APPENDIX N

Marine Environment Impact Assessment Technical Memorandum

GRAVINA ACCESS PROJECT

Marine Environment Impact Assessment
Technical Memorandum

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DOT&PF Project 67698
Federal Project ACHP-0922(5)

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1—Introduction

This technical memorandum describes general impacts that could result from the Gravina Access Project alternatives based on a set of assumptions concerning the alternative designs and engineering requirements, as described in Section 2; the nature of habitats in the vicinity of project landfalls, as described in the *Phase II Marine Reconnaissance Technical Memorandum* (Pentec, 2001); and the considerable literature on the effects of various perturbations on freshwater and marine resources.

Along the Revillagigedo (Revilla) Island shoreline, resource values in general are limited by previous alterations in the form of riprap—as at the shoreline affected by four bridge alternatives located at the airport (C3[a], C3[b], C4, and D1) and by two ferry alternatives (G2, from Peninsula Point, and G3, from downtown Ketchikan)—or by previous use of the site as a dump (Alternatives F1 and F3, Bridges Across Pennock Island). The Gravina Island shoreline in the vicinity of the Ketchikan International Airport—as at the locations of Alternatives C3(a), C3(b), C4, and D1—is currently riprapped, but some subtidal areas support eelgrass. The most natural littoral habitats potentially affected by the alternatives are at Lewis Point near the location of Alternative G2, southeast of East Clump Island near the location of Alternative G3, and on Pennock and Gravina islands near the landfalls of Alternatives F1 and F3.

Section 3 describes both the effects on the marine environment that could result during project construction (short-term), and those that could be expected during project operation (long-term), i.e., continuing as long as the project remains in place. Section 4 briefly indicates the types and approximate magnitude of habitat impacts associated with each alternative.

2—Project Assumptions

For the purposes of conducting a preliminary assessment of the potential environmental impacts resulting from construction and operation of improved access across Tongass Narrows to Gravina Island, the following assumptions have been made about the alternatives under consideration:

- All bridge alternatives would require placement of piers in shallower waters (e.g., shallower than -50 feet mean lower low water [MLLW]) near the shoreline.
- All build alternatives would increase access to and development on Gravina Island.
- Bridge alternatives with bridge abutments at the airport would require filling of nearshore areas.
- Where the conceptual ferry terminal design overlaps the shoreline, the structure would be built on pilings and not fill. Therefore, there would be a shading effect rather than a filling effect.
- Alternative F3 would require expansion of the channel west of Pennock Island (West Channel) for safer navigation by large ships.
- Regardless of the alternative selected, final design will seek to avoid or minimize effects on sensitive resources and habitats.

3—Nature of Potential Impacts

3.1 Construction Effects

3.1.1 Erosion and Turbidity

Construction of alternatives that involve movement of substantial amounts of soil and rock would have a high potential for generating sediment-laden runoff in the vicinity of Ketchikan. Dredging the harbor, in order to provide necessary navigation depths for the ferry alternatives, (G2, G3, and G4) and filling along the shoreline of the airport for the bridge alternatives, (C3[a], C3[b], C4, and D1) would generate plumes of turbid water. Activities associated with installation of inwater piers also have the potential to release turbid water.

Juvenile salmon have been shown to avoid areas with high turbid waters (e.g., Servizi, 1988), but seek out areas of moderate turbidity (10 to 80 nephelometric turbidity units [NTU]), presumably as cover against predation (Cyrus and Blaber, 1987a,b). Feeding efficiency of juveniles is also impaired by turbid water in excess of 70 NTU, well below sublethal stress levels (Bisson and Bilby, 1982). Reduced preference by adult salmon homing to spawning areas has been demonstrated where turbidities exceed 30 NTU (20 milligrams [mg] of suspended sediments per liter [L]). However, Chinook salmon exposed to 650 mg/L of suspended volcanic ash were still able to find their natal water (Whitman et al., 1982). Any adult salmon present near the project area during inwater work might avoid areas of increased turbidity or reduced oxygen, but are not expected to interrupt their upstream migrations (e.g., Whitman et al., 1982). Based on these data, it is unlikely that the locally elevated turbid waters, generated by constructing these proposed alternatives, would substantially affect juvenile or adult salmonids that are present.

Excessive sedimentation rates in marine areas with benthic communities adapted to relatively clean water conditions can alter community composition and productivity in unexpected ways. Turbid water runoff was measured by stormwater outfall at one of the marine reconnaissance survey sites, Station REV-5A (all station designations referenced in this technical memorandum refer to stations depicted in Figure 3-1, of the *Phase II Marine Reconnaissance Survey*, Pentec, 2001). Over the past 5 years, this outfall has frequently delivered turbid (sometimes highly turbid) water from a rock quarry to Tongass Narrows.

The intertidal biota in the immediate vicinity of the outfall is very different in nature from that on adjacent riprap, but this condition is attributed to the exclusion of predators from the area by the freshwater, rather than to the effects of turbidity. Bull kelp beds immediately offshore of the outfall did not appear to differ from those up and down the shoreline. Because of the strong currents in the area, intermittent discharges of waterborne sediments, especially when released in deeper waters offshore, are likely quickly dissipated with minimal effect on biota.

3.1.2 Upland Noise

Blasting in upland areas near Tongass Narrows might be required to construct bridge approaches. Upland blasting could affect marine resources such as bald eagles and marine mammals, but would not affect inwater resources.

Increased noise levels might temporarily disrupt the foraging behavior of bald eagles in the vicinity of the project.. The Washington State Department of Transportation (WSDOT) conducted monitoring to determine the potential impacts on wintering eagles associated with pile-driving activities at Orcas and Shaw islands in

San Juan County, Washington, from December 15, 1986, through March 15, 1987 (Bottorff et al., 1987). Each of the monitoring areas was associated with a Washington State ferry terminal. Background noise sources included ferry whistles, boat motors, chain saws, aircraft, front-end loaders, cranes, generators, diesel trucks, hammers, and other general noise sources associated with construction. Noise readings were taken at the construction sites and various intermediate points out to about 6,000 feet from the construction sites.

The placement of woodpiles did not visibly disturb the eagles observed during the course of the study. A steel pile, which produces some of the loudest noises during pile driving, might have disturbed a bald eagle pair at a distance of 4,000 feet. However, this same pair of eagles had been in the same location during the driving of two steel piles earlier in the day and exhibited no visible disturbance reaction. The eagles returned to their preferred perch and no further adverse reactions were observed, even after over 100 wood piles were driven into the ground (Bottorff et al., 1987).

Environmental factors such as wind and wave action, movement of tree branches and forest litter, barking dogs, bird noises, automobiles, airplanes, human voices, woodcutting, light construction activities, boats, and other unidentified noise sources create ambient noise levels that are similar to those produced by pile driving at distances of 0.25 to 0.5 mile away from the point source (Bottorff et al., 1987).

WSDOT also monitored noise levels during pile-driving activities at its Anacortes, Washington facility (Visconty, S., Washington State Ferries, pers. comm., March 9, 2000). For comparison purposes, background noise levels were monitored at the Friday Harbor, Washington, terminal. At Friday Harbor, ambient noise levels around the closest bald eagle nest (located near the terminal) ranged between 45 and 72 decibels (dB); 40 to 51 dB were recorded for local harbor traffic background noise, and 69 to 74 dB were recorded from use of a 100-ton crane at the terminal. Pile-driving noise at the Anacortes facility ranged from 105 to 115 dB at 50 feet from the noise source. Noise levels were highest when a pile was first driven and decreased near completion because of a reduction of the exposed surface area and increased stiffness as the pile became more embedded (Visconty, S., Washington State Ferries, pers. comm., March 9, 2000). Simultaneous readings taken at several distances to determine propagation loss at Anacortes indicated a 6-dB decrease in sound pressure for every doubling of distance. Given this information, at 1,850 feet from the noise source at Anacortes, the sound was 70 dB, well within measured background ambient noise levels recorded at the Friday Harbor terminal (Visconty, S., Washington State Ferries, pers. comm., March 3, 2000).

Based on this information, and the fact that bald eagles in the Ketchikan area are well acclimated to high levels of human activity (e.g., operation of large vessels and heavy equipment, and floatplane noise), short-term direct effects on eagles and other marine wildlife due to construction disturbances are anticipated to be minimal and localized.

3.1.3 Inwater Noise

In-water noise from construction can result from dredging, blasting, fill placement, pile driving, and waterborne vessel movements. Construction noise generated in assembly of bridge or ferry landing structures above the water can be transmitted into the water through steel or concrete structures. Inwater blasting might be necessary to prepare the foundations for inwater piers and would be needed under Alternative F3 to improve the navigation conditions in the channel west of Pennock Island. Noise levels associated with pile removal, driving, and pre-drilling, as well as with other aspects of the proposed action, might temporarily be elevated above existing background noise levels.

Feist et al. (1996) investigated the impacts of driving large concrete piles on juvenile pink and chum salmon behavior and distribution in Everett Harbor, Washington. The authors reported that there might be changes in general behavior and school size, and that fish appeared to be driven toward the acoustically isolated side of the site during pile driving. However, the prevalence of fish schools did not change substantially with or without pile driving, and schools were often observed about the pile-driving rigs themselves. No impacts on feeding were reported. The study concluded that any effects of concrete pile-driving noise on juvenile salmonid fitness would be very difficult to measure quantitatively. More recent experience in Puget Sound and elsewhere, however, has documented more severe effects from use of an impact hammer to drive large diameter, hollow steel piles such as those that will be required for this project (although any pile driving for this project is anticipated to use a vibratory hammer, instead of an impact hammer). Effects are believed to be exacerbated when driving piles into hard substrates (e.g., gravel, cobble) when compared with effects while driving into softer sands or mud. Impact driving of 24-inch steel piles in late 2002 at a ferry terminal in Puget Sound resulted in mortality of a number of marine perch (Embiotocidae), and similar or larger piles, driven by impact hammer at the Port of Seattle, resulted in mortality of Pacific herring (P. Erstad, WDFW, personal communications). However, impact driving of 24-inch piles at the Mukilteo, Washington, ferry dock in early 2003 did not result in documented fish kills; a bubble curtain was deployed at Mukilteo and shown to substantially reduce measured water-borne sound pressures (J. Houghton, Pentec, personal observation). Most diving sea birds left the vicinity when pile driving started but a California sea lion remained in the area (e.g., within roughly 300 and 600 ft [100 -200 m]) and continued to submerge during driving. Noise generated by dredging, rock drilling with a reverse rotary drill, or pile driving using a vibratory hammer are expected to be of lower peak intensity than that resulting from pile driving using an impact hammer.

Underwater blasting is known to cause severe effects on fish and invertebrates in the immediate vicinity (e.g., Goertner 1978, Falk and Lawrence 1973). Mortality in fish is primarily due to major trauma to internal organs, especially swim bladders and kidneys. Houghton and Munday (1987) investigated the lethal ranges for caged juvenile chum and coho salmon and sub-adult Pacific herring exposed to various quantities of linear explosives in Resurrection Bay, Alaska. They found that 50-percent lethal ranges of up to 300 ft (100 m) were not uncommon for test species. Exposed fish were held for several days after the tests and then autopsied, revealing a high potential for delayed mortality. Massive kills of unconfined native fish, that happened to be in the vicinity of the tests, were also observed with over 100,000 fish estimated killed by one test. Gadids, a group with closed swim bladders, were especially vulnerable, although many other fish species including herring, rockfish and salmonids, were also killed, along with invertebrates in the immediate vicinity of the blasts.

Based on this information, the effects of project construction on marine and anadromous fish are expected to be minimal and localized, except for those effects associated with underwater blasting. Minor fish kills could result from driving large diameter steel piles into hard sediments with an impact hammer, but this method is not anticipated. Marine mammals (e.g., seals) might also be affected by routine project construction noise, including pile driving, although the level of effect is expected to be limited to movement of mammals away from areas of noise in excess of their tolerances.

Underwater blasting can be expected to cause heavy mortalities of fish within 300 ft (100 m), with lesser numbers of fish killed with greater distances (e.g., Houghton and Munday 1987). Damaging sound pressures can propagate for greater distances along hard bottom than soft bottom areas. Preblasting visual and acoustic surveys should be required to document the presence of fish schools in the vicinity of the blasting area. If large fish schools are detected, blasting should be delayed until they leave. A biologist should check the area within 300 ft (100 m) up current and 900 ft (300 m) down current of the blast area for fish kills after blasting is completed. Underwater video surveys should be included in the post-blast monitoring to document dead fish that sink, rather than float. All project-related activities would conform to the pertinent provisions of the Marine Mammal Protection Act and the Endangered Species Act. Measures such as covering the rock to be blasted with sand, or deployment of a bubble curtain, may be used to dampen blast impact, if excessive fish mortalities are observed. Blasting should not be conducted during April/June to avoid juvenile salmonids or during August through October to avoid adult salmon. The contractor would be required to prepare a blasting plan prior to any blasting activities.

3.1.4 Direct Displacement

Construction would require placement of concrete, rock, and other fill materials in habitats that currently support important resources. Bridge piers or fill placed in the littoral zone (the area between mean higher high water [MHHW] and about -20 ft MLLW) would cover and destroy existing sedentary biota that includes commercially or recreationally harvestable clams and mussels. The relative significance of this impact would depend on the nature of the substrata and habitats present, and the depth of the affected substratum. Approximate areas of direct marine habitat impacts of each alternative are provided in Table3-1.

The most substantial resource loss would occur where areas of eelgrass or saltmarsh and associated riparian vegetation are lost. Eelgrass beds have been located at or near several of the proposed landfall areas. Eelgrass beds are important areas of feeding and refuge for several species of fish, especially juvenile salmonids (e.g., Simenstad et al., 1997) and shellfish (e.g., Dungeness crab). Eelgrass also provides a substratum (along with kelp beds and other intertidal species of algae) for spawning by Pacific herring. Herring are known to migrate and spawn in Tongass Narrows from late March through April (House, D., Alaska Department of Fish and Game [ADF&G], pers. comm., July 31, 2001). Along the western shoreline of Tongass Narrows, herring spawn from Rosa Reef west to Vallenar Point. Along the eastern banks, herring spawn from Refuge Cove west to Point Hagen and south of Pennock Island. Additionally, intermittent and sporadic spawning has occurred over the past 5 years on the eastern banks from near the U.S. Coast Guard station east to the town of Saxman (House, D., ADF&G, pers. comm., July 31, 2001).

Direct impacts to the saltmarsh in the estuary of Government Creek would be avoided under all alternatives This habitat is particularly productive; pink and chum salmon are known to spawn in Government Creek (House, D., ADF&G, pers. comm., July 31, 2001). In the project area, Government Creek enters Tongass Narrows through a shallow gravel-cobble-bottomed stream channel in a small V-shaped embayment. The stream channel bottom is covered with a dense growth of filamentous brown alga (*Pilayella littoralis).* Lower streambanks support dense rockweed (*Fucus gardneri*); in muddy pockets adjacent to the stream, soft-shell clams (*Mya arenaria*) are abundant. Finer sediments at higher elevations (e.g., > +13 ft MLLW) have a well-developed saltmarsh assemblage. Dominant plants in the lower saltmarsh are *Carex* sp*., Glaux* sp., and *Plantago* sp.; higher elevations have *Potentilla* sp*., Deschampsia* sp*.,* and *Juncus* sp. Higher areas with coarse sand and gravel, especially to the south toward East Clump Island, support patches of *Salicornia virginica* and a backshore assemblage mixed with salt-tolerant grasses and herbs (HDR 2001).

The upper intertidal area around the Airport Creek mouth consists of a relatively flat bench dominated at lower elevations by *Salicornia* and *Puccinellia.* At somewhat higher elevations, taller species such as the sedge *Carex,* velvet grass *Holcus lanata*, and tufted hairgrass *Deschampsia* dominated. Gravelly areas adjacent to the stream channel supported patches of *Honkenya peploides*, and higher-elevation sand and gravel had a dense growth of dune grass.

The least-substantial impacts on resources would result from pier placement on dynamic sand or gravel beaches, which tend to have minimal resource values except in areas that support spawning by forage fish. Surf smelt and sand lance spawn in upper intertidal sand or mixtures of sand, small gravel, and shell. The locations of forage fish spawning areas in Tongass Narrows have not been documented (House, D., ADF&G, pers. comm., July 31, 2001).

Although rocky littoral habitats are highly productive, they support few resources currently harvested in the Ketchikan area. Activities such as placement of bridge or ferry structures, and expansion of the channel west of Pennock Island, would destroy rocky habitat but would themselves provide new substrata for development of a biota that could be expected, over time, to resemble the lost biota.

Table 3-1 shows the acreage loss of marine habitats for each alternative, based on preliminary engineering design.

TABLE 3-1: POTENTIAL IMPACTS ON MARINE HABITATS (APPROXIMATE ACREAGE)

		Bridge Alternatives[1]						*Ferry Alternatives*[2]		
Impact Type	*No-Action*	*C3(a)*	*C3(b)*	*C4*	*D1*	*F1*	*F3*[3]	*G2*	*G3*	*G4*
Dredging[3]	0	0	0	0	0	0	16.0	0.20	2.14	1.22
Shading[4]	0	0	0.3	0	0	0	0.1	0.5	1.6	0.3
Filling	0	6.1	6.5	6.7	4.1	0	0	0	0	0
Pier Area[5]	0	0.13	0.21	0.13	0.18	0.16	0.16	0*	0*	0*
Marine Total[6]	**0**	**6.3**	**7.1**	**6.9**	**4.3**	**0.2**	**16.2**	**0.7**	**3.8**	**1.6**
the following three lines indicate subsets of the marine total shown above										
Eelgrass	0	0.02	0.00	0.04	0.00	0.02	0.03	0.08	0.29	0.00
Kelp	0	2.79	2.99	2.75	1.64	0.02	3.01	0.29	1.36	1.01
Saltmarsh	0	0	0	0	0	0	0	0.1	1.70	0

[1] **Bridge Alternatives:**
Alternative C3(a) = 200' Bridge between Signal Road and South of Airport Terminal
Alternative C3(b) = 120' Bridge between Signal Road and Airport Terminal
Alternative C4 = 200' Bridge Between Tongass Avenue (North of Cambria Drive) and South of Airport Terminal
Alternative D1 =120' Bridge Between Tongass Avenue (near Existing Ferry) and Airport Terminal
Alternative F1= Bridges (200' East and 120' West) Between Tongass Avenue and Airport, via Pennock Island
Alternative F3 = Bridges (60' East and 200' West) Between Tongass Avenue and Airport, via Pennock Island

[2] **Ferry Alternatives:**
Alternative G2 = Ferry Between Peninsula Point and Lewis Point
Alternative G3 = Ferry Between Downtown and South of Airport
Alternative G4 =Ferry Between New Terminals Adjacent to Existing Ferry Terminals

[3] Assumes channel modification would be required for F3. Areas shown as dredged would not permanently be lost as marine habitat.

[4] Area that is covered by over-water structures fewer than 30 feet above MHHW, both for ferry docks and the low portions of bridge alternatives. Ferry loading transfer bridge assumed to be 24'x140'; floating barge 24'x60'; apron 24'x24'.

[5] Bridge alternatives include piers 30'x30'. Ferry alternatives include small-diameter pilings, but these are not calculated. The impact of ferry pilings is included under the shaded area (two lines above).

[6] Marine Total is the total of the first four lines of the table. Impacts include loss of habitat and change in habitat function. Eelgrass, kelp, and saltmarsh impacts are a subset of this total. Total is rounded up to the next tenth acre.

3.1.5 Spills

Moderate spills (e.g., more than a few gallons) of diesel oil could occur during construction from an accidental release from a work vessel or tank truck near the water.

Spilled diesel oil that grounded in the small saltmarshes at the mouths of Lewis Cove Creek or Government Creek, or in the marsh fringes along substantial portions of the Gravina shoreline, would have substantial and lasting impacts on saltmarsh plants and animals contacted. Because both marshes are relatively close to (within 1 to 2 miles of) construction areas where spills would be initiated, oil contacting them would be relatively fresh and there would be little opportunity for weathering of toxic lighter fractions.

Diesel and hydraulic oils grounding in a soft bottom marsh are more likely to penetrate into the marsh substratum than are heavier bunker or crude oils (Baker, 1970). On the other hand, subsequent weathering of the lighter oils would proceed more rapidly than for heavier oils. Oiling of saltmarsh plants can be expected, at a minimum, and may cause some reduction of primary production in the plants for at least a year. Time of year and type of oil are extremely important in the degree of impact experienced; oiling of a marsh during the winter months can often be cleaned up mechanically or by natural processes with little residual reduction in productivity (e.g., Hoff et al., 1993). Several species of saltmarsh plants in Prince William Sound were routinely seen pushing new shoots up through several millimeters of weathered crude oil from the *Exxon Valdez* (Houghton, J., Pentec Environmental, pers. obs., July, 1991).

Diesel oil contacting aboveground saltmarsh vegetation during the active growing period (spring and summer) can be expected to cause “burning,” browning, reduced growth, and even death. Perennial plants with extensive belowground root/rhizome systems appear to be more resistant than annuals and regenerate readily following even severe damage to aboveground parts (e.g., Baker, 1970). The greatest damage in saltmarshes often results from inappropriately applied cleanup approaches that can severely damage root/rhizome systems and alter the physical structure and stability of the marsh.

A worst-case scenario in Tongass Narrows would result from a spill occurring late in a flooding peak spring tide with a strong wind, during the springtime. These circumstances could push relatively fresh oil high into the marshes and channels of one or both of the estuaries. This circumstance during a peak spring tide would result in a maximum amount of oil deposition well into the marsh, and timing relative to the tidal cycle would ensure a maximum interval before the next inundation. Contact with actively growing shoots of saltmarsh plants would maximize the damage. A high sun angle would also dry out the stranded oil and greatly reduce the rate at which the residues would be washed from the marsh.

Recovery of above-ground vegetation could be expected in 1 to 2 years for most species. Hoff et al. (1993) documented nearly full recovery of above-ground biomass of *Salicornia* and *Distichlis* (species present in both Gravina marshes) within 1 year following a crude oil spill in a marsh at Fidalgo Bay, Washington.. They noted, however, a possible trend of reduced below-ground biomass in the second year following the spill.

Heavy initial mortalities of invertebrates would be expected on intertidal shorelines oiled with fresh diesel oil, and sublethal effects on plants and invertebrates might affect physiology, growth, reproduction and development, and behavior of invertebrates. Sublethal effects might actually become lethal if there were a loss in ability to avoid predators resulting from the response to oils. For instance, No. 2 diesel fuel has a narcotic effect on invertebrates; large percentages of the limpet *Tectura scutum* exposed to diesel fuel became detached from aquarium walls (Ehrsam et al., 1972). Many bivalves exposed to *Exxon Valdez* crude oil were either killed *in situ* or found on the beach surface where they were vulnerable to predators (Houghton, J., Pentec Environmental, pers. obs., 1989; Shigenaka et al., 1997). Cardwell (1973) found that low levels of No. 2 diesel oil also inhibit the byssal attachment of the young mussels *Mytilus edulis*. However, Cardwell also found complete recovery (reattachment) within 24 hours after the mussels were placed in clean running seawater.

In general, fish are less vulnerable to effects of oil spills than are most other types of marine organisms. They are mobile, can usually avoid adverse conditions, and rapidly metabolize hydrocarbons (e.g., Craddock, 1977; Patton, 1977). However, more recent work has shown high sensitivities of fish to levels of sediment hydrocarbon concentrations in the parts per million or even parts per billion range (Horness et al., 1998). Other work has shown a very high sensitivity of salmon eggs to residual hydrocarbons from the *Exxon Valdez* spill (e.g., Bue et al, 1998). Salmon use of Government Creek is noted previously, and pink, coho, and chum salmon are known to spawn in the small creek (Airport Creek) entering Lewis Cove (House, D., ADF&G, pers. comm., July 31, 2001). If a portion of this spawning occurs in tidal areas, a spill could affect egg survival in either of these estuaries. Smolt outmigration from these and other streams in the area occurs from early April through late June. Fry would probably not be vulnerable to acute effects unless a few fish became isolated in a small embayment that received heavy oiling (Brannon et al., 1995).

Birds associated with the water or sediment surface (dabbling ducks, shorebirds) would potentially become oiled and suffer from hypothermia or might bring oil back to their nests, injuring or killing eggs or young. Many authors, including the National Research Council (NRC) (1985) and Leighton (1991), have reviewed the effects of oil on birds. These effects include:

- Effects on plumage, buoyancy, and thermoregulation
- Effects from ingestion of oil
- Effects on the alimentary tract
- Effects on blood
- Effects on salt glands and osmoregulation
- Effects on adrenal glands and corticosteroid hormones
- Effects on kidneys and liver
- Effects on reproductive system
- Suppressed immunity
- Mutagenic effects

High mortalities of bird species are often seen in the vicinity of a spill. Estimates of bird mortalities following major spills of heavy fuel oil or bunker C fuel oil from 1937 to 1991 have ranged from about 6,000 birds following the *Seagate Washington* spill (Vermeer and Vermeer, 1975) and the *Hamilton Trader* spill of 1969 (Hope Jones et al., 1970), to greater than 50,000 birds following the January 1970 spill of fuel oil off northeast Britain (Greenwood et al., 1971) and the *Nestucca* barge spill of bunker oil off Grays Harbor Washington in 1988 (Ford et al., 1991).

Water-associated mammals (e.g., harbor seals, mink, river otter) could suffer a similar fate. Geraci and Smith (1977) showed that harbor seals are relatively tolerant of ingested oil, but suffer considerably from surface contact, especially to the eyes. Because harbor seals depend on fat layers rather than fur or hair for insulation, they are less vulnerable to surface contact than are sea otters or river otters. Several hundred harbor seals were killed in the *Exxon Valdez* spill (Loughlin, 1996). Deaths occurred over a period of several months following the spill; autopsied animals displayed liver damage, skin lesions, and elevated tissue concentrations that were attributed to oil exposure.

In summary, the probability of an oil spill resulting from the project is low and the volume of oil that might be spilled in any given event associated with the proposed project is relatively limited (a few thousands of gallons). Local impacts could be severe, however, especially if large quantities of this oil were to be stranded in marshes or stream mouths. Recovery of most species of vegetation and invertebrates would be expected within 1 to 2 years, but recovery of birds and mammals could take longer.

Several measures are available that could be employed to reduce the impacts of a spill if a stream mouth or saltmarsh were impacted. Booms could be deployed to limit oil movement into tidal channels; sorbent booms could be deployed to pick up oil in those channels, and low-pressure ambient water could be used to flush oil from the marsh into areas where it could be absorbed or vacuumed from the water surface. This latter approach appears to have been successful at enhancing recovery of the *Salicornia* marsh oiled in Fidalgo Bay (Hoff et al., 1993). In all cases, care must be taken to avoid techniques that physically damage the marsh (e.g., high-pressure washes, manual cutting of vegetation, or anything that requires much foot traffic in the marsh).

3.2 Operation Effects

3.2.1 Shading

Bridges or ferry ramps would partially shade littoral areas, reducing primary productivity and possibly limiting the distribution of some algae, while extending the distribution of other taxa. Examples of the effects of partial shading on steeply sloped rocky intertidal areas were reported at Stations PEN-4 and PEN-4A (see *Phase II Marine Reconnaissance Survey*; Pentec, 2001), where the middle and upper intertidal elevations were relatively devoid of macroalgae. However, below MLLW (and out from under the influence of overhanging trees), a typically lush kelp-dominated flora was found.

The presence of over-water structures (bridges, causeways, and ferry docks) might partially shade portions of the adjacent beach and subtidal bottom areas. The area under a dock or causeway would likely receive full-time shade, whereas the area under an elevated bridge section would not, because the shadow cast by structures high above the water would move across the water as the sun traversed the sky. Because the upper limits of many intertidal species, including eelgrass, are set by the degree of desiccation experienced (shading would reduce desiccation) shading by project structures would allow some species to extend their ranges upslope.

However, since lower limits of vegetative growth are set by light level, net loss of eelgrass or kelp productivity would result from the project if deeper portions of beds were shaded. If this occurred, eelgrass or kelp bed habitat area would be incrementally reduced, reducing the area of refuge and rearing for juvenile salmonids during their migrations as well as for other aquatic organisms such as Dungeness crabs. Reduced eelgrass productivity would also decrease the eelgrass blade area available to support epiphytic crustaceans, which are an important food source for juvenile salmon.

3.2.2 Inwater Structures

Pilings and piers necessary to support bridges or nearshore components of the alternatives could alter the nearshore migration pathways of smaller juvenile salmonids (e.g., pink and chum salmon) or other marine species in Tongass Narrows. Impacts have been reduced to the extent possible by locating nearshore components in a manner that leaves a nearshore migration corridor (e.g., down to at least -5 feet MLLW) near the extreme low-water line, clear of obstruction. Deeper piers or pilings allow free passage of marine species migrating along shorelines and would develop an epifauna typical of natural deeper hard-bottom areas.

3.2.3 Overwater Structures

In addition to shading, over-water structures that create areas of darkened water can impede or delay long-shore migrations of juvenile salmonids. Studies in Washington State have shown that schools of juvenile chinook and chum salmon pause in their migration when encountering an over-water structure that creates a darkened area of water, such as a marginal wharf or wide pier. Piers that are constructed close to water or are made of dark materials, such as treated wood, are especially daunting to migrating fish (e.g., Pentec, 1997). In the Gravina Access Project, there is little expectation that an elevated bridge, constructed of concrete, would create light conditions that would impede salmon migrations, although the low elevation causeways along the northeast edge of the airport under the northern bridge alternatives (C3a, C3b, C4) could cause fish to alter their migration corridors.

3.2.4 Runoff

The increase in impervious surface area would increase the current volume of runoff from the area. Runoff from new roads, if not collected and treated, would create temporary, localized increases in water turbidity of drainage pathways and in the Tongass Narrows (see the discussion of turbidity effects in Section 3.1.1). In addition, some contaminants such as oil and metals from vehicle brake dust are also likely to reach the drainage pathways and Tongass Narrows. In the climate of Ketchikan, frequent rainfall would limit accumulation of these materials on roadways. Thus, it is unlikely that these materials would run off the bridge or roadways in concentrations that would create conditions harmful to biota; again, the high circulation rates in Tongass Narrows would quickly dilute and dissipate any releases.

3.2.5 Noise

Existing sources of noise in the project area include commercial jets, floatplanes, vehicular traffic, construction machinery, industrial plants, and watercraft. Eagles, waterfowl, and mammals in the vicinity of Ketchikan are exposed daily to noises associated with the City and the airport, and have long been adapted to the increased noise levels. The primary sources of noise associated with the proposed project would be vehicular traffic. The degree of noise impact from the project would relate to the level of traffic increase. Studies conducted near Aberdeen, Washington, a town similar in size to Ketchikan, concluded that a doubling of roadway traffic would result in a noise increase of approximately 3 dB (DOC, 1994). An increase of 0 to 5 dB is classified as insignificant by the U.S. Environmental Protection Agency (EPA) (DOC, 1994). Based on the EPA criteria, the additional noise generated by traffic would not have a substantial impact.

3.2.6 Spills

The most probable oil spill that could occur during project operation would result from a tank truck accident that spills gasoline or diesel from the bridge into the marine environment. Possible effects of marine oil spills are described in Section 3.1.5.

3.2.7 Increased Access

Increased access to Gravina Island is expected to lead to increased settlement and development along the western slope of the island. The effects of watershed development or suburbanization on streams are well documented (Leopold, 1968; Hammer, 1972; Hollis, 1975; Booth, 1991) and would be of concern for crossing alternatives and road systems that would increase development in the Government Creek and Lewis Creek drainages. Suburbanization is often measured by the proportion of basin area covered by impervious surfaces. Although impervious surfaces themselves do not generate pollution, they are the major contributor to changes in the hydrologic regime that drive many of the physical changes affecting urban streams (May, 1998). In addition to increasing area of impervious surface in the basin and the resulting stormwater runoff, development of watershed areas can also affect watershed drainage density (mile of stream length per square mile of basin area) when grading, landscaping, and associated infrastructure development result in straightening of stream channels. Chemical water quality of urban streams is generally not substantially degraded at low impervious levels, but might become a more important factor in streams draining highly urbanized watersheds (May, 1998; Pitt et al., 1995; Bannerman et al., 1993).

Streambed quality can be degraded by the deposition of fine sediment and by the streambed instability due to high flows. Basin development has the potential to cause both of these (May, 1998). Increases in fine sediments decrease the intragravel dissolved oxygen (IGDO) levels. Low IGDO is disastrous to salmonid incubation habitat (Koski, 1972, 1975).

In addition, suburbanization contributes to the degradation of the riparian zone. Degraded riparian conditions influence streambank stability and large woody debris recruitment. Without riparian-zone protection, urbanization degrades the condition of riparian zones, and therefore contributes to streambank instability and loss of large woody debris in the stream (May, 1998). In-stream habitat conditions have a substantial influence on in-stream biota. Changes of riparian-zone condition and streambed quality, including fine-sediment content and streambed stability, affect the benthic macroinvertebrate community (May, 1998). As urbanization increases and riparian-zone integrity decreases, the biotic integrity of the stream decreases as well (May, 1998). Additionally, the construction of roads, bridges, and ferry docks would increase public access to nearby streams and estuaries that had not been as accessible before construction. Increased public access might also increase risk of harassment of spawning salmon.

4—Potential Impacts of Each Alternative

This section describes the potential impacts that each of the Gravina Access Project alternatives currently under consideration would have on marine resources. The potentially affected resources were identified during the investigation for the *Phase II Marine Reconnaissance Technical Memorandum* (Pentec, 2001) and are characterized in this report by the survey station number used in the Phase II marine reconnaissance. Table 3-1, above, summarizes impacts by alternative.

4.1 Alternative C3(a)

This bridge alternative would require a pier in nearshore waters on the eastern side of Tongass Narrows that could impact bull kelp beds near intertidal Station REV-4. These beds would be expected to reestablish on the lower intertidal rock or concrete structures of the pier. Deep-water piers in mid-channel would develop a rich epifauna.

On the western side of Tongass Narrows off the Barge Dock (Station GRV-5), the required piers might be located in an area that currently supports part of the near-continuous eelgrass bed that is interspersed with beds of *Laminaria* and an area of bull kelp. The offshore causeway that leads south parallel to the airport runway would also shade or require fill in an area with near-continuous eelgrass or kelp beds. Care should be taken, where the route curves around the southern end of the runway, to ensure there is no encroachment into upper intertidal salt marshes and adjacent riparian vegetation, especially along the Government Creek Estuary (GRV-7A). Total marine impact from piers and filling would be approximately 6.3 acres (Table 3-1). Impact on areas of kelp would be substantial (2.79 acres).

4.2 Alternative C3(b)

This bridge alternative would have impacts similar to those of Alternative C3 (a), except that it would avoid some impacts on eelgrass and shallow-water biota off the Barge Dock and Barge Dock Beach (Station GRV-5A), north of the floatplane dock, by crossing over deeper water. Total marine impact from piers and filling would be approximately 7.1 acres (Table 3-1). Impact on areas of kelp would be substantial (2.99 acres).

4.3 Alternative C4

This bridge alternative would have impacts similar to those of Alternative C3(a), except that the pier in nearshore waters on the eastern side of the narrows would be in a slightly different location. Resources affected would be similar to the previous two alternatives with 0.04 acres of eelgrass impacts and 6.9 total acres of marine impacts (Table 3-1). Impact on areas of kelp would be substantial (2.75 acres).

4.4 Alternative D1

This bridge alternative would affect fewer marine resources than the other bridge alternatives in the vicinity of the airport (i.e., C3[a], C3[b], and C4) because no pier would be required in nearshore waters on the eastern side of Tongass Narrows, and because the length of shoreline affected by the pile- and fill-supported causeway along the southern half of the airport shoreline would be shorter. Total marine impact from piers and filling would be approximately 4.12 acres (Table 3-1). Impact on areas of kelp would be substantial (1.64 acres).

4.5 Alternative F1

Alternative F1 would cross Pennock Island and require bridges across both East and West Channels of Tongass Narrows. The eastern landfall leaving Revillagigedo Island would require a pier, probably in eelgrass, along the shoreline just south of the South Dump (Station REV-8). This shoreline is relatively rich, given the extent of debris remaining on the beach from the former dump. The East Channel bridge would cross kelp beds on both the eastern and western shores at an elevation of approximately 60 or more feet above the water, rising to a height of 200 feet in mid channel. This bridge elevation would likely result in minor shading impacts in the form of reduced productivity of those kelp beds. Piers on the west side of the east channel would avoid productive shallower nearshore waters.

The span of the West Channel would leave Pennock Island from a high rock bluff, but would require three piers. Two of these would be placed in deeper waters, likely avoiding direct impacts on marine vegetation. The western pier would be in shallower waters that support kelp and/or eelgrass beds. The West Channel bridge would be relatively high (120 feet) above the water surface, over the kelp and eelgrass beds as well as the mid- and upper intertidal vegetation (a diversity of algae) seen at Station GRV-9. Because of the height of the bridge, it appears unlikely that a substantial reduction of bed productivity would result. Shading would have minimal effect on the Pennock Island shore intertidal community (Station PEN-4), which is already shaded by overhanging trees. Total marine impact from piers and filling would be approximately 0.2 acre (Table 3-1). Impact on areas of kelp would be relatively small (0.02 acre).

4.6 Alternative F3

Like Alternative F1, F3 would cross Pennock Island and require bridges across both East and West Channels of Tongass Narrows. The eastern landfall leaving Revillagigedo Island would require an abutment pier along the shoreline in the vicinity of the South Dump (Station REV-8). As noted, this shoreline is relatively rich, given the extent of debris remaining on the beach from the former dump. The East Channel bridge would cross kelp beds on both the eastern and western shores at an elevation of approximately 60 feet above the water. This bridge elevation would likely result in some shading impacts in the form of reduced productivity of the kelp beds. Piers on both sides of the channel would avoid productive shallower nearshore waters.

The bridge over West Channel would leave Pennock Island from a high rock bluff and require three piers. Two of the piers would be placed in deeper waters, likely avoiding direct impacts on marine vegetation. The western pier might be in shallower waters that support kelp beds. The West Channel bridge would be relatively high (200 feet) above the water surface over the kelp beds and over the mid- and upper intertidal vegetation zones, which support a diversity of algae seen at Station GRV-9. Because of this elevation, it appears unlikely that a substantial reduction in productivity would result. Shading would have minimal effect on the Pennock Island shore intertidal community (Station PEN-4), which is already shaded by overhanging trees.

Alternative F3 would require modification to West Channel to improve navigation. Widening of the channel would modify slightly the localized nearshore flow regime but would not affect overall flow though West Channel. Channel modification would require the removal of approximately 59,000 cubic yards of surficial sediment, which would not have to be blasted out, and 125,000 cubic yards of bedrock, which would require blasting to be removed. The channel widening would require removal of material between –5 to –40 MLLW. The channel widening would consist of a combination of drilling, blasting, and dredging activities. The duration of these activities would be one to three months. Channel modification work would occur up to seven days a week with almost continuous disturbance from dredging and intermittent disturbance from blasting.

Blasting and dredging in West Channel would remove approximately 16 surface acres of subtidal habitat from areas adjacent to Gravina and Pennock Islands (Table 3-1). This action would eliminate interspersed eelgrass and kelp beds located in this area. Newly exposed soil and rock surfaces would be recolonized over a period of several years. Ultimate benthic assemblages are expected to resemble those now found in similar substrates and depths. Because of the loss of some shallow water habitats, especially on the southwest side of the channel, overall productivity in the area would be less than that currently provided in the existing shallower areas. Construction disturbance (blasting and dredging) would reduce the primary and secondary productivity of West Channel during construction and for one to two years following channel expansion. This will reduce the flux of plant matter, smaller organisms, and the prey available for larger organisms on either end of the channel, where those animals were dependent for prey on plants or algae produced in the impacted area. This effect will be short term and likely would be immeasurable since few organisms would be dependent solely on prey produced in the impacted area. The increase in channel cross sectional area will not be substantial, and little effect is expected on net flow through West Channel; hence no measurable impact is anticipated on marine communities adjacent to the channel entrances on either side.

As noted above, underwater blasting could be expected to cause heavy mortality of fish within 100 meters, with lesser numbers of fish killed with greater distances. The confined nature and rocky shorelines of West Channel may focus, rather than dissipate, acoustic energy, extending the area of impact up and down the channel. The increase in channel cross sectional area would not be substantial, and little effect is expected on net tidal flows through West Channel. Therefore, no measurable impact is anticipated on marine communities adjacent to the channel entrances.

This alternative would have a total marine impacted area of 16.2 acres (Table 3-1), primarily from dredging West Channel. Impacts on kelp beds would be substantial (3 acres).

4.7 Alternative G2

Under this alternative, a ferry would run between Peninsula Point (Station REV-3A) and Lewis Point (Station GRV-3A). It is assumed that construction of a ferry terminal at Peninsula Point would disrupt a portion of the rich rocky intertidal face of the point. However, because of the steepness of this face, the net area affected would be relatively minor. Displaced organisms would be replaced with similar species on the new hard structures placed for the terminal. No eelgrass was found in the sandy area west of the point that would require dredging for the ferry berth, but kelp (*Laminaria*) and other algae were abundant.

Construction of the ferry terminal at Lewis Point on the western side of Tongass Narrows would likely affect areas of kelp and eelgrass that lie offshore of the rocky point and in silty-sand pocketed beaches at the base of the rocky intertidal outcrops. These same pocket beaches have very high densities of butter and littleneck clams. The highest intertidal areas around the several rocky outcrops of Lewis Point support a fringe of typical saltmarsh vegetation that may be eliminated, in part, by ferry access construction. The access road from this ferry landing would cross two tributaries of Airport Creek; construction of these crossings could increase sedimentation rates in the estuary, adversely affecting the vegetation (described above).

Alternative G2 would likely have total marine impacts of 07 acre (Table 3-1). Impact on areas of kelp would be moderate (0.29 acre).

4.8 Alternative G3

Under this alternative, a ferry would run between Bar Point (Station REV-6) and an area south of East Clump Island (Station GRV-7). It is assumed that construction of a ferry terminal at Bar Point could disrupt a portion of the rich rocky intertidal bench at this site, although it might be possible to avoid this feature completely. Dredging would disrupt beds of eelgrass, kelp, and other algae offshore of Bar Point.

A band of kelp and other algae is also present and would likely be disrupted by dredging at the western ferry terminal near East Clump Island. Ferry access would also cross a relatively broad intertidal bench that has a mix of habitat types; bedrock outcrops in a mixed-soft (cobble/ gravel/ silt) lower beach and a mixed gravel/ cobble upper beach. This mix of habitat types supports a diverse biota, and hard-shell clams are abundant in the lower beach. The highest intertidal areas around the several rocky outcrops and along the shore of Gravina Island itself support a fringe of typical saltmarsh vegetation that may be eliminated, in part, by ferry access construction.

This alternative would have moderate impacts on eelgrass (0.29 acres) and substantial impacts on kelp beds (1.36 acres; Table 3-1). Total marine habitat impacted would be approximately 3.8 acres.

4.9 Alternative G4

This alternative would require construction of new ferry terminals (near the existing terminals) on each side of Tongass Narrows. Both terminals would be close to deep water and would require little, if any, dredging. Also, both would be constructed in areas that are already riprapped and thus would avoid impacts on natural intertidal areas. Narrow bands of bull kelp lie offshore of the eastern landfall and would be affected by construction. Impact on areas of kelp would be substantial (1 acre), but the total area of marine impact would be relatively low (1.6 acres; Table 3-1).

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