APPENDIX 6

Marine Benthic Assessment for Beneficial Use of Dredged Material at Two Moon Bay

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1. Introduction

The goal of this paper is to establish a framework to identify important criteria needed to assess marine benthic habitat located at an abandoned Log Transfer Facility (LTF) at Two Moon Bay, Alaska. Existing habitat evaluation tools that apply to coldwater marine benthic environments are largely deemed inadequate for Alaska coastal waters. As a result, existing scientific literature and best professional judgment form the overall basis for this assessment.

Traditionally, Habitat Suitability Indices (HSIs) have been used to evaluate various habitats nationwide. For the Two Moon Bay marine benthic environment, a conclusion was made by Corps analysts that there was no existing HSI that would be applicable. The existing HSI models often do not apply to specific Alaska species, life stages, or habitats. This problem is especially acute for marine habitats, particularly when dredged material placement for beneficial use does not focus on improving habitat for a single species. Over time, the discipline of improving habitat has evolved into improving overall habitat function rather than a single species approach. An illustration of this issue could be an HSI for salmon in Alaska. The HSI for salmon is focused on freshwater life requirements and therefore does not provide a tool for evaluating the marine benthic environment and also takes a single species approach to the evaluation process. Of all the indices that have been developed, analysts concluded that the HSI for the littleneck clam (*Protothaca staminea*) is the closest to being applicable for restoration at Two Moon Bay. However, littleneck clams were not documented at Two Moon Bay during the 1985 pre-LTF site survey and have not been documented at reference sites in Two Moon Bay during the dive surveys in 2000. Furthermore, the goal of the placement of dredged material for beneficial use is to improve the marine habitat to a habitat condition that supports the same species composition and habitat functions that existed prior to 1985 when the site was used as an LTF. This goal is a divergence from the approach of improving habitat for a particular life requirement for a single species such as the littleneck clam.

In an effort to establish criteria necessary to assess the marine benthic environment at Two Moon Bay, scientific literature was researched, dive surveys were consulted, species composition was documented, and a marine benthic value was assigned to the Two Moon Bay LTF, as it existed prior to use in 1985. The same effort was undertaken to establish values for the marine benthic environment after being used as an LTF, as well as predicting future values associated with site improvement as a result of strategically placing dredged material. Typical conditions at existing and abandoned LTFs, such as those in Two Moon Bay, are described in the text that follows. The marine benthic habitat assessment values that resulted from this effort were then compared for each alternative to determine the alternative that provided the greatest chance of improving the LTF habitat to a condition that existed prior to 1985.

The approach for assigning marine benthic habitat values is herein termed the Marine Benthic Assessment (MBA). As previously mentioned the MBA uses the 1985 pre-LTF conditions as the goal and considers those attributes to be the optimum habitat condition for this assessment and was assigned a value of 1.0.

2. LTF Site Conditions

a. Typical LTF Conditions

Bark debris can accumulate in the marine environment when logs are transferred or temporarily stored in the water before they are transported to pulp and sawmills or shipping export facilities. Accumulated wood debris smothers the bottom and usually leads to less diverse infauna, and the sediment is generally anoxic. A number of studies document that bark accumulations at LTF sites have negatively impacted anadromous fish, shellfish, marine invertebrates, aquatic plants, and water quality. Freese and O'Clair (1987) and Jackson (1986) documented that polychaetes, bivalves *(Protothaca staminea* and *Mytilus edulis)* are significantly diminished under bark deposits. Freese and O'Clair also found that bark debris 6 cm in depth reduced the survival and condition of bivalves and Jackson reported that bark debris of at least 2.5 cm in depth significantly affected the structure of the benthic community. Other studies have documented that the decomposed bark and wood products could adversely affect interstitial water quality because of low concentrations of pore water dissolved oxygen, increased elevations of interstitial reducing conditions, elevated concentrations of hydrogen sulfide, production of ammonia and alkaline products, and altered infaunal communities dominated by opportunistic species (Pease 1974, Duff 1981, Conlan and Ellis 1979, and Jackson 1986).

Large benthic predators, such as crabs and sea stars, tend to avoid wood-dominated benthic habitat, most likely due to a reduced abundance of infaunal prey species. Wood dominated sites favor planktivorous species due to the dearth of infaunal prey. Where large sunken logs are numerous, some anemones (Metridium spp.) may benefit from attachment sites. Also, sea cucumbers (Parastichopus spp.) may abound due to abundant microbe populations that provide an abundant food source (Picard et al. 2003).

High egg mortality observed in Dungeness crab at LTF sites in southeast Alaska have been attributed to elevated levels of hydrogen sulfide and ammonia from pore water of bark deposits (Freese and O'Clair 1988). The study also concluded that ammonia concentrations were acutely toxic to some crustacea. Histopathological studies of idiopathic legions of Dungeness crab in Southeast Alaska concluded that crabs at LTF sites also exhibited greater egg mortality and harbored more nemertean predators (Morado et al. 1988). Other studies concluded that bark log extracts (leachates) from Sitka spruce and western hemlock are toxic to adult and larval pink salmon *(Oncorynchus gorbuscha)* fry (Buchanan et al.I976). Lastly, the accumulation of bark and wood debris reduces benthic infauna and eradicates aquatic plants and marine animals (Pease 1974, Ellis 1973).

b. Two Moon Bay Conditions

Dive surveys were conducted by the U.S. Fish and Wildlife Service in Two Moon Bay in 2000 to document conditions at the former LTF. A summary of transect conditions follows, and species encountered in each transect are presented in table 1. Figure 1 shows the dive transects.

Transect A: Most (70%) of this 100-meter transect was covered in bark, and many of the species found in this area were either at the beginning of the transect where bark was not present or were found on non-bark structures such as debris and cables. Marine vegetation was absent except for a small patch of rockweed.

Transect B: The lowest diversity of species was documented in Transect B, which was 100 percent covered in bark debris. Transect B began at the 50-meter mark on transect A and extended east for 100 meters roughly parallel to shore. Marine vegetation was completely absent.

Transect C: This transect was approximately 225 meters west of Transect A and perpendicular to the shore. No bark debris was documented the first 100 meters. Accumulated bark debris was only documented between the 150 and 170-meter distances.

Transect D: Bark was not visible within Transect D during the dive survey. Transect D is approximately 250 meters east of Transect A.

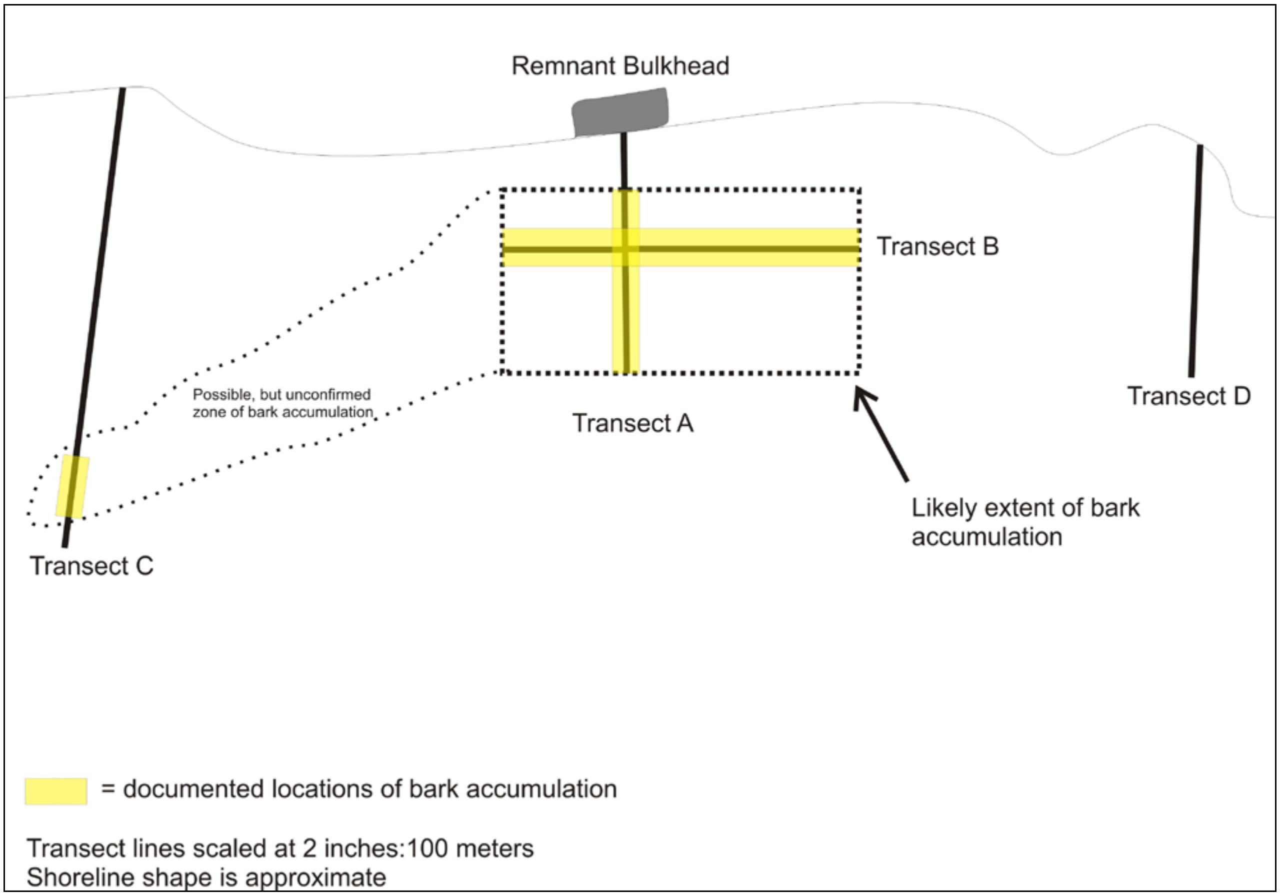

Figure 1. Dive Transects.

Table 1. Species documented in transects A-E during October 31-November 1, 2000, dive surveys conducted at abandoned Two Moon Bay LTF and adjacent areas.

	A	B	C	D
% of transect with bark accumulation	**70**	**90**	**10**	**0**
Fucus furcatus (rockweed)	X		X	X
Zostera marina (eelgrass)			X	X
Desmarestia viridis (acid kelp)			X	
Desmarestia spp. (witches hair)				
Laminaria bongardiana (Elephant-ear kelp)			X	
Laminaria saccharina (sugar kelp)			X	X
Mesophyllum spp. (coralline algae)				
Lithothamnium spp. (red rock crust)			X	
Cerianthus (burrowing anemone)			X	X
Metridium senile (Plumose anemone)			X	
Tubulanus sexlineatus (ribbon worm)			X	
Nereis brandti (sand worm)			X	
Pectinaria californiensis (cone worm)				X
Serpula vermicularis (calcareous tubeworm)			X	X
Littorina sitkana (sitka periwinkle)			X	
Fusitriton oregonensis (hairy triton)		X		
Hinnites multirugosus (rock scallop)			X	
Chlamys spp. (small scallop)		X	X	
Saxidomus giganteus (butter clam)			X	
Mytilus edulis (blue mussel)	X			
Tresus capax (horse clam)				
Onchidoris bilamellata	X			
Melibe leonine (lion nudibranch)	X		X	X
Balanus glandula (acorn barnacle)			X	X
Onchidoris bilamellata (brown barnacle nudibranch)	X			
Pododesmus cepio (rock jingle)	X		X	X
Elassochirus spp. (hermit crab)	X		X	X
Oregonia gracilis (decorator crab)	X		X	
Telmessus cheiragonus (helmet crab)	X			
Oregonia gracilis (decorator crab)	X			
Lophopanopeus bellus (black-clawed crab)				X
Pandalus spp. (shrimp)			X	X
Parastichopus californicus (regular sea cucumber)	X			X
Dermasterias imbricata (leather star)	X		X	X
Evasterias troschelii (mottled star)	X		X	X
Pycnopodia helanthoides (sunflower star)	X		X	X
Crossaster papposus (rose star)			X	
Henricia leviuscula (blood star)				X
Anarrhichthys ocellatus (wolf eel)		X		
Hexagrammos stelleri (white-spotted greenling)	X	X		
Hexawammos decagrammus (kelp greenling)				
Myoxocephalus polyacanthocephalus (great sculpin)				
Lepidopsetta bilineata (rock sole)		X		
Sebastes maliger (quillback rockfish)				
Sebastes caurinus (Copper rockfish)				

* Identified from shell only.

3. Pre-LTF Conditions in Two Moon Bay

In 1985, the U.S. Fish and Wildlife Service and the Alaska Department of Fish and Game conducted a pre-project assessment of log transfer facility sites at Two Moon Bay. The area where the LTF was eventually placed was characterized as a shallow gravel shelf sparsely inhabited by rockweed, eelgrass, and barnacles that extended 60 feet shoreline from the waters edge, where a steep 25-foot drop off flattened to a silt/mud bottom. The silt/mud bottom began approximately 90 feet offshore and was vegetated with scattered brown algae. Invertebrate species documented in the silt/mud substrate included sunflower star, leather star, Nuttall's cockles, rock oysters, sea colander, and butter clams. An annotated list of species found at the proposed LTF site is available in Table 2. Other species documented at Two Moon Bay include hermit crab, littleneck clam, limpet, nudibranch, leather star, halibut, Pacific herring, pink salmon, Dolly Varden, steelhead trout, seabirds, ducks, geese, bald eagles, and sea otters (Ferrell et al. 1985, U.S. Fish and Wildlife Service 1992).

Table 2. LTF Annotated species list from 1985 surveys conducted at Two Moon Bay.

Common Name	Scientific Name
Rockweed	Fucus distich us
Eelgrass	Zostera marina
Sea colander	Agarum cribrosum
Red rock crust	Lithothamnium sp.
Coralline algae	Corallina sp.
White-plumed anemone	Metridium senile
Tube worm	Spirorbis sp.
Blue mussel	Mytilus edulis
Rock oyster	Posodesmus macroschisma
Butter clam	Saxidomus giganteus *
Soft-shelled clam	Mya arenaria *
Nuttall's cockle	Clinocardium nuttallii *
Horse clam	Tresus capax *
Scallop	Chlamys Sf!.
Barnacle	Balanus sp.
Dungeness crab	Cancer magister
Dock shrimp	Pandalus danae
Sunflower star	Pycnopodia helianthoides
Starry flounder	Platichthys stellatus
Red Irish lord	Hemilepidotus hemilepidodus

* Identified from shell only.

4. Comparison of Alternatives

A range of alternatives for disposing of dredged material is considered below and the rationale for assigned values is discussed. The values of the alternatives are displayed graphically in figure 2.

a. Pre-LTF Conditions in the 1985 Dive Survey

This condition is assessed a value of 1.0, which is the highest score possible. This value is warranted because it represents natural conditions before the construction of the LTF and is 4 years prior to the effects of the Exxon Valdez Oil Spill of 1989.

b. Existing Conditions at the LTF in Two Moon Bay

This condition is assessed a value of 0.05. Data from table 1 indicates that native vegetation is essentially absent where bark coverage ranges from 70 to 90 percent (transects A and B). Invertebrate species present in these two transects are primarily those that are attached to debris such as cable and submerged metal structures that are either planktivorous or microbial feeders. While a few fish were observed passing through, the area does not have vegetation that provides cover for juvenile and forage fish or natural attachment sites for epifaunal invertebrates that are prey for some waterfowl. It should be recognized that marine benthic habitat need not be vegetated to be productive, but if it is unvegetated, it should at least have chemical conditions that support life. Notably, the site should not be hypoxic or anoxic and there should not be elevated concentrations of hydrogen sulfide, ammonia, and alkaline products, which can lead to altered infaunal communities dominated by opportunistic species. The value of the existing LTF site as marine habitat might only be lessened if it were filled and converted to upland habitat.

c. Dump and Level or Side Cast at LTF in Two Moon Bay

This condition is assessed a value of 0.5. The new substrate would provide improved attachment sources for marine vegetation and invertebrates and the depth of the new substrate would probably be sufficient to cover the low dissolved oxygen/reducing environment of the bark thus leading to a new benthic layer that would likely support infaunal invertebrates. However, the benefits from either of these disposal methods is tempered by the likelihood that disturbance and incidental habitat damage may occur during leveling and that side casting might result in a turbidity plume and imprecise deposition that could negatively impact adjacent habitat beyond the current zone of bark accumulation. A fair improvement in habitat would be made, but excessive disturbance within the LTF site and dumping beyond the area of bark accumulation would limit the effectiveness of this disposal method.

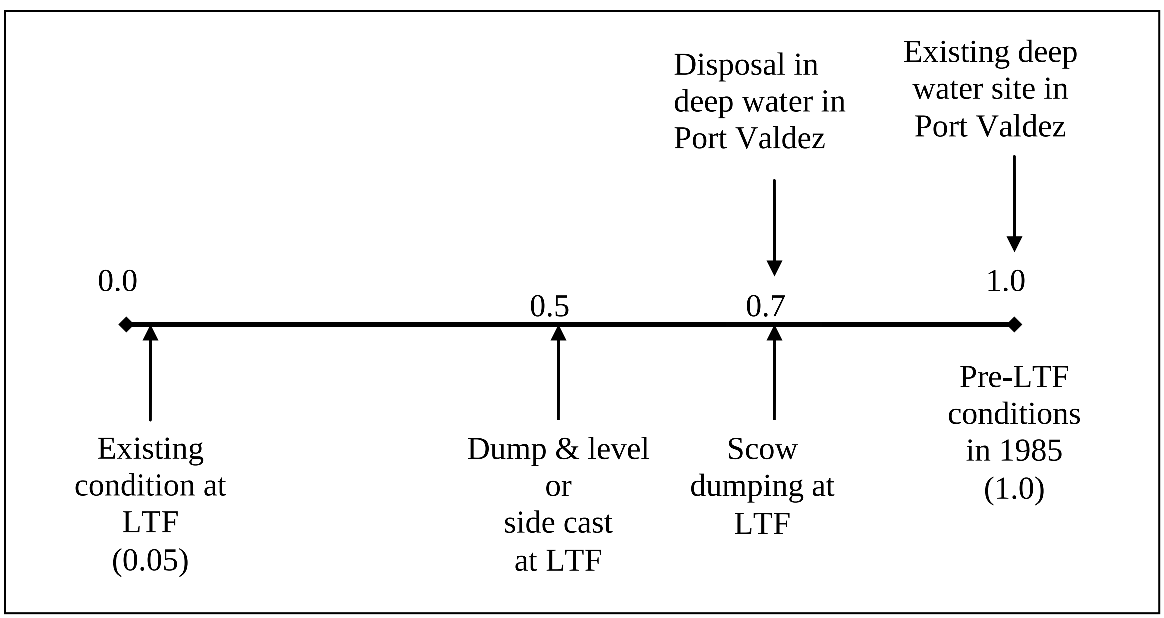

Figure 2. Values of disposal and beneficial use alternatives.

d. Scow Dumping at LTF in Two Moon Bay

This condition is assessed a value of 0.7. The new substrate would provide improved attachment sources for marine vegetation and invertebrates, and the depth of the new substrate would probably be sufficient to cover the low dissolved oxygen/reducing environment of the bark, thus leading to a new benthic layer that would likely support infaunal invertebrates. The irregularity of substrate depth/height through this method of disposal would lead to diversity and limit negative effects of mechanical leveling. Though some localized increase in turbidity is likely, it would likely be less than side casting, and the disposal could be targeted to a specific area that could be marked with buoys. A value of 0.7 would not be realized immediately, but algae and invertebrate assemblages should resemble surrounding habitat within a few years. The value is limited to 0.7 since some of the deeper water habitat that is now covered by bark used to be silt bottom. Reestablishing a silt bottom is not practical, so it is not possible to achieve a value of 1.0 after disposal. However, the new substrate would be of sufficient depth to provide the chemical and physical prerequisites for plant and animal life. Establishment of vegetation, infaunal, and epifaunal species is not the only benefit; the habitat benefits of disposal would likely extend to fish, seabirds, waterfowl, and marine mammals.

e. Existing Deep Water Habitat in Port Valdez

This condition is assessed a value of 1.0, which is the highest score possible. This value is warranted because it represents natural conditions.

f. Deep Water Disposal in Port Valdez

This condition is assessed a value of 0.7. The disposal would cover existing deep water (~600 feet) habitat with a mound of cobble, sand, and gravel. It is likely that the disposed material would be colonized, albeit with a different species assemblage. While the negative effects of this disposal method are probably minimal, it represents a departure from the existing natural environment and with existing data can only be viewed as a decrease in habitat value.

5. Conclusion

Scow dumping the dredged material at the former LTF site in Two Moon Bay represents the greatest increase in marine benthic habitat value. It will likely raise the value of the habitat from 0.05 to 0.7 and establish the physical and chemical conditions necessary for marine life similar to those before the establishment of the LTF.

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