Continued Use of Puget Sound Dredged Disposal Analysis Program (PSDDA) Dredged Material Disposal Sites

March 2005

US Army Corps
of Engineers®
Seattle District

TABLE OF CONTENTS

FIGURES

TABLES

APPENDICES

1. INTRODUCTION

The Dredged Material Management Program (DMMP) manages dredged material disposal in three regions of the Pacific Northwest, including activities under the Puget Sound Dredged Disposal Analysis (PSDDA) program, as well as programs for Grays Harbor/Willapa Bay and the Lower Columbia River. The DMMP agencies include the Army Corps of Engineers, Seattle District (Corps); the Environmental Protection Agency, Region 10 (EPA); the Washington Department of Natural Resources (DNR); and Washington Department of Ecology (Ecology). The Corps serves as the lead agency for implementation of the program.

The DMMP manages the operation and monitoring of eight PSDDA dredged material disposal sites in Puget Sound. The five non-dispersive and three dispersive sites in Puget Sound were selected after examining existing literature and conducting physical and biological studies in order to locate dredged material disposal sites in areas where the least environmental and human use impacts would occur. The site selection process was documented in two program environmental impact statements prepared in 1988 and 1989 (PSDDA/FEIS 1988, 1989). The PSDDA program has also develop a management plan to determine whether dredged materials are acceptable for unconfined open-water disposal, and to evaluate effects of dredged material disposal at the eight selected sites since inception of the program (PSDDA/MPR 1988, 1989).

1.1 PSDDA PROGRAM

1.1.1 Program Purpose and Objectives

The PSDDA program has allowed the DMMP agencies to eliminate the past system of independently planning dredged disposal activities within Puget Sound, to identify specific dredged disposal locations, and to implement regional planning. This is needed to responsibility carry out maintenance and new dredging of over 50 miles of navigable waterways, about 50 miles of port terminal shipping berths, and more than 200 small-boat harbors. Dredging is necessary to maintain the commercial and recreational services provided by these facilities, which play a vital role in the region's economic development and growth. Collectively there are over 34 port districts serving the region.

The PSDDA program goal is to provide publicly acceptable guidelines governing environmentally safe unconfined, open-water disposal of “clean” dredged material, thereby improving consistency and predictability in the decision-making process. Public acceptability involves consideration of a wide range of factors. Among these are technically sound evaluation procedures and practicability, which includes cost effectiveness.

The PSDDA program has identified eight multi-user disposal sites, defined a consistent and objective procedure for evaluating the suitability of dredged material for disposal at those sites, and formulated site use management plans to monitor the effects of dredged material disposal. These management plans ensure adequate site use controls through application of an adaptive management framework, which allows the program to be altered based on the findings of the monitoring program.

1.1.2 Program Site Designation Process

A PSDDA site designation process conducted during the development of the 1988 and 1989 environmental impact statements resulted in the selection of three dispersive sites and five non-dispersive sites throughout Puget Sound (Figure 1). Non-dispersive disposal sites are areas where currents are low enough that dredged material is retained within the disposal site; dispersive sites have higher current velocities, so dredged material does not accumulate within the disposal site.

The number of sites selected balanced the need for ecologically safe disposal with the need for economically and logistically viable disposal options. The selection process evaluated sites based on currents, biological sensitivities, and human activities, which are discussed in detail in PSDDA/FEIS (1988) for Phase I sites and PSDDA/FEIS (1989) for Phase II sites. Selection factors included:

- **navigation activities;**
- **recreational uses;**
- **cultural sites;**
- **aquaculture facilities;**
- **utilities;**
- **scientific study areas;**
- **point pollution sources;**
- **water intakes;**
- **shoreline land use designations;**
- **political boundaries;**
- **location of dredging areas;**
- **beneficial uses of dredged material;**
- **fish/shellfish harvest areas;**
- **threatened and endangered species;**
- **fish/shellfish habitat;**
- **wetlands, mudflats and vegetated shallows;**
- **bathymetry;**
- **sediment characteristics; and**
- **water currents.**

Information on these factors were collected, mapped and overlain to identify areas of high and low resource value in Puget Sound. This allowed the agencies to identify areas between higher value resource areas where disposal siting would have a minimum conflict with ecological resources or human uses of Puget Sound. In addition, attempts were made to site disposal areas within 10 nautical miles (11.5 miles) of major dredging areas. After identifying these areas, additional constraints were included in the selection process.

For non-dispersive sites, these additional factors included:

- **peak current speeds of less than 25 cm/sec to retain sediments within site boundaries,**
- **distance from shore (greater than 762 meters [2,500 feet]),**
- **site size for containment of the estimated volumes of dredged sediment to be disposed,**
- **distance from vulnerable biological resources (greater than 762 meters [2,500 feet]), and**

- **depth of water (where possible place site between 37 and 183 meters [120 and 600 feet]).**

For dispersive sites, these additional factors included:

- **current speeds in excess of 25 cm/sec for maximum dispersal of material,**
- **distance from shore not less than 1 nautical mile (1.2 miles),**
- **a goal of a minimum water depth of 55 meters (180 feet) (not an absolute requirement), and**
- **locating sites so that the ultimate fate of the dispersed material will not have a significant adverse effect on natural resources.**

Table 1 and Figures B-1 to B-8 (in Appendix B) illustrate the location of the eight PSDDA sites, their target and disposal zone boundaries, depths, and dimensions.

Figure 1. Approximate Location of Dispersive and Nondispersive PSDDA Dredged Material Disposal Sites in Puget Sound

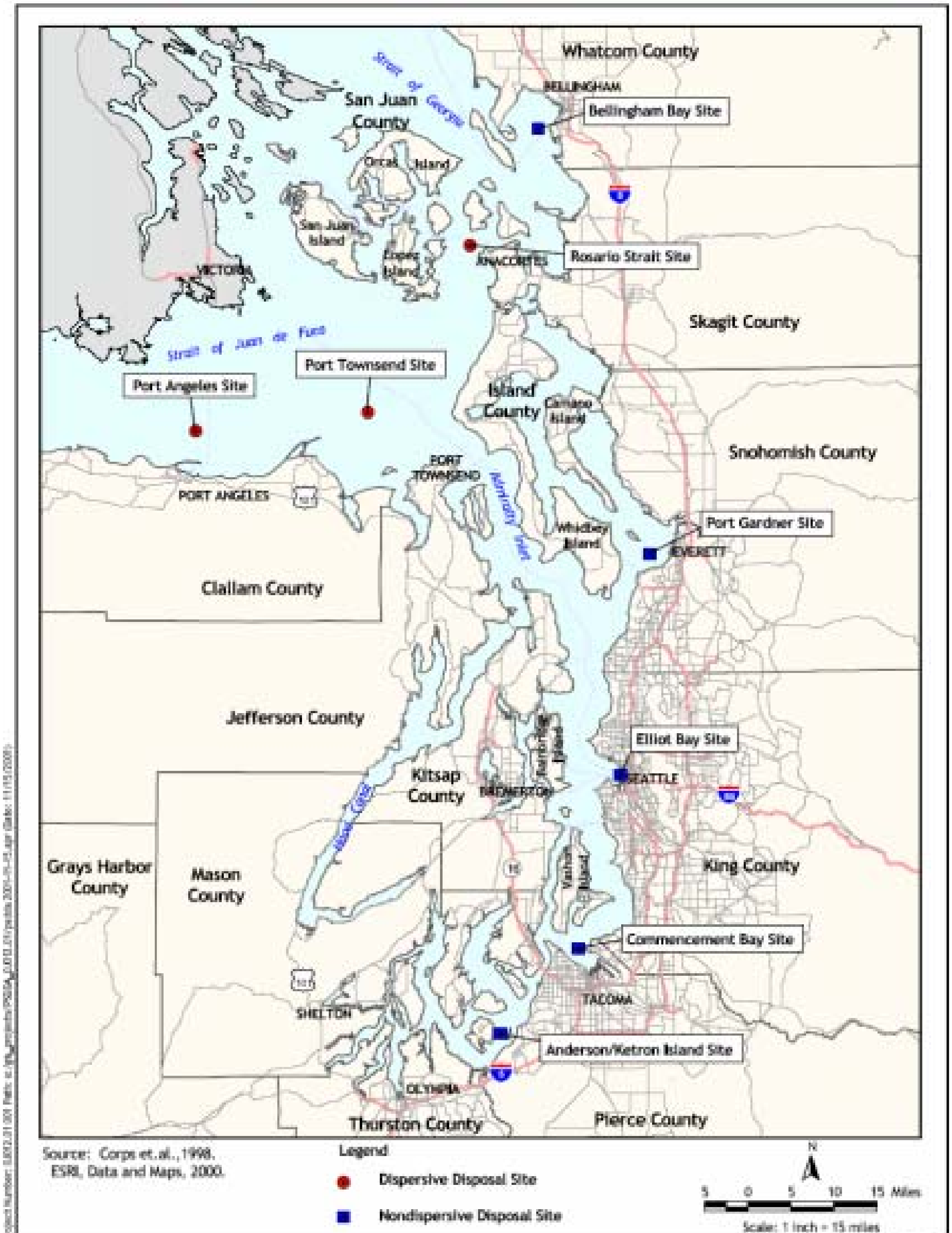


Figure 1
Approximate Location of Dispersive and Nondispersive PSDDA Dredged Material Disposal Sites in Puget Sound

Jones & Stokes

Table 1. PSDDA Disposal Site Characteristics

Site	Type	Area (acres)	Depth	Location (Lat Long NAD 83)	Disposal Zone Diameter [1]	Target Area Diameter[2]	Disposal Site Dimensions[3]	VTS/GPS[4]
Bellingham Bay	Non-Dispersive	260	96 ft (29 m)	Lat 48^{o} 42.82' Long 122^{o} 33.11'	1800 ft (549 m) (circle)	1200 ft (366 m) (circle)	3800 x 3800 ft (1158 x 1158 m) (circular)	GPS
Port Gardner	Non-Dispersive	318	420 ft (128 m)	Lat 47^{o} 58.85' Long 122^{o} 16.74'	1800 ft (549 m) (circle)	1200 ft (366 m) (circle)	4200 x 4200 ft (1280 x 1280 m) (circular)	GPS
Elliott Bay	Non-Dispersive	415	300-360 ft (91-110 m)	Lat 47^{o} 35.96' Long 122^{o} 21.45'	1800 ft (549 m) (circle)	1200 ft (366 m) (circle)	6200 x 4000 ft (1890 x 1219 m) (tear drop shape)	VTS
Commencement Bay	Non-Dispersive	310	540-560 ft (165-171 m)	Lat 47^{o} 18.21' Long 122^{o} 27.91'	1800 ft (549 m) (circle)	1200 ft (366 m) (circle)	4600 x 3800 ft (1402 x 1158 m) (ellipsoid)	VTS
Anderson Island	Non-Dispersive	318	442 ft (135 m)	Lat 47^{o} 09.42' Long 122^{o} 39.47'	1800 ft (549 m) (circle)	1200 ft (366 m) (circle)	4400 x 3600 ft (1341 x 1097 m) (ellipsoid)	GPS
Port Angeles	Dispersive	884	435 ft (133 m)	Lat 48^{o} 11.67' Long 123^{o} 24.94'	3000 ft (914 m) (circle)	None	7000 x 7000 ft (2134 x 2134 m) (circular)	VTS
Port Townsend	Dispersive	884	361 ft (110 m)	Lat 48^{o} 13.61' Long 122^{o} 59.03'	3000 ft (914 m) (circle)	None	7000 x 7000 ft (2134 x 2134 m) (circular)	VTS
Rosario Strait	Dispersive	650	97-142 ft (30-43 m)	Lat 48^{o} 30.87' Long 122^{o} 43.56'	3000 ft (914 m) (circle)	None	6000 x 6000 ft (1829 x 1829 m) (circular)	VTS

1. The disposal zone is the area that is within the disposal site that designates where surface release of dredged material will occur. It encompasses the smaller target area.

2. The target area is the specified area on the surface of Puget Sound for the disposal of dredged material. The target area is within the disposal zone and within the disposal site.

3. The disposal site is the bottom area that receives discharged dredged materials, encompassing and larger than the target area and disposal zone.
4. VTS = vessel traffic service; GPS = global positioning system

1.1.3 Program Suitability Determination Process

Only dredged material that has been determined to be "clean" enough for unconfined, open-water disposal can be discharged at the PSDDA sites. The process for determining if material is suitable for disposal at a PSDDA site is described in detail in the Users Manual for the PSDDA Program (Corps et al. 2000). The process varies depending on whether the dredging project requires a new permit (figures 2 and 3). The typical Clean Water Act Section 404 and Section 401 permitting processes are intertwined with a second process, the dredged material evaluation process (Figure 4).

This evaluation process involves a four-tiered approach for the evaluation of sediments to be dredged in order to determine the suitability of sediments for unconfined, open-water disposal at sites in Puget Sound (Figure 5). This suitability analysis determines if sediments to be dredged have the potential to adversely affect biological resources. If, based on this analysis, materials are determined to be potentially adverse to biological resources, the material is considered unsuitable for PSDDA open-water disposal and is disposed of by other means (e.g., disposal at Ecology-approved confined upland or nearshore disposal sites). A brief discussion of the tiered suitability evaluation follows.

Tier I analysis involves the review of existing sediment data. If data are sufficient and indicate that sediments are suitable, no further testing is required. If data are not sufficient, or there is some indication that sediments contain contaminants which may affect the environment, sediments are chemically tested under Tier II for concentrations of both conventional parameters and chemicals of concern (Appendix A). The chemistry of the material to be dredged is typically evaluated for various smaller sub-areas within the area to be dredged. These subdivided areas within a dredge site are termed Dredged Material Management Units (DMMUs). A DMMU is the smallest area/volume within the project which can be dredged independently from other areas within the site. The methodology for determining the number and location of DMMUs for each dredging project and the number of samples to be collected within each DMMU are detailed in the PSDDA User's Manual (Corps et al.;2000).

The chemistry data are compared to established guidelines to evaluate whether additional biological testing under Tier III and Tier IV is necessary. If the Tier II analysis indicates that all chemical concentrations are below the Screening Level (SL), then no additional biological testing is necessary. The SL is the concentration level of specific chemicals below which there is no reason to believe that disposal of that material would result in unacceptable adverse biological impacts.

A Maximum Level (ML) has been defined for each chemical. The ML is a concentration above which there is reason to believe that the material would be unsuitable for unconfined, open-water disposal. If one or more chemical concentrations of sediments within a DMMU lie between the SL and ML, or if the concentration of one chemical is greater than the ML, but less than twice the ML, then that DMMU would be required to undergo standard biological testing under Tier III (solid phase bioassays) before a suitability determination can be reached. If one chemical concentration is more than double the ML concentration, or if two or more chemicals exceed the ML within a DMMU, then those sediments would require biological testing using best-professional judgment, which would usually be more than required for an SL exceedance and could include a Tier IV evaluation. A Tier IV assessment is considered a special, non-routine evaluation that would be determined by the regulating agencies. The Tier IV assessment might involve time-sequenced bioaccumulation or tissue analysis of organisms collected from the area to be dredged in order to determine concentrations of chemicals of concern, and/or a risk assessment.

If chemical concentrations indicate that Tier III or Tier IV testing would be required, the discharger has the option of not continuing beyond Tier II, and accepting the decision that the material is not suitable for unconfined open-water disposal and must be disposed of at an Ecology-approved confined disposal site (e.g., confined upland or nearshore disposal).

In addition to comparison to the SL and ML concentration, the PSDDA sediment screening process also includes a Bioaccumulation Trigger (BT). The BT is the concentration of a chemical of concern, above which there is reason to believe there is potential for that chemical to be accumulated in the tissue of target organisms. Traditional ecological effects of sediments are evaluated and compared statistically to reference values. Human health effects are evaluated against PSDDA guidelines for allowable tissue concentrations which are a combination of risk-based numbers and Food and Drug Administration action levels.

Dispersive sites are located in areas of high bottom currents where dredged material placed at the site is expected to be rapidly transferred offsite. Accordingly, more restrictive bioassay interpretation guidelines are used for testing sediments to be disposed of at dispersive sites. The more stringent guidelines relate to interpretation of biological testing results. Specifically, bioassays test results for dispersive sites only allow a 10 percent absolute mortality (over reference sediments), as opposed to the 30 percent absolute mortality allowed for sediments which are being tested for disposal at non-dispersive sites.

Figure 2. Section 10/404 Regulatory Process (New Permit Required)

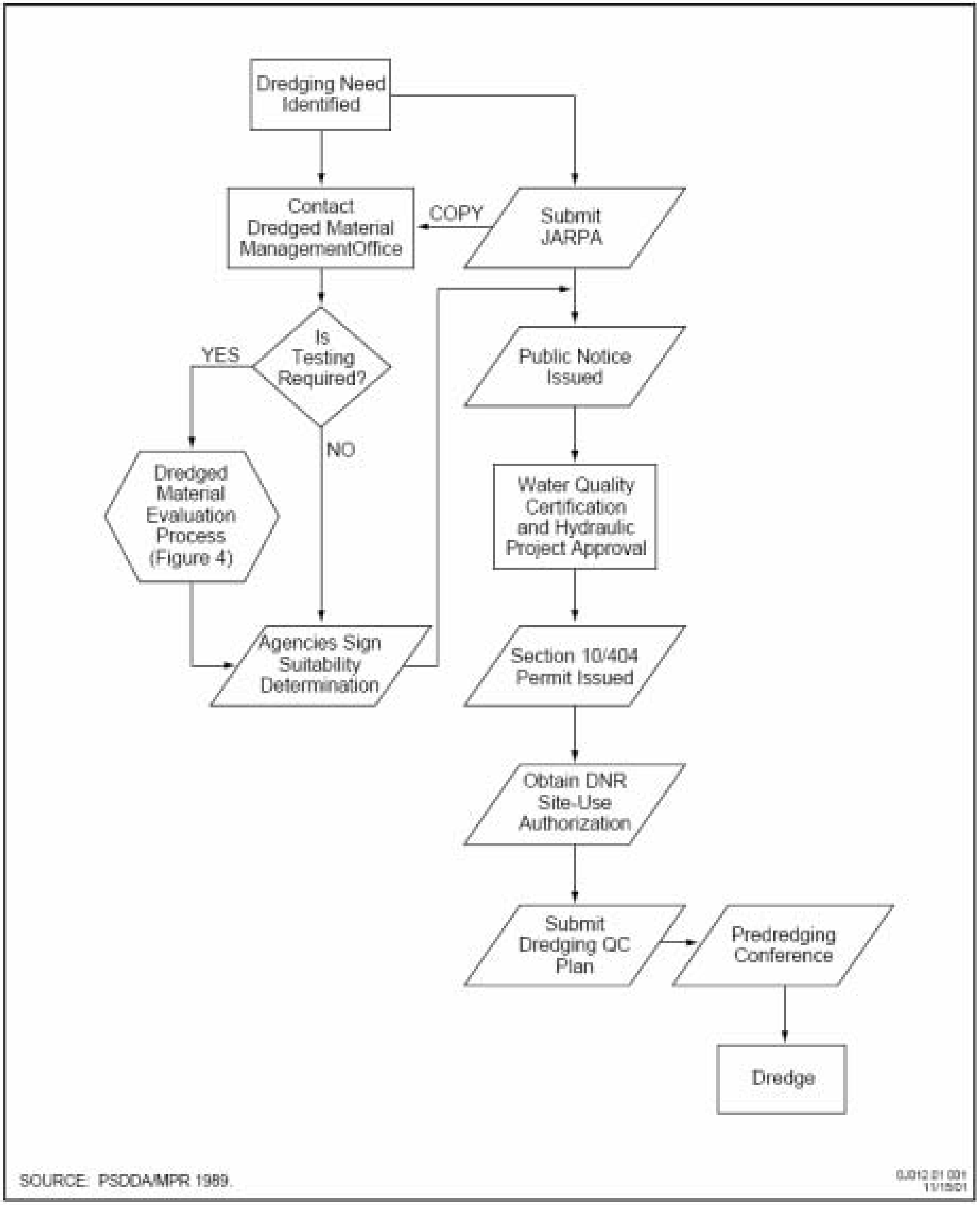


Figure 3. Section 10/404 Regulatory Process (New Permit Not Required)

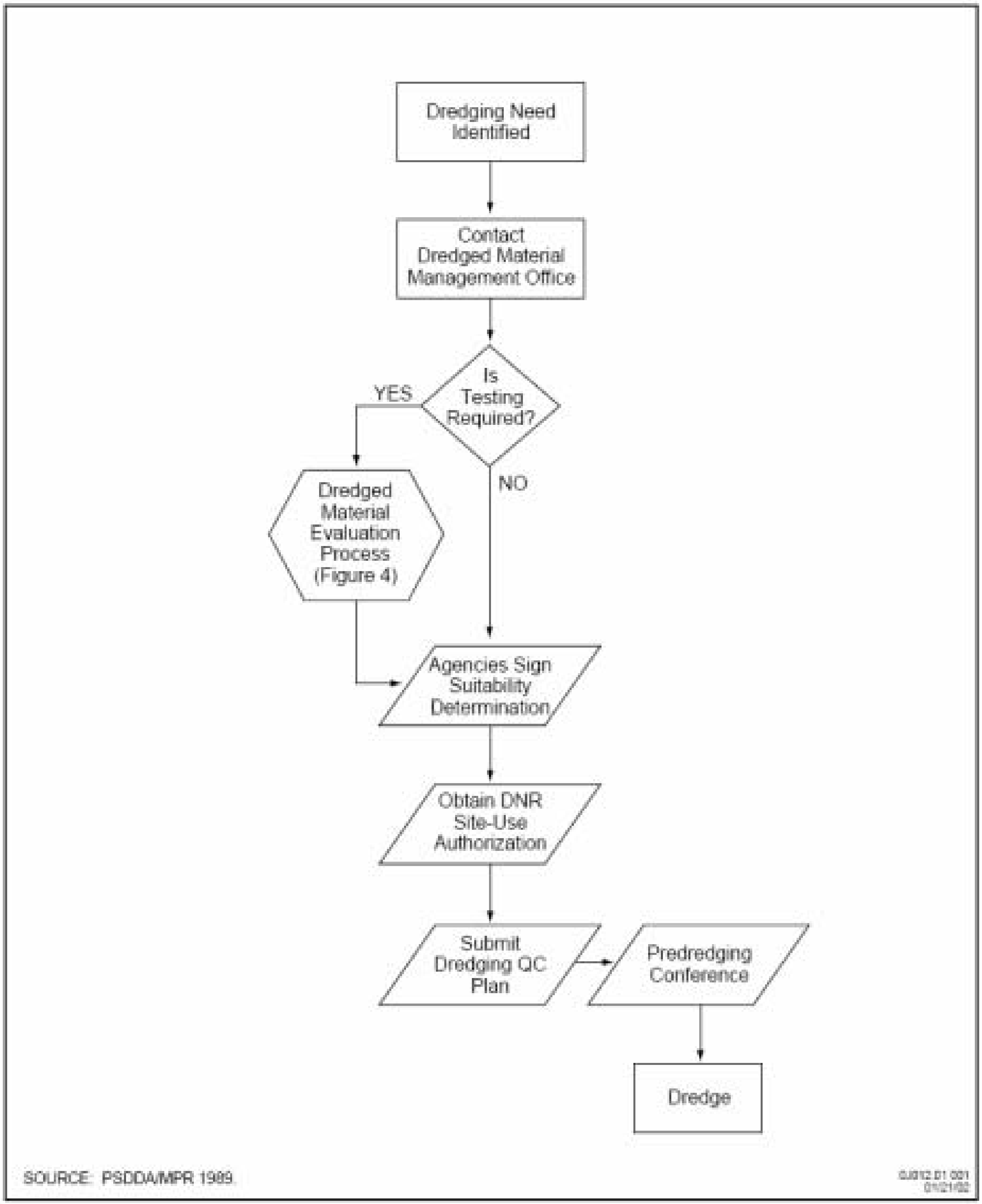


Figure 4. Dredged Material Evaluation Process

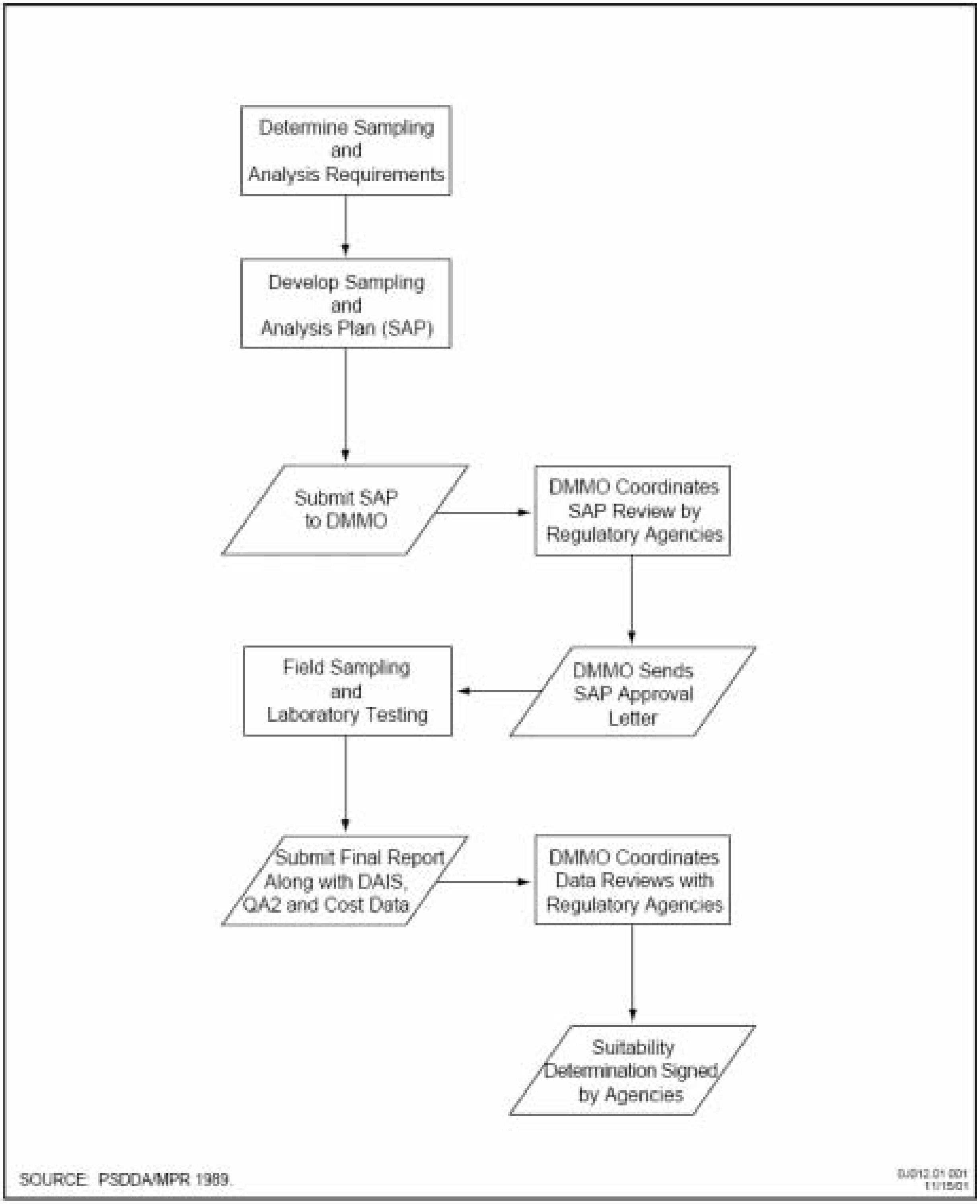
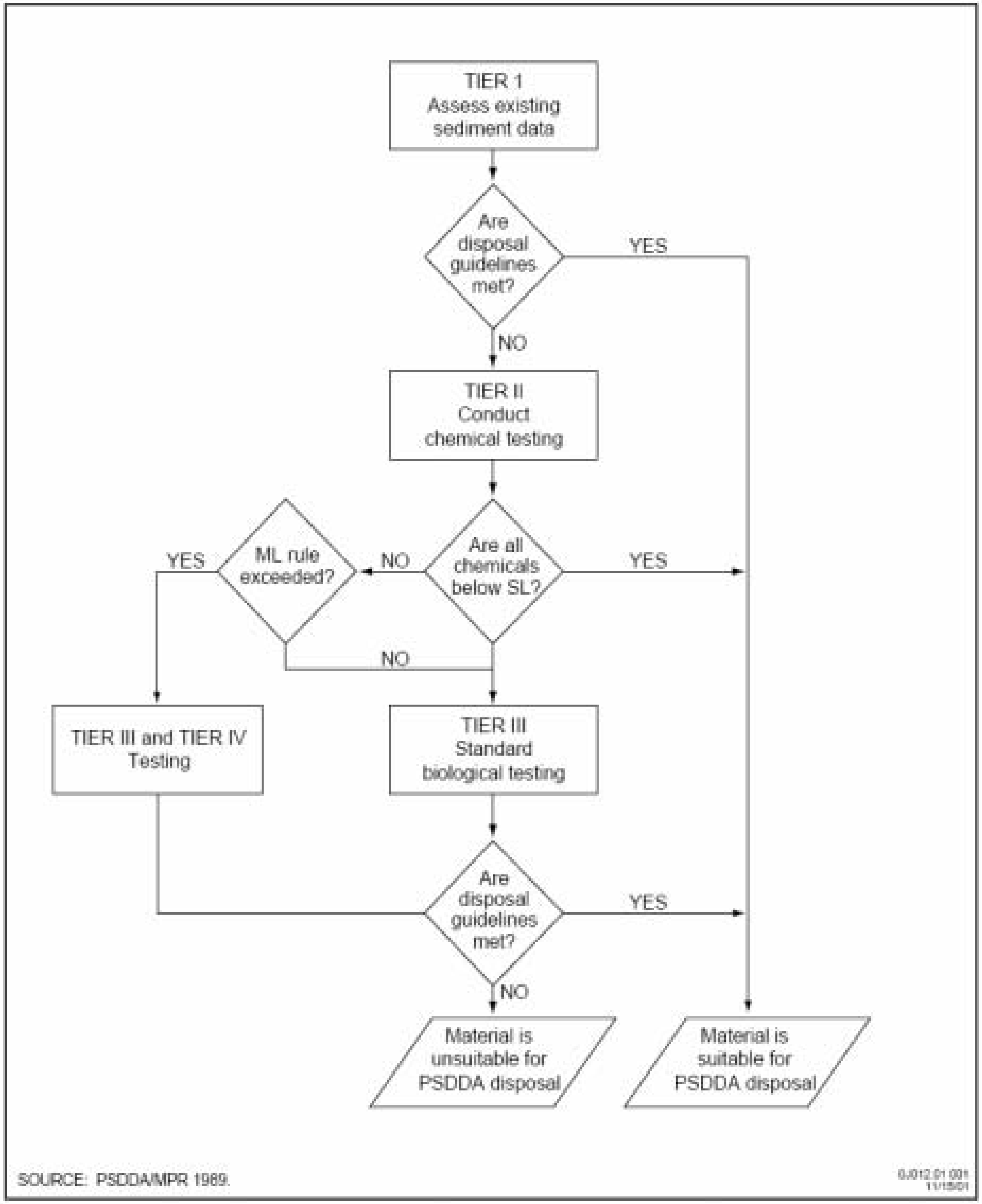


Figure 5. Tiered Testing Decision Diagram



1.2 PREVIOUS PSDAA SECTION 7 CONSULTATIONS

As part of the 1988 and 1989 PSDDA environmental impact statements, biological assessments were prepared to evaluate the potential impacts of the program on species listed under the Endangered Species Act and occurring within Puget Sound at that time — bald eagles, several species of whales, and leatherback sea turtles. These previous biological assessments concluded that disposal activities at these sites are not likely to adversely affect bald eagles, whales or leatherback turtles because these species either do not occur in Puget Sound, are transient residents in the Sound, or are not likely to congregate or feed at the disposal sites.

2. DESCRIPTION OF THE PROPOSED ACTION

The activities considered in this biological evaluation are the transport of dredged material from a dredging site to a PSDDA disposal site; the disposal of material at a PSDDA disposal site; and the return of equipment to the dredging site. These same activities have occurred over the past 16 years, since the 1989 designation of PSDDA disposal sites.

Although dredging projects in Puget Sound are also required to comply with the Endangered Species Act (ESA), dredging activities are not considered in this biological evaluation. All dredging actions that generate material for open-water disposal at PSDDA sites require the issuance of a Clean Water Act Section 404 permit. The issuance of a 404 permit is a Federal action requiring an ESA Section 7 consultation. Therefore, the potential effects of specific dredging activities on threatened and endangered species will be addressed in separate biological evaluations prepared by individual project proponents once specific future plans are known. Past and potential future disposal frequencies are addressed in Section 2.4 below.

The Corps of Engineers request that the term of this biological evaluation be five years. Disposal activities will occur concurrently with dredging projects. Since the timing of dredging activities is generally regulated by in-water work closure periods established to protect outmigrating juvenile salmon and bull trout during sensitive times in their life cycles, no additional ESA closure periods specifically for PSDDA sites are warranted. However, three of the eight PSDDA sites have closure periods for the protection of other marine resources/fisheries (see Table 2 below).

Table 2. PSDDA Site Closure Periods (non ESA)

Disposal Site	Disposal Site Closure Period	Reason
Port Townsend	September 1 to November 30	Fall shrimp closure
Port Angeles	September 1 to November 30	Fall shrimp closure
Bellingham Bay	November 1 to February 28	Crab/shrimp closure

2.1 DREDGED MATERIAL TRANSPORT

The activity considered under this biological evaluation is the transport of dredged material from dredging site to disposal site, the disposal of the material, and the return of the equipment to the dredging site. Dredged material is generally transported to the disposal site by a tugboat pulling a bottom-dump (split-hull) barge. The barges can be of various sizes, with the ability to transport between 1,200 and 2,000 cubic yards (typically 1,500 cubic yards) of material each trip. The number of barge discharges per day to a particular site varies by project, but are typically two to five per day when projects are active. The distance traveled and the number of trips required varies depending on the location and extent of the dredging activity.

Transport of the barge to and from the disposal sites is not generally a concern with regard to potential physical effects on salmon, coastal pelagic, and groundfish species or habitat. Some dredged material may possibly be lost overboard on the way to the disposal sites either by being blown overboard, sloughing, or leaking. Concern has been expressed that windborne, spilled, or leaking dredged material entering the water column during transport could in some way delay or otherwise affect freshwater entry of returning adult salmon or have deleterious effects on pelagic and groundfish species. The negligible potential for this outcome is reviewed in the following discussion.

Mechanical dredging operations are performed to achieve an economical load that will result in some overflow of dredged material within the allowable dilution zone. The determination of an economical load is made in the field, based on the consistency of the dredged material and the safe load capacity of the transport barge. Sometimes the dredged material dewaters quickly, allowing the load to be mounded along the centerline axis of the barge. If the dredged material contains fines and high water content, mounding is not feasible and appropriate freeboard is maintained on the confinement bulkhead (sideboards) to prevent spillage. When the barge capacity is reached, the deck area outside the perimeter bulkhead of either deck or bottom dump barges is inspected for accumulated sediment. Spilled sediments are flushed overboard with water in the dilution zone at the dredging site to provide safe access for the dredge crew and to prevent the materials from being lost overboard in transit from the dredging site to the disposal site.

The potential for effect from windborne sediments is minimal. The type of sediments that can typically be mounded on a barge (and thus would be most exposed to wind) are either more granular (contain little fine or organic material, would be relatively inert, and pass quickly through the water column) or are very cohesive (clay). More claylike sediments generally contain a high moisture content, which would resist windborne transport. The amount of time between loading and discharge of dredged materials at the disposal site is relatively short (hours), which gives finer material little time to dry (become less cohesive) during the transport process. Thus, potential for windborne transport of these types of materials is minimal.

The potential for sloughing or leaking of dredged material from barges during the transport of material to the disposal sites is minimized by the design of modern barges (sideboards on the deck and seals on the bottom dump doors) and the typical operation practices of the contractors (loading practices and deck cleaning for crew safety and access, as required, prior to leaving the dilution zone). If any significant leaking is noted, the contractor must correct the situation before leaving the dredging dilution zone. Thus, the potential for significant sloughing or leaking of dredged material is minimal.

Although there is always potential for a fuel spill, this possibility is extremely small. Noise and minor spills would have no measurable effect on salmon, coastal pelagic, or groundfish EFH. The number of trips and distance traveled by the tugs and barges is minimal compared to the vast number of commercial vessels sailing on Puget Sound.

2.2 DISPOSAL ACTIVITIES

2.2.1 Dispersive Sites

Dredged material disposal activities at the dispersive sites are conducted to maximize the dispersion of dredged material. Disposal occurs from the barge as the barge is being towed through the disposal site. The disposal sites were sized on the assumption that a barge is towed at an average speed of 3 knots and the load is completely dumped in 10 minutes. Dispersive site disposal zones (the area on the surface where dredged material is released) were sized based on the predicted horizontal spread of a single dump of dredged material.

Based on modeling conducted as part of the PSDDA site selection process, a disposal event in 122 meters (400 feet) of water with a current speed of 50 cm/sec (1 knot) would result in a horizontal spread of 610 meters (2,000 feet) down current of the dump spot, and 303 meters (1,000 feet) to either side. For the dispersive site, 914-meter (3,000-foot) diameter disposal zones were established. Based on the projected spread, the disposal site dimensions were set at 1,829 meters (6,000 feet) diameter for the Rosario site, and 2,134 meters (7,000 feet) diameter for the Port Townsend and Port Angeles sites.

2.2.2 Non-Dispersive Sites

Dredged material disposal activities at the non-dispersive sites are conducted to maintain the dispersion of dredged material in the 600-foot radius target zone. Disposal occurs from the barge as the barge is being towed through the disposal site at the minimum speed necessary to maintain control. All dredged material disposal tugs are required to record and report when and where the doors on the barge are opened and closed to ensure that all disposal occurs within the target zone. In addition, the DNR keeps a record of all disposal track lines that each barge traveled during the dumping using DGPS.

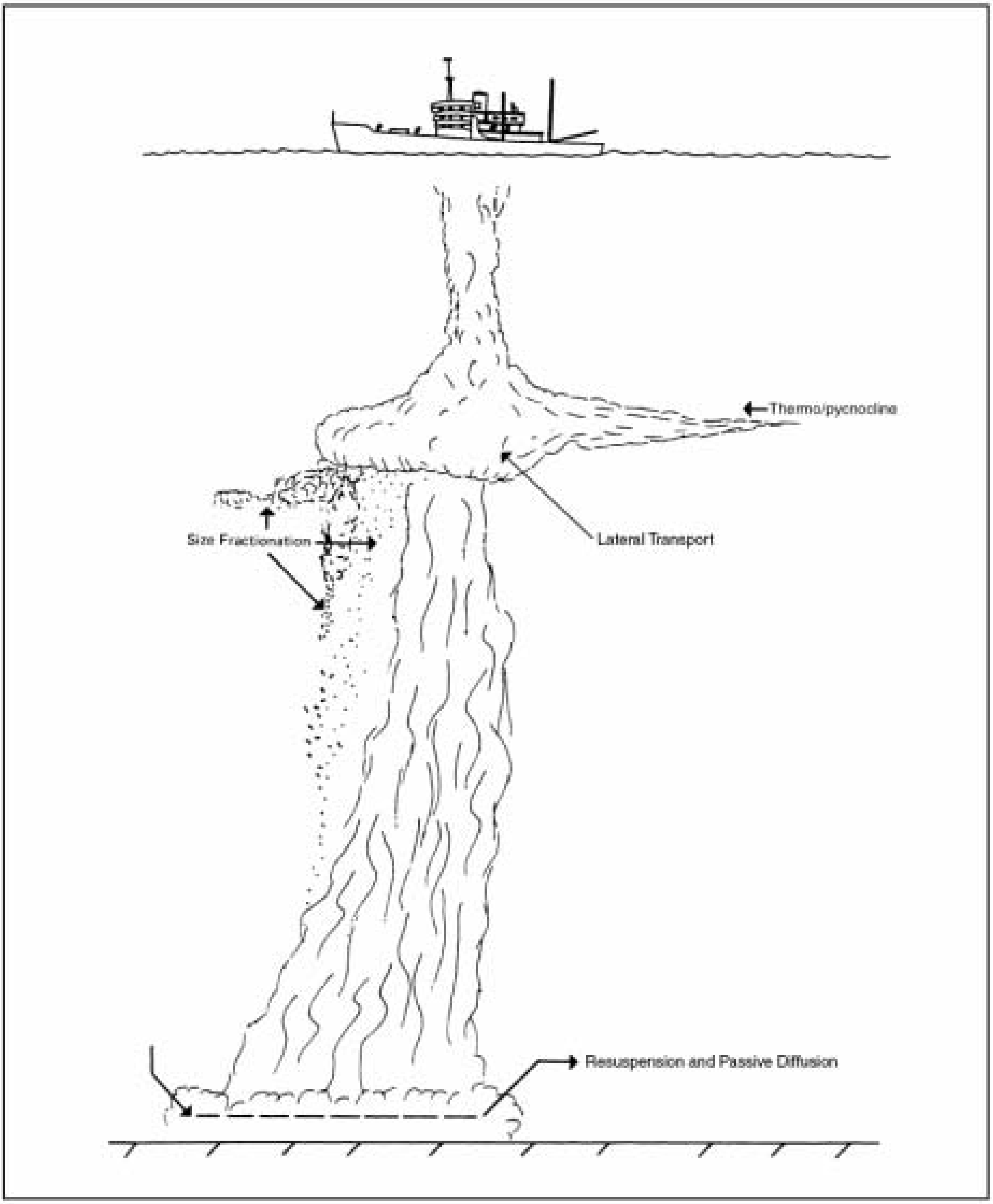
The behavior of discharged material at non-dispersive sites was modeled as part of the original site selection process (PSDDA/DSSTA, 1989). The models showed that material separated from the jet (because of turbulent shear or collapse) and settled to the bottom within the disposal site boundary within a 305-meter (1,000-foot) radius of the drop point. The depth of the deposits on the bottom varies from about 0.8 cm in the center of the disposal mound, to about 0.1 cm near the edges of the mound.

2.3 DISPOSAL MECHANISMS

As part of the PSDDA site selection analysis, the Corps conducted extensive numerical modeling simulations using the Disposal from an Instantaneous Dump (DIFID) model (Trawle and Johnson 1986). The model evaluated the fate and dispersal of dredged material of varying composition discharged from barges into waters of varying depth and current speed (PSDDA/MPR 1988, 1989). A schematic representation of a discharge event is presented in Figure 6.

Changes in the form and behavior of an instantaneous discharge of dredged material from a barge during its descent through the water column are generally described by the Corps (1986) and Pequegnat (1983). The descent from an instantaneous discharge from a moving split-hull barge is similar in some regards and can generally be divided into three phases according to the physical forces that act on the material as it descends through the water column to the bottom. These phases are convective descent, dynamic collapse, and passive diffusion.

Figure 6. Schematic Representation of the Fate of Dredged Material during Disposal



SOURCE: Adapted from Pequegnat 1983.

2.3.1 Convective Descent

During convective descent, the discharged material descends through the water column as a dense, well defined fluid-like jet. The consistency and behavior of the jet depends on the characteristics of the dredged material, moisture content, cohesiveness, size composition (e.g., silt, clay, sand, gravel), and the equipment used to dredge the material (clamshell, cutterhead, hopper/drag-arm). Material previously discharged at PSSDA sites has been of highly variable character, and a wide range of dredged material type can be expected in future disposal activities. Dredging within Puget Sound is almost entirely performed using clamshell dredges. Clamshell dredges keep the dredged material relatively consolidated and minimize the percent moisture content (PMC).

All other things being equal, the PMC will determine the amount of dredged material that will initially reach the bottom, the amount of time it takes to initially reach the bottom, the area of the bottom it covers, the direct and immediate potential impact on the pelagic water column and bottom, and the effects of the environment on the dredged material (resuspension and transport). Where the initial PMC is low, as with clamshell dredging, the transit time of the material is sufficiently brief that the influence of any currents in transporting the material laterally is minimal (Pequegnat 1983). In modeling conducted by the Corps (PSDDA/FEIS 1988, 1989), transit time of the material to the bottom in 122 meters (400 feet) of water is on the order of 30 seconds after the discharge is initiated.

As the material descends to the bottom, large volumes of water are entrained in the jet, which expands the diameter of the jet as it approaches the bottom. The Corps (1986) estimated that the diameter of the jet as it makes contact with the bottom in 122 meters (400 feet) of water would be approximately 76 meters (250 feet). As a result of several factors, including turbulent shear, some material is separated as it descends, and settles to the bottom at a slower rate. This rate is determined by material density (size fractionation). Lateral transport of this material has been a concern in the discharge of sediments that contain contaminants. However, this is not a critical issue for the present analysis because the material discharged at PSDDA sites has been evaluated thoroughly for suitability for disposal. To be suitable, the sediments must not contain unacceptable concentrations of chemicals of concern.

2.3.2 Dynamic Collapse

The dynamic collapse phase occurs as the material collides with the bottom or when the material encounters a water layer with greater ambient density (thermocline or pycnocline). As the jet material collapses, the material spreads out in all directions as a density/momentum-driven surge. The behavior of discharged material at both dispersive and non-dispersive sites was modeled as part of the original site selection process (PSDDA/DSSTA, 1989).

For dispersive sites, the models showed that material impacts the bottom within the disposal site boundary. An estimated 90% of material is deposited within a 457-meter (1,500-foot) radius of the disposal location. The initial depths of the deposits on the bottom were calculated to vary from 2.2 to 0.73 cm in water depths of 61 to 122 meters (200 to 400 feet).

For non-dispersive sites, the models showed that material separated from the jet (because of turbulent shear or collapse) and settled to the bottom within the disposal site boundary within a 305-meter (1,000-foot) radius of the drop point. The depth of the deposits on the bottom varies from about 0.8 cm in the center of the disposal mound, to about 0.1 cm near the edges of the mound.

The concentration of suspended solids, as well as the extent and duration of their presence in the water column, is of concern because of potential effects on biota. As expected, turbidity effects vary in concentration and duration depending on the type of material discharged and environmental conditions. The material to be discharged is loaded into barges with a clamshell dredge, which maximizes the cohesiveness of the material compared to other dredging methods. As such, the material tends to clump when discharged. This minimizes loss from the jet to the surrounding water and resuspension once it contacts the bottom. Various estimates have been made to characterize the loss of material to surrounding waters (Corps 1986). Studies have generally concluded that from 1 to 5% of the disposed material is lost from the jet to the water column during descent. However, monitoring has demonstrated that this material settles rather quickly (within 1 hour). Please see Section 4.1.1 for additional discussion regarding the behavior of sediments in the water column during and after disposal events.

2.3.3 Passive Diffusion

Passive diffusion is the transport of disposed material by currents. This process is not a major factor at non-dispersive sites because current velocities at the sites are too low to initiate movement of the material. The dispersive sites are located in areas where bottom currents are swift enough to completely disperse discharged dredged material out of the disposal site.

The three dispersive sites have mean current speeds greater than 40 cm/sec. Several field studies were performed and numerical models were created to evaluate the transport of dredged material from dispersive sites, based on current speeds. These studies/models indicated that at all three sites a small amount of dredged material would initially accumulate on the bottom after a discharge event, but then complete erosion of the material would likely occur over a single flood or ebb tide.

Bathymetric monitoring of the Rosario Strait site in 1991, 1994, and 1999 confirmed that dredged material is rapidly dispersed and no accumulations of dredged materials have occurred at that site since the 1989 baseline survey. The Rosario Strait site has not been monitored since 1999 due to the generally low use of the disposal site. In 2000 no disposal activities occurred, with only 10,419 cy in 2001, 500 cubic yards in 2002, and 38,223 cubic yards of dredged material in 2003. A sharp increase in disposal occurred in 2004 with 230,747 cy and bathymetric monitoring of the Rosario Strait site is planned for 2005. The other two dispersive sites have not been monitored because no dredged materials have been discharged at these sites in the past 5 years.

Passive diffusion can transport dredged materials relatively large distances. The direction and distance of transport varies for each site and depends on the stage of the tide during which the material is disposed. PSDDA/DSSTA (1989) evaluated far field dispersion using a variety of methods including observation of Lagrangian drifters and numerical simulations (Crean 1983). The studies anticipated wide dispersal of the material because of the strong currents at the sites.

The currents at the Rosario Strait site, with net current speeds of 10 to 30 cm/sec and peak speeds of 100 cm/sec, were estimated to transport suspended material up to 10 miles a day. The prevailing current flow would tend to disperse suspended material southward from the Rosario Strait site. Mean current speeds at the Port Townsend site are between 30 and 50 cm/sec, with peak speeds of 75 to 100 cm/sec. The east/west movement of the material depends on the tide, with net speeds reaching 10 miles per day. At these speeds, the prevailing currents could move suspended sediment to the mouth of Admiralty Inlet in 1 day or to Vancouver Island in 2 days. No field data exist for the Port Angeles site, but the peak current speeds are estimated at about 125 cm/sec with an east/west trajectory. Resuspended material transported in the bottom currents would predominately move eastward over time, entering the Strait of Georgia via Haro Strait and Puget Sound via Admiralty Inlet.

2.4 SITE USAGE

Table 3 details cumulative discharges to the eight PSDDA sites since their designation in 1989-1990 through 2004. The cumulative volumes are depicted in terms of the relative site capacity, as well as estimated time to exceed that volume. Over 10.7 million cubic yards of dredged material has been disposed at the 8 sites over the past 16 years. The Commencement Bay, Elliott Bay, Port Gardner, and Rosario Strait sites are the most heavily used of the PSDDA sites, with an average of 100,000 to 300,000 cubic yards disposed at each per year.

Table 4 details post dredging volumes at each site. Dredging volumes over the past 2 – 3 years provide a general trend and a rough idea of how much material would be disposed of at the PSDDA sites over the next few years. Please see detailed discussions of each disposal site in sections 3.2 and 3.3.

Table 3. Sixteen Year (1989-2004) PSDDA Site Use Summary

Nondispersive Disposal Site	Cumulative Volumes (CY)	Average Volume Per Year (CY/YR)	15-Year Predictions MPR Phase I/II (CY)	Percent of 15-Year Prediction	Estimated Time to Exceed Site Capacity (Years) [1]
Port Gardner (1989-2004)	2,017,255	126,078	8,243,000	24.5	55.4
Elliott Bay (1989-2004)	2,325,676	145,355	10,525,000	22.1	45.9
Bellingham Bay (1990-2004)	78,883	5,259	1,181,500	6.7	1,696
Commencement Bay (1989-2004)	4,679,259	292,454	3,929,000	119.1	14.8[2]
Anderson/Ketron Island (1990-2004)	24,646	1,643	785,000	3.1	5,463
SUBTOTALS:	9,125,719	570,789	24,763,500	36.8	N/A
Dispersive Disposal Site	**Cumulative Volumes (CY)**	**Average Volume per Year (CY/YR)**	**15-Year Predictions MPR Phase I/II (CY)**	**Percent of 15-Year Prediction**	**Estimated Time to Exceed Site Capacity (Years) [3]**
Rosario Strait (1990-2004)	1,548,440	103,229	1,801,000	85.9	N/A
Port Townsend (1990-2004)	28,628	1,908	687,000	4.2	N/A
Port Angeles (1990-2004)	22,344	1,490	285,000	7.8	N/A
SUBTOTALS:	1,599,412	106,627	2,773,000	49.3	N/A
GRAND TOTALS:	10,725,131	677,416	27,536,500	38.9	N/A

1. Site capacity estimated in Phase II Disposal Site Selection Technical Appendix for non-dispersive sites is approximately 9,000,000 cubic yards, therefore (Site Capacity – Cumulative Volume)/average annual disposal volume = Estimated Time to Exceed Site Capacity.

2. Estimate based on average disposal volumes over first 16 years, but site based on current and estimated future site use is expected to exceed current site capacity within the next10 years.

3. Actual site capacity for dispersive sites is not limited, assuming complete dispersal of dredged material off site.

Table 4. Disposal Site Use Summary Over Sixteen Years of DMMP Management.

Site	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	Totals:
Commencement Bay, ND	6,648		10,900				290,857	460,684		693,540	140,319	893,776	265,867		710,675	1,205,993	4,679,259
Elliott Bay, ND	4,097	129,542	12,000	230,241	17,282	132,770	93,412	95,302	18,982	110,465	414,794	360,577	557,340	133,270		15,602	2,325,676
Port Gardner, ND		992,074	17,261		109,500	236,749	143,510	121,246	102,531				248,965	45,419			2,017,255
Bellingham Bay, ND					32,883			44,800		1,200							78,883
Ketron Island, ND					10,197		8,677									5,772	24,646
Rosario Straits, D			566,694	43,850		57,010	25,250	205,500		53,000	140,761		10,419	500	38,223	230,747	1,371,954
Port Townsend, D					22,642					4,000	1,986						28,628
Port Angeles, D								22,344									22,344
Totals:	10,745	1,121,616	606,855	274,091	192,504	426,529	561,706	949,876	121,513	862,205	697,860	1,254,353	1,082,591	179,189	748,898	1,458,114	10,548,645

Legend:
ND = nondispersive
D = Dispersive
Volumes (cubic yards)

2.5 CONSERVATION MEASURES

A number of measures and procedures inherent in the Dredged Material Management Program (DMMP) act in combination to minimize the potential for impacts to listed species in Puget Sound. These include:

- consolidation of dredged material disposal sites to minimize the area and locations affected by dredged material disposal;
- siting of dredged material disposal sites in areas of relatively low habitat value or low use by biota (distance offshore, depth, areas with low known resource value);
- consideration of beneficial-use disposal sites for appropriate dredged material;
- timing of dredging and disposal events to avoid overlap with sensitive migration or life history periods of listed species;
- using dredged material testing protocols to ensure the suitability of materials for unconfined, open-water discharge;
- conducting site monitoring activities (physical, chemical and biological) to determine if unacceptable impacts are occurring at disposal sites;
- performing annual review of monitoring results; and
- using adaptive management by the DMMP agencies.

3. ACTION AREA AND PROJECT AREAS

3.1 ACTION AREA

Given the wide distribution of PSDDA sites, the distances associated with transport of dredged material from dredging sites to the disposal sites, and the sizeable dispersal zones for material discharged at the dispersive sites, the action area for this biological evaluation is defined as Puget Sound, including the Georgia Strait and the Strait of Juan de Fuca. Individual project areas are the specific disposal sites and their associated waters. Each of the eight sites is described in the following sections.

3.2 NON-DISPERSIVE SITES

3.2.1 Commencement Bay Site

The Commencement Bay disposal site is located approximately 0.65 nautical miles (0.75 mile) west of Brown's Point. The site is elliptical, covering 310 acres with dimensions of 1,402 by 1,158 meters (4,600 by 3,800 feet). The Commencement Bay site is generally located in waters 165 to 171 meters (540 to 560 feet) deep. The center of the site is now around 480 feet deep due to sixteen years of disposal.

Sediment grain size is small in this depositional area. Currents near the bottom move predominantly in a southern direction and are less than 25 cm/second, not fast enough to resuspend sediments (PSDDA/FEIS 1988).

Benthic infauna biomass at the Commencement Bay site was dominated by large polychaetes (67%), bivalve mollusks (28%), and crustaceans only constituting 5% of the biomass. The Benthic Resources Assessment Technique analysis for this area indicated that four benthic feeding strategy groups of fish were heavily using the area, primarily represented by Dover sole and English sole (PSDDA/FEIS 1988).

Bottom trawl studies in 1986 indicated that Dover sole, English sole, and ratfish were the most abundant bottom fish at the Commencement Bay site.

A post-disposal evaluation of this site in 1996 indicated that dredged material remained onsite. Dredged material at the site perimeter was <0.5 cm thick. Sediment testing at the site indicated that there was some small increase in lead sediment concentrations at one perimeter station, with several metals (copper, mercury, silver, and zinc) also increasing at one perimeter station. However, overall sediment quality was improved in 1996 over 1995 levels, and the biological effects guideline of "minor adverse effects" was not exceeded (SAIC, 1995, 1996).

Monitoring at the Commencement Bay disposal site during 2001 documented a wider spread of dredged material than originally envisioned during the site selection/designation process (SEA, 2001). The DMMP agencies closed the site pending evaluation of the offsite impacts, which showed no chemical and biological impacts within the expanded dredged material footprint. Additional sampling conducted verified that the benthic community was not impacted outside the disposal site. The site was eventually re-opened in July 2002 after all additional site investigations and modeling studies were completed, and after the DMMP agencies provided assurances to Pierce County Shoreline Board on the management actions adopted by the DMMP agencies, which included close monitoring of all disposal activity at the Commencement Bay disposal site. The DMMP agencies are currently evaluating further site management recommendations that could include expanding the current site boundaries and relocating the current disposal zone coordinates to minimize the mound height.

Additional monitoring in 2003 and 2004 further documented that the dredged material was not impacting the benthic community and that sediment quality remained high and met the site management objectives (SAIC, 2003, 2004). The monitoring during 2003 and 2004 showed that the dredged material footprint extended outside the disposal site perimeter, in general similar to that observed in 2001, but not extending as far north. Because of the relatively high disposal at the Commencement Bay site over the past six years, and the projected volumes from Port of Tacoma projects currently going through the permitting process, the DMMP agencies are initiating a NEPA/SEPA review of the Commencement bay site to evaluate future site use alternatives. They are considering potentially expanding the current site boundaries, relocating a new target disposal zone within the existing disposal site, or closing the existing site. The DMMP agencies expect to convene and interagency workgroup during 2005 to discuss the various alternatives being contemplated and solicit input on these alternatives to address the future disposal needs in Commencement bay and vicinity.

3.2.2 Elliott Bay Site

The Elliott Bay site is located near the mouth of the Duwamish River, about 0.74 nautical miles (0.85 mile) from Harbor Island. The site is egg-shaped with dimensions of 1,890 by 1,219 meters (6,200 by 4,000 feet), covering an area of 415 acres. The depth of the site is 91 to 110 meters (300 to 360 feet).

The peak current speed on the bottom at the site is less than 15 cm/second, well below the 25 cm/second threshold required to resuspend fine sediments. The direction of currents is variable in Elliott Bay, although a study by McLaren and Ren (1994) documented that sediment transport in Elliott Bay occurs in a clockwise gyre. Elliott Bay sediments are generally very fine-grained material. The inner bay sediments vary from 9 to 12% clay with the highest percentage at the greatest depths. Chemicals of concern including PCBs, PAHs, metals, organic compounds, copper, lead, zinc, cadmium, arsenic, and mercury are commonly found to be elevated in Elliott Bay (PSDDA/FEIS 1988).

Benthic infauna at the Elliott Bay site are dominated by large polychaetes and bivalve mollusks. Polychaetes make up 51%, mollusks 39%, and crustaceans only 4% of the biomass. The Benthic

Resources Assessment Technique analysis for this area indicated that four benthic feeding strategy groups of fish were heavily using the area, primarily represented by Dover sole and English sole (PSDDA/FEIS 1988).

Post-disposal evaluation of this site in 1992, 2000, and 2002 indicated that dredged materials remained onsite, and that the thickest layers were in the center of the target zone. Sediment testing at the site indicated that the concentration of chemicals of concern is well below the allowable "minor adverse effects" level and predominantly below screening levels. Comparative pre-disposal and post-disposal onsite sediment quality monitoring has shown that metals and PAH concentrations have dropped significantly due to dredged material disposal. Overall, monitoring has confirmed that there are no indications of adverse environmental effects beyond the boundary of the disposal site (SAIC, 1992, 2000, 2002).

The disposal of 414,794 cubic yards of dredged material on-site in DY99 prompted a Full Monitoring in 2000 (SAIC, 2000). In addition to meeting the goals of all monitoring efforts, the 2000 monitoring at Elliott Bay was also designed to address concerns related to dredged material disposal at PSDDA sites and the listing of Puget Sound Chinook and Bull Trout as threatened under the Endangered Species Act (ESA) of 1973 (SAIC, 2001). The tests used for ESA concerns included 45-day bioaccumulation tests using Macoma and Nephtys for sediment and tissue. Physical, chemical, and biological analyses were conducted at up to 61 sampling locations. The results of the 45 day bioaccumulation test showed accumulation of silver, copper, lead, antimony, zinc, mercury, and TBT relative to reference sediments, but no levels exceeding human health standards. The Co-planar PCB analysis of tissue samples from the bivalve Macoma and polychaete Nephtys showed that uniformly low PCB contamination was observed in the onsite sediments and tissue samples and demonstrated that PCBs were not a concern for either endangered species passing through the site or benthic feeding demersal flatfish species that may be foraging at the disposal site.

.

3.2.3 Port Gardner Site

The Port Gardner disposal site is located 2 nautical miles (2.3 miles) west of the Everett Harbor. The 318-acre site is circular with a diameter of 1,219 meters (4,000 feet). The depth of this site is 128 meters (420 feet). The site is relatively flat, with slopes of less than 0.3 meter (1 foot) over a horizontal distance of 61 meters (200 feet).

Currents are weak at this depositional site and move predominantly northward to westward. Pre-disposal sediment at the site was predominantly medium and fine silt with greater than 15% clay. Sediments along the south and east ends were coarser, ranging from fine to very fine sand (PSDDA/FEIS 1988).

Benthic infauna at the Port Gardner site are dominated by large polychaetes and bivalve mollusks. Large numbers of juvenile ophellid polychaetes were also observed in 1986. Benthic biomass averaged 36 g/m^2, with polychaetes making up 50%, bivalves 42%, and crustaceans only 2.4% of the biomass. The Benthic Resources Assessment Technique analysis for this area indicated that four benthic feeding strategy groups of fish were heavily using the area, primarily represented by Dover sole and English sole (PSDDA/FEIS 1988).

Post-disposal evaluation of this site in 1994 indicated that dredged material remained onsite. Dredged material was thickest at the center of the target zone and tapered to about 5 cm thick at the edge. Sediment testing at the site indicated that the concentration of chemicals of concern was well below the allowable “minor adverse effects” level and generally below screening levels (PSDDA 1996). The Port Gardner site has not received any dredged material since 1997 and thus has not been surveyed since 1994.

3.2.4 Bellingham Bay Site

The Bellingham Bay site is approximately 3.5 nautical miles (4 miles) south-southwest of the city of Bellingham, and 1.2 nautical miles (1.4 miles) west of Post Point. The site depth is about 29 meters (96 feet) MLLW. The site is circular with a diameter of 1,158 meters (3,800 feet), and the area of the site is 260 acres. This is the shallowest of the non-dispersive disposal sites.

The Bellingham Bay site is a low-energy depositional environment. Pre-disposal sediment conditions included a predominance of silt with 18 to 20% clay. Sediments contained a large quantity of organic material, had BOD_5 concentrations of 2,000 to 2,500 mg/kg of sediment, greater than 8% volatile solids, and about 70% water (PSDDA/FEIS 1989).

Benthic studies at the Bellingham Bay site during July 1987 described a community that was dominated by two taxonomic groups, principally the bivalve Axinopsida serricata, and polychaete worms of the families Terribellidae, Maldanidae, Onuphidae, and Chaetopteridae. Bivalve biomass constituted 61% and polychaetes constituted 21% of the biomass in the top 5 cm of sediment at the site. Crustacean biomass was relatively insignificant throughout the Bellingham Bay study area, constituting less than 3% of the community biomass in the top 5 cm of sediment, and generally less than 1% of the community biomass below 5 cm. (PSDDA/FEIS 1989).

Of the fish found at depths greater than 20 meters (66 feet), longfin smelt were the most numerous in Bellingham Bay (Donnelly et al. 1988) and would probably be the species of greatest importance to salmonids. Juvenile and adult longfin smelt are abundant in the area at times and could be preyed on by adult salmon. These fish were not considered a major predator in the Benthic Resources Assessment Technique (BRAT) analysis (PSDDA/FEIS 1989) and feed on plankton rather than the benthos. Effects of dredged material disposal on longfin smelt and other forage fish would be primarily through burying of epibenthic crustaceans that may be prey for these fish (Simenstad et al. 1979). Pacific herring and sandlance prey predominantly on pelagic copepods and would not be significantly affected by changes in the benthic and epibenthic community.

Post-disposal evaluation of this site in 1993 indicated that dredged materials remained onsite, and that most of the material was in thin layers (<10 cm thick). Sediment testing at the site indicated that the concentration of chemicals of concern was well below the allowable “minor adverse effects” level and was generally less than the screening levels (PSDDA 1994).

3.2.5 Anderson/Ketron Island Site

The Anderson/Ketron site is located approximately 3 nautical miles (3.5 miles) west-southwest of the town of Steilacoom, midway between Anderson and Ketron Islands. This oval-shaped site is approximately 1,341 by 1,097 meters (4,400 by 3,600 feet), covering 318 acres. The site is 135 meters (442 feet) deep (MLLW).

Although current speeds at depths 15 meters (49 feet) or more above the bottom at the Anderson/Ketron site are at or greater than the critical speed for fine sediment transport (about 25 cm/sec), bottom conditions indicate that this is a depositional site (PSDDA/FEIS 1989). Pre-disposal sediment conditions indicated the sediment grain size was predominantly medium to very fine sand with 4 to 8% clay at the north and south ends. Higher organic content and finer grain size covered much of the area. Sediments contained volatile solids of less than 1% to 4% (PSDDA/FEIS 1989).

The benthic infauna at the Anderson/Ketron site was somewhat different from the other non-dispersive sites in that it had a smaller biomass percentage of mollusks (13%) and a greater biomass percentage of crustaceans (44%). Polychaetes (47%) dominated the benthic infauna biomass. The predominant demersal fish at the site were English sole, Pacific tomcod, and slender sole.

This disposal site has been used only infrequently (three disposal actions) with only a relatively small quantity of material being disposed (total = 24,646 cy). Post-disposal monitoring is scheduled for Spring 2005 at the Anderson/Ketron disposal site. The monitoring results would also become the new baseline for future site evaluations.

3.3 DISPERSIVE SITES

3.3.1 Rosario Strait Site

The Rosario Strait site is located approximately 1 nautical mile (1.2 miles) south of Cypress Island, northwest of Shannon Point on Fidalgo Island. The disposal zone is a 457-meter (1,500-foot) circular area that is centered at Latitude N 48^{o} 30.87' and longitude W 122^{o} 43.56'. The disposal site is circular with a 1,829-meter (6,000-foot) radius. The average depth of the site is 37 meters (120 feet).

The seafloor at the Rosario Strait site is composed of coarse-grained sediments, rocks and cobble, typical for areas which experience strong current flows. The currents at the Rosario Strait site have a net speed of 10 to 30 cm/sec, with peak speeds of 100 cm/sec. The prevailing single layer current flow would tend to disperse suspended material southward from the Rosario Strait site. Bathymetric post-disposal monitoring of the Rosario Strait site in 1991, 1994, and 1999 showed that the material did not accumulate on site and was readily dispersed. There was no net accumulation of dredged material compared to the predisposal baseline condition.

Biota at the Rosario Strait site are typical for higher energy environments, with epibenthic organisms dominating rather than infaunal organisms. Abundance and diversity of invertebrates collected by rock dredge at the site were low. Species at stations located in and near the disposal site included non-pandalid shrimp and sea urchins. Dungeness crabs, rock crabs, and pandalid shrimp were not found at the site. Current and bottom conditions made it difficult to sample for bottomfish, and fishes captured are not necessarily representative of fishes in the area. During the siting studies, ringtail snailfish and incidental Dover sole, Pacific sandlance, sculpin, smooth alligatorfish and other snailfishes were captured at the site. Pelagic species which inhabit waters near the site include juvenile Pacific herring, Pacific sand lance, northern anchovy, surf smelt and longfin smelt. Although these forage fishes occur in the area, the site is located away from spawning beaches. Adults and juveniles of all five species of Pacific salmon may occur in the vicinity of the site as they migrate to and from the ocean. Other pelagic species which may occur in the vicinity of the site include steelhead, cutthroat trout and bull trout.

3.3.2 Port Townsend Site

The Port Townsend site is located approximately 12 nautical miles (13.8 miles) northwest of Port Townsend. The disposal zone is a 457-meter (1,500-foot) circular area that is centered at Latitude N 48^{o} 13.61' and longitude W 122^{o} 59.03'. The disposal site is circular with a 2,134-meter (7,000-foot) radius. The average depth of the site is 110 meters (361 feet). The substrate at the site is a mixture of sand, gravel and shell.

Mean current speeds at the Port Townsend site are between 30 to 50 cm/sec, with peak speeds of 75 to 100 cm/sec. The east/west movement of the material is dependent on the tide, with net speeds reaching 10 miles per day. At these speeds, the prevailing currents could move suspended sediment to the mouth of Admiralty Inlet in one day, or to Vancouver Island in two days.

Biota at the Port Townsend site are typical for higher energy environments, with epibenthic organisms dominating rather than infaunal organisms. Common biota included pandalid shrimp, scallops and sea urchins. Twelve demersal fish species were caught during the PSDDA siting studies. The most abundant commercial species included Dover sole, rex sole, Pacific cod, and walleye pollock and arrowtooth flounder. Pelagic species which inhabit waters near the site include juvenile Pacific herring, Pacific sand lance, northern anchovy, surf smelt and longfin smelt. Although these forage fishes occur in the area, the site is located away from spawning beaches. Adults and juveniles of all five species of Pacific salmon may occur in the vicinity of the site as they migrate to and from the ocean. Other pelagic species which may occur in the vicinity of the site include steelhead, cutthroat trout and bull trout.

3.3.3 Port Angeles Site

The southern border of the Port Angeles site is located approximately 4 nautical miles (4.6 miles) north of Port Angeles (Figure 1 and Figure B-3 in Appendix B). The disposal zone is a 457-meter (1,500-foot) circular area that is centered at latitude N 48^{o} 11.67' and longitude W 123^{o} 24.94'. The disposal site is circular with a 2,134-meter (7,000-foot) radius. The average depth of the site is 133 meters (435 feet). The substrate at the site is a sand/gravel mix with some shell.

No field data for currents exist for the Port Angeles site; however, the peak current speeds are estimated at about 125 cm/sec, with an east/west trajectory. Resuspended material transported in the bottom currents would predominately move eastward, over time probably entering the Strait of Georgia via Haro Strait, and Puget Sound via Admiralty Inlet.

Shrimp were seasonally abundant at the Port Angeles site. Other common invertebrates included scallops and sea urchins. Commercially important fishes caught during the PSDDA siting study included English sole, Dover sole, quillback rockfish and walleye pollock. Pelagic species that inhabit waters near the site include juvenile Pacific herring, Pacific sand lance, northern anchovy, surf smelt and longfin smelt. Although these forage fishes occur in the area, the site is located away from spawning beaches. Adults and juveniles of all five species of Pacific salmon may occur in the vicinity of the site as they migrate to and from the ocean. Other pelagic species that may occur in the vicinity of the site include steelhead, cutthroat trout and bull trout.

3.4 PSDDA SITE MONITORING

3.4.1 Dispersive Site Monitoring

Dispersive sites are located in areas of high bottom currents where dredged material placed at the site is expected to be rapidly transferred offsite. This precludes practical monitoring for chemically-induced biological effects. Consequently, the dispersive sites are only monitored for physical conditions at the site. To determine if material is remaining at the site or dispersing, baseline and post-disposal monitoring of these sites is conducted.

The surveys consist of using precision vertical soundings to detect mounding of dredged material within the target parameter. During the baseline and post-disposal phases of monitoring, soundings are made over continuous transects which are spaced 100 meters (328 feet) apart, and begin and end 100 meters outside the target area. The baseline and post-disposal soundings are then compared to determine if there is mounding of dredged material within the target area. Baseline studies of the dispersive sites were performed in 1989 (PTI Environmental Services 1989), and three post-disposal bathymetric surveys were conducted at the Rosario Strait disposal site in 1991, 1994, and 1999, and demonstrated that no accretion of material within the disposal site has occurred.

3.4.2 Non-Dispersive Site Monitoring

Monitoring for non-dispersive sites consists of more rigorous evaluations to determine if the deposited material remains onsite; if the site conditions are being met; and if biological resources are being affected. In 2002, the DMMP agencies established a volume trigger of 500,000 cy to initiate monitoring at the Commencement Bay site, Elliott Bay site, and the Port Gardner site. A 300,000 cy volume trigger remains in effect for initiating monitoring at the Bellingham Bay site and the Anderson/Ketron Island disposal site. The monitoring involves the collection of physical, chemical and biological data at and near the site. Three types of post-disposal monitoring events are distinguished in the PSDDA monitoring framework:

- Full Monitoring - Mapping of the disposal site is accomplished through the use of a sediment vertical profiling system (SVPS), which determines the depth and spread of dredged material. Box core benthic samples and SVPS photos are used to provide quantitative and qualitative information on benthic infaunal conditions onsite and offsite. Chemical monitoring is used to evaluate the concentrations of chemicals of concern present on and off the site, and whether or not they are present in concentrations that could cause unacceptable adverse impacts. Biological monitoring includes toxicity bioassays to assess onsite-dredged material. Additionally, offsite benthic communities are evaluated by a comparison of baseline data and post-disposal data along a gradient to determine if unacceptable impacts from dredged material disposal are occurring. Monitoring parameters evaluated include sediment chemistry, sediment bioassays, infaunal tissue chemistry, and infaunal abundance.

- Partial Monitoring - For material with no or few Screening Level (SL) exceedances, less rigorous site monitoring occurs. Partial monitoring includes bathymetric mapping of the site and use of a SVPS to determine the depth of dredged material and sediment dispersal. The SVPS is also used to provide information on general benthic conditions onsite and offsite. Partial monitoring also includes collection of sediment at and near the site for analysis of chemicals of concern. No quantitative biological information (box cores) is collected during partial monitoring events.

- Tiered Monitoring – Only a portion of the samples are analyzed to verify that deposited material is staying on-site and that site conditions are met. If analysis of samples indicates that there may be unacceptable impacts offsite, the archived samples are analyzed to determine if biological resources are being affected.

The frequency of post-disposal monitoring events varies by site and disposal volume. PSDDA's initial monitoring framework envisioned that monitoring would be more frequent initially, and be reduced through time as monitoring validated adherence to the site management objectives. The initial trigger for either full or partial monitoring was placement of 150,000 cubic yards at a site. In 1996, the trigger was increased to 300,000 cubic yards. Monitoring data forms the basis for the annual review of the need for changes in the evaluation procedures and site management plans.

Baseline monitoring of the non-dispersive sites was conducted in 1988 (Phase I sites) and 1989 (Phase II sites) to document existing conditions and for use as a benchmark for post-disposal monitoring studies. Details of baseline studies are provided in PTI Environmental Services (1988, 1989). The types of samples collected as part of the baseline studies included sediment chemistry, toxicity (bioassays), field collected tissue chemistry, and benthic infauna.

3.4.3 Post-Disposal Monitoring Events

Four of the five nondispersive sites have had post-disposal surveys. The only nondispersive site not yet monitored is Anderson/Ketron, which has received very little dredged material (less than 25,000 cubic yards). To date, the DMMP agencies have conducted 17 post-disposal monitoring surveys at nondispersive sites including:

- **4 full monitoring events (Port Gardner - 1990; Elliott Bay - 1992 and 2000; and Commencement Bay - 2001)**
- **3 tiered-full monitoring events (Port Gardner - 1994; Commencement Bay – 1995, 2003);**
- **2 partial monitoring events (Elliott Bay – 1990 and Bellingham Bay – 1993)**
- **3 tiered-partial monitoring events (Commencement Bay – 1996, 2004, Elliott Bay 2002)**
- **5 special surveys (side-scan survey at Bellingham Bay - 1993; side-scan survey at Elliott Bay - 1995; and SVPS survey at Commencement Bay – 1998; and 2 bathymetric surveys at Commencement Bay – 2001, 2004)**
-

Based on PSDDA site monitoring data to date (including physical mapping, onsite and offsite chemistry, sediment toxicity, offsite infaunal bioaccumulation, and offsite benthic community structure data), dredged material disposal is not causing adverse impacts at or adjacent to the nondispersive sites. The Commencement Bay site is included in these results. Despite the fact that this site extends beyond its original boundaries, no evidence of contamination, toxicity, or benthic community impacts have been documented from the extensive monitoring activities conducted. PSDDA evaluation procedures appear to adequately protect the environmental conditions at the disposal sites.

4. EFFECTS ANALYSIS

This first portion of the effects analysis focuses on the general impacts of usage of PSDDA disposal sites, while species-specific discussions follow in Section 7. The broader discussion in this section largely focuses on effects relevant to anadromous salmonids, but the sub-section on prey and trophic structure addresses potential impacts on the food chain and is therefore applicable to marbled murrelets and Steller sea lion as well.

The following evaluation is loosely based upon the NMFS Matrix of Pathways and Indicators (NMFS 1996), which is a set of guidelines designed to facilitate and standardize the determination of effects of projects/actions on listed anadromous salmonids. The NMFS matrix, along with a similar USFWS matrix developed for bull trout, was developed for freshwater environments and is not directly applicable to estuarine and marine waters. The following discussion is therefore organized around a set of modified pathways and indicators. Several pathways/indicators routinely included in evaluations for marine and estuarine waters were excluded from this analysis because they are not relevant to the deep-water PSDDA sites (e.g., shoreline and riparian conditions, refugia). Since numerical criteria for habitat functionality (e.g., between 50 and 57° F = properly functioning water temperature) are currently unavailable for estuarine and marine waters, this evaluation is qualitative rather than quantitative in nature.

4.1 WATER QUALITY

4.1.1 Turbidity

Transport Activities. The potential for overboard sloughing or leaking of dredged material from barges during the transport of material to the disposal sites is minimized by the design of modern barges (sideboards on the deck and seals on the bottom dump doors) and the typical operation practices of the contractors (loading practices and deck cleaning prior to leaving the dilution zone). If any significant leaking is noted, the contractor must correct the situation before leaving the dredging dilution zone. If an unnoticed leak were to occur, it would result in a small trailing plume, which would be spatially insignificant in relation to the movements of listed species (i.e., potential for an animal to contact this material in the water column would be negligible). Additionally, the prop wash from the tug boat would likely cause enough turbulence to quickly disperse the small amount of sediment. Therefore, significant sloughing or leaking of dredged material during transport to a PSDDA disposal site is unlikely.

The potential for winds to carry sediments from a transport barge to the water column is also small. The types of sediments that can typically be mounded on a barge (and thus would be most exposed to wind) are either granular or very cohesive and clay-like. Granular sediments contain little fine or organic material, would be relatively inert, and would pass through the water column very quickly. More claylike sediments generally have a high moisture content, which would resist windborne transport. The amount of time between loading and discharge of dredged materials at the disposal site is relatively short (hours), which gives finer material little time to dry and become less cohesive during the transport process. Thus, the potential for windborne transport of these types of materials is minimal.

Disposal Activities. Disposal of dredged material will result in elevated turbidity levels. During monitoring at other disposal sites across the country, maximum concentrations of suspended sediments observed during disposal activities were less than 1,000 mg/l (Pequegnat 1983). Truitt (1986) found that very little suspended sediment persists near the surface or midwater during dredged material disposal. As Figure 7 demonstrates, the highest concentrations tend to occur in near-bottom waters, and are typically much lower (less than 200 mg/l) in mid and upper water depths.

Turbidity levels generally return to ambient conditions rather quickly, and relatively little material is separated from the jet as it descends into the water column when a clamshell dredge has been used (as described in Section 2.3.1). PSDDA/DSSTA (1989) evaluated the transport and duration of suspended sediment in the water column following a generic disposal event at the dispersive sites. At the end of 1 hour, calculations indicated that suspended sediment traveled 1,097 meters (3,600 feet). Concentrations associated with this loss of sediment from the jet were approximately 0.25 mg/l, which is approximately one-quarter of the ambient concentration. After 6 hours (one ebb or flood tide), the material was calculated to have traveled 6,584 meters (21,600 feet) and the concentration of suspended solids was reduced to 0.0007 mg/l. Figure 7 illustrates the relatively short duration of elevated suspended sediment concentrations in the water column at a non-dispersive site. As the graph illustrates, total suspended sediments at the middle and upper depths remained elevated for about 12 minutes.

Turbidity studies cited in Pequegnat (1983) found that lethal concentrations of suspended sediments for adult marine organisms were an order of magnitude or higher than maximum suspended sediment concentrations observed in the field during dredging and disposal operations. Potential sub-lethal effects of increased suspended sediment concentrations on salmonids include: biochemical stress responses (elevated plasma glucose and cortisol levels), impaired osmoregulatory capacity, gill flaring (a response to gill irritation equivalent to a cough), impaired oxygen exchange due to clogged or lacerated gills, and reduced tolerance to infection.

For short-term exposures (<4 days) to sub-lethal concentrations (14,400 mg/l), osmoregulatory capacity of salmonids is not impaired (Servizi 1990). Sockeye have been shown to exhibit gill damage at exposures of 3,100 mg/l over 96 hours (Servizi 1990). Biochemical responses and gill flaring appear to be reversible, as recovery occurs when the stressor is removed or the fish escapes the plume. However, if the stress is chronic, a metabolic cost may be incurred (Servizi 1990). Exposure to suspended sediment loads in the range of 2,000 to 4,000 mg/l caused a temporary elevation in plasma cortisol concentration, but this response was considered moderate when compared to fish exposed to handling stress and confinement (Redding et. al. 1987).

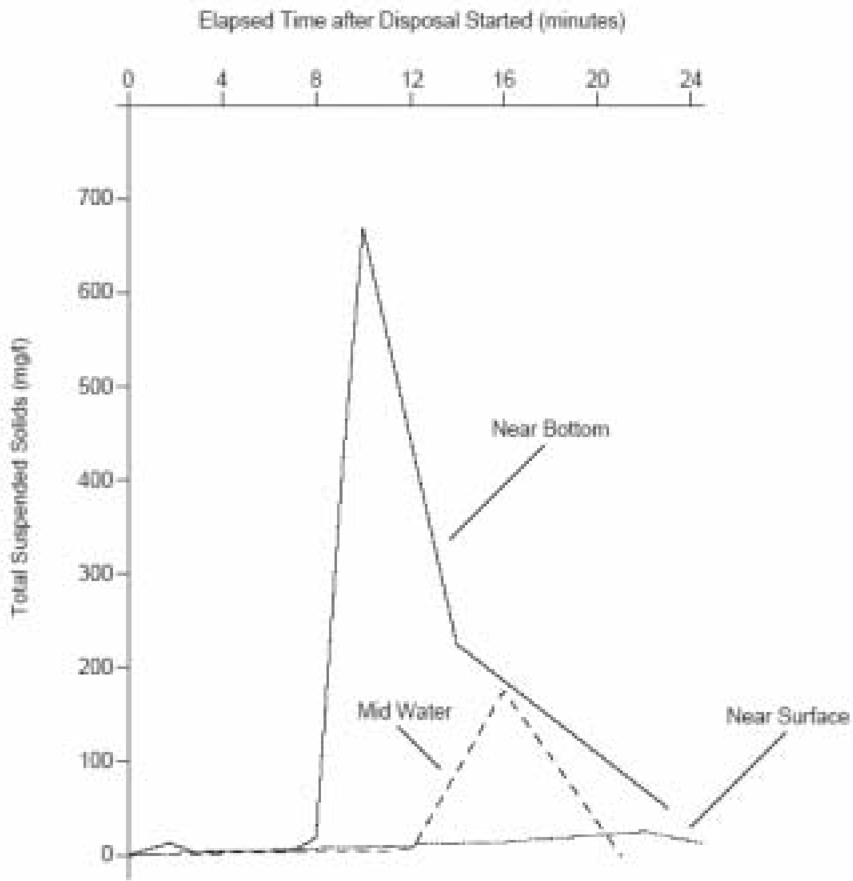
Laboratory experiments like those cited above have yielded some information on the response of fish to elevated suspended sediment concentrations, but application of this information is difficult given the often conflicting results attributable to variations in experimental design. For example, some mortality of Chinook and coho smolts occurred over short-duration exposures to suspended sediment levels from 500 mg/l to 1,400 mg/l (Newcombe and MacDonald 1991). Yet in another experiment, concentrations up to 28,800 mg/l were shown to have had no acute effects on juvenile coho (LeGore and Des Voigne 1973).

Bioassay-type tests generally measure an endpoint, often mortality, under conditions dissimilar to those organisms encounter in the field. Dose-response relationships measured under laboratory conditions tend to simulate a worse case scenario for motile organisms, which can often avoid unsuitable conditions (Clarke and Wilber 1999). Under most scenarios, fish and other motile organisms encounter localized suspended sediment plumes for exposure durations on a temporal scale of minutes to hours (Clarke and Wilber 1999). Testing protocols utilizing brief exposure periods and representative sediment periods would better clarify the actual hazards (Servizi 1990). A few generalizations can be taken from this collection of research, however. Smolts are the life history stage most sensitive to elevated turbidity. For this reason, dredging work closures periods are implemented to avoid dredging and disposal operations during juvenile salmon outmigration periods. It is also clear that the turbidity levels generally associated with disposal operations are not high enough to cause acute physiological injury to adult fish.

Effects of increased suspended sediment concentrations on salmonids may also include reduced foraging success and deterrence from migratory paths. Increased turbidity levels could affect the feeding success of marbled murrelets and Steller sea lions as well. Sediment suspended at the surface or midwater would be more likely to affect foraging than sediments dispersed on or near the bottom for all these species, except perhaps the Steller sea lion. Almost all pelagic juvenile and yearling Chinook salmon captured in Puget Sound by Beamish et al. (1998) were collected at a depth of 30 meters (98 feet) or less. Most Chinook salmon caught off the east and west coasts of Vancouver Island by Taylor (1969) were found at depths of 73 meters (240 feet) or less. Recent acoustic telemetry work in Puget Sound indicates that bull trout frequent shoreline areas and are infrequent migrants across deep waters (Goetz et al. 2004). One char monitored with a depth tag as part of the Goetz et al. (2004) study tended to spend most its time at depths of 5 to 10 meters, with mid-day migrations to deeper waters (less than 25 meters). All but two of the disposal sites are located in areas more than 90 meters (295 feet) deep; the Rosario Strait site is located at a depth of 30-43 meters and the Bellingham Bay site is located at a depth of 29 meters. The potential for turbidity associated with dredged material transport and disposal to affect salmonid migratory paths is addressed in Section 4.3 below.

Disposal activities will temporarily degrade this indicator during and immediately following discharge events, but will maintain existing conditions over the long term. The available evidence summarized above indicates that suspended sediment concentrations sufficient to cause adverse effects would be limited in extent. Dredging and disposal operations will degrade water quality on a localized and temporary basis, neither over the long term nor throughout the entire action area. Adult salmonids are expected to avoid these areas readily, while juveniles would be less able to avoid such areas. Therefore, timing restrictions are in place to reduce the potential for exposure of fish at sensitive life stages. This will reduce impacts to a discountable level.

Figure 7. Time Series of Total Suspended Solids at Three Depths during Dredged Material Disposal



SOURCE: Truitt 1986 in Corps 1986.

0J012.01 001
11/15/01

4.1.2 Dissolved Oxygen

Anaerobic sediments create an oxygen demand when suspended in the water column, which decreases dissolved oxygen levels. Given the rapid descent of material dredged by a clamshell dredge and the generally well-mixed nature of waters within the action area, disposal activities are not likely to lead to appreciable reductions in dissolved oxygen in the mid and upper portions of the water column. Conditions would be degraded in a localized area on a short-term basis, but would be maintained over the long term.

At the non-dispersive disposal sites, reductions in dissolved oxygen levels would be expected to be larger and more persistent in the lower portion of the water column. However, monitoring of experimental disposal sites in Elliott Bay during and up to 9 months after disposal showed no significant long-term impacts to water quality (PSDDA/FEIS 1988). Impacts to salmonids associated with degradation of dissolved oxygen levels near any mounds of dredged material are not expected to occur since pelagic juveniles and adults have a distribution higher in the water column. At the dispersive sites, oxygen-demanding materials would be rapidly diluted and any decrease in dissolved oxygen content in the water would be un-measurable.

4.1.3 Chemical Contamination

Sediment-bound contaminants associated with suspended sediments may dissolve in the water column and result in impacts to water quality. However, sediments are rigorously tested for chemicals of concern and potential for biological effects before they are determined to be suitable for disposal at PSDDA sites. It should be noted that the effects testing is focused on assessing benthic impacts, and not necessarily tied to protecting fish directly. The disposal sites were selected to minimize impacts to commercial invertebrate and fish resources. Any exposure to contaminants would be either avoided by fish moving through the disposal site, or of a very short duration in the water column following disposal. Dredged material that contains higher levels of contaminants is disposed at Washington Department of Ecology approved confined disposal sites in upland or nearshore areas. Therefore, exposure of listed species to significant levels of contaminants is not expected.

Nutrients in sediments released to the water column when materials are discharged could affect phytoplankton production. However, any such effect would be small, temporary, and would not affect the overall productivity of the action area. Considering the nutrient inputs to nearshore waters from rivers, any changes in primary productivity would be unmeasurable.

4.2 SEDIMENT

4.2.1 Physical Characteristics

At the non-dispersive PSDDA sites, changes in sediment character (e.g., percent silt, clay, sand, gravel) have occurred since usage of the sites began 16 years ago. In addition to temporary impacts to benthic fauna from burial, changes in sediment character can affect the structure and productivity of benthic communities within the disposal site.

The 1994 monitoring results at Port Gardner indicated that all the site management objectives were met. An evaluation of the benthic infaunal transect data indicated there was a 50% reduction in major taxa relative to baseline conditions, but the reductions were attributable to regional effects and not due to dredged material. The same benthic major taxa reductions were observed at benchmark stations outside the direct influences of dredged material disposal. The monitoring results also confirmed that there were no unacceptable adverse effects on biological resources immediately offsite due to dredged material.

Monitoring of benthic fauna just outside the Elliott Bay site in 1992 verified that there were no adverse environmental effects beyond the boundary of the disposal site (PSDDA 1994). The abundance of major benthic taxa at the transect stations was similar to the abundances measured during baseline studies.

Full monitoring at the Commencement bay site in 2001 and again in 2003 confirmed that benthic resources were not being impacted outside the site boundary by disposal of clean dredged material. Moreover, the results indicate that taxa specific abundances increased from the baseline abundances for all taxonomic groups (polychaetes, crustacean, mollusks).

Changes in sediment characteristics have not occurred at the dispersive sites since materials do not mound, and are quickly dispersed. The preponderance of material disposed of at the most used dispersive site, the Rosario Strait site, is clean sand from the Swinomish River and clean fine-textured sediment from Squalicum Waterway in Bellingham Harbor. Three bathymetric surveys conducted in 1991, 1994, and 1999 verified that no material has accumulated on the bottom within the disposal site, due to the highly dispersive environment.

Any impacts to benthic infauna resulting from changes in sediment character at the disposal sites would not have a measurable effect on salmonids because they do not typically feed or otherwise utilize habitats at the depths of the disposal sites. Food web relationships are addressed further in Section 4.4 below.

4.2.2 Chemical Contamination

The PSDDA program includes rigorous chemical testing of sediments to determine if they are suitable for unconfined, open-water disposal. Only sediments that have passed rigorous chemical (and sometimes biological) testing are discharged to PSDDA sites. Effects to listed species resulting from contamination of discharged sediments would be extremely unlikely to occur.

4.3 HABITAT CONDITIONS

The operation of tugboats used to transport dredged material to the PSDDA sites would increase ambient noise levels along the immediate travel route. Impacts of any sound disturbance would likely result in temporary, short-range displacement of animals rather than injury. Degradation would be insignificant due to the short time noise levels would increase in a given area and the minor nature of the increase. Due to the deep waters in which dredging and disposal activities occur, prop-wash from tug boats would have no effects on bathymetry in the action area.

Disposal activities will have no effect on current patterns, salinity levels, temperatures, or water column stratification within the action area. Bathymetry would not be affected at the dispersive sites, but would be altered at the non-dispersive sites. In open-water environments near the disposal sites, salmonids primarily occupy mid- to upper-level pelagic waters. As such, bathymetric changes resulting from disposal would have no effect on habitat attributes utilized by these species.

It is unlikely that the small amounts of dredged material discharged to action area waters during the transport of material to the disposal site would affect physical navigation cues used by adult salmonids. Likewise, disposal events at the PSDDA sites are localized enough and generally far enough from the mouths of major spawning rivers to have little potential for effect on salmonids migratory paths. Adult salmon use a variety of mechanisms to navigate from the open ocean to their natal spawning grounds

(Pearcy 1992). Return from the open ocean and coastal migration are thought to involve the use of either magnetic or celestial cues. As adult salmon approach the estuaries of their natal streams, Percy suggests that they rely more on a number of "navigational landmarks" for orientation, possibly including salinity, temperature, currents and bathymetry. At some point during the nearshore migration, olfaction becomes the dominant navigational cue to guide salmon upstream. Small amounts of dredged material in the water column would not affect these navigation cues, with the possible exception of visual orientation and olfaction. As described in Section 4.4.1, any dredged material leaking from a transport barge would be extremely small in quantity and would be quickly dispersed. Material separated from a disposal jet and transported laterally at the thermocline/pycnocline or subject to size fractionation would disperse in less than an hour. If a salmon did come into contact with any dredged material, it would likely be subject to visual or olfactory effects for a matter of seconds to minutes, which would be insignificant in relation to the myriad of other naturally variable conditions affecting these senses.

4.4 Prey and Trophic Structure

The PSDDA program was developed to minimize potential effects on the physical, chemical, and biological characteristics of disposal sites. The selection of both dispersive and non-dispersive sites was based on an evaluation of benthic resources at candidate sites in order to minimize the potential for effects to important prey resources. Analytical procedures, collectively called the Benthic Resources Assessment Technique (BRAT), were used to estimate the relative amount of trophic support that a given benthic habitat provides to fishes (Lunz and Kendall 1982, Clarke and Lunz 1985). Results of the BRAT analyses were used to help determine final site selections.

Large planktonic crustaceans (e.g., calanoid copepods and euphasiids) and forage fish (e.g., sand lance, surf smelt, Pacific herring) are critical links in the action area's trophic structure. These salmonid and marbled murrelet prey resources are pelagic, with no links to the deep-water benthic habitats affected by disposal operations. Therefore, water column turbidity effects to pelagic prey resources are the primary impact pathway and are the focus of the remainder of this analysis.

Increased turbidity levels are not expected to significantly affect phytoplankton productivity in the action area for a couple of reasons. As discussed in Section 4.1.1, the portion of disposal plumes resulting in the greatest turbidity increase would be located in near-bottom waters. Phytoplankton production typically occurs in the upper portion of the water column where increases in turbidity are expected to be highly localized and temporary (on the order of hours). Any reduction in phytoplankton productivity resulting from disposal-related turbidity would be small-scale relative to the large size of the action area and expected to return to pre-project conditions within days. The action area is highly dynamic, with the project sites surrounded by unaffected waters, which could serve as a source for new plankton populations. Phytoplankton have rapid replication times, so that populations can double in a day; they can generally mature to reproductive life stages within 3 days and can remain viable for days to weeks (Little 2000).

While the impacts of dredged material disposal on benthic communities are relatively well studied and understood, impacts on zooplankton have been studied less and are poorly understood. This lack of research is partly due the technical difficulties (e.g., representative sampling, need for in situ work, the subtlety of anticipated effects, and the differentiation of those effects from other anthropogenic effects) associated with studying this type of impact (Segar 1990). However, laboratory studies reviewed by Clarke and Wilber (1999) indicate that crustaceans do not exhibit detrimental responses at dosages within the realm of suspended sediment conditions associated with disposal activities; crustaceans have been shown to tolerate high suspended sediment concentrations (up to 10,000 mg/l) for durations on the order of two weeks. The high variability in zooplankton distribution and abundance would further limit the scale of potential impacts. The localized area of effect and low frequency of disposal events would result in insignificant impacts on zooplankton.

Forage fish are an important and abundant fish species in Washington, significant as an intermediate step in the marine food web between zooplankton and larger fish/seabirds. Disposal activities will not affect the intertidal and shallow subtidal spawning habitats of forage fish.

Effects to planktonic prey organisms and forage fish are expected to be discountable.
Increased turbidity in the vicinity of the sites immediately after a disposal event could cause a temporary and localized decrease in phytoplankton productivity or cause mortality of pelagic fish eggs, larvae, and zooplankton. However, the disposal sites lack components (e.g., physical habitat structure, tidal currents) that would attract or concentrate plankton or fish. These organisms are widely distributed throughout Puget Sound, so the localized, short-term, and infrequent disposal of dredged materials would not substantially affect populations of these organisms over the entire action area nor impact their availability as food for listed species.

5. INTERRELATED AND INTERDEPENDENT EFFECTS

The dredging activities that generate material for disposal at the PSDDA sites are interrelated to the proposed action. Interrelated effects associated with dredging operations will occur within portions of the action area, but far removed from the individual PSDDA site project areas where most disposal impacts will occur. Therefore, interrelated actions will not increase the size of disposal impacts to a level where take would occur. Because all interrelated dredging projects would require federal authorization in the form of a Clean Water Act Section 404 permit, each dredging project or groups of projects (maintenance dredging programs) would undergo Section 7 consultation independently.

6. CUMULATIVE EFFECTS

The Corps knows of no other non-Federal actions that are reasonably certain to occur that may adversely affect a listed, proposed, or candidate species within the action area. As described in Section 2 and Section 5, all dredging projects that generate material for disposal at PSDDA sites require a Federal permitting action. Tables 3 and 4 in Section 2.4 detail what is currently known about past disposal actions at each disposal site over the sixteen years of implementation. It is likely that future disposal actions are likely to follow this pattern. It is anticipated that relatively heavy use of the Commencement bay disposal site is anticipated over the next five years due to large construction projects currently in the regulatory review pipeline from the Port of Tacoma. The material is largely clean native material coming from the Blair Waterway.

Monitoring results verify that during the first 16 years of operation of the PSDDA sites, the program management plan has been effective in protecting the environment from unacceptable adverse impacts. Continued use of the PSDDA management and monitoring program is expected to allow continued safe and publicly acceptable disposal of dredged materials.
Therefore, no significant cumulative effects to listed species are anticipated.

7. EVALUATION OF PROJECT IMPACTS ON AFFECTED SPECIES

7.1 PUGET SOUND CHINOOK SALMON

The Puget Sound evolutionarily significant unit of Chinook salmon (Oncorhynchus tshawytscha) was listed as a threatened species in March 1999.

7.1.1 Distribution and Timing

The distribution and timing of Chinook salmon in Puget Sound are determined by life stage (i.e., adult or juvenile), race type (i.e., ocean type or stream type), size/age of juveniles, and location of natal stream.

For "ocean type" fish, adults are generally present in Puget Sound only as they pass through on the way to their spawning streams. Migrating adults may follow the shoreline (PSDDA/FEIS 1989), and milling of adults near the mouth of spawning streams may occur prior to entry (PSDDA/FEIS 1988). Juvenile Chinook salmon rear extensively in the estuarine and pelagic areas of Puget Sound (Simenstad et al. 1982; Beamish et al. 1998). Initially, they tend to follow shorelines and are associated with structures (PSDDA/FEIS 1988, 1989; Anderson 1990). They move into deeper water as they become larger. Although some may remain in Puget Sound for a year or more, most are present in the Sound for only for a short time (i.e., a few months) before they complete their outmigration to the Pacific Ocean.

Peaks of juvenile Chinook salmon in the estuary areas of Puget Sound occur in June for most populations. They apparently disperse to deeper nearby marine areas when they reach approximately 65-75 mm in fork length (Healey 1982; Simenstad et al. 1982). The amount of time spent in the estuary is dependent on size at downstream migration and growth in the estuary. Dispersal from the estuarine areas is relatively rapid. Average length of estuarine residence for Chinook salmon in the Nanaimo River estuary was about 20 to 25 days (Healey 1980).

Beamish et al. (1998) collected Chinook salmon in pelagic areas of Puget Sound during spring, summer, and fall 1997 using large rope trawls. Ocean age-1 fish predominated trawl catches in April/May, whereas ocean age-0 fish predominated catches in July and September. Lengths of ocean age-0 and age-1 Chinook salmon (respectively) averaged 89 and 249 mm in April/May, 129 mm and 323 mm in July, and 164 and 390 mm in September. Almost all fish in both age groups were caught at a depth of 30 meters (98 feet) or less. Immature Chinook salmon captured off the east and west coasts of Vancouver Island were mostly captured at depths between 57 and 73 meters (187 and 240 feet), indicating a primarily mid-pelagic vertical distribution (Taylor 1969 in Groot and Margolis 1991). Based on troll sampling in the Strait of Juan de Fuca evaluated by Argue (1970), maturing Chinook salmon were typically shallower than older immature fish with the highest rate of capture between 20 and 37 meters (66 and 121 feet). Little information is available on the vertical distribution of resident blackmouth. However, since they pursue the same types of prey (herring, sandlance, krill and different pelagic stages of crab), their vertical distribution is likely also mid-pelagic.

7.1.2 Migratory Pathways

Puget Sound Chinook salmon juveniles and returning adults could potentially pass through the dispersive disposal sites between their natal spawning streams and either the west coast of Vancouver Island or Georgia Strait. The literature indicates that "stream type" Chinook are common in the Georgia Strait during the spring and early summer of their first ocean year, and "ocean type" Chinook are most abundant during the summer and fall of their first ocean year (Healy 1980). Adult Chinook salmon enter the straits in mid-April (spring-run) and between mid-July and September (summer and fall run). However, both juveniles and adults tend to travel close to shore and migrate directly and rapidly between the ocean and their natal stream. Therefore, presence within areas influenced by dredged material disposal by Chinook salmon would be very transitory. Blackmouth could occur in Rosario Strait and the Straits of Juan de Fuca throughout the year.

7.1.3 Foraging and Food Web Relationships

Juvenile Chinook salmon use both their natal, freshwater streams and estuarine wetlands of Puget Sound for early rearing. The amount of time juveniles spend in estuarine areas is dependent upon their size at downstream migration and rate of growth. Juveniles disperse to deeper marine areas when they reach approximately 65-75 mm in fork length (Simenstad et al. 1982). While residing in upper estuaries as fry, juvenile Chinook have an affinity for benthic and epibenthic prey items such as amphipods, mysids, and cumaceans. As the juveniles grow and move to deeper waters with higher salinities, this preference changes to pelagic items such as decapod larvae, larval and juvenile fish, drift insects, and euphausiids (Simenstad et al. 1982).

The primary prey items for larger juveniles, blackmouth, and returning adult Chinook salmon in Puget Sound include Pacific herring (Clupea harengus pallasi), sandlance (Ammodytes hexapterus), and krill (euphausiids) (WDF 1981, Healey 1991; Beamish et al. 1998). Because these three prey organisms are also planktivores, they represent critical links between Chinook salmon and phytoplankton/zooplankton in the trophic structure of Puget Sound.

7.1.4 Evaluation of Project Impacts

Potential effects to Chinook salmon due to continued operations of the PSDDA dispersive and non-dispersive, unconfined, open-water disposal sites are insignificant. This determination is supported by numerous factors.

First, Chinook salmon may occur in areas of disposal activities however, their presence would be minimal and coincidental because there are no features at the sites that would cause chinook salmon to congregate.

Second, should a chinook salmon coincidentally be present in the disposal area during a discharge event, it could experience a short period of non-lethal discomfort due to high suspended sediments in the water column. The period during which sediments in the water column are elevated is relatively short (approximately 10 minutes in midwater areas studied by Truitt [1986a, 1986b]) and localized. Fish would migrate from the area affected by the discharge and recover relatively quickly from the discomfort.

Third, the potential for toxic effects of contaminants released from discharged sediments is minimal. Sediments are determined to be suitable for discharge through a series of physical, chemical and biological testing procedures that have been subject to thorough review by the regulating agencies and the public.

Fourth, adult and sub-adult chinook salmon primarily feed on pelagic organisms and do not typically feed at depths where benthic habitats are altered by dredged material disposal. Thus, foraging habitat for this species would not be directly affected.

Fifth, adult and sub-adult chinook salmon typically feed on pelagic organisms, where their primary foods are forage fish (herring and sandlance). Herring and sandlance are also pelagic, and their forage base would not be significantly affected by disposal activities. Sandlance can be demersal at times because they have no swim bladder, and sometimes rest in or on the bottom, but typically in less than 100 meters (328 feet) of water. Spawning areas for both species are in intertidal and shallow subtidal areas which are unaffected by disposal activities. Thus, continued disposal activities would not affect the prey base of adult and sub-adult chinook salmon.

Sixth, juvenile chinook salmon migrate from rivers to the Sound in the spring. Dredging activities and associated disposal activities are regulated to avoid outmigrating juveniles. During the early phases of estuarine/Puget Sound residence, juveniles reside in nearshore waters (typically no deeper than 30 to 70 meters [98 to 230 feet]) feeding on epibenthic and pelagic organisms, and would be unaffected by disposal activities. In addition, most juveniles would continue to occupy the nearshore environment during their migration to the Pacific Ocean, although they could (as noted with adult/sub-adult chinook salmon) coincidentally occur in the dredged disposal areas. Effects of elevated water column suspended sediments would be short in duration and localized (as noted above), and are not expected to be lethal or significantly affect migrating juvenile salmon.

Finally, due to the wide distribution of these species within the action area; the relatively small area of pelagic habitat affected by disposal events; the low probability of the species coming in contact with the areas affected by a disposal activity; the infrequent and short-lived nature of disposal events; and the ability of these mobile species to quickly leave the affected area, the overall effects of disposal activities on Chinook salmon would be insignificant. **The Corps has determined that the proposed action is not likely to adversely affect Puget Sound Chinook salmon.**

7.1.5 Puget Sound Chinook Salmon Proposed Critical Habitat

Critical habitat designation for Puget Sound Chinook salmon was originally designated in February 2000 but was later withdrawn. Critical habitat has been re-proposed on 14 December 2004 and is expected to be designated in June 2005 (50 CFR Part 226, FR Vol. 69, No. 239, pages 74584-74588). This section covers the primary constituent elements (50 CFR Part 226, FR Vol. 69, No. 239, pages 74581-2) determined essential to the conservation of Puget Sound Chinook salmon.:

(1) Freshwater spawning sites with water quantity and quality conditions and substrate supporting spawning, incubation, and larval development.

Project is in a marine area. There are no suitable freshwater spawning sites in the project vicinity.

(2) Freshwater rearing sites with water quantity and floodplain connectivity to form and maintain physical habitat conditions and support juvenile growth and mobility; water quality and forage supporting juvenile development; natural cover such as shade, submerged and overhanging large wood, log jams and beaver dams, aquatic vegetation, large rocks and boulders, side channels, and undercut banks.

Project is in a marine area. There are no suitable freshwater rearing sites in the project vicinity.

(3) Freshwater migration corridors free of obstruction with water quantity and quality conditions and natural cover such as submerged and overhanging large wood, aquatic vegetation, large rocks and boulders, side channels, and undercut banks supporting juvenile and adult mobility and survival.

Project is in a marine area. There are no suitable freshwater migration corridors in the project vicinity.

(4) Estuarine areas free of obstruction with water quality, water quantity and salinity conditions supporting juvenile and adult physiological transitions between fresh and saltwater; natural cover such as submerged and overhanging large wood, aquatic vegetation, large rocks and boulders, and side channels, and juvenile and adult forage, including aquatic invertebrates and fishes, supporting growth and maturation.

Project is in a marine area. There are no estuarine areas in the project vicinity.

(5) Nearshore marine areas free of obstruction with water quality and quantity conditions and forage, including aquatic invertebrates and fishes, supporting growth and maturation; and natural cover such as submerged and overhanging large wood, aquatic vegetation, large rocks and boulder and side channels.

Transport of dredged material from the dredging locations may have discountable and insignificant effects on the nearshore environment, in the unlikely event of sloughing of dredged material from the barge (see section 2.1 for more detailed information). There are no disposal areas in the vicinity of the nearshore. The minimum distance from shore for all disposal sites is 762 meters. All disposal sites are greater than the 30-meter depth as defined by NOAA for critical habitat for Puget Sound Chinook salmon, except for Bellingham Bay, which is proposed for exemption from critical habitat (50 CFR Part 226, 14 December 2004.)

(6) Offshore marine areas with water quality conditions and forage, including aquatic invertebrates and fishes, supporting growth and maturation.

The proposed designation of marine nearshore areas in Puget Sound is restricted to areas contiguous with the shoreline out to a depth no greater than 30 meters relative to the mean lower low water. This nearshore area generally coincides with the maximum depth of the photic zone in Puget Sound and contains physical or biological features essential to the conservation of salmonids (NMFS 2004). All sites except the Bellingham Bay site (29.0 meters) and the Rosario Strait sites (30-43 meters) are at depths of 30 meters or greater. Again, Bellingham Bay is proposed for exemption from critical habitat (50 CFR Part 17, 14 December 2004.)

Due to the relatively small area of pelagic habitat affected by disposal events; the temporary and discountable impacts to turbidity, dissolved oxygen, and chemical contamination, the infrequent and short-lived nature of disposal events; the ability of forage fish species to quickly leave the affected area, and the ability of benthos to survive the deposition of sediment, the overall effects of disposal activities on Chinook salmon critical habitat would be insignificant. **The Corps has determined that the proposed action is not likely to adversely affect proposed Puget Sound Chinook salmon Critical Habitat**.

7.2 HOOD CANAL SUMMER-RUN CHUM SALMON

The Hood Canal Summer-Run evolutionarily significant unit of chum salmon (Oncorhynchus keta) was listed as a threatened species in March 1999.

7.2.1 Distribution and Timing

Emigration of chum fry/smolt from rivers to estuaries is relatively rapid after emergence, occurring in a matter of hours to a few weeks for small drainages (Groot and Margolis 1995, Johnson et al. 1997). Hood Canal summer-run chum salmon appear in the estuary between February and July, with peaks in estuarine residence in February and between mid-May to mid-July (Bax et al. 1978). Juvenile chum salmon occupy the estuary for a period of time prior to migration to the ocean. Observed residence times of individuals range from 4 to 32 days, with a common residence time of approximately 24 days (Simenstad et al. 1982, Johnson et al. 1997).

Tagging studies conducted by Jensen (1956) found that juvenile chum salmon tagged in Puget Sound moved rapidly northward to the Strait of Georgia and along the west coast of Vancouver Island and continued northward within a narrow band of about 20 miles from shore, apparently moving further offshore to the southwest after reaching the Alaskan coast. Jensen (1956) found some residualism of chum salmon within Puget Sound (for months to a year), however the extent of residualism is unclear (Johnson et al. 1997).

Most chum salmon mature between 3 to 5 years of age. The highest proportion of mature chum salmon returning to Washington streams is 3 years of age (Johnson et al. 1997). Maturing chum salmon begin to move coastward from offshore, north Pacific Ocean feeding grounds in May and June, and they enter coastal waters between June and November. Hood Canal summer-run chum salmon enter their natal rivers between September and mid-October, with the exception of the Union River stock, which typically returns a month earlier (mid-August to mid-September) (WDF 1992). Swimming speed on the return migration is relatively fast, with speeds between 9 and 50 miles per day reported by various authors (in Johnson et al. 1997). Once in the estuary, chum salmon may enter the river directly or may mill in the vicinity of the natal stream prior to migrating upstream to spawn. Various authors have measured estuarine residence by returning adult chum salmon as long as 20 to 50 days (in Johnson et al. 1997).

7.2.2 Migratory Pathways

Within the Hood Canal summer-run chum salmon ESU, river/creek drainages with current spawning populations include Quilcene, Dosewallips, Duckabush, Hamma Hamma, Dewatto, Tahuya, and Union Rivers, and three streams which drain to the Strait of Juan de Fuca, Snow and Salmon Creeks in Discovery Bay, and Jimmycomelately Creek in Sequim Bay. Some streams on the eastside of Hood Canal (Big Beef and Anderson creeks and the Dewatto River), have severely depleted runs of summer-run chum salmon, and have recently had no returning adults. (Johnson et al. 1997)

Hood Canal summer-run chum salmon that are ocean-migrating juveniles and returning adults could potentially pass through the dispersive disposal sites between Hood Canal and either the west coast of Vancouver Island or Georgia Strait. However, both juveniles and adults tend to travel close to shore and migrate directly and rapidly between the ocean and their natal stream. Therefore, chum salmon presence within areas influenced by dredged material disposal by would be very transitory.

7.2.3 Foraging and Food Web Relationships

During early estuarine residence, chum salmon feed on epibenthic and neritic organisms in shallow nearshore areas. During this period, chum salmon diets are dominated by harpacticoid copepods and gamarid amphipods (Groot and Margolis 1995, Bax et al. 1978, Simenstad et al. 1980). At about 45 to 55 mm, juvenile chum salmon move to deeper water and feed on pelagic organisms such as euphausiids, copepods, hyperiid amphipods, decapod larvae, and fish larvae (Groot and Margolis 1995, Groot et al. 1995, Beamish et al. 1998). Adult chum salmon continue to feed on pelagic organisms including hyperiid amphipods, fish, pteropods, euphausiids, and calanoid copepods.

7.2.4 Evaluation of Project Impacts

Potential project effects to chum salmon are very similar to those discussed for Chinook salmon in section 7.1.4. Due to the wide distribution of these species within the action area; the relatively small area of pelagic habitat affected by disposal events; the low probability of the species coming in contact with the areas affected by a disposal activity; the infrequent and short-lived nature of disposal events; and the ability of these mobile species to quickly leave the affected area, the overall effects of disposal activities on chum salmon would be insignificant. **The Corps has determined that the proposed action is not likely to adversely affect Hood Canal summer-run chum salmon.**

7.2.5 Hood Canal Chum Salmon Proposed Critical Habitat

A February 2000 critical habitat designation for this species has been withdrawn, but critical habitat was re-proposed for designation on December 14, 2004 (50 CFR Part 226, FR Vol. 69, No. 239, pages 74599-74601). Primary constituent elements of critical habitat are as for Puget Sound Chinook salmon (FR Vol. 69, No. 238, pages 74581-2), and the effects analyses for the Hood Canal summer run chum salmon are the same as for Puget Sound Chinook (see Section 7.1.5), though actually the potential for effects are primarily at the three dispersive sites (Port Townsend, Port Angeles, and Rosario). **The Corps has determined that the proposed action is not likely to adversely affect proposed Hood Canal summer run chum salmon Critical Habitat**.

7.3 STELLER SEA LION

The Steller sea lion (Eumetopias jubatus) was listed as a threatened species in November 1990. In 1997, the North Pacific's population of Steller sea lions was separated into two distinct stocks, one of which was reclassified as endangered. The status of the eastern stock, which includes the population inhabiting the waters of the Washington coast, remains unchanged. Critical habitat has been designated for this species, but none occurs in Washington.

During the past 30 years, Steller sea lion (SSL) populations have suffered a dramatic decline. Numbers in the rookeries of central/southern California, the central Bering Sea, and in the core Alaskan ranges have all decreased substantially. A number of natural and anthropogenic factors have been hypothesized as contributing to these declines, but it is generally thought that a nutritional deficiency resulting from a lack of abundance or availability of suitable prey is involved (Steller Sea Lion Recovery Team 1992). Major shifts in the abundance of fish in the Bering Sea over the past several decades are well documented. The Alaska pollock and Atka mackerel fisheries have specifically been implicated in decreasing the availability of prey.

7.3.1 Distribution

The number of SSLs found in Washington varies significantly throughout the year, and perhaps between years. Although Puget Sound falls within the distribution of SSL, their numbers in the region are generally small and mostly concentrated in the northern portion of Puget Sound and the Strait of Juan de Fuca. However, following the large El Nino of 1985-1986, several hundred animals were reported to have appeared in south Puget Sound. There are no known annual counts and, as with offshore areas, their movements into Puget Sound seem sporadic. Steller sea lions have been seen in many inland waters, including the San Juan Islands, rock outcroppings along the Strait of Juan de Fuca, near Everett, in Shilshole Bay, off the Ballard Locks, and occasionally in south Puget Sound. Peak monthly counts indicate that SSL are most abundant off the Washington coast during March-April and August-November (Gearin and Jeffries 1996). Steller sea lions may be observed along the Washington coast year around, but they are least abundant in May-July, which corresponds to the breeding time off Oregon and British Columbia.

No breeding rookeries or major haul-out sites have been identified in Washington waters. When not on land Steller sea lions are generally seen inshore, less than 5 miles from the coast. Steller sea lion foraging patterns vary depending upon age, season, and reproductive status, as well as the distribution and availability of prey. Foraging patterns of females during the winter months vary considerably; individuals travel an average of 133 km and dive an average of 5.3 hours per day. The vast majority of feeding dives occur to a depth of 100 m (328 feet), although feeding to depths over 250 meters (820 feet) has been reported (Merrick 1995, Swain and Calkins 1997).

7.3.2 Foraging and Food Web Relationships

Early investigators in Alaska reported that, prior to the mid-1970s, stomachs examined from SSL showed a high percentage of forage species (e.g., herring, capelin, sandlances etc.) in the diet (Alverson 1992). Following a major oceanographic regime shift in the mid-1970s, diets of SSL in the Alaska region have been dominated by pollock and Atka mackerel, with smaller amounts of a variety of other species including salmon, squid, flounders, and cods. In an investigation into the decline of the SSL population during the period following the regime shift, Merrick et al. (1997) noted that the SSL diet appeared to be determined not only by the individual components or species, but by the mix or diversity of prey in the diet. The importance of prey diversity, as well as abundance, may be vital to the success of populations in a region.

Brown and Riemer (1992) investigated the feeding patterns of SSL based on fecal material collected from the haul-out and rookery sites off Oregon. They found that Pacific whiting and Pacific lamprey were the two most frequently identified prey species. Various species of salmon were also quite common.

The diet of Steller sea lions occurring in Puget Sound, the Strait of Juan de Fuca and off the coast of Washington is not well known, although they appear to be largely opportunistic feeders (Gearin and Jeffries 1996). Examination of scat and stomach contents indicate Pacific whiting (hake), rockfish, cod, pollock, herring, and smelt are frequent prey items (Beach et al. 1985, Gearin and Jeffries 1996). For the most part, SSL are not known to prey significantly on bottom-dwelling invertebrates, although in Alaska, crabs and shrimp have been noted to compose a small portion of the food items consumed.

7.3.3 Evaluation of Project Impacts

Given the lack of rookery and major haul-out areas in Puget Sound or in waters adjacent to Washington's coast, when in the action area Steller sea lions are likely on foraging expeditions. Disposal activities will have no effect on breeding habitat or behavior. Noise associated with disposal operations may have an effect on foraging behavior. However, impacts of any sound disturbance would likely result in temporary displacement of animals from the immediate disposal area rather than injury. The tugs and barges travel slowly, and thus potential take from collisions is extremely unlikely. No haul-out sites will be physically disturbed by disposal operations.

As discussed in Section 4.4, disposal operations are not expected to result in a widespread or long-term reduction in the abundance and distribution of common prey items in the action area. However, Steller sea lions forage on a wider variety of prey items than other species addressed in that analysis of effects on trophic structure, including some groundfishes (e.g., rockfish, cod, hake, flounder) whose habitats could potentially be affected by dredged material disposal. Only the Rosario Strait, Bellingham Bay, and Port Townsend sites occur at depths where both young and adult SSL might occasionally forage on benthic organisms.

The likelihood of significant impacts to the SSL prey base seems extremely remote if we take into account the very small fraction of the action area where disposal actually occurs, the wide variety of prey species taken by SSLs, and the fact that only three of the eight disposal sites are at depths generally foraged by SSLs. Indirect effects caused by toxins in prey items are also unlikely since the dredged material is tested for bioaccumulative chemicals prior to the determination of its suitability for open-water disposal. Increases in turbidity associated with disposal activities have the potential to reduce visibility in the immediate vicinity of the disposal sites, thereby reducing foraging success for any animals that happen to be in the area. This effect would be insignificant given the its temporary and highly localized, particularly with respect to this species' foraging range.

The Corps has determined that the proposed action is not likely to adversely affect the Steller sea lion since the potential for significant sound disturbance or impacts to prey abundance will be minimal. The proposed action will have no effect on designated critical habitat for this species, as none occurs within the action area.

7.4 COASTAL/PUGET SOUND BULL TROUT

The Coastal/Puget Sound population segment of bull trout (Salvelinus confluentus) was listed as a threatened species in October 1999. Bull trout populations have declined through much of the species' range; some local populations are extinct, and many other stocks are isolated and may be at risk (Rieman and McIntyre 1993). A combination of factors including habitat degradation, expansion of exotic species, and exploitation has contributed to the decline and fragmentation of indigenous bull trout populations.

7.4.1 Distribution and Timing

The scope of this BA includes three analysis areas (as defined in 64FR 58909): Strait of Juan de Fuca; Hood Canal; and Puget Sound. Within these analysis areas are included the following rivers in which bull trout occur: Elwha River, Angeles Basin, Dungeness River, Skokomish River, Nisqually River, Puyallup River, Green River, Lake Washington Basin, Snohomish River-Skykomish River, Stillaguamish River, Skagit River, and Nooksack River.

Bull trout in Puget Sound drainages exhibit four types of life history strategies. The three freshwater forms include ad fluvial forms, which migrate between lakes and streams; fluvial forms, which migrate within river systems; and resident forms, which are non-migratory. The fourth strategy, anadromy, occurs when the fish spawn in fresh water after rearing for some portion of their life in the ocean. The anadromous form of bull trout has been little studied; however, larger juvenile and adult bull trout are known to migrate through the marine waters of Puget Sound (Goetz 1989). The anadromous form may spend as many as 200 days annually in marine waters (Kraemer, 1994). Recent studies conducted by the Corps in Northern Puget Sound systems provide information on the migration patterns of anadromous native char. In the Skagit and Snohomish rivers, native char sub-adults migrate downstream between April and May at two or three years of age. By early autumn sub-adult native char are approximately 250-300 mm long when they move back to the lower portions of their natal streams where they are thought to overwinter. Native char migrate back to the marine environment as early as February where they spend several months in preparation for the spawning migration. Mature native char (age=4, >400 mm in length) leave the tidal waters in May through July and begin their upstream spawning migration. The FWS assumes bull trout could be found anywhere in Puget Sound (Spaulding, 1999).

7.4.2 Migratory Pathways

The Corps has been conducting acoustic tag studies on bull trout for several years primarily to determine presence and absence of native char in various locations in the Puget Sound along with determining migration timing and migration/movement routes. Over 50 fixed monitoring stations have been installed from Shilshole Bay in the south, northern ward to north Swinomish channel. In addition, fixed monitoring stations have been installed in the Snohomish, Stillaguamish, and the Skagit Rivers. The Corps has also conducted over one hundred hours of mobile tracking throughout the Puget Sound and the above-mentioned rivers. The results of the study indicate that native char are strongly associated with the near shore environment, the vast majority of which are detected along shorelines at a water depth of less than 18.0 meters. The few native char detected in water depths greater than 18.0 meters were still located in area less than 100.0 meters from the shoreline.

7.4.3 Foraging and Food Web Relationships

Bull trout primarily feed on surf smelt (Hypomesus pretiosus), Pacific herring, Pacific sand lance, pink salmon smolts, and chum salmon smolts (Kraemer, 1994). Jordan (1884; 1887) first qualitatively described bull trout and its food habits as "From Puget Sound northward it is generally abundant. It feeds voraciously in the salt water on smelt of various sorts, young trout, sand lances, shrimps, anchovies, herrings, and even sticklebacks. In fresh waters it probably eats whatever living thing it can get." Combining two references from Jordan (1884; 1887) for eulachon and bull trout in the Fraser River estuary – Jordan (1884) "They are taken in Fraser River at the time of the eulachon run, but they probably then ascend the river to feed upon the eulachon, and not for spawning purpose. As a food-fish this beautiful species ranks high." And Jordan (1887) -- "Victoria--…A large part of the Victoria market comes from Fraser's River. In their season (May) the eulachon (Thaleichthy pacificus) is the best panfish in this region. They run up the lower Fraser in enormous numbers, and every fish feeds on them. Even the sturgeons gorge themselves upon them." The distribution of bull trout in nearshore marine waters has been hypothesized to be highly correlated to the nearshore distribution of baitfish in Puget Sound (WDFW 1999). At that time, no formal dietary analysis of anadromous bull trout residing in wider Puget Sound had been conducted. However, field observations indicated that surf smelt (Hypomesus pretiosus), Pacific herring (Clupea harengus pallasi), Pacific sand lance (Ammodytes hexapterus), pink (Oncorhynchus gorbuscha) and chum (O. keta) salmon, and numerous invertebrate species composed the majority of the prey species for bull trout residing in northern Puget Sound (Kraemer 1994). Miller et al. (1977) captured a single bull trout in 1976 during town net surveys conducted in Padilla Bay (North Puget Sound), which had consumed 61 Dungeness crab (Cancer magister) megalops, twelve macroinvertebrates, six gammarid shrimp, and four ostracods. Footen (2000) captured seven (7) bull trout (mean FL = 360 mm) in Shilshole Bay during the late spring of 2000. Stomach contents were composed of: Pacific sand lance (61%); juvenile chinook salmon (27%); and juvenile chum salmon (12%). Pentilla (2003) captured five bull trout during forage fish beach seine surveys conducted in northern Puget Sound in 1974- 1975. Informal observations of the stomach contents of these fish captured in Utsalady Bay (northwest Camano Island) were primarily composed of surf smelt and juvenile herring.

In Puget Sound, nearshore residency periods of forage fish (Pacific sand lance, Pacific herring, and surf smelt) overlap with bull trout (Bargmann 1998; Emmett et al. 1991). Further, anadromous bull trout opportunistically utilize forage fish species (surf smelt, Pacific herring, and Pacific sand lance) almost exclusively when they are present in the nearshore marine habitats. Due to the importance of forage fish species to bull trout and many other Puget Sound species, changes in abundance of forage fish can impact a substantial number of fish, mammals, and birds (West 1997). Forage fish in Puget Sound play an important role as a midlevel food web species. Typically the populations of mid-level populations vary greatly in size and have dramatic influences on the higher trophic levels (as prey items) and the lower trophic levels (as predators) and act as both up and down control rather than in the typical bottom up or top down control mechanisms (Bakun 1996).

7.4.4 Evaluation of Project Impacts

In general, potential effects on native char are similar to those experienced by chinook salmon (see Section 7.1.4), however the potential for native char to be present in the disposal areas is much more unlikely than Chinook salmon due to their strong affinity to the nearshore environment.

Therefore, due to the relatively small area of pelagic habitat affected by disposal events; the low probability of the species coming in contact with the areas affected by a disposal activity; the infrequent and short-lived nature of disposal events; and the ability of these mobile species to quickly leave the affected area, the overall effects of disposal activities on bull trout would be insignificant. **The Corps has determined that the proposed action is not likely to adversely affect Coastal-Puget Sound bull trout.**

7.4.5 Coastal/Puget Sound Bull Trout Proposed Critical Habitat

The U.S. Fish and Wildlife Service proposed designation of critical habitat for Coastal/Puget Sound bull trout on 25 June 2004 (50 CFR Part 17, FR Vol. 69, No. 122, pages 35768-35857); it is expected to become final in June 2005. This section covers the primary constituent elements determined essential to the conservation of Coastal/Puget Sound bull trout (50 CFR Part 17, FR Vol. 69, No. 122, page 35776):

(1) Water temperatures ranging from 36 to 59 ^{o}F (2 to 15 ^{o}C), with adequate thermal Refugia available for temperatures at the upper end of this range.

Project is in a marine area. There are no fresh water habitats in the project vicinity.

(2) Complex stream channels with features such as woody debris, side channels, pools, and undercut banks to provide a variety of depths, velocities, and instream structures.

Project is in a marine area. There are no complex steam channels in the project vicinity.

(3) Substrates of sufficient amount, size, and composition to ensure success of egg and embryo overwinter survival, fry emergence, and young-of-the-year and juvenile survival.

Project is in a marine area. There are no spawning areas in the project vicinity.

(4) A natural hydrograph, including peak, high, low, and base flows within historic ranges or, if regulated, a hydrograph that demonstrates the ability to support bull trout populations by minimizing daily and day-to-day fluctuations and minimizing departures from the natural cycle of flow levels corresponding with seasonal variation.

Project is in a marine area. There area no fresh water habitats in the project vicinity.

(5) Springs, seeps, groundwater sources, and subsurface water connectivity to contribute to water quality and quantity.

Project is in a marine area. There are no freshwater habitats in the project vicinity.

(6) Migratory corridors with minimal physical, biological, or water quality impediments between spawning, rearing, overwintering, and foraging habitats, including intermittent or seasonal barriers induced by high water temperatures or low flows.

Proposed critical habitat extends offshore to the depth of 33 feet (ft) (10 meters (m)) relative to mean lower low water (MLLW; average of all the lower low-water heights of the two daily tidal levels). This equates to the average depth of the photic zone, and is consistent with the offshore extent of the nearshore habitat identified under the Puget Sound Nearshore Ecosystem Restoration Project (Corps and WDFW 2001). This area between MHHW and minus 10 MLLW is considered the habitat most consistently used by bull trout in marine waters based on known use, forage fish availability, and ongoing migration studies

(Kramer 1994; Frederick Goetz, Corps, in litt. 2003), and captures geological and ecological processes important to maintaining these habitats.

All disposal sites are located in a minimum water depth of 29.0 meters and are at least 762.0 meters from shore. Transport of dredged material will have no effect on critical habitat for Coastal-Puget Sound bull trout as cited in section 2.1. As a result the Corps has determined that the proposed action is not likely to adversely affect Coastal/Puget Sound bull trout migratory Critical Habitat.

(7) An abundant food base including terrestrial organisms of riparian origin, aquatic macroinvertebrates, and forage fish

See response to number 6 above. The Corps has determined that the proposed action is not likely to adversely affect Coastal/Puget Sound bull trout food base.

(8) Few or no nonnative predatory, interbreeding, or competitive species present.

See response to number 6 above. The Corps has determined that the proposed action is not likely to adversely affect Coastal/Puget Sound bull trout predatory of competitive species.

(9) Permanent water of sufficient quantity and quality such that normal reproduction, growth and survival are not inhibited.

See response to number 6 above. The Corps has determined that the proposed action is not likely to adversely affect Coastal/Puget Sound bull trout proposed critical habitat.

7.5 MARBLED MURRELET

The marbled murrelet (Brachyramphus marmoratus) was listed as a threatened species in October 1992. Primary causes of population decline include the loss of nesting habitat, and direct mortality from gillnet fisheries and oil spills. Critical habitat has been designated for this species in Washington, but it occurs in terrestrial nesting habitat and not in the marine waters of the action area, and is not discussed further in this BA.

7.5.1 Distribution

Marbled murrelets are permanent residents of Puget Sound, but the species is not abundant anywhere in Puget Sound (Speich and Wahl 1995). The majority of birds are found as singles or in pairs in a band about 300 to 2000 meters from shore (Strachan et al. 1995). The murrelet forages by pursuit diving in relatively shallow waters, usually between 20 and 80 meters in depth, but there have been observations of diving in waters more than 100 meters deep (Strachan et al. 1995).

Regional patterns of marbled murrelet activity in marine waters tend to be seasonal, and are tied to exposure to winter storm activity. There is a general shift of birds from the Strait of Juan de Fuca and British Columbia during spring and summer to areas in the San Juan areas and eastern bays during the fall and winter (Speich and Wahl 1995). Murrelets commonly aggregate near localized food sources, resulting in a clumped distribution. They are regularly found in specific areas (e.g., Hood Canal, Rosario Strait/San Juans), as foraging distribution is closely linked to areas of tidal mixing where prey congregate. However, occurrences are highly variable as they move from one area to another often in short periods of time.

7.5.2 *Foraging and Food Web Relationships*

The primary prey items for marbled murrelets in Puget Sound include Pacific sand lance (Ammodytes hexapterus), Pacific herring (Clupea harengus), and krill (euphausiids) (Burkett, 1995). Because these three prey organisms are also planktivores, they represent critical links between marbled murrelets and phytoplankton/zooplankton in the trophic structure of Puget Sound.

7.5.3 *Evaluation of Project Impacts*

Potential effects from continued operations of the PSDDA non-dispersive and dispersive, open-water disposal sites to the marbled murrelet, are insignificant and discountable. This determination is supported by numerous factors.

First, marbled murrelets tend to be closely associated with the shoreline, generally feeding in waters less than 30 meters in depth and less than 500 meters from shore (Sealy, 1975) thus marbled murrelets would rarely be present at any of the disposal sites.

Second, should a marbled murrelet coincidentally be present in the disposal area during a discharge event, potential take from collisions is extremely unlikely as tugs and barges travel slowly, allowing marbled murrelets to quickly migrate away from the approaching barge and move to an undisturbed area.

Third, marbled murrelets would be expected to avoid the sediment plume while feeding, especially since their forage species would likely avoid the sediment plume as well. The period during which sediments in the water column are elevated is relatively short (approximately 10 minutes in midwater areas studied by Truitt [1986a, 1986b]) and localized. Both forage fish and marbled murrelets would migrate from the area affected by the discharge and recover relatively quickly from the stress caused by the falling sediment.

Fourth, the potential for toxic effects of contaminants released from discharged sediments is minimal. Sediments are determined to be suitable for discharge through a series of physical, chemical and biological testing procedures which have been subject to thorough review by the regulating agencies and the public.

Fifth, marbled murrelets primarily feed on pelagic organisms and do not typically feed at depths where benthic habitats are altered by dredged material disposal. Thus, foraging habitat for these species would not be directly affected.

Finally, as noted above, marbled murrelets typically feed on pelagic organisms, where their primary foods are forage fish (herring and sand lance). Herring, and sand lance are also pelagic, and their forage base would not be significantly affected by disposal activities. Sand lance can be demersal at times because they have no swim bladder, and sometimes rest in or on the bottom, but typically in less than 100 meters of water. Spawning areas for both of these species are in intertidal and shallow subtidal areas which are unaffected by disposal activities. Thus, continued disposal activities would not affect the prey base of marbled murrelets.

Based on the above analysis the continued operations of the PSDDA dispersive and non-dispersive, unconfined, open-water disposal sites are not likely to adversely affect the marbled murrelet, and will have no effect on designated critical habitat.

7.6 BALD EAGLE

The bald eagle (Haliaeetus leucocephalus) was listed as threatened on 11 March 1967 and recommended for delisting in 1999. Primary causes of population decline were a result of the use of the pesticide DDT in 1947 as well as hunting, trapping and poisoning. The current causes of population decline are habitat loss due to the development of coastal areas and near rivers and waterways. No critical habitat has been established. (U.S. Fish and Wildlife Service [Internet])

7.6.1 Distribution

Bald eagles are present throughout the year in the Puget Sound basin, and nest along the coastline of the sound. Nest sites are throughout the basin where large, open, and accessible trees (usually Douglas fir, western red cedar, western hemlock, and black cottonwood) are present. Bald eagles also winter throughout the basin but are most common along streams that support salmon runs, where the eagles feed on spawned-out salmon.

7.6.2 Foraging and Food Web Relationships

Bald eagles are opportunistic feeders that prefer fish but have been know to eat a variety of mammals, amphibians, crustaceans, and birds. (U.S. Fish and Wildlife Service [Internet]) Bald eagles will also pursue and capture live birds and fish swimming close to the waters surface. Bird species taken are usually waterfowl, but may also include gulls (Hayward, et al., 1977; Richter, 1984; Leschner, 1984.)

7.6.3 Evaluation of Project Impacts

Potential effects to bald eagles from continued operations of the PSDDA non-dispersive and dispersive, open-water disposal sites are insignificant and discountable. This determination is supported by numerous factors.

First, the disposal sites are located in deep water, away from the nearshore, in low-productivity areas. Bald eagles tend to forage in nearshore areas that are shallow and therefore should rarely be present at any of the disposal sites.

Second, the prey base of the bald eagle are unlikely to be in the area of the disposal sites during disposal due to the temporary increase in turbidity. The period in which sediments in the water column are elevated is relatively short (approximately 10 minutes in midwater areas studied by Truitt [1986a, 1986b]) and localized. Forage fish and bald eagles would migrate from the area affected by the discharge and recover relatively quickly from the stress caused by the falling sediment.

Third, the large trees in which the bald eagle nest will not be impacted by the transportation or disposal of dredged material. Therefore these actions will have no impact on the nesting ability of the bald eagle.

Fourth, the potential for toxic effects of the contaminants released from discharged sediments is minimal. Sediments are determined to be suitable for discharge through a series of physical, chemical and biological testing procedures which have been subject to thorough review by the regulating agencies and the public.

Finally, bald eagles are accustomed to vessels of all sizes on Puget Sound. The introduction of barges to unload dredged material is not expected to disturb them.

Because bald eagles are present in the action area there is a potential for effect. However, for the reasons cited above, the transport of dredged material and subsequent disposal at approved PSDDA sites are not likely to adversely affect bald eagles.

7.7 North Pacific Southern Resident Killer Whales

The Southern Resident Killer whale (Orcinus orca) was proposed for listing as a threatened species on December 16, 2004. This proposed listing was determined to be necessary because the population has declined 20% from 1996-2001, the limited number of reproductive age males, the presence of females of reproductive age that are not having calves, and that the factors for the decline may continue to persist until more is known and actions are taken (NOAA 2004). Primary causes of population decline include habitat loss, pollution (PCBs, dioxins, furans), and disturbance (whale watching, vessel traffic).

7.7.1 Distribution

Although killer whales have been observed in tropical waters and the open sea, they are most abundant in coastal habitats and high latitudes. In the northeastern Pacific Ocean, killer whales occur in the eastern Bering Sea (Braham and Dahlheim, 1982) and are frequently observed near the Aleutian Islands (Scammon, 1874; Murie, 1959; Waite et al., 2001). They reportedly occur year round in the waters of southeastern Alaska (Scheffer, 1967) and the intercoastal waterways of British Columbia and Washington State (Balcomb and Goebel, 1976; Bigg et al., 1987; Osborne et al., 1988). There are occasional reports of killer whales along the coasts of Washington, Oregon, and California (Norris and Prescott, 1961; Fiscus and Niggol, 1965; Rice, 1968; Gilmore, 1976; Black et al., 1997; NMFS, 2004), both coasts of Baja California (Dahlheim et al., 1982), the offshore tropical Pacific (Dahlheim et al., 1982), the Gulf of Panama, and the Galapagos Islands. In the western North Pacific, killer whales occur frequently along the Soviet coast in the Bering Sea, the Sea of Okhotsk, the Sea of Japan, and along the eastern side of Sakhalin and the Kuril Islands (Tomilin, 1957). There are numerous accounts of their occurrence off China (Wang, 1985) and Japan (Nishiwaki and Handa, 1958; Kasuya, 1971; Ohsumi, 1975). Data from the central Pacific are scarce. They have been reported off Hawaii, but do not appear to be abundant in these waters (Tomich, 1986; Caretta et al., 2001).

Southern Residents

The Southern Resident killer whale assemblage contains three pods-- J pod, K pod, and L pod--and is considered a stock under the MMPA (NOAA 2004). Their range during the spring, summer, and fall includes the inland waterways of Puget Sound, Strait of Juan de Fuca, and Southern Georgia Strait. Their occurrence in the coastal waters off Oregon, Washington, Vancouver Island, and more recently off the coast of central California in the south and off the Queen Charlotte Islands to the north has been documented. Little is known about the winter movements and range of the Southern Resident stock. Southern Residents have not been seen to associate with other resident whales, and mitochondrial and nuclear genetic data suggest that Southern Residents interbreed with other killer whale populations rarely if at all (Hoelzel et al., 1998; Barrett-Lennard, 2000; Barrett-Lennard and Ellis, 2001).

7.7.2 Foraging and Food Web Relationships

Killer whales are classified as top predators in the food chain and Southern Resident killer whales are fish eaters. Salmon are widely considered to comprise the vast majority of their diet however the proportion of the diet they comprise is unclear (Baird et al. 2003). Numerous behavioral and population research has been conducted since the 1970’s, however, very little is known about the precise species of fish eaten by whales in this population. Ford et al. (1998) suggested that these whales feed primarily on salmon, particularly on Chinook, though other species of fish were occasionally recorded from scale samples. In addition, Ford et al. (1998) reported that stomach contents recovered from whales also contained Pacific halibut (Hippocampus stenolepis), lingcod (Ophiodon elongates), and English sole (Parophrys vetulus). However only a small proportion of samples came from the southern resident population, therefore there is much less certainty regarding the diet of this population than for the northern residents.

7.7.3 Evaluation of Project Impacts

Potential effects to killer whales due to continued operations of the PSDDA dispersive and non-dispersive, unconfined, open-water disposal sites are insignificant. This determination is supported by numerous factors.

First, should a killer whale coincidentally be present in the disposal area during a discharge event, it could experience a short period of non-lethal discomfort due to high suspended sediments in the water column. The period during which sediments in the water column are elevated is relatively short (approximately 10 minutes in midwater areas studied by Truitt [1986a, 1986b]) and localized. Killer whales would migrate from the area affected by the discharge and recover relatively quickly from the discomfort.

Second, the potential for toxic effects of contaminants released from discharged sediments is minimal. Sediments are determined to be suitable for discharge through a series of physical, chemical and biological testing procedures, which have been subject to thorough review by the regulating agencies and the public.

Third, it is widely accepted that killer whales feed primarily on adult salmon, primarily Chinook salmon. As the presence of salmon in the disposal areas would be rare it would be highly unlikely that whales would be present feeding in the area.

Fourth, whales typically feed on adult chinook salmon that typically feed on pelagic organisms, where their primary foods are forage fish (herring and sandlance). Herring and sandlance are also pelagic, and their forage base would not be significantly affected by disposal activities. Sandlance can be demersal at times because they have no swim bladder, and sometimes rest in or on the bottom, but typically in less than 100 meters (328 feet) of water. Spawning areas for both species are in intertidal and shallow subtidal areas which are unaffected by disposal activities. Thus, continued disposal activities would not affect the prey base of killer whales.

Fifth, effects of elevated water column suspended sediments would be short in duration and localized (as noted above), and are not expected to be lethal or significantly affect killer whales.

Finally, due to the wide distribution of these species within the action area; the relatively small area of pelagic habitat affected by disposal events; the low probability of the species coming in contact with the areas affected by a disposal activity; the infrequent and short-lived nature of disposal events; and the ability of these mobile species to quickly leave the affected area, the overall effects of disposal activities on killer whales would be insignificant. **The Corps has determined that the proposed action is not likely to jeopardize Southern Resident Killer Whales**.

7.8 HUMPBACK WHALE

The humpback whale (Megaptera novaeangliae) was listed as endangered on 2 June 1970. The primary cause for decline in the population of the humpback whale was due to whaling the early part of the 20^{th} century. (ARKive [Internet]) Today the primary cause for population decline is the whales' vulnerability to changes in the marine environment. Other possible causes in population decline are pollution and potential alteration of fish stocks resulting from climate change. No critical habitat has been designated for the humpback whale. (U.S. Fish and Wildlife Service [Internet])

7.8.1 Distribution

Humpback whales are found in tropical and polar seas in shallow, coastal areas (ARKive [Internet]). They occur seasonally off the coast of Washington along the continental shelf and shelf-edge waters (NMFS, 2004.) About every other year humpback whales will stray into Puget Sound but tend not to stay for extended periods of time. Although, in late spring 2004 a small humpback whale spent about two weeks in the Puget Sound near Tacoma.

7.8.2 Foraging and Food Web Relations

There are known humpback whale feeding grounds off the coast of California, Oregon, and Washington. These whales feed primarily on krill, herring, and capelin. Humpback whales utilize a wide range of feeding techniques, at times involving more than one individual and resembling a form of cooperative participation. (NMFS, 2004)

7.8.3 Evaluation of Project Impacts

Potential effects to humpback whales due to continued operations of the PSDDA dispersive and non-dispersive, unconfined, open-water disposal sites are insignificant. This determination is supported by numerous factors.

First, the likelihood of a humpback whale being present in the Puget Sound and in the disposal area during a discharge is improbable at best. If a humpback whale was in the disposal area during a discharge event, it could experience a short period of non-lethal discomfort due to the high-suspended sediments in the water column. The period during witch sediments in the water column are elevated is relatively short (approximately 10 minutes in midwater areas studied by Truitt [1986a, 1986b]) and localized. Humpback whales would migrate from the area affected by the discharge and recover relatively quickly from the discomfort.

Second, the potential for toxic effects of contaminants released from discharged sediments is minimal. Sediments are determined to be suitable for discharge through a series of physical, chemical and biological testing procedures, which have been subject to thorough review by the regulating agencies and the public.

Third, effects of elevated water column suspended sediments would be short in duration and localized (as noted above), and are not expected to be lethal or significantly affect humpback whales.

Fourth, although humpback whales are sensitive to vessel movements and noise it is expected that if the whales are present they would move out of the way of the vessels and related noise. Because of the low occurrence of humpback whales in the Puget Sound it is unlikely that there will be contact between the whales and the vessels.

Finally, due to the low occurrence of these whales within the action area; the low probability of the species coming in contact with the areas affected by a disposal activity; the infrequent and short-lived nature of disposal events; and the ability of these mobile species to quickly leave the affected area, the overall effects of disposal activities on humpback whales would be insignificant. **The Corps determined that the proposed action is not likely to adversely affect humpback whales**.

7.9 LEATHERBACK SEA TURTLE

The leatherback sea turtle (Dermochelys coriacea) was listed as endangered on 2 June 1970. The primary cause for decline of the leatherback turtle is due to accidental capture in fisheries and the over harvest of eggs. Other causes for decline in this species is habitat loss, boat strikes, and ingestion of discarded plastics. (ARKive [Internet]) Although critical habitat has been identified for this species, it does not occur within the project area, and is not addressed further in this BA.

7.9.1 Distribution

Leatherback sea turtles inhabit the shelf and offshore waters of the Pacific Ocean, including Washington, during the summer months. Their use of the inland waters of Washington is accidental at best. (NMFS, 2004.)

7.9.2 Foraging and Food Web Relationships

Adult leatherback sea turtles primarily feed on jellyfish and other soft-bodied species and feeds in temperate waters. (ARKive [Internet])

7.9.3 Evaluation of Project Impacts

Because leatherback sea turtles only use the inland waters of Washington accidentally and mechanisms of potential impact would be insignificant even if a sea turtle was present during disposal operations, the Corps has determined that the proposed action would have no effect on leatherback sea turtles nor their critical habitat.

7.10 CONCLUSION

Table 5 summarizes the effect determinations made for each of the species potentially occurring in the project vicinity.

Table 5. Determination Summary Table

Species	Effect Determination	Designated Critical Habitat/Proposed Critical Habitat
Puget Sound Chinook Oncorhynchus tshawytscha	Not likely to adversely affect	Not likely to adversely affect
Hood Canal Summer-Run Chum Oncorhynchus keta	Not likely to adversely affect	Not likely to adversely affect
Steller Sea Lion Eumetopias jubatus	Not likely to adversely affect	No effect
Coastal/Puget Sound Bull Trout Salvelinus confluentus	Not likely to adversely affect	Not likely to adversely affect
Marbled Murrelet Brachyramphus marmoratus	Not likely to adversely affect	No effect
Bald Eagle Haliaeetus leucocephalus	Not likely to adversely affect	
Southern Resident Killer Whale Orcinus orca	Not likely to jeopardize	
Humpback Whale Megaptera novaeangliae	Not likely to adversely affect	
Leatherback Sea Turtle Dermochelys coriacea	No effect	No effect

8. ESSENTIAL FISH HABITAT EVALUATION

8.1 ESSENTIAL FISH HABITAT DESIGNATIONS

Pursuant to the MSFCMA and the 1996 Sustainable Fisheries Act (SFA), an EFH evaluation of impacts is necessary for federal actions, including activities that are associated with dredge material disposal. The EFH evaluation applies to all species managed under a federal Fishery Management Plan (FMP). For the Pacific West Coast (excluding Alaska), there are three FMPs, covering groundfish, coastal pelagic species, and Pacific salmon.

Estuaries of Washington State, including Puget Sound and the Pacific coast, are designated as EFH for various groundfish, coastal pelagic, and salmonid species (PFMC 1998a, 1998b). A detailed discussion of EFH for groundfish is provided in the Final Environmental Assessment/Regulatory Impact Review for Amendment 11 to the Pacific Coast Groundfish Fishery Management Plan (PFMC 1998b) and the NMFS

Essential Fish Habitat for West Coast Groundfish Appendix (NMFS 1998). A detailed discussion of EFH for coastal pelagic species is provided in Amendment 8 to the Coastal Pelagic Species Fishery Management Plan (PFMC 1998a). Salmonid EFH is discussed in Appendix A of Amendment 14 to the Pacific Coast Salmon Plan (PFMC 1999). Appendix C of this document contains life history information for each managed fish species. Additionally, this appendix indicates whether each species was captured during sampling efforts while investigating potential disposal sites. A summary of EFH for each FMP follows:

- *Groundfish:* EFH for Pacific coast groundfish is defined as the aquatic habitat necessary to allow for groundfish production to support long-term sustainable fisheries for groundfish and for groundfish contributions to a healthy ecosystem. Descriptions of groundfish EFH for each of the 83 species and their life stages result in more than 400 EFH identifications. When these EFHs are taken together, the groundfish EFH includes all waters from the mean higher high water line, and the upriver extent of saltwater intrusion in river mouths, along the coasts of Washington, Oregon, and California seaward to the boundary of the U.S. EEZ.
- *Coastal pelagic species:* Amendment 8 to the Coastal Pelagic Species Fishery Management Plan describes the habitat requirements of five pelagic species: Northern anchovy, Pacific sardine, Pacific (chub) mackerel, jack mackerel, and market squid. These four finfish and market squid are treated as a single species complex because of similarities in their life histories and habitat requirements. EFH for coastal pelagic species is defined as the east-west geographic boundary of EFH for CPS as defined by all marine and estuarine waters from the shoreline along the coasts of California, Oregon, and Washington offshore to the limits of the EEZ and above the thermocline where sea surface temperatures range between 10^o – 26^o C. The southern boundary is the U.S.-Mexico maritime boundary. The northern boundary is more dynamic, and is defined as the position of the 10^o C isotherm, which varies seasonally and annually.
- *Pacific salmon - chinook, coho, and Puget Sound pink salmon:* EFH for the Pacific coast salmon fishery means those waters and substrate necessary for salmon production needed to support a long-term sustainable salmon fishery and salmon contributions to a healthy ecosystem. To achieve that level of production, EFH must include all those streams, lakes, ponds, wetlands, and other currently viable water bodies and most of the habitat historically accessible to salmon in Washington, Oregon, Idaho, and California. Exceptions include areas upstream of certain impassable manmade barriers (as identified by the PFMC), and longstanding, naturally impassable barriers (i.e., natural waterfalls in existence for several hundred years). In the estuarine and marine areas, salmon EFH extends from the nearshore and tidal submerged environments within state territorial waters out to the full extent of the exclusive economic zone (370.4 km/230.2 miles) offshore of Washington, Oregon, and California north of Point Conception.

Furthermore, the Groundfish FMP categorizes EFH into seven units called “composite” EFHs. EFH and life history stages for groundfish, pelagic, and salmonid species commonly found in Puget Sound that could potentially be affected by continued open dredged material disposal are listed in appendix C (NMFS 1998; WDF 1992). The seven composite EFH identifications are listed below.

Estuarine - Those waters, substrates and associated biological communities within bays and estuaries of the EEZ, from mean higher high water level (MHHW, which is the high tide line) or extent of upriver saltwater intrusion to the respective outer boundaries for each bay or estuary as defined in 33 CFR 80.1 (Coast Guard lines of demarcation).

Rocky Shelf - Those waters, substrates, and associated biological communities living on or within 10 meters (5.5 fathoms) overlying rocky areas, including reefs, pinnacles, boulders, and cobble, along the continental shelf, excluding canyons, from the high tide line MHHW to the shelf break (~200 meters or 109 fathoms).

Nonrocky Shelf - Those waters, substrates, and associated biological communities living on or within 10 meters (5.5 fathoms) overlying the substrates of the continental shelf, excluding the rocky shelf and canyon composites, from the high tide line MHHW to the shelf break (~200 meters or 109 fathoms).

Canyon - Those waters, substrates, and associated biological communities living within submarine canyons, including the walls, beds, seafloor, and any outcrops or landslide morphology, such as slump scarps and debris fields.

Continental Slope/Basin - Those waters, substrates, and biological communities living on or within 20 meters (11 fathoms) overlying the substrates of the continental slope and basin below the shelf break (~200 meters or 109 fathoms) and extending to the westward boundary of the EEZ.

Neritic Zone - Those waters and biological communities living in the water column more than 10 meters (5.5 fathoms) above the continental shelf.

Oceanic Zone - Those waters and biological communities living in the water column more than 20 meters (11 fathoms) above the continental slope and abyssal plain, extending to the westward boundary of the EEZ.

8.2 POTENTIAL EFFECTS OF PSDDA DEEP-WATER DISPOSAL ON EFH

The PSDDA program was developed to minimize potential effects on the physical, chemical, and biological characteristics of disposal sites while providing an economically feasible alternative to upland disposal. The selection of both dispersive and nondispersive sites was based on an evaluation of benthic resources at candidate sites. Analytical procedures, collectively called the Benthic Resources Assessment Technique (BRAT) (Lunz and Kendall 1982, Clarke and Lunz 1985), were used to estimate the relative amount of trophic support that a given benthic habitat provides to fishes. Results of the BRAT analyses were used to help determine final site selections.

The discharge of dredged material subsequent to dredging operations may result in a variety of potential effects on EFH. This section discusses the transport of dredged material and the dredged material disposal. Potential effects of dredged material disposal are further analyzed under the following categories: contaminants, biological oxygen demand, entrainment, turbidity, and smothering.

8.2.1 Transport of Dredged Materials

Transport of dredged material is addressed in Section 2.1 of this BE. As described in that section, transport of dredged material is very unlikely to have any effect on EFH.

8.2.2 Disposal of Dredged Materials

A number of potential effects to biota are generally considered in the evaluation of dredged material disposal. The discharge of dredged material consists of the material traveling through the water column and impacting and dispersing on the bottom (see Disposal Activities section for a more detailed discussion of dredged material disposal).

Contaminants

Exposure of salmon, coastal pelagic, and groundfish species to significant levels of contaminants is not expected. As noted throughout this analysis, sediment is rigorously tested for chemicals of concern and potential for biological effects before it is determined to be suitable for disposal at PSDDA sites. Material that contains higher levels of contaminants is disposed at approved confined disposal site in upland or nearshore areas.

Biological Oxygen Demand

The potential for biological impacts associated with oxygen demand of dredged materials is sometimes cited as a concern. Water quality monitoring of experimental disposal sites in Elliott Bay, a nondispersive site, during and after disposal showed no significant long-term impacts to water quality for up to 9 months (PSDDA/FEIS 1988). Although there was a small, short-term decrease in dissolved oxygen, concentrations never decreased below the 5-mg/l minimum set by regulatory agencies as harmful to migratory fish. Because of the high degree of mixing at the dispersive sites, oxygen-demanding materials would be rapidly diluted and any decrease in dissolved oxygen content in the water would be unmeasurable.

Entrainment

Entrainment of adult or juvenile fish by released dredged material as it falls through the water column could occur but is unlikely to affect significant numbers of individuals. Adults of most species are highly mobile and could actively avoid or escape the descending plume of dredged material. For example, chinook salmon have a maximum burst speed of about 15 body lengths per second for a fish measuring 30 cm in length, and about 8 body lengths per second for a fish measuring 100 cm in length (Webb 1995). Yearling and older fish would require from 1 to 3 seconds to escape even from the center of the release zone. Smaller species, such as sardines or mackerel, have slower swimming speeds (3 to 10 body lengths per second) and therefore entrainment is possible when individuals are located in the immediate path of the descending plume of material. Most fish would be expected to disperse during dredge material disposal operations and avoid the affected area.

Dredging (and therefore disposal) is not currently allowed between March 15 and June 15 to protect outmigrating juvenile salmon. Dredged material disposal is not allowed at the Port Townsend or Port Angeles sites between September 1 and November 30 to protect shrimp. NMFS has indicated that additional PSDDA site closures are not required to protect juvenile or adult salmon (Donnelly pers. comm.). Since juvenile salmon migrate rather rapidly to the ocean environment, these closures minimize the potential occurrence of outmigrating juvenile salmon in the disposal site areas. These timing restrictions would also protect other fish species.
Additionally, the disposal sites are located in deep pelagic offshore habitat lacking physical or biological components that would attract or concentrate salmon or coastal pelagic species. Physical structures (e.g., pilings, rock outcroppings, etc.) are not present, and dredged material disposal has not changed bottom topography at the sites. Potential effects to groundfish are discussed separately under "smothering" below.

Turbidity (Water Column)

In the course of its descent through the water column, some amount of sediment disperses into the water column.

Increases in turbidity associated with the disposal of dredged material could result in a temporary, localized reduction in the feeding success of visual predators. High levels of suspended sediment can clog gills and cause sublethal physiological effects or mortality of juvenile and adult fish. Sediment suspended at the surface or midwater would be more likely to affect salmon and coastal pelagic species than sediments dispersed on or near the bottom. Salmon are pelagic species and should not occur near the substrate at the disposal sites because of the depth of the sites.

Although dredged sediments could occur in the water column for a period of hours, turbidity would reach ambient levels rather quickly. PSDDA/DSSTA 1989 evaluated the transport and duration of suspended sediment in the water column following a generic disposal event at the dispersive sites. At the end of 1 hour, calculation indicated that suspended sediment traveled 1,097 meters (3,600 feet) and concentrations associated with loss of sediment from the jet would be approximately 0.25 mg/l, a level that is approximately one-quarter of the ambient concentration. Research by Truitt (1986a) indicates that very little suspended sediment is released near the surface or midwater during dredged material disposal (figure 7). Most sediment is released as the jet of dredged material impacts the bottom. An increase in turbidity at all locations is estimated to be short-lived (i.e., 10 to 60 minutes).

In a study published in 1983, Pequegnat reported maximum concentrations of suspended solids observed in the field in the range of 1,000 mg/l. The same researcher found that lethal concentrations of suspended sediments for adult marine organisms were an order of magnitude or higher than maximal suspended sediment concentrations observed in the field during dredging operations. Field bioassays on the tolerances of juvenile salmonids to suspended solids indicated the LC50 for wild chum salmon exposed to suspended sediments was 1,047 mg/l (Martin et al. 1977). The study also concluded that healthy juvenile chum salmon could withstand very high concentrations of suspended sediments (up to 3,056 mg/l) without apparent effects. Studies by Redding et al. (1987) found that exposure to relatively high suspended sediment loads (2,000 to 2,500 mg/l) did not seem to severely stress yearling coho salmon and steelhead.

Increased turbidity and suspended sediment in the vicinity of the disposal sites could cause a temporary and localized decrease in phytoplankton productivity or cause mortality of pelagic fish eggs, larvae, and zooplankton. However, the disposal sites lack components that would attract or concentrate plankton or fish. This factor could reduce effects, especially on mackerel, anchovy, and sardines. These species often feed in areas of high plankton abundance (e.g. upwelling fronts). Entrainment of copepods or krill could occur because of their small size and limited ability to move, as could entrainment of their food organisms (e.g., phytoplankton, rotifers, etc.). However, the localized effects and low frequency of disposal probably will not significantly impact planktonic or pelagic invertebrate populations. These organisms are widely distributed throughout the Sound, and the localized, short-term, and infrequent disposal of materials would not substantively affect Sound-wide populations of these organisms.

Smothering

For dispersive sites, only a limited amount of dredged material descends to or remains on the benthos. The high velocity of the currents at the sites leads to the rapid erosion of any remaining material. Species that persist in high current environments are adapted to the dynamic nature of these sites. Sediment transport, accumulation, and erosion are common during ebbing, flooding, and slack tides.

As the main jet of material hits bottom at nondispersive sites, the material spreads across an area usually less than 610 meters (2,000 feet) down current and 305 meters (1,000 feet) on either side of the discharge point. The impact itself can affect epibenthic and benthic organisms within the direct impact area. As the jet impacts the bottom, there is a density/momentum-driven surge of material away from the impact point. As the material settles, a gradient in the thickness of the newly deposited material tends to emerge, with thicker deposits near the impact site and thinner deposits at greater distances from the center of the site. If the disposed material settling on the bottom is thick enough, it can smother benthic fauna, including flatfish that are unable to rapidly leave the area. Monitoring studies at PSDDA sites indicate that the

benthic communities were able to recover when dredged material cover was less than 10 cm thick (Corps 1992).
Longer-term impacts can occur if sediments are sufficiently contaminated to result in toxicity or bioaccumulation. As noted throughout this analysis, only sediments that pass rigorous chemical (and sometimes biological) testing are discharged at PSDDA sites. The DMMP does not allow for the disposal of dredged material that would result in unacceptable impacts to the environment. Monitoring studies at the nondispersive disposal sites have verified that sediment conditions are within acceptable ranges. Therefore, potential toxicity and bioaccumulation associated with dredged material disposal are not likely.

Changes in sediment character (e.g. percent silt, clay, sand, gravel) have occurred at the PSDDA sites. Changes in sediment character can affect benthic community structure and productivity. Temporary and localized impacts to benthic fauna inside the disposal site are expected from burial. Monitoring of benthic fauna just outside the Elliott Bay site in 1992 verified that no adverse environmental effects occurred beyond the boundary of the disposal site (PSDDA 1994). The abundance of major benthic taxa at the transect stations was similar to the abundances measured during baseline studies. Significantly, monitoring at the Elliott Bay site also revealed lower concentrations of chemical contaminants within the disposal site than in the surrounding sediments. The disposal of clean sediments through the PSDDA program is in effect creating a cap over existing contaminated sediments within the Elliott Bay disposal site.

The 1990 monitoring results at Port Gardner after the disposal of 990,000 cubic yards of dredged material indicated that all the site management objectives were met (i.e., all three monitoring questions relative to site management objectives were not exceeded). An evaluation of the benthic infaunal transect data indicated there was a 50% reduction in major taxa relative to baseline conditions, but the reductions were attributable to regional effects and not caused by dredged material. The same benthic major taxa reductions were observed at benchmark stations outside the direct influences of dredged material disposal. The monitoring results also confirmed that there were no unacceptable adverse effects on biological resources immediately offsite caused by dredged material.

8.3 CONCLUSIONS

The PSDDA program was developed to minimize the potential effects of dredged material disposal on the environment and included a rigorous site selection process and development of toxicological screening criteria to achieve this goal. The disposal of dredged material has the potential to affect habitat, including EFH, as discussed above. The repeated accumulation of disposed material is the primary mechanism by which EFH may be affected.

Although disposed material may descend to the benthic habitats at the dispersive sites, accumulation is not likely to occur because of the high currents at these sites. Any material that reaches the bottom is rapidly exported from the site. For nondispersive sites, disposed material may accumulate on benthic habitats and may affect sessile or slow moving organisms within the disposal zone. Repeated disturbance is likely to affect the productivity of these sites and may reduce the abundance of organisms that cannot rapidly recolonize the disturbed area.

Several factors have been found to be important in determining the rate at which a disturbed site is recolonized by soft-bottom benthic invertebrate species. Soft bottom sediments are frequently disturbed because wave actions and currents can move soft sediments about. Resident organisms are adapted to such natural perturbations and tend to recover quickly. Recovery of the motile organisms on disturbed soft-bottom habitats can occur by adult migration, as well as by larval sediment and growth; both phenomena are more rapid on soft-bottom habitats than hard substrate.

The PSDDA program limits the area of potential effect by concentrating disposal activities at defined sites, chosen based on their relatively low habitat value. The limited area of the disposal sites (650 to 884 acres for dispersive sites and 260 to 415 acres for nondispersive sites) ensures that the disposal sites remain surrounded by unaltered habitat, facilitating recruitment and utilization of the areas by neighboring species. Although 2001 monitoring at the Commencement Bay site indicated that some dredged material had extended beyond the site boundary, no discernable effects on the benthic community have been identified. Analyses using the ST-FATE model will be used to formulate future Commencement Bay site recommendations. Physical surveys at other nondispersive disposal sites have confirmed that the QA/QC for dump barge positioning is effective and material is remaining in the targeted areas.

8.4 CONSERVATION MEASURES

A number of measures and procedures inherent in the DMMP act in combination to minimize the potential for impacts to biota and habitat (including EFH) in Puget Sound. These include

- consideration of beneficial-use disposal sites for appropriate dredged material;
- consolidation of dredged material disposal sites to minimize the area and locations affected by dredged material disposal;
- siting of dredged material disposal sites in areas of relatively low habitat value or low use by biota (distance offshore, depth, areas with low known resource value);
- timing of dredging and disposal events to avoid overlap with sensitive migration or life history periods of salmon;
- using dredged material testing protocols to ensure the suitability of materials for unconfined, open-water discharge;
- conducting site monitoring activities (physical, chemical and biological) to determine if unacceptable impacts are occurring at disposal sites;
- performing annual review of monitoring results; and
- using adaptive management of the DMMP by multiagency task force.

The PSDDA program addresses all recommended conservation measures put forth by the Pacific Fisheries Management Council in their management plans for Pacific salmon, coastal pelagic species, and Pacific coast groundfish species (PFMC 1999, 1998a and b).

8.5 DETERMINATION OF EFFECT

8.5.1 Pacific Salmon EFH

Based on the analysis provided in this document the transport and disposal of dredged material under the PSSDA program will have *no effect* on EFH for pacific salmon species. The disposal sites, because of their location and depth, do not substantially contribute as habitat for salmon or their prey base. Although indirect food web linkages between deeper benthic environments and salmon species exist, the short-term and localized disturbances associated with dredged material disposal would be minimal and discountable.

8.5.2 Coastal Pelagic EFH

Based on the analysis provided in this document the transport and disposal of dredged material under the PSSDA program will have *no effect* on EFH for coastal pelagic species. The disposal sites, because of their location and depth, do not substantially contribute as habitat for coastal pelagic species and their prey base. Potential effects on water column habitat are limited and short-term, primarily restricted to several hours after disposal events. The intermittent use of the disposal sites ensures that temporary effects do not rise to significant levels that may result in harm to coastal pelagic EFH.

8.5.3 Groundfish EFH

Based on the analysis provided in this document the transport and disposal of dredged material under the PSDDA program may adversely affect the EFH for groundfish species, but the adverse effect on EFH would not be substantial because of the conservation measures listed above. The PSDDA program has, by design, included site selection criteria to minimize the potential for deleterious effects caused by impacts to the trophic structure that supports groundfish species.

9. EFH References

Baird R.W. et al. 2003. Studies of Foraging in "Southern Resident" Killer Whales During July 2002: Dive Depths, Bursts in Speed, and the Use of a "Crittercam" System for Examining Sub-Surface Behavior. National Marine Fisheries Service, National Marine Mammal Laboratory. Seattle WA.

Goetz, F.A. E. Jeanes, and E. Beamer. 2004. Bull Trout in the Nearshore (Preliminary Draft Report). U.S. Army Corps of Engineers, Seattle District. Seattle, WA. Available at: http://www.nws.usace.army.mil/publicmenu/DOCUMENTS/Prelim_Bull_Trout_Report.pdf

Federal Register / Vol. 69, No. 239 / Tuesday, December 14, 2004 / Proposed Rules

Jordan, D.S. 1887. The fisheries of the Pacific Coast. Pages 591-629 in G.B. Goode. The fisheries and fishery industries of the United States. Sect. II. U.S. Comm. Fish and Fisheries. U.S. Government Printing Office, Washington, D.C.

Kraemer, C. 1994. Some observations on the life history and behavior of the native char, Dolly Varden (Salvelinus malma) and bull trout (S. confluentus) of the North Puget Sound Region. Draft Report prepared by the Washington Department of Fish and Wildlife, Mill Creek.

Miller, B.S., C.A. Simenstad, L.L. Moulton, K.L. Fresh, Frederick C. Funk, William A. Karp, and S.F. Borton. 1977. Puget Sound baseline program Nearshore fish survey. University of Washington, Fisheries Research Institute, Contract No. 75-017, Seattle.

Pentilla, D. 2003. Unpublished Puget Sound data provided to F. Goetz. Washington Department of Fish and Wildlife, LaConner, Washington.

U.S. Fish and Wildlife Service [Internet]. Species Information Threatened and Endangered Animals and Plants [updated 2005 Feb 11, cited 2005 Feb 11]. Available from: http://ecos.fws.gov/docs/life_histories/B008.html

ESA References

Allen, M.A., and T.J. Hassler. 1986. Species profiles: life histories and environmental requirements of coastal fisheries and invertebrates (Pacific Southwest) chinook salmon. U.S. Fish and Wildlife Service Biological Report 82 (11.49). U.S. Army Corps of Engineers, TR EL-82-4.

Alverson, D.L. 1992. A review of commercial fisheries and the Steller sea lion (*Eumetopias jubatus*); the conflict arena. Reviews in Aquatic Sciences 6(3,4):203-256.

Anderson, J.J. 1990. Assessment of the risk of pile driving to juvenile fish. Paper presented at the 15th annual members meeting and seminar of the Deep Foundations Institute, October 10-12, 1990. Seattle, WA.

Argue, A.W. 1970. A study of factors affecting exploitation of Pacific salmon in the Canadian gauntlet fishery of Juan de Fuca Strait. Fisheries Service, Canada. Pacific Region Technical Report 1970-11.

ARKive/Images of Life on Earth [Internet]. Globally Endangered Chapter [cited 2005 Feb. 11]. Available from: http://www.arkive.org/species/GES/

Bax, N.J., E.O. Salo, B.P. Snyder, C.A. Simenstad and W.J. Kinney. 1978. Salmon Outmigration studies in Hood Canal: A summary-1977. Contribution No. 501. Fisheries Research Institute, University of Washington. Seattle, WA.

Beach, R.J., A.C. Geiger, S.J. Jeffries, and S.D. Treacy. 1985. Marine mammals and their interactions with fisheries on the Columbia River and adjacent water, 1980-82. NWAFC Proceedings Report 85-04. U.S. Department of Commerce, NMFS, NWAFC, Seattle, WA.

Beamish, R.J., M. Folkes, R. Sweeting, and C. Mahnken. 1998. Intra-annual changes in the abundance of coho, chinook, and chum salmon in Puget Sound in 1997. Pages 531-541, Puget Sound Research '98.

Beauchamp, D.A., M.F. Shepard, and G.B. Pauley. 1983. Species profiles: life histories and environmental requirements of coastal fisheries and invertebrates (Pacific Northwest) chinook salmon. U.S. Fish and Wildlife Service Biological Report 82. U.S. Army Corps of Engineers, TR EL-82-4.

Bickham, J.W., J.C. Patton, and T.R. Loughlin. 1996. High variability for control-region sequences in a marine mammal: Implications for conservation and biogeography of Steller sea lions, *Eumetopias jubatus*. Journal of Mammalogy 77(1):95-108.

Brown, Robin. DFWS. 1999 - personal communication.

Brown, R.F., and S.D. Riemer. 1992. Steller sea lion counts in Oregon during June and July, 1975 - 1992. Unpublished report. Oregon Department of Fish and Wildlife, Newport, OR.

Calkins, D.G., and K.W. Pitcher. 1982. Population assessment, ecology and trophic relationships of Steller sea lions in the Gulf of Alaska. U.S. Department of Commerce, NOAA. OCSEAP Final Report 19 (1983), pp. 445-546.

Chumbley, K. J. Sease, M. Strick, and R. Towell. 1997. Field studies of Steller sea lions *Eumetopias jubatus* at Marmot Island, Alaska. 1979 through 1994. NOAA Technical. Memorandum NMFS-AFSC-77.

Corps. See “U.S. Army Corps of Engineers”.

Crean, P.B. 1983. The development of rotating, non-linear numerical models (GF2, GF3) simulating barotrophic mixed tides in a complex coastal system located between Vancouver Island and the mainland. Canadian Technical Report, Hydrography and Ocean Science, No 31.

Dames and Moore. 1981. Commencement Bay studies. Prepared for the U.S. Army Corps of Engineers, Seattle District. Seattle, WA.

Donnelly, Robert. Fisheries biologist, National Marine Fisheries Service, Lacey, WA. June 28, 1999 - telephone conversation.

Donnelly, R.F., B.S. Miller, J.H. Standler, L. Christensen, K. Larsen, and P.A. Dinnel. 1988. Puget Sound Dredged Disposal Analysis (PSDDA) Phase II disposal site bottomfish investigations. Prepared by the University of Washington School of Fisheries, Fisheries Research Institute. Seattle, WA

Federal Register / Vol. 69, No. 122 / Friday, June 25, 2004 / Proposed Rules. 50 CFR Part 17

Friedman, Rachel. NMFS. Lacey, WA. Telephone conversation, 23 August, 1999.

Garrison, K.J., and B.S. Miller. 1982. Review of the early life history of Puget Sound fishes. Publication FRI-UW-8216 of the Fisheries Research Institute, University of Washington, Seattle, WA.

Gearin, P.J., and J.J. Jeffries. 1996. Steller sea lion research in Washington state. In house publication.

Gentry, R.C. 1970. Social behavior of Steller sea lions. Ph.D. thesis, University of California, Santa Cruz, CA.

Gerke, R.J. and V.W. Kaczynski. 1972. Food of juvenile pink and chum salmon in Puget Sound, Washington. Washington Department of Fisheries Technical Report No. 10. Olympia, Washington.

Groot, C., L Margolis and W.C. Clarke. 1995. Physiological Ecology of Pacific Salmon. UBC Press, Vancouver, Canada.

Groot, C. and L. Margolis. 1991. Pacific salmon life histories. UBC Press. Vancouver, Canada.

Healey, M.C. 1980. The ecology of juvenile salmon in Georgia Strait, British Columbia. Pages 203-229 in: W.J. McNeil and D.C. Himsworth (eds.). Salmonid ecosystems of the North Pacific. Oregon State University Press, Corvallis, OR.

Healey, M.C. 1982. Juvenile Pacific salmon in estuaries: the life support system. Pages 315-341 in V.S. Kennedy (ed.). Estuarine comparisons. Academic Press, New York.

Healey, M.C. 1991. Life history of chinook salmon (*Oncorhynchus tshawytscha*). Pages 311-393 in C. Groot and L. Margolis (eds.). Pacific salmon life histories. UBC Press, Vancouver, British Columbia.

Hill, P.S., and D.P. DeMaster. In prep. Draft Alaska marine mammal stock assessments 1998. National Marine Fisheries Service, National Marine Mammal Laboratory, Seattle, WA

Jensen, H.M. 1956. Recoveries of immature chum salmon tagged in southern Puget Sound. Washington Department of Fisheries, Fisheries Research Paper 1(4):32

Johnson, O.W., W.S. Grant, R.G. Kope, K. Neely, F.W. Waknitz, and R.S. Waples. 1997. Status review of chum salmon from Washington, Oregon, and California. U.S. Department of Commerce, NOAA Technical Memorandum. NMFS-NWFSC-32, 280 p.

Johnson, R.C., R.J. Gerke, D.W. Heiser, R.F. Orrell, S.B. Mathews, and J.G. Olds. 1971. Pink and chum salmon investigations, 1969: supplementary progress report. Washington Department of Fisheries, Fisheries Management and Research Division, Olympia, WA.

Jones & Stokes Associates. 2000a. Programmatic biological evaluation. Puget Sound dredged disposal analysis (PSDDA) non-dispersive disposal sites. Prepared for the U.S. Army Corps of Engineers, Seattle District. Seattle, WA.

Jones & Stokes Associates. 2000b. Programmatic biological evaluation. Puget Sound dredged disposal analysis (PSDDA) dispersive disposal sites. Prepared for the U.S. Army Corps of Engineers, Seattle District. Seattle, WA.

Kaczynski, V.W., R.J. Feller, J. Clayton, and G.J. Gerke. 1973. Trophic analysis of juvenile pink and chum salmon (*Oncorhynchus gorbuscha and O. keta*) in Puget Sound. Journal of the Fisheries Research Board of Canada 30(7):1003-1008

Kendall, David. U.S. Army Corps of Engineers, Seattle District. Written comment -August 23, 1999.

Kenyon, K.W. and V.B. Scheffer. 1962. Wildlife surveys along the northwest coast of Washington. Murrelet 42:29-37.

Kraemer, Kurt. Fisheries biologist. Washington Department of Fish and Wildlife, Mill Creek, WA. July 13, 1999 – telephone conversation.

Loughlin, T.R. 1997. Using the phylogeographic method to identify Steller sea lion stocks. Molecular Genetics of Marine Mammals, Special Publication 3:159-171.

Loughlin, T.R., M.A. Perez, R.L. Merrick. 1987. *Eumetopias jubatus*. Mammalian Species 283.

Martin, J.D., E.O. Salo and B.P. Snyder. 1977. Field bioassay studies on the tolerances of juvenile salmonids to various levels of suspended solids. University of Washington School of Fisheries, Fisheries Research Institute. Seattle, WA. FRI-UW-7713.

McCain, B.B., D.C. Malins, M.M. Krahn, D.W. Brown, W.D. Gronlund, L.K. Moore, and S.-L. Chan. 1990. Uptake of aromatic and chlorinated hydrocarbons by juvenile chinook salmon (*Oncorhynchus tshawytscha*) in an urban estuary. Arch Environ Contam Toxicol 19:10-16.

McLaren, P., and P. Ren. 1994. Sediment transport in Elliott Bay and the Duwamish River, Seattle: Implications to estuarine management. Prepared for the Ecology Toxic Cleanup Program, Seattle, WA.

Merrick, R.L. 1995. Thesis, University of Washington, Seattle, WA.

Merrick, R.L., and T.R. Loughlin. 1997 Foraging behavior of adult female and young-of-the-year Steller sea lions *Eumetopias jubatus* in Alaskan waters. Canadian Journal of Zoology 75 (5): 776-786.

Merrick, R.L., M.K. Chumbley, and G.V. Byrd. 1997. Diet diversity of Steller sea lions (*Eumetopias jubatus*) and their population decline in Alaska: a potential relationship. Canadian Journal of Fisheries and Aquatic Science 54:1342-1348.

Merrick, R.L., R. Brown, D.G. Calkins, and T.R. Loughlin. 1995. A comparison of Steller sea lion, *Eumetopias jubatus*, pup masses between rookeries with increasing and decreasing populations. Fisheries Bulletin. 93:753-758.

Moyle, P.B. 1976. Inland fishes of California. University of California Press, Berkeley, CA.

Myers, J.M., R.G. Kope, G.J. Bryant, D. Teel, L.J. Lierheimer, T.C. Wainwright, W.S. Grand, F.W. Waknitz, K. Neely, S.T. Lindley, and R.S. Waples. 1998. Status review of chinook salmon from Washington, Idaho, Oregon, and California. U.S. Department of Commerce, NOAA Technical Memorandum. NMFS-NWFSC-35.

National Marine Fisheries Service. 1996. Making Endangered Species Act determinations of effect for individual or grouped actions at the watershed scale. Lacey, WA.

National Marine Fisheries Service. 1997. Investigation of scientific information on the impacts of California sea lions and Pacific harbor seals on salmonids and on the coastal ecosystems of Washington, Oregon, and California. U.S. Department of Commerce., NOAA Technical Memorandum NMFS-NWFSC-28.

National Marine Fisheries Service. 1999. Biological opinion on groundfish fisheries in the BSA1 & GOA. NMFS/NOAA, Seattle, WA.

National Oceanic and Atmospheric Administration [Internet]. The Humpback Whale [cited 2005 Feb. 14]. Available from: http://www.nwr.noaa.gov/mfr611/mfr6113.pdf

National Oceanic and Atmospheric Administration. 2004. Puget Sound Chinook Harvest Resources Management Plan Final Environmental Impact Statement. National Marine Fisheries Service Northwest Region with Assistance from the Puget Sound Treaty Tribes and Washington Department of Fish and Wildlife. Pp. 3-205 to 3-206.

Nehlsen, W., J.E. Williams, and J.A. Lichatowich. 1991. Pacific salmon at the crossroads: stocks at risk from California, Oregon, Idaho, and Washington. Fisheries 16(2):4-21.

NMFS. See “National Marine Fisheries Service”.

Pearcy, W.G. 1992. Ocean ecology of north Pacific salmonids. Washington Sea Grant Program. Seattle, WA.

Pequegnat, W.E. 1983. Some aspects of deep ocean disposal of dredged material. Pages 230-252 in: D.R. Kester, B.H. Ketchum, I.W. Kuedall and P.K. Park (eds.). Wastes in the ocean, Volume 2: dredged material disposal in the ocean. John Wiley and Sons, New York, NY.

Pike, G.C., and B.E. Maxwell. 1958. The abundance and distribution of the northern sea lion, *Eumetopias jubatas* on the coast of British Columbia. Journal of the Fisheries Research Board Canada 15:5-17.

Pitcher, K.W., and D.G. Calkins. 1981. Reproductive biology of Steller sea lions in the Gulf of Alaska. Journal of Mammalogy. 62:599-605.

Pitcher, K.W., D.G. Calkins, and G.W. Pendleton. In review. Reproductive performances of female Steller sea lions from the Gulf of Alaska: Indications of nutritional stress? Can. J. Zool.

Popper, N.A. and T.J. Carlson. 1998. Application of sound and other stimuli to control fish behavior. Transactions of the American Fisheries Society. 127(5)673-707

PSDDA. 1994. Puget Sound Dredged Disposal Analysis (PSDDA) biennial report, dredged material management years 1992/1993. Prepared by the Corps of Engineers in cooperation with the Environmental Protection Agency and the Washington Departments of Ecology and Natural Resources. Seattle, WA.

PSDDA. 1996. Puget Sound Dredged Disposal Analysis (PSDDA) sediment management program biennial report, dredging years 1994/1995. Prepared by the Corps of Engineers in cooperation with the Environmental Protection Agency and the Washington Departments of Ecology and Natural Resources. Seattle, WA.

PSDDA. 1998. Puget Sound Dredged Disposal Analysis (PSDDA) sediment management program biennial report, dredging years 1996/1997. Prepared by the Corps of Engineers in cooperation with the Environmental Protection Agency and the Washington Departments of Ecology and Natural Resources. Seattle, WA.

PSDDA/DMEAR. 1991. Dredged material evaluation application report (dredging year 1990). Prepared by the Corps of Engineers in cooperation with the Environmental Protection Agency and the Washington Departments of Ecology and Natural Resources. Seattle, WA.

PSDDA/DMEAR. 1992. Dredged material evaluation application report (dredging year 1991). Prepared by the Corps of Engineers in cooperation with the Environmental Protection Agency and the Washington Departments of Ecology and Natural Resources. Seattle, WA.

PSDDA/DSSTA. 1988. Puget Sound Dredged Disposal Analysis (PSDDA) Phase I (Central Puget Sound). Disposal site selection technical appendix. Prepared by the Corps of Engineers in cooperation with the Environmental Protection Agency and the Washington Departments of Ecology and Natural Resources. Seattle, WA.

PSDDA/DSSTA. 1989. Puget Sound Dredged Disposal Analysis (PSDDA) Phase II (North and South Puget Sound). Disposal site selection technical appendix. Prepared by the Corps of Engineers in cooperation with the Environmental Protection Agency and the Washington Departments of Ecology and Natural Resources. Seattle, WA.

PSDDA/FEIS. 1988. Final environmental impact statement - unconfined open-water disposal sites for dredged material disposal, Phase I (Central Puget Sound). Prepared by the Corps of Engineers in cooperation with the Environmental Protection Agency and the Washington Departments of Ecology and Natural Resources. Seattle, WA

PSDDA/FEIS. 1989. Final environmental impact statement - unconfined open-water disposal sites for dredged material disposal, Phase II (North and South Puget Sound). Prepared by the Corps of Engineers in cooperation with the Environmental Protection Agency and the Washington Departments of Ecology and Natural Resources. Seattle, WA.

PSDDA/MPR. 1988. Puget Sound Dredged Disposal Analysis (PSDDA) management plan report, unconfined open-water disposal sites for dredged material disposal, Phase I (Central Puget Sound). Prepared by the Corps of Engineers in cooperation with the Environmental Protection Agency and the Washington Departments of Ecology and Natural Resources. Seattle, WA.

PSDDA/MPR. 1989. Puget Sound Dredged Disposal Analysis (PSDDA) management plan report, unconfined open-water disposal sites for dredged material disposal, Phase II (North and South Puget Sound). Prepared by the Corps of Engineers in cooperation with the Environmental Protection Agency and the Washington Departments of Ecology and Natural Resources. Seattle, WA.

PTI Environmental Services. 1988. Puget Sound Dredged Disposal Analysis. Baseline survey of Phase I disposal sites. Prepared for Washington Department of Ecology. Bellevue, WA.

PTI Environmental Services. 1989. Puget Sound Dredged Disposal Analysis. Baseline survey of Phase II disposal sites. Prepared for Washington Department of Ecology. Bellevue, WA

Raleigh, R.F., T. Hickman, R.C. Solomon, and P.C. Nelson. 1986. Habitat suitability index models and instream flow suitability curves: chinook salmon. U.S. Fish and Wildlife Service, Biological Report 82(10.122). Washington, D.C.

Redding, J.M. C.B. Schreck and F.H. Everest. 1987. Physiological effects on coho salmon and steelhead of exposure to suspended solids. Transactions of the American Fisheries Society 116:737-744.

Repenning, C.A. 1976. Adaptive evolution of sea lions and walruses. Syst. Zoo. 25

SAIC. 1991. PSDDA 1990 monitoring. Post-disposal surveys of Elliott Bay and Port Gardner. Prepared for the Washington Department of Natural Resources. Olympia, WA

SAIC. 1992. Full monitoring at Elliott Bay. Prepared for the Washington Department of Natural Resources. Olympia, WA

SAIC. 1993. Partial monitoring in Bellingham Bay. Prepared for the Washington Department of Natural Resources. Olympia, WA

SAIC 1994. Tiered full monitoring at the Port Gardner PSSDA disposal site. Prepared for the Washington Department of Natural Resources. Olympia, WA

SAIC, 1995. Full Monitoring at the Commencement Bay PSDDA Site. Prepared for WA DNR, and the PSDDA Agencies by Science Applications International Corporation, Bothell, WA.

SAIC, 1996. Partial Monitoring at the Commencement Bay PSDDA Disposal Site. Prepared for WA DNR, and the PSDDA Agencies by Science Applications International Corporation, Bothell, WA.

SAIC, 2000. 2000 Full Monitoring at the Elliott Bay PSDDA Disposal Site. Prepared for WA DNR and the PSDDA Agencies by Science Application International Corporation, Bothell, WA.

SAIC, 2001. PCB analysis and cell-line assay testing at the Elliott Bay PSDDA disposal site. November 28, 2001. Prepared for Washington DNR and the PSDDA Agencies by Science Application International Corporation, Bothell, WA.

SAIC, 2003. Tiered-Full Monitoring at Commencement Bay, Tacoma, Washington. Prepared for WA DNR and the PSDDA Agencies by Science Application International Corporation, Bothell, WA.

SAIC, 2004. Partial Monitoring at Commencement Bay, Tacoma, Washington. Prepared for WA DNR and the PSDDA Agencies by Science Application International Corporation, Bothell, WA.

Sandgren, F.E. 1970. Breeding and maternal behavior of the Steller sea lion, *Eumetopias jubatus* in Alaska. The Zoological Institute, University of Stockholm, Swedish Museum of Natural History.

Scheffer, V.B. 1944. Airplane reconnaissance of sea lions in Washington. J. Wildl. Manage. 8(4):340-341.

Scheffer, V.B. and P.P. Macy. 1944. Airplane reconnaissance of sea lions in Washington. Journal of Wildlife. Management 8: 340-341.

SEA, 2002. 2002 Tiered-Partial Monitoring in Elliott Bay, Seattle, WA. Prepared for WA DNR and PSDDA Agencies by Striplin Environmental Associates, Olympia, WA.

SEA, 2001. 2001 Full Monitoring in Commencement Bay. Prepared by Striplin Environmental Associates for WA DNR and the PSDDA Agencies.

Simenstad, C.A., B.S. Miller, C.F. Nyblade, K. Thornburgh, and L.J. Bledsoe. 1979. Food web relationships of northern Puget Sound and the Strait of Juan de Fuca: A synthesis of the available knowledge. Prepared for the U.S. Environmental Protection Agency by University of Washington School of Fisheries, Fisheries Research Institute. Seattle, WA

Simenstad, C.A., J.R. Cordell, R.C. Wissmar, K.L. Fresh, S. Schroder, M. Carr, and M. Berg. 1988. Assemblage structure, microhabitat distribution, and food web linkages of epibenthic crustaceans in Padilla Bay National Estuarine Research Reserve, Washington. NOAA Technical Report Series OCRM/MEMD, FRI-UW-8813, Fisheries Research Institute, University of Washington, Seattle, WA.

Simenstad, C.A., K.L. Fresh, and E.O. Salo. 1982. The role of Puget Sound and Washington coastal estuaries in the life history of Pacific salmon: an unappreciated function. Pages 343-364 in V.S. Kennedy (ed.). Estuarine comparisons. Academic Press, New York, NY.

Simenstad, C.A., W.J. Kinney, S.S. Parker, E.O. Salo, J.R. Cordell and H. Buechner. 1980. Prey community structure and trophic ecology of outmigrating juvenile chum and pink salmon in Hood Canal. A synthesis of three years' studies, 1977-1979. FRI-UW-8026. Fisheries Research Institute, University of Washington. Seattle, WA

Smith, R.I., and J.T. Carlton (eds.). 1975. Light's manual. Intertidal invertebrates of the central California Coast. University of California Press, Berkeley, CA.

Splash [Internet]. 31 August 2004. Progress Report – Summer/feeding areas 2004 [cited 2005 Feb. 14]. Available from: http://www.cascadiaresearch.org/SPLASH/Prog-Rep-Sum-04.html

Stanford, Bruce. Fisheries Biologist, WDFW, Olympia, WA. Telephone Conversation, 23 August, 1999.

Strickland, R.M. 1983. The fertile fjord: Plankton in Puget Sound. Puget Sound Books.

Strick, J.M., R.L. Merrick, D.C. McAllister, L.W. Fritz, and K.M. Wynne. In press. Aerial and ship-based surveys of Steller sea lions, *Eumetopias jubatus*, in southeast Alaska, the Gulf of Alaska, and Aleutian Islands during June and July 1996. U.S. Department of Commerce, NOAA Technical Memorandum. NMFS-AFSC-00.

Strict, J.M., L.W. Fritz, and J.P. Lewis. 1997. Aerial and ship-based surveys of Steller sea lions *Eumetopias jubatus* in southeast Alaska, the Gulf of Alaska, and Aleutian Islands during June and July 1994. U.S. Department of Commerce, NOAA Technical Memorandum. NMFS-AFSC-71, 55pp.

Swain, V.G. and D.G. Calkins. 1997. Foraging behavior of juvenile Stellar sea lions in the northeastern Gulf of Alaska: Diving and foraging trip duration in Steller sea lions recovers investigations in Alaska, 1995-1996. Alaska Department of Fish and Game, Division of Wildlife Conservation. NOAA Contract Report, Contract NA57FX0256.

Taylor, F.H.C. 1969. The British Columbia offshore herring survey, 1968-69. Fisheries Research Board of Canada, Technical Report 140.

Trawle, M.J., and B.H. Johnson. 1986. Puget Sound generic dredged material disposal alternatives. Miscellaneous Paper HL-86-5. U.S. Army Corps of Engineers, Waterways Experiment Station, Vicksburg, Mississippi.

Truitt, C. L. 1986a. The Duwamish Waterway capping demonstration project: Engineering analysis and results of physical monitoring. Technical Report D-86-2. U.S. Army Corps of Engineers Waterways Experiment Station, Vicksburg, Mississippi.

Truitt, C.L. 1986b. Environmental effects of dredging: fate of dredged material during open water disposal. Technical Note EEDP-10-2, U.S. Army Engineer Waterways Experiment Station, Vicksburg, Mississippi.

U.S. Army Corps of Engineers. 1986. Fate of dredged material during open water disposal. Environmental Effects of Dredging Technical Notes. EDP-01-2. Waterways Experiment Station, Vicksburg, Mississippi

U.S. Army Corps of Engineers. 1992. Eagle Harbor benthic effects assessment for West Harbor thin layer dredged material placement alternatives. Thin layer placement of dredged material. Feasibility analysis. Seattle, WA.

________. 1999. Programmatic Biological Evaluation, Puget Sound Dredged Disposal Analysis (PSDDA), non-dispersive disposal sites. Submitted to U.S. Fish and Wildlife Service. Seattle District Corps of Engineers, Seattle, WA.

U.S. Army Corps of Engineers, U.S. Environmental Protection Agency, Washington Department of Natural Resources and Washington Department of Ecology. 1998. Dredged material evaluation and disposal procedures. A user's manual for the Puget Sound Dredged Material Disposal Analysis (PSDDA) Program. U.S. Army Corps of Engineers, Seattle District. Seattle, WA.

Washington Department of Fish and Wildlife. 1999a. Washington state forage fish. Sandlance. http://www.wa.gov/wdfw/ fish/forage/lance.htm#lbiology

Washington Department of Fish and Wildlife. 1999b. Washington state forage fish: Pacific herring http://www.wa.gov/wdfw/ fish/forage/herring.htm#hbiology

Washington Department of Fisheries. 1981. Food habits of Pacific salmon, baitfish, and their potential competitors and predators in the marine waters of Washington, August 1978 to September 1979. Progress Report No. 145. Olympia, WA.

WDF. See "Washington Department of Fisheries".

WDFW. See "Washington Department of Fish and Wildlife".

Webb, P.W. 1995. Chapter 2: locomotion. Pages 71-99 in C. Groot, L. Margolis, and W.C. Clarke (eds.). Physiological ecology of chinook salmon. UBC Press, Vancouver, British Columbia.

Williams, R.W., R.M. Laramie, and J.J. Ames. 1975. A catalog of Washington streams and salmon utilization. Volume 1. Puget Sound. Washington Department of Fisheries, Seattle, WA.

York, A.E. 1994. The population dynamics of northern sea lions 1975-85. Mar. Mamm. Sci 10:38-51.

York, R.E., R.L. Merrick, and T.R. Loughlin. 1996. An analysis of the Stellar sea lion metapopulation in Alaska. In D.R. McCollough (ed.) Metapopulations & Wildlife Conservation, Island Press, Washington, DC.

Appendix A

Screening Level (SL), Bioaccumulation Trigger (BT), and Maximum Level (ML) Guideline Chemistry Values (Dry Weight Normalized)

2004 SCREENING LEVEL (SL), BIOACCUMULATION TRIGGER (BT), AND MAXIMUM LEVEL (ML) GUIDELINE CHEMISTRY VALUES

CHEMICAL	CAS (1) NUMBER	SCREENING LEVEL	BIOACCUM TRIGGER	MAXIMUM LEVEL
METALS (mg/kg)				
Antimony	7440-36-0	150	---	200
Arsenic	7440-38-2	57	507.1	700
Cadmium	7440-43-9	5.1	11.3	14
Chromium	7440-47-3	---(2)	267	---(2)
Copper	7440-50-8	390	1027	1,300
Lead	7439-92-1	450	975	1,200
Mercury	7439-97-6	0.41	1.5	2.3
Nickel	7440-02-0	140	370 (3)	370
Selenium	7782-49-2	---(2)	3	---(2)
Silver	7440-22-4	6.1	6.1 (4)	8.4
Zinc	7440-66-6	410	2783	3,800
ORGANOMETALLIC COMPOUNDS (ug/L)				
Tributyltin (5) (interstitial water)	56573-85-4	0.15	0.15	---
ORGANICS (ug/kg)				
Total LPAH	---	5,200	---	29,000
Naphthalene	91-20-3	2,100	---	2,400
Acenaphthylene	208-96-8	560	---	1,300
Acenaphthene	83-32-9	500	---	2,000
Fluorene	86-73-7	540	---	3,600
Phenanthrene	85-01-8	1,500	---	21,000
Anthracene	120-12-7	960	---	13,000
2-Methylnaphthalene	91-57-6	670	---	1,900

CHEMICAL	CAS (1) NUMBER	SCREENING LEVEL	BIOACCUM TRIGGER	MAXIMUM LEVEL
Total HPAH	---	12,000	---	69,000
Fluoranthene	206-44-0	1,700	4,600	30,000
Pyrene	129-00-0	2,600	11,980	16,000
Benz(a)anthracene	56-55-3	1,300	---	5,100
Chrysene	218-01-9	1,400	---	21,000
Benzofluoranthenes (b+k)	205-99-2 207-08-9	3,200	---	9,900
Benzo(a)pyrene	50-32-8	1,600	---	3,600
Indeno(1,2,3-c,d)pyrene	193-39-5	600	---	4,400
Dibenz(a,h)anthracene	53-70-3	230	---	1,900
Benzo(g,h,i)perylene	191-24-2	670	---	3,200
CHLORINATED HYDROCARBONS				
1,3-Dichlorobenzene	541-73-1	170	---	---
1,4-Dichlorobenzene	106-46-7	110	---	120
1,2-Dichlorobenzene	95-50-1	35	---	110
1,2,4-Trichlorobenzene	120-82-1	31	---	64
Hexachlorobenzene (HCB)	118-74-1	22	168	230
PHTHALATES				
Dimethyl phthalate	131-11-3	71 (7)	---	1,400 (7)
Diethyl phthalate	84-66-2	200 (7)	---	1,200 (7)
Di-n-butyl phthalate	84-74-2	1,400 (7)	---	5,100 (7)
Butyl benzyl phthalate	85-68-7	63 (7)	---	970 (7)
Bis(2-ethylhexyl) phthalate	117-81-7	1,300 (7)	---	8,300 (7)
Di-n-octyl phthalate	117-84-0	6,200	---	6,200 (7)
PHENOLS				
Phenol	108-95-2	420	---	1,200
2-Methylphenol	95-48-7	63	---	77
4-Methylphenol	106-44-5	670	---	3,600
2,4-Dimethylphenol	105-67-9	29	---	210
Pentachlorophenol	87-86-5	400	504	690

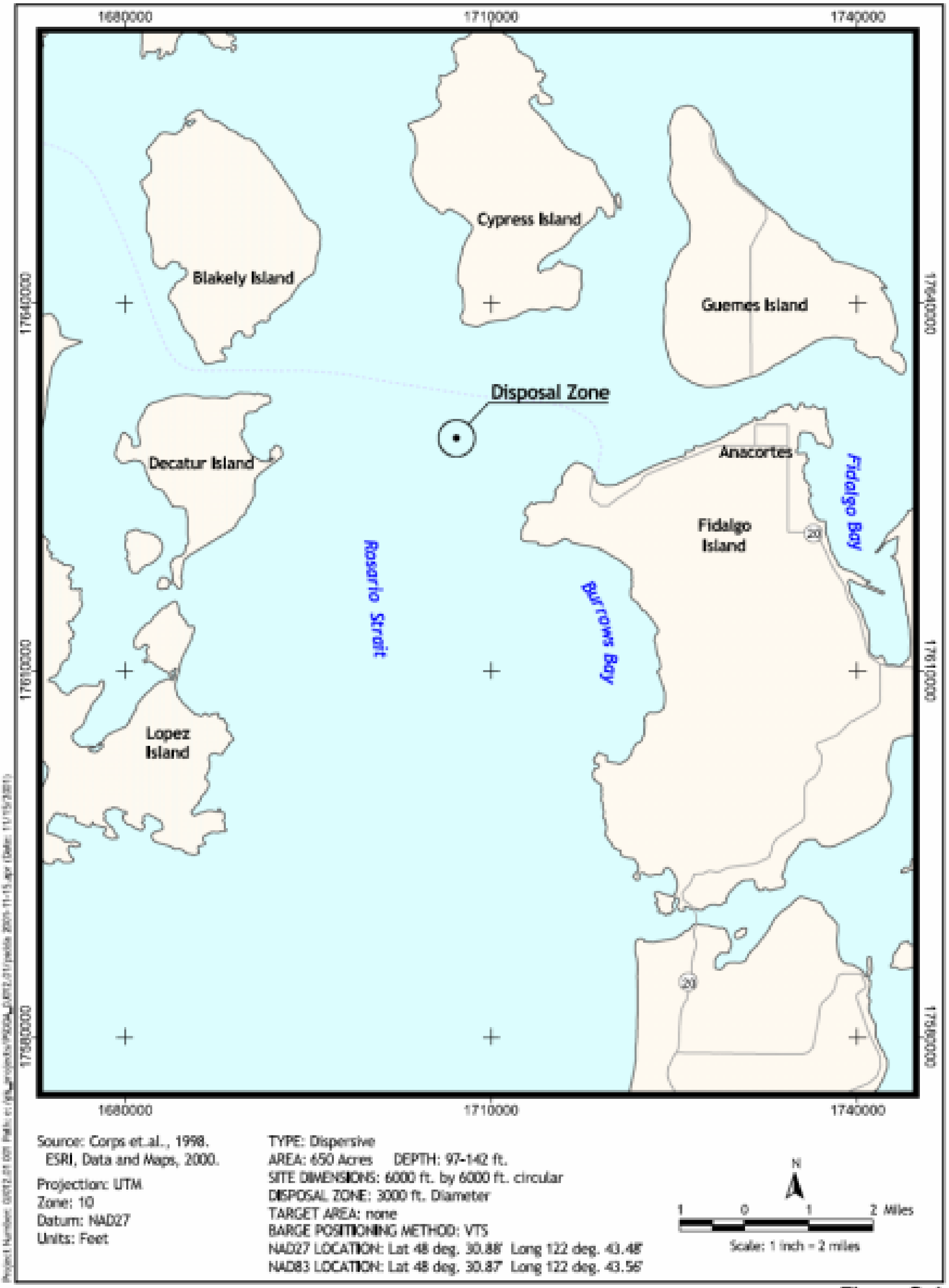
CHEMICAL	CAS (1) NUMBER	SCREENIN G LEVEL	BIOACCU M TRIGGER	MAXIMU M LEVEL
MISCELLANEOUS EXTRACTABLES				
Benzyl alcohol	100-51-6	57	---	870
Benzoic acid	65-85-0	650	---	760
Dibenzofuran	132-64-9	540	---	1,700
Hexachloroethane	67-72-1	1,400	---	14,000
Hexachlorobutadiene	87-68-3	29	---	270
N-Nitrosodiphenylamine	86-30-6	28	---	130
VOLATILE ORGANICS				
Trichloroethene	79-01-6	160	---	1,600
Tetrachloroethene	127-18-4	57	---	210
Ethylbenzene	100-41-4	10	---	50
Total Xylene (sum of o-, m-, p-)	95-47-6 108-38-3 106-42-3	40	---	160
PESTICIDES				
Total DDT (sum of 4,4'-DDD, 4,4'-DDE and 4,4'-DDT)	72-54-8 72-55-9 50-29-3	6.9	50	69
Aldrin	309-00-2	10	---	---
Chlordane	54-74-9	10	37	---
Dieldrin	60-57-1	10	---	---
Heptachlor	76-44-8	10	---	---
Alpha-BHC	319-84-6	---	10 (6)	---
Gamma-BHC (Lindane)	58-89-9	10	---	---
Total PCBs	---	130	38 (6)	3,100

(1) Chemical Abstract Service Registry Number
(2) As no SL value exists to trigger toxicity testing, this chemical will only be evaluated for its bioaccumulative potential.
(3) BT adjusted to new ML for nickel.
(4) BT adjusted to new SL for silver.
(5) See Testing, Reporting, and Evaluation of Tributyltin Data in PSDDA and SMS Programs at URL http://www.nws.usace.army.mil/dmmo/8th_arm/tbt_96.htm
(6) This value is normalized to total organic carbon, and is expressed in mg/kg (TOC normalized).
(7) 2004 SL's based on 1998 AETs.

Appendix B

Disposal Sites

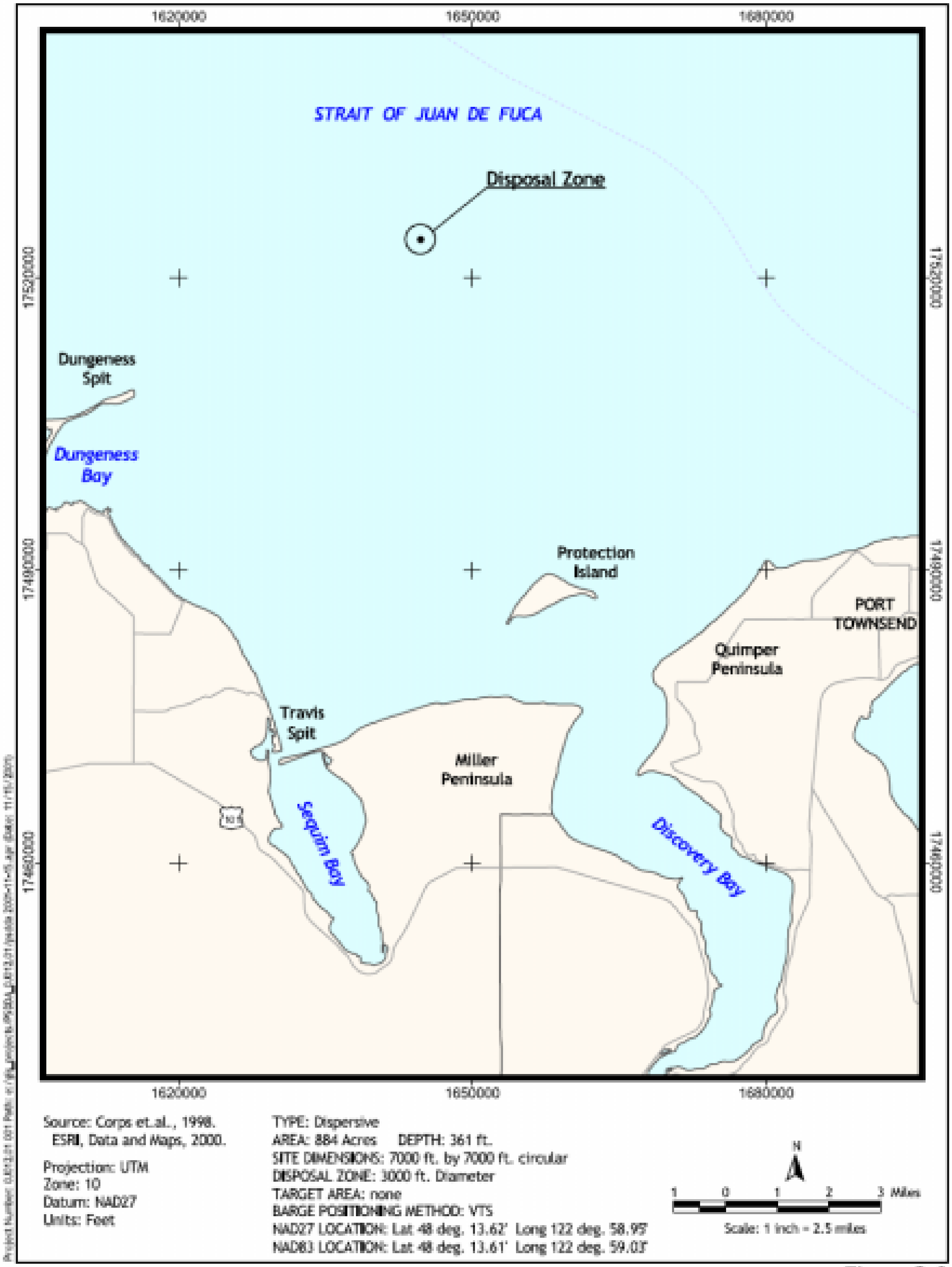
Figure B-1. Rosario Strait Disposal Site



Jones & Stokes

Figure B-1
Rosario Strait Disposal Site

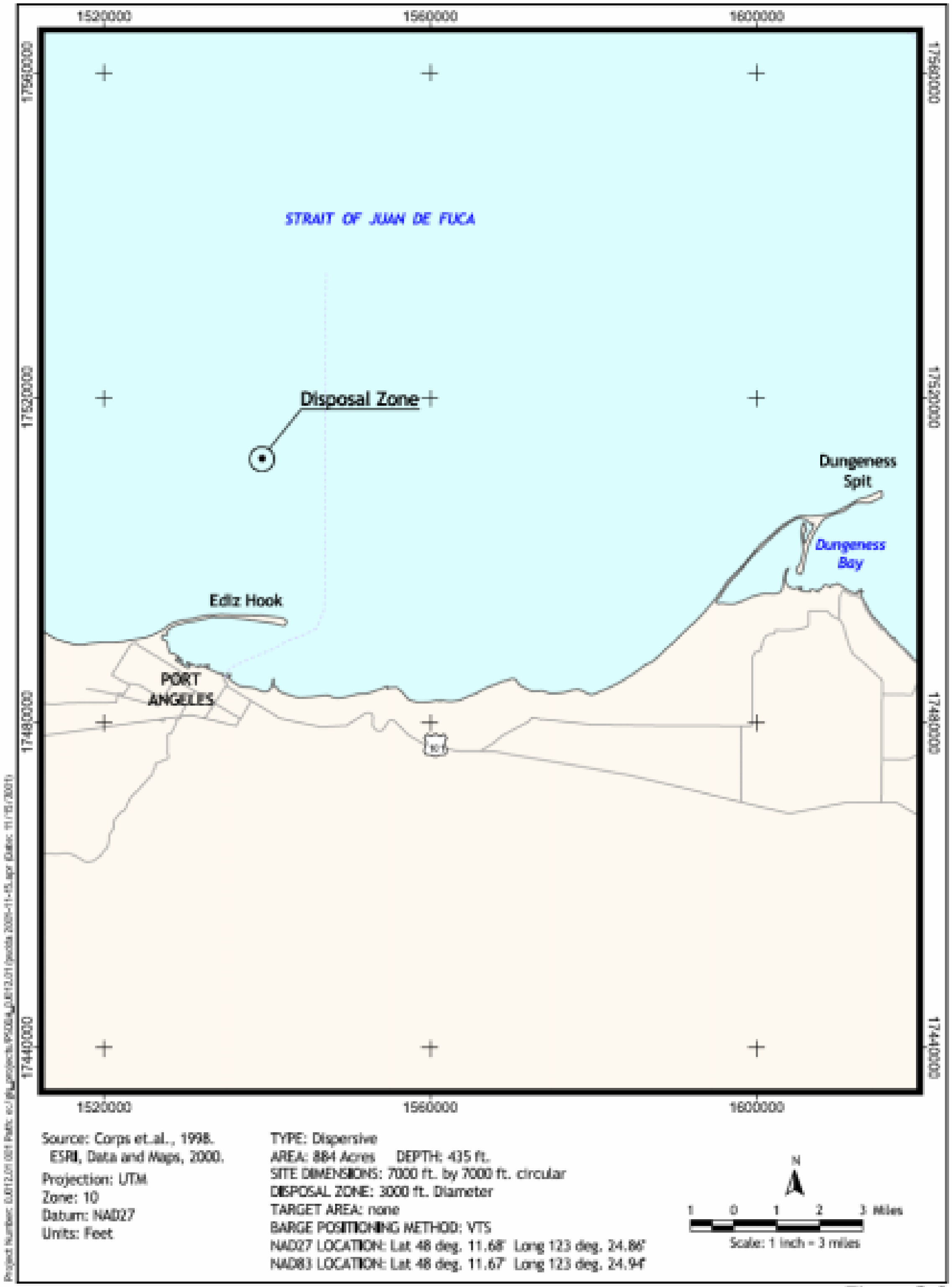
Figure B-2. Port Townsend Disposal Site



Jones & Stokes

Figure B-2
Port Townsend Disposal Site

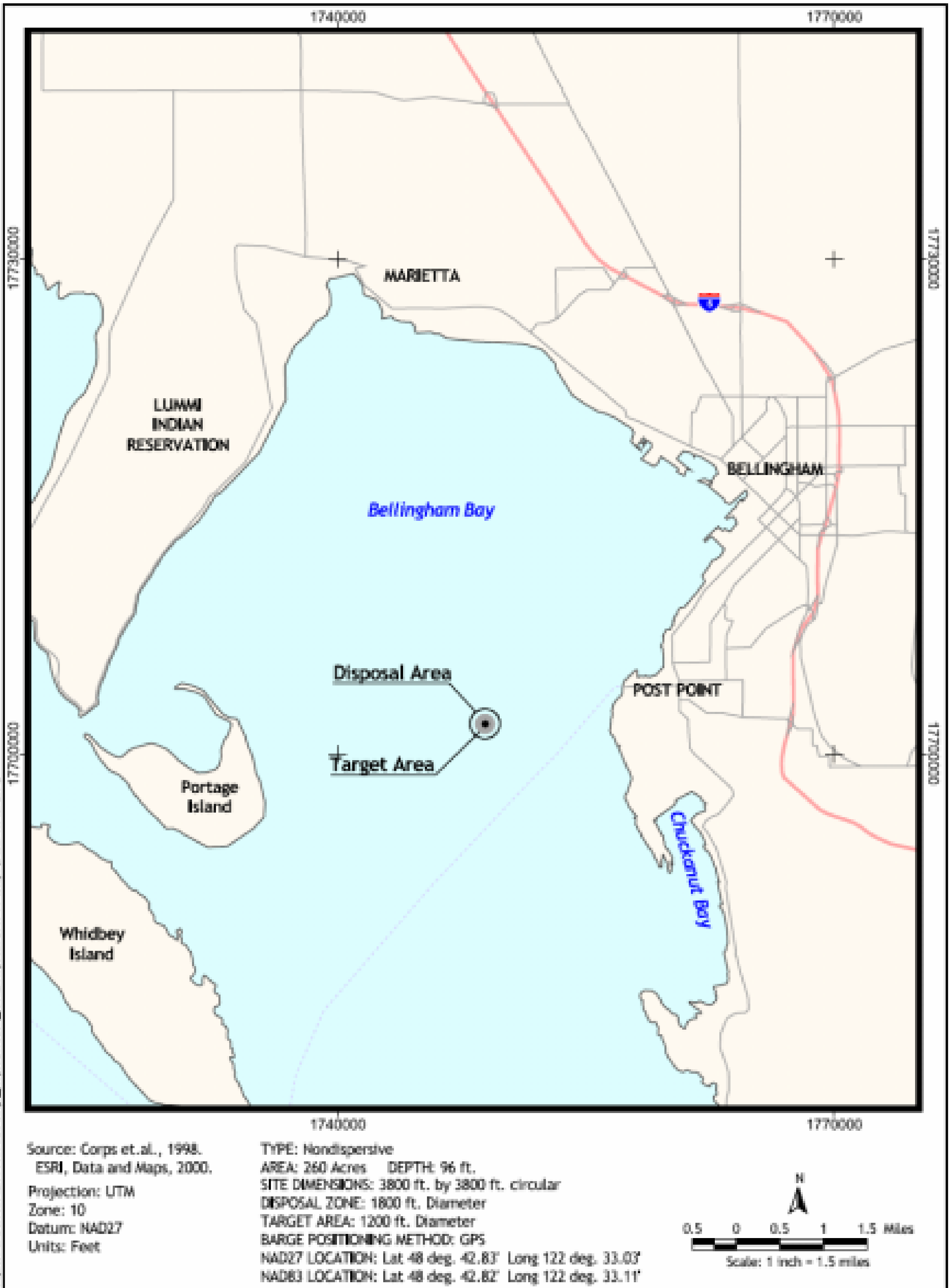
Figure B-3. Port Angeles Disposal Site



Jones & Stokes

Figure B-3
Port Angeles Disposal Site

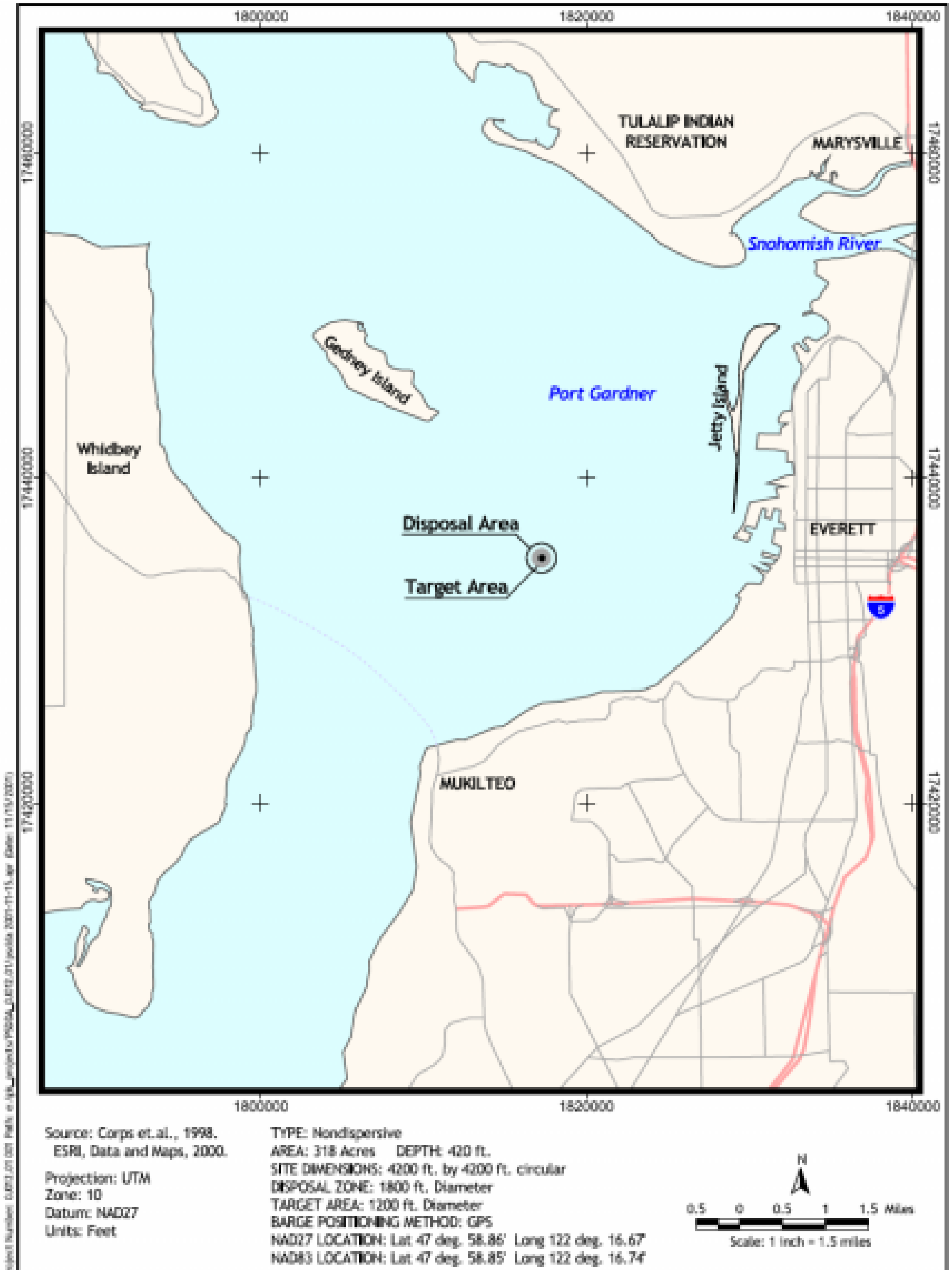
Figure B-4 Bellingham Bay Disposal Site



Jones & Stokes

Figure B-4
Bellingham Bay Disposal Site

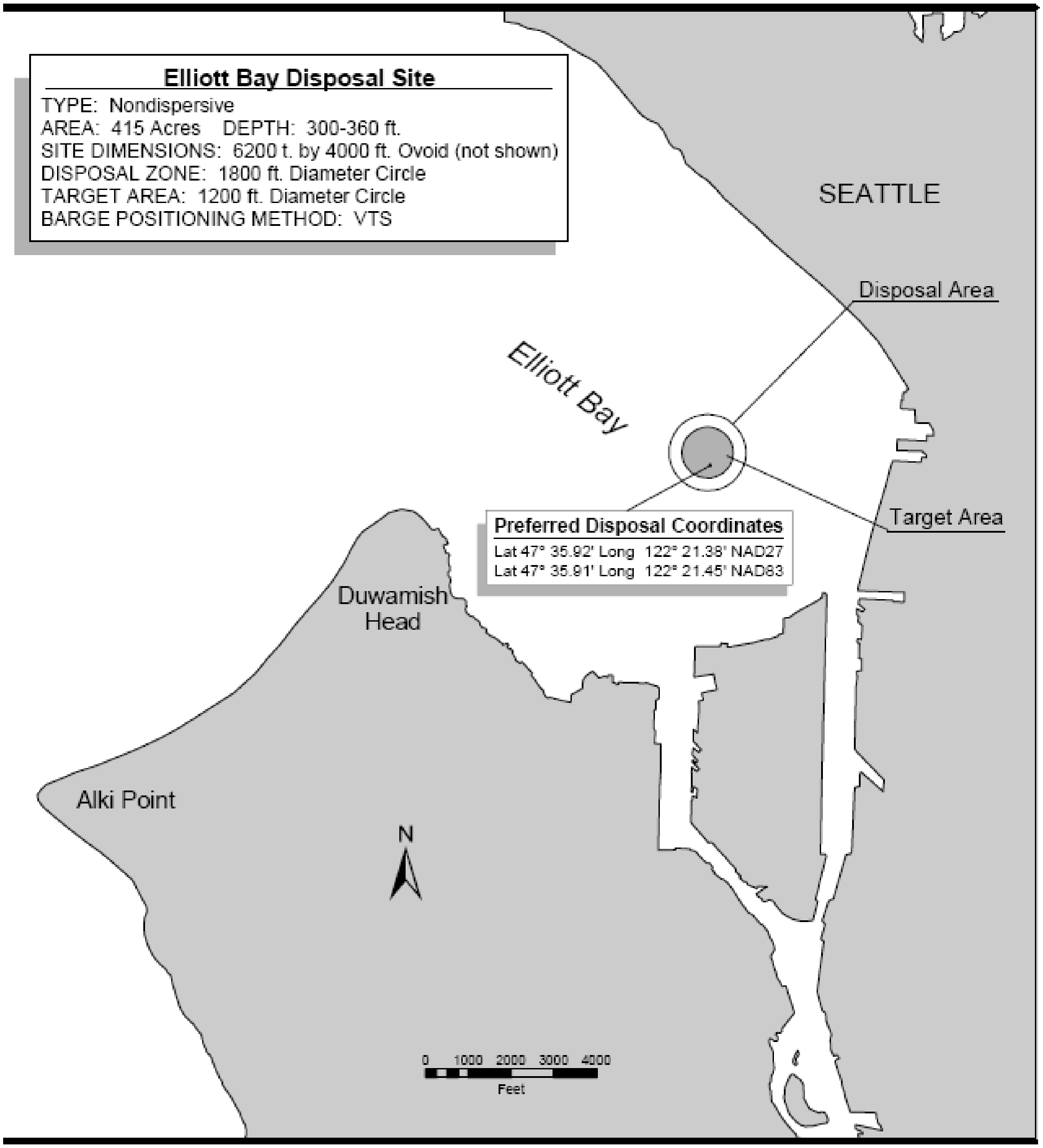
Figure B-5. Port Gardner Disposal Site



Jones & Stokes

Figure B-5
Port Gardner Disposal Site

Figure B-6. Elliott Bay Disposal Site



PURPOSE:

DATUM:

ADJACENT PROPERTY OWNERS:

(1)

(2)

IN

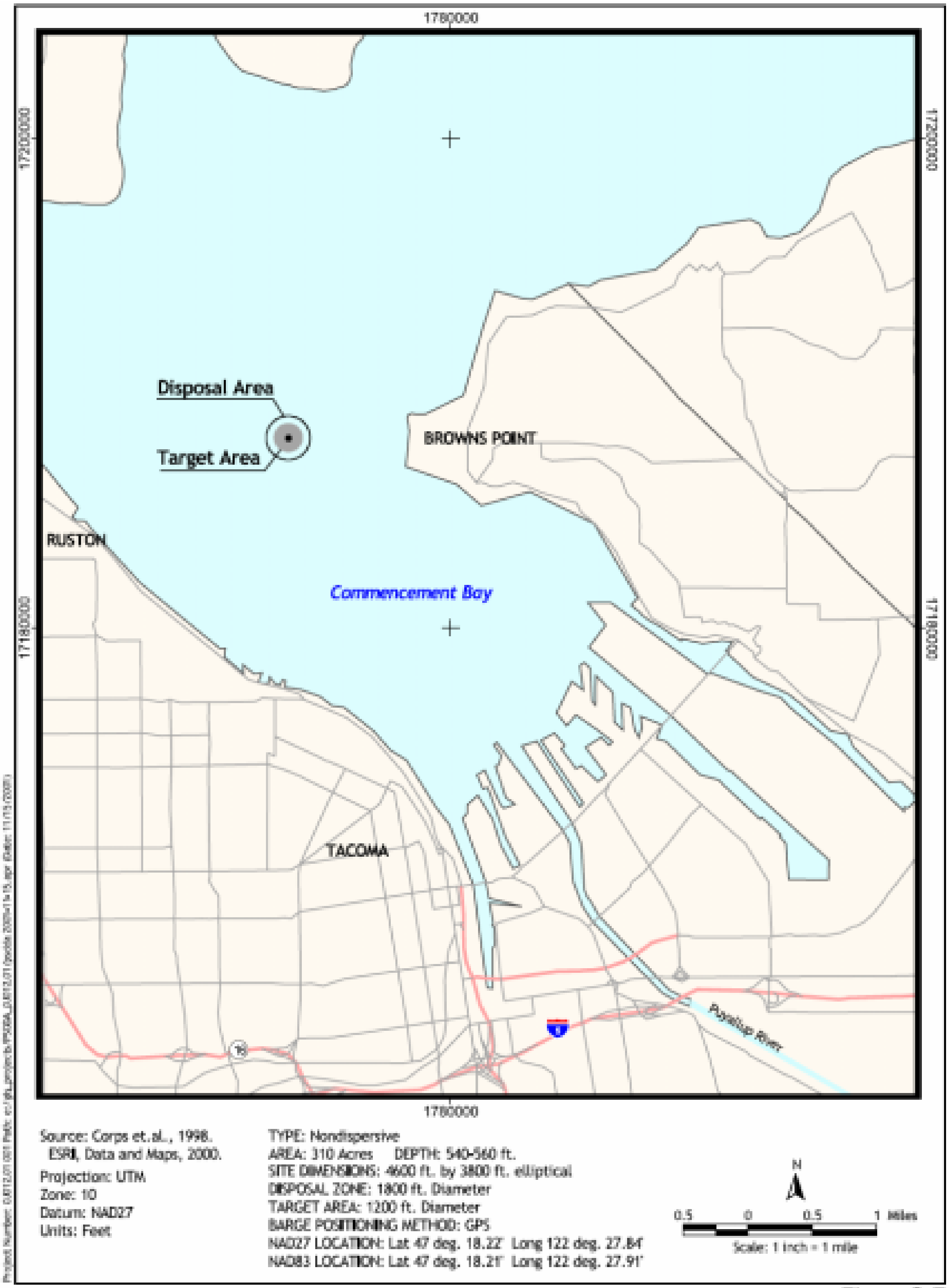
AT

COUNTY OF STATE

APPLICATION BY

SHEET OF DATE

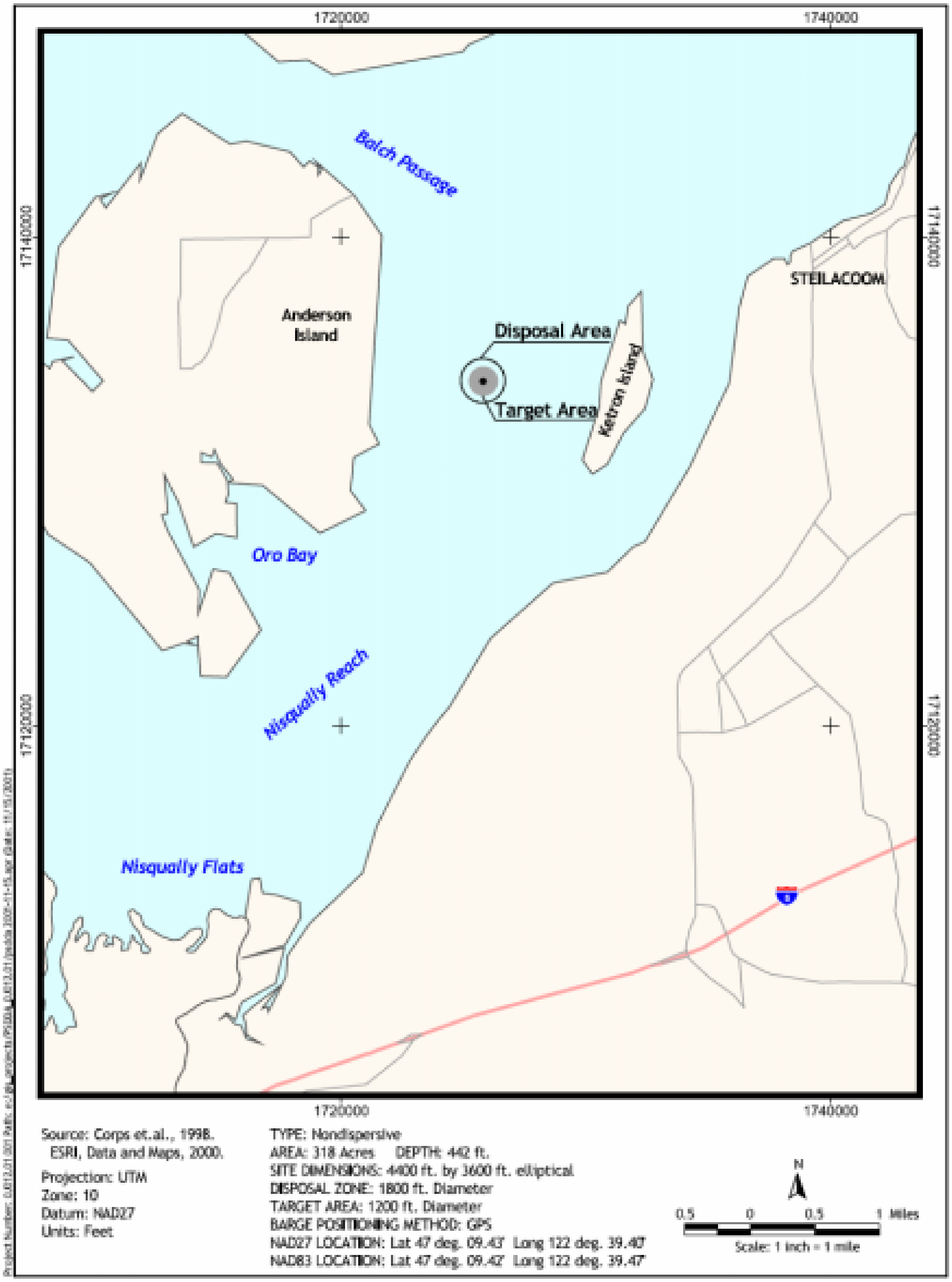
Figure B-7. Commencement Bay Disposal Site



Jones & Stokes

Figure B-7
Commencement Bay Disposal Site

Figure B-8. Anderson/Ketron Island Disposal Site



Jones & Stokes

Figure B-8
Anderson/Ketron Island Disposal Site