Final Environmental Impact Statement for

Designation of an Ocean Dredged Material Disposal Site off Humboldt Bay, California

Prepared by:

EPA

U.S. Environmental Protection Agency
Region IX
San Francisco, California

Contact:
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In association with:

Jones & Stokes Associates, Inc.
Bellevue, Washington

July 1995

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FINAL
ENVIRONMENTAL IMPACT STATEMENT
FOR DESIGNATION OF AN
OPEN OCEAN
DREDGED MATERIAL DISPOSAL
SITE OFF HUMBOLDT BAY, CALIFORNIA

U.S. Environmental Protection Agency
Region IX
San Francisco, California

Comments on this administrative action should be addressed to:

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San Francisco, California 94105

Comments must be received no later than:

September 5, 1995, 30 days after publication of the notice of availability in the Federal Register for the FEIS.

Copies of this EIS may be viewed at the following locations:

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Arcata, CA

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FINAL
ENVIRONMENTAL IMPACT STATEMENT
FOR DESIGNATION OF AN
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SITE OFF HUMBOLDT BAY, CALIFORNIA

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Abbreviations and Acronyms

CAA	Clean Air Act
CEQA	California Environmental Quality Act
CO	carbon monoxide
Corps	U.S. Army Corps of Engineers
CWA	Clean Water Act
CZM	coastal zone management
CZMA	Coastal Zone Management Act
CZMP	California Coastal Zone Management Plan
DDLS	Dredge Data Logging System
DEIS	draft environmental impact statement
DO	dissolved oxygen
EIR	environmental impact report
EIS	environmental impact statement
EPA	U.S. Environmental Protection Agency
ESA	Endangered Species Act
FEIS	final environmental impact statement
FWCA	Fish and Wildlife Coordination Act
HC	hydrocarbons
HOODS	Humboldt Open Ocean Disposal Site
L-P	Louisiana-Pacific Corporation
LC	London Convention
MHHW	mean higher high water
MLLW	mean lower low water
MMS	Mineral Management Service
MPRSA	Marine Protection, Research and Sanctuaries Act
NCUAQMD	North Coast Unified Air Quality Management District
NDS	Nearshore Disposal Site
NEPA	National Environmental Policy Act
NHPA	National Historic Preservation Act
NMFS	National Marine Fisheries Service
NO_x	nitrogen oxides
NPDES	National Pollutant Discharge Elimination System
ODMDS	ocean dredged material disposal site
PM	particulate matter
PM_{10}	particulate matter smaller than or equal to 10 microns in diameter
ROG	reactive organic gases
SBDs	seabed drifters
SHPO	State Historic Preservation Officer
SMMP	site management and monitoring plan
SO_2	sulfur dioxide
USCG	U.S. Coast Guard

USFWS .... U.S. Fish and Wildlife Service
WRDA .... Water Resources Development Act
ZSF .... Zone of Siting Feasibility

Units of Measure and Conversions

cm/s	centimeters per second
ft	feet
gm^2	grams per square meter
$g/C/m^2/day$	grams of carbon per square meter per day
m	meters
mg/l	milligrams per liter
mg/m^2	milligrams per square meter
mm	millimeters
nmi	nautical miles
ppt	parts per thousand
yd^3	cubic yards
µg/g	microgram per gram
µg/kg	microgram per kilogram
µg/l	microgram per liter
µm	micro meters

To Convert From	To	Multiply By
cubic yards	cubic meters	0.7646
nautical miles	miles	1.1508
miles	kilometers	1.6093
short tons	pounds	2,000
meters	feet	3.2808
centimeters	inches	0.3937
feet	fathoms	0.1667

Executive Summary

The proposed action is the designation of an ocean disposal site for dredged material from Humboldt Bay, California. The site is located in the Pacific Ocean at a depth of 49 to 55 meters (160 to 180 feet) approximately 3 to 4 nautical miles northwest of the mouth of Humboldt Bay. The site would be used for disposal of dredged material from federal projects permitted under Section 103 of the Marine Protection, Research, and Sanctuaries Act (MPRSA) of 1972, as amended. This site, known as the Humboldt Open Ocean Disposal Site (HOODS), has been used on an interim basis for disposal of material dredged from the navigation channels in Humboldt Bay since September 1990. The HOODS was sized to have a capacity of 50 million cubic yards of dredge material over a 50-year operational period.

Continued use of the proposed site is not expected to cause significant long-term adverse environmental effects. The sediments and the benthic community have been altered by previous disposal operations at the proposed site. The smothering effect on the benthos caused by sediment inundation is expected to continue, but impacts would be localized and are not considered significant. No significant environmental impacts are expected to occur outside of the HOODS. Impacts on water quality, which would be temporarily experienced during disposal operations, are expected to be minimal. Short-term effects on organisms in the water column would be negligible.

Few of the potentially adverse environmental effects of dredged material disposal at the proposed site are likely to be irreversible or to involve any irretrievable commitment of resources. A site management and monitoring plan (SMMP) is incorporated into this final environmental impact statement (FEIS). Implementation of the SMMP will be a requirement of site use.

The seven alternatives considered for dredged material disposal are No Action, disposal off the continental shelf, upland disposal, beach nourishment, the SF-3 site, the nearshore disposal site (NDS), and the HOODS. After detailed field investigations and analysis of each alternative, EPA Region IX determined that ocean disposal at a designated dredged material disposal site was the only viable alternative for the proposed action. The preferred alternative identified in this FEIS is the HOODS. This decision is based on the potential for disposal activities to adversely affect the alternative sites, the demonstrated need for an ocean disposal site for dredged material, and the insignificance of the long-term environmental impacts at the HOODS.

Section 1

Introduction

Section 1. Introduction

1.1 GENERAL INTRODUCTION

This final environmental impact statement (FEIS) evaluates the proposed designation of an ocean dredged material disposal site (ODMDS) northwest of the mouth of Humboldt Bay, California. The purpose of this action is to provide an environmentally acceptable site for disposal of materials dredged from Humboldt Bay by the U.S. Army Corps of Engineers (Corps). The preferred site for final designation is the Humboldt Open Ocean Disposal Site (HOODS) (Figure 1-1).

The U.S. Environmental Protection Agency (EPA) has the authority to designate ODMDSs under Section 102 of the Marine Protection, Research and Sanctuaries Act (MPRSA) of 1972 (33 USC 1401 et seq.). The Act established a permitting program for ocean disposal of dredged material. The permitting program requires the determination of environmental impacts, designation of sites, enforcement of permit conditions, and management of disposal sites. It is the EPA's policy to publish an environmental impact statement (EIS) for all ODMDS designations (39 FR 37119, October 21, 1974).

The EPA promulgated final Ocean Dumping Regulations to implement the MPRSA in 40 CFR 220-229 (January 11, 1977). The regulations set forth criteria and procedures for the selection and designation of ocean disposal sites. In addition, the regulations designated interim ocean sites for the disposal of dredged material to allow the necessary time for site designation studies as required by EPA regulations. Use of the interim designated sites was dependent on compliance with the requirements and criteria contained in the EPA's Ocean Dumping Regulations (40 CFR 220-229).

The Corps, in close cooperation with the EPA, with federal and state resource agencies, and with members of the concerned public, has conducted studies of the ocean area offshore of Humboldt Bay for the purpose of characterizing the physical, chemical, and biological environment of these ocean waters. The EPA requested the Corps San Francisco District to assist with the preparation of the ODMDS designation EIS because the Corps will use the site for disposal of sediments dredged from Humboldt Bay. The EPA retains responsibility for selection of the preferred alternative, for authorizing the site, and for publication of the EIS and related public coordination.

The final designation process is being conducted in accordance with the requirements of the MPRSA, as amended (33 USC 1401 et seq.); the EPA's Ocean Dumping Regulations (40 CFR 220-229); and other applicable regulations.

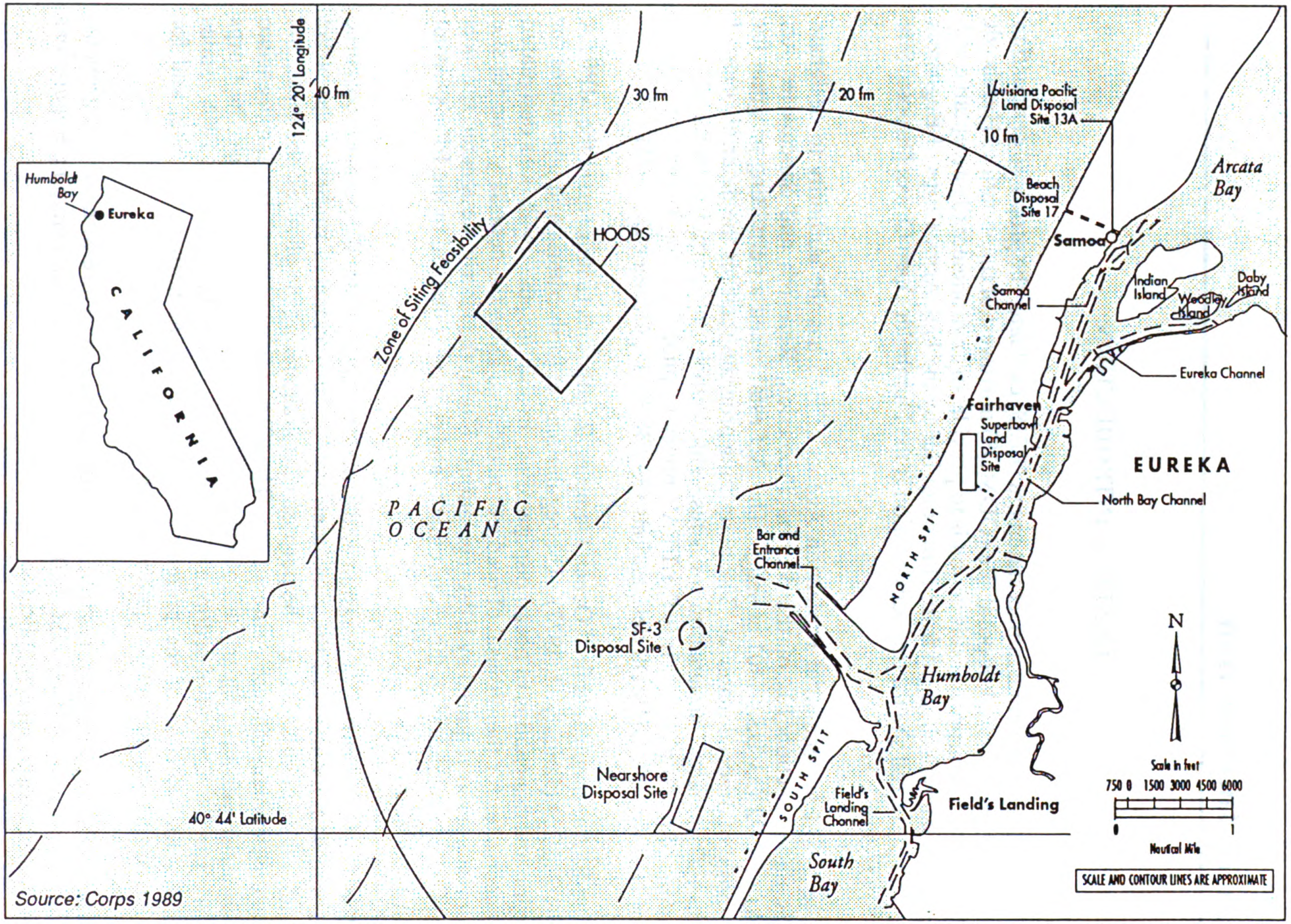


Figure 1-1. Location of Past and Present Ocean and Land Dredged Material Disposal Sites Near Humboldt Bay, California

Humboldt Bay is a deep-draft harbor located near Eureka, California. The natural transport of sediment in the area results in shoaling at the Harbor entrance and within Humboldt Bay. To provide for safe navigation into and through the Harbor, the Corps has conducted annual maintenance dredging of the Harbor and entrance channels since 1931.

The Corps currently has two dredging cycles each year, one in the fall and one in the spring. During the fall, the Corps dredges the Bar and Entrance and North Bay Channels, removing 145,000 to 1,400,000 cubic yards (yd^3) of sediment. During the spring, a smaller quantity of material (1,900 to 192,000 yd^3) is dredged from the Eureka, Samoa, and Field's Landing Channels, as well as the North Bay Channel. (Corps 1994a, 1994b.)

Several ocean sites have been used to dispose of the dredged materials from Humboldt Bay; however, there is currently no permanently designated ODMDS. Interim disposal sites were selected, based on historical use, by the EPA in consultation with the Corps. The three ocean sites that have been used are the SF-3 disposal site, the Nearshore Disposal Site (NDS), and the HOODS (Figure 1-1).

The SF-3 site has been used for dredged material disposal since the 1940s. Interim designation of the SF-3 site was originally issued for a 3-year period between 1977 and 1980 but was later extended by the EPA to February 1, 1983. An additional extension until December 31, 1988, was granted to allow completion of field studies, environmental evaluation, and preparation of an EIS for designation of SF-3 as an ODMDS.

In the mid-1980s it was discovered that dredged materials placed at the SF-3 disposal site were not dispersing as had been anticipated. The mounding at the SF-3 site caused adverse surface wave conditions and resulted in navigation hazards to commercial fishing and recreational boats traversing the site. The commercial fishing community expressed concern to the Corps. In light of mounting concern, the site was closed in 1988.

Because of the problems associated with disposal at the SF-3 site, the Corps decided that an investigation of other potential sites near Humboldt Bay should be undertaken to select a permanent disposal site that would not interfere with navigation and that would minimize impacts on the ocean environment.

In 1988 and 1989, the Corps disposed of sand dredged from the Bar and Entrance Channel and the North Bay Channel at the NDS. The material was disposed at the NDS because of the impacts on navigation associated with disposal at the SF-3 site and to keep the material within the littoral cell. Concerns have also been raised about the use of the NDS, including the effect of the disposal on navigational safety and commercial fisheries resources, and dispersion of disposed sediments toward the Harbor mouth.

The Corps was authorized by EPA to use the SF-3 site to dispose of dredged materials from Humboldt Bay on one occasion in 1990.

The Corps has used the HOODS for disposing of dredged material from Humboldt Bay since fall 1990. The HOODS was sized to provide the capacity for 50,000,000 yd^3 of dredged material (Corps/HBHRCD 1995). Between 1990 and 1994, the HOODS has been used on 10 occasions for dredged material disposal. Approximately 2,860,000 yd^3 have been disposed of at this site.

1.1.2 Local Need

Humboldt Bay is the second largest coastal estuary in California. The Bay consists of two shallow basins, South Bay and Arcata Bay, which are connected by a narrow channel (Figure 1-1). The Bay is the only naturally enclosed, deep-draft harbor for major commercial shipping between San Francisco, California, and Coos Bay, Oregon. The Harbor provides berthing for deep-draft vessels serving the forest products industries, shallow-draft vessels serving the petroleum and chemical industries, and a large commercial fishing fleet. In 1993, 154 deep-draft vessels called on Humboldt Bay, representing the shipment of 1,125,544 short tons of cargo (Corps/HBHRCD 1995). This accounted for approximately 70% of the total tonnage shipped through the Harbor. The fishing industry is the third largest economy in Humboldt Bay, supporting approximately 500 vessels and delivering catches with an average annual dockside value of $10-20 million (Corps/HBHRCD 1995). Other beneficial uses of the Bay include hunting, sport fishing, and educational and recreational use.

Natural sediment transport processes result in the shoaling of the Harbor and entrance channels and thereby create hazards to vessel navigation into and within the Harbor. Shoaling occurs rapidly in the Bar and Entrance Channel as a result of the large volume of littoral material that is transported by ocean currents along the northern California coast. The Bar and Entrance Channel requires annual dredging to maintain safe depths for deep-draft vessels. To provide safe passage for deep-draft vessels into and through the Harbor, it is necessary to dredge the Harbor entrance and inner Harbor channels on an annual basis. The other in-bay channels, taken individually, require less frequent dredging; however, each year there is a need to dredge specific in-bay channels.

Between 1982 and 1994 (excluding 1989), an average of 802,000 yd^3 of material was dredged annually by the Corps to maintain sufficient operating depths (Corps 1994a, 1994b, 1995). No upland disposal sites that have the capacity to contain the volume of material generated during maintenance dredging have been identified. The Corps has disposed of this material at the HOODS since 1990. The Corps has asked the EPA to propose the HOODS as a designated ODMDS for disposal of dredged materials from Humboldt Bay.

The only federal dredging operation presently occurring in the Humboldt Bay region is the annual maintenance dredging of the Bay and Harbor by the Corps. The Corps uses a self-propelled hopper dredge for dredging the Harbor. As noted earlier, the Corps performs maintenance dredging in two phases each year. During the spring, the Corps dredges the Bar and Entrance Channel and portions of the North Bay Channel. During the fall, the Corps dredges the interior channels (i.e., the Samoa, Eureka, Field's Landing Channels and portions of the North Bay Channel) as needed. The Corps splits the maintenance dredging operations into two phases to take advantage of periods of relatively calm weather and ocean conditions. The average volume of material dredged annually during these operations is 802,000 yd^3.

The Bar and Entrance Channel and the southern portion of the North Bay Channel lie within an exposed ocean environment subject to large swells, breaking seas, and strong currents. This area contributes 84% of the total annual dredge volume (687,400 yd^3) of the project. The remaining average annual volume dredged from the interior channels (Samoa, Eureka, Field's Landing, and North Bay Channels) during spring is 106,100 yd^3.

The Corps has utilized three ocean disposal sites for placement of sediments dredged from Humboldt Bay navigation channels. These include the SF-3 disposal site, the NDS, and the HOODS. The SF-3 site has been used since the 1940s, most recently in April 1990. The NDS has been used twice, once in 1988 and again in 1989. Only sand is suitable for disposal at the NDS, because the purpose of disposal at the NDS is to maintain the disposed sand in the littoral zone and nourish the south spit of Humboldt Bay. The HOODS has been used on 10 occasions for dredged material disposal since the fall of 1990. It is anticipated that the HOODS will be used for all future maintenance dredge disposal under Section 103 permitting authority until a permanent EPA designation is complete.

In addition to the discharge of materials from the annual maintenance dredging operations, the Corps is also proposing to dispose of dredged material generated from the proposed Humboldt Harbor and Bay Deepening Project at the HOODS. The proposed Harbor and Bay Deepening Project is scheduled to occur in 1997. The proposed project would generate 5,600,000 yd^3 of spoils. The Corps is proposing to dispose of all of this dredged material at the HOODS, except for 26,000 yd^3 which would be disposed at the Louisiana-Pacific upland disposal site (Corps/HBHRCD 1995). The Corps has recently published its Final Feasibility Report and EIS/EIR for the proposed deepening project (Corps/HBHRCD 1995).

The Corps does not issue permits for its own projects. However, each Corps project is subject to the same suitability determination as nonfederal projects requiring permits, including the EPA Ocean Dumping Criteria at 40 CFR 227 and sediment testing requirements in accordance with EPA/Corps 1991 Evaluation of Dredged Material Proposed for Ocean Disposal - Testing Manual (the Green Book).

1.1.4 Non-Federal Dredging Operations

To date, non-federal dredging and disposal operations at Humboldt Bay have not utilized ocean disposal. For dredging work at Humboldt Bay for the years 1977 through 1988, the Corps issued 16 permits for non-federal projects, authorizing the dredging and disposal of approximately 350,000 yd^3 of sediment. These projects typically involved dredging of local public marinas and forest product berthing facilities. Disposal was usually at upland locations, with at least one occurrence of disposal in the surf zone along the North Spit (the beach disposal site shown in Figure 1-1).

Should there be a future need for non-federal dredging operations to utilize an EPA-authorized ocean disposal site, those projects would be assessed on an individual project basis in accordance with the provisions of EPA/Corps 1991 Green Book testing requirements; EPA's Ocean Dumping Regulations; 40 CFR 220-225, 227-228; and the Corps dredged material disposal permitting procedure under Section 103 of the MPRSA.

1.2 PURPOSE OF AND NEED FOR ACTION

The Corps considers maintenance dredging of Humboldt Bay essential to the continued safe navigation of vessels into and within the Bay. Upland disposal sites do not have the capacity to receive dredged materials from annual dredging operations. At present, there is also no permanently designated open ocean disposal site for dredged materials from the Bay.

Since expiration of the interim designation of the SF-3 site in 1988, ocean disposal has been authorized by the EPA on a case-by-case basis under Section 103 of the MPRSA at the SF-3 site, NDS, and the HOODS. However, use of interim sites would be terminated under provisions of the Water Resources Development Act (WRDA), which would not allow disposal of dredged material at interim ocean sites under Section 103 of the MPRSA after January 1, 1997, unless the site has received final designation. The purpose of the proposed action is to respond to the need for a permanently designated ODMDS to receive dredged materials from Humboldt Bay.

1.3 ALTERNATIVES CONSIDERED

The proposed action is the designation of an ODMDS for disposal of dredged materials from Humboldt Bay. A number of alternatives were considered to identify the most suitable and least environmentally damaging site: No Action, upland disposal, disposal off the continental shelf, beach nourishment, disposal at site SF-3, disposal at the NDS, and disposal at the HOODS.

If the No Action alternative were implemented, there would be no regionally designated ocean disposal site. The HOODS could continue to be used under MPRSA Section 103 permit authority. In the short term, the EPA and the Corps would continue to evaluate ocean disposal sites on a case-by-case basis; however, use of interim sites would be terminated on January 1, 1997, under provisions of WRDA, which specifies using only permanently designated ocean disposal sites for disposal of dredged materials.

Upland disposal alternatives are not practicable due to the limited availability and capacity of upland disposal areas, increased costs, and vessel safety.

The Corps conducted a Zone of Siting Feasibility (ZSF) analysis for the proposed Humboldt Bay ODMDS (Appendix A). Disposal off the continental shelf was not considered feasible due to operational constraints on the Corps' maintenance dredging for the Humboldt Bay region. U.S. law defines the continental shelf as the seaward extension of the coast to a depth of 183 meters (m) (600 feet [ft]). Seaward of Humboldt Bay, the continental shelf break (the 600 ft contour line) occurs at an approximate distance of 10 nautical miles (nmi) from shore.

The ZSF analysis defined an area within which disposal of dredged material would be feasible based on operational and economic criteria. Candidate disposal sites within this zone were then evaluated according to environmental and important resources criteria. The analysis concluded that the ZSF boundary for an ODMDS located outside Humboldt Bay should be set at a radius of 4 nmi from the end of the Humboldt Harbor jetty heads. The 600 ft line is not encountered within the 4 nmi operational radius outside Humboldt Bay as set by the ZSF. Therefore, for Humboldt Bay, it is not feasible to designate an ocean disposal site beyond the continental shelf.

The HOODS, SF-3, and the NDS are all historical sites located within the ZSF. These three potential sites were evaluated according to criteria established in the EPA's Ocean Dumping Regulations. The HOODS is the preferred alternative for designation.

1.4 REGULATORY FRAMEWORK

An international treaty as well as federal and state laws and regulations apply to the designation of an ODMDS. The relevance of these statutes to the proposed action and related compliance requirements for the proposed site are described below.

1. **Convention on the Prevention of Marine Pollution by Dumping of Wastes and Other Matter (26 US Treaties and Other International Agreements 2403: Treaties and Other International Acts Series 8165)**

The principal international agreement governing ocean dumping is the Convention on the Prevention of Marine Pollution by Dumping of Wastes and Other Matter, also known as the London Convention (LC). This agreement became effective August 30, 1975, after ratification by 15 contracting countries, including the United States. Ocean dumping criteria, incorporated into MPRSA permits for ocean dumping, have been adapted from the provisions of the LC. Thus, when material is found to be acceptable for ocean disposal under MPRSA, it is also acceptable under the LC.

2. The Marine Protection, Research and Sanctuaries Act of 1972, as amended (33 USC 1401 et seq.)

The MPRSA regulates the transportation and disposal of materials in the ocean and prohibits ocean disposal of certain wastes. Section 102 of the MPRSA gives the EPA designating authority for multiple-user, long-term, dredged material disposal sites. Section 102 of the MPRSA also allows the EPA to promulgate environmental evaluation criteria for all dumping permit actions and to retain review authority over Corps MPRSA 103 permits. The EPA's regulations for ocean dumping are published as 40 CFR 220-229. This FEIS is for designation of an ocean disposal site rather than permitting of dredged material disposal; therefore, it only relates to the criteria of 40 CFR 228.

Section 103 of the MPRSA sets forth requirements for obtaining Corps permits to transport dredged material for the purpose of ocean disposal. Under Section 103, those using ocean disposal must comply with both EPA and Corps requirements for transportation and disposal of dredged material in the ocean. The permitting regulations promulgated by the Corps under the MPRSA appear in 33 CFR 320-330 and 335-338. Based on an evaluation of compliance with the regulatory criteria of 40 CFR 227, both the EPA and the Corps may prohibit or restrict disposal of material that does not meet the criteria. The EPA and the Corps also may determine that ocean disposal is inappropriate because of ODMDS management restrictions or because options for beneficial use exist (i.e., using spoils beneficially).

3. Water Resources Development Act of 1992 (PL 102-580)

Section 506 of the WRDA amends Section 102(c) of the MPRSA. These amendments require, in part, that a site management plan be developed for each designated ocean disposal site. This site management plan is required to include:

- a baseline assessment of conditions at the site;
- a program for monitoring the site;
- special management practices necessary for protection of the site;
- consideration of the quantity and contaminant levels of the material to be disposed at the site;
- consideration of the active life of the site and management requirements after site closure; and
- a schedule for review and revision of the site management plan.

Section 506 of the WRDA further requires that after January 1, 1995, a site management plan must be developed and approved before final designation is issued. After January 1, 1997, no permit for dumping may be issued under Section 103 of the MPRSA for a site unless the site has received final designation.

In the case of this proposed action, the final designation is scheduled for fall 1995. Thus, a site management plan is required to be developed and approved, pursuant to the WRDA, before the final designation may be issued. A site management and monitoring plan has been developed and incorporated into this FEIS (Appendix B).

4. The National Environmental Policy Act of 1969 (42 USC 4341 et seq., as amended)

The National Environmental Policy Act (NEPA) requires that environmental consequences and alternatives be considered before a decision is made to implement a federal project. It also establishes requirements for preparation of an EIS for major federal projects having potentially significant environmental impacts, including opportunities for public review and comment. NEPA regulations specifically require integration with requirements of the Fish and Wildlife Coordination Act (FWCA), the National Historic Preservation Act, the Endangered Species Act, and other applicable laws and executive orders. This FEIS has been prepared to fulfill NEPA requirements and to satisfy EPA policy.

The President's Council on Environmental Quality has published regulations for implementing NEPA in 40 CFR 1500-1508. EPA NEPA regulations are published in 40 CFR 6, and Corps regulations for implementing NEPA are published in 33 CFR 220.

5. The Clean Water Act of 1977 (33 USC 1251 et seq., as amended)

The Clean Water Act (CWA) was passed to restore and maintain the chemical, physical, and biological integrity of the nation's waters. Specific sections of the CWA control the discharge of pollutants and wastes into aquatic and marine environments. Section 404 established a program to regulate the discharge of dredged material into waters of the United States inside the boundary drawn to differentiate coastal waters from oceanic waters.

The preferred site for designation (HOODS) lies outside of state territorial waters. Both alternative sites (SF-3 and NDS) lie within state waters. Section 401 of the CWA applies to ocean disposal of dredged material within state waters. This section requires the State of California, prior to any discharge, to certify that the permitted action complies with all effluent limitations and state water quality standards. The Section 401 water quality certification by the state would not be applicable if the HOODS is selected for designation. However, if either of the two alternative ocean sites is selected, state certification would be required.

6. The Clean Air Act of 1990 (42 USC 7401 et seq., as amended)

The Clean Air Act (CAA) is intended to protect and enhance the nation's air quality by regulating the emission of air pollutants through the development and execution of air pollution prevention and control programs. The CAA is applicable to permits and planning procedures related to disposal within the 2.6 nmi territorial sea limit (3 statute miles). The HOODS is not within state territorial waters. The SF-3 site and the NDS are located within the state territorial sea, and are within the North Coast Air Basin. Air quality issues related to permitting and planning procedures for the alternative disposal sites would fall under the jurisdiction of the North Coast Unified Air Quality Management District. Air quality issues associated with the transport of dredged material to the HOODS have been evaluated as part of the Corps EIS/EIR for the proposed Harbor deepening project (Corps/HBHRCD 1995).

7. The Fish and Wildlife Coordination Act of 1958 (16 USC 661 et seq.)

The FWCA is intended to protect aquatic resources. The FWCA requires that water resource development programs consider fish and wildlife conservation. The FWCA also requires that the lead agency consult with both state and federal fish and game agencies and fully consider their recommendations in decision-making. Section 106 (e) of the MPRSA requires compliance with the FWCA.

8. The Coastal Zone Management Act of 1972 (16 USC 1456 et seq.)

The Coastal Zone Management Act (CZMA) regulates development and use of the coastal zone and encourages states to develop and implement coastal zone management (CZM) programs. Federally permitted projects occurring within state territorial waters must be certified as consistent with approved state CZM programs under Section 307(c) of the CZMA. The Coastal Zone Reauthorization Amendments of 1990 (Section 6208) require that any federal agency conducting or supporting activities which affect the coastal zone prepare a determination of consistency with the state's coastal management program. No federal agency activities are categorically exempt from this requirement. Although the preferred site for designation lies beyond state territorial waters, the EPA has a policy of preparing a coastal consistency determination for all site designations even if they are beyond state territorial limits, because dredged materials are transported through state waters. Transport of dredged materials through state waters to the HOODS has been evaluated as part of the Corps EIS/EIR for the proposed Harbor deepening project (Corps/HBHRCD 1995).

9. The Endangered Species Act of 1973 and Amendments (16 USC 1531 et seq., as amended)

The Endangered Species Act (ESA) was enacted to protect threatened and endangered species. Section 7 of the ESA requires that lead federal agencies consult with the U.S. Fish and Wildlife Service (USFWS) and/or the National Marine Fisheries Service (NMFS) regarding any federal project which could jeopardize the continued existence of federally listed threatened or endangered species, or destroy or adversely modify any designated critical habitat of such species. During the site designation process, the USFWS and NMFS evaluate potential impacts of ocean disposal on threatened or endangered species. These agencies are asked to certify, or concur with the sponsoring agency's findings, that the proposed activity will not adversely affect the endangered or threatened species. Documentation of the Section 7 consultation is presented in Section 5 of this FEIS.

10. The National Historic Preservation Act of 1966 (16 USC 470 et seq.)

The National Historic Preservation Act (NHPA) is intended to preserve and protect historic and prehistoric resources. Federal agencies are required to identify cultural resources that might be damaged, destroyed, or otherwise made inaccessible by a project, and to coordinate project activities with the State Historic Preservation Officer (SHPO). This consultation process was informally initiated; however, no written response was received following the comment period.

11. Executive Order 11514, Protection and Enhancement of Environmental Quality (May 1977), as amended by Executive Order 11991

Executive Order 11514 requires the Corps to prepare NEPA documents that are concise, clear, and supported by evidence that the necessary analyses have been made. It also establishes a NEPA and CAA dispute resolution procedure.

12. Executive Order 11593, Protection and Enhancement of the Cultural Environment (36 FR 8921, May 15, 1971)

Executive Order 11593 requires federal agencies to initiate measures necessary to direct their policies, plans, and programs in such a way so that federally owned sites, structures, and objects of historical, architectural, or archaeological significance are preserved, restored, and maintained for the inspiration and benefit of the people. This consultation process was informally initiated; however, no written response was received following the comment period.

13. Executive Order 12372, Intergovernmental Review of Major Federal Programs (47 FR 3959, July 16, 1982)

Executive Order 12372 requires federal agencies, to the extent permitted by law, to utilize the state process to determine official views of state and local elected officials and communicate with state and local officials as early in the program planning cycle as is reasonably feasible to explain specific plans of action. The Resources Agency of California was contacted to notify appropriate state agencies.

14. The California Coastal Act of 1976 (PRC Section 3000 et seq.)

The California Coastal Act establishes the California Coastal Zone Management Plan (CZMP), which has been approved under the federal CZMA. All federal actions that affect the CZMP must be certified as consistent with this state program (see "Coastal Zone Management Act of 1972," above).

15. **The California Environmental Quality Act of 1986 (PRC Section 21001)**

The California Environmental Quality Act (CEQA) establishes requirements similar to those of NEPA for consideration of environmental impacts and alternatives and for preparation of an environmental impact report (EIR) prior to implementation of applicable projects. This proposed action is a federal action involving site designation outside state boundaries and therefore does not fall under the purview of CEQA. However, if either of the alternative sites is selected for designation, CEQA would apply. Actions requiring state approval are subject to CEQA.

1.5 RELATIONSHIP TO PREVIOUS NEPA ACTIONS AND OTHER MAJOR FACILITIES IN THE VICINITY OF THE PROPOSED SITE

The only known NEPA actions or facilities in the project area that could possibly be affected by or affect the designation of an ODMDS for the Humboldt Bay region are the annual maintenance dredging operations in Humboldt Bay and the Corps' proposed Humboldt Harbor and Bay Deepening Project. Discharge of dredged material from the annual maintenance dredging program has been permitted on a case-by-case basis under Section 103 of the MPRSA. However, use of interim sites will be terminated under provisions of the WRDA, which would not allow disposal of dredged material at interim ocean disposal sites under Section 103 after January 1, 1997, unless the site has been permanently designated. If an ocean disposal site is not designated, the Corps would not have the option of ocean disposal after 1997, and would have to utilize other disposal options (i.e., upland disposal) which could adversely affect the maintenance dredging program and the economies related to navigation into and within the Harbor.

The Harbor and Bay Deepening Project proposed by the Corps will generate approximately 5,600,000 yd^3 of dredged material. If no permanently designated ODMDS is available for the project, the EPA can permit the Corps to dispose of the material at the HOODS or another interim site under Section 103 of the MPRSA until January 1, 1997. However, there are no other upland or ocean disposal sites other than the HOODS which could contain the volume of dredged material generated from the proposed project, and the lack of a designated ODMDS after January 1997 would adversely affect the project.

Section 2

Alternatives

Section 2. Alternatives

This section describes each disposal alternative considered and selection of the preferred alternative. Evaluation of a reasonable range of alternatives is required by NEPA as part of 40 CFR 1502.14. Once the need for an ODMDS is established, potential sites are screened for feasibility through the ZSF process. The feasible alternative sites are evaluated according to the EPA's 5 general disposal site selection criteria and 11 specific disposal site selection criteria (40 CFR 228.5-228.6 [a]) (Table 2-1). The detailed discussion of each specific criterion can be found in Sections 3 and 4.

2.1 DESCRIPTION OF ALTERNATIVES

2.1.1 The No Action Alternative

The EPA has the authority under MPRSA Section 102 (c) to designate a recommended site for disposal of dredged material. Selection of the No Action alternative would mean that there would not be an EPA-designated ocean disposal site for material dredged from Humboldt Bay. The Corps would either continue requesting approval from the EPA under the MPRSA Section 103 for disposal of sediment at the HOODS or other ocean disposal sites on a case-by-case basis until January 1, 1997, or it would cancel dredging operations in Humboldt Bay because upland disposal would not provide the capacity needed to contain the average annual quantities of sediment dredged from Humboldt Bay's federal navigation channels.

2.1.2 Upland Disposal

Several upland disposal sites were considered for disposal of dredged materials from Humboldt Bay. The "Superbowl" site (Figure 1-1), a 60-acre site on the North Spit, was originally designed to contain 1,000,000 yd^3. This site was used once in 1979. Presently the site has capacity for approximately 400,000 yd^3 of dredge material. The Superbowl site was eliminated from further consideration because it does not have the capacity to serve as the permanently designated site. However, this site could be used for future smaller dredging projects requiring upland disposal if sensitive areas (wetlands and endangered plant species) are avoided.

Table 2-1. List of EPA's Five General and Eleven Specific Site Selection Criteria

General Site Selection Criteria - 40 CFR 228.5

(a) The dumping of materials into the ocean will be permitted only at sites or in areas selected to minimize the interference of disposal activities with other activities in the marine environment, particularly avoiding areas of existing fisheries or shellfisheries, and regions of heavy commercial or recreational navigation.

(b) Locations and boundaries of disposal sites will be so chosen that temporary perturbances in water quality or other environmental conditions during initial mixing caused by disposal operations anywhere within the site can be expected to be reduced to normal ambient seawater levels or to undetectable contaminant concentrations or effects before reaching any beach, shoreline, marine sanctuary, or known geographically limited fishery or shellfishery.

(c) If at any time during or after disposal site evaluation studies, it is determined that existing disposal sites presently approved on an interim basis for ocean dumping do not meet the criteria for site selection set forth in Sections 228.5 through 228.6, the use of such sites will be terminated as soon as suitable alternate disposal sites can be designated.

(d) The sizes of the ocean disposal sites will be limited in order to localize for identification and control any immediate adverse impacts and permit the implementation of effective monitoring and surveillance programs to prevent adverse long-range impacts. The size, configuration, and location of any disposal site will be determined as a part of the disposal site evaluation or designation study.

(e) EPA will, wherever feasible, designate ocean dumping sites beyond the edge of the continental shelf and other such sites that have been historically used.

Specific Site Selection Criteria - 40 CFR 228.6(a)

(1) Geographical position, depth of water, bottom topography, and distance from the coast;

(2) Location in relation to breeding, spawning, nursery, feeding, or passage areas of living resources in adult or juvenile phases;

(3) Location in relation to beaches and other amenity areas;

(4) Types and quantities of wastes proposed to be disposed of, and proposed methods of release, including methods of packaging the waste, if any;

(5) Feasibility of surveillance and monitoring;

(6) Dispersal, horizontal transport and vertical mixing characteristics of the area, including prevailing current direction and velocity, if any;

(7) Existence and effects of current and previous discharges and dumping in the area (including cumulative effects);

(8) Interference with shipping, fishing, recreation, mineral extraction, desalination, fish and shellfish culture, areas of special scientific importance and other legitimate uses of the ocean;

(9) Existing water quality and ecology of the site as determined by available data or by trend assessment or baseline surveys;

(10) Potentiality for the development or recruitment of nuisance species in the disposal site; and

(11) Existence at, or in close proximity to, the site of any significant natural or cultural features of historical importance.

The Louisiana-Pacific site, also on the North Spit, was also excluded fr consideration as the designated site because of its small capacity. However, the Corps proposing to use this site during the Harbor and Bay Deepening Project for the disposal 26,000 yd^3 of dredged material considered to be unsuitable for ocean disposal.

Several other land disposal sites were originally considered for perman designation, but they were not investigated further because of the potential for adve effects on wetlands, prohibitive costs, inadequate capacity, or conflicts with other land us

2.1.3 Beach Nourishment

Much of the material dredged from Humboldt Bay consists of sand; therefore, bea nourishment warrants consideration as a disposal alternative. Sediment dredged from t Bar and Entrance and North Bay Channels and the Field's Landing Channel in the ar north of Buhne Point is predominantly medium- to fine-grained sand. Sediments in t southern reach of the Field's Landing Channel and the Samoa and Eureka Channels ha historically been silty sand (much finer grained than the native material on the beach) tl would not be suitable for beach nourishment.

At this time, disposal of the Bar and Entrance and North Bay Channels' dredg material onto the beach face of the spits is not considered practicable. The bulk of t sediment suitable for beach nourishment is located in areas that are exposed to rough s conditions where stationary dredging plants are not suitable. Use of a hopper dredge wou require that the material be deposited in a sheltered area in the back bay adjacent to o of the spits, thereby producing adverse effects on in-bay biota near the disposal site. stationary hydraulic dredge would then slurry it across the spit to the beach for fi disposal, causing further localized adverse effects. This approach to beach nourishme would increase the cost of dredging, increase adverse impacts on the Bay, and increa operational time.

2.1.4 Disposal off the Continental Shelf

The EPA Ocean Dumping Regulations state in Section 228.5(e) that the "EPA w whenever feasible, designate ocean dumping sites beyond the edge of the continental sh and other such sites that have been historically used." As described in the ZSF, the Co must site the ODMDS within a 4 nmi radius from the center point at the end of t Humboldt Bay jetties (Appendix A). This limitation reflects the constraints on dredging a disposal operations for the Humboldt Bay area. Disposal off the continental shelf wou require use of a site located 10 nmi or farther from Humboldt Bay, a distance beyond t point at which dredged material disposal is considered feasible. Because historical si (NDS, SF-3, and the HOODS) exist on the continental shelf within the ZSF, this alternati will not be considered in this FEIS.

2.1.5 The Nearshore Disposal Site

Another approach to beach nourishment would be nearshore disposal within the longshore current system. The Corps has used a nearshore disposal area known as the NDS for this purpose. The site is located 2 nmi southwest of the Harbor mouth. Two disposal episodes were conducted at this site and were considered test disposals to investigate whether material placed at the NDS remained in the littoral zone and promoted beach nourishment. The NDS has been monitored by periodic bathymetric surveys to determine sediment movement.

The Humboldt Fishermen's Marketing Association and the Commercial Fishermen's Wives of Humboldt have objected to disposal at this site (Corps/HBHRCD 1995). Their concerns relate to potential adverse impacts on navigational safety in the vicinity of the southern approach, and commercial fishery resources in the nearshore area. Egg-brooding Dungeness crab females, juvenile Dungeness crab, and juvenile English sole are of primary concern.

2.1.6 Disposal Site SF-3

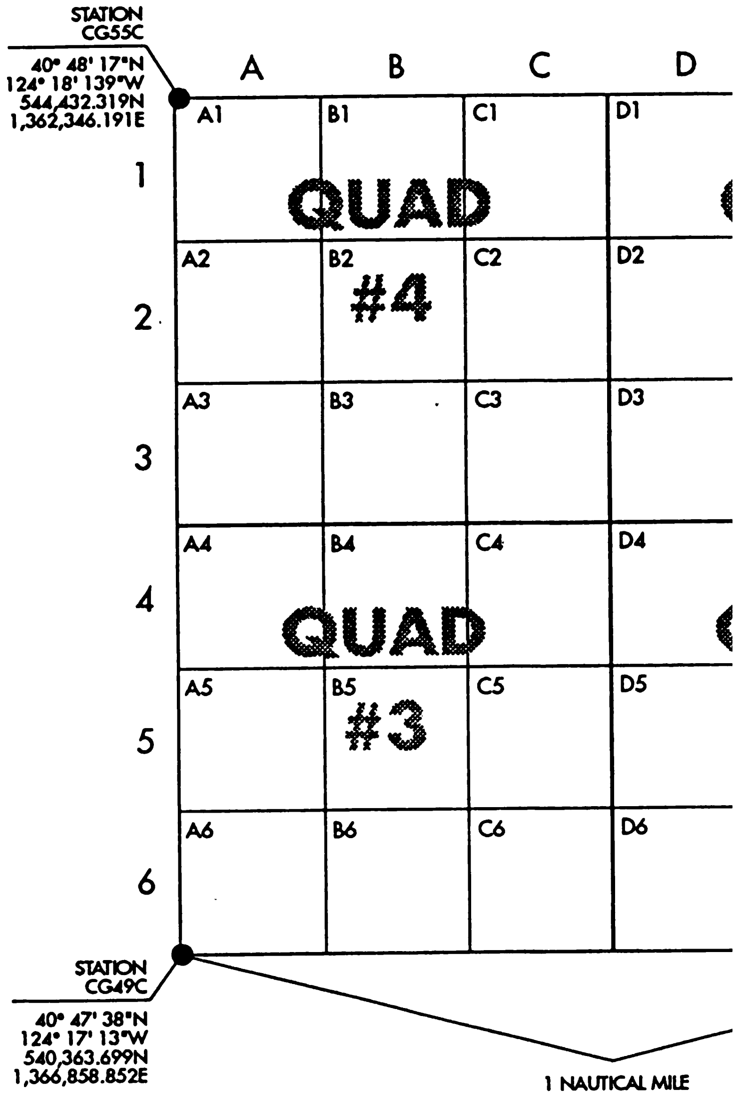
This disposal site has been used by the Corps since the 1940s for disposal of sediment dredged from Humboldt Bay. This former EPA interim disposal site lost its interim status on December 31, 1988. The Corps has used the SF-3 site for disposal of dredged material on several occasions since the site lost its interim status. Approval for this disposal was granted under Section 103 of the MPRSA. The most recent use occurred in April 1990. The SF-3 site is located approximately 1.1 nmi southwest of the Harbor mouth (Figure 1-1). The SF-3 site is 457 m (1,500 ft) in diameter.

2.1.7 Preferred Alternative

The preferred alternative for designation of a site for disposal of dredged material from Humboldt Bay is the HOODS, which has been used for disposal of dredged material since autumn 1990. The HOODS is 1 square nmi in size (Figure 2-1) and is located between the 49 m and 55 m (160 ft and 180 ft) depth contours.[1] It is positioned within the coordinates 40°48'25"N, 124°16'22"W; 40°49'3"N, 124°17'22"W; 40°47'38N, 124°17'22"W; 40°48'17"N, 124°18'12"W (Figure 2-1). The site lies approximately 3 to 4 nmi from the mouth of Humboldt Bay.

The HOODS has been identified as the preferred alternative for the following reasons: the site is located within a distance that is economically and operationally feasible

[1] All ocean depths reported in this FEIS are relative to mean lower low water (mllw).



Source: Corps 1994b

Figure 2-1. Humboldt Open Ocean Disposa

(Appendix A); the site reflects the preference of the local boating and fishing community; use of the site will minimize unavoidable adverse ecological effects; and the site complies with the EPA's siting criteria (40 CFR 228.5-228.6 [a]).

2.2 DISCUSSION OF ALTERNATIVES

2.2.1 Alternatives Not Considered for Further Analysis

The No Action, upland disposal, beach nourishment, and disposal off the continental shelf alternatives were eliminated from further consideration. These alternatives are not cost effective and/or would increase navigational and operational hazards. The No Action alternative would result in evaluation of disposal on a case-by-case basis until 1997. After 1997, dredged material disposal would not be permitted at undesignated sites.

Upland disposal is not a viable option for the large quantities of suitable dredged material removed annually as part of the Corps' maintenance dredging at Humboldt Bay. Although this alternative has been eliminated from further evaluation as a designated site in this FEIS because of excessive cost and the present lack of land availability, it remains an option for disposal of smaller quantities of materials unsuitable for ocean disposal.

2.2.2 Compliance of the Three ODMDS Alternatives with the EPA's 5 General Criteria for Selection of Sites (40 CFR 228.5 [a])

a. "The dumping of materials into the ocean will be permitted only at sites or in areas selected to minimize the interference of disposal activities with other activities in the marine environment, particularly avoiding areas of existing fisheries or shellfisheries, and regions of heavy commercial or recreational navigation."

As part of the site selection process, the Corps conducted several information surveys of the local fishing and other maritime operators active in the Humboldt Bay area. The Corps requested information on navigation routes into and out of Humboldt Bay, as well as preferred areas for dredged material disposal and nondisposal within the ZSF. The selection of the HOODS as the preferred alternative was in part based upon the information gathered from these surveys, and it is believed that disposal at the HOODS has not interfered with commercial fishing, sport fishing, recreational activities, or navigation in the Humboldt Bay area.

In contrast, the SF-3 site and the NDS are both objected to by local members of the commercial and recreational fishing community because of their perceived negative impacts on safe navigation.

b. "Locations and boundaries of dispo temporary perturbations in water conditions during initial mixing cause within the site can be expected to be re levels or to undetectable concentratic beach, shoreline, marine sanctuary, fishery or shellfishery."

None of the alternative ODMDS sites a boundaries. The dredged material is composed p and some clay/silt. Results of dispersion modeli the bottom rapidly and are initially contained wit and Pequegnat 1983, see Scheffner 1990 in Ap HOODS is 3 nmi offshore, and disposal at this pr for water quality impacts to beaches, shorelin shellfisheries.

c. "If at any time during or after disp determined that existing disposal sites basis for ocean dumping do not meet forth in Sections 228.5 through 228. terminated as soon as suitable alternat

The MPRSA site selection process is desig minimizes or avoids unacceptable impacts to the environment. The continued use of any site desig part of the site management and monitoring management and monitoring program will be a Corps.

d. "The sizes of ocean disposal sites will identification and control any immedia implementation of effective monitori prevent adverse long-range impacts. T of any disposal site will be determi evaluation of designation study."

The specific locations and sizes of the ocea to minimize the area affected by the disposal monitoring of the sites. Evaluation of the co ODMDS will be accomplished through the impl monitoring program.

e. "EPA will, where feasible, designate oc of the continental shelf and other suc used."

None of the ODMDS site alternatives lies beyond the edge of the continental shelf. The existing historical sites are all located on the continental shelf. Furthermore, based on the ZSF conducted by the Corps (Appendix A), disposal of dredged materials from Humboldt Bay off the continental shelf is not considered to be feasible.

2.2.3 Compliance of the Three ODMDS Alternatives with the EPA's 11 Specific Criteria for Selection of Sites (40 CFR 228.6 [a])

Detailed discussions of the 11 specific criteria are contained in Section 3, "Affected Environment" and Section 4, "Environmental Consequences". A summary table of these comparisons (Table 2-2) is presented here to support the decision-making process in selecting the preferred alternative over the other viable alternatives.

2.2.4 Selection of the Preferred Alternative

The EPA and the Corps have determined that a site must be designated for disposal of materials dredged from Humboldt Bay. The HOODS was selected as the preferred site alternative for the following reasons:

- The HOODS is a historical site which lies within the ZSF.
- The HOODS has the capacity necessary to sustain the maintenance dredging program for Humboldt Bay.
- Use of the HOODS would comply with EPA's 5 general and 11 specific site selection criteria.
- Use of the HOODS would comply with all international, federal, state, and local regulations.
- Use of the HOODS would result in minimal environmental impact.

Table 2-2. Comparison of Alternative Ocean Disposal Sites Based on EPA's Eleven Specific Site Designation Criteria

40 CFR 228.6(a) Criteria	Site SF-3	NDS	HOODS
1. Geographical position, depth of water, bottom topography and distance from coast.	• located 1.1 nmi WSW of harbor entrance • site depth 12 m (40 ft) • relatively flat bottom topography with mostly sandy substrates • located 1.2 nmi from coast	• located 2 nmi SSW of harbor entrance • site depth 15-18 m (50-60 ft) • relatively flat bottom topography with mostly sandy substrates • located 0.6 nmi from coast	• located 3-4 nmi W of harbor entrance • site depth 49-55 m (160-180 ft) • relatively flat bottom topography with substrates ranging from sandy to silty • located 3-4 nmi from coast
2. Location in relation to breeding, spawning, feeding or passage areas of living resources in adult or juvenile stages.	• typical demersal fish community but lower abundance and diversity than nearshore reference site • general commercially important fish species spawn in waters of this depth • lower Dungeness crab abundance than	• typical demersal fish community but lower abundance and diversity than nearshore reference site • general commercially important fish species spawn in waters of this depth • greater Dungeness crab abundance	• typical demersal fish community but lower abundance and diversity than SF-3 • fewer commercially important fish species spawn at this depth • lower Dungeness crab abundance than

Table 2-2. Continued

40 CFR 228.6(a) Criteria	Site SF-3	NDS	HOODS
6. Dispersal, horizontal transport and vertical mixing characteristics of the area, including prevailing current direction and velocity, if any.	• currents predominantly NW in winter and offshore and SW in summer, but relatively non-dispersive	• currents predominantly shoreward but relatively non-dispersive	• currents relatively non-dispersive
7. Existence and effects of current and previous discharges and dumping in the area (including cumulative effects).	• site used as an interim disposal site since the 1940s • last disposal event occurred in fall 1990 • sediments did not disperse from the site as anticipated • site was closed due to navigational safety concerns by interaction of waves with accumulated dredge material	• site has been used for disposal of dredged material from Humboldt Bay on two occasions in 1988 and 1989 • site has not been used since 1989 due to navigational safety concerns like those at SF-3 site	• site has been used for disposal of dredged material from Humboldt Bay on 10 occasions between fall 1990 and fall 1994
8. Interference with shipping, fishing, recreation, mineral extraction, desalination, fish and shellfish culture, areas of special scientific significance and other legitimate uses of the ocean.	• navigational safety concerns • no other activities in area	• navigational safety concerns • no other activities in area	• fewer navigational safety concerns than SF-3 or NDS site • no other activities in area
9. Existing water quality and ecology of the site as determined by available data or by trend assessment or baseline surveys.	• water quality good • lower density and diversity of demersal fish than nearshore reference site • possible spawning area for commercially important fish species • lower abundance of Dungeness crab than at other sites	• water quality good • lower density and diversity of demersal fish than nearshore reference site • possible spawning area for commercially important fish species • greater Dungeness crab abundance than at other sites considered	• water quality good • lower density and diversity of demersal fish than SF-3 site
10. Potentiality for the development or recruitment of nuisance species in the disposal site.	• unlikely to recruit nuisance species	• unlikely to recruit nuisance species	• unlikely to recruit nuisance species
11. Existence at, or in close proximity to, the site of any significant natural or cultural features of historical significance.	• no known significant natural or cultural features	• no known significant natural or cultural resources	• three potential shipwreck sites are located in HOODS

Section 3

Affected Environment

Section 3. Affected Environment

3.1 OCEAN DISPOSAL SITE CHARACTERISTICS

3.1.1 Historical Use of the Disposal Sites

The SF-3 disposal site has been used by the Corps to dispose of maintenance dredge material since the 1940s. The most recent use of SF-3 was in the spring of 1990. It is estimated that a total of 20 to 25 million yd^3 of material dredged from Humboldt Bay federal navigation channels has been disposed of at SF-3.

The NDS has been used for two fall disposal episodes. In September 1988 and September 1989, approximately 837,000 yd^3 and 585,000 yd^3 of sand were deposited at the NDS respectively. Material deposited at the NDS was dredged from the Bar and Entrance and North Bay Channels.

The HOODS has been used for disposal of sediments dredged from Humboldt Bay by the Corps on an interim basis since the fall of 1990. As of autumn 1994, the site will have been used on 10 occasions (Table 3-1). A total of approximately 2,861,289 yd^3 of dredged material has been disposed of at the site (Corps 1994a, 1994b).

The HOODS lies in the mud-sand transition zone. The site has been divided into four quadrants (Quads 1 through 4), each containing nine cells (Figure 2-1). The site has been divided to facilitate the disposal of dredged materials into areas of the site containing substrates similar in character to the dredged material. Quads 2 and 3 contain sandier substrates, while Quads 1 and 4 contain finer substrates.

In the fall of 1990, 683,000 yd^3 of dredge materials were dumped into Quad 2 Cell E5 to monitor the long-term fate of dredged materials at the site.

3.1.2 Proposed Use of the Preferred Alternative Site

The preferred alternative ODMDS will be used for the disposal of all suitable materials dredged by the Corps for new work in, and maintenance dredging of, the Humboldt Bay federal navigation channels. In addition to annual maintenance dredging, the Corps is currently proposing to deepen and widen the navigation channels and dispose of that portion of the dredged materials suitable for unconfined open ocean disposal at the ODMDS (Corps/HBHRCD 1995). All permit applications and Corps civil works projects

Table 3-1. Volumes (cubic yards) of Dredged Material Disposed at the HOODS, the NDS, and Site SF-3 by the Corps (1982-1994)

Year	Fall	Spring	Total	Location of Dredged Material Disposal
1982	490,447	98,000	588,447	Site SF-3 only
1983	1,010,676	1,900	1,012,576	Site SF-3 only
1984	494,000	12,830	506,830	Site SF-3 only
1985	1,414,156	163,500	1,577,656	Site SF-3 only
1986	1,119,776	64,250	1,184,026	Site SF-3 only
1987	698,431	93,605	792,036	Site SF-3 only
1988	836,966	130,254	967,220	Site SF-3 in Spring, NDS in Fall
1989	585,000			NDS in Fall, no disposal in Spring
1990	414,208	123,203	537,411	Site SF-3 in Fall, HOODS in Spring
1991	682,000	192,224	874,224	HOODS
1992	145,000	152,912	297,912	HOODS
1993	536,350	150,395	686,745	HOODS
1994	509,200	90,000	599,200	HOODS
Annual Average	687,401	106,089	802,024	

Source: Corps 1994a, 1994b, 1995

will be evaluated for suitability for ocean disposal at the site in accordance with the EPA Ocean Dumping Regulations (40 CFR 220-227).

3.1.3 Quantities and Characteristics of Maintenance Dredging Sediments

Between 1982 and 1994 (1989 excluded), the Corps has dredged an annual average of 802,000 yd^3 of sediment from Humboldt Bay (Table 3-1). Dredging operations typically occur twice yearly for maintenance of federal navigation channels at Humboldt Bay. Dredging of the Samoa, Eureka, and Field's Landing Channels occurs in the spring (March-April). Depending upon need, portions of the North Bay Channel may also be dredged in the spring. The average annual volume of material dredged in the spring is 106,089 yd^3. Larger average annual quantities of materials are dredged in the fall (687,401 yd^3) when the Corps performs maintenance dredging of the Bar and Entrance Channel and portions of the North Bay Channel.

In September 1992, the EPA, the Corps, and the Northern Coast Regional Water Quality Control Board developed testing requirements for sediments dredged annually from the Humboldt Bay channels (Corps 1994b). To better define contaminants of concern and to determine how frequently the sediments should be tested, the agencies agreed to conduct baseline studies of existing sediment quality in the harbor channels. The baseline studies include three sediment evaluations. Two evaluations have already been conducted (October 1993, March 1994) and are summarized below. The third evaluation will occur in 1995.

Based on analyses of dredged sediment composition, sand will usually account for 80% to 90% of the total material dredged from Humboldt Bay (Corps/HBHRCD 1995). Sediments dredged from the Bar and Entrance and North Bay Channels and the Field's Landing Channel north of Buhne Point have historically been composed of sand (grain size >0.075 mm). Sediments dredged from these channels may be determined to be acceptable for ocean disposal without further testing. This determination would be based on acceptable existing information including grain size, sediment chemistry, bioassays, and reports of spills and other contaminants.

Sediments dredged from the Eureka and Samoa Channels and the Field's Landing Channel south of Buhne Point have been composed of predominately (more than 50%) silt and clay (grain size <0.075 mm) with some (less than 50%) fine sand. Sediment chemistry and toxicity testing were conducted on samples from these channels. The samples contained relatively few detectable organic contaminants, and the concentration of detected contaminants was not significant. Toxicity tests of sediments from these channels also did not indicate significant levels of toxicity compared to reference samples. (Corps/HBHRCD 1995.) Thus far, all sediments that would be dredged during maintenance dredging activities have been considered environmentally acceptable for ocean disposal.

The Corps is proposing to deepen and widen the navigation channels in Humboldt Bay. Physical and chemical sediment sampling for the proposed Humboldt Bay channel deepening project was conducted in December 1991 (EVS Consultants 1993) to determine the suitability of dredged materials from the channel deepening project for disposal at the ODMDS, in compliance with MPRSA Section 103. The proposed project would generate approximately 5,600,000 yd^3 of dredged material to be disposed at an ODMDS and approximately 26,000 yd^3 of material, unsuitable for unconfined aquatic disposal, which would be disposed at an upland disposal site. (Corps/HBHRCD 1995.)

3.1.4 Existence and Effects of Current and Previous Discharges and Dumping in the Area

This section describes significant discharges into the ocean in the vicinity of the ODMDS alternatives where potential cumulative or synergistic impacts are possible. There are two significant discharges into the marine environment offshore of Humboldt Bay (Figure 3-1). The Simpson Paper Company and the Louisiana-Pacific Corporation both operate pulp mills on the Samoa Peninsula and discharge wastewaters outside of Humboldt Bay.

3.1.4.1 The Simpson Paper Company

The Simpson Paper Company owns a pulp mill located near the community of Fairhaven on the Samoa Peninsula in Humboldt County, California (Figure 3-1). The company discharges through an outfall into ocean waters adjacent to the Samoa Peninsula. The Simpson plant is not operating currently, but it is discharging fresh water through its outfall. Historically, the discharge consisted of:

- process wastewater from kraft pulping, pulp bleaching, and pulp drying;
- solids from its water treatment plant;
- power boiler effluent;
- sawmill effluent;
- treated sanitary sewage; and
- stormwater.

Effluents are discharged from an 866 m (2,840 ft) outfall through a 58 m (189 ft) multiple-port diffuser at an average depth of 10.6 m (35 ft).

As authorized under its National Pollutant Discharge Elimination System (NPDES) Permit, the Simpson Paper Company is prohibited from discharging wastewater in violation of effluent standards or prohibitions established under Section 307(a) of the Clean Water Act, and it is prohibited from discharging sewage sludge.

The outfall is approximately 3 nmi east of the HOODS, 3 nmi north of the SF-3 site, and 3.5 nmi north of the NDS. It is not expected that there would be either a cumulative or synergistic effect from the disposal of dredged material and wastewater effluent discharged by the Simpson Paper Company at any of the ODMDS alternatives considered

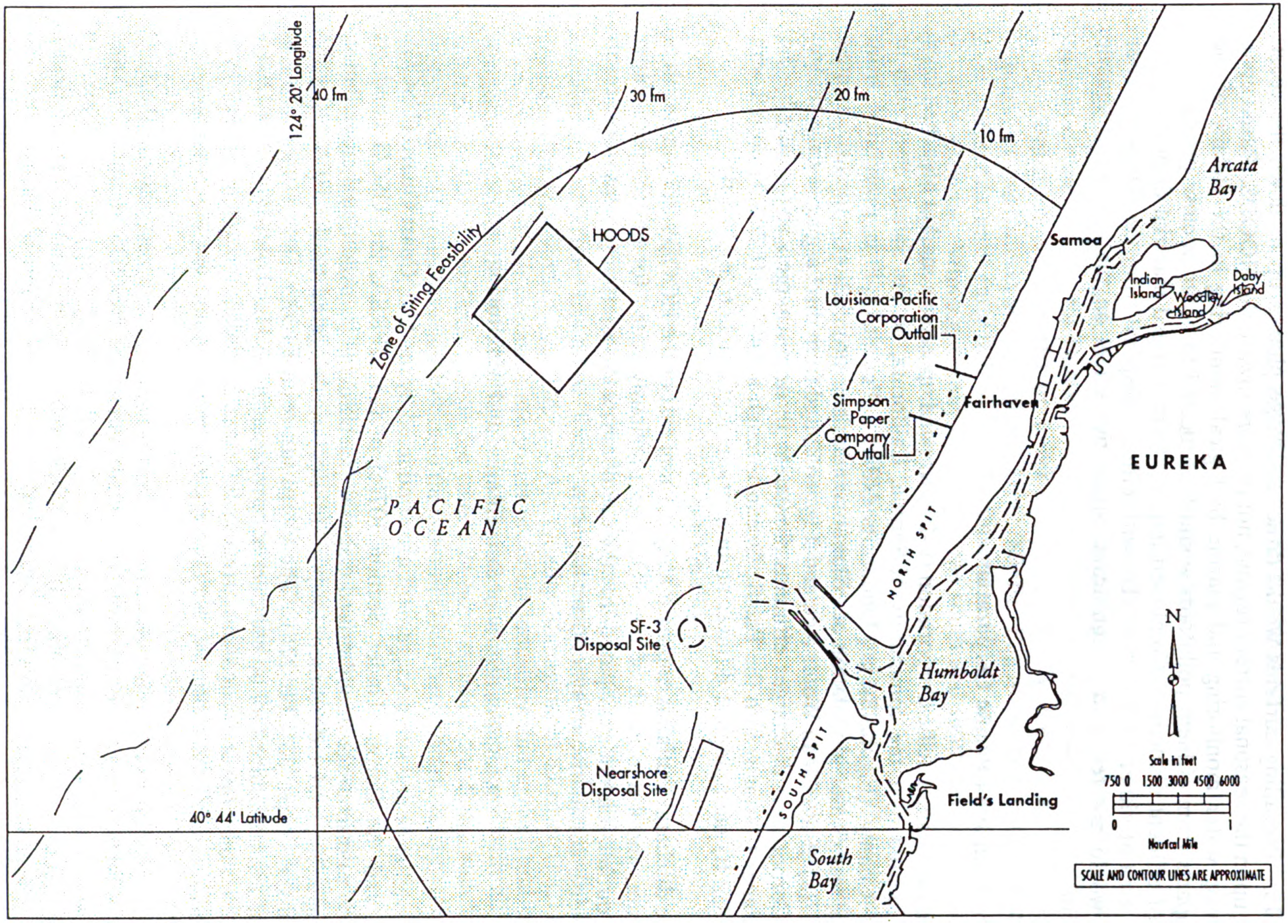


Figure 3-1. Approximate Locations of Louisiana-Pacific Corporation and Simpson Paper Company Ocean Outfalls

in this FEIS. Prevailing currents would direct discharge plumes up or down the coast, depending upon the seasonal current regime, not offshore toward the HOODS. Based upon past receiving water monitoring and marine biological monitoring in the vicinity of the outfall, impacts from effluent pollutants would be expected to occur in close proximity to the point of effluent discharge. Combined impacts from dredged material disposal in the nearshore area at either SF-3 or the NDS with effluent disposal from the Simpson Paper Company would not result in a significant cumulative effect on the nearshore aquatic environment.

3.1.4.2 The Louisiana-Pacific Corporation

The Louisiana Pacific Corporation (L-P) owns and operates a market bleached kraft pulp mill located near the community of Samoa, California, on the Samoa Peninsula in Humboldt County (Figure 3-1). Under its NPDES Permit, L-P is prohibited from discharging wastewater in violation of effluent standards or prohibitions established under Section 307(a) of the Clean Water Act, and it is prohibited from discharging sewage sludge. The L-P Corporation discharges effluents similar to those discharged historically by the Simpson Paper Company into the Pacific Ocean through a 2,497 m (8,200 ft) outfall with a 258 m (852 ft) multiple-port diffuser at an average depth of 12.6 m (41.5 ft).

The discharge outfall is approximately 3.5 nmi east of the HOODS, 3.5 nmi north of the SF-3 site, and 4 nmi north of the NDS. As previously stated for the Simpson Paper Company outfall, it is not anticipated that the use of any of the alternative sites would result in any adverse cumulative or synergistic impacts.

3.1.5 Feasibility of Surveillance and Monitoring

Surveillance and site management are conducted by the U.S. Coast Guard (USCG), the EPA, and the Corps. Under Section 107(c) of the MPRSA, the USCG conducts surveillance to discourage unauthorized disposal (33 USC 1417). Additional surveillance, site management, and enforcement responsibilities are delegated to the EPA (40 CFR 22.36) and the Corps (33 CFR 226). The Corps utilizes a Dredge Data Logging System (DDLS) as a surveillance tool on contract hopper dredging at Humboldt Bay. The DDLS is installed on the hopper dredge and provides full-time, hard-disk records of all pertinent dredge performance data (position, draft, date and time, work and disposal area, etc.).

Monitoring is practicable at all three alternative sites. The accessibility of the SF-3 site and the NDS may at times be more restricted than at the HOODS because SF-3 and the NDS are located in shallower water (14 to 17 m [45 to 56 ft] deep) and are subject to a more rigorous wave climate than the HOODS (49 to 55 m [160 to 180 ft] deep). However, these conditions have not interfered with the collection of bathymetric and biological data at SF-3 and the NDS in the past.

3.2 PHYSICAL ENVIRONMENT

3.2.1 Meteorology

The northern California coast has a moderate climate. Average minimum and maximum temperatures for Eureka are 5°C (41°F) (January) and 17°C (62°F) (August). Temperatures of 0°C (32°F) or lower can occur nearly every year along the coast. Maximum temperatures seldom exceed 27°C (80°F). Fog is common in the coastal region from late spring until early fall. It usually remains until late morning and returns again in the early evening. Winds generally blow from the south and southwest in the winter, and from the north and northwest in the summer.

The Humboldt Bay area is noted for its high precipitation (97 centimeters [cm] [38 inches] of rainfall annually) and associated episodic storms. Most of the rainfall occurs between mid-October and mid-May. During the winter, storms are most severe, with high wind and squall conditions occurring frequently.

3.2.2 Air Quality

The study area lies within the North Coast Air Basin, which includes Del Norte, Humboldt, and Trinity Counties. Onshore air pollution sources in Humboldt County are regulated by the North Coast Unified Air Quality Management District (NCUAQMD). Primary sources of air pollution are forest products industries and agricultural operations (Corps/HBHRCD 1995). The NCUAQMD presently is in compliance with all state and federal air quality standards except the state's 24-hour standard for PM_{10}, which has been violated several times between 1985 and the present (Herr pers. comm. in Corps/HBHRCD 1995).

The Corps' existing maintenance dredging program involves ships dredging and hauling dredged material for ocean disposal. Exhaust emissions from these ships contain reactive organic gases (ROG), nitrogen oxides (NO_x), carbon monoxide (CO), particulate matter (PM), sulfur dioxide (SO_2), and hydrocarbons (HC), all of which are released to the atmosphere during operations. The proposed designation and the disposal at an ODMDS of material from the maintenance dredging would not increase the loading of these pollutants above the present level. However, dredge operation during the proposed harbor deepening project may have a short-term significant impact on air quality (Corps/HBHRCD 1995).

3.2.3 Physical Oceanography

The dominant circulation influence offshore of Humboldt Bay is the California Current. The California Current system is a broad (540 nmi), sluggish current flowing southward off the Oregon and California coasts. It is the eastern boundary current of the large clockwise current circulation pattern that occupies most of the North Pacific Ocean. The California Current is largely wind-driven, affected to a lesser degree by tides and coastal topography.

The California Current system along the northern California coast undergoes seasonal fluctuation. Three basic oceanographic regimes that influence the waters and hydrographic conditions within the nearshore environments of northern California have been described: the upwelling, Davidson Current, and oceanic regimes (Pirie and Steller 1987, Pequegnat et al. 1990). Each of these regimes is dominant during specific times of the year; however, current conditions are influenced by wind events such that it is possible for the regimes to occur any time of the year. Pequegnat and Mondeel-Jarvis (1991) describe the three regimes as follows:

- **The upwelling regime.** This regime occurs most commonly in the spring and early summer months and is characterized by strong winds from the north and northwest and a southerly current on the shelf of 26 to greater than 100 cm/sec (0.5 to greater than 2.0 knots). Nearshore waters associated with this regime have low temperatures, high nutrient concentrations, and moderately high salinities (at least for the North Pacific Ocean).

- **The Davidson Current regime.** This regime is associated with the storms common in the late fall and winter and is characterized by strong south and southwest winds, large waves, and a northerly current of up to 50 cm/sec (1 knot). During these periods, nearshore waters have low salinities, high concentrations of suspended sediment, moderate nutrient concentrations, and saturated dissolved oxygen concentrations.

- **The oceanic regime.** This regime is common in late summer and early fall, when winds are light and from no predominant direction. During these periods, the California Current, normally offshore, moves closer to shore and causes low nutrient concentrations, high temperature, and moderate salinities in the nearshore environment.

3.2.3.1 Nearshore Circulation

Nearshore currents in the northern California region are determined by the alignment of the coast, the width of the continental shelf, oceanic currents, topography, bathymetry, winds, tides, density structure of the water, waves, and river discharge. At any location or time, one or more of these forces can be the predominant influence on local currents.

Some limited data have been collected on current systems in the vicinity of the two nearshore disposal sites (SF-3 and the NDS). In a report on sediment transport at the SF-3 disposal site, Borgeld and Pequegnat (1986) state that existing current data for the shelf area near the SF-3 disposal site are generally inadequate to permit precise estimation of sediment transport. Borgeld and Pequegnat (1986) utilized a nearshore current data set collected by Winzler and Kelly Consulting Engineers (1984) along the north spit of Humboldt Bay in their description of dredged material transport at the SF-3 site. The time periods summarized by Winzler and Kelly Consulting Engineers have been used to produce a year-long summary of the currents in the vicinity of these stations. Winzler and Kelly Consulting Engineers (1984) noted that the major current signal was best correlated with local winds, and that tidally produced currents were of secondary importance. Borgeld and Pequegnat (1986) believe that the proximity of the SF-3 site to the mouth of Humboldt Bay increases the importance of surface tidal currents in the formation of nearshore currents and the bottom currents as well. Borgeld and Pequegnat (1986) describe currents in the nearshore area as unidirectional, with the predominant winter movement offshore and to the northwest; less vigorous transport is characteristic of the summer conditions, with current motion generally offshore and to the southwest.

In November 1988, the Corps San Francisco District, in cooperation with the Corps Waterways Experiment Station - Coastal Engineering Research Center, released 475 seabed drifters (SBDs) at SF-3 and the NDS to investigate current direction at both disposal sites. The SBDs were released at five sites. One set was released at the center of SF-3, and the other four sets were released at the edges of the NDS.

The total SBD recovery was extremely high (67%) compared to similar studies at other sites. Recovery of drifters released from the SF-3 site and the offshore edge of the NDS was noticeably lower than from the northern and southern boundaries and the inshore boundary of the NDS. There was an even stronger distinction in direction of flow from SF-3 as compared to direction of flow from the NDS. No NDS seabed drifters were found north of the entrance channel to Humboldt Bay, whereas all but one of the SF-3 recoveries indicated northward transport of the SBDs, either across or around the entrance channel.

Although this SBD study was short and indicative only of bottom current trajectories (not of sediment transport specifically), the results do support the hypothesis that sediment from the NDS was more likely to disperse shoreward and away from the entrance channel than sediment from the SF-3 site under the conditions existing at the time of the study.

3.2.3.2 Offshore Circulation

Offshore current data are available for several sites near the HOODS. Long-term current measurements were collected for the U.S. Department of the Interior's Mineral Management Service (MMS) as a component of the Northern California Coastal Circulation Study (MMS 1989). These data were made available to the Corps for subsequent analysis for the site designation process. The current data were collected at two mooring sites: Mooring E60 at a depth of 60 m (197 ft) supported a 2 current meter array at depths of 10 m (33 ft) and 15 m (49 ft), and mooring E90 at a depth of 90 m (295 ft) supported a

3 current meter array with meters at depths of 15, 45, and 75 m (49, 148, and 246 ft) (Figure 3-2). The current meters were deployed during four time periods between 1987 and 1989. Summary plots of the four recorded periods are shown in Figure 3-3. The current vectors (representing current velocity in different directions) shown in the figure indicate current direction upcoast (positive vector value) and downcoast (negative vector value). Summary computations in the form of northerly (+U) and easterly (+V) component averages, velocity magnitudes, standard deviation, and percent magnitudes above 50 cm/sec are shown in Table 3-2.

In general, these data indicate 10 m to 15 m deep current velocities on the order of 25 cm/sec (0.5 knot); 45 m deep current velocities of 20 cm/sec (0.4 knot); and bottom current velocities of 15 cm/sec (0.3 knot).

3.2.3.3 Waves

Low-pressure storms are the most important source of storm waves reaching the California coast during winter months. These storms originate near Japan and proceed eastward across the Pacific, with the intensity of the waves decreasing southward along the California coast. The summer months are dominated by the high-pressure storms, with predominant wave action generated by the prevailing west/northwest winds along the coast.

Borgeld and Pequegnat (1986) utilized wave data from two wave rider buoys offshore of Humboldt Bay and described a seasonal wave spectra pattern. During the winter months, the wave spectra are dominated by longer period swells (periods greater than 12 seconds between waves). During the rest of the year, the spectra demonstrate a greater predominance of waves with shorter periods (i.e., less than 12 seconds between waves).

3.2.3.4 Tides

The Humboldt area experiences mixed tides. Mixed tides refer to two sets of tides each day (two high and two low tides). The sets of tides are not equal in amplitude. The tidal range between mean lower low water (MLLW) and mean higher high water (MHHW) is 1.95 m (6.4 ft) at the south entrance jetty to Humboldt Bay. Extreme low tides have been observed, as low as 0.6 m (2 ft).

3.2.4 Water Quality

Ocean water temperatures along the California coast respond to seasonal current changes, wind direction, insolation, and upwelling. The temperature of the nearshore waters of northern California normally ranges from 9°C to 14°C (48°F to 57°F). The salinities of the nearshore environment range from less than 25 parts per thousand (ppt) during periods of high runoff to greater than 34 ppt when deeper water is advected to the surface during periods of intense upwelling (Pequegnat and Mondeel-Jarvis 1990).

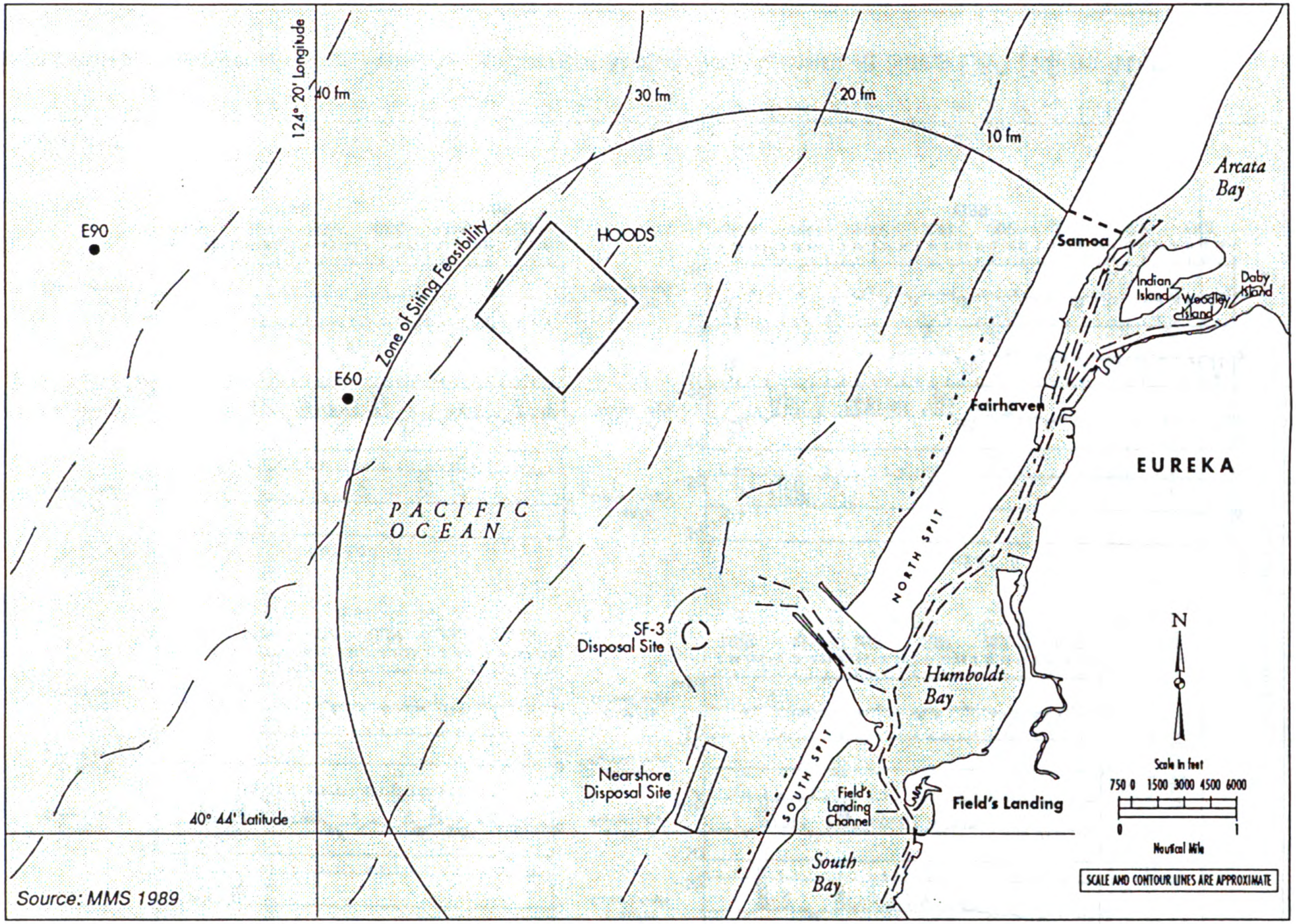
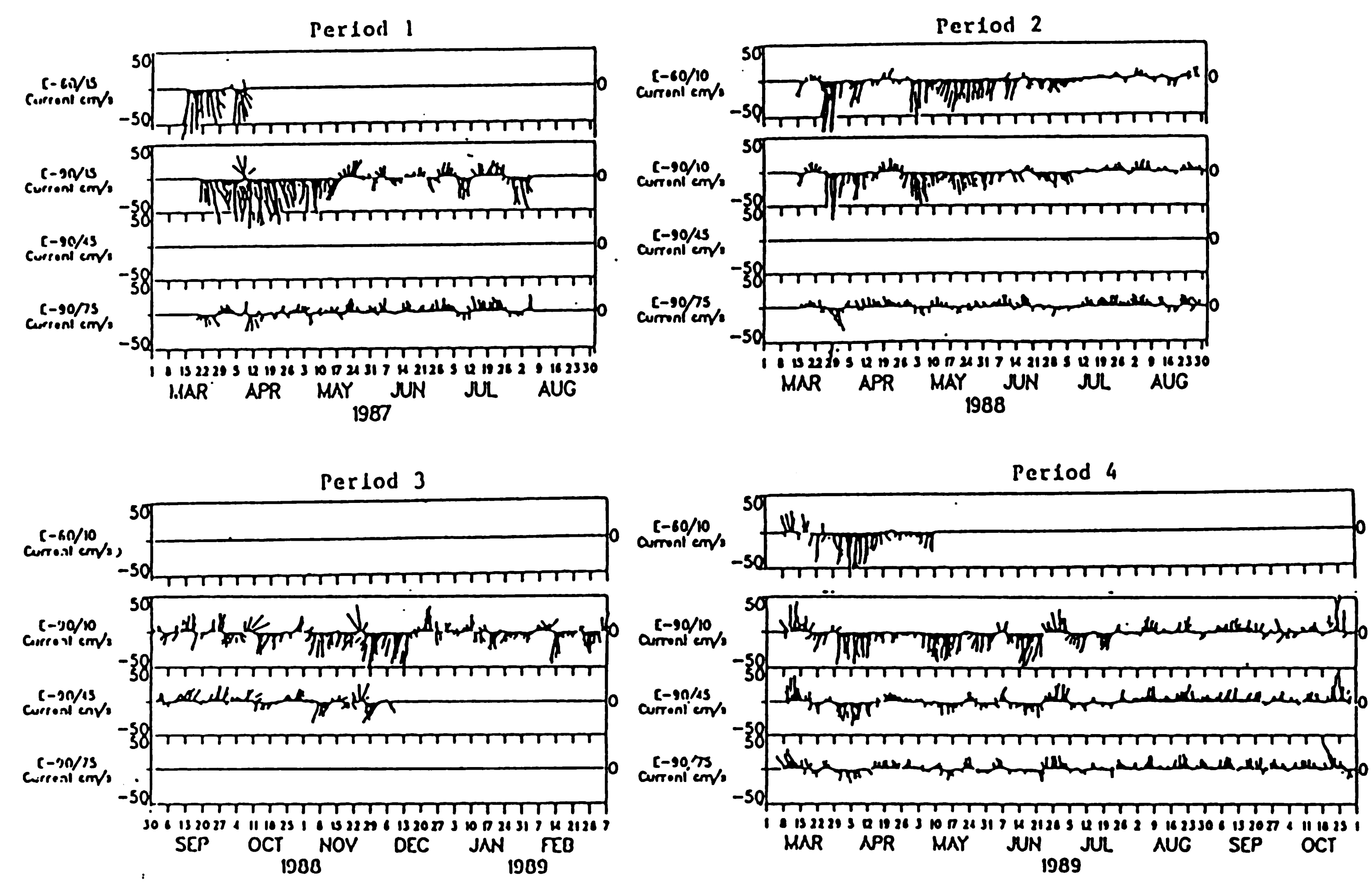


Figure 3-2. Approximate Location of Current Meter Stations E60 and E90



Source: MMS 1989

Figure 3-3. Record of Four Periods of Current Meter Deployment at Sites E60 (15 m, 10 m) and E90 (15 m, 45 m, 75 m)

Table 3-2. Current Speed and Direction from Current Meter Mooring Stations E60 and E90

Mooring Number/ Depth (m)	Average U[1] (cm/sec)	Average V[2] (cm/sec)	Average Velocity (cm/sec)	Standard Deviation (cm/sec)	% of Time Exceeding 50 cm/sec
Period 1					
E-60/15	-1.90	-4.36	30.51	17.63	15.29
E-90/15	-5.37	14.08	27.12	17.03	11.08
E-90/45					
E-90/75	2.46	3.52	15.54	8.28	0.00
Period 2					
E-60/10	-6.70	-8.40	17.82	14.45	3.79
E-90/10	-2.88	-6.81	17.63	13.51	3.24
E-90/45					
E-90/75	0.41	4.06	14.90	8.06	0.10
Period 3					
E-60/10					
E-90/10	-4.49	-5.48	22.12	12.71	3.25
E-90/45	1.89	-0.44	16.65	10.23	0.45
E-90/75					
Period 4					
E-60/10	-7.82	-12.23	24.79	13.96	4.42
E-90/10	-3.74	-3.68	20.60	13.12	3.26
E-90/45	2.47	1.91	14.80	9.46	0.58
E-90/75	1.11	3.93	15.79	8.79	0.17

[1] U - Positive values indicate current flow to the north; negative values indicate current flows to the south.

[2] V - Positive values indicate current flow to the east; negative values indicate current flows to the west.

Pequegnat and Mondeel-Jarvis (1990) describe temperature and salinity changes in nearshore waters adjacent to Humboldt Bay in relation to the hydrographic regimes as follows:

- **The upwelling regime.** During upwelling periods, the nearshore water temperature drops to below 10°C (50°F) and the salinity rises to over 33.6 ppt. During intense upwelling periods, the sea surface temperature may drop to less than 8°C (46°F), with salinities greater than 34 ppt. The water column is not stratified shoreward of the upwelling front. The distance offshore at which the upwelling front is found depends on both the wind velocity and the wind duration but is typically more than 4 nmi offshore during periods of moderate upwelling.

- **The Davidson Current regime.** Because the northerly flowing Davidson Current is associated with winter storms, the nearshore surface waters tend to be cool (less than 11°C [52°F]) and of low salinity (less than 32 ppt) because of high runoff. The nearshore waters also tend to be highly stratified, primarily due to the vertical salinity gradient.

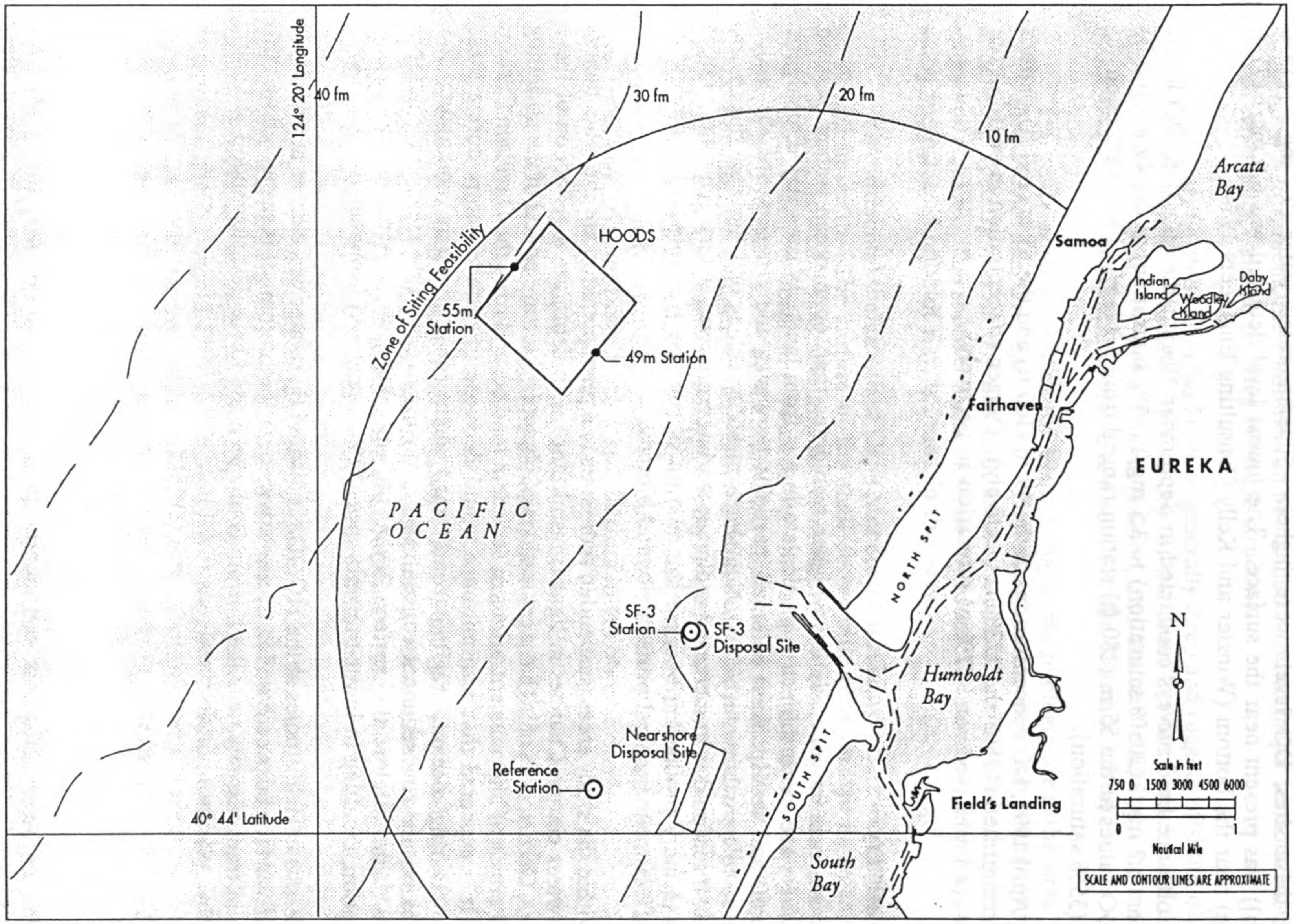
- **The oceanic regime.** During periods of light and variable winds, the warm surface water offshore tends to move onshore. Consequently, the sea surface temperature typically rises to greater than 13°C (55°F) and the salinity is usually less than 33.5 ppt. The waters are usually vertically stratified with respect to temperature and, to a lesser extent, salinity.

As part of this designation effort and an earlier effort to designate the SF-3 site, water column characteristic studies were performed at the preferred site (the HOODS), the SF-3 site, and a nearshore reference site (Figure 3-4). The studies were conducted at the HOODS in September 1990 and April 1991, and at SF-3 in May 1983 and July 1983. They included the evaluation of temperature, salinity, and density (SIGMA-t) profiles at two stations located at the shoreward and seaward boundaries of the HOODS (in 49 m [160 ft] and 55 m [180 ft] of water respectively). These same profiles were also collected at SF-3 and at a reference station (both in approximately 21 m [70 ft] of water). (Pequegnat and Mondeel-Jarvis 1991, Winzler and Kelly Consulting Engineers 1984.)

3.2.4.1 Dissolved Oxygen

The surface layers of the ocean are usually saturated with dissolved oxygen (DO), and DO concentration generally decreases with depth. During upwelling conditions, the oxygen concentration in the surface waters may be less than 50% of the saturation concentration; this low oxygen concentration is associated with the deeper, low-oxygen water that is advected to the surface.

During nearshore field surveys conducted in May 1983 at the SF-3 disposal site and at a reference site, DO levels ranged from a high of 8.2 milligrams per liter (mg/l) (98% saturation) to a low of 6.4 mg/l (70% saturation) near the bottom. During the July 1983



Sources: Pequegnat and Mandeel-Jarvis 1991, Winzler and Kelly 1984

Figure 3-4. Location of Offshore and Nearshore Field Surveys for Water Column Characteristics survey of these sites, DO levels were higher. Supersaturated water (9.7 mg/l [117% saturation]) was present near the surface. The lowest level detected was 6.8 mg/l (77% saturation) near the bottom (Winzler and Kelly Consulting Engineers 1984).

In offshore field surveys conducted in September 1990 at the HOODS, DO levels ranged from 6.2 mg/l (105% saturation) to 3.5 mg/l (55% saturation) at the 49 m (160 ft) station; DO values at the 55 m (180 ft) station ranged from 5.9 mg/l (100% saturation) to 2.2 mg/l (35% saturation).

In April 1991, DO concentrations at the 49 m (160 ft) and the 55 m (180 ft) stations were supersaturated (115% and 123% respectively). Oxygen concentration in near-bottom samples were lower (66% and 62% of saturation respectively).

3.2.4.2 Turbidity

Coastal waters generally have higher turbidities than open ocean waters because coastal waters are more subject to particulate inputs from land. Wastewater dischargers, river runoff, and resuspension of small particles by waves and currents are the major contributors to nearshore turbidity. Nearshore turbidity values will increase during the spring runoff season due to increased sediment loading from river waters. This has a direct effect on primary production because the amount of sunlight available to phytoplankton directly affects primary algal productivity and biomass.

Within the study areas, suspended sediments and phytoplankton are the main factors affecting water clarity. Changes in light transmittance with depth are a reflection of these two factors. Occurrences of high concentrations of phytoplankton are typical of the upwelling regime. Periods of high concentrations of sediment load occur during the Davidson Current regime. It is expected that transmittance would decrease in surface waters during these periods. During oceanic regime conditions, when surface waters containing low phytoplankton and low sediment concentrations move into the study areas, transmittance would be high. Below the surface layer, phytoplankton would tend to increase in concentration, resulting in lower transmittance. (Pequegnat and Mondeel-Jarvis 1990.)

Results of field studies at the HOODS indicated that water was clearer at mid-depth than at the surface but decreased in transmissivity near the bottom. It is suspected that this decrease in transmissivity near the bottom could be caused by either suspended sediment, sinking phytoplankton, or detritus.

3.2.5 Regional Geology

The northern California continental shelf has a complex morphology that has developed because of active tectonic movements in the area. The study area lies in close proximity to the Gorda-Pacific-North American triple junction, which is usually defined as the juncture of the San Andreas fault and the Mendocino Escarpment. North of the

Mendocino Escarpment, the coastline can be divided into two major sections based on the coastal morphology and underlying geologic structure.

The coast north of Trinidad Head is generally steep and rugged; offshore islands and seastacks are common. Beneath this section of the coast lies the Franciscan Formation. The beaches are generally steep, coarse-grained, and limited in lateral extent (the only major exception is Gold Bluffs Beach, just south of the Klamath River).

The study areas lie within the second major morphologic area, the area between Cape Mendocino and Trinidad Head. The coast in this area has been formed over underlying Tertiary marine deposits and features a coastal plain dissected by meandering rivers and streams. The shore consists of relatively broad, flat beaches. The only major bay along the coast, Humboldt Bay, is found in this area.

The continental shelf north of Cape Mendocino is relatively narrow, ranging from 5.2 to 19 nmi in width. The surface of the shelf shows little relief except in areas near the major headlands where seastacks and underwater promontories are common. The lack of shelf relief, which is surprising considering the active tectonism, is due to the rapid sedimentation in the area. The shelf area has been called the Eel River Shelf by Borgeld (1985) because the modern sedimentation is dominated by material supplied by the Eel River. Sedimentation rates vary but apparently range from 0.5 to 2.0 cm (0.8 inch) per year (Borgeld 1985, 1986). This rate is rapid for shelf areas supplied by all but the world's largest rivers. The rate is high because sediment yield from the local rivers is higher than that of any watershed of comparable size in the United States.

3.2.6 Sedimentation Patterns

Sedimentation patterns on the Eel River Shelf are produced by a number of processes acting together. Sediments are supplied to the shelf in a series of short-term deposition events. The pulsed nature of the sediment supply system is extremely important in the production of the sediment stratification on the shelf.

Numerous rivers and streams empty directly onto the coast in this area. Of these, two deliver the majority of the sediment to the coast. The major supplier is the Eel River, which delivers an average of 27,282,000 tons of suspended sediment per year to the continental shelf (Borgeld 1985). The Mad River supplies approximately one tenth of this amount to the shelf, an average of 2,774,000 tons of suspended sediment per year. The rivers along the northern California coastline have short drainage basins and highly variable stream flows. These rivers characteristically carry the majority of their sediment load during two or three flood events per year. (Borgeld 1985.)

Borgeld (1988) has documented a secondary sediment supply system in the study area that is produced by the ebb-tidal plume exiting Humboldt Bay. This plume acts like an additional river sediment plume by supplying sediment to the shelf. It delivers less sediment than the Eel River but delivers the majority of its sediment during spring tides rather than during river flooding.

Each major sediment supply event (i.e., major flood or major spring tide) deposits a layer of sediment on the shelf. The layer is generally thickest near the sediment source and decreases in thickness with distance from the source. Therefore, floods tend to produce layers that are thickest near river mouths, and the layers produced by the ebb-tidal plume from Humboldt Bay tend to be thickest near the bay mouth.

Once deposited, a layer is mixed physically by waves and currents, and biologically by benthic organisms (bioturbation). The amount of physical mixing is primarily controlled by the size of incoming waves and the water depth; wave mixing is more intense in shallower water. Borgeld (1986) collected box cores near the mouth of the Eel River and noted that the flood history of the river has been preserved in the sediments near the river mouth. Thick layers (up to 10 to 12 cm [4 to 5 inches] thick) have been deposited during past floods of the river. In shallower water, generally less than 40 m (131 ft) deep, these layers exhibited structure typical of sediment remobilization and mixing caused by incoming waves. In water depths greater than 40 m (131 ft), many of the sediment layers were preserved, since presumably the water depths were too great for the incoming waves to significantly remix the bottom sediments. Instead, the mixing that occurred was generally limited to bioturbation.

Biological mixing occurs during the day-to-day activities of organisms that live in the bottom (infauna) or near the bottom (epifauna). It is unlikely that biologically produced mixing is uniform on the continental shelf, but no detailed study of this mixing in the study area has been conducted. Borgeld (1985) noted that the biological mixing history of a layer was apparently related to the layer thickness; thick layers had little if any biological mixing, while thin layers were commonly intensely mixed.

Wave mixing has an additional effect on the shelf's sediment distribution: areas where the bottom sediments are continually resuspended by wave action tend to have coarser sediments than deeper areas less influenced by waves. Fine-grained sediments (silts and clays) settle slowly compared to larger particles, and their continual resuspension effectively prevents them from accumulating in an area influenced by wave activity.

3.3 BIOLOGICAL ENVIRONMENT

The area of study described herein encompasses the region identified by the Corps in 1989 as the Zone of Siting Feasibility (ZSF) (Appendix A). Within ZSF boundaries, three candidate sites have been chosen for disposal of material dredged from Humboldt Bay. These sites are the HOODS, SF-3, and the NDS.

Commercially important biological resources include groundfish (e.g., English sole, Dover sole, Pacific sanddab, rockfish), Dungeness crab, and salmon, all of which seasonally occur in the region, including the sites proposed for dredged material disposal. A variety of seabirds and marine mammals also occur in the region, including the disposal sites. Of lesser importance commercially, but of great importance ecologically, are the planktonic communities (phytoplankton and zooplankton) and benthic communities (polychaete worms and clams) that provide food for higher trophic level organisms (fish, marine mammals, and birds).

3.3.1 The Plankton Community

The open waters off Humboldt Bay are part of the California Current region, where biological components from a variety of marine biotic provinces mix. Few endemic (native) species or distinct neritic assemblages (organisms that occur on the coastal shelf) are found in this pelagic environment, but warm-water species from the central Pacific province and warmer-water cosmopolitan species occasionally occur. (Jones & Stokes Associates 1981.)

Plankton biomass and species composition in this region are influenced by the southern-flowing California Current and the Davidson Current that flows sporadically northward in winter. In addition, the upwelling of cold, nutrient-rich deep water during late spring and summer fertilizes surface waters, promoting phytoplankton production.

3.3.1.1 Phytoplankton

Phytoplankton are chlorophyll-bearing microscopic algae that passively drift or have limited means of locomotion and are, therefore, carried by waves and currents. Phytoplankton form the basis of marine food chains by using solar energy to convert inorganic nutrients into organic matter through photosynthesis. The distribution and abundance of phytoplankton depend on light intensity, nutrient concentrations, intensity of grazing, turbulence, turbidity, upwelling, and circulation. The abundance and variety of phytoplankton in surface waters, in turn, influence the subsequent production of zooplankton and other organisms.

Phytoplankton concentrate in surface waters where light is available, but vertical distribution is mainly affected by turbulence, stratification, and limited mobility (i.e., dinoflagellates). Phytoplankton biomass (as indicated by chlorophyll a concentration) is usually lower offshore (15 to 20 milligrams of chlorophyll a per square meter [mg chlorophyll a/m^2] in the upper 150 m [500 ft]) than nearshore (approximately 300 mg chlorophyll a/m^2 in the upper 150 m [500 ft]) (Owen 1974).

Phytoplankton populations in the coastal waters of northern California are generally composed of diatoms, dinoflagellates, coccolithophores, and flagellates (Hood et al. 1990). Primary production and phytoplankton biomass increase after persistent upwelling periods during the late spring and summer when cold, nutrient-rich waters induce intense blooms of diatoms. Photosynthetic carbon production rates can be 2 to 10 times higher in areas of pronounced upwelling than in open ocean waters. The rate of primary production in northern California coastal waters is about 150 grams of carbon per square meter per year

($g/C/m^2$/year) but may reach 300 $g/C/m^2$/year in upwelling regions (Jones & Stokes Associates 1981). Following blooms, phytoplankton biomass declines as nutrients become limiting and phytoplankton is eaten by zooplankton or other grazers.

The warmer, nutrient-poor oceanic water of the California Current supports less biomass and smaller phytoplankton species than those present during upwelling (Hood et al. 1990). During the stormy fall and winter season, primary production rates are low due to reduced solar radiation, reduced upwelling, increased mixing of surface waters below the euphotic (light-penetration) zone, and increased turbidity due to wave action and increased flow of sediment-laden river water. The northern-flowing Davidson Current occasionally influences phytoplankton composition offshore of Humboldt Bay during winter months by bringing warm-water phytoplankton species from central Pacific waters.

3.3.1.2 Zooplankton

Zooplankton are aquatic invertebrates that have limited mobility or passively drift with water currents. Zooplankton transfer some of the energy of primary producers (phytoplankton) to larger invertebrates, fish, birds, and marine mammals. Zooplankton are divided into two main groups: (1) holoplankton, which spend their entire life cycle in the water column; and (2) meroplankton, which consist mostly of the larvae of benthic macroinvertebrates that are temporary members of the pelagic zooplankton community. The larvae of polychaetes, bivalves, gastropods, and crustaceans are typical meroplanktonic organisms, while holoplanktonic organisms include copepods, opossum shrimp (*Mysidacea*), krill (*Euphausiacea*), and arrow worms (*Chaetognatha*).

Zooplankton populations are regulated by water temperature, food availability, and predation. Zooplankton are most abundant within the top 20 to 30 m (66 to 100 ft) of the water column (Peterson and Miller 1977) and closer to the shore over the continental shelf (Pearcy 1972, Colebrook 1977, Peterson and Miller 1977).

Zooplankton distribution tends to be extremely patchy, largely as a result of ocean currents (Wickett 1967). The vertical distribution of zooplankton is determined by light, phytoplankton density, food, and the biology of each species. Zooplanktonic species from the Subarctic, Transition, and Central Pacific faunal groups have been identified in the coastal upwelling regions offshore of Oregon (Peterson and Miller 1977). The oceanic currents that influence the zooplankton composition in the coastal waters of Oregon are similar to those that influence the area offshore of Humboldt Bay (Hickey 1979); therefore, the species composition of zooplankton found offshore of Humboldt Bay is comparable to that reported for the coast of Oregon.

Peak zooplankton abundance in the coastal waters of northern California occurs from May through July in response to increased food availability following upwelling. Zooplankton species characteristic of northern faunal groups dominate in the summer when the California Current flows to the south. The copepod *Pseudocalanus* spp. is an abundant component of the California Current zooplankton, with highest densities occurring within the nearshore zone (2.6 nmi off the coast). In general, the nearshore zone is an important habitat for many other species of zooplankton. *Acartia* spp. and *Centropages abdominalis* are restricted to this zone, while other important zooplankton, *Pseudocalanus* spp. and *Calanus marshallae*, move into the nearshore zone to reproduce. Many higher trophic level organisms (i.e., pelagic fishes, marine birds, and mammals) occur seasonally in the area in an apparent response to the increased abundance of zooplankton and other prey. During the winter, however, warm-water species are transported northward by the Davidson Current, and zooplankton species abundance is generally lower (Peterson and Miller 1977).

The predominant holoplanktonic organisms in the coastal waters of northern California are copepods such as *Calanus pacificus*, *Acartia* spp., and *Pseudocalanus* sp.; mysids such as *Neomysis kadiakensis* and *N. rayi*; and euphausiids, including *Thysanoessa spinifera* (Peterson and Miller 1977, Lockheed Center 1979, Pequegnat et al. 1990).

Of the meroplankton, the pelagic larval stages of many shallow-shelf benthic invertebrates (such as the Dungeness crab[1]) are an important seasonal component (Jones & Stokes Associates 1981). Following hatching, zoea stages of Dungeness crab larvae remain in the plankton off central California from mid-December to mid-March (Reilly 1983a). Considerable offshore movement of this larvae occurs during this time, and these larvae can be found at depths greater than 30 m (100 ft) (Reilly 1985). After upwelling begins in April and May, megalopae, the final pelagic stage of the Dungeness crab, appear near shore in large concentrations. The mechanism by which they move inshore is unclear (Pauley et al. 1989). Megalopae occur off Humboldt Bay from April to June, concentrating at the surface, especially at dawn and dusk (Toole 1989). They are frequently associated with floating materials, slicks, and upwelling fronts (Toole 1989). Dungeness crab larvae feed on zooplankton and are important prey items for plankton-feeding fish such as salmon (Reilly 1983b) and rockfish (Prince and Gotshall 1976).

No data are available describing the seasonal abundance and distribution of other meroplanktonic invertebrate larvae in the area offshore of Humboldt Bay. Oliver and Slattery (1976) reported that the reproductive patterns of the benthic invertebrate fauna correlated well with day length and phytoplankton blooms in the spring and fall in a study of a similar environment in Monterey Bay.

The zooplankton species that accompany the current regimes occurring offshore of Humboldt Bay are an essential link in the food web of the waters of the area but are not of direct economical or commercial importance.

3.3.2 The Benthic Algae Community

Attached plants are uncommon in open coastal waters with sandy bottoms because of a lack of nutrients, few attachment sites, and inhibition by waves and longshore currents. Some seaweed, mostly *Fucus distichus* and *Ulva* sp., is found along the intertidal and subtidal

[1] Scientific names for species mentioned in text are presented in Appendix D.

portions of the north and south jetties. The lack of suitable substrate and the intensity of wave action prohibit the development of large kelp beds in the subtidal area off of Humboldt Bay.

3.3.3 The Benthic Invertebrate Community

Benthic macrofaunal invertebrates are those organisms (generally > 1 mm [0.04 inches]) that occur in bottom sediments. Several detailed studies of the benthic invertebrate communities offshore of Humboldt Bay have been performed (ERC 1976, Lockheed Center 1979, IEC 1981, Winzler and Kelly Consulting Engineers 1984, Pequegnat and Mondeel-Jarvis 1990, Pequegnat et al. 1990). However, only one study sampled the benthic macrofauna in water deeper than 30 m (100 ft) (Pequegnat et al. 1990). Benthic invertebrate communities have been surveyed more thoroughly at the shallower ocean alternative sites (the NDS and SF-3) than at the HOODS, which ranges in depth from 49 to 55 m (160 to 180 ft). A summary of the dominant benthic macrofaunal invertebrates reported near Humboldt Bay is provided in Table 3-3.

3.3.3.1 Benthic Infauna

Benthic infauna are invertebrates that burrow into the bottom sediments. The distribution, abundance, and species composition of benthic infauna communities in nearshore continental shelf sediments are related to sediment grain sizes (Gray 1974), organic content of sediments, production of organic matter in overlying waters, interactions among organisms, and environmental disturbances (such as storm waves and high sediment loads associated with episodic floods and drag fishing) (Pequegnat et al. 1990).

Pequegnat et al. (1990) conducted a study of benthic fauna in the area of study from 1989 to 1990. Polychaetes, mollusks, and crustaceans account for over 90% of the species and numbers of individuals of the benthic infauna in the area. The polychaete biomass is also greater in the finer sediments within the region. In general, the number of species and the abundance of benthic infaunal invertebrates increased with increasing depth in the benthic environment offshore of Humboldt Bay.

A total of 295 species of benthic invertebrates were identified by Pequegnat et al. (1990). Annelids, primarily polychaete worms, are the most abundant species group found in the benthic environment, accounting for over 70% of the individuals. The abundance of polychaetes, in general, increased with increasing depth. Mollusks, primarily gastropods and bivalves, were the next most abundant species group of the benthic infauna. The most abundant gastropod snail, *Olivella pycna*, occurred primarily in the shallower depths, while the most abundant bivalve was found in highest densities in the deeper areas. Crustaceans, especially amphipods, were the third largest species group contributing to benthic infaunal abundance.

Table 3-3. List of the Dominant Benthic Macrofaunal Invertebrates Reported near Humboldt Bay

Annelida
- Polychaeta
  - *Chaetazone setosa pugettensis*
  - *Decamastus gracilis*
  - *Glycera oxcephala*
  - *Heteromastus filobranchus*
  - *Lumbrineris luti*
  - *Mediomastus californiensis*
  - *Scoloplos armiger*
  - *Spiophanes bombyx*
  - *Tharyx* spp.

Arthropoda
- Crustacea
  - Malacostracans
    - Cumacea
      - *Diastylopsis dawsoni*
    - Amphipoda
      - *Ampelisca careyi*
      - *Anisogammarus pugettensis*
      - *Atylus tridens*
      - *Monoculodes spinipes*
      - *Protomedia prudens*
    - Isopoda
      - *Synidotea bicuspida*

Mollusca
- Gastropoda
  - *Olivella pycna*
  - *Mitrella* spp.
- Bivalvia
  - *Axinopsida sericata*
  - *Siliqua patula*

Source: Pequegnat et al. 1990.

Overall, the abundance of benthic infaunal invertebrates declines during the winter in the region. Total benthic infaunal abundances range from 2,400 organisms/m^2 in March 1990 to 3,450 organisms/m^2 in August 1989. Polychaetes are the most abundant infaunal species group in both summer and winter. Mollusks account for a greater percentage of the total number of individuals in the region during the winter than during the summer (Pequegnat et al. 1990).

Three zones of benthic infauna have been identified (Pequegnat et al. 1990): (1) the nearshore zone (< 35 m [115 ft] in depth), (2) the mid-depth zone (> 35 m [115 ft] but < 55 m [180 ft] in depth), and (3) the offshore zone (> 75 m [250 ft] in depth).

The nearshore benthic zone contains clean sand with little organic debris and is swept by waves. The infaunal diversity in the nearshore is low, and there are more suspension-feeders and fewer burrowing deposit-feeders than are found farther offshore. Small polychaetes, amphipods, cumaceans, and mollusks are the principal infauna in the nearshore zone (Lockheed Center 1979, IEC 1981, Winzler and Kelly Consulting Engineers 1984, Pequegnat et al. 1990). The abundance and diversity of infauna in the nearshore zone vary seasonally (Pequegnat et al. 1990, Winzler and Kelly Consulting Engineers 1984), probably because of seasonal wave action in the relatively shallow depths.

Two alternative ocean disposal sites, the NDS and SF-3, are located within this nearshore zone. Following disposal of dredged material, the abundance and numbers of infaunal species were lower than offshore and at nearby reference stations (Lockheed Center 1979, IEC 1981, Winzler and Kelly Consulting Engineers 1984, Pequegnat et al. 1990). The dredged material disposed at the sites was coarser than that of the adjacent habitat at similar depths, and the frequency of dumping inhibited benthic succession. Therefore, the benthic fauna at the site was characterized by opportunistic, small, mobile, surface-dwelling invertebrates. There has been no disposal at SF-3 since April 1990, or at the NDS since fall 1989. This period of respite from disposal disturbance is reportedly long enough to allow the benthic communities at these disposal sites to recolonize to an assemblage more similar to the adjacent benthic habitats (Bott and Diebel 1982, Tatem 1984).

The sandy sediments of the mid-depth zone contain more organic debris and so support a more diverse and abundant infauna than is found in the nearshore zone. The mid-depth zone also supports more burrowing deposit feeders, which have limited mobility and feed from burrows within the sediments. Sediments with high organic content provide better habitat for non-motile deposit-feeders than is found in the nearshore zone.

The break between the mid-depth and the offshore zones does not occur at a fixed depth but ranges from a depth of 55 to 75 m (180 to 250 ft) in response to wave energy and sediment supply. At water depths greater than 55 m (180 ft), the percentage of silt in the sediment increases, as does the amount of organic material. The boundary between the sands found in the nearshore and mid-depth zones and the muds found farther offshore (in waters greater than 75 m [250 ft] in depth) lies in this area. This transition area between the mid-depth and offshore zones is called the "mud-sand transition zone." The HOODS is located within the outer limit of the mid-depth zone and the inner limit of the mud-sand transition zone.

Higher diversity and greater abundances of infaunal species, including burrowing, deposit-feeding polychaetes and mollusks, are found in this transition zone than nearer to shore. The sediments in this zone are finer and contain more organic material, and so provide a more suitable habitat for burrowing infaunal organisms than the sand substrates characteristic of the nearshore and mid-depth zones. For example, the bivalve *Axinopsida serricata* has been found only in water > 49 m (161 ft) deep, probably because the finer-grained sediments found in deeper water are better for burrowing (Pequegnat et al. 1990). The stability of this environment is partly responsible for its relatively higher diversity and the increase in sedentary burrowing and tube-dwelling infauna (Oliver et al. 1980).

The offshore zone (> 75 m [250 ft] in depth) contains fine sands with silty clays and terrestrial organic debris. The area of study extends only a short distance into the offshore zone, so the offshore muds were not sampled. It is likely that even higher numbers of species and individuals would be found in samples from deeper locations.

The benthic invertebrate infauna of the region may be an important link in the food web supporting higher trophic level species, some of which are of commercial significance. Although the feeding preferences of demersal fish species and of Dungeness crab include benthic infaunal invertebrates, specific areas important for feeding have not been identified. These feeding habitats are likely to be widespread within similar depth zones and sediment types in the region.

3.3.3.2 Benthic Epifauna

Epifauna refers to animals that are associated with the surface of the sea floor rather than those that burrow into sediments. Most of the epibenthic species captured in trawls offshore of Humboldt Bay are carnivorous or omnivorous. These species affect the distribution and abundance of their infaunal prey (Woodin 1974, Virnstein 1977).

Decapods, particularly Dungeness crabs, and three species of shrimp (bay shrimp, sand shrimp, and coon-stripe shrimp), are numerically dominant organisms in the region. Pequegnat et al. (1990) report that these species are generally more abundant and found at greater depths in March than in August. Common echinoderms include sea stars, the short-spined star, the brown mud star, and the Pacific sand dollar. Large numbers of sand dollars are found in the nearshore and mid-depth zones.

The most economically important epifaunal invertebrate reported in this region is the Dungeness crab, which is fished commercially along the northern California coast. Most of these crabs are taken from water less than 55 m (180 ft) deep; however, this may be partly due to the depths to which fisherman are willing to lower their crabpots (Pequegnat et al. 1990). Adult crabs are found living over several substrate types, but they prefer sandy mud bottoms (Karpov 1983, Lawton and Elner 1985). Dungeness crabs are highly mobile and change depths in response to local conditions such as turbulence due to storms.

Adult male and female Dungeness crabs move into shallow sandy areas to mate between March and July; between September and November, egg-brooding females partially bury themselves in the sand in shallow subtidal and intertidal areas until their eggs hatch. The distribution of the planktonic life stages of the crab is discussed in Section 3.3.1.2. Juvenile Dungeness crabs remain at the bottom of estuaries or shallow nearshore areas for 11 to 15 months before moving offshore. Researchers are currently debating whether juvenile crabs need specific areas such as estuaries for nursery grounds for rearing (Toole 1989, Pauley et al. 1989, Pequegnat et al. 1990).

Dungeness crabs occupy successive trophic levels as they develop. Larvae eat zooplankton and are, in turn, preyed upon by fish. Adult Dungeness crabs are opportunistic feeders that eat mollusks, crustaceans, and fish, as well as serving as prey to numerous predators. According to Stevens et al. (1982), crabs eat bivalves during their first year, shrimp (*Crangon* spp.) in their second year, and juvenile fish in their third year. Cannibalism is common among these crabs and probably influences juvenile and adult abundance. Crabs move into shallower water at night and deeper water in the day; this response has been correlated with food availability (Stevens et al. 1984).

The field data obtained by Pequegnat et al. (1990) indicate that Dungeness crabs in the region are more abundant and found at greater depths in March in comparison to August. The greatest abundance of Dungeness crab has been found at and adjacent to the NDS (Lockheed Center 1979, IEC 1981, Winzler and Kelly Consulting Engineers 1984, Pequegnat et al. 1990), with the highest abundances in November at that site (Pequegnat et al. 1990).

Few or no crabs were reported from trawls made at the SF-3 site in April (IEC 1981), May (Winzler and Kelly Consulting Engineers 1984), or July (Winzler and Kelly Consulting Engineers 1984); or in the vicinity of the HOODS in April (IEC 1981) or August (Pequegnat et al. 1990). However, an increased abundance of Dungeness crabs was found at SF-3 in February (Lockheed Center 1979) and at the HOODS in March (Pequegnat et al. 1990). Lockheed Center (1979) found a greater abundance of Dungeness crabs in February in the areas adjacent to SF-3 compared to the trawls performed within the disposal site boundaries.

Caridean shrimp (bay and sand shrimp) found offshore of Humboldt Bay are important food items for demersal fish and crabs. The commercially fished pink ocean shrimp was not found in any of the trawl samples collected by Pequegnat et al. (1990). Pink shrimp are reportedly commercially fished in depths of over 70 m (230 ft) approximately 26.9 nmi north of the study areas at Patrick's Point.

The sea stars *Pisaster brevispinus* and *Luidia foliolata* are important predators of the benthic invertebrate community. They have been reported to prey heavily upon juvenile Dungeness crabs, olive snails, and clams. Sand dollars are found in extensive, densely-packed beds at depths of 0 to 100 m (0 to 330 ft) (Pearse 1975). Sand dollars migrate in response to sea conditions, moving into shallow water when seas are calm and moving offshore during storms. Sand dollars are found in narrow bands along the shore off of

Humboldt Bay throughout the year and are common at 12 m (40 ft) in September (Pequegnat and Mondeel-Jarvis 1990). They have been reported in large numbers at the NDS (Pequegnat et al. 1990).

3.3.3.3 Pelagic Macroinvertebrates

A few squid (*Loligo* sp.) were captured in trawls made by Pequegnat et al. (1990) offshore of Humboldt Bay at depths of 31 to 55 m (102 to 180 ft) in August and March. However, squid have not been reported in previous trawl samples from this vicinity (Lockheed Center 1979, IEC 1981, Winzler and Kelly Consulting Engineers 1984). The distribution of market squid is unclear, and environmental influences are largely unknown (Kaskiwada and Reckseik 1978). Squid egg sacks are occasionally found on crab pots off the Humboldt County coast and are an incidental catch by trawling shrimp fisherman in water 72 to 182 m (240 to 600 ft) deep. However, they apparently do not occur in adequate numbers to support a commercial fishery in this area.

3.3.4 The Fish Community

A total of 562 species of fish have been identified in California's coastal waters. In discussing the ecology of fishes, species are commonly grouped into assemblages based on broad similarities in biology or habitat (Miller and Lee 1972). Nearshore bottomfish, deep-water benthic fish, schooling marine fish, and anadromous fish are examples of major fish assemblages. Nearshore bottomfish and deep-water benthic fish are called demersal because they are associated with the sea floor, whereas schooling and anadromous fish are called pelagic because they live in open water. The following sections discuss the demersal and pelagic fish found within the region, as well as the occurrence of these fish in the vicinity of the alternative disposal sites.

3.3.4.1 Demersal Fish

Demersal fish are characterized as either nearshore species living at depths of 11 to 100 m (36 to 330 ft) or deep-water species occurring in shelf habitats at depths of 100 to 550 m (330 to 1,800 ft). Common demersal fish found near shore in the waters off of Humboldt Bay are English sole, Pacific sanddab, starry flounder, butter sole, sand sole, speckled sanddab, curlfin turbot, pricklebreast poacher, tubenose poacher, warty poacher, plainfin midshipman, staghorn sculpin, and showy snailfish (Table 3-4) (Winzler and Kelly Consulting Engineers 1984, Pequegnat et al. 1990). In addition, lingcod may occur near rocks off the Harbor entrance jetties, and California halibut may occur in nearshore waters outside the Bay (Monroe 1973). Of these species, the commercially important fish are English sole, Pacific sanddab, starry flounder, California halibut, and lingcod. Critical life history stages of these species are summarized in Table 3-5.

Table 3-4. Demersal Fish Known to Occur near Humboldt Bay

Common Name	Scientific Name
Class: Osteichthyes (Bony Fishes)	
Righteye flounders: Pleuronectidae	
English sole	*Parophrys vetulus*
starry flounder	*Platichthys stellus*
butter sole	*Isopsetta isolepsis*
sand sole	*Psettichthys melanostictus*
curlfin turbot	*Pleuronichthys decurrenss*
Dover sole	*Microstomus pacificus*
petrale sole	*Eopsetta jordani*
rex sole	*Glyptocephalus zachirus*
Lefteye flounders: Bothidae	
Pacific sanddab	*Citharichthys sordidus*
California halibut	*Paralichthys californicus*
speckled sanddab	*Citharichthys stigmaeus*
Poachers: Agonidae	
pricklebreast poacher	*Stellerina xyosterna*
tubenose poacher	*Pallasina barbata*
warty poacher	*Occella verrucosa*
Sculpins: Cottidae	
staghorn sculpin	*Leptocottus armatus*
Toadfishes: Batrachoididae	
plainfin midshipman	*Porichthys notatus*
Snailfishes: Cyclopteridae	
showy snailfish	*Liparis pulchellus*
blacktail snailfish	*Careproctus melanurus*
Greenlings: Hexagrammidae	
lingcod	*Ophiodon elongatus*
Rattails: Macrouridae	
roughscale rattail	*Coryphaenoides acrolepis*
black rattail	*C. acrolepis*
giant rattail	*C. pectoralis*

Table 3-4. Continued

Common Name	Scientific Name
Eelpouts: Zoarcidae	
twoline eelpout	*Bothrocara brunneum*
Sablefishes: Anoplopomatidae	
sablefish	*Anoplopoma fimbria*
Scorpionfishes: Scorpaenidae	
widow rockfish	*Sebastes entomelas*
canary rockfish	*S. pinniger*
bocaccio	*S. paucispinis*
darkblotched rockfish	*S. crameri*
chilipepper rockfish	*S. goodei*
Class: Chondrichthyes (Cartilaginous Fishes)	
Ratfishes: Chimaeridae	
ratfish	*Hydrolagus colliei*
Skates: Rajidae	
longnose skate	*Raja stellulata*
Dogfish sharks: Squalidae	
spiny dogfish	*Squalus acanthias*

Sources: Pequegnat et al. 1990, Winzler and Kelly Consulting Engineers 1977, Lockheed Center 1979.

Table 3-5. Summary of Critical Stages of Commercially Important Nearshore Demersal Fish Found near Humboldt Bay

Species	Spawning Habitat/Season	Egg Habitat	Larval Habitat	Juvenile Habitat/ Seasonal Feeding	Adult Seasonal Distribution/Habitat, Range, Feeding
English sole[a,b,c,d,e] *Parophrys vetulus*	spawn in sand and sand/mud bottoms at depths of 60 to 110 m; most abundant from December to February, but occur year-round	pelagic, November to March	pelagic; most larvae within 2 km of shore; December to May	larval juveniles settle to bottom from November to May into open coastal areas, mainly <16 m deep; nursery areas are mainly estuaries but also open coastline, April to October; juveniles emigrate to deeper waters, August to November Diet: amphipods, cumaceans, polychaetes, benthic invertebrates	summer depths of 20 to 70 m, winter depths of 40 to 130 m; offshore sand, sand/mud substrate; Baja, California to Bering Sea Diet: epifaunal, infaunal prey, including polychaetes, bivalves, small crustaceans, brittle stars
Pacific sanddab[b,f] *Citharichthys sordidus*	spawn in 30 to 90 m, sandy bottoms; July to September, with peak activity in August	pelagic	pelagic; inshore to 724 km offshore; July to August peak abundance in October to November	most occur in 66 to 92 m, spring to fall Diet: amphipods, copepods, cumaceans, mysids	commonly occur at depths of 35 to 90 m; deep sand to sand/mud areas; Baja, California to Bering Sea Diet: euphausiids and mysid crustaceans
Starry flounder[d] *Platichthys stellus*	spawn in shallow, coastal and bay areas, December to January	pelagic	pelagic	juveniles settle to bottom, probably in shallow waters	most abundant over soft sand, mainly in shallow water; Santa Barbara, California to Arctic Alaska Diet: crabs, shrimp, worms, clams
Lingcod[a,b,d,g] *Ophiocon elongatus*	spawn in rocky bottoms, from intertidal to 19 m; November to April with peak activity in late December to early February	demersal, rocks in tidepools from lower intertidal to 19 m depth	demersal, January to July; rocks and vegetation in lower intertidal, but older larvae are pelagic, near surface	pelagic, January to July; 1-yr juveniles may recruit to sandy, shallow bottoms, down to 60 m but usually in bays, estuaries	rocky habitat, mainly in waters less than 100 m deep; Baja, California to Shumagin Islands, Alaska
California halibut[a,d,h] *Paralichthys californicus*	spawn at depths of 6 to 20 m over sandy bottoms; February to August, peak in May	pelagic, concentrated in areas with depths of 6 to 20 m	pelagic, usually found between 12 and 45 m isobaths	March to May move to deeper, offshore waters with growth; juveniles recruit to sand and mud bottoms off coastal embayments/ estuaries in June Diet: copepods, mysids, cumaceans, amphipods	adults most common from surf (55 m) zone to 60 m; Baja, California to Quillayute River, Washington Diet: anchovies, croakers, flatfish, squid

Sources:

[a] MCP Applied Environmental Sciences 1987
[b] Toole 1989
[c] Toole et al. 1987
[d] Hart 1973
[e] Lassuy 1989
[f] Rackowski and Rikitch 1989
[g] Shaw and Hussler 1989
[h] Kucas and Hussler 1986

The most abundant demersal fish living in the deeper shelf environments are chimaeras, sharks, skates, flatfishes, and rockfishes (Winzler and Kelly Consulting Engineers 1977). The commercially important fish species in the deeper shelf areas are Dover sole, petrale sole, rex sole, black rattail, widow rockfish, canary rockfish, bocaccio rockfish, darkblotched rockfish, and chilipepper rockfish. Other fish species common to the deeper shelf areas include ratfish, roughscale rattail, giant rattail, blacktail snailfish, twoline eelpout, longnose skate, and spiny dogfish.

Many deepwater flatfishes and rockfishes move between deep and shallow water during their development (Pequegnat et al. 1990). Adult bottomfishes tend to move from deep to shallow water to aggregate and spawn; their eggs and larvae are pelagic and move with the currents. Juveniles settle to the bottom and move into nursery grounds in estuaries or shallow coastal areas. The juvenile stages of deepwater fish, in particular, are sensitive to conditions in nearshore habitats. The juvenile stages of many commercial deep-water bottomfish, including Dover sole, petrale sole, widow rockfish, canary rockfish, bocaccio rockfish, darkblotched rockfish, and chilipepper rockfish, occur in nearshore areas (Toole 1989). Critical life history stages of these species are summarized in Table 3-6.

3.3.4.2 Pelagic Fish

Pelagic fish are found in the epipelagic zone, which roughly encompasses the upper 200 m (660 ft) of the water column. The epipelagic zone extends over the continental shelf where upwelling occurs. The abundant phytoplankton and zooplankton in this area support vast schools of pelagic fish. Pelagic fish offshore of Humboldt Bay include anadromous fish and schooling marine species (Table 3-7).

Adult anadromous fish migrate through Humboldt Bay on their way to freshwater spawning grounds, and juveniles pass through the nearshore environment during their seaward migration. Anadromous fish species in Humboldt Bay include chinook salmon, coho salmon, steelhead trout, and coastal cutthroat trout (Monroe 1973).

Other species known to occur commonly in this open coastal area (the study area) include schooling fish such as blue rockfish, black rockfish, Pacific tomcod, Pacific herring, northern anchovy, night smelt, whitebait smelt, eulachon, shiner surfperch, spotfin surfperch, silver surfperch, walleye surfperch, white seaperch, and bay pipefish (Toole 1989, Pequegnat et al. 1990). Pacific cod, a year-round commercial and sport species, may also be found in this area (Dames and Moore 1981). The brown smoothhound shark also occurs in this area; it is a member of the family Triakididae, a group of schooling shark species (Eschmeyer et al. 1983). Critical life history stages of pelagic fishes found near Humboldt Bay are summarized in Table 3-8.

3.3.4.3 Occurrence of Pelagic and Demersal Fish at the Proposed Disposal Sites

The HOODS. Trawl surveys were conducted by Humboldt State University in August 1989 and March 1990 at depths of 49 and 55 m (160 and 180 ft) just south of the HOODS

Table 3-6. Summary of Critical Stages of Commercially Important Deep-Water Demersal Fish Found near Humboldt Bay

Species	Spawning Habitat/Season	Egg Habitat	Larval Habitat	Juvenile Habitat/ Seasonal Feeding	Adult Seasonal Distribution/Habitat, Range, Feeding
Dover sole[a,b,c,d] *Microstomus pacificus*	spawning aggregations in 80 to 732 m, November to March	pelagic eggs primarily in upper 50 m, from November to March	pelagic, primarily in upper 50 m	mud bottom, on shelf; February, 130 to 183 m depth, may move into shallows (10 to 183 m) in summer Diet: same as adults	mud bottoms, 18 to 915 m; Baja, California to Bering Sea Diet: polychaetes, bivalves, benthic crustaceans, brittle stars
Petrale sole[a,b,e] *Eopsetta jordani*	major spawning aggregations in 274 to 450 m, November to March; move offshore in winter and inshore in summer	pelagic eggs, float with current, sink before reaching nearshore areas	pelagic, in shallow waters	benthic in fall of first year (64 to 82 m depths), May to August found 18 to 90 m Diet: mysids, sculpins, juvenile flatfishes	sandy bottom; 18 to 547 m; Baja, California to Gulf of Alaska Diet: euphausiids, shrimp, pelagic fish, juvenile flatfish
Rex sole[d] *Glyptocephalus zachirus*	spawn at 100 to 300 m	pelagic	pelagic	become benthic in winter, 150 to 200 m, use this depth as nursery	sand or mud bottom; 18 to 614 m depth, but mainly below 61 m; San Diego to Bering Sea
Sablefish[a,b,e] *Anoplopoma fimbria*	deep water, January to February	pelagic	pelagic, upper 1 m, 5.6 to 370 km from shore, March to July	shallow waters; occur at depths of 100 to 200 m, occasionaly 30 m deep Diet: euphausiids, copepods, amphipods, larvaceans	mud/clay bottoms; bottoms at 305 to 1,829 m; Baja, California to Bering Sea Diet: squid, octopus, euphausiids, shrimp
Rockfish spp.	mid-November to mid-March	ovoviviparous	pelagic, found year-round, commonly at depths >100 m		
Widow rockfish[a,b,e] *Sebastes entomelas*	little known; spawning may be confined to restricted areas, January to March	ovoviviparous	pelagic, March	become benthic, small juveniles occur from surface to depths of 20 m; older juveniles at depths of 9 to 37 m, mainly June to August Diet: euphausiids, salps	rocky banks; 34 to 366 m; Baja, California to Kodiak, Alaska Diet: amphipods, euphausiids, shrimp, salps
Canary rockfish[b,e] *Sebastes pinniger*	spawning may be confined to specific areas, mid-winter	ovoviviparous	not in epipelagic, or shallow waters	become benthic, occur at depths less than 22 m; mainly May to August	rocky bottom; 91 to 274 m; Baja, California to Southeastern Alaska
Boccaccio rockfish[a,b,e] *Sebastes paucispinis*	two broods; spawning in mid-November and March	ovoviviparous	occur often far offshore in the upper 100 m, mid-December and April	some benthic juveniles occur in less than 22 m, but not common Diet: perches, jack mackerel, juvenile rockfishes	rocky reefs and open bottom; 27 to 320 m; Baja, California to Gulf of Alaska Diet: Pacific hake, northern anchovy

Table 3-6. Continued

Species	Spawning Habitat/Season	Egg Habitat	Larval Habitat	Juvenile Habitat/ Seasonal Feeding	Adult Seasonal Distribution/Habitat, Range, Feeding
Thornyhead rockfish[b,e] (shortspine and longspine) *Sebastolobus alascanus* and *S. altivelis*	little known	pelagic; eggs float at surface in gelatinous masses, January to May	pelagic	not restricted to shallow, nursery areas	
Darkblotched rockfish[b,e] *Sebastes crameri*	little known; spawning may be confined to restricted areas, February	ovoviviparous	pelagic, March	not restricted to shallow, nursery areas; 0-yr old found at 73 to 130 m	soft bottom, 29 to 549 m; southern California to Bering Sea
Chilipepper rockfish[a,e] *Sebasates goodei*	spawn in mid-November to mid-March	ovoviviparous	pelagic, occur near surface; December to April	age 0 found at surface to 8 m, around rocky reefs during summer; subadults and adults occur at depths of 50 to 350 m Diet: planktonic crustaceans	sand and mud bottom; 61 to 329 m; Baja, California to British Columbia Diet: euphausiids, anchovies, laternfish

References:

[a] MPC Applied Environmental Sciences 1987
[b] Toole 1989
[c] Horton 1989
[d] Miller and Lee 1972
[e] Hart 1973

Table 3-7. Pelagic Fish Known to Occur near Humboldt Bay

Common Name	Scientific Name
Class: Osteichthyes (Bony Fishes)	
Trouts: Salmonidae	
chinook salmon	*Oncorhynchus tshawytscha*
coho salmon	*O. kisutch*
steelhead trout	*O. mykiss*
coastal cutthroat trout	*O. clarki clarki*
Scorpionfishes: Scorpaenidae	
blue rockfish	*Sebasates mystinus*
black rockfish	*S. paucispinis*
Codfishes: Gadidae	
Pacific tomcod	*Microgaddus proximus*
Pacific cod	*Gadus macrocephalus*
Herrings: Culpeidae	
Pacific herring	*Culpea harengus pallasi*
Anchovies: Engraulidae	
northern anchovy	*Engraulis mordax*
Smelts: Osmeridae	
night smelt	*Spirinchus starkis*
whitebait smelt	*Allosmerus elongatus*
eulachon	*Thaleichthys pacificus*
Surfperches: Embiotocidae	
shiner surfperch	*Cymatogaster aggregata*
spotfin surfperch	*Hyperprosopon anale*
silver surfperch	*H. ellipticum*
walleye surfperch	*H. argenteum*
white surfperch	*Phanerodon furcatus*
Pipefishes: Syngnathidae	
bay pipefish	*Syngnathus leptorhynchus*

Table 3-7. Continued

Common Name	Scientific Name
Class: Chondrichthyes (Cartilaginous Fishes)	
Requiem sharks: Carcharhinidae	
brown smoothhound	*Mustelus henlei*

Source: Pequegnat et al. 1990, Winzler and Kelly Consulting Engineers 1977, Lockheed Center 1979.

Table 3-8. Summary of Critical Stages of Commercially Important Pelagic Fish Found near Humboldt Bay

Species	Spawning Habitat/Season	Egg Habitat	Larval Habitat	Juvenile Habitat/ Seasonal Feeding	Adult Seasonal Distribution/Habitat, Range, Feeding
Anadromous Fish					
Chinook salmon[a,b] *Oncorhynchus tshawytscha*	fish return to Humboldt County rivers and must hold in estuaries and nearshore areas until rains provide sufficient flows to move upstream; September to February	freshwater	freshwater	juveniles in nearshore waters, but little information on nearshore distribution in ocean; concentrate near canyon heads; May to October in some locations	ocean; San Diego to Bering Sea
Coho salmon[a,b] *Oncorhynchus kisutch*	fish return to Humboldt County rivers and must hold in estuaries and nearshore areas until rains provide sufficient flows to move upstream; September to February	freshwater	freshwater	juveniles in nearshore waters, in ocean off Oregon, most juveniles found within 4 m of surface; concentrate near canyon heads; March to June	ocean; Baja, California to Arctic Alaska
Steelhead trout[b,c,d] *Oncorhynchus mykiss*					
Summer run	return to Middle Fork Eel River; May to October	freshwater	freshwater	juveniles (1 to 4 yr olds) move through nearshore waters; March to April	ocean; Baja, California to Bering Sea
Winter run	return to Humboldt County rivers; November to April	freshwater	freshwater	juveniles (1 to 4 yr olds) move through nearshore waters; March to April	ocean; Baja, California to Bering Sea
Coastal cutthroat trout *Oncorhynchus clarki clarki*	spend summer in ocean and estuaries; spawn in January and February	freshwater	freshwater	seaward smolt migration peaks in May; fish remain close inshore	ocean; Eel River to southeast Alaska

Table 3-8. Continued

Species	Spawning Habitat/Season	Egg Habitat	Larval Habitat	Juvenile Habitat/ Seasonal Feeding	Adult Seasonal Distribution/Habitat, Range, Feeding
Rockfish					
Blue rockfish[b] *Sebastes mystinus*	spawn in mid-November to mid-April	pelagic	pelagic	become benthic in <25 m; late May to June	schooling rockfish; off bottom near reefs and pinnacles; surface to 550 m; Baja, California to Bering Sea
Black rockfish[e] *Sebastes melanops*	spawning area unknown; maybe offshore; January to April	pelagic	pelagic; April to June	restricted to benthic; 40 to 50 m depth; mainly in June; range is from April to October	primarily found in areas with depths of 54 m or less; mainly found in mid-waters; southern California to Aleutian Islands
Yellowtail rockfish[b] *Sebastes flavidus*	spawn in mid-November to mid-March	not applicable	pelagic	juveniles have been found in bay, nursery areas	mostly pelagic, 24 to 46 m; San Diego to Kodiak Island
Beach and Bay Fish					
Herring[a,f] *Clupea harengus pallasi*	spawn in protected embayments, especially Humboldt Bay; December to March	eggs restricted to embayments, especially Humboldt Bay; December to March	restricted to bays and shallow coastal areas near shore; spring and early summer	not restricted to shallow water nursery areas	when not spawning, typically offshore; Baja, California to Arctic Alaska
Surf, night smelt, whitebait smelt[a,b] *Hypomesus pretiosus, Spirinchus starksi, Allosmerus elongatus*	restricted to spawning in surf zone of sandy beaches; March to August; surf smelt spawns at day; night smelt spawn at night	eggs attached to sand grains in surf zone of sandy beaches; March to August	little known	little known	little known; generally, southern California to British Columbia or Alaska
surfperches[a,b] *Cymatogaster aggregata, Amphistus rhodoterus, Hyperprosopon ellipticum, H. argenteum, Phanerodon furcatus*	spawn in protected embayments and shallow coastal waters; spring and early summer	viviparous	viviparous	restricted to bays and shallow areas, especially Humboldt Bay; summer and fall	shallow surf, sheltered bays; generally, southern California to British Columbia or Alaska

References:

[a] Toole 1989
[b] Hart 1973
[c] Pauley et al. 1986
[d] Pauley et al. 1989
[e] Stein and Hussler 1989
[f] Lassuy 1989

(Pequegnat et al. 1990). In August 1989, the trawl catch in the HOODS was composed primarily of whitebait smelt and, in order of decreasing abundance, Pacific sanddab, rex sole, Dover sole, Pacific tomcod, and juvenile sanddab. More species were found during the March 1990 surveys; in order of decreasing abundance these were night smelt, whitebait smelt, Pacific tomcod, Pacific sanddab, shiner surfperch, black rockfish, English sole, speckled sanddab, Pacific sand sole, showy snailfish, curlfin turbot, eulachon, Pacific herring, juvenile sanddab, and larval smelt. Most of the catch (by weight) was made up of black rockfish, night smelt, English sole, Pacific sanddab, and Pacific tomcod.

These trawl surveys also showed that fish assemblages change with distance offshore. At the HOODS, two fish assemblages are likely to occur: an assemblage at mid-depth waters (40 to 49 m [130 to 160 ft] deep) composed mainly of Pacific sanddab, rex sole, and Dover sole; and another deep-water assemblage (greater than 55 m [180 ft] deep) with a species composition that is not clearly understood (Pequegnat et al. 1990). In comparison, fish communities captured in shallow waters at a depth similar to that of SF-3 (18 to 40 m [59 to 130 ft]) consisted mainly of smelt.

Commercially important bottomfish species occurring within the HOODS are English sole, Pacific sanddab, and probably lingcod and California halibut (Table 3-5 summarizes the life histories of these species). The English sole that use the HOODS are primarily adults and older juveniles. Adults live at depths of 20 to 70 m (66 to 230 ft) in the summer and 40 to 130 m (130 to 426 ft) in the winter; larger juveniles move from nearshore to deeper waters and may be found within the HOODS. Adult Pacific sanddab spawn at depths of 35 to 90 m (115 to 295 ft) between July and September, with most spawning activity in August. Juvenile lingcod could potentially use the HOODS since they are found in sandy bottoms from the intertidal zone to depths of 200 m (656 ft). Also, adult California halibut are found in waters as shallow as 55 m (180 ft), and older juvenile California halibut move from shallow bays to deeper offshore water such as the HOODS.

Of the deep-water bottomfish, Dover sole, petrale sole, and juvenile stages of widow rockfish, canary rockfish, bocaccio rockfish, and chilipepper rockfish are likely to occur in the vicinity of the HOODS (Table 3-6 summarizes the life stages of these bottomfish in relation to the importance of nearshore habitats). Juvenile Dover sole and petrale sole are likely to occur within the HOODS during the summer; adults may also occur in this area during their nonspawning period (April to October). Juvenile rockfish are commonly found in shallow waters (less than 37 m [121 ft] deep) in late spring and summer, but older juveniles gradually move offshore as they grow and may occur within the HOODS.

Many commercially important pelagic fish, including anadromous and schooling marine species, may occur in the HOODS (Table 3-7). Adult anadromous fish may occasionally pass through the HOODS as they migrate toward their natal streams to spawn, and juveniles may pass through in their seaward migration. However, Pacific salmon are not expected to concentrate at the HOODS, and their presence at or near the site would be highly transitory. Of the schooling marine species, juvenile black rockfish, adult yellowtail rockfish, and juvenile and adult stages of whitebait smelt and night smelt may all occur in the vicinity of the HOODS (Pequegnat et al. 1990).

Results from Humboldt State University's trawl surveys showed a general tendency toward decreased fish abundance and total biomass in the deeper, offshore areas (Pequegnat et al. 1990). The number of fish caught at the HOODS in August (32) was lower than the number of fish caught at the SF-3 site (1,150) during the same survey period. There was also a correspondingly lower total biomass (weight) of fish caught at the HOODS (1,102 grams) compared to the shallower SF-3 site (3,503 grams) (Pequegnat et al. 1990). Similar trends were apparent during the surveys conducted in March.

Species diversity, however, did not decrease in all cases toward offshore sites. In August, the number of species appeared reduced at depths of 55 m (180 ft) and deeper, but in March surveys, species diversity seemed similar at most depths.

The SF-3 Site. SF-3 was surveyed by otter trawls on several occasions in the late 1970s and early 1980s (Lockheed Center 1979). The diversity of fish caught at SF-3 was characteristic of the fishes in the surrounding area. In February 1979, the trawl catches were dominated by Pacific tomcod, pricklebreast poacher, and showy snailfish. Trawl catches were composed primarily of night smelt in May 1983 and speckled sanddab in July 1983. These differences in catch were probably a function of season. In another survey, comparison of the SF-3 catches to catches at a nearby control site at similar depths indicated that fish species diversity and fish abundance were lower at SF-3 than at the control site. In February 1979, 55 individuals of 8 species were collected within the SF-3 site. Just outside SF-3, 178 individuals representing 18 different taxa were found. In the 1983 surveys, the assemblage of fish species was not significantly different between SF-3 and a nearby control site (outside the SF-3 disposal area). However, several species were more abundant at the control site, with a greater biomass than at SF-3. In May, Pacific tomcod were much more abundant at the control site than at SF-3; in July, English sole juveniles were the second most abundant species at the control site while only a few were found at SF-3. As with the benthic communities, differences in fish diversity and abundance were probably the result of the deposition of dredged material. (Winzler and Kelly Consulting Engineers 1984.)

Many nearshore bottomfish found at the SF-3 site are important to commercial and recreational fisheries. Pacific sanddab, English sole, starry flounder, lingcod, and California halibut are found year round (Table 3-5). During the summer, adult English sole are found at depths similar to that of the SF-3 site (average depth of 20 m [66 ft]). Juvenile English sole use shallow (16 m [52 ft] and shallower) sandy bottoms from November to May and may use the SF-3 site as a nursery. Several life stages of Pacific sanddab may use the SF-3 site: adults spawn in shallow (35 to 90 m [115 to 295 ft]) waters from July to September. Juvenile Pacific sanddab reside in the nearshore zone, and adults live in sandy to sand/mud shallow habitats. Adult starry flounder live and spawn in shallow, sandy areas, and juveniles probably reside in the nearshore habitat. The juvenile stages of lingcod and California halibut also may occur in the SF-3 site. Year-old lingcod move into sandy bottom habitats from the intertidal zone to 200 m deep, and juvenile California halibut use shallow, sandy bottoms as they gradually move to more offshore waters.

Commercially important deepwater bottomfish may use the SF-3 site as juveniles (Table 3-6). Dover sole, petrale sole, widow rockfish, canary rockfish, and bocaccio rockfish species all occur in waters with depths similar to those at the SF-3 site.

Commercially important anadromous fish, rockfish, and bay and beach fish may be found at the SF-3 site during all seasons. Adult and juvenile stages of anadromous fish species (chinook salmon, coho salmon, winter-run and summer-run steelhead trout, and coastal cutthroat trout) are found within the SF-3 site year round. Juvenile blue rockfish move to benthic habitats in waters less than 25 m (82 ft) deep from late May to June. Surfperches are also restricted to shallow coastal waters during spawning in spring and early summer. Juvenile surfperch use shallow waters in summer and fall. Night and surf smelt (adults and juveniles) are also common to this area.

Fish populations appeared to be higher at the SF-3 site than at other alternative disposal sites (Pequegnat et al. 1990). Trawl surveys conducted by Humboldt State University showed that fish abundance and biomass were generally higher in nearshore areas; in August samplings, abundance and biomass seemed to be higher in an area near the SF-3 disposal site than at the HOODS or the NDS.

The NDS. Otter trawl surveys were conducted at the NDS in August and November 1989 and March 1990 (Pequegnat et al. 1990). The most common fishes collected were night smelt, larval smelt, and whitebait smelt (93.9% total). Other species collected, in order of declining abundance, were Pacific sanddab, butter sole, Pacific tomcod, spotfin and shiner perch, Pacific sand sole, bay pipefish, larval flatfish, English sole, pricklebreast poacher, juvenile poacher, speckled sanddab, plainfin midshipman, and brown smoothhound. Surveys showed that species diversity and biomass increased by more than 60% between summer and late fall. The highest number of species and greatest biomass occurred in November, and the lowest occurred in August. Also notable was the presence of larval flatfish in the November trawl catch, suggesting that flatfishes use the nearshore zone as a nursery. The fish biomass at the NDS was low as compared to a nearby control site (Pequegnat and Mondeel-Jarvis 1990). An average of 740 grams per trawl was collected at this site, compared to catches in nearby control waters (adjacent to the Samoa Peninsula) of 6,100 grams per trawl and 1,500 grams per trawl in September 1988 and September 1989, respectively.

Since the NDS is similar in depth to SF-3, and because fish assemblages have been shown to vary with depth, the commercially and recreationally valuable fish using this site are probably very similar to those at the SF-3 site. Nearshore bottomfish include English sole, Pacific sanddab, starry flounder, lingcod, and California halibut. Adult English sole may reside within the NDS, and it is likely that juvenile English sole use the site since they are found in sandy, shallow bottoms in less than 16 m (52 ft) of water from November to May. Juvenile and adult stages of Pacific sanddab and starry flounder species prefer sandy, shallow areas nearshore and are also likely to use the NDS. Juveniles of both lingcod and California halibut occur in shallow bottoms and may occur at the NDS. Commercially important demersal fish living in deeper waters that may use this nearshore habitat include Dover sole, petrale sole, widow rockfish, canary rockfish, and bocaccio rockfish (Table 3-6).

Juveniles of all of these species settle to the bottom in shallow nearshore waters during late spring and summer.

Pelagic species of commercial importance occurring in the NDS are anadromous species (chinook salmon, coho salmon, winter-run and summer-run steelhead trout, coastal cutthroat trout), blue rockfish, night and surf smelt, and surfperches. Anadromous fish may pass through the NDS throughout the year as adults and juveniles. Juvenile blue rockfish occur in shallow waters less than 25 m (82 ft) deep in late May and June. Smelt spawn in sandy areas near the surf zone; surveys off the Samoa Peninsula found adult smelt in nearshore waters (ERC 1976). Adult surfperches also are restricted to shallow surf areas and spawn in coastal waters; juveniles are found in shallow waters as well.

In August 1989, Humboldt State University's trawl surveys showed that fish abundance and biomass may be lower at the NDS than at the HOODS. However, in March 1990, fish abundance was higher at the NDS, with fish biomass similar to that of the HOODS.

3.3.5 Coastal and Sea Birds

The Humboldt Bay area provides habitat for a large number of migrant and resident bird species. The Bay and coastal area serve as both a stopover point in migration and as an over-wintering area for migratory shorebirds and waterfowl. Shorebirds and wading birds such as turnstones, plovers, and sandpipers are found only near shore and can occur along the shoreline within and outside of Humboldt Bay (see Table 3-9 for scientific names). Coastal species of seabirds and waterfowl such as alcids, loons, cormorants, California brown pelican, gulls, terns, and scoters and other sea ducks also occur throughout the Bay and nearshore waters of the area. Humboldt Bay is an important California breeding site for double-crested cormorants. Small numbers of western gulls breed within the Bay, and snowy plovers nest on the south spit of the Bay. The coastline of the region, including northern Humboldt and Del Norte Counties, provides critical habitat for 41% (13 species) of the state's breeding seabirds (Table 3-9) (Sowles et al. 1980).

The offshore waters of the Humboldt continental shelf provide habitat for seabirds that feed on fish and marine invertebrates at the surface or in the water column. The species likely to use the area for feeding and resting will be those regularly found in continental shelf waters. Common species include those listed above as well as phalaropes, shearwaters, and jaegers (ECI 1988).

Species of concern occurring in the region include the California brown pelican, the short-tailed albatross, the marbled murrelet, and the Aleutian Canada goose (discussed in Section 3.3.7).

Table 3-9. Breeding Seabirds Found in Humboldt and Del Norte Counties

Common Name	Scientific Name
Fork-tailed storm petrel	*Oceanodroma furcata*
Leach's storm petrel	*O. leucorhoa*
Double-crested cormorant	*Phalacrocorax auritus*
Brandt's comorant	*P. penicillatus*
Pelagic comorant	*P. pelagicus*
Black oystercatcher	*Haematopus bachmani*
Western gull	*Larus occidentalis*
Common murre	*Uria aalge*
Pigeon guillemot	*Cepphus columba*
Marbled murrelet	*Brachyramphus marmoratus*
Cassin's auklet	*Ptychoramphus aleuticus*
Rhinoceros auklet	*Cerorhinca monocerata*
Tufted piffin	*Fratercula cirrhata*
Snowy plover	*Charadrins alexandrinus*

Source: Sowles et al. 1980.

3.3.6 Marine Mammals

3.3.6.1 Pinnipeds

Five species of pinnipeds (seals) occur in the Humboldt area. The northern (Steller) sea lion (see Section 3.3.7) and harbor seal breed in the area, and the California sea lion, northern elephant seal, and northern fur seal use the area for feeding and during migration (ECI 1988).

Humboldt Bay is one of California's most important pupping grounds for harbor seals. Peak numbers (on land) occur in May during the spring breeding season and in June when adults are on land to molt (ECI 1988). Harbor seals are usually found within 10.8 nmi from shore in waters less than 200 m (656 ft) deep (Bonnell et al. 1983).

The California sea lion is the most frequently sighted pinniped in the area. Sea lions migrate to and from breeding grounds in southern California and the Baja Peninsula. Major haul-out sites in the Humboldt region are to the north of Humboldt Bay at St. George Reef and Castle Rock (ECI 1988). The number of sea lions in the area peaks in September and October during the northward migration and again in May during their southward migration (ECI 1988).

Northern elephant seals occur regularly off Humboldt County in spring and summer after the winter breeding season (December-March) as pelagic, widely dispersed, solitary feeders. Northern fur seals occur seasonally in the region from December to June, mostly offshore along the continental shelf and shelf break. (ECI 1988.)

3.3.6.2 Cetaceans

At least 20 species of cetaceans (whales and dolphins) have been recorded in waters off of Humboldt Bay, and about half of these can be considered relatively common. The most common continental shelf species in the area are the harbor porpoise and the gray whale. Harbor porpoises are present throughout the year but are seen more frequently during fall, usually within 0.5 nmi of shore (ECI 1988) in waters 30 to 80 m (98 to 262 ft) deep.

The gray whale is the most common cetacean in the nearshore coastal waters and has recently been removed from the federal list of threatened or endangered species. Gray whales migrate south in December and January and north from March through May, usually passing within 0.8 to 4.3 nmi of the shore (ECI 1988). Gray whales pass closest to shore during spring migration when cows with calves stay close to the shoreline. Gray whales may feed during migration, particularly during the northward migration when females are with young. Their diet consists of soft-bottom benthic invertebrates found at depths of 9 to 40 m (30 to 131 ft) as well as dense swarms of shrimp and spawning squid (Jones et al. 1984). Dohl et al. (1983) noted that gray whales avoid very turbid water and change direction when approaching large river plumes such as the ones off the Klamath and Eel Rivers and San Francisco Bay during periods of heavy runoff.

Humpback whales are found in nearshore waters during their annual migrations between the southern winter breeding grounds and the feeding areas in Alaska. Minke whales also occur in nearshore waters. Other less common large migrant cetaceans in the area include the blue whale, finback whale, and sperm whale. These species generally occur in deeper waters, offshore from the HOODS.

Other common smaller cetaceans in waters off of Humboldt Bay are the Pacific white-sided dolphin, northern right-whale, Dall's porpoise, and Risso's dolphin. These species also occur primarily in deeper waters offshore from the HOODS. All but the northern right-whale also occur in smaller numbers in shelf waters (ECI 1988).

3.3.7 Threatened and Endangered Species

Four birds, four cetaceans, a pinniped, a marine turtle, and a fish that are federally and/or state listed as threatened or endangered may occur in the region: the California brown pelican, the marbled murrelet, the short-tailed albatross, and the Aleutian Canada goose; the humpback, blue, finback, and sperm whales; the northern (Steller) sea lion; the leatherback turtle; and the winter-run chinook salmon (Table 3-10).

The brown pelican is found in estuarine, coastal, and oceanic waters along the California coast. In northern California, pelicans are common from June through November and rare to uncommon from December to May (ECI 1988). In other areas of California, they breed from March to July on the Channel Islands at Anacapa Island and near Santa Barbara Island. Breeding also occurs on islands off the Pacific Baja California coast of Mexico and in the Gulf of California (Sowles et al. 1980). Pelicans feed during daylight hours, mostly on small schooling fish. They are plunge divers and prefer clear waters for easy prey detection. Because their feathers are wettable, pelicans usually forage within 8 nmi of shore and return to specific coastal roosts for the evening, usually arriving by late afternoon (Schrieber and Clapp 1987). Within the area of study, pelicans use the south spit of Humboldt Bay for roosting.

Marbled murrelet populations have been reduced, in part, due to the loss of old-growth forests where these birds nest. In California, the marbled murrelet is found from the Oregon border south to Santa Cruz. During the summer breeding season, murrelets concentrate nearshore closer to their nests. Marbled murrelets feed on fish they catch by surface diving within 1 nmi of shore in depths of 30 m (98 ft) (Ehrlich et al. 1988).

The short-tailed albatross was once abundant in the northwest Pacific and off northern California but was thought to be extinct by the late 1940s. By 1954, a few birds had returned to nest on Torishima, an island south of Japan. The present worldwide population is estimated at 250. North American sightings in recent years have been mainly

Table 3-10. Federally Listed Threatened or Endangered Marine Species Occurring in the Project Region

Common Name	Scientific Name	Status
Cetaceans		
Blue whale	*Balenoptera musculus*	Endangered
Fin whale	*B. physalus*	Endangered
Humpback whale	*Megaptera novengliae*	Endangered
Sperm whale	*Physter catodon*	Endangered
Pinnipeds		
Northern (Steller) sea lion	*Eumetopias jubatus*	Endangered
Sea Turtles		
Leatherback sea turtle	*Dermochelys coriacea*	Endangered
Sea Birds		
California brown pelican	*Pelicanus occidentalis*	Endangered
Short-tailed albatross	*Diomedea albatrus*	Endangered
Marbled murrelet	*Brachyramphus marmoratus*	Endangered
Aleutian Canada goose	*Branta canadensis leucopareia*	Endangered
Fish		
Winter-run chinook salmon	*Onchorhynchus tshawytscha*	Endangered

from Alaska, although two have been recorded in California. Prior to their population decline, short-tailed albatrosses flew in large flocks offshore (Harrison 1983, Stallcup 1990). Their diet consists of fish, shrimp, and squid.

The Aleutian Canada goose is a subspecies of the Canada goose and prefers lacustrine, fresh emergent wetlands, moist grasslands, croplands, pastures, and meadow habitats. It feeds on green shoots, seeds, wild grasses, forbs, and aquatic plants. In northeastern California, it nests mainly from March to June and prefers to nest near water on a dry, slightly elevated site, with good visibility from the nest. It will also use man-made structures such as platforms, baskets, and artificial rock islands. Approximately 12,000 geese were counted in a 1993 USFWS survey in Crescent City (Shoulak and Kay 1994). Historically, Humboldt County has been used as an important staging area during spring and fall migration; however, since their population levels are low, use of the project area by the Aleutian Canada goose is unpredictable (USFWS 1994).

The humpback whale has a worldwide range. The summer feeding grounds range from the coasts of Japan and southern California north to the Chukchi Sea. Humpback whales typically can be found off the California coastline from approximately March through January, with the greatest concentrations occurring from mid-August through October (Dohl et al. 1983). According to recent National Marine Fisheries Service (NMFS) surveys conducted in 1991 and 1993, approximately 600 humpbacks were counted off the California coast (Shoulak and Kay 1994).

Summer feeding occurs from the Aleutian Islands to the Farallon Islands off central California. Humpback whales feed on baitfish, euphausiids, pelagic crabs, and a variety of other prey in the summer and early fall.

Blue whales are pelagic and may occur offshore from Humboldt Bay in summer and early fall. Blue whales are usually found in continental slope and deeper waters. Because their primary food is euphausiids, they almost always occur within 200 nmi of the continental shelf. Off northern and central California, Dohl et al. (1983) noted blue whales in waters from 80 to 3,600 m (262 to 11,800 ft) deep, and recent NMFS surveys have counted approximately 2,200 blue whales off the California coast (Shoulak and Kay 1994).

The finback whale ranges in the Pacific from the Bering Sea to Cabo San Lucas, Baja California. They are most abundant off northern and central California during summer and autumn; approximately 985 were recorded in recent NMFS surveys. The finback whale feeds on small fish, pelagic crustaceans, and squid.

The sperm whale occurs in deep oceanic waters and is rarely reported over the shelf. Sperm whales range in the Pacific from the Bering Sea to the equator. They are deep divers and prey mostly upon large squid, skate, and bottomfish.

The northern (Steller) sea lion was recently listed as threatened because of a worldwide decline in populations. The cause for their decline in California is unclear; several factors may be acting synergistically, including infertility due to pollutants and disease, interspecific competition with California sea lions, and a depleted food source.

Northern sea lion populations have been declining throughout their range over the past two decades. Recent counts in Alaska indicate that northern sea lion populations have declined by 70% since 1979 (Sease et al. 1993). Waters off Humboldt Bay are not identified as critical habitat for this species.

The endangered leatherback turtle is the only marine turtle that commonly occurs in the offshore waters of northern California; however, it is unlikely to occur in nearshore waters in this region due to its pelagic habits (Dames and Moore 1981).

Winter-run chinook salmon, an anadromous species, reside as adults off the Pacific coast, including areas off Humboldt Bay (USFWS 1994). Adult chinook salmon tend to be opportunistic feeders, their diet consisting primarily of krill, larval crabs, and fish. Waters off Humboldt Bay have not been identified as critical habitat for this species.

The NMFS is reviewing petitions to list coastwide populations of coho salmon and steelhead trout. The NMFS is expecting to publish their determination for listing (warranted, not warranted, or warranted but precluded from listing actions for other higher priority species) soon (previous deadlines have expired). Like chinook salmon, coho salmon and steelhead trout may reside as adults off the Pacific coast, including areas off Humboldt County. However, these species are not expected to concentrate at or near the HOODS, and their presence at the HOODS would be highly transitory.

3.3.8 Potential for Development of Nuisance Species

Dredged material that is high in organic content or contaminants may promote conditions favorable to the growth of nuisance species. Opportunistic or pollution-tolerant species can dominate disturbed or contaminated substrates and prevent recolonization by the surrounding benthic fauna (SAIC 1986). Examples of nuisance species previously reported in organically enriched contaminated sediments include the polychaetes *Capitella capitata* and *Streblospio benedicti* (Pearson and Rosenberg 1978).

Opportunistic and generalist species commonly occur in the benthic fauna offshore of Humboldt Bay, especially in the nearshore zone. These species respond to the availability of uncolonized substrate and not to the presence of organically enriched or contaminated sediments. Winzler and Kelly Consulting Engineers (1984) observed the changes in benthic fauna following the disposal of dredged material offshore of Humboldt Bay and found that opportunistic fauna were composed of small, surface-dwelling crustaceans, gastropods, and polychaetes.

Pequegnat et al. (1990) reported the polychaete *Ophelia assimilis* in the sediments at the NDS following disposal of dredged material. This organism has been reported in high densities in the channels in Humboldt Bay and is a generalist with regard to substrate. Pequegnat et al. (1990) did not find *O. assimilis* at sufficient densities to consider it a nuisance species.

Since the sediment dredged from Humboldt Bay has a high sand content and is low in organics and contaminants, disposal of the material at any of the alternative sites should not promote the development of nuisance species over the long term. Previous examinations of the benthic fauna present at the SF-3 site and at the NDS support this prediction (Winzler and Kelly Consulting Engineers 1984, Pequegnat et al. 1990).

3.4 SOCIOECONOMIC ENVIRONMENT

3.4.1 Commercial Fishing

Humboldt County has a long history of commercial fishing and ranks as one of the most productive areas on the west coast. A variety of fish and shellfish are caught year round in waters adjacent to the County. About 500 vessels fish primarily out of Eureka, Field's Landing, Trinidad, King Salmon, and Shelter Cove, and land seafood with a dockside value of $10 to 20 million annually (Corps/HBHRCD 1995). Seafood processors in Eureka and Field's Landing fillet, pack seafood, and ship Humboldt County products throughout the United States and overseas.

There are 45 marine species that contribute to the commercial fishing effort. Oyster culture is the largest commercial fishing activity within Humboldt Bay itself and is limited to the North Bay, where a small amount of sea perch and clam are also taken. In other areas, the primary fishes caught commercially are groundfish (flatfish and rockfish), albacore tuna, Dungeness crab, and salmon. Flatfishes averaged 31% to 42% of the total annual landings for Humboldt Bay region from 1981 to 1985 (Barnhart et al. 1989), with Dover sole and English sole being the most important of these. Rockfish are caught by commercial fishermen outside the Bay and comprised 25% to 31% of the commercial landings from 1981 to 1985. Salmon is the most valuable finfish on a per pound basis, but landings in recent years have been greatly reduced due to declines in salmon runs and a restricted commercial season.

During the 1981 to 1985 period, commercial fishermen annually landed an average of nearly 1.6 million pounds of Dungeness crab, worth over $1.4 million, at Eureka (Corps/HBHRCD 1995). The Bay supports a minor commercial fishery for sevengill and leopard sharks, which are caught by hook and line and drift gill nets. There is a commercial gill net fishery each winter in Arcata Bay for adult herring, primarily to obtain herring roe, which is exported to Japan, and there is a live anchovy bait fishery by albacore fishermen in the fall. A minor commercial fishery for surfperch exists, primarily for redtail, which are captured by beach seine and hook and line.

3.4.2 Commercial Shipping

Humboldt Bay is the only harbor between San Francisco, California, and Coos Bay, Oregon, with channels deep enough to permit passage of large, commercial ocean-going vessels. In 1988, 120 deep-draft vessel trips accounted for 1,145,922 tons of commerce, consisting of woodchips, pulp, logs, lumber, petroleum, and particle and fiber board. Historically, annual deep-draft tonnage accounts for approximately 70% of the total annual tonnage passing through the Harbor, with all but petroleum representing exports (Corps/HBHRCD 1995).

3.4.3 Recreational Activities

Humboldt Bay provides a multitude of outdoor recreational opportunities associated with its biological resources. The unique combination of redwood forests, rocky headlands, sandy beaches, and estuaries makes the Humboldt County coastline particularly attractive. The number of visitors to the area is increasing, and their importance to the local economy is high. Cold air and water temperatures limit the use of the area for swimming, waterskiing, and other such water contact sports. The greatest use is, therefore, closely tied to fish, wildlife, and aesthetic values. Use of these resources can be divided into two types: appropriative and nonappropriative uses. Appropriative uses involve the actual removal of individual units such as fish or game. Nonappropriative uses involve the same resources but without any removal -- activities such as nature study, photography, or wildlife observations. Both of these are important and each has its place in the overall recreational picture.

3.4.4 Hunting

The most significant appropriative use in the immediate area of the Bay is waterfowl hunting, which is estimated to supply over 25,000 hunter-days of recreation annually (Monroe 1973). Most hunting is done from temporary or permanent blinds along the shorelines of the Bay, marshes, sloughs, and agricultural lands. Another popular waterfowl hunting style here, which is rarely seen in other parts of the state, is known as sculling. This is accomplished by approaching rafted birds on open water in a uniquely designed low-profile boat. These vessels are highly efficient when in the hands of a skilled operator.

The regular waterfowl season usually opens in October and extends into January. The black brant season opens in November and ends in late February. Humboldt Bay is the most important brant hunting area in California, contributing up to 75% of the total state kill. Wilson's snipe is a bird found in salt marshes, freshwater marshes, and wet pasturelands adjacent to the Bay, and these are also hunted on a limited scale over a season that coincides with the waterfowl season. There are many private hunting clubs in operation, and many private landowners permit hunting on their farmlands. Upland game hunting species include pheasant, quail, dove, bandtailed pigeon, grouse, squirrel, and rabbit. Deer hunting is the major appropriative use of big game. (Corps/HBHRCD 1995.)

3.4.5 Sportfishing

Humboldt Bay is one of the primary sportfishing areas in California. Anglers fishing in the Bay catch at least 41 species of fish as well as collecting oysters, 10 species of clams, and 3 species of crabs. Animals such as shore crabs and ghost shrimp are collected by fishermen for bait, thereby indirectly contributing to sport fishing activities. Seven of California's 12 shellfish reserves are within Humboldt Bay. These areas are state lands that have been set aside for clam digging and native oyster taking by the public, as authorized by the State Fish and Game Code.

Sport clam diggers operate mostly in the South Bay due to the easier access to and greater abundance of the more desirable clams. The most popular areas are the northern end of Clam Island and Buhne Point. The clamming that takes place in Arcata Bay is focused on Indian Island, Bird Island, San Island, and along the Mad River Channel. Of the 25 species of clam found, only 10 are harvested to any extent. These include two species of gaper clams, two species of Washington clams, the littleneck clam, basket cockle, softshell clam, bentnose clam, geoduck, and rough piddock. Mussels and native oysters are also taken in Arcata Bay, the greatest abundance of these being north of Woodley Island and within the Arcata Channel. Sport crabbers usually operate in the winter months and catch market, red, and rock crabs.

The fishing effort can be separated into shore, pier, skiff, and skindiving categories. Shore fishing is the most popular type of sport fishing effort and takes the form of surf-casting, surf-netting, and rocky shore fishing. Shore anglers operate predominantly on the South Jetty and Buhne Point Jetty and catch the widest variety of species, approximately 27 different kinds. These include surfperches, night and surf smelt, blennies, greenlings, rockfish, flatfish, and salmon. Salmonids are caught during the summer at the entrance, particularly from the jetties or in a boat between the jetties, but most are caught in the nearshore waters outside the Bay.

Some 10,000 to 15,000 anglers operate from 500 boats out of Humboldt Bay annually. The Pacific Fishery Management Council reported that for the years from 1971 to 1975, recreational salmon anglers fished an average of 40,000 angler days out of the Bay and averaged about 10,000 chinook salmon. Salmon anglers took 26,000 chinook in 1985 from ports on the Bay. Several licensed party boats operate from Humboldt Bay, predominantly from June through September. Salmon and crabs have been the target species.

Pier anglers catch the most sport-caught fish in terms of tonnage. Given the general area in which these structures are located, this type of fishing is limited to surf-frequenting species, bottom-dwellers, and surface-feeders. Smelt dipping is popular and makes up a large portion of the angling catch taken from piers. Greenling and lingcod are usually taken from the jetties and other rocky areas but also occur in waters of mud flats and channels. Rockfish as well as surfperch are commonly caught by anglers fishing from the jetties.

Humboldt Bay supports a very active marine skiff fishing center and is the most important area in Northern California for this effort. Most skiff fishing occurs during the summer and fall, and the fishery is showing a growing trend. Harvest by skindivers is increasing in popularity, and target species include lingcod, seaperch, rockfish, kelp greenling, and cabezon. Divers are also in search of abalone, sea urchins, shells, coral, and clams.

3.4.6 Nature Study

Nonappropriative uses of the Bay constitute by far the heaviest recreational use. These include nature study, wildlife observation, and photography, and are enjoyed by residents and visitors in excess of 135,000 user days annually. The Humboldt Bay National Wildlife Refuge is a location for many of these uses, and the number of people engaging in these activities is increasing. The Audubon Society and the Sierra Club are among the environmental organizations with local chapters in the Humboldt area.

3.4.7 Scientific and Educational Use

Humboldt Bay, with its wealth of natural resources and physical features, is highly attractive for educational and scientific purposes. It offers almost unlimited possibilities for the study of natural history, ecology, and marine sciences. The College of the Redwoods and Humboldt State University are located close to the Bay, and these institutions provide research results on the many facets of the Bay environment. High school and grammar school classes also use the Bay and its resources for field trips and classroom work, both of which have become a regular part of many school conservation programs. Scientific use of the Bay is also made by many governmental agencies, independent foundations, and private industry, as is evidenced by the hundreds of publications on record concerning the Bay and its resources. These uses are expected to increase.

3.4.8 Cultural Resources

The ocean waters in the vicinity of Humboldt Bay have been the site of numerous vessel accidents and sinkings. Coordination with the California Office of Historic Preservation and the State Lands Commission has indicated that several ships have been reported as sinking in the vicinity of the HOODS. No shipwrecks are recorded as situated within the disposal site.

To assist in identifying the possible presence of marine archaeological properties at the HOODS, an archaeological survey (magnetometer and side-scan sonar) was completed in 1990, under contract to the Corps. A report entitled Historic Shipwreck Survey of the Humboldt Bay Dredged Material Disposal Site (Land and Sea Surveys/BioSystems - copy available from the Corps) was issued in 1991. This project was coordinated with the State Historic Preservation Officer and the National Park Service, including submittal of review copies of the report. Numerous magnetic and sonar anomalies were identified within the HOODS. Three of the identified seafloor features were interpreted as potential shipwreck locations. No further investigation of the suspected wrecks was conducted, but such study was recommended should disposal possibly affect these locations. Subsequent to the marine survey, these potential locations were avoided during disposal of dredged materials from maintenance dredging projects.

3.4.9 Public Health and Welfare

Ensuring that public health and welfare are not adversely affected by ocean disposal of dredged materials is a primary concern. Here only two issues, health and safety, are discussed.

Health hazards may arise if the chemical nature of the dredged materials has the potential to cause bioaccumulation of toxic substances in organisms. Potential impacts on human health can be inferred from bioassay and bioaccumulation tests performed on marine mammals. Since marine waters, including those at the HOODS and at other alternative sites, provide a large amount of fish and invertebrates for human consumption, the public health issue gains added importance. Green Book testing requirements for proposed dredged materials are intended to minimize these risks.

The disposal of dredged material could present safety hazards to navigation either as a result of mounding within the disposal site or as a result of the disposal barges interfering with shipping traffic. Mounding effects on wave height which would affect navigation would only occur if sediments accumulating at the disposal site were shallow enough to interact with waves. This has occurred at the NDS and the SF-3 site. Potential mounding effects on waves at the HOODS site are discussed under Section 4.2.1.2.

Section 4

Environmental Consequences

Section 4. Environmental Consequences

4.1 INTRODUCTION

The purpose of this section is to provide a detailed discussion of the potential impacts of the proposed and alternative actions on the physical, biological, and socioeconomic environment. This FEIS has been prepared in accordance with the National Environmental Policy Act (NEPA) guidelines. Potential impacts identified in this section are classified according to the following scheme (modeled after EPA 1988):

- **Significant adverse impacts that cannot be mitigated to insignificance.** No measures can be taken to avoid or reduce the adverse impacts to insignificant or negligible levels.

- **Significant adverse impacts that can be mitigated to insignificance.** These impacts potentially are similar in magnitude to nonmitigatable impacts, but the severity can be reduced or avoided by implementation of specific mitigation measures.

- **Adverse but insignificant impacts or no effects anticipated.** No mitigation measures are necessary to reduce the magnitude or severity of these impacts.

- **Beneficial effects.** These effects could improve conditions relative to existing or preproject conditions. These can be classified further as significant or insignificant beneficial effects.

The definition of "significant" under the NEPA guidelines (40 CFR 1508.27) requires the consideration of both the context and intensity of the impact. The context of an impact refers to analyzing the impact in relation to society (human, national), the affected region (localized or regional), the affected interests, and the locality. Both short-term and long-term effects are relevant.

Intensity of an impact refers to the severity of the impact. The following factors need to be considered in the evaluation of the intensity of an impact:

- Impacts may be either beneficial or adverse. A significant effect may exist even if the federal agency believes that on balance the effect will be beneficial.

- The degree to which the proposed action affects public health or safety.

- Unique characteristics of the geographical area such as proximity to historic or cultural resources, park lands, prime farmlands, wetlands, wild and scenic rivers, or ecologically critical areas.

- The degree to which the effects on the quality of the human or ecological environment are likely to be highly controversial.

- The degree to which the possible effects on the human or ecological environment are highly uncertain or involve unique or unknown risks.

- The degree to which the action may establish a precedent for future actions with significant effects or represents a decision in principle about a future consideration.

- Whether the action is related to other actions with individually insignificant but cumulatively significant impacts. Significance exists if it is reasonable to anticipate a cumulatively significant impact on the environment. Significance cannot be avoided by terming an action temporary or by breaking it down into small component parts.

- The degree to which the action may adversely affect districts, sites, highways, structures, or objects listed in or eligible for listing in the National Register of Historic Places or may cause loss or destruction of significant scientific, cultural, or historical resources.

- The degree to which the action may adversely affect an endangered or threatened species or its habitat that has been determined to be critical under the Endangered Species Act of 1973.

- Whether the action threatens a violation of federal, state, or local law or requirements imposed for the protection of the environment.

Based on these broad definitions, significance criteria were developed and applied to the environmental impact assessment for each of the resource areas evaluated in this FEIS. Specific significance criteria for physical, biological, and socioeconomic resources are presented at the beginning of each section.

The following sections identify potential impacts associated with the designation of the HOODS or the alternative sites. Additional mitigation sections are included where significant impacts are identified.

4.2 THE HOODS - THE PREFERRED ALTERNATIVE

4.2.1 Physical Environment

4.2.1.1 Air Quality

Project Significance Criteria. Significance criteria for air quality impacts are based on federal, state, and local air pollution standards and regulations. An impact was considered significant if project emissions are projected to:

- increase ambient pollutant levels from below to above federal or state air quality standards; or
- substantially contribute to an existing or projected air quality standard violation.

Project Impacts. No significant impacts to regional air quality are expected as a result of the proposed designation of the HOODS as the regional ODMDS (Corps/HBHRCD 1995). Although combined regional emissions sometimes result in exceedance of regional air quality criteria (PM_{10}), exhaust emissions from annual maintenance dredging and disposal operations are not expected to increase from present levels. Emissions associated with the transport and disposal of dredged materials at the HOODS are not expected to adversely impact any sensitive receptors.

Potential air quality impacts associated with the proposed Harbor and Bay Deepening Project are discussed in the EIR/EIS for that project, and will not be discussed in detail in this FEIS. Briefly, as a worst case, the deepening project is expected to result in exceedance of NCUAQMD criteria for NO_x and PM_{10}. However, disposal of dredged materials at the HOODS would not cause emissions significantly different than those generated by disposal at any of the alternative sites.

Mitigation. The Corps will operate equipment in a manner which minimizes emissions, including avoidance of unnecessarily idling construction equipment. Additional mitigation measures that would reduce potential air quality problems include obtaining and complying with all required AQMD and NCUAQMD permits and applicable rules and regulations.

4.2.1.2 Physical Oceanography

Project Significance Criteria. Impacts of the proposed and alternative actions on physical oceanography were considered significant if the project would:

- produce any measurable effect on regional or site-specific physical oceanographic conditions (i.e., waves or currents); or

- substantially change the character of sediments at the disposal site.

Project Impacts. Disposal of dredged material at the HOODS is expected to result in accumulation of dredged material over the seafloor, changes in the bathymetry, and slight changes in sediment characteristics within the site. Over the 50-year life of the site (a site capacity of 50,000,000 yd^3), accumulations of material and changes in bathymetry could be substantial. Assuming the dredged material is distributed evenly across the site and there is no transport of material outside of the site, the depth of the site would be reduced by 11 m (36 ft) over the 50-year life of the site.

Numerical modeling of sediment dispersion indicated that, due to the relatively weak bottom currents, the HOODS is a non-dispersive site (see Scheffner 1990 in Appendix C). Accumulations at other non-dispersive sites (site SF-3 and the NDS) inshore of the HOODS have resulted in the creation of adverse sea surface conditions by waves shoaling on the accumulated mounds of dredged material. The HOODS site is located in much deeper water (49 to 55 m [160 to 180 ft]) than the SF-3 site and the NDS (less than 18 m [60 ft]). Therefore, the potential for adverse sea surface conditions or wave refraction caused by mounding of sediments at the HOODS is much lower than at the shallower sites.

Disposal of dredged material which is dissimilar in character to bottom sediments can potentially adversely affect the recolonization of the site by benthic fauna. The HOODS is located between the 49 and 55 m (160 to 180 ft) depth contours, which is generally described as the mud-sand transition zone. General physical impacts to the character of the seafloor within the site can be minimized by disposing of sandy materials at sandy areas within the HOODS, and disposing of finer materials at locations within the HOODS with siltier bottom conditions.

Mitigation. Although significant impacts to sediment characteristics are not anticipated under the proposed action, accumulations of dredged material in the site are unavoidable. To minimize the significance of disposal impacts on the site, several mitigation measures have been included in the site management and monitoring plan (Appendix B), including:

- Periodic surveys of the site and surrounding area will be conducted to determine changes in bathymetry.

- Accurate positioning of the hopper dredge will used to ensure that dredged material is deposited over seafloor areas within the site with similar sediment character.

- A Dredge Data Logging System (DDLS) will be used as a monitoring and surveillance tool on contract hopper dredges. Disposal logs will be maintained and spot inspection will be performed during disposal operations.

- Hopper dredges will not be overloaded to minimize the potential for accidental spillage of materials outside the HOODS.

4.2.1.3 Water Quality

Project Significance Criteria. Significance criteria for water quality impacts are based on federal, state, and local water quality criteria and regulations, and the potential for long-term degradation or endangerment to the environment.

Project Impacts. No significant, long-term water quality impacts are anticipated to occur as a result of designation of the HOODS as the regional ODMDS. Dredged material disposal typically has a short-term (several hours to days) localized impact on the water column. Water quality variables which could be temporarily affected by disposal of dredged material from Humboldt Bay include: total suspended solids, light transmittance through the water column, dissolved oxygen, and nutrients. Materials dredged from Humboldt Bay during routine dredging operations have not been found to contain significant concentrations of potentially toxic substances. Any materials proposed for disposal at the site will be tested and approved in accordance with EPA Ocean Dumping Regulations (40 CFR 227) and EPA/Corps testing guidelines (EPA/Corps 1991 "Greenbook") prior to disposal at the HOODS.

The disposal of dredged material in the marine environment occurs through three major phases (convective descent, dynamic collapse, and passive dispersion) which affect the behavior of the material in the water column and the nature of the deposit on the bottom. The convective descent phase occurs as the majority of the dredged material falls to the bottom as a concentrated cloud under the influence of gravity. Dynamic collapse occurs as the downward momentum of the cloud is converted to horizontal dispersion of the material as it contacts the bottom. Passive diffusion occurs following the loss of momentum when ambient currents and turbulence act as the major forces of dispersion.

Dredged materials to be disposed of at the HOODS during maintenance dredging operations are primarily coarse sand, with a smaller volume of sediment characterized as sand/silt. Coarser materials fall relatively rapidly to the bottom. Finer materials can remain in the water column for longer periods of time. Numerical models can provide reasonable estimates of the transport and fate of coarser materials (Koh and Chang 1973). The fate and transport of finer material are difficult to model because some fraction of the finer material descends as relatively large aggregates. However, some fraction of the finer materials remains in suspension in the water column following disposal operations. The ultimate fate of this suspended material depends primarily on its settling rate and the ambient currents and water column conditions at the disposal site at the time of disposal. Scheffner (1990) evaluated the dispersion of sands and silt-clays following a disposal episode. He found that the sand and silt-clay concentrations would be near ambient in the top 18 m (60 ft) of water within 15 minutes after disposal, and near ambient at 37 m (120 ft) within 45 minutes after disposal (Appendix C).

Although some pelagic fishes such as salmon may be present during disposal operations, their presence at the site is highly transitory, and the HOODS represents a relatively insignificant portion of their migratory corridor. Localized short-term decreases in water quality are not expected to cause significant impacts to pelagic fish species.

Mitigation. Short-term water quality (primarily turbidity) impacts during disposal operations are unavoidable. To minimize potentially significant impacts to water quality, sediments will be chemically analyzed in order to determine suitability for disposal at the HOODS. A chemical characterization study of sediments dredged during annual maintenance dredging of federal channels in Humboldt Bay is currently being performed. Based on the results of this study, a schedule of sediment quality studies for these channels will be established and become a part of the site management and monitoring program.

Sediments dredged as part of the proposed Harbor and Bay Deepening Project have been tested (Corps/HBHRCD 1995). The Corps proposes to dispose of the materials acceptable for unconfined ocean disposal at the HOODS. The Corps proposes to dispose of unacceptable materials at a confined upland site.

Any dredged materials from non-federal projects would also require testing in order to determine suitability for ocean disposal at the HOODS.

4.2.2 Biological Environment

4.2.2.1 Project Significance Criteria

A biological impact was considered significant if it:

- is expected to affect the population status of a state or federally listed, proposed, or candidate threatened or endangered species or is expected to affect the breeding or foraging habitat of such species so as to result in increased mortality or reduced reproductive success;

- causes the loss or long-term degradation of any environmentally sensitive species;

- interferes substantially with the movement of any resident or migratory fish or wildlife species; or

- causes a measurable change in species composition or abundance of a sensitive community or causes a substantial, long-term change to marine habitats.

4.2.2.2 Phytoplankton

Project Impacts. The disposal of dredged material at the preferred site may cause mortality to phytoplankton due to entrainment in the sediment plume and may temporarily reduce phytoplankton production by increasing turbidity, consequently reducing light available to algae. However, the increased turbidity produced during disposal of dredge spoils is localized and temporary, and the impacts are expected to be insignificant compared to natural fluctuations in primary production (Copeland and Dickens 1974, Hirsch et al. 1978). The pelagic environment offshore of Humboldt Bay is seasonally subjected to large amounts of suspended sediments discharging from the Eel River and Humboldt Bay. The impact from the disposal of the projected amounts of maintenance dredged materials at the HOODS is not expected to have any significant long-term adverse effects on the phytoplankton offshore of Humboldt Bay.

4.2.2.3 Zooplankton

Project Impacts. Impacts on zooplankton, including planktonic larvae of fish and invertebrates, as a result of dredged material disposal may include mortality due to entrainment in the sediment plume and interference with filter feeding caused by a temporary increase in suspended sediments. These impacts are expected to be short-term and localized and not significantly affect planktonic conditions over the nearshore waters in the region.

4.2.2.4 Benthic Algae

Project Impacts. Disposal of dredged material at the preferred site would not have any significant short-term or long-term effects on the benthic algae communities in the area. The only significant benthic algae communities in the study area are along the intertidal and subtidal portions of the jetties. Disposal operations are not expected to affect the limited algal communities along the jetties because those communities are about 3 nmi from the HOODS.

4.2.2.5 Benthic Infauna

Project Impacts. Survival of organisms varies according to species and their ability to burrow through the sediments; it also depends on the thickness of disposed materials (Hirsch et al. 1978). Direct mortality due to burial of organisms and reductions in the number of species and the abundance of infaunal organisms is expected to be restricted to the immediate disposal area (Oliver and Slattery 1976, Scott et al. 1987, Hirsch et al. 1978). Recolonization by opportunistic species occurs within 3 to 6 months (Bingham 1977, Scott et al. 1987).

The most permanent impact of dredged material disposal is a change in substrate (Tatem 1984). Although the grain size of the substrate at the HOODS ranges from approximately 50% sand in the easterly cells to approximately 10% sand in the westerly cells (Pequegnat et al. 1990), the sediments dredged from Humboldt Bay are predominantly sand (approximately 85% to 90%). Many benthic invertebrates will be unable to move through the spoils, and the lateral migration of adults from the adjacent benthic community will be hindered because those individuals are adapted to finer-grained sediments (Hirsch et al. 1978). In addition, the planktonic larvae of many benthic invertebrates respond to specific cues, including grain size of the substrate, for settlement and metamorphosis (Meadows and Campbell 1972). Dexter et al. (1984) found that although the sediments at a dredged material disposal site in Elliott Bay, Washington, were sandier than ambient sediments, 3 years after disposal there was a greater abundance and biomass of benthic invertebrates in the dredged spoils mound than in the surrounding area. However, this may have been the result of organisms introduced by currents around the mound (Tatem 1984).

From previous observations of macrobenthic recolonization at dredged material disposal sites, it is expected that after the dredged material is deposited, the initial recolonization will be by motile, short-lived, shallow-burrowing, opportunistic species, probably small crustaceans (e.g., amphipods and cumaceans) and polychaetes (Oliver and Slattery 1976, Winzler and Kelly Consulting Engineers 1984). Deposit-feeding fauna will have a more difficult time recolonizing because the low organic content and coarseness of the dredged spoils are not conducive to burrowing infauna. The rate at which the benthic community at the HOODS recovers will depend on the length of time between disposal operations. Recolonization of a diverse and stable benthic assemblage at the HOODS would probably be complete for 1 to 3 years after the cessation of all disposal operations (Dillon 1984, Scott et al. 1987). Hence, impacts of dredged material disposal on the benthic infauna community within the disposal area are expected to be significant but localized.

Mitigation. Several operational procedures are designed to minimize potential impacts to benthic infauna. The selection of the HOODS was based in part on the sediment characteristics of the site. The HOODS lies within a mud-sand transition zone with fine sand to sandy silt substrates in the eastern portion of the site, and silty sands and clay in the western portion of the site. The variability in substrate composition allows the disposal of dredged materials on bottom substrates of similar character.

Significant accumulations of dredged materials and associated burial of infaunal organisms is an unavoidable significant impact within the site. Numerical modeling conducted by the Corps and a sediment dispersion analysis performed by Scheffner (1990) for the HOODS concluded that the site is non-dispersive (see Appendix C). To ensure that impacts to benthos are isolated to the site, the Corps is conducting post-disposal bathymetric surveys to verify the non-dispersive nature of the site. The Corps requires that accurate positioning is used during disposal events and that performance data (position, time, draft, disposal area) be collected via DDLS to verify dredged material disposal within the site. The Corps will also be required by EPA to conduct periodic monitoring to verify the nontoxic nature of disposed sediments, and that significant quantities of sediments have not been transported out of the HOODS.

4.2.2.6 Benthic Epifauna

Project Impacts. Of particular concern is the potential impact of disposal operations on Dungeness crab. The impacts on planktonic larval stages (zooplankton) were discussed above. Dredged material disposal operations offshore of Humboldt Bay generally occur during April and May, when Dungeness crabs are mating in shallow, sandy areas; and in September and October, when egg-brooding females partially bury themselves in the sand in the shallow subtidal areas. Juvenile Dungeness crabs settle in shallow offshore areas from April to July. During these critical life stages, Dungeness crabs caught beneath the disposal plume would be smothered. With regard to the alteration in sediment type following disposal, however, Dungeness crabs are found in association with a range of substrates, so this change should not have a detrimental effect on colonization of the site by crabs.

Because the HOODS is located in waters deeper than those usually associated with Dungeness crabs at their critical life stages, relatively few Dungeness crabs are expected to be affected. The HOODS has not been identified as a critical habitat for any life stages of Dungeness crab or any other epifaunal species reported in this area. Since the impacts will be short-term and restricted to the area within the disposal site boundaries, significant long-term impacts on Dungeness crabs and other epifauna populations in the study area are not expected.

4.2.2.7 Pelagic Invertebrates

Project Impacts. The HOODS is not known to provide critical spawning habitat for the market squid *Loligo opalescens*. In addition, this species is highly mobile and would be able to avoid the disposal plume. Although this species has been reported to be a component of the biological community offshore of Humboldt Bay, there is no evidence that this species would be adversely affected by dredged material disposal at the preferred site.

4.2.2.8 Demersal Fishes

Project Impacts. Disposal of dredged material at the HOODS is likely to adversely affect the demersal fishes. The immediate local effect of dredged material disposal would be the burial of adult and juvenile bottomfish as well as their epifaunal and infaunal food resources. After dredged material is dumped, much of the fine-grained sediment would remain suspended near the ocean floor (Hirsch et al. 1978). This may physically stress fish by clogging their gills and reducing the absorption of dissolved oxygen. Adults can avoid suspended material by moving out of the area, but juvenile fish may be more vulnerable and susceptible to stress (SAIC 1986). Sediments can remain suspended for weeks or months, and areas outside of the immediate disposal area might be affected if bottom currents transport suspended sediments. The HOODS, however, is far enough offshore (3 to 4 nmi) that, except during storms, bottom current velocities are small, and suspended sediments are not expected to move beyond the disposal area (see Scheffner 1990 in Appendix C).

Over the long term, dredged material disposal at the HOODS may result in a localized decrease in species diversity and abundance. Previous studies at the NDS and SF-3 indicate that past disposal actions have adversely affected demersal fish fauna (ERC 1976, Lockheed Center 1979, Winzler and Kelly Consulting Engineers 1984, Pequegnat et al. 1990). These reductions could be caused, in part, by reduced food availability. Benthic infauna and epifauna populations, which are the main food source for demersal fish, decline when disposal occurs frequently because the benthic fauna are unable to reestablish themselves (SAIC 1986). Some recovery of the benthic community occurs within months, but complete recovery of the original benthic communities requires about 1 to 3 years (Dillon 1984, Scott et al. 1987). When dumping occurs more than once a year, it is likely that the benthic community will be reduced and so support a more limited demersal fish community. However, dredged material disposed at the HOODS might have a smaller effect on fish populations than would disposal at nearshore areas (such as SF-3 and the NDS) since, in general, fish abundance and biomass decrease toward offshore areas.

To reduce the effects of suspended sediments on fish, very fine-grained sediments should be deposited in the smallest area possible so that the least amount of benthic habitat is affected (Hirsch et al. 1978). However, sandy sediment deposited in an area with similar indigenous sediments should be dispersed over a large area. The similar-grained sediment should minimally modify the disposal area, and a thin layer of sediment would allow bottomfish a better chance of surviving burial (Hirsch et al. 1978).

Mitigation. Mitigation for potential impacts to demersal fish communities is the same as that discussed for benthic infauna (Section 4.2.2.5). The effects of disposal could be further minimized by scheduling activities during seasons that would least affect fish reproduction. Recovery from physical impacts is most rapid when disposal operations are completed shortly before seasonal peaks in spawning or larval abundance (Hirsch et al. 1978). Peak spawning activity of many benthic fish occurs from December to February, and usually eggs and larvae are pelagic by spring. Disposal of dredged material in November, just before the peak in spawning activity, might allow a rapid recovery. Preservation of nursery areas is also critical. Juveniles of many species usually occur in the shallow, sandy bottoms from May through August. Older juvenile English sole might use the area from August to November as they move from protected areas to deeper waters off the open coast (Lassuy and Moran 1989).

4.2.2.9 Pelagic Fishes

Project Impacts. Disposal activities at the HOODS are expected to minimally affect pelagic marine and anadromous fishes. The area affected by disposal operations is small relative to the distribution of pelagic fishes along the coast, and their presence within the affected area during disposal operations would be minimal. Pelagic fish passing through the immediate area might be forced to change their route during discharge operations. Adult fish within and immediately adjacent to the disposal area may experience short-term clogging of their gills by suspended materials, as well as a slight decrease in available oxygen due to the biological oxygen demand of the dredged material. Adult fish may also experience stress from avoidance reactions. However, conditions which could impact pelagic fishes are expected to be short-term (hours) and localized (less than 1 mile), and the effects on pelagic adults in the water column are not expected to be significant.

Juveniles may be more susceptible to the effects of released dredged material. Juveniles passing through a turbidity plume may be subject to gill clogging, interference with oxygen exchange, and slightly lowered oxygen availability due to the biological oxygen demand of the suspended sediments. Juvenile anadromous fish generally move seaward between March and October, and juvenile black rockfish usually move to benthic habitats in June. Release of dredged material is expected to be least likely to affect juvenile anadromous and marine fish during the late fall and winter. However, the presence of juvenile fishes within affected areas would be minimal relative to their distribution along the coast.

4.2.2.10 Coastal and Sea Birds

Project Impacts. Disposal of dredged material at the HOODS would have no direct effect on seabird breeding colonies in the area because the site is located offshore, away from known colonies. Indirect impacts on seabirds from dredged material disposal at the HOODS could result from temporary turbidity, which would displace and obscure prey items in the water column. This would affect surface-diving seabirds (such as alcids) and lunge divers (such as brown pelicans) that feed in clear water. Turbidity from disposal would be both localized and temporary; consequently, birds that feed in clear water and in the mid-water column will likely avoid plumes and feed elsewhere. Benthic fish and invertebrates at the preferred site are not generally used as food by seabirds. Only a few deep-diving species (e.g., common murres, cormorants, and loons) dive to depths of more than 35 m (115 ft), and studies indicate that bottomfish compose only a small portion of their diet (Ainley and Boekelheide 1990). Disposal of dredged material might actually provide a brief supply of food for surface-feeding seabirds such as shearwaters, storm petrels, fulmars, and gulls, depending on the abundance of marine organisms present within the spoils. This food source, however, would be temporary and incidental to the total diet of these birds.

Use of the HOODS would have no direct effect on the marbled murrelet, snowy plover, or double-crested cormorant breeding populations because these species usually occur closer to the coastline.

4.2.2.11 Marine Mammals

Project Impacts. Use of the HOODS will have no direct impact on populations of marine mammals in the Humboldt Bay area. Many marine mammals occur in offshore waters deeper than those found at the preferred site. It is possible that the plume or disposal ship traffic would cause gray and humpback whales to slightly alter migratory routes. Gray whales might move offshore to avoid ship traffic and turbid water (Dohl et al. 1983). Disposal at this site would probably have little direct effect on marine mammal foraging, since most marine mammals in the area forage on mobile organisms that would likely avoid the disposal area during disposal operations.

Use of the HOODS will have no direct effect on pinniped breeding or haul-out sites because the proposed disposal site is located offshore of known breeding colonies and haul-out sites.

4.2.2.12 Threatened or Endangered Species

Project Impacts. No significant impacts to threatened or endangered species are expected to occur as a result of the proposed designation of the HOODS as the regional

ODMDS. Potential impacts are expected to be temporary in nature, and confined to the disposal site. Therefore, no loss of critical foraging habitat, increases in mortality, or reductions in reproductive success for these species are expected to occur relative to the entire region as a result of the proposed action.

Brown pelicans are plunge divers and thus require relatively clear waters in which to feed (Ashmore 1971). Therefore, depending on the amount and duration of disposal, dumping at the HOODS would temporarily exclude brown pelicans from foraging in the local area. Pelicans may be indirectly affected if reproduction and abundance of favored prey are reduced by dumping activities. However, as noted above, pelagic fish species (pelican prey) are expected to be only minimally affected by disposal operations at the HOODS. There would be no direct effects on the brown pelican roosts on the south spit of Humboldt Bay.

The short-tailed albatross is rarely sighted in California (Stallcup 1990). Therefore, it is highly unlikely that dredged material disposal at the HOODS would affect this species.

The marbled murrelet nest in the coastal forests of the Humboldt Bay area and can be observed feeding in waters near the Bay entrance. Because murrelets generally feed in waters closer to shore, this species is not expected to be affected by disposal operations at the HOODS.

Winter-run chinook salmon may occasionally pass through the site during disposal operations. However, any impact of turbidity to this species would be short-term and localized. No significant impact to this stock of chinook salmon is anticipated.

4.2.3 Socioeconomic Environment

4.2.3.1 Project Impacts

Impacts to commercial fishing and shipping, recreation, hunting, sport fishing, nature study, or science and education are not anticipated as a result of designation of the HOODS site. The site is situated 3 to 4 nmi offshore and does not lie within any established shipping routes or at a commercially important fishing ground.

Several magnetic and sonar anomalies were identified within the HOODS. Three of these anomalies were identified as potential shipwreck locations; however, no positive identification of these sites has been made.

4.2.3.2 Mitigation

The Corps will avoid disposal of dredged materials at potential shipwreck sites within the HOODS to protect their cultural value.

4.3 SF-3

4.3.1 Physical Environment

Disposal of dredged material at the SF-3 site has resulted in significant impacts to the oceanic conditions near the Bay entrance. Waves shoaling on the accumulated mound of previously disposed dredged materials are reported to have resulted in breaking waves within the site. This condition affects safe navigation when entering the Bay from the south. If SF-3 is designated as the regional ODMDS, continued disposal of materials would result in continuation and magnification of navigation hazards. No mitigation has been identified which would reduce this significantly adverse impact to less than significant levels.

Potential impacts to water quality would be similar to those discussed for the HOODS. However, higher current and more intense wave action at the SF-3 site would likely resuspend and disperse suspended sediment over a greater area.

4.3.2 Biological Environment

4.3.2.1 Phytoplankton

The impacts of dredged material disposal on phytoplankton at SF-3 are expected to be similar to those discussed for the preferred alternative.

4.3.2.2 Zooplankton

The impacts of dredged material disposal on zooplankton at SF-3 are expected to be similar to those discussed for the preferred alternative.

4.3.2.3 Benthic Algae

Although SF-3 is closer than the other sites to the intertidal and subtidal algal communities on the jetties, dredged material disposed at this site is not expected to be transported from SF-3 to the jetties in significant quantities. No significant adverse effects on the benthic algae are anticipated.

4.3.2.4 Benthic Infauna

The benthic communities in the shallow nearshore zone are better adapted for surviving physical disturbances than the more stable offshore communities. Initially, dredged material disposal would smother the resident infauna. Although the grain size of dredged spoils from Humboldt Bay is more like that of the nearshore zone sediments than that of the mid-depth and offshore zones, previous studies have shown that disposal at SF-3 clearly affected the infaunal community (Winzler and Kelly Consulting Engineers 1984). Coarse-grained sediments do not provide a suitable habitat for most infaunal burrowing species. Species diversity at the SF-3 disposal site was low while the site was active; the benthic community consisted mainly of small surface-dwelling, surface-deposit feeders. This indicates that disposal disrupted the ecology of the area and provided newly deposited sediments for recolonization by generalist and opportunistic species. Because of substrate type, wave action, and the annual disturbance resulting from disposal activities, the benthic community observed at SF-3 remained unstable during its use as a disposal site. Long-term use of SF-3 for dredged material disposal would cause biological impacts on the benthic infauna that would be significant and would adversely affect this community. Oliver and Slattery (1976) reported that 1 to 3 undisturbed years would have to pass before the benthic communities recovered to a state similar to the unaffected adjacent areas.

No mitigation has been identified which would reduce this significantly adverse impact to less than significant levels.

4.3.2.5 Benthic Epifauna

The dredged material disposal operations offshore of Humboldt Bay generally occur during periods of Dungeness crab breeding and spawning. The SF-3 site is located within the shallow subtidal area that serves as habitat for critical life stages of Dungeness crabs. Brooding females partially bury themselves in shallow subtidal areas from September to November offshore of Humboldt Bay. Dungeness crabs mate in shallow, sandy areas from March to July; the process can take up to 9 days as the male waits for the female to molt. During these critical life stages, individuals in the immediate disposal area would be adversely affected by burial under dredged material. These impacts would be limited to the boundaries of the disposal site and are not expected to have significant long-term adverse impacts on Dungeness crab populations offshore of Humboldt Bay. If the disposal of dredged material offshore of Humboldt Bay became more frequent, as might occur if a channel widening and deepening project in Humboldt Bay were undertaken, the magnitude of these impacts would increase.

4.3.2.6 Pelagic Invertebrates

The impacts of dredged material disposal on the market squid *Loligo opalescens* at SF-3 are expected to be similar to those discussed for the preferred alternative.

4.3.2.7 Demersal Fishes

Disposal of material at the SF-3 site is expected to adversely affect resident demersal species at the site. The immediate effects of dredged material disposal are similar to those discussed for the HOODS. Disposal at SF-3 has already modified the fish community and lowered the density of fish species (Lockheed Center 1979, Winzler and Kelly Consulting Engineers 1984). Resumption of disposal at this site would reduce the epifaunal and infaunal food resources, as in the past, limiting the number of fish that the area can support. Species diversity would also continue to be depressed. However, previous studies at SF-3 did not definitively determine that certain species previously occurring in the area became excluded as a result of disposal activities. Also, nuisance fish species did not become established.

No mitigation has been identified which would reduce this significantly adverse impact to less than significant levels.

4.3.2.8 Pelagic Fishes

Disposal operations are expected to minimally affect pelagic species. Migrating fishes might temporarily avoid SF-3 during disposal activities but would not be blocked from the entrance channel to Humboldt Bay and could pass around the disposal site. Pelagic fishes present inside or immediately adjacent to the disposal site during operations might experience physiological stresses similar to those discussed for the preferred alternative.

4.3.2.9 Coastal and Sea Birds

Selection of SF-3 as a disposal area is expected to have little direct effect on breeding colonies of seabirds because the site is located approximately 16.5 nmi from the nearest coastal seabird colonies. The only impacts would be the short-term loss of prey and foraging habitat that would result from increased turbidity. This would apply especially to diving seabirds such as common murres, rhinoceros auklets, and cormorants. The degree of seabird displacement from foraging areas depends upon the duration and size of sediment plumes and the volume of dredge spoils. The effect on seabirds could be significant if the reproduction and abundance of favored prey are affected in nearshore waters. The loss of the benthic community at SF-3 would result in a loss of localized feeding habitat for seabirds that feed on benthic organisms; however, seabirds would likely find food elsewhere in the area. Disposal at this site might briefly provide food for seabirds such as gulls, depending on the number of marine organisms in the dredged sediments. This food source, though, would be temporary and incidental to the main diet of these birds.

4.3.2.10 Marine Mammals

The impacts of dredged material disposal on marine mammals at the SF-3 site would be similar to those discussed for the preferred alternative. Pinniped breeding and haul-out sites are not expected to be affected by the use of SF-3. All breeding and haul-out sites, except for harbor seal rookeries, are located more than 8 nmi from the SF-3 disposal site, and the nearest harbor seal rookery is located approximately 0.9 nmi away, inside Humboldt Bay.

The SF-3 site may provide some foraging habitat for marine mammals because of its relatively shallower depths and proximity to shore. However, loss of this habitat in relation to the foraging range of marine mammals would be less than significant.

4.3.2.11 Threatened or Endangered Species

The impacts of dredged material disposal at SF-3 on threatened or endangered species would be similar to those discussed for the preferred alternative site, but with the exceptions discussed below.

The SF-3 site lies within potential foraging range of both marbled murrelets and Steller sea lions. However, the foraging habitat at the SF-3 site is small in relation to the foraging range of these species, and use of the site is not expected to cause significant impacts to threatened and endangered species.

4.3.3 Socioeconomic Environment

4.3.3.1 Project Impacts

Designation and dredged material disposal will result in accumulations of sediments at the SF-3 site. These accumulations will likely intensify the present navigation hazards at the site. Additionally, the site is not large enough to adequately contain disposed dredge materials, given the anticipated quantity of 50,000,000 yd^3 over the 50-year life of the site.

4.3.3.2 Mitigation

Enlargement of the SF-3 site is the only potential mitigation to reduce impacts to navigation. However, the environmental impacts associated with enlarging the site enough to contain 50,000,000 yd^3 without impacts to surface navigation would likely preclude this mitigation alternative.

4.4 THE NDS

4.4.1 Physical Environment

Potential impacts of designating the NDS as the regional ODMDS are similar to those discussed for the SF-3 site.

4.4.2 Biological Environment

4.4.2.1 Phytoplankton

The impacts of dredged material disposal on phytoplankton at the NDS are expected to be similar to those discussed for the preferred alternative.

4.4.2.2 Zooplankton

The impacts of dredged material disposal on zooplankton at the NDS are expected to be similar to those discussed for the preferred alternative.

4.4.2.3 Benthic Algae

Although the NDS disposal site would be closer to benthic algal communities than the HOODS or SF-3, these communities are still located at a safe distance from the site. Dredged material disposal at the NDS is not expected to have any significant adverse effects on the benthic algae in the study area.

4.4.2.4 Benthic Infauna

A month after the disposal of dredged material at the NDS, benthic invertebrate species diversity and abundance were observed to be reduced (Pequegnat et al. 1990). However, benthic communities tend to be unstable in shallow water due to wave action. Since the NDS has not been used for dredged material disposal since the fall of 1989, the benthic community has most likely recolonized, with the fauna more like that of the adjacent environment.

The impacts of dredged material disposal on the benthic infauna at the NDS are expected to be similar to those discussed for the SF-3 site alternative. The number of species and individuals decreased by more than 60% between the August and November 1989 samplings conducted by Pequegnat et al. (1990). Although this might have been related to the disposal of dredged material at this site prior to the November sampling, it is also probable that this is a seasonal trend (Pequegnat et al. 1990).

No mitigation has been identified which would reduce this significantly adverse impact to less than significant levels.

4.4.2.5 Benthic Epifauna

The potential impacts of dredged material disposal on the benthic epifauna at the NDS might be greater than at either of the other two alternative disposal sites because of the relatively high seasonal abundance of Dungeness crab reported there. The highest abundances of Dungeness crab were recorded in the vicinity of the NDS, with the greatest numbers observed in November following the disposal of dredged material in the fall. Both the April-May and September-October disposal periods offshore of Humboldt Bay occur when Dungeness crabs can be found at the shallow depths.

4.4.2.6 Pelagic Invertebrates

The impacts of dredged material disposal on the pelagic invertebrates at the NDS are expected to be similar to those discussed for the SF-3 site alternative.

4.4.2.7 Demersal Fishes

Project Impacts. Dredged material disposal activities are expected to adversely affect bottomfish species at the NDS and in areas adjacent to the site. Such disposal operations have only occurred twice at this site, but trawl catches indicated that species diversity and biomass were reduced as compared to catches in control areas. The immediate effect of disposal is expected to be similar to that described for the SF-3 site alternative. The long-term effects of disposal would include reduced food resources and modified sedimentation patterns. Disposal material would be composed of fine-grained sediment (fine sand to silt and clay) in the spring and of coarse-grained materials in the fall (see Scheffner 1990 in Appendix C). Fine-grained material differs from the indigenous sediment at the NDS and is not suitable for nearshore disposal. When disposed sediments differ from bottom sediments, recolonization of dredged material by epifauna and infauna might be slow, and food resources for fish might be limited (Hirsch et al. 1978).

Mitigation. The effects of dredged material disposal could be reduced by conducting disposal operations before peak spawning periods and when juveniles are unlikely to use the area, and by using material with similar grain size. Recovery from physical impacts is most rapid when dredged material disposal occurs just prior to peak spawning periods, which for bottomfish are typically from December to February. Also, juveniles are most likely to be in nearshore areas such as the NDS from April to August, except for juvenile English sole, which might be found as late as November.

4.4.2.8 Pelagic Fishes

The impacts of dredged material disposal on pelagic species at the NDS are expected to be similar to those discussed for the preferred alternative.

4.4.2.9 Coastal and Sea Birds

The impacts of dredged material disposal on coastal and sea birds at the NDS are expected to be similar to those discussed for the SF-3 alternative.

4.4.2.10 Marine Mammals

The impacts of dredged material disposal on marine mammals at the NDS are expected to be similar to those discussed for the preferred and SF-3 alternatives. Pinniped rookeries and haul-out sites would probably not be affected by disposal at the NDS because all rookery and haul-out sites, except for harbor seal rookeries, are located more than 8 nmi from this alternative site. Harbor seal haul-out sites are about 0.65 nmi away, inside Humboldt Bay.

4.4.2.11 Threatened or Endangered Species

The impacts of dredged material disposal on threatened or endangered species at the NDS are expected to be similar to those discussed for the SF-3 site alternative.

4.4.3 Socioeconomic Environment

4.4.3.1 Project Impacts

Designation and dredged material disposal will result in accumulations of sediments at the NDS. These accumulations will likely intensify the present navigation hazards at the site. Additionally, the NDS is not large enough to contain disposed dredged materials, given the anticipated quantity of 50,000,000 yd^3 over the 50-year life of the site.

4.4.3.2 Mitigation

Enlargement of the NDS is the only potential mitigation to reduce impacts to navigation. However, the environmental impacts associated with enlarging the site enough to contain 50,000,000 yd^3 without impacts to surface navigation would likely preclude this mitigation alternative.

4.5 LONG-TERM IMPACTS AS A RESULT OF THE PROJECT

Long-term significant impacts on the biological community are expected to be localized within the boundaries of the preferred alternative site. Impacts may include a decrease in benthic infaunal and epifaunal populations and lowered fish diversity. Benthic infaunal communities at the preferred alternative site are expected to be affected as long as disposal is taking place. Benthic infauna would be buried during disposal and, depending on the volumes dumped, the thickness of deposited material on the bottom, and the length of time between disposal operations, might not have sufficient time to recolonize. Benthic epifauna, including Dungeness crabs, might also be affected to some extent; however, few, if any, of the critical life stages of this crab species are found at the HOODS.

The long-term effect of dredged material disposal on demersal fish at the preferred site may be a decrease in species diversity and abundance. This effect has been documented offshore of Humboldt Bay at the NDS and at SF-3 (ERC 1976, Lockheed Center 1979, Winzler and Kelly Consulting Engineers 1984, Pequegnat et al. 1990) and at other coastal disposal sites (EPA 1987). These reductions are partially caused by reduced populations of benthic infauna and epifauna populations, a main food source for fish.

Overall, disposal of dredged material at the preferred alternative site is not expected to affect any geographically limited species or affect any unique habitats, breeding areas, or critical areas that are essential to commercially important species and to rare or endangered species.

4.6 RELATIONSHIP BETWEEN SHORT-TERM USE AND LONG-TERM RESOURCE USES

The proposed designation of any of the alternative sites as an ODMDS is not expected to produce significant, long-term, adverse impacts to resources, including the physical, biological, and socioeconomic environments, within the Humboldt Bay region. Impacts to benthic invertebrates within the site are expected to persist as long as the site is used for disposal. However, cessation of disposal should result in gradual recovery over time. Recolonization of a diverse and stable benthic community would probably be complete 1 to 3 years after cessation of disposal operations (Dillon 1984, Scott et al. 1987).

Use of the proposed ODMDS is not expected to interfere with uses of resources outside of the boundaries of the alternative sites. These resources include commercial and sport fishing, marine bird and mammal observation, and use of the regional by commercial and recreational vessels. No significant mineral or oil and gas resources occur within any of the alternative sites. Therefore, use of the ODMDS does not represent a potential conflict with the long-term use of resources.

Any impacts or restricted uses of resources within the site boundaries would represent a very small percentage of these resources within the Humboldt Bay study region. This marginal loss of some resources is balanced by the significant benefit that would be derived from the proposed action. In contrast, lack of a designated ocean disposal site capable of receiving large quantities of dredged material could have a significant adverse effect on the economic productivity associated with Humboldt Bay.

4.7 IRREVERSIBLE OR IRRETRIEVABLE COMMITMENT OF RESOURCES

Irreversible or irretrievable resources that would be committed if an ocean disposal site is designated will include:

- energy resources used as fuel for dredges, pumps, and disposal vessels, and for research vessels involved in monitoring studies;
- economic resources associated with ocean disposal including monitoring and surveillance;
- unavailability of sediments disposed at the ODMDS for potential beach restoration or other beneficial use projects; and
- some loss or degradation of the benthic habitat and associated benthic communities at the site for at least the duration of site use.

The commitment of energy and economic resources will increase with increased distance of a site from dredging areas. However, the three alternative sites are similar distances from Humboldt Bay, and no significant differences in the resources contained within the alternative sites are evident. Therefore, the magnitude of any long-term commitment of irreversible or irretrievable resources that can be determined from the existing information is essentially the same for each of the three alternative sites.

Section 5

Coordination

Section 5. Coordination

This section contains information on public involvement and interagency activities related to the DEIS and FEIS for designation of the ODMDS off Humboldt Bay, California. Several scoping meetings occurred between January 1989 and January 1991. Initial field studies were conducted by the Corps in 1990.

During preparation of the DEIS, EPA initiated coordination with agencies regarding the potential impacts of the proposed site designation on threatened or endangered species that may occur in the area of the alternative sites. Documentation of Endangered Species Act (ESA) consultation, including responses from these agencies, is included in this section.

Written responses from other agencies and the public on the DEIS are presented in Section 6. No written comments regarding the DEIS (including ESA coordination) were received from the USFWS following the comment period. A letter from the National Marine Fisheries Service addressing the DEIS in general, as well as threatened and endangered species consultation, is included in this section.

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
REGION IX
75 Hawthorne Street
San Francisco, CA 94105-3901

DEC 12 1994

Mr. James Bybee
Environmental Coordinator, Northern Area
National Marine Fisheries Service
777 Sonoma Avenue, Room 325
Santa Rosa, CA 95404

Dear Mr. Bybee:

The U.S. Environmental Protection Agency Region IX (EPA) is preparing an Environmental Impact Statement (EIS) for the designation of an ocean dredged material disposal site off Humboldt Bay, California. A range of alternative sites will be evaluated for receiving dredged material from the Humboldt Bay region over a 50-year period. The proposed action will involve only the designation of the site itself; before any disposal is permitted, dredged material must be evaluated in accordance with the Marine Protection, Research and Sanctuaries Act of 1972 and its implementing regulations and guidance, and shown to meet all ocean disposal criteria [40 CFR §§ 220-227].

In this site designation process, EPA is evaluating three alternative sites on the continental shelf, the Humboldt Open Ocean Disposal Site (HOODS), the SF-3 Disposal Site (SF-3), and the Nearshore Disposal Site (NDS), ranging in depths from 50 to 180 feet. These alternative sites are delineated on the enclosed map. The HOODS has been used as an interim disposal site since 1990 for suitable dredged material from Humboldt Bay. The SF-3 site was first used in the 1940s and most recently in 1990. The NDS has been used for test dumping to determine whether the sandy material remained in the littoral zone and promoted beach nourishment. In the draft EIS, which is scheduled for release in early 1995, EPA will identify the alternative sites and will identify a preferred alternative site.

In accordance with Section 7(c) of the Endangered Species Act, please advise EPA of the presence of any listed, or candidate, threatened or endangered species in the vicinity of the alternative sites identified above. In addition, please advise EPA of any critical habitat for these species which may be impacted by the proposed action. Similar requests have been forwarded to the U.S. Fish and Wildlife Service and the California Department of Fish and Game. EPA would appreciate

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this information by January 16, 1995. Please direct any questions or requests for additional information to Allan Ota at (415) 744-1980.

Sincerely yours,

Jeff Rosenbloom, Chief
Wetlands and Sediment Management Section

Enclosure

Section 6

Comments Received and Responses to Comments

Section 6. Comments Received and Responses to Comments

The DEIS was published on April 21, 1995. A 45-day public review and comment period extended from the publication date through June 5, 1995. A total of four letters from various agencies, organizations, and individuals were received during the public review and comment period. The comment letters and responses to comments are included in this section. A letter from the National Marine Fisheries Service addressing threatened and endangered species coordination, as well as general comments on the DEIS, is included in Section 5.

EPA also held two public meetings in Eureka, California, following the release of the DEIS; however, no comments requiring responses were given at those meetings.

Comments	Responses

Letter #1

United States Department of the Interior

OFFICE OF THE SECRETARY
Washington, D.C. 20240

JUN 16 1995

In Reply Refer To:
ER 95/301

Ms. Alexis Strauss
Acting Director, Water Management Division
U.S. Environmental Protection Agency, Region IX
75 Hawthorne Street (W-1)
San Francisco, California 94105

Dear Ms. Strauss:

The Department of the Interior (DOI) has reviewed the Draft Environmental Impact Statement (DEIS) for Designation of an Ocean Dredged Material Disposal Site off Humboldt Bay, California. The enclosed comments are provided for your use and information when preparing the Final Environmental Impact Statement (FEIS).

We appreciate the opportunity to review and comment on the DEIS for this project. We hope our comments are useful and look forward to reviewing the FEIS when it is completed. If you have any questions regarding our comments, please contact Ken Havran in the Office of Environmental Policy and Compliance at (202) 208-7116.

Sincerely,

Willie R. Taylor
Director
Office of Environmental Policy
and Compliance

Enclosure

Comments

. Enclosure

COMMENTS ON DRAFT ENVIRONMENTAL IMPACT STATEMENT FOR DESIGNATION OF AN OCEAN DREDGED MATERIAL DISPOSAL SITE OFF HUMBOLDT BAY, CALIFORNIA

<u>Page xix, Executive Summary</u> The Executive Summary should indicate the expected disposal capacity and period of disposal in addition to where they are stated in the DEIS on page 4-4 to be 50 million cubic yards and 50 years, respectively. Likewise, they should be stated in the FEIS Executive Summary. 1-1

<u>Page 2-3, Paragraph 5</u> The four nautical mile constraint on the limit of disposal operations is considerably closer than other sites, such as the SF-DODS. The FEIS should further explain how this constraint was determined. 1-2

<u>Page 3-18, Paragraph 2</u> We note that the depth of the proposed site, stated in the DEIS to be 160 to 180 feet, is only slightly greater than the minimum depth at which sediments are considered non-dispersive (40 meters or 131 feet). The FEIS needs to provide an additional discussion on the location of the referenced box cores in relation to the disposal site for evaluating potential dispersion of dredged material. 1-3

<u>Page 4-4, Paragraph 1</u> When the 131 foot criterion referenced above is applied, the expected change in bathymetry (a decrease in depth by 36 feet) would subject the upper layers of the disposal site to dispersion of the dredged material. This inconsistency needs to be reconciled in the FEIS. 1-4

<u>Pages 4-4, Paragraph 4; 4-8, Paragraph 2; and 4-10, Paragraph 2</u> These sections discuss the need for monitoring, but do not indicate conditions which would be considered acceptable or unacceptable for the expected rate of disposal. These conditions should be identified in the FEIS. 1-5

<u>Page 4-5, Paragraph 2</u> The FEIS should provide information about the number of disposal events, the timing of disposal in relation to fish abundance and schooling patterns, and expected size and duration of plumes which would occur during disposal. This information is needed for evaluating whether the conclusions for impacts on water quality or related impacts on fishes (as discussed on pages 4-9 to 4-10) are significant. 1-6

For example, impacts could occur if disposal were to coincide in time and space with the schooling of anadromous salmonids prior to the spawning season. Notably, the need for November disposal overlaps the spawning season indicated in Table 3-8, but additional information is needed to determine if the nearshore distribution of anadromous fishes includes the disposal area.

Responses

1-1 Comment noted. Details concerning the expected capacity of the site and periods of disposal, 50 million cubic yards and 50 years, have been included in the Executive Summary of the FEIS.

1-2 The San Francisco District of the Corps has prepared a Zone of Siting Feasibility (ZSF) analysis to establish an outer boundary within which to evaluate the candidate ocean disposal sites for the disposal of dredged sediments from Humboldt Bay. A copy of this analysis is presented as Appendix A in the FEIS.

Determination of an outer limit of the ZSF is based on an evaluation of operational and economic constraints for authorized dredging and disposal projects specific to Humboldt Bay as discussed in Section 2.3 of Appendix A. A site to be designated for ocean disposal must be located within an economically and operationally feasible radius from the point of dredging. This is called the Zone of Siting Feasibility. The delineation of the ZSF in selecting a disposal site is dictated by several region-specific factors including, but not limited to:

- the cost of transporting dredged material to the disposal site ($165,000 per nautical mile west of SF-3) and the cost of the navigation project;
- the types of dredging and disposal plants;
- navigational restrictions;
- political boundaries;
- the distance to the edge of the continental shelf; and
- the feasibility of monitoring and surveillance.

For the Humboldt Bay disposal site, a ZSF has been set at 4 nautical miles. The operational limit was based on a combination of factors including the availability of dredging equipment and weather and sea conditions, which together limit the operational time for completion of maintenance dredging in the harbor to between 60 and 90 days. The ZSF assumed 60 days as a dredging window because equipment is not always available to the Corps more than that.

MPRSA requires, whenever feasible, consideration of designating ocean disposal sites beyond the continental shelf. The continental shelf off Humboldt Bay lies approximately 10 nautical miles from the harbor entrance. In the case of this site designation, the continental shelf does not lie within the ZSF. Selection of a site 2-1/2 times farther away than the HOODS would not allow dredging of the harbor in the required time frame.

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	The EIS evaluated three alternative sites within the ZSF and the No Action alternative. The alternatives were selected in accordance with 40 CFR Section 228.5(e) because they were sites of historical disposal activity. The ZSF concluded that all of the alternative sites could be used economically. Cost differences for individual alternative sites were not considered further in site selection. 1-3 The discussion of Borgeld's study of Eel River sedimentation patterns in the DEIS on page 3-18 was based on information presented as an abstract and a poster at a conference, and the information has not been published. The depth indicated in the paragraph was a depth at which some modification of the surficial layers had occurred, and it should not be considered a critical depth above which sediment transport will occur. Typically, where these modified layers occurred, the sediments consisted primarily of sand, indicating that wave or tidal influences transported the lighter material. Although it is likely that some lighter materials may be transported if the pile attains a great enough height, significant transport of material outside the HOODS is not anticipated. Borgeld and Pequegnat (1983) evaluated transport of dredged material from the SF-3 site, which is located close to the HOODS (approximately 2 nmi SSW), but in much shallower waters (18-21 m [60-70 ft]) than the HOODS (49-55 m (160-180 ft]). Studies at the SF-3 site concluded that this site is non-dispersive, except for very fine materials (<0.125 mm) which represent about 3.5% of the total dredge volume. These fine materials were hypothesized to be transported as suspended load during the actual disposal operation (clay and silts) or by subsequent sand events (fine sands). Coarser materials, which constitute the bulk of the material that will be disposed at the HOODS, are typically transported as bedload. Although bedload transport caused some spreading of the pile, these coarser materials remained within the site boundary. The SF-3 site is subject to a much more energetic wave climate than the HOODS. Because of the findings at the SF-3 site, and the modeling conducted for the HOODS, the HOODS is anticipated to be non-dispersive. To verify this conclusion, the Corps is currently evaluating bathymetric data collected from a test dump cell at the HOODS. In the fall of 1990, 683,000 yd^3 of material was dumped into Cell E5 in Quad 2. Bathymetric data were collected for this cell quarterly during 1991 and annually since 1992. The draft of that study is expected to be released in September 1995. 1-4 There is no depth criterion for dispersion or non-dispersion of sediments from the site. See comment 1-3 above.

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1-5 Threshold conditions are outlined in the Site Management and Monitoring Plan (SMMP; Appendix B in the FEIS). Briefly, the SMMP has three tiers. Tier 1 consists of periodic physical surveys of the disposal site to determine the areal extent of disposed dredge materials and whether material is being deposited outside of the disposal site boundaries. If significant adverse impacts on selected biological resources are suspected based on the Tier 1 surveys (i.e., significant accumulations of dredged material outside the site boundaries), a management decision would be made to initiate additional studies such as Tier 2 (benthic community surveys) and Tier 3 (body burden of chemicals in benthos). Samples collected during the Tier 2 and Tier 3 surveys will be compared to samples collected from reference sites.

The monitoring program is designed to test hypotheses concerning the health of biological resources. The distribution of disposed dredged materials will be monitored under Tier 1 of the program. If these surveys indicate that accumulations of disposed materials exceed 10 cm (4 inches) outside the site boundary, a management decision may be made to initiate Tier 2 monitoring. Tier 2 monitoring is used to determine if these accumulations have adversely altered the benthic community structure in the affected areas. Data collected in the affected areas will be statistically compared to benthic community data collected at reference sites. If communities are found to be significantly different, a management decision may be made to initiate Tier 3 monitoring. Tier 3 monitoring would evaluate if communities in the affected areas have significantly higher body burdens of potentially toxic chemicals than organisms found at the reference sites.

In addition to the tiered monitoring approach, the EPA will require the Corps to conduct periodic confirmatory monitoring of the site. This monitoring will be used to evaluate sediment distribution, sediment quality, and extent of benthic impacts resulting from disposal at the site. This monitoring may include sediment chemistry, benthic sampling and community analysis, additional studies of sediment transport, additional bathymetric surveys, mound stability evaluations, or additional water current studies if it is determined that the dredged material is accumulating or moving more than expected. The confirmatory monitoring may also include conducting bioassays of sediments taken from the disposal site using one or more sensitive species consistent with applicable ocean disposal testing guidance ("Green Book" or related implementation agreements).

1-6 A variety of salmon species reside and migrate along the northern California coastline. Fish migrating to the Eel and Mad Rivers would not be expected to congregate offshore in the vicinity of the HOODS. There is potential for salmon or other pelagic fishes to be present in the HOODS during a disposal event. However, the area affected by the disposal is negligible compared to the total nearshore habitat available to pelagic species, and the impacts would be short-term and localized. In the fall, the dredged materials consist of coarser material

Comments		Responses
		(96-100% sand), which is not detectable above ambient conditions within 45 minutes after the disposal event (see Scheffner 1990 in Appendix C). In addition, the selection of the HOODS was based in part on the decreased biotic diversity of this depth range compared to shallower or deeper sites.
<u>Appendix A. Site Management and Monitoring Plan for HOODS ODMDS</u> This section discusses the regulatory authorities on how a Site Management and Monitoring Plan (SMMP) for the Humboldt Open Ocean Disposal Site (HOODS) is developed. The SMMP should provide specific criteria which would trigger management actions or mitigation for impacts. Further, because the monitoring and decision framework is restricted to benthic impacts and the disposal site is close to the Eel and Mad River estuaries, additional consideration must be provided in the FEIS for avoiding impacts to anadromous salmonids, and other fish and wildlife in the area.	1-7	1-7 See responses to comments 1-5 and 1-6.
The monitoring plan also provides for three-tiered monitoring. Tiers 1 and 2 will address the possible physical impacts to the HOODS and the surrounding areas as a result of disposing of dredged materials there. Tier 3 will address the possible impacts to biological resources if dredged material, deposited outside of the disposal site, is found to contain contaminants which could potentially cause adverse impacts to benthic resources (page A-17). However, the DEIS does not include a monitoring plan to measure possible resource impacts from chemical contaminants within HOODS. We recommend the U.S. Environmental Protection Agency develop a monitoring plan to conduct biological monitoring within the HOODS site and include the plan in the FEIS.	1-8	1-8 All dredged materials proposed for ocean disposal must be evaluated for suitability in accordance with the Green Book (EPA/Corps 1991) based on criteria set in the Ocean Dumping Regulations (40 CFR Part 227). In addition, the EPA will require some confirmatory monitoring within the site to verify that the sediments disposed at the site are suitable (see response to comment 1-5).
The DEIS on page A-10 states: "A reference site, or sites, shall be used to document background conditions for comparison in site monitoring activities." The reference site (or sites) should be identified in the FEIS, and their description(s) should provide detail sufficient for evaluating the appropriateness of the selected site(s).	1-9	1-9 It is anticipated that several reference sites will be used in the monitoring process. These sites will be located outside the boundary of the dredged material disposal site, but near enough to the disposal site that the reference sediment and biotic communities are in the same water mass and subject to all the same influences (except previously disposed dredged material) as the disposal site. If there is a potential for sediment migration, the reference sites would not be located in areas outside the disposal site in the direction of the net sediment transport.

Comments	Responses

Letter #2

STATE OF CALIFORNIA—THE RESOURCES AGENCY PETE WILSON, Governor

DEPARTMENT OF FISH AND GAME
1416 NINTH STREET
P.O. BOX 944209
SACRAMENTO, CA 94244-2090

May 9, 1995

Ms. Alexis Strauss, Acting Director
Water Management Division
U.S. Environmental Protection Agency, Region IX
75 Hawthorne Street (W-1)
San Francisco, California 94105

Dear Ms. Strauss:

The Department of Fish and Game (DFG) has reviewed the U.S. Environmental Protection Agency's (USEPA's) Draft Environmental Impact Statement (DEIS) for Designation of an Ocean Dredged Material Disposal Site off Humboldt Bay, California. The purpose of the proposed action is to provide an environmentally acceptable site for the disposal of sediments dredged from Humboldt Bay by the U.S. Army Corps of Engineers (Corps) and other potential dredge project sponsors.

The DEIS describes in detail three alternatives which have historically been used for the disposal of these sediments. SF-3 is a site located 1.1 nautical miles (nmi) southwest of the Harbor mouth and was used for Humboldt Bay and Harbor dredging projects since the early 1940s. Eventual mounding of sediments at this site created hazardous navigational conditions for the local fishing fleet, and the Corps suspended disposal activities there in 1988. An adjacent nearshore disposal site (NDS) was developed approximately 2 nmi southwest of the Harbor and was used on two occasions in 1989 for Harbor sediments. Evidence of shoaling also became apparent at this site, and additional concerns about resource impacts (e.g., Dungeness crab) were expressed. The Humboldt Open Ocean Disposal Site (HOODS) was developed in 1990 to address theses issues and is identified in the DEIS as the preferred alternative. This 1-nmi square site lies between 3 and 4 nmi from the Harbor mouth and is located in a sediment transition zone which allows dredge matererial of differing grain sizes to be placed over compatible sediments. Approximately 3 million cubic yards (cys) of material have been disposed of at this site since 1990.

The DFG finds the DEIS to have adequately described the environmental setting and potential biological impacts for the

Comments

Ms. Alexis Strauss
May 9, 1995
Page Two

continued use of the HOODS for dredge materials from Humboldt Bay and Harbor, and we concur with the selection of the preferred alternative for final designation. However, we are somewhat surprised that no monitoring data from the recent disposal of dredged material at the HOODS was included in the DEIS. If such information is available from the USEPA or Corps, the DFG recommends that it be provided in the Final EIS to support determinations made in the DEIS. 2-1

The DFG also has some concerns relating to the Site Management and Monitoring Plan (SMMP). The SMMP indicates that reference sites for determining sediment suitability will be identified prior to designation of the HOODS. Considering the fact that designation is expected by the end of summer 1995, we believe that some information on the possible location of these reference sites should have been included in the SMMP. For example, what is the potential value of the reference sites used over the past 4 years for evaluating the 3 million cys of Harbor maintenance sediment currently deposited at the HOODS? 2-2

We are also concerned that no provision is made in the SMMP for the periodic testing of the disposal site's biological resources. Although annual bathymetric surveys are planned to determine physical impacts to the HOODS, it appears that resource impacts (e.g., contaminant body burdens) will not be measured unless dredged material has been demonstrated to have moved beyond the boundaries of the site. The DFG recommends that the USEPA consider including biological monitoring on a periodic basis (e.g., every 3 to 5 years) for the SMMP. 2-3

As always, DFG personnel are available to discuss our concerns and comments in greater detail. To arrange for discussion, please contact Mr. Robert N. Tasto, Environmental Specialist, Department of Fish and Game, Marine Resources Laboratory, 411 Burgess Drive, Menlo Park, California 94025, (415) 688-6360.

John L. Turner, Chief
Environmental Services Division

cc: Honorable Douglas C. Wheeler
Secretary for Resources
Resources Agency
Sacramento, California

Mr. Robert N. Tasto
Department of Fish and Game
Menlo Park, California

Responses

2-1 The only monitoring data that have been collected from the HOODS are annual bathymetric surveys conducted before each dredging cycle, and bathymetric data collected from an area where the Corps conducted a single disposal event. The latter data will be used to validate the sediment transport characteristics of the site. The Corps is evaluating the bathymetric data collected from the test cell. It is anticipated that the draft report will be available to the San Francisco District Corps in September 1995.

2-2 There is no current reference station for monitoring of disposal impacts at the HOODS. The reference station that was monitored in the past was a reference station to the SF-3 site which is much shallower than the HOODS. Reference sites for monitoring at the HOODS are discussed in the revised SMMP (Appendix B).

2-3 The SMMP also includes a confirmatory monitoring program that will include periodic sampling of sediments and biota within the HOODS (see response to comment 1-5).

Letter #3

The Resources Agency
of California

Pete Wilson, *Governor*

Douglas P. Wheeler, *Secretary*

California Conservation Corps • Department of Boating & Waterways • Department of Conservation
Department of Fish & Game • Department of Forestry & Fire Protection • Department of Parks & Recreation • Department of Water Resources

May 26, 1995

Alexis Strauss, Acting Director
Water Management Division
U. S. Environmental Protection Agency
75 Hawthorne Street
San Francisco, California 94105

Dear Ms. Strauss:

The State has reviewed the Draft Environmental Impact Statement for Designation of an Ocean Dredged Material Disposal Site off Humboldt Bay, Humboldt County, submitted through the Office of Planning and Research.

We coordinated review of this document with the Integrated Waste Management, and North Coast Regional Water Quality Control Boards; the California Coastal, and State Lands Commissions; the State Coastal Conservancy; and the Departments of Conservation, Fish and Game, and Transportation.

The North Coast Regional Water Quality Control Board has submitted the attached comments for your consideration. The California Coastal Commission will be reviewing this project under their federal consistency jurisdiction.

The Resources Building Sacramento, CA 95814 (916) 653-5656 FAX (916) 653-8102

California Coastal Commission • California Tahoe Conservancy • Colorado River Board of California
Energy Resources, Conservation & Development Commission • San Francisco Bay Conservation & Development Commission
State Coastal Conservancy • State Lands Commission • State Reclamation Board

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Comments	Responses
Ms. Alexis Strauss May 26, 1995 Page Two Thank you for providing an opportunity to review this project. Sincerely, Nadell A. Gayou For James T. Burroughs Deputy Secretary and General Counsel Attachment cc: Office of Planning and Research 1400 Tenth Street Sacramento, CA 95814 (SCH 95044009)	

Comments	Responses
STATE OF CALIFORNIA - CALIFORNIA ENVIRONMENTAL PROTECTION AGENCY — PETE WILSON, Governor CALIFORNIA REGIONAL WATER QUALITY CONTROL BOARD NORTH COAST REGION 5550 SKYLANE BLVD., SUITE A SANTA ROSA, CA 95403 PHONE: (707) 576-2220 May 15, 1995 Nadell Gayou Department of Water Resources 1020 Ninth Street, Third Floor Sacramento, CA 95814 Dear Ms. Gayou: Subject: SCH No. 95044009, Designation of an Ocean Dredged Material Disposal Site off Humboldt Bay, California, U.S. EPA We have reviewed the Draft Environmental Impact Statement (DEIS) of the subject project. The Regional Board supports the designation of the Humboldt Open Ocean Disposal Site (HOODS) for disposal of dredge spoil from Humboldt Bay. The site was chosen after extensive public meetings and is preferred by the local fishing and boating interests. A correction to Section 3.1.4.2, The Louisiana-Pacific Corporation is needed. The ocean outfall for the mill has been extended approximately 1 mile in length to the 25 meter depth contour. The outfall is now about 2,497 m (8,200 ft) long with a multiport diffuser that is 258 m (852 ft) in length. Significant improvement in effluent quality has occurred at the mill since the use of chlorine for bleaching was terminated in January of 1994. Judging from past off-shore monitoring efforts no adverse water quality impacts will result from the combined effects of the outfall and the HOODS. 3-1 Please call me at Calnet 8-590-2683 or (707) 576-2683 if you have any questions. Sincerely, John R. Hannum for William T. Rodriguez Sanitary Engineering Associate WTR:tab/hoods	3-1 Comment noted. Information on the Louisiana-Pacific outfall has been updated in Section 3.1.4.2 of the FEIS.

Section 7

Preparers and Contributors

Section 7. Preparers and Contributors

Agency and Name	Expertise	Experience	Responsibility
EPA Allan Ota/M.S.	Biological Oceanography	13 years conducting research and preparation and review of technical reports.	Work Assignment Manager and EIS review
Corps Dave Hodges/B.S.	Geology	4 years experience in preparation and review of dredging projects.	Project Manager
Jones & Stokes Associates Richard Oestman/M.S.	Fisheries, Marine Biology, Dredged Material Disposal Analysis, NEPA Document Preparation	Over 8 years experience in managing and conducting environmental studies and impact assessments in the marine environment, and EIS management and preparation.	Project Manager, preparation of EIS, EIS review
Jones & Stokes Associates Grant Bailey/B.S.	Marine Biology, Regulatory Compliance, NEPA EIS Preparation	Over 20 years experience in managing and conducting environmental studies and impact assessments in marine environment, and EIS management and preparation.	EIS review
Jones & Stokes Associates Larry Larsen/Ph.D.	Physical Oceanography, Numerical Modeling	Over 25 years experience in conducting research in physical oceanography and pollutant transport.	Preparation of EIS sections: Affected Environment and Environmental Consequences
Jones & Stokes Associates Andrew Wones/M.S.	Marine Biology	Over 5 years experience in conducting research and preparing technical reports and EIS sections.	Preparation of EIS sections: Affected Environment and Environmental Consequences
Jones & Stokes Associates Sara Noland/B.S.	Technical Editing	Over 3 years experience in performing editing and production of NEPA documents and technical reports.	Editing and production of EIS

Section 8

Glossary

Section 8. Glossary

advected - horizontally or vertically transported, as by a current

ambient - the existing level of air pollutants or other environmental factors

amphipods - an order of crustaceans with laterally compressed bodies, including sand fleas and beach fleas

amplitude - for a wave, the vertical distance from sea level to crest, or sea level to trough, or one-half the wave height

anadromous - migrating from the sea up rivers to breed in fresh water; salmon are anadromous

annelids - members of the phylum annelidea; includes segmented worms such as polychaetes

bathymetric - pertaining to seafloor elevations and variations of water depth

benthic - of the seafloor, or pertaining to organisms living on or in the seafloor

bioaccumulation - the uptake of substances, such as heavy metals, leading to elevated concentrations of those substances within plant or animal tissues

biomass - the weight of living organisms in a given area or volume at a given time

biota - the plants and animals living in a given area

bivalves - marine shellfish with two shells, such as oysters and clams

bloom - an explosive growth of algae that can contribute to reduced clarity of the water

box core - a device used to collect sediment samples from the ocean floor

carbon monoxide (CO) - a colorless, odorless gas resulting from incomplete combustion; high concentrations can cause sickness and death in humans

carnivorous - having a diet consisting of the flesh of other animals

chlorophyll - a pigment found in plants that converts sunlight, water, and carbon dioxide into sugars needed for plant growth; gives green plants their color chlorophyll a - a specific chlorophyll pigment characteristic of higher plants and algae, frequently used as a measure of phytoplankton biomass

copepods - a large diverse group of small planktonic crustaceans representing an important link in oceanic food chains

cosmopolitan species - species with world-wide distribution

crustaceans - a class of animals with jointed legs and hard external skeletons; includes crabs, barnacles, shrimp, and lobsters

decapods - crustaceans such as crabs, lobsters, and shrimp having 10 legs

demersal - living at or near the bottom of the sea

deposit-feeder - an animal which feeds on organic material in and on the seafloor

diatoms - microscopic phytoplankton with a cell wall made of overlapping silica plates

dinoflagellates - a large, diverse group of phytoplankton with flagella (whip-like appendages used for locomotion); some dinoflagellates are responsible for toxic red tides

dissolved oxygen (DO) - the quantity of oxygen dissolved in a unit volume of water

diversity - a statistical measurement which generally combines a measure of the total number of species in a given environment with the number of individuals of each species; species diversity is high when there are many species with a similar number of individuals, and low when there are fewer species and when one or two species dominate

echinoderms - a group of marine invertebrates that includes sea urchins, sea cucumbers, sea stars, and sand dollars

epifauna - animals that live on bottom sediments or hard surfaces

epipelagic zone - the upper portion of the pelagic zone, including surface waters

estuary - a partially enclosed coastal body of water where fresh water (such as a river) and salt water mix

euphasiids - planktonic, shrimp-like crustaceans

faunal group - a group of biologically or ecologically related animals

flagellates - one-celled animals with flagella (whip-like appendages used for locomotion) food web - the complex of feeding relationships within a community of organisms including production, consumption, decomposition, and the flow of energy within the community and the environment

gastropods - mollusks that have a distinct head, a flat foot, and usually a spiral shell, such as snails

hopper dredge - a self-propelled vessel with capabilities to dredge, store, transport, and dispose of dredged materials

hydrocarbons (HC) - organic compounds containing only hydrogen and carbon, occurring in petroleum, natural gas, and coal

hydrographic - related to the physical conditions of waters

infauna - animals that live in the bottom sediment

insolation - exposure to sunlight

invertebrates - a group of animals lacking backbones; includes many marine species such as worms, jellyfish, snails, and clams

jetty - a structure located to influence currents or protect the entrance to a harbor or river from waves

littoral - of or pertaining to the seashore, especially the area between tide lines

macrofaunal - pertaining to animals large enough to see with the unaided eye

macroinvertebrates - animals lacking backbones (invertebrates) that are large enough to be visible to the unaided eye

mollusk - a group of animals lacking body segments and usually having a shell made of calcium; examples are snails, clams, and octopus

multiple-port diffuser - the terminus of an outfall pipe fitted with several holes or ports to enhance the mixing of effluent in receiving waters

nitrogen oxides (NO_x) - a group of compounds containing varying proportions of nitrogen and oxygen; one of these, nitrogen dioxide, is a primary component of smog

omnivorous - having a diet consisting of both plants and animals

otter trawl - a large conical net dragged along the seafloor to catch fish and other marine life

pelagic - pertaining to near surface waters of the ocean phytoplankton - that portion of the plankton that consists of microscopic plants

plankton - the passively floating or weakly swimming, usually microscopic plant and animal life in a body of water

particulate matter (PM) - particulates suspended in the air that contribute to air pollution

PM_{10} - particulate matter smaller than or equal to 10 microns in diameter; PM_{10} is of health concern because particles this size are small enough to reach the lungs when inhaled

polychaetes - a type of marine worms

primary production - the amount of organic matter (such as starches) produced by plants from inorganic substances per unit time and volume of water

reactive organic gases (ROG) - the components of organic gases which react with nitrogen oxides to form ozone

salinity - a measure of the salt content of water

seabed drifter (SBD) - an umbrella-shaped device which is used to determine the direction of transport along the seafloor

sulfur dioxide (SO_2) - an air pollutant that reacts with sunlight and other pollutants to contribute to atmospheric haze

suspension-feeder - an animal that feeds on nutrients and other animals suspended in the water column

synergistic effect - an effect caused by two or more interacting factors

tectonic - relating to the movement of the earth's crust and production of earthquakes

Tertiary - a geologic period of time between 65 and 2 million years ago

topography - the description of the physical features of a place or region

transmittance - a measure of light passing through a specific distance in water, used as a measure of light penetration or water clarity

trophic level - the position of an organism in a food chain or food web such as primary producers, secondary producers, consumers, and detritivores

turbidity - the measure of sediment suspended in a volume of water

upwelling - the rising of nutrient-rich bottom waters to the surface; usually the result of divergent surface currents wave period - time required for two successive wave crests or troughs to pass a fixed point

zoea stage - a stage in the development of certain crustaceans such as crabs

zooplankton - that portion of the plankton that consists of microscopic animals

Section 9

References

Section 9. References

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Appendix A

Zone of Siting Feasibility Analysis for the Humboldt Harbor and Bay Ocean Dredged Material Disposal Site

ZONE OF SITING FEASIBILITY ANALYSIS
FOR THE HUMBOLDT HARBOR AND BAY
OCEAN DREDGED MATERIAL DISPOSAL SITE

US Army Corps of Engineers
San Francisco District

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April 1989

1.0 INTRODUCTION

1.1 PURPOSE

The San Francisco District of the U.S. Army Corps of Engineers has prepared a Zone of Siting Feasibility (ZSF) analysis to establish an outer boundary within which to evaluate candidate ocean disposal sites for disposal of dredged sediments from Humboldt Harbor and Bay, California. Determination of the outer limit of the ZSF is based on an evaluation of operational and economic constraints for authorized dredging and disposal projects in Humboldt Harbor and Bay. Upon completion of the ZSF, the Corps of Engineers (COE) in consultation with the Environmental Protection Agency (EPA), will investigate candidate ocean sites for the purpose of the EPA designating a permanent ocean site for dredged material under Section 102 of the Marine Protection, Research, and Sanctuaries Act (MPRSA) of 1977 and EPA's Ocean Dumping Regulations and Criteria (40 CFR 220-225, 227-229). In the past, the San Francisco District COE used the EPA interim designated ocean disposal site SF-3 located 1.1 nautical miles (nmi) outside Humboldt Bay, for disposal of sediments dredged from Humboldt Harbor and Bay navigation channels. However, the SF-3 ocean disposal site lost its interim status as an approved ocean disposal site on December 31, 1988. Currently, there are no EPA designated ocean disposal sites available for disposal of material dredged from Humboldt Harbor and Bay

1.2 REPORT ORGANIZATION

This report documents the initial review process for identifying a general area, based upon operational and economic considerations, within which unconfined, open water disposal of dredged material could take place. In Chapter 2, a general description of the area evaluated, the operational considerations, and the economic factors are presented. Afterwards, the considerations and factors are evaluated to delineate the Zone of Siting Feasibility (ZSF). The evaluation is based on review of the available literature and information on the study area.

1.3 PROCEDURES FOR SITE DESIGNATION

General procedures and criteria for designating ocean disposal sites are specified in the Ocean Dumping Regulations (40 CFR 220 (July 1, 1986) et seq.) which implement Title I of the Marine Protection, Research, and Sanctuaries Act. The COE and the EPA have added to this general framework by developing the concept of the ZSF (COE/EPA 1984; Science Applications International Corporation 1986). The ZSF analysis defines the area within which disposal of dredged material would be feasible based on operational and economic criteria. Candidate disposal sites within this zone are then evaluated according to environmental and important resources criteria. The EPA has determined that an Environmental Impact Statement (EIS) or its functional equivalent will be issued by the EPA for each of its disposal site designations under Section 102 of the MPRSA (Memorandum of Understanding Between the Department of the Army and the EPA 1987). The EIS prepared for this ocean disposal site designation will contain an evaluation of each of the candidate sites within the Zone of Siting Feasibility, including the preferred site. The lead agency for the site selection EIS will be Region IX of EPA; the COE will be a cooperating agency. The EIS will comply with all aspects of the National Environmental Policy Act (NEPA). Based upon guidance developed jointly by the EPA and COE (General Approach To Designation Studies For Ocean Dredged Material Disposal Sites - May 1984), the designation process is structured into three major phases, see Figure 1-1. Phase I includes delineation of the general area being considered for site designation (Zone of Siting Feasibility) and identification and collection of necessary information on resources, uses and environmental processes for the area. Phase II involves identification of candidate sites within the area based on information collected and processed in Phase I. The final Phase III includes evaluation of candidate sites and selection of a site or sites for designation.

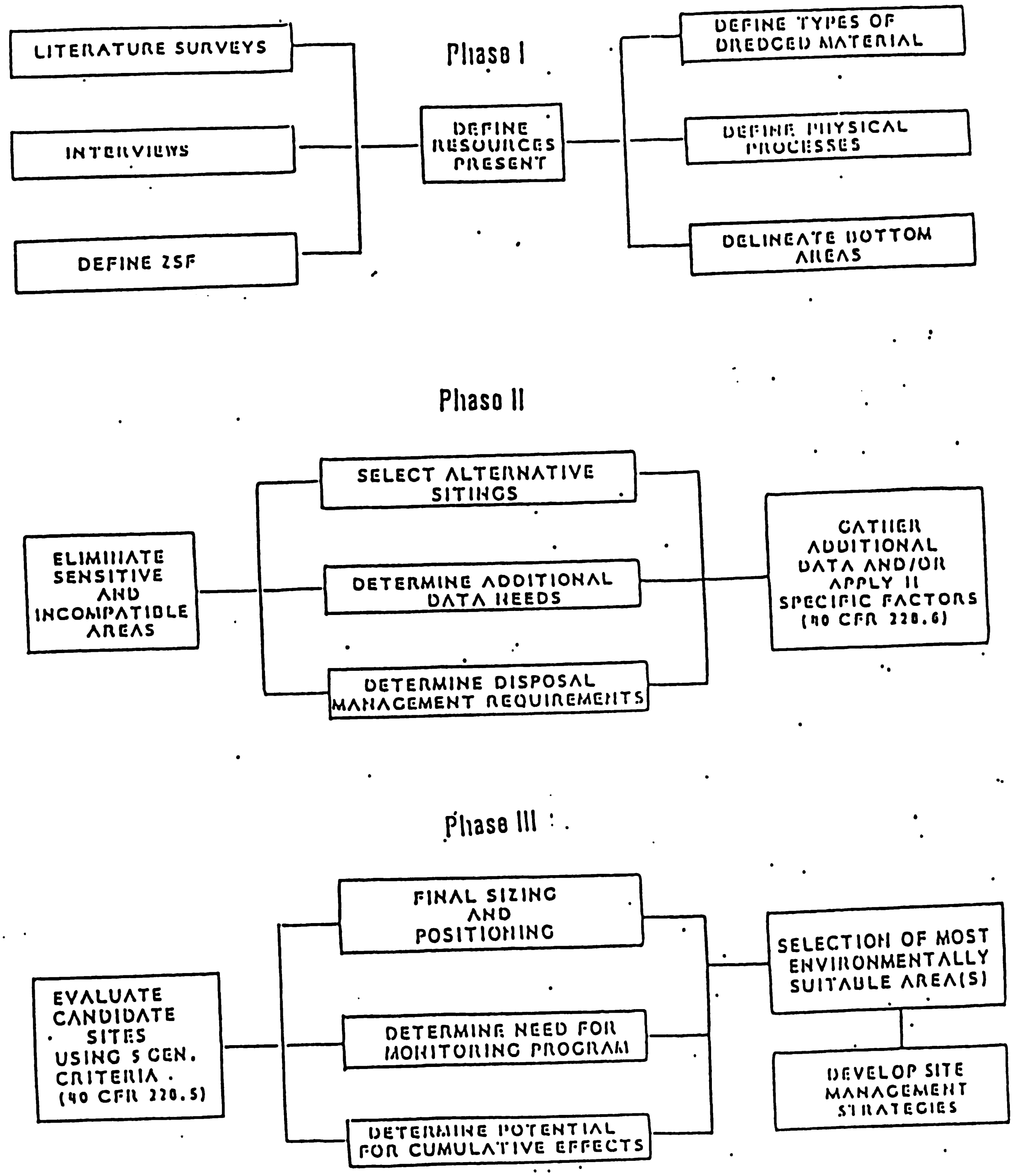
1.4 NEED FOR OCEAN DISPOSAL

1.4.1 LOCAL NEED

Humboldt Harbor and Bay is the only naturally enclosed, deep-draft harbor for major commercial shipping between San Francisco, California, and Coos Bay, Oregon. The harbor provides berthing for deep-draft vessels serving the forest products industry on the Bay and a large commercial fishing fleet as well. Humboldt Bay consists of two shallow basins, South Bay in the south and Arcata Bay in the north, connected by a narrow channel approximately 5 miles long. Natural sediment transport processes result in the shoaling of the harbor and entrance channels. An average of 740,000 cubic yards of material is dredged annually by the COE to maintain sufficient operating depths to accommodate commercial shipping traffic.

Authorized dimensions of the Humboldt Harbor and Bay project are as follows: the entrance channel to Humboldt Harbor and Bay is approximately 9,000 feet long with channels branching to the northeast (North Bay Channel - which at its northern terminus branches into the Eureka Channel and Samoa Channel) and to the south (Fields Landing Channel and Turning Basin), see Figure 1-2; the Bar and Entrance Channel decreases in width from 1,600 to 500 feet and has a project depth of 40 feet Mean Lower Low Water (MLLW); the North Bay Channel is 18,700 feet long and 400 feet wide with a project depth of 35 feet; Samoa Channel is 8,200 feet long, 400 feet wide and 35 feet deep, and the adjoining turning basin is 1,000 feet wide by 1,100 feet long and 35 feet deep; Eureka Channel from mile 4.29 to mile 5.00 (3750 feet) is 400 feet wide and 35 feet deep, and from mile 5.00 to mile 6.30 (6,900 feet) is 400 feet wide and 26 feet deep; Fields Landing Channel is 12,000 feet long, 300 feet wide and 26 feet deep and, the adjoining turning basin is 600 feet wide and 800 feet in length with a depth of 26 feet. See Figure 1-2 for location of Humboldt Harbor and Bay Federal navigation channels.

FIGURE 1-1. Three Phase Designation Process



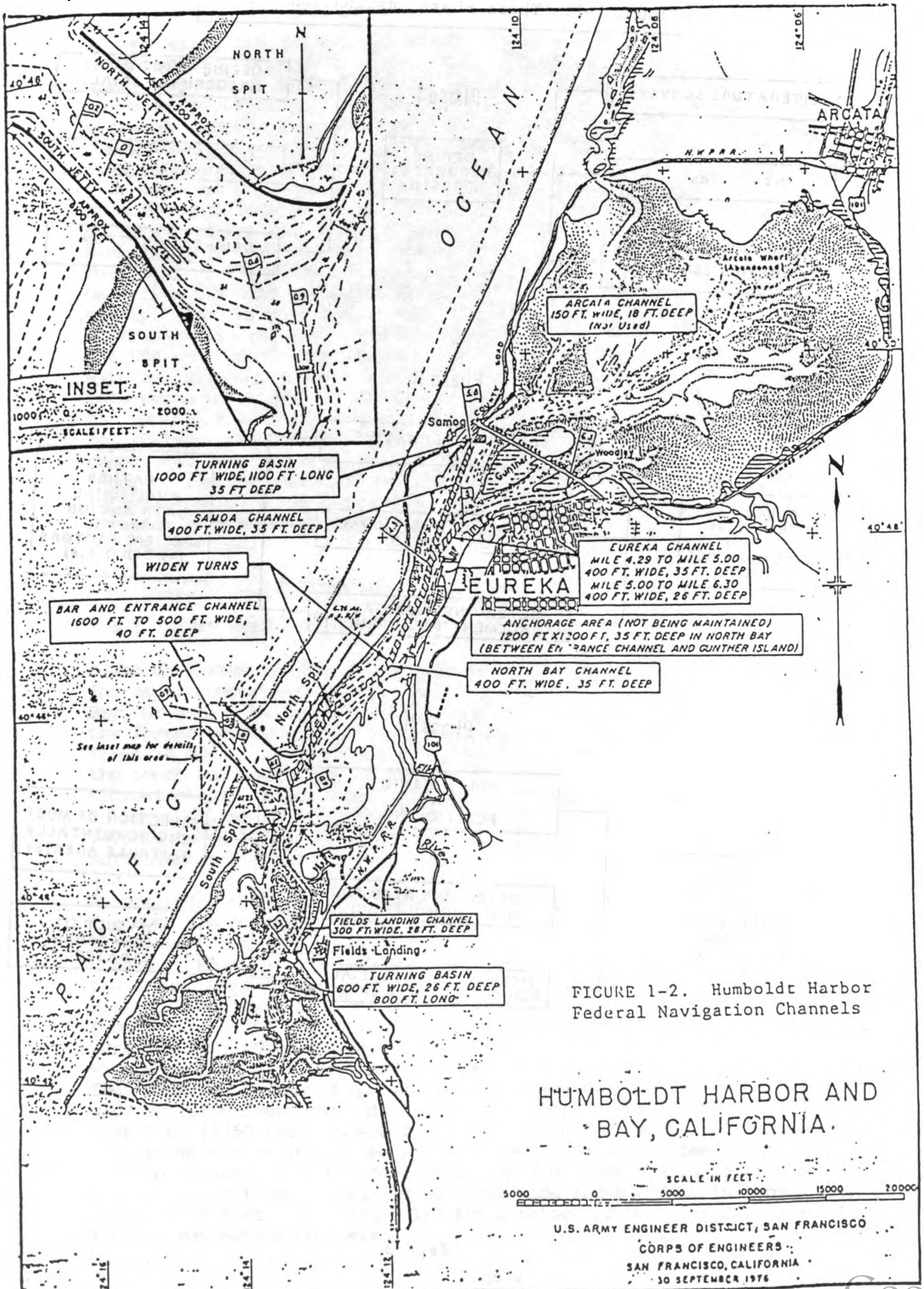


FIGURE 1-2. Humboldt Harbor Federal Navigation Channels

Shoaling occurs rapidly in the Bar and Entrance Channel as a result of the large volume of littoral material in transport along the northern California Coast. The Bar and Entrance channel requires annual dredging to maintain safe depths for deep draft vessels. The other in-bay channels taken individually require dredging less frequently, however, each year there is a need to dredge specific in-bay channels. Table 1-1 shows average annual amounts of material dredged from the Humboldt Harbor and Bay navigation channels.

Corps of Engineers records indicate that over the past 12 years, approximately 350,000 cubic yards of sediment has been dredged from Humboldt Harbor and Bay under authorization from the COE regulatory program. These projects typically involved dredging of local public marinas and forest product berthing facilities. Disposal of dredged material was accomplished either by contained upland disposal, or uncontained beach disposal. Ocean dumping at Disposal Site SF-3 was not utilized for any projects authorized under the COE regulatory program during this twelve year period. In some cases, this resulted from the higher cost and nonavailability of equipment required for ocean disposal.

1.4.2 PAST OCEAN DISPOSAL

1.4.2.1 Disposal Site SF-3

Since the 1940's, sediments dredged from the Humboldt Harbor and Bay navigation channels have been disposed of at the EPA interim-designated disposal site SF-3, located offshore and to the south of the entrance jetties at the mouth of Humboldt Bay. Disposal site SF-3 was granted interim designation by the EPA in 1977 (40 CFR 228.12(a)). However, the National Wildlife Federation (NWF) filed suit against EPA in 1977 challenging the legality of interim site designations nationwide. NWF contended that the interim designations permitted the use of sites that had not been evaluated according to the criteria stipulated in MPRSA, and that use of such interim sites should halt pending completion of the requisite analysis. Although the court ruled in favor of EPA, EPA and NWF entered into a Consent Agreement whereby EPA would complete EISs for a number of the interim designated sites. SF-3 was included in the Consent Agreement and required the preparation of an EIS prior to designation. Due to the mounding of dredged material at the SF-3 disposal site, and subsequent concern about navigational safety in the vicinity of SF-3, the COE did not pursue Final designation of SF-3 as an EPA approved ocean disposal site. Consequently, as of December 31, 1988, Disposal Site SF-3 was dedesignated, as its interim status expired. Therefore, no EPA approved ocean disposal site currently exists to receive sediments dredged from COE authorized work in Humboldt Harbor and Bay.

TABLE 1-1

CORPS OF ENGINEERS
AVERAGE ANNUAL MAINTENANCE DREDGING
FOR HUMBOLDT BAY

Bar and Entrance Channel

1975 - 1980	Six Year Average	362,160 Cubic Yards/Year
1981 - 1986	Six Year Average	640,387 Cubic Yards/Year
1975 - 1986	Twelve Year Average	501,274 Cubic Yards/Year

Cubic Yards/Year Applied in Economic and Operational
Evaluation of ZSF = 550,000 CY/Year

North Bay Channel

1975 - 1980	Six year Average	93,583 Cubic Yards/Year
1981 - 1986	Six Year Average	139,348 Cubic Yards/Year
1975 - 1986	Twelve Year Average	116,465 Cubic Yards/Year

Cubic Yards/Year Applied in Economic and Operational
Evaluation of ZSF = 120,000 CY/Year

Samoa Channel

1982		63,439 Cubic Yards/Year

Cubic Yards/Year Applied in Economic and Operational
Evaluation of ZSF = 10,000 CY/Year

Fields Landing Channel

1985 - 1986	Two Year Average	56,300 Cubic Yards/Year

Cubic Yards/Year Applied in Economic and Operational
Evaluation of ZSF = 50,000 CY/Year

Eureka Channel

1966 - 1969	Four Year Average	77,228 Cubic Yards/Year
1971 - 1976	Six Year Average	5,000 Cubic Yards/Year
1986		7,150 Cubic Yards

Cubic Yards/Year Applied in Economic and Operational
Evaluation of ZSF = 10,000 CY/Year

1.4.2.2 Beach Nourishment

Past sediment particle-size analysis, performed prior to COE dredging of the Bar, Entrance, and North Bay channels, has consistently shown that the majority (>95%) of sediment removed from these channels was fine to course grained sand. Sediment samples taken from the Fields Landing channel have varied in particle size composition, with samples containing up to 50% silt or clay combined with 50% sand. The results of particle-size analysis taken prior to COE dredging of the Samoa and Eureka channels have shown that in some years, sediments are composed of fine to medium grained sand with some silt, and in other years, sediments are composed primarily of silt and clays. The Samoa and Eureka channels are dredged less frequently than the other Humboldt Harbor and Bay navigation channels.

In the fall of 1988, the COE performed advanced maintenance dredging of approximately 832,000 cubic yards of sediment from the Bar, Entrance, and North Bay channels. The dredged material contained greater than 95% sand. Disposal of this sandy material was accomplished by a first time ever use of a nearshore ocean disposal site, authorized under Section 103 of the MPRSA. The nearshore disposal site is rectangular with dimensions of 4,500 feet by 1,100 feet within the -50 foot Mean Lower Low Water (MLLW) and -60 foot MLLW contours and and having coordinates 40 44'46"N; 124 15'36'W; 40 44'42"N; 124 15'23"W; 40 44'05"N; 124 15'59"W; and 40 44'01"N; 124 15'46"W; see Figure 1-3. The center of the rectangular disposal site is located at a distance of approximately 2 nautical miles (nmi) southwest from the Humboldt Bay Jetty Heads. The nearshore ocean disposal site is not a general use (MPRSA 102) designated ocean disposal site. The COE anticipates that disposal of sandy material at the nearshore site, would keep the sand in the littoral current cell, and possibly provide beach nourishment to the south spit. As part of the nearshore ocean disposal operation, the COE is conducting a pre- and post-disposal site monitoring program. If the nearshore ocean disposal site is found to be successful for retaining sandy dredged material in the littoral transport process, and does not pose any environmentally unacceptable consequences, pursuit of EPA designation of the nearshore ocean disposal site, would be considered. Disposal of dredged material at the nearshore site would be evaluated under Section 404 of the CWA (33 CFR 336.0(b)). The nearshore site, however, would be unavailable to accept all material dredged from Humboldt Harbor and Bay. It would only be available for use by those projects with sediment composed predominantly of sand, and during that period of time when any adverse environmental impacts would be minimal (e.g. the largest population of Dungeness crabs to potentially migrate through the Nearshore ocean site occurs from November through June, therefore it is unlikely that disposal at the Nearshore site should occur during this period). Other material, such as that coming from the Fields Landing, Samoa, and Eureka channels, which may not be composed predominantly of sand, and typically dredged during the spring months, would either have to be disposed of at a contained upland disposal site, or, at an acceptable ocean disposal site. Also, operational considerations such as sea state conditions, which may effect safe hopper dredge transport to and from the nearshore site, could at times preclude the use of the site. In addition, should future dredged material from the Bar, Entrance, and North Bay channels fail to be composed predominantly of sand, the nearshore site may not be an environmentally acceptable location for disposal of such material. Therefore, a need exists to locate and designate a dredged material ocean disposal site or sites capable of receiving all material dredged from Humboldt Harbor and Bay.

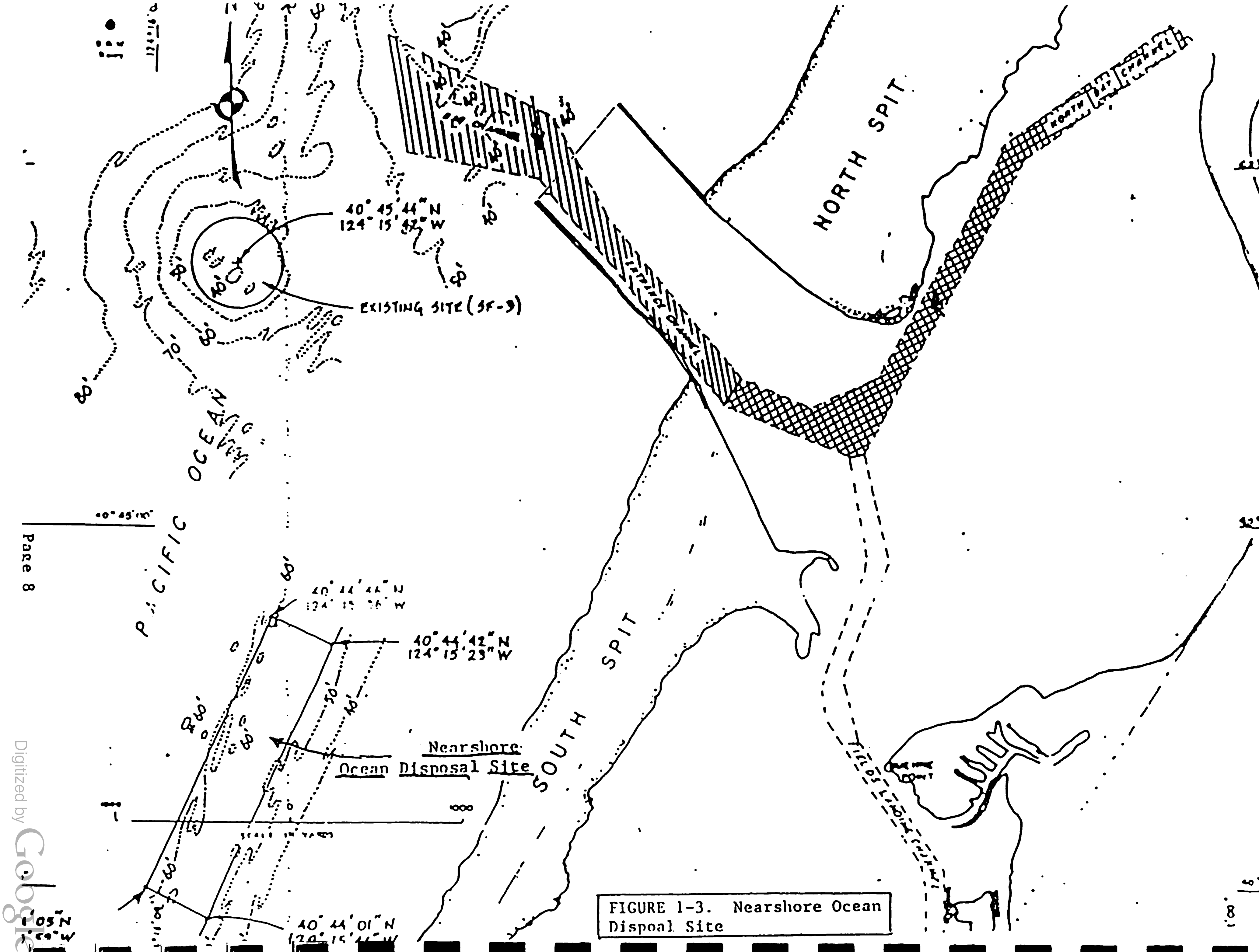


FIGURE 1-3. Nearshore Ocean Dispoal Site

2.0 ZONE OF SITING FEASIBILITY

2.1 INTRODUCTION

An ocean dredged material disposal site must fulfill certain basic criteria to be considered feasible for use by the COE. The site must be economically and operationally feasible, and not pose unacceptable adverse impacts to the marine environment and important resources. The designation process will utilize a hierarchical framework which initially defines a zone of economic and operational feasibility within which candidate locations for disposal sites may be evaluated. Further sabres within the ZSF may be eliminated upon their identification as zones of incompatibility. Areas and resources which may be incompatible with disposal of dredged material include geographical boundaries of fisheries and shell fisheries, navigation lanes, marine sanctuaries, beaches, shipwrecks and other cultural sites, habitats of endangered, threatened, or rare species, mineral extraction sites, industrial or municipal water intake areas.

The EPA and COE joint document titled General Approach To Designation Studies For Ocean Dredged Material Disposal Sites, May 1984, provides the following guidance:

> "A site to be designated for the ocean disposal of dredged material must be located within an economically and operationally feasible radius from the point of dredging. This is called a Zone of Siting Feasibility (ZSF). The delineation of the ZSF in selecting a disposal site is dictated by several factors. Important among these are:
>
> - Cost of transporting dredged material to the disposal site and costs of the navigation project.
> - Type of dredging and disposal plant
> - Navigation restrictions
> - Political boundaries
> - Distance to the edge of the continental shelf
> - Feasibility of monitoring and surveillance"

2.2 ANALYSIS TO DETERMINE BOUNDARY LOCATION

2.2.1 APPROACH

For this analysis, the outer limits of the ZSF are determined by operational and economic constraints. Operational factors include equipment type and availability, sea condition limitations, vessel safety, disposal surveillance, and environmental monitoring of the disposal site. Economic factors are primarily controlled by the haul distance to the disposal site, but can also be affected by equipment type and availability, weather or sea conditions, and fuel use.

2.2.2 OPERATIONAL CONSIDERATIONS

2.2.2.1 Equipment Type and Availability. The predominant volume of material to be dredged (an average of 550,000 CY at the Bar and Entrance Channel and 80,000 CY of the 120,000 the North Bay Channel) lies within channel reaches which are located in an exposed ocean environment subject to large swells, breaking seas, and strong currents. Fixed plant operations such as clamshell dredges with dump scows and hydraulic pipeline dredges would be in jeopardy and subject to severe damage if operated at the aforementioned locations. Therefore, fixed plant operations are not considered a viable alternative available to perform necessary dredging for the major portion of work in Humboldt Harbor and Bay.

The remaining volumes within the interior channels (averaging 10,000 CY at Samoa Channel, 10,000 CY at Eureka Channel, 50,000 CY at Fields Landing Channel, and the remaining 50,000 CY at the North Bay Channel) could be dredged by clamshell or hydraulic pipeline equipment. Both types of equipment would have extremely high mobilization and demobilization costs as the closest location of this equipment is the San Francisco Bay Area, located approximately 225 nautical miles to the south. An alternative would be to clamshell dredge the interior channels with disposal by tug and dump scow at an ocean site. However, this alternative would result in low production and very high cost. From an operational perspective, the viable alternative is to tie the maintenance dredging of the interior channels to the dredging of those channel reaches exposed to the ocean. Historically, this later alternative is the operational policy used by the COE, with dredging performed by sea-going hopper dredges. For the operational and economic analyses performed as part of this ZSF, hopper dredges will used as the plant in all analyses.

Currently, the availability of both private and government hopper dredges, is limited due to equipment allocation among nine Oregon coastal projects, two Washington projects, seven California projects, and one Navy project.

2.2.2.2 Sea Condition Limitations. Dredging and disposal operations along the coastal region of the Northwest Pacific are susceptible to restriction by weather and sea state conditions. Severe winds and wave conditions produced by extratropical cyclones occur along the Northern California Coast from November to May and severe storms develop an average of two to three times per month during the winter.

Regionally, the Northwest Pacific is dominated by the North Pacific High during the late spring and summer months. In the Humboldt Bay area, summer winds are characteristically from the northwest, with intensification in the afternoon in response to the thermal low in the central valley of California. Wind speeds during late spring and summer months average 5 to 15 knots. When the high weakens near the end of summer, wind patterns are dominated by low pressure systems migrating from the Aleutian Low. Winds associated with this low pressure system are typically from the southwest and much stronger than during the summer; averaging 10 to 20 knots with maximums of 50 to 55 knots (Borgeld and Pequegnat, 1983). The result of this seasonal change in wind and weather conditions, is that Humboldt Bay, in addition to exposure to high waves and swell from distant Pacific storms, is also exposed to high waves and winds generated by local coastal storms. When such storms occur, wave action often makes the Humboldt Bay and Harbor entrance channel impassable.

Wave data for the vicinity of Humboldt Bay have been collected by wave rider buoys installed by the U.S. Army Corps of Engineers (1980, 1981, and 1982). The wave spectra show a basic seasonal pattern similar to the wind data previously discussed. During the winter months (late October through early April) the wave data are dominated by longer period swell(periods greater than 12 seconds) generated by distant storms. The rest of the year the spectra demonstrate a greater predominance of locally generated waves (periods less than 12 seconds) (Borgeld and Pequegnat, 1983).

In response to hazardous climatic wind and wave conditions generated on a seasonal basis, the COE has attempted to confine its period of maintenance activity to the months April through October. Even during this preferred period of operation, unpredictable rough seas and unusually large swells are characteristic of the Humboldt Bay entrance, and often make dredging operations hazardous and time consuming. Typically, during this preferred period of operation, a 60% efficiency rate for small class hopper dredges and a 75-80% rate for medium class hopper dredges is reported for dredging activities in Humboldt Harbor and Bay. It is anticipated that should dredging and disposal operations occur outside the preferred period of operation (April through October), the efficiency rate for hopper dredges working in Humboldt Harbor and Bay would decrease from those numbers stated above. The efficiency rate defines the percentage of time the dredging plant is typically operational during the contract period as a result of lost time due to inclement weather or sea conditions, shipping delays, minor repairs, and etc.

2.2.2.3 <u>Navigational Safety</u>. In the past, traversing the Bar Channel to the Humboldt Harbor and Bay entrance channel was considered treacherous and dangerous. Even with present improvements, extreme caution must be used when crossing the bar due to rapid changes in channel sea conditions. The bar is smoothest during the last of the flood current, and it is often passable at this time and impassable 1/2 hour later, when the ebb current has set in.

Pilots report that strong currents create a north set in the Bar Channel from October to April (U.S. Coast Pilot 7, NOAA, 1988). When vessels enter the channel between the jetties at low speed, this hazardous current, sometimes has a tendency to turn vessels by setting the stern north and the bow south toward the south jetty.

COE and contractor hopper dredges enter and depart Humboldt Bay only when bar conditions allow safe navigation between the work and the ocean disposal site. Work on the bar channel itself will halt when conditions make it unsafe to operate dredging equipment in the channel.

COE operations include hydrographic survey monitoring of the ocean disposal site bathymetry. These hydrographic surveys are conducted prior to and following the completion of channel dredging. The degree of accuracy of hydrographic surveys is very much influenced by the wave conditions at the time of surveying. Survey crew safety and methods of horizontal survey positioning are both subject to being adversely impacted as a result of increasing disposal site distance from Humboldt Bay.

Consideration of operational time constraints reflective of insuring the navigational safety of plants and survey vessels working on Humboldt Bay and Harbor maintenance dredging projects, poses a restricting factor in the number of operational days available to the Corps for completion of annual maintenance work.

2.2.2.4 Dredge Production Analysis. A production analysis for hopper dredging and ocean disposal has been prepared for each of the Federal navigation channels in Humboldt Bay (Bar and Entrance, North Bay, Samoa, Eureka, Fields Landing). A determination of project completion time for harbor dredging and disposal at various ocean sites (ocean sites varied by distance in nautical mile radii from the mid-point between the end of the jetty heads), and comparison of project completion times, was the scope of this analysis. The results of the production analyses are presented in Table 2-1. Dredging and disposal time for each Federal navigation channel verses disposal distance are presented in Appendix A.

2.2.2.5 Factors used in dredge production analysis.

-Average cycle time.

This consists of estimating (in minutes) the time of a dredge cycle which is composed of: pumping time, turning time, haul time, and dump time; all of which when totaled equal the average cycle time.

-Monthly Production.

Monthly production analysis used the following factors:

A. Available Minutes/Day

B. Average Cycle Time

C. Percent (%) Efficiency Time

D. Number of Loads/Day

E. Cubic Yards/Load

F. Operating Days/Month

G. Monthly Production Rate = Cubic Yards/Month

TABLE 2-1. HUMBOLDT HARBOR DREDGING AND DISPOSAL OPERATIONAL PERIOD AS A FUNCTION OF HAUL DISTANCE TO THE DISPOSAL SITE.

CHANNEL / DISPOSAL SITE	ANNUAL VOLUME C.Y.	DREDGE & DISPOSAL TIME (DAYS) w/o MOB & DEMOB/b/	DREDGE & DISPOSAL TIME (DAYS) with MOB & DEMOB
Bar & Entrance Channel			
1.1 nmi from Jetty Head /a/	550,000	16.2	19.4
2.0 nmi from Jetty Head	550,000	19.4	22.5
3.0 nmi from Jetty Head	550,000	23.0	26.1
5.0 nmi from Jetty Head	550,000	30.2	33.4
10.0 nmi from Jetty Head	550,000	48.0	51.2
20.0 nmi from Jetty Head	550,000	84.3	87.3
North Bay Channel			
1.1 nmi from Jetty Head /a/	120,000	6.0	9.1
2.0 nmi from Jetty Head	120,000	6.7	9.8
3.0 nmi from Jetty Head	120,000	7.4	10.6
5.0 nmi from Jetty Head	120,000	9.0	12.2
10.0 nmi from Jetty Head	120,000	12.9	16.0
20.0 nmi from Jetty Head	120,000	20.6	23.8
Samoa Channel			
1.1 nmi from Jetty Head /a/	10,000	1.3	4.5
2.0 nmi from Jetty Head	10,000	1.3	4.5
3.0 nmi from Jetty Head	10,000	1.4	4.6
5.0 nmi from Jetty Head	10,000	1.6	4.8
10.0 nmi from Jetty Head	10,000	2.0	5.2
20.0 nmi from Jetty Head	10,000	2.8	6.0
Eureka Channel			
1.1 nmi from Jetty Head /a/	10,000	1.3	4.5
2.0 nmi from Jetty Head	10,000	1.5	4.7
3.0 nmi from Jetty Head	10,000	1.6	4.8
5.0 nmi from Jetty Head	10,000	1.9	5.1
10.0 nmi from Jetty Head	10,000	2.5	5.7
20.0 nmi from Jetty Head	10,000	3.8	7.0
Fields Landing Channel			
1.1 nmi from Jetty Head /a/	50,000	13.2	14.5
2.0 nmi from Jetty Head	50,000	14.9	16.2
3.0 nmi from Jetty Head	50,000	16.8	18.1
5.0 nmi from Jetty Head	50,000	20.6	21.8
10.0 nmi from Jetty Head	50,000	30.0	31.3
20.0 nmi from Jetty Head	50,000	48.9	50.2

COMBINED HUMBOLDT NAVIGATION CHANNELS		DREDGE & DISPOSAL TIME (DAYS)
1.1 nmi from Jetty Heads /a/	740,000	43
2.0 nmi from Jetty Heads	740,000	48
3.0 nmi from Jetty Heads	740,000	55
5.0 nmi from Jetty Heads	740,000	67
10.0 nmi from Jetty Heads	740,000	100
20.0 nmi from Jetty Heads	740,000	165

/a/ Dedesignted SF-3 Disposal Site
/b/ Mobilization and Demobilization of the Hopper Dredge

-Dredging time:

Dredging time simply equals the gross cubic yardage of the project divided by the monthly production rate, plus any clean-up time if necessary.

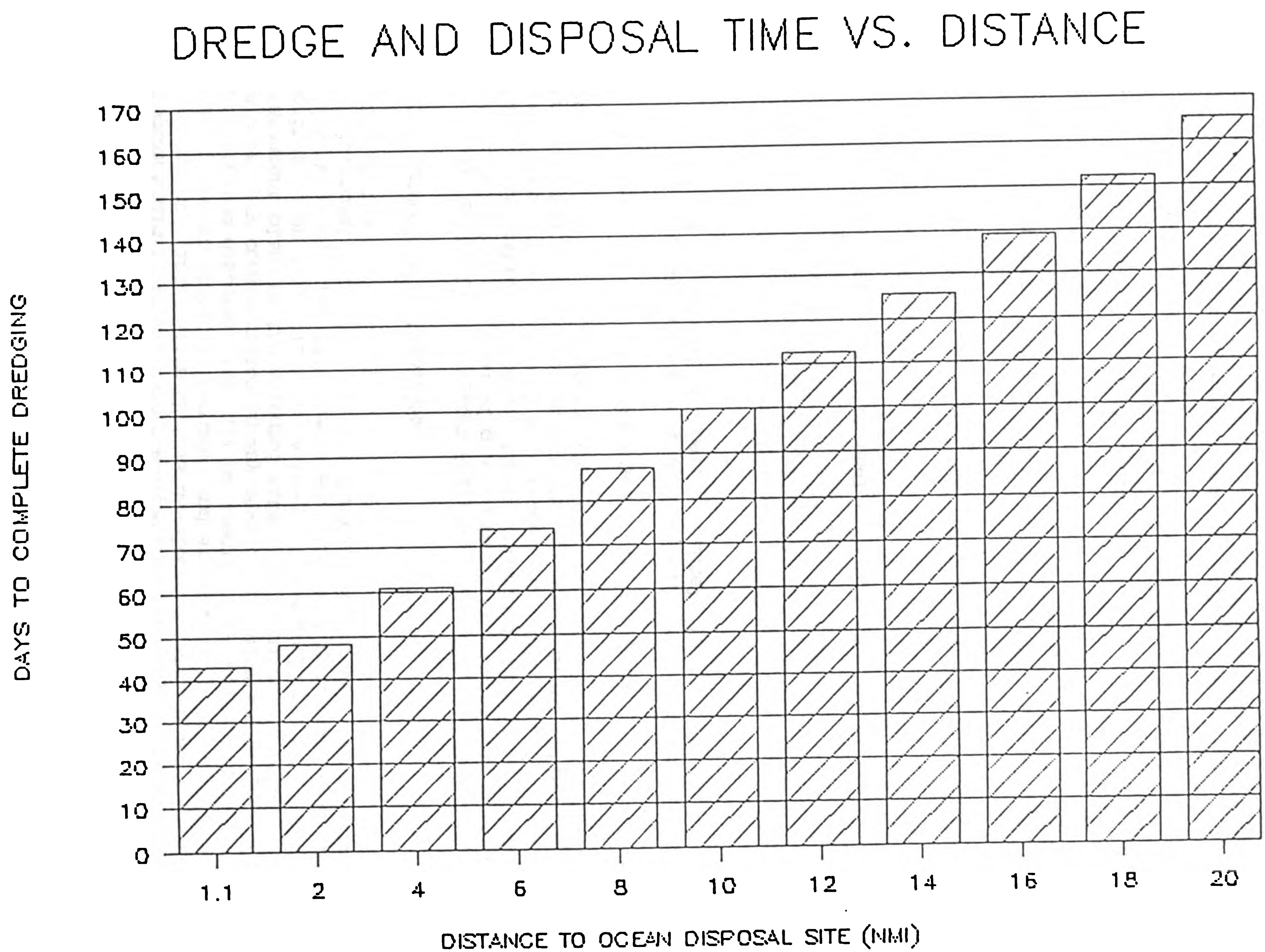
2.2.2.6 Results of Production Analysis. Table 2-1 shows the time required to complete dredging and disposal operations (one operating plant) using various ocean disposal sites ranging from the dedesignated SF-3 disposal site, out to a distance of 20 nautical miles (nmi). All ocean disposal site distances are measured from the jetty heads at the entrance to Humboldt Bay. Production analysis results show that for an ocean disposal site located 1.1 nmi (SF-3) outside Humboldt Bay, it would require 43 days to dredge and dispose of 740,000 CY of sediment from Humboldt Bay; an ocean disposal site located 3 nmi from the jetty heads would require 55 days to dredge and dispose of 740,000 CY of sediment from Humboldt Bay; a disposal site located 10 nmi from the jetty heads would require 100 days to dredge and dispose of 740,000 CY of sediment from Humboldt Bay; and a disposal site located approximately 20 nmi from the jetty heads would require 165 days to dredge and dispose of 740,000 CY of sediment from Humboldt Bay. The production analysis did not factor in decreased production efficiency due to weather delays for those disposal sites located at such a distance that they would extend the project completion time beyond 90 days, and may push the project time into the unfavorable weather period.

The increase in project completion time results from the additional time required for transporting the dredged material to the disposal site. The disposal time for hopper dredges operating from Humboldt Bay increase as a linear function of the distance to the disposal site. The efficiency of time spent dredging by a hopper dredge in relation to a dredge and disposal cycle, decreases with increasing disposal site distance from the work site. This is due to the fact that actual time dredging (loading of material) remains constant with increases in haul distance being an increasing variable.

In summary, for every nautical mile increase in distance traveled beyond the dedesignated SF-3 disposal site, there is an increase of approximately 6.5 days to complete the annual dredging requirements in Humboldt Bay, see Figure 2-1.

2.2.2.7 Surveillance Constraints. For all dredging and ocean disposal operations in Humboldt Bay, the COE requires that all dredges be equipped with an approved Electronic Positioning System (EPS) which is to be operated and maintained during the entire dredging and disposal activity. The EPS system is capable of displaying and recording a dredge's location in an acceptable coordinate system related to, or directly based on, the standard Lambert plane rectangular coordinate system. During disposal operations the EPS system displays and records the dredge's location at 1-minute intervals in the vicinity of the disposal site. Enroute to the disposal site, the EPS is activated within 1 mile from the disposal site and not deactivated until 1 mile from the disposal site. Positional data is annotated for the time actual dumping is in progress.

FIGURE 2-1


DREDGE AND DISPOSAL TIME VS. DISTANCE
DAYS TO COMPLETE DREDGING
0
10
20
30
40
50
60
70
80
90
100
110
120
130
140
150
160
170
1.1
2
4
6
8
10
12
14
16
18
20
DISTANCE TO OCEAN DISPOSAL SITE (NMI)

The requirement for the use of an EPS system for dredges operating in Humboldt Bay and utilizing an ocean disposal site, does not appear to be a restraining element in the size of the ZSF.

2.2.2.8. Monitoring Operations. A site management and monitoring plan, if deemed necessary by the Regional Administrator or the District Engineer, will be developed for any designated ocean dredge material disposal site outside Humboldt Bay. The primary purpose of the monitoring program would be to evaluate the impact of the disposal on the marine environment. Information that is developed during the site designation study phase on critical resources and areas located in close proximity to the selected disposal site will be specifically identified and emphasized as a primary consideration in any developed monitoring program and management plan for the selected site. If required, the final site monitoring program will be site specific and would not be determined until the site process has been completed. Costs of monitoring will increase with disposal site distance from Humboldt Bay as well as with increases in depth of the disposal site.

2.2.3 ECONOMIC CONSIDERATIONS

2.2.3.1. Assumptions for Cost Analysis. The COE developed cost estimates for direct ocean disposal of dredged material for each of the Humboldt Bay Federal navigation channels. The COE combined the cost of hopper dredging and disposal to obtain both a unit cost per cubic yard ($/CY) of dredged material and total volume cost (Total $) for each navigation channel (see Table 2-2). The following assumptions were used to develop the estimates:

-Type and volume of material to be dredged;

The estimated annual volume of material to be dredged from each of the Federal navigation channels in Humboldt Bay are given below:

-Bar and Entrance Channel - 550,000 CY,
-North Bay Channel - 120,000 CY,
-Samoa Channel - 10,000 CY,
-Eureka Channel - 10,000 CY,
-Fields Landing Channel - 50,000, CY

-Period of operation;

The operational days per month for dredging and disposal is 29.5.

Percent efficiency time for hopper dredges operating in Humboldt Bay is estimated at 62% for small hopper dredges and 75% for medium hopper dredges.

-Dredging and disposal equipment;

The required equipment is available.

Sea-going hopper dredges, both small and medium class, are the most efficient plant operation for Humboldt Bay.

TABLE 2-2. HUMBOLDT HARBOR DREDGING AND DISPOSAL COST PER C.Y. AS A FUNCTION OF HAUL DISTANCE TO THE DISPOSAL SITE.

CHANNEL DISPOSAL SITE	VOLUME C.Y.	UNIT COST $/C.Y.	TOTAL $
Bar & Entrance Channel			
1.1 nmi from Jetty Heads /a/	550,000	0.91	500,500
2.0 nmi from Jetty Heads	550,000	1.06	583,000
3.0 nmi from Jetty Heads	550,000	1.23	676,500
5.0 nmi from Jetty Heads	550,000	1.57	863,500
10.0 nmi from Jetty Heads	550,000	2.39	1,314,500
20.0 nmi from Jetty Heads	550,000	4.11	2,260,500
North Bay Channel			
1.1 nmi from Jetty Heads /a/	120,000	1.44	172,800
2.0 nmi from Jetty Heads	120,000	1.59	190,800
3.0 nmi from Jetty Heads	120,000	1.76	211,200
5.0 nmi from Jetty Heads	120,000	2.09	250,800
10.0 nmi from Jetty Heads	120,000	2.94	352,800
20.0 nmi from Jetty Heads	120,000	4.61	553,200
Samoa Channel			
1.1 nmi from Jetty Heads /a/	10,000	2.60	26,000
2.0 nmi from Jetty Heads	10,000	2.78	27,800
3.0 nmi from Jetty Heads	10,000	3.00	30,000
5.0 nmi from Jetty Heads	10,000	3.39	33,900
10.0 nmi from Jetty Heads	10,000	4.43	44,300
20.0 nmi from Jetty Heads	10,000	6.51	65,100
Eureka Channel			
1.1 nmi from Jetty Heads /a/	10,000	2.76	27,600
2.0 nmi from Jetty Heads	10,000	3.05	30,500
3.0 nmi from Jetty Heads	10,000	3.40	34,000
5.0 nmi from Jetty Heads	10,000	4.07	40,700
10.0 nmi from Jetty Heads	10,000	5.77	57,700
20.0 nmi from Jetty Heads	10,000	9.15	91,500
Fields Landing Channel			
1.1 nmi from Jetty Heads /a/	50,000	6.96	348,000
2.0 nmi from Jetty Heads	50,000	7.76	388,000
3.0 nmi from Jetty Heads	50,000	8.68	434,000
5.0 nmi from Jetty Heads	50,000	10.47	523,500
10.0 nmi from Jetty Heads	50,000	14.98	749,000
20.0 nmi from Jetty Heads	50,000	24.00	1,200,000
COMBINED HUMBOLDT NAVIGATION CHANNELS			
1.1 nmi from Jetty Heads /a/	740,000	-----	1,074,900
2.0 nmi from Jetty Heads	740,000	-----	1,220,100
3.0 nmi from Jetty Heads	740,000	-----	1,385,700
5.0 nmi from Jetty Heads	740,000	-----	1,712,400
10.0 nmi from Jetty Heads	740,000	-----	2,518,300
20.0 nmi from Jetty Heads	740,000	-----	4,170,300

/a/ Dedesignated SF-3 Disposal Site

-Production rates;

Dredging and disposal time is determined by an analysis of the average cycle time, monthly production rate, and monthly dredging time (see section 2.2.2.5.)

Haul time is determined by the time required to travel to and from the disposal site.

-Equipment ownership and operating costs;

Equipment ownership costs are calculated based on the following factors: depreciation, interest on capital investment, taxes, insurance and storage, and repair costs.

Operating costs include the following: payroll, fuel, water and dockage, small tools, lubricants, subsistence and quarters, travel.

Monthly field office costs are also included as an operational cost in the analysis.

Price Levels;

All cost estimates are based on the value of 1987 dollars.

2.2.3.2 Results of costs analysis. Table 2-2 shows the unit cost (dollars/cubic yard) of dredging with ocean disposal at various distances from Humboldt Bay. Table 2-2 demonstrates that disposal costs are a direct function of the increase in distance to the disposal site. Table 2-2 shows the costs required to complete dredging and disposal operations using ocean disposal sites ranging from the dedesignated SF-3 disposal site, out to a distance of approximately 20 nautical miles (nmi). Results show that for a disposal site located 1.1 nmi (SF-3) from the jetty heads, it would cost $1,074,900 to dredge and dispose of 740,000 CY of material from Humboldt Bay; for a disposal site located 3 nmi out, it would cost $1,385,700 to dredge and dispose of 740,000 CY from Humboldt Bay; for a disposal site located 10 nmi out, it would cost $2,518,300 to dredge and dispose of 740,000 CY from Humboldt Bay; and for a disposal site located approximately 20 nmi out, it would cost $4,170,000 to dredge and dispose of 740,000 CY of sediment from Humboldt Bay. The dredging and disposal costs for each Federal navigation channel verses disposal distance are presented in Appendix B.

2.2.3.3. Benefit Analysis. The maritime character of the city of Eureka and the communities of the North Spit and the South Bay is due to the presence of commercial fisherman and the docks and wharving facilities for deep-draft vessels which receive forest products and discharge chemicals and fuel. Continued maintenance of navigation channels for these vessels is vital to the community. Table 2-3 shows the quantity in short tons of the primary commodities shipped through Humboldt Harbor for the years 1987 and 1988. In addition to those commodities given in Table 2-3, commercial fishing operations are also part of the vessel traffic using maintained navigation channels at Humboldt Harbor. In 1986 and 1987, the fish and seafood landings were 12,251 tons ($9,732,800 value) and 14,507 tons ($12,957,800 value) respectively.

For the purpose of establishing a quantitative cost benefit accruing from Federal maintenance of the existing navigation channels in Humboldt Harbor, a comparison of the economic advantage of waterborne commerce over trucking was investigated. The analysis assumes that if the Humboldt Harbor were no longer available as a deep draft harbor, petroleum products would be trucked via Los Angeles and San Francisco to the Humboldt Bay area. Conversely, forest products currently being shipped from Humboldt Harbor would have to be trucked to San Francisco for shipping and distribution.

It is estimated that the cost advantage of waterborne commerce over trucking is $21.75 per ton for petroleum shipped in, and $30.00 per ton for forest products that would be trucked out to San Francisco. (1987 price levels).

If the maintenance dredging operations were halted, it is assumed that deep draft operations would become infeasible in the very near future. Using the average (mean) of 1987 and 1988 traffic figures, the affected tonnages would be 85,900 tons for petroleum products and 960,000 tons for forest products. These figures pertain to deep draft traffic only. Barge traffic and commercial fishing operations could eventually be adversely affected if maintenance dredging were halted; however, such impacts would occur in the future, and their extent is indeterminate.

The analysis is not based on a detailed study of the overall traffic patterns for all modes of transportation, but is based on limited information and the above assumptions.

In summary, the value of the harbor and maintenance dredging, compared to a scenario such that the major commodities now shipped by deep draft vessels would alternatively be trucked-in or out, is estimated to be over $30,000,000 annually.

FIGURE 2-2. PRIMARY COMMODITIES SHIPPED THROUGH HUMBOLDT HARBOR

Major Commodities -- In Short Tons

	1987 Vessel Type		1988 Vessel Type	
	Deep Draft	Barge	Deep Draft	Barge
Woodchips	322,402		453,637	
Pulp	353,942		355,231	
Logs	144,336		188,710	
Part.Bd/FibreBd	24,755	15,480	43,446	
Lumber	23,731	201,316	11,442	181,366
Total Forest Products, incl Lumber	869,166	216,719	1,052,446	181,366
Petro.Products	95,211	325,334	76,601	319,516
Chemicals		79,419		71,102
Totals	964,377	622,049	1,129,067	571,984
Overall Total	1,586,426		1,701,051	

2.3 ZONE OF SITING FEASIBILITY DETERMINATION

2.3.1. ZSF ANALYSIS

2.3.1.1 Overview. The intent of the ZSF analysis is to define a region in which the disposal of dredged material at a specific offshore ocean site would be practicable. Both operational and economic factors are considered in defining the zone. For the purpose of this analysis, since the San Francisco District COE has historically been the sole user of a dredge material ocean disposal site for Humboldt Bay dredging, operational and economic constraints have been evaluated with respect to the COE annual maintenance program for Humboldt Bay Federal navigation channels.

2.3.1.2 Operational ZSF. Determination of the operational boundary of the Humboldt ZSF is based upon two primary operational restrictions which are significant not only to Humboldt Bay, but to much of the Pacific Northwest region. These restrictions are: plant availability (ocean-going hopper dredges); and, weather and sea state conditions.

As a result of the various seasonal windows of weather and sea state conditions during which dredging and disposal may occur along coastal regions of the Pacific Northwest, and the availability of government hopper dredges to perform portions of the work, annual coordination between the COE Districts of the Pacific Northwest region is required to develop the most efficient scheduling of government hopper dredges to accomplish required work. Typically, the San Francisco District, COE attempts to schedule two episodes of dredging for Humboldt Bay per year. This requires a mixed use of both government and privately owned hopper dredges. Annually the San Francisco District COE attempts to schedule 40 to 60 days of private contractor dredging for the fall months of August to October. Fall dredging accomplishes the majority of the required annual maintenance dredging at Humboldt Bay. This includes the dredging of the Bar, Entrance and North Bay Channels, and is usually accomplished by medium class (bin capacity - 2,500 cubic yards) ocean-going hopper dredges. The San Francisco District COE also attempts to schedule 20 to 30 days of government owned hopper dredging for the spring months of April-May. The spring maintenance dredging is usually accomplished by a small class (bin capacity - 500 cubic yards) ocean-going hopper dredge, and includes, as necessary, the dredging of Fields Landing, Samoa, and Eureka Channels, and any sediment accumulated in the Bar, Entrance, and North Bay Channels since the previous fall dredging.

As previously noted, the average annual amount of material dredged from Humboldt Bay was calculated to be 740,000 CY, and this figure was used in the dredging and disposal operational and economic calculations for this study. However, it should be noted there is a degree of variability in the total amount dredged from Humboldt Bay on an annual basis. For example, in 1984 the COE maintenance dredging of Humboldt Bay required removal of approximately 506,502 CY of sediment; 1985 advance maintenance dredging of Humboldt Bay required removal of approximately 1,364,150 CY of sediments.

The operational ZSF boundary for COE maintenance dredging activities in Humboldt Bay has been set at a four nautical mile radius from the harbor jetty heads. This conclusion is based upon the combination of availability of dredging equipment plus weather and sea conditions which together limit the operational time period for completion of Humboldt Bay dredging to between 60 to 90 days. For this study, a 60 day period of allotted dredge time was chosen as the outer limit of the operational window for Humboldt Bay dredging. This was done to reflect uncertainties concerning: (1) in some years, 90 days of dredge time may not be available to the San Francisco District COE to perform maintenance work in Humboldt Bay due to scheduling conflicts with, and priorities of, other west coast maintenance projects; (2) as shown above, in some years the amount of material to be removed from Humboldt Bay navigation channels will be significantly above 740,000 CY. Should a selected disposal site be set at the furthest distance allowable based upon an assumed annual availability of 90 days of dredge time and a constant 740,000 CY annual dredging requirement, accomplishment of dredging needs above 740,000 CY, would not be possible. Therefore, the use of a 60 day window would help mitigate the uncertainty of actual dredging time available to the San Francisco District COE, and annual dredging needs which will at times exceed 740,000 CY. The time required to complete dredging of the average annual amount of 740,000 CY from Humboldt Bay, with disposal at an ocean disposal site located at a distance of four nautical miles out would be 61.5 days.

2.3.1.3 <u>Economic ZSF</u>. The cost analysis of performing Federal navigation channel maintenance at Humboldt Bay does not demarcate a zone economic feasibility within which an ocean dredged material disposal site (ODMDS) must be located. As previously stated at section 2.2.3.2 disposal costs are directly dependent and proportionate to the increase in distance of the disposal site oceanward from Humboldt Bay. The cost analysis demonstrates an increase in project cost of approximately $165,000 for every nmi traveled oceanward from the dedesignated SF-3 disposal site.

As an attempt to set an economic ZSF, an approach may be taken that compares the economic impact of discontinuing the maintenance dredging at Humboldt Harbor to the costs of transporting dredged material to alternative sites. Estimates of cost for dredging and disposal verses disposal distance are shown on Table 2-2. Considering the estimate of $30,668,330 derived in section 2.2.3.3. to be the annual value of the Humboldt Harbor from a National Economic Development benefit standpoint, it is apparent that disposing of the dredged materials as far as or greater than 20 nmi from Humboldt Bay would not be constrained by a lack of economic benefits. However, acceptable costs not only need to be considered in terms of the economic constraints on a specific project, but also in terms of impacts on regional dredging needs and budgetary constraints of the COE District.

To date, non-Federal use of an ODMDS outside Humboldt Bay has been nonexistent (section 1.4.1). Therefore, this analysis did not investigate the costs of ocean disposal that would be economically feasible for private interests in the Humboldt Harbor and Bay area.

To conclude, when dredging costs are compared to cost benefits accruing from Federal maintenance of the existing navigation channels, unlike the operational ZSF, there is not a discernible break at which hopper dredging and disposal becomes economically infeasible within the 20 nmi zone investigated. There does occur however, a fourfold increase in dredging and disposal costs between the inner and outer limits of this 20 mile zone. The COE, San Francisco District will follow the national COE "Federal standard" for dredging and disposal projects which states that "It is Corps' policy to regulate the discharge of dredged material from its projects to assure that dredged material disposal occurs in the least costly, environmentally acceptable manner consistent with engineering requirements established for the project." 33 CFR 335.7 and 33 CFR 336.1(c)(1).

2.3.2 <u>CONCLUSION</u>

Based upon operational considerations and constraints, a Zone of Siting Feasibility (ZSF) boundary for an ODMDS located outside Humboldt Bay has been set at a four nautical mile radius from the end of the Humboldt Harbor Jetty Heads, see Figure 2-2. The ZSF boundary was based primarily upon the combination of the availability of dredging equipment plus weather and sea conditions which together limit the operational time period for completion of Humboldt Bay dredging.

The Marine Protection, Research and Sanctuaries Act of 1972 and EPA Ocean Dumping Regulations (40 CFR 228.5(e)) require, whenever feasible, consideration of designating ocean disposal sites beyond the continental shelf. United States laws define the continental shelf as the seaward extension of the coast to a depth of 600 feet (100 fathoms or 183 meters). Seaward of Humboldt Bay, the continental shelf break (100 fathom contour line) occurs at an approximate distance of 10 nmi. from shore. The 100 fathom line is not encountered within the 4 nmi operational radius outside Humboldt Bay. Therefore, for Humboldt Bay, it is not feasible to designate an ocean disposal site beyond the continental shelf, and the requirement to consider an off shelf site under 40 CFR 228.5(e) is satisfied.

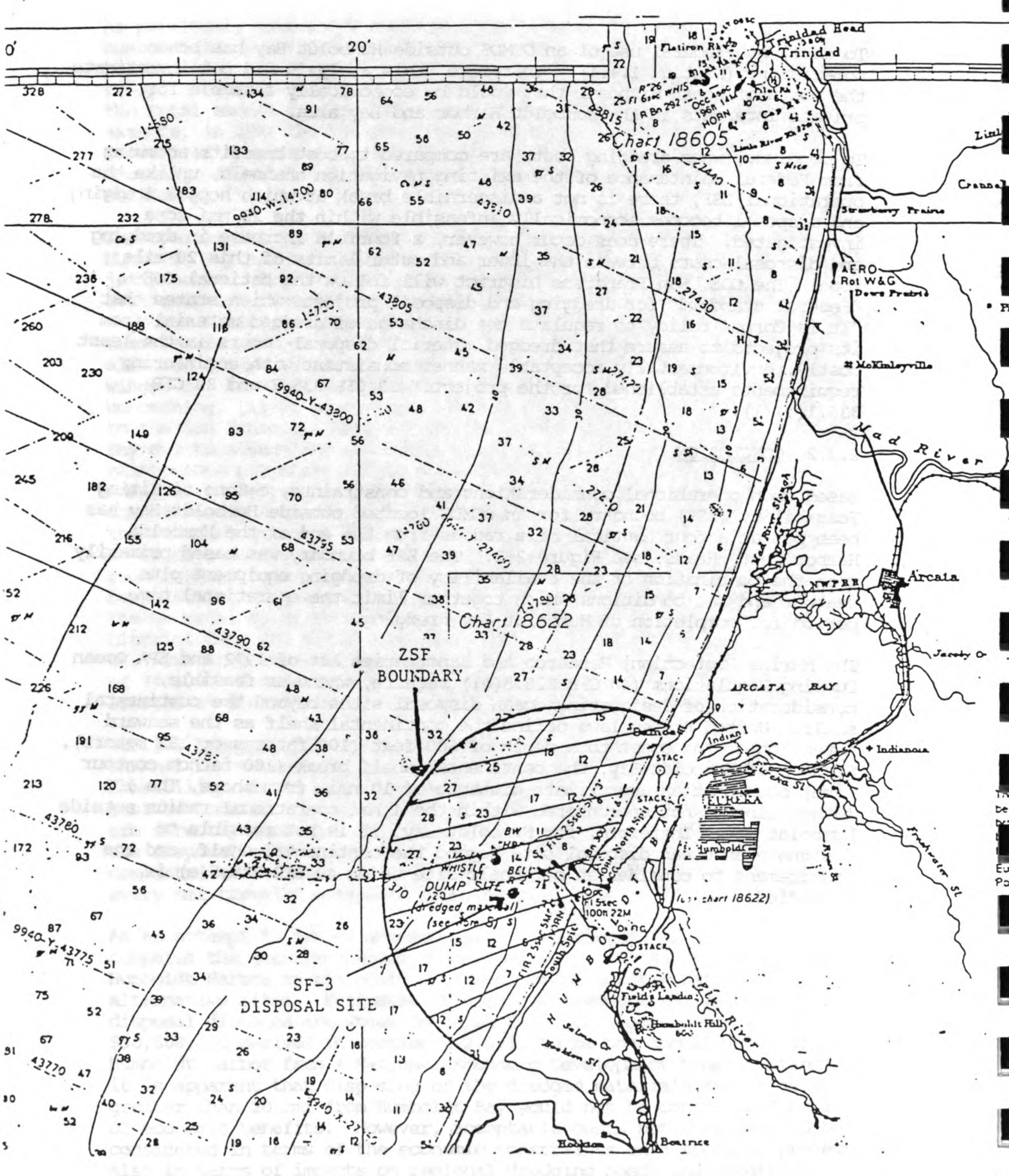


FIGURE 2-3. ZONE OF SITING FEASIBILITY BOUNDARY, 4 NMI FROM MID-POINT BETWEEN THE END OF HUMBOLDT HARBOR JETTY HEADS

Scale: 1" = 2.75 NMI

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Appendix B

This appendix consists of Corps of Engineers developed graphs of the dredging and disposal time (months) that would be required for ocean disposal of dredged material at increasing distances from the end of the jetty heads at the entrance to Humboldt Harbor.

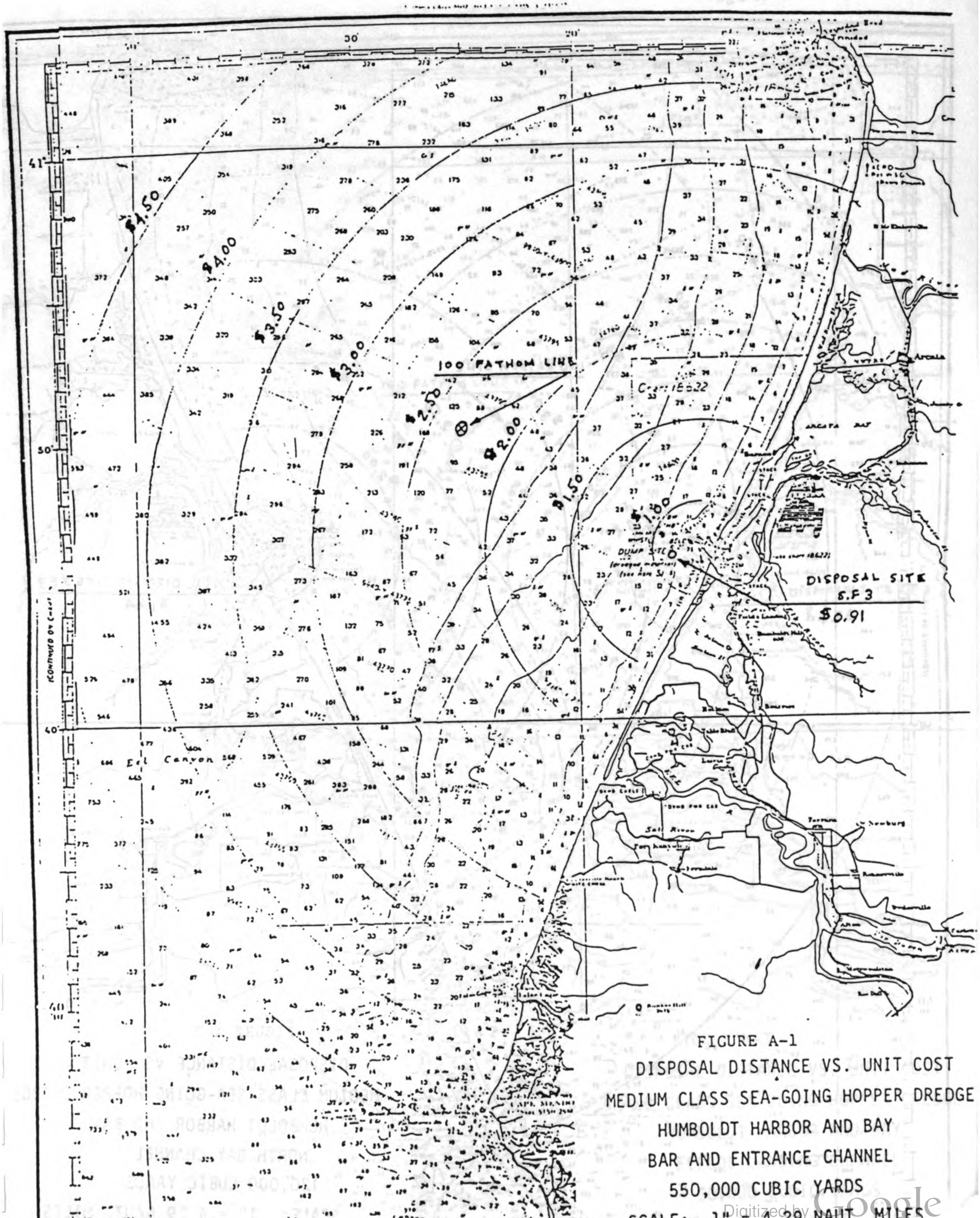


FIGURE A-1
DISPOSAL DISTANCE VS. UNIT COST
MEDIUM CLASS SEA-GOING HOPPER DREDGE
HUMBOLDT HARBOR AND BAY
BAR AND ENTRANCE CHANNEL
550,000 CUBIC YARDS
SCALE: 1" = 4.29 NAUT. MILES

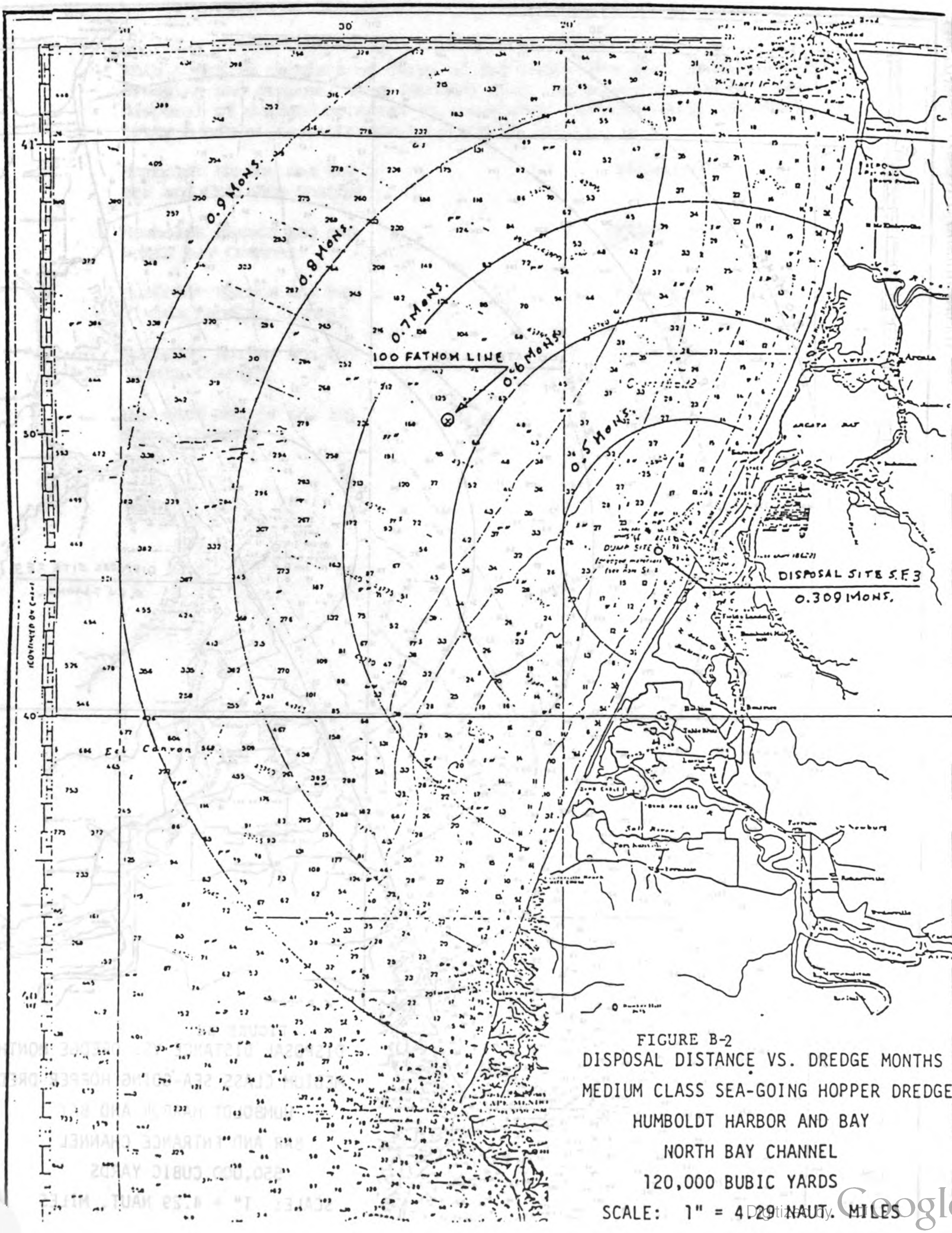


FIGURE B-2
DISPOSAL DISTANCE VS. DREDGE MONTHS
MEDIUM CLASS SEA-GOING HOPPER DREDGE
HUMBOLDT HARBOR AND BAY
NORTH BAY CHANNEL
120,000 BUBIC YARDS
SCALE: 1" = 4.29 NAUT. MILES

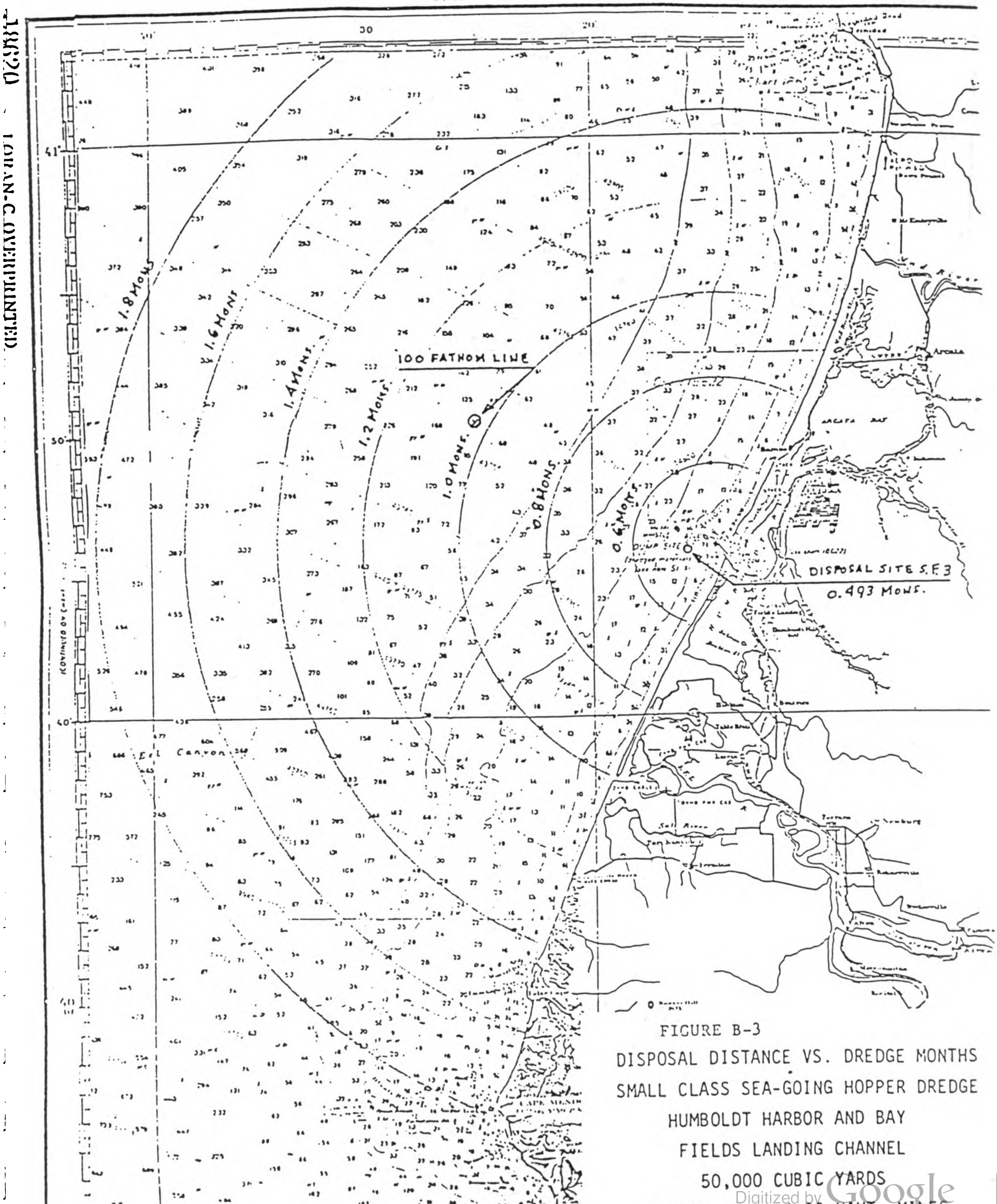


FIGURE B-3
DISPOSAL DISTANCE VS. DREDGE MONTHS
SMALL CLASS SEA-GOING HOPPER DREDGE
HUMBOLDT HARBOR AND BAY
FIELDS LANDING CHANNEL
50,000 CUBIC YARDS
SCALE: 1" = 4.29 NAUT. MILES

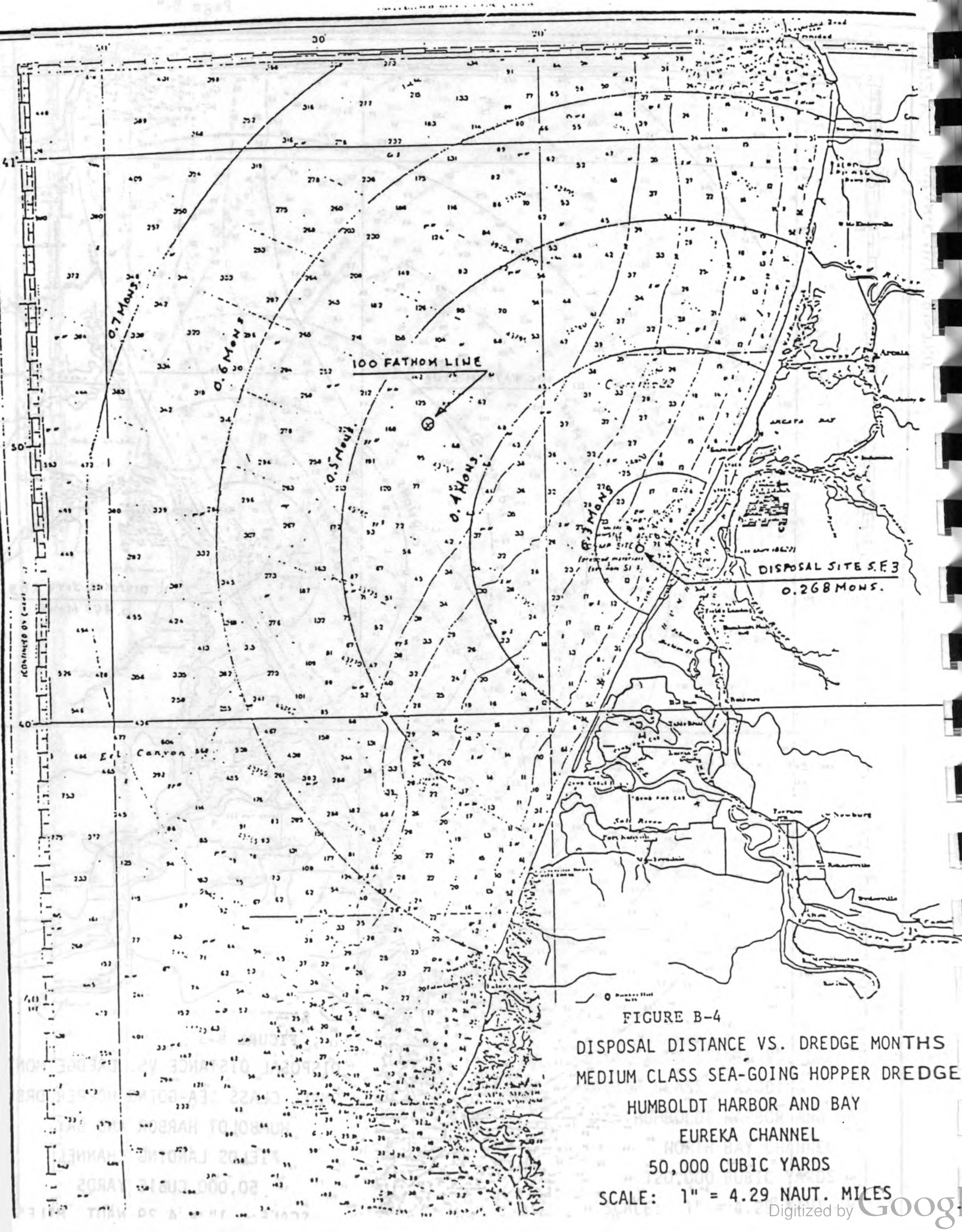


FIGURE B-4

DISPOSAL DISTANCE VS. DREDGE MONTHS

MEDIUM CLASS SEA-GOING HOPPER DREDGE

HUMBOLDT HARBOR AND BAY

EUREKA CHANNEL

50,000 CUBIC YARDS

SCALE: 1" = 4.29 NAUT. MILES

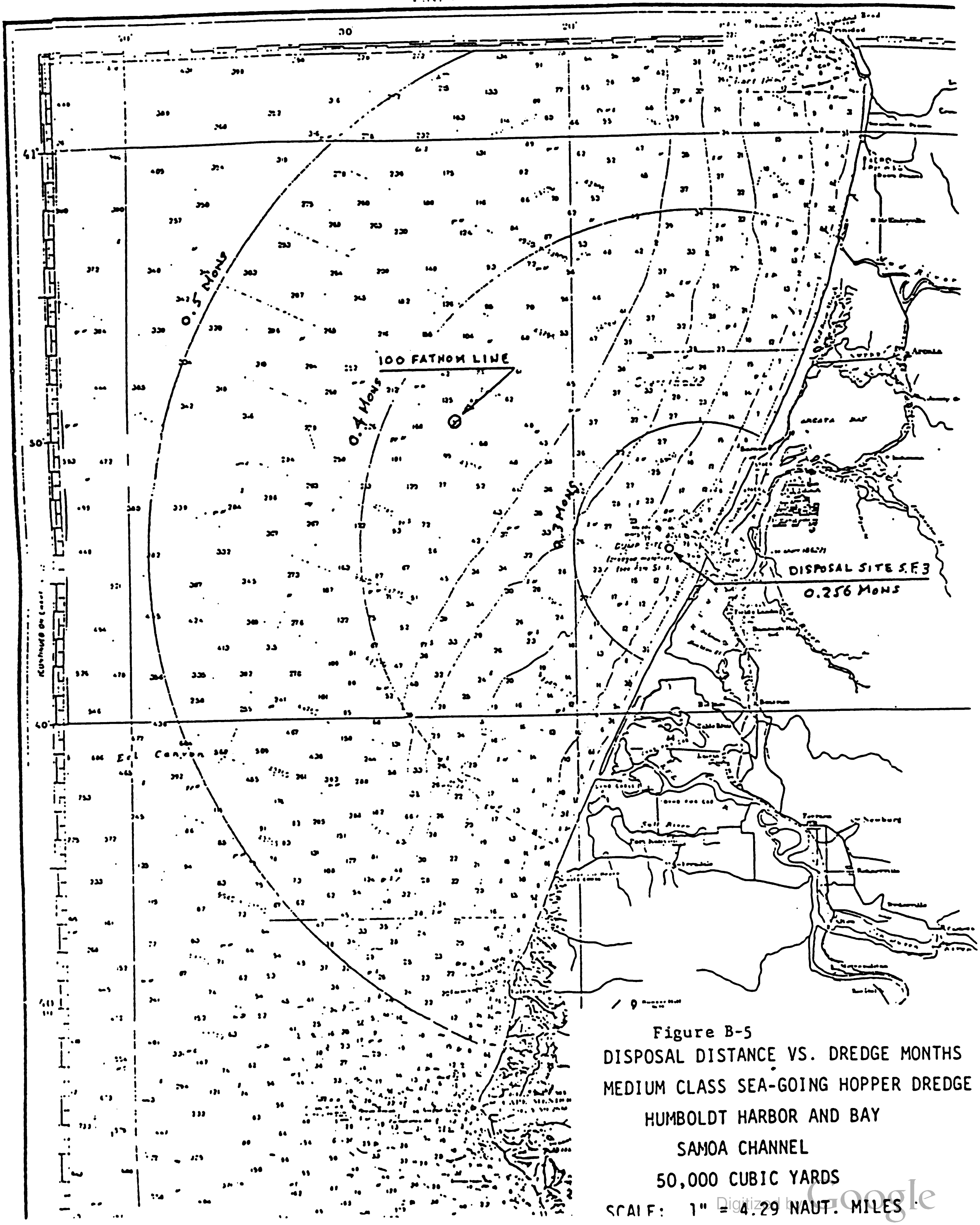


Figure B-5
DISPOSAL DISTANCE VS. DREDGE MONTHS
MEDIUM CLASS SEA-GOING HOPPER DREDGE
HUMBOLDT HARBOR AND BAY
SAMOA CHANNEL
50,000 CUBIC YARDS
SCALE: 1" = 4.29 NAUT. MILES

Appendix B

Site Management and Monitoring Plan for HOODS ODMDS

APPENDIX B

SITE MANAGEMENT AND MONITORING PLAN (SMMP) FOR HUMBOLDT BAY (HOODS) OCEAN DREDGED MATERIAL DISPOSAL SITE

I. INTRODUCTION

The Marine Protection, Research and Sanctuaries Act (MPRSA) of 1972 (33 USC Section 1401 et seq.) is the primary legislative authority regulating the disposal of dredged material into ocean waters. The MPRSA prohibits disposal activities that would unreasonably degrade or endanger human health or the marine environment. Under the act, the U.S. Environmental Protection Agency (EPA) and the U.S. Army Corps of Engineers (Corps) have joint authority for regulating ocean disposal of dredged material and for managing ocean disposal sites. Management of an ocean disposal site consists of: (a) regulating the quantities, types of material, times, rates, and methods of disposing dredged material at an ocean disposal site; (b) development and maintenance of an effective monitoring program for the site; (c) recommending changes to site use, disposal amounts, or designation for a limited time based on periodic evaluation of site monitoring results; and (d) enforcement of permit conditions.

Section 506 of the Water Resources Development Act (WRDA) amends Section 102(c) of the MPRSA. These amendments require, in part, that a site management plan be developed for each designated ocean disposal site. This site management plan is required to include:

- a baseline assessment of conditions at the site;
- a program for monitoring the site;
- special management practices necessary for protection of the site;
- consideration of the quantity and contaminant levels of material to be disposed at the site;
- consideration of the active life of the site and management requirements after site closure; and
- a schedule for review and revision of the site management plan.

Section 506 of the WRDA further requires that, after January 1, 1995, a site management plan must be developed and approved before final designation is issued. After January 1, 1997, no permit for dumping may be issued under Section 103 of the MPRSA for a site unless the site has received final designation.

In the case of this proposed action, the final designation is scheduled for fall 1995. Thus, a site management plan is required to be developed and approved, pursuant to the WRDA, before the final designation may be issued.

Two key parts of an effective management plan are the flexibility to accommodate unforeseen needs, and the ability to revise the plan as changes are identified. The primary goal of site management is to ensure adequate environmental protection and regulatory compliance. To this end, the SMMP (see Exhibit A) for the ocean dredged material disposal site (ODMDS) off Humboldt Bay (HOODS) will be reviewed periodically by EPA Region IX and the Corps' San Francisco District. Agency representatives will meet to review site operations, to discuss potential problems with the condition at the HOODS or monitoring activities, and to address public concerns about disposal at the HOODS. Any changes must meet the approval of both agencies. Resolution of management and monitoring issues and public concerns will be worked out cooperatively.

A. Purpose of the SMMP

The SMMP for the HOODS has been developed jointly by EPA Region IX and the Corps' San Francisco District. It is designed to identify possible unacceptable adverse environmental impacts that may occur beyond the site boundary, and to ensure that disposal operations comply with established permit conditions. This document provides guidance to EPA Region IX and the Corps' San Francisco District staff on available management options and the proper times when management decisions may be required.

The HOODS is located in water depths between 49 and 55 meters (160 and 180 feet) and is positioned within the coordinates 40° 48 25N, 124° 16 22W; 40°49'3"N, 124°17'22"W; 40°47'38"N, 124°17'22"W; 40°48'17" N, 124°18'12"W (Figure 1). The site is one square nautical mile (nm^2; 850 acres) in area and is divided into 4 quadrants (1-4), each containing 9 cells (Figure 2). Management decisions must reflect local characteristics of the disposal site such as: (1) geographic location; (b) oceanographic conditions; (c) physical, chemical, and biological characteristics and composition of the proposed dredged material; and (d) adjacent amenities and resources that might be adversely affected by disposal operations.

As an integral part of the SMMP, a site monitoring program has been designed for the HOODS to provide necessary data for site management. These data will address potential and actual impacts to the marine environment and biological resources at the HOODS or in areas adjacent to the site boundaries. The program design facilitates monitoring of both short-term and long-term impacts, enabling EPA Region IX and the Corps' San Francisco District to make management decisions in a timely manner should potential or actual unacceptable adverse impacts be detected. Specific portions of the SMMP will also help EPA Region IX and Corps' San Francisco District staff to verify whether disposal operations are carried out in compliance with permitting requirements and other environmental laws.

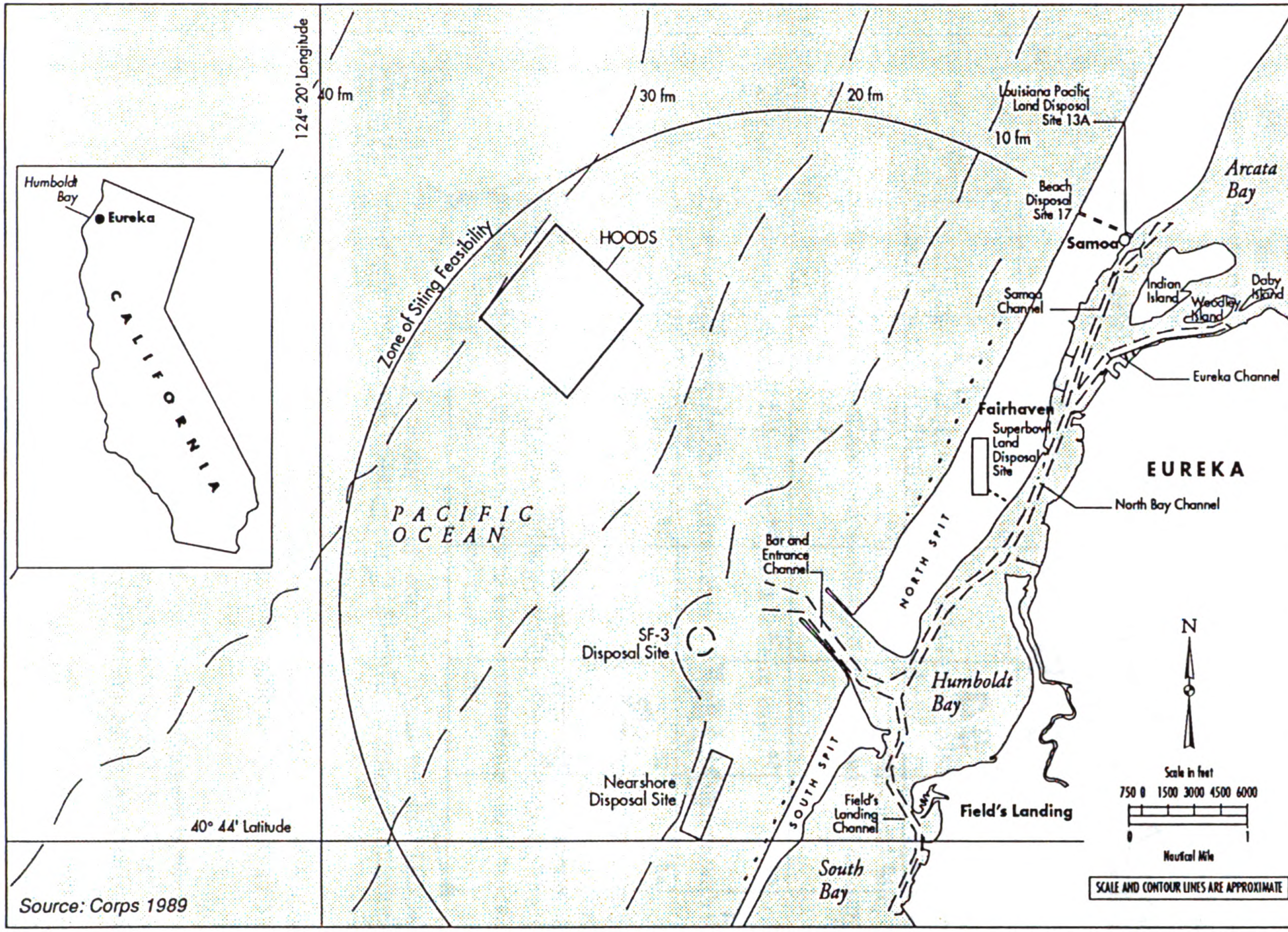
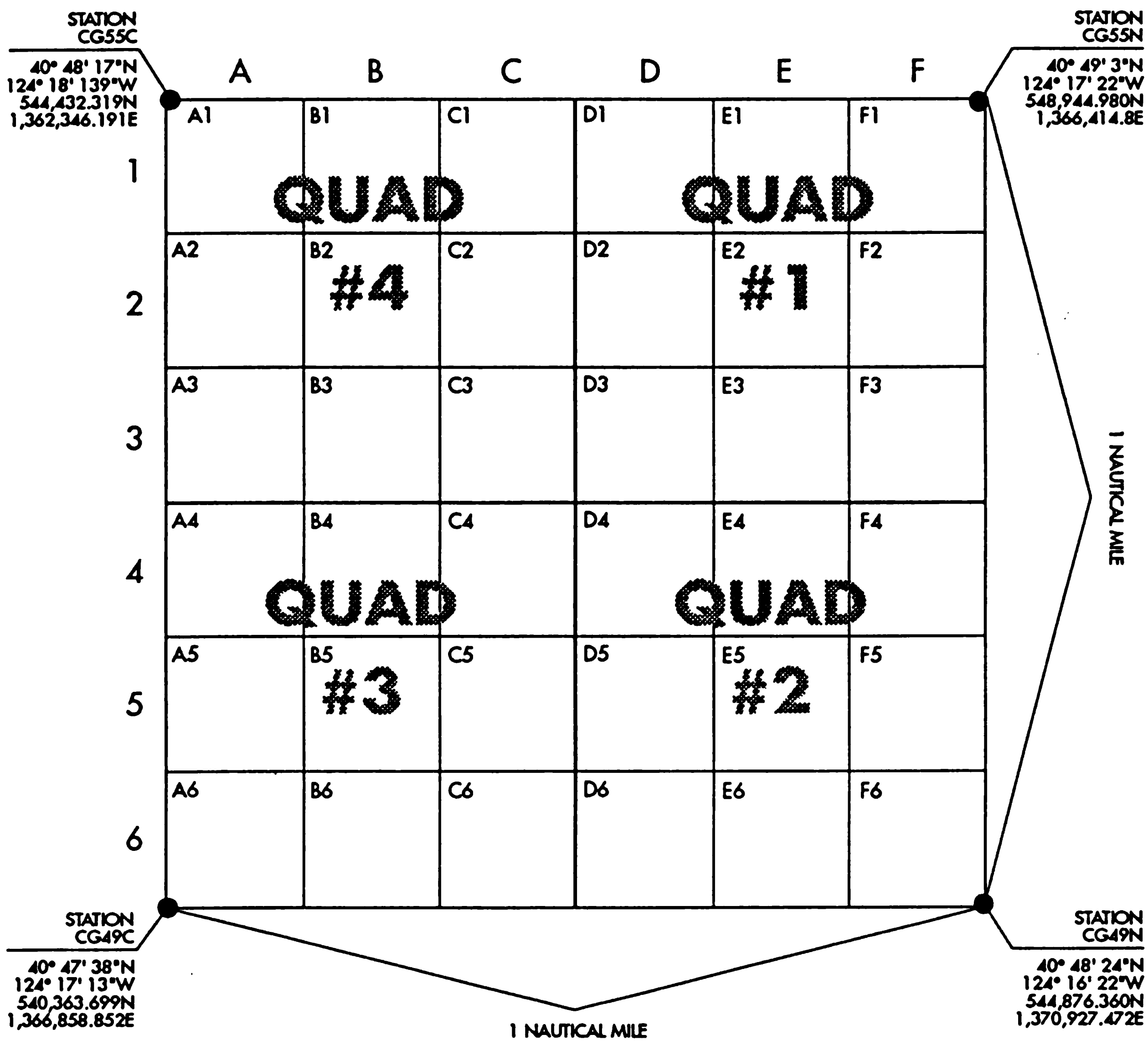


Figure 1. Location of Past and Present Ocean and Land Dredged Material Disposal Sites Near Humboldt Bay, California



Source: Corps 1994b

Figure 2. Humboldt Open Ocean Disposal Site

The SMMP addresses the options available to the federal agencies for modification of activities at the site to avoid significant environmental impacts, or options to mitigate potentially adverse impacts. Management actions may include: (a) adjustment of permitting and monitoring procedures, (b) adequate enforcement of permit conditions, or (c) modification of disposal activities, either temporarily or permanently. Specific considerations may include a change in dredging or disposal practices, restrictions on amounts of dredged material disposal, revision of site size, use of the site for a limited time, or designation of a new site.

B. SMMP Objectives

1. The following specific objectives are included in the SMMP to ensure acceptable long-term use of the HOODS as the designated site. These objectives may be used to revise the configuration or location of the disposal site, and will accommodate disposal of acceptable dredged material without causing adverse impacts outside site boundaries:

    a. Define the overall strategy and rules for site use.

    b. Establish specific site use requirements to ensure compliance with the EPA's Ocean Dumping Regulations.

    c. Publish sediment testing and reporting requirements jointly agreed to by EPA Region IX and the Corps' San Francisco District to complement national guidance on sediment testing. This will be accomplished by publishing a San Francisco District Public Notice defining the proposed testing and reporting procedures to obtain comments from other agencies, prospective permit applicants, and contractors.

    d. Identify biological resources of concern based on the HOODS Final Environmental Impact Statement (U.S. Environmental Protection Agency, Region IX, 1995).

    e. Facilitate assessment of any potential problems which may be identified as a result of routine site monitoring, and implement changes to avoid such problems.

    f. Provide an instrument of agreement for site management between the EPA Region IX, the Corps' San Francisco District, the U.S. Coast Guard, and other concerned regulatory and resource agencies responsible for successful site operation or enforcement.

2. The suitability of any dredged material proposed for disposal will be determined before disposal at the HOODS. This involves appropriate physical, chemical and biological testing of the proposed dredged sediments based on requirements and procedures defined in EPA's Ocean Dumping Regulations at 40 CFR Parts 220,

225, 227 and 228. The following information will be supplied by the permit applicant to EPA Region IX and the Corps' San Francisco District as part of the permit application process (33 CFR Parts 335 to 338):

a. Written documentation of the need to dispose the dredged material in the ocean, including a disposal alternatives analysis. This will be used to decide the proper disposal alternative for the sediments proposed for dredging.

b. A description of historical dredging and activities at or adjacent to the proposed dredging site that may have contaminated the sediments. The historical analysis will give the federal agencies information on potential sources of contamination at the site. Additional chemicals of concern may be identified by this report.

c. The quantity of dredged material proposed for disposal, including overdredge (tolerance) material. EPA Region IX and the Corps' San Francisco District will use this information to determine whether the HOODS can accommodate the amount of sediment proposed for disposal.

d. A recent condition survey of the proposed dredging area showing present hydrographic data at the proposed dredging site, including proposed dredging depths, overdredge depths, side slopes, and depths adjacent to the boundary of the proposed dredging area. This survey is required before field sampling occurs to locate the sampling stations at the proposed dredging site.

e. Characteristics and composition of the proposed dredged material, including physical, chemical, and biological tests. These data will be used by the federal agencies to determine whether the proposed dredged materials are suitable for disposal at the HOODS.

f. An estimate of the starting and ending dates for the dredging project. This information will be used to plan inspections at the dredging site or during disposal operations at the HOODS.

g. A debris management plan and the most likely types of equipment to be used in the project. This plan will address the disposal of materials other than approved sediment (such as piling, tires, metal debris, etc.) to assure that these other materials are not disposed of at the HOODS.

II. SITE MANAGEMENT

Site management consists of three major activities jointly administered by EPA Region IX and the Corps' San Francisco District. These activities are:

- ocean dumping permit requirements,

- site monitoring program requirements, and
- evaluation of permit compliance and monitoring results.

A. MPRSA Section 103 Permitting

Management decisions about the suitability of dredged material for ocean disposal will be guided by criteria set out in MPRSA and EPA's Ocean Dumping Regulations. MPRSA Section 103 authorizes the Corps to administer the permit program. This section provides for EPA review of Corps' Public Notices and permits. Initial opportunities for management decisions begin with the MPRSA Section 103 permitting process. Guidance on specific aspects of these regulations is provided in the Evaluation of Dredged Material Proposed for Ocean Disposal (the Green Book, U.S. Environmental Protection Agency and U.S. Army Corps of Engineers 1991). EPA Region IX and the Corps are developing regional guidance for sediment testing which should be used in addition to the 1991 Green Book. The current regional guidance is EPA (1991).

An adequate sampling plan must be developed by the permittee to characterize sediment quality. The sampling plan should address information listed in EPA Region IX's 1991 sediment testing requirements. This plan and the information listed in Section I.B.2. above are submitted to the Corps' San Francisco District and interested federal and state regulatory agencies. Early consultation with concerned federal and state regulatory and resource agencies is highly recommended to prevent delays in sampling, sediment testing and agency review. This consultation is normally conducted with the Corps' San Francisco District Permit and Regulatory Branch; however, it is advisable that the permit applicant or the Corps' Civil Works planner coordinate with EPA Region IX on the sampling before any sampling is conducted.

A reference site will be identified prior to the designation of the HOODS. Proposed dredging site sediment characterization test results are compared to similar information from the HOODS reference site to determine whether the sediment is suitable for ocean disposal. Management decisions related to the proposed dredged material and the disposal operations at the HOODS will be based on:

1. compliance with applicable criteria defined in the EPA's Ocean Dumping Regulations at 40 CFR Part 227,

2. the requirements imposed on the permittee under the Corps' Permitting Regulations at 33 CFR Parts 320-330 and 335-338, and

3. the potential for significant adverse environmental impacts at the HOODS from the disposal of the proposed dredged material.

For any environmental impact to be considered significant and, therefore, a basis for a management decision at the permitting stage, such an impact or change must be shown to be statistically significant and to pose an unacceptable risk to the marine environment or human health. These determinations will be based on appropriate statistical methods to evaluate differences between the proposed dredged material and reference site conditions for the chemicals of concern, acute toxicity of the proposed dredged material, the magnitude of bioaccumulation, and potential ecological impacts. The main concerns are: (1) disposal of sediments that may cause significant mortality or bioaccumulation of contaminants at the disposal site or adjacent to the site boundaries, and (2) adverse ecological changes to the HOODS and the surrounding ocean floor. Changes in the benthic community inside the HOODS site could occur because coarser or finer grain sizes in dredged material are expected to allow different benthic species to colonize the site. If material is found moving off the disposal site, benthic community changes adjacent to the site may be evaluated to determine whether these changes are acceptable.

Management decisions will be implemented to reduce or mitigate any significant adverse environmental impacts. Management options for the permitting process may include: full or partial approval of dredged material proposed for ocean disposal, prohibition of sediments proposed for ocean disposal, or special management restrictions for ocean disposal of the proposed material such as limits on disposal quantities or disposal at specific areas within the HOODS site.

Existing regulatory information, such as the Federal Water Quality Criteria and the State of California Water Quality Objectives, may also be management decision triggers in some cases. Such mathematically precise tests cannot be applied to all proposed dredged material disposal projects. Most permit reviews will require the agencies' best professional judgment to manage the MPRSA Section 103 permitting process properly. The Corps' San Francisco District staff will prepare the Public Notice and EPA Region IX will participate in its review. EPA Region IX will only approve, disapprove, or propose conditions on the draft of the MPRSA Section 103 permit, because EPA must review the MPRSA Section 103 permit as specified in 40 CFR Section 220.4(c). The possible management options for the draft permit will be concurrence or denial.

B. Conditions at the HOODS

Conditions at the HOODS were documented in EPA Region IX's Final EIS for the proposed designation action (U.S. Environmental Protection Agency, Region IX, 1995). These two documents will be used, with reference site data, to evaluate future changes at the site. As part of the three-tiered site monitoring program, EPA Region IX and the Corps' San Francisco District can evaluate the physical, chemical, and biological parameters:

1. inside the HOODS site boundaries,

2. over an area adjacent to the HOODS site boundaries that may be found to be affected by dredged material disposal, and/or

3. at the reference site or sites.

Both agencies are particularly concerned with effects at the HOODS site boundary and the adjacent area. When evaluations of biological resources of concern are made, a reference site or sites will be used as the point of comparison for data obtained from the areas adjacent to the HOODS and stations within the HOODS.

C. Surveillance and Enforcement of Permits

Once dredging and disposal activities have begun, management responsibilities, including surveillance and inspection of dredging and disposal operations, will be initiated to ensure compliance with permit conditions. Surveillance of the disposal operations will be carried out by the U.S. Coast Guard with the assistance of EPA Region IX and the Corps' San Francisco District. EPA Region IX has the authority to enforce against illegal dumping activities, including non-compliance with permit conditions. Section 105 of MPRSA defines EPA's enforcement authority over these permits. Management options by the Corps' San Francisco District could involve the temporary or permanent withdrawal of a permit by the Corps' San Francisco District.

Surveillance and inspection may consist of one or more of the following activities:

1. On-board inspection by EPA Region IX or the Corps' San Francisco District staff to ensure that transportation and disposal of the sediment occur within the designated dump zone, and that the permittee complies with all the permit terms and special conditions.

2. On-board inspection by a certified inspector hired by the permittee or a regulatory agency to ensure that transportation and disposal of the sediment occur within the designated dump zone, and that the permittee complies with all the permit terms and special conditions.

3. Plots of barge navigation course while inside the confines of the disposal site. Permittees may be required to provide a record of the barge navigation course, annotated with the coordinates at the beginning and end of the disposal operation. For example, dumping contractors will be required to navigate using an electronic positioning system or other approved navigation system with sufficient accuracy to dispose of dredged material at specific locations within the disposal site.

4. The permittee will be required to prepare a detailed postdredging hydrographic survey of the dredging site to determine the quantity of dredged material disposed at the HOODS and to confirm that only permitted dredged material was disposed at the site. This survey will be compared to the predredging survey. An estimate of the total amount of dredged material disposed at the HOODS site should be provided based on pay yardage and any non-pay overdredged sediment.

III. SITE MONITORING

A. Overview

The site monitoring activities were designed specifically for the HOODS. They are an integral part of the SMMP framework. The major concerns and hypotheses are explained in Exhibit A. Implementation of site monitoring is a shared responsibility of EPA Region IX and the Corps' San Francisco District. The primary purpose of the site monitoring activities is to evaluate the impact of the disposal on the marine environment at the HOODS.

Monitoring activities will ensure that the area of acceptable impact is primarily restricted to the disposal site and that unacceptable environmental impacts do not occur beyond the site boundaries. To accomplish this, the site monitoring activities have been designed to:

- Identify the physical extent of dredged material disposal at the HOODS and to see whether material is moving outside the site boundaries.
- Identify what effects sediment moving outside the disposal site are having on sensitive benthic resources identified by EPA Region IX and the Corps' San Francisco District compared to similar benthic resources at a reference site or sites.
- Determine whether body burdens of chemicals of concern exist in benthic resources that show significant adverse impacts at the HOODS compared to the reference site, and determine whether any potentially adverse impacts on resident fisheries resources or other amenities are possible, if significant body burden impacts are found.

The site monitoring activities are designed as a three-tiered hypothesis testing framework. Management decisions at each tier are defined for sediment fate and effects, body burdens of chemicals of concern or benthic biological community effects. Each tier will require a management decision based on the information gathered. If the null hypothesis for a particular tier is rejected, then a more complex set of tests are invoked at the next higher tier to determine the extent of impacts. Sequential-tiered testing is used to facilitate rapid, accurate and economical collection of information for use by the EPA Region IX and the Corps' San Francisco District in the management process. If monitoring results show that significantly adverse environmental impacts are predicted to occur or have occurred, then management actions may be necessary to avert or minimize such impacts.

B. Reference Site(s)

Because the HOODS site has been used as an interim disposal site, pre-dumping conditions cannot be used as a reference for site monitoring. A reference site, or sites, as appropriate, shall be used to document background conditions for comparison in site monitoring activities at Tiers 2 and 3, and to evaluate the suitability of sediment for ocean disposal as part of the sediment testing program. A reference site or sites will serve as a basis for determining natural variability in the future at a site not affected by dredged material disposal. The reference site or sites will be located approximately 0.5 nmi from the HOODS within the same depth ranges of the HOODS. The site(s) will be located within an area which is removed from any potential influence of disposal activities, yet close enough that the sediments and biotic communities are in the same water mass and exposed to the same influences (except previous dredged material disposal).

IV. TIERED MONITORING AND MANAGEMENT DECISION OPTIONS

Appropriate management responses will be decided by EPA Region IX and the Corps' San Francisco District on a case-by-case basis. This SMMP does not attempt to specify particular responses to any predicted or actual adverse impact resulting from disposal activities. It does address possible management options, including those defined within the Ocean Dumping Regulations. The timing of monitoring surveys and other activities will be governed by agency funding resources, the frequency of disposal at the HOODS and acceptance or rejection of null hypotheses. The following information provides examples of actions to be considered for each tier.

A. Tier 1 - Sediment Transport Evaluation

The concerns for the sediment deposition and transport are: identifiable progressive movement or accumulation of disposed dredged materials that may affect any shoreline, marine sanctuary or critical biological area; and consistent detection of significant amounts of dredged material outside the disposal site using side-scan sonar, bathymetric surveys, sub-bottom profiling, sediment profile camera surveys, or other appropriate oceanographic survey methods. It is expected that Tier 1 (target) mapping surveys of the deposits within the disposal site would be conducted annually. If the null hypothesis for Tier 1 is rejected, then management decisions could include:

1. Revise size or location of the dump zone, or move dump zone to the upcurrent portion of the HOODS based on current data.

2. Enforce permit conditions on navigation and placement of barges.

3. Limit the amount of dredged material disposed at the site each year.

4. Reconfigure the disposal site boundaries.

5. Specify dredged material density or modify the consistency (i.e., percent clumping) of disposal material.

6. Evaluate the effect of sediment movement outside the HOODS site on sensitive benthic communities under Tier 2 or 3.

7. Implement other feasible and responsible management options that are developed as the monitoring program progresses.

8. Limit designation of the HOODS to a finite time and initiate environmental studies for a new disposal site.

9. Designate a new disposal site.

B. Tier 2 - Physical Impacts on Biological Resources of Concern

If dredged material moving out of the HOODS site is affecting sensitive biological resources identified by EPA Region IX and the Corps San Francisco District, then identification of these impacts will occur in Tier 2. An assessment of the sensitive benthic resource will be made by comparing the specific resources of concern at the HOODS to the same type of resources at a reference site or sites. Resources of concern could be benthic infauna, benthic epifauna, recreational fisheries or commercial fisheries resources.

Biological samples collected and archived from the reference site(s) as part of confirmatory monitoring will be used for this evaluation.

Possible responses to rejection of the Tier 2 null hypothesis could include:

1. Restrict disposal to specific locations within the dump site to allow portions of the disposal site to recolonize.

2. Restrict disposal to upcurrent portions of the disposal site based on seasonal current patterns to prevent material from moving outside the site boundaries.

3. Enforce permit conditions on navigation and placement of barges.

4. Determine extent of adverse impacts on commercial and recreational fisheries resources or human health.

5. Evaluate body burden impacts on bioaccumulation effects in Tier 3.

6. Reconfigure the disposal site boundaries.

7. Implement other feasible and responsible management options that are developed as the monitoring program progresses.

8. Initiate environmental studies for a new disposal site.

9. Designate a new disposal site.

C. Tier 3 - Body Burden Analysis of Biological Resources

During the permitting process, proposed sediment is tested to determine whether there is a potential for the sediment to cause test species to bioaccumulate contaminants at a higher level than those animals exposed to the reference sediment. Proposed dredged material that shows the potential to cause significant bioaccumulation cannot be permitted for ocean disposal without the District Engineer seeking a waiver from the EPA Ocean Dumping Regulations.

If sensitive benthic resources outside the HOODS boundaries are significantly affected by disposal, then monitoring of body burdens of resident species will occur in Tier 3. EPA Region IX will conduct Tier 3 monitoring as part of its oversight responsibilities for site designation. Body burdens of chemicals of concern will be assessed by comparing tissues of specific resources of concern at the HOODS to the same resources collected from a reference site or sites. These tests should not be confused with testing of proposed dredged materials that must be conducted for each permit application. The resources of concern would be the same as those identified in Tier 2 or higher trophic levels that feed on the benthic resources.

Possible responses to rejection of the Tier 3 null hypothesis could include:

1. Re-evaluate bioaccumulation testing and analytical procedures before issuing disposal permits.

2. Define the levels of contaminants in dredged material that would be suitable for ocean disposal, or restrict the quality of material to be dredged.

3. Determine extent of adverse impacts on commercial and recreational fisheries resources or human health.

4. Implement other feasible and responsible management options that are developed as the monitoring program progresses.

5. Initiate environmental studies for a new disposal site.

6. Designate a new disposal site.

D. Periodic Confirmatory Monitoring

The EPA may require confirmatory monitoring activities periodically on an other than annual basis. This monitoring may include but not be limited to periodic sediment chemistry, benthic sampling and community analysis, studies of sediment transport, bathymetric surveys, mound stability evaluations, or additional water current studies if it is determined that the dredged material is accumulating or moving more than expected. Confirmatory monitoring may also include conducting bioassays of sediments taken from the disposed dredged material footprint using one or more appropriate sensitive marine species consistent with applicable ocean disposal testing guidance ("Green Book" or related Regional Implementation Agreements), as determined by the Regional Administrator, to confirm whether contaminated sediments are being deposited at the HOODS despite pre-disposal testing of sediments. Other confirmatory activities may include testing for bioaccumulation by placement of near-surface arrays of appropriate filter-feeding organisms (mussels) in and around the disposal site for at least one month during active site use, to confirm whether substantial bioaccumulation of contaminants may be associated with exposure to suspended sediment plumes from multiple disposal events.

If a concern for water column impacts develops, EPA Region IX and the Corps' San Francisco District may require the permittees to monitor their discharge plumes as a special condition of the MPRSA Section 103 permit. The agencies would require the permittee to comply with the Limiting Permissible Concentration of the disposed dredged material and prevent unacceptable impacts on pelagic fisheries resources or coastal areas from the disposal plumes. If required, plume tracking would occur on a limited basis only, unless a management decision is made to continue these measurements.

E. Cancellation of the Designated Site

An overall management decision to cease all disposal activities at the site, either on a temporary or permanent basis, is also an option if other corrective actions are ineffective in preventing adverse environmental impacts beyond the site boundary. Temporary halts will allow the opportunity for further study to investigate means of preventing further impacts. If EPA Region IX and the Corps' San Francisco District determine that the HOODS has caused unacceptable environmental impacts, permanent cessation of disposal operations could be required. Closing the disposal site may be preceded by identification of an acceptable alternative ocean disposal site. Monitoring of the closed site may continue to ensure that adverse effects do not worsen and to allow remedial actions to proceed in a timely manner.

V. REFERENCES

U.S. Environmental Protection Agency, Region IX. 1991. EPA Region IX general requirements for sediment testing of dredged material proposed for ocean dumping.

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EXHIBIT A

HUMBOLDT BAY (HOODS) OCEAN DREDGED MATERIAL DISPOSAL SITE SITE MONITORING PROGRAM

I. INTRODUCTION

Disposal of dredged material is expected to change benthic conditions inside the HOODS boundary because the variation of grain sizes in dredged material disposed at the HOODS is expected to allow different species to colonize the area. Site monitoring activities are necessary to assure that long-term unacceptable adverse environmental impacts do not occur within the HOODS site or beyond the site boundaries. A three-tiered monitoring program has been designed to evaluate conditions at the HOODS. Tier 1 consists of periodic physical surveys of the disposal site to determine the areal extent of disposed dredged material and whether material is being deposited outside of the disposal site boundaries. If significant adverse impacts on selected biological resources are suspected based on the Tier 1 survey, data on physical impacts (Tier 2) and body burdens of chemicals of concern (Tier 3) at the HOODS site and adjacent areas will be compared to a reference site.

The HOODS site monitoring activities are a part of the overall HOODS SMMP. The site monitoring program is based on testing specific hypotheses at three sequential tiers. Several aspects of the site monitoring program were developed in direct response to concerns identified in the HOODS Final Environmental Impact Statement (FEIS). These concerns include questions on the movement of dredged material disposed at the HOODS and possible associated impacts on resident marine resources or fisheries resources if the disposed sediments move outside the site boundaries. Procedures defined in the site monitoring program should provide data required to make management decisions; however, the site monitoring program will be managed with the flexibility to modify, delete or substitute new monitoring procedures as other needs are identified.

II. OBJECTIVES

One of the major objectives of the HOODS site monitoring activities is to detect potentially adverse impacts beyond the HOODS site boundaries. Adjustments in site use will be selected to prevent adverse impacts from occurring in areas adjacent to the HOODS. Scientific analysis of the fate of the disposed dredged material is essential to meet this objective. With regard to physical sedimentation impacts, the objective is to determine whether benthic biological resources of concern have been adversely affected by sediment movement out of the site. The objective of biological monitoring is: (1) to determine if the ODMDS is causing detrimental bioaccumulation in resident infauna, epifauna or fisheries resources, (2) to provide early detection of potential threats to marine community structure, and (3) to evaluate whether potential impacts on biological resources will adversely affect higher trophic levels.

III. SITE MONITORING OVERVIEW

The site monitoring activities designed for the HOODS involve sequential collection of physical and biological data to help achieve the objectives outlined above. These objectives are defined to ensure compliance with state and federal laws, to provide guidance for EPA Region IX and Corps' San Francisco District staff for site management, and to address the concerns raised by other interested parties. The following concerns are addressed:

A. Sediment Impacts at the HOODS and Outside the Site Boundary

- Adverse physical environmental impacts on benthic communities near the ODMDS boundary.
- Habitat alterations displacing resident benthic communities near the ODMDS.

B. Water Column Impacts Outside the HOODS Site Boundaries

- Potential violation of established criteria at or beyond the site boundary at any time, or violation of criteria within the site boundary 4 hours after disposal.

C. Biological Impacts at the HOODS and Outside the Site Boundary

- Bioaccumulation of contaminants.
- Significant alteration in benthic communities based on bioaccumulation of contaminants.
- Significant changes in the resident epifauna or fish communities.

Each of these concerns is addressed in the site monitoring activities summarized in Table 1. Monitoring in a particular tier is based upon a testable hypothesis. If the null hypothesis for a specific tier is accepted, advancement to the next tier is not necessary. If the null hypothesis is rejected, an appropriate management action can be considered, or the prescribed monitoring from the next tier may be required. Information on management actions is provided in the HOODS SMMP.

Table 1. Tiered Monitoring at the HOODS Ocean Dredged Material Disposal Site

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TIER 1

- Periodic bathymetric, side-scan sonar and/or sub-bottom surveys of the HOODS funded by the Corps' San Francisco District based on site use.

TIER 2

- Assessment of sedimentation impacts on biological resources of concern as identified by EPA Region IX and the Corps' San Francisco District. This tier is triggered if dredged material moving out of the disposal site is determined by Tier 1 analysis to be a potential adverse impact to benthic resources.

TIER 3

- Body burden analyses of chemicals of concern in identified biological resources based on EPA Region IX's site designation and management oversight responsibilities. This tier is triggered if dredged material deposited outside of the disposal site is found to contain contaminants which could potentially cause adverse impacts to benthic resources.

CONFIRMATORY MONITORING

- Additional monitoring requirements imposed as needed by EPA Region IX or the Corps' San Francisco District to evaluate sediment dispersion, sediment quality, and extent of benthic impacts.

Tier 1 bathymetric, side-scan sonar and/or sub-bottom surveys are expected to be scheduled on an annual basis, although this schedule may be modified based on the frequency of disposal, the amount of dredged material disposed at the HOODS, and the results of the monitoring activities. EPA Region IX and the Corps' San Francisco District will evaluate the survey data to test the Tier 1 hypothesis. We will determine whether movement of material out of the HOODS may cause adverse impacts on biological resources of concern adjacent to the site. If management options require additional monitoring, then physical (Tier 2) or biological impact (Tier 3) evaluations will be conducted as needed.

Monitoring actions described in Tiers 2 and 3 involve analyses of data from the HOODS in relation to a reference site described in Section II.A of the SMMP. The characteristics of the reference site or sites will represent the conditions of the HOODS before disposal of dredged material occurred. Thus, meaningful comparisons can be made between the sites to determine the impacts of dredged material disposal operations at the HOODS. Future reference site measurements will provide information on natural variability and periods of any unusual conditions in the region.

IV. DETAILS OF TIERED MONITORING

A. Tier 1 - Bathymetric Survey of the Site

Hypothesis: Dredged material accumulation outside of the HOODS boundary averages less than 4 inches (10 centimeters) relative to the bottom sediment surface defined at the time of site designation.

Monitoring at Tier 1 is designed to determine whether significant amounts of dredged material move beyond the HOODS boundary, thus providing an indication of potentially adverse impacts to nearby benthic resources of concern. Tier 1 monitoring is designed to evaluate the accumulation of dredged material outside of the disposal area, relative to baseline conditions at the time of site designation. Equipment such as precision bathymetry, side-scan sonar, sub-bottom profiling, or other similar oceanographic survey techniques will be used to detect accumulation of dredged material greater than 4 inches (10 centimeters) relative to the bottom sediment surface at the time of site designation. These data will have a resolution of 0.5 inch to test the Tier 1 hypothesis. If Tier 1 analyses show sediment movement outside the site boundary and the null hypothesis is rejected, then management options will be evaluated to mitigate the impacts, or monitoring in Tier 2 can be scheduled.

B. Tier 2 - Sediment Impacts on Biological Resources of Concern

Hypothesis: Dredged material accumulation at or beyond the HOODS boundary does not show significant adverse impacts on biological resources of concern based on sediment physical properties compared to similar biological communities at a reference site or sites.

Tier 2 monitoring activities are designed to detect significant changes in biological resources of concern as a result of dredged material movement outside the HOODS. Biological resources of concern will be identified by EPA Region IX and the Corps' San Francisco District based on information contained in the HOODS EIS, the survey of the HOODS and information on fisheries resources in the area.

If benthic infauna are identified as a resource of concern, then analysis of this community can be accomplished by examining sediment profiles using techniques including but not limited to sediment profiling camera surveys taken in areas where dredged material has accumulated significantly. This type of information can be compared to other locations within the HOODS, zones outside the HOODS that have not been affected by dredged material disposal, or a reference site(s). The sediment profiling camera method has the advantage of providing in situ estimates of grain size distribution and infaunal community structure (Rhoads and Germano 1982). In addition, depending on the characteristics of previously deposited materials, newly deposited material can be differentiated by the photographs to indicate the rate of deposition at the site boundary for accumulation depths of from 2-8 inches (5-20 centimeters). Publications on this photographic profiling technique indicate that oxidized surface layer of previously deposited dredged material can be identified photographically when covered by similar material for up to a year (Germano and Rhoads 1984).

If resident benthic epifauna (invertebrates or fish) are identified as biological resources of concern, then bottom trawls can be used to sample areas where dredged material has accumulated. Samples can be compared to locations within the HOODS, zones outside the HOODS, or a reference site(s). The Tier 2 sampling is limited to assessment of physical impacts, such as the loss of a biological resource based on sediment movement, grain size changes or other effects from direct contact with disposed dredged material. Disposal of dredged material with a different grain size than the ambient sediments at the disposal site will change the biological community characteristics of the HOODS. Different species may colonize the disposal area because they can live in the finer or coarser grained dredged material. Simple changes in community structure in response to grain size changes are not considered significant impacts at the HOODS. If Tier 2 analyses show significant adverse impacts to biological resources of concern and the null hypothesis is rejected, then management options will be evaluated to mitigate the impacts, or monitoring in Tier 3 can be scheduled.

C. Tier 3 - Analyses of Body Burdens in Biological Resources

Hypothesis: Contaminant body burdens in biological resources of concern at stations where dredged material has moved out of the HOODS and within the HOODS are not significantly greater than body burdens detected in similar biological communities at a reference site or sites.

Analysis of contaminant body burdens will be conducted as part of EPA Region IX's site designation and management oversight responsibilities. If chemicals of concern (listed in EPA Region IX's August 1989 sediment testing guidance) bioaccumulate to a higher degree at the HOODS compared to a reference site(s), significant adverse impacts could affect resident biological communities at the HOODS or the adjacent areas where dredged material has moved out of the site. Tier 3 monitoring is designed to determine whether the HOODS is a site of significant bioaccumulation and to provide early detection of the potential for adverse impacts on nearby biological resources or human health.

Tier 3 monitoring will assess the concentration of chemical contaminants in resident infaunal or epifaunal organisms at the HOODS or other areas where dredged material has moved outside the site. The body burdens of organisms collected at or adjacent to the HOODS will be compared to similar organisms at a reference site(s). Collection of resident organisms for this analysis does not need to be quantitative. However, a large enough sample of the target species should be collected to provide adequate tissue for analysis. Sampling devices such as box cores, grabs or benthic sleds may be used. Selection of target species for this portion of the monitoring program should follow the protocols outlined in U.S. Environmental Protection Agency (1987) guidance.

If the Tier 3 hypothesis is rejected, management decisions will be evaluated to mitigate any impacts, or EPA Region IX and the Corps' San Francisco District will consider closing the HOODS and initiating the designation process for another suitable site.

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Appendix C

A Dispersion Analysis of the Humboldt Bay, California Interim Offshore Disposal Site

A DISPERSION ANALYSIS OF THE HUMBOLDT BAY, CALIFORNIA INTERIM OFFSHORE DISPOSAL SITE

By

Norman W. Scheffner

Coastal Engineering Research Center

Final Report
October 1990

Prepared for
US Army Engineer District, San Francisco
San Francisco, California 94105-1905

PREFACE

This report describes a site designation study which investigates the potential dispersion characteristics of an Interim Offshore Disposal Site located seaward of the entrance to Humboldt Bay, California. The study was conducted at the request of the San Francisco District of the U.S. Army Corps of Engineers. The evaluation of the site was separated into two categories, a short-term investigation and a long-term mound stability analysis. The short-term analysis investigates the potential impact of the actual disposal operation on the local environment. This phase represents the initial minutes to hours immediately following the disposal operation during which time the material is entrained and dispersed as it descends through the water column to be deposited on the ocean floor. The dispersion analysis is concerned with both the time rate of change of concentration of the descending sediment plume during the descent and whether ambient currents are sufficiently strong to carry material out of the designated site before deposition. A dispersive site would be one in which either the suspended concentrations of material are unacceptably high or one in which significant amounts of material are transported from the site before being deposited on the ocean floor.

The second aspect of the study is a long-term analysis of the stability of the proposed site. Assuming that a disposal mound has been created as a result of the disposal operation, the question of interest is whether the mound will remain stable over long periods of time or whether the combined action of waves and currents are sufficient to erode and transport material from the mound to be deposited outside of the limits of the designated site. Loss of significant amounts of material from the site would result in a classification of the site as dispersive. The above two phases of the study represent the approach utilized for the site evaluation. The methodologies used to accomplish these goals are described in this report.

Both short- and long-term analyses are dependent, in part, on the local wave fields and currents at the disposal site. Usually, these data must be either estimated for or collected from the site. This study was fortunate in that current data were available for several locations near the interim site. The data were collected by EG&G Oceanographic Services for the US Department of the Interior's Minerals Management Service (MMS) as a component of the

Northern California Coastal Circulation Study. Appreciation is extended to the MMS for authorizing release of the data and to Dr. Bruce Magnell and Mr. Bruce Andrews of EG&G for supplying the data to CERC. Appreciation is also extended to Mr. David Hodges of the San Francisco District of the Corps of Engineers for providing information and insight crucial to the timely completion of this project. Both phases of the numerical investigation and the final report were prepared by Dr. Norman W. Scheffner of the Coastal Processes Branch, Research Division, CERC. This study was conducted at the US Army Engineer Waterways Experiment Station's (WES) Coastal Engineering Research Center (CERC).

Providing general supervision were Dr. James R. Houston and Mr. Charles C. Calhoun, Jr., Chief and Assistant Chief, respectively, CERC; direct supervision of the project was provided by Mr. H. L. Butler, Chief of the Research Division, and Mr. Bruce A. Ebersole, Chief of the Coastal Processes Branch of the Research Division. Commander and Director of WES during the course of this study was Col Larry B. Fulton, CE. Technical director of WES was Dr. Robert W. Whalin.

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INTERIM OFFSHORE DISPOSAL SITE

PART I: INTRODUCTION

Background

1. The San Francisco District of the Corps of Engineers will begin dredging activities in the vicinity of Humboldt Bay, California in early September and November of 1990. It is proposed that the Interim Offshore Disposal Site, located approximately 3 nautical miles northwest of the entrance to Humboldt Bay and shown in Figure 1 (Hodges 1990), be used for the placement of the dredged material. The objective of this report is to evaluate the probable impact of this disposal site on the local environment.

2. The proposed disposal site is one square nautical mile in dimension with the corners located at the coordinates indicated in Figure 1. The nearshore limits of the site are located approximately 3 nautical miles from shore. The offshore boundary of the site is located in 55 meters of water while the nearshore boundary is in 49 meters of water. Laboratory analyses of sediment samples (Hodges 1990) collected at the corners of the disposal site indicate that native ocean floor materials range from fine sand at the nearshore boundary (D_{50} = 0.072 - 0.092 mm) to silts and fine sands (D_{50} = 0.044 - 0.057 mm) at the outer boundary.

3. The proposed disposal site will be utilized for disposal of both fine-grained sediment dredged from the interior channel areas during the Spring and coarse-grained materials dredged from the general proximity of the entrance channel during the Fall months. It is anticipated that the fine material will be disposed near the outer boundaries of the site while the coarser grained materials will be placed near the shoreward boundary (Hodges 1990). The objective of this report is to evaluate the dispersive or non-dispersive nature of the proposed disposal site.

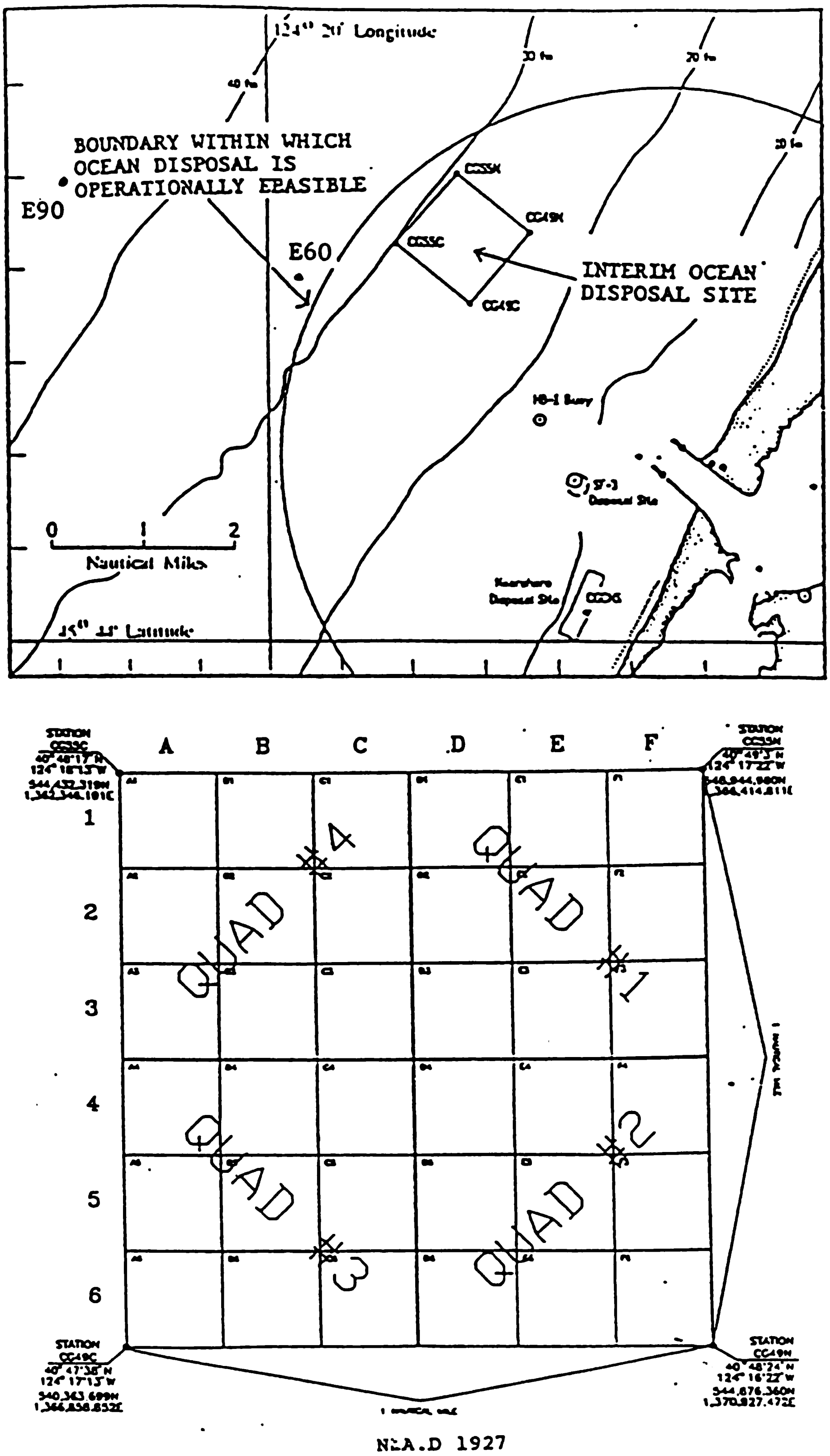

Figure 1. Humboldt Bay interim offshore disposal site location (CE 1990)

Objective

4. The objective of this study is to determine the dispersive characteristics of the proposed site by determining whether material can effectively be deposited within the designated limits of the site and remain within those limits over time. This site analysis is evaluated in a two-phase approach. First, the short-term effects of the dredging operation are investigated to determine whether material will be carried from the site by ambient currents as it descends from the barge to the ocean bottom. The modeling of this short-term phase of the operation is performed by the Disposal From an Instantaneous Dump (DIFID) numerical model (Johnson 1987). This model computes the convective descent and dynamic collapse of the sediment following its release from the barge. Results of the simulations are presented in the form of time rate of change of suspended sediment in the water column immediately following the disposal and the final configuration of the material on the ocean floor.

5. The second phase of the investigation examines the behavior of the sediment mound over long periods of time. This long-term analysis focuses on whether the local wave and current climate are sufficient to erode and transport deposited material outside of the designated limits of the site. These simulations are performed with a coupled hydrodynamic, sediment transport, and bathymetry change model (Scheffner 1989) which computes mound stability as a function of mound composition and environmental forcings. Both modeling efforts require site specific information, including waves, currents, bathymetry, sediment types, and disposal methods.

6. A realistic analysis of the dispersion characteristics of the candidate disposal site can only be made if the prediction is based on site specific wave and current information. This investigation is fortunate in that current data for several sites near the disposal site are available. Current measurements were collected for the U.S. Department of the Interior's Minerals Management Service (MMS) as a component of the Northern California Coastal Circulation Study (MMS 1989). This data was collected for the MMS by EG&G Oceanographic Services and was made available to CERC for subsequent analysis and use in this study.

7. This report concentrates on the three primary components of the study; boundary condition development, short-term, and long-term modeling. The most important component of the three is the development of realistic boundary conditions at the site. The accuracy and credibility of the numerical modeling results is dependent on the realistic approximation of waves and currents at the disposal site. The importance of this aspect of the study has been stressed in similar site designation studies (Scheffner, 1989 and Scheffner and Swain, 1989) and will be the subject of Part 2 of this report.

PART 2: WAVE AND CURRENT BOUNDARY CONDITIONS

8. Both short- and long-term modeling phases of this investigation require specification of local waves and currents. This specification is not as critical for the short-term analysis as it is in the long-term modeling since the DIFID model applies only to the time immediately following disposal. This time is normally on the order of a few minutes to an hour. A single valued, depth averaged velocity is adequate for this purpose. The long-term modeling phase however requires a more precise and accurate definition of local waves and currents since the modeling approach investigates the behavior of the mound over long periods time, on the order of months. As such, a realistic representation of the local wave and current time series is required for the site, otherwise realistic predictions of mound stability can not be made. The following two sections will concentrate on defining these wave and current time series for input to the long-term sediment model.

Wave Height, Period, and Direction Time Series

9. The long-term transport model computes sediment transport as a function of a time series of both waves and currents. The wave time series component of the input is specified as a statistical simulation of the 20-year hindcast data base of the Wave Information Study (WIS) Phase III Station 69 "sea" conditions. The location of Station 69 is shown in Figure 2. The statistical approach to defining time series of wave height, period, and direction for a specific WIS station is reported in detail by Borgman and Scheffner (1990). The approach allows the user to simulate wave sequences which preserve the statistical qualities of the entire 20-year data base, including seasonality and wave sequencing. The statistically based time series provides a site specific wave climate which is ideal for the long-term simulation.

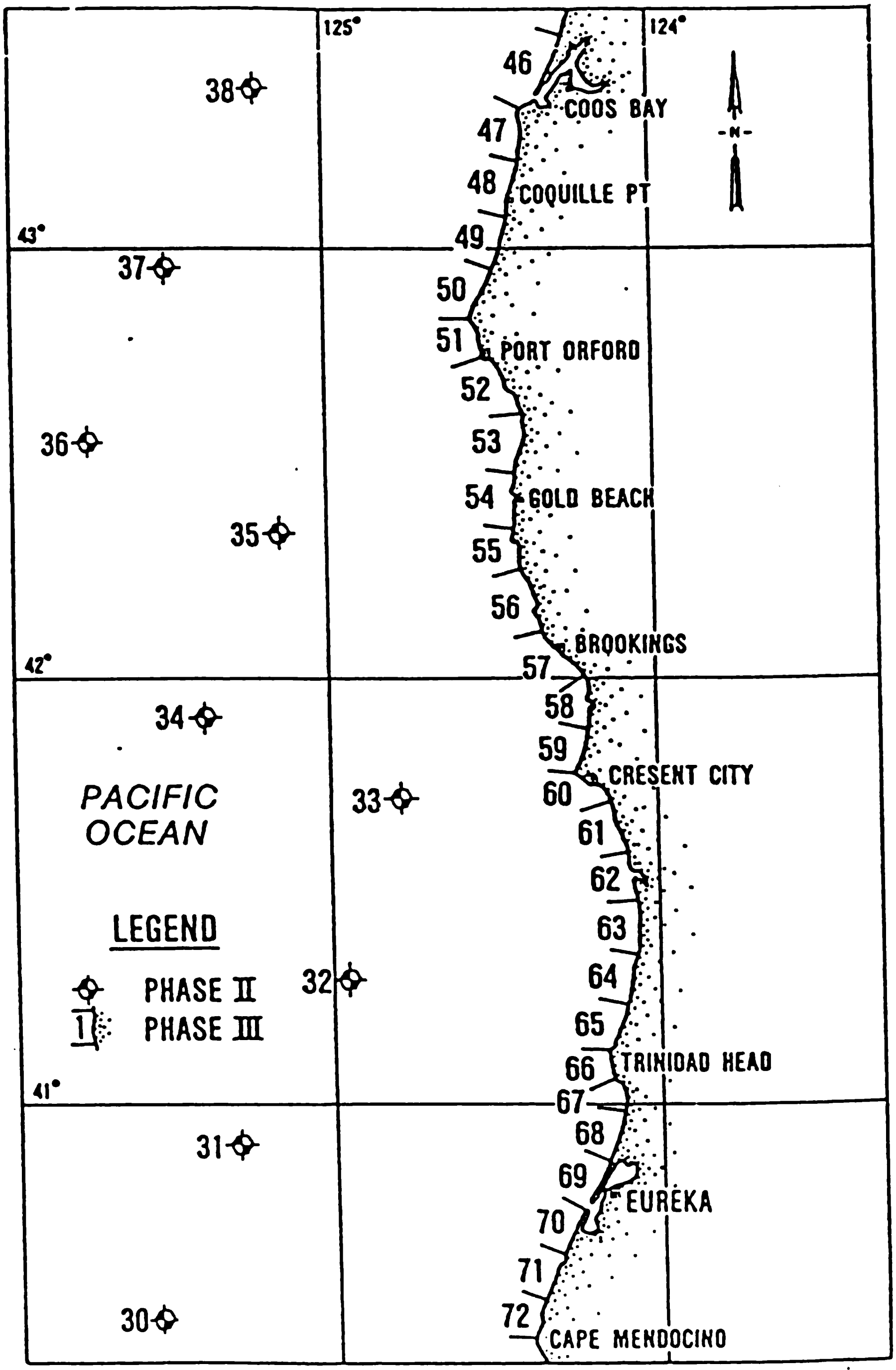

Figure 2. WIS hindcast data station location

10. A one-year time series of waves was generated as input for the long-term model. Plots of the simulated sequence of wave height, period and direction are shown in Figure 3. In order to demonstrate the similarity between the simulated wave field and actual hindcast data, Figures 4 and 5 represent one-year time series of WIS data for the years 1956 and 1964. All plots begin on 1 January and extend through 31 December. The similarity in patterns of increased winter activity with a decrease in intensity during the summer months can be seen in all plots. A more quantitative comparison of the data can be seen the percent probability histogram plots in which the probability statistics of the simulated waves are overlaid with those of the WIS data. Comparisons of the simulated and the 1956 data are shown in Figure 6, while Figure 7 corresponds to 1964. A comparison of computed maximum, minimum, average, and standard deviation for the three series shown in Table 1 also demonstrate the similarity of the simulated and hindcast data.

TABLE 1

Comparison of Wave Statistics

	Simulated	1956 WIS	1964 WIS
Maximum Wave Height (meters)	5.90	3.68	5.26
Minimum Wave Height (meters)	0.00	0.00	0.00
Average Wave Height (meters)	1.32	1.30	1.43
Standard Deviation (meters)	0.65	0.78	0.96
Maximum Wave Period (sec)	16.95	14.30	16.70
Minimum Wave Period (sec)	0.00	0.00	0.00
Average Wave Period (sec)	7.32	7.51	7.44
Standard Deviation (sec)	2.27	2.95	2.88

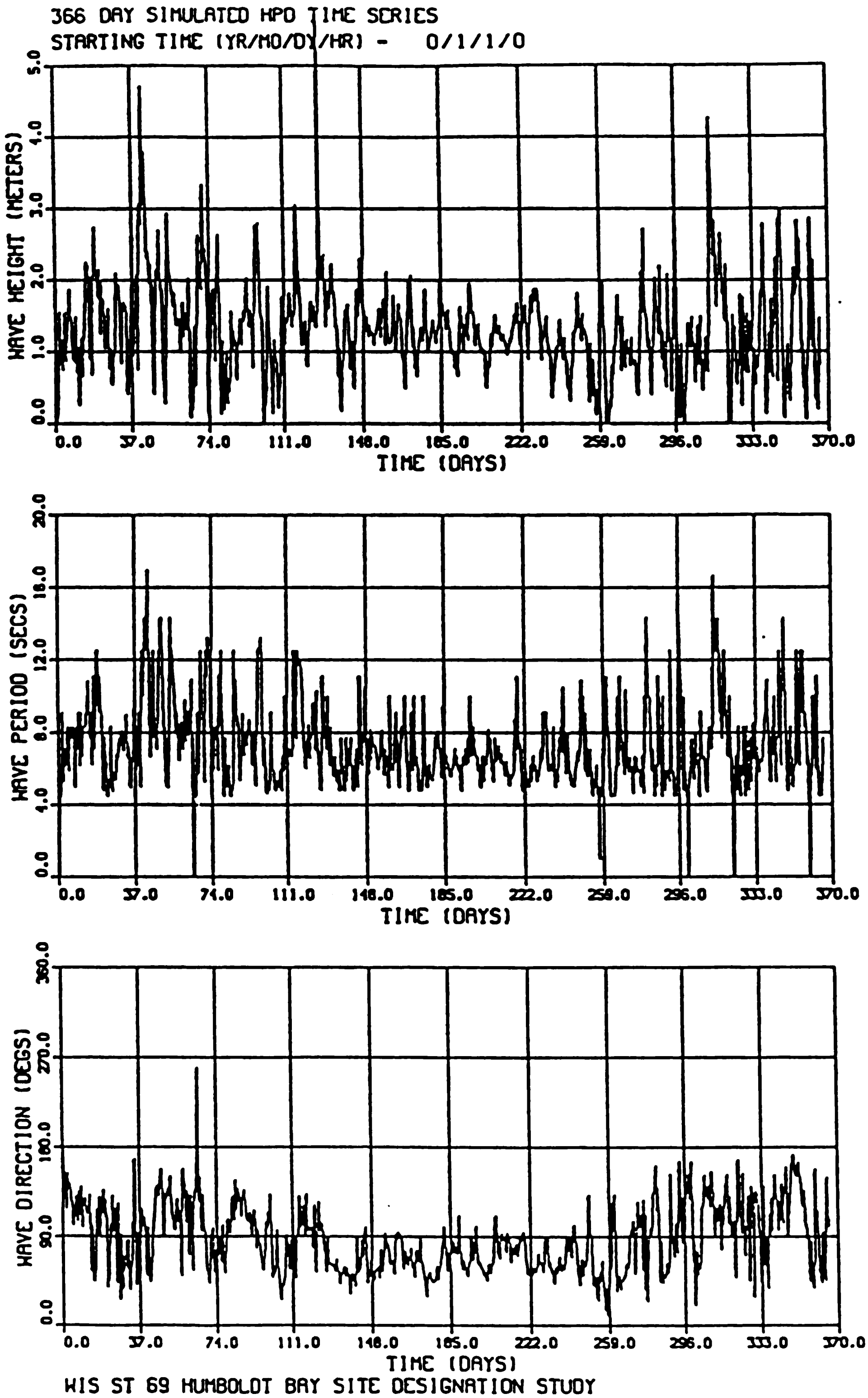

Figure 3. Simulated one-year time series of wave height, period, and direction

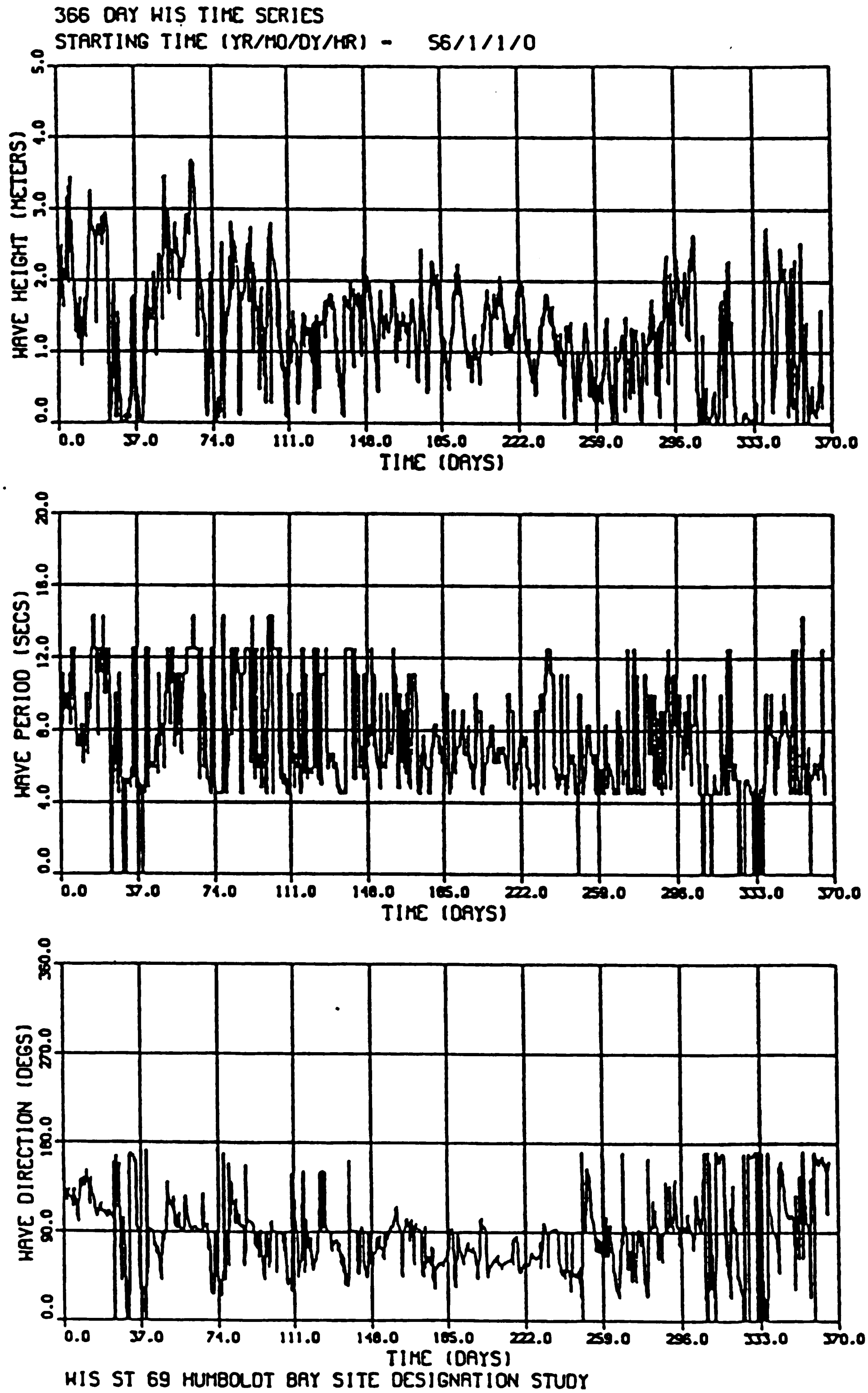

Figure 4. WIS station 69 time series for 1956

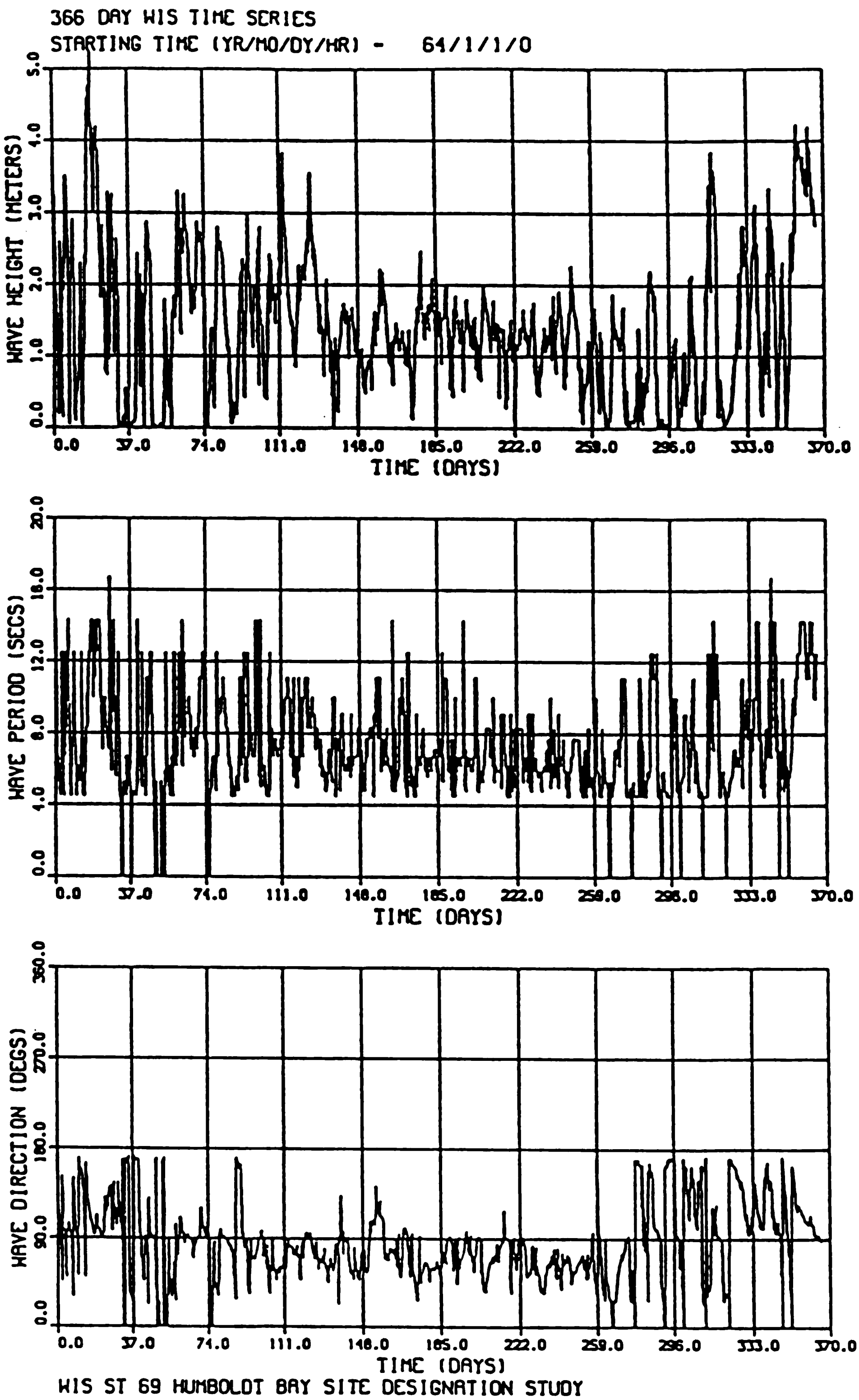

Figure 5. WIS station 69 time series for 1964

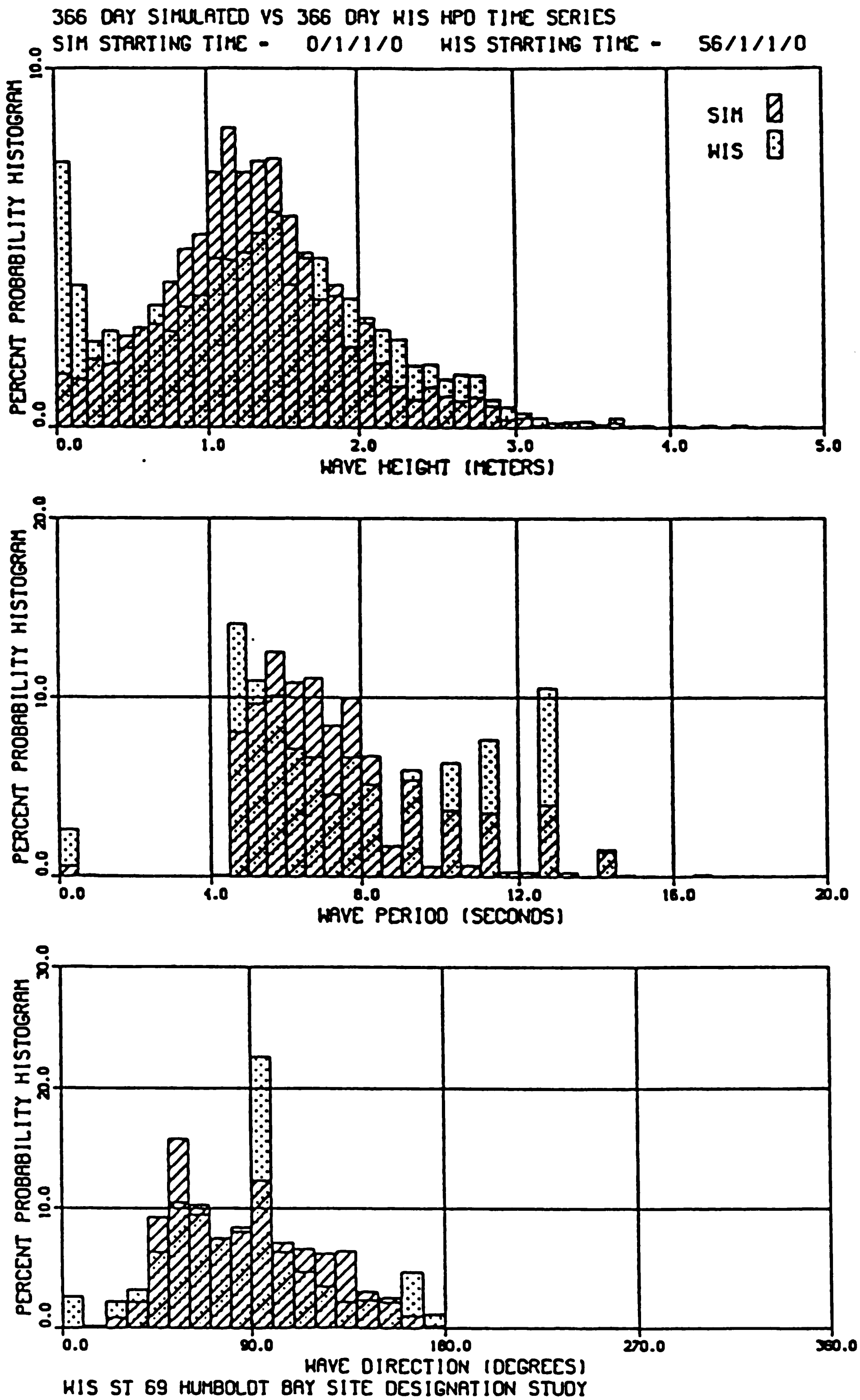

Figure 6. Probability histograms for simulated wave and 1956 WIS data

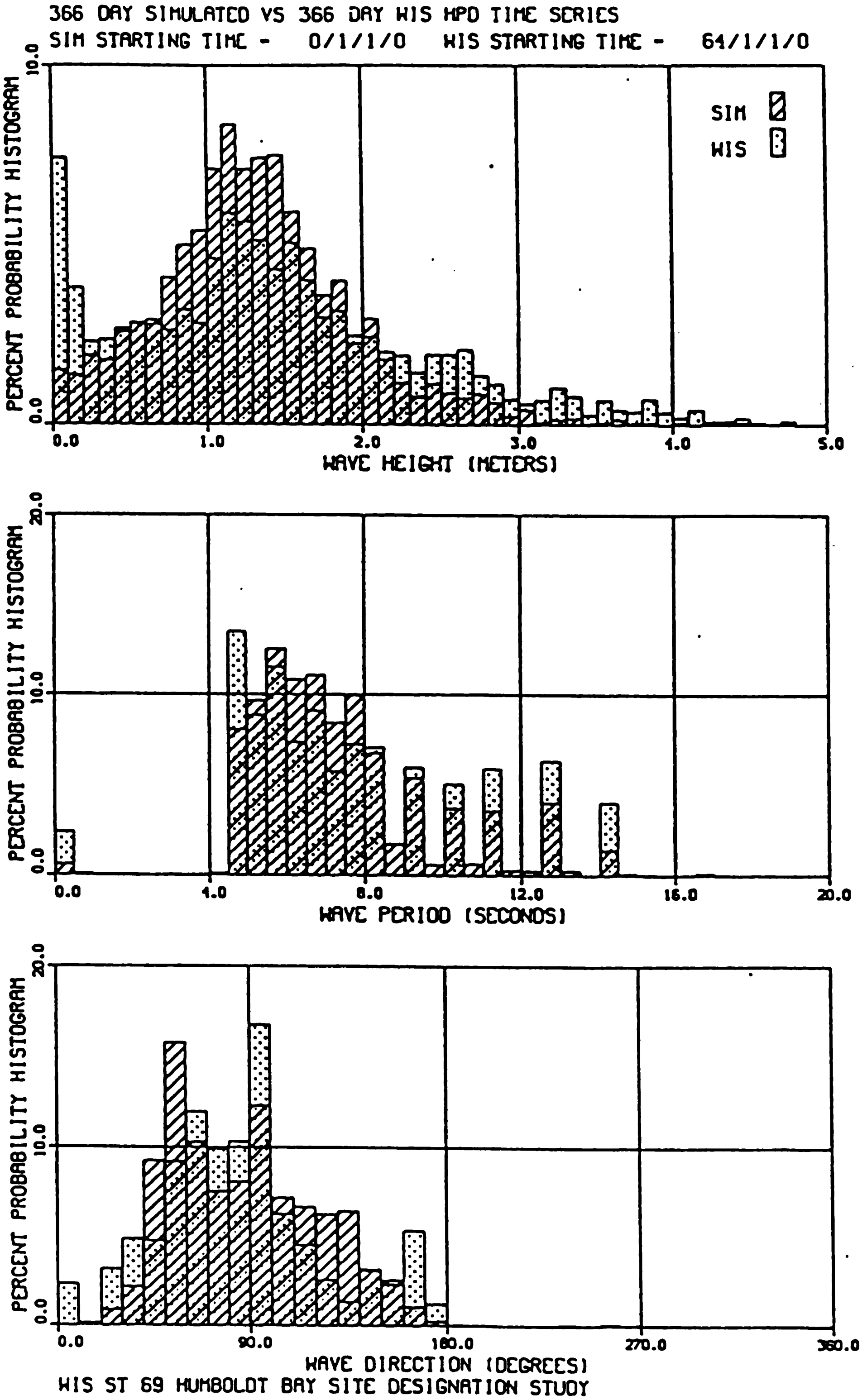

Figure 7. Probability histograms for simulated wave and 1964 WIS data

11. Station 69 represents a Phase III WIS hindcast station, as such, the hindcast is developed for 10 meters of water. The following relationships were used to transform the wave height from 10 meters to deep water and then to shoal the wave from deep water to the disposal site (Ebersole, Cialone, and Prater 1986):

$$H = H_0 \, k_s$$

where H_0 is the deep water wave height and the shoaling coefficient k_s is defined as

$$k_s = \left[\frac{1}{\left(1 + \frac{2kh}{\sinh(2kh)} \right) \tanh(kh)} \right]^{1/2}$$

12. The parameters h and k represent the local depth and the wave number respectively.

Depth Averaged Current Time Series

13. The current information obtained from EG&G Oceanographic Services was measured at two mooring sites, station E60 at a depth of 60 meters and station E90 in 90 meters of water. The location of both stations are indicated in Figure 1. The current meters were deployed during the four time periods shown in Table 2. Station E60 consisted of one current meter at a depth of 10 meters for three of the deployments and 15 meters for the other. Station E90 consisted of three current meters, at depths of 10 (15), 45 and 75 meters. The data were provided in the form of hourly averages, as requested by CERC. Additional background data were also provided which included wind velocities, temperatures, and pressure gage information. Summary plots of the data were provided CERC by EG&G which included 33-hour low-pass filter plots for the current meter data to indicate non-tidal trends and magnitudes of the data. The summary plots of the four velocity record time periods are shown in

Table 2

Velocity Data Time Series Lengths

Meter	Beginning (yr-mo-day @hr)	Ending (yr-mo-day @hr)	Length (days)
Period 1			
E-60/15	87-03-13 @2300	87-04-11 @0600	28.3
E-90/15	87-03-19 @2000	87-08-08 @1400	141.8
E-90/45	-	-	-
E-90/75	87-03-20 @0000	87-08-11 @0500	141.2
Period 2			
E-60/10	88-03-15 @1000	88-08-30 @1800	168.4
E-90/10	88-03-15 @0600	88-08-30 @1600	168.5
E-90/45	-	-	-
E-90/75	88-03-15 @0600	88-08-30 @1600	168.5
Period 3			
E-60/10	-	-	-
E-90/10	88-08-30 @1900	89-03-07 @0300	188.4
E-90/45	88-08-30 @1900	88-12-09 @2000	101.2
E-90/75	-	-	-
Period 4			
E-60/10	89-03-06 @2100	89-05-11-@2100	66.0
E-90/10	89-03-06 @2300	89-10-31-@1500	238.7
E-90/45	89-03-06 @2100	89-10-31-@1500	238.7
E-90/75	89-03-06 @2100	89-10-31-@1500	238.7

Figure 8. The current vectors shown in the figure are oriented up/down coast with upcoast as positive.

14. The raw (unfiltered) data for each of the time series of Table 2 were obtained in the form of a northerly (+U) and easterly (+V) component. Separate analyses of each data series were performed in order to determine the average value and magnitude, defined as the square root of the sum of the squared U and V component. Since sediment is primarily transported by local

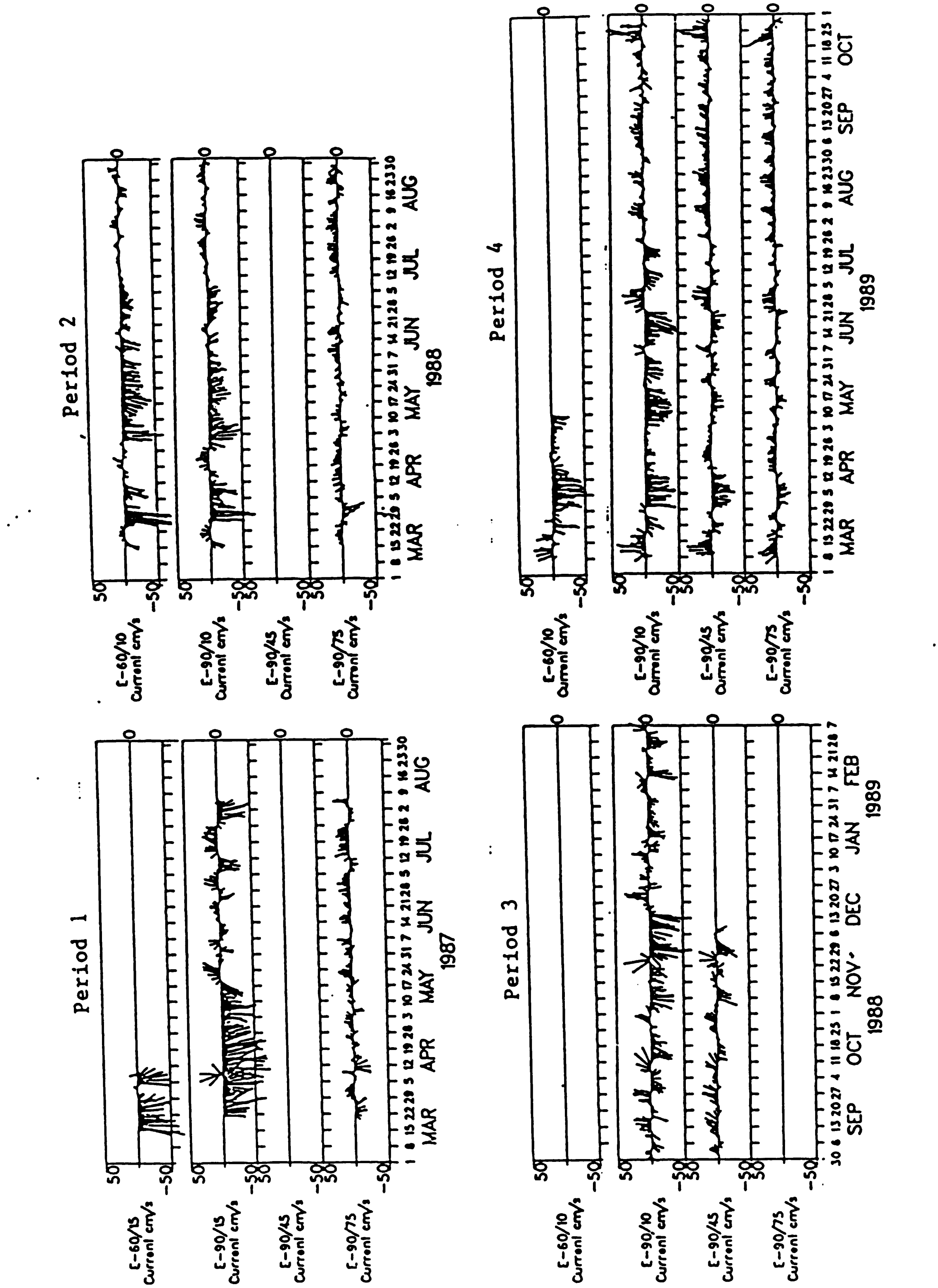

Figure 8. 33-Hour low-pass filtered currents (EG&G 1990)

currents, this computed total magnitude of local currents provides an indication of maximum anticpated erosion rate. The computed average values of the seperate components, however, provide a measure of net movement. For example, although the velocity magnitude may be sufficient to transport material, the net transport effect may be zero if the magnitudes first flood then ebb in equal magnitudes but opposite directions. Summary computations of U and V averages, velocity magnitudes, standard deviation, and percent magnitudes above 50 cm/sec are shown in Table 3.

15. In addition to the above computations, a 40-hour low pass filter was applied to the velocity magnitude time series in order to determine the tidal contribution to the total current. This filtering technique effectively separates the diurnal and semidiurnal high frequencies (period less than 40 hours) from the time series such that low frequency nonperiodic events, such as storm or residual currents, can be identified in the time series. This separation can be seen for each time series in Appendix A in which the upper diagram represents the velocity magnitude, the middle shows the high and low frequency components, and the lower represents the computed angle of direction of the velocity magnitude. The general trends of the data can be seen in the plots of Appendix A and in Table 3. Average surface velocities are on the order of 25 cm/sec, mid-depth of 20 cm/sec and bottom velocities of 15 cm/sec. Elevated surface standard deviation values are probably due to the effect of local winds.

16. The sediment transport formulation used in this analysis requires a depth-averaged velocity distribution for input to the transport computations. The selection of an appropriate depth-averaged velocity distribution from the limited data shown in Table 2 is made as follows. Unfortunately, mid-depth data are not available for the gage at site E60, located nearest the disposal site. However, if it can be shown that the surface data for gages E60/10 and E90/10 are well correlated, it is reasonable to assume that the mid-depth velocity at gage location E60 would be equally correlated with that of E90. If this correlation between the two gages for Periods 2 and 4 can be demonstrated, then data from the E90/45 gage from sampling period 4 can be selected as representative of the currents to be anticipated at the candidate disposal site. The development of this correlation follows.

Table 3

Summary Statistics of the Velocity Time Series

	Ave. U (cm/sec)	Ave. V (cm/sec)	Ave. Mag. (cm/sec)	Mag.St.Dev. (cm/sec)	% Exceeding 50 cm/sec
Period 1					
E-60/15	-1.90	-4.36	30.51	17.63	15.29
E-90/15	-5.37	14.08	27.12	17.03	11.08
E-90/45					
E-90/75	2.46	3.52	15.54	8.28	0.00
Period 2					
E-60/10	-6.70	-8.40	17.82	14.45	3.79
E-90/10	-2.88	-6.81	17.63	13.51	3.24
E-90/45					
E-90/75	0.41	4.06	14.90	8.06	0.10
Period 3					
E-60/10					
E-90/10	-4.49	-5.48	22.12	12.71	3.25
E-90/45	1.89	-0.44	16.65	10.23	0.45
E-90/75					
Period 4					
E-60/10	-7.82	-12.23	24.79	13.96	4.42
E-90/10	-3.74	-3.68	20.60	13.12	3.26
E-90/45	2.47	1.91	14.80	9.46	0.58
E-90/75	1.11	3.93	15.79	8.79	0.17

17. The general similarity in magnitude and distribution of gages E60/10 and E90/10 velocity data can be seen from the Table 3 statistics and from the time series plots in Appendix A. A comparison of the Period 3 U and V components for the two gages shown in Figures 9 and 10 also exhibit this similarity. Auto-correlation and cross-correlation functions were computed for each time series to quantify the similarity in data from the two gage locations. Auto- and cross-correlation functions of the U and V time series are defined as follows (Burington and May 1958):

AUTO-CORRELATION

$$f(k) = \frac{1}{(2N + 1)} \sum_{j=1}^{N} U60/10(j+k)\ U60/10(j)$$

CROSS-CORRELATION

$$f(k) = \frac{1}{(2N + 1)} \sum_{j=1}^{N} U90/10(j+k)\ U60/10(j)$$

where the time lag k was computed for 0 to 480 hours. The auto- and cross-correlation function plots are shown in Figures 11 and 12. Both curves are normalized to the computed zero lag auto-correlation value for gage E60/10.

18. The auto-correlation function shows periodicities in the data by performing a self correlation with an increasing time shift in the data. At a zero time shift, the perfect correlation of 1.0 is shown. As the time lag of the data increases to span tidal periods, the tidal peaks of the two series come in phase producing a characteristic peak in the correlation function. These peaks, clearly visible in Figures 11 and 12, show both the diurnal and semidiurnal tidal signal. If the cross-correlation function is identical to the auto-correlation, then the two signals are identical. A time lag between the signals is indicated when the signals are shifted horizontally. This phase shift is a measure of the difference in arrival time of the same signal at different locations. The shift in the functions shown in Figures 11 and 12 indicates an approximate lag of 4.5 hours between the two signals.

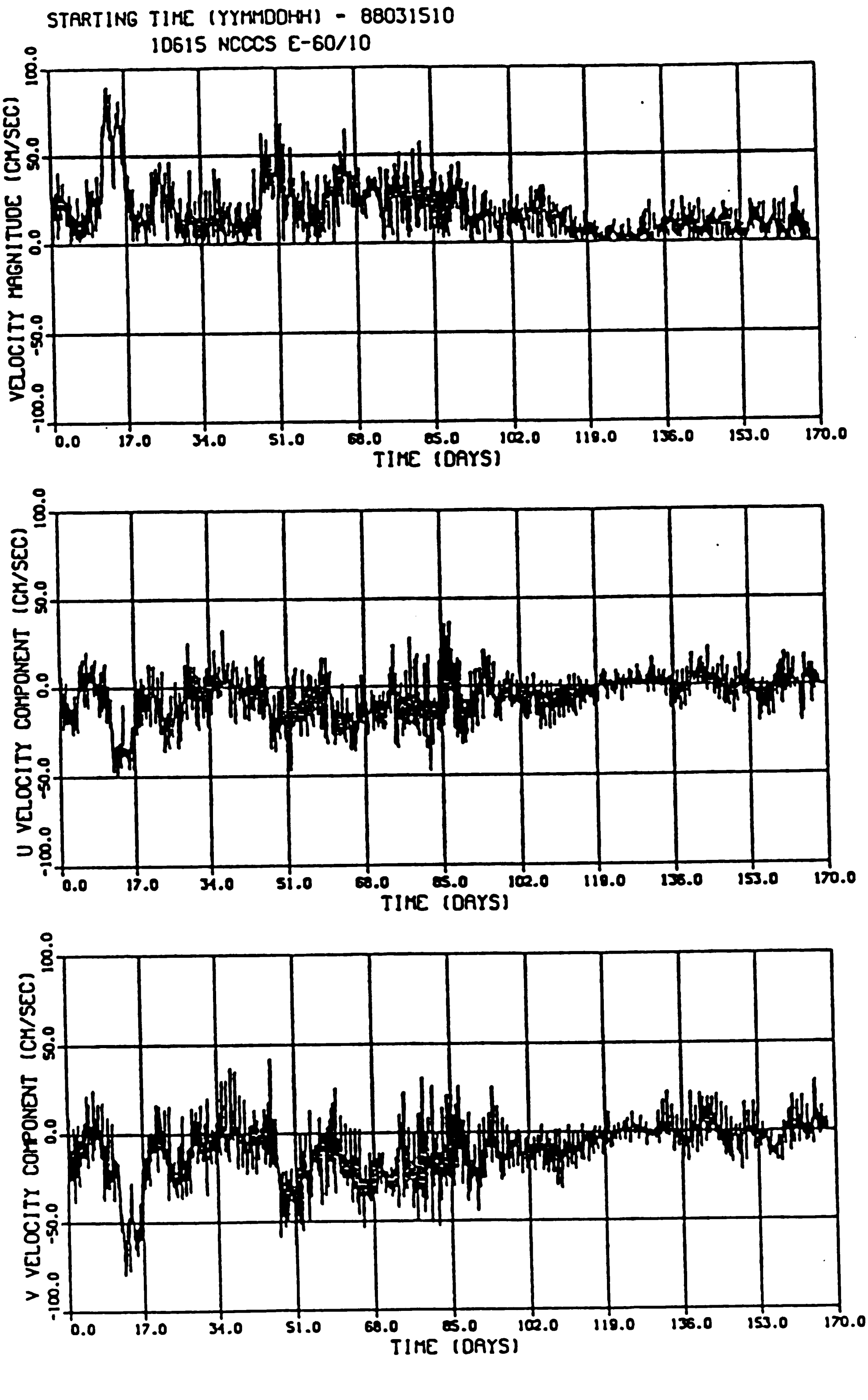

Figure 9. Period 2 Velocity components for gage E60/10

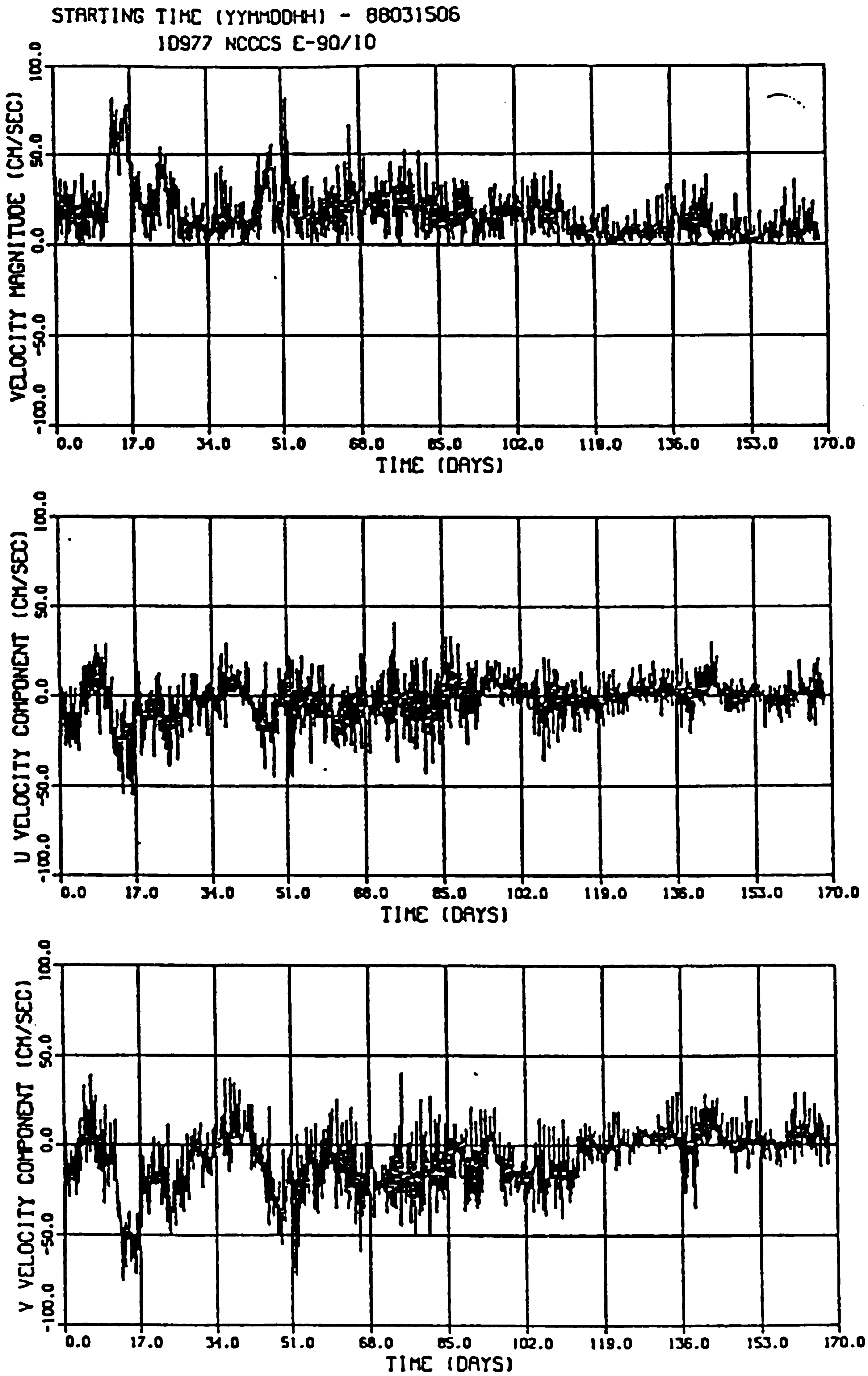

Figure 10. Period 2 Velocity components for gage E90/10

19. A vertical offset in the two signals can indicate a lower mean value for the second data set. For example, the vertical offset in the auto-correlation function of Figure 11 is indicative of the fact that the mean U magnitude for gage E60/10 is larger (-6.7 cm/sec) than that of the mean U magnitude for gage E90/10 (-2.9 cm/sec). Less offset is shown in Figure 12, reflecting the fact that the V data averages are closer in value, -8.4 cm/sec for E60/10 and -6.8 cm/sec for E90/10. A similarity in shape demonstrates a similarity in data. Results shown in Figures 11 and 12 demonstrate a sufficiently strong correlation to justify the selection of the mid-depth E90/45 data as representative of the interim site.

20. The long-term modeling goal is to generate a data base of simulated current data which is realistically representative of currents at the disposal site. In the same manner that the wave fields were simulated to reflect the same statistical distribution as the WIS data, the 240-day time series for period 4 of gage E90/45 is used to compute harmonic constituents which can be used to simulate prototype velocity time series. A plot of the velocity magnitude and the U and V component of the E90/45 time series are shown in Figure 13. A 16-constituent harmonic analysis was performed on each component of the time series. Although the data are not of sufficient length for a reliable harmonic analysis, the procedure provides an approximate estimate of tidal influence. Results show that approximately 28 percent of the U and 20 percent of the V velocity time series are tide related. These results are not surprising in view of the relative magnitudes of the low and high frequency components of the data shown in the figures of Appendix A. Even though the tidal energy is small in comparison to the total signal, the primary astronomical constituents were extracted from the time series and are shown in Table 4.

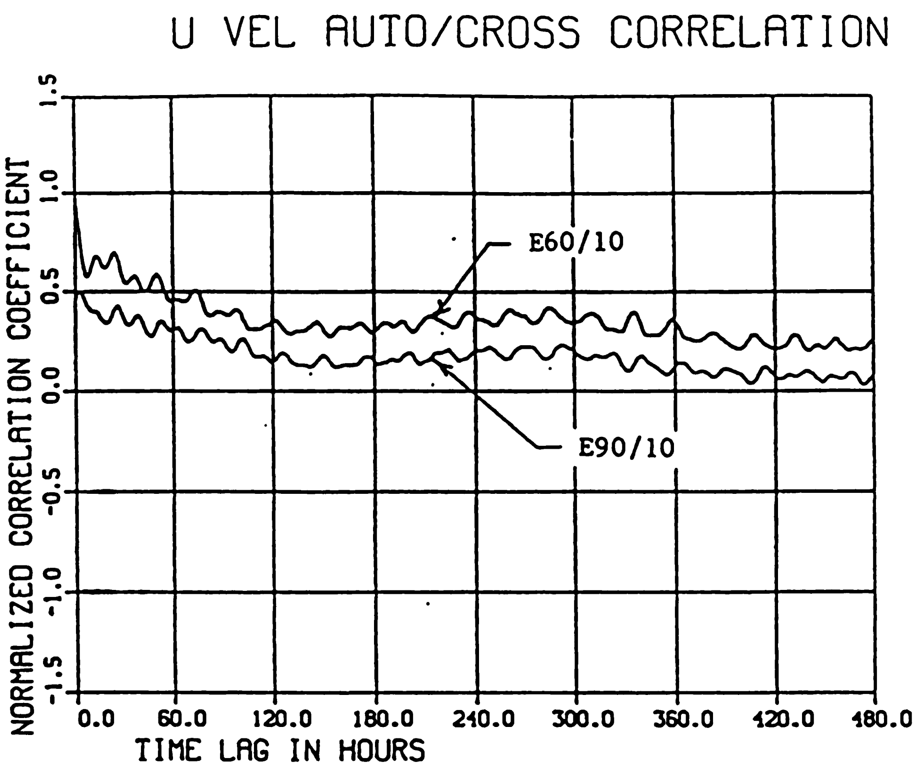

Figure 11. Auto- and cross-correlation functions for U velocity component for gages E60/10 and E90/10

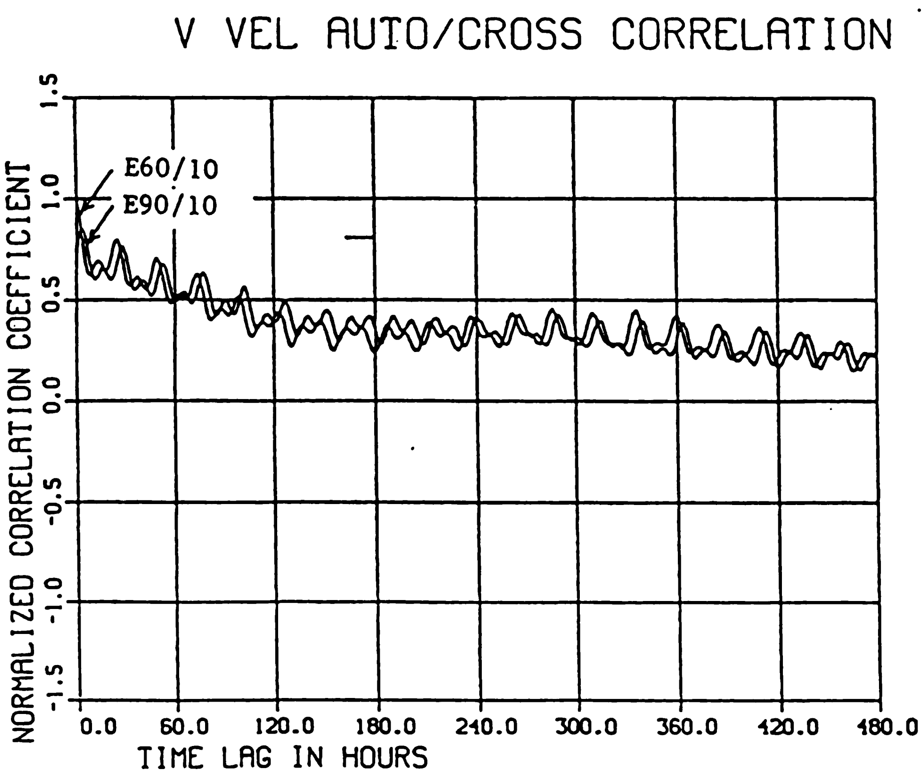

Figure 12. Auto- and cross-correlation functions for V velocity component for gages E60/10 and E90/10

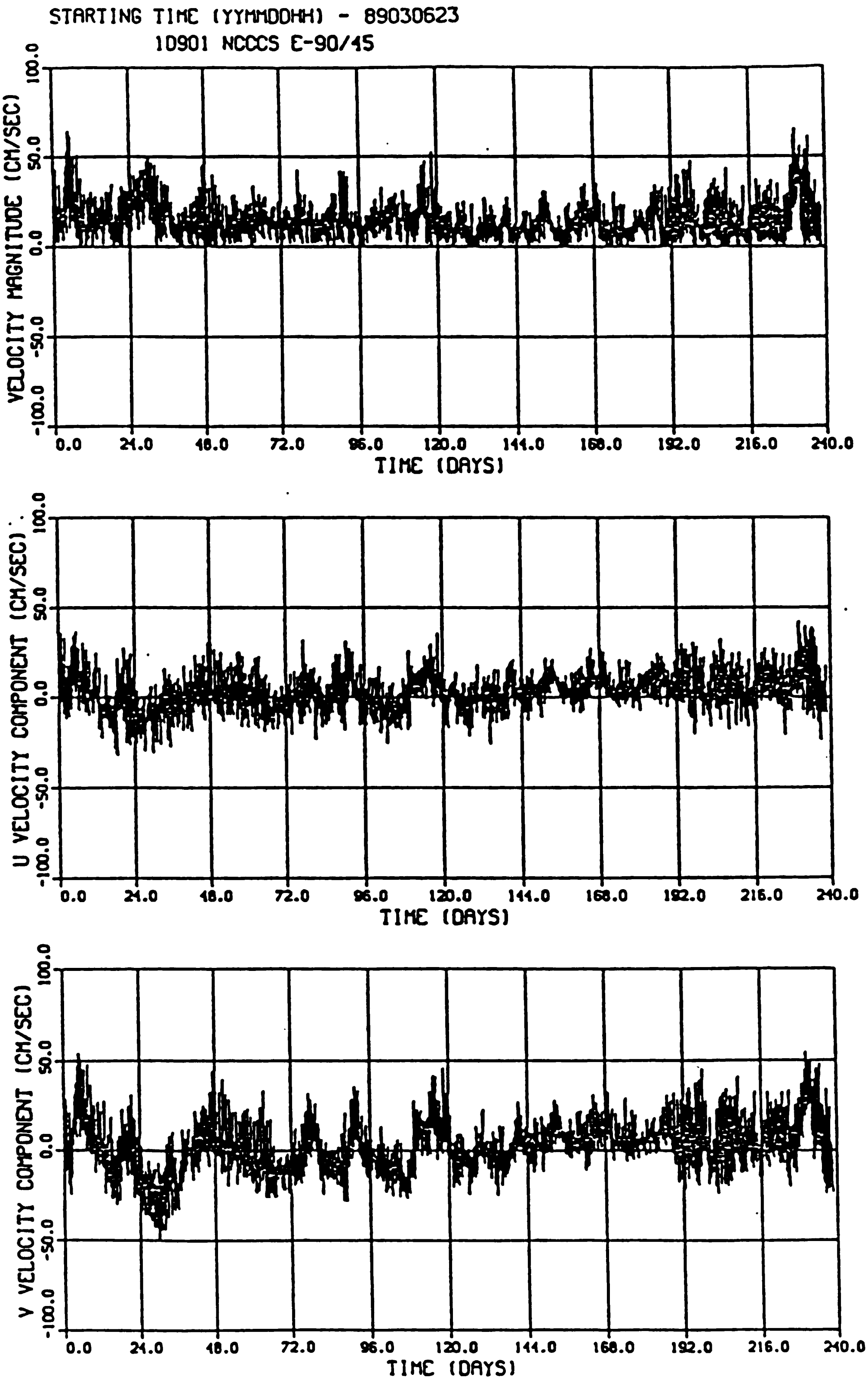

Figure 13. Velocity components for gage E90/45

Table 4

Primary Astronomical Constituents for Gage E90/45

CONST	SPEED-deg/hr	AMP-cm/sec	PHASE-deg	AMP-cm/sec	PHASE-deg
		VEL-V		VEL-U	
O_1	13.943036	3.3	337.	2.1	54.
K_1	15.041069	5.6	221.	3.4	293.
M_2	28.984104	5.4	186.	2.5	218.
S_2	30.000000	2.7	222.	1.2	310.
M_n	0.544400	1.9	118.	2.0	76.
M_{sf}	1.105900	1.5	165.	.6	146.

21. Average current values for Period 4 for the U and V components of gage E90/45 were 2.47 and 1.91 cm/sec respectively, indicating a mean current direction to the Northeast. This directionality is in contrast to the mean surface direction to the Southwest, indicated by the mean value data for gages E60/10 and E90/10. Inspection of the low and high frequency portions of the velocity magnitude as well as the actual U and V components of the data shown in Figure 13 suggest that the addition of a long period, large amplitude component to the tidal signal would produce fluctuations in the simulated current time series which would be representative of prototype conditions. Therefore, a synthetic tidal component with an amplitude of 30 cm/sec and a period of 48 days was added to the constituent list shown in Table 4. The resulting tidal signal is shown in Figure 14. Note that the maximum magnitude approaches 50 cm/sec approximately 6 times in the 240 day simulation. Prototype data also approaches (or slightly exceeded) this value about the same number of times. As such, the tidal constituents listed in Table 4 and the 48-hour component are used to simulate tidal height and current fluctuation in the long-term modeling effort. A residual current of 5 cm/sec was imposed on the computed V component of the tidal signal.

22. A single velocity value is specified for the short-term modeling effort since the model simulations are only made for a total of one hour. In view of the magnitudes shown in Figure 13, a sustained depth-averaged value of 45.7 cm/sec (1.5 ft/sec) was used for both the fine-grained and coarse-grained computations. As shown in Table 3, this value is more

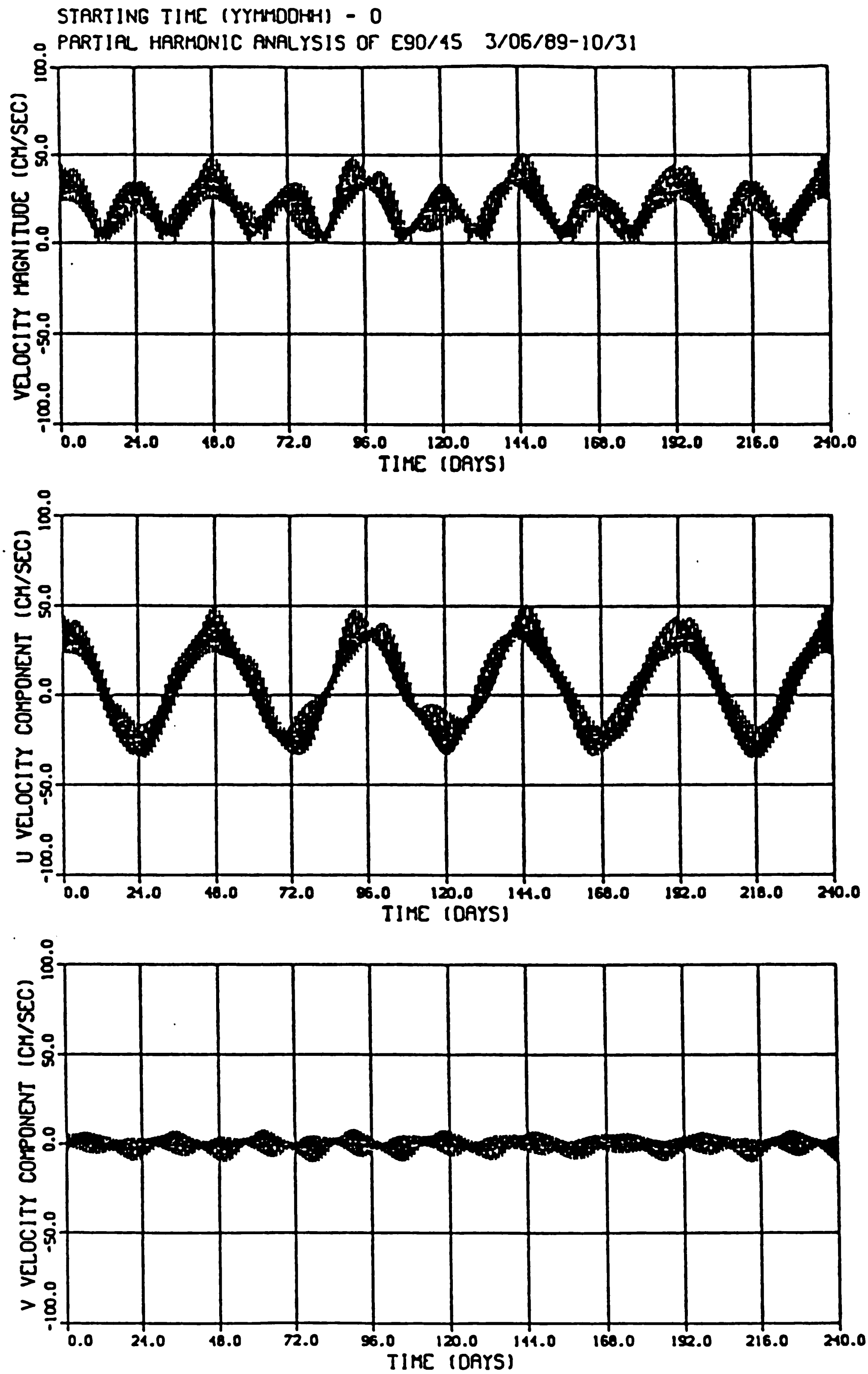

Figure 14. Synthesized tidal series for interim site

representative of extreme conditions than of average conditions; however, it was selected to produce an "upper envelop" dispersion pattern. A description of both the short-term and long-term simulations follow.

PART 3: SHORT-TERM MODELING

General

23. The short-term modeling component of this investigation examines the immediate impact of the actual disposal operation on the surrounding area. Numerical simulations of the discharge are used to determine whether the combined effects of the local topography at the site and the depth-averaged velocity field adversely impact the effectiveness of the dredged material disposal operation. Can the material be physically placed within the limits of the designated site as the material descends through the water column to the ocean floor or are the local currents of sufficient magnitude to transport material out of the site before deposition?

24. The short-term site evaluation phase is made by numerically modeling the disposal operation using the DIFID numerical model. Theory and background of the model are reported in Johnson and Holliday (1978), Johnson (1987), and Johnson, Trawle, and Ademec (1988). Applications of the model are reported in Trawle and Johnson (1986), Scheffner (1989), and Scheffner and Swain (1990). The model computes the time history of a single disposal operation from the time the dredged material is released from the barge until it reaches equilibrium on the ocean floor. The DIFID model separates the dumping operation into three distinct phases. In the first phase, material released from the bin is assumed to form a hemispherically shaped cloud which descends through the water column under the influence of gravity. This phase is called the convective descent phase.

25. The convective descent phase continues until the cloud of material either impacts the bottom or reaches a stable point of neutral buoyancy. In either case, horizontal spreading of material marks the beginning of the dynamic collapse phase in which the material spreads horizontally. When the rate of spreading becomes less than spreading due to turbulent diffusion, the final phase of transport begins, the transport-diffusion phase. The termination of this phase marks the end of the short-term investigation and initializes the boundary conditions for the long-term transport computations to be described in Part 4. An idealization of all three phases of the short-term disposal are shown in Figure 15.

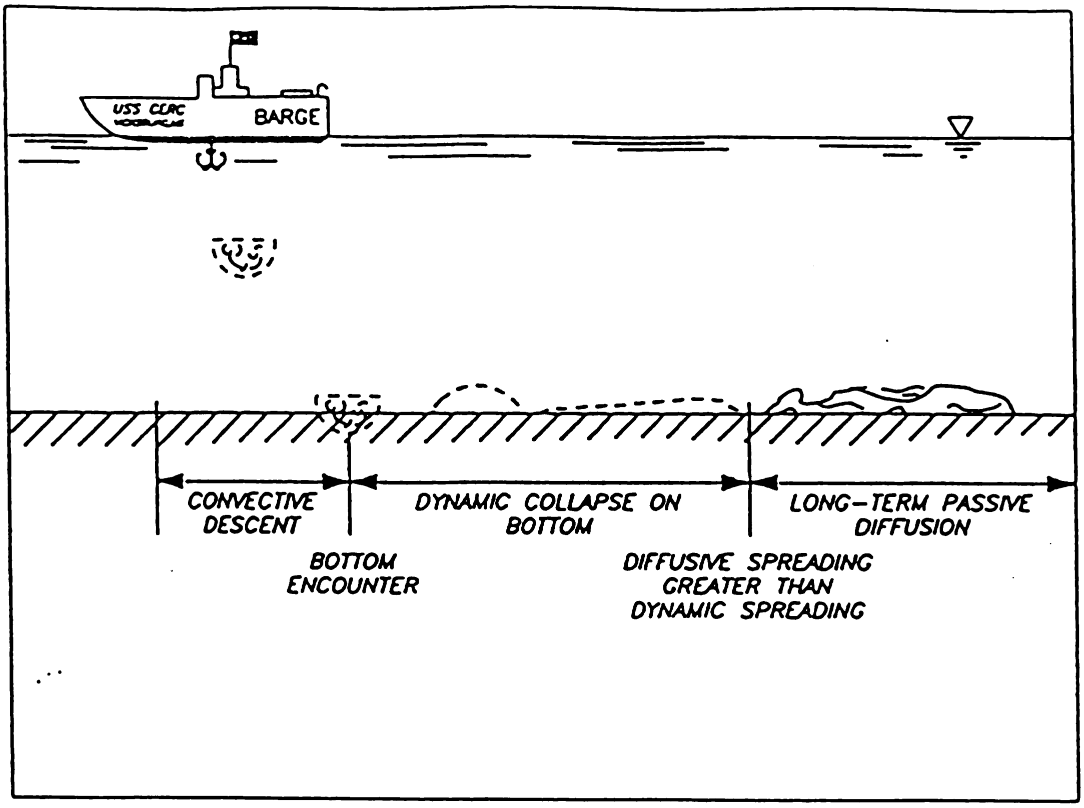

Figure 15. Computational phases of the DIFID model
(from Brandsma and Divoky, 1976)

Input Data Requirements

26. The DIFID model requires site-specific input data in order to quantitatively predict the short-term sediment fate of a disposal operation. These data include the physical dimensions of the dredge, a description of the local environment, to include the local depth and velocity field, and a knowledge of the composition and characteristics of the dredged material in the dredge. In addition, numerous modeling parameters and coefficients must be specified. Since the input parameters are dependent on the specific disposal operation, two simulations are performed to effectively analyze the dispersive characteristics of the interim site, one for the placement of fine-grained material and one for the coarse-grained.

27. Model input requires the specification of the size and capacity of the dredge. It is anticipated that the dredge "Yaquina", or one of similar dimensions, will be used for the Spring disposal of fine-grained material. The Yaquina is a single hopper type dredge which will deposit material at the outer boundary of the interim site, in 55 meters of water. Capacities and dimension of the Yaquina are given in Table 5.

Table 5

Capacities and Dimensions of the Dredge Yaquina

Overall length	200 ft
Width	58 ft
Depth	17 ft
Unloaded draft	8 ft
Loaded draft of vessel	13 ft
Volume	500 cu yds

28. The dredge "Newport", or a similar capacity dredge, is anticipated for use in the Fall disposal of coarse-grained material. The disposal operation will operate near the shoreward boundary of the interim site in a depth of approximately 49 meters of water. Capacities and dimension of the Newport are given in Table 6.

Table 6

Capacities and Dimensions of the Dredge Newport

Overall length	260 ft
Width	60 ft
Depth	22 ft
Unloaded draft	9-10 ft
Loaded draft of vessel	18-19 ft
Volume	2500 cu yds

29. Additional site specific parameters include specification of grid resolution, total simulation duration, and time step parameters to best represent the disposal operation. The bottom slope was computed from the location map shown in Figure 1. Values for the internal model coefficients were based on recommendations and applications reported by Johnson (1989) and Johnson and Holliday (1978). The parameters and coefficients used in both simulations are shown in Table 7.

Table 7

Model Input Parameters and Coefficients

Variables	Values
Grid size (ft)	100
Number of cells:	
cross-shore direction	105
alongshore direction	28
Time step (sec)	100
Duration of simulation (sec)	3600 (fine-grained site)
	400 (coarse-grained site)
Ambient velocity (ft/sec)	1.50
Local depth (meters)	55.0 (fine-grain site)
	49.0 (coarse-grain site)
X-Direction (on-offshore)	
bottom slope (deg)	0.315
Y-Direction (alongshore)	
bottom Slope (deg)	0.0
Ambient density (gm/cc)	1.018
DINCR1	1.0
DINCR2	1.0
Entrainment coefficient ALAPHO	0.235
BETA	0.0
CM	1.0
Drag coefficient for sphere, CD	0.5
GAMA	0.25

Drag coefficient for elliptic cylinder, CDRAG	1.0
CFRIC	0.01
CD3	0.10
CD4	1.00
ALPHAC	0.0010
Bottom friction, FRICTN	0.0100
FI	0.10
ALAMDA	0.005
AKYO	0.05

30. Final input to the DIFID model is the specification of the composition of the solid material in the dredge according to percent volume of sand, clay and silt, clumps, rocks, etc. Each component must be defined according to its respective density, concentration by volume, fall velocity, and voids ratio. Sediment composition for the fine and coarse sites were based on sediment gradation curves corresponding to sediment samples collected from 20 locations within the Humboldt Bay navigation channel complex (Hodges 1990). The median sediment diameter (D_{50}) was extracted from each gradation curve and the respective sample was defined as coarse if this value was greater than 0.075 mm. Those samples with a D_{50} value below 0.075 mm were defined as fine. Based on this criteria, 13 of the 20 samples were determined to be coarse-grained for deposition in the 49 meter site and 7 of the 20 samples were defined as fine-grained for deposition at the 55 meter site.

31. The percent distribution of sediments within each category (coarse or fine) was made by first tabulating the percent distribution above and below 0.075 mm for each distribution of sediments within the sample and then averaging the total percent distributions. Results indicate the coarse sediments to contain a 93 percent/7 percent distribution of sand/silt-clay while the fine sediments contained a 25 percent/75 percent distribution of sand/silt-clay. These percentages represent only the solids portion of the material. The total fluid composition of each sample was based on a separate percent distribution computation for the water content of the sand portion and the silt-clay portion. Results show the coarse materials to be 72 percent

solids, of which 93 percent is sand and 7 percent is silt-clay. The fine-grained samples were computed to be 33.3 percent solid, with 25 percent sand and 75 percent silt-clay. Final results of the computations are shown in Table 8 for the fine grained material and Table 9 for the coarse grained material.

Table 8

Fine Grained Sediment Composition and Characteristics

Description	Density g/cc	Concentration percent	Fall Velocity ft/sec	Voids Ratio	Cohesive? (1 or 0)
SAND	2.600	0.0830	0.06500	0.80	0
SILT-CLAY	2.600	0.2500	0.02560	0.80	1
WATER	1.018	0.6670	0.00		

Table 9

Coarse Grained Sediment Composition and Characteristics

Description	Density g/cc	Concentration percent	Fall Velocity ft/sec	Voids Ratio	Cohesive? (1 or 0)
SAND	2.600	0.6700	0.06500	0.80	0
SILT-CLAY	2.600	0.0500	0.02560	0.80	1
WATER	1.018	0.2800	0.00		

32. The above data was input to the DIFID model. Result of the computations are presented below.

Short-Term Model Simulations

33. The objective of the short-term simulations is to determine whether dredged material can be effectively placed within the limits of the designated disposal sites under the action of a realistic localized velocity field. Two measures of impact can be addressed by the model. The first measure of impact is the calculation of the movement and concentration distribution of the suspended sediment as it descends to the bottom. During

the descent and collapse phases, the sediment cloud grows larger (diffuses) and becomes less concentrated. Calculations during this phase can be used to estimate the time change in sediment concentration with depth and distance from the barge. Model results also provide an estimation of the spatial extent of the deposited material on the ocean floor with respect to the initial release site. Both concentration distribution and total deposition results are presented separately for the fine- and coarse-grained sites.

Fine-Grained Disposal Site Analysis

34. The coefficients presented above for the 55 meter deep fine-grained deposition site were input to the numerical model. Model results include the spatial distribution of each component (sand and silt-clay) of the sediment load in the form of sediment concentration in parts per million (ppm) above background level. An example of transport and diffusion of the sediment cloud is shown in Figure 16 through 19 in which the horizontal distribution of the suspended sediment concentration of the silt-clay cloud is shown at the 120-foot depth (below the surface) for the quarter point times of 900, 1800, 2700, and 3600 secs. These concentration snapshots show the increase in size and corresponding decrease in concentration of the settling cloud as it is dispersed and diffused from the point of disposal.

35. Results of the concentration computation are used to produce a concentration versus distance relationship along the central axis of the grid at five discrete depths for four specified time periods (i.e., along the axis of symmetry at grid 14 of Figures 16-19). Quarter-point times were selected to show results at the 1/4, 1/2, 3/4 and termination times following the initial release of material from the barge. These plots were prepared for both the sand and silt-clay components of the disposed material. Figure 20 presents the concentration history plots for sand while Figure 21 presents the plot corresponding to the silt-clay.

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CONCENTRATIONS ABOVE BACKGROUND OF SIL-CLAY (VOL RATIO OF SOLIDS---MG/L OF TRACER) IN THE CLOUD    900.00 SECONDS AFTER DUMP

          120.00 FT BELOW THE WATER SURFACE
...MULTIPLY DISPLAYED VALUES BY  0.1000E-04      LEGEND... + = .LT. .01   . = .LT. .0001   0 = .LT. .0000001)
K I=  1  2  3  4  5  6  7  8  9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28
 1 00000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000
 2 0000  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  00000
 3 0000  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  00000
 4 0000  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  00000
 5 0000  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  00000
 6 0000  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  00000
 7 0000  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  00000
 8 0000  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  00000
 9 0000  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  00000
10 0000  0  0  0  0  0  0  0  0  0  0  0  0  0  0 <-- Point of Disposal             .  .  00000
11 0000  0  0  0  0  0  0  0  0  .  .  .  .  .  .  .  .  .  .  .  .  .  .  .  .  .  00000
12 0000  0  0  0  0  0  0  .  .  .  .  .  .  .  .  .  .  .  .  .  0  0  0  0  0  0  00000
13 0000  0  0  0  0  .  .  .  .  .  +  +  +  +  +  +  +  .  .  .  .  .  0  0  0  0  00000
14 0000  0  0  0  .  .  .  .  +  +  +  +  +  +  +  +  +  +  +  .  .  .  .  0  0  0  00000
15 0000  0  0  .  .  .  +  +  +  +  +  +  +  +  +  +  +  +  +  +  +  .  .  .  0  0  00000
16 0000  0  .  .  .  +  +  +  +  + .01 .02 .02 .03 .02 .02 .01 +  +  +  +  +  .  .  .  0  00000
17 0000  0  .  .  +  +  +  + .01 .02 .04 .07 .09 .10 .09 .07 .04 .02 .01 +  +  +  +  .  .  0  00000
18 0000  .  .  .  +  +  + .01 .03 .07 .13 .20 .26 .28 .26 .20 .13 .07 .03 .01 +  +  +  .  .  .  00000
19 0000  .  .  +  +  + .01 .03 .07 .16 .30 .46 .60 .65 .60 .46 .30 .16 .07 .03 .01 +  +  +  .  .  00000
20 0000  .  .  +  +  + .02 .06 .15 .32 .59 .90 1.1 1.2 1.1 .90 .59 .32 .15 .06 .02 +  +  +  .  .  00000
21 0000  .  .  +  +  + .03 .09 .25 .54 .97 1.4 1.9 2.0 1.9 1.4 .97 .54 .25 .09 .03 +  +  +  .  .  .0000
22 0000  .  +  +  + .01 .04 .13 .35 .74 1.3 2.0 2.6 2.8 2.6 2.0 1.3 .74 .35 .13 .04 .01 +  +  +  .  .0000
23 0000  .  +  +  + .01 .05 .16 .40 .87 1.5 2.4 3.1 3.3 3.1 2.4 1.5 .87 .40 .16 .05 .01 +  +  +  .  .0000
24 0000  .  +  +  + .01 .05 .15 .40 .86 1.5 2.3 3.0 3.3 3.0 2.3 1.5 .86 .40 .15 .05 .01 +  +  +  .  .0000
25 0000  .  +  +  + .01 .04 .13 .33 .72 1.3 1.9 2.5 2.7 2.5 1.9 1.3 .72 .33 .13 .04 .01 +  +  +  .  .0000
26 0000  .  .  +  +  + .03 .09 .23 .50 .91 1.4 1.8 1.9 1.8 1.4 .91 .50 .23 .09 .03 +  +  +  .  .  .0000
27 0000  .  .  +  +  + .01 .05 .14 .30 .54 .83 1.0 1.1 1.0 .83 .54 .30 .14 .05 .01 +  +  +  .  .  00000
28 0000  .  .  +  +  +  + .02 .07 .15 .27 .41 .54 .58 .54 .41 .27 .15 .07 .02 +  +  +  +  .  .  00000
29 0000  .  .  .  +  +  + .01 .03 .06 .11 .17 .22 .24 .22 .17 .11 .06 .03 .01 +  +  +  .  .  .  00000
30 0000  0  .  .  .  +  +  + .01 .02 .04 .06 .08 .08 .08 .06 .04 .02 .01 +  +  +  .  .  .  0  00000
31 0000  0  0  .  .  +  +  +  +  + .01 .01 .02 .02 .02 .01 .01 +  +  +  +  +  .  .  0  0  00000
32 0000  0  0  .  .  .  +  +  +  +  +  +  +  +  +  +  +  +  +  +  +  .  .  .  0  0  00000
33 0000  0  0  0  .  .  .  .  +  +  +  +  +  +  +  +  +  +  +  .  .  .  .  0  0  0  00000
34 0000  0  0  0  0  .  .  .  .  .  +  +  +  +  +  +  +  .  .  .  .  .  0  0  0  0  00000
35 0000  0  0  0  0  0  0  .  .  .  .  .  .  .  .  .  .  .  .  .  0  0  0  0  0  0  00000
36 0000  0  0  0  0  0  0  0  0  .  .  .  .  .  .  .  .  .  0  0  0  0  0  0  0  0  00000
37 0000  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  00000
38 0000  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  00000
39 0000  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  00000
40 0000  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  00000
41 0000  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  00000
42 0000  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  00000
43 0000  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  00000
44 0000  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  00000
45 0000  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  00000
46 0000  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  00000
47 0000  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  00000
48 0000  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  00000
49 0000  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  00000
50 0000  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  00000
51 0000  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  00000
52 0000  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  00000
53 0000  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  00000
54 0000  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  00000
55 0000  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  00000
56 0000  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  00000
57 0000  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  00000
58 0000  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  00000
59 0000  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  00000
60 0000  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  00000
61 0000  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  00000
62 0000  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  00000
63 0000  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  00000
64 0000  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  00000
65 0000  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  00000
66 0000  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  00000
67 0000  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  00000
68 0000  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  00000
69 0000  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  00000
70 0000  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  00000
```

Figure 16. Suspended sediment cloud at 120 ft deep at 900 sec after disposal

CONCENTRATIONS ABOVE BACKGROUND OF SILT-CLAY (VOL RATIO OF SOLIDS—MG/L OF TRACER) IN THE CLOUD 1800.00 SECONDS AFTER DUMP

120.00 FT BELOW THE WATER SURFACE

...MULTIPLY DISPLAYED VALUES BY 0.1000E-05 (LEGEND... + = .LT. .01 . = .LT. .0001 0 = .LT. .000001)

K I=	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27 28
1	0000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000																										
2	0000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	00000
3	0000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	00000
4	0000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	00000
5	0000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	00000
6	0000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	00000
7	0000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	00000
8	0000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	00000
9	0000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	00000
10	0000	0	0	0	0	0	0	0	0	0	0	0	0	0	← Point of Disposal										0	0	00000
11	0000	0	0	0	0	0	0	0	0	0	0	0	0	0	.	.	.	.	.	.	.	.	.	.	0	0	00000
12	0000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	00000
13	0000	0	0	0	0	0	0	0	.	.	.	.	.	.	.	.	.	.	.	0	0	0	0	0	0	0	00000
14	0000	0	0	0	0	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	0	0	0	0	00000
15	0000	0	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	0	00000
16	0000	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	00000
17	0000	.	.	.	.	.	.	.	+	+	+	+	+	+	+	+	+	+	+	.	.	.	.	.	.	.	.0000
18	0000	.	.	.	.	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	.	.	.	.	.0000
19	0000	.	.	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	.	.	.0000
20	0000	.	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	.	.0000
21	0000	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	.0000
22	0000	+	+	+	+	+	+	+	+	.01	.01	.01	.01	.01	.01	.01	.01	.01	+	+	+	+	+	+	+	+	+0000
23	0000	+	+	+	+	+	+	.01	.01	.02	.02	.03	.03	.03	.03	.03	.02	.02	.01	.01	+	+	+	+	+	+	+0000
24	0000	+	+	+	+	.01	.01	.02	.03	.04	.05	.06	.06	.06	.06	.06	.05	.04	.03	.02	.01	.01	+	+	+	+	+0000
25	0000	+	+	+	.01	.02	.03	.05	.06	.08	.10	.11	.12	.12	.12	.11	.10	.08	.06	.05	.03	.02	.01	+	+	+	+0000
26	0000	+	.01	.01	.02	.04	.06	.09	.11	.15	.18	.20	.22	.22	.22	.20	.18	.15	.11	.09	.06	.04	.02	.01	.01	+	+0000
27	0000	+	.01	.03	.04	.07	.11	.15	.20	.25	.30	.34	.37	.38	.37	.34	.30	.25	.20	.15	.11	.07	.04	.03	.01	+	+0000
28	0000	.01	.02	.04	.07	.12	.17	.24	.32	.41	.49	.56	.60	.62	.60	.56	.49	.41	.32	.24	.17	.12	.07	.04	.02	.01	+0000
29	0000	.02	.04	.07	.12	.18	.27	.38	.50	.63	.76	.86	.93	.95	.93	.86	.76	.63	.50	.38	.27	.18	.12	.07	.04	.02	.010000
30	0000	.03	.06	.10	.17	.27	.40	.55	.73	.93	1.1	1.2	1.3	1.3	1.3	1.2	1.1	.93	.73	.55	.40	.27	.17	.10	.06	.03	.010000
31	0000	.04	.08	.15	.24	.37	.55	.77	1.0	1.2	1.5	1.7	1.8	1.9	1.8	1.7	1.5	1.2	1.0	.77	.55	.37	.24	.15	.08	.04	.020000
32	0000	.06	.11	.20	.32	.50	.73	1.0	1.3	1.7	2.0	2.3	2.4	2.5	2.4	2.3	2.0	1.7	1.3	1.0	.73	.50	.32	.20	.11	.06	.030000
33	0000	.08	.14	.25	.40	.62	.92	1.2	1.6	2.1	2.5	2.9	3.1	3.2	3.1	2.9	2.5	2.1	1.6	1.2	.92	.62	.40	.25	.14	.08	.040000
34	0000	.09	.17	.29	.48	.74	1.0	1.5	2.0	2.5	3.0	3.4	3.7	3.8	3.7	3.4	3.0	2.5	2.0	1.5	1.0	.74	.48	.29	.17	.09	.050000
35	0000	.11	.19	.33	.54	.84	1.2	1.7	2.2	2.8	3.4	3.9	4.2	4.3	4.2	3.9	3.4	2.8	2.2	1.7	1.2	.84	.54	.33	.19	.11	.050000
36	0000	.11	.21	.36	.59	.91	1.3	1.8	2.4	3.0	3.7	4.2	4.5	4.6	4.5	4.2	3.7	3.0	2.4	1.8	1.3	.91	.59	.36	.21	.11	.060000
37	0000	.12	.21	.37	.60	.93	1.3	1.9	2.5	3.1	3.7	4.2	4.6	4.7	4.6	4.2	3.7	3.1	2.5	1.9	1.3	.93	.60	.37	.21	.12	.060000
38	0000	.11	.21	.36	.58	.90	1.3	1.8	2.4	3.0	3.6	4.1	4.5	4.6	4.5	4.1	3.6	3.0	2.4	1.8	1.3	.90	.58	.36	.21	.11	.060000
39	0000	.10	.19	.33	.54	.83	1.2	1.7	2.2	2.8	3.3	3.8	4.1	4.2	4.1	3.8	3.3	2.8	2.2	1.7	1.2	.83	.54	.33	.19	.10	.050000
40	0000	.09	.17	.29	.47	.73	1.0	1.4	1.9	2.4	2.9	3.3	3.6	3.7	3.6	3.3	2.9	2.4	1.9	1.4	1.0	.73	.47	.29	.17	.09	.050000
41	0000	.07	.14	.24	.39	.60	.89	1.2	1.6	2.0	2.4	2.8	3.0	3.1	3.0	2.8	2.4	2.0	1.6	1.2	.89	.60	.39	.24	.14	.07	.040000
42	0000	.06	.11	.19	.31	.48	.70	.98	1.3	1.6	1.9	2.2	2.4	2.4	2.4	2.2	1.9	1.6	1.3	.98	.70	.48	.31	.19	.11	.06	.030000
43	0000	.04	.08	.14	.23	.36	.53	.74	.98	1.2	1.4	1.6	1.8	1.8	1.8	1.6	1.4	1.2	.98	.74	.53	.36	.23	.14	.08	.04	.020000
44	0000	.03	.06	.10	.16	.25	.38	.53	.70	.88	1.0	1.2	1.2	1.3	1.2	1.2	1.0	.88	.70	.53	.38	.25	.16	.10	.06	.03	.010000
45	0000	.02	.04	.07	.11	.17	.25	.36	.47	.60	.71	.81	.88	.90	.88	.81	.71	.60	.47	.36	.25	.17	.11	.07	.04	.02	.010000
46	0000	.01	.02	.04	.07	.11	.16	.23	.30	.38	.46	.52	.56	.58	.56	.52	.46	.38	.30	.23	.16	.11	.07	.04	.02	.01	+0000
47	0000	+	.01	.02	.04	.07	.10	.14	.18	.23	.28	.32	.34	.35	.34	.32	.28	.23	.18	.14	.10	.07	.04	.02	.01	+	+0000
48	0000	+	+	.01	.02	.04	.05	.08	.11	.13	.16	.18	.20	.20	.20	.18	.16	.13	.11	.08	.05	.04	.02	.01	+	+	+0000
49	0000	+	+	+	.01	.02	.03	.04	.06	.07	.09	.10	.11	.11	.11	.10	.09	.07	.06	.04	.03	.02	.01	+	+	+	+0000
50	0000	+	+	+	+	.01	.01	.02	.03	.04	.04	.05	.05	.06	.05	.05	.04	.04	.03	.02	.01	.01	+	+	+	+	+0000
51	0000	+	+	+	+	+	+	.01	.01	.02	.02	.02	.02	.03	.02	.02	.02	.02	.01	.01	+	+	+	+	+	+	+0000
52	0000	+	+	+	+	+	+	+	+	+	.01	.01	.01	.01	.01	.01	.01	+	+	+	+	+	+	+	+	+	+0000
53	0000	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	.0000
54	0000	.	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	.	.0000
55	0000	.	.	.	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	.	.	.	.0000
56	0000	.	.	.	.	.	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	.	.	.	.	.	.0000
57	0000	.	.	.	.	.	.	.	.	+	+	+	+	+	+	+	+	+	.	.	.	.	.	.	.	.	.0000
58	0000	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	00000
59	0000	0	0	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	0	0	00000
60	0000	0	0	0	0	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	0	0	0	0	00000
61	0000	0	0	0	0	0	0	0	0	.	.	.	.	.	.	.	.	.	0	0	0	0	0	0	0	0	00000
62	0000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	00000
63	0000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	00000
64	0000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	00000
65	0000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	00000
66	0000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	00000
67	0000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	00000
68	0000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	00000
69	0000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	00000
70	0000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	00000

Figure 17. Suspended sediment cloud at 120 ft deep at 1800 sec after disposal

CONCENTRATIONS ABOVE BACKGROUND OF SIL-CLAY (VOL RATIO OF SOLIDS—MG/L OF TRACER) IN THE CLOUD 2700.00 SECONDS AFTER DUMP

120.00 FT BELOW THE WATER SURFACE

...MULTIPLY DISPLAYED VALUES BY 0.1000E-05 (LEGEND... + = .LT. .01 . = .LT. .0001 0 = .LT. .000001)

K I=	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28
1	0000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000																											
2	0000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0000
3	0000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0000
4	0000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0000
5	0000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0000
6	0000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0000
7	0000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0000
8	0000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0000
9	0000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0000
10	0000	0	0	0	0	0	0	0	0	0	0	0	0	0	←Point of Disposal											0	0	0000
11	0000	0	0	0	0	0	0	0	0	0	0	0	0	0	0											0	0	0000
12	0000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0000
13	0000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0000
14	0000	0	0	0	0	0	0	0	0	0	0	.	.	.	.	.	0	0	0	0	0	0	0	0	0	0	0	0000
15	0000	0	0	0	0	.	.	.	:	.	.	.	.	.	.	.	.	.	.	.	.	.	0	0	0	0	0	0000
16	0000	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	0	0000
17	0000	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	0000
18	0000	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	0000
19	0000	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	0000
20	0000	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	0000
21	0000	.	.	.	.	.	.	+	+	+	+	+	+	+	+	+	+	+	+	+	.	.	.	.	.	.	.	0000
22	0000	.	.	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	.	.	.	0000
23	0000	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	.	0000
24	0000	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	0000
25	0000	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	0000
26	0000	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	0000
27	0000	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	0000
28	0000	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	0000
29	0000	+	+	+	+	+	+	+	.01	.01	.01	.01	.01	.01	.01	.01	.01	.01	.01	+	+	+	+	+	+	+	+	0000
30	0000	+	+	+	+	.01	.01	.01	.01	.01	.01	.02	.02	.02	.02	.02	.01	.01	.01	.01	.01	.01	+	+	+	+	+	0000
31	0000	+	+	.01	.01	.01	.01	.02	.02	.02	.02	.03	.03	.03	.03	.03	.02	.02	.02	.02	.01	.01	.01	.01	+	+	+	0000
32	0000	.01	.01	.01	.02	.02	.02	.03	.03	.04	.04	.04	.04	.04	.04	.04	.04	.04	.03	.03	.02	.02	.02	.01	.01	.01	+	0000
33	0000	.01	.01	.02	.03	.03	.04	.04	.05	.06	.06	.07	.07	.07	.07	.07	.06	.06	.05	.04	.04	.03	.03	.02	.01	.01	.01	0000
34	0000	.02	.02	.03	.04	.05	.06	.07	.08	.08	.09	.10	.10	.10	.10	.10	.09	.08	.08	.07	.06	.05	.04	.03	.02	.02	.01	0000
35	0000	.03	.04	.05	.06	.07	.08	.10	.11	.12	.13	.14	.14	.14	.14	.14	.13	.12	.11	.10	.08	.07	.06	.05	.04	.03	.02	0000
36	0000	.04	.05	.06	.08	.10	.12	.14	.15	.17	.18	.19	.20	.20	.20	.19	.18	.17	.15	.14	.12	.10	.08	.06	.05	.04	.03	0000
37	0000	.05	.07	.09	.11	.14	.16	.18	.21	.23	.25	.26	.27	.28	.27	.26	.25	.23	.21	.18	.16	.14	.11	.09	.07	.05	.04	0000
38	0000	.07	.09	.12	.15	.18	.21	.25	.28	.31	.33	.35	.36	.37	.36	.35	.33	.31	.28	.25	.21	.18	.15	.12	.09	.07	.05	0000
39	0000	.10	.12	.16	.19	.24	.28	.32	.36	.40	.43	.46	.47	.48	.47	.46	.43	.40	.36	.32	.28	.24	.19	.16	.12	.10	.07	0000
40	0000	.12	.16	.20	.25	.30	.35	.41	.46	.51	.55	.58	.60	.61	.60	.58	.55	.51	.46	.41	.35	.30	.25	.20	.16	.12	.09	0000
41	0000	.15	.20	.25	.31	.37	.44	.51	.57	.63	.68	.72	.74	.75	.74	.72	.68	.63	.57	.51	.44	.37	.31	.25	.20	.15	.12	0000
42	0000	.19	.24	.31	.38	.45	.53	.62	.70	.77	.83	.88	.90	.91	.90	.88	.83	.77	.70	.62	.53	.45	.38	.31	.24	.19	.14	0000
43	0000	.22	.27	.36	.45	.54	.64	.73	.83	.91	.99	1.0	1.0	1.0	1.0	1.0	.99	.91	.83	.73	.64	.54	.45	.36	.29	.22	.17	0000
44	0000	.26	.34	.42	.52	.63	.74	.85	.96	1.0	1.1	1.2	1.2	1.2	1.2	1.2	1.1	1.0	.96	.85	.74	.63	.52	.42	.34	.26	.20	0000
45	0000	.30	.38	.48	.59	.72	.84	.97	1.1	1.2	1.3	1.3	1.4	1.4	1.4	1.3	1.3	1.2	1.1	.97	.84	.72	.59	.48	.38	.30	.23	0000
46	0000	.33	.43	.54	.66	.80	.94	1.0	1.2	1.3	1.4	1.5	1.5	1.6	1.5	1.5	1.4	1.3	1.2	1.0	.94	.80	.66	.54	.43	.33	.25	0000
47	0000	.36	.47	.59	.72	.87	1.0	1.1	1.3	1.4	1.5	1.6	1.7	1.7	1.7	1.6	1.5	1.4	1.3	1.1	1.0	.87	.72	.59	.47	.36	.27	0000
48	0000	.39	.50	.62	.77	.93	1.0	1.2	1.4	1.5	1.6	1.7	1.8	1.8	1.8	1.7	1.6	1.5	1.4	1.2	1.0	.93	.77	.62	.50	.39	.29	0000
49	0000	.40	.52	.65	.80	.97	1.1	1.3	1.4	1.6	1.7	1.8	1.9	1.9	1.9	1.8	1.7	1.6	1.4	1.3	1.1	.97	.80	.65	.52	.40	.31	0000
50	0000	.41	.53	.66	.82	.99	1.1	1.3	1.5	1.6	1.7	1.8	1.9	1.9	1.9	1.8	1.7	1.6	1.5	1.3	1.1	.99	.82	.66	.53	.41	.31	0000
51	0000	.41	.53	.66	.82	.98	1.1	1.3	1.5	1.6	1.7	1.8	1.9	1.9	1.9	1.8	1.7	1.6	1.5	1.3	1.1	.98	.82	.66	.53	.41	.31	0000
52	0000	.40	.52	.65	.80	.96	1.1	1.3	1.4	1.6	1.7	1.8	1.9	1.9	1.9	1.8	1.7	1.6	1.4	1.3	1.1	.96	.80	.65	.52	.40	.30	0000
53	0000	.38	.49	.62	.76	.92	1.0	1.2	1.4	1.5	1.6	1.7	1.8	1.8	1.8	1.7	1.6	1.5	1.4	1.2	1.0	.92	.76	.62	.49	.38	.29	0000
54	0000	.36	.46	.58	.71	.86	1.0	1.1	1.3	1.4	1.5	1.6	1.7	1.7	1.7	1.6	1.5	1.4	1.3	1.1	1.0	.86	.71	.58	.46	.36	.27	0000
55	0000	.33	.42	.53	.65	.79	.93	1.0	1.2	1.3	1.4	1.5	1.5	1.5	1.5	1.5	1.4	1.3	1.2	1.0	.93	.79	.65	.53	.42	.33	.25	0000
56	0000	.29	.38	.47	.58	.70	.83	.95	1.0	1.1	1.2	1.3	1.4	1.4	1.4	1.3	1.2	1.1	1.0	.95	.83	.70	.58	.47	.38	.29	.22	0000
57	0000	.26	.33	.41	.51	.62	.73	.84	.94	1.0	1.1	1.1	1.2	1.2	1.2	1.1	1.1	1.0	.94	.84	.73	.62	.51	.41	.33	.26	.19	0000
58	0000	.22	.28	.36	.44	.53	.62	.72	.81	.89	.96	1.0	1.0	1.0	1.0	1.0	.96	.89	.81	.72	.62	.53	.44	.36	.28	.22	.17	0000
59	0000	.18	.24	.30	.37	.44	.52	.60	.68	.75	.81	.85	.88	.87	.88	.85	.81	.75	.68	.60	.52	.44	.37	.30	.24	.18	.14	0000
60	0000	.15	.19	.24	.30	.36	.43	.49	.56	.61	.66	.70	.72	.73	.72	.70	.66	.61	.56	.49	.43	.36	.30	.24	.19	.15	.11	0000
61	0000	.12	.15	.19	.24	.29	.34	.39	.45	.49	.53	.56	.58	.59	.58	.56	.53	.49	.45	.39	.34	.29	.24	.19	.15	.12	.09	0000
62	0000	.09	.12	.15	.19	.23	.27	.31	.35	.39	.42	.44	.45	.46	.45	.44	.42	.39	.35	.31	.27	.23	.19	.15	.12	.09	.07	0000
63	0000	.07	.09	.12	.14	.17	.20	.24	.27	.30	.32	.34	.35	.35	.35	.34	.32	.30	.27	.24	.20	.17	.14	.12	.09	.07	.05	0000
64	0000	.05	.07	.09	.11	.13	.15	.18	.20	.22	.24	.25	.26	.26	.26	.25	.24	.22	.20	.18	.15	.13	.11	.09	.07	.05	.04	0000
65	0000	.04	.05	.06	.08	.09	.11	.13	.15	.16	.17	.18	.19	.19	.19	.18	.17	.16	.15	.13	.11	.09	.08	.06	.05	.04	.03	0000
66	0000	.02	.03	.04	.05	.07	.08	.09	.10	.12	.12	.13	.14	.14	.14	.13	.12	.12	.10	.09	.08	.07	.05	.04	.03	.02	.02	0000
67	0000	.02	.02	.03	.04	.05	.05	.06	.07	.08	.09	.09	.09	.10	.09	.09	.09	.08	.07	.06	.05	.05	.04	.03	.02	.02	.01	0000
68	0000	.01	.01	.02	.02	.03	.04	.04	.05	.05	.06	.06	.06	.06	.06	.06	.06	.05	.05	.04	.04	.03	.02	.02	.01	.01	.01	0000
69	0000	+	.01	.01	.01	.02	.02	.03	.03	.03	.04	.04	.04	.04	.04	.04	.04	.03	.03	.03	.02	.02	.01	.01	.01	+	+	0000
70	0000	+	+	.01	.01	.01	.01	.02	.02	.02	.02	.02	.03	.03	.03	.02	.02	.02	.02	.02	.01	.01	.01	.01	+	+	+	0000

Figure 18. Suspended sediment cloud at 120 ft deep at 2700 sec after disposal

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CONCENTRATIONS ABOVE BACKGROUND OF SIL-CLAY (VOL RATIO OF SOLIDS---MG/L OF TRACER) IN THE CLOUD   3600.00 SECONDS AFTER DUMP

          120.00 FT BELOW THE WATER SURFACE
...MULTIPLY DISPLAYED VALUES BY  0.1000E-05     (LEGEND... + = .LT. .01   . = .LT. .0001   0 = .LT. .000001)
 K I= 1   2   3   4   5   6   7   8   9  10  11  12  13  14  15  16  17  18  19  20  21  22  23  24  25  26  27 28
  1 000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000
  2 0000  0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0  00000
  3 0000  0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0  00000
  4 0000  0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0  00000
  5 0000  0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0  00000
  6 0000  0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0  00000
  7 0000  0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0  00000
  8 0000  0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0  00000
  9 0000  0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0  00000
 10 0000  0   0   0   0   0   0   0   0   0   0   0   0   0 <-Point of Disposal                       0   0  00000
 11 0000  0   0   0   0   0   0   0   0   0   0   0   0   0                                           0   0  00000
 12 0000  0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0  00000
 13 0000  0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0  00000
 14 0000  0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0  00000
 15 0000  0   0   0   0   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   0   0   0   0  00000
 16 0000  .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .  .0000
 17 0000  .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .  .0000
 18 0000  .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .  .0000
 19 0000  .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .  .0000
 20 0000  .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .  .0000
 21 0000  .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .  .0000
 22 0000  .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .  .0000
 23 0000  .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .  .0000
 24 0000  .   .   .   .   .   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   .   .   .   .   .  .0000
 25 0000  .   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   .  .0000
 26 0000  +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +  +0000
 27 0000  +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +  +0000
 28 0000  +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +  +0000
 29 0000  +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +  +0000
 30 0000  +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +  +0000
 31 0000  +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +  +0000
 32 0000  +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +  +0000
 33 0000  +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +  +0000
 34 0000  +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +  +0000
 35 0000  +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +  +0000
 36 0000  +   +   +   +   +   + .01 .01 .01 .01 .01 .01 .01 .01 .01 .01 .01 .01 .01   +   +   +   +   +   +  +0000
 37 0000  +   + .01 .01 .01 .01 .01 .01 .01 .01 .01 .01 .01 .01 .01 .01 .01 .01 .01 .01 .01 .01 .01   +   +  +0000
 38 0000 .01 .01 .01 .01 .01 .01 .01 .02 .02 .02 .02 .02 .02 .02 .02 .02 .02 .02 .01 .01 .01 .01 .01 .01 .01  +0000
 39 0000 .01 .01 .01 .01 .02 .02 .02 .02 .02 .02 .03 .03 .03 .03 .03 .02 .02 .02 .02 .02 .02 .01 .01 .01 .01 .010000
 40 0000 .01 .02 .02 .02 .02 .03 .03 .03 .03 .03 .04 .04 .04 .04 .04 .03 .03 .03 .03 .03 .02 .02 .02 .02 .01 .010000
 41 0000 .02 .02 .03 .03 .03 .04 .04 .04 .04 .05 .05 .05 .05 .05 .05 .05 .04 .04 .04 .04 .03 .03 .03 .02 .02 .020000
 42 0000 .03 .03 .03 .04 .04 .05 .05 .05 .06 .06 .06 .06 .06 .06 .06 .06 .06 .05 .05 .05 .04 .04 .03 .03 .03 .020000
 43 0000 .03 .04 .04 .05 .06 .06 .07 .07 .07 .08 .08 .08 .08 .08 .08 .08 .07 .07 .07 .06 .06 .05 .04 .04 .03 .030000
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 46 0000 .07 .08 .09 .10 .11 .12 .13 .14 .15 .15 .16 .16 .16 .16 .16 .15 .15 .14 .13 .12 .11 .10 .09 .08 .07 .060000
 47 0000 .09 .10 .11 .12 .14 .15 .16 .17 .18 .19 .19 .20 .20 .20 .19 .19 .18 .17 .16 .15 .14 .12 .11 .10 .09 .070000
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 52 0000 .20 .23 .26 .28 .31 .34 .37 .39 .41 .43 .44 .45 .45 .45 .44 .43 .41 .39 .37 .34 .31 .28 .26 .23 .20 .170000
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 63 0000 .44 .51 .57 .63 .70 .76 .82 .87 .91 .95 .98 .99 1.0 .99 .98 .95 .91 .87 .82 .76 .70 .63 .57 .51 .44 .390000
 64 0000 .45 .51 .57 .64 .70 .76 .82 .87 .92 .96 .98 1.0 1.0 1.0 .98 .96 .92 .87 .82 .76 .70 .64 .57 .51 .45 .390000
 65 0000 .44 .51 .57 .63 .70 .76 .82 .87 .91 .95 .98 .99 1.0 .99 .98 .95 .91 .87 .82 .76 .70 .63 .57 .51 .44 .390000
 66 0000 .44 .50 .56 .62 .68 .74 .80 .85 .90 .93 .96 .98 .98 .98 .96 .93 .90 .85 .80 .74 .68 .62 .56 .50 .44 .380000
 67 0000 .42 .48 .54 .60 .66 .72 .78 .83 .87 .91 .93 .95 .95 .95 .93 .91 .87 .83 .78 .72 .66 .60 .54 .48 .42 .370000
 68 0000 .41 .46 .52 .58 .64 .69 .75 .80 .84 .87 .90 .91 .92 .91 .90 .87 .84 .80 .75 .69 .64 .58 .52 .46 .41 .350000
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 70 0000 .36 .41 .46 .52 .57 .62 .67 .71 .75 .78 .80 .81 .82 .81 .80 .78 .75 .71 .67 .62 .57 .52 .46 .41 .36 .310000
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Figure 19. Suspended sediment cloud at 120 ft deep at 3600 sec after disposal

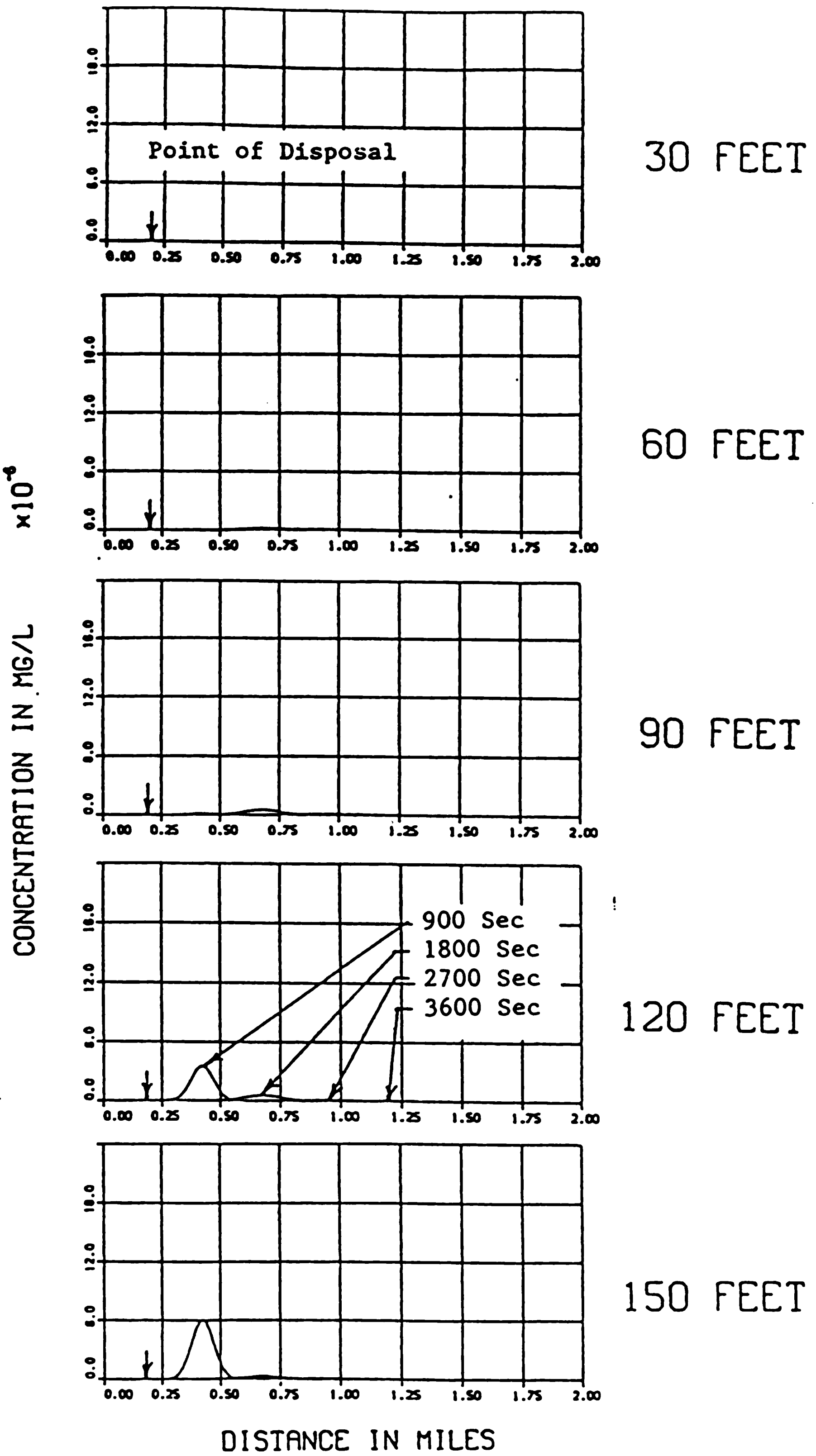

Figure 20. Sand concentration evolution relationships for the fine-grained site

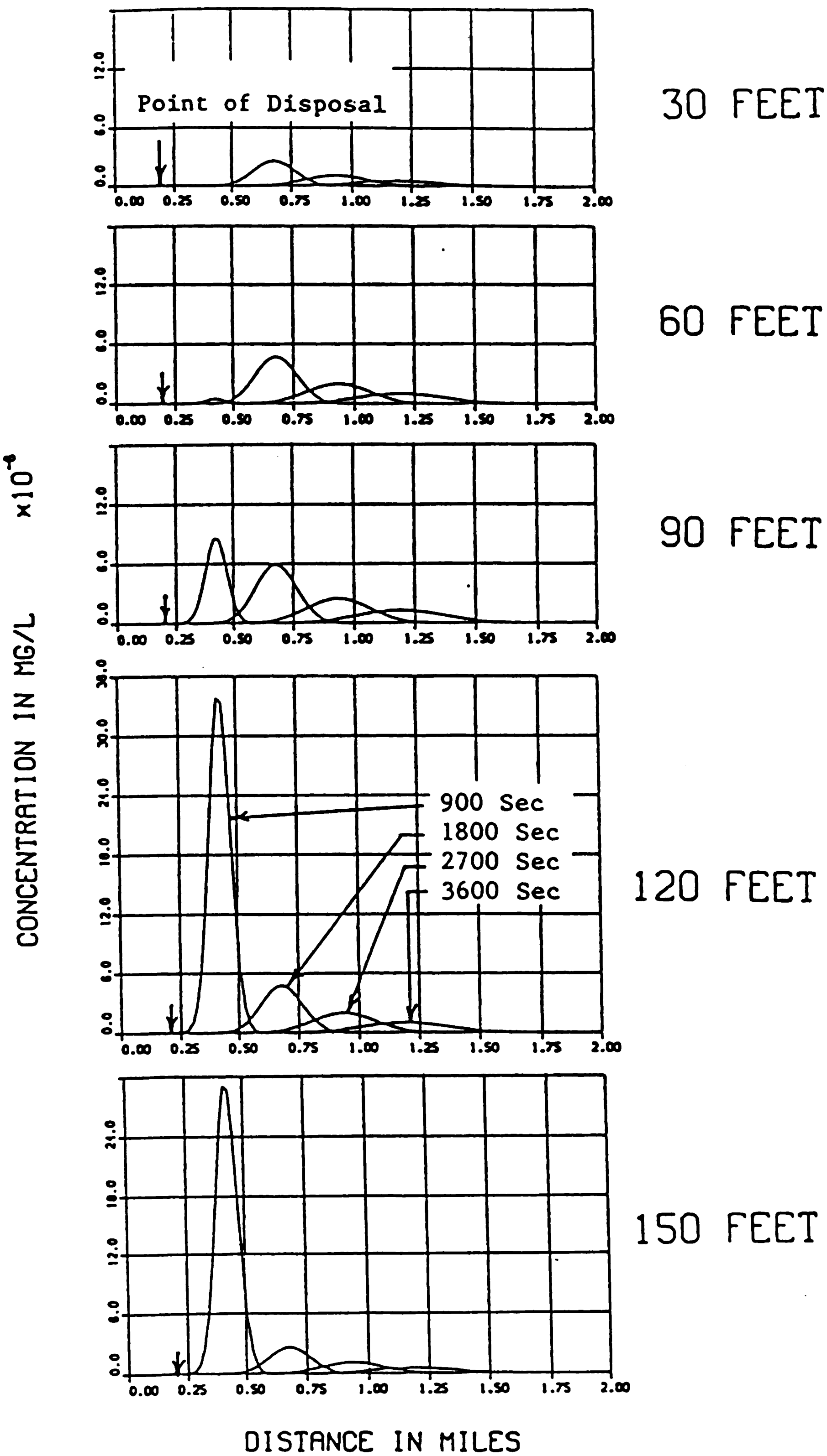

Figure 21. Silt-clay concentration evolution relationships for the fine-grained site

36. The results shown in Figures 20 and 21 represents time-concentration histories along the suspended sediment cloud axis. The four concentration profiles shown at the 120-ft level of Figure 21 correspond to the central axis of Figures 16 through 19. The five depths of 30, 60, 90, 120, and 150 ft were used to demonstrate the sediment distribution through the water column. For example, simulations of the disposal operation in depths of 180 ft (55 meters) indicate essentially no suspended sediment, either sand or silt-clay, in the upper 60 ft of the water column 900 sec after the initial dump, i.e., the material has passed through that depth. Results demonstrate that the descent phase of the hemispherically shaped cloud passes through the water rapidly leaving little sediment in the upper water column. The examples presented in Figures 20 and 21 indicate that the maximum sand concentration is located near the bottom while the point of maximum silt-clay concentration stabalizes at approximately mid-depth and that a concentration decrease is seen both above and below this point. This relationship of maximum concentration at the 90-ft depth is maintained for the second, third, and fourth quarter point as the cloud disperses. All results indicate a decreasing concentration in both time after disposal and distance from the release point. A summary of the sand and silt-clay concentration simulations are shown in Tables 10 and 11. In both Figures, the point of disposal is at grid cell 10 of Figures 16-19, corresponnding to the 0.19 mile point of Figures 20 and 21.

Table 10

Summary of Computed Maximum Suspended Sand Concentration

(Concentration in mg/l above ambient)

Depth	Time (sec)/Approximate Distance from Disposal (Miles)			
(ft)	900/0.25	1800/0.51	2700/0.76	3600/1.02
30	4.0×10^{-13}	6.4×10^{-8}	6.3×10^{-8}	2.3×10^{-8}
60	9.0×10^{-10}	2.5×10^{-7}	1.1×10^{-7}	4.3×10^{-8}
90	1.8×10^{-7}	5.3×10^{-7}	1.4×10^{-7}	5.3×10^{-8}
120	3.5×10^{-6}	5.6×10^{-7}	1.1×10^{-7}	4.3×10^{-8}
150	6.0×10^{-6}	3.1×10^{-7}	6.4×10^{-8}	2.3×10^{-8}

Table 11

Summary of Computed Maximum Suspended Silt-Clay Concentration

(Concentration in mg/l above ambient)

Depth	Time (sec)/Approximate Distance from Disposal (Miles)			
(ft)	900/0.25	1800/0.51	2700/0.76	3600/1.02
30	5.7×10^{-9}	2.5×10^{-6}	1.0×10^{-6}	5.4×10^{-7}
60	4.7×10^{-7}	4.7×10^{-6}	1.9×10^{-6}	1.0×10^{-6}
90	8.6×10^{-6}	5.8×10^{-6}	2.4×10^{-6}	1.2×10^{-6}
120	3.3×10^{-5}	4.7×10^{-6}	1.9×10^{-6}	1.0×10^{-6}
150	2.9×10^{-5}	2.6×10^{-6}	1.0×10^{-6}	5.5×10^{-7}

A plot of the total sediment deposition versus distance along the axis of the disposal grid is shown in Figure 22. A three-dimensional view of the resulting disposal pattern is shown in Figure 23 with the corresponding contour plot shown in Figure 24.

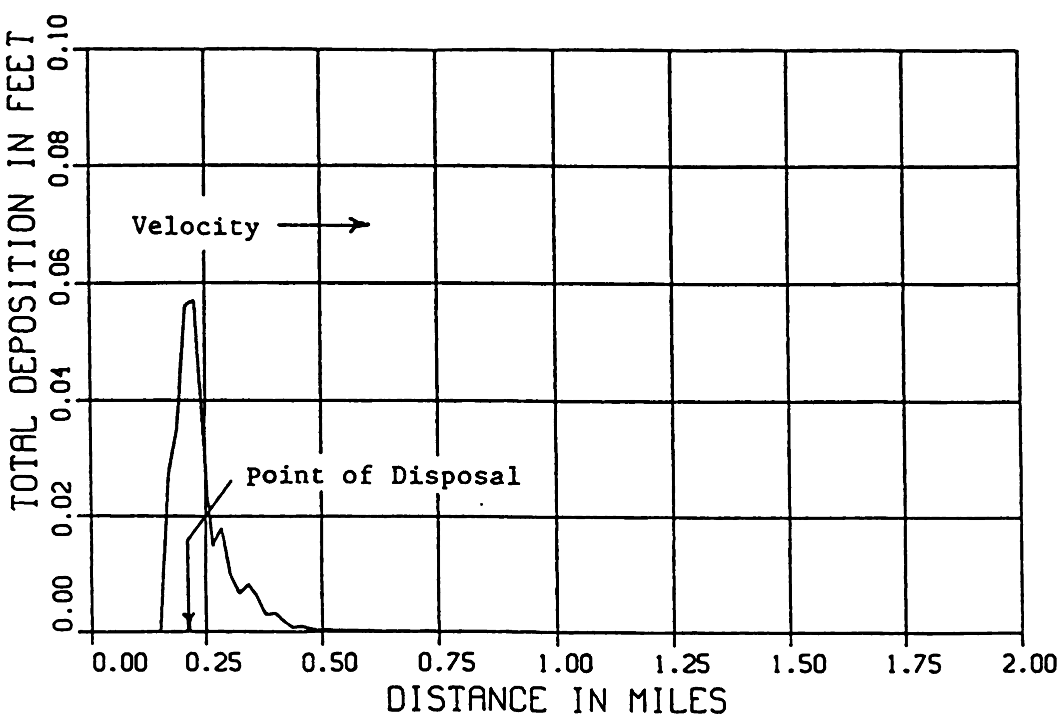

Figure 22. Total deposition pattern for the fine-grained site

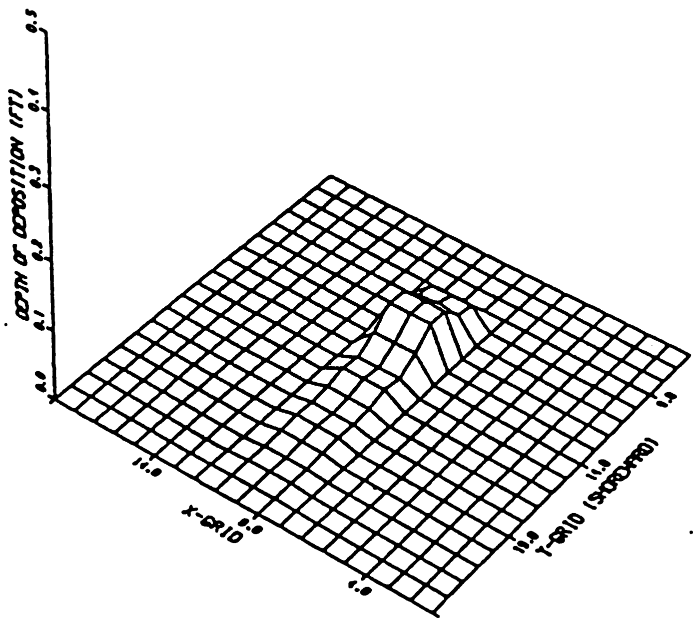

Figure 23 · Three-Dimensional View of the Fine-Grained Site Deposition Pattern

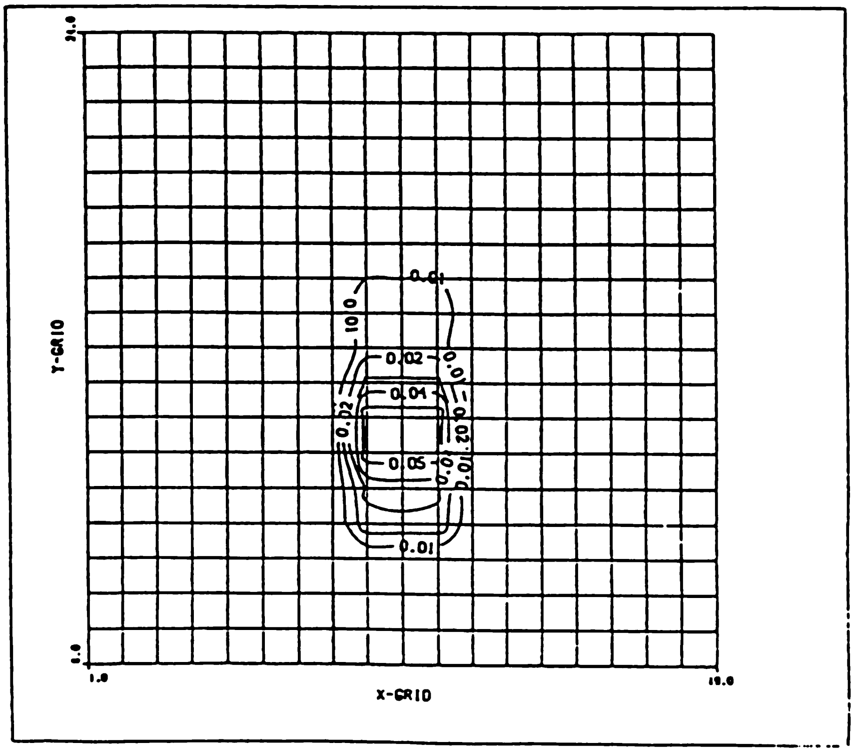

Figure 24 Contour Plot of the Fine-Grained Site Deposition Pattern

Coarse-Grained Disposal Site Analysis

37. The single load deposition simulation for the coarse-grained material was performed using the coefficients shown in Tables 6 and 8. Results of the simulations showed that the material descended rapidly to the ocean floor, leaving no material in suspension within the water column. Therefore, time-concentration plots comparable to Figures 20 and 21 for the fine-grained material are not available. Model results are necessarily limited to total material deposition patterns. These results are shown in the cross-sectional plot of Figure 25, the three-dimensional view of the mound of Figure 26, and the computed contour map of the site shown in Figure 27. As shown in the figures, the maximum thickness of deposition is approximately 0.23 ft, covering an approximate 400-500 ft diameter area. Deposition is shown to be confined to this immediate area.

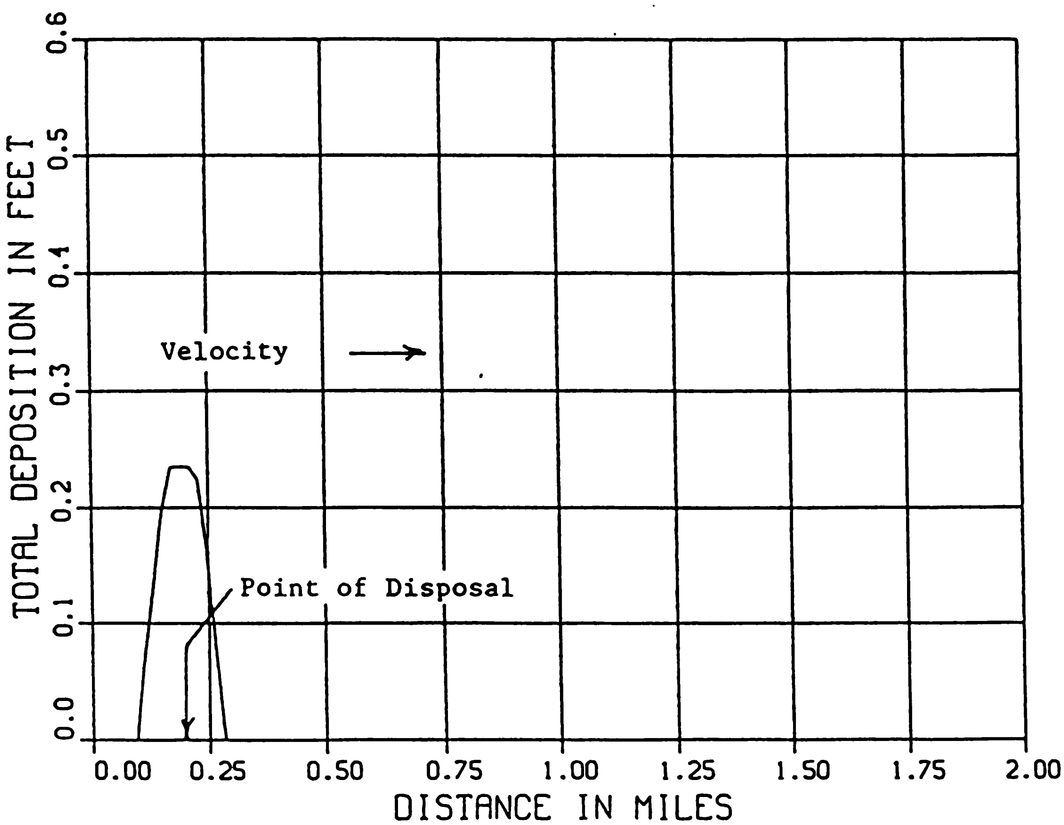

Figure 25. Total deposition pattern for the coarse-grained site

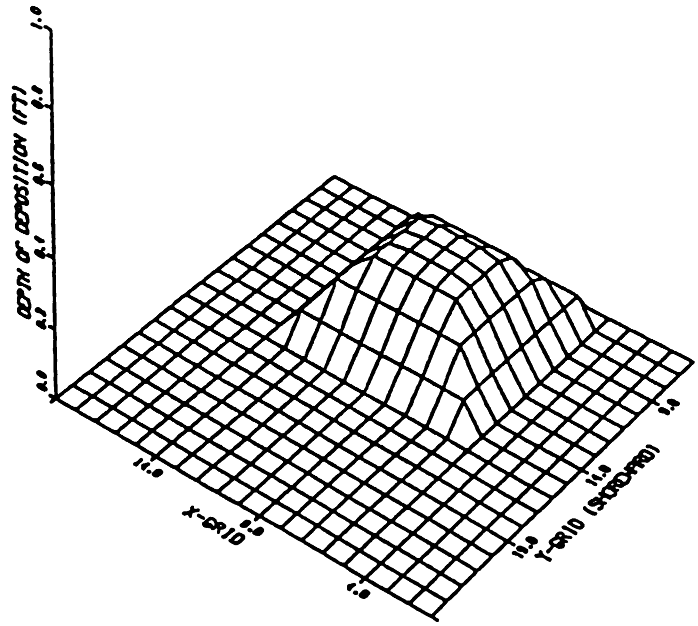

Figure 26 Three-Dimensional Coarse-Grained Site Deposition Pattern

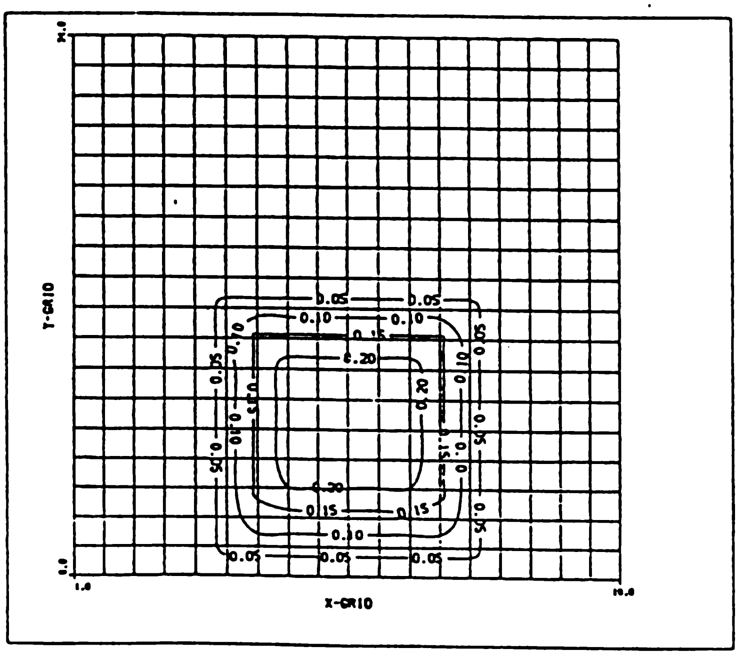

Figure 27 Contour Plot of the Coarse-Grained Site Deposition Pattern

38. Both DIFID analyses were based on an assumed depth-averaged velocity of 45.7 cm/sec (1.5 ft/sec). As shown in the prototype data analysis, this velocity represents a much higher than average condition. As such the results presented for the short-term simulation can be considered as conservative with respect to the dispersion of the suspended sediments. An analysis of the short-term analysis results will be presented following the long-term simulations described in Part 4.

PART 4: LONG-TERM MODELING

General

39. The long-term simulation phase of the site designation study investigates the behavior of a dredged material mound over time. This analysis is accomplished by developing a means of classifying disposal sites as either dispersive or non-dispersive based on whether local wave and velocity fields are adequate to erode and transport significant amounts of material from the site. The local currents can be due to either normal tidal action and mean flow circulation patterns or to storm related activity. Sediment transport calculations use these waves and currents to estimate mound stability as a function of the local bathymetry and sediment characteristics at both the fine-grained and coarse-grained sites.

40. This final phase of the site evaluation represents an extension of the short-term fate analysis of Part 3 in which site dispersiveness was based on the ability to effectively place material within a designated site during the disposal operation. The long-term analysis begins with the assumption that the short-term disposal operation is successful in creating a stable mound configuration. Whether the mound is dispersive or non-dispersive depends on whether the local wave and current conditions are capable of resuspending and transporting significant amounts of material from the mound such that areas adjacent to the disposal site are impacted.

41. The long-term site stability analysis approach adopted for this study utilizes the simulated wave and current time series described in Part 2 to provide a quantitative estimate of the stability of the mound as a function of localized environmental conditions. The analysis approach is based on coupled hydrodynamic and sediment transport models which compute the transport of non-cohesive sediment as a function of the local velocity and depth. The resulting distribution of transport is used in a sediment continuity model to compute changes in the bathymetry of the sediment mound. Bathymetry change computations are made at every 3-hr time step. The long-term simulations of mound stability indicate whether the local wave and current regime at the disposal site are of sufficient magnitude to suspend and transport bottom sediments.

Input Data Requirement

42. The site stability methodology is dependent on the accurate prediction of sediment transport at the site under investigation. Empirical relationships for computing sediment transport as a primary function of depth-averaged water velocity, local depth, and sediment grain size were reported by Ackers and White (1973). These relationships were subsequently modified (Swart 1976) to reflect an increase in sediment transport rate when the ambient currents are accompanied by surface wave fields. This additional transport reflects the fact that wave induced orbital velocities are capable of suspending bottom sediments, independent of the sediment put in suspension by mean currents. The total amount of sediment put into suspension by waves and currents is then transported by the ambient current field.

43. The modified Ackers-White relationships are used to compute the transport of uniformly graded non-cohesive sediment in the grain diameter (D_{50} for example) range of 0.04 mm to 4.00 mm (White, 1972). The average of the tabulated D_{50} values from the gradation curves for the coarse-grained site was computed to be 0.277 mm, with a maximum value of 0.48 mm and a minimum of 0.18 mm. Computed sediment transport versus depth averaged velocity for a range of depths corresponding to those at the coarse-grained site are shown in Figure 28. The Phase III WIS Station 69 summary value mean wave height of 2.7 meters and wave period of 10.9 sec (Jensen, Hubertz, and Payne, 1989) were specified in the preparation of this family of curves.

44. Analysis of the gradation curves for the fine-grained site indicate an average D_{50} value to be 0.0384 mm, with a maximum of 0.080 mm and a minimum of 0.009 mm. Since the sediments contain approximately 25 percent non-cohesive sand, the non-cohesive formulation is appropriate for simulating the overall sediment transport rate (Kamphuis 1990), however, this computed grain size is slightly below the range for which the Ackers-White formulas should be applied. For example, the computed transport/velocity relationship for a 0.0384 mm sediment are shown in Figure 29. The curves predict the sediment transport magnitude to become infinitely high as the velocity approaches 2.0 ft/sec. Although the data reported in Part 1 of this report does not attain this value, the inappropriateness of the theory can clearly be

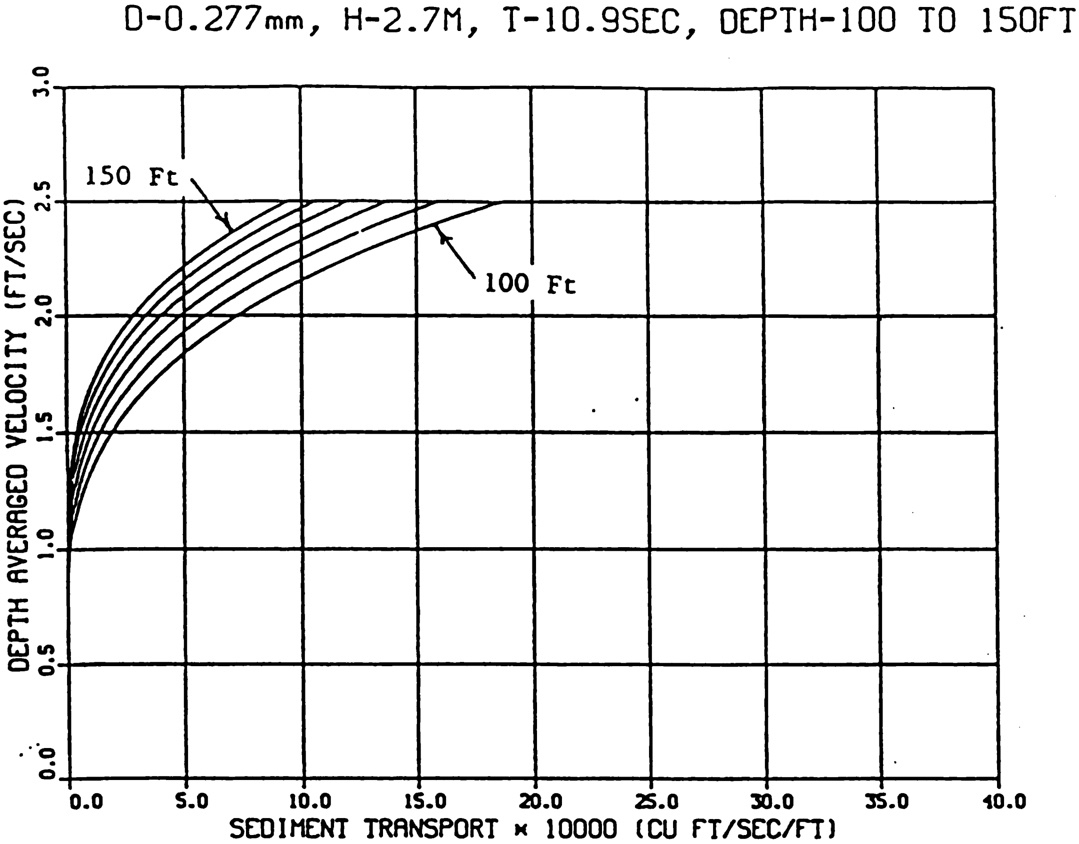

Figure 28. Sediment transport-velocity relationships for D_{50} = 0.277 mm

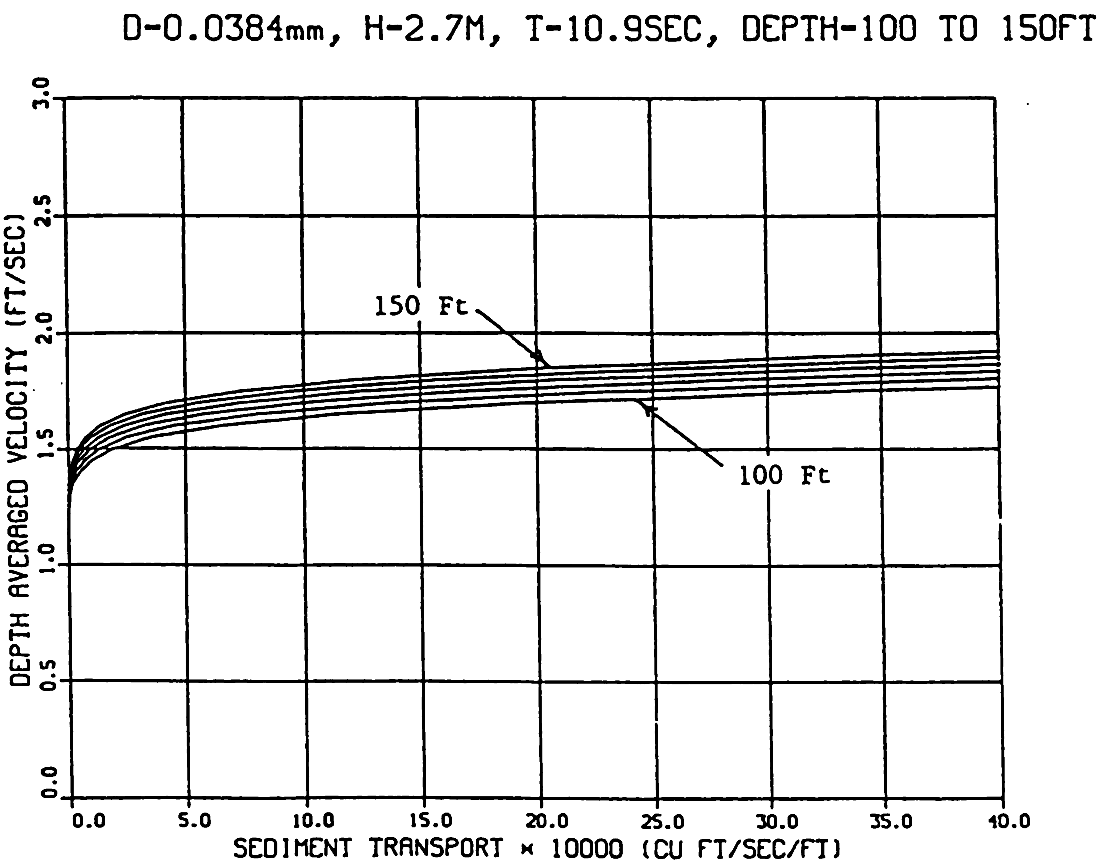

Figure 29. Sediment transport-velocity relationships for D_{50} = 0.0384 mm

seen in the unrealistically high computed transport values at the higher velocities. A D_{50} value of 0.0625 was therefore selected to more realistically represent the fine-grained site for a usable range of velocities, to include 2.0 ft/sec. The transport-velocity relationship for a 0.0625 mm sediment is shown in Figure 30.

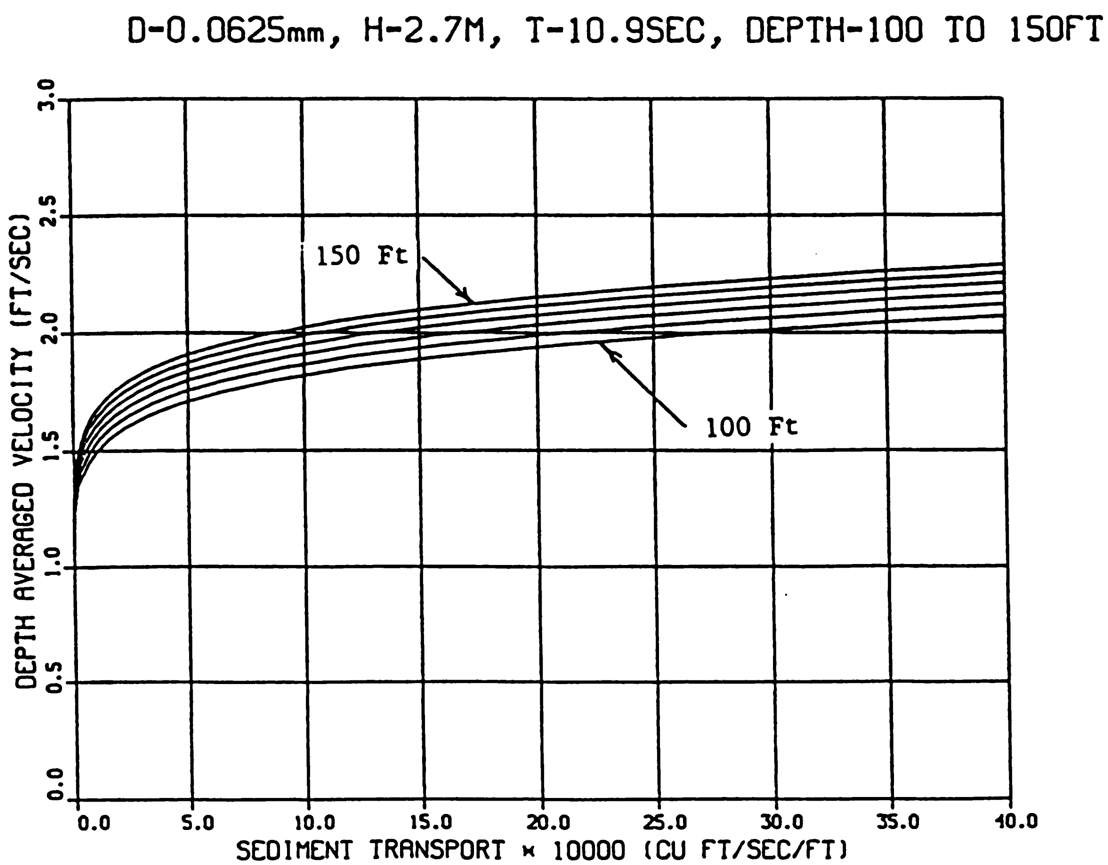

Figure 30. Sediment transport-velocity relationships for D_{50} = 0.0625 mm

45. The threshold velocities necessary for the initiation of
ment erosion can be seen to be nearly identical in Figures 29 and 30.
e the two curves are very similar within the velocity range of interest,
the specification of the 0.0625 mm sediment avoids the possibility or
alistically large transport predictions, the use of the larger grain size
etter accommodate the empirical relationship is justified. Therefore, the
25 mm sediment is used for all long-term simulations pertaining to the
-grained site.

46. The final data input data requirement is that of specifying
geometric configuration of the sediment mound. The proposed Fall 1990
dging operation will dispose of 415,000 cubic yards of sand in cell E5 of
drant #2 (Figure 1). This approximate volume of material was selected as
target volume for the test mound. An approximate mound height was
ermined from the bathymetric surveys of the SF-3 disposal area denoted in
ure 1. A pre-disposal survey of the site was collected in September 1984
n subsequent surveys in June 1985, May 1987, and April 1988. These data
icate well defined disposal features covering areas of 1000 ft to 1500 ft
diameter. The features contain multiple mounds with an average total
ght above the undisturbed bottom of 15 to 20 feet. A truncated pyramid
h a height of 16 ft, 1100 ft square base, and side slopes of 1:25 was
ected as the test mound configuration for the long-term modeling effort.
computed volume of the mound is 409,000 cubic yards, approximately that of
proposed Fall 1990 disposal operation. A three-dimensional perspective
w and contour map of the test mound are shown in Figures 31 and 32.

Long-Term Model Simulations

47. The long-term analysis described in the following section
lizes wave and velocity time series to compute the time evolution of the
pe of the mound. A quantitative assessment of mound stability is made by
puting the location of the centroid of the mound along the central mound
s for each computational time step of the simulation. These computations
made by balancing the summation of moments at each computational grid.
ulation results are also presented in the form of post-simulation

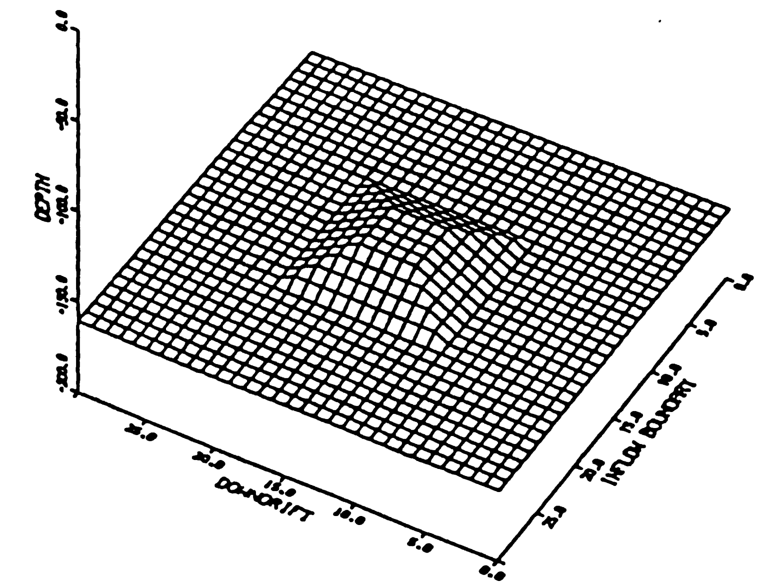

Figure 31. Idealized disposal mound perspective view

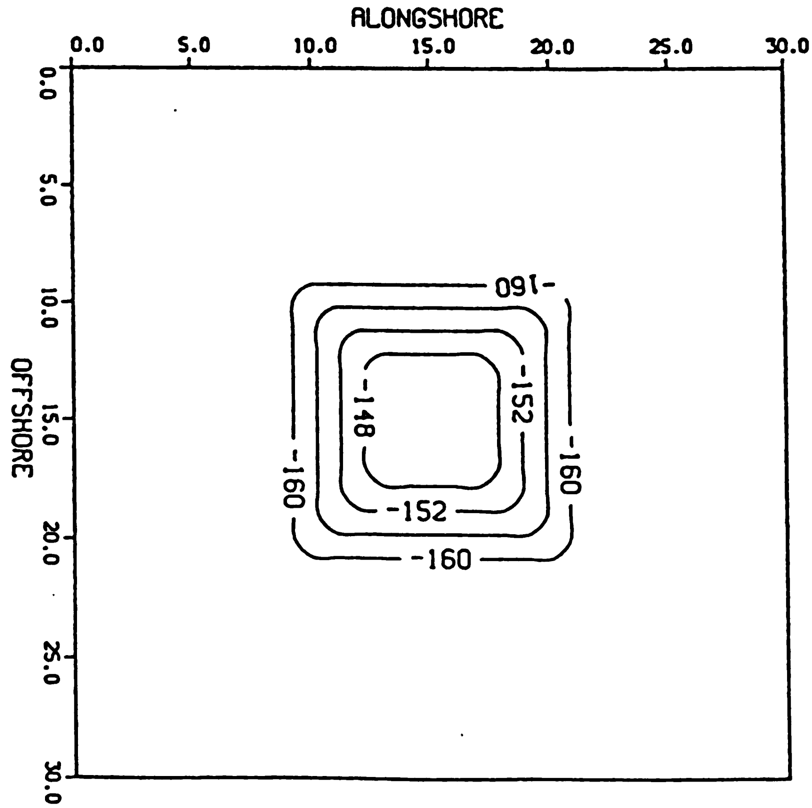

Figure 32. Idealized disposal mound contour map

rspective and contour plots as well as time evolution plots of the changing oss-sectional profile along the axis of the mound.

48. The stability analysis is made by estimating mound response long periods of exposure to the wave and current conditions developed in rt 2. In addition to this normal condition simulation, a storm event alysis was performed in an attempt to investigate single event related osion of the test mound. The filtered velocity data were examined to termine a typical duration of high intensity storm activity. The result was e selection of an 8-day event, a period which approximates that shown in ys 10-18 of Period 2 or days 226-234 of Period 4. A simulated V component nstituent of the velocity field with this period and an amplitude of 60 /sec was combined with the computed astronomical constituents shown in Table The resulting 8-day time series is shown in Figure 33.

Fine-Grained Disposal Site Analysis

49. The long-term boundary conditions of Part 2 were subjected to e test mound configuration described above. The mean depth of flow was ecified as 55 meters and the mound was assumed to consist of non-cohesive diment with an effective diameter of 0.0625 mm. Results of the simulations dicate that sediment movement is only initiated during periods of spring de and/or during storm events when the depth averaged velocities may exceed proximately 1.5 ft/sec. Since the velocities are generally below this value d only reach peak values of approximately 1.6 ft/sec, the computations owed very little net movement of the mound centroid. If fact, due to the ow and predictable migration rate, simulations were limited to 96 days ring which time two full cycles of the 48-day low-frequency current are perienced at the mound. Computed net movement of the mound during the tire simulation was only 0.31 ft. In view of the repetitive nature of locity field shown in Figure 14, and the fact that the imposed wave field rresponds to the high energy Winter period beginning 1 January of the mulated year, longer simulations were not necessary. A plot of the post mulation contour map of the mound and the computed cross-sectional evolution the mound axis are shown in Figures 34 and 35. As shown, no perceptible

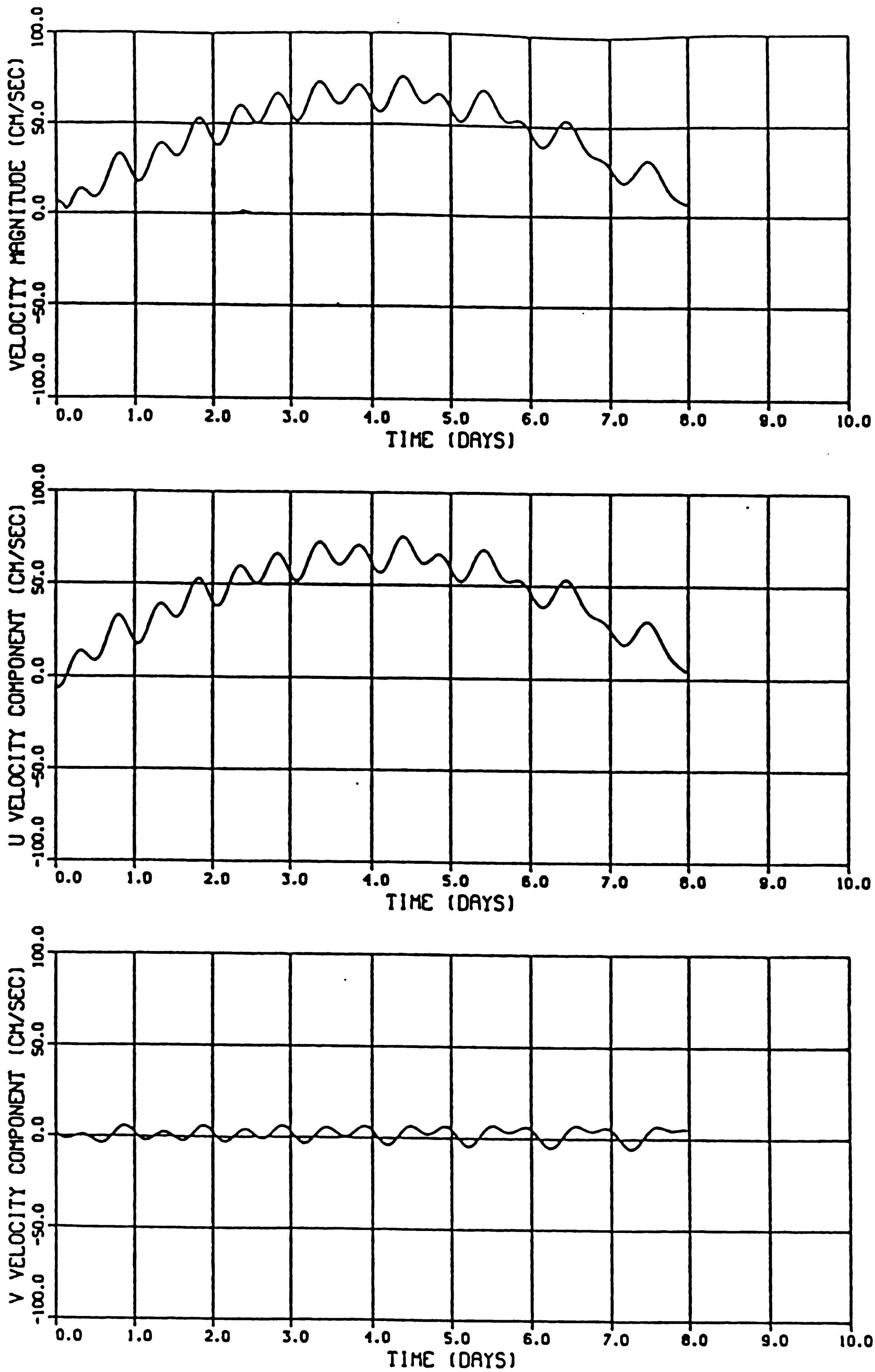

Figure 33. Simulated storm surge time series

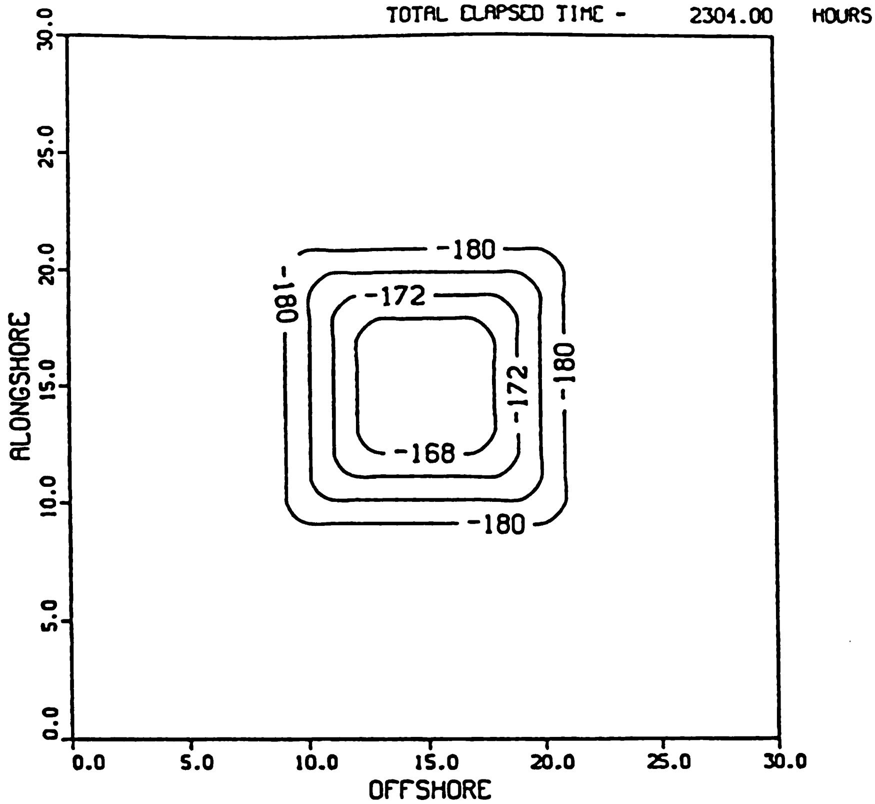

Figure 34. Long-term simulation contour of the fine-grained site

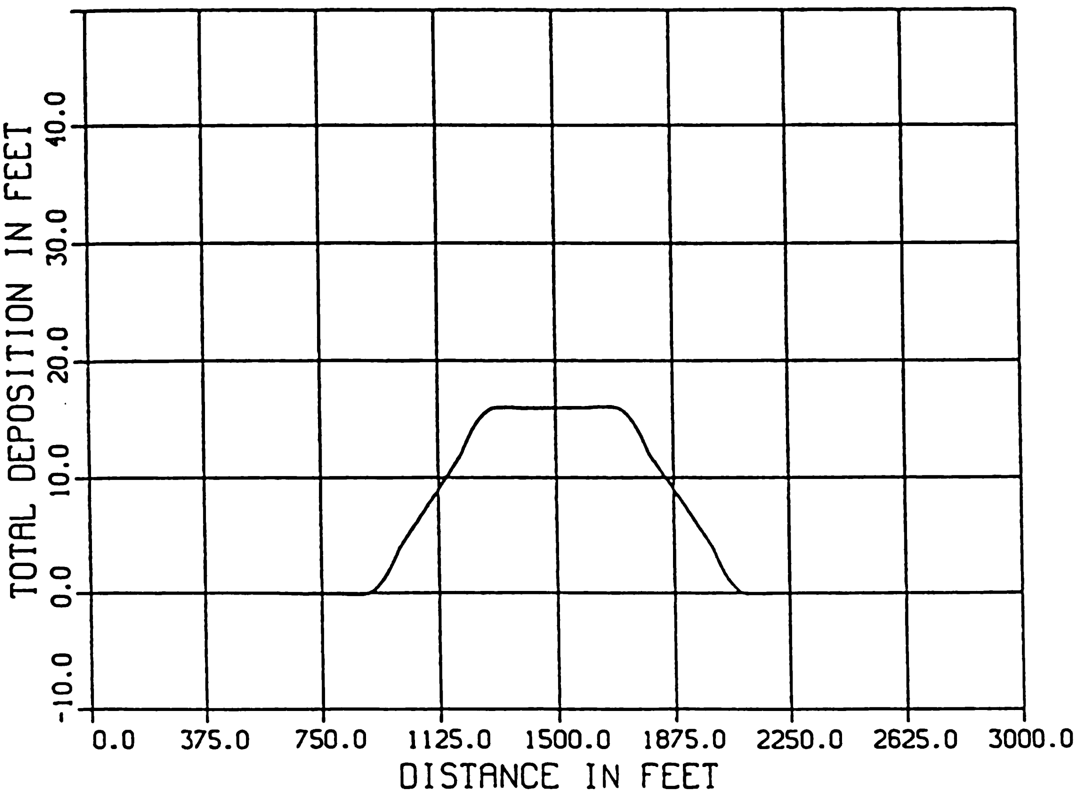

Figure 35. Long-term simulation mound axis migration history for the fine-grained site

net change in mound configuration is shown, although sediment movement is indicated during peak current events.

50. The simulation of the 8-day high intensity event for the fine-grained mound resulted in a 32.3 ft movement of the centroid, with slight erosion indicated in front of the mound and deposition on the leeward crest and face. The contour map and cross-sectional profile migration plots are shown in Figures 36 and 37. These results indicate that definite movement of the mound occurs during extreme events, however, the velocities necessary for this movement are not common. For example, peak velocity magnitudes shown in Figure 33 are not shown in the Period 2 and 3 mid-depth prototype data. The simulated storm therefore represents a severe event; however, the computed erosion is not severe.

Coarse-Grained Disposal Site Analysis

51. Long-term simulations for the coarse-grained disposal site are based on the identical boundary conditions used for the 55 meter site analysis. Simulation results were similar to those of the fine-grained simulations in that the velocities are near the threshold value necessary for sediment movement. The 96-day simulation only predicted a 0.37 ft net migration of the mound. As in the fine-grained site simulations, sediment is only transported during peak flow periods, and these periods represent only a small percentage of the flow. The similarity of results is due to a balancing of greater depths and lower wave induced orbital velocities at the fine-grained site versus reduced depths and elevated orbital velocities at the coarse-grained site. The storm surge simulation results indicate little net movement of the coarse material, with a total centroid migration distance computation of only 3.1 ft. As in the fine-grained site, coarse material is transported during high energy periods; however, the net effect is small since the long-term average currents are small, below 5.0 cm/sec.

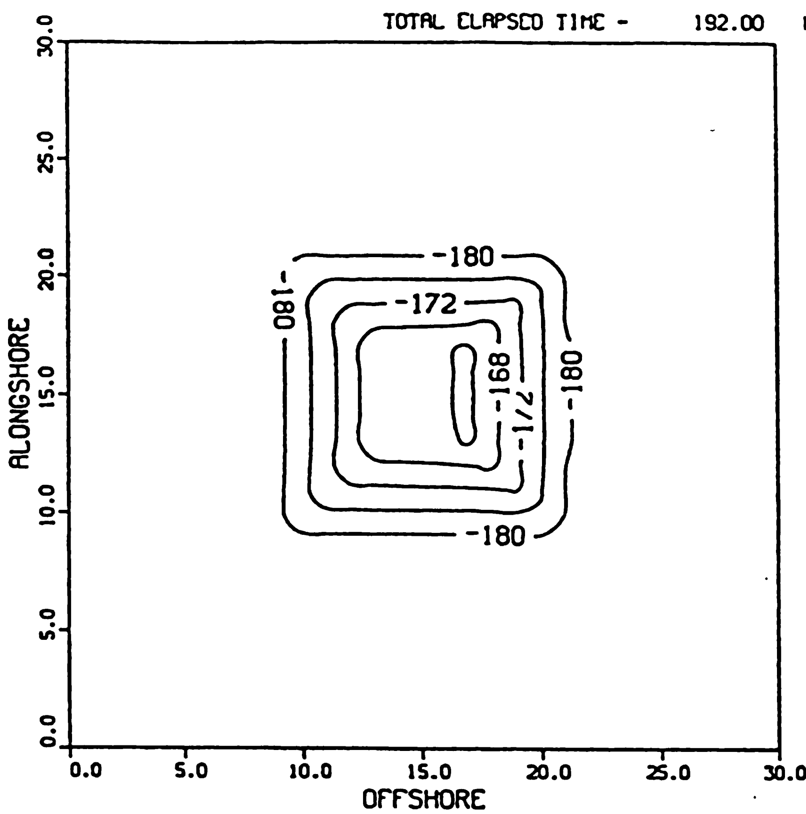

Figure 36. Storm event simulation contour of the fine-grained site

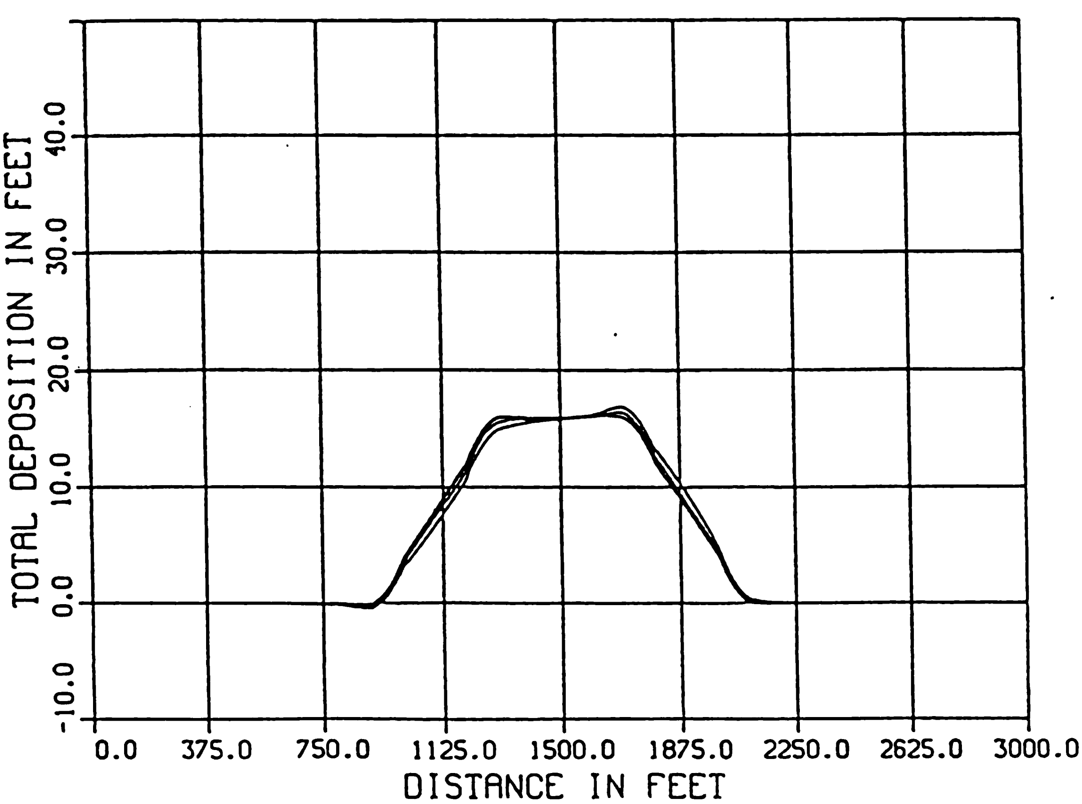

Figure 37. Storm event simulation mound axis migration history for the fine-grained site

PART 5: CONCLUSIONS

Fine-Grained Site

52. The short-term dispersion analysis of the disposal site for fine-grained materials was based on the results of the DIFID model. The sediments to be disposed at the site were specified to be composed of 75 percent silt-clay and 25 percent fine sand. The dispersion computations were performed for a one hour simulation. Results are reported in the form of the spatial and temporal distribution of the suspended sediment cloud through the water column as well as the total sediment deposition pattern on the ocean floor.

53. Suspended sediment computations were reported separately for the sand and silt/clay components of the sediment. Results of the computations show that the maximum concentration of suspended sand in the water column, one hour after disposal is approximately $5X10^{-8}$ mg/l or 0.00005 parts per billion (ppb) above ambient concentration levels. This concentration corresponds to approximately one mile from the disposal site. The corresponding concentration of silt/clay in suspension is approximately $1X10^{-6}$ mg/l (0.001 ppb). These results indicate that the material rapidly disperses following its release from the dredge. The computed deposition pattern indicates maximum depths of approximately 0.06 ft occur approximately 300 ft from the release point and that essentially all material is contained within 0.30 mile radius of the disposal point. The minimal impact outside of the immediate disposal area is due to the low ambient currents in the vicinity of the disposal site.

54. The long-term analysis of site stability was based on both a 96-day simulated time series of wave and tide data and an 8-day simulated storm surge hydrograph. Results of the 96-day simulation indicate that movement of material occurs only during periods of large current activity. Analysis of the prototype data indicate that currents required for this movement occur at a frequency of approximately 20 to 30 days. However, these large currents do not occur in a consistent direction. In fact the long-term mean depth-averaged currents are on the order of less than 5.0 cm/sec. As such, the computed net migration of the mound was only 0.31 ft. This figure does not imply that sediment does not move, but that the net movement,

considering ebb and flood as well as spring and neap tides, is essentially zero.

55. A storm hydrograph (half sine wave) was defined as an 8-day event in which the maximum depth-averaged velocities approached 2.5 ft/sec. These magnitudes are greater than any observed in the 348 days of mid-depth prototype data (Periods 3 and 4). The simulated storm represents a severe event; however, the computed movement of the mound was only on the order of 30 ft. This amount of mound erosion and deformation is small compared to the intensity of the storm required to produce a peak depth-averaged velocity of 2.5 ft/sec in 180 ft of water.

Coarse-Grained Site

56. The short-term dispersion analysis for the coarse-grained disposal site are based on a sediment distribution of 93 percent sand and 7 percent silt/clay. Due to the large percentage of sand, and the corresponding rapid descent of the material, dispersion computations were only performed for 400 secs. Results of the suspended sediment concentration distribution indicate that all sediment was deposited within the first 100 sec following disposal and that no material remained in suspension. The total sediment deposition pattern is symmetric with the centroid located approximately 150 ft from the point of disposal. The computed mound covered an approximate 600 ft diameter area with 0.2 ft of material. The negligible impact outside of the immediate disposal area is due to both the low ambient currents and the high percentage of sand contained in the load.

57. The long-term site stability analysis was also based on a 96-day simulated wave and tide record and an 8-day storm surge hydrograph. Results for the 96-day simulation were similar to those at the fine-grained site. Ambient currents only transport sediment during periods of high wave and current intensity, and these periods only occur at a frequencies on the order of 20-30 days. When these currents are combined with the residual flow of only approximately 5 cm/sec, the maximum excursion of the mound was computed to be only 0.4 ft. The identical storm defined for the fine-grained site only produced a mound movement of approximately 3 ft.

Conclusions

58. Conclusions of the study indicate that both proposed disposal sites are basically non-dispersive. This conclusion is based on two approaches of analysis. Short-term simulations of the disposal operation indicate that sediments are deposited on the bottom rapidly, leaving very little or no sediment in suspension for subsequent transport into sensitive areas. A long-term simulation of sediment mound stability shows that, although sediment at either location can be moved short distances during peak current periods, the net long term effect of local waves and currents on the mound is negligible. It would appear, therefore, that either site will remain in place following disposal.

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APPENDIX A

RAW AND FILTERED VELOCITY DATA FROM MMS GAGES E60 AND E90

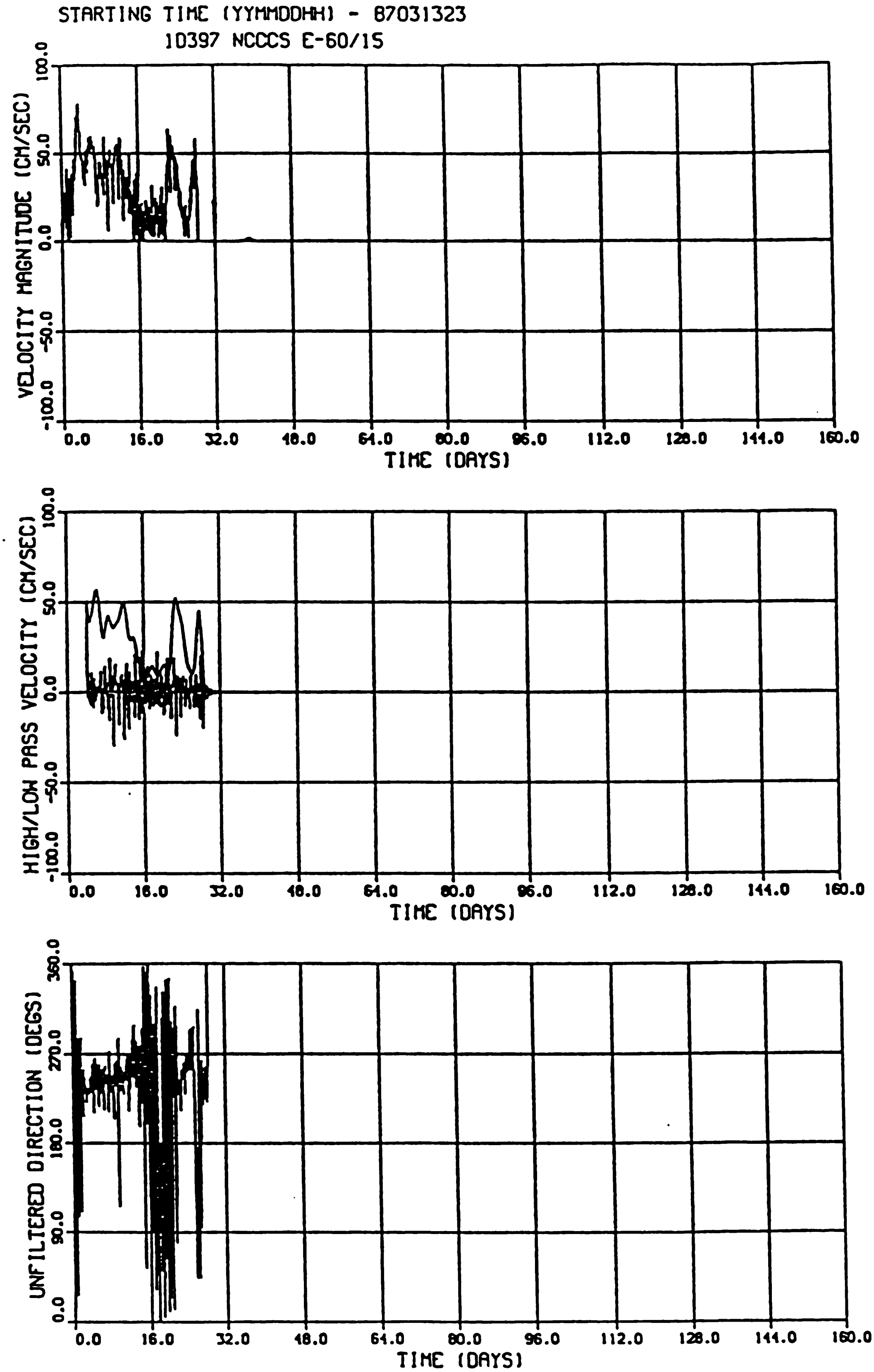

Figure A1. Meter E60/15 Current Data - Period 1

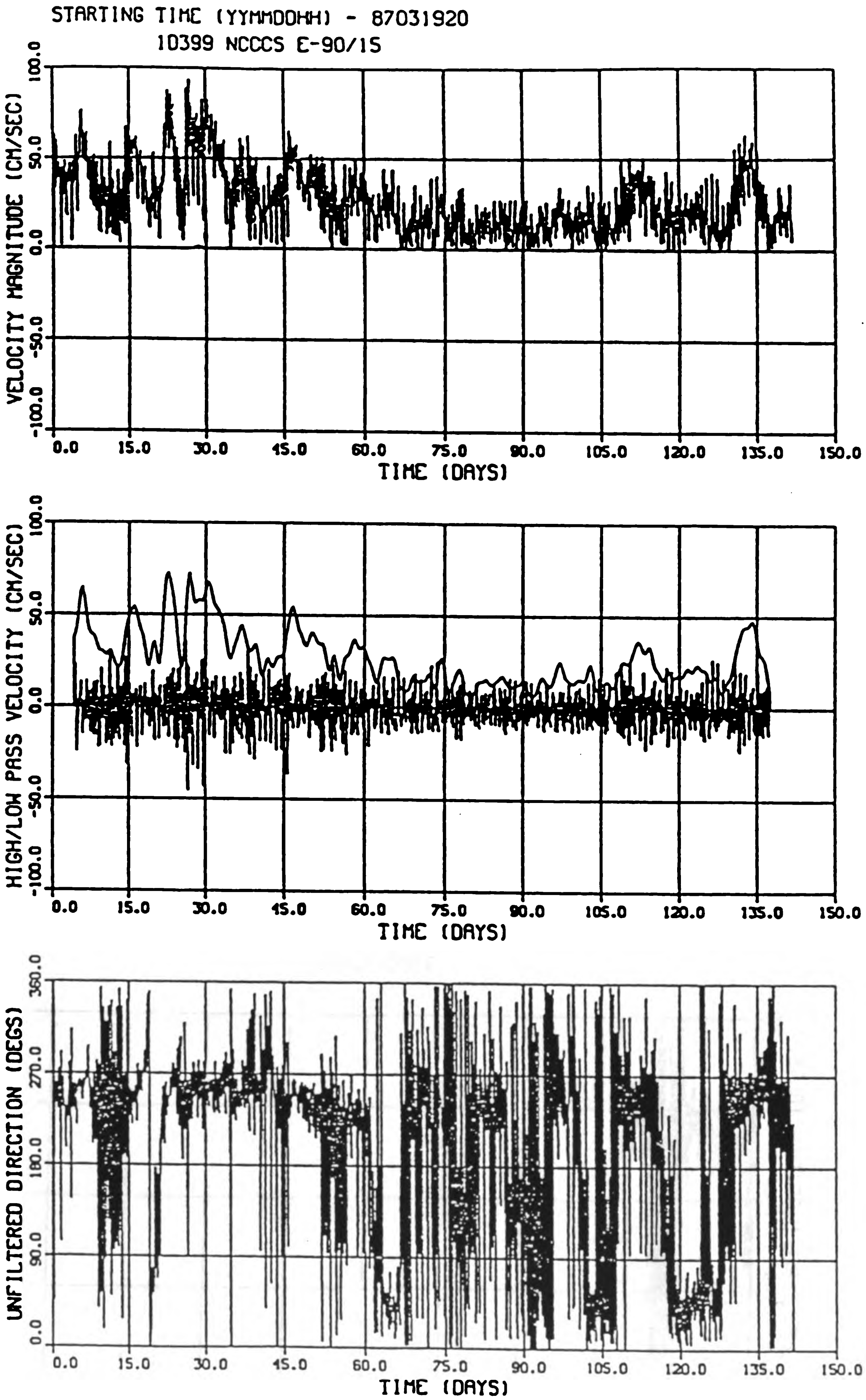

Figure A2. Meter E90/15 Current Data - Period 1

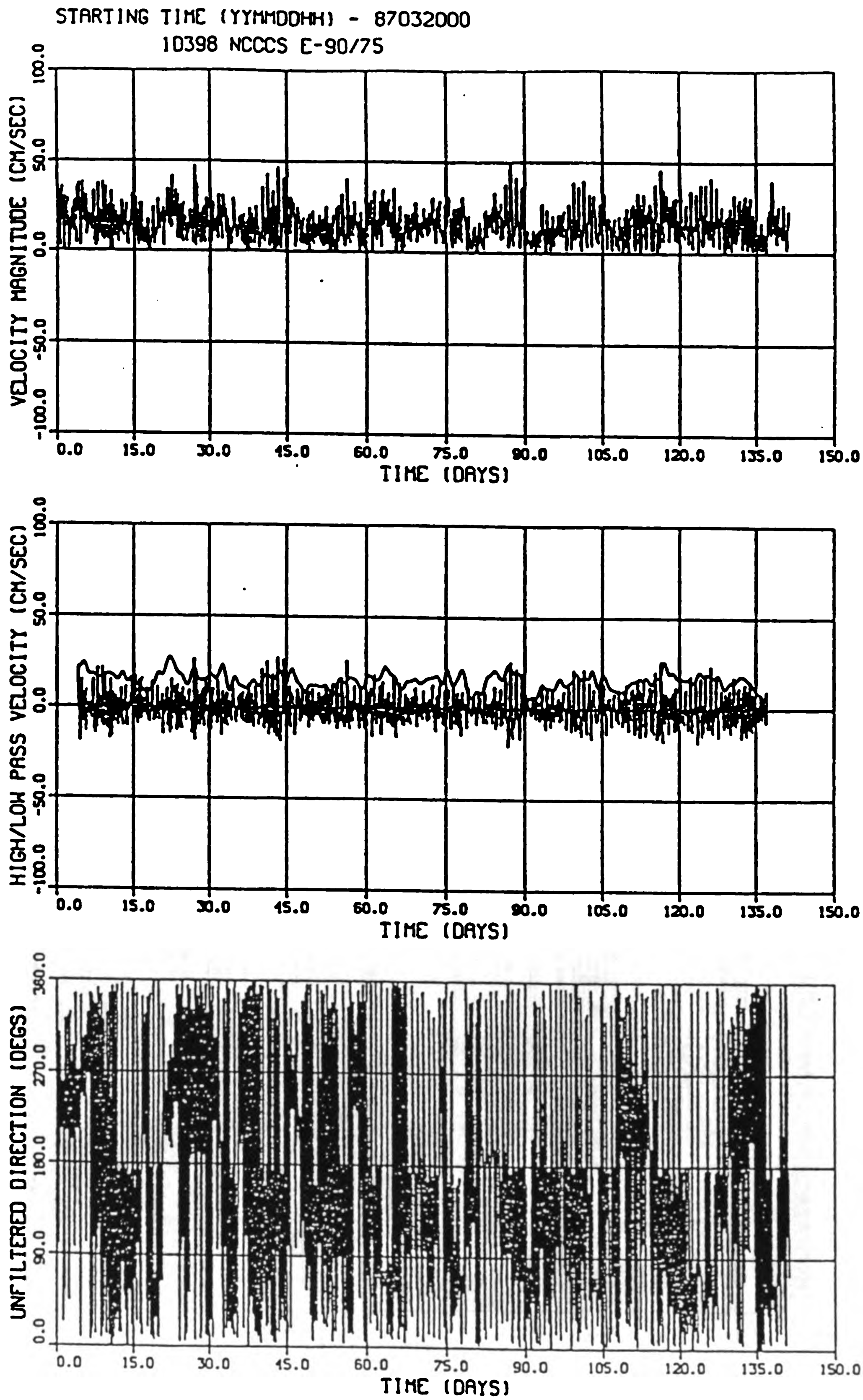

Figure A3. Meter E90/75 Current Data - Period 1

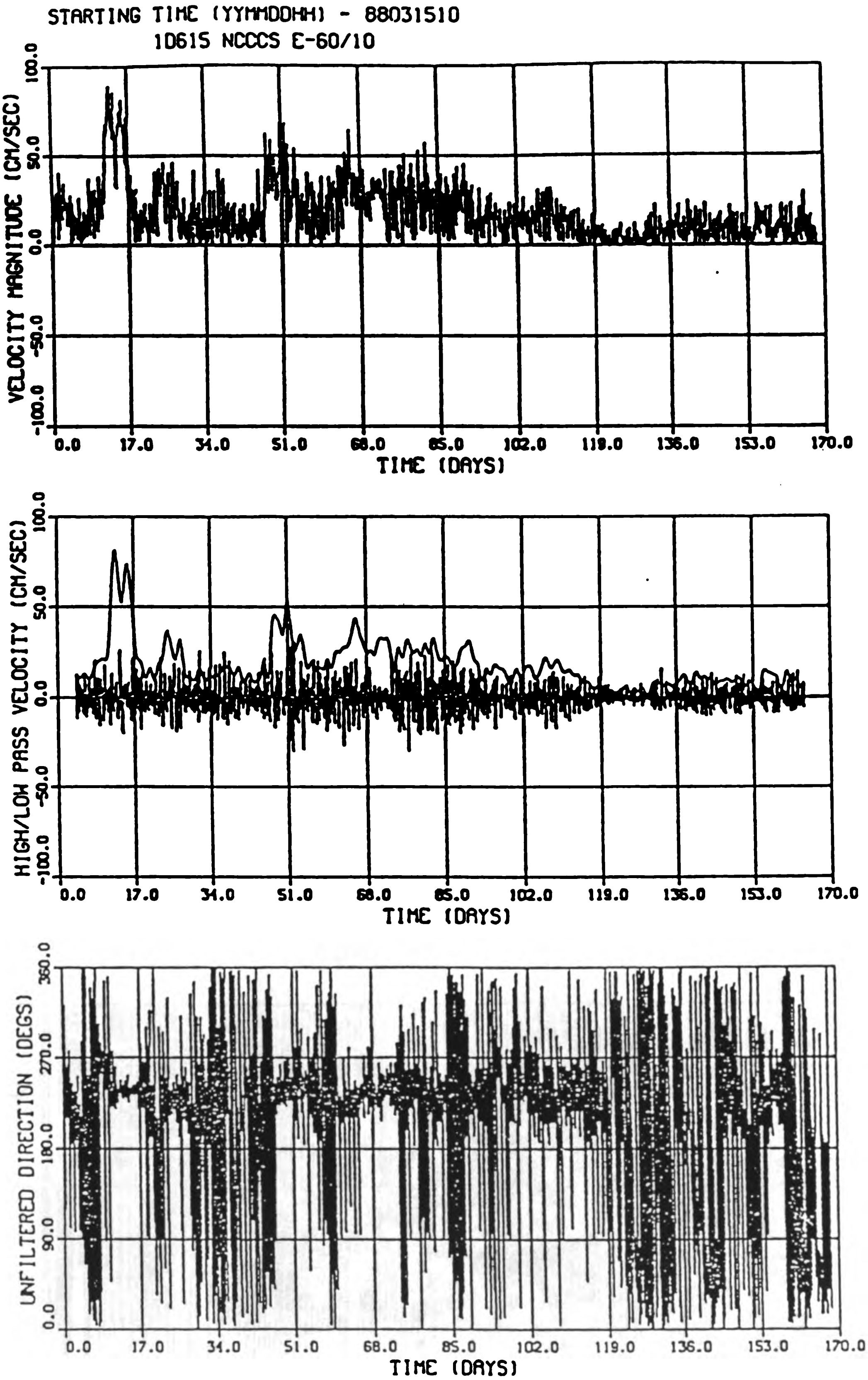

Figure A4. Meter E60/10 Current Data - Period 2

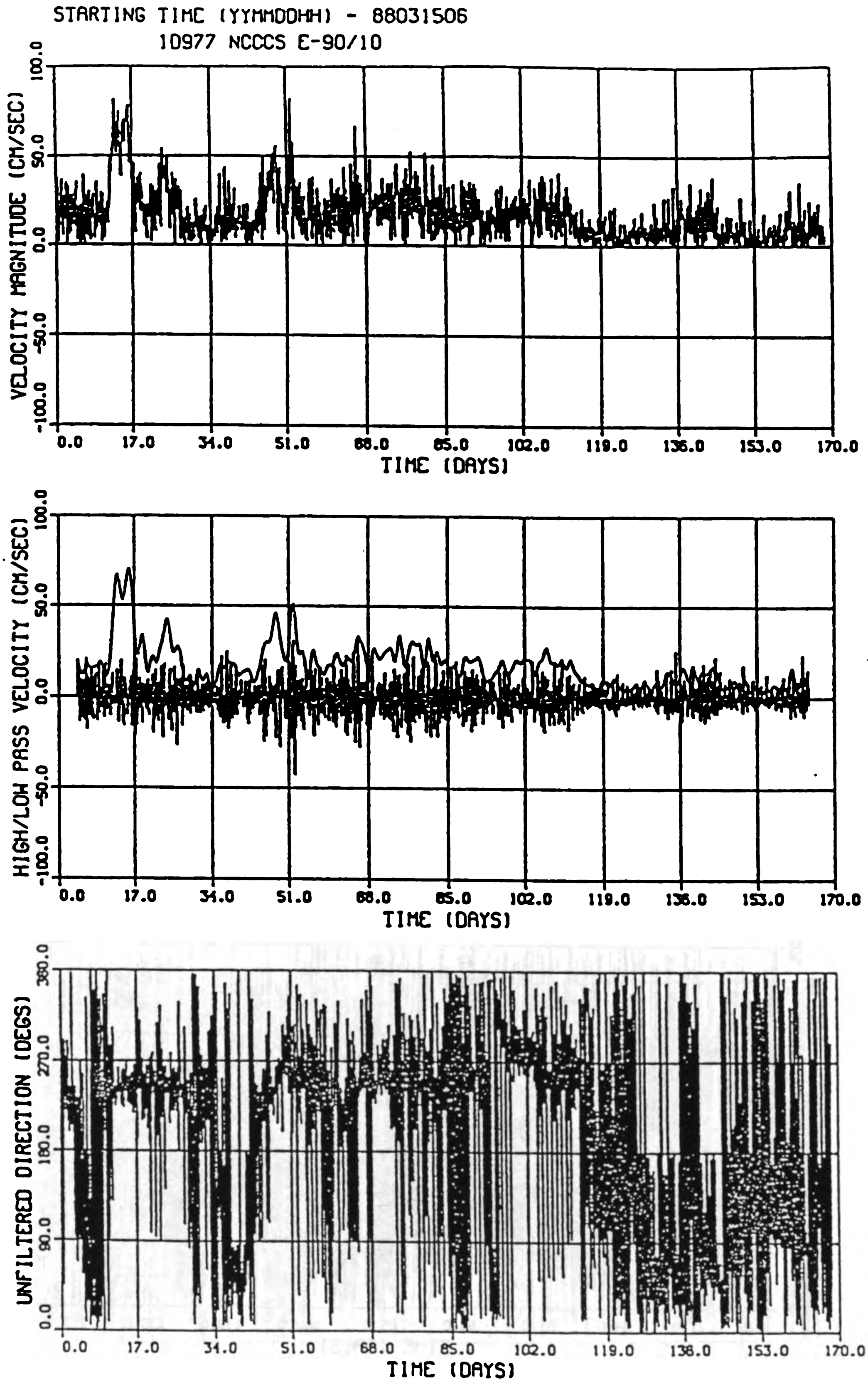

Figure A5. Meter E90/10 Current Data - Period 2

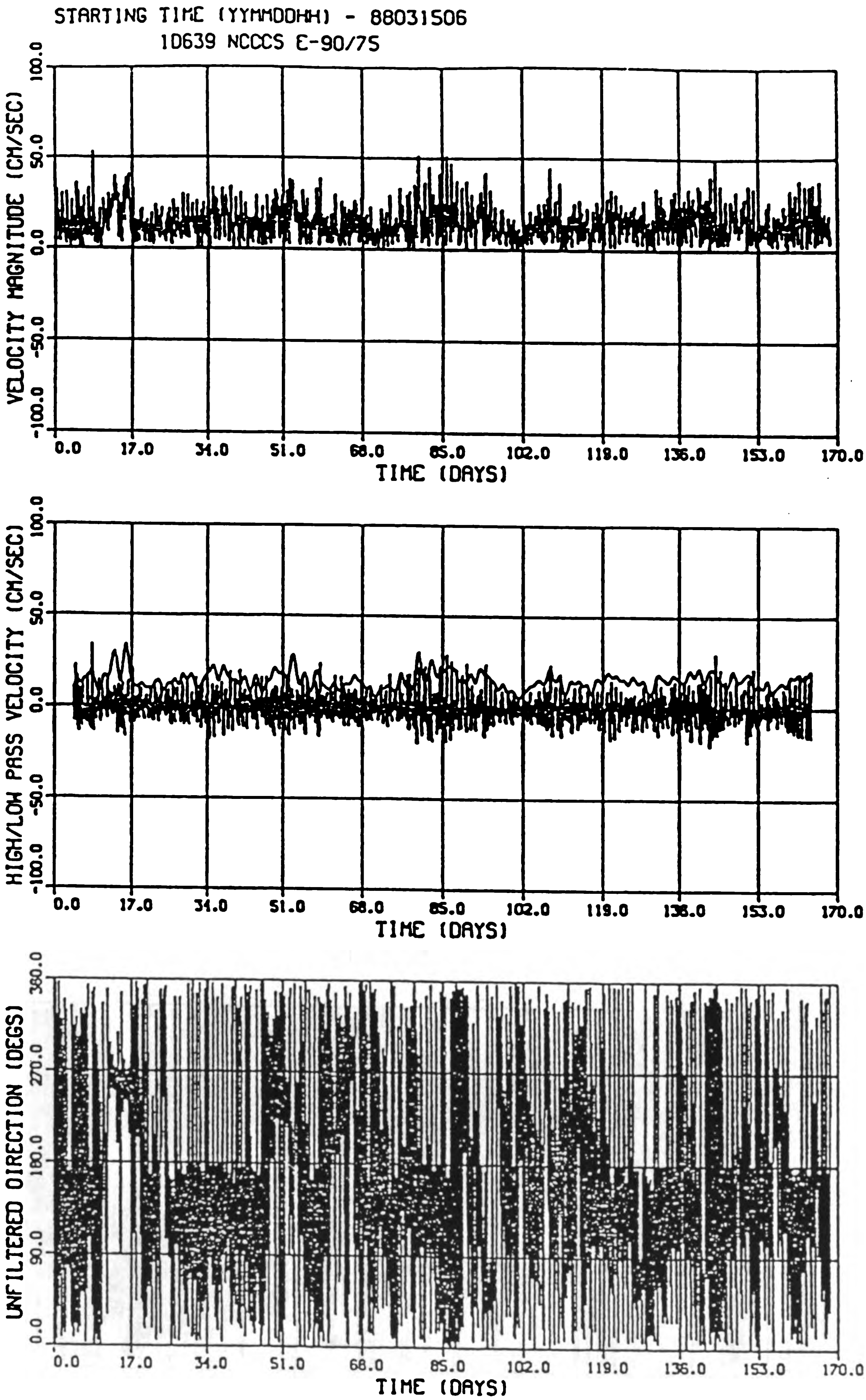

Figure A6. Meter E90/75 Current Data - Period 2

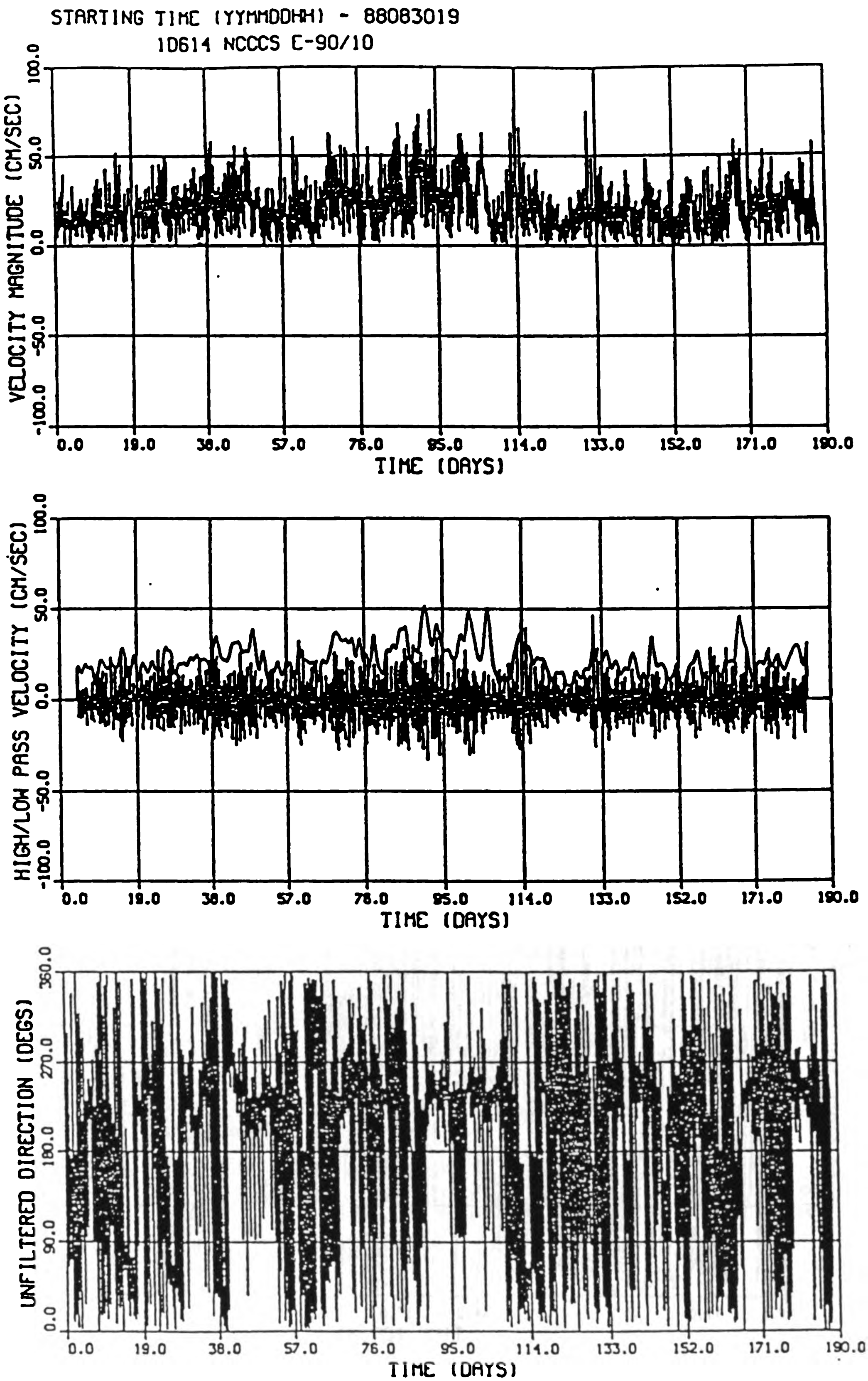

Figure A7. Meter E90/10 Current Data - Period 3

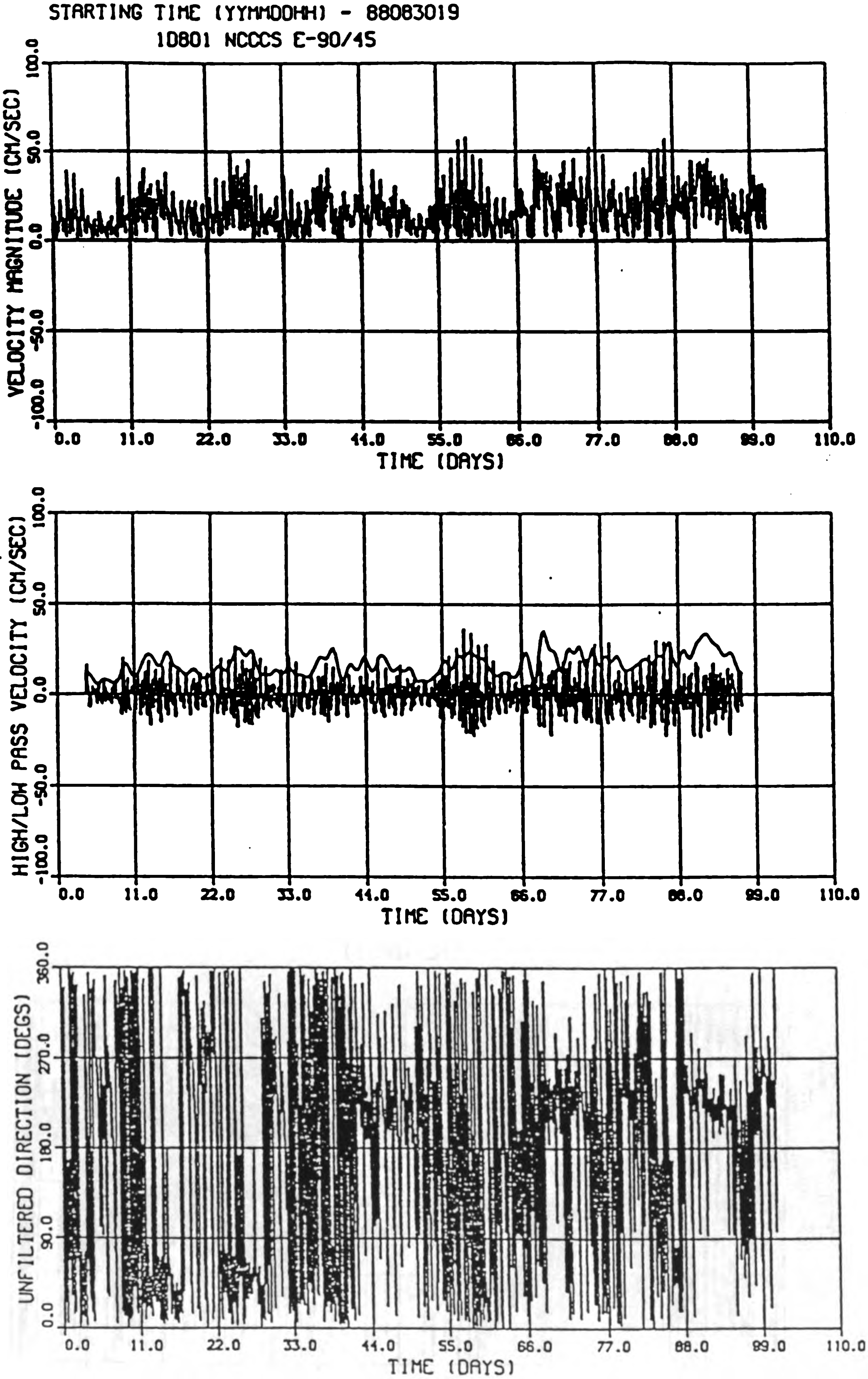

Figure A8. Meter E90/45 Current Data - Period 3

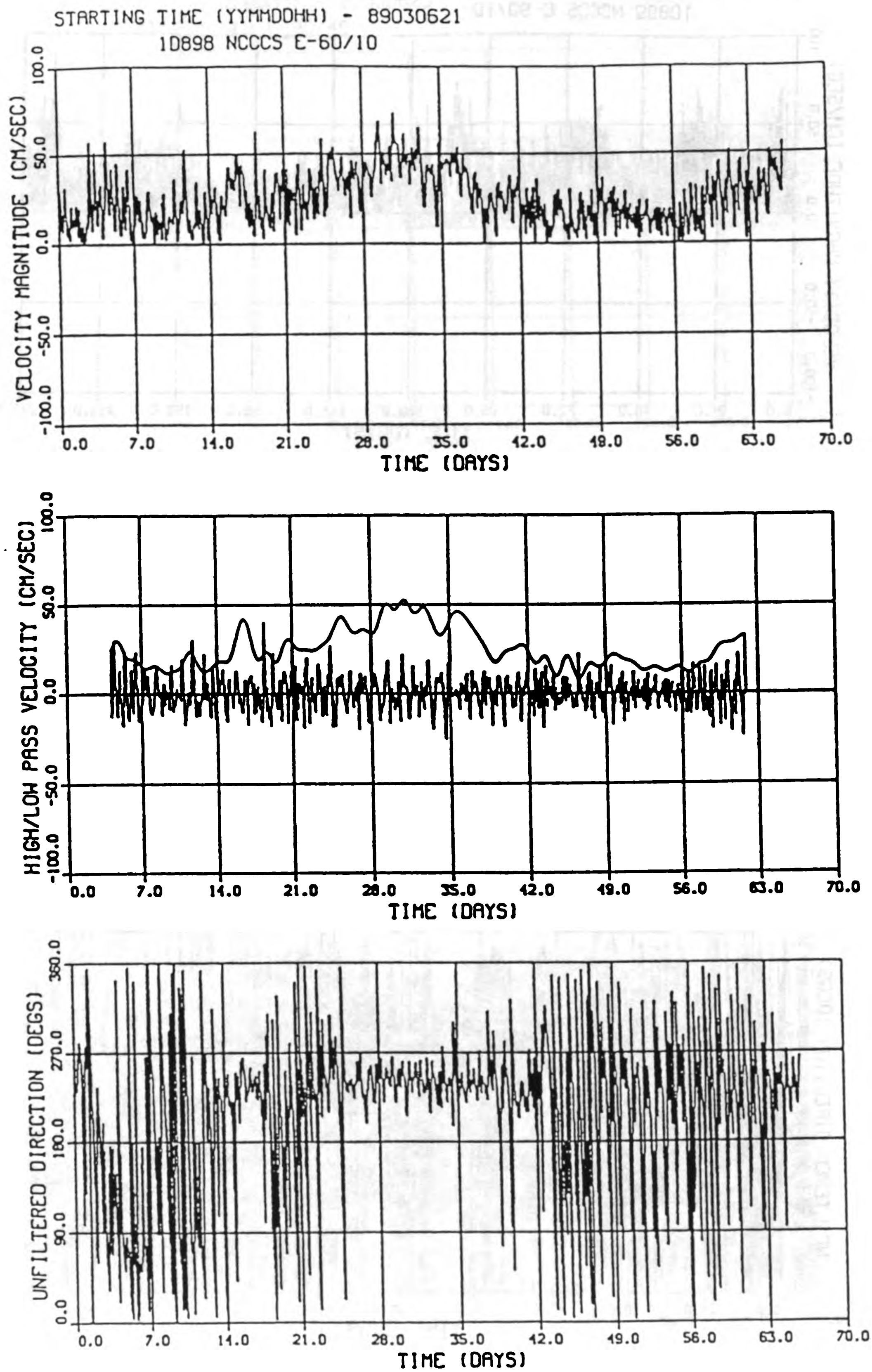

Figure A9. Meter E60/10 Current Data - Period 4

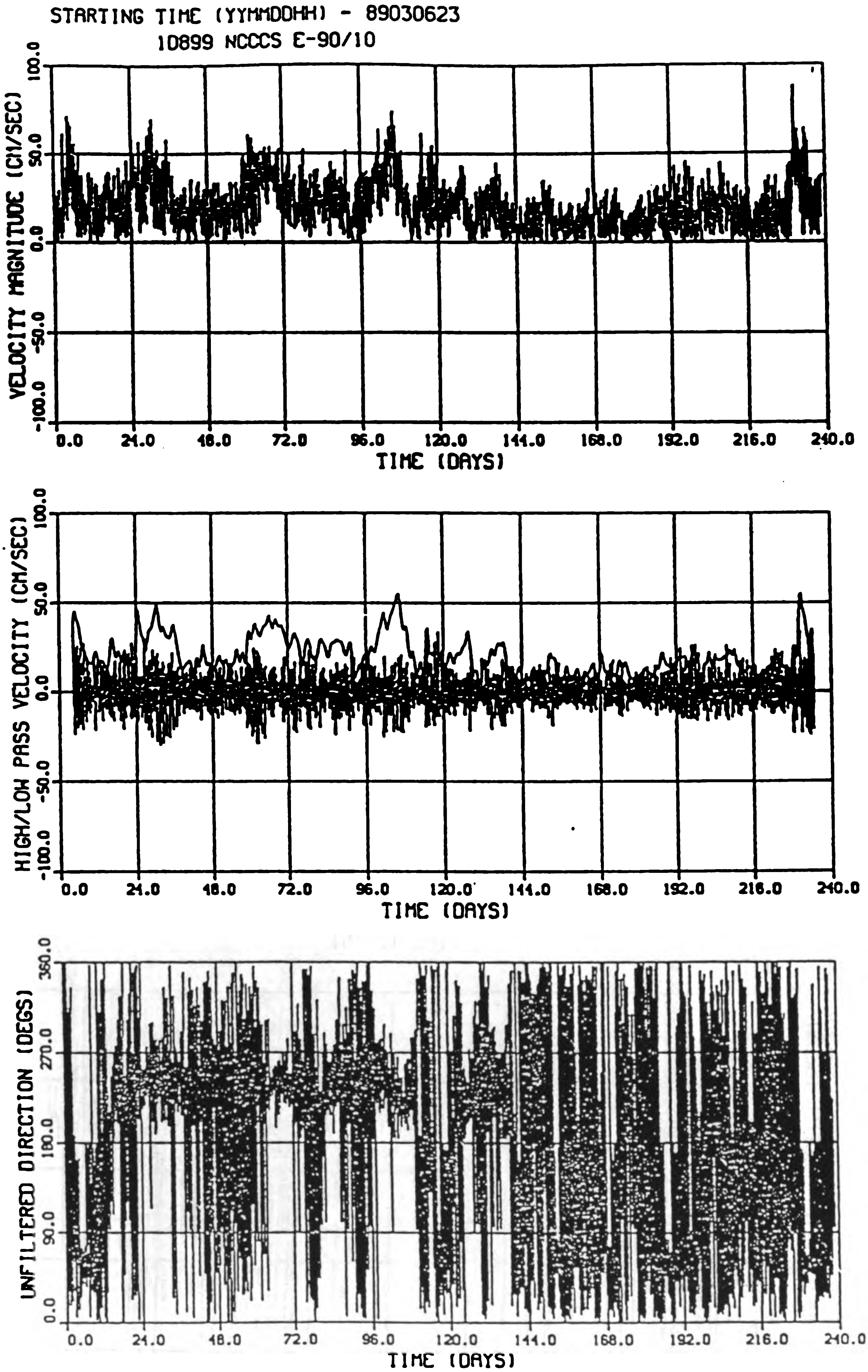

Figure A10. Meter E90/10 Current Data - Period 4

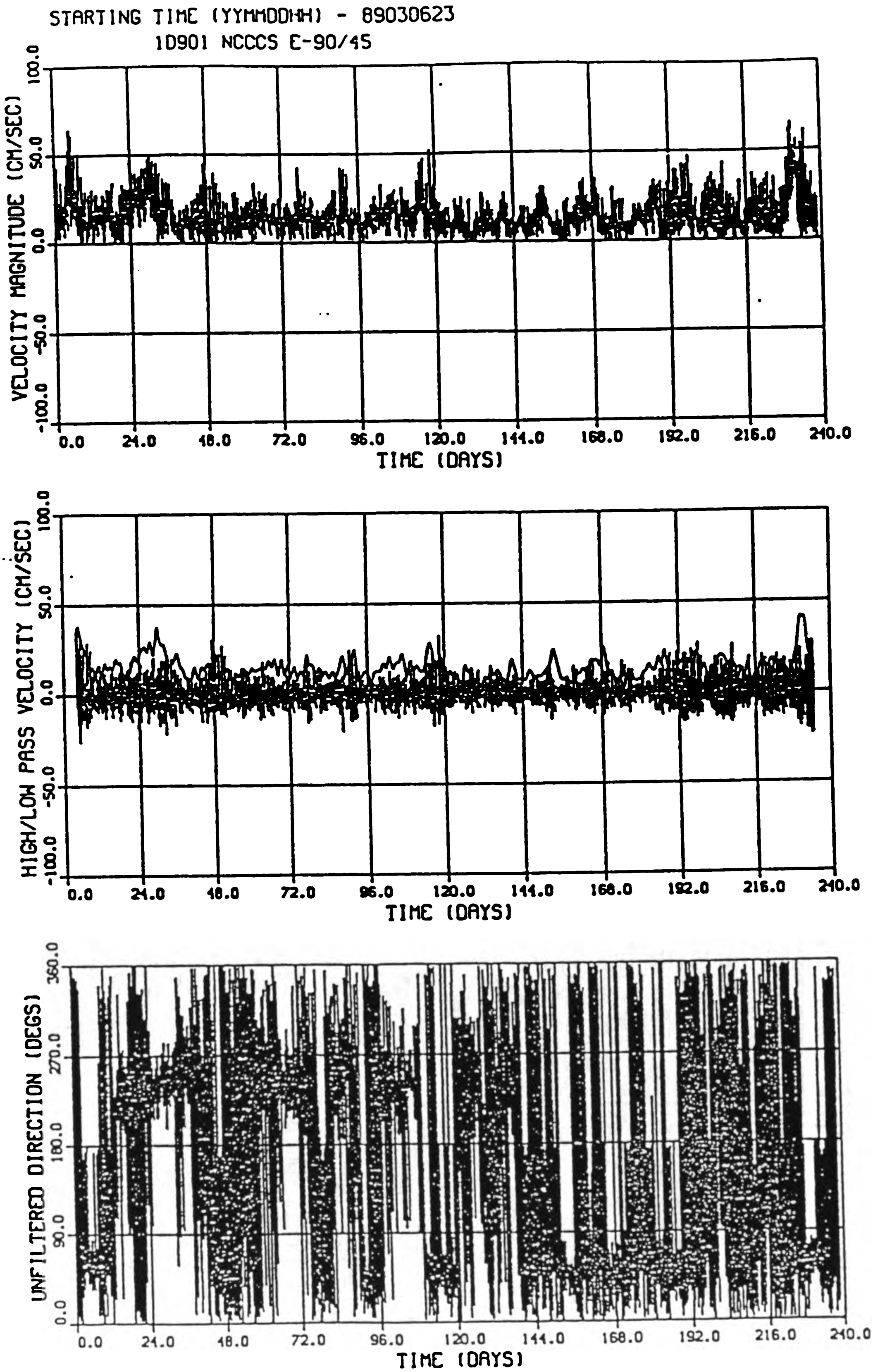

Figure A11. Meter E90/45 Current Data - Period 4

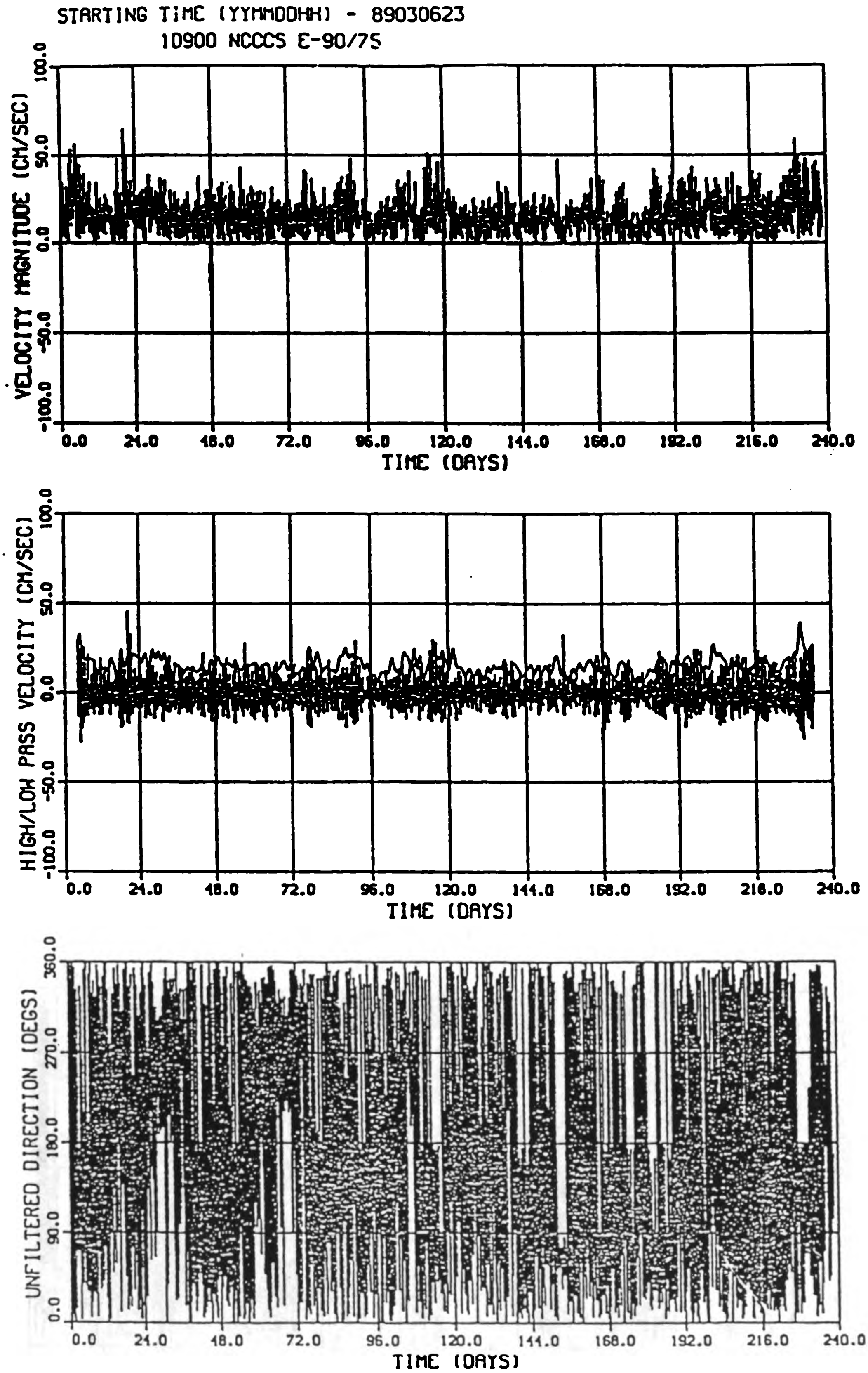

Figure A12. Meter E90/75 Current Data - Period 4

Appendix D

Common and Scientific Names of Species Mentioned in Text

Appendix D. Common and Scientific Names of Species Mentioned in Text

Common Name	Scientific Name
Fish	
Butter sole	*Isopsetta isolepsis*
Dover sole	*Microstomus pacificus*
English sole	*Parophrys vetulus*
Petrale sole	*Eopsetta jordani*
Rex sole	*Glyptocephalus zachirus*
Sand sole	*Psettichthys melanostictus*
Starry flounder	*Platichthys stellus*
Pacific sanddab	*Citharichthys sordidus*
Speckled sanddab	*Citharichthys stigmaeus*
Rockfish	*Sebastes* sp.
Black rockfish	*Sebastes melanops*
Blue rockfish	*Sebastes mystinus*
Bocaccio rockfish	*Sebastes paucispinis*
Canary rockfish	*Sebastes pinniger*
Chilipepper rockfish	*Sebastes goodei*
Darkblotched rockfish	*Sebastes crameri*
Widow rockfish	*Sebastes entomelas*
Yellowtail rockfish	*Sebastes flavidus*
Salmon	*Oncorhynchus* sp.
Chinook salmon	*Oncorhynchus tshawytscha*
Coho salmon	*Oncorhynchus kisutch*
Coastal cutthroat trout	*Oncorhynchus clarki clarki*
Steelhead trout	*Oncorhynchus mykiss*
Curlfin turbot	*Pleuronichthys decurrens*
Pricklebreast poacher	*Stellerina xyosterna*
Tubenose poacher	*Pallasina barbata*
Warty poacher	*Occella verrucosa*
Plainfin midshipman	*Porichthys notatus*
Staghorn sculpin	*Leptocottus armatus*
Showy snailfish	*Liparis pulchellus*
California halibut	*Paralichthys californicus*
Lingcod	*Ophiodon elongatus*
Brown smoothhound shark	*Mustelus henlei*
Longnose skate	*Raja rhina*
Black rattail	*Coryphaenoides acrolepis*
Giant rattail	*Coryphaenoides pectoralis*
Roughscale rattail	*Coryphaenoides acrolepis*
Blacktail snailfish	*Careproctus melanurus*

Appendix D. Continued

Common Name	Scientific Name
Twoline eelpout	*Bothrocara brunneum*
Spiny dogfish	*Squalus acanthias*
Pacific tomcod	*Microgadus proximus*
Pacific herring	*Clupea harengus pallasi*
Northern anchovy	*Engraulis mordax*
Night smelt	*Spirinchus starkis*
Whitebait smelt	*Allosmerus elongatus*
Eulachon	*Thaleichthys pacificus*
Shiner surfperch	*Cymatogaster aggregata*
Spotfin surfperch	*Hyperprosopon anale*
Silver surfperch	*Hyperprosopon ellipticum*
Walleye surfperch	*Hyperprosopon argenteum*
White seaperch	*Phanerodon furcatus*
Bay pipefish	*Syngnatus leptorhynchus*
Pacific cod	*Gadus macrocephalus*
Crustaceans	
Dungeness crab	*Cancer magister*
Bay shrimp	*Crangon franciscorum*
Coon-stripe shrimp	*Pandalus danae*
Pink ocean shrimp	*Pandalus jordani*
Sand shrimp	*Crangon nigricauda*
Market squid	*Logigo opalescens*
Echinoderms	
Brown mud star	*Luidia foliolata*
Short-spined star	*Pisaster brevispinus*
Pacific sand dollar	*Dendraster excentricus*
Molluscs	
Olive snail	*Olivella pycna*
Coastal and Sea Birds	
Turnstone	*Arenaria* sp.
Snowy plover	*Charadrius alexandrinus*
Loon	*Gavia* sp.
Cormorant	*Phalacrocorax* sp.
Double-crested cormorant	*Phalacrocorax auritus*
California brown pelican	*Pelecanus occidentalis*

Appendix D. Continued

Common Name	Scientific Name
Western gull	*Larus occidentalis*
Tern	*Sterna* sp.
Phalarope	*Phalaropus* sp.
Shearwater	*Puffinus* sp.
Jaeger	*Stercorarius* sp.
Short-tailed albatross	*Diomedea albatrus*
Marbled murrelet	*Brachyramphus marmoratus*
Aleutian Canada goose	*Branta canadensis leucopareia*
Marine Mammals	
Northern (Stellar) sea lion	*Eumetopias jubatus*
Harbor seal	*Phoca vitulina richardi*
California sea lion	*Zalophus californianus*
Northern elephant seal	*Mirounga angustirostris*
Northern fur seal	*Callorhinus usinus*
Dall's porpoise	*Phocoenoides dallii*
Harbor porpoise	*Phocoena phocoena*
Gray whale	*Eschrichtius robustus*
Humpback whale	*Megaptera novaeangliae*
Minke whale	*Balaenoptera acutorostrata*
Blue whale	*Balaenoptera musculus*
Finback whale	*Balaenoptera physalus*
Sperm whale	*Physeter catodon*
Northern right-whale	*Lissodelphis borealis*
Risso's dolphin	*Grampus griseus*
White-sided dolphin	*Lagenorhynchus obliquidens*
Reptiles	
Leatherback turtle	*Dermochelys coriacea*