US Army Corps
of Engineers

Los Angeles District

LOS ANGELES COUNTY REGIONAL DREDGED MATERIAL MANAGEMENT PLAN PILOT STUDIES

LOS ANGELES COUNTY, CALIFORNIA

APPENDIX B1 - CEMENT-BASED STABILIZATION OF DREDGED MATERIAL BENCH SCALE STUDY

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EXECUTIVE SUMMARY

In early 2001, the Los Angeles District of the U.S. Army Corps of Engineers (COE) initiated a series of pilot studies to evaluate the feasibility for treating and/or disposing of contaminated sediments located within the Los Angeles County Region. The four alternatives evaluated were identified in the Los Angeles County Regional Dredged Material Management Plan (DMMP), and included:

- **Aquatic Capping** – dredging and placing contaminated sediments into an inner harbor borrow pit and capping with clean sediments.

- **Cement Stabilization** – dredging and transferring contaminated sediments to an upland treatment area where dredged sediments are mixed with a cement-based product to create structurally stable soil material.

- **Sediment Washing** – dredging and transferring contaminated sediments to an upland staging area where the dredged sediments are washed to remove chloride, allowing disposal at an upland landfill.

- **Sediment Blending** – dredging and transferring contaminated sediments to an upland staging area and blending the sediments with various additives to create structurally stable material.

The four pilot studies were performed in late 2001 through early 2002, and post-construction monitoring for the Aquatic Capping alternative was completed in the spring of 2002. This appendix details the results and project evaluation of the Cement-Based Stabilization (CBS) Bench-Scale Study (Bench Study).

Cement-Based Stabilization

Disposal of contaminated dredged material from harbors and river estuaries can pose difficult problems. Unconfined ocean disposal of contaminated materials is regulated by strict environmental standards. In addition, the material is frequently unsuitable for engineered structural fill and has the potential to impact the environment through groundwater and soil contamination and through biological uptake by plants and animals.

The COE developed and implemented the Cement-Based Stabilization Bench Scale Test (CSBST) program to evaluate stabilization treatment alternatives for contaminated dredge sediments within the Los Angeles County region. The purpose of the CSBST was to determine the effectiveness of cement and cement-based binders on controlling loss of contaminants and to supply materials with minimal mechanical properties for use as engineered fill.

Cement-based stabilization (CBS) technology has been successfully applied for the beneficial re-use of contaminated dredged sediments on the East Coast of the U.S. The primary objective of this study was to evaluate the effectiveness of cement-based stabilization technology for contaminated dredged materials in the Los Angeles County region in a laboratory setting. The focus of the study was to identify a range of effective stabilization reagent mixtures that could be used to allow for beneficial use of these materials in regional upland applications. This study

was prepared under the authorities of the 1852 Rivers and Harbors Act modified by the 1968 Rivers and Harbors Act and Section 103 of the Marine Protection, Research and Sanctuaries Act of 1972.

Effectiveness of CBS technology was assessed for four different sites representing a broad range of regional dredged sediments, including:

- Marina del Rey
- Los Angeles River Estuary
- Port of Long Beach – Channel 2
- Port of Los Angeles – Consolidated Slip

Specific site locations are illustrated in Figure E-1.

The bench test program evaluated combinations of three stabilization binders including Portland cement, coal fly ash and fluidized bed ash. The dredge sediment samples were stabilized with varying amounts of these reagents. For each of the three reagents, three mixtures of varying reagent amounts were prepared. Selection of the mixture amounts was based on the following considerations: The upper limit should significantly prevent loss of contaminants and improve strength. The lower limit should show some improvement in contaminant binding and strength. The median should be the approximate mid-point between upper and lower. Each of three reagents tested at three percentages (upper, lower, mid) resulted in nine binder combinations for each site.

All stabilization mixtures were initially evaluated for set-time using a modified Vicat measurement apparatus. The stabilized mixtures were then subjected to a detailed suite of geotechnical testing and chemical analysis. The geotechnical testing methods used to evaluate samples from the testing program relied on ASTM procedures that were developed to evaluate typical soil-cement mixtures. The laboratory sediment stabilization test program was designed to simulate, as closely as possible, large-scale field operations. Consequently, the geotechnical tests performed on test program samples were modified due to WBR laboratory stabilization mixing and curing times and the need to optimize sample moisture contents for geotechnical tests. The modified ASTM tests provide useful information about sample characteristics, but should not be directly related to strict ASTM testing criteria for soil cement mixtures. Results of the physical and chemical testing program are summarizes as follows:

Physical Test Results

The engineering qualities of a soil are determined by a range of physical parameters, including strength, compressibility, and permeability. Of the four source sites, raw dredged materials from Marina del Rey and the Los Angeles River Estuary already possess generally good engineering properties based on their high sand content, and would be generally suitable for beneficial re-use as fill material. However, the CBS process significantly improved the mechanical properties, and significantly increased the ability to manage the material in a timely manner through

hydration of excess porewater. This benefit will be a function of the amount of excess water in the dredged material as well as the material's drainage characteristics.

The Port of Long Beach material possessed greater silt and clay content, and clearly benefited from the CBS process. The material became manageable in a matter of hours, whereas the untreated material would require extensive drying time. Unexpectedly, the CBS process either did not impact or increased compressibility, depending on the specific reagent mix. Increased compressibility may have resulted in the higher cement mixes resulting from a more readily formed a soil-cement matrix that were collapsed during compression testing. None of the other mixes resulted in any appreciable reduction in compressibility relative to the raw material. However, the process greatly increased the permeability of the material improving drainage characteristics.

The Port of Los Angeles material also demonstrated poor inherent engineering properties, and benefited from the CBS process. Similar to the Port of Long Beach material, the CBS treatment rendered manageable material in a matter of hours, except for the low reagent binder mixes. Both compressive and shear strength were improved. The process greatly reduced the compressibility of the untreated material. Permeability was moderately increased.

In summary, the CBS process resulted in substantial improvement of the POLB and POLA material for general upland use. However, high fine content and low density may limit their broad application, particularly the POLA material. Final assessment of suitability would be based on the specific application and associated material performance requirements.

Chemical Test Results

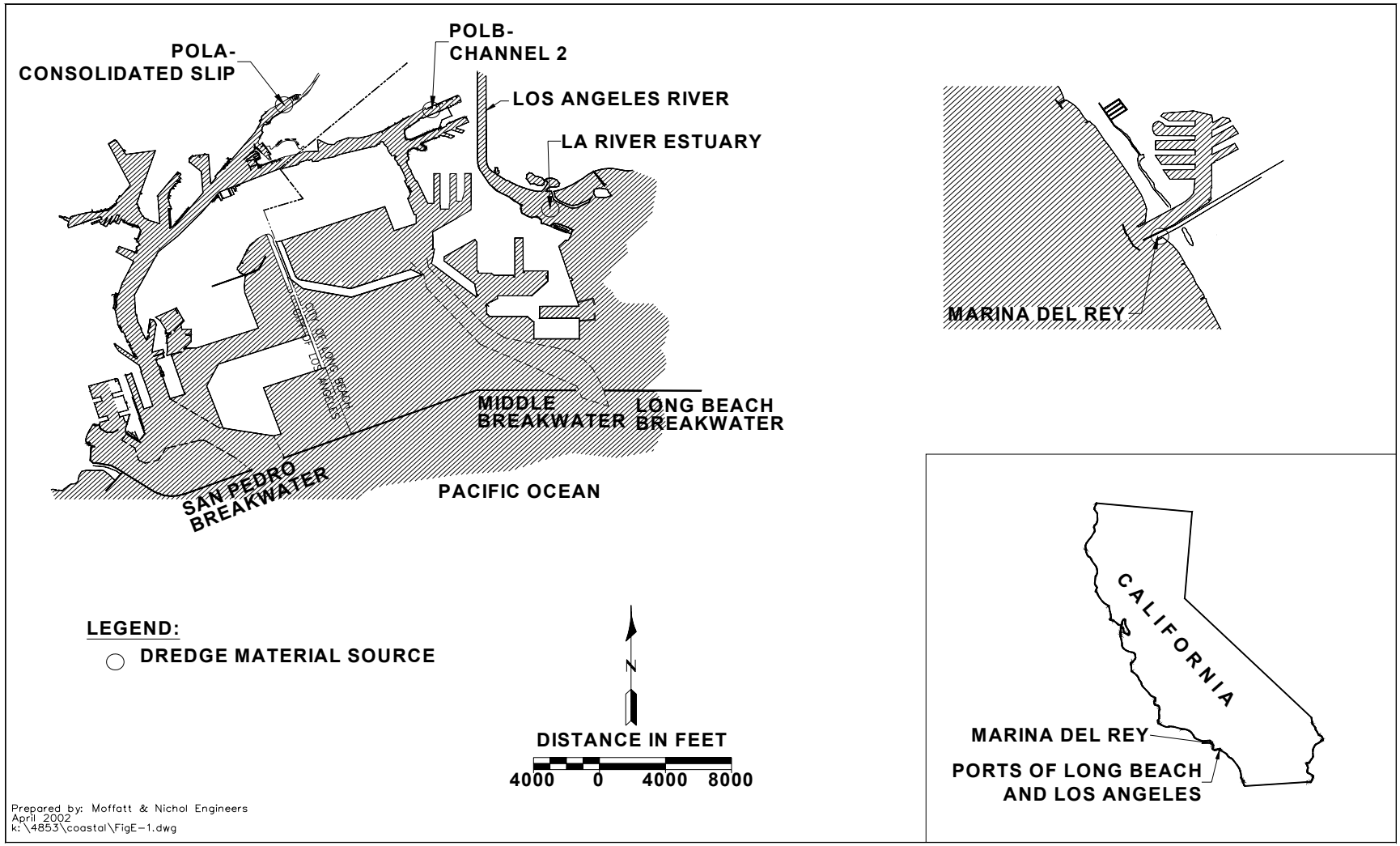
The focus of the chemical testing program was to investigate the reduction in contaminant availability associated with the CBS process. Following the stabilization procedures, raw and stabilized samples were tested for analytes, the WET and SPLP leaching procedures, and porewater salinity. Analyte concentrations were compared with Effects Range – Median (ER-M) values. The Total Threshold Limit Concentrations (TTLC) were compared to the values reported for the raw sediment (solids), and Soluble Threshold Limit Concentrations (STLC) were compared to the values reported for the extracts (liquids). Values above these threshold limits are believed to be harmful and defined as hazardous waste by Title 22 criteria.

All raw sediment samples exceeded Effects Range – Median (ER-M) values in at least one category, indicating elevated contaminant levels. POLA Consolidated Slip exceeded the most ER-M values at 23. However, none of the raw sediment samples exceeded TTLC values. Similarly none of the extracts exceeded STLC values, either before or after stabilization. The results indicate that none of the samples (raw or treated) would be considered hazardous waste under California Title 22 criteria, implying acceptability for upland application.

Full Scale Cost Projection

A subsequent pilot-scale study of cement-based stabilization technology under preparation for the Los Angeles District (draft to be published June 2002) projects costs on the order of $45 per cubic yard for dredging through treatment. The cost was based on a reagent mix of 5 percent

cement. Of that amount, only about $7 was associated with reagent purchase. Thus, the overall treatment costs is not highly sensitive to type nor volume of reagent.



CEMENT-BASED STABILIZATION OF DREDGED MATERIAL	LOCATION MAP	Figure E-1

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1.0 INTRODUCTION

In early 2001, the Los Angeles District of the U.S. Army Corps of Engineers (COE) initiated a series of pilot studies to evaluate the feasibility for treating and/or disposing of contaminated sediments located within the Los Angeles County Region. The four alternatives evaluated were identified in the Los Angeles County Regional Dredged Material Management Plan (DMMP), and included:

- **Aquatic Capping** – dredging and placing contaminated sediments into an inner harbor borrow pit and capping with clean sediments.

- **Cement Stabilization** – dredging and transferring contaminated sediments to an upland treatment area where dredged sediments are mixed with a cement-based product to create structurally stable soil material.

- **Sediment Washing** – dredging and transferring contaminated sediments to an upland staging area where the dredged sediments are washed to remove chloride, allowing disposal at an upland landfill.

- **Sediment Blending** – dredging and transferring contaminated sediments to an upland staging area and blending the sediments with various additives to create structurally stable material.

The four pilot studies were performed in late 2001 through early 2002, and post-construction monitoring for the Aquatic Capping alternative was completed in the spring of 2002. This appendix details the results and project evaluation of the Cement-Based Stabilization (CBS) Bench-Scale Study (Bench Study).

1.1 BACKGROUND

Los Angeles County's coastline includes two of the nation's largest commercial ports and several major marina complexes and small-vessel harbors. Maintenance of authorized depths in existing channels and berthing areas and expansion and modernization of ports, harbors, and marinas, requires periodic dredging in virtually all of these facilities. Some of the sediments dredged from these harbors contain elevated levels of heavy metals, pesticides, and other contaminants. In most cases, the concentrations of these contaminants do not approach hazardous levels. However, the sediments contain enough contaminants that they are not suitable for unconfined ocean disposal. Additionally, California's Bay Protection and Toxic Cleanup Program identified bays and estuaries containing areas with contaminated sediments. Remediation of these sites may require dredging and disposal of this material. Disposal of any contaminated dredged materials requires special management, such as placement in a confined aquatic disposal site,

capping, or disposal in an upland site. Some ports and harbors have considered other management techniques, such as treatment and beneficial re-use.

Recently, the ports and harbors have delayed or canceled several dredging projects because of contaminated sediment issues. The regulatory agencies evaluated disposal options for these projects on a case-by-case basis without the benefit of a regional perspective on management alternatives, cumulative impacts, and long-term solutions to prevent re-contamination of sediment. This approach has lead to public concern over the ecological and human health implications of contaminated dredged material disposal. To resolve these issues, the regulatory and resource agencies, ports and harbors, environmental groups, and other interested parties agreed to establish a task force. The Los Angeles Contaminated Sediments Task Force (CSTF) was formed in 1998 and chartered with developing a long-term management strategy for contaminated sediments. This strategy will be presented in the CSTF's Strategy Report. The COE, State and Federal resource and regulatory agencies, and local environmental groups are active participants in the CSTF.

Even though the COE is an active participant in the CSTF, the COE is independently developing a long-term management strategy (i.e., DMMP) for both clean and contaminated sediments. The project study area for the DMMP is located along the coastal waters of Los Angeles and includes Marina del Rey, the Port of Long Beach, the Port of Los Angeles, and the Los Angeles River Estuary. The non-Federal sponsors for the feasibility phase of the DMMP study are the County of Los Angeles, City of Long Beach, Port of Long Beach and Port of Los Angeles. While many of the objectives under the COE DMMP Feasibility Study and the CSTF Strategy Report overlap, there may be key differences in approach or conclusions reached under each program. The intent of both the COE and CSTF is to coordinate the two study efforts as much as possible to minimize duplication of effort, and to develop a unified approach for the long-term management of contaminated dredged sediment.

1.2 STUDY PURPOSE

The COE developed and implemented the Cement-Based Stabilization Bench Scale Test (CSBST) program to evaluate stabilization treatment alternatives for contaminated dredge sediments from the Los Angeles County region. The purpose of the CSBST was to determine the effectiveness of cement and cement-based binders on controlling loss of contaminants and to supply materials with minimal mechanical properties for use as engineered fill.

1.3 CEMENT-BASED STABILIZATION PROCESS

Cement-based stabilization (CBS) has been used to treat waste materials since the early 1950's. Some of the first uses of cement for waste stabilization included the treatment of radioactive wastes from various uranium sources, weapons and fuels programs. CBS use has been increased to treat a wide range of industrial waste materials, including oil-based and chemical wastes. The use of cementitious materials to accomplish solidification and stabilization is well established. Solidification and stabilization may be accomplished by the same treatment method, but the terms refer to different mechanisms.

Solidification refers to the addition of reagents to change the physical characteristics of waste materials in a manner that increases the strength and decreases the material compressibility. This is especially important for water saturated fine-grained clayey materials or materials with high organic contents that might be considered for construction fill use. Such materials generally exhibit long drying times and poor structural characteristics for use as engineered fill.

Stabilization refers to changes in the chemical structure of the waste material that renders the hazardous constituents less soluble and less toxic. This is especially important when there is the potential for biological uptake.

Relies upon pozzolanic and cement setting reactions to form stable new chemical compounds. Portland cement and fly ash react with water to form various calcium silicates and calcium aluminate compounds that produce materials, which encapsulate and incorporate heavy metals (arsenic, chrome, lead, etc.) into a new compound matrix that is insoluble under most conditions. The overall goal of CBS in the treatment of contaminated dredge materials is to:

1. Eliminate all free liquids

2. Reduce the mobility, toxicity and leachability of hazardous components

3. Improve the physical properties of the stabilized material

Produce a material that can be used as structural fill or that can be disposed of without concern for future environmental impact

1.4 CEMENT-STABILIZATION OF MARINE SEDIMENTS

Marine sediments in U.S. port and harbor areas are often contaminated due to long term industrial activity. This activity includes ship loading, fueling, maintenance and associated spills, industrial operations such as refineries, chemical plants and runoff from other industrial, municipal and agricultural areas. Environmental regulations of the past 20 years have greatly reduced the amount of environmental contamination from industrial materials. However, as marine sediments are dredged to maintain and expand port facilities, sediments that were contaminated from previous activities must be dealt with in an environmentally sound manner.

While clean dredged material can be disposed in open water environments under both the Section 103 of the Marine Protection, Research, and Sanctuaries Act (MPRSA) and Section 404 of the Clean Water Act (CWA), management of contaminated dredged material has become increasingly complex. Land based disposal sites are fewer in number, transportation and handling costs continue to escalate and environmental regulations have become more restrictive. Consequently, opportunities for the potential treatment and/or beneficial re-use of contaminated dredged materials are being sought as a potential solution to this dilemma.

One alternative is to simply dispose of contaminated materials in secure, lined landfills. While this option is effective, it is extremely costly and is difficult to achieve for the large volumes of materials produced in port dredging operations. An example of this was a 1996 Port of New York & New Jersey project that aimed for disposal of contaminated marine sediments in landfills. Since the local landfill facilities would not accept the material, a decision was made to

transport the material by barge and rail to a remote disposal facility. Cost for this activity was about $235 per cubic meter for 91,000 cubic meters of contaminated dredge material; clearly an option that is not economically viable for the long term.

Another alternative allowing beneficial re-use of the material is to solidify and stabilize the contaminated marine sediments to produce a material that can be utilized as fill in port and local area construction projects. The key criteria are that the material must exhibit good structural properties and not contaminate the environment.

Subsequent to the 1996 disposal project, the Port of New York & New Jersey considered a range of beneficial reuse options, and ultimately modified its approach to require that contaminated marine sediments be stabilized and utilized for upland fill material. This approach has resulted in the successful stabilization treatment and construction utilization of over 4 million cubic meters of contaminated dredged materials (Loest, 1998).

Treatment has been accomplished with a variety of stabilization equipment, including onshore pug mill mixers and in-barge mixers. A typical project included the following activities:

- **Dredging** - dredging operations were conducted in a manner that minimized mobilization and spreading of fine sediments and silt.

- **De-watering** - removal of excess water.

- **Debris removal** - this activity is necessary to remove cables, pilings etc. and can be accomplished with screens at the dredge site or onshore. Another alternative is the use of excavator units to remove debris from loaded barges or land based processing tanks or cells prior to treatment.

- **Solidification and/or stabilization** - this activity can be carried out onshore or in the barge. For onshore operations, marine sediments are offloaded to a holding area and then conveyed to a pug mill to be mixed with cement based reagents. For in-barge treatment, the cement-based reagents are added to the sediments and mixed with a separate hydraulic mixer.

- **Offloading** - the reagent mix is important in order to minimize the set time so the stabilized sediments can be offloaded as quickly as possible. Typically, the sediments are offloaded or handled as soon as there is no free water and the sediments are in a wet soil consistency.

- **Placement** - even though cement based reagents absorb and eliminate free water, the resulting stabilized material still has a high moisture content and must be dried before use. This is typically accomplished by laying down 0.3 meter lifts of the stabilized material in the use area. The material is aerated with discs or other implements and allowed to dry to optimum moisture content. Following drying, the material is compacted, typically with vibratory rollers or any standard soil compaction equipment. The result is a firm construction base and beneficial reuse of contaminated marine sediments.

All of the methods described rely on cement and/or cement/ash combinations to achieve solidification and stabilization. Stabilized marine sediments were used as structural fill for the New Jersey Metro Mall in Elizabeth, New Jersey and are currently being used in the development of a golf course, resort and condominium project. Over 2 million cubic meters of solidified and stabilized marine sediments were also used to fill and provide a low-permeability cap for a brown-field development site in New Jersey. These projects typically utilized Portland Type II cements at about 8 percent mixture by weight, and in some cases also incorporated limekiln dust and coal fly ash.

The key aspect of these projects was to treat the contaminated marine sediments in a manner that produced a stable, structural fill material that could be quickly utilized. Typical dredge sediments can take months or years to dry to a level that allows for use and, after drying, still provide the potential for environmental contamination. The use of cement based materials for solidification and stabilization allows the dredge sediments to be used as fill within a matter of days.

2.0 BENCH SCALE STUDY SCOPE

The following summarizes the scope of the Cement-Based Stabilization Bench Study:

2.1 FIELD SAMPLING PLAN

A field-sampling plan was prepared at the outset of the study detailing the collection, handling and management of sediments from the four regional source sites that were to be tested. The sampling plan included the following items:

- Overview of the sampling program
- Proposed sampling locations
- Volumes and types of samples to be collected at each location
- Description of positioning and sampling methods
- Handling and shipping procedures
- Project management, team responsibility, and contact information.

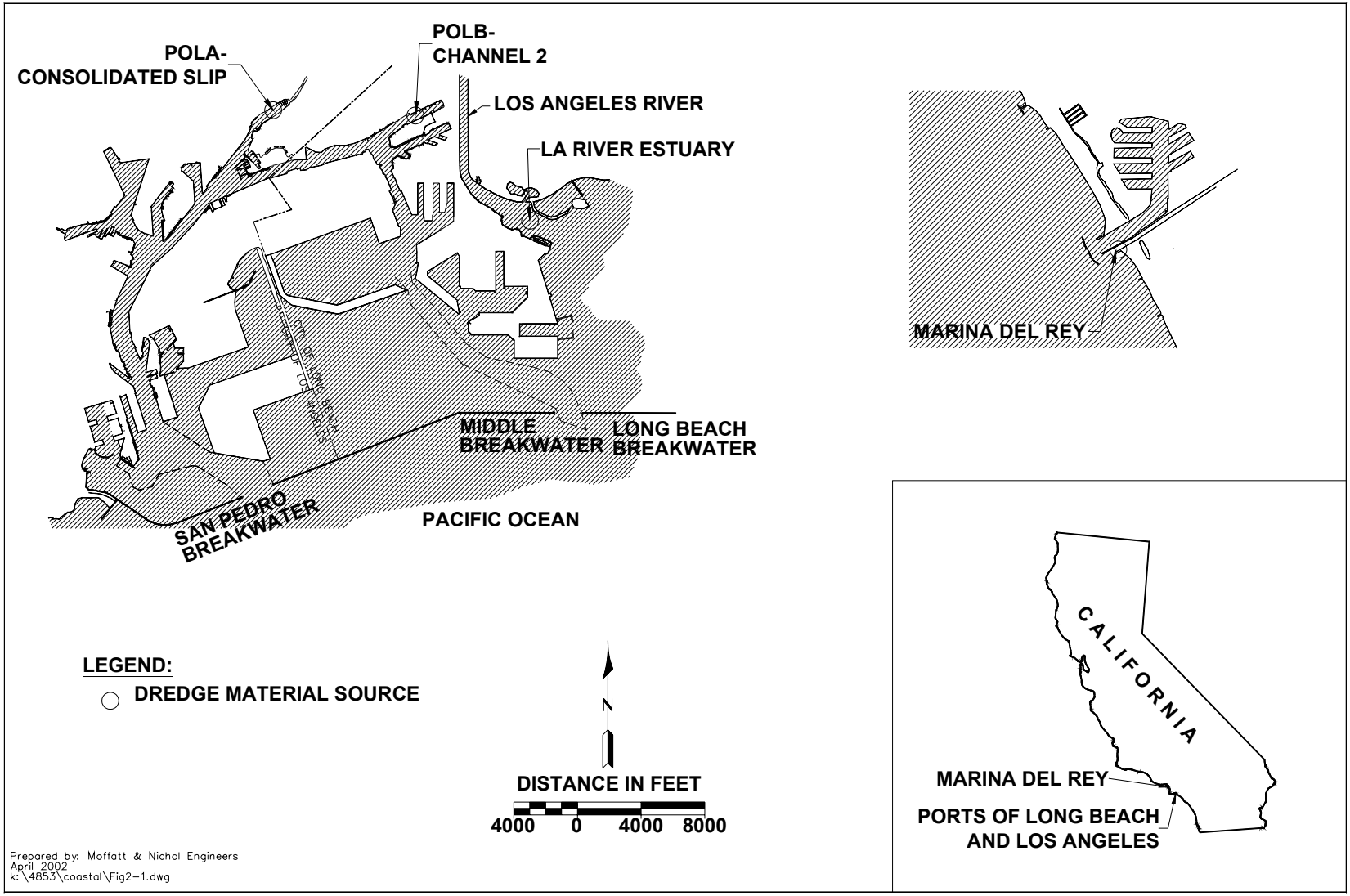
The plan was prepared in accordance with the current state of the practice for sampling and testing of marine sediments and applicable sections of the *Green Book*, *RIA*, and *Gold Book* (USEPA/USACE, 1991; USACE/USEPA, 1993; AND USEPA/USACE, 1998, respectively). The field-sampling plan is included as Attachment A to this report.

2.2 SEDIMENT AND WATER SAMPLE COLLECTION

Sediment and water samples were collected from the four source sites including:

- Marina del Rey – Mouth of Ballona Creek
- Los Angeles River Estuary
- Port of Long Beach – Channel 2
- Port of Los Angeles – Consolidated Slip

Specific sample locations were selected based on coordination with the Corps of Engineers, port personnel and regulatory agencies. Figure 2-1 shows the location of the four sample sites. Minimum sediment and water sample volumes are summarized in Table 2-1.



CEMENT-BASED STABILIZATION OF DREDGED MATERIAL	LOCATION MAP	Figure 2-1

Table 2-1 Minimum Sample Volumes

Sample Location	Physical Testing	Chemical Testing	
	Sediment (liters)	Sediment (liters)	Water (liters)
All Sites	170	3.5	3.5

Sediment samples for chemical testing were placed in appropriate containers and stored in accordance with Plumb (1981). Any sample showing external contamination due to handling or incorrect sampling procedures required re-sampling. A detailed inventory of each sample was maintained and is presented in this report. Formal chain-of-custody procedures were followed and documented. In addition, a detailed soils log was maintained for each sampling site.

2.3 CEMENT-BASED STABILIZATION TESTING PLAN

A testing plan for the cement-based stabilization bench scale testing (CSBST) was prepared detailing the following:

- Sample handling and storage upon arrival from the field.
- Procedures and equipment for re-agitation, mixing, and self-weight consolidation of each sample.
- Procedures and equipment for removing free water from the surface of the consolidated sample.
- Procedures and equipment for the collection of representative sub-samples for physical and chemical testing and bench scale stabilization testing.
- Certification of binder materials to be used in the investigations.
- Procedures and equipment for adding binder agents.
- Method for determining time of setting.
- Method and duration of curing.
- Procedures and equipment for collection of samples for physical and chemical testing from each post-stabilization sample.
- General description of physical and chemical tests to be performed on samples collected before and after stabilization.
- Recommended percentages of different binder agents to be added. If percentages were found to vary with moisture content, grain size, or other factors, then the relationship for determining the quantity of binder to be added was presented.

2.4 CEMENT-BASED STABILIZATION BENCH SCALE TESTING

2.4.1 Sample Preparation

Prior to testing, sufficient seawater was specified to be added to the samples such that the samples were completely in suspension in order to reasonably replicate material characteristics during dredging operations. At least twice the sample volume of site seawater was mixed with the soil samples. Upon mixing, the sample was allowed to consolidate under its own weight for two hours without disturbance. Upon completion of the self-weight consolidation period, excess surface water was immediately removed by suction or other acceptable means.

2.4.2 Pre-Stabilization Sub-Sampling

Upon removal of excess surface water, sub-samples were immediately collected for the tests listed Table 2-2.

Table 2-2 Pre-Stabilization Sub-Sampling Requirements

Physical Testing	Chemical Testing
• Grain Size • Atterberg Limits • Specific Gravity • Compaction • Consolidation • Permeability • Unconfined Compressive Strength • Direct Shear	• Bulk Chemistry • Conventionals • Waste Extraction Test (WET) • Synthetic Precipitation Leaching Procedure (SPLP) • Pore Water Salinity

2.4.3 Mixture Proportions

The effects of three different binder additives were evaluated at three different mixture percentages for a total of nine post-stabilization samples at each source site. The percentage of binder represents the ratio of binder material to dry weight soil (sampled and prepared native material). The three different binder additives evaluated for this study were:

- Portland cement (ASTM C 150, Type II)
- Coal fly ash (ASTM C 618, Class F)
- High lime fluidized bed ash (acceptance based on submittal of a minimum nine kilogram record sample for additional testing by the Government)

For each of the three binder additive materials, the quantity amount of binder to be added to the sampled and prepared native material was determined based on the following criteria:

- An upper boundary, lower boundary, and a median percentage of additive were determined based on site specific sediment characteristics, data gathered from the pre-stabilization lab test results, and previous experience of corresponding end effects for the type of the native material being tested.

- The upper limit was specified to correspond to a percentage of binder which, when added to the prepared native material and cured, clearly and significantly prevents the loss of contaminants as well as improves the strength properties of the native material. The upper limit of binder was designated to be a percentage of material, which is reasonable in comparison with the state of the practice of soil-cement stabilization technology.

- Similarly, the lower limit was to correspond to an amount of binder additive which corresponds to the minimum percentage of binder which when added to the prepared native material and cured will show some improvement in strength characteristics and indicate some improvements and capability of binding contaminants.

- The median percentage was chosen as the concentration at the mid-point of the upper and lower limits.

An additional sample of POLB sediments was collected, processed, and manipulated in the same way with the exception that no binder was added. This sample served as a control to estimate contaminant loss or addition during the CSBST process.

The methods of introducing and mixing of binder as well as curing methods and procedures were specified to be representative of anticipated construction procedures.

2.4.4 Post-Stabilization Sub-Sampling

- For all site sediments at seven (7) days, a sample was obtained and tested for unconfined compressive strength and vane shear strength from each of the different site's nine (9) different binder combinations.

- For all site sediments at twenty-eight (28) days, a sample was tested for unconfined compressive strength and vane shear strength from each of the different site's nine (9) different binder combinations.

- For Los Angeles River Estuary (LARE) sediments only at twenty-eight (28) days, a sample was obtained and tested for all of the physical and chemical tests listed in Table 2-3 from each of the nine (9) different binder combinations.

- For all site sediments, except LARE, at twenty-eight (28) days, a sample was obtained and tested from the middle binder concentration for each of the binder combinations for all of the physical and chemical tests listed in Table 2-3. Three (3) additional samples were chosen and approved by the Contracting Officer, and tested for all of the physical and chemical tests listed in Table 2-3.

Table 2-3 Post-Stabilization Sub-Sampling Requirements

Physical Testing	Chemical Testing
• Grain Size • Atterberg Limits • Compaction • Consolidation • Permeability • Vane Shear • Unconfined Compressive Strength • Direct Shear	• WET • SPLP • Pore Water Salinity

2.4.5 Laboratory Physical Testing

Physical testing was performed by Smith-Emery Geoservices in accordance with Table 2-4.

Table 2-4 Test Methods for Physical Testing

Test	Test Method
Moisture Content	ASTM D 2216
Grain Size	ASTM D 422
Atterberg Limits	ASTM D 4318
Specific Gravity	ASTM D 854
Compaction	ASTM D 1557
Permeability	ASTM D 5856 or ASTM D 2434
Vane Shear	ASTM D 2573 or ASTM D 4648
Unconfined Compressive Strength	ASTM D 1633, Method A
Consolidation	ASTM D 2435
Shear Strength	ASTM D 3080

2.4.6 Laboratory Chemical Testing

Chemical testing was performed by ToxScan, Inc. in accordance with the test methods shown in Table 2-5 and the minimum laboratory reporting limits shown in Table 2-6. All testing was conducted using EPA approved methodologies suitable for marine sediments and which yield the required detection limits with good precision and accuracy.

Table 2-5 Chemical Testing - Analytical Methods for Sediment and Water Samples.[1]

Analyte	Sediments	Water and Elutriates
Arsenic	EPA 7061	EPA 206.3
Cadmium	EPA 6020 or 7131	EPA 200.8 or 213.2
Chromium	EPA 6020 or 7191	EPA 200.8 or 218.2
Copper	EPA 6020 or 7211	EPA 200.8 or 220.2
Lead	EPA 6020 or 7421	EPA 200.8 or 239.2
Mercury	EPA 7471	EPA 245.1
Nickel	EPA 6020 or 7520	EPA 200.8 or 249.2
Selenium	EPA 7741	EPA 270.3
Silver	EPA 6020 or 7761	EPA 200.8 or 272.2
Zinc	EPA 6020 or 7950	EPA 200.8 or 289.2
Organotins (Butyltins)	Uhler and Durell, 1989	Uhler and Durell, 1989
Sulfides	EPA 9030	EPA 376.1
Petroleum Hydrocarbons	EPA 1664	EPA 1664
Pesticides	EPA 8081 GC-ECD	EPA 8081 GC-ECD
PCBs	EPA 8082 GC-ECD	EPA 8081 GC-ECD
PAHs	EPA 8270C GC-MS	EPA 415.1
Total Organic Carbon	Gaudette, et al., 1974	
Grain Size	Plumb 1981	
Percent Moisture	EPA 160.3	
Pore Water Salinity		
Waste Extraction Test (WET)	CCR, Title 22	
Synthetic Precipitation Leaching Procedure (SPLP)	EPA Method 1312	

NOTES

(1) Table based on Table 5, "Analytical Methods for Sediment, Water, and Tissue Samples," p. 20, Sampling and Analysis Plan, Chemical Evaluation of Sediments Proposed for Dredging in Los Angeles River Estuary, Port of Los Angeles, California, prepared by Kinnetic Laboratories/Toxscan, Inc., for the US Army Corps of Engineers, Los Angeles District, DRAFT dated 31 Jan 01.

(2) Allen D. Uhler and Gregory S. Durell, Measurement of Butyltin Species in Sediments by n-Pentyl Derivatization with Gas Chromatography/Flame Photometric Detection (GC/FPD) and Optional Confirmation by Gas Chromatography/Mass Spectometry (GC/MS), February, 1989.

(3) Henri, E. Gaudette, Wilson R. Flight, Lois Toner, and David W. Folger, "Determination of Organic Carbon in Recent Sediments" in Journal of Sedimentary Petrology, Vol. 44, No. 1, pp. 249-253, 1974.

(4) Russell H. Plumb, Jr., Procedures for Handling and Chemical Analysis of Sediment and Water Samples, Environmental Laboratory, US Army Engineer Waterways Experiment Station, 1981.

(5) Francis A. DiGiano, Cass T. Miller, Jeyong Yoon, Dredging Elutriate Test (DRET) Development, US Army Corps of Engineers, Waterways Experiment Station, Contract Report D-95-1, August 1995.

(6) James M. Brannon, Tommy E. Meyers and Barbara A. Tardy, Leachate Testing and Evaluation for Freshwater Sediments, US Army Corps of Engineers, Waterways Experiment Station, Miscellaneous Paper D-94-1, April 1994.

(7) Title 22, California Code of Regulations, Appendix II, Chapter 11, Division 4.5, paragraph 66700.

Table 2-6 Chemical Testing - Target Analytes and Reporting Limits[1]

	Reporting Limits	
Analyte	**Sediment (mg/kg or ppm, dry weight)**	**Water (µg/L or ppb)**
Conventionals		
TOC	0.1%	1.0
Percent Solids	0.1%	--
pH	0.1 pH units	0.1 pH units
Total Sulfides	0.1	0.1
Grain Size	0.1%	--
Total Recoverable Petroleum Hydrocarbons	100	5.0
Pore Water Salinity	0.1ppt?	--
Metals		
Arsenic	0.1	1.0
Cadmium	0.1	0.3
Chromium	0.1	0.5
Copper	0.1	0.5
Lead	0.1	0.5
Mercury	0.02	0.2
Nickel	0.1	1.0
Silver	0.1	0.2
Zinc	1.0	5.0
Semivolatiles		
2-Methylnaphthalene	20	10
Acenaphthene	20	10
Acenaphthylene	20	10
Anthracene	20	10
Benzo(a)anthracene	20	10
Benzo(a)pyrene	20	10
Benzo(b)fluoranthene	20	10
Benzo(g,h,i)perylene	20	10
Benzo(k)fluoranthene	20	10
Chrysene	20	10
Dibenzo(a,h)anthracene	20	10
Fluorene	20	10
Fluoranthene	20	10
Indeno(1,2,3-c,d)pyrene	20	10
Naphthalene	20	10
Perylene	20	10
Phenanthrene	20	10
Pyrene	20	10
Pesticides		
2,4-DDD	0.002	0.05
2,4-DDE	0.002	0.05
2,4-DDT	0.002	0.05
Aldrin	0.002	0.05
Chlordane and derivatives	0.002	0.05
Dieldrin	0.002	0.05
Endosulfan I	0.002	0.05
Endosulfan II	0.002	0.05
Endosulfan Sulfate	0.002	0.05

	Reporting Limits	
Analyte	**Sediment (mg/kg or ppm, dry weight)**	**Water (μg/L or ppb)**
Endrin	0.002	0.05
Heptachlor	0.002	0.05
Heptachlor epoxide	0.002	0.05
Hexachlorocyclohexane isomers	0.002	0.05
Lindane	0.002	0.05
Technical Chlordane	20	1.0
Toxaphene	20	1.0
PCBs		
Arochlor 1016	20	1.0
Arochlor 1221	20	1.0
Arochlor 1232	20	1.0
Arochlor 1242	20	1.0
Arochlor 1248	20	1.0
Arochlor 1254	20	1.0
Arochlor 1260	20	1.0
Total PCBs	20	1.0
Organotins		
Monobutyltin	0.001	0.002
Dibutyltin	0.001	0.002
Tributyltin	0.001	0.002
Tetrabutyltin	0.001	0.002

NOTES

(1) Table based on Table 6, "Target Analytes and Reporting Limits," pp. 21-22, Sampling and Analysis Plan, Chemical Evaluation of Sediments Proposed for Dredging in Los Angeles River Estuary, Port of Los Angeles, California, prepared by Kinnetic Laboratories/Toxscan, Inc., for the US Army Corps of Engineers, Los Angeles District, DRAFT dated 31 Jan 01.

3.0 SAMPLE ACQUISITION

3.1 SAMPLING TECHNIQUES

Several different sampling techniques were utilized in the collection of material for the CSBST study. Material from Marina del Rey (MdR), Consolidated Slip in the Port of Los Angeles (POLA), and Channel 2 in the Port of Long Beach (POLB) were collected using a boxcore device. Material from the Los Angeles River Estuary (LARE) was collected using a vibracore and hammer core.

3.1.1 Boxcore Sample Collection

Sampling was performed by MEC personnel from the research vessel *JB* on July 16 and 17, 2001. Sites were located using differential Global Positioning System (dGPS). Samples were collected using a boxcore as shown in Photo 3-1 with a 0.25 m^2 sample surface area. The boxcore and all sampling utensils were decontaminated between stations by washing with alconox and rinsing with seawater.

Photo 3-1

Once a sample was on deck, it was assessed for acceptability. Only samples with an intact surface area were accepted. Accepted samples were transferred from the boxcore to a plastic tub and a digital photograph of each accepted grab sample was taken. Physical characteristics of each sample such as color, consistency, and odor were recorded on a field-sampling log. The samples were then transferred to clean, polyethylene bags placed inside pre-cleaned 19-liter (5-gallon) HDPE sealable buckets. Multiple drops were required to collect the 170 liters (45 gallons) required for subsequent testing and analyses. Full buckets were kept cold on the boat in coolers using ice, then transferred to a refrigerated truck maintained at 4° C at the end of each sampling day.

3.1.2 Vibracore and Hammer Core Sample Collection

Cores were collected using a Rossfelder P-5 electric vibracore (Photo 3-2) deployed from a sampling barge. The vibracore was equipped with a pre-cleaned 0.10 meter (four-inch) diameter aluminum barrel and stainless steel cutter head. The barrel and all sampling utensils were decontaminated between stations by washing with alconox and rinsing with seawater. The standard system is capable of collecting cores up to 6 meters (20 feet) long and can be equipped to handle greater depths up to an additional 3 meters (10 feet). Sediment cores were collected to project depth (9.1 meters), plus the 0.6 meter (2 feet) of over-dredging allowance, unless refusal was encountered. Refusal is defined as less than 0.05 meters (2 inches) of penetration per minute.

Due to the composition of the sediment, two of the stations at the LARE site (Station 2 and 4) could not be penetrated to project depth with the vibracore. At these stations a hammer core was used. The hammer core employs the use of a 27-kilogram (60-pound) slide hammer, which is placed over the end of a barrel and is manually driven into the sediment (Photo 3-3). This method permits for greater penetration at stations where consolidated sediments are encountered.

Each core was retrieved to the vessel platform where the sediment sample was extruded from the core barrel onto polyethylene lined collection trays. Each core was then examined by a technician and the core description and other pertinent data and observations were logged. Representative photographs of each station were taken. The cores were then transferred to clean, polyethylene bags placed inside pre-cleaned 19-liter (5-gallon) HDPE sealable buckets. A sufficient number of cores were collected to provide the required volume of material per station for subsequent testing and analyses. Buckets of sediment were kept cold on the boat in coolers using ice, and were transferred to a refrigerated truck maintained at 4° C at the end of each sampling day.

Photo 3-2

Photo 3-3

3.2 SAMPLING LOCATIONS

Sampling locations at Marina Del Rey, the Port of Los Angeles, the Port of Long Beach, and the Los Angeles River Estuary are shown in Figure 2-1. Details of location coordinates and other sampling specifics are provided in Table 3-1. Sampling stations were located using a Leica MX400B differential Global Positioning System (dGPS) accurate to ±5 meters.

Table 3-1 Sampling Station Locations

Sample Location		NAD 83		Sampling Dates	Target Penetration	Equipment
		Latitude	Longitude			
Marina Del Rey		33° 57.652	118° 27.503	7/16/01	0-.15 m	Box Core
POLA		33° 46.60	118° 14.52	7/17/01	0-.25 m	Box Core
POLB		33° 46.336	118° 13.197	7/17/01	0-.25 m	Box Core
LARE	1	33° 45.645	118° 12.035	7/24-26/01	5.9 m	Vibracore
	2	33° 45.653	118° 12.057	7/26/01	5.9 m	Hammer core
	3	33° 45.623	118° 12.082	7/26/01	5.8 m	Vibracore
	4	33° 45.598	118° 12.028	7/25/01	5.8 m	Hammer core

3.3 SAMPLE BLENDING

Samples were processed at MEC's Carlsbad laboratory. Sediment from each site was homogenized to a consistent color and texture utilizing a pre-cleaned 260 liter (9.0 cubic foot) electric mixer. Homogenized samples were returned to clean, double lined polyethylene bags inside of 19 liter (5 gallon) buckets, and stored in a refrigerated truck at 4° C until shipment.

3.4 SAMPLE PRESERVATION AND CHAIN-OF-CUSTODY

Upon collection, sediment samples were transferred from the sampling device to polyethylene bags inside pre-cleaned 19 liter (5-gallon) HDPE sealable buckets. All samples were double bagged for safety and sealed with cable ties. The bags were labeled with all pertinent information (sample location, date, time, grab or attempt number, and technician's initials), and a sample collection log was completed for each. Samples were kept cold in the field in coolers using wet ice, and were transferred to a refrigerated truck maintained at 4° C at the end of each sampling day. This truck was also used to transport and store the samples during their processing at MEC. Proper Chain of Custody (COC) procedures was followed from the field to the MEC laboratory. After the samples were processed at the MEC laboratory, sub samples of each site were shipped to ToxScan, Inc. for chemical analyses. These samples were placed in pre-cleaned glass jars with Teflon® lined lids. These jars were then sent overnight via FedEx inside of coolers packed with blue ice. COC forms were included with each shipment. The remaining material in the buckets was delivered by refrigerated truck to Waste by Rail by an MEC courier, along with proper COC forms.

3.5 SAMPLING PHOTOS

The following are selected photographs of representative samples at each sampling station.

4.0 CEMENT-BASED STABILIZATION BENCH SCALE TESTING

Cement-based stabilization bench testing was performed at the Waste By Rail, Inc. (WBR) laboratory facility located adjacent to WBR offices in Newport Beach, California. Project samples were received at the laboratory from MEC on July 30, 2001. The samples were stabilized according to the Scope of Work (SOW) and all samples of stabilized dredge material were forwarded to the appropriate laboratory for chemical or physical testing.

4.1 LABORATORY EQUIPMENT

The WBR laboratory is equipped to perform small-scale tests of dredge sediments and other materials. The following summarizes the equipment utilized for the bench test program:

- **Platform scale -** WBR maintains a certified Ohaus electronic platform scale with a capacity of 50 kg (110 lbs.). The scale was checked and certified by California Scale Company on August 10, 2001 and was primarily used to weigh samples before mixing.

- **Pulp balance -** An Ohaus triple beam pulp balance with a capacity of 20 kg (44 lb) was used to weigh reagents.

- **Bench top mixer -** A Kitchen Aide mixer with a 1.9 liter (0.5 gallon) capacity was used for mixing small amounts of samples and reagents to evaluate various properties.

- **Testing mixer -** Imer Mix 60 low speed mortar mixer (approximately 70 rpm) with a removable mixing tub was used to mix samples and reagents. Each bucket portion of sample weighed between 17 kg and 33 kg (37.5 lbs. to 72.5 lbs.). The mixer capacity was about 57 liters (15 gallons). A low speed mortar mixer is more appropriate than a high-speed mixer in that it more closely resembles operating speeds of large field mixers.

- **Refrigerator -** A refrigerator was maintained in the laboratory to provide for temporary storage of samples prior to shipment.

- **Modified Vicat equipment -** An ELE-Soil Test Vicat unit was used to evaluate stabilized mixture set-time. The Vicat unit applies a standard weight of 300 grams in the form of a 10 mm diameter solid steel tube plunger to the surface of the stabilized sample (a smaller diameter needle can also be used for ASTM cement testing). Readings of the depth of the plunger penetration are taken with time. Depending upon the degree of penetration of the Vicat plunger, the firmness or "set" of the mixture can be estimated. This "modified" Vicat test allows for evaluation of a "soft set" time with respect to identifying material handling

- **Characteristics for Loading and Hauling -** The conventional ASTM C187/C191 Vicat tests use much smaller needles, with greater penetration potential, and are designed to evaluate cement mixtures for a relatively "hard set" on a cement surface such as a cement used in a roadway

Although set-time measurement was not included in the Scope of Work, the WBR group felt it was important to track this parameter and modified Vicat measurements were taken for all of the stabilization sample groups. Mixture set-time is important because quicker setting mixes can greatly reduce field equipment requirements and speed production. This is an important aspect in evaluating overall operating costs with different reagent mixtures. Photo 4-1 shows the modified Vicat test apparatus. More detailed discussion of the modified Vicat testing is provided in Attachment B.

Photo 4-1

4.2 PRELIMINARY EVALUATION

Prior to beginning the bench testing program, WBR undertook a preliminary evaluation of the four samples to determine water content and optimum mixture combinations. This preliminary evaluation focused on small-scale tests and visual observation of sample behavior. The optimum testing conditions were chosen based upon WBR's experience in working with contaminated dredged sediments using cement based stabilizing reagents.

4.2.1 Sample Receipt

MEC delivered project samples on July 30, 2001 (Photo 4-2). MEC also forwarded raw samples from each of the four sample areas directly to ToxScan for chemical analysis. Chain of custody

protocol was observed for all samples received and sent by WBR. All samples were stored in the WBR laboratory prior to shipment.

Photo 4-2

Samples from each of the four areas were inspected and the following general characteristics were noted:

- **MdR** - very coarse, sandy material with little or no cohesion. Strong sulfide odor and shells and debris evident.
- **LARE** - also very sandy material; not as coarse as MdR. Strong sulfide odor.
- **POLB** - heavy cohesive material. Very strong sulfide odor and numerous shells.
- **POLA** - oily material with cohesive and crude oil consistency. Strongest sulfide odor of all samples, with very strong organic vapor odors.

4.2.2 Scoping Tests

Samples from each project area were evaluated to determine the optimum stabilization treatment approach. A key aspect of cement-based stabilization is that adequate water must be present to allow for thorough mixing. The bench test aim was to simulate stabilization treatment of sediments from a dredging operation. The samples obtained by MEC for the program were optimum for sampling purposes, but had a somewhat lower water content than would generally be expected from ongoing dredging operations.

Preliminary discussions regarding testing plans had assumed that excess water would have to be removed from the samples prior to mixing in order to achieve the appropriate water content for an efficient stabilization mixture. However, observation of the samples in preliminary testing indicated that water would have to be added to POLB and POLA samples in order to begin approximating "as dredged" moisture conditions. Preliminary evaluation of small quantity (approximately 1 liter samples) indicated that the various reagents would solidify the samples in a reasonable amount of time at concentrations previously estimated.

4.2.3 Seawater Acquisition

In order to provide material with characteristics that would approximate dredging conditions, WBR obtained a quantity of seawater that would be used throughout the testing program. On August 1, 2001, WBR loaded a 1,900 liter (500 gallon) plastic water tank at the LARE boat ramp in Long Beach (see Photo 4-3). The tank was triple rinsed with seawater and then filled using a new hose and pump. The seawater tank was towed to WBR's laboratory and the seawater was temporarily stored in the tank until new 208 liter (55 gallon) drums were delivered. Following delivery of the drums, the seawater was transferred to the drums and the seawater was used throughout the test program for water addition to the samples and for rinsing mixing equipment. The seawater was recorded in the laboratory notebook as "WBR 001" and a sample was retained in a glass jar in the laboratory refrigerator.

Photo 4-3

4.2.4 Seawater Addition

Typical dredging operations for contaminated material utilize clamshell dredge buckets. Depending upon the thickness of the sediment "face" being dredged and dredge bucket manipulation, the water content of the dredged material can vary significantly. In general, water content will be reduced with increasing face thickness. This is due to the ability of the dredge operator to obtain a dredge bucket full of sediment (with a thick face) vs. a bucket with a high water content (thin face mixture of sediment and water).

The bench test sediments were obtained with care and most likely minimized water content compared with production scale dredging. In order to more closely simulate production samples, seawater was added to the POLB and POLA samples. Samples from the four test areas were evaluated in bench scale "scoping" tests to determine mixing characteristics and the optimum water content to allow thorough sample and reagent blending.

Original bench testing plans called for simulating “as dredged” samples, i.e., conditions by mixing each sample with seawater, allowing the sample to settle and then decanting the seawater to a fixed level. In order to evaluate this procedure, WBR began testing samples from the four areas with seawater addition. Five gallons (approximately 19 liters) of seawater was mixed with each five gallon sample using the Imer Mix 60 mixer. The samples were allowed to settle out after mixing for one to five hours, the supernatant water was siphoned and the samples evaluated.

This procedure was disappointing in that the samples did not settle quickly and showed great variability. Also, the siphoning procedure inevitably removed significant amounts of sample fines, raising a concern that the samples might become biased due to removal of contaminates. After consulting with COE representatives and Moffatt & Nichol Engineers representatives, the seawater addition procedure was abandoned and the samples were evaluated in the bench top mixer to determine optimum water content for each sample.

Preliminary scoping tests were performed on all samples using the bench top mixer and 1 liter samples with 8% cement as the reagent. The preliminary scoping tests indicated that LARE and MdR samples could be adequately mixed as received from MEC. However, the POLB and POLA samples were simply too thick to mix on an as-received basis. After trial seawater additions, the optimum was chosen as:

- **LARE and MdR** - no seawater added. Reagents to be added as-received.

- **POLB** - very thick viscous sample requiring 12% by weight of seawater to approximate an ‘as-dredged’ condition. All POLB samples to include 12% seawater addition as part of the testing protocol.

- **POLA** - thick, oily sample requiring 5% by weight of seawater to approximate an ‘as-dredged’ condition. All POLA samples to include 5% seawater addition as part of the testing protocol.

4.3 CEMENT STABILIZATION REAGENTS

Three reagents were used to evaluate stabilization of the four dredged sediment samples:

- **Cement -** The cement used for stabilization tests was ASTM C150, Type II cement from Calaveras Cement Company, located in California. This was "fresh" un-carbonated cement from a bulk silo (ISG Resources).

- **Fly Ash -** Fly ash used was ASTM C 618, Class F fly ash. The fly ash source for this test series was Navajo Generating Station (NGS) in Page, Arizona (obtained through ISG Resources). NGS ash is routinely imported into Southern California and is readily available in commercial quantities.

- **Fluidized Bed Coal and Wood Ash -** Fluidized bed ash used for the test series was a highly reactive high lime content ash from the Coal Mac Power Plant in Southern California. It is readily available in commercial quantities.

Reagent samples were received and stored at the WBR laboratory in late July. Portland cement and fly ash reagents were received in plastic lined paper bags. The fluidized bed ash was received in 19 liter (5 gallon) plastic buckets. About 4.5 kgs of each reagent was placed in a labeled plastic container with a tight fitting plastic lid. Reagents from these containers were weighed out and used for the stabilization mixing tests. The following table summarizes reagent costs:

Table 4-1 Reagent Source and Cost

Reagent	Source	Cost per Ton Range For Southern CA
Portland cement	Calaveras	$67 to $82
Fly ash	Navajo GS	$32 to $36
Fluidized bed ash	Coal Mac GS	$17 to $20

4.4 BENCH TEST PROCEDURES

All bench test stabilization procedures were performed in the WBR laboratory. Table 4-2 summarizes specific test mixtures by location.

4.4.1 Stabilization Mixing Procedure

Samples for each of the four project areas were placed in 57-liter (15-gallon) HDPE (polyethylene) plastic mixing tubs designed especially for the low speed mixer (see Photo 4-4). In order to avoid sample cross contamination, four mixing tubs were used, i.e., one tub for each of the four sample areas. The procedure for each sample is described in Attachment B.

Photo 4-4

4.4.2 Observations During Sample Preparation

Samples from the four project areas showed considerable physical variability. All samples were successfully mixed at the specified reagent addition levels but reacted differently to mixing procedures and reagent addition. The following notes summarize some of the more noteworthy aspects:

- **LARE -** This material had a high content of coarse sand. It exhibited a strong sulfide odor upon opening the sample buckets. The high coarse sand content abraded the HDPE mixing tub, but the samples mixed easily and set quickly with 8% cement, showing a firm consistency about 3.5 hours after mixing.

- **MdR -** The MdR samples also had a high sand content that was even coarser than LARE. Sulfide odor was strong. There was also a large amount of debris present in the MdR samples, ranging from wood and plastic scraps to wire and metal pieces. Large portions of debris were removed as appropriate and the sample weight adjusted accordingly. The MdR samples also abraded the HDPE mixing tubs during stabilization mixing. The heavy coarse sand content of the MdR samples made mixing difficult. After pre-mixing, it was sometimes necessary to use a small shovel to make sure that unmixed material did not remain on the bottom of the mixing tub. The addition of reagents (especially fly ash and fluidized bed ash) greatly aided the suspension of the coarse sand and improved mixing characteristics. MdR samples also set very quickly with 8% cement, showing a firm consistency about 3 hours after mixing.

- **POLB -** This material had a high clay and/or silty-clay content and a strong sulfide odor. There was a significant amount of shells in the sample, but it was not practical to remove the shell debris. The POLB samples as received were very difficult to mix due to the minimal water and high clay content. Following initial scoping tests, 12% by weight of seawater was added to each POLB sample during the pre-mixing stage. This greatly improved the mixing characteristics and produced a material that more closely resembles "as-dredged" sediments. POLB samples were also quick setting with 8% cement, showing firmness after about 2 hours.

- **POLA -** The POLA material also had a high clay content and a very strong sulfide odor coupled with a very strong organic odor. The POLA material was also very oily, with the appearance of a high content of crude oil sludge. Following the scoping tests, 5% by weight of seawater was added to each of the POLA samples during the pre-mixing stage. POLA material set quickly with 8% cement, with a firm set in about 3 hours. However, lower levels of cement greatly extended the set times.

Discussion of the relevance of the modified Vicat tests is included in the following section, along with discussion of other physical test parameters.

Following completion of stabilization mixing and modified Vicat testing, the remainder of the sample was placed in the original 19-liter (5-gallon) plastic sample bucket (Photo 4-5), labeled and recorded on a chain of custody form. The stabilized sample was then sent to Smith-Emery GeoServices for geotechnical testing. As part of the testing procedure, Smith-Emery prepared samples of stabilized material that were sent to ToxScan Laboratories for chemical analysis.

Photo 4-5

4.5 DISCUSSION REGARDING TIMING OF PHYSICAL TESTING

At the outset of the study, the following general protocol was agreed upon:

- One of the key purposes of the bench test series was to test materials under conditions and timelines that were consistent with full-scale operational procedures. Projected full scale operations timelines were:
    - Materials would be mixed in a holding area and allowed to cure.
    - Approximately 12 to 24 hours following mixing, the stabilized material would be excavated and stockpiled.
    - In the following 2 to 10 days, the stockpile material would be placed in the laydown working area and dried to optimum moisture for compaction.
- Bench samples were to be mixed with cement and other binders in the WBR laboratory. Following mixing, the samples were placed in plastic buckets, labeled and held for Smith-Emery (SE) pick-up per chain of custody records.

- SE technicians generally obtained the mixed samples about 12 to 24 hours following mixing in the WBR laboratory. However, some samples were picked up by SE two to three days following mixing.

- Prior to geotechnical testing, SE dried the mixed samples to optimum moisture content. This procedure added days to the testing protocol and simulated the overall testing intent of following actual full-scale operational procedures.

The intent of the bench test program in simulating field operations meant that standard ASTM procedures for testing soil-cement would be modified per bench program test timelines. For example, rather than immediately placing mixed samples in a mould for compaction testing per ASTM procedures, the material was allowed to cure, was dried to optimum moisture and then reformed into an optimum test sample. Table 4-3 summarizes sample mix times and SE testing times.

Table 4-3 Bench Test Timing

Source Site & Reagent Mix	Sample Mixed	Smith-Emery Received	Grain Size	Atterberg Limits	Vane Shear*	Compaction	Direct Shear*	Unconfined Compression*	Consolidation	Permeability
MDR 6% cement	8/14/01	8/15/01	9/25/01	8/23/01	09/26-10/17/01	8/28/01	09/13-10/04/01	09/17-10/08/01	9/15/01	9/7/01
MDR 4% cem + 8% FB	8/14/01	8/15/01	9/25/01	8/23/01	09/26-10/17/01	8/28/01	09/04-10/05/01	09/17-10/08/01	9/15/01	9/8/01
MDR 4% cem + 6% TF + 4% FB	8/14/01	8/15/01	9/25/01	8/23/01	10/01-22/01	8/28/01	09/17-10/08/01	09/20-10/11/01	9/15/01	9/10/01
MDR 8% cement	9/3/01	9/4/01			10/4/01	9/26/01		10/4/01		
MDR 4% cement	9/3/01	9/4/01			10/5/01	9/27/01		10/5/01		
MDR 6% cement + 6% FB	9/3/01	9/4/01			10/5/01	9/26/01		10/5/01		
MDR 2% cem + 10% FB	9/3/01	9/4/01			10/5/01	9/27/01		10/5/01		
MDR 6% cem + 4% TF + 2% FB	9/3/01	9/4/01			10/5/01	9/27/01		10/5/01		
MDR 2% cem + 8% TF + 6% FB	9/3/01	9/4/01			10/5/01	9/27/01		10/5/01		
LARE 8% cement	8/12/01	8/13/01	9/16/01	8/14/01	09/01-22/01	8/15/01	08/25-09/15/01	09/01-22/01	8/21/01	8/17/01
LARE 6% cement	8/12/01	8/13/01	9/16/01	8/14/01	09/01-22/01	8/15/01	08/25-09/15/01	09/01-22/01	8/22/01	8/18/01
LARE 4% cement	8/12/01	8/13/01	9/16/01	8/14/01	09/01-22/01	8/15/01	08/24-09/14/01	09/01-22/01	9/11/01	8/19/01
LARE 6% cem + 6% FB	8/12/01	8/13/01	9/16/01	8/14/01	09/03-24/01	8/16/01	08/27-09/17/01	09/03-24/01	8/28/01	8/25/01
LARE 4% cem + 8% FB	8/12/01	8/13/01	9/16/01	8/14/01	09/03-24/01	8/16/01	08/28-09/18/01	09/03-24/01	8/31/01	8/23/01
LARE 2% cem + 10% FB	8/12/01	8/13/01	9/16/01	8/14/01	09/04-25/01	8/16/01	08/29-09/19/01	09/04-25/01	8/31/01	8/26/01
LARE 6% cem +4% TF + 2% FB	8/14/01	8/15/01	9/25/01	8/23/01	09/22-10/13/01	8/27/01	09/08-09/29/01	09/13-10/04/01	9/12/01	9/6/01
LARE 4% cem + 6% TF + 4% FB	8/14/01	8/15/01	9/25/01	8/23/01	09/24-10/15/01	8/27/01	09/12-10/03/01	09/14-10/05/01	9/12/01	9/10/01
LARE 2% cem + 8% TF + 6% FB	8/14/01	8/15/01	9/25/01	8/23/01	09/24-10/15/01	8/28/01	09/12-10/03/01	09/14-10/05/01	9/15/01	9/13/01
POLB 6% cement	8/13/01	8/14/01	9/29/01	8/21/01	09/22-10/13/01	8/21/01	09/01-09/22/01	09/04-25/01	9/7/01	8/29/01
POLB 4% cem + 8% FB	8/13/01	8/14/01	029/29/01	8/21/01	09/22-10/13/01	8/21/01	09/01-09/22/01	09/11-10/02/01	10/13/01	8/29/01
POLB 4% cem + 6% TF + 4% FB	8/13/01	8/14/01	9/29/01	8/21/01	09/22-10/13/01	8/22/01	09/03-09/24/01	09/11-10/02/01	10/13/01	9/6/01
POLB 8% cem	9/4/01	9/6/01			10/2/01	9/24/01		10/3/01		
POLB 4% cem	9/4/01	9/6/01			10/3/01	9/24/01		10/3/01		
POLB 6% cem + 6% FB	9/4/01	9/6/01			10/3/01	9/24/01		10/3/01		
POLB 2% cem + 10% FB	9/4/01	9/6/01			10/3/01	9/25/01		10/3/01		
POLB 6% cem + 4% TF + 2% FB	9/4/01	9/6/01			10/3/01	9/26/01		10/3/01		
POLB 2% cem + 8 % TF + 6% FB	9/4/01	9/6/01			10/4/01	9/26/01		10/4/01		
POLB 2% cement	12/4/01	12/5/01	11/18,21/01	12/19/01	01/17,28/02	12/19/01	1/7/02	01/9,25/02	12/26/01-01/04/02	01/2,4/02
POLB raw check sample	9/5/01	9/6/01	02/13,14/02	2/14/02	2/14/02	2/12/02	2/13/02	2/13/02	02/12,19/02	02/13,14/02
POLA 6% cement	8/13/01	8/14/01	10/2/01	8/22/01	09/22-10/13/01	8/22/01	09/04-09/25/01	09/12-10/03/01	10/13/01	9/6/01
POLA 4% cem + 8% FB	8/13/01	8/14/01	10/2/01	8/22/01	09/22-10/13/01	8/22/01	09/08-09/29/01	09/12-10/03/01	10/13/01	9/6/01
POLA 4% cem + 6% TF + 4% FB	8/13/01	8/14/01	9/29/01	8/22/01	09/22-10/13/01	8/25/01	09/11-10/02/01	09/13-10/04/01	9/11/01	9/13/01
POLA 8% cement	8/26/01	8/27/01			9/21/01	9/6/01		9/21/01		
POLA 4% cement	8/26/01	8/27/01			9/21/01	9/6/01		9/21/01		
POLA 6% cem + 6% FB	8/26/01	8/27/01			10/1/01	9/7/01		10/1/01		
POLA 2% cem + 10% FB	8/26/01	8/27/01			10/1/01	9/7/01		10/1/01		
POLA 6% cem + 4% TF + 2% FB	8/26/01	8/27/01			10/1/01	9/7/01		10/1/01		
POLA 2% cem + 8% TF + 6% FB	8/26/01	8/27/01			10/1/01	9/7/01		10/1/01		
POLA 2% cement	12/4/01	12/5/01	11/18,21/01	12/19/01	01/17,28/02	12/18/01	12/27/01	01/9,25/02	12/26/01-01/10/02	12/27,28/01
POLA 2% cem + 4% TF	12/4/01	12/5/01	11/18,21/01	12/19/01	01/17,28/02	12/19/01	12/28/01	01/4,20/02	12/26/01-01/08/02	12/28,31/01

* Multiple dates are for 7-day and 28-day (after re-molding) tests

5.0 PHYSICAL TEST PROGRAM AND RESULTS

The purpose of the physical test program was to assess the improvement of the engineering characteristics of the source site sediments as a result of the CBS process. This section describes the physical testing program and summarizes the results.

5.1 PHYSICAL TEST PROGRAM

Smith-Emery GeoServices performed the physical testing in accordance with the contract scope summarized in Section 2.4.5 of this report. The engineering qualities of a soil are determined by a range of physical parameters. The following provides a general description of each of the physical tests performed including their relevance. The ASTM testing method used is also referenced.

- **Grain Size** – Grain size distribution is a key parameter in characterizing a soil type, and plays an important role in determining both physical and chemical (i.e., contaminant binding) characteristics (ASTM D 422). The relative distribution of sands, silts and clays are reported for each raw site material. The Unified Soil Classification System (USCS) was also used to classify the materials.

- **Atterberg Limits** – Test determines the *liquid limit* (LL), *plastic limit* (PL), and the *plasticity index* (PI) of soils. The test is commonly used as an integral part of several engineering classification systems to characterize the fine-grained fractions of soils. The LL, PL and PI are also used extensively with other soil properties to correlate with engineering behavior such as compressibility, permeability, compactibility, shrink-swell and shear strength (ASTM D 4318).

- **Vane Shear** – This is a test to measure shear strength in cohesive soil. Vane is turned and torque required to initiate failure is measured, as well as post-failure shear strength (ASTM D 2573).

- **Compaction** – This test is used to determine the relationship between water content and dry unit weight of soils. Soil placed as engineering fill (embankments, foundation pads, road base) is compacted to a dense state to obtain satisfactory engineering properties such as shear strength, compressibility, or permeability. Laboratory compaction tests provide the basis for determining the percent compaction and water content needed to achieve the required engineering properties, and for controlling construction to assure that the required compaction and water contents are achieved. Results are provided in terms of *maximum dry density* and *optimum moisture content* (ASTM D 1557).

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- **Direct Shear** – Measures consolidated drained shear strength in direct shear. Key test results include the *cohesion*, or *strength intercept* of the material, and *the friction angle* (ASTM D 3080). These values were used to calculate the *remolded shear strength* of the various mixes for strength comparison purposes.

- **Unconfined Compressive Strength** – Determines compressive strength of soil-cement using molded cylinders as test specimens (ASTM D 1633 Method A). It should be noted that test accuracy is within approximately 700 psf.

- **Consolidation** – Test to determine rate and magnitude of consolidation of a soil. Compressibility of soils as determined from this test is used to estimate rate and total amount of differential and total settlement of a structure or landfill (ASTM 2435). Test results were used in this study to calculate the *compression index* of the material, providing a relative measure of its compressibility.

- **Permeability** - This test measures ease at which water passes through soil. Results are applied in drainage, seepage and consolidation analyses (ASTM D 2434).

5.2 PHYSICAL TEST RESULTS

Results of the physical testing program for each source site are summarized in the following sections. Due to the inherent variations in the composition of the various source site soils, each is considered separately. Plots of result summaries (Figures 5-1 through 5-4) are included at the end of this chapter. Detailed test results are included in Attachment C.

5.2.1 Marina del Rey

Key CSBST physical test results for Marina del Rey are illustrated in Figure 5-1. The following summarizes the key test results:

General Discussion

Granular soils such as sand are generally suitable for upland engineering applications due to good strength, limited compressibility and ease of drainage. Grain size analysis results indicate the raw MdR material was described as a dark gray silty sand, with a sand content of 93.4 percent. The material was classified under the Unified Soil Classification System (USCS) as SP-SM. Thus from a physical standpoint, the raw MdR material already possesses good engineering qualities. Of interest here, then, is the relative improvement of those qualities associated with the CBS process. Although not specifically required for these materials, containment of contaminants was also an objective of this study. The results are discussed in Section 6.0.

Set Time

Raw dredged material can be difficult to handle due to high moisture content. After placement in a construction compaction area, the raw material can exhibit substantial drying time before reaching optimum moisture content for compaction. The CBS process clearly improved the manageability of the material through reduced set times based on the modified Vicat testing. In effect, the CBS process reduces the water content through the hydration process, thereby reducing the need to drain the material by other means such as air drying and sluicing. When the material is defined as "set" in the modified Vicat testing, it has achieved consistency that can be handled by typical earth moving equipment without the presence of free liquids. Figure 5-1 shows the higher cement concentrations resulted in shorter set times. The other reagents tended to extend set times, but only to a limited extent.

A suggested general and desirable field operating goal is that the stabilized mixtures should be "set" for handling purposes within 12 to 16 hours after mixing. A short set time allows the material to be loaded, transported and placed in the desired fill area with optimum land based and marine equipment usage. Materials with shorter set times also generally exhibit shorter drying times in the field as the stabilized materials are dried to optimum moisture for compaction. In using the modified Vicat procedure as described, a 10mm plunger rod penetration of about 1 to 4 mm is taken as "set" for field equipment handling purposes. At this level of penetration, WBR field experience has shown that the stabilized material does not have free liquids and has a high angle of repose, rendering the material suitable for excavation, loading and hauling purposes. At "zero" plunger rod penetration, the material is competent and easily handled for excavation and hauling purposes.

Atterberg Limits

This test is a classification test similar to the Grain Size Analysis. It is used to determine whether fine-grained materials are plastic, having clay-like properties, or non-plastic, having properties more similar to sands, i.e., fine-grained, non-plastic materials such as silts. Test results found all MdR site samples to be non-plastic.

Vane Shear

The vane shear strength was greatly improved. However, it is important to note that this test is used primarily for soft, saturated cohesive soils, and the samples are not allowed to drain water prior to testing. Thus the limited raw material shear strength is likely due to the relatively high moisture content, which at 24.3 percent upon receipt at the lab was well above the optimum moisture content range of 12.5 percent (see Compaction Test results below). In field applications, this granular material would have generally good draining characteristics (see Permeability Test results) and a drained strength measure would be more appropriate for engineering applications.

The mix with fluidized bed ash (4% cement + 6% Type F ash + 4% fluidized bed ash) resulted in the greatest shear strength. Strengths were improved between the 7-day and 28-day tests, though not as dramatic as for the unconfined compression test.

Compaction Test

Key results of compaction testing include the maximum dry density and the optimum moisture content. Soil density contributes to strength. Maximum dry density of 110 pcf is desired for select fill (Holtz & Kovacs, 1981). The results show minimum effect of the CBS process on maximum dry density, though the higher cement content mix resulted in the least maximum dry density. Note that the raw and mixed materials fall just short of the 110 pcf desired for select fill.

Optimum moisture content is important since it represents the amount of water to be added to achieve the maximum dry density, for a given amount of compactive effort. Optimum moisture content in granular soils is not as critical as for cohesive soils, with variations of up to 2 percent resulting in no significant variation in material properties.

Direct Shear Test

Using the results of the direct shear tests, the remolded shear strength at a depth of 5 feet and 10 feet was calculated and plotted. Ten feet was considered a representative value in the case where many yards of fill may be required to bring a site to grade; five feet was considered as more representative of a shallow footing. For both cases, there was a significant increase in the remolded shear strength relative to the raw material.

Unconfined Compressive Strength

As shown in Figure 5-1, the raw material had no unconfined compressive strength. When mixed with CBS reagents, significant unconfined compressive strength was achieved. For engineering applications, enhanced unconfined compressive strength results in less confinement of the soil required to resist shear failure.

A typical allowable bearing pressure per the *Uniform Building Code* (1997) is 1,500 pounds per square foot (psf). Each of the mixes tested for 28-day strength achieved this strength level, indicating acceptability, for example, for a foundation footing without soil confinement.

The higher cement content was found to provide the greatest 28-day compressive strength. There was also a definite increase in unconfined compressive strength between the 7-day and 28-day tests, with the greatest relative increase associated with the highest cement content. This was likely due to the greater cure time required for the greater amount of cement in the reagent mix.

Consolidation Test

A convenient parameter for expressing the relative compressibility of soils is the *compression index*, which can be determined from stress-strain relationships measured in the consolidation test. Smaller values represent less compressible material. Sowers (1979) suggest soils with compression indices ranging from 0 to 0.19 as having slight or low compressibility. Compression indices along the virgin compression curve were calculated and are illustrated in Figure 5-1. As shown in the figure, both the raw and all the mixed materials are well within the

range of low compressibility. The CBS process did, however, provide some further reduction in compressibility of the raw material.

Permeability Test

Permeability of the material was reduced as a result of the CBS process, except for the mix with the cement/fly ash/fluidized bed ash. Reduction in the permeability could have resulted from increased binding of the material, changing its consistency. However, all the measured permeability coefficients are considered representative of permeable, well-draining material.

5.2.2 Los Angeles River Estuary

Key CSBST physical test results for the Los Angeles River Estuary are plotted in Figure 5-2. Key results are discussed in the following paragraphs. The LARE site material was subjected to a more complete suite of physical testing based on its characterization of typical material requiring ongoing maintenance dredging in the LA County region.

General Discussion

As discussed for the Marina del Rey site soils, sandy soils are generally suitable for upland engineering applications due to good strength, limited compressibility and ease of drainage. Grain size analysis results indicate the raw LARE material was described as dark gray silty sand with a sand content of 89.0 percent and a USCS classification of SP-SM. Thus from a physical standpoint, the raw LARE material already possesses good engineering qualities. Of interest here, then, is the relative improvement of those qualities associated with the CBS process.

Set Time

The CBS process clearly improved the manageability of the material through reduced set times based on the modified Vicat testing. Again as discussed for the MdR material, the CBS process reduces the water content through the hydration process, thereby reducing the need to drain the material by other means such as air drying and sluicing. When the material is defined as "set" in the modified Vicat testing, it has achieved consistency that can be handled by typical earth moving equipment.

Test results indicate that in general, the higher the cement content, the shorter the set time. For the 4% and 6% cement mixture combinations, the cement mix alone set quicker than with the other added reagents. This further confirms the observation that the pozzolanic reagents tend to retard set times.

Atterberg Limits

This test is a classification test similar to the Grain Size Analysis. It is used to determine whether fine-grained materials are plastic, having clay-like properties, or non-plastic, having properties more similar to sands, i.e., fine-grained, non-plastic materials such as silts. Test results found all LARE site samples to be non-plastic.

Vane Shear

The vane shear strength was greatly improved. However, as was noted for the MdR results, this test is used primarily for soft, saturated cohesive soils, and the samples are not allowed to drain water prior to testing. For the LARE material, the moisture content upon receipt at the lab was 26.6 percent; again well above the optimum moisture content range of 14.9 percent. In field applications, this granular material would have generally good draining characteristics (see Permeability Test results) and a drained strength measure would be more appropriate for engineering applications.

The only mix that did not exceed the maximum of 5,000 psf after 28 days was the 2 percent cement combination mix.

Compaction Test

The results in Figure 5-2 show minimum effect of the CBS process on maximum dry density. Again, as for the MdR material, the higher cement content mix resulted in the least maximum dry density. Note that the raw and mixed materials fall just short of the 110 pcf desired for select fill. Optimum moisture content test results show, as for the MdR material, the CBS process had little impact on compactive properties of the LARE material.

Direct Shear Test

Using the results of the direct shear tests, the remolded shear strength at a depth of 5 feet and 10 feet was calculated and plotted. The CBS process results in a clear improvement in shear strength, again most pronounced at higher cement concentrations. The Type F coal ash additive provided the least relative improvement.

Unconfined Compressive Strength

As shown in Figure 5-2, the raw material had no unconfined compressive strength. When mixed with CBS reagents, significant unconfined compressive strength was achieved. For engineering applications, enhanced unconfined compressive strength results in less confinement of the soil required to resist shear failure.

Each of the mixes tested for 28-day strength exceeded the typical allowable bearing pressure of 1,500 psf for a foundation footing without soil confinement, except for the 2% cement combination mix. As for the Marina del Rey material, the highest cement content was found to provide the greatest 28-day compressive strength, although it is surprising that the 6 percent cement mix exhibited less strength than the 4 percent cement mix. Regardless, the LARE material mixes exhibited much greater strengths relative to the MdR material.

Again, there was a definite increase in unconfined compressive strength between the 7-day and 28-day tests, though with less relative effect than the MdR material.

Consolidation Test

Compression indices along the virgin compression curves were calculated and are illustrated in Figure 5-2. As shown in the figure, both the raw and all the mixed materials are well within the range of low compressibility (less than 0.19). The CBS process had minimal impact on LARE material compressibility, except the 2% cement + 10% fluidized bed ash mix, where the compression index more than doubled. This result may be an outlier, and has no significant bearing on the results. It was initially thought that this material may have been mixed at a later date. However, review of the test timing summarized in Table 4-3 indicates that the consolidation test for this reagent mix was performed within the range of test times for the other reagent mixes.

Permeability Test

There was no clear trend indicating the impact on material permeability as a result of the CBS process. All the measured permeability coefficients are considered representative of permeable, well-draining material.

5.2.3 Port of Long Beach

Figure 5-3 summarizes the key CSBST physical test results for the Port of Long Beach. An additional control sample was tested for the POLB material only. The control sample, also referred to as a raw mixed sample, consisted of raw POLB material that was subjected to the same agitation, handling and storage as for the stabilized samples, in order to assess any impact on material characteristics associated with the physical mixing processes, but without addition of stabilizing reagents. Key test results are discussed in the following:

General Discussion

Granular soils such as sand are generally suitable for upland engineering applications due to good strength, limited compressibility and ease of drainage. Finer, cohesive soils are less desirable, and in some cases require some form of physical stabilization. The raw POLB was described in the grain size analysis as dark gray clayey silt, including a 38 percent clay content. The material was classified under the USCS as ML. It is generally these finer materials that can most benefit from the physical stabilization associated with the CBS process.

Set Time

The CBS process clearly improved the manageability of the POLB material through reduced set times based on the modified Vicat testing. The raw material did not set, whereas the set time for processed material ranged from three hours (8 percent cement) to 15 hours (2% cement + 8% Type F +6% fluidized bed ash). Test results indicate that in general, the higher the cement content, the shorter the set time. In all cases, mixes with only cement alone set quicker than with the other added reagents.

Atterberg Limits

This test is typically applied for fine-grained, cohesive soils such as the POLB material. The results indicate minimal impact of the CBS process on material plasticity, except for the 2 percent cement only mix, which significantly increased the plastic range of the material.

Vane Shear

Vane shear strength measurements exceeded 5,000 psf for the raw material and all of the 28-day mixtures.

Compaction Test

Key results of compaction testing include the maximum dry density and the optimum moisture content. As stated previously, soil density contributes to strength, with a maximum dry density of 110 pcf specified in this report as desired for select fill. The results show a fairly significant reduction in maximum dry density when subjected to the CBS processes. The raw and raw mixed (control) samples exhibited densities of approximately 110 pcf, whereas the treated material maximum densities were reduced to around 90 pcf. The results also show a relatively high optimum moisture content required to achieve maximum density for the treated materials, i.e., increasing from around 15 percent for raw materials to between 25 and 30 percent for the treated materials.

Direct Shear Test

Using the results of the direct shear tests, the remolded shear strength at a depth of 5 feet and 10 feet was calculated. The results show some significant increase for the 6 percent cement and 2 percent cement (at 10 feet only) mixes.

Unconfined Compressive Strength

Figure 5-3 shows mixed results for the unconfined compressive strength tests. The 6 percent cement mix showed the greatest 28-day strength improvement. All tests demonstrated strengths well above the minimum 1,500 psf for footing bearing pressure per the *Uniform Building Code* (1997). There was also a general increase in unconfined compressive strength between the 7-day and 28-day tests.

Consolidation Test

Compression indices along the virgin compression curve were calculated and are illustrated in Figure 5-3. As shown in the figure, the 2 percent and 6 percent cement mixes actually increased the compressibility of the material from moderate compressibility range (C.I. = 0.20 to 0.39) into the highly compressible range (C.I. > 0.40) (Sowers, 1979). Given the time delay between stabilization mixing in the WBR laboratory and modified ASTM testing at Smith-Emery, it may be that the higher cement mixes more readily formed a soil-cement matrix that were collapsed during compression testing. None of the other mixes resulted in any appreciable reduction in compressibility relative to the raw material.

Permeability Test

Permeability of the material was significantly increased as a result of the CBS process, with increases relative to the raw material of two orders of magnitude. This is most likely due to creating more of a granular material. The net result is a significant improvement in the drainage characteristics of the material, raising it from a permeability classified as very low to medium to low (Sowers, 1979).

5.2.4 Port of Los Angeles

Key CSBST physical test results for the Port of Los Angeles are plotted in Figure 5-4. Key results are discussed in the following:

General Discussion

The Port of Los Angeles site material from the Consolidated Slip area represents the lowest engineering quality raw material of all the four source sites. The raw composition consists of 41 percent clay, 49 percent silt and only 10 percent sand per the grain size analysis. Such materials generally have poor drainage and high plasticity, shrinkage and swell potential. These characteristics are further demonstrated by the USCS classification of MH for this material. It is these characteristics and the potential to improve these characteristics that is the primary focus of the physical test program.

Set Time

The CBS process clearly improved the manageability of the material, except for the low cement mixes. The 8% cement and 6% cement + 6% fluidized bed ash resulted in set times within six hours. Conversely, the 4% cement alone and both 2% cement mixtures did not set up.

Atterberg Limits

Test results for the plasticity index indicate minimal impact of the CBS process on material plasticity, except for the 6 percent cement only mix, which significantly increased the plasticity index of the material.

Vane Shear

Vane shear strength measurements demonstrated significant shear strength improvement relative to the raw material. Whereas the raw material strength was measured at approximately 800 psf, and all of the 28-day mixtures exceeded 5,000 psf.

Compaction Test

Key results of compaction testing include the maximum dry density and the optimum moisture content. The results show a moderate reduction in maximum dry density when subjected to the CBS processes. The raw sample exhibited a maximum dry density of approximately 90 pcf, whereas the treated material maximum densities were reduced to 80 to 83 pcf. The results also show a relatively high optimum moisture content required to achieve maximum density for the

treated materials, i.e., increasing from around 20 percent for raw materials to between 28 and 30 percent for the treated materials.

Direct Shear Test

Using the results of the direct shear tests, the remolded shear strength at a depth of 5 feet and 10 feet was calculated. The results indicate limited impact on shear strength.

Unconfined Compressive Strength

Figure 5-4 shows a general correlation between cement content and 28-day unconfined compressive strength, with the 6 percent cement mix showing the greatest strength improvement. All tests demonstrated strengths well above the minimum 1,500 psf for footing bearing pressure per the *Uniform Building Code* (1997). Comparing the 7-day and 28-day strength tests indicates consistent, though generally limited improvement in strength.

Consolidation Test

Compression indices along the virgin compression curve were calculated and are illustrated in Figure 5-4. The results show significant improvement in the compressibility characteristics of the material as a result of the CBS process. The raw material compression index falls into the highly compressible range (> 0.50), whereas all but the 2 percent cement mixes were shifted into the low compressibility range (< 0.19).

Permeability Test

Permeability of the material was moderately increased as a result of the CBS process, though the 4 percent cement + 8 percent fluidized bed ash exhibited on order of magnitude increase.

5.3 DISCUSSION OF PHYSICAL TESTING RESULTS

In summary, the CBS process provides for rapid enhancement of dredged material manageability, to the extent that the material can "set up" to a consistency conducive to effective loading and transportation operations. The higher the cement content typically resulted in the shortest set time, and the addition of either of the other reagents tended to extend set times. This was a consistent finding for each of the four source site materials.

As for improvement of engineering properties, the Marina del Rey and Los Angeles River Estuary materials were found to comprise mostly sandy material, with inherent good quality and suitability for beneficial re-use without additional solidification.

The engineering quality of the Port of Long Beach material benefited as a result of the CBS process, mostly through increased remolded shear strength and increased permeability resulting in improved drainage characteristics. The CBS process did not reduce compressibility of the material, which is characterized as moderately compressible, and in some cases increased it. The CBS mixes demonstrating the best combination of engineering qualities were the 4% cement + 8% fluidized bed ash, and the 4% cement + 8% Type F ash + 4% fluidized bed ash combinations.

The Port of Los Angeles material, dredged from the Consolidated Slip area, was considered at the outset of the study to be the most challenging test of the CBS process, both in terms of poor engineering qualities and high contaminant levels. As for improvement of its physical qualities, the CBS process significantly improved shear strength per the vane shear tests, and significantly reduced the material compressibility. Some improvements in drainage characteristics were also garnered, particularly for the 4% cement + 8% fluidized bed ash mixture. This mixture was found to produce the best overall improvement of engineering qualities. The 6% cement mixture was also quite effective, though it was found to significantly increase the plasticity index.

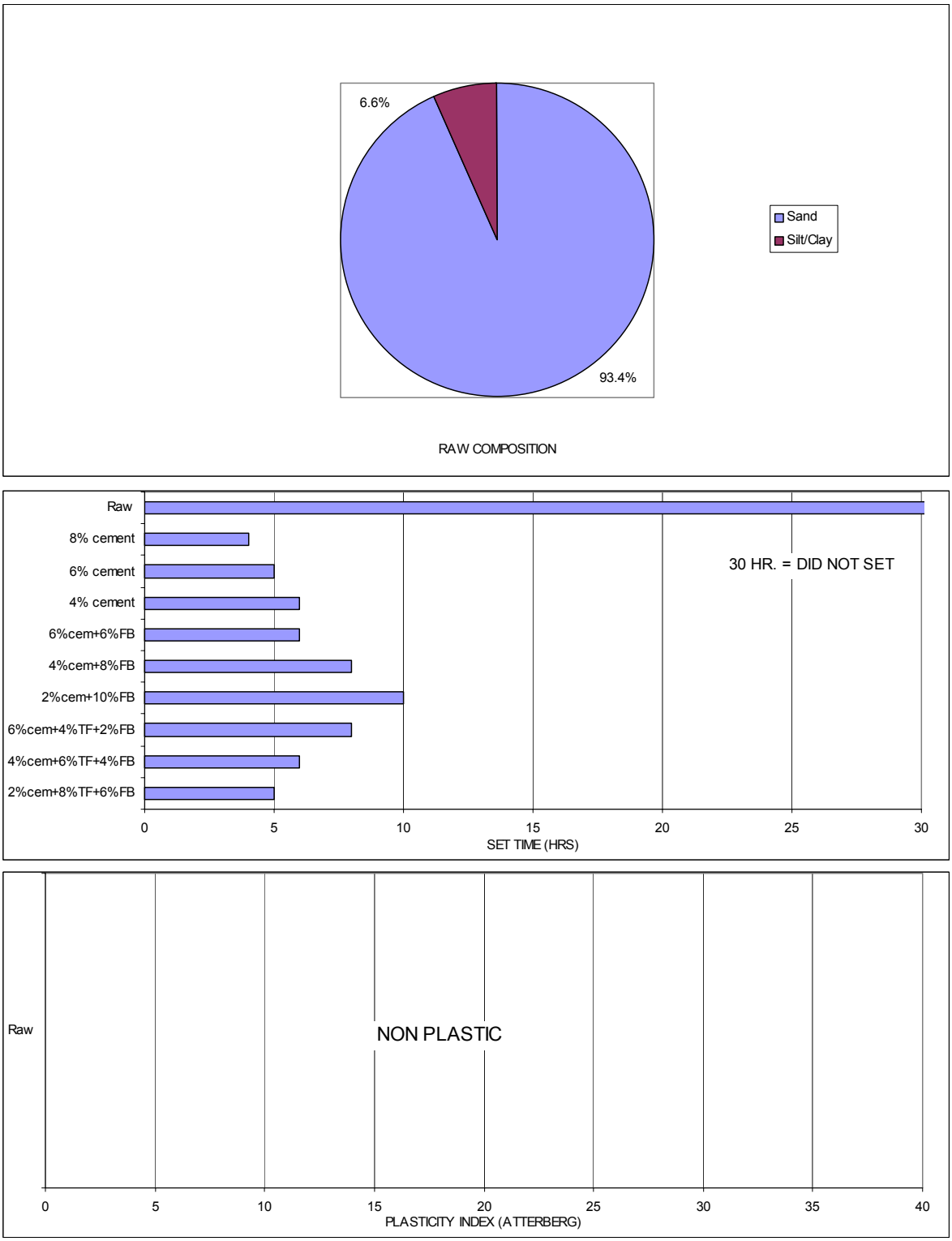

Figure 5-1. Marina del Rey Physical Test Results

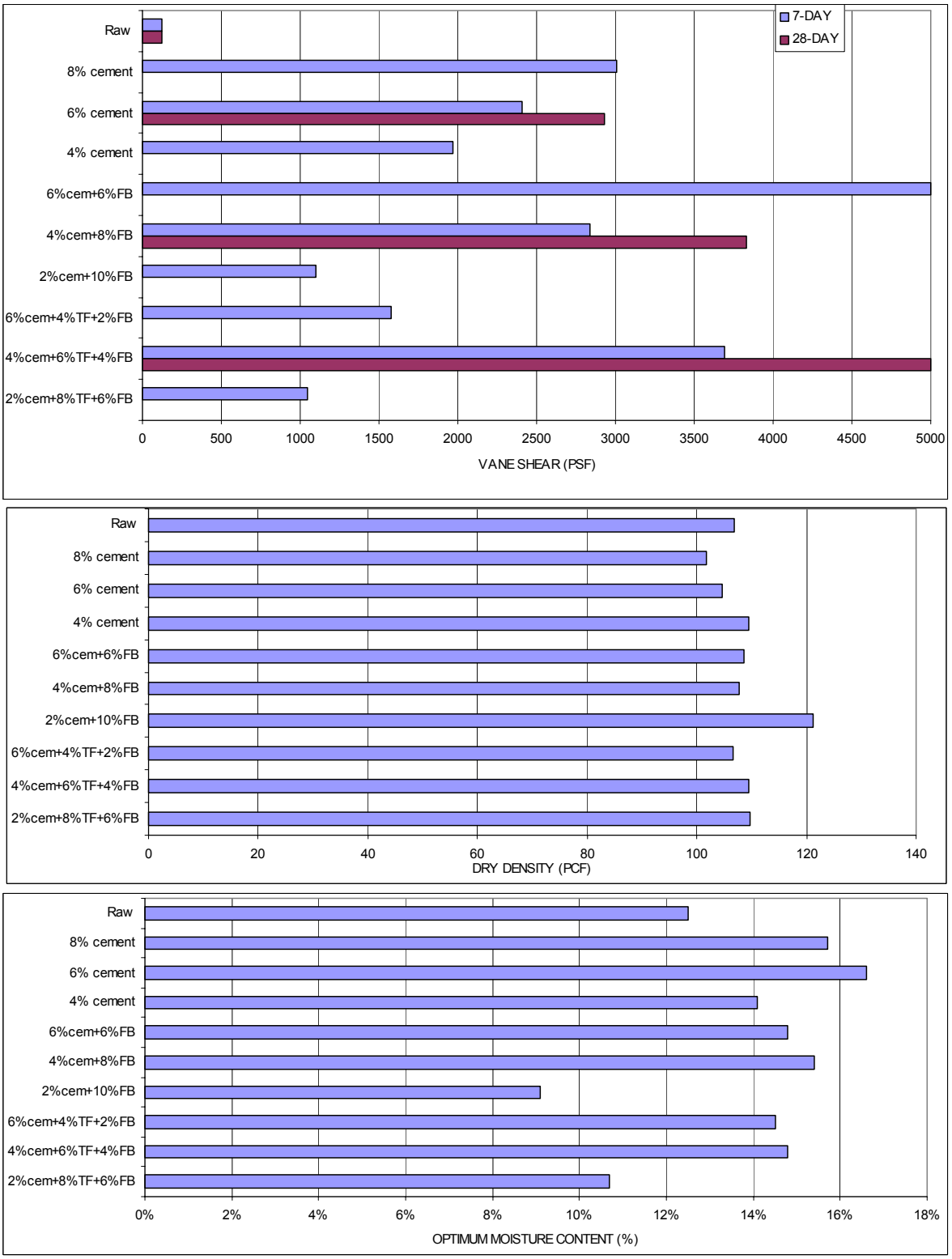

Figure 5-1. Marina del Rey Physical Test Results

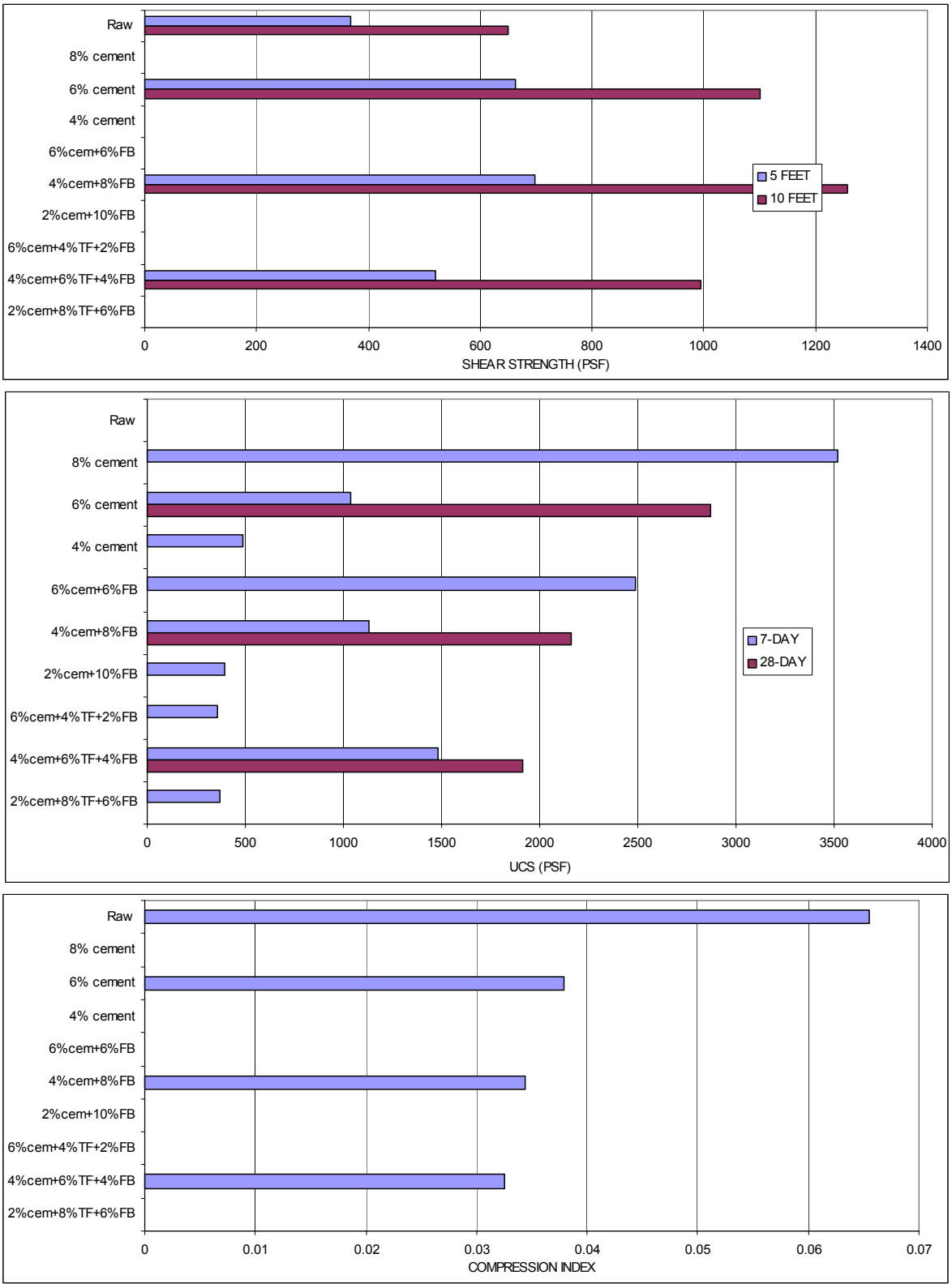

Figure 5-1. Marina del Rey Physical Test Results

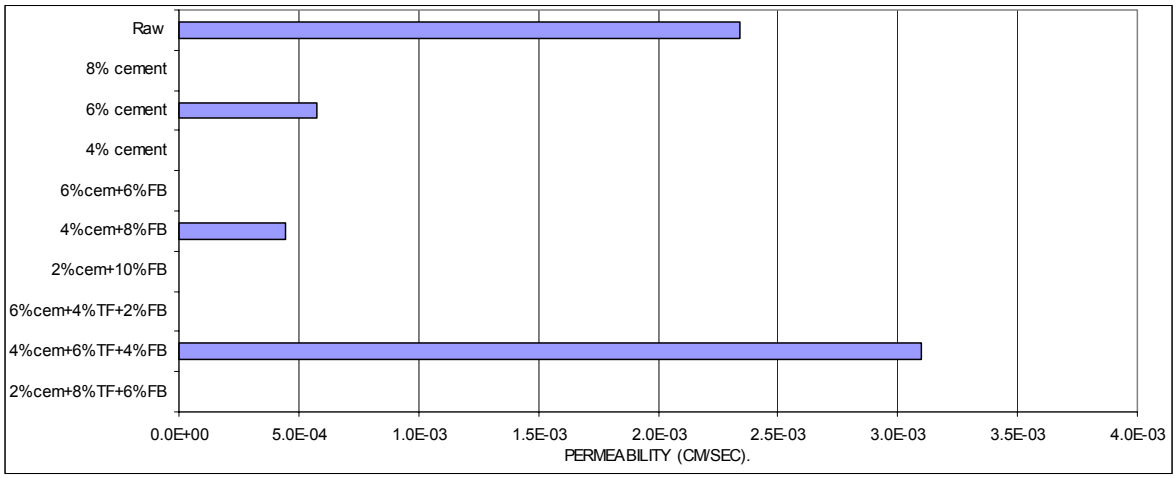

Figure 5-1. Marina del Rey Physical Test Results

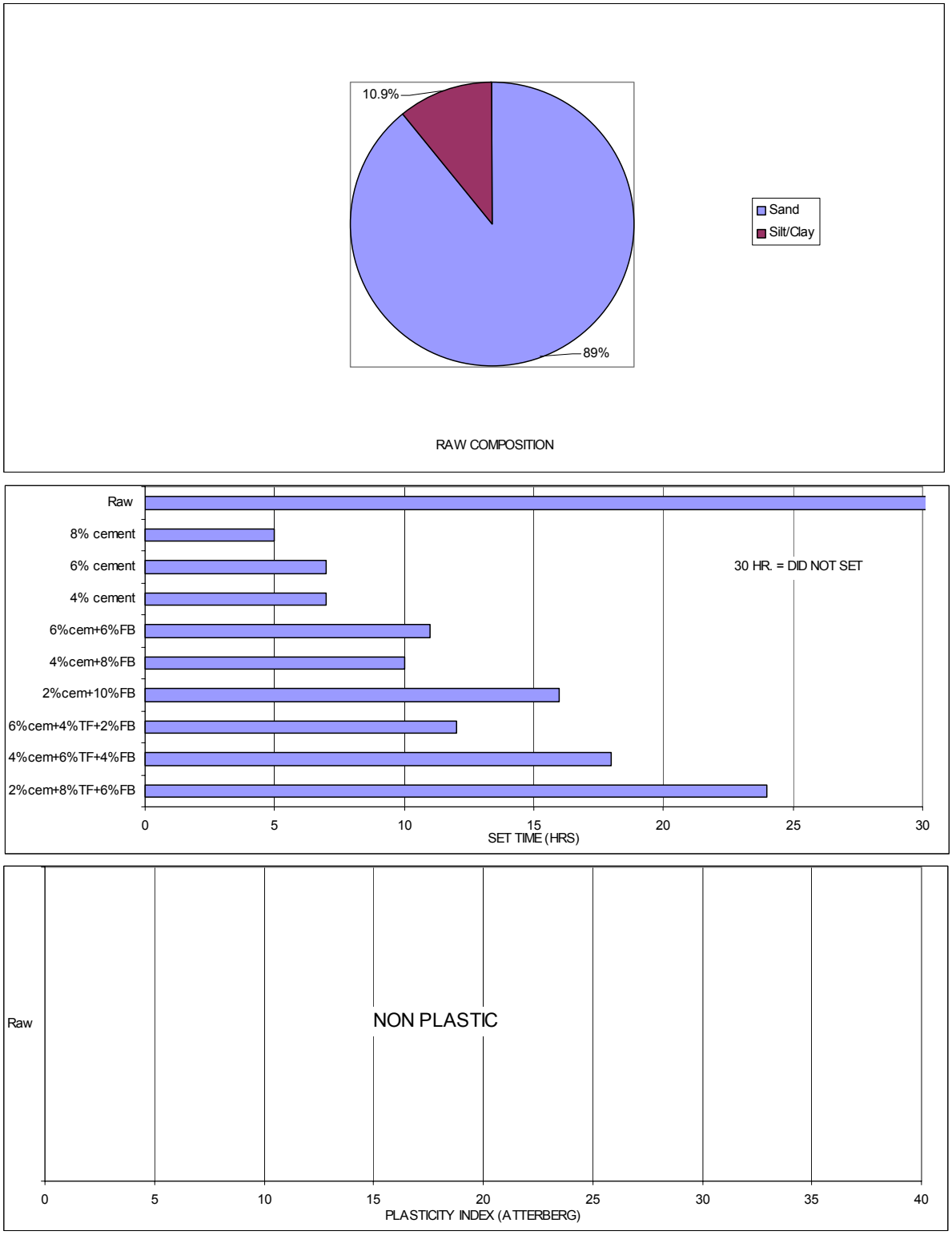

Figure 5-2. Los Angeles River Estuary Physical Test Results

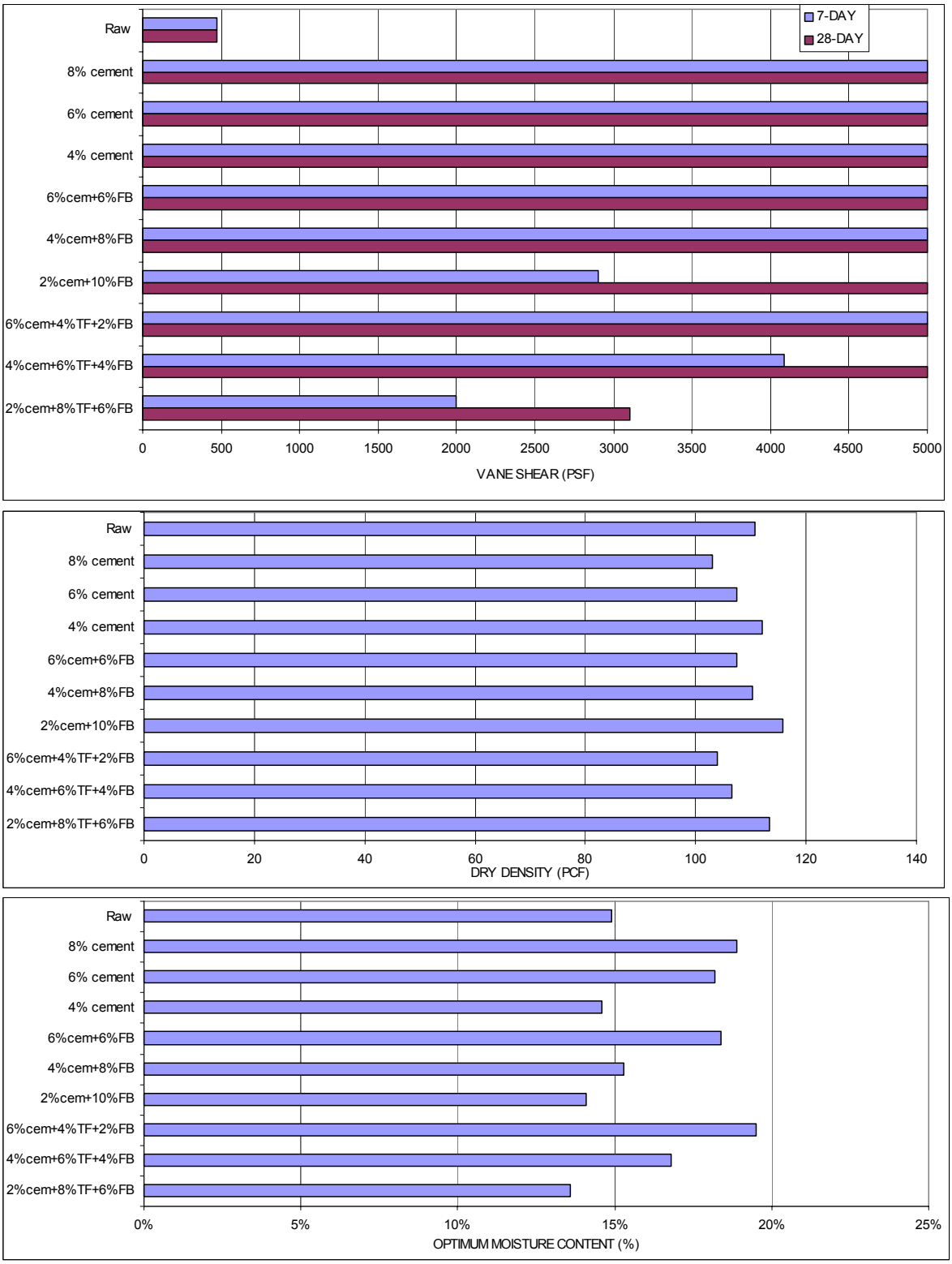

Figure 5-2. Los Angeles River Estuary Physical Test Results

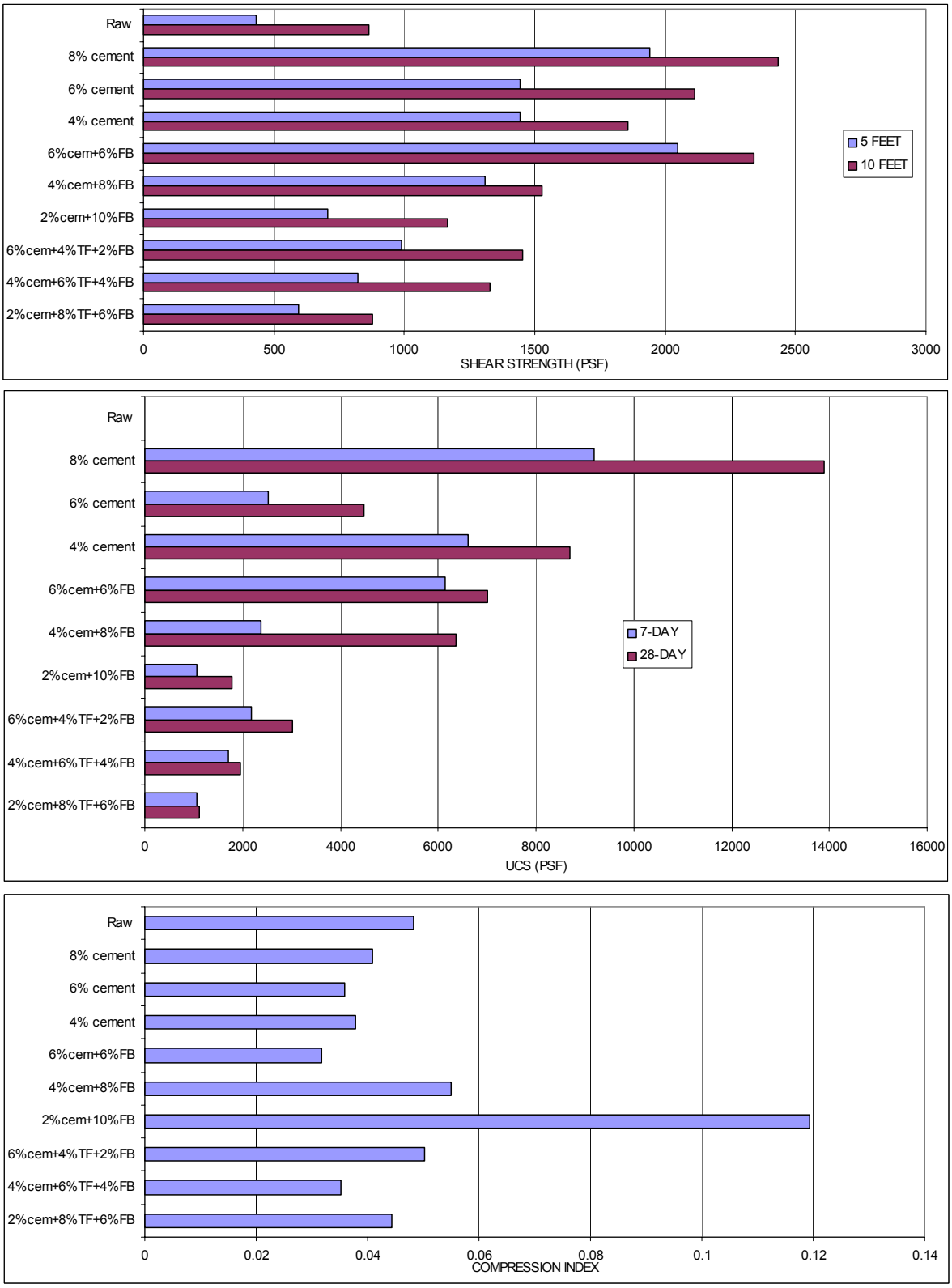

Figure 5-2. Los Angeles River Estuary Physical Test Results

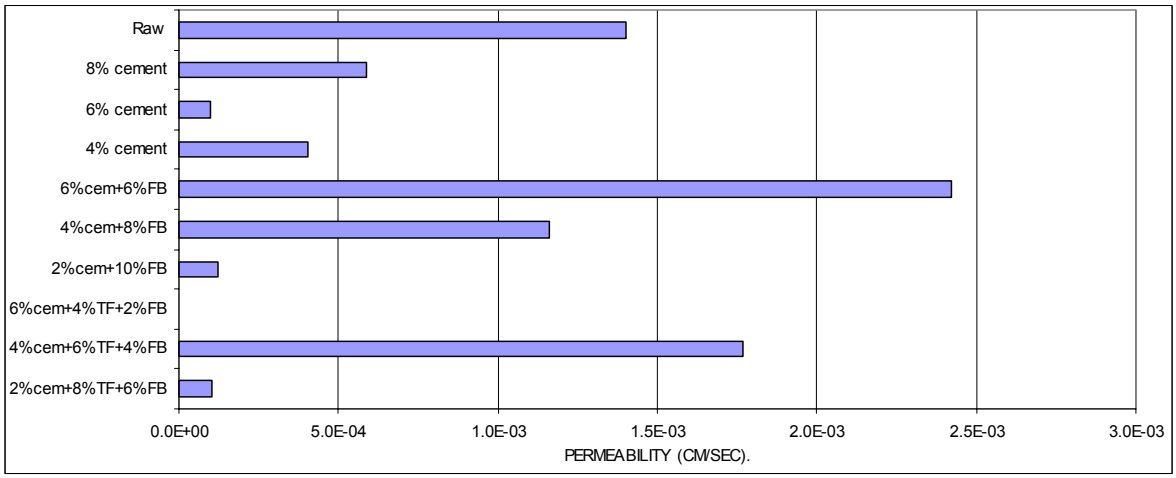

Figure 5-2. Los Angeles River Estuary Physical Test Results

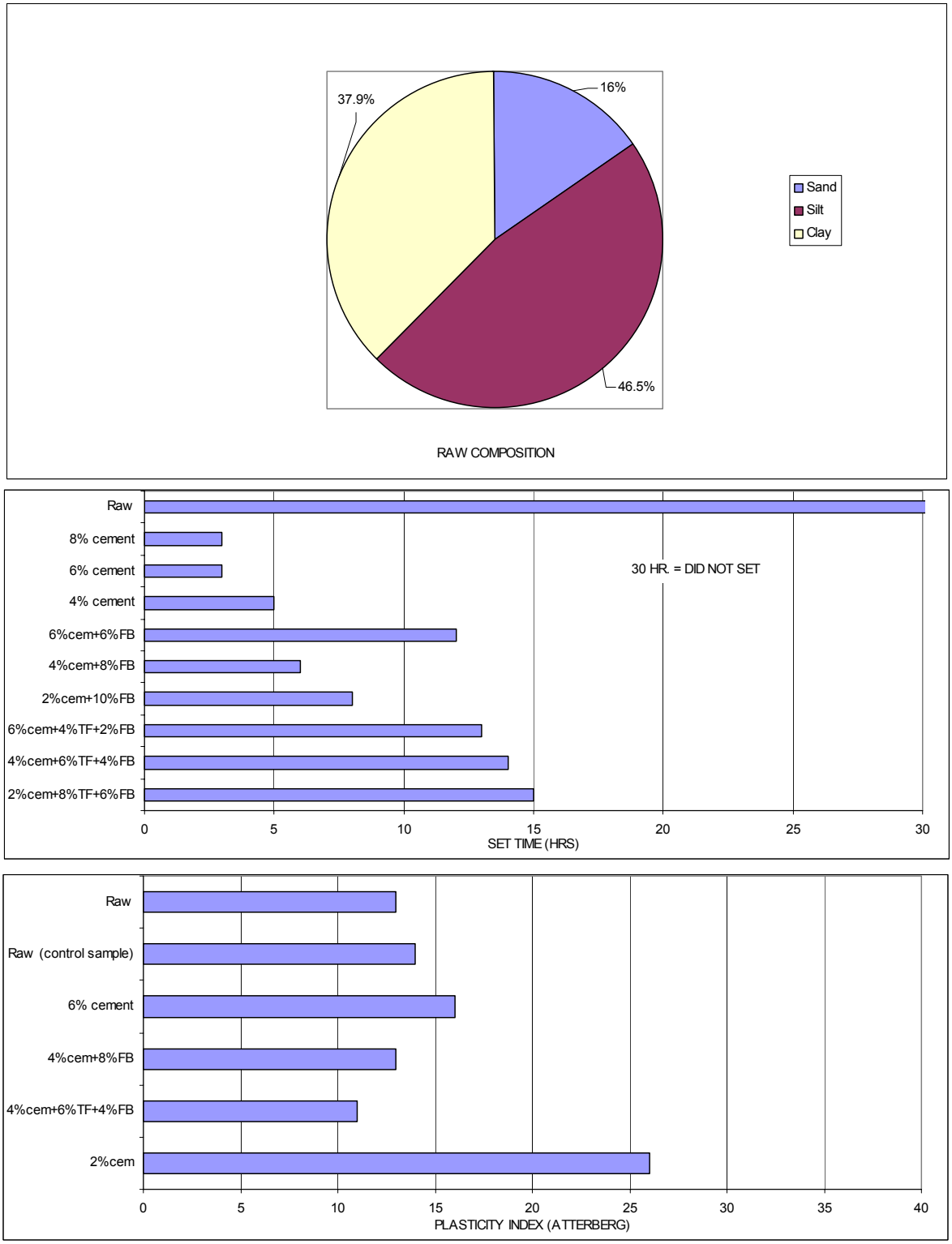

Figure 5-3. Port of Long Beach Physical Test Results

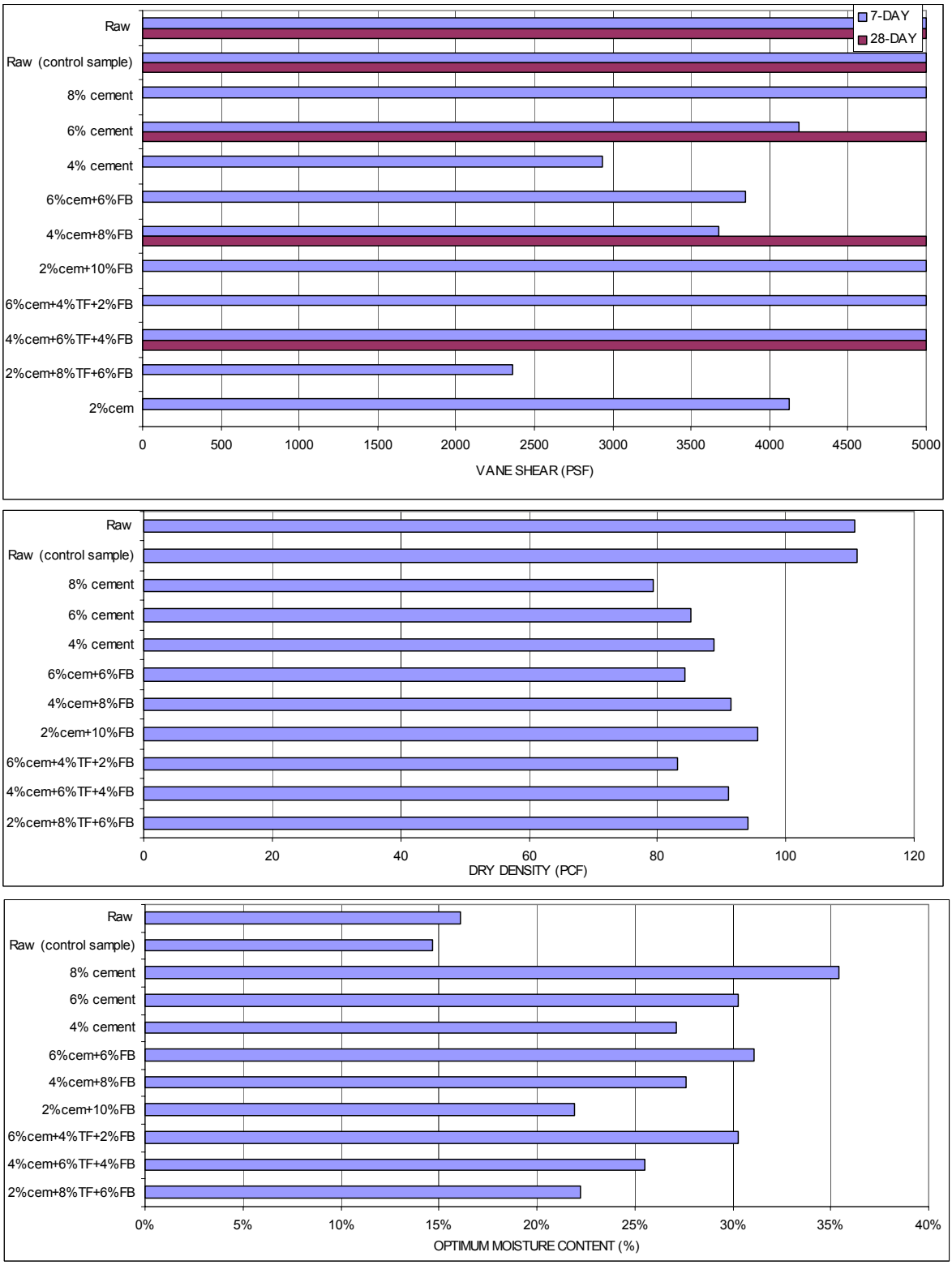

Figure 5-3. Port of Long Beach Physical Test Results

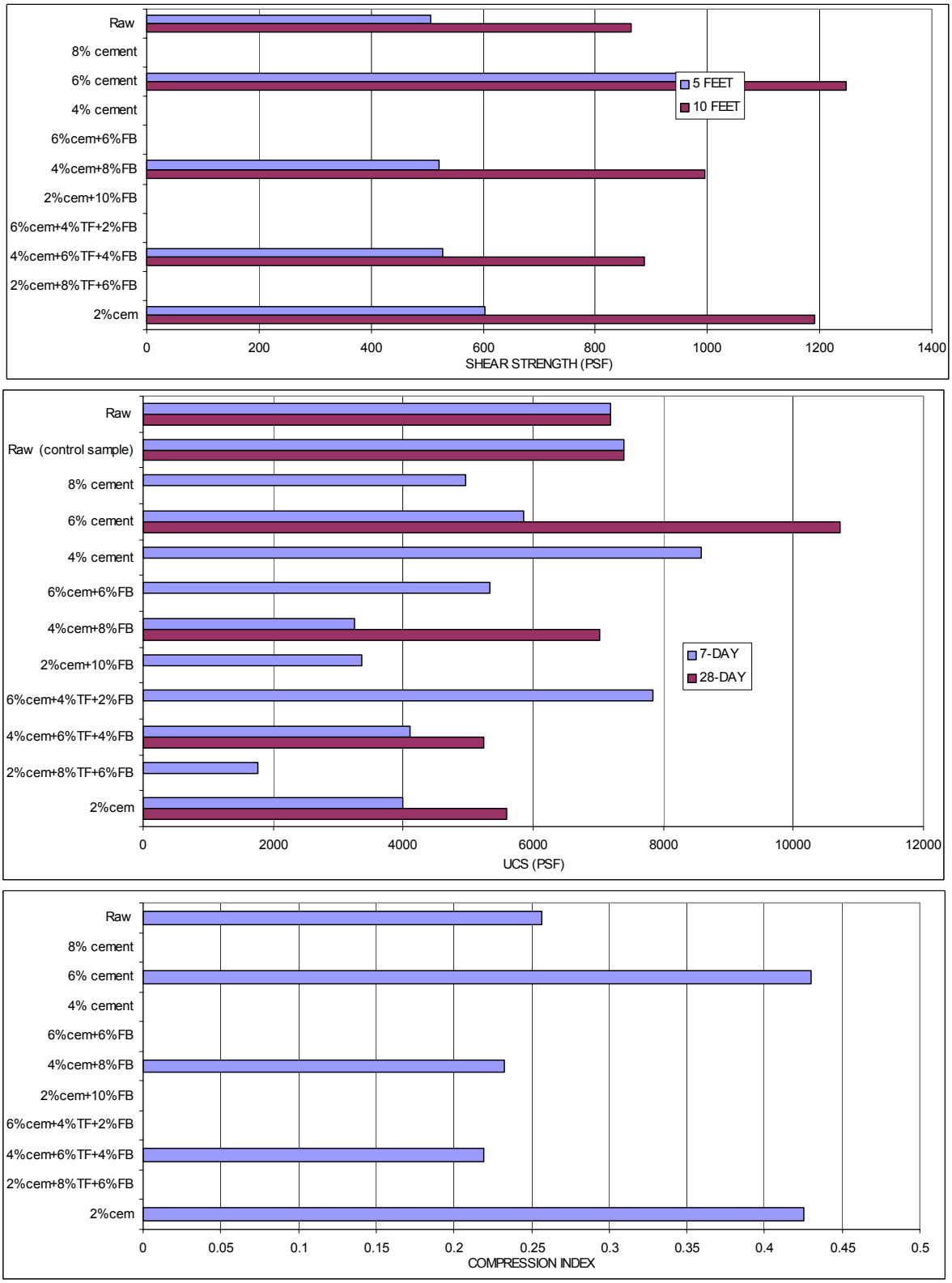

Figure 5-3. Port of Long Beach Physical Test Results

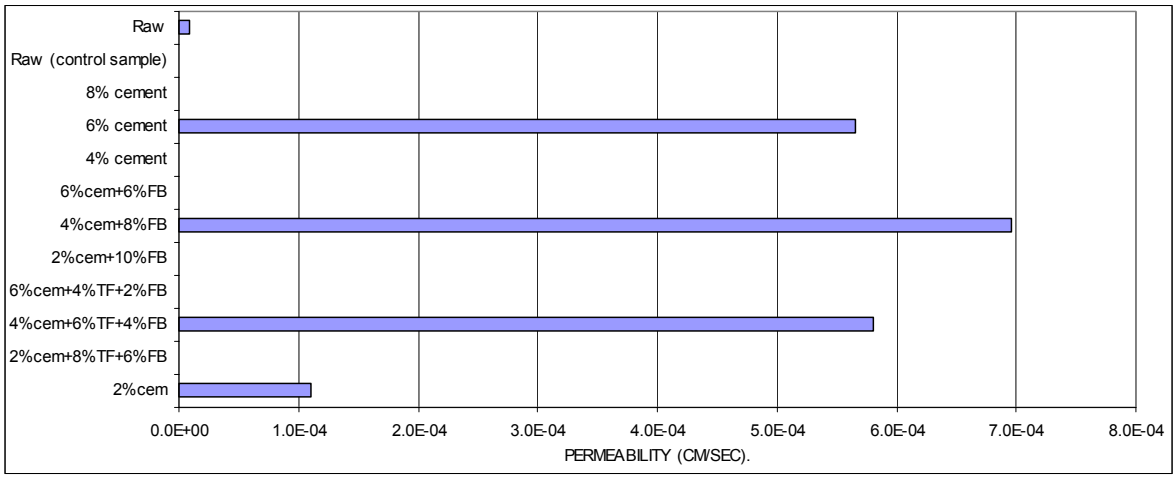

Figure 5-3. Port of Long Beach Physical Test Results

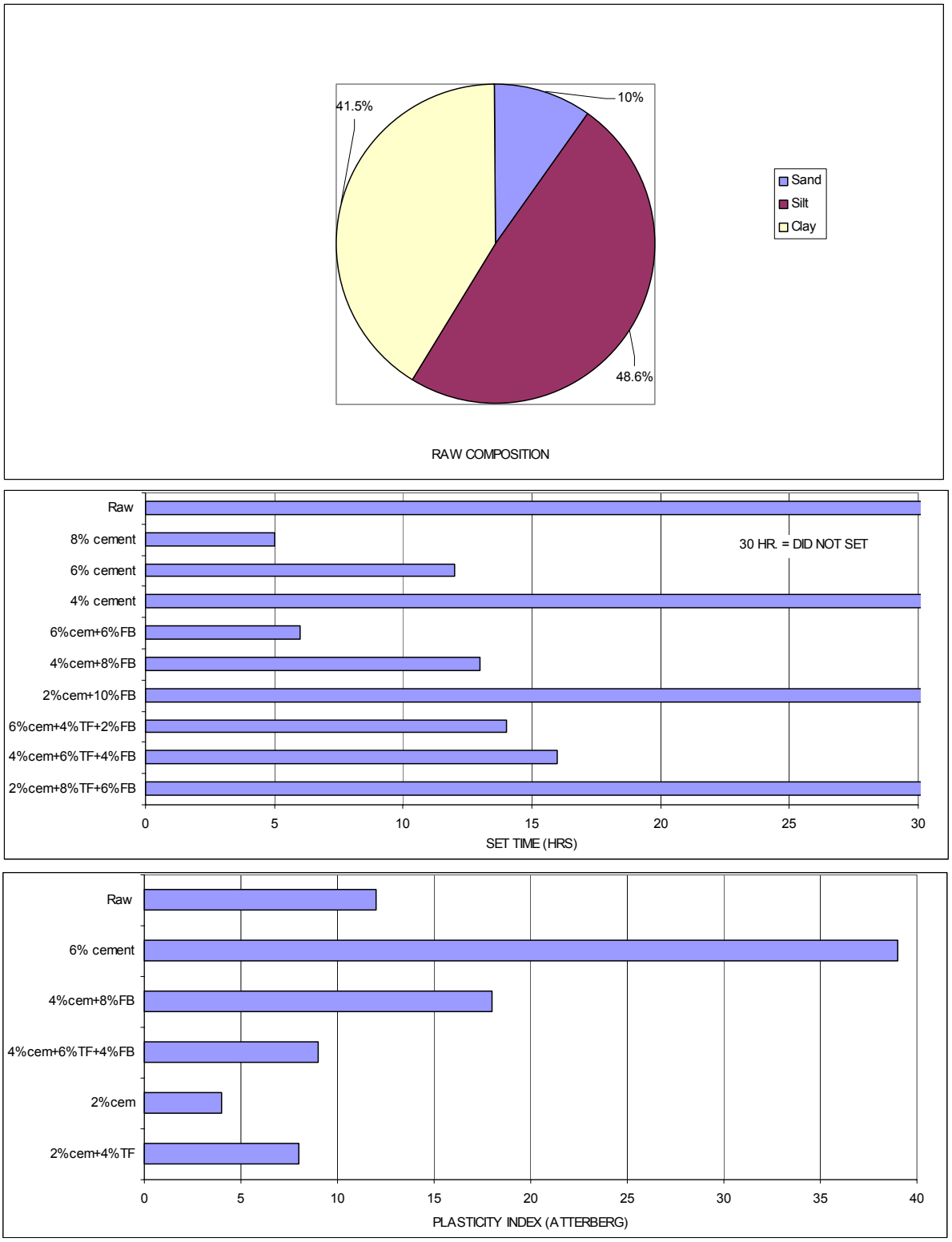

Figure 5-4. Port of Los Angeles Physical Test Results

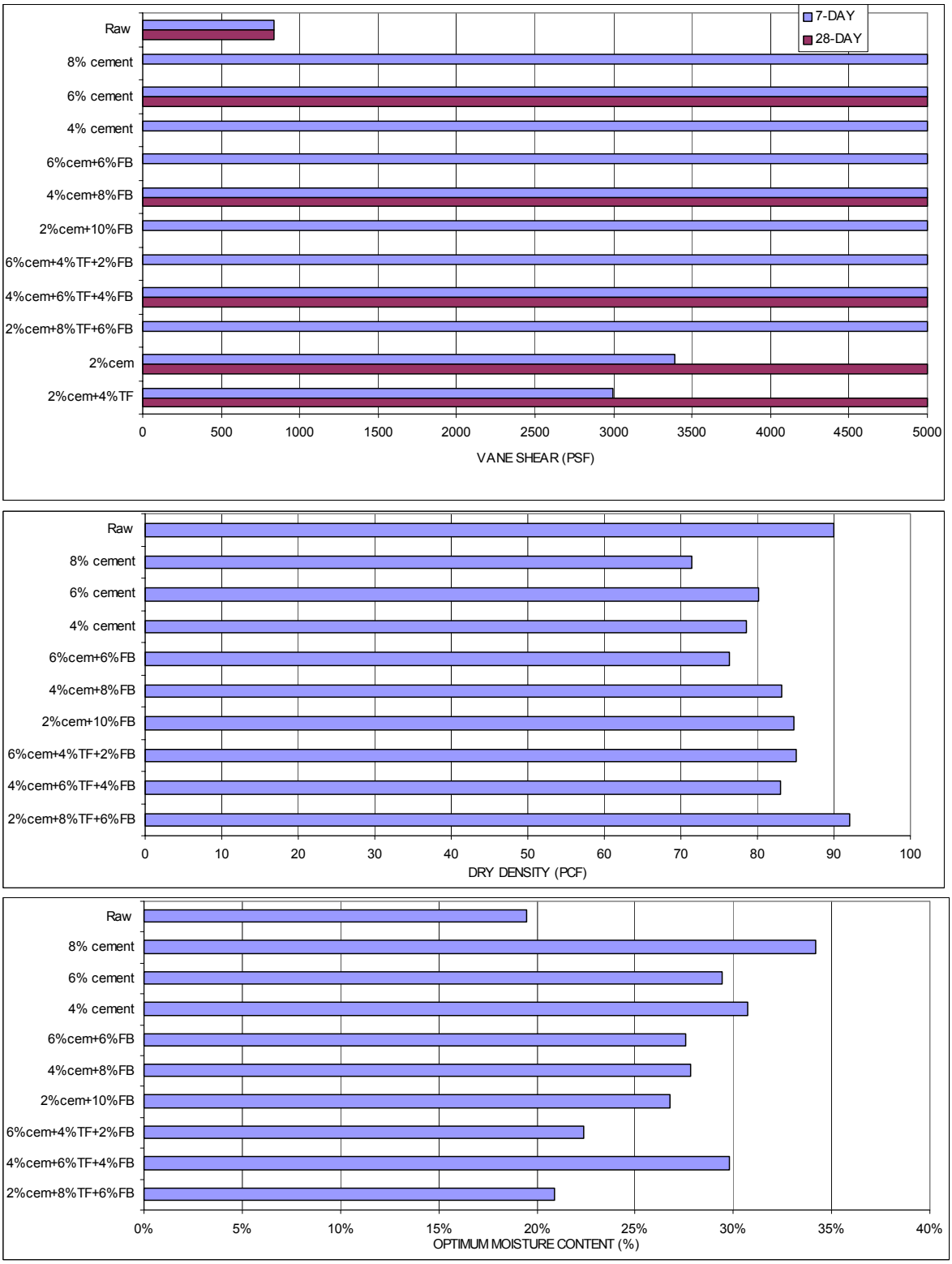

Figure 5-4. Port of Los Angeles Physical Test Results

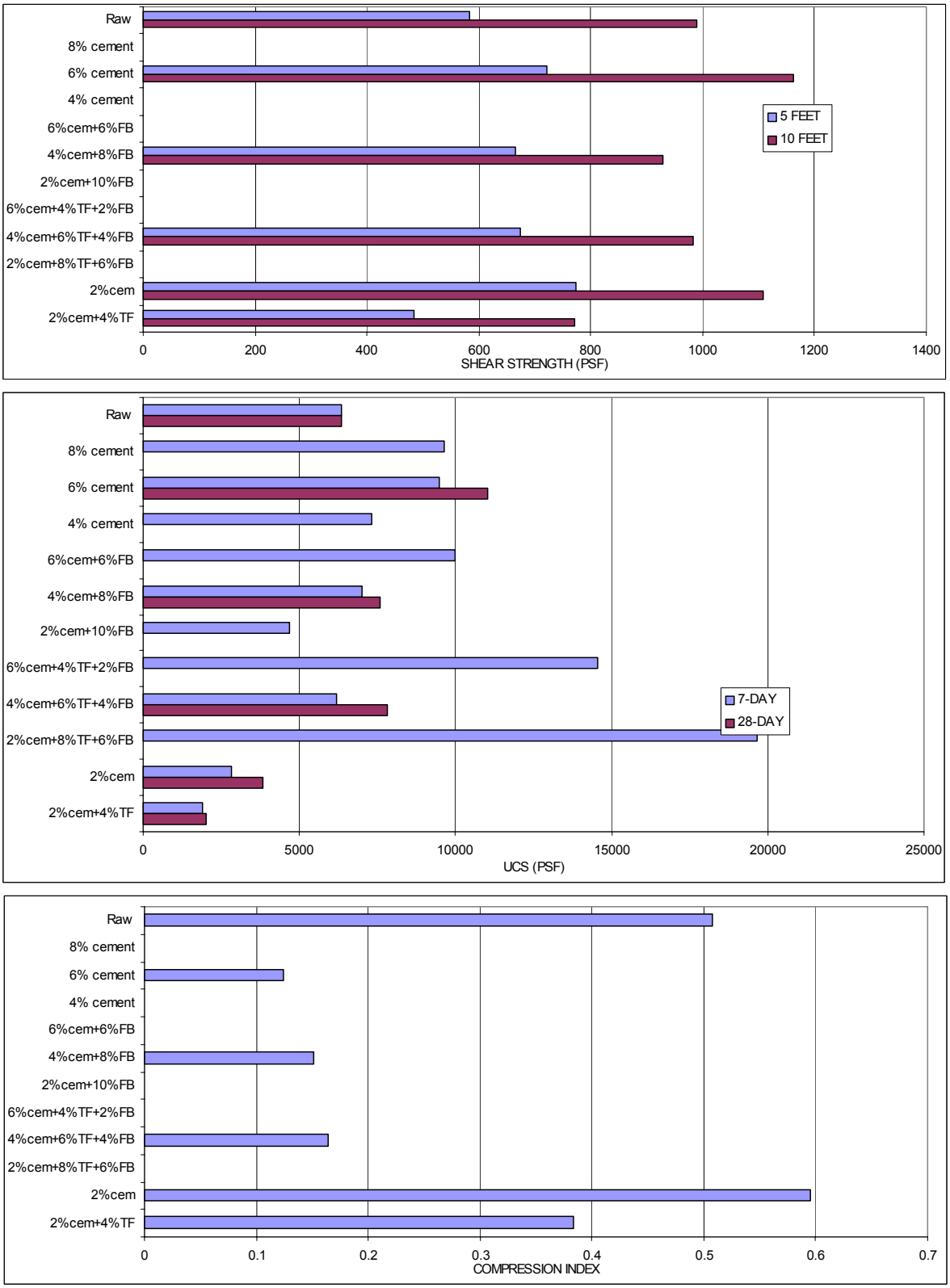

Figure 5-4. Port of Los Angeles Physical Test Results

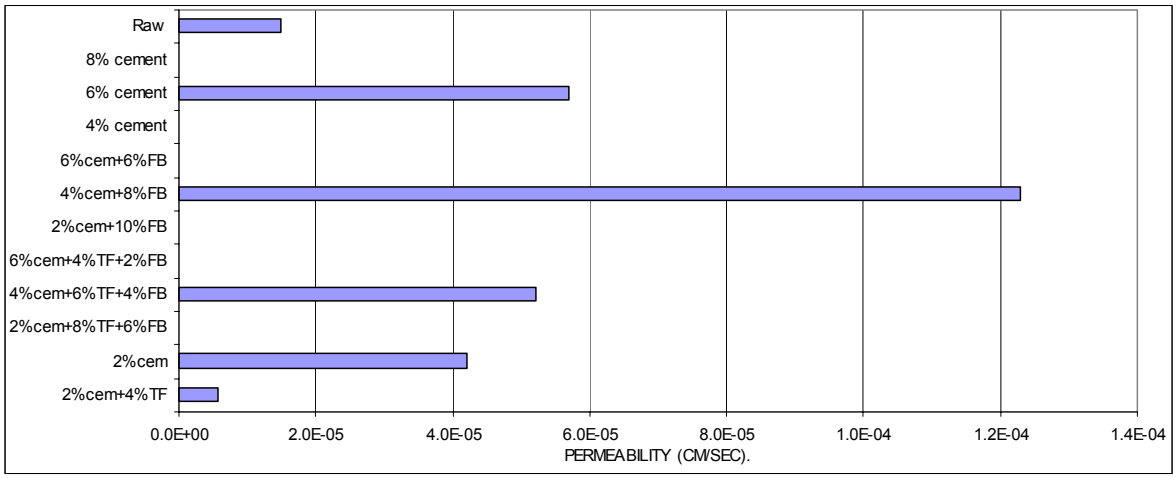

Figure 5-4. Port of Los Angeles Physical Test Results

6.0 CHEMICAL TEST PROGRAM AND RESULTS

The preceding section summarized the *solidification* effects of the cement-based stabilization (CBS) technology. Equally important are the *stabilization* effects, i.e., reduction in mobility, toxicity and leachability of hazardous chemical constituents within the dredged material. The purpose of the chemical testing program was to assess the effectiveness of CBS technology to allow for beneficial reuse of regional contaminated dredged sediments in upland applications.

6.1 CHEMICAL TESTING PROGRAM

The chemical testing was performed by ToxScan, Inc. of Watsonville, California. Details of the chemical testing program are described in Section 2.4.6 of this report. Analytical procedures associated with sediment samples from this project include:

- Total metals—As, Cd, Cr, Cu, Pb, Hg, Ni, Se, Ag, Zn.
- Pesticides and PCB's
- Semi-volatile compounds
- Butyltins
- Grain size
- Percent moisture
- Total organic carbon
- Total and dissolved sulfides
- Oil and grease
- Total petroleum hydrocarbons
- Ammonia
- Pore water salinity
- WET leaching procedure
- SPLP leaching procedure

Following the stabilization procedures, the stabilized samples were tested for the WET and SPLP leaching procedures as well as porewater salinity:

- The WET procedure (Title 22, Waste Extraction Test), uses deionized water as a leaching medium and involves mixing the water and solid in a 10:1 ratio, tumbling the mixture for 72 hours and then analyzing the leachate for the major contaminates listed above.

- The SPLP (Synthetic Precipitation Leaching Procedure) uses an acidic extractant in the range pH 2 or 5, depending upon the initial pH of the sediment. The extractant is mixed with the solid at a 20:1 ratio and is tumbled for 18 hours, followed by analysis of the extract.

Porewater salinity is measured in the interstitial waters found within the sediments. Porewater samples were collected via centrifugation of sediment samples.

6.2 CHEMICAL TEST PROCEDURES

MEC shipped samples of the raw sediment from the LARE, MdR, POLB and POLA sites to ToxScan on July 30, 2001. These samples were received on July 31, 2001 in good condition. Proper chain-of-custody procedures were followed. A portion of this raw material was retained for physical and chemical testing including porewater salinity. A second portion was extracted following the SPLP procedure with chemical testing performed on the extract. A third portion was extracted following the WET procedure with chemical testing performed on this extract as well. The procedures for SPLP and WET extraction are outlined in the preceding section.

After the stabilization process, Smith-Emery forwarded samples of the processed material to ToxScan for chemical analysis. These samples were collected, shipped and received between September 25, 2001 and October 26, 2001. The samples each underwent SPLP and WET extraction prior to chemical analysis. Porewater salinity was measured prior to extraction.

The analyses performed on each sample and extract are listed in Table 6-1 below.

Table 6-1 Chemical and Physical Analyses

Sample Type	Grain Size	Percent Solids	Pore-water Salinity	TOC	pH	Total Sulfides	TRPH	Metals	Butyltins	Pesticides	PCBs	PAHs
Raw Sediment	X	X	X	X	X	X	X	X	X	X	X	X
Raw Sediment SPLP Extraction				X	X	X	X	X	X	X	X	X
Raw Sediment WET Extraction				X	X	X	X	X	X	X	X	X
Stabilization Blend SPLP Extractions			X[1]	X	X	X	X	X	X	X	X	X
Stabilization Blend WET Extractions				X	X	X	X	X	X	X	X	X

1 =Porewater salinity measured on stabiliztion blends prior to extraction.

Grain size was analyzed utilizing procedures described by Plumb (1981), and percent solids were measured by EPA method 160.3. Porewater salinity was measured by electrical conductance following EPA Standard Method 2520B. Total organic carbon (TOC) was measured by EPA Method 415.1. Measurement of pH followed EPA Method 9045B for the raw material, and Method 150.1 for the extracts. Total sulfides were measured by EPA Method 9030 for the raw material, and EPA Method 376.1 for the extracts. Total recoverable petroleum hydrocarbons (TRPH) were measured by EPA Method 1664. Arsenic was measured by hybrid AA using EPA Method 7061 for the raw material, and Method 206.3 for the extracts. Mercury was measured utilizing cold vapor AA in accordance with EPA Method 7471 for the raw material, and a modified Method 245.1 for the extracts. All other metals were measured by ICP/MS by EPA Method 6020 for the raw material, and Method 200.8 for the extracts. Butyltins were measured using a gas chromatograph with a flame photometric detector (GC/FPD). Organochlorine pesticides and PCBs were measured by EPA Method 8081A. PCBs were identified to the arochlor level. PAHs were measured by EPA Method 8270C.

6.3 QUALITY CONTROL SUMMARY

The laboratory analyses met the quality assurance and quality control criteria outlined in the Scope of Work (SOW), with the exception of duplicate analyses. Duplicate analyses were not run on 10% of the samples, as specified by the SOW.

All samples were analyzed within the holding time limits and met the laboratory's quality assurance criteria established for the appropriate methods, except where noted below.

- **Percent Solids** - All QC data were acceptable.
- **Total Organic Carbon** - All QC data were acceptable.
- **pH** - All QC data were acceptable.
- **Sulfides** - All QC data were acceptable.
- **TRPH** - All QC data were acceptable.
- **Metals** - All QC data were acceptable.

Butyltins - Dibutyltin was detected (2.8µg/kg) in the method blank for the raw sediment samples. Tributyltin was detected (4.3 µg/kg) in the method blank for the extracts of blend samples WBR-54 through 56. Surrogate recovery (46%) was below acceptable limits (50-140%) for DI WET analysis of the POLB-Channel 2 raw sediment sample. Surrogate recovery was also below acceptable limits for the SPLP extract of the MdR raw sample (34%), and the DI WET extract of the WBR-29 blend sample (47%). Laboratory control spike recovery was below acceptable limits (50-140%) for monobutyltin (0 and 6%) and dibutyltin (47 and 48%) for the SPLP extracts of blends WBR-14 through 31 and for monobutyltin (10 and 9%) for the DI WET extracts of blend samples WBR-14 through 31. Monobutyltin laboratory control spike recovery was below the acceptable limit (12 and 16%) for both DI WET and SPLP extracts for the blend samplesWBR-54 through 56. Because of the large number butyltin samples affected by high

method blank contamination and/or poor spike and surrogate recoveries, all butyltin data are qualified and should not be used in the evaluation of the stabilized material.

- **Organochlorine Pesticides** - All QC data were acceptable.

- **PCBs** - Surrogate recovery (43%) was below acceptable limits (50-140%) for the POLA-Consolidated Slip SPLP raw sample. All other QC data met acceptability requirements and the method is believed to be in control.

- **PAHs** - Surrogate recovery (130%) was above acceptable limits (23-120%) for the POLA-Consolidated Slip raw sample. All other QC data met acceptability requirements and the method is believed to be in control. Reporting limits were increased for the POLA Consolidated Slip raw sample due to matrix interference. As almost all PAHs were reported well above detection limits, this is not expected to affect the usability of the results. A Marina del Rey stabilization mix and a LARE stabilization mix were re-extracted by SPLP methods because the first extract of these samples yielded low surrogate recoveries. Results of the second analysis fell within acceptable limits. This is not expected to affect the usability of the results.

6.4 CHEMICAL TEST RESULTS

Summaries of the chemistry results are provided in Table 6-2 through Table 6-7. Complete chemical test results are included in Attachment D.

Table 6-2 provides a summary of analyte concentrations reported as dry weight for the raw sediment from the four test sites (LARE, MdR, POLB Channel 2, POLA Consolidated Slip) prior to extraction. Applicable Effects Range -Median (ER-M) values[1] developed by Long et al (1995), are included in this table for comparison, where available. While these values are useful for identifying elevated sediment-associated contaminants, they should not be used to infer toxicity because of the inherent variability and uncertainty of the approach. Those values equal to or exceeding ER-M levels are in bold.

[1]Briefly, these values were developed from a large data set where results of both sediment bioassays (e.g., amphipod tests) and chemical analysis were available for individual samples. For each chemical, data were arranged in order of increasing concentration. Samples that showed no toxicity were excluded. The ER-M was then calculated as the 50th percentile of the observed effect concentrations.

Table 6-2 Raw Sediment Chemistry Results Reported As Dry Weight For Source Materials With Available Effects-Range Median (ER-M) Values (Long et al. 1995) Provided For Comparison

Analyte	LARE	Marina del Rey	POLB Channel 2	POLA Consolidated Slip	ER-M
Grain Size (%)					
Sand	92.8	97.5	40.2	28.3	N/A
Silt	4.0	1.5	35.1	23.7	N/A
Clay	3.2	1.2	24.7	48.0	N/A
Percent Solids	81	78	60	40	N/A
Salinity (ppt)	32.3	33.3	33.2	32.4	N/A
TOC (%)	0.44	0.21	1.26	8.67	N/A
pH	8.0	7.8	8.1	8.0	N/A

Analyte	LARE	Marina del Rey	POLB Channel 2	POLA Consolidated Slip	ER-M
Total Sulfides (mg/kg)	84	120	150	2300	N/A
TRPH (mg/kg)	540	440	760	41000	N/A
Metals (mg/kg)					
Arsenic	1.6	2.7	14	23	70
Cadmium	0.29	ND	0.22	4.7	9.6
Chromium	12	12	48	**560**	370
Copper	15	8.4	65	**830**	270
Lead	31	39	80	**400**	218
Mercury	0.030	0.028	0.59	**4.8**	0.71
Nickel	7.7	9.3	20	**70**	51.6
Silver	ND	ND	0.18	**9.0**	3.7
Zinc	69	45	150	**710**	410
Butyltins (µg/kg)[1]					
Monobutyltin	3.8	2.0	6.8	ND	N/A
Dibutyltin	46	ND	12	14	N/A
Tributyltin	16	ND	ND	ND	N/A
Tetrabutyltin	ND	ND	ND	ND	N/A
Pesticides (µg/kg)					
Aldrin	ND	ND	ND	23	N/A
alpha-BHC	ND	ND	ND	ND	N/A
beta-BHC	6.6	ND	9.3	ND	N/A
delta-BHC	ND	ND	ND	ND	N/A
gamma-BHC	ND	ND	ND	ND	N/A
alpha-Chlordane	5.1	3.8	ND	2.7	N/A
gamma-Chlordane	2.9	2.7	2.3	ND	N/A
Technical Chlordane	ND	ND	ND	ND	N/A
Total Chlordane	**8.0**	**6.5**	2.3	2.7	6
4,4'-DDD	7.1	4.1	**20**	**60**	20
2,4'-DDD	ND	ND	ND	ND	20
4,4'-DDE	5.1	2.4	**40**	**45**	27
2,4'-DDE	ND	ND	ND	ND	27
4,4'DDT	ND	ND	ND	ND	7
2,4'-DDT	ND	ND	ND	ND	7
Dieldrin	ND	ND	ND	3.0	8
Endosulfan I	ND	ND	ND	ND	N/A
Endosulfan II	ND	ND	ND	ND	N/A
Endosulfan Sulfate	ND	ND	ND	ND	N/A
Endrin	4.8	ND	ND	ND	N/A
Endrin Aldehyde	ND	ND	ND	ND	N/A
Endrin Ketone	ND	ND	ND	ND	N/A
Heptachlor	ND	ND	ND	ND	N/A
Heptachlor Epoxide	ND	ND	ND	ND	N/A
Methoxychlor	ND	ND	ND	ND	N/A
Toxaphene	ND	ND	ND	ND	N/A
PCBs (µg/kg)					
Arochlor-1016	ND	ND	ND	ND	N/A
Arochlor-1221	ND	ND	ND	ND	N/A
Arochlor-1232	ND	ND	ND	ND	N/A
Arochlor-1242	ND	ND	ND	ND	N/A
Arochlor-1248	ND	ND	ND	ND	N/A
Arochlor-1254	34	18	71	190	N/A
Arochlor-1260	ND	ND	ND	ND	N/A
Total PCBs	34	18	71	**190**	180
PAHs (µg/kg)					
Naphthalene	ND	ND	ND	**9000**	2100
2-Methylnaphthalene	ND	ND	ND	**65000**	670
Acenaphthylene	ND	ND	61	**2000**	640
Acenaphthene	ND	ND	36	**11000**	500
Fluorene	ND	ND	89	**19000**	540
Phenanthrene	120	27	580	**95000**	1500
Anthracene	ND	ND	250	**16000**	1100
Flouranthene	210	74	980	**5500**	5100
Pyrene	260	99	1600	**23000**	2600

Analyte	LARE	Marina del Rey	POLB Channel 2	POLA Consolidated Slip	ER-M
Benzo(a)anthracene	82	41	460	**3700**	1600
Chrysene	110	42	680	**5500**	2800
Benzo(b)fluoranthene	82	56	860	1600	N/A
Benzo(k)fluoranthene	84	37	860	ND	N/A
Benzo(a)pyrene	48	ND	380	1300	1600
Perylene	ND	ND	ND	ND	N/A
Indeno(1,2,3-cd)pyrene	45	ND	350	ND	N/A
Dibenzo(a,h)anthracene	ND	ND	150	**320**	260
Benzo(g,h,i)perylene	ND	ND	ND	ND	N/A
Total PAHs	1000	380	7300	**260000**	44792

ND = Not Detected

N/A = Not Available

Bold = Value equal to or above ER-M values.

[1] All butyltin data are qualified due to QC issues and are provided for informational purposes only.

Table 6-3 through Table 6-6 summarize the results of the chemistry analyses of the raw sediment (concentrations reported as wet weight), the SPLP and WET extracts of the raw sediment, and the SPLP and WET extracts of the stabilization blends. The tables are listed by site. The Total Threshold Limit Concentrations (TTLC) and Soluble Threshold Limit Concentrations (STLC) for inorganic persistent and bio-accumulative toxic substances from the California Code of Regulations, Title 22, are provided for comparative purposes where available. TTLC values are compared to the values reported for the raw sediment (solids), and STLC values are compared to the values reported for the extracts (liquids). Values above these threshold limits are believed to be harmful and the sample is defined as hazardous waste by Title 22 criteria.

Table 6-3 SPLP And WET Chemistry Results For The LARE Raw Source Material And Associated Blends With Available TTLC And STLC Values For Comparison.

Identification / Analyte	Raw Sample (Wet Weight)	TTLC (Wet Weight)	Raw Sample SPLP/ WET	8% Cement SPLP/ WET	6% Cement SPLP/ WET	4% Cement SPLP/ WET	6% Cement + 6% Fluid-Bed Fly Ash SPLP/WET	4% Cement + 8% Fluid-Bed Fly Ash SPLP/WET	2% Cement + 10% Fluid-Bed Fly Ash SPLP/WET	6% Cement + 4% Type F Fly Ash + 2% Fluid-Bed Fly Ash SPLP/WET	4% Cement + 6% Type F Fly Ash + 4% Fluid-Bed Fly Ash SPLP/WET	2% Cement + 8% Type F Fly Ash + 6% Fluid-Bed Fly Ash SPLP/WET	STLC
WBR ID Number[1]	N/A	-	N/A	14	15	16	17	18	19	26	27	28	-
Grain Size (%)													
Sand	92.8	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Silt	4.0	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Clay	3.2	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Percent Solids	81	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Porewater Salinity (ppt)	32.3	N/A	N/A	12.8[2]	12.8[2]	12.8[2]	12.8	10.8	10.8	7.0	9.0	12.8	N/A
TOC (mg/l)	0.44%	N/A	4.9/9.7	12/20	12/20	11/18	11/19	11/17	11/17	11/19	11/13	10/18	N/A
pH	8.0	N/A	7.5/8.0	11/12	11/11	11/11	11/11	11/11	11/11	11/11	11/11	10/11	<2, >12.5[4]
Total Sulfides (mg/kg)	68	N/A	ND/ND	ND/ND	ND/ND	ND/ND	ND/ND	ND/ND	ND/ND	ND/ND	ND/ND	ND/ND	N/A
TRPH (mg/kg)	430	N/A	ND/ND	ND/ND	ND/ND	ND/ND	ND/ND	ND/ND	ND/ND	ND/ND	ND/ND	ND/ND	N/A
Metals	(mg/kg)	(mg/kg)	(µg/l)	(µg/l)	(µg/l)	(µg/l)	(µg/l)	(µg/l)	(µg/l)	(µg/l)	(µg/l)	(µg/l)	(µg/l)
Arsenic	1.3	500	3.3/6.7	ND/ND	ND/ND	ND/ND	ND/ND	ND/ND	ND/ND	ND/ND	ND/ND	ND/ND	5000
Cadmium	0.23	100	ND/ND	ND/ND	ND/ND	ND/ND	ND/ND	ND/ND	ND/ND	ND/ND	ND/ND	ND/ND	1000
Chromium	9.3	2500	ND/ND	ND/ND	ND/ND	ND/ND	ND/ND	ND/ND	ND/ND	ND/ND	ND/ND	ND/ND	5000
Copper	12	2500	ND/ND	ND/ND	ND/ND	ND/ND	ND/ND	ND/ND	ND/ND	ND/ND	ND/ND	ND/ND	25000
Lead	25	1000	ND/ND	ND/ND	ND/ND	ND/ND	ND/ND	ND/ND	ND/ND	ND/ND	ND/ND	ND/ND	5000
Mercury	0.028	20	ND/ND	ND/ND	ND/ND	ND/ND	ND/ND	ND/ND	ND/ND	ND/ND	ND/ND	ND/ND	200
Nickel	6.3	2000	ND/ND	ND/ND	ND/ND	ND/ND	ND/ND	ND/ND	ND/ND	ND/ND	ND/ND	ND/ND	20000
Silver	ND	500	ND/ND	ND/ND	ND/ND	ND/ND	ND/ND	ND/ND	ND/ND	ND/ND	ND/ND	ND/ND	5000
Zinc	56	5000	ND/ND	ND/ND	ND/ND	ND/ND	ND/ND	ND/ND	ND/ND	ND/ND	ND/ND	ND/ND	250000
Butyltins[5]	(µg/kg)	(µg/kg)	(ng/l)	(ng/l)	(ng/l)	(ng/l)	(ng/l)	(ng/l)	(ng/l)	(ng/l)	(ng/l)	(ng/l)	(ng/l)
Monobutyltin	3.1	N/A	ND/ND	ND/ND	ND/ND	ND/ND	ND/ND	ND/ND	ND/ND	ND/ND	ND/ND	ND/ND	N/A
Dibutyltin	37	N/A	ND/ND	ND/ND	ND/ND	ND/ND	ND/ND	ND/ND	ND/ND	ND/ND	ND/ND	ND/ND	N/A
Tributyltin	13	N/A	ND/ND	7.9/ND	8.9/ND	ND/ND	ND/ND	ND/ND	ND/ND	ND/8.2	8.1/8.2	ND/8.1	N/A
Tetrabutyltin	ND	N/A	ND/ND	ND/ND	ND/ND	ND/ND	ND/ND	ND/ND	ND/ND	ND/ND	ND/ND	ND/ND	N/A
Pesticides	(µg/kg)	(µg/kg)	(µg/l)	(µg/l)	(µg/l)	(µg/l)	(µg/l)	(µg/l)	(µg/l)	(µg/l)	(µg/l)	(µg/l)	(µg/l)
Aldrin	ND	1400	ND/ND	ND/ND	ND/ND	ND/ND	ND/ND	ND/ND	ND/ND	ND/ND	ND/ND	ND/ND	140
alpha-BHC	ND	N/A	ND/ND	ND/0.06	ND/ND	ND/ND	ND/ND	ND/ND	ND/ND	ND/ND	ND/ND	ND/ND	N/A
beta-BHC	5.3	N/A	ND/ND	ND/ND	ND/ND	ND/ND	ND/ND	ND/ND	ND/ND	ND/ND	ND/0.054	ND/ND	N/A
delta-BHC	ND	N/A	ND/ND	ND/ND	ND/ND	ND/ND	ND/ND	ND/ND	ND/ND	ND/ND	ND/ND	ND/ND	N/A
gamma-BHC	ND	N/A	ND/ND	ND/ND	ND/ND	ND/ND	ND/ND	ND/ND	ND/ND	ND/ND	ND/ND	ND/ND	N/A
alpha-Chlordane	4.1	N/A	ND/ND	ND/ND	ND/ND	ND/ND	ND/ND	ND/ND	ND/ND	ND/ND	ND/ND	ND/ND	N/A
gamma-Chlordane	2.3	N/A	ND/ND	ND/ND	ND/ND	ND/ND	ND/ND	ND/ND	ND/ND	ND/ND	ND/ND	ND/ND	N/A

Identification / Analyte	Raw Sample (Wet Weight)	TTLC (Wet Weight)	Raw Sample SPLP/ WET	8% Cement SPLP/ WET	6% Cement SPLP/ WET	4% Cement SPLP/ WET	6% Cement + 6% Fluid-Bed Fly Ash SPLP/WET	4% Cement + 8% Fluid-Bed Fly Ash SPLP/WET	2% Cement + 10% Fluid-Bed Fly Ash SPLP/WET	6% Cement + 4% Type F Fly Ash + 2% Fluid-Bed Fly Ash SPLP/WET	4% Cement + 6% Type F Fly Ash + 4% Fluid-Bed Fly Ash SPLP/WET	2% Cement + 8% Type F Fly Ash + 6% Fluid-Bed Fly Ash SPLP/WET	STLC
Technical Chlordane	ND	N/A	ND/ND	ND/ND	ND/ND	ND/ND	ND/ND	ND/ND	ND/ND	ND/ND	ND/ND	ND/ND	N/A
Total Chlordane	6.4	2500	ND/ND	ND/ND	ND/ND	ND/ND	ND/ND	ND/ND	ND/ND	ND/ND	ND/ND	ND/ND	250
4,4'-DDD	5.7	1000	ND/ND	ND/ND	ND/ND	ND/ND	ND/ND	ND/ND	ND/ND	ND/ND	ND/ND	ND/ND	100
2,4'-DDD	ND	1000	ND/ND	N/A/N/A[3]	N/A/N/A[3]	N/A/N/A[3]	N/A/N/A[3]	N/A/N/A[3]	N/A/N/A[3]	N/A/N/A[3]	N/A/N/A[3]	N/A/N/A[3]	100
4,4'-DDE	4.1	1000	ND/ND	ND/ND	ND/ND	ND/ND	ND/ND	ND/ND	ND/ND	ND/ND	ND/ND	ND/ND	100
2,4'-DDE	ND	1000	ND/ND	N/A/N/A[3]	N/A/N/A[3]	N/A/N/A[3]	N/A/N/A[3]	N/A/N/A[3]	N/A/N/A[3]	N/A/N/A[3]	N/A/N/A[3]	N/A/N/A[3]	100
4,4'DDT	ND	1000	ND/ND	ND/ND	ND/ND	ND/ND	ND/ND	ND/ND	ND/ND	ND/ND	ND/ND	ND/ND	100
2,4'-DDT	ND	1000	ND/ND	N/A/N/A[3]	N/A/N/A[3]	N/A/N/A[3]	N/A/N/A[3]	N/A/N/A[3]	N/A/N/A[3]	N/A/N/A[3]	N/A/N/A[3]	N/A/N/A[3]	100
Dieldrin	ND	8000	ND/ND	ND/ND	ND/ND	ND/ND	ND/ND	ND/ND	ND/ND	ND/ND	ND/ND	ND/ND	800
Endosulfan I	ND	N/A	ND/ND	ND/ND	ND/ND	ND/ND	ND/ND	ND/ND	ND/ND	ND/ND	ND/ND	ND/ND	N/A
Endosulfan II	ND	N/A	ND/ND	ND/ND	ND/ND	ND/ND	ND/ND	ND/ND	ND/ND	ND/ND	ND/ND	ND/ND	N/A
Endosulfan Sulfate	ND	N/A	ND/ND	ND/ND	ND/ND	ND/ND	ND/ND	ND/ND	ND/ND	ND/ND	ND/ND	ND/ND	N/A
Endrin	3.9	200	ND/ND	ND/ND	ND/ND	ND/ND	ND/ND	ND/ND	ND/ND	ND/ND	ND/ND	ND/ND	20
Endrin Aldehyde	ND	N/A	ND/ND	ND/ND	ND/ND	ND/ND	ND/ND	ND/ND	ND/ND	ND/ND	ND/ND	ND/ND	N/A
Endrin Ketone	ND	N/A	ND/ND	ND/ND	ND/ND	ND/ND	ND/ND	ND/ND	ND/ND	ND/ND	ND/ND	ND/ND	N/A
Heptachlor	ND	4700	ND/ND	ND/ND	ND/ND	ND/ND	ND/ND	ND/ND	ND/ND	ND/ND	ND/ND	ND/ND	47
Heptachlor Epoxide	ND	N/A	ND/ND	ND/ND	ND/ND	ND/ND	ND/ND	ND/ND	ND/ND	ND/ND	ND/ND	ND/ND	N/A
Methoxychlor	ND	100000	ND/ND	ND/ND	ND/ND	ND/ND	ND/ND	ND/ND	ND/ND	ND/ND	ND/ND	ND/ND	10000
Toxaphene	ND	5000	ND/ND	ND/ND	ND/ND	ND/ND	ND/ND	ND/ND	ND/ND	ND/ND	ND/ND	ND/ND	500
PCBs	(µg/kg)	(µg/kg)	(µg/l)	(µg/l)	(µg/l)	(µg/l)	(µg/l)	(µg/l)	(µg/l)	(µg/l)	(µg/l)	(µg/l)	(µg/l)
Arochlor-1016	ND	N/A	ND/ND	ND/ND	ND/ND	ND/ND	ND/ND	ND/ND	ND/ND	ND/ND	ND/ND	ND/ND	N/A
Arochlor-1221	ND	N/A	ND/ND	ND/ND	ND/ND	ND/ND	ND/ND	ND/ND	ND/ND	ND/ND	ND/ND	ND/ND	N/A
Arochlor-1232	ND	N/A	ND/ND	ND/ND	ND/ND	ND/ND	ND/ND	ND/ND	ND/ND	ND/ND	ND/ND	ND/ND	N/A
Arochlor-1242	ND	N/A	ND/ND	ND/ND	ND/ND	ND/ND	ND/ND	ND/ND	ND/ND	ND/ND	ND/ND	ND/ND	N/A
Arochlor-1248	ND	N/A	ND/ND	ND/ND	ND/ND	ND/ND	ND/ND	ND/ND	ND/ND	ND/ND	ND/ND	ND/ND	N/A
Arochlor-1254	27	N/A	ND/ND	ND/ND	ND/ND	ND/ND	ND/ND	ND/ND	ND/ND	ND/ND	ND/ND	ND/ND	N/A
Arochlor-1260	ND	N/A	ND/ND	ND/ND	ND/ND	ND/ND	ND/ND	ND/ND	ND/ND	ND/ND	ND/ND	ND/ND	N/A
Total PCBs	27	50000	ND/ND	ND/ND	ND/ND	ND/ND	ND/ND	ND/ND	ND/ND	ND/ND	ND/ND	ND/ND	N/A
PAHs	(µg/kg)	(µg/kg)	(µg/l)	(µg/l)	(µg/l)	(µg/l)	(µg/l)	(µg/l)	(µg/l)	(µg/l)	(µg/l)	(µg/l)	(µg/l)
Naphthalene	ND	N/A	ND/ND	ND/ND	ND/ND	ND/ND	ND/ND	ND/ND	ND/ND	ND/ND	ND/ND	ND/ND	N/A
2-Methylnaphthalene	ND	N/A	ND/ND	ND/ND	ND/ND	ND/ND	ND/ND	ND/ND	ND/ND	ND/ND	ND/ND	ND/ND	N/A
Acenaphthylene	ND	N/A	ND/ND	ND/ND	ND/ND	ND/ND	ND/ND	ND/ND	ND/ND	ND/ND	ND/ND	ND/ND	N/A
Acenaphthene	ND	N/A	ND/ND	ND/ND	ND/ND	ND/ND	ND/ND	ND/ND	ND/ND	ND/ND	ND/ND	ND/ND	N/A
Fluorene	ND	N/A	ND/ND	ND/ND	ND/ND	ND/ND	ND/ND	ND/ND	ND/ND	ND/ND	ND/ND	ND/ND	N/A
Phenanthrene	100	N/A	ND/ND	ND/ND	ND/ND	ND/ND	ND/ND	ND/ND	ND/ND	ND/ND	ND/ND	ND/ND	N/A
Anthracene	ND	N/A	ND/ND	ND/ND	ND/ND	ND/ND	ND/ND	ND/ND	ND/ND	ND/ND	ND/ND	ND/ND	N/A
Flouranthene	170	N/A	ND/ND	ND/ND	ND/ND	ND/ND	ND/ND	ND/ND	ND/ND	ND/ND	ND/ND	ND/ND	N/A
Pyrene	210	N/A	ND/ND	ND/ND	ND/ND	ND/ND	ND/ND	ND/ND	ND/ND	ND/ND	ND/ND	ND/ND	N/A
Benzo(a)anthracene	66	N/A	ND/ND	ND/ND	ND/ND	ND/ND	ND/ND	ND/ND	ND/ND	ND/ND	ND/ND	ND/ND	N/A
Chrysene	87	N/A	ND/ND	ND/ND	ND/ND	ND/ND	ND/ND	ND/ND	ND/ND	ND/ND	ND/ND	ND/ND	N/A
Benzo(b)fluoranthene	66	N/A	ND/ND	ND/ND	ND/ND	ND/ND	ND/ND	ND/ND	ND/ND	ND/ND	ND/ND	ND/ND	N/A

Identification / Analyte	Raw Sample (Wet Weight)	TTLC (Wet Weight)	Raw Sample SPLP/ WET	8% Cement SPLP/ WET	6% Cement SPLP/ WET	4% Cement SPLP/ WET	6% Cement + 6% Fluid-Bed Fly Ash SPLP/WET	4% Cement + 8% Fluid-Bed Fly Ash SPLP/WET	2% Cement + 10% Fluid-Bed Fly Ash SPLP/WET	6% Cement + 4% Type F Fly Ash + 2% Fluid-Bed Fly Ash SPLP/WET	4% Cement + 6% Type F Fly Ash + 4% Fluid-Bed Fly Ash SPLP/WET	2% Cement + 8% Type F Fly Ash + 6% Fluid-Bed Fly Ash SPLP/WET	STLC
Benzo(k)fluoranthene	68	N/A	ND/ND	ND/ND	ND/ND	ND/ND	ND/ND	ND/ND	ND/ND	ND/ND	ND/ND	ND/ND	N/A
Benzo(a)pyrene	39	N/A	ND/ND	ND/ND	ND/ND	ND/ND	ND/ND	ND/ND	ND/ND	ND/ND	ND/ND	ND/ND	N/A
Perylene	ND	N/A	ND/ND	ND/ND	ND/ND	ND/ND	ND/ND	ND/ND	ND/ND	ND/ND	ND/ND	ND/ND	N/A
Indeno(1,2,3-cd)pyrene	36	N/A	ND/ND	ND/ND	ND/ND	ND/ND	ND/ND	ND/ND	ND/ND	ND/ND	ND/ND	ND/ND	N/A
Dibenzo(a,h)anthracene	ND	N/A	ND/ND	ND/ND	ND/ND	ND/ND	ND/ND	ND/ND	ND/ND	ND/ND	ND/ND	ND/ND	N/A
Benzo(g,h,i)perylene	ND	N/A	ND/ND	ND/ND	ND/ND	ND/ND	ND/ND	ND/ND	ND/ND	ND/ND	ND/ND	ND/ND	N/A
Total PAHs	840	N/A	ND/ND	ND/ND	ND/ND	ND/ND	ND/ND	ND/ND	ND/ND	ND/ND	ND/ND	ND/ND	N/A

[1] Waste By Rail identification number provided for reference to the chemistry results appendix.

[2] Porewater salinity measured prior to extraction.

[3] 2,4'-DDD, 2,4'-DDE and 2,4'-DDT not measured in blend extracts.

[4] Limits set in Article 3, section 66261.22 of California, Title 22.

[5] All butyltin data are qualified due to QC issues and are provided for informational purposes only.

N/A = Not Available

ND = Not Detected

Table 6-4 SPLP And WET Chemistry Results For The Marina Del Rey Raw Source Material And Associated Blends With Available TTLC And STLC Values For Comparison.

Identification / Analyte	Raw Sample (Wet Weight)	TTLC	Raw Sample SPLP/WET	6% Cement SPLP/WET	4% Cement + 8% Fluid Bed Fly Ash SPLP/WET	4% Cement + 6% Type F Fly Ash + 4% Fluid Bed Fly Ash SPLP/WET	STLC
WBR ID Number[1]	N/A	-	N/A	29	30	31	-
Grain Size (%)							
Sand	97.5	N/A	N/A	N/A	N/A	N/A	N/A
Silt	1.5	N/A	N/A	N/A	N/A	N/A	N/A
Clay	1.2	N/A	N/A	N/A	N/A	N/A	N/A
Percent Solids	78	N/A	N/A	N/A	N/A	N/A	N/A
Porewater Salinity (ppt)	33.3	N/A	N/A	9.0[2]	7.0[2]	7.0[2]	N/A
TOC (mg/l)	0.21%	N/A	2.3/2.3	9.9/15	6.8/11	5.5/9.7	N/A
pH	7.8	N/A	8.1/7.6	11/12	11/11	11/11	<2, >12.5[4]
Total Sulfides (mg/kg)	90	N/A	ND/ND	ND/ND	ND/ND	ND/ND	N/A
TRPH (mg/kg)	350	N/A	ND/ND	ND/ND	ND/ND	ND/ND	N/A
Metals	(mg/kg)	(mg/kg)	(µg/l)	(µg/l)	(µg/l)	(µg/l)	(µg/l)
Arsenic	2.1	500	2.8/3.5	ND/ND	ND/ND	ND/ND	5000
Cadmium	ND	100	ND/ND	ND/ND	ND/ND	ND/ND	1000
Chromium	9.4	2500	ND/ND	ND/ND	ND/ND	ND/ND	5000
Copper	6.6	2500	ND/ND	ND/ND	ND/ND	ND/ND	25000
Lead	31	1000	ND/ND	ND/ND	ND/ND	ND/ND	5000
Mercury	0.022	20	ND/ND	ND/ND	ND/ND	ND/ND	200
Nickel	7.3	2000	ND/ND	ND/ND	ND/ND	ND/ND	20000
Silver	ND	500	ND/ND	ND/ND	ND/ND	ND/ND	5000
Zinc	35	5000	ND/ND	ND/ND	ND/ND	ND/ND	250000
Butyltins[5]	(µg/kg)	(µg/kg)	(ng/l)	(ng/l)	(ng/l)	(ng/l)	(ng/l)
Monobutyltin	1.5	N/A	ND/ND	ND/ND	ND/ND	ND/ND	N/A
Dibutyltin	ND	N/A	ND/ND	ND/ND	ND/ND	ND/ND	N/A
Tributyltin	ND	N/A	ND/ND	ND/ND	ND/ND	ND/10	N/A
Tetrabutyltin	ND	N/A	ND/ND	ND/ND	ND/ND	ND/ND	N/A
Pesticides	(µg/kg)	(µg/kg)	(µg/l)	(µg/l)	(µg/l)	(µg/l)	(µg/l)
Aldrin	ND	1400	ND/ND	ND/ND	ND/ND	ND/ND	140
alpha-BHC	ND	N/A	ND/ND	ND/ND	ND/ND	ND/ND	N/A
beta-BHC	ND	N/A	ND/ND	ND/ND	ND/ND	ND/ND	N/A
delta-BHC	ND	N/A	ND/ND	ND/ND	ND/ND	ND/ND	N/A
gamma-BHC	ND	N/A	ND/ND	ND/ND	ND/ND	ND/ND	N/A
alpha-Chlordane	3.0	N/A	ND/ND	ND/ND	ND/ND	ND/ND	N/A
gamma-Chlordane	2.1	N/A	ND/ND	ND/ND	ND/ND	ND/ND	N/A
Technical Chlordane	ND	N/A	ND/ND	ND/ND	ND/ND	ND/ND	N/A
Total Chlordane	5.1	2500	ND/ND	ND/ND	ND/ND	ND/ND	250
4,4'-DDD	3.2	1000	ND/ND	ND/ND	ND/ND	ND/ND	100
2,4'-DDD	ND	1000	ND/ND	N/A/N/A[3]	N/A/N/A[3]	N/A/N/A[3]	100
4,4'-DDE	1.9	1000	ND/ND	ND/ND	ND/ND	ND/ND	100
2,4'-DDE	ND	1000	ND/ND	N/A/N/A[3]	N/A/N/A[3]	N/A/N/A[3]	100
4,4'DDT	ND	1000	ND/ND	ND/ND	ND/ND	ND/ND	100
2,4'-DDT	ND	1000	ND/ND	N/A/N/A[3]	N/A/N/A[3]	N/A/N/A[3]	100
Dieldrin	ND	8000	ND/ND	ND/ND	ND/ND	ND/ND	800
Endosulfan I	ND	N/A	ND/ND	ND/ND	ND/ND	ND/ND	N/A
Endosulfan II	ND	N/A	ND/ND	ND/ND	ND/ND	ND/ND	N/A
Endosulfan Sulfate	ND	N/A	ND/ND	ND/ND	ND/ND	ND/ND	N/A

Identification / Analyte	Raw Sample (Wet Weight)	TTLC	Raw Sample SPLP/WET	6% Cement SPLP/WET	4% Cement + 8% Fluid Bed Fly Ash SPLP/WET	4% Cement + 6% Type F Fly Ash + 4% Fluid Bed Fly Ash SPLP/WET	STLC
Endrin	ND	200	ND/ND	ND/ND	ND/ND	ND/ND	20
Endrin Aldehyde	ND	N/A	ND/ND	ND/ND	ND/ND	ND/ND	N/A
Endrin Ketone	ND	N/A	ND/ND	ND/ND	ND/ND	ND/ND	N/A
Heptachlor	ND	4700	ND/ND	ND/ND	ND/ND	ND/ND	47
Heptachlor Epoxide	ND	N/A	ND/ND	ND/ND	ND/ND	ND/ND	N/A
Methoxychlor	ND	100000	ND/ND	ND/ND	ND/ND	ND/ND	10000
Toxaphene	ND	5000	ND/ND	ND/ND	ND/ND	ND/ND	500
PCBs	(µg/kg)	(µg/kg)	(µg/l)	(µg/l)	(µg/l)	(µg/l)	(µg/l)
Arochlor-1016	ND	N/A	ND/ND	ND/ND	ND/ND	ND/ND	N/A
Arochlor-1221	ND	N/A	ND/ND	ND/ND	ND/ND	ND/ND	N/A
Arochlor-1232	ND	N/A	ND/ND	ND/ND	ND/ND	ND/ND	N/A
Arochlor-1242	ND	N/A	ND/ND	ND/ND	ND/ND	ND/ND	N/A
Arochlor-1248	ND	N/A	ND/ND	ND/ND	ND/ND	ND/ND	N/A
Arochlor-1254	14	N/A	ND/ND	ND/ND	ND/ND	ND/ND	N/A
Arochlor-1260	ND	N/A	ND/ND	ND/ND	ND/ND	ND/ND	N/A
Total PCBs	14	50000	ND/ND	ND/ND	ND/ND	ND/ND	5000
WBR ID Number[1]	N/A	-	N/A	29	30	31	-
PAHs	(µg/kg)	(µg/kg)	(µg/l)	(µg/l)	(µg/l)	(µg/l)	(µg/l)
Naphthalene	ND	N/A	ND/ND	ND/ND	ND/ND	ND/ND	N/A
2-Methylnaphthalene	ND	N/A	ND/ND	ND/ND	ND/ND	ND/ND	N/A
Acenaphthylene	ND	N/A	ND/ND	ND/ND	ND/ND	ND/ND	N/A
Acenaphthene	ND	N/A	ND/ND	ND/ND	ND/ND	ND/ND	N/A
Fluorene	ND	N/A	ND/ND	ND/ND	ND/ND	ND/ND	N/A
Phenanthrene	21	N/A	ND/ND	ND/ND	ND/ND	ND/ND	N/A
Anthracene	ND	N/A	ND/ND	ND/ND	ND/ND	ND/ND	N/A
Flouranthene	58	N/A	ND/ND	ND/ND	ND/ND	ND/ND	N/A
Pyrene	77	N/A	ND/ND	ND/ND	ND/ND	ND/ND	N/A
Benzo(a)anthracene	32	N/A	ND/ND	ND/ND	ND/ND	ND/ND	N/A
Chrysene	33	N/A	ND/ND	ND/ND	ND/ND	ND/ND	N/A
Benzo(b)fluoranthene	44	N/A	ND/ND	ND/ND	ND/ND	ND/ND	N/A
Benzo(k)fluoranthene	29	N/A	ND/ND	ND/ND	ND/ND	ND/ND	N/A
Benzo(a)pyrene	ND	N/A	ND/ND	ND/ND	ND/ND	ND/ND	N/A
Perylene	ND	N/A	ND/ND	ND/ND	ND/ND	ND/ND	N/A
Indeno(1,2,3-cd)pyrene	ND	N/A	ND/ND	ND/ND	ND/ND	ND/ND	N/A
Dibenzo(a,h) anthracene	ND	N/A	ND/ND	ND/ND	ND/ND	ND/ND	N/A
Benzo(g,h,i) perylene	ND	N/A	ND/ND	ND/ND	ND/ND	ND/ND	N/A
Total PAHs	290	N/A	ND/ND	ND/ND	ND/ND	ND/ND	N/A

[1] Waste By Rail identification number provided for reference to the chemistry results appendix.

[2] Porewater salinity measured prior to extraction.

[3] 2,4'-DDD, 2,4'-DDE and 2,4'-DDT not measured in blend extracts.

[4] Limits set in Article 3, section 66261.22 of California, Title 22.

[5] All butyltin data are qualified due to QC issues and are provided for informational purposes only.

N/A = Not Available

ND = Not Detected

Table 6-5 SPLP and WET chemistry results for the POLB Channel 2 raw source material and associated blends with available TTLC and STLC values for comparison.

Identification / Analyte	Raw Sample (Wet Weight)	TTLC	Raw Sample SPLP/ WET	6% Cement SPLP/ WET	4% Cement + 8% Fluid Bed Fly Ash SPLP/WET	4% Cement + 6% Type F Fly Ash + 4% Fluid Bed Fly Ash SPLP/WET	2% Cement SPLP/ WET	STLC
WBR ID Number[1]	N/A	-	N/A	20	21	22	56	-
Grain Size (%)								
Sand	40.2	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Silt	35.1	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Clay	24.7	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Percent Solids	60	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Porewater Salinity (ppt)	33.2	N/A	N/A	26.4[2]	28.4[2]	24.4[2]	21.8[2]	N/A
TOC (mg/l)	1.26%	N/A	8.6/8.3	10/17	9.5/16	9.0/15	15/26	N/A
pH	8.1	N/A	7.4/8.2	11/11	9.9/9.8	10/10	7.0/2.5	<2, >12.5[4]
Total Sulfides (mg/kg)	89	N/A	ND/ND	ND/ND	ND/ND	ND/ND	ND/ND	N/A
TRPH (mg/kg)	460	N/A	ND/ND	ND/ND	ND/ND	ND/ND	ND/ND	N/A
Metals	(mg/kg)	(mg/kg)	(µg/l)	(µg/l)	(µg/l)	(µg/l)	(µg/l)	(µg/l)
Arsenic	8.5	500	12/25	ND/ND	ND/ND	ND/ND	15/12	5000
Cadmium	0.13	100	ND/ND	ND/ND	ND/ND	ND/ND	ND/0.33	1000
Chromium	29	2500	ND/ND	ND/ND	ND/ND	ND/ND	0.74/1.8	5000
Copper	39	2500	ND/ND	ND/ND	ND/ND	ND/ND	64/75	25000
Lead	48	1000	ND/ND	ND/ND	ND/ND	ND/ND	ND/ND	5000
Mercury	0.36	20	ND/ND	ND/ND	ND/ND	ND/ND	ND/ND	200
Nickel	12	2000	ND/ND	ND/ND	ND/ND	ND/ND	2.0/6.8	20000
Silver	0.11	500	ND/ND	ND/ND	ND/ND	ND/ND	ND/0.55	5000
Zinc	89	5000	ND/ND	ND/ND	ND/ND	ND/ND	ND/ND	250000
Butyltins[5]	(µg/kg)	(µg/kg)	(ng/l)	(ng/l)	(ng/l)	(ng/l)	(ng/l)	(ng/l)
Monobutyltin	4.1	N/A	ND/ND	ND/ND	ND/ND	ND/ND	ND/ND	N/A
Dibutyltin	7.1	N/A	6.3/5.9	12/14	8.0/9.6	ND/ND	2.1/3.7	N/A
Tributyltin	ND	N/A	20/27	200/210	310/220	40/69	8.5/26	N/A
Tetrabutyltin	ND	N/A	ND/ND	ND/ND	ND/ND	ND/ND	ND/ND	N/A
Pesticides	(µg/kg)	(µg/kg)	(µg/l)	(µg/l)	(µg/l)	(µg/l)	(µg/l)	(µg/l)
Aldrin	ND	1400	ND/ND	ND/ND	ND/ND	ND/ND	ND/ND	140
alpha-BHC	ND	N/A	ND/ND	ND/ND	ND/ND	ND/ND	ND/ND	N/A
beta-BHC	5.6	N/A	ND/ND	ND/ND	ND/ND	ND/ND	ND/0.087	N/A
delta-BHC	ND	N/A	ND/ND	ND/ND	ND/ND	ND/ND	ND/ND	N/A
gamma-BHC	ND	N/A	ND/ND	ND/ND	ND/ND	ND/ND	ND/ND	N/A
alpha-Chlordane	ND	N/A	ND/ND	ND/ND	ND/ND	ND/ND	ND/ND	N/A
gamma-Chlordane	1.4	N/A	ND/ND	ND/ND	ND/ND	ND/ND	ND/ND	N/A
Technical Chlordane	ND	N/A	ND/ND	ND/ND	ND/ND	ND/ND	ND/ND	N/A
Total Chlordane	1.4	2500	ND/ND	ND/ND	ND/ND	ND/ND	ND/ND	250
4,4'-DDD	12	1000	ND/ND	ND/ND	ND/ND	ND/ND	ND/ND	100
2,4'-DDD	ND	1000	ND/ND	N/A/N/A[3]	N/A/N/A[3]	N/A/N/A[3]	N/A/N/A[3]	100
4,4'-DDE	24	1000	ND/ND	ND/ND	ND/ND	ND/ND	ND/ND	100
2,4'-DDE	ND	1000	ND/ND	N/A/N/A[3]	N/A/N/A[3]	N/A/N/A[3]	N/A/N/A[3]	100
4,4'DDT	ND	1000	ND/ND	ND/ND	ND/ND	ND/ND	ND/ND	100
2,4'-DDT	ND	1000	ND/ND	N/A/N/A[3]	N/A/N/A[3]	N/A/N/A[3]	N/A/N/A[3]	100
Dieldrin	ND	8000	ND/ND	ND/ND	ND/ND	ND/ND	ND/ND	800
Endosulfan I	ND	N/A	ND/ND	ND/ND	ND/ND	ND/ND	ND/ND	N/A
Endosulfan II	ND	N/A	ND/ND	ND/ND	ND/ND	ND/ND	ND/ND	N/A
Endosulfan Sulfate	ND	N/A	ND/ND	ND/ND	ND/ND	ND/ND	ND/ND	N/A
Endrin	ND	200	ND/ND	ND/ND	ND/ND	ND/ND	ND/ND	20
Endrin Aldehyde	ND	N/A	ND/ND	ND/ND	ND/ND	ND/ND	ND/ND	N/A
Endrin Ketone	ND	N/A	ND/ND	ND/ND	ND/ND	ND/ND	ND/ND	N/A
Heptachlor	ND	4700	ND/ND	ND/ND	ND/ND	ND/ND	ND/ND	47
Heptachlor Epoxide	ND	N/A	ND/ND	ND/ND	ND/ND	ND/ND	ND/ND	N/A
Methoxychlor	ND	100000	ND/ND	ND/ND	ND/ND	ND/ND	ND/ND	10000

Identification / Analyte	Raw Sample (Wet Weight)	TTLC	Raw Sample SPLP/ WET	6% Cement SPLP/ WET	4% Cement + 8% Fluid Bed Fly Ash SPLP/WET	4% Cement + 6% Type F Fly Ash + 4% Fluid Bed Fly Ash SPLP/WET	2% Cement SPLP/ WET	STLC
Toxaphene	ND	5000	ND/ND	ND/ND	ND/ND	ND/ND	ND/ND	500
PCBs	(µg/kg)	(µg/kg)	(µg/l)	(µg/l)	(µg/l)	(µg/l)	(µg/l)	(µg/l)
Arochlor-1016	ND	N/A	ND/ND	ND/ND	ND/ND	ND/ND	ND/ND	N/A
Arochlor-1221	ND	N/A	ND/ND	ND/ND	ND/ND	ND/ND	ND/ND	N/A
Arochlor-1232	ND	N/A	ND/ND	ND/ND	ND/ND	ND/ND	ND/ND	N/A
Arochlor-1242	ND	N/A	ND/ND	ND/ND	ND/ND	ND/ND	ND/ND	N/A
Arochlor-1248	ND	N/A	ND/ND	ND/ND	ND/ND	ND/ND	ND/ND	N/A
Arochlor-1254	43	N/A	ND/ND	ND/ND	ND/ND	ND/ND	ND/ND	N/A
Arochlor-1260	ND	N/A	ND/ND	ND/ND	ND/ND	ND/ND	ND/ND	N/A
Total PCBs	43	50000	ND/ND	ND/ND	ND/ND	ND/ND	ND/ND	5000
WBR ID Number[1]	N/A	-	N/A	20	21	22	56	-
PAHs	(µg/kg)	(µg/kg)	(µg/l)	(µg/l)	(µg/l)	(µg/l)	(µg/l)	(µg/l)
Naphthalene	ND	N/A	ND/ND	ND/ND	ND/ND	ND/ND	ND/ND	N/A
2-Methylnaphthalene	ND	N/A	ND/ND	ND/ND	ND/ND	ND/ND	ND/ND	N/A
Acenaphthylene	37	N/A	ND/ND	ND/ND	ND/ND	ND/ND	ND/ND	N/A
Acenaphthene	22	N/A	ND/ND	ND/ND	ND/ND	ND/ND	ND/ND	N/A
Fluorene	54	N/A	ND/ND	ND/ND	ND/ND	ND/ND	ND/ND	N/A
Phenanthrene	350	N/A	ND/ND	ND/ND	ND/ND	ND/ND	ND/ND	N/A
Anthracene	150	N/A	ND/ND	ND/ND	ND/ND	ND/ND	ND/ND	N/A
Flouranthene	590	N/A	ND/ND	ND/ND	ND/ND	ND/ND	ND/ND	N/A
Pyrene	990	N/A	ND/ND	ND/ND	ND/ND	ND/ND	ND/ND	N/A
Benzo(a)anthracene	280	N/A	ND/ND	ND/ND	ND/ND	ND/ND	ND/ND	N/A
Chrysene	410	N/A	ND/ND	ND/ND	ND/ND	ND/ND	ND/ND	N/A
Benzo(b)fluoranthene	520	N/A	ND/ND	ND/ND	ND/ND	ND/ND	ND/ND	N/A
Benzo(k)fluoranthene	520	N/A	ND/ND	ND/ND	ND/ND	ND/ND	ND/ND	N/A
Benzo(a)pyrene	230	N/A	ND/ND	ND/ND	ND/ND	ND/ND	ND/ND	N/A
Perylene	ND	N/A	ND/ND	ND/ND	ND/ND	ND/ND	ND/ND	N/A
Indeno(1,2,3-cd)pyrene	210	N/A	ND/ND	ND/ND	ND/ND	ND/ND	ND/ND	N/A
Dibenzo(a,h)anthracene	90	N/A	ND/ND	ND/ND	ND/ND	ND/ND	ND/ND	N/A
Benzo(g,h,i)perylene	ND	N/A	ND/ND	ND/ND	ND/ND	ND/ND	ND/ND	N/A
Total PAHs	4500	N/A	ND/ND	ND/ND	ND/ND	ND/ND	ND/ND	N/A

[1] Waste By Rail identification number provided for reference to the chemistry results appendix.
[2] Porewater salinity measured prior to extraction.
[3] 2,4'-DDD, 2,4'-DDE and 2,4'-DDT not measured in blend extracts.
[4] Limits set in Article 3, section 66261.22 of California, Title 22.
[5] All butyltin data are qualified due to QC issues and are provided for informational purposes only.
N/A = Not Available
ND = Not Detected

Table 6-6 SPLP And WET Chemistry Results For The POLA Consolidated Slip Raw Source Material And Associated Blends With Available TTLC And STLC Values For Comparison

Identification / Analyte	Raw Sample (Wet Weight)	TTLC	Raw Sample SPLP/WET	6% Cement SPLP/WET	4% Cement + 8% Fluid Bed Fly Ash SPLP/WET	4% Cement + 6% Type F Fly Ash + 4% Fluid Bed Fly Ash SPLP/WET	2% Cement SPLP/WET	2% Cement + 4% Type F Fly Ash SPLP/WET	STLC
WBR ID Number[1]	N/A	-	N/A	23	24	25	54	55	-
Grain Size (%)									
Sand	28.3	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Silt	23.7	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Clay	48.0	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Percent Solids	40	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Porewater Salinity (ppt)	32.4	N/A	N/A	63.2[2]	38.0[2]	32.2[2]	47.6[2]	43.2[2]	N/A
TOC (mg/l)	8.67%	N/A	18/12	14/21	13/31	14/23	33/53	28/47	N/A
pH	8.0	N/A	8.0/8.1	10/10	9.8/9.7	10/3.5	6.9/6.6	7.0/2.6	<2, >12.5[4]
Total Sulfides (mg/kg)	930	N/A	ND/ND	ND/ND	ND/ND	ND/ND	ND/ND	ND/ND	N/A
TRPH (mg/kg)	17000	N/A	ND/ND	ND/ND	ND/ND	ND/ND	ND/ND	ND/ND	N/A
Metals	(mg/kg)	(mg/kg)	(µg/l)	(µg/l)	(µg/l)	(µg/l)	(µg/l)	(µg/l)	(µg/l)
Arsenic	9.0	500	33/79	ND/ND	ND/ND	ND/ND	18/13	16/13	5000
Cadmium	1.9	100	ND/ND	ND/ND	ND/ND	ND/ND	0.53/0.89	0.46/0.88	1000
Chromium	220	2500	ND/ND	ND/ND	ND/ND	ND/ND	2.6/4.8	3.6/6.0	5000
Copper	330	2500	ND/ND	ND/ND	ND/ND	ND/1.0	130/180	100/160	25000
Lead	160	1000	ND/ND	ND/ND	ND/ND	ND/ND	1.8/1.8	2.2/2.0	5000
Mercury	1.9	20	ND/ND	ND/ND	ND/ND	ND/ND	ND/ND	ND/ND	200
Nickel	28	2000	ND/ND	ND/ND	ND/ND	ND/ND	5.8/13	6.0/13	20000
Silver	3.6	500	ND/ND	ND/ND	ND/ND	ND/ND	6.0/26	2.6/21	5000
Zinc	290	5000	ND/ND	ND/ND	ND/ND	ND/ND	ND/ND	ND/ND	250000
Butyltins[5]	(µg/kg)	(µg/kg)	(ng/l)	(ng/l)	(ng/l)	(ng/l)	(ng/l)	(ng/l)	(ng/l)
Monobutyltin	ND	N/A	ND/ND	ND/ND	ND/ND	ND/ND	ND/ND	ND/ND	N/A
Dibutyltin	5.6	N/A	37/ND	ND/ND	ND/ND	ND/ND	ND/ND	2.2/ND	N/A
Tributyltin	ND	N/A	11/ND	8.4/ND	ND/ND	ND/ND	5.6/4.9	6.6/6.4	N/A
Tetrabutyltin	ND	N/A	ND/ND	ND/ND	ND/ND	ND/ND	ND/ND	ND/ND	N/A
Pesticides	(µg/kg)	(µg/kg)	(µg/l)	(µg/l)	(µg/l)	(µg/l)	(µg/l)	(µg/l)	(µg/l)
Aldrin	9.1	1400	ND/ND	ND/ND	ND/ND	ND/ND	ND/ND	ND/ND	140
alpha-BHC	ND	N/A	ND/ND	ND/ND	ND/ND	ND/ND	0.26/0.35	0.15/0.19	N/A
beta-BHC	ND	N/A	ND/ND	ND/ND	ND/ND	ND/ND	ND/ND	ND/ND	N/A
delta-BHC	ND	N/A	ND/ND	ND/ND	ND/ND	ND/ND	ND/ND	ND/ND	N/A
gamma-BHC	ND	N/A	ND/ND	ND/0.19	ND/0.077	0.15/ND	ND/ND	ND/ND	N/A
alpha-Chlordane	1.1	N/A	ND/ND	ND/ND	ND/ND	ND/ND	ND/ND	ND/ND	N/A
gamma-Chlordane	ND	N/A	ND/ND	ND/ND	ND/ND	ND/ND	ND/ND	ND/ND	N/A

Identification / Analyte	Raw Sample (Wet Weight)	TTLC	Raw Sample SPLP/WET	6% Cement SPLP/WET	4% Cement + 8% Fluid Bed Fly Ash SPLP/WET	4% Cement + 6% Type F Fly Ash + 4% Fluid Bed Fly Ash SPLP/WET	2% Cement SPLP/WET	2% Cement + 4% Type F Fly Ash SPLP/WET	STLC
Technical Chlordane	ND	N/A	ND/ND	ND/ND	ND/ND	ND/ND	ND/ND	ND/ND	N/A
Total Chlordane	1.1	2500	ND/ND	ND/ND	ND/ND	ND/ND	ND/ND	ND/ND	250
4,4'-DDD	24	1000	ND/ND	ND/0.12	ND/0.31	ND/ND	ND/ND	ND/ND	100
2,4'-DDD	ND	1000	ND/ND	N/A/N/A[3]	N/A/N/A[3]	N/A/N/A[3]	N/A/N/A[3]	N/A/N/A[3]	100
4,4'-DDE	18	1000	ND/ND	ND/0.25	ND/0.42	ND/0.29	0.27/0.38	0.29/0.35	100
2,4'-DDE	ND	1000	ND/ND	N/A/N/A[3]	N/A/N/A[3]	N/A/N/A[3]	N/A/N/A[3]	N/A/N/A[3]	100
4,4'DDT	ND	1000	ND/ND	ND/ND	ND/ND	ND/ND	ND/ND	ND/ND	100
2,4'-DDT	ND	1000	ND/ND	N/A/N/A[3]	N/A/N/A[3]	N/A/N/A[3]	N/A/N/A[3]	N/A/N/A[3]	100
Dieldrin	1.2	8000	ND/ND	0.093/ND	ND/ND	0.063/0.089	ND/ND	ND/ND	800
Endosulfan I	ND	N/A	ND/ND	ND/ND	ND/ND	ND/ND	ND/ND	ND/ND	N/A
Endosulfan II	ND	N/A	ND/ND	ND/ND	ND/ND	ND/ND	ND/ND	ND/ND	N/A
Endosulfan Sulfate	ND	N/A	ND/ND	ND/ND	ND/0.093	ND/ND	ND/ND	ND/ND	N/A
Endrin	ND	200	ND/ND	ND/ND	ND/0.31	ND/0.27	0.066/ND	0.079/0.098	20
Endrin Aldehyde	ND	N/A	ND/ND	ND/ND	ND/ND	ND/ND	ND/ND	ND/ND	N/A
Endrin Ketone	ND	N/A	ND/ND	ND/ND	ND/ND	ND/ND	ND/ND	ND/ND	N/A
Heptachlor	ND	4700	ND/ND	0.22/ND	ND/ND	ND/ND	ND/ND	ND/ND	47
Heptachlor Epoxide	ND	N/A	ND/ND	ND/ND	ND/ND	ND/ND	ND/ND	ND/ND	N/A
Methoxychlor	ND	100000	ND/ND	ND/ND	ND/ND	ND/ND	ND/ND	ND/ND	10000
Toxaphene	ND	5000	ND/ND	ND/ND	ND/ND	ND/ND	ND/ND	ND/ND	500
PCBs	(µg/kg)	(µg/kg)	(µg/l)	(µg/l)	(µg/l)	(µg/l)	(µg/l)	(µg/l)	(µg/l)
Arochlor-1016	ND	N/A	ND/ND	ND/ND	ND/ND	ND/ND	ND/ND	ND/ND	N/A
Arochlor-1221	ND	N/A	ND/ND	ND/ND	ND/ND	ND/ND	ND/ND	ND/ND	N/A
Arochlor-1232	ND	N/A	ND/ND	ND/ND	ND/ND	ND/ND	ND/ND	ND/ND	N/A
Arochlor-1242	ND	N/A	ND/ND	ND/ND	ND/ND	ND/ND	ND/ND	ND/ND	N/A
Arochlor-1248	ND	N/A	ND/ND	ND/ND	ND/ND	ND/ND	ND/ND	ND/ND	N/A
Arochlor-1254	77	N/A	ND/ND	ND/ND	ND/ND	ND/ND	ND/ND	ND/ND	N/A
Arochlor-1260	ND	N/A	ND/ND	ND/ND	ND/ND	ND/ND	ND/ND	ND/ND	N/A
Total PCBs	77	50000	ND/ND	ND/ND	ND/ND	ND/ND	ND/ND	ND/ND	5000
PAHs	(µg/kg)	(µg/kg)	(µg/l)	(µg/l)	(µg/l)	(µg/l)	(µg/l)	(µg/l)	(µg/l)
Naphthalene	3600	N/A	11/ND	ND/ND	ND/ND	ND/ND	ND/ND	ND/ND	N/A
2-Methylnaphthalene	26000	N/A	21/13	14/12	13/13	11/ND	ND/ND	ND/ND	N/A
Acenaphthylene	790	N/A	ND/ND	ND/ND	ND/ND	ND/ND	ND/ND	ND/ND	N/A
Acenaphthene	4600	N/A	ND/ND	ND/ND	ND/ND	ND/ND	ND/ND	ND/ND	N/A
Fluorene	7600	N/A	ND/ND	ND/ND	ND/ND	ND/ND	ND/ND	ND/ND	N/A
Phenanthrene	38000	N/A	ND/ND	ND/10	ND/10	ND/ND	ND/ND	ND/ND	N/A
Anthracene	6400	N/A	ND/ND	ND/ND	ND/ND	ND/ND	ND/ND	ND/ND	N/A
Flouranthene	2200	N/A	ND/ND	ND/ND	ND/ND	ND/ND	ND/ND	ND/ND	N/A
Pyrene	9300	N/A	ND/ND	ND/ND	ND/ND	ND/ND	ND/ND	ND/ND	N/A
Benzo(a)anthracene	1500	N/A	ND/ND	ND/ND	ND/ND	ND/ND	ND/ND	ND/ND	N/A
Chrysene	2200	N/A	ND/ND	ND/ND	ND/ND	ND/ND	ND/ND	ND/ND	N/A
Benzo(b)fluoranthene	640	N/A	ND/ND	ND/ND	ND/ND	ND/ND	ND/ND	ND/ND	N/A
Benzo(k)fluoranthene	ND	N/A	ND/ND	ND/ND	ND/ND	ND/ND	ND/ND	ND/ND	N/A

Identification / Analyte	Raw Sample (Wet Weight)	TTLC	Raw Sample SPLP/WET	6% Cement SPLP/WET	4% Cement + 8% Fluid Bed Fly Ash SPLP/WET	4% Cement + 6% Type F Fly Ash + 4% Fluid Bed Fly Ash SPLP/WET	2% Cement SPLP/WET	2% Cement + 4% Type F Fly Ash SPLP/WET	STLC
Benzo(a)pyrene	510	N/A	ND/ND	ND/ND	ND/ND	ND/ND	ND/ND	ND/ND	N/A
Perylene	ND	N/A	ND/ND	ND/ND	ND/ND	ND/ND	ND/ND	ND/ND	N/A
Indeno(1,2,3-cd)pyrene	ND	N/A	ND/ND	ND/ND	ND/ND	ND/ND	ND/ND	ND/ND	N/A
Dibenzo(a,h)anthracene	130	N/A	ND/ND	ND/ND	ND/ND	ND/ND	ND/ND	ND/ND	N/A
Benzo(g,h,i)perylene	ND	N/A	ND/ND	ND/ND	ND/ND	ND/ND	ND/ND	ND/ND	N/A
Total PAHs	100000	N/A	32/13	14/22	13/23	11/ND	ND/ND	ND/ND	N/A

[1] Waste By Rail identification number provided for reference to the chemistry results appendix.
[2] Porewater salinity measured prior to extraction.
[3] 2,4'-DDD, 2,4'-DDE and 2,4'-DDT not measured in blend extracts.
[4] Limits set in Article 3, section 66261.22 of California, Title 22.
[5] All butyltin data are qualified due to QC issues and are provided for informational purposes only.
N/A = Not Available
ND = Not Detected

6.5 SUMMARY OF CHEMICAL TESTING RESULTS

The LARE, MdR, POLB Channel 2 and POLA Consolidated Slip raw sediment samples all exceeded ER-M values in at least one category, indicating elevated contaminant levels. POLA Consolidated Slip exceeded the most ER-M values at 23.

None of the raw sediment samples exceeded TTLC values. Similarly none of the extracts exceeded STLC values, either before or after stabilization. The results indicate that none of the samples (raw or treated) would be considered hazardous waste under California Title 22 criteria.

All metals analyzed were measured in the four raw sediment samples, with the exception of silver in the LARE and Marina del Rey samples, and cadmium in the Marina del Rey sample. Values ranged from 0.022 mg/kg for mercury in the Marina del Rey sample, to 330 mg/kg for copper in the POLA Consolidated Slip sample (wet weight). The only metal to persist through the SPLP and WET extractions of the raw sediment samples was arsenic, at values of 2.8 µg/l for Marina del Rey SPLP to 79µg/l for POLA Consolidated Slip WET. The only blend extracts with reported values above non-detect for metals were POLA Consolidated Slip 4% Cement + 6% Type F Fly Ash + 4% Fluid Bed Fly Ash (WBR-25) DI WET, POLB Channel II 2% Cement (WBR-56), POLA Consolidated Slip 2% Cement (WBR-54), and POLA Consolidated Slip 2% Cement + 4% Type F Fly Ash (WBR-55). Copper was detected at a level of 1.0 µg/l in WBR-25. Arsenic, cadmium, copper, nickel, and silver were detected in the extracts of the last three of these blends, and lead was detected in the extracts of WBR-54 and 55.The highest metal value reported in the blend extracts was 180 µg/l for copper in WBR-54 WET extract, which is well below the STLC limit of 25000 µg/l.

The differences in metal results between the WBR-54 through 56 blend extracts and the previous blend extracts (WBR-14 through 31) may be attributable to the holding time for the source material and the fact that source material was held in sealed buckets at ambient temperatures (i.e., not refrigerated). The initial batch of blends was prepared in August 2001, and the second batch was prepared in December 2001 (i.e., source material for the second batch was held four months longer than the source material used initially). The same lots of cement and fly ash were used to prepare both batches of blends, so it is unlikely that the differences in chemical results are attributable to differences in the additives. However, it is possible that the metals might have become more available over time in the original sediment sample. Additionally, the fact that samples were held at ambient temperatures may have resulted in changes in moisture content and other factors that might have influenced metal availability through the treatment and extraction process. Sample WBR-25 DI WET was analyzed for metals about five months later than the rest of the first batch of samples, which may have contributed to it being the only extraction of the first set of blends to have a reported value for a metal. QC data were not provided for this analysis.

Butyltin data for seven of the samples analyzed were qualified due to method blank issues (values reported were within 3x that reported for the method blank). Butyltin data were also qualified from forty-two of the samples due to low recovery issues (both surrogate recovery and laboratory spike recovery). Five of these samples were qualified for both method blank and low recovery issues (WBR-54 and 55 SPLP and WET extracts, and WBR-56 SPLP extract). As 85%

of the samples were affected by least one of the issues mentioned above, all butyltin data were qualified and no analysis of the data was performed.

Low levels of pesticides were present in some of the stabilization blend extracts for LARE and POLA Consolidated Slip. These pesticides were not present in the extracts from the raw sediment. It is not clear why pesticides were detected in extracts of the blends and not in the extracts of the raw source material. Some plausible explanations for higher concentrations in the blend extracts include: 1) an error in the chemistry analysis (though all measures of quality assurance and quality control indicate that analytical methods were in control with the exception of the butyltin analysis); 2) pesticides were contributed from another source such as the additives being used for the blends; 3) matrix interferences in the raw material were eliminated in the stabilization blends making it possible to detect the pesticides; and/or 4) a constituent in the blends caused the pesticides to be more extractable. In all cases, whether the pesticide was present in the raw sediment or not, the level of pesticides in the extracts were close to the limits of detection and well below STLC values. The highest level is 0.42 μg/l of 4,4'-DDE in the WET extract of the 4% cement + 8% fluid bed fly ash blend (WBR -24) of POLA Consolidated Slip, the STLC value for p,p'-DDE is 100 μg/l.

The PCB arochlor-1254 was present in all four raw sediment samples, however it was not detected in any of the WET or STLC extracts of the raw sediment or the stabilization blends.

PAHs were measured in all four raw sediment samples, however, they were only present in the extracts when the values exceeded 10,000 μg/kg wet weight in the raw sediment, with one exception (napthalene, reported at a level of 3600 μg/kg wet weight in the raw sediment of POLA Consolidated Slip, and a level of 11 μg/l in the raw sample SPLP extract). The only site that had values above 10,000 μg/kg-wet weight was POLA Consolidated Slip. 2-methylnaphthalene, which was reported at a level of 26000 μg/kg wet weight in raw sample, was present in all of the extracts with the exception of the 4% cement + 6% type F fly ash + 4% fluid bed fly ash (WBR-25) WET extract. Values ranged from 11 μg/l in the WBR-25 SPLP extract to 21 μg/l in the raw sample SPLP extract. Phenanthrene, which was reported at a level of 38000 μg/kg wet weight in the raw sediment sample, was present in two of the extracts at a reported level of 10 μg/l. Those extracts were the 6% cement (WBR-23) WET extract and the 4% cement + 8% fluid bed fly ash (WBR-24) WET extract.

Though the total PAH values for the first batch of POLA Consolidated Slip extracts (WBR-23 – 25) were similar, WBR-25 had the lowest values at non-detect for the WET extract and 11 μg/l for the SPLP extract. The highest values were reported for the raw sample extracts, at 13 μg/l for the WET extract and 32 μg/l for the SPLP extract. There were no PAHs detected in the second batch of extracts (WBR-54-56). This may be attributable to the increased holding time associated with raw source material used to prepare these blends. Additionally, the raw sediment samples were not refrigerated so it is possible that some loss due to volatilization of PAHs may have occurred. There are no published Title 22 STLC values for PAHs.

7.0 CONCLUSIONS AND RECOMMENDATIONS

7.1 CONCLUSIONS

Of the four source sites, raw materials from Marina del Rey and the Los Angeles River Estuary already possess generally good engineering properties based on their high sand content, and would be generally suitable for upland applications. However, the CBS process improved the ability to manage the material in a timely manner through hydration of excess porewater. This benefit will be a function of the amount of excess water in the dredged material as well as its drainage characteristics.

The Port of Long Beach (POLB) material possessed greater silt and clay content, and clearly benefited from the CBS process. The material became manageable in a matter of hours, whereas the untreated material would require extensive drying time. Unexpectedly, the CBS process either had no impact or increased compressibility, depending on the specific reagent mix. However, the process greatly increased the permeability of the material to improve drainage characteristics. The CBS mixes demonstrating the best combination of engineering qualities were the 4% cement + 8 % fluidized bed ash, and the 4% cement + 8% Type F ash + 4% fluidized bed ash combinations.

The Port of Los Angeles (POLA) material also demonstrated poor inherent engineering properties, and benefited from the CBS process. Similar to the Port of Long Beach material, the CBS treatment rendered manageable material in a matter of hours, except for the low cement mixes. Both compressive and shear strength was improved. The process greatly reduced the compressibility of the untreated material. Permeability was moderately increased. The 4% cement + 8% fluidized bed ash mixture was found to produce the best overall improvement of engineering qualities.

In summary, the CBS process resulted in significant improvement of the POLB and POLA material for general upland use. However, high fine content and low density may limit their broad application, particularly the POLA material. Final assessment of suitability would be based on the specific application and associated material performance requirements.

Chemical testing results showed that none of the raw sediment samples evaluated exceeded the TTLC limits indicating these sediments are not hazardous waste by California Title 22 criteria. Similarly, none of the extracts (i.e., either the raw sediments or stabilization blends) exceeded STLC limits indicating that these materials would not be considered hazardous waste by California Title 22 criteria. With the exception of some pesticides and metals, contaminants appeared to be less available in the blends than in the raw samples. The blend with the lowest reported values of contaminants overall was the 4% cement + 6% type F fly ash + 4% fluid bed fly ash blend.

A subsequent pilot-scale study of cement-based stabilization technology under preparation for the Los Angeles District (draft to be published June 2002) projects costs on the order of $45 per cubic yard for dredging through treatment. The cost was based on a reagent mix of 5 percent cement. Of that amount, only about $7 was associated with reagent purchase. Thus, the overall treatment costs is not highly sensitive to type nor volume of reagent.

7.2 RECOMMENDATIONS

One surprising result of the study was the limited levels of contaminants in the raw materials, particularly the Port of Los Angeles material from the Consolidated Slip. One known contaminant of concern in this area is the pesticide DDT. It would be of interest to conduct further sampling and process those samples with more representative detection levels to further assess the efficacy of the CBS process in binding regional contaminants of concern.

To further assess the potential applicability of the CBS technology, the findings of this and the upcoming pilot-scale study should be integrated with studies of the market demand for such beneficial re-use material, including the market study currently being conducted under the direction of the Contaminated Sediments Task Force (CSTF).

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