6 MANAGEMENT OPTIONS

Section 6 provides an overview of available management options for the treatment and/or disposal of contaminated sediments in Los Angeles County. An evaluation of the feasibility of these alternatives and criteria for alternative selection is presented in Section 9 of this report.

6.1 Introduction

Management of contaminated sediments can occur preemptively in the form of source control measures, or reactively in the form of isolation, remediation or removal. Source control/reduction can occur either by controlling aqueous contaminant inputs to the watershed or by controlling sediment inputs to the watershed. Options for contaminated sediment isolation include various forms of in-situ and post-removal containment. If sediments are removed, management options include in-water or upland disposal. Some form of beneficial uses for dredged contaminated sediments is possible with nearly all sediment types. However, sediment treatment, market development, or policy development is needed before some of the beneficial reuse options can be implemented. Each of these issues is discussed in more detail in this section.

6.2 No Action Alternative

If the contaminated sediments are not located in an area where dredging is required for navigational or other purposes, a no action alternative may be possible assuming ecological and human health risks are not compromised. Potential risks resulting from leaving the material in place must be balanced against the potential risks associated with removal or isolation, including resuspension and remobilization. One example where the risks of leaving the material in place exceeded the risks associated with removal is the Lauritzen Channel in Richmond Harbor of San Francisco Bay. In this case, despite the lack of need for navigational dredging, the sediments were removed and transported to an upland permitted landfill.

While the preferred alternative is frequently removal, it is sometimes advantageous to leave contaminated sediments in place rather then risk increasing chemical bioavailability by dredging. This is because chemicals present in bottom sediments typically exist in two basic forms: 1) adsorbed or otherwise bound to particulates and 2) dissolved in bottom sediment pore waters (the water between particulate grains in the sediment). Contaminant releases from sediments tend to increase during resuspension due to increased surface area exposure and conditions suitable for increased chemical oxidation. This process, referred to as chemical partitioning, can allow chemicals previously bound to sediment particles to be released into the water column where they can be absorbed by aquatic organisms, possibly causing detrimental effects. This alternative may be suitable for low energy areas where natural sedimentation can assist in burying the contaminated sediment layers and only when source control has already been implemented.

6.3 Contaminant Reduction at the Source

Watershed-derived contaminated sediment is created when organic and inorganic contaminants released or deposited within the watershed come into contact with the sediment on erodible and impervious surfaces of the watershed through natural processes or human activities. Contaminated sediment can also be generated in the water bodies where elevated contaminant levels exist as a result of releases from local sources in the water bodies or discharges from upland. Hence, a potentially effective option for the management of contaminated sediment is through the control or reduction of contaminant releases in the watersheds and water bodies.

The sources of contaminants in the watershed of the Los Angeles region include chemicals released from accidents, industrial, commercial and residential activities, chemicals released from improper operation and maintenance of disposal systems, point sources, atmospheric deposition and marine vessel activities. Watershed activities that are known to release chemicals include transportation and commercial activities on freeways and at parking lots and gas stations. Industrial activities in the Los Angeles/Long Beach Harbors, including cargo handling and heavy machinery operations at the terminals, also tend to release contaminants to the harbor waters either directly or in runoff. Point sources, primarily POTWs, release contaminated particulates as well as dissolved contaminants into receiving waters. An example of such facilities is the Terminal Island Waste Water Treatment Plant, which discharges directly into the Los Angeles Harbor. Atmospheric deposition of contaminants occurs when contaminants in the atmosphere, originating from aerial emission during industrial, commercial and transportation activities in the watersheds, bind to suspended particulates and settle on land and in aquatic systems. Marine vessel activities may result in the release of contaminants from sources such as oil and petroleum products (hydrocarbons, lead, PAHs), antifouling paint additives (metals and TBT) and sacrificial anodes (metals).

Reduction of contaminant release from these sources through the implementation of control measures can reduce the amount of contaminated sediment in the watershed and water bodies in the area. The sources of contaminated sediments in the Los Angeles region, as well as potential source control measures, are discussed further in Section 7.

6.4 Sediment Source Reduction/Containment

Sediments deposited in the regional estuaries, harbors, navigational channels and coastal waters are composed of materials of both upland and littoral origins. Sediment movement and deposition as a result of littoral processes from wave and current action along the coast contributes to the accretion of sediment in harbor channels on the open coast. Sediment deposited at the mouths of regional streams such as Ballona Creek and the Los Angeles River Estuary is a result primarily from watershed runoff during storms. Since an appreciable fraction of the sediment discharged from upland areas has been found to be contaminated, reduction and containment of sediment sources within the watersheds are, therefore, a potentially effective option for the management of contaminated sediment within the study area for this project.

The primary sources of sediment within the watersheds in the region include erosion from construction sites, land development, foothills, canyons, and burned areas. For the Los Angeles region, over a hundred debris basins are presently in place at the outlets of canyons and foothills to trap eroded sediment and thus reduce sediment delivery downstream and to the coast. In addition, over 200 soil stabilization structures were constructed and are functioning to prevent erosion in the canyons (LACDWP 2001). Emergency structures have also been constructed downstream of burned areas in the watersheds to trap eroded sediment and debris to protect downstream properties. Opportunities exist, however, to enhance the siting and trapping efficiencies of erosion control structures throughout the watershed to reduce bypassing and coastal delivery of eroded sediment. Opportunities also exist to improve management practices for erosion control at urban transitional lands and barren lands to reduce erosion.

Reduction and containment of sediment-producing sources within the watersheds can reduce the overall volume of coastal sediment requiring management in the region. By trapping sediment from natural foothills and canyons above urban basins, this option reduces the amount of natural sediment that can be contaminated during migration through the urban areas en route to the ocean. By implementing monitoring and containment of contaminated sediment-producing sources within the watersheds, the option reduces the volume of contaminated sediment discharged to the coast, although it also tends to deprive beaches of natural supplies of sand.

An example of this is currently underway in Santa Monica where the USACE is evaluating alternatives for controlling sediment within the Ballona Creek watershed as a way to alleviate the problems with sedimentation in the Marina del Rey entrance channel. One of the alternatives under consideration is the construction of in-stream sediment traps to collect the Ballona Creek sediment prior to discharge. It should be noted, however, that such control measures tend to be less effective for fine-grained sediment especially during large storm events.

6.5 In-Situ Remediation

In-situ treatment/remediation of contaminated sediments is a developing science that has not previously been applied in the Los Angeles region at the time this report was prepared. Currently, two primary methods of in-situ remediation are being studied by researchers in the U.S. and Canada. One method relies on injecting chemicals into the sediments (primarily oxidants) to speed up the bacterial degradation processes or to inactivate reactive sulfides (e.g. with ferric chloride). Example projects have been conducted in Hamilton Harbor, Canada (Murphy et al. 1995a) and the St. Mary's River, Canada (Murphy et al. 1995b).

The other method uses a proprietary (Weiss Associates Electrochemical Remediation Technologies) AC/DC electrical signal to mineralize organic compounds and mobilize and remove metal contaminants (Doering et al. 2000). This process, which has been used in Europe, is being tested in the U.S. with support from the Remediation Technology Development Forum (RTDF). The RTDF was established in 1992 by the U.S. Environmental Protection Agency to foster collaboration between the public and private sectors in developing innovative solutions to mutual hazardous waste problems. Since then, the RTDF has grown to include partners from industry, several government agencies, and academia who share the common goal of developing more effective, less costly hazardous waste characterization and treatment technologies.

Both methods have been tested on small pilot scale projects and are currently being investigated for more wide-scale use. As in the case with the no-action alternative, in-situ remediation of contaminated sediments is not feasible for areas where sediment removal is required for navigational or other purposes. In addition, costs for this alternative are currently much higher than with other alternatives, partially due to the proprietary nature of the technology.

6.6 In-Situ Isolation/Containment

In-situ isolation/containment of contaminated sediment consists of capping the material in place using either clean sand, geo-textile material, or a combination thereof to provide an engineered isolation of the contaminants, thus preventing migration to the water column. The technical aspects of sediment capping design and implementation are similar to those employed during construction of a confined aquatic disposal facility, which are described in detail in the final report for the DMMP Pilot Studies (see Strategy Report Technical Appendices) and summarized below in Section 6.7.1.2.1.

6.7 Sediment Removal (Dredge Material Disposal Options)

Contaminated sediment disposal alternatives following dredging in the Los Angeles region consist of either aquatic or upland disposal options. This section describes potential alternatives under each scenario.

6.7.1 Aquatic Disposal

This section describes aquatic disposal options for contaminated sediments included in the evaluation for developing the Contaminated Management Strategy. State and Federal regulations relevant to aquatic disposal are also discussed.

6.7.1.1 Current Regulations

Unconfined aquatic disposal of contaminated sediments is prohibited by law under the Clean Water Act, Section 404(b) and the Marine Protection, Research and Sanctuaries Act of 1972. The U.S. EPA and the U.S. Army Corps of Engineers have jointly developed testing manuals to determine dredge material suitability for aquatic disposal proposed for ocean disposal (Evaluation of Dredged Material Proposed for Ocean Disposal, U.S.EPA 1991) and for disposal in inland environments (Inland Testing Manual, U.S.EPA 1998). Within the State of California, aquatic disposal of dredged sediments is regulated by the U.S. Army Corps of Engineers (South Pacific Division) following Federal guidelines under the oversight of the U.S. EPA (Table 6-1). NOAA Fisheries as well as the U.S. Fish and Wildlife Service also play consultative roles in the permitting process. Additionally, the California Coastal Commission and the Los Angeles Regional Water Quality Control Board ensure State water quality and coastal zone management act guidelines are met by providing input to the U.S. EPA and USACE during the permit review process. To comply with the regulations set forth by the above State and Federal entities, aquatic disposal options for contaminated sediments in the Los Angeles region are limited to alternatives where confinement of the contaminants will be provided.

Table 6-1. Agency oversight for aquatic disposal of contaminated sediments.

Agency/Organization	Governing Authority
U.S. Army Corps of Engineers	Sections 9 and 10 of the Rivers and Harbor Act; Section 404 of the Clean Water Act; all in-water fill or construction activities
U.S. EPA	Protection of ecological and human health resources – concurrence with Corps authority for in-water disposal
NOAA – National Marine Fisheries Service	Protection of all marine resources – federal coordinating agency
U.S. Fish and Wildlife Department	Protection of fish and wildlife resources – federal coordination agency
California Coastal Commission	Ensure compliance with the Coastal Zone Management Act
Los Angeles Regional Water Quality Control Board	Protection of surface water resources; issue Waste Discharge Permits for disposal facilities and/or operations, ensure compliance with Section 401 of the federal Clean Water Act.

6.7.1.2 Potential Options

Potential aquatic disposal options considered in the evaluation process include submerged confined aquatic disposal, nearshore confined disposal, and shallow water habitat creation. Each is described in more detail in the following sections and presented graphically in Figure 6-1.

6.7.1.2.1 Confined Aquatic Disposal

Confined aquatic disposal (CAD) is a procedure where contaminated sediments are typically placed into a submerged depression or pit and covered with clean sediments to form a cap that will prevent upward migration of contaminants into the water column or surficial sediment layer. Occasionally, sediments will simply be mounded and capped rather than placed in a depression. The primary issues associated with a CAD include: (1) the short-term effects from turbidity and potential contaminant release during placement; (2) cap stability under hydrodynamic stresses (waves and currents); (3) cap integrity under biological perturbations (bioturbation); (4) chemical diffusion through the cap layer; and (5) uneven site consolidation.

This method was evaluated in great detail by the CSTF by conducting a pilot field study using contaminated dredge materials removed from the LARE and placed in the North Energy Island Borrow Pit, located in Long Beach. Approximately 100,000 cubic meters of contaminated sediment was dredged for the pilot study and capped with approximately 60,000 cubic meters of clean sediment from a previous maintenance dredging project. The pilot study, which was conducted between the summer of 2001 and the winter of 2002, relied on standard dredging equipment such as mechanical (re-handling) buckets and bottom dump scows. Dredge material placement and cap construction were designed to prevent uneven placement and smooth surface areas. A minimum of 1 meter cap thickness was ensured through daily bathymetric surveys and post construction monitoring. Water quality monitoring occurred both at the point of dredging and at the disposal location. Immediately following cap construction, field samples were collected to ensure accurate placement of the cap material, cap thickness and lack of mixing between the cap and LARE material. Since construction, intensive monitoring of the cap surface has been conducted annually for the past two years and is scheduled to occur for one additional year, concluding in the summer of 2004. Long-term monitoring will continue (subject to the availability of funds) to confirm the initial findings of the pilot project. Additional details of the aquatic capping pilot study are contained in the final report for the DMMP pilot studies which is included in the Management Strategy Technical Appendices as part of this document.

6.7.1.2.2 Confined Disposal Facility

A nearshore confined disposal facility (CDF) involves placing contaminated dredged materials inside a diked nearshore area or island constructed with containment and control measures such as lining, covering and effluent control. Primary issues with nearshore CDF disposal include: (1) coastal land availability and costs, (2) wave protection, (3) short-term effects from effluent discharge during and after filling, (4) solids retention during filling, (5) contaminant containment structure design, and (6) long-term end use of the site after closure. Nearshore CDFs constructed with contaminated sediments as fill material have been constructed by the Port of Los Angeles (POLA) and the Port of Long Beach (POLB) for many years and have been the standard method for disposing of contaminated dredge sediments.

Examples of regional CDFs include the Pier 400 construction project at the POLA and the Pier E, Slip 2 project at the POLB. In both instances, dikes were constructed across the entrance to the slip or around the perimeter of the disposal area with open areas to allow vessel traffic. Sediments were then placed into the fill area, initially via bottom dump barge and then hydraulically as the fill area became too shallow to allow access via barge. As the sediment accumulated in the fill area, the dike walls were increased in height until they broke the surface of the water. Weirs were then used to drain the remaining water from the fill area. After de-watering, the fill areas were covered with asphalt and developed to support various port facilities.

The POLA Pier 400 project is a 590 acre CDF constructed using over 58 million cubic meters of dredged sediment. Construction began in 1994 and was completed six years later in 2000 at a cost of approximately $400 million (Port of Los Angeles website). The POLB Pier T, Slip 2 fill project was also completed in 2000. Approximately 2 million cubic meters of dredged sediment was used to construct the 29 acre CDF by filling a former slip at the California Unified Terminal (LA CSTF Interim Advisory Meeting Minutes, 8/21/98).

6.7.1.2.3 Shallow Water Habitat Creation

Shallow water habitat creation refers to a process that involves placing the contaminated dredge material in a diked sub-aqueous containment area in shallow water and covering the material with a clean cap designed to provide the proper elevation and consistency needed to enhance the biological value of the site. Primary issues of concern with shallow-water habitat creation include: (1) final cap elevation determination, (2) cap material thickness and selection, and (3) target organism colonization, as well as all of the issues associated with aquatic capping of contaminated dredged materials. An example of this type of aquatic disposal option is the POLA Cabrillo Shallow-Water Habitat project completed in 1999. The 190 acre habitat area was created to mitigate for port development projects and included contaminated dredged sediments as foundation material (LA CSTF Advisory Committee Meeting Notes, 4/9/02). The concept for the Cabrillo habitat project was to create a subsurface disposal area that would effectively raise the bathymetry of the area to a point where light penetration could reach the bottom and provide conditions that support a more diverse habitat compared to a previously deep-water area.

6.7.2 Upland Disposal

Upland disposal alternatives involve placing contaminated dredge material in an upland facility constructed with containment measures such as lining, diking, and covering. Typical upland disposal locations include upland confined disposal facilities and commercial landfills.

The primary issues of concern with upland landfill disposal of contaminated dredged materials include: (1) contaminant and chloride leaching; (2) availability of suitable existing landfills; (3) land availability and cost for new landfill facilities; (4) land availability and costs for dewatering facilities, and (5) transportation costs. The primary issues of concern with upland CDF disposal of contaminated dredged materials include: (1) land availability and cost for the facility; (2) contaminant leaching; (3) effluent control, solids retention and surface runoff control, and (4) the long-term end use of the site after closure.

6.7.2.1 Current Regulations

There are currently no State or Federal laws or regulations that apply specifically to upland disposal of contaminated dredge materials. Instead, potential upland disposal projects would be reviewed by the U.S. Army Corps of Engineers, U.S. EPA, California Integrated Waste Management Board, California Department of Toxics and Substance Control, California Coastal Commission, or Los Angeles Regional Water Quality Control Board depending on the nature and location of the planned disposal.

Each organization would then determine compliance with existing regulations specific to their authority as they relate to standard waste disposal practices. The following table briefly summarizes the governing authority of each of these agencies, as they may relate to upland disposal of dredge materials.

Table 6-2. Agency oversight for upland disposal of contaminated sediments.

Agency/Organization	Governing Authority
U.S. Army Corps of Engineers	Section 404 of the Clean Water Act; all in-water fill activities
U.S. EPA	Protection of ecological and human health resources – concurrence with Corps authority
California Integrated Waste Management Board	Disposal of solid wastes in upland landfills
California Department of Toxics and Substances Control	Oversight of State and some Federal (e.g., Navy Installation Restoration program) cleanup sites.
California Coastal Commission	Ensure compliance with the Coastal Zone Management Act
Los Angeles Regional Water Quality Control Board	Protection of surface water and ground resources; issue Waste Discharge Permits for disposal facilities and/or operations

6.7.2.2 Potential Options

To ensure the protection of human health and environmental resources, only two potential options currently exist for upland disposal of untreated contaminated dredged materials: containment in a confined upland disposal facility or disposal at a commercial landfill permitted to accept contaminated sediments. Both options are described in more detail in the following sections.

6.7.2.2.1 Upland Confined Disposal Facility

An upland CDF is operated similar to a nearshore CDF, except that it is constructed entirely out of the water and in some cases many miles inland from the dredge location. Sediments are transported to the facility either via truck or hydraulically pumped into the containment area. The material is dewatered and then either reused or capped with clean soils. A clay base or synthetic liner may be required to prevent seepage of water from the CDF into the underlying groundwater. Decant water leaving the facility is typically treated to remove solids or contaminants and then discharged back to the dredge location via pipeline. In the Los Angeles region, a typical upland CDF would be located near the coast where groundwater resources are not utilized.

The use of contaminated dredge materials as general or engineered fill for nearshore upland areas is common practice in the Los Angeles region and numerous examples exist for reference. Typically these events coincide with port expansion projects such that the contaminated sediments are used to fill newly diked areas slated for port development. Briefly, the fill areas are designed to meet seismic protection and load bearing capacity for the final surface grade, depending on the intended use. Construction generally entails hauling the partially de-watered dredge material to the fill location and then mixing the material with imported sand to reduce the moisture and increase the strength. A detailed discussion of this process, including specific geotechnical specifications for the fill material, can be found in the Sediment Blending Pilot Study report (USACE 2001) contained in the technical appendices to this document.

6.7.2.2.2 Commercial Landfill

Disposal of contaminated sediments at upland (Class III) commercial landfills is not currently authorized by the Los Angeles Regional Water Quality Control Board due to concerns about chloride and contaminant leaching into the groundwater. Other issues associated with landfill disposal of contaminated sediments include reducing landfill capacity; and infrastructure impacts related to transporting the material to the landfill. An alternative more likely to be acceptable to regulatory agencies would be to beneficially reuse the material as daily landfill cover (see Section 6.8.4.2.1). Projects to reuse dredge material as daily cover are currently evaluated on a case-by-case basis by the Los Angeles Regional Water Quality Control Board.

6.8 Dredge Material Beneficial Reuse Options

This section discusses issues associated with beneficial reuse of dredge materials, including current State and Federal regulations, identification of treatment technologies, and potential end use products for the treated material. Further discussion on this subject, including the results of a market survey of potential end users for treated sediments in the Los Angeles Region can be found in the report entitled *Contaminated Sediments Market Evaluation: A Report on the Market for Beneficial Use of Contaminated Dredged Sediments in the Greater Los Angeles Area* (GeoSyntec, 2003). A copy of the report is included in the technical appendices to this document. For this study, beneficial reuse is defined as providing some use for the material other than simply as disposal (e.g., landfill). It is possible, however, to construct a disposal facility (e.g., shallow water habitat or CDF) that can serve a beneficial use by altering the topography or bathymetry such that other benefits are achieved.

6.8.1 Current Regulations

According to GeoSyntec (2003), there are no state or federal laws or regulations that apply specifically and exclusively to the treatment and beneficial use of clean or contaminated dredged sediments. Treatment and beneficial use of dredged sediments is, however, subject to state and federal laws and regulations that pertain to any construction material or product involving borrowing, dredging, treatment, manufacture, transport, sale, purchase, use, environmental protection, and product liability.

6.8.2 Identification of Potential Treatment Technologies

Potential treatment alternatives for contaminated dredge materials include cement stabilization, sediment washing, sediment blending, vitrification and soil separation. Each is briefly described in the following sections.

6.8.2.1 Cement Stabilization

Stabilization of contaminated marine dredged materials with cement-based additive mixes is a treatment technology that converts contaminants in the material into their least soluble, mobile or toxic forms and enhances the physical properties of the material. The technology, commonly known as cement stabilization, has been widely used in upland soil remediation projects. Its application to contaminated marine dredged materials, however, has been relatively limited, due partly to the large volumes of the materials involved per project, special material handling requirements, and special physical and chemical characteristics of marine dredged materials.

A cement stabilization process uses select cement-based binders (binders) such as Portland cement based on their ability to precipitate metal ions, react with specific analytes, and bind/encapsulate specific contaminants. In a typical process, the binder is mechanically blended into the dredged material. The cement reacts with process water and pore water in the dredged material (hydration) to produce a binding gel (e.g. Tobermorite gel). The binding gel coats the contaminated fine particles, cements them into larger clusters, and fills up the micro-pores in the material's microstructure. The reactions consume water through hydration, produce calcium hydroxide that reacts with siliceous particles to create additional binding gel, and generate heat that accelerates dewatering. Upon adequate curing, the reactions immobilize/encapsulate contaminants in the microstructure of the treated material and enhance the material's engineering properties such as shear strength, compaction, and consolidation characteristics.

In addition to processes using pure Portland cement, coal ash, or fly ash, is often used in combination with cement for bulking and pozzolanic reactions to reduce binder cost while maintaining and, in some cases, improving treatment results. Fly ash generally relies on products from the hydration of Portland cement, primarily calcium hydroxide, to trigger pozzolanic reactions, produce cementing characteristics, and harden on curing. With appropriate proportioning with Portland cement, cement/fly ash-treated products can exceed those by cement alone in strength characteristics. Since fly ash is typically less expensive than Portland cement, it has been used in combination with cement in cement stabilization projects.

A pilot-scale study of cement stabilization was conducted in 2002 to evaluate the effectiveness, operation, cost, and environmental impacts of the technology for treating contaminated dredged material from the region. The study results are presented in the DMMP pilot study report located in the Management Strategy Technical Appendices (USACE 2002(a).

6.8.2.2 Sediment Washing

Sediment washing as a treatment technology for contaminated sediments typically refers to a process that involves slurrying the contaminated dredged material and subjecting the slurry to physical collision, shearing, and abrasive actions and aeration, cavitation, and oxidation processes while reacting with chemical additives such as chelating agents, surfactants, and peroxides. In doing so, the contaminants are transferred from the sediments to the water phase in the process. The washed material is then dewatered using hydrocyclones and centrifuges or by settling to a point where 70 to 80 percent of the solids remain. The process water containing the contaminants is collected and treated and the washed material beneficially reused. Primary issues of concern associated with the traditional sediment washing process include treatment requirements for the residual effluent water, and the end use of the dewatered fine material cake, which is a primary product if the dredged material consists predominantly of silt and clay.

For the Los Angeles region, the sediment washing treatment alternative was modified to focus not specifically on chemical removal from the sediments, but rather salt removal so that the material could be beneficially re-used as daily landfill cover without jeopardizing underlying groundwater reserves. A pilot laboratory study was conducted using material dredged from the LARE and the study results and contained in the DMMP pilot study report located in the Management Strategy Technical Appendices (USACE 2002(b)).

6.8.2.3 Sediment Blending

Sediment blending is not a true treatment technology in that is does not reduce or eliminate contaminant concentrations, except through dilution with cleaner material. The alternative involves blending the fine-grained contaminated dredged material with borrowed clean sandy material to create an aggregate that exhibits enhanced engineering properties and reduced apparent contamination levels. One of the primary issues of concern with sediment blending is the cost of obtaining large quantities of the clean sand required to achieve the treatment objective. Other issues include: (1) the availability of borrow materials; (2) costs associated with large-volume material handling; (3) the methods used to achieve the specified level of blending; (4) land availability for the blending facility, and (5) cost for dewatering. Also of concern are the environmental acceptability and the engineering properties of the material after blending.

The CSTF originally planned to conduct a laboratory pilot study to test the feasibility of the sediment blending option for use in the Los Angeles region, but instead elected to conduct a detailed literature investigation of past uses within the region and opportunities and constraints for future use. This was done because preliminary results of the user's survey showed that the process, in its original form, would not currently be used by the most likely candidates in the region, the ports of Los Angeles and Long Beach. Detailed study results are presented in the DMMP pilot study report which is included in the Management Strategy Technical Appendices.

6.8.2.4 Thermal Desorption/Vitrification

Thermal desorption system (TDS) is an ex-situ technology applying direct and indirect heat to contaminated material, such as sediment, soil, or sludge, to vaporize the contaminants. TDS is a thermal induced physical separation process and is not designed to destroy contaminants. Contaminants and water are vaporized from a solid matrix and transported by either a carrier gas or vacuum system to a gas treatment system. The bed temperatures and residence times designed into these systems will volatilize selected contaminants but will typically not oxidize them. This gas can then be treated by a number of secondary treatment processes. The residual contaminant levels achieved are usually low to non-detect (Downing et al. 1998, FRTR 2002, NFESC 1998). There are a variety of thermal desorption systems available: rotary dryer, thermal screw, heated ovens, and hot air vapor extraction (HAVE).

Vitrification, another variant of this process is conducted at temperatures sufficiently high to melt the sediment particles, resulting in the formation of a glass aggregate. This process, known as vitrification, is currently offered for contaminated dredge sediments (McLaughlin et al.) and has been shown to eliminate and sequester the contaminants, producing a final product that should be free from the liabilities associated with some of the less effective treatment alternatives. The downside to this technology is that the process requires significant electrical energy to generate extremely high heat produced by an electric arc furnace, and thus costs significantly more than many of the other treatment alternatives.

Issues of concern for use of these alternatives include: (1) contractor availability in the region, (2) site-specific effectiveness (they have had limited if any use on the West Coast), (3) production costs, (4) space for a treatment facility, and (5) a disposal area or beneficial use for the treated product.

6.8.2.5 Cement Lock Technology

The Cement Lock Technology is a proprietary process developed by the Gas Technology Institute and marketed by Biomass Energy Solutions, Inc. The process uses extremely high heat (2400 to 2650°F) to convert contaminated sediments into a material called Ecomelt, which resembles a partially vitrified rock material. This material is then blended with Portland cement and used to create a variety of by-products. Test applications with the process have been completed with the following types of materials: dredged sediment from the New York/New Jersey Harbor, dredged sediment from the Detroit River, Michigan, contaminated building debris/concrete, PCB contaminated sediment/soil, petroleum contaminated soil, and organic contaminated soil.

Issues of concern for the use of this alternative include: (1) contractor availability in the region, (2) site-specific effectiveness, (3) production costs, (4) space for a treatment facility, and (5) a disposal area or beneficial use for the treated product.

6.8.2.6 Soil Separation

Soil separation is a procedure where, through a series of mechanical processes, sediment particles are separated into sands and finer grained fractions for beneficial reuse. Since contaminants are typically bound to the organic layers of fine-grained particles, the first step (sand separation) is usually quite effective in producing a clean product which can then be beneficially reused without further treatment, and a fine grained particle slurry containing most of the contaminants. The fine-grained particle slurry can then be subjected to a series of mechanical and chemical processes (e.g., flocculants) to further separate and concentrate the contaminants, eventually resulting in a manageable waste stream that can be de-watered and disposed of through conventional means.

Issues of concern for the use of this alternative include: (1) contractor availability in the region, (2) high production costs due to variable dredge material supply, (3) near shore space for a treatment facility, and (4) a disposal area or beneficial use for the treated product.

6.8.3 Temporary Storage

Occasionally, contaminated sediments may be destined for reuse as future fill material or as feed material for a treatment program not yet fully implemented. In these instances, temporary storage is needed and may include either aquatic or upland facilities.

6.8.3.1 Aquatic Storage Sites

Dredged sediment may be stockpiled on a temporary basis at aquatic sites awaiting further transfer to end-use destinations if contaminant concentrations are sufficiently low enough that aquatic risks are not probable. Suitable types of aquatic stockpiling include placement in nearshore depressions, sub-aqueous mounds, or islands. The stockpiling sites need to be located in sheltered areas with minimum wave energy to ensure stability. The construction of temporary dikes or berms may be needed to confine the contaminated sediment within the stockpiling area. Given the involvement of open-water placement of dredged material, aquatic stockpiling would be subject to regulatory constraints and requirements similar to those for aquatic disposal, with emphasis on short-term impacts due to double handling in the form of placement and re-dredging within a relatively short period of time. These constraints would likely limit this option to include only mildly contaminated sediments, unless some form of isolation were included (e.g., a cap) during the storage process. Additional requirements would prevent the creation of navigational hazards as a result of the alteration of existing nearshore bathymetry, among other aspects.

6.8.3.2 Upland Storage Sites

Dredged sediment may be stockpiled on a temporary basis at upland sites awaiting further transfer to end-use destinations. Suitable types of upland stockpiling include placement in existing sediment storage facilities in the Ports and any new storage areas that can be designated for the same purpose on a temporary basis. Existing facilities include the Anchorage Road dredge material holding basin at the Port of Los Angeles, which receives dredged materials from various berthing basins in Los Angeles Harbor. Placement of dredged materials at existing facilities would be subject to similar regulatory constraints and requirements that are already in place for these facilities. New stockpiling sites could include confined disposal facilities, and new holding basins similar to the existing facilities in the Ports. Given the constraints on land availability and the limited capacities of existing sediment holding facilities, upland storage capacities are expected to be limited in the region. Logistic arrangement and end-use timelines have to be integrated into storage planning to ensure efficient use and uninterrupted service of existing and new facilities.

6.8.4 Potential End Uses

Left untreated, contaminated dredged sediments may only be beneficially re-used as fill material in an application that ensures they will not pose a threat to the aquatic or upland environment. Potential end uses within the Los Angeles region include either nearshore fill (with nearshore defined as areas near the coast where saltwater intrusion has already impacted shallow groundwater), or as upland fill in areas where groundwater resources are not impacted. This section details potential fill alternatives and uses.

6.8.4.1 Nearshore Fill

Contaminated dredged sediment may be used as construction fill material in nearshore waters where confinement is provided. Suitable types of nearshore fill include harbor fill and wetland fill.

Historically, harbor fill has been, by far, the most important type of end use of dredged material in the Los Angeles region. During the period of 1976-2001, approximately 42% of the 1.5 million cy from the Marina del Rey/Ballona Creek Entrance Channel maintenance, 97% of the 55 million cy from Los Angeles Harbor capital improvement dredging, and 32% of the 11 million cy from Long Beach Harbor capital improvement dredging were used as harbor fill for construction and improvement of harbor facilities.

Contaminated dredged sediment could be used as harbor and wetland fills subject to regulatory constraints and requirements. The mobility of contaminants within the dredged materials tends to decrease significantly with compaction of the fill over time or by mechanical means that reduces the leaching potential of the constituents present within the fill mass. Such effects are particularly pronounced with materials containing sufficient amounts of fines, which is the case with most of the contaminated dredged sediment generated in the region. Harbor fill is expected to continue to be a predominant end use for contaminated dredged sediment in the region. Wetland fill using contaminated sediments, while a possibility, is very unlikely due to regulatory constraints.

6.8.4.2 Upland Fill

Contaminated dredged sediment may be used as construction fill at upland sites as long as groundwater resources are not put at risk from either contaminant or chloride leaching. Suitable types of upland fill include landfill daily cover, Brownfield development projects, mine reclamation fill, and transportation infrastructure construction fill.

6.8.4.2.1 Landfill Daily Cover

Contaminated dredged sediment may be used for landfill daily cover and closure works subject to regulatory constraints and requirements.

For placement in landfills, the Los Angeles Regional Water Quality Control Board generally requires testing by Waste Extraction Test (WET) and comparison with the Soluble Threshold Limit Concentrations (STLC) for acceptability determination. For placement on open lands, the LARWQCB generally requires testing by Synthetic Precipitation Leaching Procedure (SPLP) (EPA Method 1312) and comparison with the Maximum Contaminant Levels (MCL) of Title 22, California Code of Regulations, to determine acceptability for the protection of groundwater resources. For coastal sites such as harbor areas with saline groundwater aquifers, leach test results are to be compared with the Ocean Plan objectives for acceptability determination.

A particular concern regarding the use of marine dredged sediment at landfills is the water and salt contents in the material. Landfills require sediment to pass the paint filter test to limit water content to 12-15%. The Los Angeles Regional Water Quality Control Board does not have stated limits for chlorides in sediment, but does regulate salt concentration in waters entering groundwater (CH2M Hill 1999). The current State of California groundwater criteria is 30 mg/L chloride and 500 mg/L TDS (USACE 2002(b)). Requirements for dewatering and chloride reduction tend to limit the economy of using marine dredged contaminated sediment at landfills, especially when large quantities of dredged materials are involved. Evidence suggests, however, that the mobility of chlorides tend to significantly decrease upon compaction of the material after placement (USACE, 2002).

In addition to constraints on sediment quality for use at landfills, few active landfills in the Los Angeles region are within economic transport distance from potential dredge areas. The available capacity for this end use in the region is, therefore, expected to be limited.

6.8.4.2.2 Brownfield Re-Development

Contaminated dredged sediment may be used as fill for development projects at Brownfield sites such as abandoned industrial sites and cleanup/remediation sites. The in-situ soil at a Brownfield site under development may contain contaminants at levels that are deemed acceptable for the project. Opportunity, therefore, exists for such a project to use contaminated sediment with constituent levels that are consistent with those permitted for the project. For substantially clean Brownfield sites, leach testing of dredged sediment by SPLP as described previously may be required by the Los Angeles Regional Water Quality Control Board before placement as fill. The issue of chlorides may also have to be addressed depending on the location of the site and quantities of the fill. Reduction of chloride leaching upon compaction of the fill as discussed previously may also be taken into consideration in the acceptability determination.

Because there are many historical industrial sites within close proximity of the study area, options for using contaminated dredged materials for Brownfield re-development should be available. Applicability will, however, be highly site dependent (e.g., proximity to underlying groundwater resources, local use of groundwater, proximity to residential areas, etc.) and final acceptance by the regulatory agencies would likely be determined based on these conditions and possibly the results a risk assessment.

6.8.4.2.3 Mine and pit reclamation

Contaminated dredged sediment may be used as backfill at mine reclamation sites subject to regulatory constraints and requirements. Mine reclamation sites in the Los Angeles region include abandoned sand and gravel mining pits. Some of the existing mining pits are currently functioning as groundwater recharge facilities. Backfilling these pits would conflict with regional conservation objectives. For the rest of the abandoned pits in the region, a recent survey (GeoSyntec 2003) found that there is generally ample supply of backfill material generated from mine development that has been stockpiled on site. The need for additional backfill material, therefore, is expected to be limited. Leach testing of dredged sediment by SPLP as described previously may be required by the Los Angeles Regional Water Quality Control Board before placement as backfill in the pits. Similar to other upland fill options, the issue of chlorides may also have to be addressed.

6.8.4.2.4 Transportation Infrastructure

Contaminated dredged sediment may be used as construction fill for transportation infrastructure projects such as construction of roadways, railroads, and airports. However, engineering and regulatory requirements of construction fill for these types of projects can be substantial (USACE 2002c). In general, construction fill material is required to exhibit sufficient engineering properties as determined through geotechnical testing. For contaminated dredged sediment, leach testing by SPLP as described previously may be required by the Los Angeles Regional Water Quality Control Board before placement. The issue of chlorides may have to be addressed on a case-by-case basis depending on the location of the site and quantities of the fill, among other considerations. Reduction of chloride leaching upon compaction of the fill as discussed previously may also be required.

6.8.5 Potential End Products

Treated contaminated dredged materials may be beneficially reused and several options exist for this process, including the production of manufactured soils, aggregates, cement-based products, or glass. The following sections briefly describe these potential end products.

6.8.5.1 Manufactured soil

Pilot studies have been conducted to evaluate the feasibility of creating manufactured topsoil using dredged materials as the base; however, this process has not yet been fully evaluated to the point where a commercial application could be launched (USACE 2002c). The procedure involves mixing the de-watered dredge material with an organic biosolid, usually derived from municipal sewage sludge, and then blending and drying the material until the desired consistency is achieved. Two example studies utilizing this technology include a project conducted with freshwater dredged sediment from Toledo Harbor in Ohio (Sturgis et al. 2001a) and marine dredged sediments from New York/New Jersey Harbor (Sturgis et al. 2001b). Both studies concluded that while successful topsoil blends were produced, several limitations would make full-scale operation difficult. The two primary difficulties were (1) the fact that the optimal ratio of dredged material to organic additives was very site-specific and would need to be developed for each region, and (2) the final process developed during the studies was proprietary, thus limiting its use by other firms.

6.8.5.2 Aggregates

A concrete aggregate generally refers to the mixture of sand and gravel material typically used in the preparation of concrete. It is possible that some contaminated dredge material may contain sufficient quantities of aggregate to make it cost effective to employ a mechanical process to separate the finer grained particles from the sand and gravel such that it could be beneficially reused for the production of concrete. Final acceptance of any material for use in load bearing forms would ultimately be determined by the engineering requirements of the final product.

6.8.5.3 Cement

Cement production using dredged materials, described in detail in Section 6.8.2.1, provides one of the most probable end use products for contaminated dredged materials. In this scenario, imported clean sand is substituted with contaminated dredge material, thus reducing the need for importing sand. Great quantities of contaminated material may be disposed of quickly and a direct cost recovery benefit may be observed. There are, however, several variables that could affect the success of this technology. One of the most critical is the nature of the dredge material, more specifically the ratio of sand and silt particles present in the material and resulting water content. The closer the material matches that of imported sand, the more successful this alternative will be for providing a beneficial product that result in costs recovery to the project. As with aggregate, final acceptance of any material for use in load bearing forms would ultimately be determined by the engineering requirements of the final product.

6.8.5.4 Glass

The end result of the vitrification process described in Section 6.8.2.4 is molten sand (glass). There is currently no known market for this material in the region and it should not be considered as an alternative for producing a beneficially reusable product.

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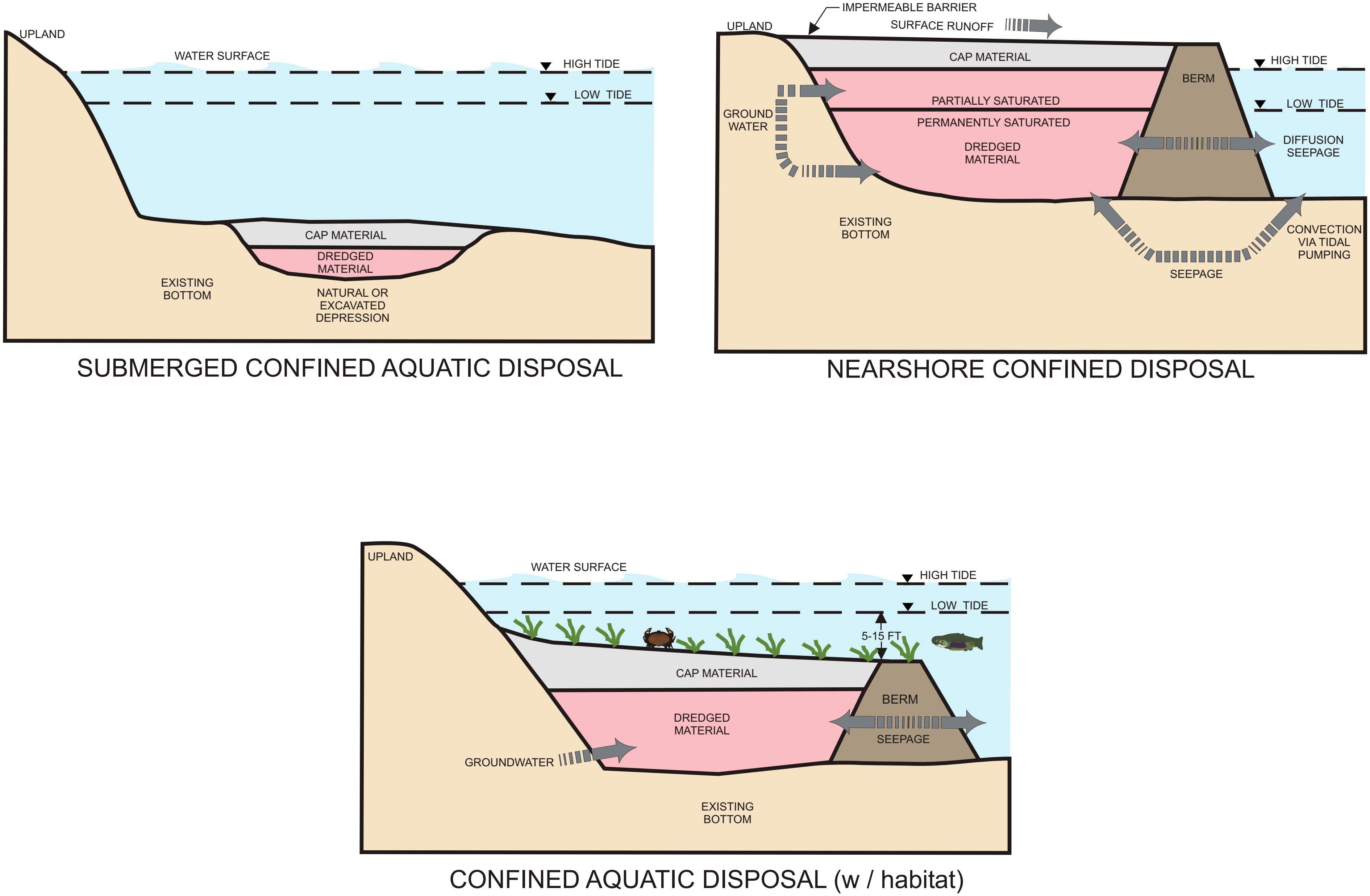

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Figure 6-1
Example Aquatic Disposal Options