WHITE PAPER
Prepared by the Seattle District, Corps of Engineers
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SUBJECT: Supplement to Corps of Engineers March 2005 Biological Evaluation for Puget Sound Dredged Disposal Analysis Program (PSDDA) Dredged Material Disposal Sites: Consideration of Puget Sound Dredged Material Management Program (DMMP) Activities (Specifically Dredging, Transport, and Unconfined Disposal of Dredged Material) As They Affect Bioaccumulation of Contaminants of Concern in Southern Resident Killer Whales.

I. OVERVIEW:

The purpose of this information paper is to evaluate potential risks from Dredged Material Management Program activities to the population of Southern resident killer whales (*Orcinus orca*), newly-listed as Threatened and Endangered Species. The risks evaluated are dredging operations, including the act of dredging itself, transport and openwater disposal of dredged material. This information paper is based on a review of literature and current on-going studies of bioaccumulation in killer whales and their prey. Pertinent literature is cited and listed in a reference list at the end of the paper.

This paper supplements the existing Corps' Programmatic Biological Evaluation (BE: Corps of Engineers, 2005 (March)) of the effects of transport and open water disposal at the designated Puget Sound Dredge Disposal Analysis (PSDDA) sites. The BE is incorporated by reference and will be quoted herein. A prior consultation addressing potential impacts to essential fish habitat (EFH) was conducted in 2003; NMFS concurred with that EFH assessment in 2003, and renewed EFH concurrence when it concurred with the 2005 biological assessment (NMFS, 2003; NMFS, 2005a; NMFS Tracking #2005/00484). A brief summary of EFH effects is also presented at the end of this white paper.

This white paper has been prepared to determine whether reinitiation of consultation is necessary based upon the new listing. The 2005 BE at page 52 concluded the following with respect to SRKW:

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

Under the DMMP disposal-site-related effects including toxicity and bioaccumulation are limited to “no unacceptable adverse” effects, as determined through testing for chemistry, toxicity, and (for *persistent, bioaccumulative toxins*, PBTs) bedded bioaccumulation tests, and at times site specific evaluations such as risk assessment are used as tools for making this determination. Sediments with unacceptable levels of adverse effect must be disposed of at an approved upland confined disposal site, or in an approved confined aquatic site. In addition to these topics, the potential effects of vessel noise and turbidity are also briefly addressed to “close the loop” on these issues relative to PSDDA disposal operations.

II. BACKGROUND:

A. <u>Listing and Potential Bioaccumulative Threat</u>
The Southern Resident killer whale (SRKW) was listed as endangered on November 18, 2005 (70 FR 69903). When SRKW was listed, the Corps included analysis of the species in its Biological Evaluation for transport and disposal of dredged material at open water PSDDA sites in March 2005. NMFS concurred with that assessment (NMFS, 2005a), but has since expressed verbal concerns that effects to the endangered SRKW are not specifically addressed (Friedman, Rachel: personal communication, 3/2006).

SRKW are known to almost exclusively consume salmon in Puget Sound, resulting in high levels of PBTs, and in particular polychlorinated biphenyls (PCB).

Several factors may affect SRKW survival and well-being, but chiefly physical disturbance of behavior patterns by boat noise or intrusive boating activities, reduction of food source (chiefly adult resident Chinook salmon), and bioaccumulation of PBTs.

According to Ross, et al., (2000), "The Southern Resident and transient killer whales of British Columbia can now be considered among the most contaminated cetaceans in the world." In the population-level analysis associated with NMFS' proposal to list SRKW, the following reference was made. [1] [The embedded acronyms are: TCDD: tetrachlorodibenzo-*p*-dioxin or sometimes just dioxin; DDT: 4,4'-(2,2,2-trichloroethane-1,1-diyl)bis(chlorobenzene).]

> "On the basis of studies in other mammals, additional adverse health effects of DDT and metabolites, PCBs, dioxins, and furans are possible in killer whales, and even likely in individuals with high exposure. Exposure to mono-*ortho* and di-*ortho* PCB (non dioxin-like) congeners and metabolites may result in effects not mediated by the same biochemical pathways as 2,3,7,8-TCDD, and therefore not predicted by TEQs. Such effects include neurobehavioral, neurochemical, carcinogenic, and endocrinological changes (Ahlborg et al., 1992). Because these types of effects are difficult to observe in wild populations, there is no way to account for such effects in Southern Resident killer whales with available information. Direct assessments of DDT, PCB, dioxin, and furan effects in many species of mammals (as well as fish and birds) have proven these organochlorines to be potent agents of numerous adverse health effects (Eisler and Belisle, 1996; Eisler, 1986; Smith, 1991). For example, Beland et al. (1993) and DeGuise et al. (1995) documented high incidences of tumors, including malignant neoplasms, in St. Lawrence beluga whales contaminated with several organochlorines types, including DDT and metabolites (3.36 – 389 mg/kg lipid weight in blubber), PCBs, (8.3 – 412 mg/kg lipid weight in blubber) and lower levels of dioxins and furans (Muir et al. 1996).
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> "From a population estimated at 500 animals, 18 collected post-mortem had tumors, a rate of 3.6 percent. The possibility that such effects occur in Southern Resident killer whales is relevant to its risk of extinction: an animal fighting an infection or the development of a tumor, one that has neurobehavioral abnormalities, liver disease or an altered endocrine system, or some combination of these effects, will be less fit for survival in the wild."

B. Proposed <u>critical habitat</u>

Critical habitat for SRKW has recently been proposed in Puget Sound for most of Puget Sound, including the Strait of Juan de Fuca and the San Juan Islands (71 FR 34571, June 15, 2006). Aquatic lands and water at depths less than 20 feet below extreme high tide are excluded, as are military properties, and Hood Canal.

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[1] http://www.fakr.noaa.gov/protectedresources/whales/killerwhales/attachmentb.pdf

NMFS (2005b) proposed three primary constituent elements (PCEs) for southern killer whale critical habitat. These are:

(1) Water quality to support growth and development;

(2) Prey species of sufficient quantity, quality and availability to support individual growth, reproduction and development, as well as overall population growth; and

(3) Passage conditions to allow for migration, resting, and foraging.

There is some potential at some locations that dredging and disposal operations could have an effect on each of these PCEs. This paper addresses in detail the pathways and exposure risks of bioaccumulation in salmon, the principal prey of southern resident killer whales (PCEs 1 and 2). It also addresses the potential effects of vessels, and dredging and disposal, on fish movements, as well as killer whale behavior (PCE 3). See sections V and VI for these analyses, which pertain as much to the animals as it does to habitat. It is worth noting here that should there be dredged sediments that contain minor amounts of contamination (but at levels that pass PSDDA criteria for open-water disposal), it is our considered opinion that removing these sediments from shallow water (where juvenile salmon most often feed) to deep-water disposal sites, in many cases several hundred feet deep, makes it much less likely that salmon would encounter these contaminants.

C. Life History and Environmental Baseline of Southern Resident Killer Whale

Killer Whales are the most widely-distributed marine mammal and are classified as top predators in many marine food webs. Three distinct forms of killer whales, termed as residents, transients, and offshores, are recognized in the northeastern Pacific Ocean. Although there is considerable overlap in their ranges, these populations have little or no membership interchange (Barrett-Lennard 2000). Important differences in ecology, behavior, and morphology also exist (Ford et al. 2000).

The Southern Resident killer whale assemblage contains three pods – J pod, K pod, and L pod – and is considered a stock under the Marine Mammal Protection Act. Their range during the spring, summer, and fall includes the inland waterways of Puget Sound, including south Sound areas of Nisqually Reach and Budd Inlet, Strait of Juan de Fuca, and Southern Georgia Strait. [2] 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, although Balcomb (2006) recently published the results of a three year study in which he asked the public for killer whale sightings during the winter months. He found that all three pods of the Southern Residents tend to stay in Puget Sound and lower Georgia Strait through early winter (December). By January, they have moved to the coast of Washington and south to central California. In mid-February, they begin a northward migration and are back to Washington and British Columbia waters in March.

Both Northern and Southern Resident killer whales experienced population declines in the mid-1980s and mid-1990s. During a presentation of the 2006 Symposium on Southern Resident Killer Whales at the NOAA Regional Center in Seattle, Washington (April, 2006), John K. B.

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[2] Orcanet, 2006. www.nwfsc.noaa.gov/features/kwsightings.com.

Ford postulated that these declines were not coincidental, but that both are positively correlated with declines in Chinook salmon populations. These declines are also potentially a result of global warming, increased shipping traffic and boating-related disturbance, coastal development, wild salmon loss, increased salmon farming and pollution (Taylor and Plater, 2001). The increase in boat traffic and industrial activity in the killer whales habitat has caused changes in killer whale behavior, leading to distress, lost foraging opportunities, even abandonment of microhabitats, loss of sleep, and reduced immune function (Williams, et al, 2001). The authors indicated it is too soon to draw a correlation between boat traffic effects and long-term declines in killer whale populations.

D. SRKW Prey

Numerous behavioral and population research has been conducted since the 1970's. Salmon comprise the vast majority of the Southern Residents' diet from May through October—96% of the diet consists of salmon (Ford, et al, 1998). Chinook salmon (*Oncorhynchus tshawytscha*) comprised 65% of salmonids and were selected (May-August) out of all proportion to their availability relative to other salmon species (Coho (*O. kisutch*) and pink salmon (*O. gorbuscha*)), which greatly outnumber Chinook (millions versus ~150,000) (Ford et al. 2000; 2005). Chinook is also the preferred prey of the northern resident killer whale stock (Ford, 2005). Chum salmon (*O. keta*) become the primary salmonid in the diet September-October once the other species of salmon return to the rivers to spawn, especially of the SRKW. Very little is known about the species of fish eaten by SRKW during other months of the year. Nevertheless, because of the selectivity for salmon, and Chinook salmon in particular, during the months when adult salmon are present in Puget Sound environs, this paper will focus on the pathways and exposures by which salmon could bioaccumulate contaminants as a result of dredging, transport of dredged material, and open water disposal of dredged material.

Ford (2005) showed that both Northern and Southern Resident killer whales eat Chinook salmon in Puget Sound preferentially, because Chinook dietary intake is out of proportion to the salmon's relative abundance in the fishery. This may be a primary cause of the high contaminant levels found in SRKW. Chinook salmon appear to gain the majority of their body load of PCB (and possibly other bioaccumulating) contaminants in Puget Sound, as opposed to freshwater streams (O'Neill, et al, 1998). "Resident" Chinook that remain resident in Puget Sound instead of migrating to the open ocean have a much higher body burden of PCBs and PBDEs than other salmon (O'Neill, et al, 2006).

III. Action Area: PSDDA Disposal Sites

Given the wide distribution of PSDDA sites (for which, see the BE which is incorporated by reference), 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 all of the PSDDA sites 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. These sites are managed as described in the BA, including monitoring of site chemical and biological properties to assure that the site conditions remain within the programmatic and Comprehensive Conservation Management Plan goals.

IV. PSDDA Testing Procedures

The PSDDA Users' Manual [3], located at the following URL, is incorporated by reference and was considered in the NMFS approval of the Programmatic BE. This document describes dredged material testing procedures.

The DMMP has actively sought to update the list of PBTs that are chemicals of concern. [4] The most recent list of PBTs follows.

Table 1. Current DMMP List of Chemicals of Concern for Bioaccumulation

Metals/Organometals:	**PAH:**
Arsenic	Pyrene
Cadmium	Fluoranthene
Chromium	**Phenols:**
Copper	Pentachlorophenol
Lead	**Volatile Organic:**
Mercury	Hexachlorobenzene
Nickel	**Pesticides:**
Selenium	Alpha-Benzene Hexachloride
Silver	Chlordane
Tributyltin	DDT (total)
Zinc	**Other:**
	PCB (total)
	PCDD/PCDF
	(Potentially other chemicals)

Polychlorinated dibenzo-p-dioxins (PCDD) and furans (PCDF) are a compounds of concern for special areas, which are determined by review of nearby sources and historic databases. In a recent project for the Port of Olympia, for instance, sediment testing for PCDD/F was required. (Below, we discuss how the programmatic response for that project proceeded.)

Another suite of compounds of concern for marine mammals and cetaceans in particular include polybrominated diphenyl ethers (PBDEs); which may be added in future as part of programmatic updates. [5]

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[3] http://www.nws.usace.army.mil/publicmenu/Attachments/040226%20UM1.pdf

[4] http://www.nws.usace.army.mil/publicmenu/DOCUMENTS/BCOC_TS.981.pdf, http://www.nws.usace.army.mil/publicmenu/DOCUMENTS/BCOC_Technical_Appendix_090804.pdf, http://www.nws.usace.army.mil/publicmenu/DOCUMENTS/revisedSL_MLtable1.pdf

[5] This compound suite will be considered in future DMMP programmatic updates but, at this writing, insufficient information is available to complete an analysis. For example, Striplin Environmental Associates (2004) noted that there are analytical difficulties in reaching target detection limits for PBDEs; however, no detections occurred in the urban Elliott Bay PSDDA site chemistry. http://www.nws.usace.army.mil/publicmenu/DOCUMENTS/EB_2002_BCOC_Analysis.pdf

Bioaccumulation testing of is conducted on representative benthic organisms (marine worms and mollusks) against reference area sediments and statistical significance is determined with a one-tailed test at an alpha level of 0.1. Statistical significance from reference plus exceedance in the test organism of Target Tissue Levels causes failure of a Dredged Material Management Unit (DMMU).

The protocol in the DMMP for decision-making is as follows, using PCB as an example.

- Below the sediment screening level of 130 µg/kg (dry wt), there is no reason to believe that adverse impacts to benthic biota would occur.
- Between 130 µg/kg (dry wt) and the sediment bioaccumulation trigger (BT) of 38 mg/kg (OC normal), benthic toxicity testing alone determines the suitability of materials for open-water disposal.
- Above 38 mg/kg (OC normal) and 3.1 mg/kg (dry wt), results of both bioaccumulation <u>and</u> benthic toxicity testing must meet be less than or equal to the TTL. The TTL for PCB was derived for Human Health, and is 0.75 mg/kg wet wt (DMMO, 1999).

The other relevant decision logic for a compound of particular significance for SRKW follows. For DDT+DDE, the ecologically-based BT for sediment is 50 µg/kg dry wt, and the TTL is 3.0 mg/kg wet wt.

There is currently no BT nor TTL for PCDD/F. A different evaluation paradigm is being used. (See Section IV-C-2 below.)

With respect to potential uptake into the benthic → pelagic food web, this is deemed to be a protective procedure, consistent with the NMFS' 2005 concurrence letter on the BE. For further analysis, see Section IV.

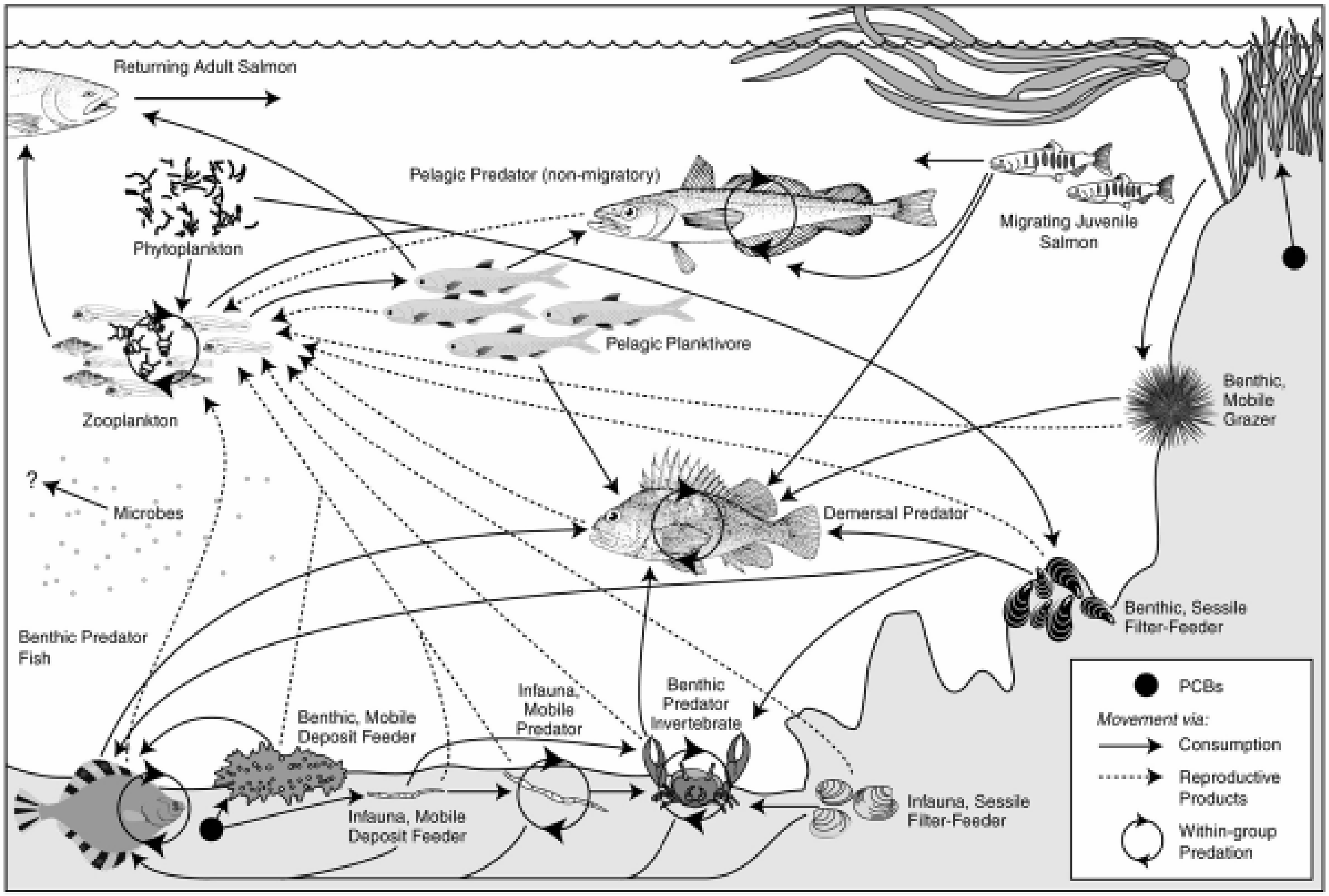
V. Exposure Pathways for SRKW

This paper will assess whether dredging, and subsequent transport and disposal of dredged material at an open-water site, leads to increased risk via bioaccumulation in the critical SRKW food species, Chinook salmon. In this section, potential pathways of contamination are examined. The following pathways to salmon are discussed: benthic, pelagic (Collier, 2003), and water-borne; and at least three anthropogenic pathways: dredging, transport of dredged material, and open-water disposal of dredged material.

A. <u>Benthic and Pelagic Trophic Pathways</u>

Figure 1. Conceptual model for cycling of organic compounds such as PCB and PCDD/F. (Source: http://www.psat.wa.gov/shared/PSAT_Recommendations_Final_10_03.pdf) citing Figure 3-1 from O'Neill and West.

Figure 3-1: Conceptual model for PCB cycling in the lower food web of the Puget Sound aquatic environment (courtesy of J. West and S. O'Neill of WDFW).



Hundreds of potentially toxic chemicals are present in Puget Sound sediments, including pesticides, metals, PCBs, DDT, PBDEs, and PCDD/F. Benthic invertebrates that live in the sediments bioconcentrate these contaminants through contact with the sediments. Benthic invertebrates are important prey items for numerous taxa, which may lead to bioaccumulation at higher trophic levels (Hall, 2002).

Phytoplankton form the base of Puget Sound's ecosystem. Heavy metals and organic pollutants are absorbed by plankton and biomagnified to significant concentrations at higher trophic levels (Bard, 1999, in Hall, 2002). Plankton take up chemicals directly from the water through the process of bioconcentration. Zooplankton prey on phytoplankton and further bioaccumulate chemicals, which are further bioaccumulated at the next level of the food web through the consumption of zooplankton by small animals. Filter feeders, such as bivalves and polychaetes, consume large quantities of plankton from the water they filter. Filter feeding bivalves and polychaetes are important prey items for many species, including decapods, asteroids, and gastropods. These in turn comprise important prey items for many species of fish, including juvenile salmon, while residing in Puget Sound.

The ability of chemical contaminants to be bioaccumulated in higher trophic levels, including salmon, pinnipeds, and cetaceans is usually dependent upon the level of bioconcentration and bioaccumulation in benthic invertebrates (Morrison, 1996, in Hall, 2002). Juvenile salmon prey on benthic invertebrates. Since Chinook salmon are a key link in the SRKW diet, their foraging behavior and food preferences are shown below, as summarized by Duffy (2003).

- In general, juvenile salmon shifted from predominantly epibenthic feeding in April-May and at delta sites to more planktonic and neustonic feeding during June-July and at nearshore marine and neritic sites
- Adult Chinook prey composition in South Sound was predominately planktonic crustaceans. Northern Puget Sound Chinook utilized more insects, possibly related to higher stream-flows there.
- Chinook adults fed mainly on crab larvae, euphausiids and hyperiid amphipods..
- Fish constituted only 5-10% of the diet for Chinook and Coho salmon <200mm FL, and piscivory increased with increasing size of the predator.
- Larger Chinook and Coho salmon became more piscivorous at twilight and post-dusk hours, feeding mainly on sand lance and juvenile salmon (Pink and Chum) in April-June.
- Juvenile and subadult Chinook and Coho salmon have the potential to be significant predators on smaller juvenile salmon (Pink and Chum salmon mainly, but also Chinook salmon) during peak outmigration pulses.

In PSAMP findings 1998-2000 (http://wdfw.wa.gov/fish/psamp/findings.htm#_Toc67864.), the following statements are made, with emphasis added:

> "PCBs in Chinook and Coho salmon also correlated positively with tissue lipid concentration. (O'Neill et al. 1995; 1998, Puget Sound Water Quality Action Team,1998) . Unlike English sole, PCB accumulation in adult Pacific salmon, a pelagic migratory species, was not directly linked to contaminated sediments. The body burden

> of PCBs in Chinook salmon smolt from the Duwamish estuary accounted for only approximately 1.1% of the body burden of returning adults. The majority of PCB body burden in salmon is thought to be taken on in the marine phase and total residence time in Puget Sound probably has a strong influence on PCB exposure in Pacific salmon (O'Neill et al. 1998)."

Growing evidence indicates that PCBs flow from benthic food web to pelagic food web via maternal transfer. PCBs are transferred from adult benthic/demersal species to their planktonic eggs, larvae which then biomagnify up through the pelagic food web as higher trophic level pelagic predators consume benthic prey (Duncan et al. 2003, quoting Sandy O'Neill).

B. Direct Water Uptake Pathway.
The key question is whether the PSDDA bioaccumulation protocol focused on benthic organisms is also protective of higher level predators such as SRKW eating adult resident Chinook.

Generally, PSDDA sites are in waters of sufficient depth (90-460 ft) and of such low resource value that Chinook would not likely be significantly exposed to benthos, in particular given their foraging patterns described in the paragraphs above. For pelagic fish such as adult Chinook, direct gill uptake is likely to be the key exposure pathway. This pathway consists of diffusion through the gill's interlamellar water, epithelium, and lamellar blood plasma;

C. Exposure Pathways During Dredging.
Many dredges and similar mechanical excavators have clamshell shaped buckets consisting of hinged jaws with an open top. A clamshell dredge, mounted to a floating barge, lowers a clamshell bucket with cables to the bottom. The weight of the clamshell penetrates the sediment and as the bucket is pulled up, the clamshell closes, "biting" and retrieving the sediment within to the surface where it is loaded onto the barges. A mechanical excavator also works from a barge but the jaws are operated hydraulically from an arm. The barge platforms from which both types of dredges are operated are positioned via a system of anchors and wires or spuds, with or without the aid of tug boats.

Dredging typically results in the release of some sediment to the water column as the bucket contacts the bottom, closes, and is raised through the water column to load dredged material into the barges. Dredging results in pulsed and localized increases in suspended solids to the water column.

The principal water quality impact of dredging is that of increased total suspended solids (TSS) concentrations in waters near the dredging sites. As noted above, sediments may be resuspended into the water column by lowering of the clamshell or other mechanical bucket, impacting the bottom with the bucket, closing the bucket, and raising the bucket through the water column and onto the haul barge. This method of dredging has been documented to produce a downcurrent plume, which in certain circumstances, could extend up to 300 m at the surface and 500 m near the bottom, depending on currents and tides (Gordon 1973; Cronin et al. 1976; Sustar et al. 1976; Williamson and Nelson 1977; Yagi et al. 1977; Nakai 1978; Onuschuk 1982, ALL as cited in LaSalle 1988).

The plumes from clamshell dredging and other mechanical bucket operations are relatively localized and pulsed. The characteristics of the plume (persistence downstream, depth of plume, concentration of TSS) are dependent on several factors including the type of dredge used, the rate at which sediments are dredged, the percent fines in the sediment, stratification of the water, tidal dynamics and currents. This sediment plume is the primary (only?) pathway resulting from dredging that could lead to bioaccumulation of contaminants in salmon. See the section on exposures for an analysis of how bioaccumulation could result from this activity.

The effects of turbidity on anadromous fish can be classified as behavioral, sublethal, or lethal, depending on the level of turbidity (Newcombe and MacDonald 1991). For this analysis, only behavioral effects are addressed, as sublethal and lethal effects have been addressed in the Duwamish Maintenance Dredging BE (Corps, 2005b). The following discussion is included as additional evidence to support the conclusion that the exposure risk to salmon from the dredging pathway is limited. Budd Inlet has seasonal high turbidity levels driven by algal blooms; however, the proposed dredge and disposal window avoids the seasonal period of poor water quality.

Behavioral effects are described as any effect that results in a change of activity usually associated with an organism in an undisturbed environment. These effects include affects to avoidance responses, territoriality, feeding and homing behavior (Sigler et al. 1984, cited in LaSalle 1988). Suspended sediments in the 30–60 Nephelometric Turbidity Unit (NTU) range resulted in a breakdown of the dominance hierarchies of Coho salmon, accompanied by more frequent gill-flaring activity and territorial defense cessation; a return to lower turbidities (0–20 NTU) allowed reestablishment of social organization (Berg and Northcote 1985, cited in LaSalle 1988). Such behavioral modifications may denote impairment of the fitness (sublethal effects) of salmonids populations exposed to short-term, low-level suspended sediments.

It is apparent that salmonids have the ability to cope with some level of turbidity at certain life stages (Gregory and Northcote 1993). Evidence of this is illustrated by the presence of juvenile salmonids in turbid estuaries prior to leaving for the ocean and in local streams characterized by high natural levels of glacial silt, and therefore high turbidity and low visibility (Gregory and Northcote 1993). However, salmonid populations not normally exposed to high levels of natural turbidity or exposed to anthropogenic sediment sources may be deleteriously affected by levels of turbidity considered to be relatively low (18–70 NTU) (Gregory 1992).

Although suspended sediment can adversely affect the visual abilities of estuarine fishes, it should similarly affect a reduction in their vulnerability to predation (Gradall and Swenson 1982; Guthrie 1986; Ritchie 1972; All cited in Gregory 1988). Therefore, it is not surprising that there is a decrease in foraging at very low levels of turbidity, and moderate increases in turbidity are not necessarily detrimental to the survival of young salmonids (Gregory 1988).

It is unlikely that impacts to gills would occur during normal dredging activities, particularly because of avoidance. However, very high levels of suspended solids can erode the gill mucosa and cause phagocytosis of particles of sediments. This impact occurs at levels far above those seen in typical dredging. (La Salle 1988).

D. Transport Pathways.

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 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. The daily production is typically barge limited so only a few barge trips per day typically occur.

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 via leaking barges or spillage on the way to the disposal sites. 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, windborne transport of these types of materials is immeasurable and discountable.

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, and would be insignificant if it did occur.

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.

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 discountable.

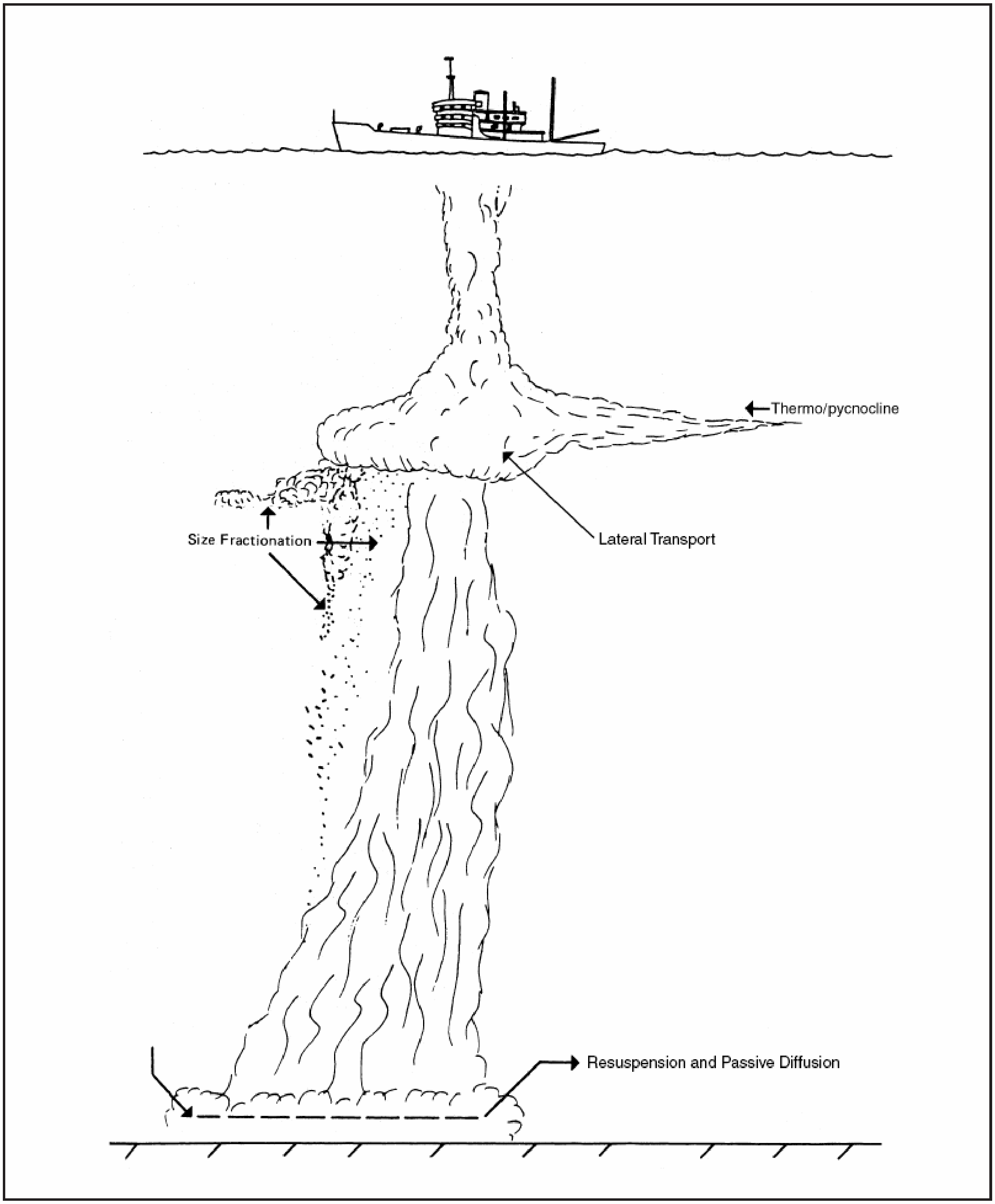
E. Exposure Pathways During Open Water Disposal.

Dredged material disposal activities at the non-dispersive sites are conducted to maintain the dispersion of dredged material in the target zone for the PSDDA nondispersive sites. 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. Subsequent site monitoring verify the dredged material footprint within the disposal site.

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.

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); see Figure 2. 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. These three phases are discussed in detail in Appendix I.

Figure 2. Schematic Representation of the Fate of Dredged Material during Disposal

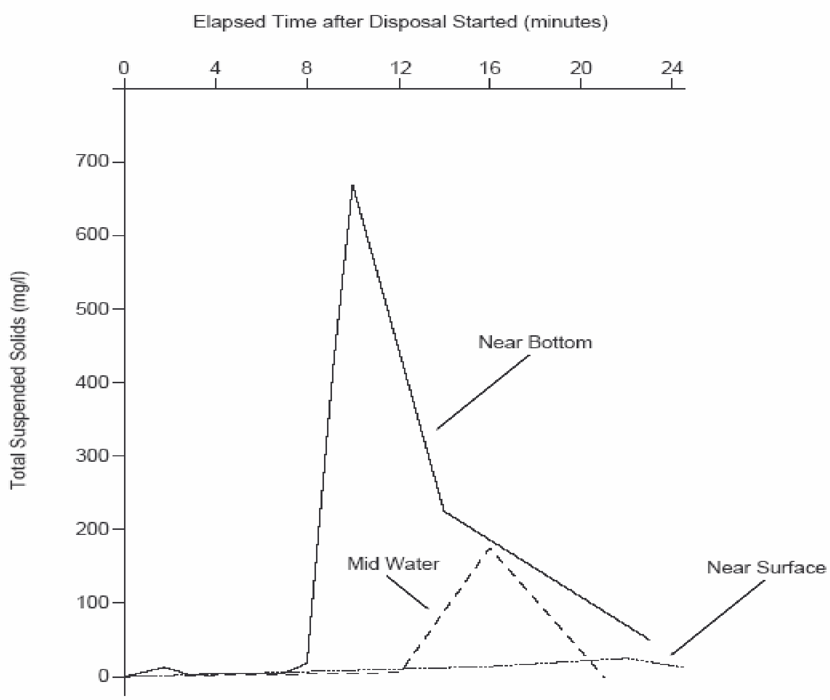


SOURCE: Adapted from Pequegnat 1983.

Disposal of dredged material will result in elevated turbidity levels for a period of a few minutes only. 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 3 illustrates, 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.

Figure 3--Time Series of Total Suspended Solids at Three Depths during Dredged Material Disposal



SOURCE: Truitt 1986 in Corps 1986.

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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 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 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. Therefore, effects to planktonic prey organisms and forage fish are expected to be discountable.

VI. Exposure Risks

A number of conservation measures and procedures are cited in the BE; these act in combination to minimize the potential for exposure to listed species and their prey in Puget Sound. Some of the key ones 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);
- timing of dredging and disposal events to avoid overlap with sensitive migration or life history periods of listed species; and
- use of dredged material testing protocols.

A. Dredging.

Juvenile salmon pass through estuaries on their way to Puget Sound and the ocean, and therefore must, in some cases, pass through shipping lanes and may potentially become exposed to dredging activities.

Adult salmonids are expected to avoid dredged plume areas, 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. Exposure could occur through two avenues: 1) direct contact with the dredged plume, and 2) consumption of contaminated organisms contained in the dredged plume. The former is discountable because direct contact with contaminated materials would only occur for a matter of seconds at most. Prolonged and “intimate contact” with contaminated sediments is necessary before organisms might bioconcentrate contaminants (Hall, 2002). This would not likely occur in the case of pulsed dredging operations and temporary suspension of sediments and organisms in the water column.

Consumption of contaminated organisms, then, is a means by which salmon could be exposed to potential bioaccumulation of contaminants. Juvenile Chinook eat a wide variety of prey in different estuaries and within estuaries (numerous authors, cited in Groot and Margolis, 1991). Chironomid larvae and pupae, *Daphnia*, *Eogammarus*, *Corophium*, and *Neomysis* are all reported prey items. Larger juveniles may also eat adult insects, gammarids, crab larvae, amphipods and small fish (numerous authors, cited in Groot and Margolis, 1991). Juvenile salmon, while passing through an estuary, hug the shorelines at high tide, and move into marsh tidal channels at low tides (Groot and Margolis, 1991). Residence time of a juvenile Chinook in a riverine estuary is approximately 4-6 weeks (Groot and Margolis, 1991).

Assuming juvenile salmon could be present during dredging events, the exposure risk to bioaccumulation of contaminants would be very low, based on the following points: 1) limited time of contact with the dredged sediments in the estuary; 2) limited time of suspension of sediments/organisms; 3) limited availability of organisms (deeper water than juveniles would be in); 4) limited feeding duration in sediment plume; 5) therefore, limited number of organisms consumed; and 6) timing of dredging is set to avoid presence of juvenile salmon.

1) Compared to the amount of time salmon live in Puget Sound and the ocean, 4-6 weeks in the estuary is insignificant, representing roughly 4% of their time away from fresh water (assuming a 3-year residency in marine waters). Thus, even if a juvenile salmon were exposed to contaminated prey for a full 6 weeks in the estuary, it would result in about 4% of its body burden. O'Neill (1998, 2006) points out that salmon pick up the great majority of their body burden of contaminants by feeding in shallow (<60 ft MLLW) marine waters.

2) Assuming a dredge operates continuously throughout the daylight hours, suspended sediments may be present in the water column in various concentrations throughout the day. However, tides and currents carry the suspended sediment away from the dredge, and cause it to dissipate. The rate of dissipation also depends on the percent fines in the sediment as well as stratification of the water. The proposed dredging window avoids seasonal periods of poor water quality, thereby not significantly increasing dissolved oxygen deficits that could be biologically adverse. Suspended sediment and water quality will be monitored during dredging to assure compliance with provisions of a State 401 Water Quality Certification.

3) Maintenance dredging normally takes place in the shipping channels, typically more than 100 feet from shore and in depths of 15-50 feet. However, there are exceptions, such as at Olympia harbor, where berth dredging is adjacent to shore and in shallower water. Juvenile salmon tend to stay close to shore, in relatively shallow water. Thus, it is unlikely that a juvenile salmon would come into contact with a dredge plume, unless the dredging occurs in shallow water relatively near shore. This could happen if an area is being dredged for the first time, for a new harbor or marina, or new shipping channel; or, as in the case of Olympia harbor, a cost-sharing sponsor will dredge the berthing areas in association with a Federal navigation project, and is therefore becomes a Federal responsibility.

4) The sediment held in suspension as a result of the dredging activity will not stay in one location for long, as currents, tides, and general water movement will act to keep the suspended sediment moving. Given that juvenile salmon have been demonstrated to avoid turbidity when able to do so (Sigler et al. 1984, cited in LaSalle 1988), they would avoid any suspended sediments that would approach them. This may require a brief time of swimming through the plume in order to "get to the other side", and it is possible they may even consume some prey items while doing so (though if in fact their behavior is being driven to escape the plume, it seems unlikely they would be looking for prey while trying to escape the suspended

sediments). Thus, it seems highly unlikely that juvenile salmon would be exposed to suspended sediments for more than a few minutes at a time.

5) Since it is unlikely that juvenile salmon will spend more than a few minutes in a dredge plume, the number of contaminated prey items they could eat will be correspondingly small.

6) Points 1-5 above all assume the presence of juvenile salmon during dredging events. Dredging activities are typically timed to AVOID the times when juvenile salmon would be present. Therefore, as points 1-5 give strong evidence that dredging activities are unlikely to increase the exposure of juvenile salmon to bioaccumulation of contaminants, even if they were to be present during the activity, then it becomes a discountable chance that juvenile salmon could increase their body burden of contaminants during dredging events that occur when juvenile salmon are absent from the area.

B. Transport and Disposal.

The discussion under pathways of transport already indicate that exposures to salmon from wind-blown or spilled transported dredged material is immeasurable, and therefore discountable.

Turbidity levels from disposal of dredged material 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. Figure 42 illustrates the relatively short duration of elevated suspended sediment concentrations in the water column at a non-dispersive site. Total suspended sediments at the middle and upper depths remained elevated for about 12 minutes. Which means that exposures to the most concentrated suspended sediments is even less than calculated above, which is based on a 30-minute exposure.

Effects of increased suspended sediment concentrations on salmonids may also include reduced foraging success and deterrence from migratory paths. 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.

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. Thus, daily exposure to water column contaminants are typically no more than 2.5 hours (5 disposal events X 30 minutes per event). Therefore, exposure of listed species to significant levels of contaminants is not expected.

Adult salmonids are expected to avoid disposal plumes readily, while juveniles would be less able to avoid such areas—though in fact juveniles are highly unlikely to be present in the deep-water shipping lanes and at PSDDA sites that are generally several hundred feet in depth. Timing restrictions are in place for transport to and disposal at PSDDA open-water disposal sites to reduce the potential for exposure of fish at sensitive life stages. This will reduce impacts to a discountable level.

In addition, the disposal sites were selected to minimize impacts to commercial invertebrate and fish resources. Any exposure to contaminants would be of a very short duration in the water column (less than 30 minutes per disposal event—see Figure 2) through direct contact with contaminants following disposal as fish move through the plume (sediment-bound contaminants associated with suspended sediments may dissolve in the water column and result in impacts to water quality).

While it is probable that some adults may swim through a dredged disposal plume (or be "caught" in the plume as it is released over the fish), there is therefore a likelihood that salmon in a dredged disposal plume would consume organisms in the brief time they are available in the water column. However, the impact is likely extremely low, since the time-course of uptake of the contaminants by the pelagic prey organisms is much longer than the short duration of the presence of the plume. The very limited time frame in which an adult salmon could consume organisms that have contacted the plume means that the bioaccumulation potential—especially in comparison to the high body loads the adults already have from several years residency in marine waters—is likely immeasurable by laboratory methods. In feeding experiments, it takes weeks for penned salmon fed diets containing neutral organic compounds to come to a steady state with the concentrations in the food. Furthermore, dredged material that contain higher levels of contaminants that do not pass PSDDA open-water disposal guidelines are disposed at Washington Department of Ecology approved confined disposal sites in upland or nearshore confined areas.

C. Long Term Conditions at the Dredged Material Management Site.

This evaluation considers the longer-term release pattern that would be expected to the water column after sediments have been placed. However, the conclusions are relevant also to the somewhat higher releases during dredging but very short exposure times. PCB and PCDD/F are considered in particular, given their potential pathogenic importance to the SRKW evolutionary unit.

The DMMP bioaccumulation protocol (described in paragraph C2 below) is intended to assure that sediment placed at PSDDA sites does not cause a significant increase in benthic body burdens for PBTs. We will evaluate whether bioaccumulation protocols for PCB and PCDD/F are protective, given these compounds' suspected role in SRKW health and vitality. In the BE (cited in Section 1 – Overview), a reason was given for lack of linkage of orca food to the sediments. However, from recent information cited above, it appears that there is a developing consensus that the linkage is somewhat stronger than previously thought, and comprises maternal transfer through larval stages which are rich in lipids and therefore may transport PCB in the trophic web.

This section will qualitatively evaluate the comparative risk of use of dredged material sites within program constraints versus non-placement of dredged material at the sites.

1. *Comparative Risk Assessment*. Since body burdens for pelagic species such as Chinook salmon are obtained across a large area, which may include both multiple dredge sites and disposal areas, this discussion is necessarily a Comparative Risk Assessment (CRA). This paragraph describes the status of CRA, relying upon a review of the subject by Cura and McArdle (2001). EPA is attempting to apply the past decade's experience and lessons learned in CRA within the developing context of the USEPA Science Advisory Board's (SAB) Integrated Environmental Decision Making (USEPA, 1999). Integrated Environmental Decision Making (IED) is SAB's response to EPA's charge to revisit its 1990 report, Reducing Risk. The IED report updates and extends the thinking about how science can best inform and serve the decision making process.

For ecological risks, SAB focused primarily on USEPA's stressor-effects model. The proposed SAB Ecological Risk Ranking Methodology proceeds by:

- Determining the potential ecological importance of each stressor at the ecosystem or landscape level for the ecological systems at risk;
- Transforming stress-effect relationships into a relative ranking of risk at a specific scale (regional, national, global);
- Determining relative risk by comparing scores across the stressors and grouping scores in qualitative categories (very high, high, medium, and low relative risks).

The SAB identified the stressors that pose potential ecological risk and the set of ecosystems for consideration. The stressors included individual chemicals, chemical classes, biological stressors such as introduced species, and physical stressors such as habitat alteration. They then developed stressor profiles that plotted the estimated frequency with which that stressor occurred at low, medium and high levels of intensity. The "level of intensity" is related to the distribution of the stressor in the environment on a national scale. The levels are relative. That is, a stressor profile equated high intensity to the highest levels that a stressor occurs in the environment, not the level or levels at which various effects might occur. The document does not define "high", "medium", or "low", nor does it explain how the authors derived the frequency distribution of a stressor.

The method then overlaid these stressor profiles onto an effect profile that relates the intensity of ecological effects (high, medium, low) to each stressor level. The method defines the intensity of ecological effects as:

- high – those involving major changes to the structure, composition, and/or function of the system;
- medium – significant changes in the ecosystem's structure, composition, or function; and
- low – detectable changes that are not significant.

However, these definitions appear to beg the question of what is major versus what is significant. As Menzies and McCarthy (*in* Cura and McArdle, 2001) summarize via review of a number of EPA Regions and State experiences with CRA, the latter determination is value-driven. As an example, EPA Region 2 utilized the following ranking procedure:

Group members scored an assigned problem area based on four criteria:

- Intensity of impact - a subjective evaluation of the severity of effects on ecosystems based on available hazard information and exposure levels. The evaluation endpoints depended on the ecosystem under consideration and included such widely varying parameters as primary production, diversity, habitat loss, etc.

- Scale - indicates how widespread the work group judged the ecological effects from a given problem with the assumption that more widespread effects are of greater concern than localized problems;

- Value - accounts for threats to areas of high ecological importance such as areas of high diversity or production, spawning areas, migration areas, etc.

- Uncertainty - scored as a qualitative descriptor (low, medium, and high) with no corresponding numerical expression.

Preliminarily applying this approach to the SRKW bioaccumulation and evolutionarily-significant unit population trajectory:

- Impact intensity to the SRKW pods are currently be *high*, as local orca population extinction is predicted in the listing documents based upon current presence of high levels of PCBs and other PBTs in orca body burden.
- The scale of the impact is the range of the affected SRKW pods, which range over a considerable distance in Puget Sound, as do their principal food, resident Chinook. The impact is regional and even multinational. This would likely score *significant* according to the ranking in the SAB Report.
- Value. Since this cetacean is a top marine predator, it integrates PBTs from wide areas and its absence could alter bioenergetics over a wide area. The orca is a cultural icon as well. This would likely score *significant*.
- Uncertainty in the means by which individual *sites* or areas of sediment contamination influence the overall bioaccumulation of PBTs for orcas is clearly *high*.

The listing as endangered supports the first three points. Focusing on the discussion of uncertainty, the link to a *site-related* activity such as dredging appears to be tenuous.

2. *PCB.*
As noted in Duncan et al. (2003), quoting Alan Mearns of NOAA and Sandy O'Neill of WDFW and Puget Sound Ambient Monitoring Program.

> "The data on PCBs, for example, indicate that only a few areas (Bremerton, Seattle, off the north end of Maury Island, Commencement Bay, Everett, Bellingham Bay, and potentially off the northwest end of San Juan Island have concentrations that exceed 150 ppb [in sediment]. The take-home story from the MARPLOT output is that looking at all the sites in Puget Sound, the problem isn't "all of Puget Sound," but rather a few locations, specifically in a few estuaries."
>
> "…In Puget Sound water flow is predominantly from Whidbey and Admiralty Inlet Basins into the Central Basin where it is retained for long periods of time due to the basin's morphometry. The Whidbey Basin receives a lot of contaminant input from the city of Everett, which is routed into the Central Basin where it accumulates. Inputs from the Admiralty Inlet Basin are relatively low due to its underwater sills and greater water circulation that keeps it flushed of contaminants. Organism retention in each basin is also a function of hydrology and basin morphometry with organisms in the Central Basin being retained for long periods of time. Consequently, organisms in the Central Basin are exposed to higher concentrations of contaminants over longer periods of time compared to organisms in the other Puget Sound basins."

Further, from the same paper, based upon information from Eric Crecelius of Battelle:

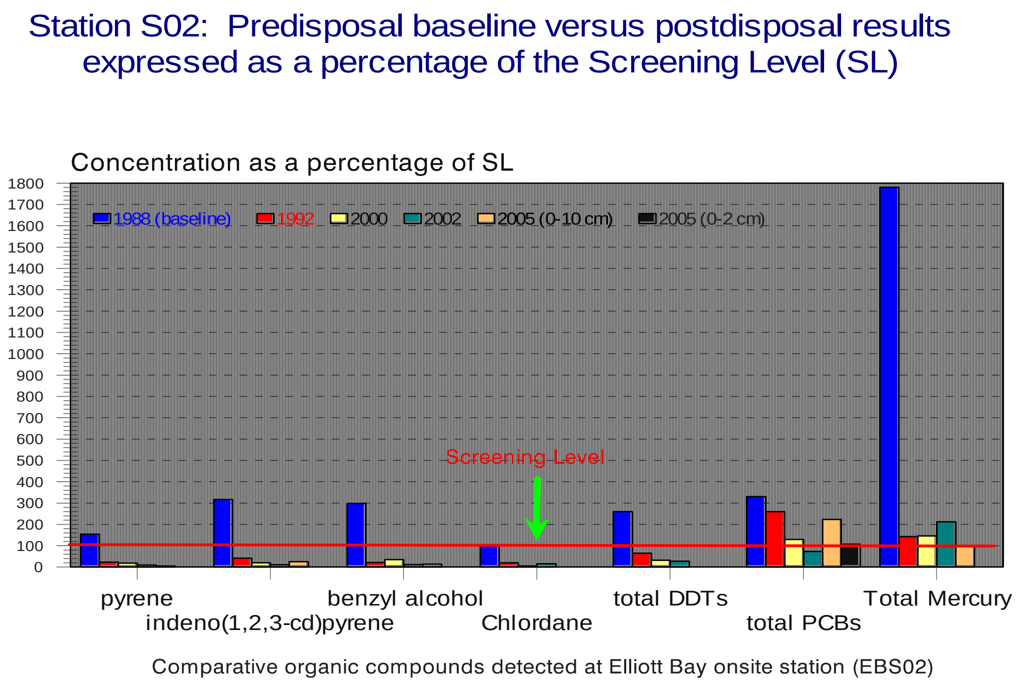
> "…Concentrations of PCBs in sediments peaked in the early 1970s and have been decreasing ever since. …Using the formula of sedimentation rate multiplied by concentration will provide a PCB mass balance budget. For example, the mass balance computes out to about 9.2 kg/yr of PCBs deposited in the Central Basin of Puget Sound during the 1990s. "

When dredging occurs, it does **not** increase the mass of PCBs in the aquatic environment, but it does potentially **move** PCBs from one place in the ecosystem to another. Dredging may either increase or reduce the PCB concentration at a given site, but it likely reduces it system-wide, due to suitability determinations that exclude certain volumes of unsuitable sediment from open water disposal. (The logic for this portion of the program is described in the next paragraphs.) The summary action from dredging-related activities is to reduce the quantity of PCBs in the budget; however, it is acknowledged that this may be an insignificant mass compared to the yearly budget. For urban bays, site conditions may be improved by the placement of dredged material.

Therefore, in considering the DMMP activities and their efficacy in the context of SRKW, it is necessary to balance the bioavailability at the marine or riverine dredging site against bioavailability at the disposal site in a comparative manner. Given the range of the SRKW and their food, all disposal sites should likely be considered, not just one.

Site monitoring in the DMMP has produced evidence that, in the Central Basin urban embayments, the sites are being incidentally "cleaned up" for PCBs; values are diminishing from the original pre-use site characterization investigations and are lower than areas not used for dredged material disposal. Thus, the critically-impacted Central Basin populations PCB impacts are less than before the program began.(see Figure 4).

Figure 4. Comparison of Concentrations at Elliott Bay PSDDA Site Over Time



The DMMP established nondispersive disposal sites in deep water and in areas with low benthic resource value based upon an evaluation of potential invertebrate food for demersal fish. Bellingham Bay is the shallowest, with 98 ft of depth; it is also probably the most productive. Others (such as Port Gardner in North Sound and Anderson-Ketron in South Sound) are in quite deep water of over 400 feet. Overall at PSDDA sites, benthic productivity can be stated to be low.

Since productivity is related to the generation of lipid-rich eggs and larval forms that become the basis for the pelagic portion of the food web, the case could be made that this is a conservation measure for PCB. In the absence of dredging, the PCB would remain in river or shallow coastal sediments which may be directly contacted by juvenile salmonids. In addition, these sediments would likely be more accessible to salmonid food organisms such as sand lance. Also, in many cases, the sediments would ultimately wash into the deltas of the river systems, which are likely to be much more highly productive than the PSDDA sites. Therefore, the activities in the DMMP would be less likely, on balance, to produce mobile PCBs as larval inputs to the pelagic food web.

This evaluation indicates that small amounts of PCB that would enter the food web as a result of disposal is unlikely to significantly increase the system-wide quantity or bioavailability to the pelagic food web which forms the basis for SRKW diet. Therefore, with respect to this important toxicant, the DMMP dredged-material testing and dredged-material site management program is deemed to be protective of SRKW.

This logic applies to DDT+DDE and mercury as well.

3. *PCDD/F.*
A recently-developed DMMP PCDD/F interim procedure is being implemented for material from the 2006 Olympia Harbor Federal-Port project proposed for disposal at the Anderson-Ketron site. The interim procedure is outlined in Figures 5a and 5b on the next two pages.

The interim procedure establishes two conditions for suitability of dredged material placement at this nondispersive site:

- No dredged material management unit (DMMU) sediment concentration may exceed the maximum value for the site, which was determined during the 2005 site monitoring event. (For the Anderson-Ketron site, this ceiling value is 7.3 ng/kg TEQ. (Figure 6) Note that this site is unlikely to have received prior PCDD/F loading from earlier projects.)
- The volume-weighted mean for the Anderson/Ketron Island site is 3.8 ng/kg TEQ and the weighted mean for all the project material below 7.3 ng/kg TEC may not exceed 3.8 ng/kg TEQ.

Figure 5a and 5b. Suitability Determination Process for PCDD/F at Anderson-Ketron Island Disposal Site (two steps).

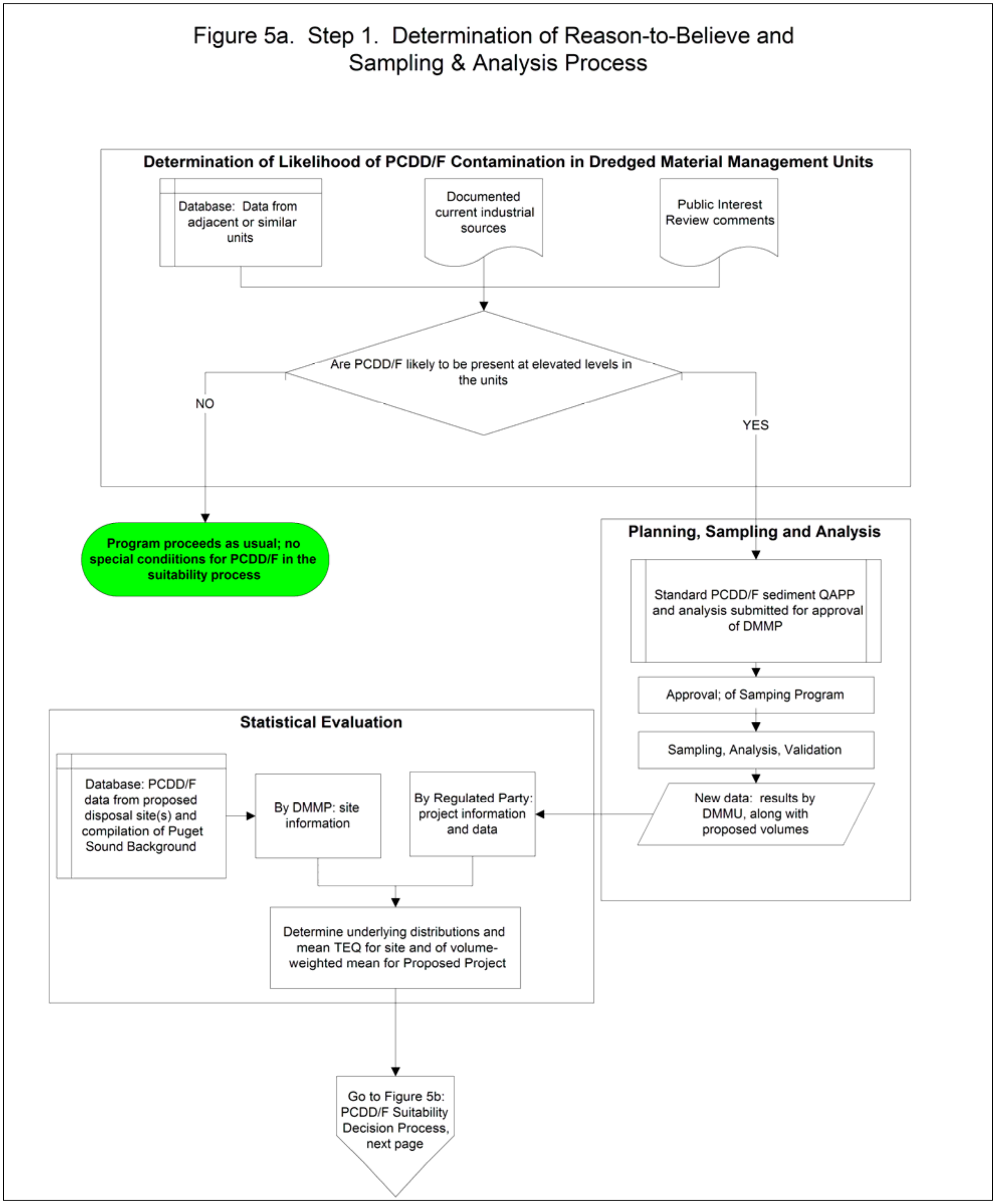


Figure 5b. Step 2. PSDDA Suitability Determinations for PCDD/F

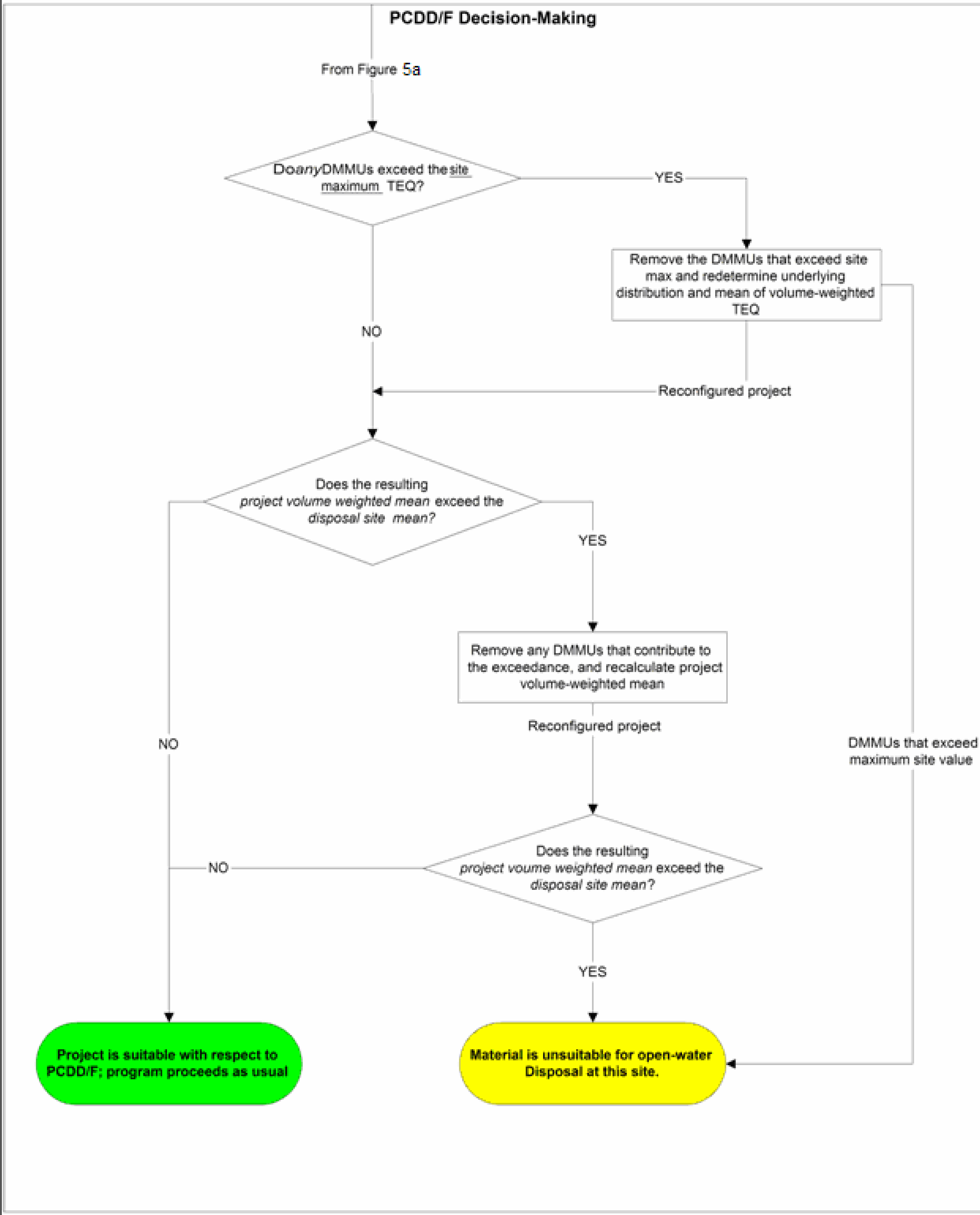
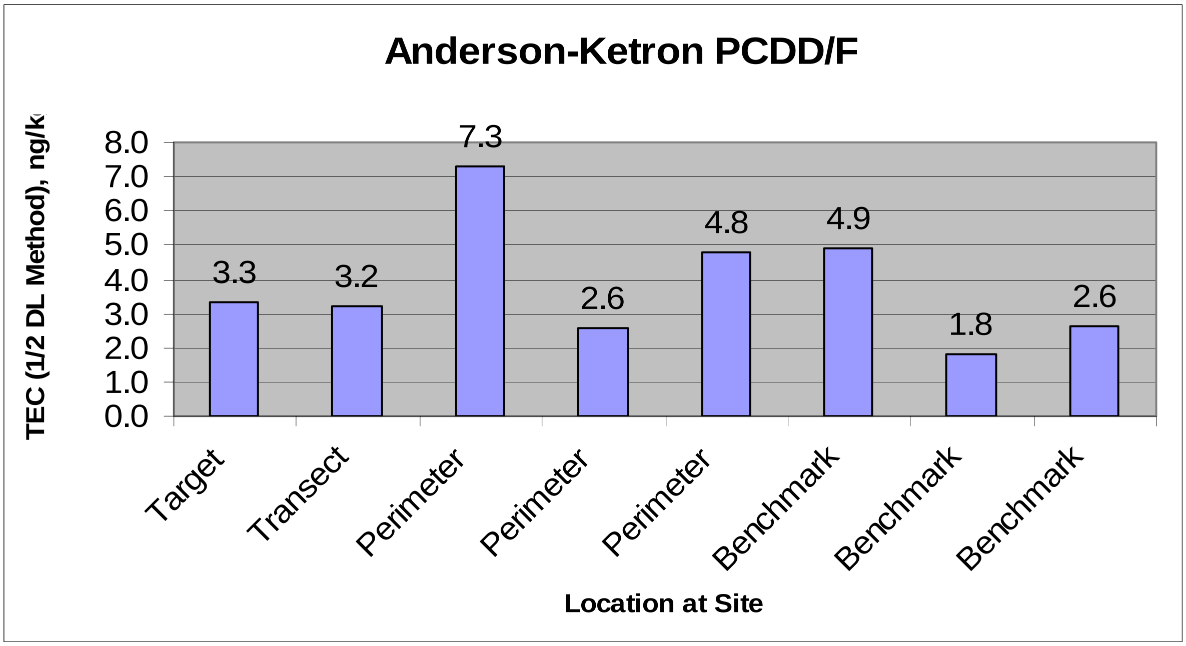


Figure 6. PCDD/F Information from Anderson-Ketron Site. (The Mean is 3.8 ng/kg TEQ)



This procedure is only being used to evaluate the material from the Olympia Harbor Project for disposal at the Anderson/Ketron Island site. The DMMP agencies plan to conduct a stakeholders workshop during 2006 to discuss regional options for regulating disposal for dioxin/furans in Puget Sound as a next step before regional guidance can be formulated at other sites and for other projects. To apply this procedure to other non-dispersive sites would require the collection of an environmental baseline at the site and its vicinity.

This procedure assures that PSDDA sites will not increase in concentration for these potent PBTs at nondispersive sites. While the program has not developed a policy for dispersive sites and PCDD/F, it appears that projects with known or suspected industrial PCDD/F sources may be directed to non-dispersive sites until the DMMP has evaluated existing information, and are satisfied that sufficient information exists to establish a Puget Sound-wide baseline for these compounds.

It should be noted that the PCDD/F procedure is unlike that for other PBTs for two reasons.

- A recent programmatic evaluation of potential health effects due to ingestion of crab and fish from Puget Sound for Reasonably Maximally Exposed subsistence fishers suggests that, at the high levels of consumption noted in regional tribal publications, the risks from background bioaccumulation (i.e., non-disposal-site-related) significantly exceed programmatic limits of 1E-05 estimated incremental lifetime cancers. Therefore, it appears that it is not possible to develop a PCDD/F “ceiling” value for sediment at disposal sites.

- The cited evaluation is believed to be very conservative, and has a substantial amount of irreducible uncertainty at this time. In future, it may be possible to refine and reduce the estimated risk.

VII. Effects of Vessel Noise.

Killer whales produce three categories of sounds: echo-location clicks, tonal whistles, and pulsed calls (Ford 1989). Certain sound vocalizations are used for navigation and discriminating between prey and other objects in the local environment, while other calls have communicative functions within pods (Barrett-Lennard et al. 1996). Some calls are used for maintaining acoustic contact when beyond visual range and other calls are used when the whales are in close proximity and physical contact (Ford 1989). Foote, et al (2006) conducted a study specifically targeted at identifying whether boat traffic noise affected killer whale behavior. They found that the call duration of killer whales in the vicinity of a large number of boats increased significantly, suggesting that "a threshold level of disturbance beyond which anti-masking behavior began." In other words, killer whales responded to increased boat noise by significantly increasing call durations, presumably to assure they were heard and recognized by other members of the pod.

Noise pollution from marine vessel traffic and how it may affect orca vocalizations and hearing is one of the main concerns with decline in the southern resident killer whale population. Killer whales rely on their highly developed acoustic sensory system for navigating, locating prey, and communicating with other individuals. Excessive noise levels may mask echolocation and other signals used by the species, as well as temporarily or permanently damage hearing sensitivity (NMFS 2005b). The main issue stems from increases in whale-watching traffic in which vessels are deliberately following animals, however, dredging operations are another source of underwater noise with an anthropogenic origin. Individual orcas have been observed making a variety of short-term reactions to the presence of whale-watching vessels including swimming faster, making shorter or longer dives, and moving into open water, while in some cases, no disturbance seems to occur (Kruse 1991). Morton and Symonds (2002) showed that killer whales actively avoided an area in which acoustic harassment devices (AHDs) were installed to keep pinnipeds away from fish farms, and then returned to the area when the AHDs were no longer in use. Aside from avoidance, another behavior modification that whales use to communicate in a noisy environment is to lengthen the duration of calls in order to minimize masking of their communication and echolocation (Wood and Evans 1980). Several studies have failed to find significant behavioral effects, but these null results have not been published or reported, so it is important to emphasize that while many studies have shown short-term effects, this is not universally the case (Trites and Bain 2000). The most important variables for analysis are the sound threshold at which orcas modify behavior and the level at which they suffer ill effects due to anthropogenic noise. The physiological costs of changing behavior to ameliorate effects of masking are also unknown. Three studies that measured the killer whale audiogram show the range is approximately 500 Hz up to 105 kHz with varying sensitivities; the range of highest sensitivity is 18-42 kHz, which includes their most common clicking noise at 20kHz (Hall and Johnson 1971, Bain et al. 1993, Szymanski et al. 1999). Very few data are available for the important parameter of received noise levels for killer whale tolerances and reactions. Erbe (2002) measured boat noise source levels at 145 to 169 dB re 1 μPA at 1m, and found this noise level elicited a behavioral response at 200m, and masked killer whale vocalizations at 14km distance. This study also found orca vocalizations to fall in the range of 105 to 124 dB re 1 μPA.

Two studies that attempted to characterize dredge noise of a clamshell dredge found that the digging cycle is approximately 60 to 90 seconds, and there are 6 discrete events in the cycle: clamshell hits water, winch out, clamshell hits bottom, scrape, winch in, dump load; the bucket hitting the bottom is the most intense sound event of the cycle (Dickerson et al. 2001, Clarke et al. 2002). Measurements 150 m away from this event were at approximately 124 dB re 1 μPA with peak frequency 162.9 Hz, attenuated to 95 dB re 1 μPA at the 5000m listening station with peak frequency 72.7 Hz, and were only barely detectable at the 7000 m listening station. These frequencies are below the range of killer whale hearing as determined by Hall and Johnson (1971) and Szymanski et al. (1999). For the full cycle of bucket dredging, the frequency range was typically 30 to 900 Hz, and no sounds with a frequency over 400 Hz were detected beyond the 2 km distance (Dickerson et al. 2001); in addition, the range of sound pressure levels was typically 85 to 120 dB re 1 μPA for discrete events Beyond the distance of approximately 2 km from the clamshell dredge operation, sounds from the dredge are not likely to be audible to the southern resident killer whales, or would not be loud enough to cause masking of their echolocation and communication calls.

The months of October through December—when killer whales may be present in Puget Sound—include the planned dredging period of at least one of the Corps' planned dredging projects: Olympia Harbor. The noise from dredging and transport activities are not expected to significantly affect killer whales due to the infrequency of barge trips to the disposal site (probably no more than 2/day). While the tugs pulling the barges will add to the noise production in the southern Sound, it is doubtful that four tugs (including the return trip) over the course of one day would measurably add to the noise masking of killer whale vocalizations. It should also be noted that the "behavior" of the tugs and barges is not directed at searching out and racing towards killer whales—these are not whale-watching vessels, which tend to cause the greatest disturbance to killer whales because of their focused activity. Still, to be protective of killer whales that may be in the vicinity of tugs hauling dredged material, tug pilots will be instructed to initiate avoidance activities to a distance of at least 100 yards when they observe a killer whale, unless there is imminent human hazard associated with so doing.

VIII. Conclusion of the Revisited Biological Assessment.

Although there will be a short-term resuspension of sediments into the water column from both dredging activities and disposal of dredged material, the likelihood of bioaccumulation of contaminants in salmon—due to the extremely limited time of exposure—is expected to be insignificant and discountable and therefore is not expected to adversely affect either Chinook salmon or Southern Resident killer whales. Similarly, the placement of sediments with conservative levels of PCDD/F over the long term at a managed disposal sites will not affect Chinook by way of toxicity owing to increased body burdens. This should not result in a significant increase in bioaccumulative body burden of PBTs in either Chinook or SRKW. The PSDDA BE conclusion is still valid: **the DMMP activities are not likely to jeopardize SRKW or adversely affect proposed Critical Habitat thereof**. The net effect of the DMMP is to reduce the concentration, even if slightly, in areas where juvenile Chinook have a higher probability of exposure to PBTs in productive, shallower waters of Puget Sound.

IX. EFH.

The Corps prepared an analysis of the effects of transport of dredged material and subsequent disposal at PSDDA open water disposal sites in 2002 (Corps, 2002). That analysis concluded that these operations would have no effect on Pacific salmon and coastal pelagic EFH, and may adversely affect groundfish EFH. However, the Corps also committed to several conservation measures, which would minimize the effect to groundfish EFH. The conservation measures 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.

While sediments that are disposed at PSDDA sites may contain measurable levels of contaminants that are justified by the programmatic guidelines and suitability determinations, the EFH conclusions from 2002 remain unchanged because of the insignificance of the potential for bioaccumulative effects resulting from transport and disposal of dredged material.

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