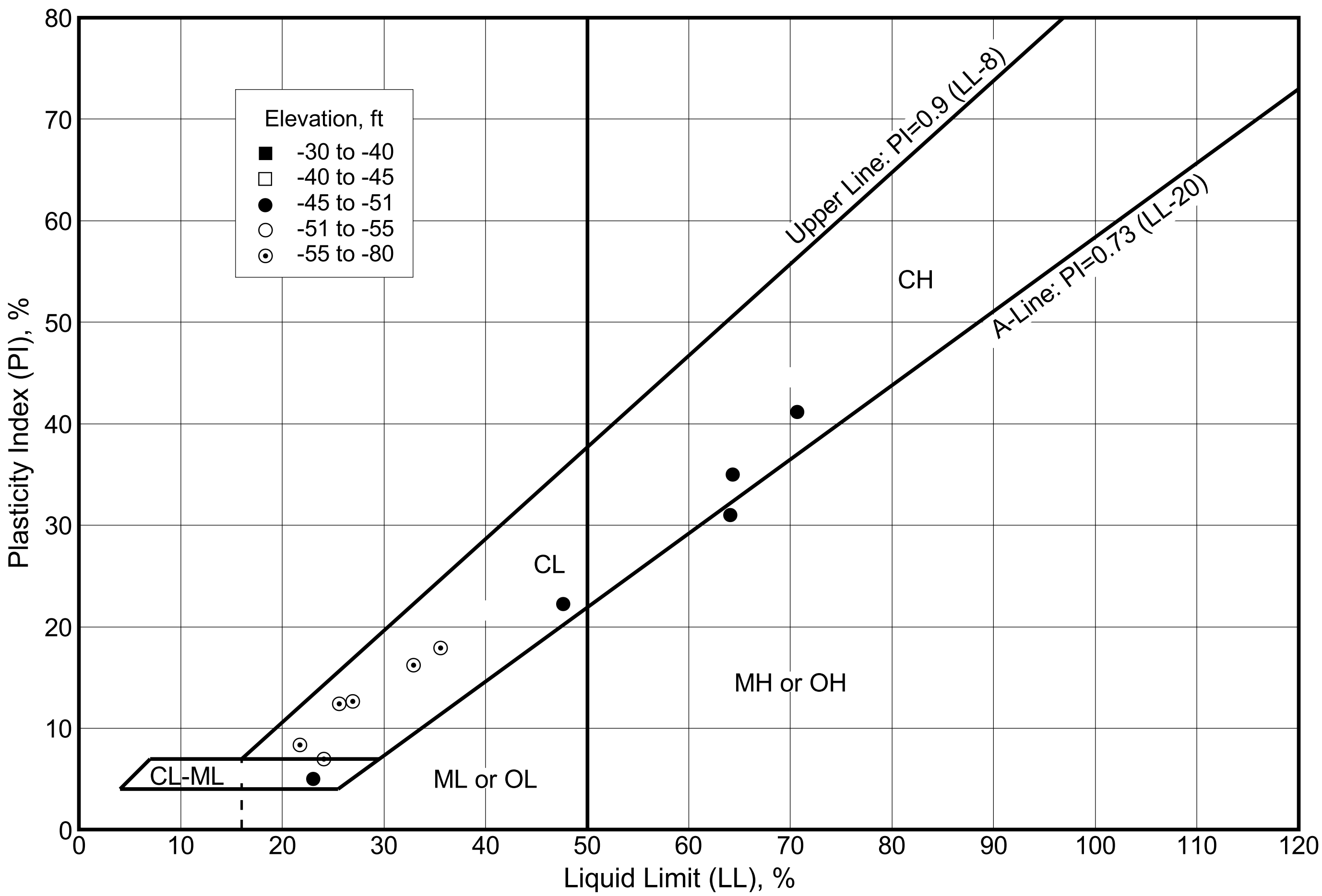


D_{50} PROFILE

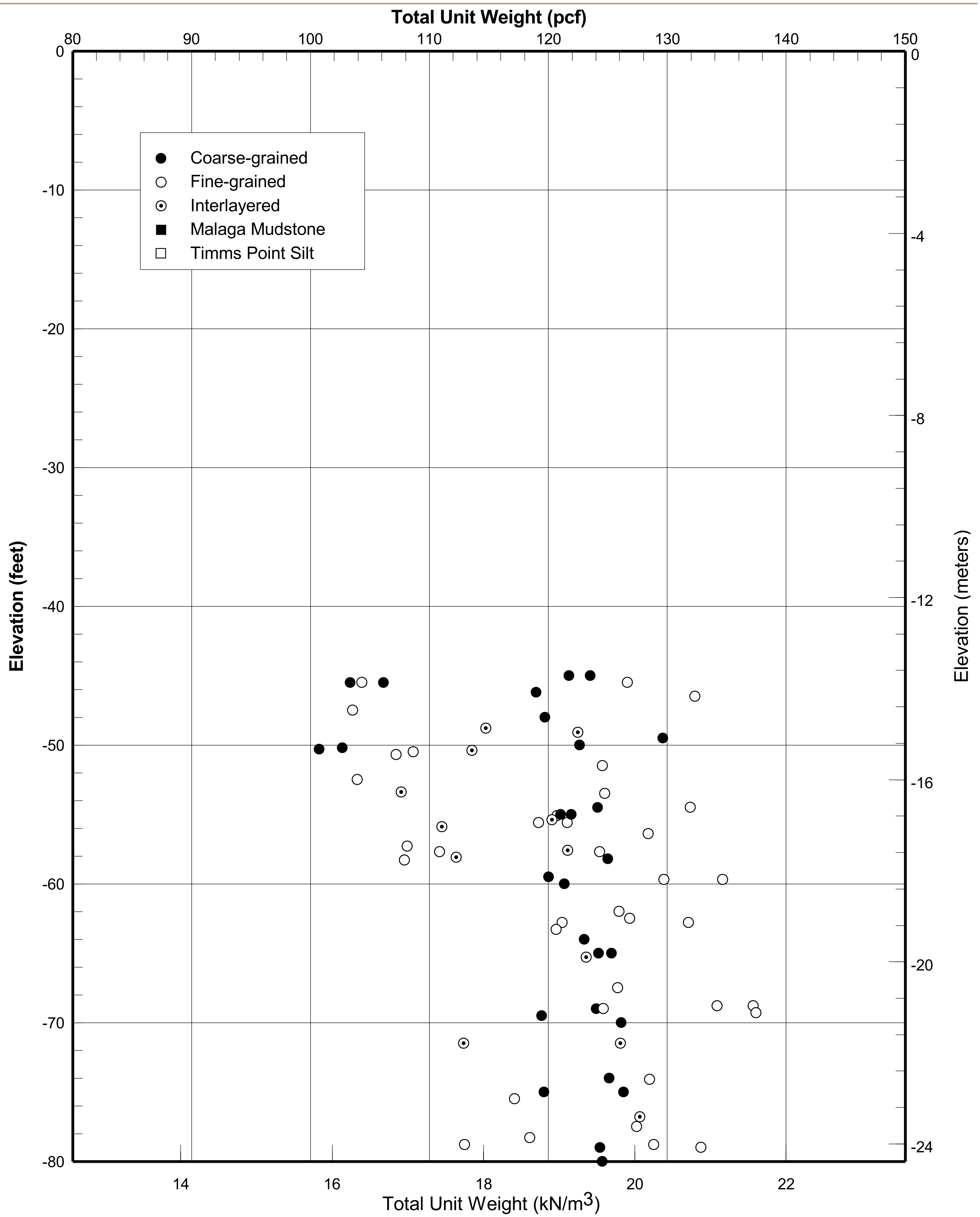
Native Dredge Unit CG-3

Channel Deepening Project

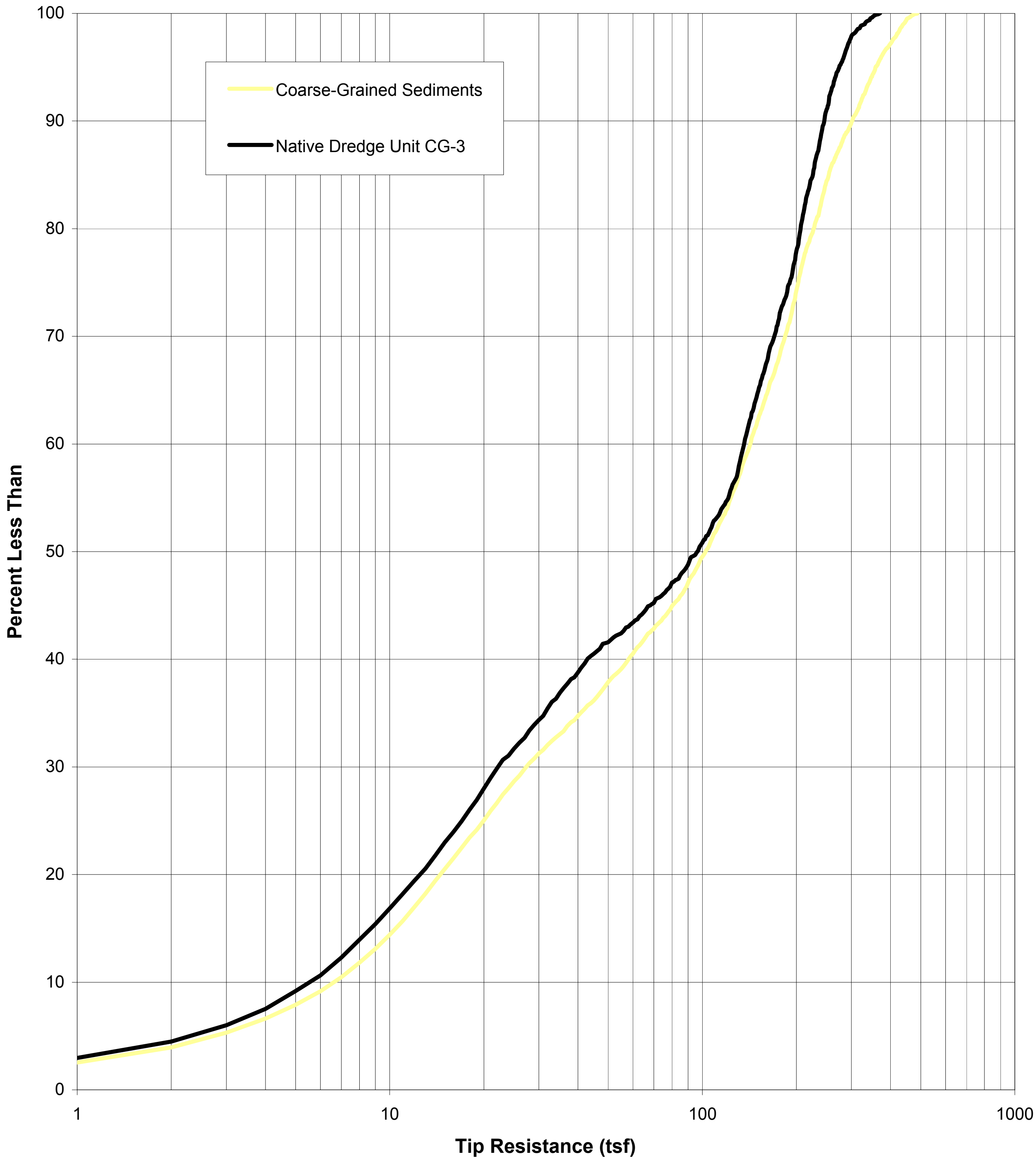
Port of Los Angeles, California



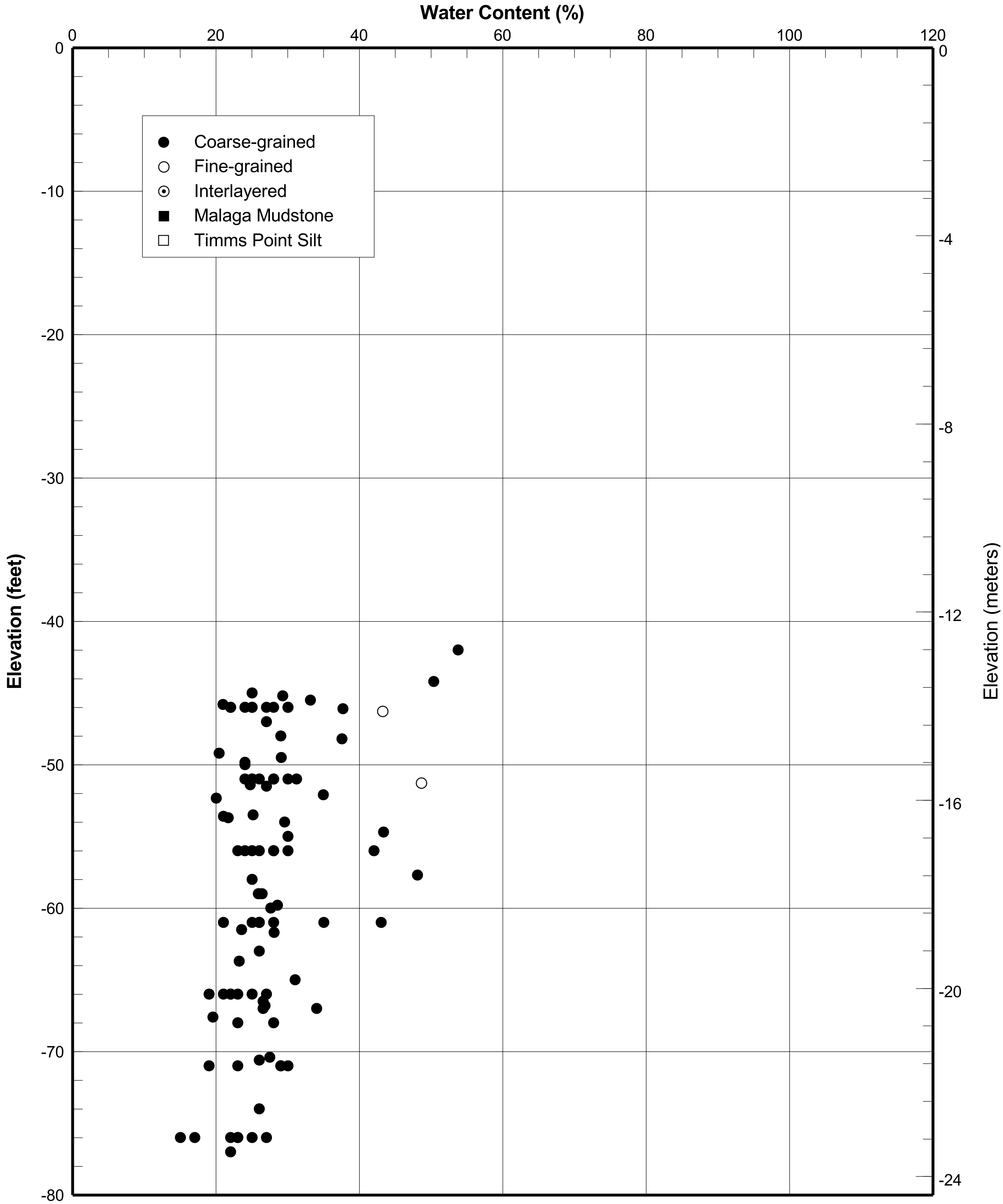
PLASTICITY CHART
Native Dredge Unit CG-3
Channel Deepening Project
Port of Los Angeles, California



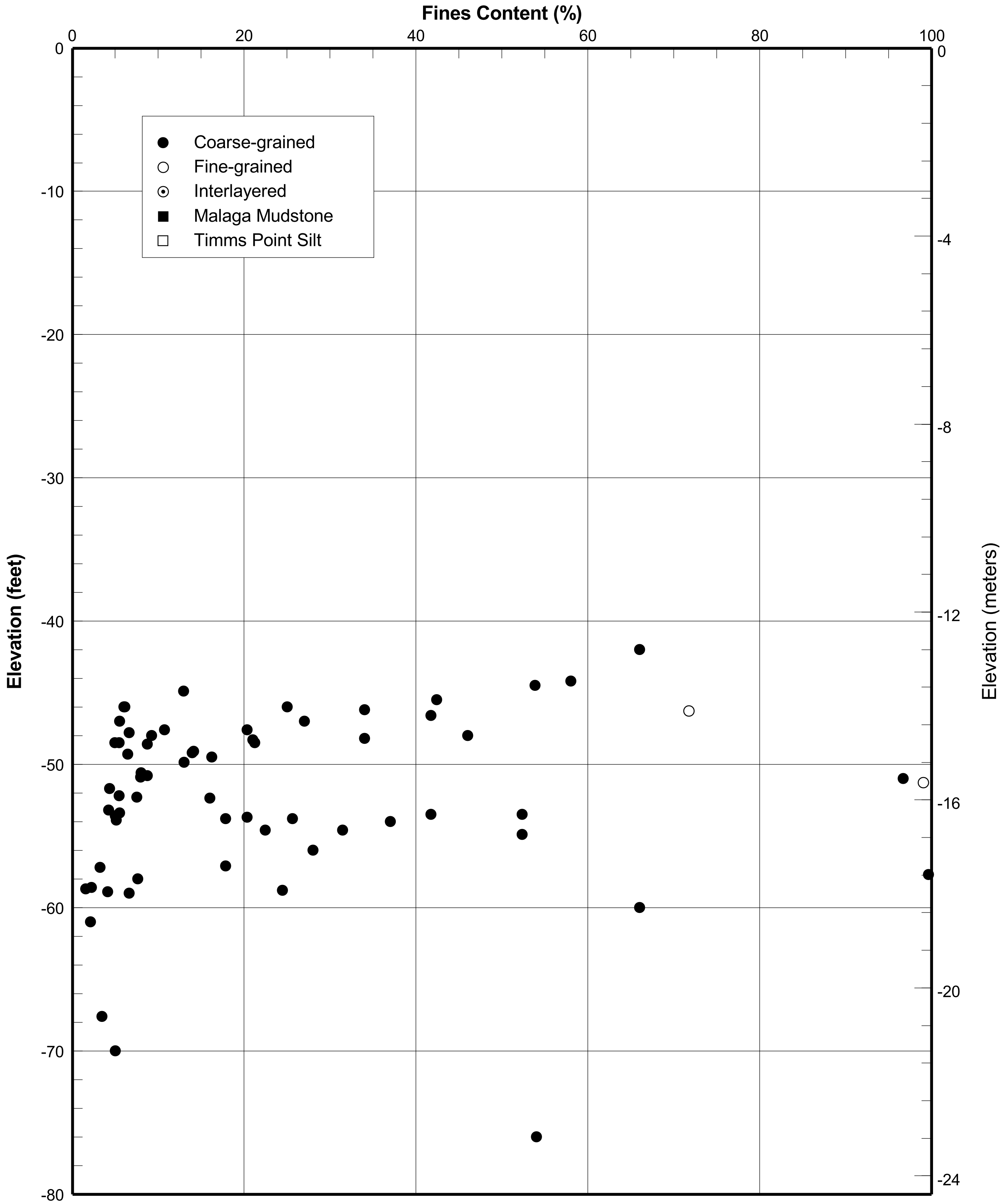
TOTAL UNIT WEIGHT PROFILE
Native Dredge Unit CG-3
Channel Deepening Project
Port of Los Angeles, California



CUMULATIVE FREQUENCY DISTRIBUTION
Native Dredge Unit CG-3
Channel Deepening Project
Port of Los Angeles, California



WATER CONTENT PROFILE
Native Dredge Unit CG-4
Channel Deepening Project
Port of Los Angeles, California



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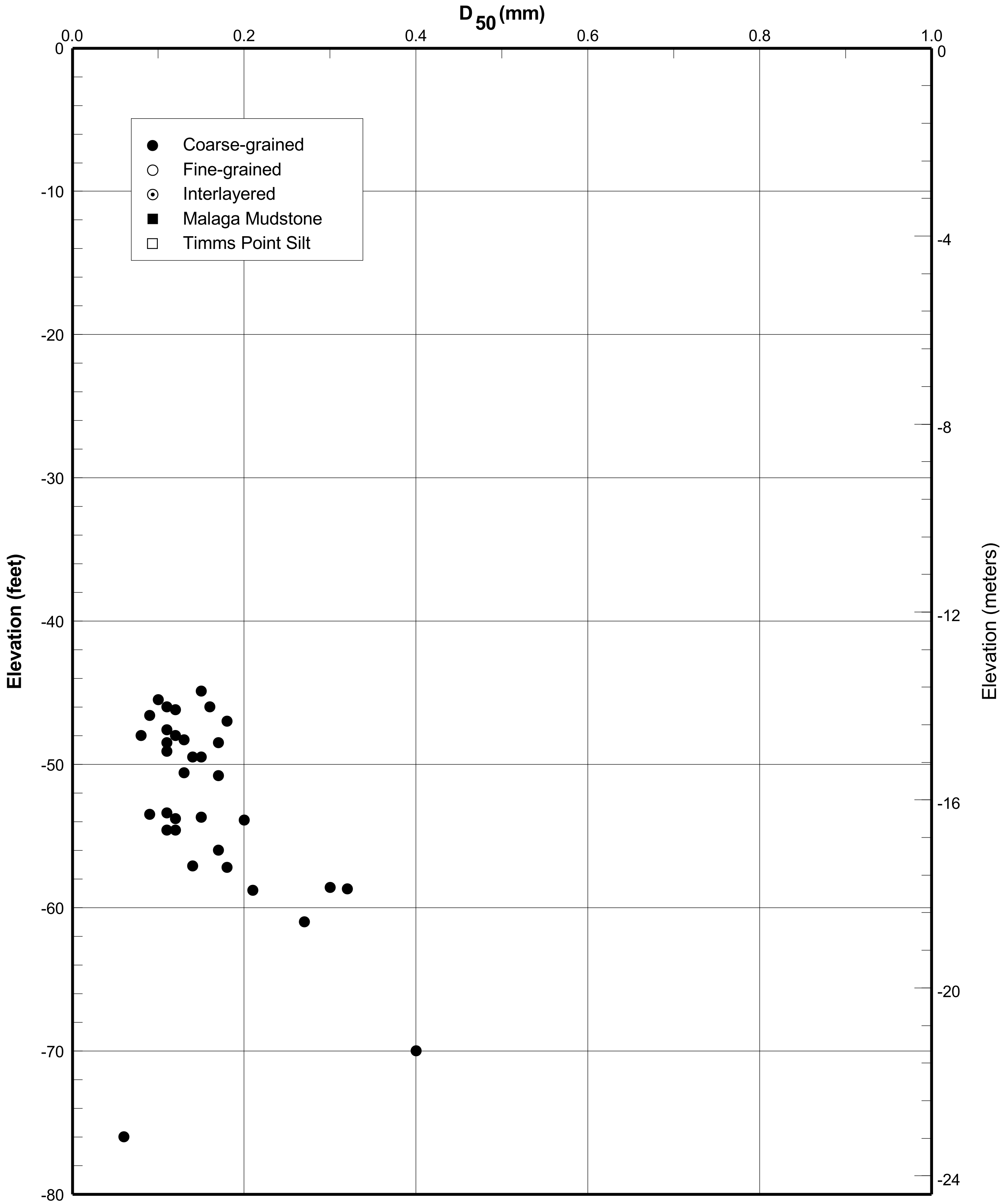
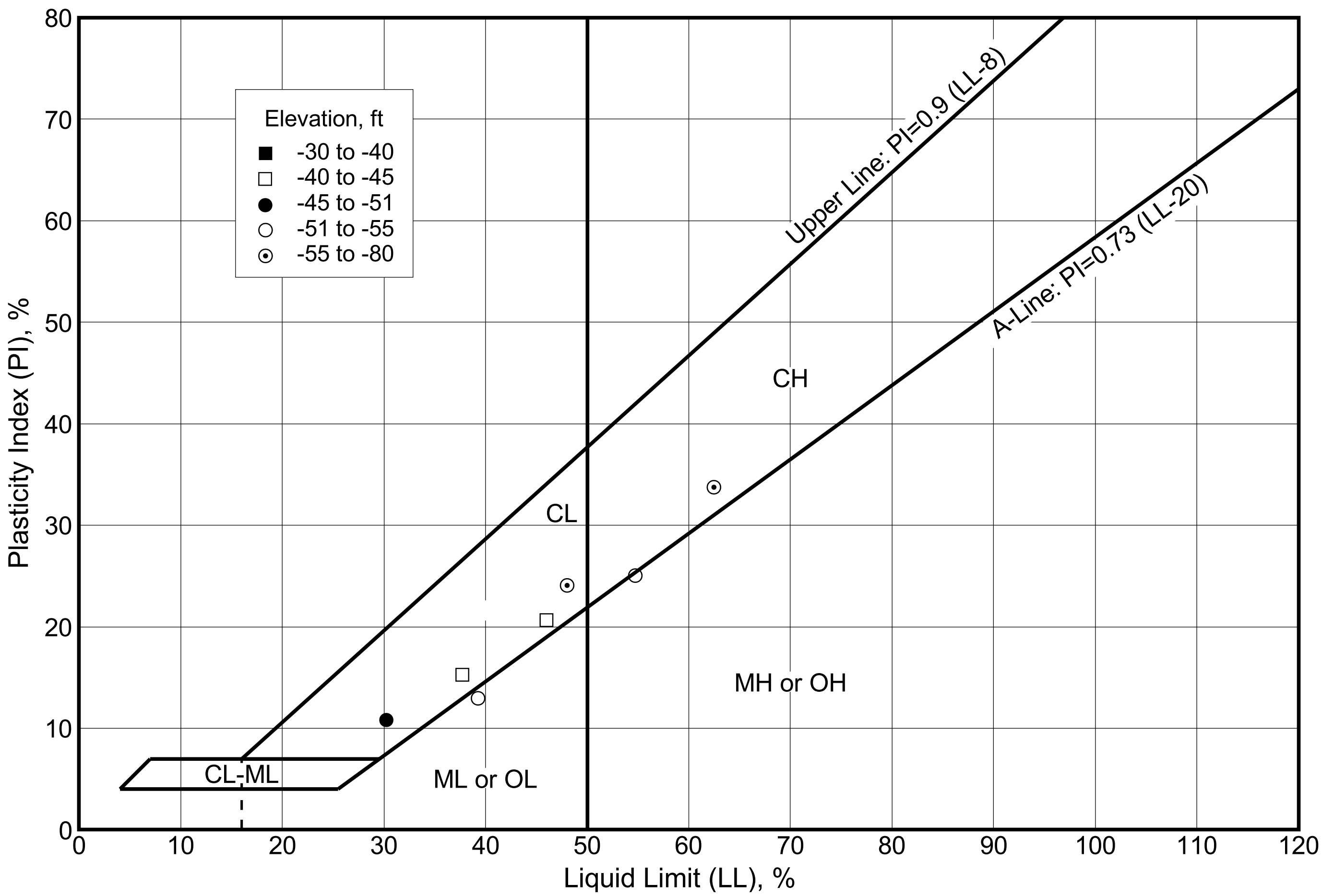
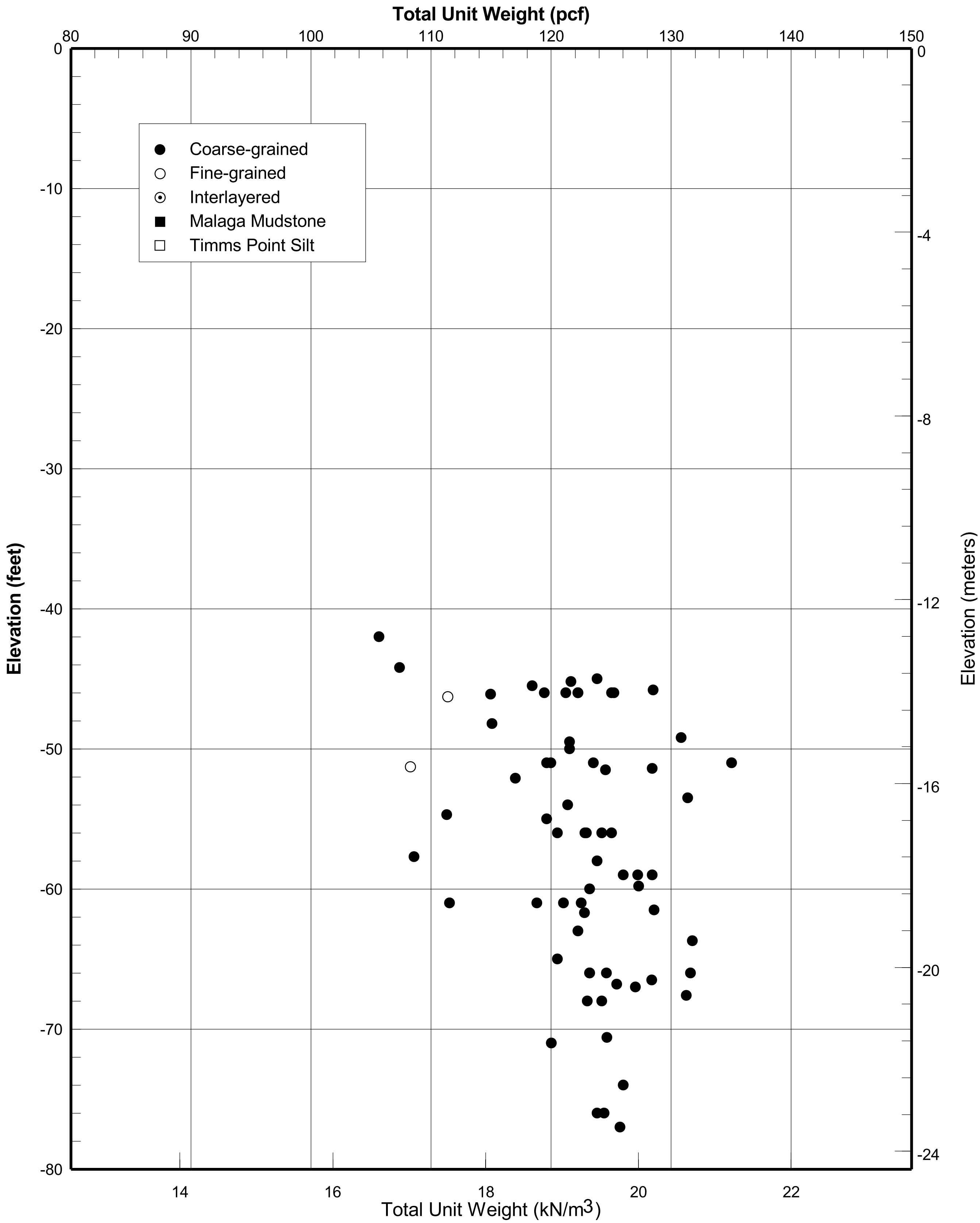
Native Dredge Unit CG-4
Channel Deepening Project
Port of Los Angeles, California



D_{50} PROFILE
Native Dredge Unit CG-4
Channel Deepening Project
Port of Los Angeles, California

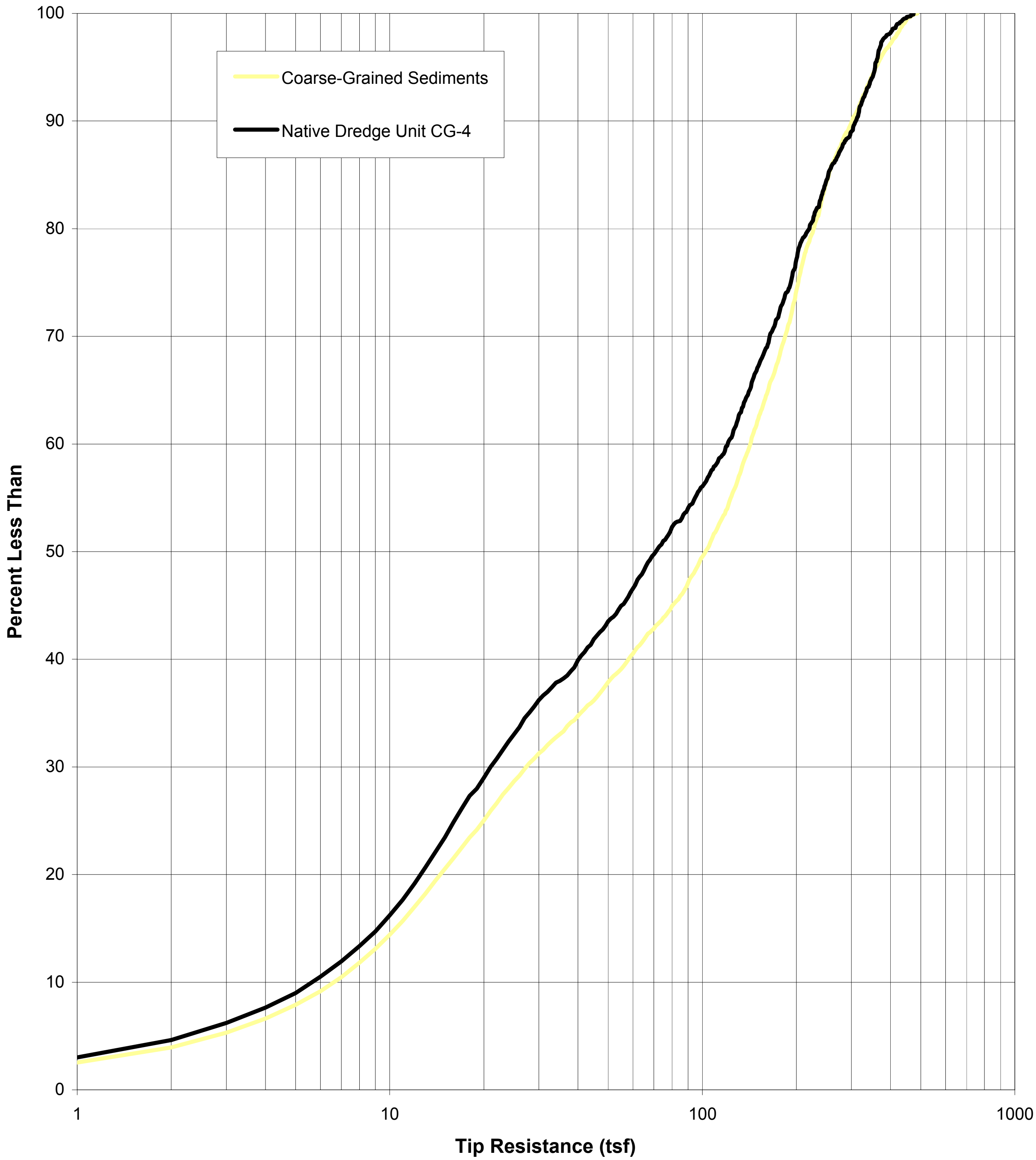


PLASTICITY CHART
Native Dredge Unit CG-4
Channel Deepening Project
Port of Los Angeles, California

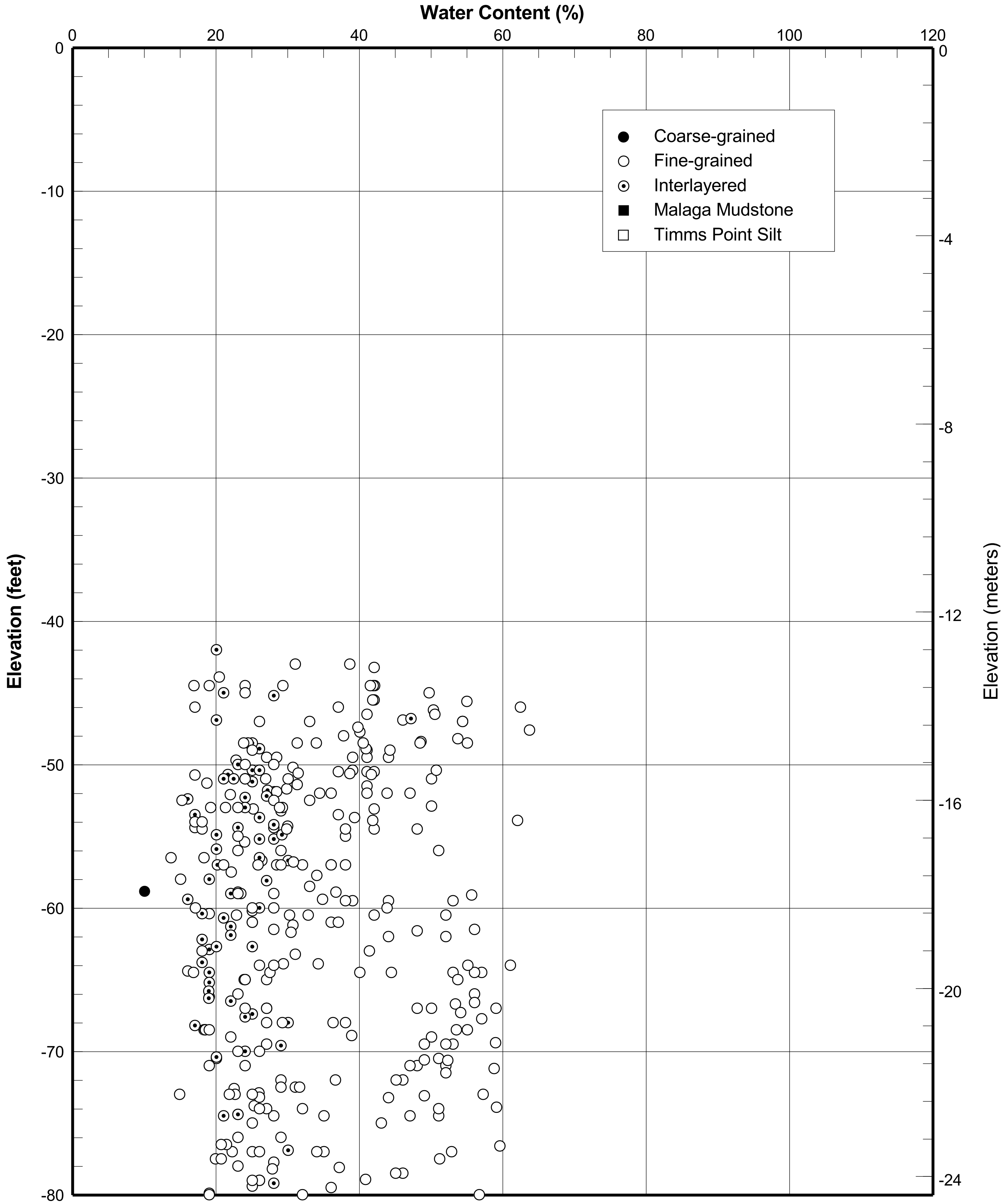


TOTAL UNIT WEIGHT PROFILE
Native Dredge Unit CG-4
Channel Deepening Project
Port of Los Angeles, California

PLATE 6.4e

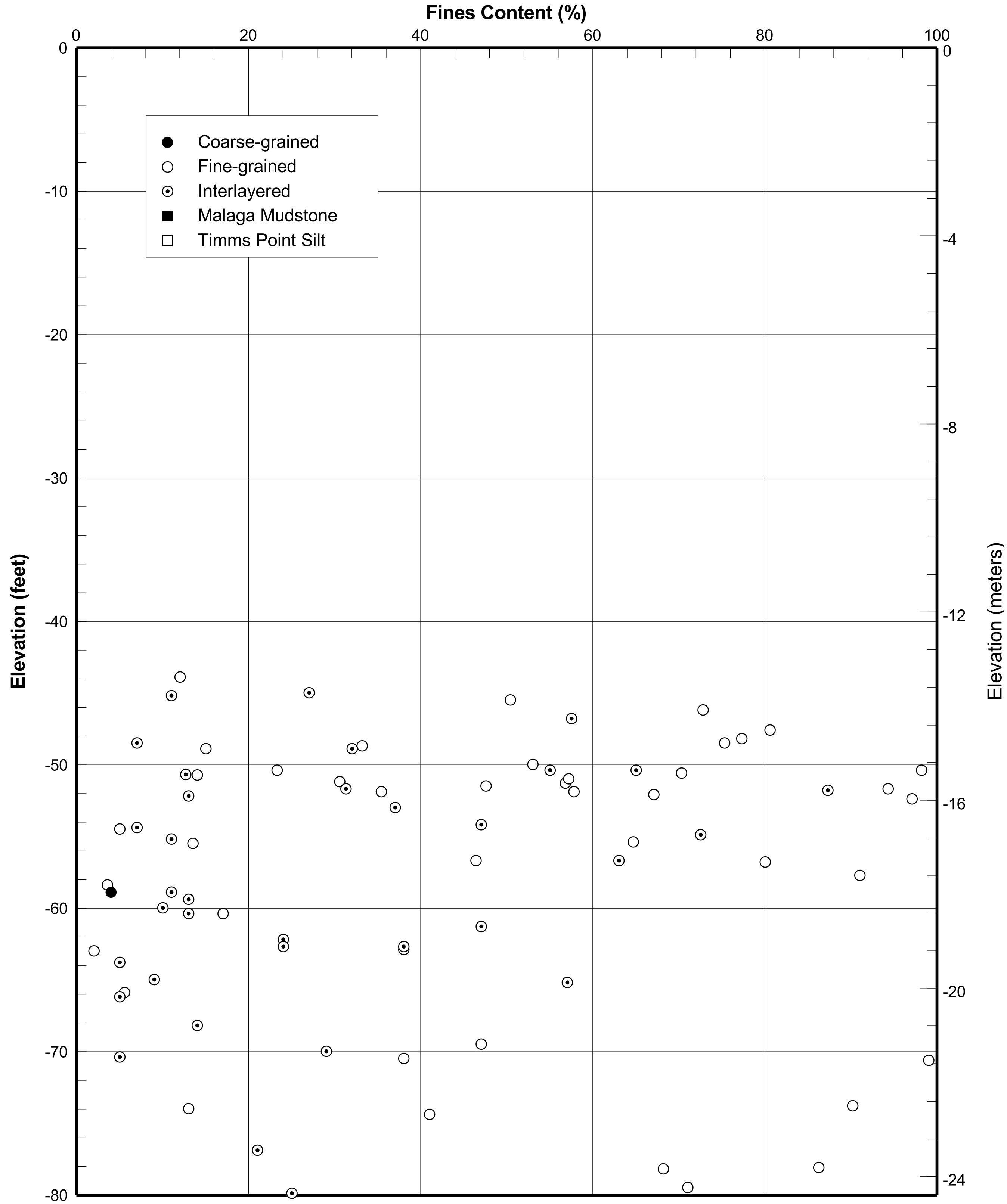


CUMULATIVE FREQUENCY DISTRIBUTION
Native Dredge Unit CG-4
Channel Deepening Project
Port of Los Angeles, California



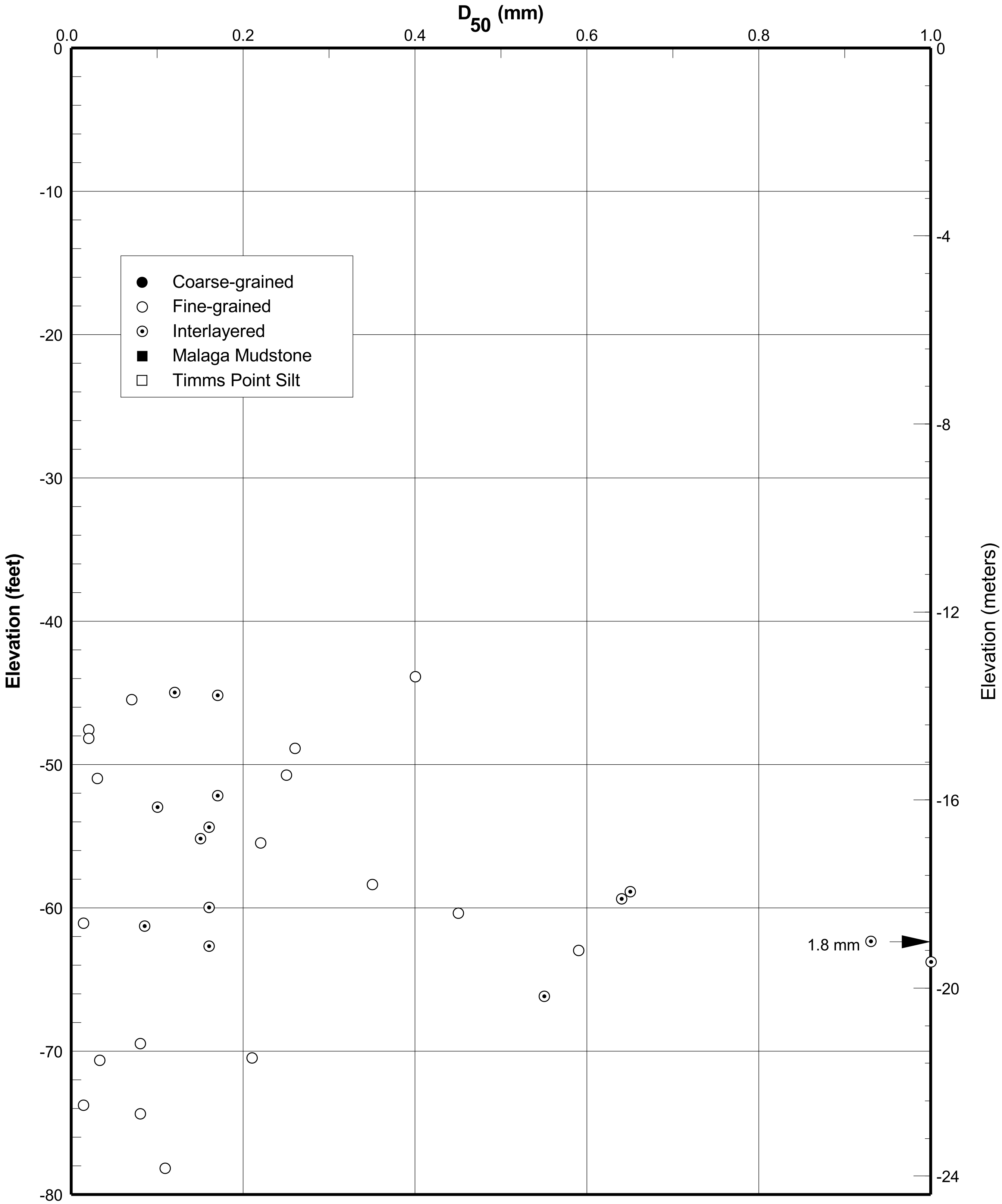
WATER CONTENT PROFILE
Native Dredge Unit FG-1
Channel Deepening Project
Port of Los Angeles, California

PLATE 6.5a



FINES CONTENT PROFILE
Native Dredge Unit FG-1
Channel Deepening Project
Port of Los Angeles, California

PLATE 6.5b



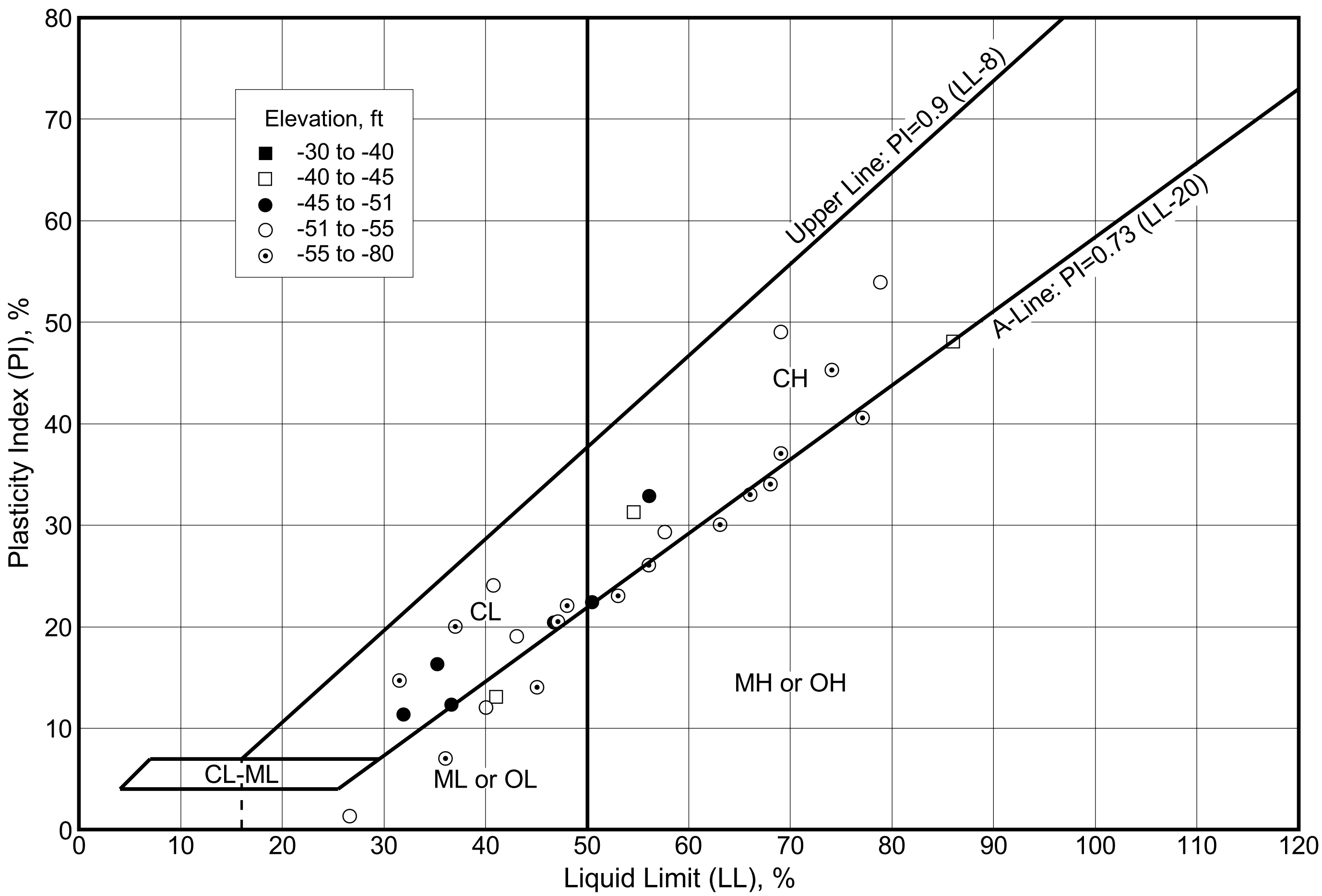
D_{50} PROFILE

Native Dredge Unit FG-1

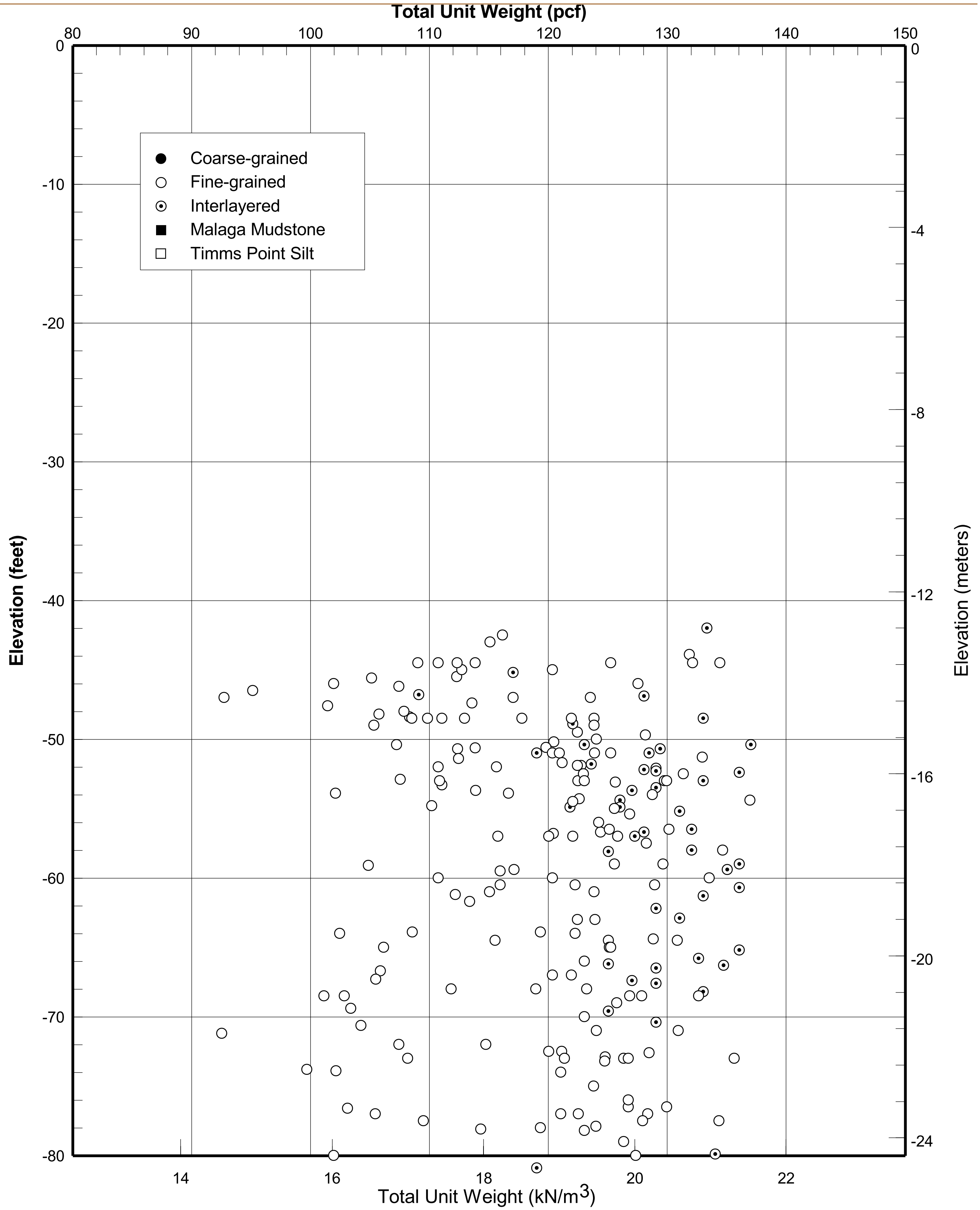
Channel Deepening Project

Port of Los Angeles, California

PLATE 6.5c

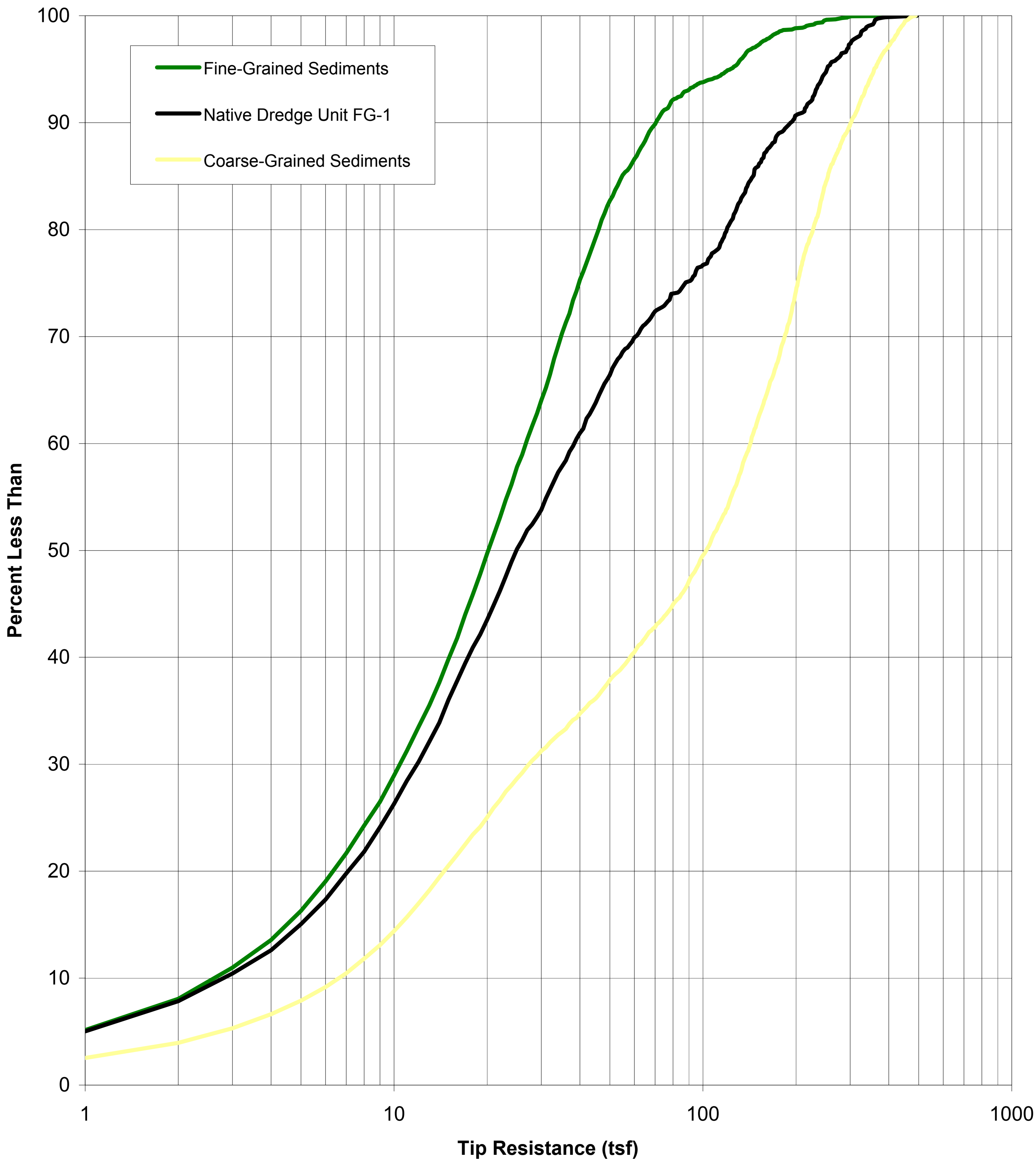


PLASTICITY CHART
Native Dredge Unit FG-1
Channel Deepening Project
Port of Los Angeles, California

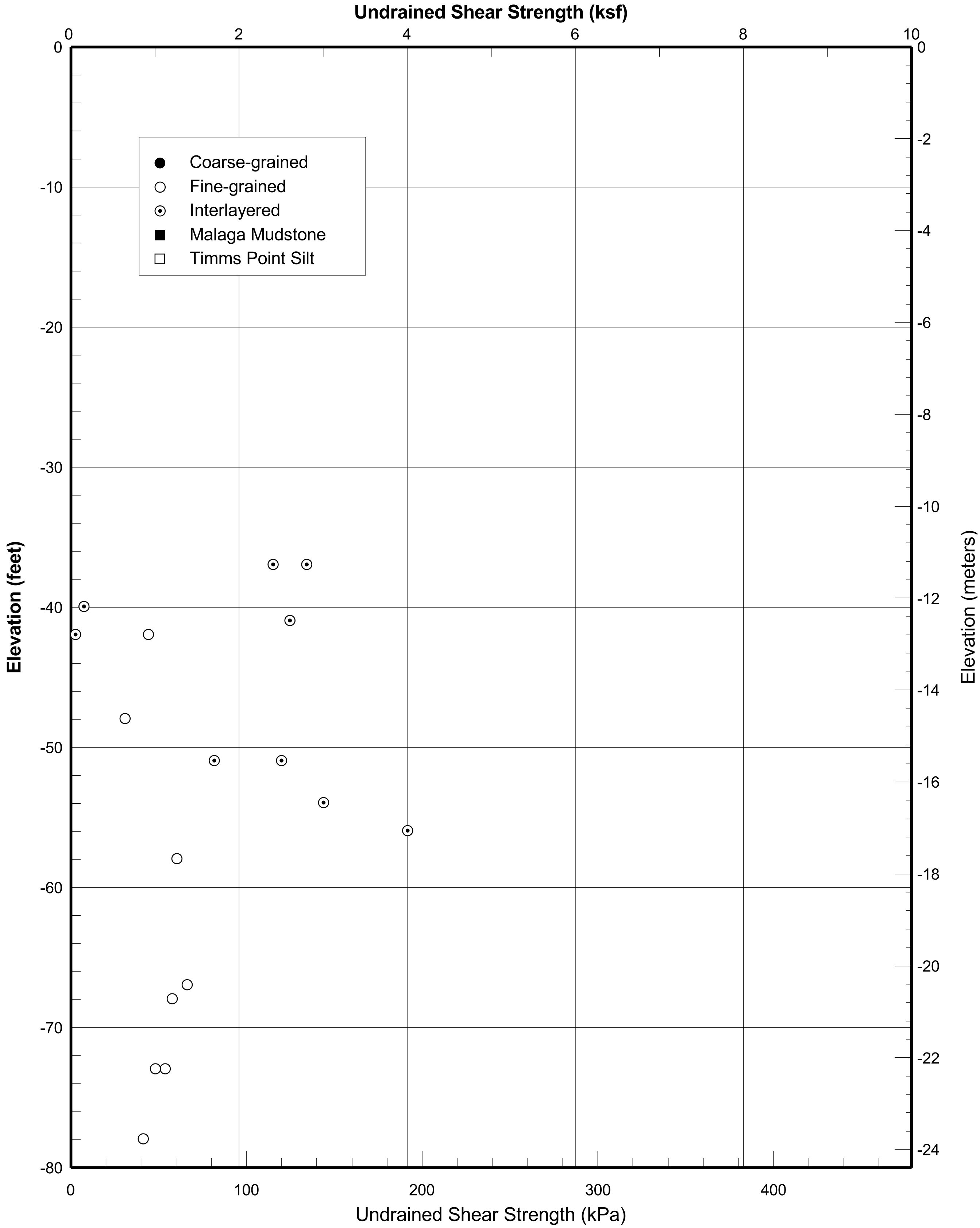


TOTAL UNIT WEIGHT PROFILE
Native Dredge Unit FG-1
Channel Deepening Project
Port of Los Angeles, California

PLATE 6.5e

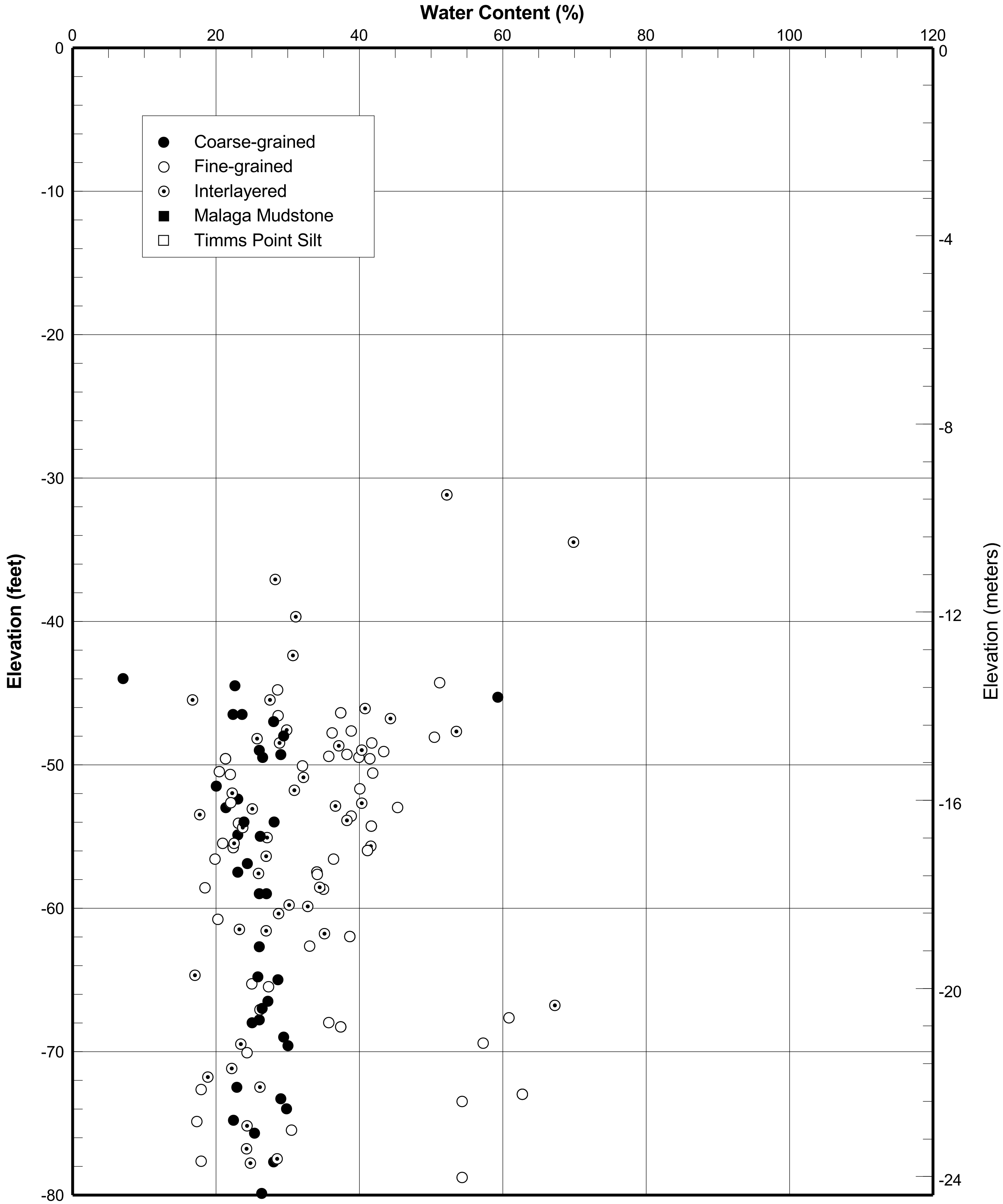


CUMULATIVE FREQUENCY DISTRIBUTION
Native Dredge Unit FG-1
Channel Deepening Project
Port of Los Angeles, California



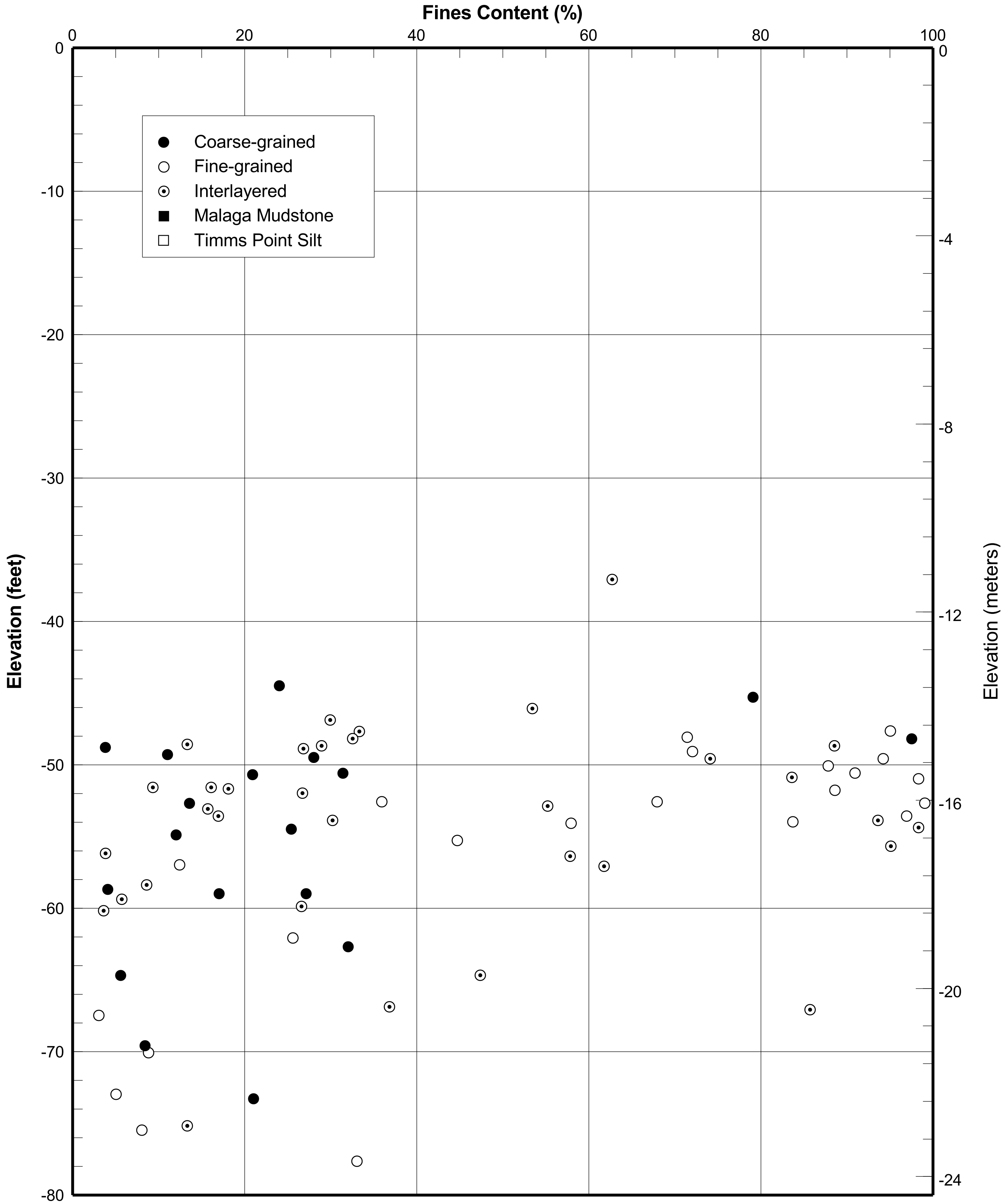
UNDRAINED SHEAR STRENGTH PROFILE
Native Dredge Unit FG-1
Channel Deepening Project
Port of Los Angeles, California

PLATE 6.5g

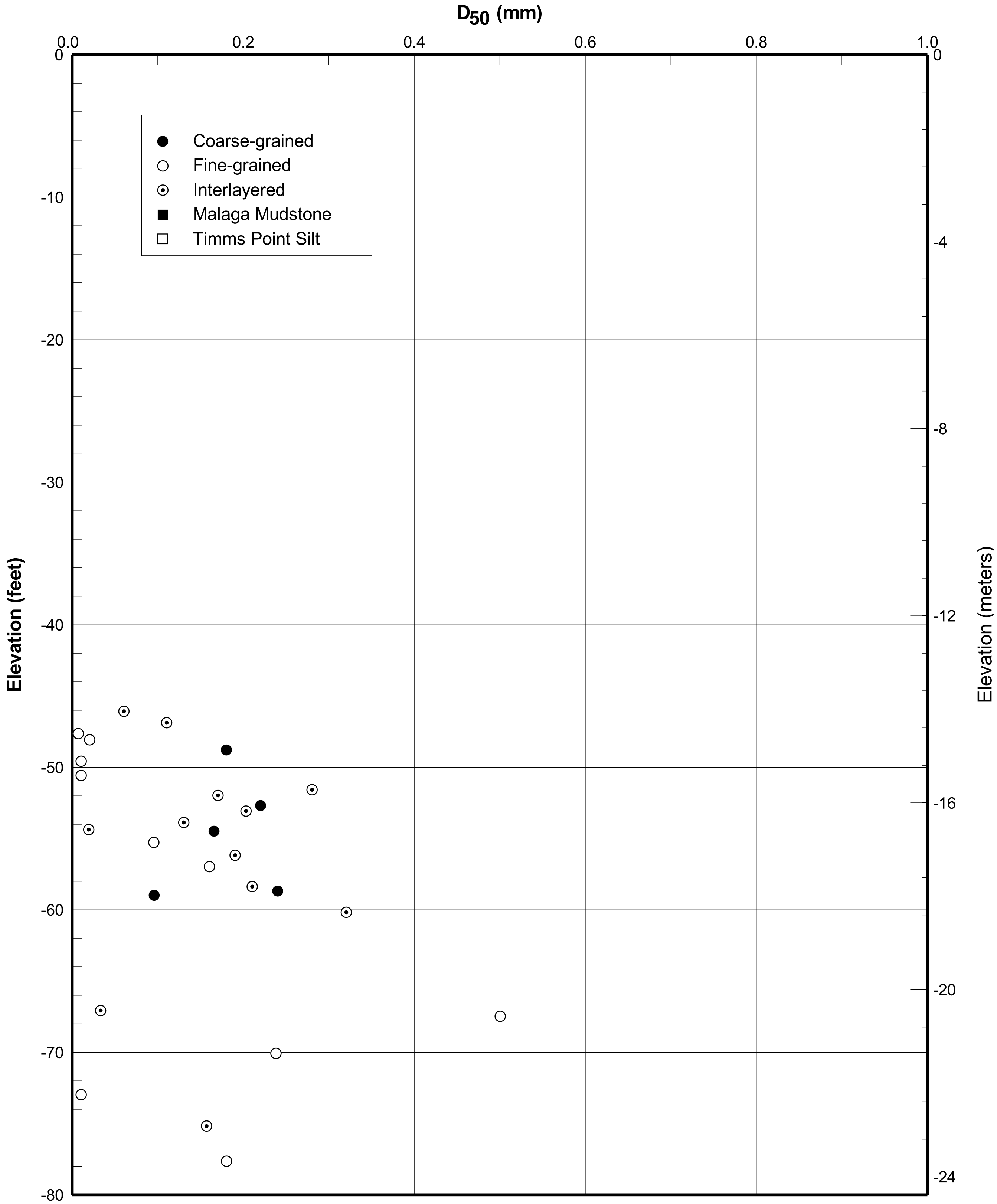


WATER CONTENT PROFILE
Native Dredge Unit FG-2
Channel Deepening Project
Port of Los Angeles, California

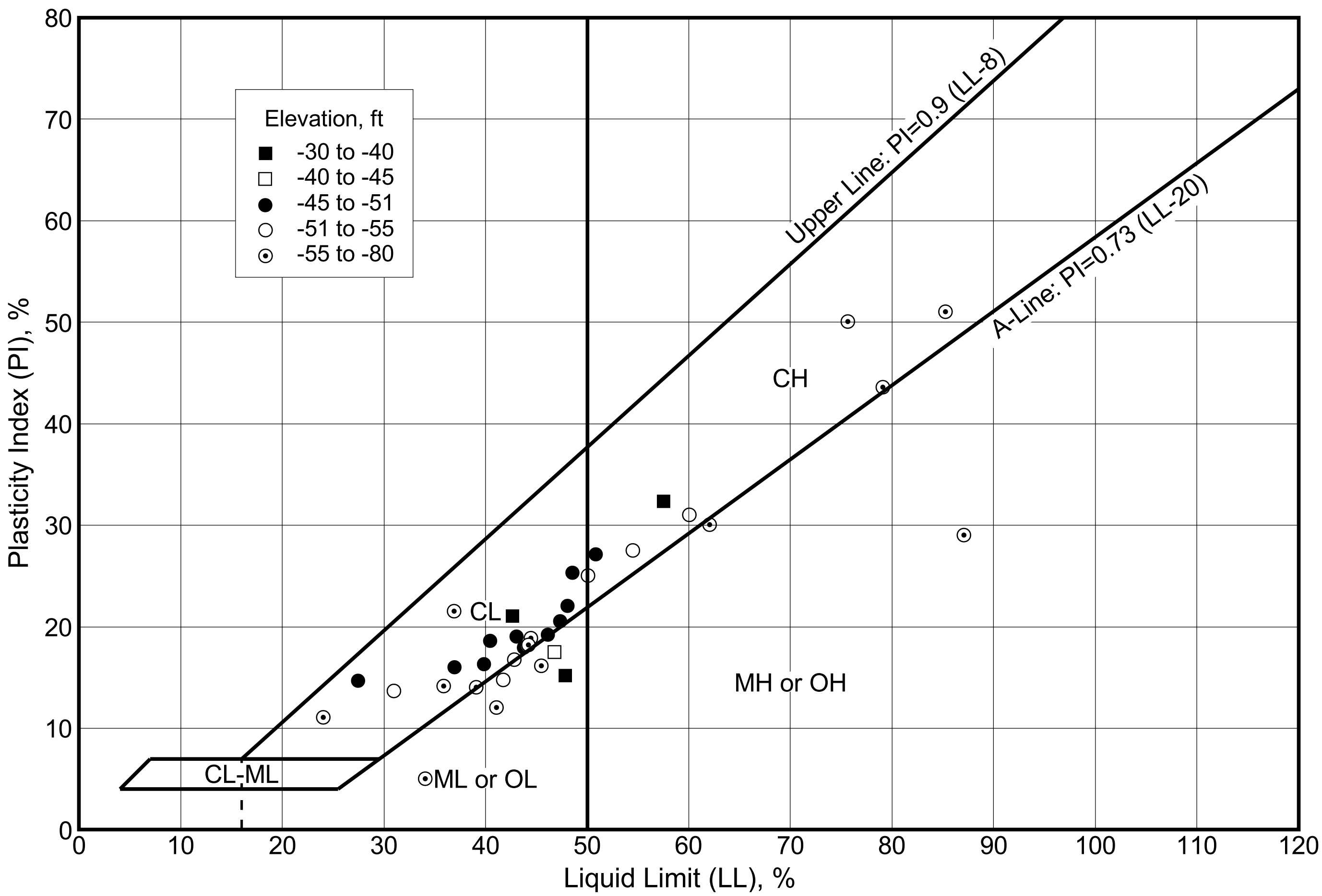
PLATE 6.6a



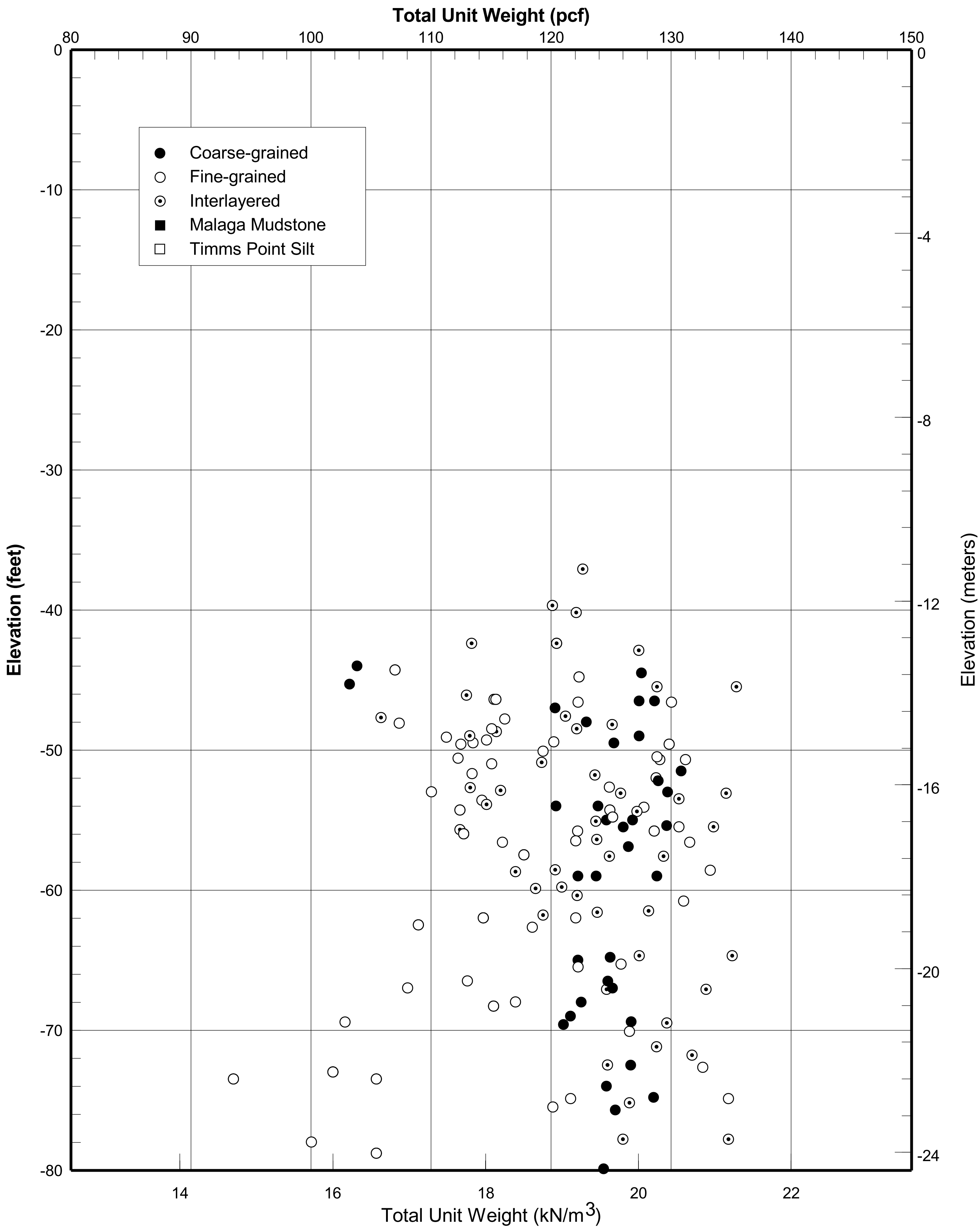
FINES CONTENT PROFILE
Native Dredge Unit FG-2
Channel Deepening Project
Port of Los Angeles, California



D_{50} PROFILE
Native Dredge Unit FG-2
Channel Deepening Project
Port of Los Angeles, California



PLASTICITY CHART
Native Dredge Unit FG-2
Channel Deepening Project
Port of Los Angeles, California



TOTAL UNIT WEIGHT PROFILE
Native Dredge Unit FG-2
Channel Deepening Project
Port of Los Angeles, California

PLATE 6.6e

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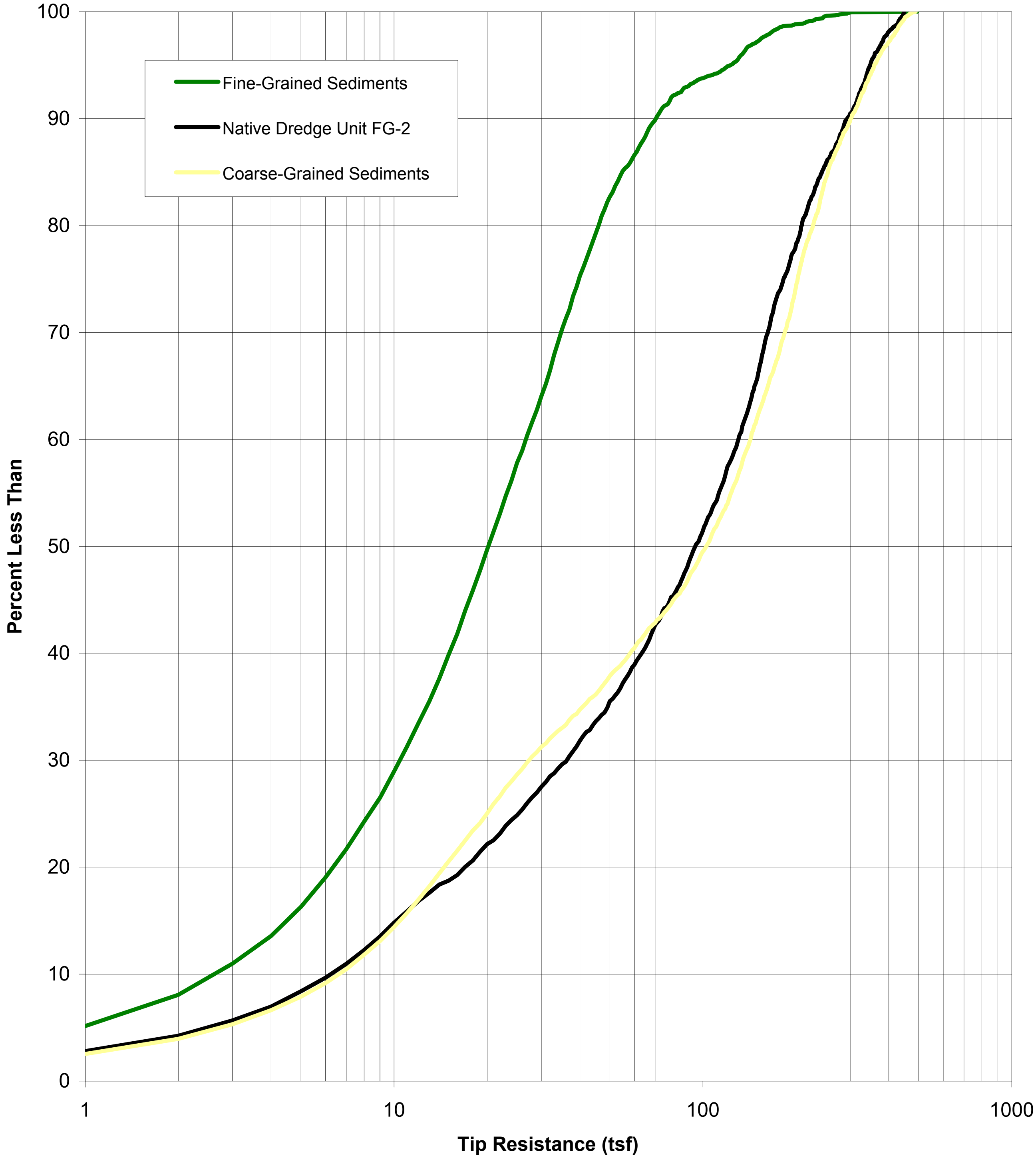
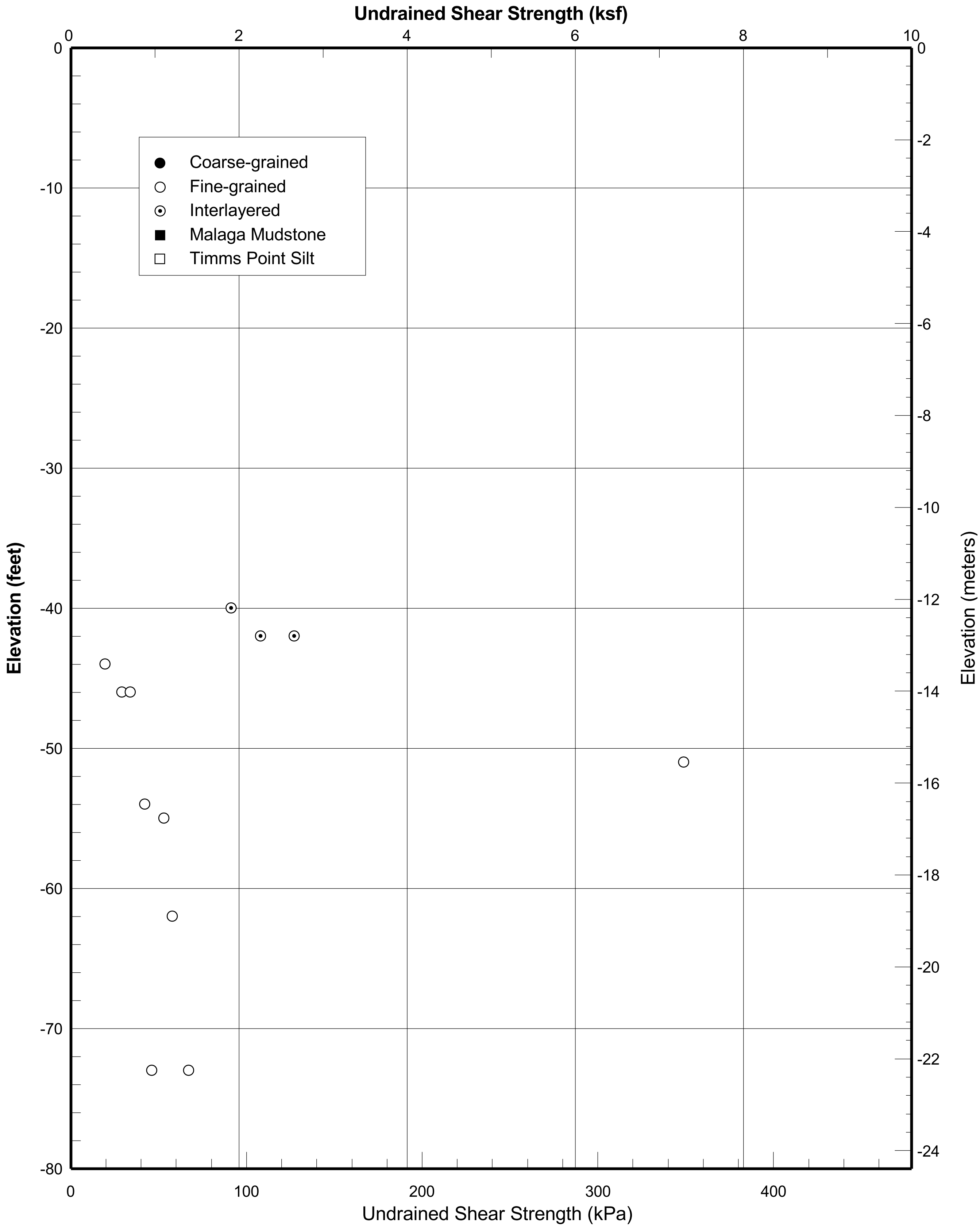


CUMULATIVE FREQUENCY DISTRIBUTION
Native Dredge Unit FG-2
Channel Deepening Project
Port of Los Angeles, California



UNDRAINED SHEAR STRENGTH PROFILE
Native Dredge Unit FG-2
Channel Deepening Project
Port of Los Angeles, California

PLATE 6.6g

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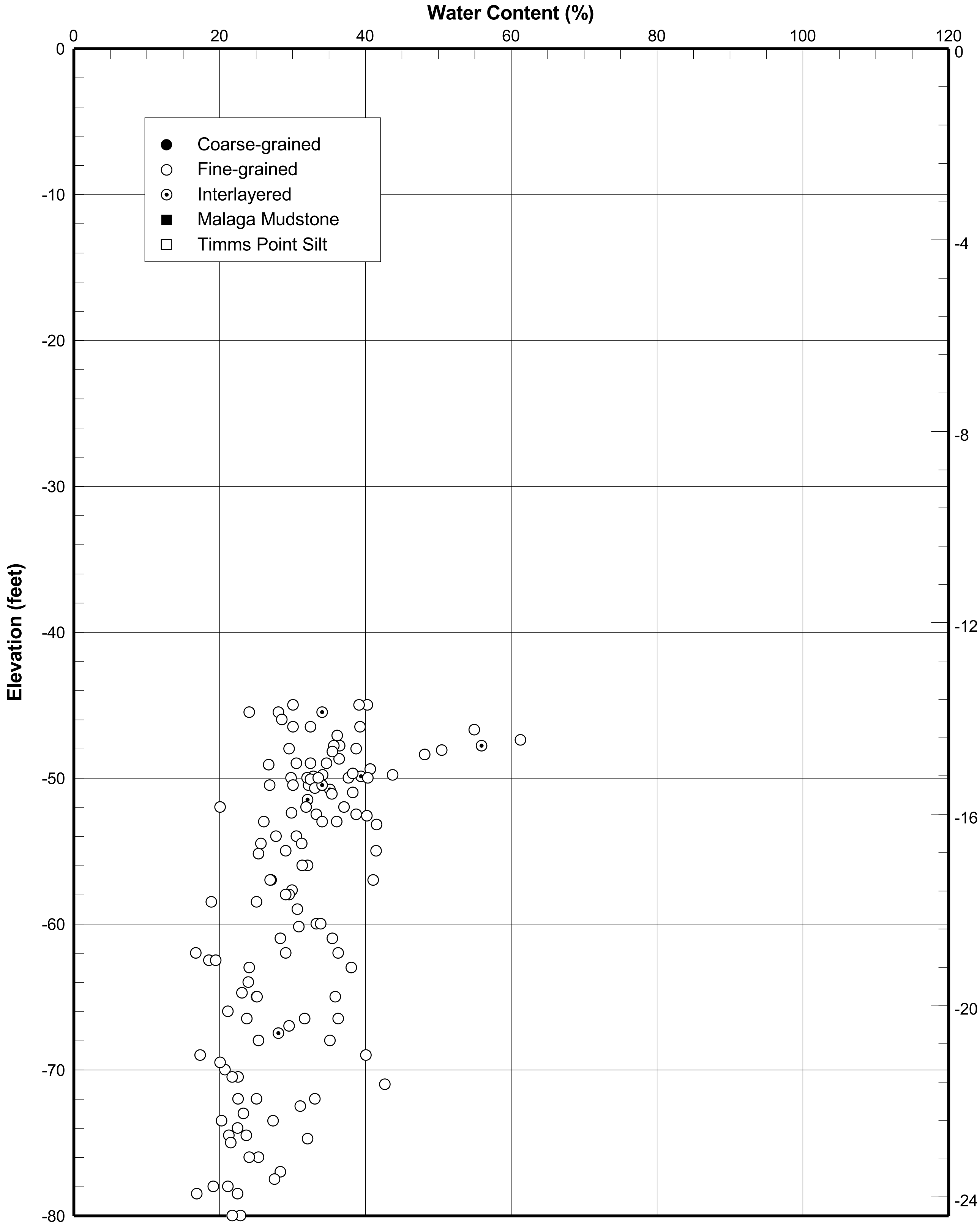
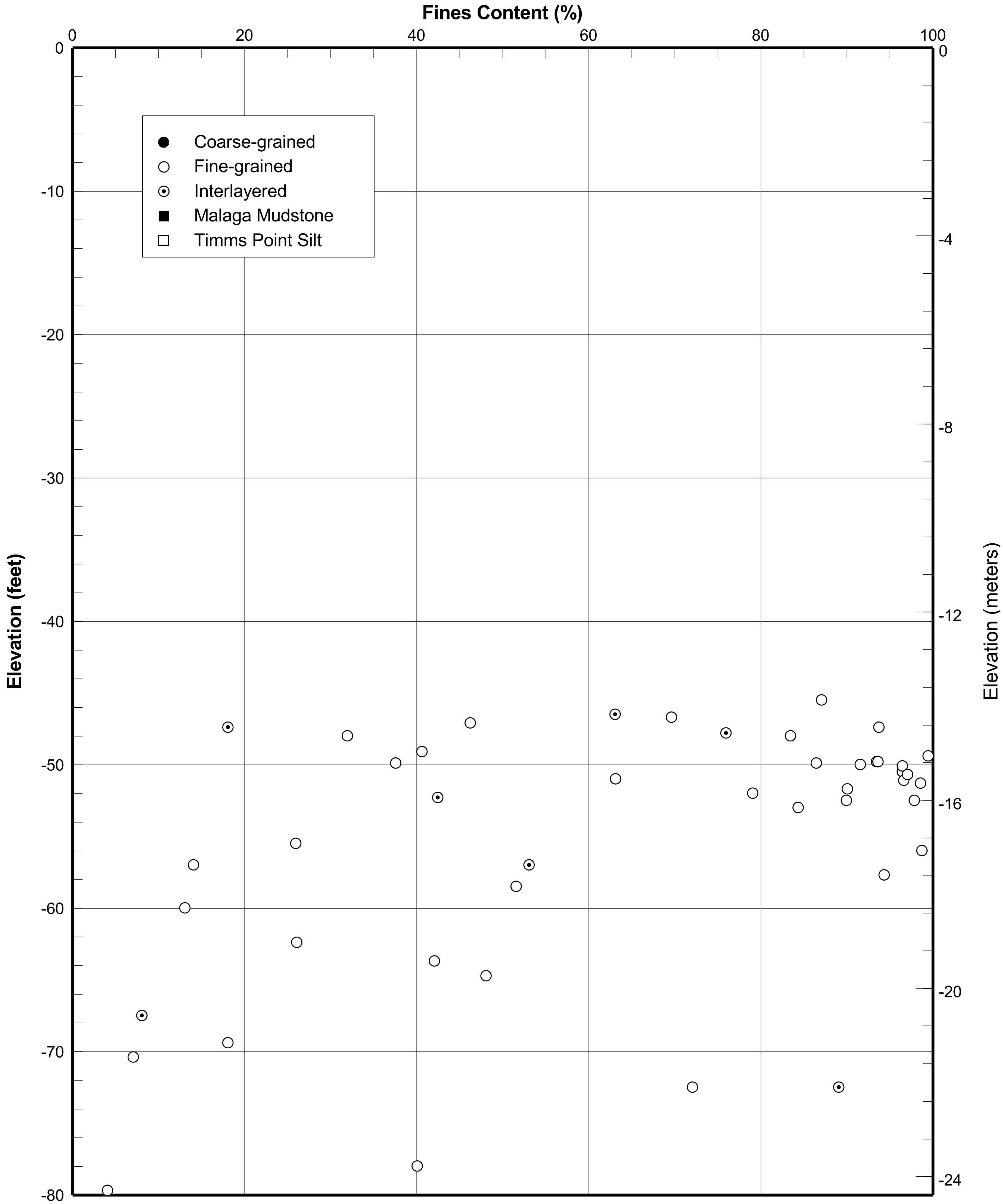


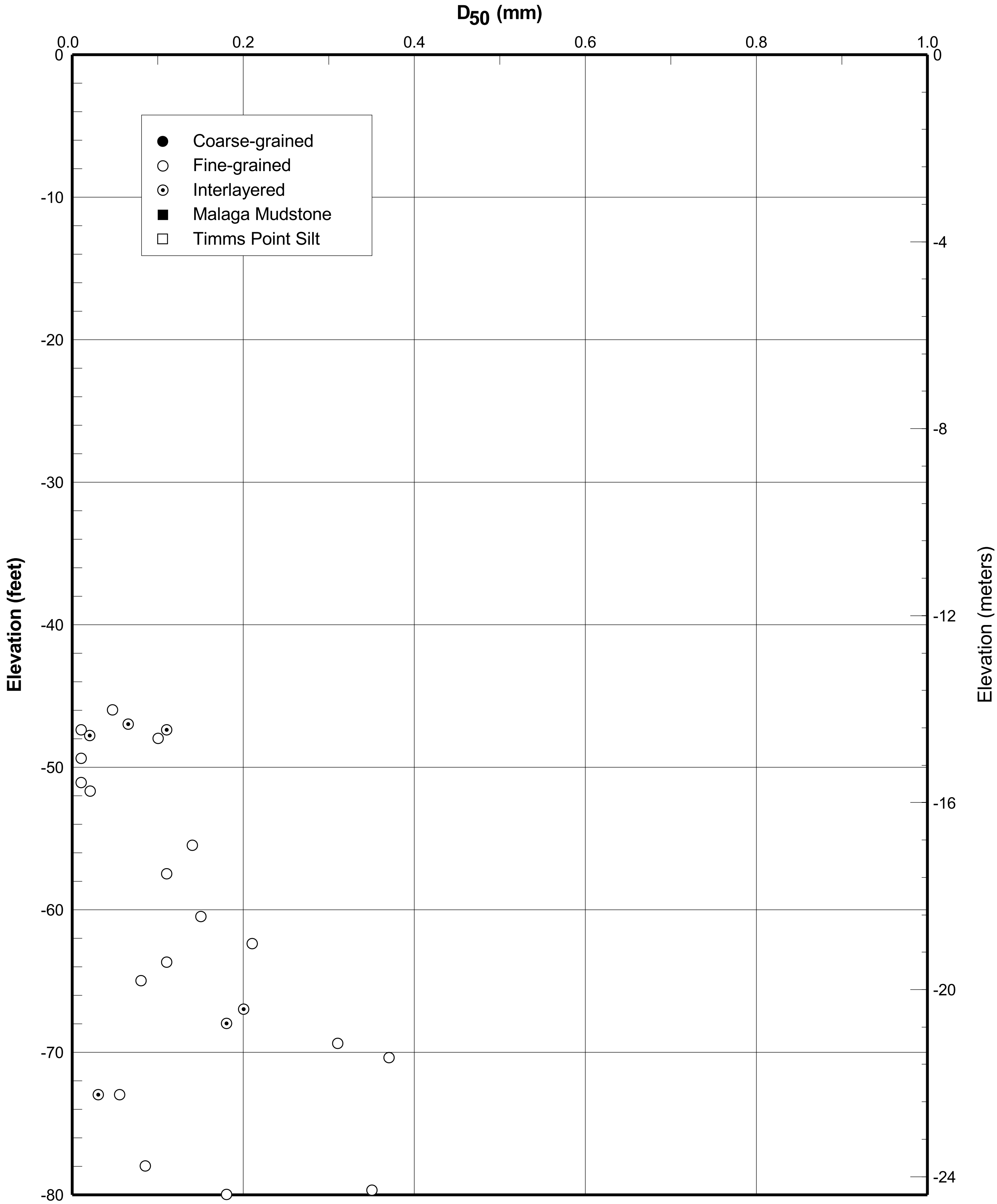
WATER CONTENT PROFILE
Native Dredge Unit FG-3
Channel Deepening Project
Port of Los Angeles, California

PLATE 6.7a

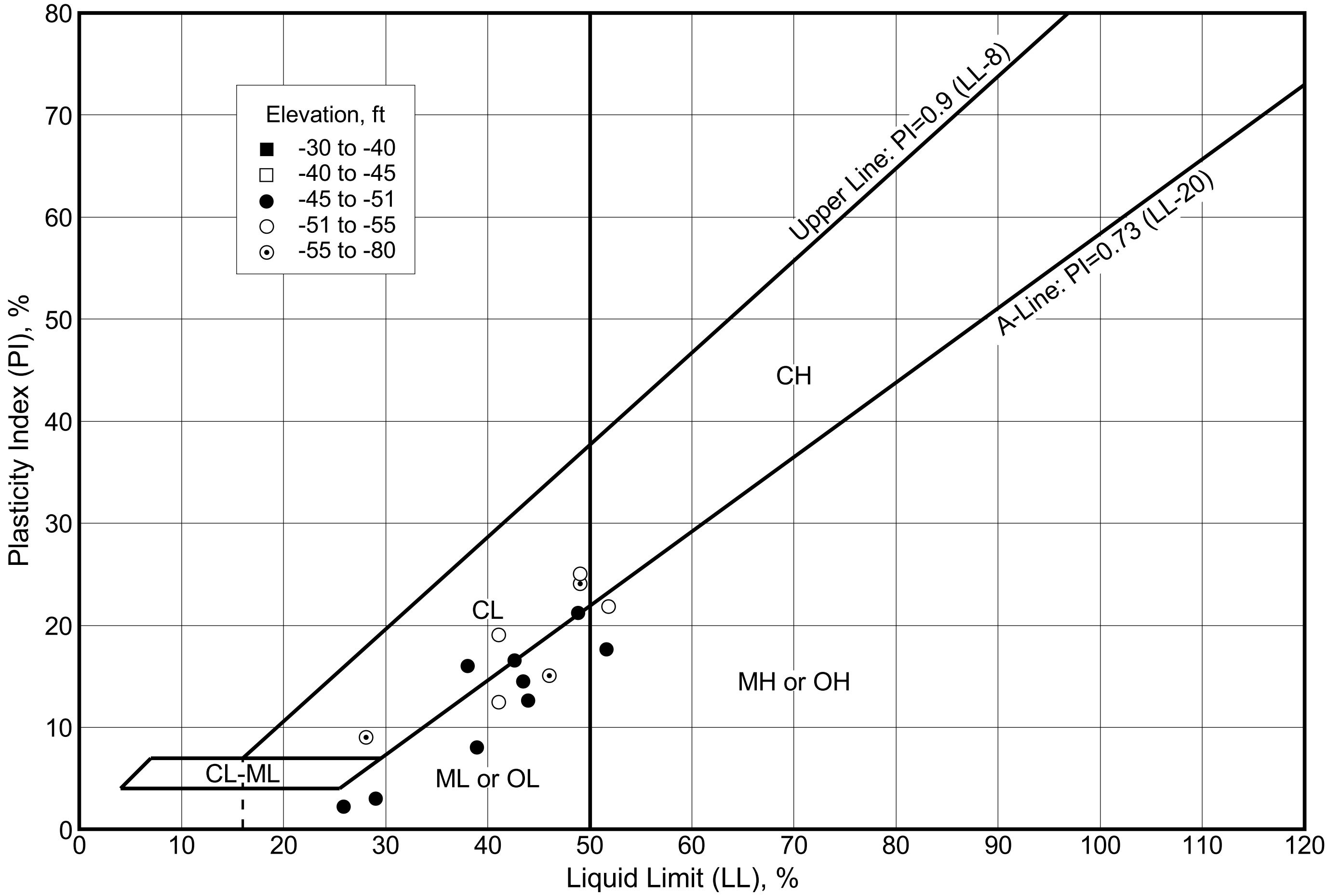


FINES CONTENT PROFILE
Native Dredge Unit FG-3
Channel Deepening Project
Port of Los Angeles, California

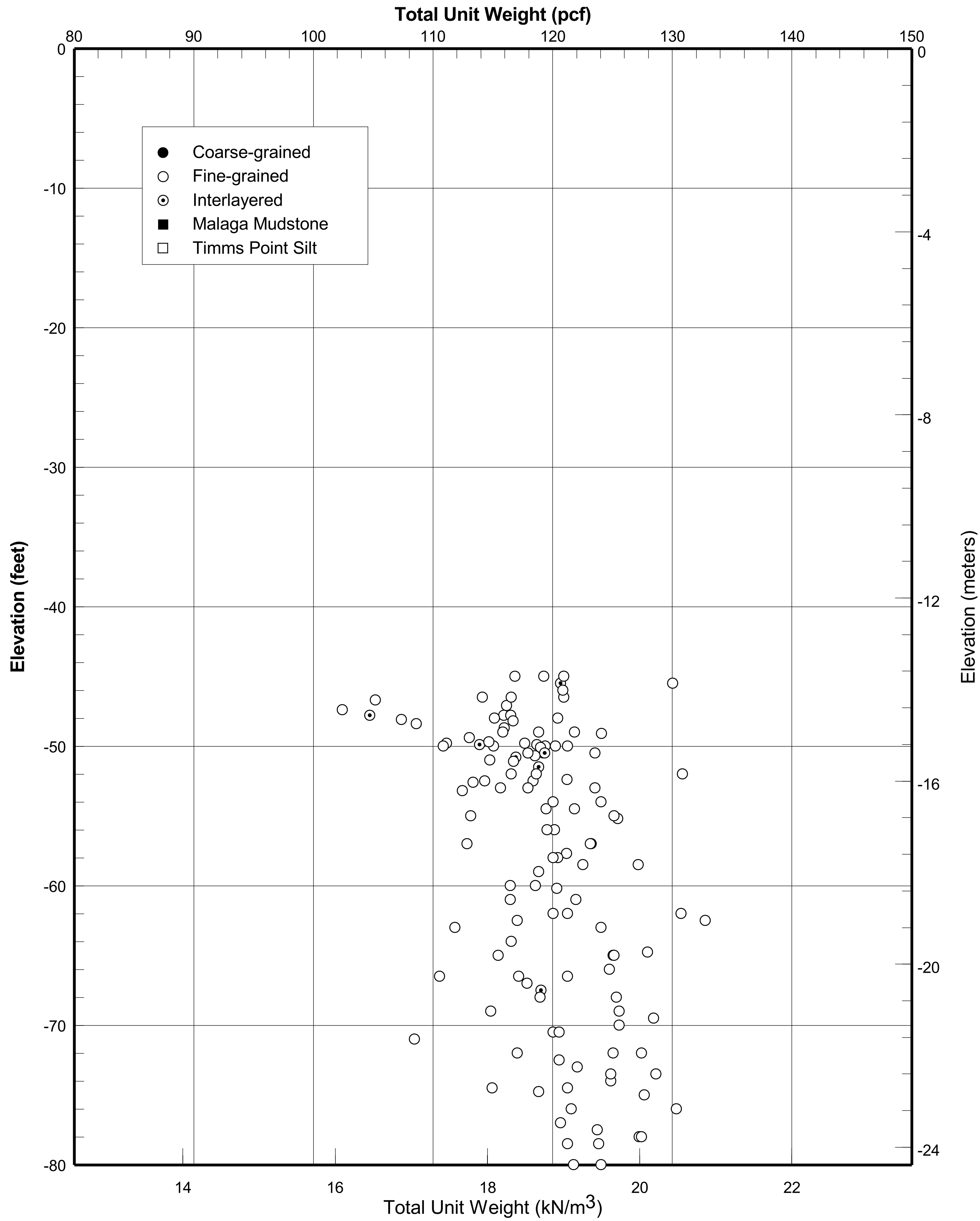
PLATE 6.7b



D_{50} PROFILE
Native Dredge Unit FG-3
Channel Deepening Project
Port of Los Angeles, California

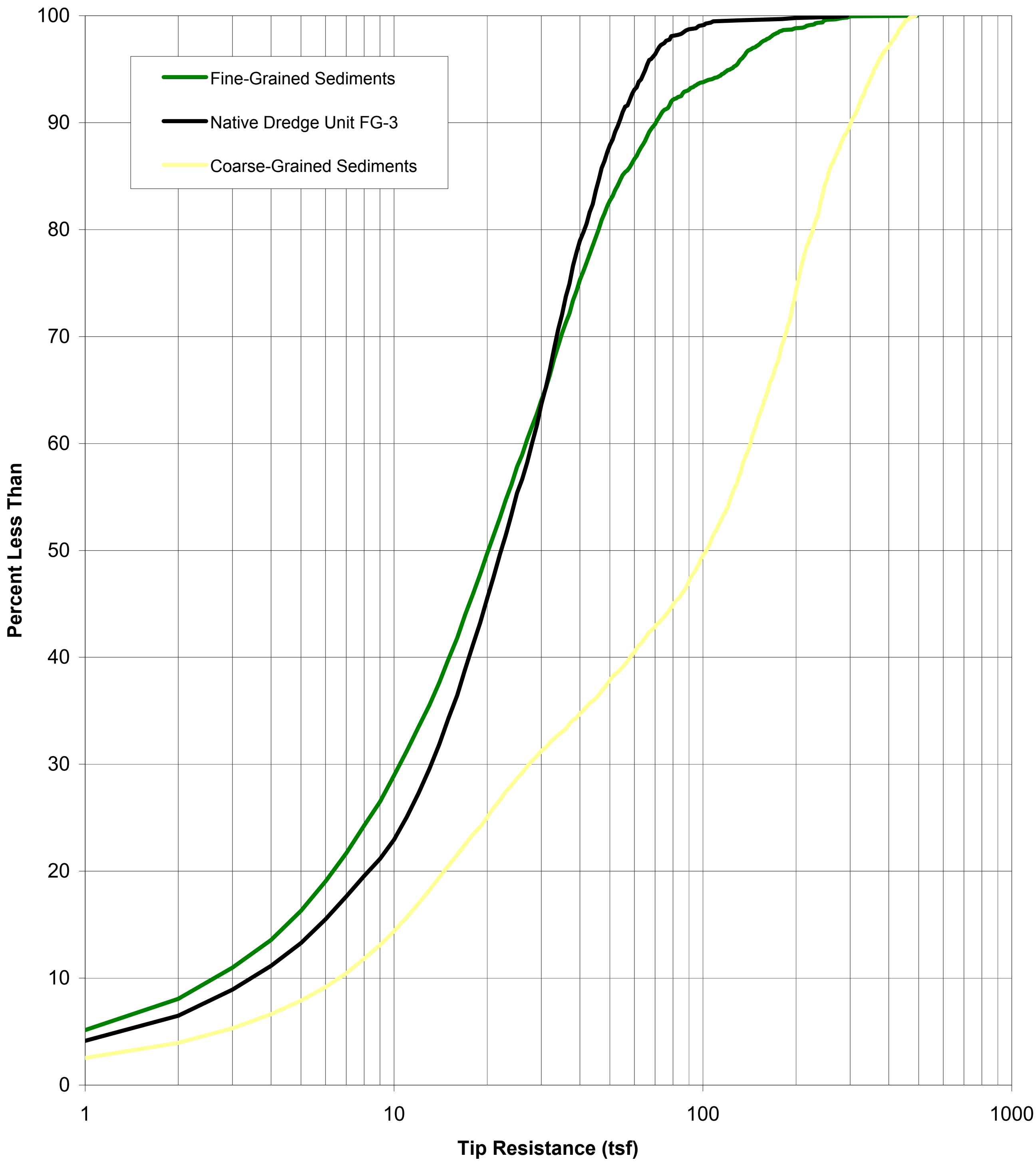


PLASTICITY CHART
Native Dredge Unit FG-3
Channel Deepening Project
Port of Los Angeles, California

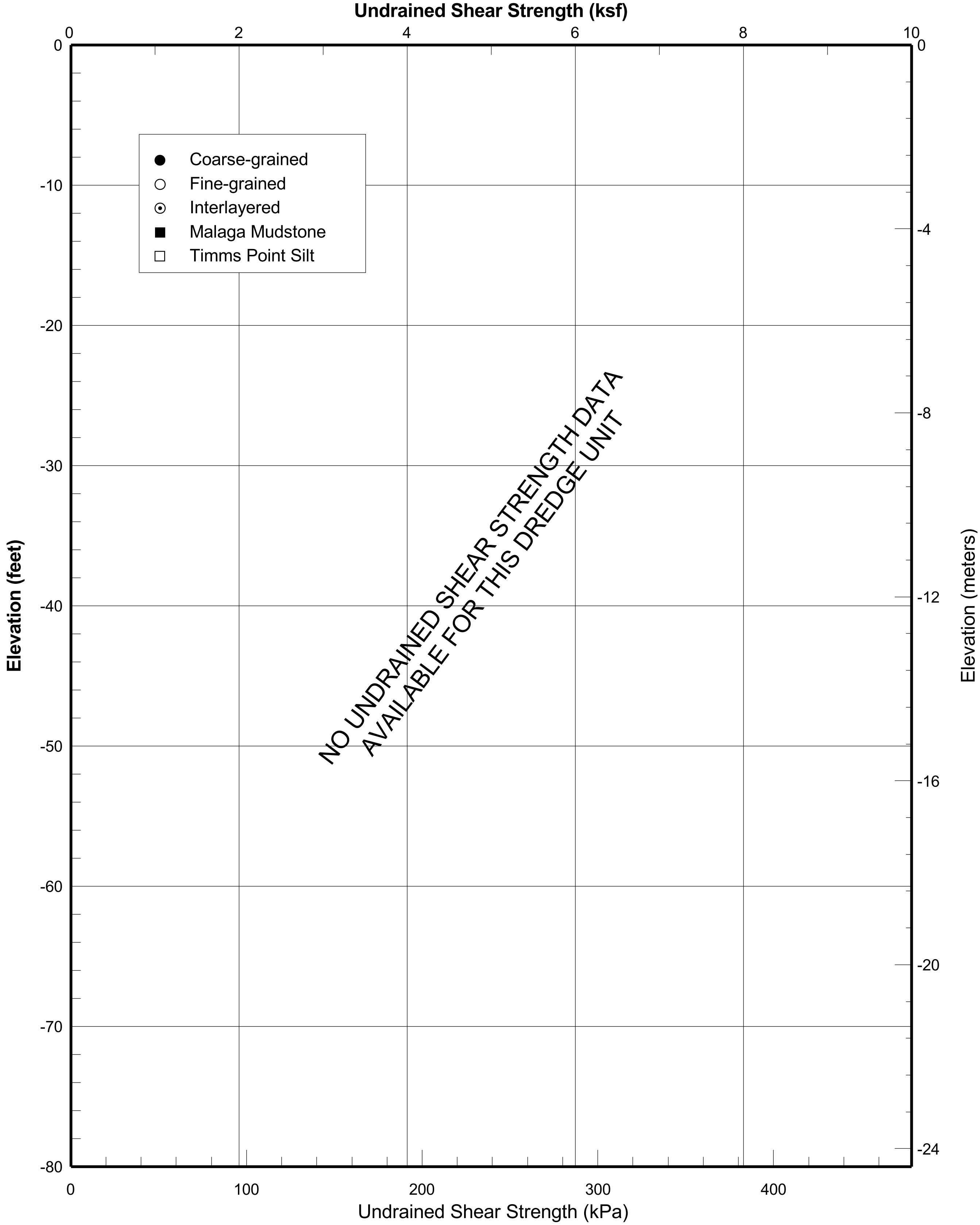


TOTAL UNIT WEIGHT PROFILE
Native Dredge Unit FG-3
Channel Deepening Project
Port of Los Angeles, California

PLATE 6.7e

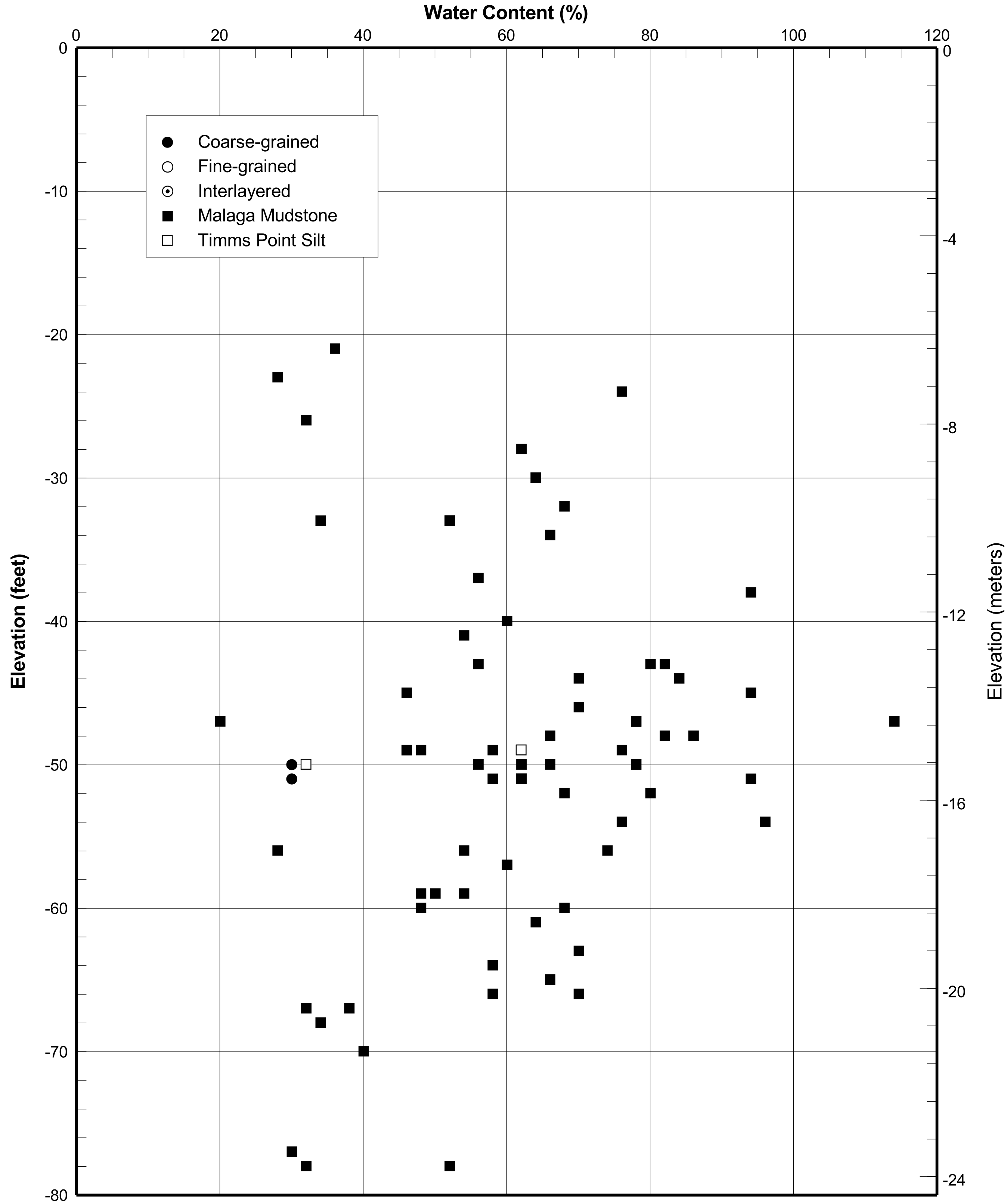


CUMULATIVE FREQUENCY DISTRIBUTION
Native Dredge Unit FG-3
Channel Deepening Project
Port of Los Angeles, California



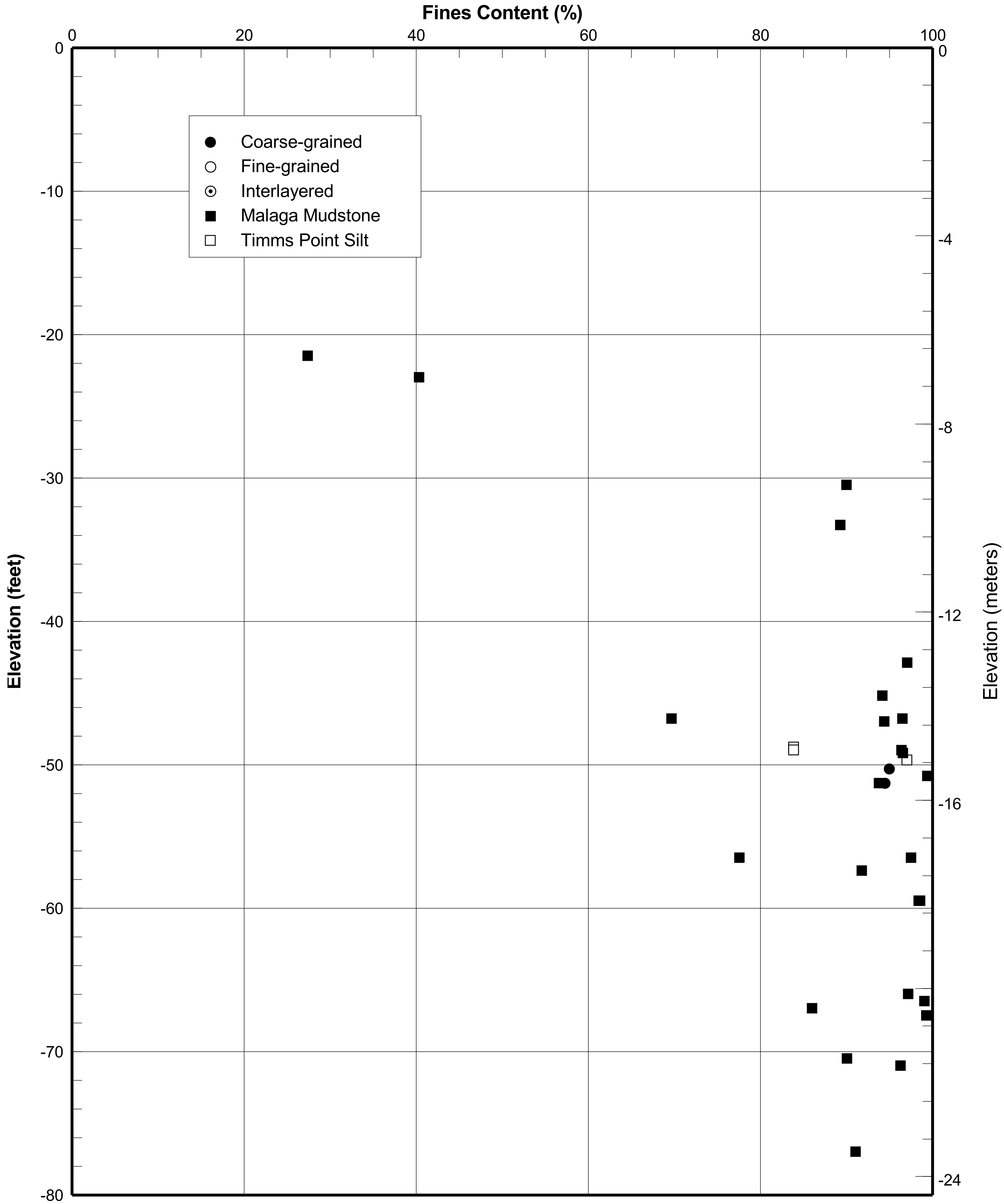
UNDRAINED SHEAR STRENGTH PROFILE
Native Dredge Unit FG-3
Channel Deepening Project
Port of Los Angeles, California

PLATE 6.7g

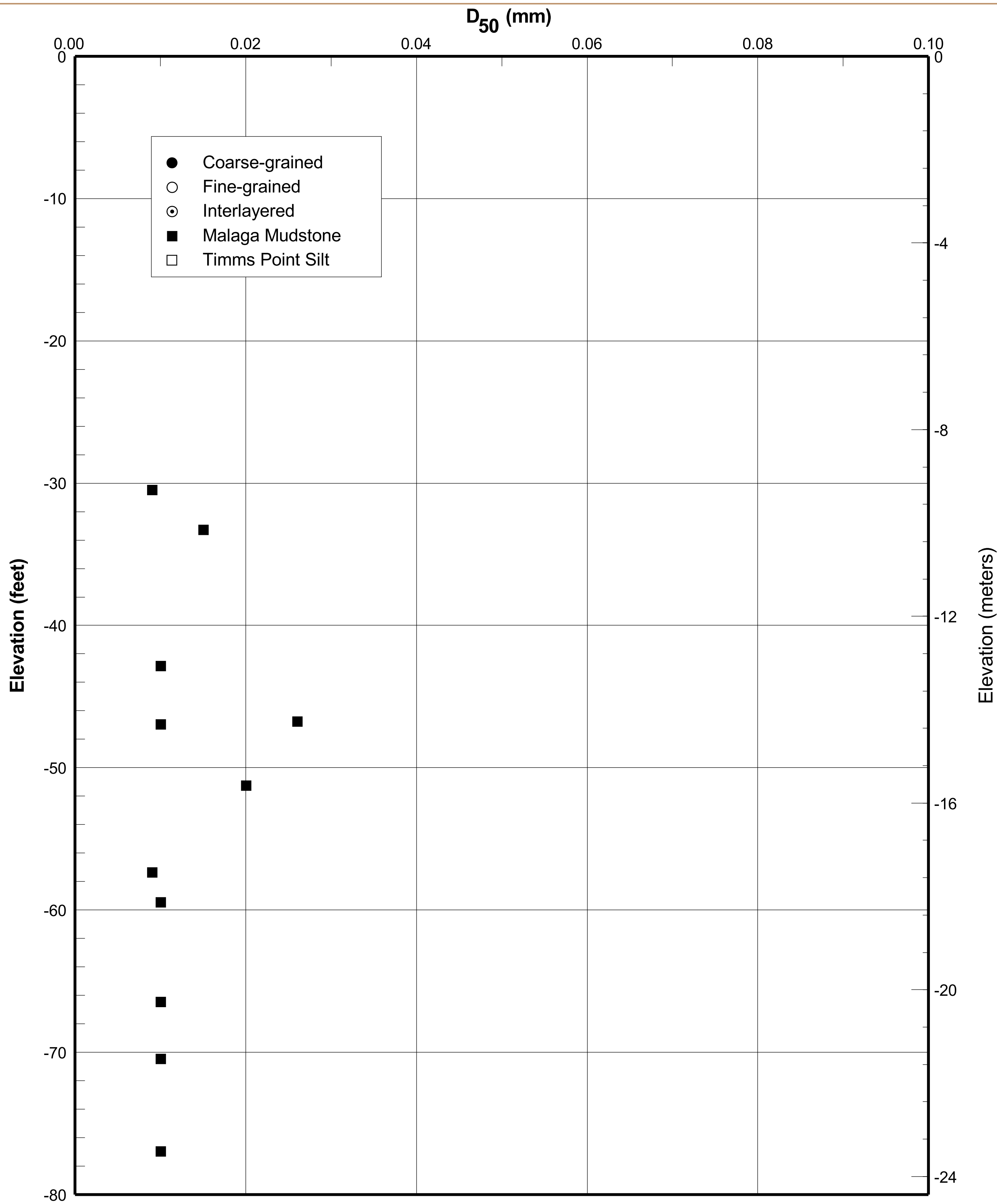


WATER CONTENT PROFILE
Native Dredge Unit FM-1
Channel Deepening Project
Port of Los Angeles, California

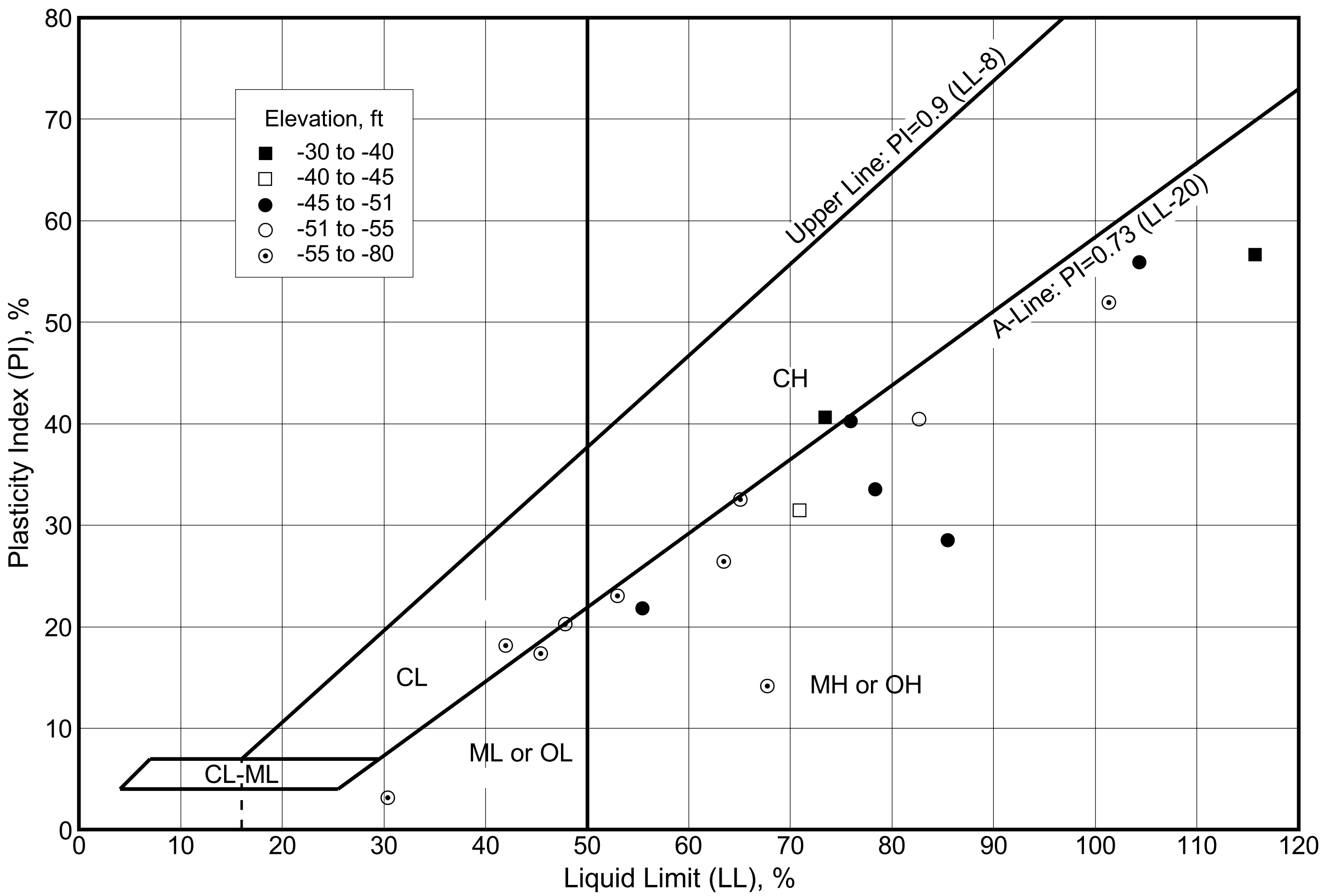
PLATE 6.8a



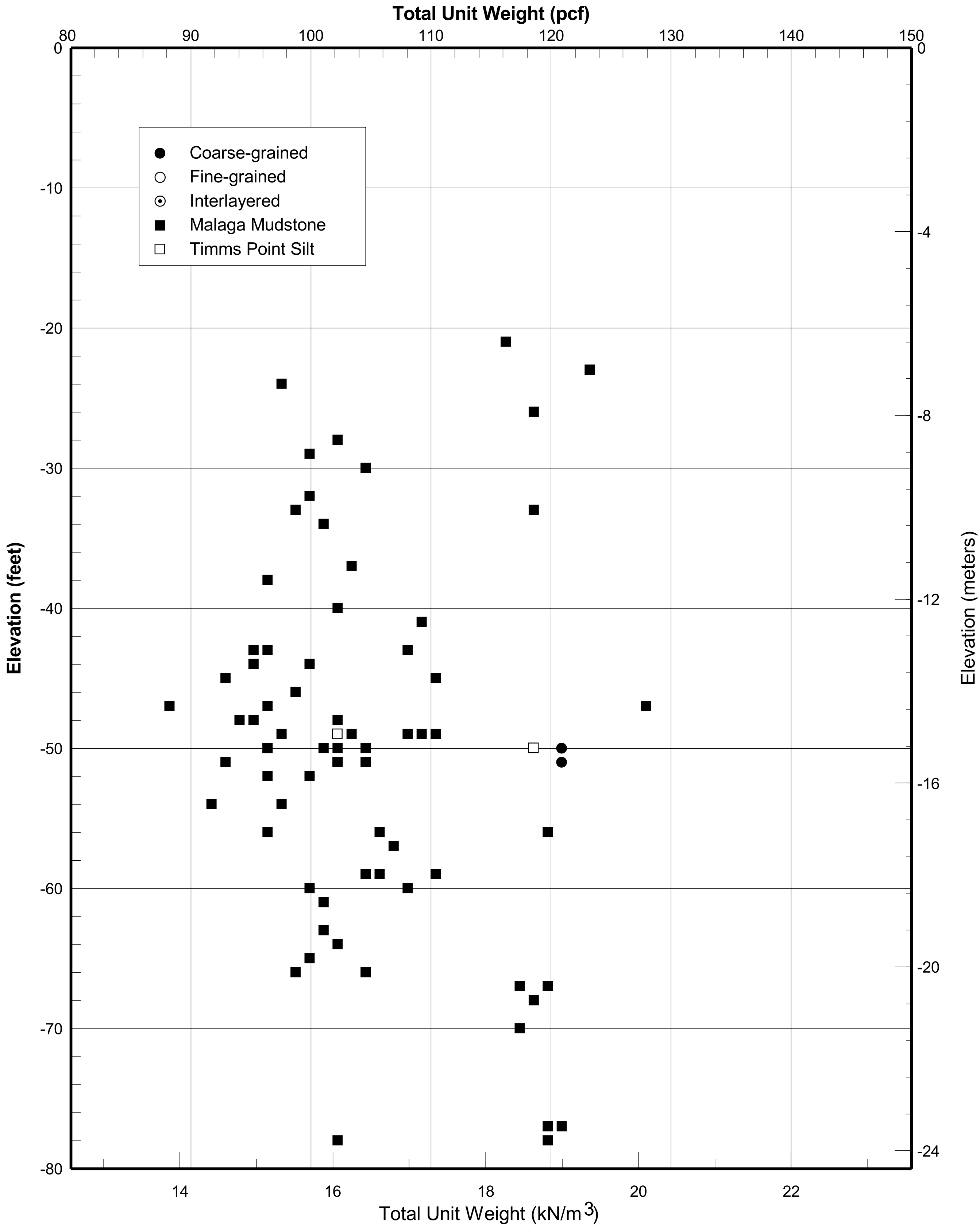
FINES CONTENT PROFILE
Native Dredge Unit FM-1
Channel Deepening Project
Port of Los Angeles, California



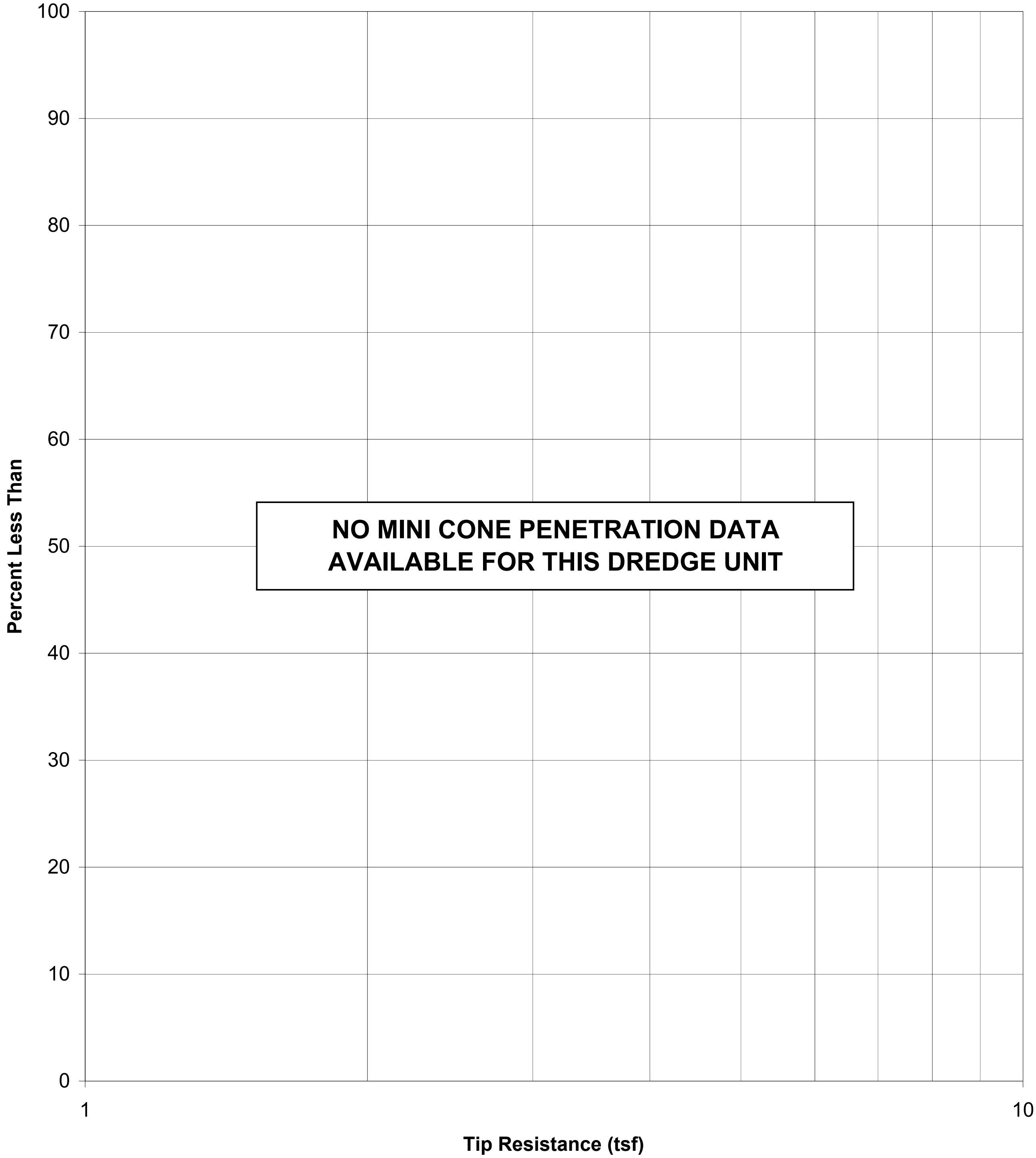
D_{50} PROFILE
Native Dredge Unit FM-1
Channel Deepening Project
Port of Los Angeles, California



PLASTICITY CHART
Native Dredge Unit FM-1
Channel Deepening Project
Port of Los Angeles, California



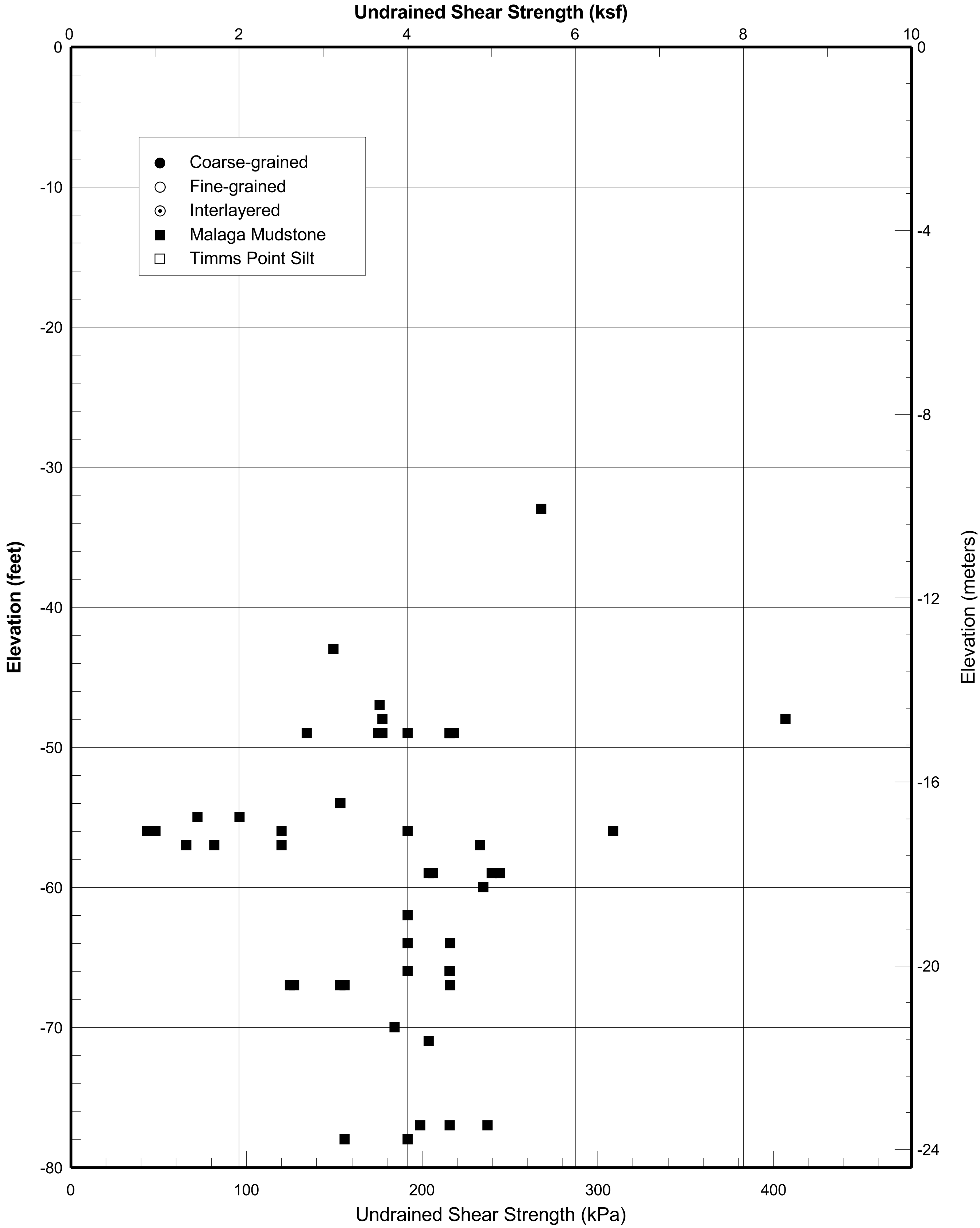
TOTAL UNIT WEIGHT PROFILE
Native Dredge Unit FM-1
Channel Deepening Project
Port of Los Angeles, California



CUMULATIVE FREQUENCY DISTRIBUTION
Native Dredge Unit FM-1
Channel Deepening Project
Port of Los Angeles, California

U.S. Army Corps of Engineers
Project No. 01-32-0633

FUGRO

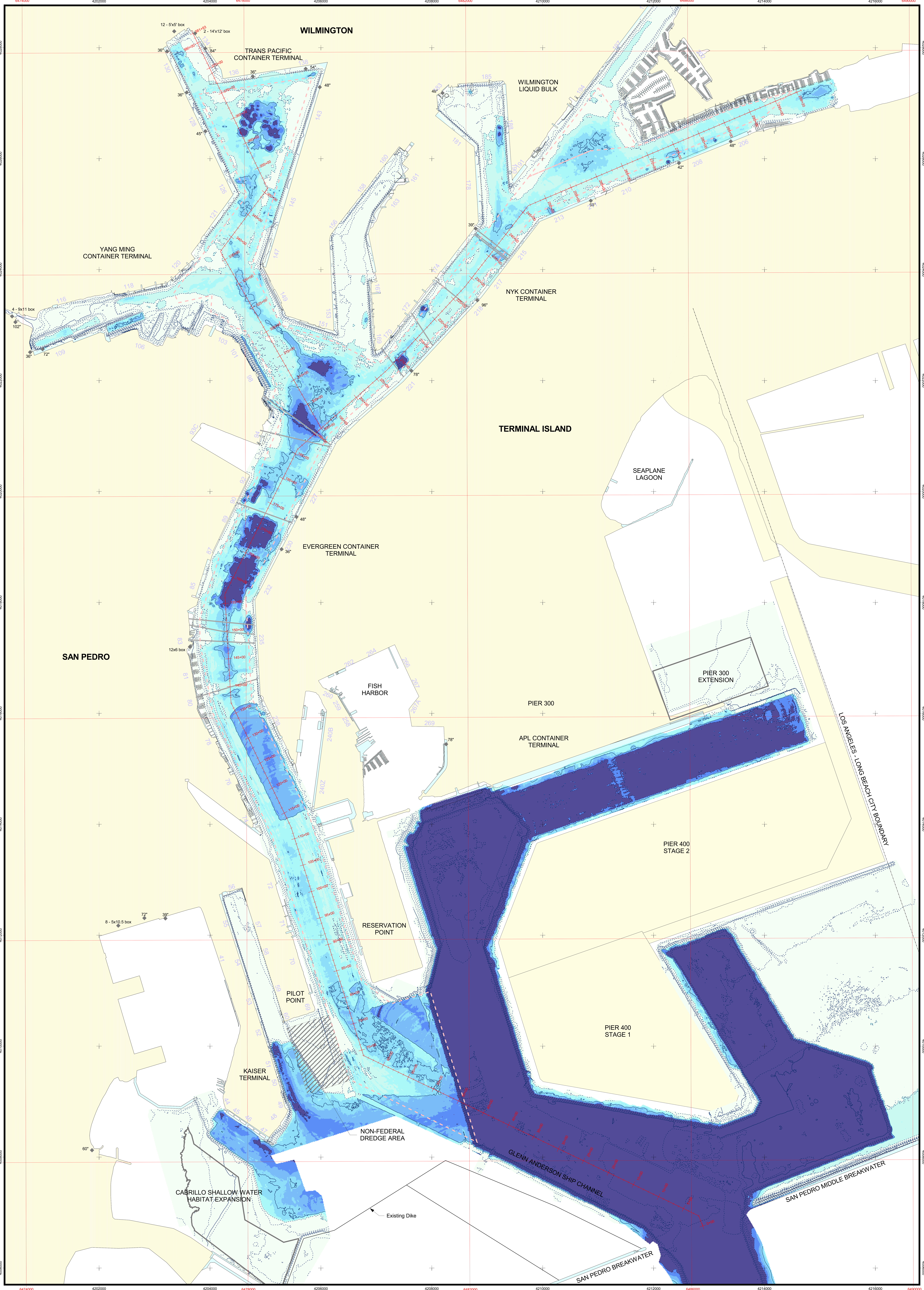


UNDRAINED SHEAR STRENGTH PROFILE
Native Dredge Unit FM-1
Channel Deepening Project
Port of Los Angeles, California

PLATE 6.8g

j:\pola\plots\main channel deepening\odbs\fm-1.su.odb, odbs, 04/26/2002

MAPS



NOTES

1. Bathymetric elevations for the Main Channel and Pier 400 areas are from 1999 to 2001 multibeam hydrographic surveys performed by Gahagan & Bryant Associates, Inc. Data were provided to Fugro West with a bin grid interval ranging from 0.25 to 9.84 feet. The data were then gridded and contoured at 5-foot intervals.

2. Bathymetric elevations for the Southwest Slip are from a survey performed by the Port of Los Angeles in 2001. Data were provided to Fugro West with a bin grid interval of 5 feet. The data were then gridded and contoured at 5-foot intervals.

3. Utility locations from a Fugro West report, "Subbottom Profiling and Side Scan Sonar Survey, Port of Los Angeles Main Channel Deepening Project, Phase 1 Field Surveys" (2001).

4. Outfall locations are approximate and are based on an untitled map (provided by the Port of Los Angeles) that shows the locations of outfalls that are 36 inches in diameter or larger. Note that Fugro did not verify the existence and locations of the outfalls.

LEGEND

Bathymetric Elevations, Feet MLLW (see notes 1 and 2). Compilation of data from 1999 and 2001 multibeam surveys by Gahagan & Bryant Associates, Inc., and 2001 Port of Los Angeles survey.

Major (Contour interval = 25)

Minor (Contour interval = 5)

0 to -45

-45 to -47

-47 to -49

-49 to -51

-51 to -53

-53 to -55

Deeper than -55

100+00 Survey Control Line and Stationing (feet) for Channel Deepening Project

Federal Channel Limits

70 Berth Number

Utility Crossing Location (refer to notes)

36" Outfall Location (refer to notes)

Coordinate system in red is California State Plane, Zone 5, NAD 83, Feet

Coordinate system in black is California State Plane, Zone 7, NAD 27, Feet

N

SCALE = 1:9000

1000 0 1000 Feet

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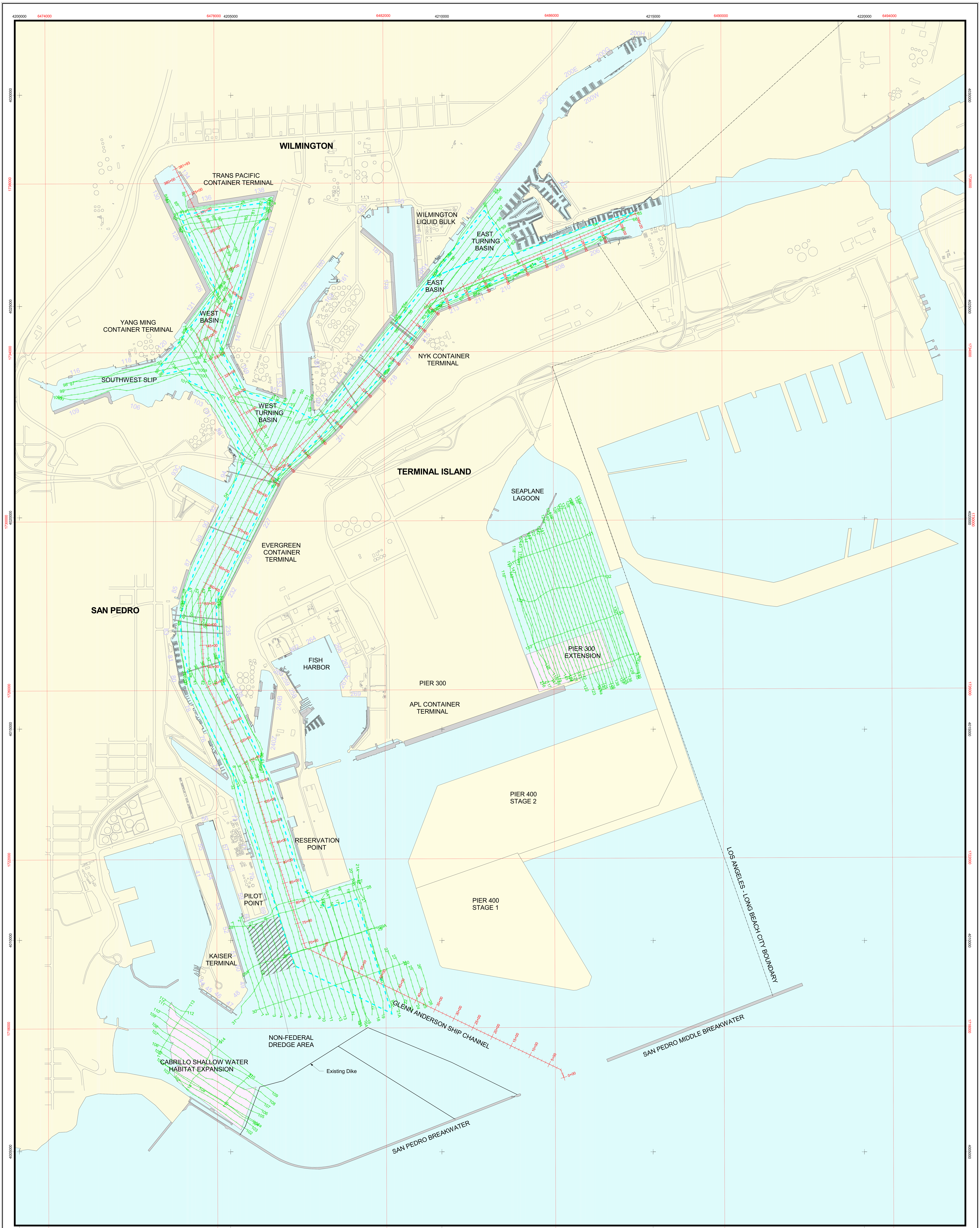
MULTIBEAM BATHYMETRY
Channel Deepening Project
Port of Los Angeles, California

April 2002 | 01-32-0633 | Map 1



NOTES

1. Utility locations from a Fugro West report, "Subbottom Profiling and Side Scan Sonar Survey, Port of Los Angeles Main Channel Deepening Project, Phase 1 Field Surveys" (2001).

2. Geophysical survey conducted in July and August 2001 by Fugro West, Inc., included the following:
   - Side scan sonar survey using the EdgeTech 260 sonar with navigation fixes taken every 150 feet.
   - Bathymetry survey using an Odom MK-II survey grade echo sounder
   - Subbottom Profiler Survey using an EdgeTech Geo-star spread spectrum subbottom profiling system that employs a swept frequency between 2.0 and 16.0 kHz.

3. Horizontal positioning achieved using a STARFIX II Differential GPS positioning system integrated with a Hypack navigation package.

4. Navigation fixes were taken nominally at intervals of 150 feet. Due to the shallow water conditions in the Pier 300 Extension Area, the interval there was reduced to 75 feet.

LEGEND

- 33 — Geophysical Survey and Side Scan Sonar Survey Lines. Bold number is survey line number. Tick indicates navigation fix.
- 100+00 — Survey Control Line and Stationing (feet) for Channel Deepening Project
- Utility Crossing Location (refer to notes)
- Primary Cultural Features
- Federal Channel Dredging Limit
- 264 — Berth Number

Coordinate System in red is California State Plane, Zone 5, NAD 83, Feet

Coordinate System in black is California State Plane, Zone 7, NAD 27, Feet

N

SCALE = 1:12000

1000 0 1000 Feet

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GEOPHYSICAL TRACKLINES
Channel Deepening Project
Port of Los Angeles, California

April 2002 | 01-32-0633 | Map 2

j:\pola\reports\main_channel_deep\report1201\plates\odb\map2-tracklines.odb, svarnell, 04/30/2002

NOTES

1. Utility locations from a Fugro West report, "Subbottom Profiling and Side Scan Sonar Survey, Port of Los Angeles Main Channel Deepening Project, Phase 1 Field Surveys" (2001).

2. Outfall locations are approximate and are based on an untitled map (provided by the Port of Los Angeles) that shows the locations of outfalls that are 36 inches in diameter or larger. Note that Fugro did not verify the existence and locations of the outfalls.

LEGEND

FUGRO WEST EXPLORATIONS (1991 - 2000)
- Borings
- CPTs
- Vibracores

NON-FUGRO WEST EXPLORATIONS (1958 - 2001)
- Borings
- CPTs
- Vibracores

Note: Explorations located in the Outer Harbor that are included in the Field Investigation Report, 2020 Plan Geotechnical Investigation, Port of Los Angeles (Fugro-McClelland (West), Inc., 1991) are not shown on this map.

100+00 Survey Control Line and Stationing (feet) for Channel Deepening Project
Federal Channel Limits
Utility Crossing Location (refer to notes)
36" Outfall Location (refer to notes)
70 Berth Number
Primary Cultural Features

Coordinate system in red is California State Plane, Zone 5, NAD 83, Feet

Coordinate system in black is California State Plane, Zone 7, NAD 27, Feet

N

SCALE 1:7200

600 0 600 Feet

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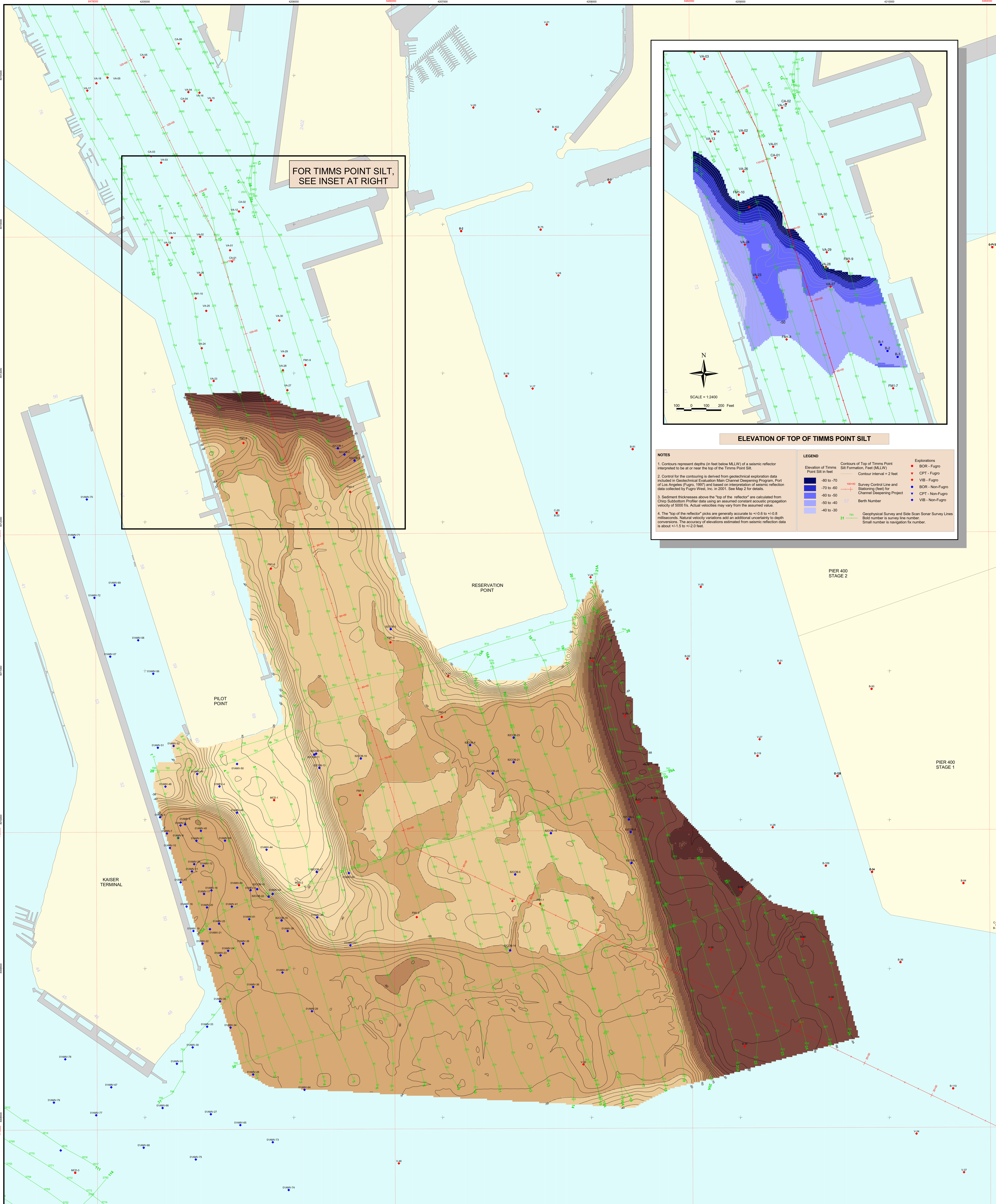
EXPLORATION LOCATIONS
Channel Deepening Project
Port of Los Angeles, California

April 2002 | 01-32-0633 | Map 3



NOTES

1. Contours represent depths (in feet below MLLW) of a seismic reflector interpreted to be at or near the top of the Malaga Mudstone (above) or Timms Point Silt (see inset).

2. Control for the contouring is derived from geotechnical exploration data included in Geotechnical Evaluation Main Channel Deepening Program, Port of Los Angeles (Fugro, 1997) and based on interpretation of seismic reflection data collected by Fugro West, Inc. in 2001. See Map 2 for details.

3. Sediment thicknesses above the "top of the reflector" are calculated from Chirp Subbottom Profiler data using an assumed constant acoustic propagation velocity of 5000 f/s. Actual velocities may vary from the assumed value.

4. The "top of the reflector" picks are generally accurate to +/-0.6 to +/-0.8 milliseconds. Natural velocity variations add an additional uncertainty to depth conversions. The accuracy of elevations estimated from seismic reflection data is about +/-1.5 to +/-2.0 feet.

LEGEND

31 793 — Geophysical Survey and Side Scan Sonar Survey Lines
Bold number is survey line number.
Small number is navigation fix number.

Contours of Top of Bedrock Formation (Malaga Mudstone, Feet [MLLW])
Contour interval = 2 feet

Elevation of Top of Bedrock
(Malaga Mudstone) in feet (MLLW)

-105 to -90	-60 to -50
-90 to -80	-50 to -40
-80 to -70	-40 to -30
-70 to -60	-30 to -20

100+00 — Survey Control Line and Stationing (feet) for Channel Deepening Project

57 — Berth Number

FUGRO WEST EXPLORATIONS (1991 - 2000)
- Borings
- CPTs
- Vibracores

NON-FUGRO WEST EXPLORATIONS (1958 - 2001)
- Borings
- CPTs
- Vibracores

Coordinate System in red is California State Plane, Zone 5, NAD 83, Feet

Coordinate System in black is California State Plane, Zone 7, NAD 27, Feet

N

SCALE = 1:2400

200 0 200 400 Feet

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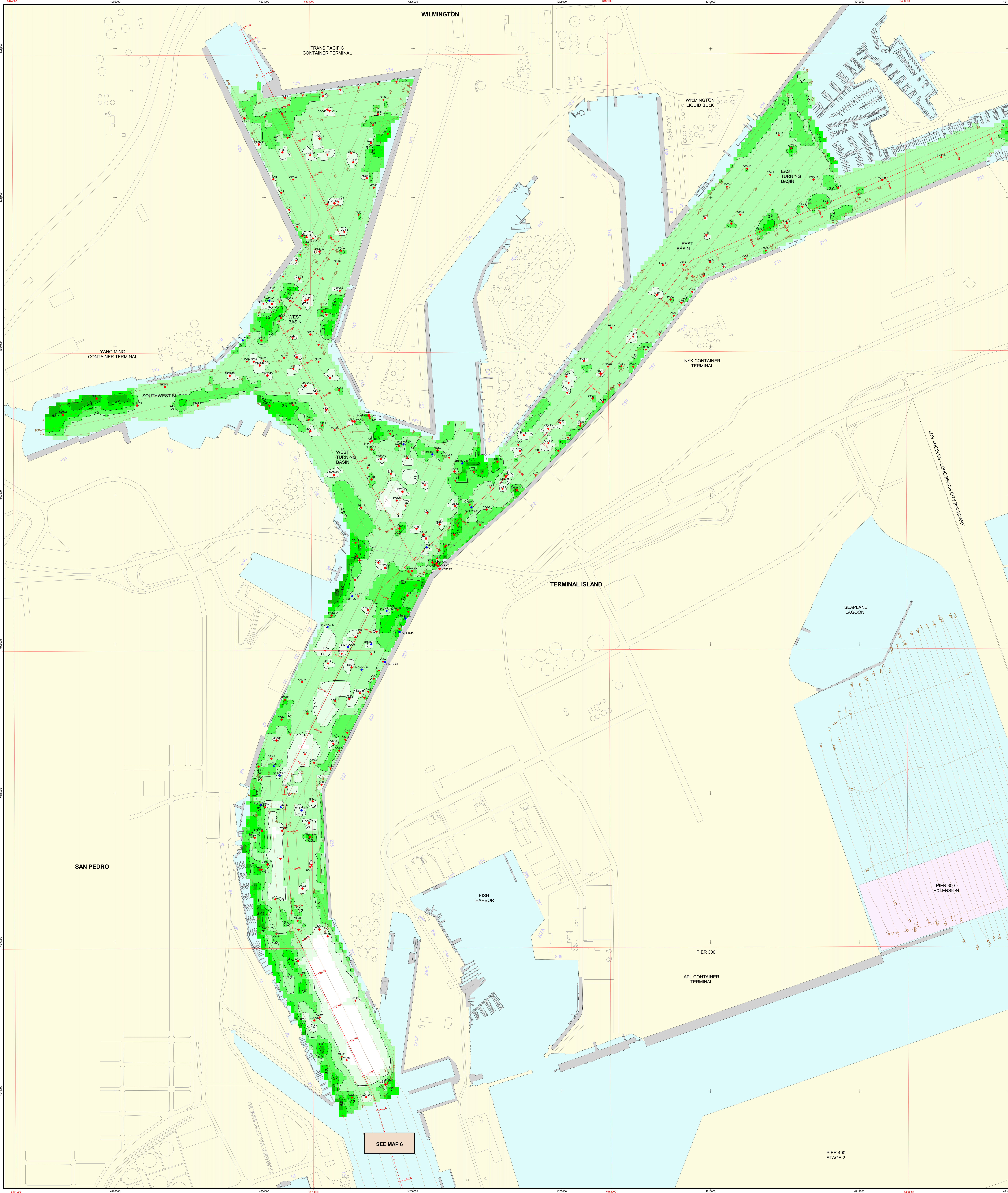
ELEVATION OF TOP OF BEDROCK (MALAGA MUDSTONE)

Channel Deepening Project
Port of Los Angeles, California

April 2002 | 01-32-0633 | Map 4



NOTES

1. Isopach values were determined from geophysical data using an assumed acoustic velocity of 5000 f/s to convert the reflection time between the mudline and the top of the native sediment surface to a thickness in feet. Actual velocities may vary from the assumed value, thereby affecting the thickness estimates.

2. Refer to report text for discussion on precision and accuracy of isopach contours, correlation with geotechnical explorations, and local statistical adjustments of the isopach thickness based on ground truthing from geotechnical explorations.

3. Vertical resolution of subbottom reflectors on geophysical data for Harbor Bottom Sediments is +/- 0.5 to +/- 1.0 millisecond, which represents about 1.2 to 2.5 feet.

4. Vertical precision on geotechnical data used for ground truthing of geophysical data is about 0.5 to 1.0 foot depending upon the method of exploration.

5. The soft mud layer could be subject to continuous change due to propeller wash from passing ships.

6. Vertical datum is MLLW, in feet.

LEGEND

Contours of Isopach (Thickness) of Harbor Bottom Sediments Overlying Native Sediments

Contour interval = 1 foot

Thickness of Harbor Bottom Sediments in feet

0	3 - 4
0 - 1	4 - 5
1 - 2	5 - 6
2 - 3	6 - 7

Sediment thicknesses are calculated from CHIRP Subbottom Profiler data using an assumed constant acoustic propagation velocity of 5,000 f/s, locally adjusted based on geotechnical exploration ground truthing.

30+00 Survey Control Line and Stationing (feet) for Channel Deepening Project

31 Geophysical Survey and Side Scan Sonar Survey Lines
Bold number is survey line number.
Tick indicates navigation fix.

Primary Cultural Features

101 Berth Number

FUGRO WEST EXPLORATIONS (1991 - 2000)
- Borings
- CPTs
- Vibracores

NON-FUGRO WEST EXPLORATIONS (1958 - 2001)
- Borings
- CPTs
- Vibracores

Coordinate System in red is California State Plane, Zone 5, NAD 83, Feet

Coordinate System in black is California State Plane, Zone 7, NAD 27, Feet

N

SCALE = 1:4800

500 0 500 Feet

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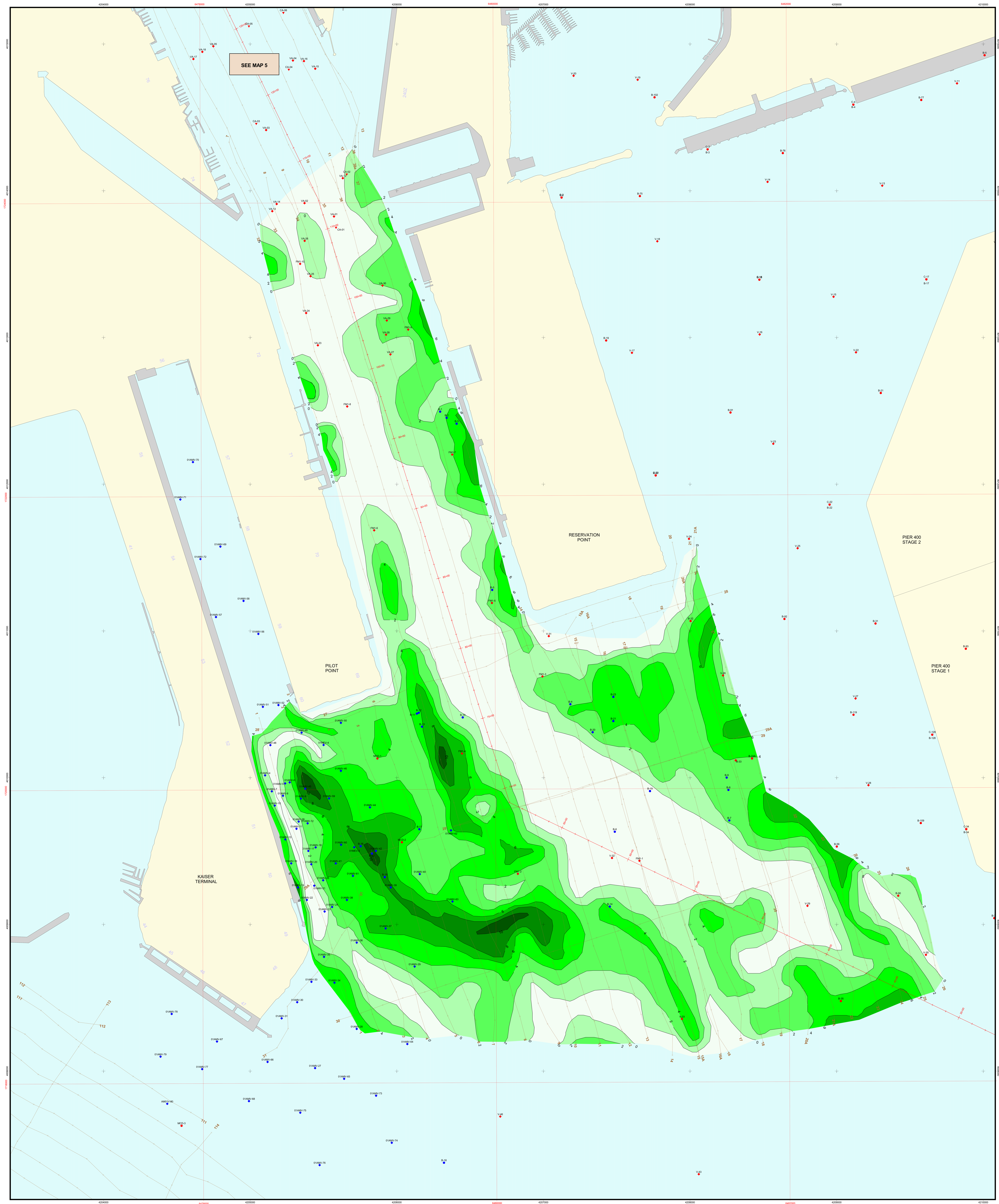
ISOPACH (THICKNESS) OF HARBOR BOTTOM SEDIMENTS OVERLYING NATIVE SEDIMENTS
Channel Deepening Project
Port of Los Angeles, California

April 2002 | 01-32-0633 | Map 5



NOTES

1. Isopach values were determined from geophysical data using an assumed acoustic velocity of 5000 f/s to convert the reflection time between the mudline and the top of the native sediment surface to a thickness in feet. Actual velocities may vary from the assumed value, thereby affecting the thickness estimates.

2. Refer to report text for discussion on precision and accuracy of isopach contours, and correlation with geotechnical explorations.

3. Vertical resolution of subbottom reflectors on geophysical data for Harbor Bottom Sediments is +/- 0.5 to +/- 1.0 millisecond, which represents about 1.2 to 2.5 feet.

4. Vertical precision on geotechnical data used for ground truthing of geophysical data is about 0.5 to 1.0 foot depending upon the method of exploration.

5. The soft mud layer could be subject to continuous change due to propeller wash from passing ships.

6. Vertical datum is MLLW, in feet.

LEGEND

Contours of Isopach (Thickness) of Harbor Bottom Sediments Overlying Bedrock
Contour interval = 2 feet

Thickness of Harbor Bottom Sediments in feet

- 0
- 0 - 2
- 2 - 4
- 4 - 6
- 6 - 8
- 8 - 10
- 10 - 12

Sediment thicknesses are calculated from CHIRP Subbottom Profiler data using an assumed constant acoustic propagation velocity of 5,000 f/s.

FUGRO WEST EXPLORATIONS (1991 - 2000)

- Borings
- CPTs
- Vibracores

NON-FUGRO WEST EXPLORATIONS (1958 - 2001)

- Borings
- CPTs
- Vibracores

30+00 — Survey Control Line and Stationing (feet) for Channel Deepening Project

31 793 — Geophysical Survey and Side Scan Sonar Survey Lines
Bold number is survey line number.
Tick indicates navigation fix.

101 — Berth Number

Coordinate System in red is California State Plane, Zone 5, NAD 83, Feet

Coordinate System in black is California State Plane, Zone 7, NAD 27, Feet

N

SCALE = 1:2400

300 0 300 Feet

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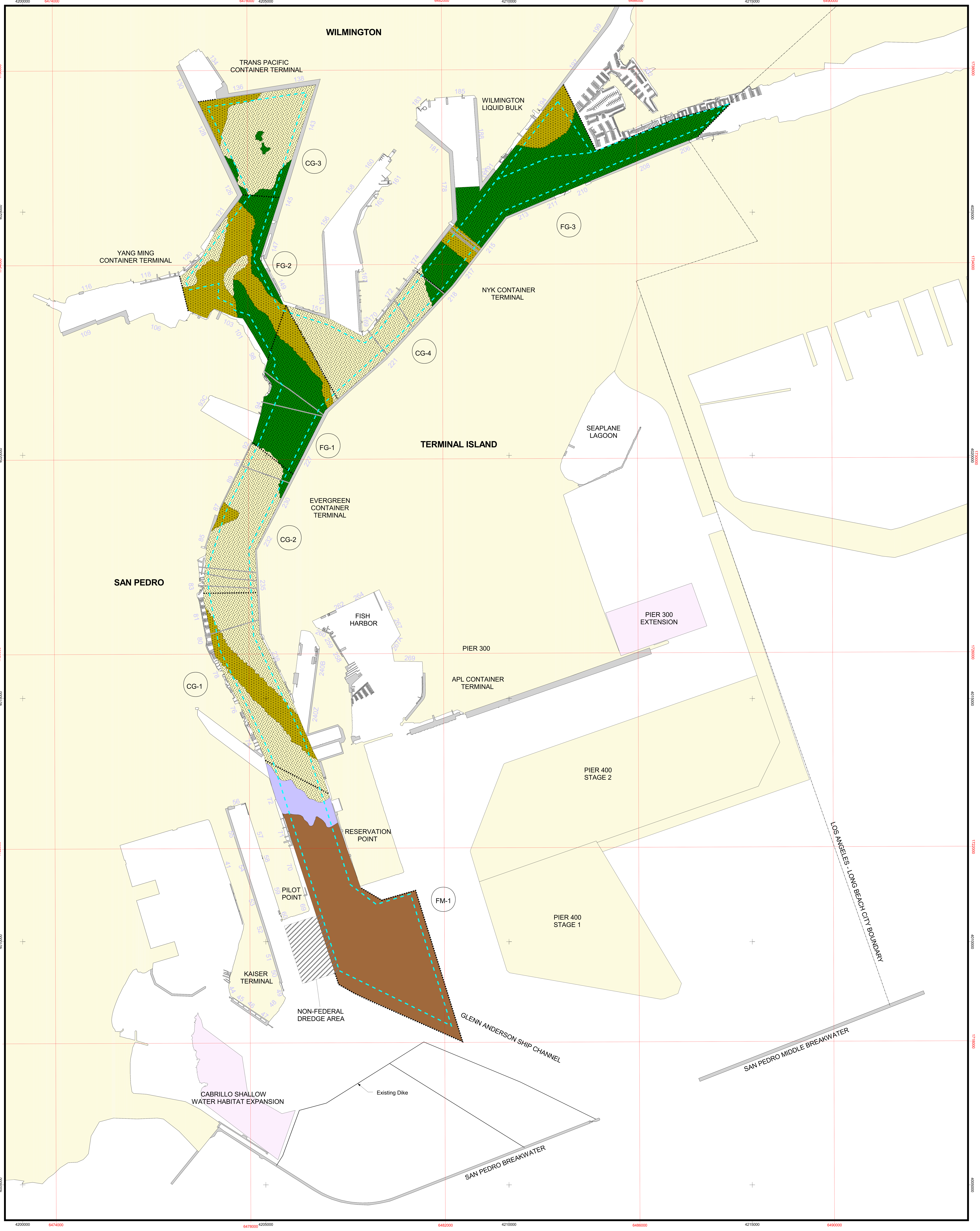
ISOPACH (THICKNESS) OF HARBOR BOTTOM SEDIMENTS OVERLYING BEDROCK
Channel Deepening Project
Port of Los Angeles, California

April 2002 | 01-32-0633 | Map 6



NOTES

1. The interpreted shallow stratigraphic conditions shown on this map are generally representative of native sediments present above an elevation of about -55 feet (MLLW). Non-native Harbor Bottom Sediments overlie the native sediments throughout much of the Inner Harbor (see Maps 5 and 6). The presence of those Harbor Bottom Sediments did not influence delineation of the different stratigraphic deposits. Contact locations are approximate.

2. Utility locations from a Fugro West report, "Subbottom Profiling and Side Scan Sonar Survey, Port of Los Angeles Main Channel Deepening Project, Phase 1 Field Surveys" (2001).

3. Vertical resolution of subbottom reflectors on geophysical data is +/- 0.5 to 1 millisecond, which represents 1.2 to 2.5 feet.

4. Vertical datum is MLLW, in feet.

Landfill Use Desirability	Material Types
High	Primarily coarse-grained sediments (sand and silty sand)
Low-Moderate	Interlayered deposits of coarse- and fine-grained sediments
Very Low	Primarily fine-grained sediments (silt, sandy silt, and clay)
Low-Very Low	Intact and/or weathered Timms Point Silt (silt, sandy silt, silty sand) (Approximate location of contact between Holocene sediments and Timms Point Silt as projected vertically from an elevation of -60 ft MLLW.)
Very Low	Intact and/or weathered Malaga Mudstone (elastic silts) (Approximate location of contact between Malaga Mudstone and Timms Point Silt as projected vertically from an elevation of -60 ft MLLW.)

LEGEND

- Native Dredge Unit Boundary
- Utility Crossing Location (refer to notes)
- 232 Berth Number
- CG-1 Native Dredge Unit Designation
- Federal Channel Dredging Limit

Coordinate System in red is California State Plane, Zone 5, NAD 83, Feet

Coordinate System in black is California State Plane, Zone 7, NAD 27, Feet

N

SCALE = 1:10800

1000 0 1000 Feet

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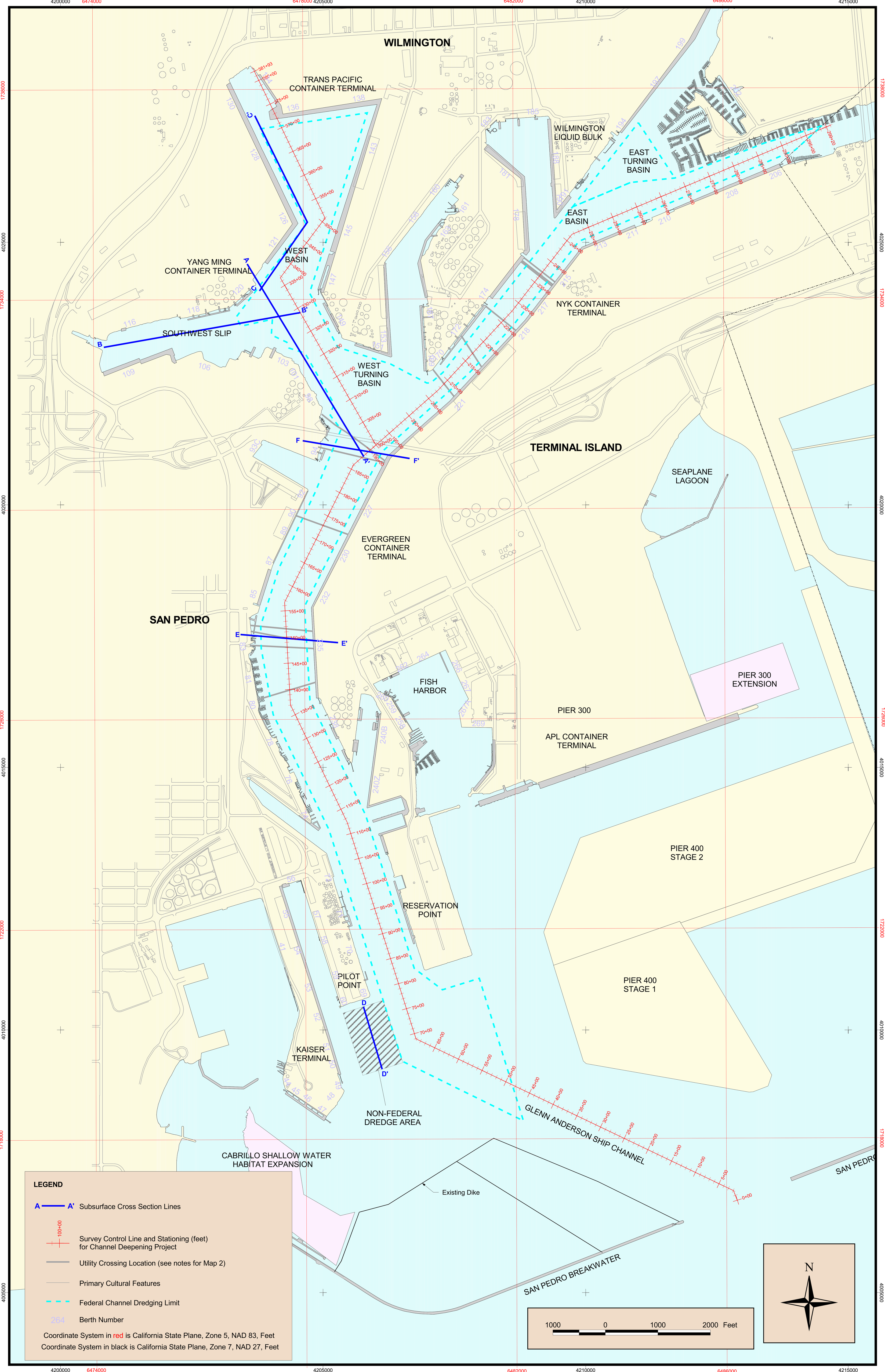
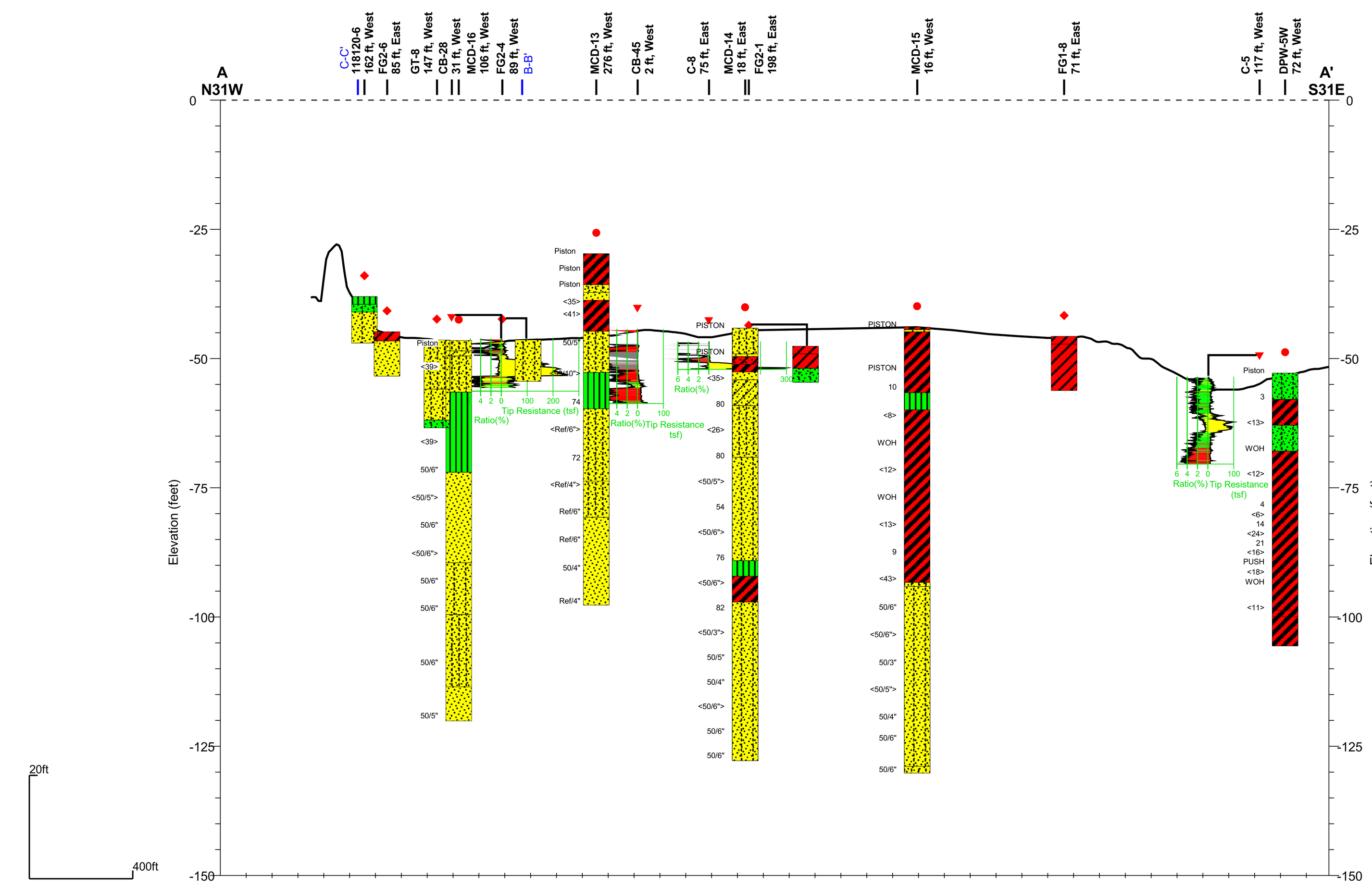
INTERPRETED SHALLOW SUBSURFACE CONDITIONS

Channel Deepening Project
Port of Los Angeles, California

April 2002 | 01-32-0633 | Map 7





SUBSURFACE CROSS SECTION A-A'
West Basin and Southwest Slip
Port of Los Angeles, California

GENERAL NOTES:

1) Data concerning subsurface conditions were obtained at boring and CPT locations only. Strata breaks were interpreted from geophysical records and were interpolated between exploration locations. Actual conditions between exploration points may differ from the generalized profile shown here.

2) CPT and boring logs were projected onto the section line.

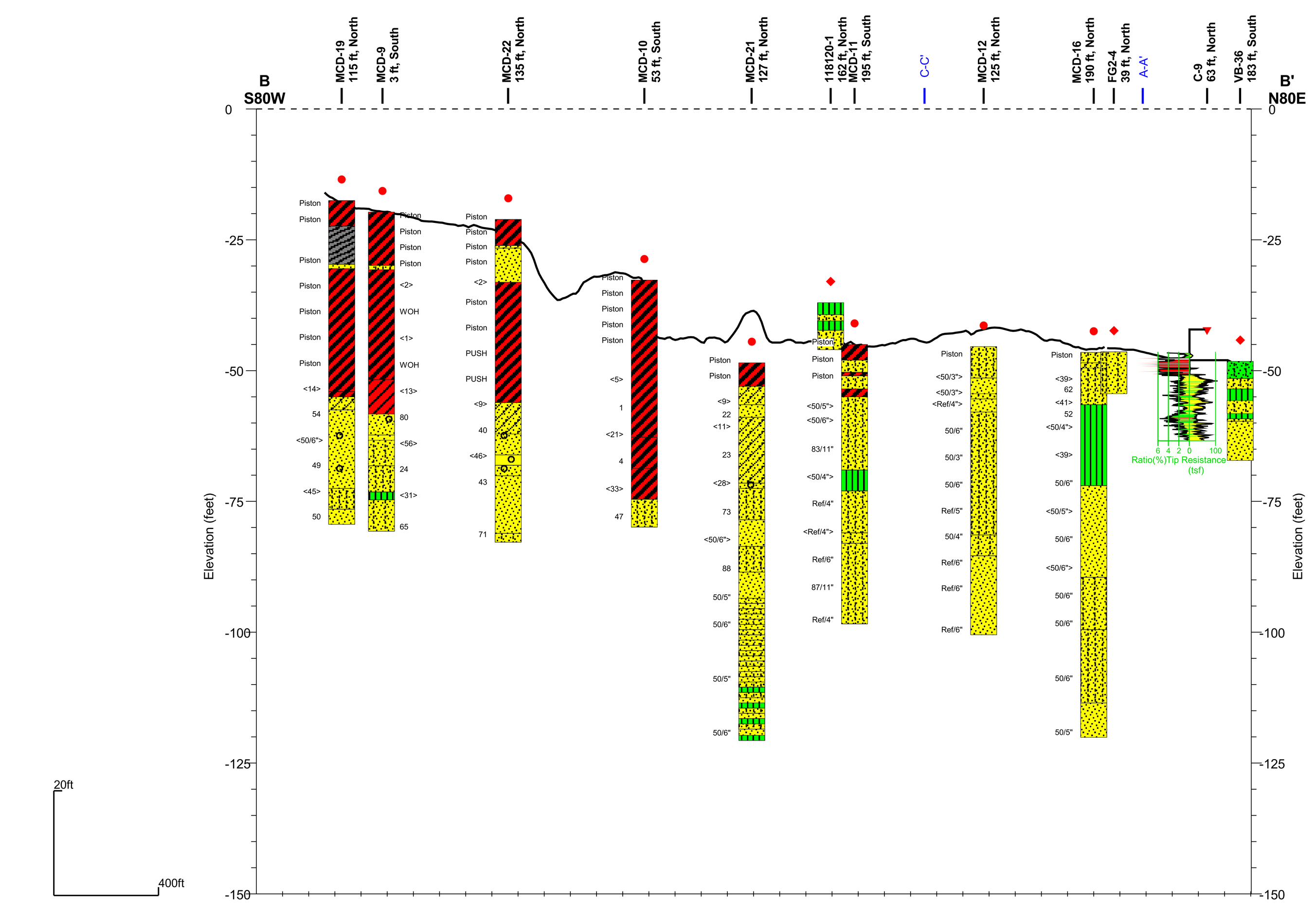
3) Indicated blow counts are SPT and equivalent SPT blow counts estimated from Modified California Sampler blow counts.

4) CPT tip resistance and blow counts are uncorrected for overburden.

5) Vertical : Horizontal Exaggeration = 20:1

6) Elevation relative to MLLW.

7) Bathymetry from Gahagan & Bryant Associates, Inc. (May-September 1999) and survey data acquired by the Port of Los Angeles in late March and early April 1996.



SUBSURFACE CROSS SECTION B-B'
West Basin and Southwest Slip
Port of Los Angeles, California

GENERAL NOTES:

1) Data concerning subsurface conditions were obtained at boring and CPT locations only. Strata breaks were interpreted from geophysical records and were interpolated between exploration locations. Actual conditions between exploration points may differ from the generalized profile shown here.

2) CPT and boring logs were projected onto the section line.

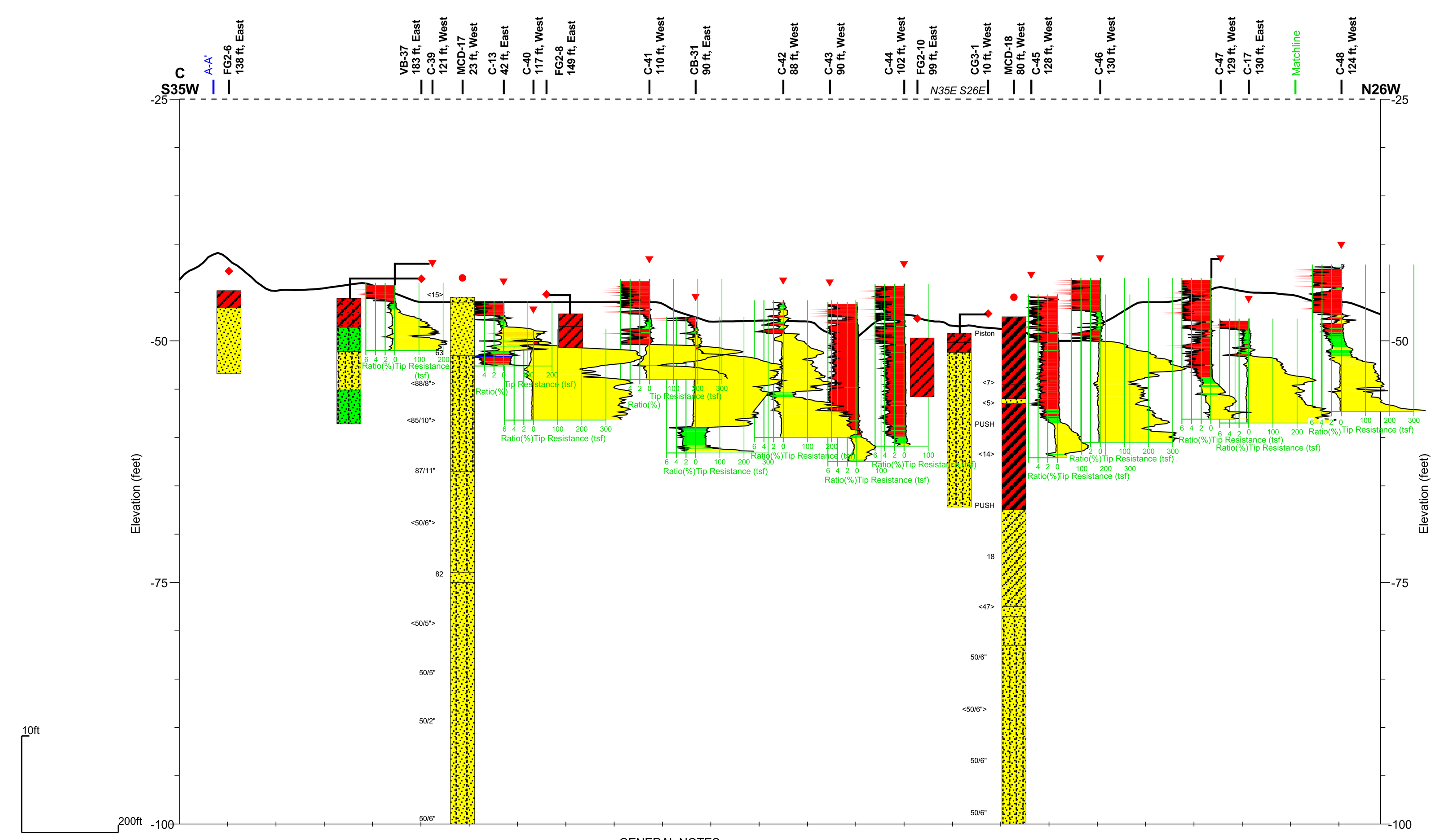
3) Indicated blow counts are SPT and equivalent SPT blow counts estimated from Modified California Sampler blow counts.

4) CPT tip resistance and blow counts are uncorrected for overburden.

5) Vertical : Horizontal Exaggeration = 20:1

6) Elevation relative to MLLW.

7) Bathymetry from Gahagan & Bryant Associates, Inc. (May-September 1999) and survey data acquired by the Port of Los Angeles in late March and early April 1996.



SUBSURFACE CROSS SECTION C-C'
West Basin and Southwest Slip
Port of Los Angeles, California

GENERAL NOTES:

1) Data concerning subsurface conditions were obtained at boring and CPT locations only. Strata breaks were interpreted from geophysical records and were interpolated between exploration locations. Actual conditions between exploration points may differ from the generalized profile shown here.

2) CPT and boring logs were projected onto the section line.

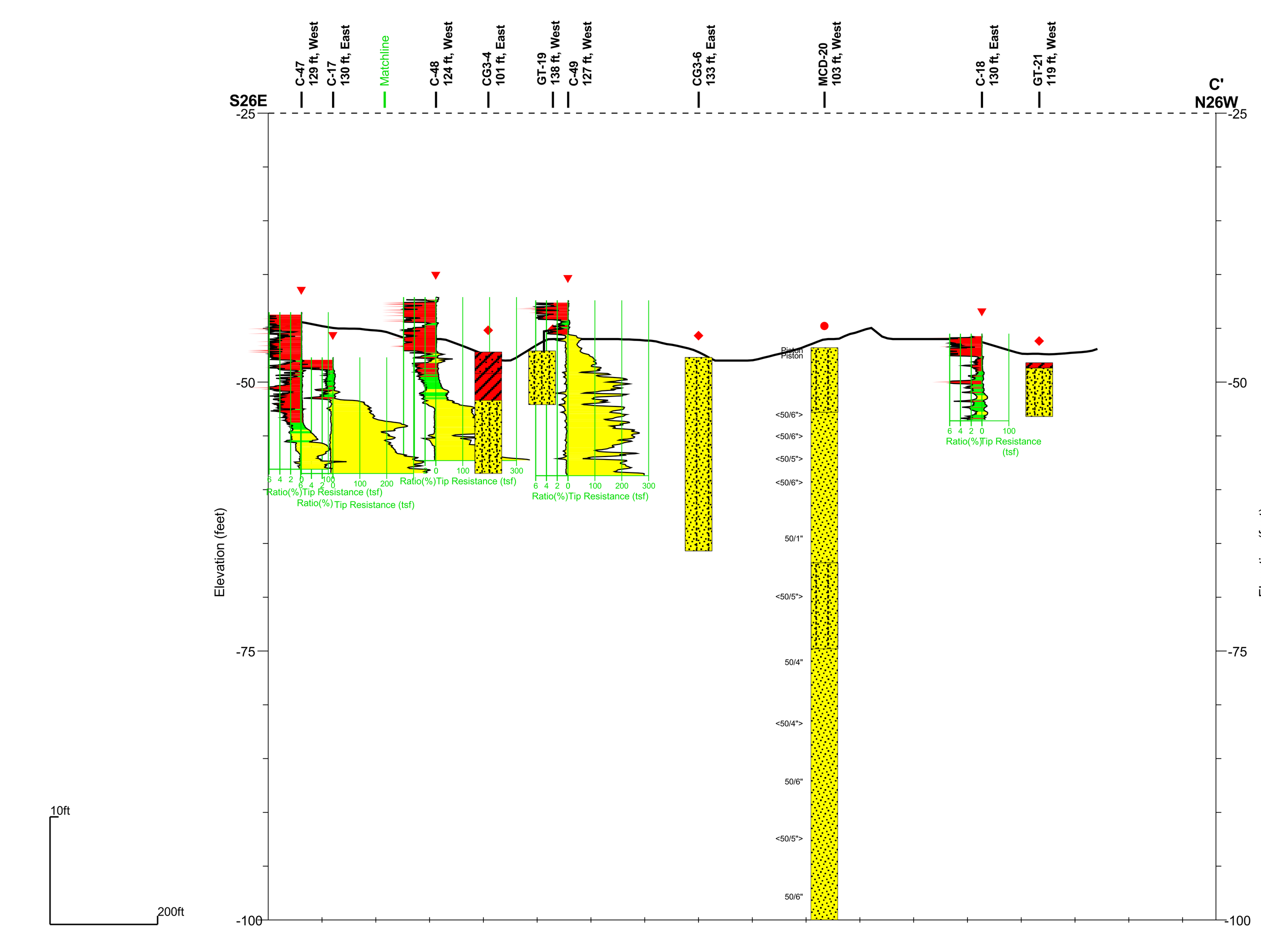
3) Indicated blow counts are SPT and equivalent SPT blow counts estimated from Modified California Sampler blow counts.

4) CPT tip resistance and blow counts are uncorrected for overburden.

5) Vertical : Horizontal Exaggeration = 20:1

6) Elevation relative to MLLW.

7) Bathymetry from Gahagan & Bryant Associates, Inc. (May-September 1999) and survey data acquired by the Port of Los Angeles in late March and early April 1996.



SUBSURFACE CROSS SECTION C-C' (Continued)
West Basin and Southwest Slip
Port of Los Angeles, California

GENERAL NOTES:

1) Data concerning subsurface conditions were obtained at boring and CPT locations only. Strata breaks were interpreted from geophysical records and were interpolated between exploration locations. Actual conditions between exploration points may differ from the generalized profile shown here.

2) CPT and boring logs were projected onto the section line.

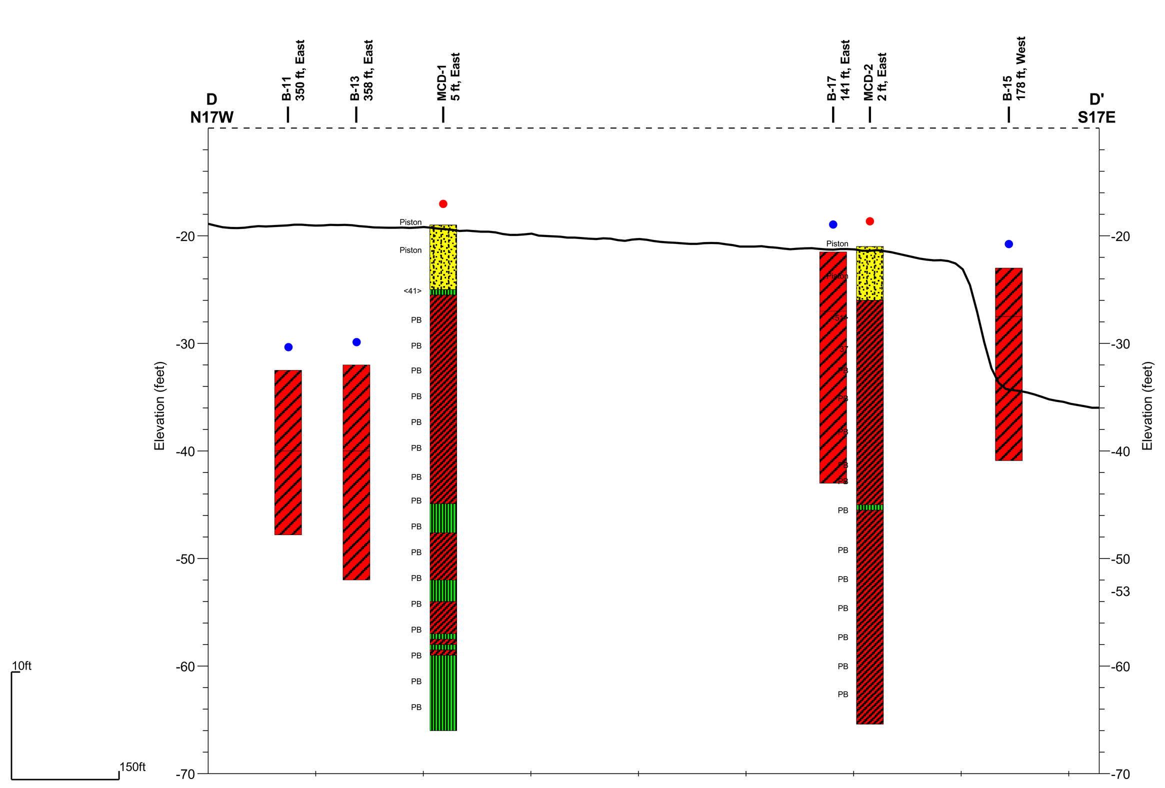
3) Indicated blow counts are SPT and equivalent SPT blow counts estimated from Modified California Sampler blow counts.

4) CPT tip resistance and blow counts are uncorrected for overburden.

5) Vertical : Horizontal Exaggeration = 20:1

6) Elevation relative to MLLW.

7) Bathymetry from Gahagan & Bryant Associates, Inc. (May-September 1999) and survey data acquired by the Port of Los Angeles in late March and early April 1996.



SUBSURFACE CROSS SECTION D-D'
Non-Federal Dredge Area
Port of Los Angeles, California

GENERAL NOTES:

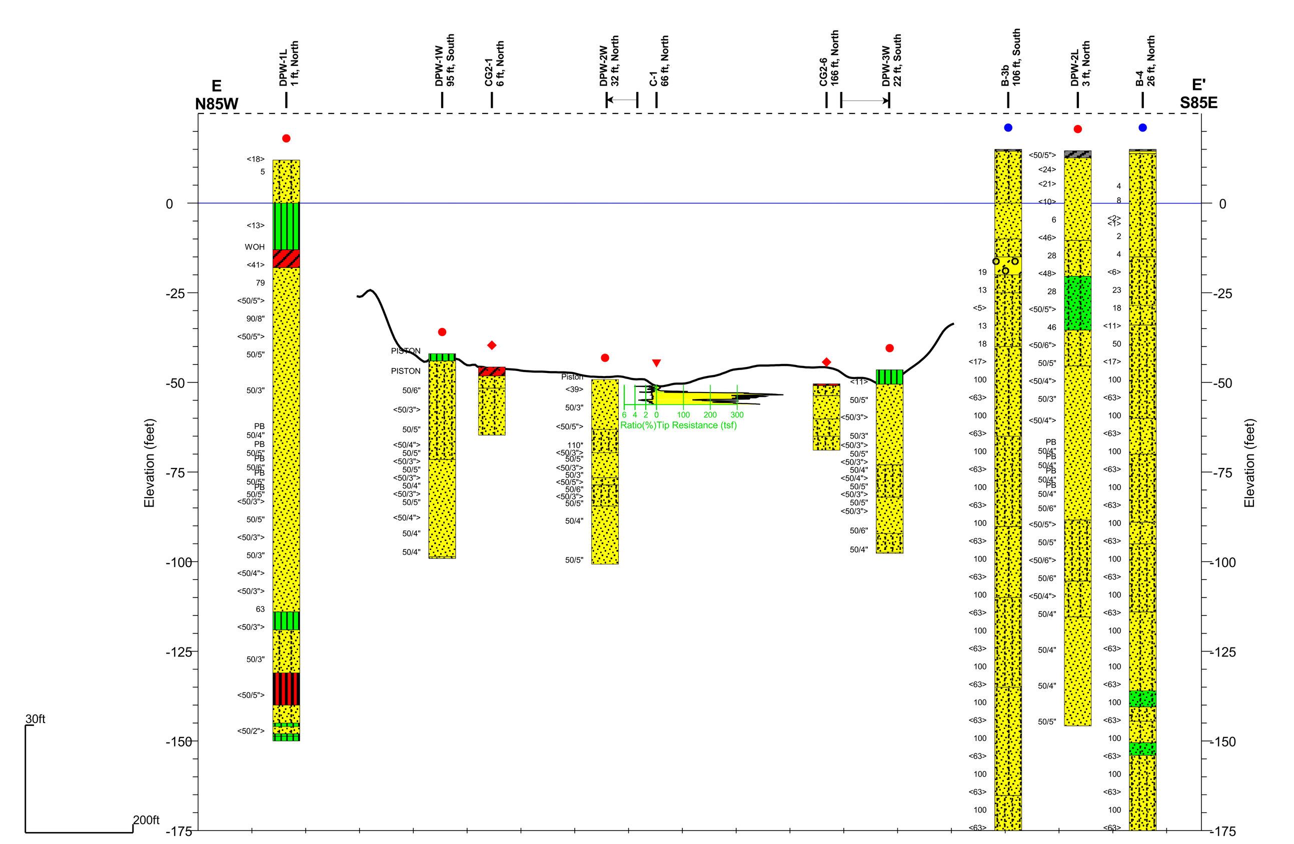
1) Data concerning subsurface conditions were obtained at boring locations only. Actual conditions between exploration points may differ from the generalized profile shown here.

2) Boring logs were projected onto the section line.

3) Indicated blow counts are SPT and equivalent SPT blow counts estimated from Modified California Sampler blow counts.

4) Vertical : Horizontal Exaggeration = 15:1

5) Elevation relative to MLLW.



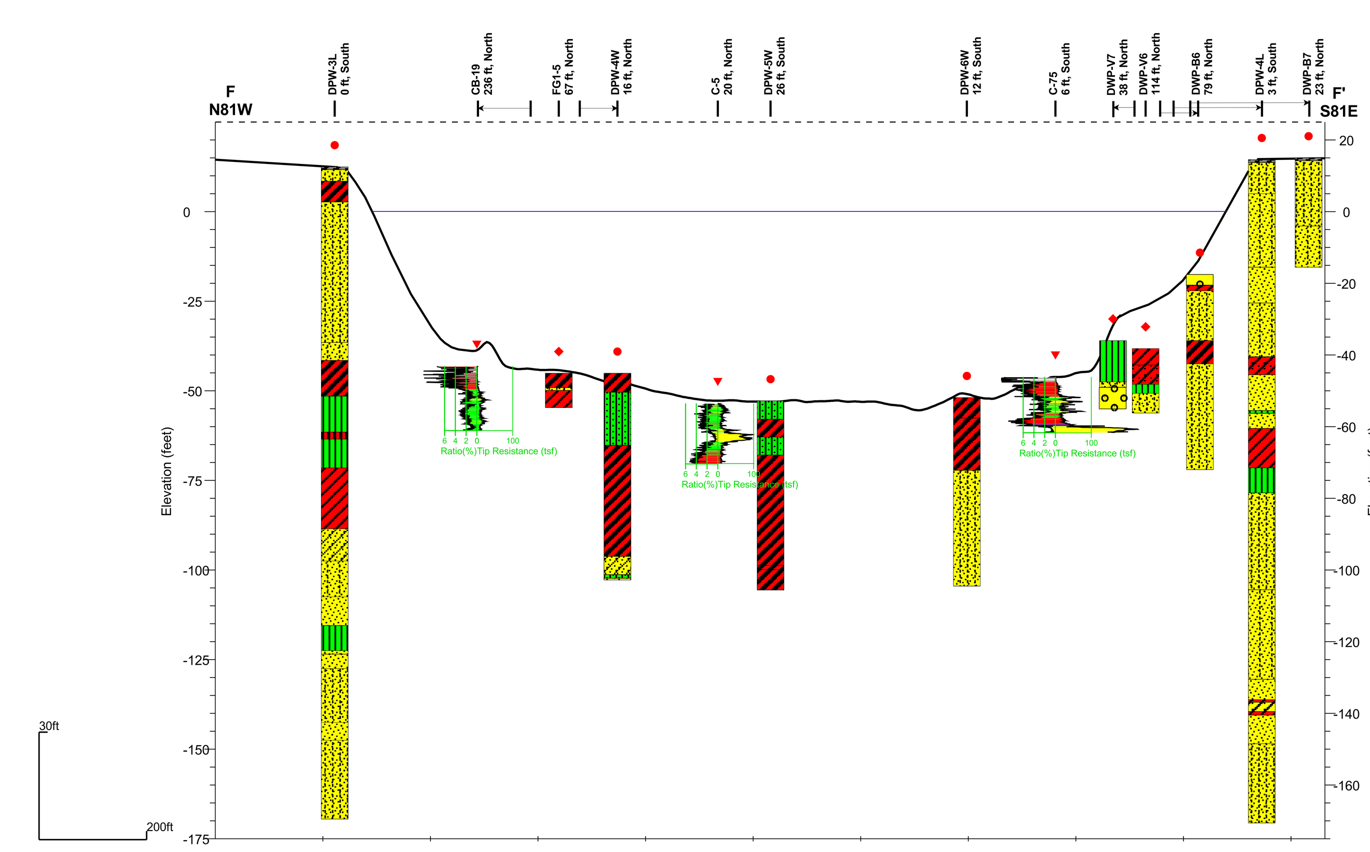
SUBSURFACE CROSS SECTION E-E'
Siphon Harbor Crossing Relocation
Port of Los Angeles, California

GENERAL NOTES:

1) Data concerning subsurface conditions were obtained at boring and CPT locations only. Strata breaks were interpreted from geophysical records and were interpolated between exploration locations. Actual conditions between exploration points may differ from the generalized profile shown here.

2) CPT and boring logs were projected onto the section line.

3) CPT tip resistance and blow counts are uncorrected for overburden.



SUBSURFACE CROSS SECTION F-F'
San Pedro Force Main Relocation
Port of Los Angeles, California

GENERAL NOTES:

1) Data concerning subsurface conditions were obtained at boring and CPT locations only. Strata breaks were interpreted from geophysical records and were interpolated between exploration locations. Actual conditions between exploration points may differ from the generalized profile shown here.

2) CPT and boring logs were projected onto the section line.

3) CPT tip resistance and blow counts are uncorrected for overburden.

Exploration Legend

FUGRO WEST EXPLORATIONS (1991 - 2000)
- Borings
- CPTs
- Vibracores

NON-FUGRO WEST EXPLORATIONS (1958 - 2001)
- Borings
- CPTs
- Vibracores

NOTES:

1. See Map 8b for the Key to Cross Sections.
2. Note that the scales vary in the cross sections presented.
3. Bold black line in each cross section indicates bathymetric surface.

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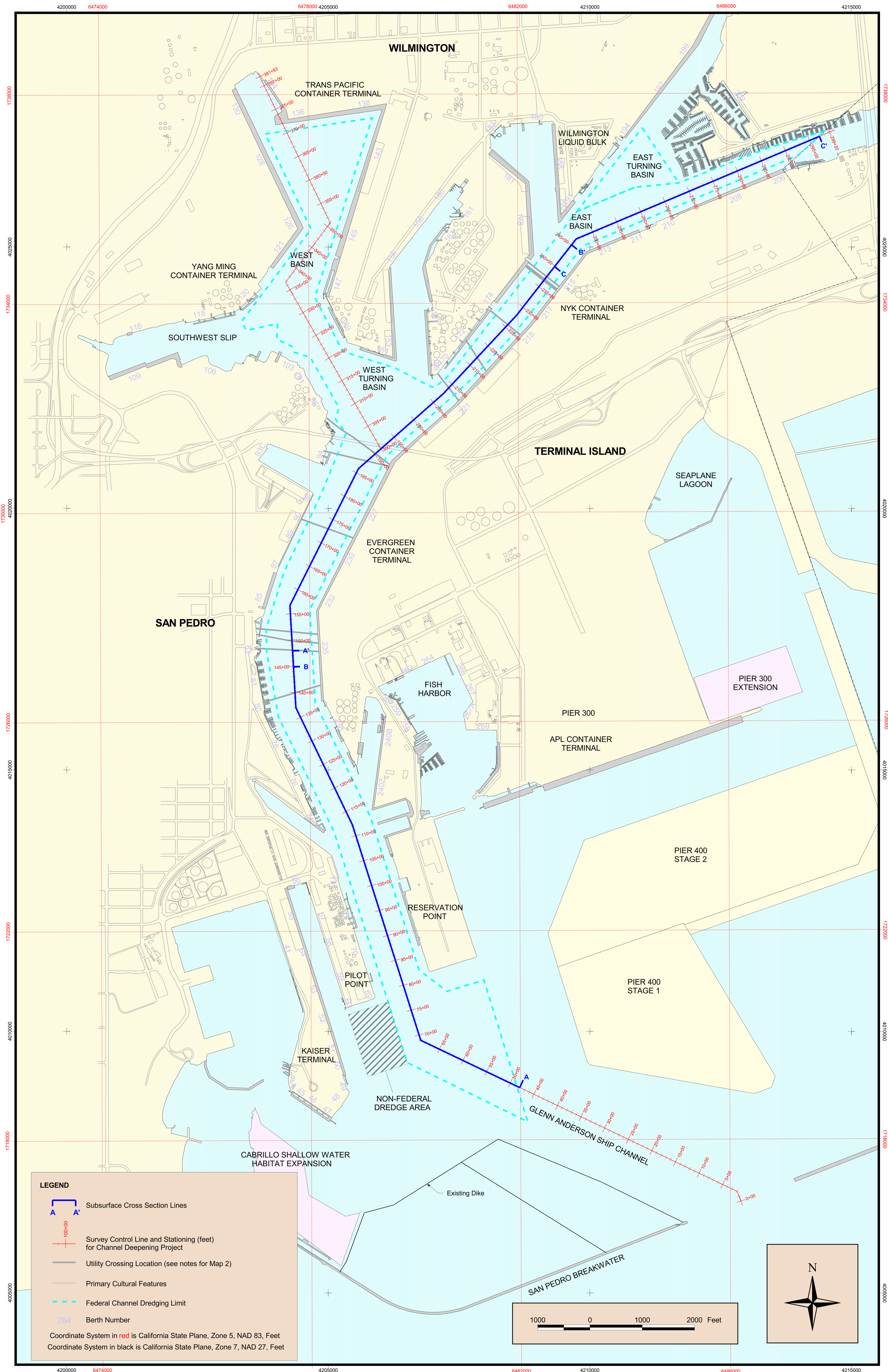
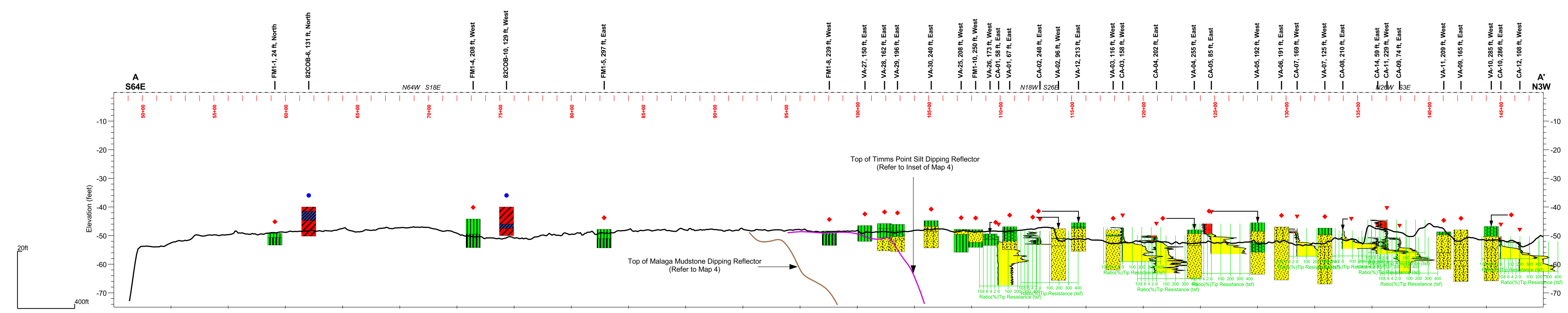
SUBSURFACE CROSS SECTIONS
Channel Deepening Project
Port of Los Angeles, California

April 2002 | 01-32-0633 | Map 8a





SUBSURFACE CROSS SECTION A-A'
Main Channel (South)
Port of Los Angeles, California

GENERAL NOTES:

1) Data concerning subsurface conditions were obtained at boring and CPT locations only. Strata breaks were interpreted from geophysical records and were interpolated between exploration locations. Actual conditions between exploration points may differ from the generalized profile shown here.

2) Exploration logs were projected onto the section line. Therefore stratigraphic contacts may not exactly correspond to the contact indications (lithology, shear strength, etc.) in the logs.

3) Indicated blow counts are SPT and equivalent SPT blow counts estimated from Modified California Sampler blow counts.

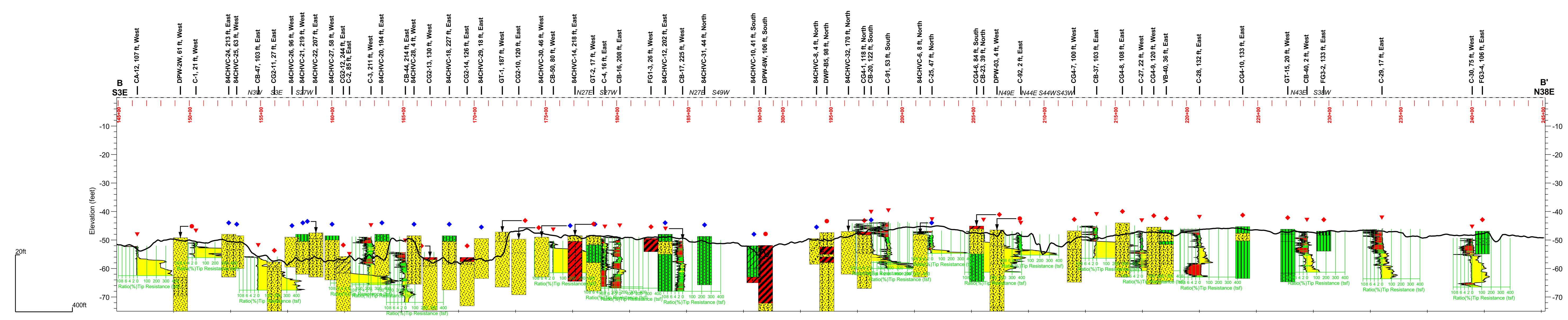
4) CPT tip resistance and blow counts are uncorrected for overburden.

5) Vertical : Horizontal Exaggeration = 20:1

6) Elevation relative to MLLW.

7) Refer to Key to Cross Sections for descriptions of boring and CPT data shown above.

8) Bathymetry (in black) taken from 1999 to 2001 multibeam hydrographic surveys performed by Gahagan & Bryant Associates, Inc., and the Port of Los Angeles.



SUBSURFACE CROSS SECTION B-B'
Main Channel (Central)
Port of Los Angeles, California

GENERAL NOTES:

1) Data concerning subsurface conditions were obtained at boring and CPT locations only. Strata breaks were interpreted from geophysical records and were interpolated between exploration locations. Actual conditions between exploration points may differ from the generalized profile shown here.

2) Exploration logs were projected onto the section line. Therefore stratigraphic contacts may not exactly correspond to the contact indications (lithology, shear strength, etc.) in the logs.

3) Indicated blow counts are SPT and equivalent SPT blow counts estimated from Modified California Sampler blow counts.

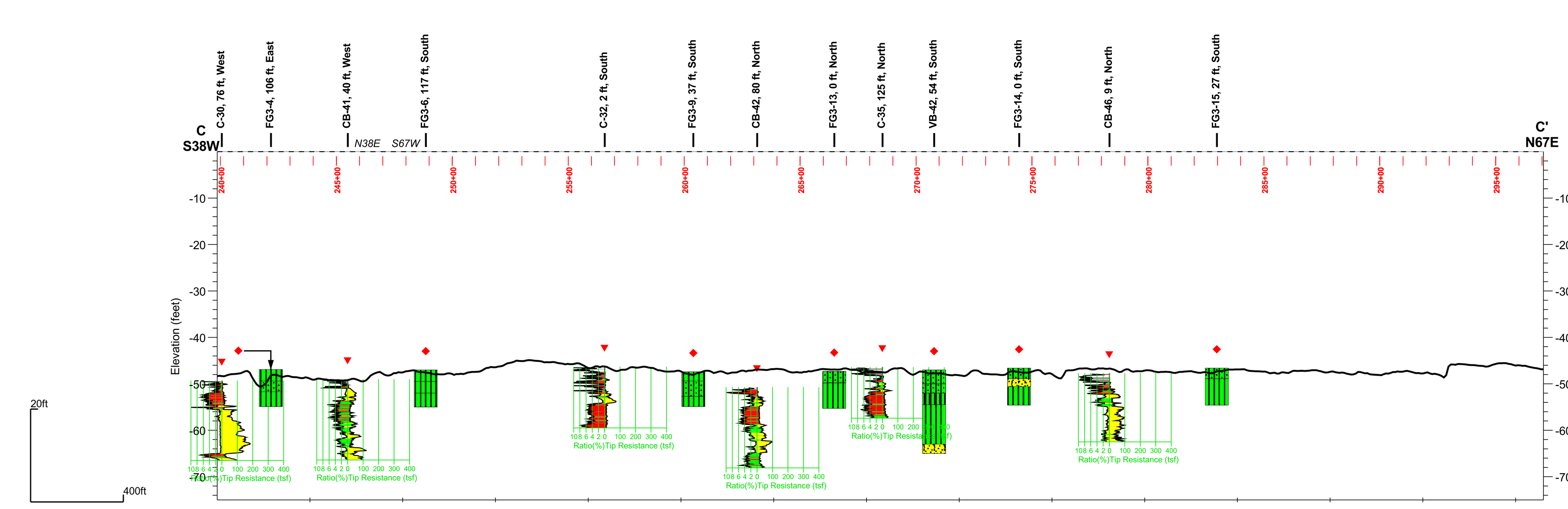
4) CPT tip resistance and blow counts are uncorrected for overburden.

5) Vertical : Horizontal Exaggeration = 20:1

6) Elevation relative to MLLW.

7) Refer to Key to Cross Sections for descriptions of boring and CPT data shown above.

8) Bathymetry (in black) taken from 1999 to 2001 multibeam hydrographic surveys performed by Gahagan & Bryant Associates, Inc., and the Port of Los Angeles.



SUBSURFACE CROSS SECTION C-C'
Main Channel (Northeast)
Port of Los Angeles, California

GENERAL NOTES:

1) Data concerning subsurface conditions were obtained at boring and CPT locations only. Strata breaks were interpreted from geophysical records and were interpolated between exploration locations. Actual conditions between exploration points may differ from the generalized profile shown here.

2) Exploration logs were projected onto the section line. Therefore stratigraphic contacts may not exactly correspond to the contact indications (lithology, shear strength, etc.) in the logs.

3) Indicated blow counts are SPT and equivalent SPT blow counts estimated from Modified California Sampler blow counts.

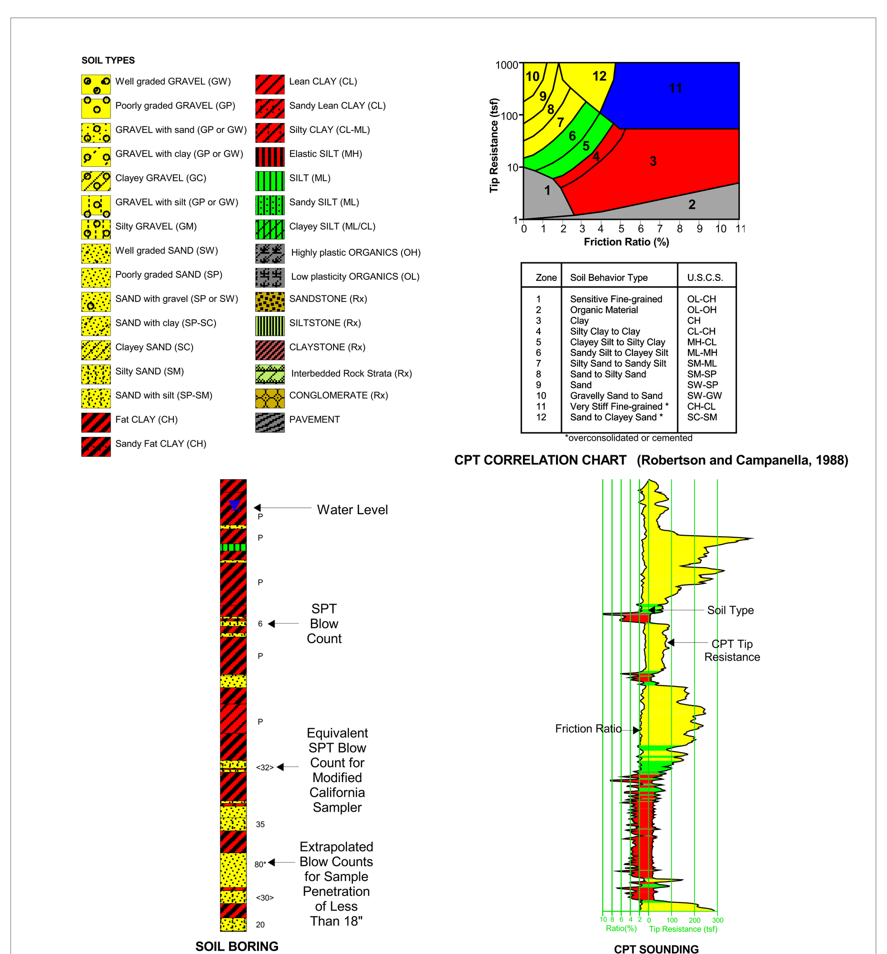
4) CPT tip resistance and blow counts are uncorrected for overburden.

5) Vertical : Horizontal Exaggeration = 20:1

6) Elevation relative to MLLW.

7) Refer to Key to Cross Sections for descriptions of boring and CPT data shown above.

8) Bathymetry (in black) taken from 1999 to 2001 multibeam hydrographic surveys performed by Gahagan & Bryant Associates, Inc., and the Port of Los Angeles.



KEY TO CROSS SECTIONS
Channel Deepening Project
Port of Los Angeles, California

Exploration Legend

FUGRO WEST EXPLORATIONS (1991 - 2000)
- Borings
- CPTs
- Vibracores

NON-FUGRO WEST EXPLORATIONS (1958 - 2001)
- Borings
- CPTs
- Vibracores

NOTES

1. Scales are at the lower left of each cross section.

2. Numbers in red along the top of each cross section correspond to the stationing along the channel centerline shown in the cross section location map in the upper left.

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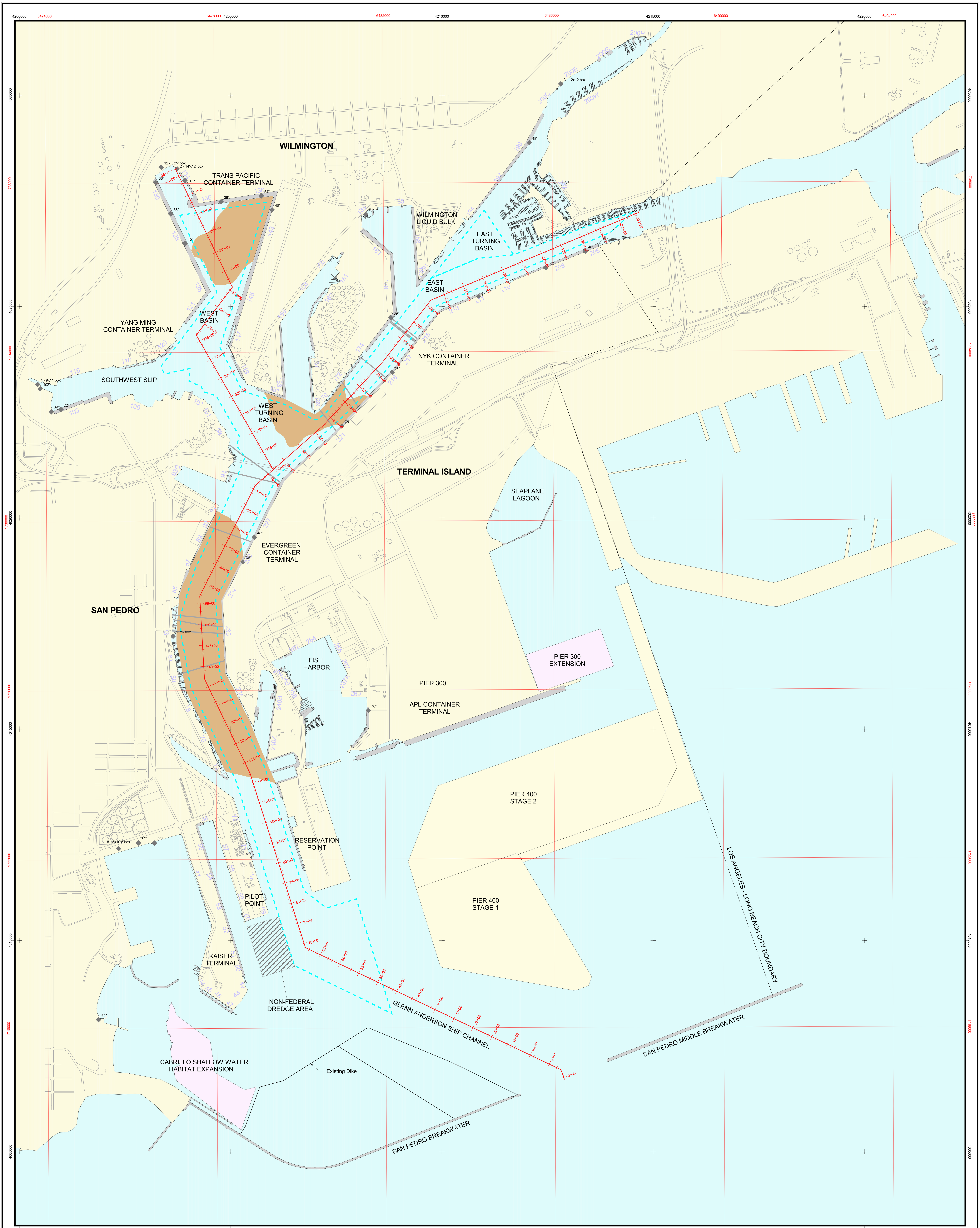
SUBSURFACE CROSS SECTIONS
Channel Deepening Project
Port of Los Angeles, California

April 2002 | 01-32-0633 | Map 8b



NOTES

1. Recommended mining areas are based on interpretation of available stratigraphic data, which are generally limited to no deeper than about elevation -60 to -65 feet (MLLW), except for explorations performed within existing borrow pits.

2. Utility locations from a Fugro West report, "Subbottom Profiling and Side Scan Sonar Survey, Port of Los Angeles Main Channel Deepening Project, Phase 1 Field Surveys" (2001).

3. Outfall locations are approximate and are based on an untitled map (provided by the Port of Los Angeles) that shows the locations of outfalls that are 36 inches in diameter or larger. Note that Fugro did not verify the existence and locations of the outfalls.

LEGEND

- Areas where appreciable deposits of coarse-grained sediments (sand and silty sand) are present below about elevation -55 feet (MLLW) (refer to text).
- 100+00 Survey Control Line and Stationing (feet) for Channel Deepening Project
- Utility Crossing Location (refer to notes)
- Primary Cultural Features
- Federal Channel Dredging Limit
- 264 Berth Number
- 36" Outfall Location (refer to notes)

Coordinate System in red is California State Plane, Zone 5, NAD 83, Feet

Coordinate System in black is California State Plane, Zone 7, NAD 27, Feet

N

SCALE = 1:12000

1000 0 1000 Feet

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RECOMMENDED MINING AREAS
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