Exxon Valdez Oil Spill
Restoration Project Final Report

Workshop Report: Residual Shoreline Oiling

Restoration Project 95266
Final Report

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Study History: This report summarizes the findings of a workshop held November 1 and 2, 1995 by the Alaska Department of Environmental Conservation. It includes a cost estimate for potential shoreline treatment prepared by Petroleum Environmental Services, Inc. The cost estimate was requested by the Alaska Department of Environmental Conservation to provide information for the workshop and was completed under Contract #18-9012-96.

Abstract: Significant surface and subsurface oil from the 1989 *Exxon Valdez* oil spill remains at numerous locations in Prince William Sound, many of which are near the village of Chenega Bay. Residents of Chenega Bay have repeatedly indicated the presence of the residual oil is a significant problem for the community, and asked that the Trustee Council fund projects to remove the remaining oil. The Trustee Council sponsored the workshop on Residual Shoreline Oil to attempt to answer the significant technical, social, and policy questions that surround this issue. These include the financial cost, environmental cost, and benefits of additional shoreline treatment. Workshop attendees concluded that it was possible to construct a treatment program that might provide significant benefits to residents of Chenega Bay without incurring environmental harm with area-wide significance. To provide options for Trustee Council consideration, DEC and residents of Chenega Bay constructed five treatment alternatives. One alternative is for no additional treatment. The remaining four alternatives treat between 8 and 15 beach segments at a cost estimated to range from $1.9 to $2.6 million. Costs include estimates for treatment, monitoring, and agency project management. The workshop also made recommendations with respect to future monitoring of the persistence or degradation of surface and subsurface oil on shorelines in the spill area.

Key Words: Clean-up, *Exxon Valdez,* monitoring, PES-51, Prince William Sound, residual oil, sediments, shoreline oil, shoreline monitoring, subsistence, subsurface oil, surface oil.

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SUMMARY

In November 1995, the Trustee Council sponsored a workshop on Residual Shoreline Oiling to address issues concerning future funding of shoreline treatment and monitoring. Over 50 people attended the workshop, including 14 people from the Village of Chenega Bay.

Shoreline Treatment

Significant surface and subsurface oil remains at many locations in Prince William Sound. The 1993 Prince William Sound shoreline survey identified 225 locations at 45 ground survey sites with surface oil. The average oiled location with surface oil residue, asphalt, or mousse was 160 m^2 in size and had about a 23% oil coverage. The survey identified 109 locations with subsurface oil.

Much of the most significant oiling remains in the Chenega area. Residents of Chenega Bay have repeatedly indicated the presence of the residual oil is a significant problem for the community. They believe that it affects the recovery of injured resources, and the enjoyment and confidence in subsistence use of the shorelines. They believe that additional treatment is necessary to remove the oil, restore the resources they depend on, and restore their use of Prince William Sound.

The question of whether to remove some residual oil has been a difficult one for the Trustee Council. Scientists have indicated that treatment may not aid the resources, and may, in fact, set back recovery of intertidal areas. In addition, total removal of the oil is technically and financially infeasible, and the Trustee Council is unclear whether partial removal would satisfy those concerned about the presence of oil.

The shoreline treatment part of the workshop was designed to allow scientists, citizens of Chenega Bay, and other interested users to discuss these issues, and to provide the Trustee Council with information to allow them to decide whether or not to fund additional treatment. Workshop conclusions are summarized below.

- Workshop participants agreed that surface and subsurface oil remains on many beaches near the village and in other locations, and that the oil is not likely to disappear naturally in the near future, perhaps for decades.

- In general, Trustee Council scientists believe that residual oil is unlikely to be affecting the health or population of many of the subsistence resources such as harbor seals, shrimp, and deer. In some locations, the oil may be affecting local populations of harlequin ducks and sea otters. However, Chenega Bay residents believe that residual oil continues to exert a significant adverse affect on the Prince William Sound environment.

- Chenega Bay residents indicated that they believed that further treatment of oiled beaches near Chenega Bay would make their use of the beaches more enjoyable and safer, and start to relieve their perception that the village is surrounded by oil pollution.

- The experts invited to the workshop felt that if additional treatment was decided upon, the entire toolbox of treatments should be evaluated to determine the most cost-effective, beneficial, least environmentally costly method of reaching the treatment goals for each beach segment. However, the technique previously tested near Chenega Bay using airknife application of PES-51 is a useful treatment method and is probably appropriate for many locations identified by Chenega Bay residents.

- With respect to the environmental cost of treatment, the experts attending the workshop felt that a limited treatment program could provide benefits to Chenega Bay residents and other shoreline users without incurring significant environmental harm. However, the experts also indicated that a large-scale treatment program—done throughout Prince William Sound—would incur cumulative environmental costs that could significantly set back intertidal recovery.

- If the Trustee Council decides to fund additional treatment, the legal basis and rationale for the decision should be clear as it may open up a broader issue of continued cleanup throughout the spill area. It appears that the regulatory rationale for additional cleanup should be based primarily on land management objectives rather than environmental risk. The presence of asphalt and mousse diminishes the public-use value of the tidelands. In addition, the public policy rationale should be based primarily on the impact of the spill on Chenega Bay and environs. Residual oil exists elsewhere in the spill area, but the effects of residual oiling fall disproportionately on the Chenega Bay residents who use the shorelines and the waters of the area.

- Following the workshop, ADEC scientists and Chenega Bay residents worked together to identify beaches that may be appropriate for treatment. Their recommendations are outlined in Appendix F.

- Options for shoreline treatment are outlined in Part 2A of this report. The estimated cost is summarized below.

Option No.	Description	Estimated Cost
No. 0	No additional treatment	No additional cost
No. 1	Treat high priority shorelines	$1.9 million
No. 2	Also treat medium priority shorelines	$2.1 million
No. 3	Also treat areas up to 5,000 m^2 yet to be located	$2.3 million
No. 4	Also treat high priority shorelines requiring complex treatment methods	$2.6 million

Shoreline Monitoring

Periodic monitoring of residual shoreline oil has been a responsibility of the Trustee Council since its inception. However, during deliberations on the FY 96 work plan, Council staff could not come to consensus about the type of monitoring needed for the future, how frequently it was needed, nor where it should be done. The shoreline monitoring section of the workshop was held to resolve these questions by bringing together third-party experts, agency staff, and Trustee Council scientists.

The workshop discussed the objectives of future monitoring, as well as field methods to provide cost-effective, useful results. Attendees at the workshop made the following recommendations.

- Objectives for monitoring must be set at the outset with the principal stakeholders inside and outside of government.
- The links to the stakeholders' interests must be made at the field level, since it is hard to generalize about how conditions change and do not change at various sites.
- Similarly, the links to other scientific disciplines (biology, chemistry) and the analysis in those areas must be done at the field level.
- A monitoring program should include experts in all fields—including subsistence/tribal/village knowledge—at the specific sites.
- Regional geographic differences should be built into the program; oil arrived at different parts of the Gulf of Alaska in different forms and in different volumes than in the Sound.
- The "consistently qualitative" method of monitoring may continue to be used.
- Attention should be given to the level of specificity and detail required for individual sites.
- Methods, protocols, and other design features should assume long-term persistence of the residual oiling.
- The design of any monitoring program, since it is built on the assumption of long-term persistence, should depend as little as possible on individual personnel and experience; better site identification is critical.
- The number of sites should be scaled down; the level and categories of observations, scaled up, so that we look at more things in more detail at each site.
- The site selection process should be expanded beyond the basic ADEC/Exxon/USCG response data base by including the broad universe of *Exxon Valdez* site information (Other agency data, local knowledge, other restoration projects).

Part 1A. Shoreline Treatment

Costs and Benefits of Additional Treatment of Shorelines with Residual Surface Oil

Background

Chenega Bay residents indicate that the presence of residual oil is a significant problem for the community. They have repeatedly stated that it affects the recovery of injured resources, and that it affects their enjoyment and confidence in subsistence use of the shorelines.

The question of whether to remove residual oil has been a difficult one for the Trustee Council. Neither the number of segments of shorelines which need treatment nor the total cost have been clearly identified. The Council's scientists have indicated that additional treatment may not aid the recovery of injured resources and may, in fact, set back the recovery of the intertidal areas. And finally, since total removal of the oil from all oiled beaches is technically and financially infeasible, it is unclear wither partial action would be satisfactory to those concerned with the presence of oil.

Part 1A of the Residual Oiling Workshop was intended to allow scientists, interested subsistence and other shoreline users, and Trustee Council staff to provide information to the Trustee Council to resolve the issues posed above. Specifically the workshop was intended to answer the following questions:

- ***What is the problem?*** Put another way, what are the benefits of additional treatment to subsistence and other shoreline users?
- ***Would additional treatment benefit the recovery of injured resources?*** Will the program achieve restoration objectives for injured resources?
- ***What treatment techniques are appropriate? What is the acceptable level of treatment?*** Without infinite time or funds, a treatment program is unlikely to produce shorelines that are 100% clean.
- ***What is the financial cost of a treatment program?*** The Trustee Council should have available both the annual and total program costs before a program can reasonably be considered.
- ***What is the environmental cost of a treatment program?*** This is the "more harm than good" issue; cleanup should not continue if the potential environmental damage from the work is a greater threat than leaving the oiling in place.

Over 50 people participated in the Shoreline Treatment portion of the workshop, including 14 people from Chenega Bay. The 14 people from Chenega Bay represent a significant portion of that village's adult population and indicates the importance of this issue to the people of Chenega Bay.

A copy of the Workshop Agenda is attached as Appendix A. A list of workshop participants and the flyer used to announce the workshop are in Appendix B.

What is the Problem?

At the beginning of the workshop, Chenega Bay residents were asked to identify problems that they view as potentially caused by shoreline oil.

All of the Chenega Bay residents attending the workshop voiced concern about the amount and extent of residual shoreline oil—both surface and subsurface oil. The problems were categorized into three groups:

1. Residents believe that residual oil affects the population and health of subsistence resources.
2. Oil affects residents' use of the shorelines: their enjoyment and safe use of the resources is impaired.
3. Residents are concerned that there is more residual oil than is generally acknowledged, and that it has a long-term, adverse effect on the ecosystem.

Residents believe that residual shoreline oil affects the population and health of subsistence resources. All of the workshop participants from Chenega Bay voiced this concern in one way or another. Specifically, they said that there were larger populations of resources before the spill than exist today, and they blamed the declines, in part on the continuing presence of oil. Harbor seals were frequently cited as an example.

A number of residents stressed that populations of fish and wildlife have decreased in an area south of a line from Crafton Island to Green Island. (Chenega residents and Trustee Council scientists indicate that the area contains most of the shorelines with significant residual oil.)

Concern was voiced about the following resources[1]:

- Harbor seals: "Seal populations have not recovered. Pups are gone, compared to before."
- Shrimp and king crab: "Shrimp pots now come up empty" There used to be a king crab fishery in Prince William Sound and now there is none.
- Octopus (This resource was mentioned but not extensively discussed)
- Sea lions are bigger north of the "line" (from Crafton to Green Island that describes where residents see the most problems, and where there is the most oil).
- Salmon. Pink salmon runs are weaker than expected in the southwest district, even though they are strong in the northern part of the Sound. Some participants said that red salmon have measles (i.e., spots) and are smaller than before the spill. In 1995, one commercial fisherman noted that the ovaries of red salmon are larger on the right side than on the left.

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1. Quotes in this section are approximate. That is, they are based on hand-written notes, rather than taped transcripts and may paraphrase what was actually said.

- Ducks: Ducks eat mussels; mussels absorb (and still have) oil.

- Deer: "Deer eat seaweed. There is oil near the high-water mark of storm tides. What are the effects on deer?"

- Other Upland Resources: "Could inland residue from oil be affecting ducks and other upland resources?"

Oil affects residents' use of the shorelines: their enjoyment and safe use of the resources. A number of residents said that the presence of oil—whether or not it affects the health or populations of the resources—affects the use of the shorelines. The best summary of this concern was stated as follows: "If you went into a supermarket and it was filthy, would you buy your food there?" The resident went on to say that Prince William Sound is the supermarket for Chenega Bay; it is where their food comes from; and the fact that it is dirty makes a difference in their use, enjoyment, and possibly health.

Residents have a general concern that there is more residual oil than is generally acknowledged, and that it has a general, long-term, adverse effect on the ecosystem. Chenega Bay residents voiced this concern early in the workshop, but it was not completely understood by many other participants until later. The concern clearly transcended the concern for individual resources as well as the ability of people to use or feel comfortable using specific beaches. It was a more far-reaching concern about the long-term, general, sinister effect of the remaining oil on the overall ecosystem.

Would Additional Treatment Benefit Recovery of the Injured Resources?

This part of the workshop report summarizes Trustee Council scientists' conclusions about residual oil's effect on particular subsistence resources.

In general, scientists at the workshop indicated that to the best of their knowledge, residual shoreline oil is not currently affecting the health or populations of many injured resources, but may be affecting at least local populations of others.

Harbor Seals[2]. Removing residual oil is unlikely to have any measurable effect on the population or health of harbor seals. Marine mammals can efficiently process and rid themselves of oil. Recent tests of harbor seals for oil exposure do not show on-going contamination or affects on health, and it is very unlikely at this point that residual oil is affecting their health.

While an estimated 300 harbor seals were killed by the spill in 1989, harbor seal populations in Prince William Sound declined before the spill, and recent evidence shows that they are still declining. The decline is similar in oiled and unoiled areas.

2. Summary of Presentation by Dr. Kathy Frost, ADF&G.

When asked if harbor seals near oiled beaches were safe to eat, Dr. Frost answered that she eats marine mammal meat, and would not hesitate to eat marine mammals harvested in Prince William Sound. She has and would eat them, and would not hesitate to feed them to her children.

Harlequin Ducks. Stan Senner, Trustee Council Science Coordinator, indicated that about 1,500 sea duck carcasses were recovered following the oil spill, and that many of these were harlequin ducks. He indicated that there is also concern because few broods of young harlequins have been seen in western Prince William Sound since the spill, but that this lack of broods is difficult to interpret because there is such poor pre-spill information about breeding harlequins in the western Sound.

Harlequin ducks feed almost entirely in intertidal and shallow water habitats, and there is concern that mussels taken from oiled mussel beds could still be a pathway for contamination. If mussel beds are a problem, the effects are probably local. The Nearshore Vertebrate Predator Project (025) should help provide answers about whether residual oil in mussel beds is an important problem for harlequin ducks.

Sea Otters. About one-third to one-half of Prince William Sound's sea otter population of 10,000 may have died as a result of the spill, and there were lingering effects, such as reduced survival of recently weaned juveniles. Unlike the harbor seal, the sea otter population was expanding and growing at the time of the spill. Boat surveys since the spill have not documented any population increases, and local populations, such as around Knight Island, continue to be depressed. The Nearshore Vertebrate Predator Project (025) is intended to provide answers about whether oil contamination is an important problem for sea otters.

King Crab[3]. In 1989, scientists tried to study the effect of the spill on king crab. Unfortunately, they could not find enough king crab in either oiled or unoiled areas to complete the study. By 1989, the king crab population in both the oiled and the unoiled areas was low. However, there is little evidence of detectable *Exxon Valdez* oil below 300 feet in Prince William Sound, and only a few locations where it has been detected below 120 feet, so there is not much reason to suspect a link between the disappearance of the crabs and the presence of oil in the deep water.

Shrimp[4]. The discussion only briefly focused on shrimp. However, the state and federal governments studied shrimp in 1989, 1990, and 1991. The studies found some differences between oiled and unoiled areas in 1989, but not in 1990 or 1991. The scientists concluded that

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3. Summary of the discussion. Various scientists contributed.

4. Not discussed extensively at the workshop. Information in this paragraph taken from Trowbridge, Charles. 1992. Injury of Prince William Sound spot shrimp, *Exxon Valdez* Oil Spill State/Federal Natural Resource Damage Assessment Final Report (Subtidal Study Number 5), Alaska Department of Fish and Game, Commercial Fisheries Management and Development Division, Anchorage, Alaska. Page I.

there was "little or no oil contamination to the adult population." They also suggested that assessing any damage done by the oil spill would be difficult due to the large pre-spill commercial shrimp harvests.

Pink Salmon[5]. Pink salmon eggs have shown an injury that may be caused or made worse by oil buried in or near salmon streams. Studies have shown that up to 50% more pink salmon eggs die in oiled streams than unoiled streams. However, by 1994, the effect of the spill may have disappeared—researchers in both 1994 and 1995 were unable to determine a difference in the proportion of dead eggs between oiled and unoiled streams.

Red Salmon[6]. Don Kompkoff, Sr., who is a commercial salmon fisherman, noted that nearly all the female sockeye salmon he caught during the summer of 1995 had ovaries of different sizes; the left ovary was smaller than the right ovary. This is the first time Mr. Kompkoff had noted this difference. When asked if this is irregular, fisheries scientists at the National Marine Fisheries Service's Auke Bay Fisheries Laboratory said this is normal with sockeye salmon and is common with other salmon species too. The measle-like spots on some salmon, as noted by Mr. Kompkoff, could not be explained.

Deer. Dr. Bob Spies, the Trustee Council's Chief Scientist, indicated that damage assessment studies on deer conducted after the spill did not find a direct effect from the spill. Dr. Frost said that she conducted or helped with many of the autopsies on the dead deer sound after the spill, and that the she and others determined that the deer had died of starvation—that there just wasn't enough food around that year for reasons that are probably unrelated to oil. Dr. Spies does not believe that there is any significant effect on deer or other upland species from residual oil found near seaweed or above high tide line.

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5. Presentation given by Bruce Wright of the National Oceanic and Atmospheric Administration.

6. Summary of discussion. Various scientists contributed.

Residual Oiling Summaries: Presentation by Invited Experts

Four presentations were given by scientists invited for the workshop. The presentations gave all participants a similar foundation concerning the scientific understanding of the mechanisms by which shoreline oil is naturally removed, how residual oil in Prince William Sound has responded to the time and treatment, the extent and locations of residual oil, and how intertidal areas have recovered from the oiling and cleanup.

Summaries of the presentations are in Appendix C. Some of the points that attracted significant discussion and questions during the workshop are repeated below.

- Stranded oil may appear fresh, even after many years. However, it is fresh chemically (i.e., retains any of the lighter ends) only if it has been sealed by surrounding sediments. Thus, a sheen is not evidence of fresh or unweathered oil. Chemical tests are usually necessary to determine the state of weathering.

- Oil that remains in 1995, almost seven years after the spill, is very likely to remain for a long, long time. If it is still here, it is probably degrading or dispersing very slowly. In fact, while ADEC's 1993 PWS shoreline survey showed that there has been significant reduction of surface oil at many sites from 1991 to 1993, investigators attributed the improvement that did occur to manual removal and raking in 1991 and 1992, and found no measurable reduction from 1992 to 1993.

- It is possible for shorelines to contain deeply penetrated, stable, relatively fresh subsurface oil without any expression on the surface. Some of this oil is very weathered, some is not. The amount and condition of the remaining oil is a function of microhabitats—detailed geomorphological and oiling conditions—and can only be predicted or evaluated site by site.

- ADEC's 1993 PWS shoreline survey discovered surface oil at 225 locations at 45 ground survey sites. AP, MS, and SOR alone covered about 3.5 km of shoreline and occurred at 171 locations. (Definitions of the oiling categories such as AD, MS, or SOR are given in Appendix H.) The average oiled location with SOR, AP, or MS was 160 m^2 in size and had about a 23% oil coverage. AP and SOR occur in about equal amounts and dominate the surface oiling in Price William Sound. There was considerable discussion about whether all oiled sites were visited during the 1993 survey. The investigators felt that almost all sites were surveyed except those in the Port Bainbridge area which were missed with significant residual oil because of weather. There was also discussion of the meaning of the distance and areas measurements presented. Dr. Gibeaut indicated that the measurements were "effective distance and area" meaning that the actual measure was corrected for the amount of oil coverage at the location.

- In 1993, surveyors measured 109 distinct locations with visually detectable subsurface oil The areas of these locations ranged from four square meters to several thousand square meters with varying percentages of oil coverage. A total of 2,041 m^3 of oiled, subsurface sediment was discovered. Subsurface oil lenses were typically 3 cm to 15 cm thick and had clean overlying sediments.

What Treatment Techniques are Appropriate? What is the Acceptable Level of Treatment?

AVAILABLE TREATMENT TECHNIQUES

Ernie Piper of ADEC provided a presentation of the shoreline treatment techniques appropriate for use on Chenega-area shorelines. His presentation is summarized below. A more complete version is in Appendix D.

General Points.

- Treatment is site-specific. That is, it must be tailored individually to the specific situation including beach substrate, oiling conditions, and treatment objectives including the target effectiveness (i.e., "How clean is clean?").

- When considering the effectiveness, cost, and environmental effects of any treatment technique (such as a chemical agent), it is necessary to consider the entire treatment episode including any chemical to be used, method of application, method of containment, monitoring, any flushing, etc.

Shoreline Cleaning Agents (Surfactants).

- *What Agents to Consider—Experience of the* Morris Berman *Spill*[7]. For the January 1994 *Morris Berman* Oil Spill near San Juan Puerto Rico, NOAA was asked to select and field test shoreline treatment agents. They developed four criteria:
    - The agent must be listed on EPA's National Product Schedule.
    - The agent must has been shown to have greater than 20% removal effectiveness in standard laboratory screening tests, using the Environment Canada effectiveness test protocols.
    - Field tests must have demonstrated the agent to be an effective shoreline cleaning agent.
    - The product must be immediately available.

  NOAA found that three products met these criteria: Corexit 9580 M-2; PES-51; and Corexit 7664.

- *ADEC Recommendation with Respect to Shoreline Cleaning Agents.* The NOAA criteria appear reasonable for Prince William Sound. Of the three products that NOAA found to meet the criteria, two of them—Corexit 9580 and PES-51—have been tested in Prince William Sound. (The third, Corexit 7664, in addition to not having been tested in northern waters, is a dispersant and is not appropriate for a situation where the chemical is intended to be recovered).

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7. See Michel and Benggio, Testing and Use of Shoreline Cleaning Agents during the *Morris J. Berman* Oil Spill, in Proceedings of the 1995 International Oil Spill Conference.

In 1989 and 1990, Corexit 9580 was generally determined to be effective in removing surface oiling. However, field workers could not demonstrate proficiency at containing and collecting the oil-water-Corexit mixture once it was in nearshore waters. Further, it did not appear to be effective at removing subsurface oil. Therefore, Corexit was not approved for widespread application during the *Exxon Valdez* response, and for the same reasons it does not appear to be appropriate for use on beaches of concern to Chenega Bay.

Thus, the only shoreline cleaning agent which meets the NOAA criteria, appears to be effective on both surface and subsurface oil, and can be removed from the water during treatment appears to be PES-51.

Technology—Mechanical. Backhoes and other machines are suitable for tilling the extremes of bedrock and sand, but few are effective on the pebble/cobble substrates that dominate the shorelines of Prince William Sound.

Technology—Bioremediation. Bioremediation is the process of adding fertilizers to enhance the productivity of naturally occurring microbes that degrade oil. Surface oiling that is extremely weathered, such as asphalt, predominates in the Chenega area and is likely to be relatively unaffected by bioremediation.

Manual Treatment. Manual treatment extends from simple techniques, such as wiping up pools of oil, to treatment aided by simple mechanical equipment such as airknives, shovels, or rakes. These techniques typically move sediment or cobbles to break up oil, or expose it to sunlight and the tide in order to accelerate natural degradation.

Summary. There is no single technique or product that is likely to produce an adequate result on its own. Any cleanup effort at any site near Chenega Bay would likely entail manual and mechanical methods (shovels, rakes, air knives, small backhoes), some kind of water flush, and in many cases the application of a surfactant such as PES-51. The exact treatment scheme would be tailored to the individual beach, oiling conditions, and treatment objective.

SHORELINE RESTORATION—TREATMENT GOALS & PES TECHNIQUE

For this workshop, ADEC contracted with PES, Inc. to describe a technique it developed and tested for shoreline treatment, and to prepare a cost estimate for use of the technique on beaches that had been jointly identified by Chenega Bay residents and ADEC staff.

Petroleum Environmental Services, Inc. is the manufacturer of PES-51, the surfactant identified above that may be suitable for use at some of the Chenega-area beaches. After the *Exxon Valdez* oil spill, the company (then part of Tesoro Alaska Petroleum Co.) identified a technique that combines flushing and manual treatment with application of PES-51. In 1993, in cooperation with Chenega Corporation, the company tested the technique on a stretch of shoreline at Sleepy Bay—one of the problem beaches identified by Chenega. The test was conducted in association with the ADEC's Alaska Hazardous Substance and Spill Technology Review Council Technology Demonstration Program.

Proposed Treatment Goals—PES Process. As previous discussions have indicated, the treatment goal is an important part of the planning process—what the treatment is intended to achieve (How clean is clean?). Most of the Chenega Bay residents at the workshop had been at the 1993 PES demonstration and were familiar with the results.

PES identified the following treatment goals that they believed their cleaning technique had achieved at the 1993 demonstration.

IMMEDIATE

- Visually observable significant decrease in the amount of oil residue on the surface and in subsurface sediment.

- Significant decrease in the levels of measurable petroleum hydrocarbons in the sediment.

- No evidence of petroleum hydrocarbons being introduced into the water column.

LONG TERM

- Further visually observable decrease in the amount of oil residue on the surface and in subsurface sediments.

Results of the 1993 test at Sleep Bay indicated that the treatment produced both immediate and long-term benefits. Qualitatively, there was a visible decrease in subsurface oil residue. From a quantitative perspective, approximately 120 gallons of oily liquids were recovered. PES reports that there was an immediate and significant decrease in semivolatile petroleum hydrocarbons in the subsurface sediment. In May 1994, measurements indicated that semivolatile petroleum hydrocarbons had decreased even further. These improvements were accomplished without introducing any detectable levels of petroleum hydrocarbons into the water column along the shoreline below the treatment area.

PES Shoreline Treatment Process—Description.

- Shoreline is double boomed below the treatment area for collection of displaced oil.

- Deluge Header System is placed above the upper intertidal zone to provide a continuous flow of ambient temperature sea water over the treatment area.

- Airknife Injection System uses air pressurized at 100 to 200 pounds per square to penetrate into the subsurface sediment.

- PES-51 is injected as an aerosol or liquid into the sediment.

- Flush hoses are used to directly apply ambient temperature sea water to the injection site during and after application of PES-51.

- Displaced oil is collected with skimmers from the boomed area and pumped into a storage tank.

- Sorbents (materials that absorb oil) are used to collect oil from surfaces that do not drain to the shoreline. Oiled debris are stored in bags or drums for disposal.

- Water is decanted from the storage tank and returned to the shoreline. Oil is stored in drums for disposal.

Video and Description of 1993 Test at Sleepy Bay. The 1993 demonstration used the technique on a 120 ft x 135 ft area of Sleepy Bay near Chenega Bay. During the cleanup from 1989 to 1992 the test each had been subjected to almost every technique used in Prince William Sound: hand wiping; cold- and warm-water header-hose flood; cold-water high-pressure wash; warm/hot-water, medium-pressure wash; hot-steam-water, high-pressure wash; omni boom; and bioremediation using Inipol and Customblen.

The video of the demonstration made a visible impression on the workshop participants—the video showed a lot of oil and oil-water mixture flowing out of the ground. A number of people at the workshop mentioned that the video surprised them—they were unaware of just how much oil remained in the sediments. The video showed sheen, mousse, dark brown to black crude oil specks, and stringers mixed with water as the PES/water mixture was injected and flushed down the beach.

Test results indicated that 165 gallons of PES-51 was used; 120 gallons of oily liquids were recovered using the skimmer and a variety of absorbent materials. Tests indicated no oil was present in the water, and that treatment goals were met. A variety of publications documenting the test have been published and are not included in this workshop report.

Draft Cost Estimate. The PES Shoreline Restoration Cost Estimate is attached as Appendix D. PES estimated that seven beach segments identified jointly by ADEC and Chenega Bay residents would require 68 days in the field if done in one season and cost approximately $1.3 million. Two seasons of work (the more likely scenario) would require 71 days and cost approximately $1.4 million. These costs do not include the cost of permitting, agency management, nor monitoring.

Following the workshop, the potential target beaches were revised, and ADEC revised the cost estimate accordingly. The revised cost estimate is included in Appendix G. The revised cost estimate includes permitting, agency project management, and monitoring. The revision indicates a cost of between $1.9 million and $2.6 million to treat the beach segments jointly identified by Chenega Bay residents and ADEC representatives.

There are several regulatory and legal layers to address in crafting a cleanup plan. These questions were not addressed during the workshop, but are included here to assure that the Trustee Council has complete information on the issue.

ADEC has authority to conduct or require cleanup under its oil pollution regulations which are based on environmental or human risk. Land managers, such as the Alaska Department of Natural Resources, have general statutory responsibility to protect the value of public lands. The Trustee Council, through the court order establishing the Council and the member agencies' status as natural resource trustees, may find that removal of the oil aids restoration.

ADEC would probably not take on this project under its statutory authority to control and abate oil pollution. This authority, in both statute and regulation, deals with releases of oil into the environment, and turns on the issue of whether the release constitutes and actual or imminent threat to human health or the environment. Once a cleanup begins, it continues to "the satisfaction of the department," a broad authority that is fenced by two considerations at 18 AAC 35.727: The cleanup continues until it is no longer technically feasible to continue, or when continued removal causes more harm than leaving the oil in place.

The cleanup reached these limits in 1992, and ADEC ended the response. If ADEC were to reopen the response, its commissioner would have to make some kind of formal finding that new information showed there was an imminent threat, that technology made more cleanup feasible, or that cleanup would not cause more harm than good. There does not appear to be technical or scientific information to support such a justification. The residual oiling is undesirable, but it does not appear to pose an environmental risk. If the Trustee Council chooses to go ahead with some additional cleanup, the decision should be based on the land managers' general authority to maintain the quality of public lands.

Finally, the trustees should consider carefully and state the rationale for continued cleanup. If removal of all weathered oil—or as much as possible—using chemical shoreline cleaning agents becomes an environmentally and economically acceptable method of restoration at a single site or set of sites, the trustees should be aware of the possible scope of a cleanup effort beyond a limited area.

With the exception of NOAA sampling data showing that mussels are taking up oil at some sites, damage assessment and restoration studies do not lead ADEC to conclude that the residual oiling is affecting recovery of intertidal plants and animals, or higher trophic species such as seals, sea ducks, otters, and sea birds. The justification, then, would probably involve a mix of land management objectives and public interest from people who live in the area.

Discussion and Conclusions

This section of the report summarizes the major points of the discussion and conclusions that occurred during the last session of the workshop.

What is the problem? Workshop participants agreed that surface and subsurface oil remains on many beaches near the village and in other locations, and that the oil is not likely to disappear naturally in the near future. Evidence shows significant oil on the beaches near Chenega Bay such as Sleepy Bay, Point Helen, ER 20, EV 37, and EV 39, and others. While there may be some discussion about the exact location and amount of oil on individual beaches, for the most part there is good agreement among agency scientists, and outside scientists, and Chenega Bay residents on the extent and location of residual shoreline oil in Prince William Sound.

What are the benefits of treatment? During the discussion at the conclusion of the workshop, Chenega Bay residents indicated that they believed that treatment of beaches in areas important to them—most likely those areas near the community—would, in fact, have great benefits to residents. While some residents indicated that it is not the preferred alternative—cleanup of all of the remaining oil throughout the spill area is preferred, though admittedly impractical—residents felt that additional treatment would greatly benefit the village, make their use of the beaches more enjoyable and safer, and start to relieve their perception of the oil pollution that surrounds the village. These conclusions were emphasized by the Chenega Bay participants both at the workshop and afterwards in discussions.

Would additional treatment benefit recovery of injured resources? The conclusions of the Trustee Council scientists concerning the oil's effect on recovery of injured resources is discussed earlier in this report. In general, the scientists believe that residual oil is unlikely to be affecting the health or population of many of the subsistence resources such as harbor seals, shrimp, and deer. In some locations, the oil may be affecting local populations of harlequin ducks and sea otters. That possibility is under investigation in other Trustee Council research projects. In discussion during the workshop and afterwards, Chenega Bay residents indicated that they understood that removing residual oil is unlikely to bring back prespill populations of harbor seals and some other injured resources. However, they also made clear that they still believe that the remaining oil has a sinister affect on the ecosystem, and that the ecosystem and some injured resources will be much better off if the oil is removed.

What treatment program is appropriate? The scientists felt that if additional treatment was decided upon, PES-51 and the airknife technique described earlier is a useful treatment method and is probably appropriate for many locations identified by Chenega Bay residents. However, they also indicated that it was not the "magic bullet." That is, it is not appropriate for all locations, and that each beach must be evaluated separately in order to determine the appropriate treatment. Some beaches are likely to be most appropriately treated with PES-51; others with only manual treatment; etc. The scientists felt that the entire toolbox of treatments should be evaluated to determine the most cost-effective, beneficial, least environmentally costly method of reaching the treatment goals for each beach.

What is the acceptable level of treatment? (How clean is clean?) Chenega Bay residents made specific reference to the treatment goals proposed by PES, Inc. in their discussion (and presented earlier in this report). They indicated that those treatment goals appeared acceptable. In addition, many residents and other participants had been to the portion of Sleepy Bay where the PES treatment had been tested, and understood how the treatment objectives had been accomplished. They appeared to have a ground-tested vision of what the goals meant for residual oil on the shorelines—a significant reduction but not 100% clean of oil.

What is the environmental cost of a treatment program? The experts were unanimous in their opinion that surfactants such as Corexit 9580 and PES-51 are, at some level, toxic to intertidal life. In addition, the simple matter of bringing a lot of treatment equipment and people on to a beach, as described by PES, can be invasive to the local intertidal habitat. However, they were also unanimous that Prince William Sound is a big place, and the environmental cost of treatment in a limited number of locations may be more than balanced by the benefits of the treatment to Chenega Bay residents.

Put another way, assuming that treatment was appropriately applied, the experts had no objection to a limited program if, in fact, it would significantly benefit Chenega Bay residents or other shoreline users. A limited program could provide those benefits without incurring significant environmental harm. However, the experts also indicated that a large-scale treatment program—done throughout Prince William Sound—would incur cumulative environmental costs that could significantly set back intertidal recovery. Thus, if the Trustee Council decides that the benefits are worth the costs, the program must be appropriately applied and be limited in order to avoid significant environmental harm.

What Beaches are Appropriate for Treatment? Which beaches *can* be cleaned with available technology and reasonable cost, and without unreasonable environmental harm? ADEC representatives had thought that the beaches identified for the PES cost estimate (Appendix E) were those beaches. Chenega Bay participants at the workshop did not agree, and felt that the previously identified beaches were not the complete set of beaches needing treatment, and that additional beaches may be necessary. Dr. Owens proposed a method to resolve this question. His suggestion was followed, and ADEC and Chenega Bay representatives met following the workshop to develop the treatment options that are described in Part 1B of the report.

What is the Regulatory Rationale? The question how much treatment is appropriate was a significant issue during the response to the spill. Before the Trustee Council undertakes further treatment, its legal basis should be clear. Treatment may also open up other important issues: How might additional cleanup affect other provisions in the settlement among the state, the federal government, and Exxon? What is the practical rationale for additional cleanup, and would it open up a broader issue of continued cleanup throughout the spill area? From information presented at the workshop, it appears that the regulatory rationale for additional cleanup should be based primarily on the objectives of the land manager, such as those of the Alaska Department of Natural Resources rather than on the environmental risk authority of the Alaska Department of Environmental Conservation. The presence of asphalt and mousse diminishes the public-use value of the tidelands. In addition, the public policy rationale should be based primarily on the impact of the spill on Chenega Bay and environs. Residual oil exists elsewhere in the spill area, but the effects of residual oiling fall disproportionately on Chenega Bay residents who use the shorelines and the waters of the area.

What is the Financial Cost? The financial cost of additional treatment is discussed in Part 1B of this report.

A Limited, Comprehensive Program Must be Outlined <u>Before</u> a Decision is Made. There was a long discussion on whether a list of beaches should be identified for potential treatment, or whether treatment, if it was decided upon, could begin without a comprehensive program identified in advance. A number of people attending the workshop (including one member of the Public Advisory Group) stated that the Trustee Council could not reasonably approve any program until it was fully fleshed out. That is, the entire scope of the program necessary to address Chenega's concerns should be clear *before* the Trustee Council makes a decision. One person at the workshop stated that the public would not accept a program without a clear and well-defined end. They went on to say that to begin without a clear endpoint would risk starting down an infinitely expensive road; there are other uses for the money; and unlimited spending on this problem is not acceptable to the general public. In addition, a few people spoke about the possibility of cumulative environmental impact, and how the Trustees cannot evaluate a program without knowing how large the impacts will be. Finally, one person added that to begin a program without understanding its scope will risk spending a significant amount of money without knowing that it will, in fact, have significant benefits for Chenega Bay.

Part 1B. Options for Treating Chenega-area Shorelines

This section of the workshop report presents treatment options for Chenega-area beaches. The beach segments and treatment techniques were developed jointly by representatives of Chenega Bay and ADEC in the weeks following the workshop.

Background

Following the workshop, ADEC comprehensively reviewed Prince William Sound oiled shorelines. Significantly oiled sites were identified using data from the 1993 Restoration Survey (Project 93038), response data gathered before 1993, other information such as field visits since the 1993 survey, other restoration projects, and local knowledge.

Beach segments identified as having "significant surface or subsurface oil" were those that had surface oil with characteristics ranging from asphalt (AP) to surface oil residue (SOR), or subsurface oil with characteristics ranging from medium oil residue (MOR) to oil-saturated pores (OP). In addition, a segment classified as having "significant oil" must have the residual oil over a significant portion of the beach. The classification system used for characterizing shoreline surface and subsurface oil is explained in Appendix H.

The map on the next page shows areas with significant surface and or subsurface oil in Prince William Sound. The map shows that these areas are scattered through much of the Sound. The map also shows the concentration of these sites near the Village of Chenega Bay.

Following ADEC's review, ADEC representatives reviewed the information with a committee of Chenega Bay residents. The village and ADEC representatives jointly discussed the sites that might require treatment. They focused on frequently used shorelines near the village both in order to maximize the effect on village use and to ensure a limited program.

Appendix F contains a segment-by-segment summary of ADEC's oiling data and the joint ADEC—Chenega Bay conclusions about the probable treatment technique and the segment's importance. It also includes a map that shows the locations of oiled shorelines in the Chenega area.

ADEC staff used the cost methodology presented in Appendix G to come up with a cost for the proposed treatment program.

Summary of the Treatment Options

This part of the report summarizes treatment options for Trustee Council consideration. The costs presented in the summary use the cost estimate developed by PES, Inc (attached as Appendix E). It was revised by ADEC to reflect revisions by Chenega Bay and ADEC representatives in the location and number of beach segments for treatment, and to include costs for monitoring, and agency project management. Appendix G outlines the methodology that ADEC used to revise the PES cost estimate. It also describes the cost estimate for the treatment alternatives in greater detail than is presented in this section of the report.

Information on the oiling status and subsistence use of beaches in each option is given in Appendix F.

Option 0. No Additional Treatment. In 1992, the cleanup ended following a determination that it had reached the limit of technical feasibility or that further treatment would cause more harm than good. Thus far, the Trustee Council has continued this status quo. A decision not to fund further treatment is the "no action alternative." It was not extensively discussed with nor supported by Chenega Bay representatives.

Option 1. Treat High Priority Shorelines: $1.9 million. The Chenega-ADEC committee identified eight beaches as high priority sites for treatment: five on Latouche Island; two on Evans Island; and one on Elrington Island. The Village of Chenega Bay is on Evans Island with two sites just up the coast from the village. The Elrington Island site is opposite the village and can be seen from the village. Latouche Island is opposite Chenega Bay, and the five sites are around the northern tip of the Island.

Collectively, three sites—LA 19A, LA 20B, and LA 20C—are within Sleepy Bay. The third of these sites, LA 20 C, has large discontinuous areas of surface asphalt and buried subsurface oil which in some cases is OP (oil fills the pores of the sediment) and in some cases somewhat less concentrated oil residue. Together, the Sleepy Bay sites represent 72% of the area of Chenega's high priority beaches.

ADEC estimates that the cost of Option 1 is approximately $1.9 million.

Table 1. High Priority Beaches for Treatment

Location	Significant Oiling		Probable Treatment Area (square meters)	Probable Treatment Method
	Surface?	Subsurface?		
LATOUCHE ISLAND				
LA 15 C	Yes	Yes	1,560	Washing, PES-51
LA 19 A	Yes	Yes	3,700	Washing, PES-51
LA 20 B	Yes	Yes	1,000	Washing, PES-51
LA 20 C	Yes	Yes	14,000	Washing, PES-51
LA 21 A	Yes	Yes	1,500	Washing, PES-51
EVANS ISLAND				
EV 37 A	Yes	Yes	1,724	Washing, PES-51
EV 39 A	Yes	Yes	1,000	Washing, PES-51
ELRINGTON ISLAND				
ER 20 B	Yes	Yes	1,430	Washing, PES-51 Mechanical Tilling

Option 2. Also Treat Medium Priority Shorelines: $2.1 million. Two additional shoreline areas were identified as medium priority. The oil at these sites is less concentrated and covers a smaller area than the high priority sites. Additionally, past survey data indicates improvement at these sites despite the lack of treatment. Both of these are on the east side of Latouche Island.

Table 2. Medium Priority Beaches for Treatment

Location	Significant Oiling		Probable Treatment Area (square meters)	Probable Treatment Method
	Surface?	Subsurface?		
LATOUCHE ISLAND				
LA 15 B	Yes	Yes	1,587	Washing, PES-51
LA 15 D	Yes	Yes	200	Washing, PES-51

ADEC estimates that the cost of Option 2 is approximately $2.1 million. This cost assumes treatment of the eight beaches identified in Option 1 as well as the two identified in Table 2.

Option 3. Also treat areas up to 5,000 m² yet to be located: $2.3 million. ADEC and Chenega Bay representatives discussed whether problem beaches existed that were not on the ADEC inventory. The Chenega Bay representatives felt that the ADEC data may be missing sites on the northern parts of the islands bordering Knight Island Passage or possibly in the Port Bainbridge area. ADEC has not visited sites in the Port Bainbridge area since before the cleanup ended in 1992. The area that the Chenega Bay representatives felt may warrant additional cleanup includes: Shelter Bay, on Flemming Island, and nearby areas.

There was some discussion about the exact oiling conditions in these areas, and additional survey work is required to resolve the exact conditions. Rather than complete the survey work immediately, the group felt that it could estimate that two or three additional sites might be necessary. For cost-estimating purposes, ADEC chose to include 5,000 square meters of additional beach clean-up.

ADEC estimates that adding up to three sites and a total of 5,000 m^2 in additional beach treatment would add an estimated $230,000 to the treatment program. The estimated cost for treating these yet-to-be-located areas and the beach segments identified in Options 1 and 2 is approximately $2.3 million.

Option 4. Also Treat High Priority Shorelines That Require Complex Treatment Methods: $2.6 million. Two additional beaches were high priority, but will require complex and expensive treatment methods. Treatment at these two beach segments involves cleaning mussel beds.

The mussel bed at EV 36 is located very low in the intertidal area among cobbles and boulders. It would be very difficult to manually remove the bed. In addition, staff is unsure if washing with PES-51 so low in the intertidal zone would cause unacceptable environmental impacts. Finally, it is unclear whether washing would work very well with mussel beds.

The LA 15E mussel bed has difficult access onto a rocky, low-angle beach. Treatment would likely require the complete removal of the bed and its subsurface oiled sediments which could be time consuming and expensive. Additionally, this type of treatment has never yet been attempted.

Table 3. High Priority Beaches Requiring Complex Treatment Methods

Location	Significant Oiling		Probable Treatment Area (square meters)	Probable Treatment Method
	Surface?	Subsurface?		
LATOUCHE ISLAND				
LA 15 E	Yes	Yes	850	Unknown
EVANS ISLAND				
EV 36 A	Yes	Yes	2,300	Unknown

ADEC estimates that the cost of Option 4 is approximately $2.6 million. This cost assumes treatment of the beach segments identified in previous options.

Other Sites not Proposed for Treatment. Not all of the sites with some level of residual oil are appropriate for treatment. Some sites, like Point Helen have significant oil, but are not feasible to treat further without exceptional effort and cost. Point Helen is a large 1,180-meter long area on the southern tip of Knight Island. Subsurface oil is deeply buried beneath clean surface cobbles and boulders. Residents report that sheens are still visible on the water at some tide conditions. The area is difficult to treat because of its size, oiling conditions, the surf, and the current. There is strong surf at the beach at many tide conditions, and the current runs strongly along the beach making it difficult or impossible to boom.

Other areas with significant oil such as Seal Island or Green Island were not recommended because of their distance from the village. Finally, some areas close to the village were not recommended for treatment because of the small amount of oil that remains.

Summary. Table 4 shows that treating the high-priority sites will likely cost $1.5 million. Additional costs for monitoring and management bring the total to approximately $1.9 million. If medium priority sites were added, the cost would grow by $140,000 to over $2 million. If approximately 5,000 square meters at three unknown sites were added, the cost would grow by an additional $230,000. If all sites were completed, the cost would total approximately $2.5 million. The agency management and monitoring costs are not estimated incrementally. That is, one estimate was made and is assumed to be sufficient to cover a program that includes all of the sites.

Table 4. Cost of Potential Treatment Alternatives

	Option 0: No Treatment	Option 1: High Priority	Option 2: Medium Priority	Option 3: Other Sites	Option 4: High Priority but Complex Treatment
Treatment	$0	$1,500,000	$140,000	$230,000	$300,000
Monitoring	$0	$175,000			
Agency Management	$0	$243,700			
Total	$0	$1,918,700	$140,000	$230,000	$300,000
CUMULATIVE TOTAL	$0	$1,918,700	$2,058,700	$2,288,700	$2,588,700

Table 4 shows the cost of treatment, agency management, and monitoring. The treatment and agency management costs have been made in significant detail. The monitoring costs need further scrutiny. They include an allowance for physical, chemical, and biological monitoring of the treatment areas before and after treatment. With greater scrutiny and planning, the monitoring costs may decrease.

The costs assume a two-season project. It does not appear feasible to complete even the high priority beaches with a single season. It is likely to be difficult but feasible to complete all of the sites identified above within two seasons.

Part 2: Shoreline Monitoring

Guidelines Regarding Future Monitoring of Residual Oil in the Spill Area

Background

The Trustee Council has sponsored two shoreline survey projects, one each in Prince William Sound (1993) and the Kodiak archipelago (1995). These surveys were fundamentally the same as the response surveys from 1989-1992 in terms of both site selection and field methodology:

- *Sites were chosen from a set of shorelines that had been treated consistently during the response.* Therefore, site selection was biased towards response objectives and limitations (seasonal wildlife restrictions, limits and side-effects of treatment methods, temporary compromises based on priorities of Exxon, the state, or the federal government) rather than the absence or presence of oil.

- *Field methods and the information they produced did not support quantitative conclusions about the changes or persistence in oiling.* One could describe the area of oiling, describe the physical characteristics of the stranded oil, and make some judgments about whether it seemed to be degrading or dispersing. However, there was a degree of subjectivity in those judgments, and they tended to be highly dependent on the experience of the observer or the calibration in judgments among survey team members.

During deliberations over the FY97 work plan, the Trustee Council staff could not come to consensus about what type or location of monitoring that was needed. The executive director suggested that third-party experts be brought to a workshop to help resolve the issues.

Discussion

The morning session of the Shoreline Oiling Workshop in Anchorage on November 1 was dedicated to a discussion of future monitoring. Ed Owens of OCC Ltd., Jacqui Michel of Resource Planning Inc., and Jim Gibeaut of the University of Texas Bureau of Economic Geology served as technical panelists. The discussion was framed by four questions:

- *What would be the objectives of future monitoring?* Up to now, Trustee Council monitoring projects have concentrated on the absence or presence of oiling at selected shorelines that received significant treatment or attention during the response. Is this type of sampling likely to produce the kind of answers to the questions scientists, resource managers, and the public pose?

First, the panelists all noted, the Trustee Council should tightly define the issues of concern held by the community of interests involved. The most basic questions probably revolve around what oiling remains in the area, how long it will stay there, how it may or may not change, and what effects it might have on the environment at each stage of change.

The total extent of residual oiling in the spill area—the "how much" question—is answerable within a range of certainty. Going back over all the oiling information from March 1989 and doing some field checking based on an analysis of that data is do-able, but it would cost a lot relative to quality of the answer. Further, it may provide only incremental fine-tuning to what is already known: Generally, the sites on the response team's list from year to year represented the sites with the most significant oiling or the highest levels of concern from agencies or the public. However, the "how much" question has been a persistent one, and we have not yet developed a credible and consistent answer to it.

The persistence of residual oiling—the "how long" question—is somewhat more amenable to a good answer, and further, it should be the basis of any future monitoring program. Based on the panelists' work in Prince William Sound and other arctic and subarctic sites (notably Baffin Island in the Canadian high arctic and sites oiled by the *T/V Arrow* in Atlantic Canada 25 years ago), the answer to "how long" is: A very long time. The panelists agreed that the residual oil is either so deeply buried, so weathered, or both, that it will stay in place and in its current form for a decade or more, absent some major geologic or weather event. That assumption should be fundamental to the design of a future monitoring effort.

The chemical make-up of the residual oiling—the "what's it like" question—is a little harder to answer broadly. The panelists offered information that suggested significant variations in how residual oil has or has not weathered relative it its state at the time it washed ashore. Drs. Michel and Owens both observed that we are dealing with "micro habitats" at this point—small areas of residual oiling with complex and site-specific suites of conditions and settings affecting the persistence and chemistry of the oil.

Whether the oil remains a significant threat to the environment or to other concerns is only partly answerable by future monitoring. Dr. Owens suggested that due to the site-specific nature of the conditions, the scattered and discrete areas with oil, and the mix of scientific and community concerns involved, that experts (including local people and resource users) be included at all stages of the monitoring program, so that there will be an opportunity to connect field observations to primary concerns in the area.

- *Are the field methods and terms used to describe oiling conditions worth using in the future?* The qualitative results we have generated so far depend on survey techniques and descriptive terms born of the *Exxon Valdez* response and refined since then. Should future monitoring use other techniques, ones that perhaps will lead to more quantitative conclusions?

Generally, the panel agreed that a "consistently qualitative" approach is acceptable, in part for purposes of comparison to earlier information collected in that way. But also, they noted, the qualitative methods now in use have been refined enough that they constitute a consistent methodology. They suggested, however, that site identification be more precise (for example, use of GPS should be expanded, and that aerial photography should be included more consistently), and that project designers should come up with methods that are less dependent on site-specific experience and individual surveyors. This is especially important, given that sampling and monitoring is likely to be spread out over a longer period of time.

- *Can we design a program that is both useful and cost-effective?*

- *Are the data and information sets that currently exist useful enough to serve as a partial foundation for future monitoring?*

The panel felt that we could learn a lot from looking at these "micro habitats" over time, and that the sampling intervals would be sufficiently long—perhaps five years—that a monitoring program need not be a huge on-going expense. The quality of existing information varies depending on the weather in which it was gathered, the quality of the crew doing the work, and other factors, but generally the panel felt this information base did not need major reconstruction to be useful.

Conclusions and Recommendations

- Objectives for monitoring must be set at the outset with the principal stakeholders inside and outside of government.

- The links to the stakeholders' interests must be made at the field level, since it is hard to generalize about how conditions change and do not change at various sites.

- Similarly, the links to other scientific disciplines (biology, chemistry) and the analysis in those areas must be done at the field level.

- A monitoring program should include experts in all fields—including subsistence/tribal/village knowledge—at the specific sites.

- Regional differences should be built into the program; oil arrived at different parts of the Gulf of Alaska in different forms and in different volumes than in the Sound.

- The "consistently qualitative" method of monitoring may continue to be used.

- Attention should be given to the level of specificity and detail required for individual sites.

- Methods, protocols, and other design features should assume long-term persistence of the residual oiling.

- The design of any monitoring program, since it is built on the assumption of long-term persistence, should depend as little as possible on individual personnel and experience; better site identification is critical.

- The number of sites should scaled down; the level and categories of detail, scale up.
- The site selection process should be expanded beyond the basic ADEC/Exxon/USCG response data base by including the broad universe of *Exxon Valdez* site information (Other agency data, local knowledge, other restoration projects).

Appendix A
Workshop Agenda
Residual Oiling Workshop
Exxon Valdez Trustee Council

November 1-2, 1995
645 G Street; Anchorage, Alaska

Workshop objectives

Part 1. What type of monitoring, if any, should continue in future years?

Part 2. Provide information for the public, the executive director, and the Trustee Council so that they may make informed decisions about remediation with chemical shoreline cleaning agents as a restoration option.

Part 1 — Future Monitoring

Agenda — November 1

8:30 am Technical discussion concerning recommended areas and techniques for future monitoring

12:00 End of Part 1

LUNCH

Part 2 — Beach Remediation

1:00 pm Welcome and comments from the executive director
Objectives for the Beach Remediation Section of the Workshop

1:30 Discussion: What are the impressions and conclusions of residents and resource users? (Subsistence users, area residents, etc.)

Product: List the key problems or perceptions that residents and users believe can be resolved by removing residual oiling.

Break

2:30 pm Technical session: Stan Senner, Bob Spies, Kathy Frost, Bruce Wright — "Status of the key resources and their relationship to residual oiling" Researchers working on key subsistence resources (salmon, sea ducks, seals, clams, etc.) summarize their status with special emphasis on whether residual oiling appears to be an impediment to recovery.

Break

3:30 pm Technical session: Residual oiling summaries

Ed Owens — "Long-term residual oiling effects and considerations." Owens will review and interpret information from spills in other cold-water, northern sites.

Jacqui Michel — "Review of shoreline oiling research from Prince William Sound." Michel will summarize Resource Planning, Inc.'s research at Prince William Sound study sites since 1989. She and Miles Hayes have published extensively on their study sites, especially on Knight Island.

Jim Gibeaut — "Summary of restoration monitoring from Prince William Sound and the Kodiak Archipelago." Gibeaut will review results of the 1993 Prince William Sound survey and the 1995 Kodiak Archipelago survey.

Alan Mearns, NOAA — "Summary of intertidal research, 1989-1995"

5:00 Adjourn

November 2 (Beach Remediation Continued)

8:30 am Residual Oiling Summaries Continued: We do not expect the previous session to be completed on Day 1.

Break

10:00 Technical session: Remediation techniques and practical options

PES-Alaska — "Cost estimate for treatment of selected beaches." PES Inc. will present a working estimate for cleaning several Chenega-area shorelines.

Ernie Piper — "Remediation options for the selected sites" Piper will explain which remediation techniques are practically available, from the standpoint of technical effectiveness and regulatory approval.

Questions from the public and the panel

11:00 Discussion: Are the remediation options identified likely to produce a quantifiable and substantial result on the shorelines? What problems identified yesterday are likely to be solved or amelioriated by remediation?

Discussion: What are the likely side effects of remediation? Will this proposed remediation project retard or damage other restoration goals or projects?

Lunch

1:00 pm Discussion Continued

3:30 Conclusions for the Trustee Council:
Financial Cost; Environmental Cost; Benefits to Subsistence, Recreation and other shoreline uses.

4:30 pm ADJOURN

Appendix B
Workshop Participants and Publicity

Workshop Participants

Chenega Residents
Paul Kompkoff, Jr.
Patti Totemoff, Chenega Corporation
Chuck Totemoff, CEO, Chenega Corporation
Charles (Peter) Selanoff
John Totemoff
Phillip Totemoff
Mike Eleshansky
Don Kompkoff, Sr., President, Chenega Village Council
Carol Ann Wilson, Board Member of Chenega Corporation and of Chenega Village Council
Gail Evanoff, Board Member of Chenega Corporation
Larry Evanoff, Village Council Administrator
Jewel Boyles
Peter (last name unknown)
Darrell Totemoff
Pete Kompkoff, Jr.

Expert Reviewers
Dr. Ed Owens, OCC Limited.
Dr. Jaqui Michel, Research Planning, Inc.
Dr. Jim Gibeaut, Bureau of Economic Geology, University of Texas, Austin
Kathy Frost, ADF&G
Dr. Bob Spies, Trustee Council Chief Scientist
Bruce Wright, NOAA
Stan Senner, Trustee Council Science Coordinator
Ernie Piper, Special Assistant to the Commissioner, ADEC
[Dr. Alan Mearns was invited, but family illness kept him from participating. He did send materials for presentation, and Dr. Jaqui Michel presented the results of his work.]

Trustee Council Staff
Bob Loeffler, Planning Director, Trustee Council
Sandra Schubert, Project Coordinator, Trustee Council
Dr. Joe Sullivan, ADF&G
Ray Thompson, USFS
Bud Rice, National Park Service
Eric Myers, Director of Operations, Trustee Council
Molly McCammon, Executive Director, Trustee Council
Dean Hughes, ADF&G
Cherri Womac, Trustee Council Staff
Catherine Berg, Department of Interior

Martha Vlasoff, Chugach Heritage Foundation, Public-at-Large, Public Advisory Group

Other Participants
Pam Brodie, Environmental Representative, Public Advisory Group
Chris Beck, Public-at-Large, Public Advisory Group
Rita Miraglia, ADF&G (Principal Investigator, Subsistence Planning & Coor. Projects)
Malin M. Babcock, NOAA (Also Principal Investigator for the Mussel Projects)
Brad Hahn, ADEC, State On-scene Coordinator
John Bauer, ADEC
Gail Irvine, NBS, (Principal Investigator, Shoreline Monitoring Projects)
Tex Edwards, PWS RCAC
Karl Pulliam, Seldovia Response Team
John Whitney, NOAA Scientific Coordinator
Dianne Munson, ADEC
Ann McCord, Executive Director, Cook Inlet RCAC
Name Unknown, Cook Inlet RCAC
Dr. Bill Alter, Petroleum Environmental Services
Steve Rogg, Petroleum Environmental Services
David Bruce, ADEC
Dick McKean, ADEC
Harry Young, ADEC
Leslie Pearson, ADEC
Marie Becker, CIRCAC-State Chamber
Joel Cusick, NPS
Judith Miller, Gallagher Marine Systems
Dan Mann, UAF
Carol Fries, ADNR
(Two other people attended but did not sign in.)

Workshop Public Notification

Chenega Bay residents have been most vocal about issues concerning residual shoreline oil. Representatives of Chenega Bay and Chenega Corporation helped plan the workshop and publicized it within Chenega Bay. To ensure that people concerned about the issue had a chance to participate, a flyer announcing the meeting, and in most cases an agenda, was faxed to the entire Trustee Council Workforce, the Trustee Council's Public Advisory Group, and Village Coordinators for Tatitlek, Port Graham, and Nanwalek. Because of their interest in the issue, flyers and agendas were faxed to Cook Inlet and Prince William Sound RCACs. Finally, Bob Loeffler made a few phone calls to individuals he expected to be interested in the issue such as individuals active in the Trustee Council process who are knowledgeable and concerned about recreation and tourism in Prince William Sound.

The flyer used to announce the workshop is on the next page.

Appendix C
Summaries of Presentations by Invited Experts

Four presentations were given by scientists invited to the workshop. The presentations gave workshop participants a similar foundation concerning the scientific understanding of the mechanisms by which shoreline oil is naturally removed, how residual oil in Prince William Sound has responded over time and to treatment, the extent and locations of residual oil, and how intertidal areas have recovered from the oiling and cleanup.

Dr. Ed Owens, Owens Coastal Consultants Ltd. "Long-term residual oiling effects and considerations." Dr. Owens reviewed and interpreted information from spills in other cold-water, northern sites.

Dr. Jacqui Michel, Research Planning, Inc. "Review of shoreline oiling research from Prince William Sound." Michel summarized Research Planning, Inc.'s research at Prince William Sound study sites since 1989. Drs. Michel and Hayes have published extensively on their study sites, especially on Knight Island.

Dr. Jim Gibeaut, Consulting Geologist. "Summary of restoration monitoring from Prince William Sound and the Kodiak Archipelago." Dr. Gibeaut reviewed results of the 1993 Prince William Sound survey and the 1995 Kodiak Archipelago survey.

Dr. Alan Mearns, NOAA. "Summary of intertidal research, 1989-1995" Dr. Mearns was not able to attend the workshop due to family illness, and the presentation of his work was done by Dr. Michel.

A brief summary of the presentations follow.

DR. ED OWENS, OCC Ltd. (Handout summarizing Mr. Owens presentation is contained in an Attachment to this appendix.)

1) No single parameter controls oil penetration or retention. A combination of oil properties, such as adhesion and viscosity, and sediment properties, in particular grain size and sorting, affect penetration and retention of oil in sediment.

2) The long-term retention of subsurface oil in sediments is strongly determined by the initial oiling.

3) In general, and particularly for ANS (Alaska North Slope crude oil, the type spilled by the *Exxon Valdez)*, more oil can penetrate, but less oil is retained, on coarse sediment beaches.

4) Any oil, including ANS, that can penetrate fine-grained or mixed, sandy-gravel beaches is more likely to be retained in the subsurface of those beaches.

5) Stranded oil may appear fresh, even after many years, but only is fresh chemically (i.e. retains any of the lighter ends) if it is sealed in the sediments.

6) An irony might be that it is the very small (micron-size) particles that control the natural cleaning of oil on these coarse sediment beaches.

DR. JACQUI MICHEL, RESEARCH PLANNING, INC.

Dr. Michel presented oiling data on specific beaches with different geomorphological conditions, oiling histories, and treatment histories. The data showed how the oiling conditions have reacted to cleanup and time. Dr. Michel typically surveyed the worst sites and the ones with the most persistent oil.

Her research showed that deeply penetrated, heavily oiled gravel beaches have the slowest natural rates of degradation and recovery. In these cases the winter storms do not penetrate the beaches to the depth of the penetrated oil. Thus, the natural churning effect of winter storms has not acted to disperse the deeply trapped oil to any significant extent. She indicated that oil that remained now, almost seven years after the spill, is very likely to remain for a long, long time—"that deepest stuff is not going anywhere." For very deeply penetrated oil, the removal options are quite limited. One has to almost remove the entire beach to remove the oil. For many of these beaches, treatment and winter storms have removed all or almost all of the surface oil. That is, these beaches may have deeply penetrated, stable, relatively fresh subsurface oil without any expression on the surface. Some of this oil is very weathered, some is not. The amount and condition of the remaining oil is a function of microhabitats—detailed geomorphological and oiling conditions—and can only be predicted or evaluated site by site.

DR. JIM GIBEAUT, CONSULTING GEOLOGIST

Dr. Gibeaut reviewed the results of the annual shoreline assessments in Prince William Sound done in 1989 through 1993. He characterized their methodology as a "consistently qualitative method" of assessing the character and extent of surface and subsurface oil. That is, the method involves judgements that can be duplicated by different experts from year to year. However, the quantitative measurements are order-of-magnitude and are best used relative to other, similarly made measurements (such as from a previous year), as opposed to using the absolute quantities represented by the numbers.

The results presented by Dr. Gibeaut are documented in Project 93038. This summary is taken from that project's final report.

(1) Surface oil was discovered at all the 45 ground survey sites visited in 1993 and sheening was apparent at many sites. Roughly 6,600 m^2 of asphalt (AP), mousse (MS), surface oil residue (SOR), cover (CV), and coat (CT) was documented. This oil was distributed in 225 locations along a total of about 5.4 km of shoreline. AP, MS, and SOR alone covered about 3.5 km of shoreline and occurred at 171 locations. The average oiled location with SOR, AP, or MS

was 160 m^2 in size and had about a 23% oil coverage. AP and SOR occur in about equal amounts and dominate the surface oiling in Price William Sound.

(2) It is apparent that there has been significant reduction of surface oil from 1991 to 1993 on the order of 50%. Many sites have shown little or no improvement since 1991, however, and we attribute the improvement that did occur to manual removal and raking in 1991 and 1992. There was no measurable reduction from 1992 to 1993.

(3) Surface oil amount and distribution in 1993 are both a function of natural protection from waves and surface water flow and difficultly in performing cleanup. By 1992, most of the surface oil easily removed by natural and unnatural means had disappeared. Reduction since 1992 has been incremental and mostly related to treatment. Because no further effective treatment is likely in the spill area, we can expect to see little improvement in surface oil over the next several years.

(4) In 1993, surveyors measured 109 distinct locations with visually detectable subsurface oil The areas of these locations ranged from four square meters to several thousand square meters with varying percentages of oil coverage. A total of 2,041 m^3 of oiled, subsurface sediment was discovered. Subsurface oil lenses were typically 3 cm to 15 cm thick and had clean overlying sediments.

(5) The heaviest type of subsurface oil, oil pore, and heavy-oil residue, occurred in 69 distinct locations with a total estimated oil-sediment volume of 738 m^3.

(6) Subsurface oil decreased by at least 50% from 1991 to 1993. The overall volume of oiled sediment decreased less because some of the oil reduction is a reduction in oil concentration, only. There also appears to have been a significant slowing in the rate of reduction from 1992 to 1993 compared to what occurred between 1991 and 1992. This slowing is because of less treatment occurring in 1992 than in 1991 and the natural entrenchment of remaining oil.

(7) Subsurface oil reduction has been both a function of treatment and physical setting. Tilling was much more effective at high-energy locations than at moderate-energy locations. The reasons for the difference in treatment success are a function of sediment dynamics. Overall, sites that were aggressively treated showed about a 56% greater decrease than sites that were not treated. Low-energy locations responded to treatment better than moderate-energy locations. This is because of the reliance on oiled-sediment removal instead of tilling for treatment of low-energy locations.

(8) Because of the unlikelihood of further effective treatment and the natural entrenchment of the remaining oil there will probably not be a significant reduction in subsurface oil for several more years.

(9) Locations with recalcitrant subsurface oil are typically along boulder-dominated limbs of pocket beaches and in bedrock-sheltered areas along otherwise high-energy shorelines.

Large surface armor or local wave shadowing has prevented natural or unnatural physical removal. Subsurface oil also remains in some very-low energy settings.

(10) We visited a large number and a wide variety of sites, but our absolute numbers for remaining oil are minimum values.

DR. ALAN MEARNS' CONCLUSIONS PRESENTED BY DR. MICHEL

The information presented was developed by a group of scientists at NOAA's Biological Assessment Team, Hazardous Materials Response and Assessment Division in Seattle, headed by Dr. Alan Mearns. Dr. Mearns was not able to attend the workshop due to a family illness. He did send some slides. Dr. Michel is a consultant to that team, and since she is familiar with Dr. Mearns' work, presented the information. The information focused on the impact of the spill versus the cleanup. That is, it focused on the impact to intertidal organisms from high-pressure hot-water washing.

The presentation first focused on the mid-intertidal zone of rocky shorelines. Most of the remaining stranded oil is higher than that, but the mid-intertidal zone is affected by work that goes on above it. The presentation described the effect on a number of intertidal organisms. The conclusions for four are summarized below.

Fucus. After the spill, stranding of the oil alone reduced the *fucus* cover by about half. Hot-water wash reduced it by another 40%. *Fucus* cover had returned to normal 2-3 years later in the middle intertidal zone. For the upper intertidal zone, recovery has been delayed. (Peak abundance was in 1993, there has been some decline since then, and a little greater decline at sites that were hot-water washed).

Limpets are grazers; they eat the slime of the rocks, etc. They were only slightly affected by the oil spill. However, hot-water wash severely affected them. They have generally recovered by now and are undergoing huge increases in oiled areas. The probable reason for the increase is that limpets have recovered faster than their predators and so their populations are relatively unrestricted. In some cases, the hot-water washed areas now have four times the "normal" populations.

Litterines or periwinkles (snails). Populations of these resources are highly variable and are hard to analyze. Some types have planktonic eggs (i.e., they float around and wash up on the rocks), some lay directly on the rocks. The oil and hot-water wash severely affected both types. The planktonic types recovered within approximately two years (in fact, in some cases they overpopulated because of lack of predators—they remain abnormally abundant even seven years after the spill). Those that brood eggs on the beach recovered more slowly.

Mussels. The mussels that are the subject of Dr. Mearns' research are those attached to the rocks in the mid-intertidal—not the sediment-substrate mussel beds that have been the subject of Trustee Council restoration. These rock-attached mussels do not have the permeable substrate, so have neither significant amounts of trapped oil beneath them nor the same level of contamination. These rock-attached mussels normally cover 5-10% of the intertidal zone in the surface area. They are a key organism in the food chain and are a significant part of the biomass in the intertidal zone. These mussels were wiped out by high-pressure hot-water washing but recovered quickly. By the second year following the spill, these mussels were normally abundant and in some cases overabundant. The amount of cover due to mussels actually dropped in 1995. This may be due to the fact that older animals are now being counted (i.e., fewer numbers, more space, but some are now larger animals).

Barnacles. These normally cover 15-20% of the surface of this part of the intertidal area. They are eaten by starfish, birds, etc. These survived the oiling pretty well, but were wiped out by the washing. After three years, there is little difference in populations between oiled and unoiled sites. They have totally recolonized the wash sites, but were then preyed upon—which apparently means that the species that eat them have come back.

Appendix D
Shoreline Treatment Techniques
—Prepared by Ernie Piper, ADEC—

Background

The southwest section of the Sound from Chenega and southern Knight Islands to Evans and Latouche Islands includes areas that were heavily oiled in 1989. Exxon and state-sponsored crews conducted work at many of the sites in this area through 1992; however, this area contains sites with some of the most persistent residual oiling in the spill area. Residents of the village of Chenega Bay have consistently requested additional cleanup at a variety of sites near the village.

Principal issues

The prospect of additional cleanup raises these issues for individual resource agencies and the Trustee Council as a whole:

- *Technical feasibility.* Can oil be removed from these sites using existing technology and techniques?
- *Environmental sensitivity.* Would further cleanup hinder recovery of intertidal areas in the area?

Summary of Conclusions

The following conclusions are intended as practical guidance on a complex problem. I do not pretend to represent the official view of any single trustee agency or the Trustee Council. However, these conclusions are based on information from a variety of sources, including national experts in these fields. My general findings are:

- *Technical Feasibility.* Additional cleanup is technically feasible, although results would be difficult to both predict and to quantify after the fact. There have been no major leaps in proven shoreline cleanup methods or products since 1992; any cleanup program in the area would include a mix of existing techniques.
- *Environmental Sensitivity.* A cleanup program limited to relatively small, scattered areas in the southwest part of Prince William Sound would probably have no significant effect on the overall biological health, diversity, and recovery of the area's intertidal community. Disruption during cleanup would be relatively brief and its physical effects on shoreline geomorphology would be short-term.

Technical Feasibility

The Trustee Council directed ADEC to investigate whether any advances in shoreline cleanup technology since 1992 might make additional cleanup in the Chenega Bay area more feasible, more precisely, the trustees were interested in finding whether any new products seemed promising.

Some introductory comments here might help put the rest of this report into context.

Generally, technology or product choice is not necessarily the principal limiting factor in a remote site cleanup. Rather, factors such as weather, personnel, equipment, and (perhaps even more important) waste management tend to define the shape of a cleanup. Getting the contamination off the shoreline is just the first, and often the easiest step. Collection, handling, transportation, and eventual disposal of the waste can be the most difficult and expensive set of tasks. Therefore, products that increase the amount of waste, or complicate the disposal process (the mix of a chemical cleaner and oil can be more hazardous than oil alone), are not especially attractive.

Second, it is only recently that independent tests of product efficiency have begun to emerge. Vendors make all kinds of claims about their products, but the variability of conditions and application efficiency in a field setting make it very hard to pin down just how effective a given product or technique may be. And in some cases (such as bioremediation), there is a fair amount of uncertainty among scientists about how one can tell whether a product is "working."

Lastly, there has been a recent retrenchment in oil spill cleanup research and development. After an initial rush of interest and funding in the years immediately after the *Exxon Valdez* oil spill, the major players have begun to focus less on finding new products and more on improving existing fundamental techniques. For example, *in situ* burning of oil on the water has received a considerable amount of attention, in part because *a)* it is a technique intended to avoid costly and difficult shoreline cleanup operations, and *b)* it improves, rather than complicates, the waste management in a response. In addition, research money has flowed into the development of improved prevention and spill management systems, targeting such things as human error, or streamlined emergency management procedures.

Technology—Mechanical. Mechanical cleanup falls generally into two categories: basic mechanical agitation of sediments with conventional heavy equipment, and beach material processing or cleaning machines.

Basic mechanical and mechanical-assisted cleanup, such as was used in the Sound during the *Exxon Valdez* response, consisted primarily of backhoes rolling back boulders or pulling down oiled storm berms. These techniques would be of limited utility at this point, partly due to problems with access to sites, and partly because the residual oiling is stuck either in extremely large boulders, or along bedrock shelves and outcrops.

The most-used beach cleaning machines are variations of farm implements and are designed for sand and other fine-grain sediment shorelines. They are really not suitable for the pebble/cobble/boulder substrates that dominate the shorelines in Prince William Sound. (Taylor, Owens and Nordvik, 1994; Taylor, Belore, Simmons, 1995). The Canadian government sponsored development of a prototype rock-washing machine (Ross, 1990), but it did not advance past the prototype stage.

In any case, even if good rock washers did exist, they would probably not be optimal for conditions to the Sound—scattered sites, discontinuous oiling, heavily weathered mousse and asphalt.

Technology—Bioremediation. Bioremediation of asphalt and other heavily weathered residual oiling is an unlikely choice of techniques if the goal is complete or nearly complete removal of the residual oiling. Current research indicates that enhanced biodegradation techniques may be employed after gross contamination has been removed, and only while oil is relatively fresh. (ASTM, 1994).

Technology—Washing. Water washing, using various combinations of heat and pressure, has been and still is a common method for cleaning stranded oil from bedrock, coarse sediment beaches and manmade structures such as docks, rip-rap, seawalls, pilings, etc. One of the engineering successes from the *Exxon Valdez* response was the development and use of innovative ways to conduct a water wash operation at sites with difficult access. The "omnisweeps" operating from barges just offshore of bedrock cliffs or large boulder shorelines were very effective at removing oil from these kinds of settings.

Studies of water-washing using high pressure and hot water during the *Exxon Valdez* response suggest that despite its effectiveness at removing oil, this aggressive technique may actually reduce survival and impede recovery of intertidal plants and animals exposed to it. (Lees, Houghton, Driskell 1995; Houghton and Gilmour, 1995) Nonetheless, on-scene commanders continue to keep washing "in the toolbox" for certain situations, although the general guidance is to limit exposure of intertidal areas to either the direct washing or the effluent. (NOAA Hazardous Materials Response and Assessment, 1994)

Environment Canada has recently completed a laboratory/pilot scale study designed to give responders a better, quantitative idea of the ranges and combinations of temperature and pressure that will optimize cleanup effectiveness, while minimizing environmental damage from the treatment. For several common types of intertidal plants and animals, the study found that mortality rose significantly at temperatures from 40 to 60 degrees C, and 2.7 to 8.7 psi; unfortunately, this was precisely the range at which oil removal from oiled cobbles and ceramic tiles appeared to increase most rapidly. (Environment Canada, 1996).

Technology—Shoreline cleaning agents. Shoreline cleaning agents comprise a relatively new class of response technology, and to date, they have occupied a small niche in response research and development. Much of the current research effort has been concentrated on techniques that can be used relatively early in a response, such as *in-situ* burning or chemical dispersants, or on relatively low-cost, low-impact cleanup alternatives such as bioremediation.

Shoreline cleanup with a chemical cleaning agent is the most labor-intensive and costly phase of a response, in part because it requires secondary steps such as water-flushing, effective containment and collection, and disposal.

Still, there are emerging niches for shoreline cleaning agents. Using a shoreline cleaning agent in conjunction with a water-washing operation may be one of the best ways to gain the benefits of washing, without having to turn up the heat and pressure as high as one would have to do with washing alone. This is the type of application we expect might be used to remove the heavily weathered residual oil from shorelines in southwest Prince William Sound.

The Marine Spill Response Corporation has conducted an extensive literature search and market survey in an attempt to identify the various types of oil spill chemical countermeasures, which include chemical shoreline cleaning agents among a list of seven general classes of products. The MSRC classification breaks shoreline cleaning agents into two subclasses: hydrocarbon solvents, which lower the viscosity of the oil, and surface-active agents, which soften the oil and break the surface tension between the oil and the substrate. (Walker, Michel, et al., 1993)

Many shoreline cleaning agents are not listed on the National Product Schedule and few have been field-tested. Three sets of laboratory tests have been developed (by U.S. EPA, Environment Canada, and the French consortium CEDRE) but none has been selected as the standard for determining effectiveness. Further, there has not been a concentrated effort to develop appropriate containment and recovery methods specific to use of the products. (Walker, Kucklick et al., 1995)

The research and development of these products was spurred, in large part, by Exxon's attempts to formulate and use the product Corexit 9580, which went through several development phases in 1989-90, and was tested extensively on Prince William Sound shorelines. The product was never used outside of tests primarily because of difficulties in controlling and collecting the mix of oil and product that was flushed into the near shore waters (Piper, 1993).

A second major test of a shoreline cleaning agent took place at Sleepy Bay on Latouche Island in 1993, sponsored in part by Tesoro Alaska and the state Hazardous Substance Spill Technology Review Council. Tesoro Environmental, which then owned the rights to the product PES-51, treated less than a 100 meter section of rocky shoreline by injecting the product into the substrate, under pressure, then following with ambient-temperature wash under pressure. Observers reported that product and flushing proved effective at removing surface and subsurface oiling that had been stranded at the site since cleanup operations ceased there in 1990 (Rog, et al., 1994; Pearson, 1993).

The most recent major test for which there are published reports took place in January 1994 during the response to a spill of No. 6 fuel oil from the barge *Morris J. Berman* near San Juan, Puerto Rico. The Regional Response Team authorized testing of three products (Corexit 9580, Corexit 7664, and PES-51) in combination with water washes at various temperatures and pressures. Recognizing that the emergency response phase was a poor time to open up the testing to all vendors or potential products, the RRT decided to consider only those products that were on the National Product Schedule, that had shown 20 percent removal effectiveness using the Environment Canada lab tests, and had shown effectiveness in field trials (Michel and Benggio, 1995).

ADEC selected two of those three products for consideration in this project: Corexit 9580 and PES-51. These are the only two shoreline cleaning agents that meet the criteria established by the RRT in Puerto Rico, and have also been tested in the field in Prince William Sound.

Corexit 9580 went through several sets of field trials during the *Exxon Valdez* response in 1989 and 1990. It is, essentially, a dearomatized kerosene with some surfactants added. The preferred method of application was to spray the shoreline with the product, let it soak for 30-90 minutes, then follow with a warm-water wash.

In 1989 and 1990, Corexit 9580 was generally determined to be effective as removing surface oiling. However, field workers could not demonstrate proficiency at containing and collecting the oil-water-Corexit mixture once it was in the near shore waters. Further it did not appear to be effective at removing subsurface oil, which was emerging as a major concern at the time. Therefore, Corexit was not approved for widespread application during the *Exxon Valdez* response.

Exxon continued with its development of Corexit 9580 after the spill in Alaska, and has published a number of laboratory studies designed to test the effectiveness of the product under various spill response scenarios, including cleanup of oiled trees and other vegetation.

In January 1994, after the *Morris J. Berman* spill, the product was tested alongside another Corexit formulation, 7664, PES-51, and washing without cleaning agents. Corexit 9580, when used with high-pressure and hot water after a 30-minute pre-soaking period, was effective at removing the heavy bunker oil from a sandstone boulder substrate. Field observations and subsequent water quality monitoring suggested that Corexit 9580 did not fully separate from the released oil, resulting in a brown or muddy plume that tended to disperse in the water column. (Michel and Benggio, 1995; Shigenaka, et al., 1995) Corexit 9580 was also used in conjunction with Corexit 7664, which falls more into the category of a dispersant. The intent was to use the mixture in areas of high wave energy where recovery of the released oil and product would not be feasible—the 9580 lifting the oil off the boulders, and the 7664 aiding the dispersion in the rough waters.

PES-51 was originally developed as a "lifter" for use in secondary and tertiary recovery of heavy oil in cold formations (Steve Rog and Dennis Owens, personal communication, 1993), then as a cleaner for equipment used in oil field work or spill response. It is d-limonene with biosurfactants added. The test in 1993 at Sleepy Bay was the product's first major application as a shoreline cleaning agent. It tended to remove the oiling effectively when used in conjunction with high-pressure injection into the substrate with an "airknife," and subsequent flushing with ambient temperature seawater (Rog, et al., 1994).

The January 1994 test in Puerto Rico did not include the injection into the substrate, but the product showed similar results at removing the bunker oil from the sandstone boulders with the aid of the pressurized, hot-water wash. Also, as in the 1993 test in Alaska, the PES-51 and released oil separated cleanly, making recovery somewhat easier than with the other products.

However, the RRT selected Corexit 9580 over PES-51, apparently based on the results of standard LC50 toxicity testing with four species that suggested the PES-51 was relatively more toxic than Corexit 9580 (Michel and Benggio, 1995). The literature also suggests that the RRT had additional biological monitoring information specific to Corexit 9580 tests (Shigenaka, et al., 1995). In any case, the authors of both papers put qualifiers on their conclusions, in one casing noting that standard toxicity testing has some limitations when using insoluble products, and in the other noting that the methods and observations from the field, during an emergency situation, are not as rigorous as those in more controlled experimental science.

Conclusion: Cleanup Techniques and Technology. There is no single technique or product that is likely to produce an adequate result on its own. Any cleanup effort at any one of these sites would entail manual and mechanical methods (shovels, rakes, small backhoes), some kind of water flush, and probably the application of a surfactant. Collection of the oil, water, and product would be through a combination of sorbent pads, pom-poms, sorbent boom, and possibly a small skimmer.

The sites identified as priorities by the village of Chenega Bay have some built-in impediments to effective cleanup, which is primarily why they still have residual oil. The setting, the location of the oiling, and the type of substrates involved all worked to limit cleanup effectiveness during the response.

For example, LA 15C, just outside Sleepy Bay, is a difficult candidate for mounting a cleanup effort. The physical setting—a narrow, steep boulder field—would make access and staging of equipment difficult, and could limit our ability to control and contain the release of oil and product in the water. A big boulder field like that also raises significant worker safety issues, especially with equipment, hoses, and other obstacles spread around the site.

EV 37 and 39, and ER 20, have sporadic oiling conditions. Unfortunately, mobilization and demobilization costs would be similar regardless of oiling conditions. Further, at ER 20, subsurface oiling appears to be decreasing fairly steadily at one of the subsections; in the other, the oiling is relatively low in the mid-intertidal area and it overlaps or butts up against a mussel bed. And at Point Helen on Knight Island, the oiling is extremely deep in a large cobble beach (it *begins* at 60 centimeters) and would require a substantial effort to merely reach it.

In situations where a addition of a chemical shoreline cleaning agent to the operation is appropriate, we believe that PES-51 is the better choice over Corexit 9580, largely because PES-51 is more amendable to recovery than the dispersant Corexit. The company that markets this product has also developed a field-tested method for applying the product to subsurface oil areas.

This recommendation does not turn on the issue of relative effectiveness of a given product. "Effectiveness" is very difficult to quantify, for either product, because in field trials it is hard to determine how much of the removal is related to temperature/and or pressure and how much is attributable to the product. Further, the quality of the application can have a significant effect on removal. This can be one of the most important considerations in evaluating a specific product. (Clayton, 1992) Indeed, in the *Berman* spill test, temperature and pressure seem to have played a significant role in increasing removal; also, at Sleepy Bay in 1993, observers noted that results might have been better had a more powerful pumping system been in place. Further, an ambient temperature wash during the Sleepy Bay PES-51 test (11-13 degrees C) did not appear to mobilize the heavily weathered oil by itself, or with air injection alone. (Pearson, 1993). Our qualitative observations lead us to conclude that a shoreline cleaning agent helps, but we would not go so far as to say it is essential.

Environmental Sensitivity

We have put aside the issue of product toxicity for the purpose of this analysis. We have assumed substantial mortality to intertidal plants and animals present at the sites to be cleaned. Moreover, the physical effects of cleanup—temperature changes in the water, disruption by machines or tools—are often more stressful on plants and animals than the chemical agent itself.

At the residual oiling workshop sponsored by the Trustee Council in November 1995, and in later conversations with Alan Mearns of NOAA HazMat, the consensus is that a limited cleanup program including small sites at a handful of shorelines scattered in the area will not significantly retard area-wide recovery of intertidal areas. Most of the oiling occurs high on the shorelines, or in settings where intertidal life is scarce; in addition, the usual measures we use to mitigate damage (working on a rising tide, keeping waste out of the lower-intertidal) would be employed.

Other potential side effects of note:

- There would be short-term impacts from noise, air emissions from generators, and a risk of small spills of fuel, bilge water, and runoff from decontamination areas.

- Removing armor layers and disruption of the sediment matrix could result in an undetermined transport of sediments into lower intertidal areas and near shore waters.

Conclusion: Side effects Shoreline remediation at this point could have significant adverse effects, at least locally but a limited program is unlikely to have significant area-wide effects.

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Appendix E
Shoreline Restoration — Cost Estimate Project
Final Report
by
Petroleum Environmental Services, Inc.

SHORELINE RESTORATION - COST ESTIMATE PROJECT

FINAL REPORT

CONDUCTED BY

PETROLEUM ENVIRONMENTAL SERVICES, INC.

FOR

ALASKA
DEPARTMENT OF ENVIRONMENTAL CONSERVATION

Contract # 18-9012-96

November 15, 1995

EXECUTIVE SUMMARY

The Alaska Department of Environmental Conservation (ADEC), the *Exxon Valdez* Oil Spill Trustee Council, and other federal and state government organizations and public interest groups continue to monitor the recovery of shorelines along Prince William Sound that had been impacted by the *Exxon Valdez* oil spill in 1989. In response to concerns primarily expressed by Chenega Village Corporation, ADEC in the fall of 1995 contracted with Petroleum Environmental Services, Inc. (PES) to develop estimates of the costs for treatment of selected beaches that contain residual oil from the *Exxon Valdez* oil spill in 1989. Seven beach segments were jointly selected by ADEC and the Chenega Village Corporation for this project. These sites are on Elrington, Evans and LaTouche Islands in Prince William Sound.

Data from surveys conducted on these beach segments between 1992 and 1994 were reviewed to identify those sites that warranted further evaluation. Representatives of ADEC, PES and Chenega Village Corporation conducted a reconnaissance of the candidate beaches in September, 1995. Results of the reconnaissance and earlier survey data were integrated to determine the size and locations of areas that could warrant treatment.

The process proposed for treatment of these candidate beach segments was developed by PES and used in a demonstration project on a section of LA-19A on LaTouche Island in 1993. The team that conducted this demonstration project included PES, the Chenega Village Corporation and the University of Alaska Fairbanks. The project was partially funded by the Hazardous Substance Spill Technology Review Council. Results of this project revealed an immediate visible decrease in subsurface oil residue and a recovery of approximately 100 gallons of oily liquid. Analysis of subsurface sediment samples indicated an immediate 70% decrease in semivolatile range total petroleum hydrocarbons while there was no detectable presence of oil in the water column before, during and after treatment. Because of the stimulation of natural degradative processes, the overall decrease was 90% in sediment samples obtained one year later.

The PES Shoreline Treatment Process uses an Airknife Injection System to access and displace petroleum hydrocarbons from the surface and subsurface. PES-51®, a biosurfactant, is applied to displace the oil and float it to the surface where ambient temperature sea water supplied by a deluge header hose system and direct flushing hoses that moves the oil/product mixture to the shoreline. The displaced oil is then collected within containment booms located below the treatment area. This oil is recovered by a skimmer and pumped into a storage tank from which the water can be decanted and returned to the Sound. Sorbents are used to recover any displaced oil that remains on the beach. All the equipment, supplies and waste materials are deployed and recovered onto a landing craft which permits ready access to these rocky shorelines.

Based on the experiences gained from the 1993 project, the results of the 1995 reconnaissance and the ADEC survey data, estimates were developed of the resource requirements, the treatment times for the candidate beaches, and the costs for conducting this project in either one or two seasons. These estimates were developed in accordance with three general goals - maximize the effectiveness and cost-efficiency of the treatment process while minimizing the environmental impact on the beaches segments.

It was determined that treatment of these candidate beach segments could be completed in 68 days if the project were conducted in one season. This time includes work days, as well as time for mobilization/demobilization, crew rest and an estimate of the delays that will be encountered due to inclement weather. The overall cost for the one season project is estimated to be approximately $1.3 million. This cost includes all expenses for the field phase, as well as pre- and post field tasks that are an integral part of the project.

If the project is conducted over two seasons, the field phase could be completed in 71 days at an estimated cost of approximately $1.4 million. The additional time is required for mobilization and demobilization for two seasons rather than one. The additional costs are due to the increased number of field days and the repetition in several of the pre- and post field tasks.

PES is grateful for the opportunity to participate in this project and for the assistance provided by ADEC and the Chenega Village Corporation.

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I. INTRODUCTION

The Alaska Department of Environmental Conservation (ADEC), the *Exxon Valdez* Oil Spill Trustee Council, and other federal and state government organizations and public interest groups continue to monitor the recovery of shorelines along Prince William Sound that had been impacted by the *Exxon Valdez* oil spill in 1989. In response to concerns primarily expressed by Chenega Village Corporation, the Alaska Department of Environmental Conservation in the fall of 1995 contracted Petroleum Environmental Services, Inc. (PES) for purposes of estimating the costs for treating these beach segments with a process that was used for a 1993 demonstration project on Prince William Sound.

Seven beach segments along Prince William Sound were jointly selected by ADEC and the Chenega Village Corporation for further evaluation and possible additional treatment (see Figure 1). Information obtained during surveys conducted in 1992 through 1994 indicate that these beach segments have varying types and distributions of residual oil. The types include the full range of oil residue - heavy (HOR), medium (MOR) and light (LOR); mousse (M); tar balls and tar patties (TB); and asphalt pavement (AP). Distribution varies from traces to sporadic or patchy areas of residual oil on or among the boulders and cobble surfaces and/or in the subsurface sediment.

The PES Shoreline Treatment Process was first used in 1993 on an oil impacted section of LaTouche Island. This demonstration project was partially funded by the Hazardous Spill Science Technology Review Council. The team that conducted this project included PES, the Chenega Village Corporation and the University of Alaska Fairbanks. Results obtained after completion of the treatment and one year later indicated that application of this process had both immediate and long term benefits.

This report contains the results of the 1995 project and provides a brief description of the candidate beach segments and the PES Shoreline Treatment Process. Also included are the proposed resource requirements, estimated treatment times; and the cost estimates for application of this process on these beach segments. These results were presented at an ADEC sponsored meeting entitled "Residual Oiling Workshop" that was held in Anchorage, Alaska on November 1 and 2, 1995. For results of this workshop and decisions on the further treatment of these beach segments, the reader is referred to the Alaska Department of Environmental Conservation.

II. METHODS

A. THE PROJECT TEAM

This project was conducted by a team of representatives from the Alaska Department of Environmental Conservation (ADEC), the Chenega Village Corporation (CVC), the *Exxon Valdez* Restoration Office (EVRO) and Petroleum Environmental Services (PES).

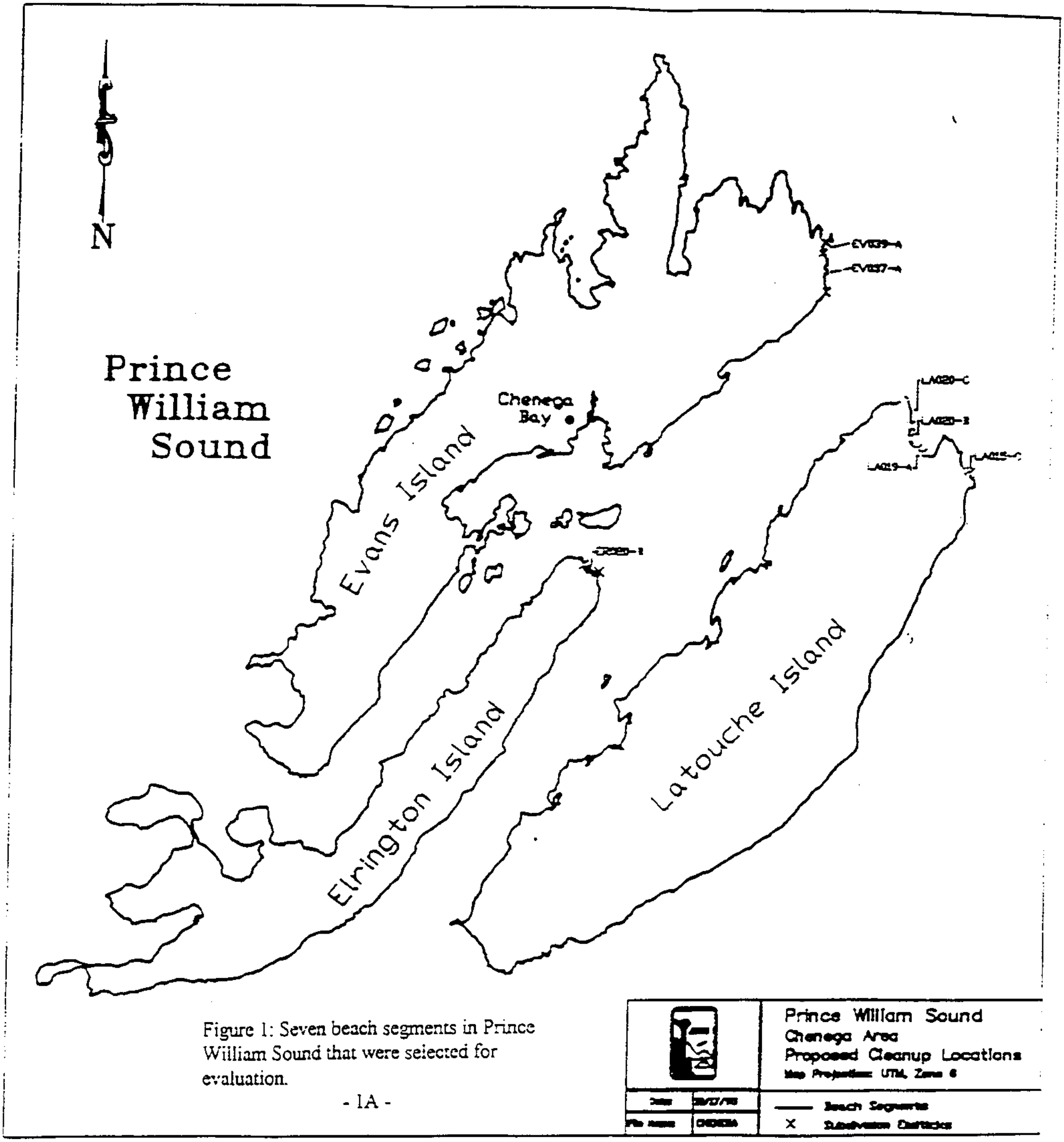

Figure 1: Seven beach segments in Prince William Sound that were selected for evaluation.

B. EVALUATION OF THE BEACHES

Data and narrative summaries of surveys conducted on these beach segments between 1992 and 1994 were provided by ADEC. In addition, information was provided on the treatment measures that have been applied to these beaches between 1989 and 1992.

The project team conducted a reconnaissance of these beach segments on September 26 and 27, 1995. To maximize the efficiency of this effort, the survey reports and sketch maps were used to focus on those areas that been found most recently to contain residual oil. Where feasible, cobble and boulders were displaced to determine the presence of residual oil on the underlying surface sediment. Test pits were also dug to determine the condition of the subsurface sediment. Time was allocated for the pits to backfill with water to enable the detection of sheen.

C. BASIS FOR THE COST ESTIMATES

Several factors were considered in developing the cost estimates. In general, the basis for determining the resource requirements and treatment rates were based on experience gained during the 1993 demonstration project. In addition, several assumptions were made as to what would be required of the contractors as opposed to activities that would be the responsibilities of the government agency.

1. Treatment Rate

The 1993 demonstration project was conducted on a section of LA-19A which is characterized by boulders (and some cobble) over gravel sediment. The total area treated was approximately 37 meters by 36 meters or 1,332 square meters. The team spent a total of seven days at this site in July. Based on lessons learned from this project, it is estimated that mobilization and demobilization tasks would require approximately one-half day each. Mobilization tasks at a treatment site would include placement of double containment booms along the shoreline below the area to be treated; movement of the landing craft to enable the deployment of the airknife injection systems, deluge header hoses and flushing hoses; placement of the deluge header hose system, etc. Demobilization tasks would include decontamination and removal of all equipment, supplies and project debris from the beach. Depending on the length of beach that needs to be treated, more than one resetting of the booms may be needed. These boom settings include movement of the containment booms (as well as any deflection booms that might be placed to protect streams), movement of the header hose system, the airknife injection systems, the flushing hoses and the landing craft. Based on the 1993 project experience, it is estimated that it would take one-half day each time the booms are reset and the equipment moved to enable treatment of a new beach segment.

During the 1993 project, approximately one day was expended in mobilization and demobilization, one day was lost due to inclement weather, therefore, the total treatment time was actually five days. Since two airknife injection systems were used, the average treatment rate was approximately 133 square meters per day per airknife injection system. Given that this was the first application of the airknife injection system on a shoreline and that the flushing system was found to be less than adequate, it is projected that the efficient employment of this shoreline treatment process would permit a treatment rate of up to 200 square meters per day per airknife injection system. This rate will be effected by several factors including landing craft accessability to the shoreline, "down time" because of equipment malfunctions, and the expertise of the work crews. To ensure that the treatment process is applied effectively, it is recommended that a single crew be trained and used throughout this project.

2. Assumptions

The following assumptions were made after discussions with representatives of the Alaska Department of Environmental Conservation.

a. The Alaska Department of Environmental Conservation

1) Will prepare and submit the National Environmental Protection Act Environmental Assessment (if required), as well as obtain archeological site clearances, state land use permits, and Alaska Regional Response Team approval.

2) Will contract separately for obtaining and analyzing sediment and water samples and monitoring the potential impact on flora and fauna. No additional time will be allocated in the cost estimates for the time required to complete these efforts. If required, this time could be included, but this would incur additional field related expenses.

3) Will make arrangements for and provide funding to cover all the costs for any additional personnel that might be required to monitor and observe this project.

4) May decide to conduct this restoration project in one season or over a two season period.

b. Project Duration

1) To maximize the efficiency of the time spent on these beach segments, four Airknife Injection Systems will be used for this project. Based on the previously stated rate of 200 square meters per day per airknife, it is estimated that up to 800 square meters can be treated per day.

2) The overall project duration will include time for the contractor(s) to perform tasks prior to and after the field activities. Pre-field tasks include identifying and contracting for a team of qualified personnel and subcontractors; developing the work plan and the health and safety plan; identifying and ordering equipment and supplies; coordinating the arrangements for movement of personnel, equipment and supplies to the embarkation point; assisting ADEC in obtaining required

approvals and permits; and participating in meetings with ADEC as required. Post field tasks include coordinating the return, storage (as appropriate), or transfer/disposal of equipment and supplies; ensuring the disposal of the recovered oil and oily wastes; developing reports of the project; and participating in meetings with ADEC as required.

3) If conducted in two phases, additional time will need to be added for pre-field and post field tasks during the second summer.

4) The time frame for performance of the field work is likely to be August and September. There may be a need to provide additional time because of delays encountered due to salmon spawning or other beach specific constraints.

5) Time will be provided for crew rest on the basis of one day for every seven days worked.

6) Time will be provided for delays due to inclement weather. For purposes of this project, this will be estimated on the basis of 25% of the total required work days.

D. RESOURCE REQUIREMENTS AND ESTIMATED COSTS

Based in part on the experience gained from the 1993 demonstration project, requirements for personnel, equipment, supplies and mobilization/demobilization were developed on the basis of optimizing the effectiveness of the treatment process while minimizing the expenses incurred. Costs for these items were determined on the basis of fully burdened personnel costs, costs for equipment and supplies that could be obtained in Anchorage in the Fall of 1995, and projected costs for items like travel and insurance. To provide a more complete picture of total project costs, estimates were made for indirect costs and profit. For purposes of this project, profit was estimated on the basis of a percentage of direct costs. In accordance with AS.36.30.370, profit would be an item negotiated between a state agency and the contractor.

III. RESULTS

A decision to treat these beach segments should be made on the basis of benefits that can be achieved, risks involved, and the costs that would be incurred. An integral part of this decision making process and implementation of a treatment program must be a clearly defined set of goals that reflect the consensus of the parties involved. This section contains a set of treatment goals that can be considered as a template on which to build ones that are specific to the project under consideration by ADEC. Also described in this section is the PES Shoreline Treatment Process as it could be applied on these beach segments, the results of the evaluations of the seven beach segments, the resources that would be required for treatment of these sites, and the costs that would be involved.

A. TREATMENT GOALS

The goals of a treatment process should include both immediate and long term improvements in terms of decreasing the presence and levels of oil while minimizing the potential harmful effects to the flora and fauna. The immediate effects would be due primarily to the physical removal of residual oil, whereas the long term effects would be due to stimulation of natural degradative processes. The following are recommended immediate and long term goals:

1. Immediate Goals

- Visually observable significant decrease in the amount of residual oil within the surface and subsurface sediments immediately post treatment. Observable (direct) changes include physical removal, change in the character of residual oil deposits (softening and/or displacement of tar balls, tar patties and asphalt pavement), and reduction of sheen in areas of water pooling.

- Significant decrease in the concentrations of recoverable petroleum hydrocarbons, e.g. total petroleum hydrocarbons and diesel range organics. While the former parameter indicates overall levels of recoverable hydrocarbons, the latter indicates the levels of the most toxic components of oil that could be expected to be found six years after the *Exxon Valdez* oil spill.

- No detectable levels of petroleum hydrocarbons in the water column along the shoreline below the treatment areas. While the removal of the oil will involve the displacement from the subsurface sediment to the shoreline, this treatment remove this oil without allowing it to disperse into the water column where it could effect intertidal fauna and flora.

2. Long Term Goals

- Further visually observable decrease in the amount of residual oil on the surface and in subsurface sediments.

- Further reduction in the measurable amounts of recoverable petroleum hydrocarbons in the subsurface sediment.

These immediate and long term effects should be achieved without introducing any of the displaced oil into the water column along the shoreline where it could have an adverse impact on flora and fauna.

B. THE PES SHORELINE TREATMENT PROCESS

The PES Shoreline Treatment Process uses an airknife injection system to penetrate and dilate subsurface sediment, and to apply a biosurfactant to displace oil from surface and subsurface sediment. The biosurfactant used in this process is PES-51®, a product that reduces the interfacial tension between petroleum hydrocarbons and surfaces thereby releasing it onto water that is used to flush it away. Most importantly, the displaced oil is not altered chemically or emulsified. Instead, the oil/product complex floats on the water surface where it can be collected and recovered. The displaced oil is flushed into a double boomed region of shoreline by using a deluge header hose system to provide a continuous flow of ambient temperature sea water over the treatment area, as well as direct flushing of the injection sites during and after administration of the biosurfactant. Figure 1 demonstrates how the work crew used the airknife, applied the biosurfactant, and flushed away the displaced oil during the 1993 demonstration project. The oil collected along the shoreline is recovered by skimmers and pumped into a storage tank from which the water can later be decanted and returned to the Sound. Sorbents are also used to collect the oil whenever it fails to drain to the shoreline. These sorbents are stored in bags or drums. The equipment, supplies and waste material are deployed and recovered onto a landing craft. This vessel permits ready access to rocky shorelines thereby minimizing the logistics of mobilization, treatment and demobilization.

In addition to the immediate effects achieved by displacement, collection and recovery of displaced oil, this treatment process has additional benefits because it aerates the subsurface sediment and increases the bioavialability of the oil residue thereby enhancing biodegradation by indigenous micro flora.

As was described in the Introduction Section of this report, the PES Shoreline Treatment Process was used previously on a beach that had residual oil from the *Exxon Valdez* oil spill in 1989. Results of this project indicate that the process has both immediate and long term benefits. Qualitatively, there was a visible decrease in subsurface oil residue. From a quantitative perspective, approximately 100 gallons of oil liquid were recovered and there was an immediate 70% decrease in semivolatile petroleum hydrocarbons in the subsurface sediment. The following May, this decrease exceeded 90%. These improvements were accomplished without introducing any detectable levels of petroleum hydrocarbons into the water column along the shoreline below the treatment area[1].

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[1] Mark A. Tumeo and Joan Braddock. Final Report - Effectiveness of a PES-51® in Removing Weathered Crude Oil from Sub-Surface Beach Material. Results of a Field Study at Sleepy Bay on LaTouche Island in Prince William Sound. December, 1994.

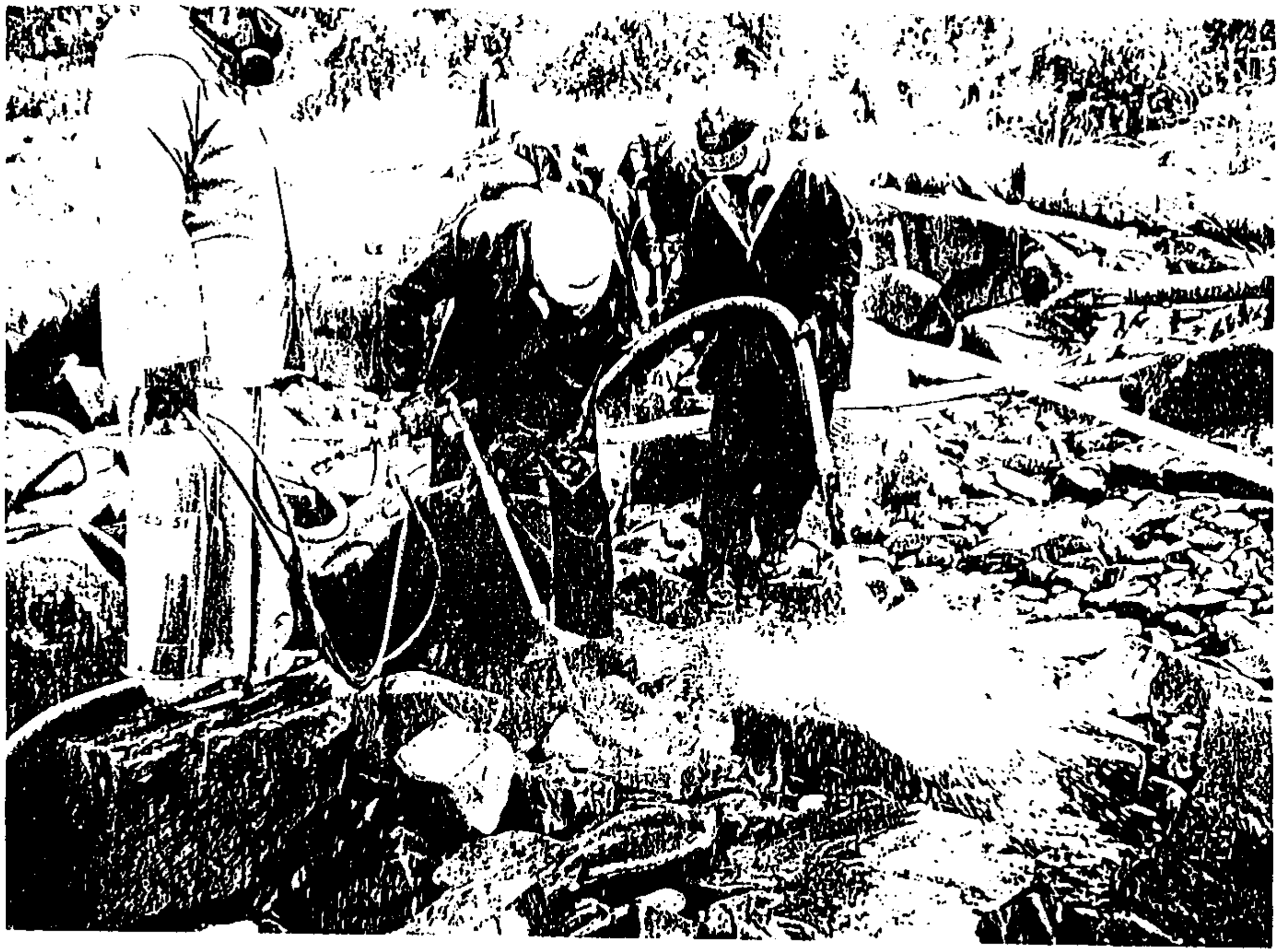


Figure 2: Shoreline Treatment Process. High pressure air is used to penetrate into the subsurface, PES-51® is injected to displace residual oil, and water is used to flush the oil to the shoreline.

C. EVALUATION OF THE BEACHES

Seven beach segments were jointly selected by ADEC and the Chenega Village Corporation as candidates for further treatment and were the focus of this project. In actuality, two were segments of one beach on LaTouche Island; LA-20B and LA-20C. Two other beach segments on this same island were also selected; LA-15C and LA-19A. Beaches on two other islands were also included; ER-20B on Elrington Island, as well as EV-37A and EV-39A on Evans Island.

In general, these beach segments are characterized by a cobble, boulder or cobble/boulder armor covering a gravel sediment. Visually observable residual oil was found in the upper and middle intertidal zones on all seven sites. This included surface oil residue ranging from heavy to light, mousse and asphaltic pavement. Most often, the residual oil was found on, or adhering to, or below, the boulder and cobble layers, especially in sheltered crevices and other areas that were protected from wave energy.

Photographic evidence of the sediment types and residual oil serve as a visual record of the findings from the reconnaissance conducted in September, 1995.

Figure 3 - LA-15C is an example of a beach segment that is covered by large boulders. Sheen was observed in a water pool in the upper intertidal zone. In addition, mousse was found on the underside of a small boulder.

Figure 4 - LA-20B is another example of a boulder armor surface. Several sites were found to have surface oil residue.

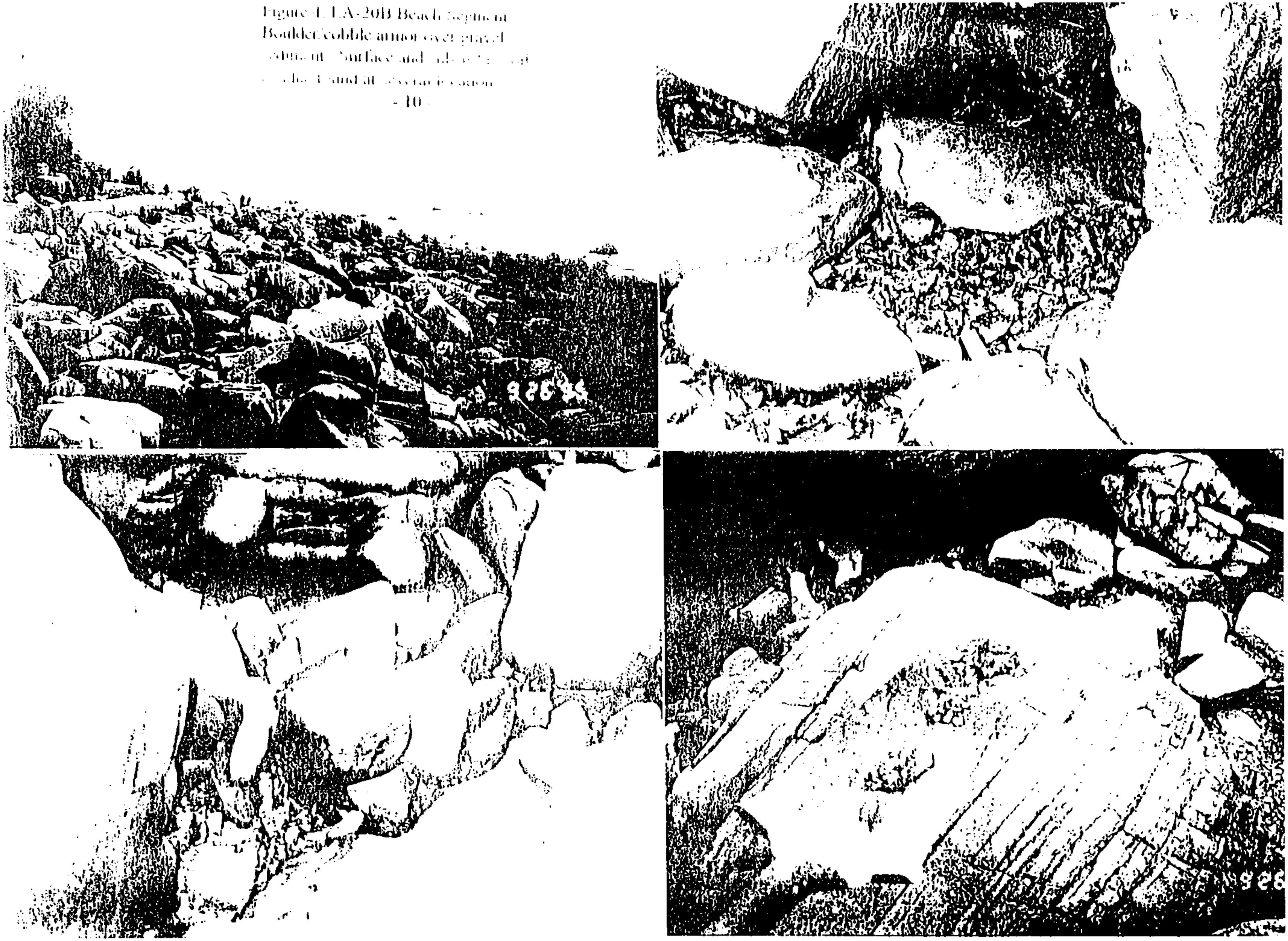
Figure 5 - ER-20B has two pocket beaches. The western pocket is characterized by cobble over a mixed gravel/sandy sediment. Sheen was observed after water seeped into test pits. The eastern pocket is characterized by cobble and boulders covering a mixed gravel/sand sediment. Asphalt pavement was found adhering to the underside of a small boulder.

Figure 6 - EV-37A is characterized by boulder/cobble armor over a gravel sediment. Test pits dug into the subsurface were found to contain heavy oil residue and sheen when water seeped in and filled these pits.

A brief description of all the beach segments and the types of oil residue found during the reconnaissance trip are shown in Table 1. A more detailed description and a sketch map of these beach segments is contained in Appendix A. These descriptions integrate the information obtained during the reconnaissance trip with data obtained by ADEC during surveys conducted from 1992 through 1994.

Figure 5: LA-15C Beach Segment
Boulder armor over gravel sediment
Mousse found on underside of a boulder.

Figure 4. LA-20B Beach Segment
Boulder/cobble armor over gravel
sediment. Surface and [illegible]
[illegible] and at [illegible] location



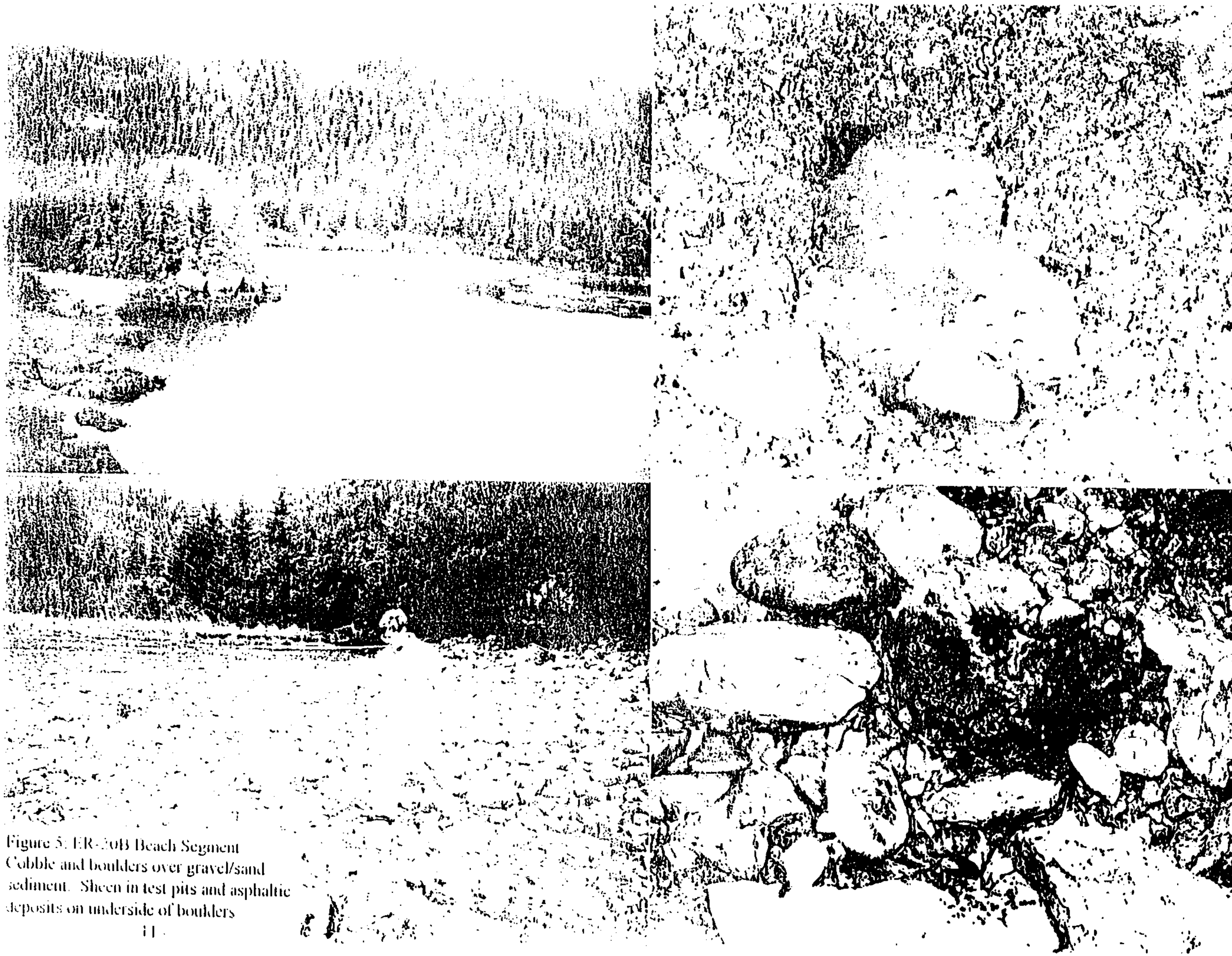


Figure 5: ER-20B Beach Segment
Cobble and boulders over gravel/sand sediment. Sheen in test pits and asphaltic deposits on underside of boulders

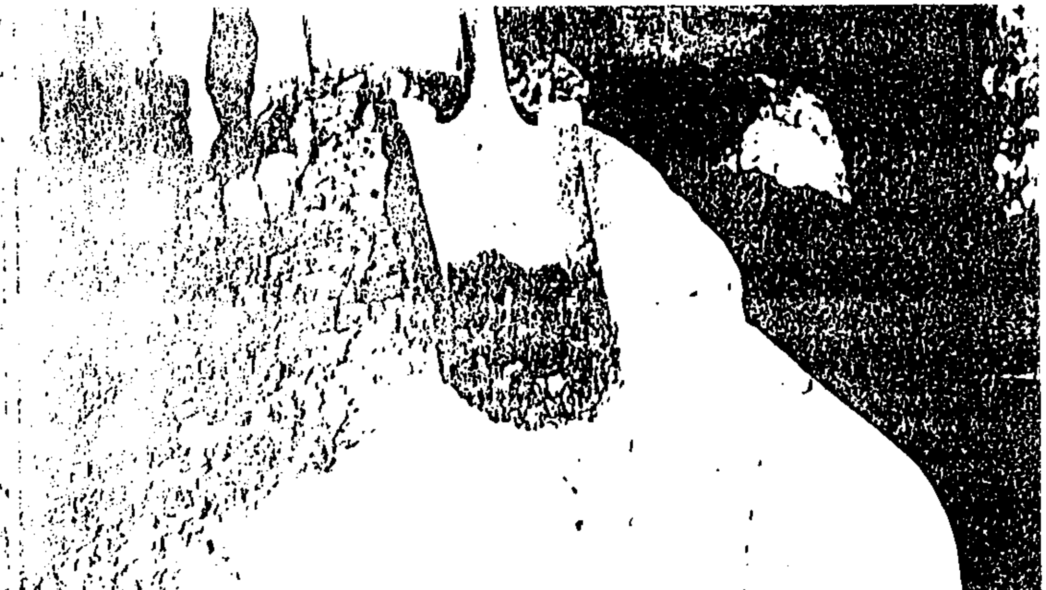


Figure 6. FV-37A Beach Segment Boulder/cobble armor over gravel sediment. Sheen in test pits and subsurface oil residue on shovel

Table 1: Candidate Beach Segments

SITE	SURFACE AND SUBSURFACE SEDIMENTS	RESIDUAL OIL
LA-15C	Boulders over gravel sediment, stream near eastern border	Mousse on the underside of boulders, sporadic pockets of surface oil residue, tar patties and sheen in water pools
LA-19A	Boulder armor over gravel sediment	Asphalt pavement, mousse and surface oil residue among the boulders
LA-20B	Cobble and boulder armor over gravel sediment, stream near norther border	Patchy areas of asphalt pavement, as well as surface and subsurface oil residue
LA-20C	Boulder armor over vertically aligned shale bedrock and gravel sediment	Patchy areas of asphalt pavement, as well as surface and subsurface oil residue, sheen in water pools
ER-20B	Cobble and boulders over gravel sediment	Surface and subsurface oil residue, sheen in water pools and asphalt pavement in western and eastern pockets
EV-37A	Large boulders over gravel sediment	Asphalt pavement, as well as surface and subsurface oil residue, sheen in water pools
EV-39A	Cobble and boulder armor over gravel sediment, beach divided by stream	Asphalt pavement, tar patties, as well as surface and subsurface oil residue

D. TREATMENT TIMES FOR THE SELECTED BEACH SEGMENTS

Based on the estimated treatment rate for an airknife injection system, times required for mobilization, demobilization and for resetting the booms, and assumptions described in the Methods section, estimates were developed of the number of work days which would be required at each of these beach segments. Specific locations described in the following beach summaries refer to sites identified on the sketch maps that appear in Appendix A. The estimated work days for these beach segments are shown in Table 2.

1. LA-15C

ADEC estimates a total area of 1,500 square meters total treatment area. Based on a coverage rate of 200 square meters per day per airknife injection system, one-half day for mobilization, one-half day for demobilization, and one-half day for resetting the booms once, it is estimated that the total work days would be up to four days for LA-15C.

2. LA-19A

ADEC estimates a total area of 5,000 square meters could warrant treatment. Based on a coverage rate of 200 square meters per day per airknife injection system, one-half day for mobilization, one-half day for demobilization, and one-half day for resetting the booms once, it is estimated that the total work days would be up to eight days for LA-19A. Based on the results obtained immediately and one year after treatment of a section of this beach, it is likely that this section will not need another treatment. This reduces the total area estimate to 3,700 square meters and reduces the total work days to six days for LA-19A.

3. LA-20B

ADEC estimates a total area of 1,000 square meters could warrant treatment. Based on a coverage rate of 200 square meters per day per airknife injection system, one-half day for mobilization, one-half day for demobilization, and one-half day for resetting the booms once, it is estimated that the total work days would be up to three days for LA-20B.

4. LA-20C

ADEC estimates a total area of 14,000 square meters could warrant treatment. Based on a coverage rate of 200 square meters per day per airknife injection system, one-half day for mobilization, one-half day for demobilization, and one day for resetting the booms twice, it is estimated that the total work days would be up to 20 days for LA-20C.

Table 2: Estimated Work Days for Each Site

SITE	ESTIMATED TREATMENT AREAS (square meters)	ESTIMATED WORK DAYS
LA-15C	1,500	4
LA-19A	3,700	6
LA-20B	1,000	3
LA-20C	14,000	20
ER-20B	1,500	5
EV-37A	1,100	3
EV-39A	2,000	4
TOTALS	**24,800**	**45**

5. ER-20B

ADEC estimates a total area of 1,500 square meters could warrant treatment. Based on a coverage rate of 200 square meters per day per airknife injection system, one-half day for mobilization, one-half day for demobilization, and one day for resetting the booms twice, it is estimated that the total work days would be up to five days for ER-20B.

6. EV-37A

ADEC estimates a total area of 1,100 square meters could warrant treatment. Based on a coverage rate of 200 square meters per day per airknife injection system, one-half day for mobilization, one-half day for demobilization, and one-half day for resetting the booms once, it is estimated that the total work days would be up to three days for EV-37A.

7. EV-39A

ADEC estimates a total area of 1,125 square meters could warrant treatment. Based on a coverage rate of 200 square meters per day per airknife injection system, ½ day for mobilization, one-half day for demobilization, and one-half day for resetting the booms once, it is estimated that the total work days would be up to three days for this area. PES estimates that the total treatment area could be up to 2,000 square meters including the intervening area between location "A" and the stream. Several pits dug in this area during the pits found to contain medium oil residue during the 1994 ADEC survey. This would increase the total work days up to four days for EV-39A.

E. TOTAL TIME REQUIRED FOR THE PROJECT

Determination of the total treatment time for these beaches should include allocation of time for mobilization and demobilization from Anchorage, crew rest and delays due to inclement weather.

1. Single Season Option

It is estimated that it would take two days to mobilize the team, equipment and supplies, and get them to the first site. Based on the estimates of the treatment areas, the total work days are estimated to be 45 days. Allocating a crew rest day for each seven work days adds up to seven days. For purposes of this project, an additional 12 days are allocated for inclement weather (estimated at 25% of the work days). It is estimated that it would take two days to demobilize the team, equipment, supplies and project debris, and get them back to Anchorage. Therefore, it is estimated that the total field time for treatment of all the beach segments in a single summer would be 68 days. The components of this estimate are summarized in Table 3.

Table 3: Duration of Field Phase

OPTIONS	MOB.	WORK DAYS	REST DAYS	INCLEMENT WEATHER	DEMOB.		TOTAL DAYS FOR FIELD PHASE
ONE SEASON	2	45	7	12	2		= 68
TWO SEASONS							
YEAR ONE	2	29	4	8	2	= 45	
YEAR TWO	2	16	2	4	2	= 26	
							= 71

2. Two Season Option

If the decision is made to conduct this project over two seasons, the following estimates would apply.

a. Year One - It is recommended that LA-19A, LA-20B and LA-20C on LaTouche Island be treated in the first summer. It is estimated that it would take two days to mobilize the team, equipment and supplies, and get them to the first beach segment. Based on the estimates of the treatment areas, the total work days on these beach segments would be 29 days. Time for crew rest would be at least four days. For purposes of this project, an additional eight days are allocated for inclement weather. It is estimated that it would take two days to demobilize the team, equipment, supplies and project debris, and get them back to Anchorage. Therefore, it is estimated that the total field time for treatment of these beach segments would be 45 days.

b. Year Two - It is recommended that LA-15C, ER-20B, EV-37A and EV-39A be treated in the second summer. It is estimated that it would take 2 days to mobilize the team, equipment and supplies (including those in storage), and get them to the first beach segment. Based on the estimate of treatment areas, the total work days on these beach segments would be 16 days. Time for crew rest would be 2 days. For purposes of this project, an additional 4 days are allocated for inclement weather. It is estimated that it would take 2 days to demobilize the team, equipment, supplies and project debris, and get them back to Anchorage. Therefore, it is estimated that the total field time for treatment of these beaches in a summer would be 26 days.

c. Summary For The Two Season Option - Based on the times required to complete this project over two summers, it is estimated that it would take a total of 71 days for the field phase. The components of this estimate are also summarized in Table 3.

F. RESOURCE REQUIREMENTS

Tables 4 and 5 summarize the requirements for personnel, equipment, supplies, and mobilization/demobilization, respectively. For purposes of this Cost Estimate Project, personnel were categorized as "off-site", i.e. coming from outside the immediate area, and "on-site", i.e. personnel with the requisite qualifications who are nearby the treatment area. To maximize the efficiency of this project, it is recommended that a field team of 17 personnel would be required.

Off-site personnel would acquire, prepare and ship the equipment and supplies to an embarkation point. Based on information available at this time, it is recommended that Seward be used for transfer of personnel, equipment and supplies to vessels for transportation to the treatment area.

Off-site personnel would be lodged on a berthing vessel for the duration of the project. On-site personnel would be transported to/from the treatment areas by a fishing vessel.

Table 4: Personnel and Equipment Requirements

PERSONNEL

Off-Site Personnel
- Project Manager
- Assistant Project Manager
- Administrative Assistant
- Equipment Operators (2)

On-Site Personnel
- Work Crew Supervisor
- AKIS Operators (4)
- Flush Hose Operators (4)
- General Labor (4)

EQUIPMENT

Treatment Process Equipment
- Airknife Injection Systems (4)
- Air Compressors (2)
- 6" Water Pump for the Header Hose System
- 4" Water Pump for Direct Flushing
- 2" Water Pump for Spot Flushing (2)
- Assorted Hoses for Suction and Pumping
- Skid Mounted Vacuum Skimming System and Storage Tank
- Containment Booms

Vessels
- Berthing Vessel
- Landing Craft
- Fishing Boat
- Skiff

Miscellaneous Equipment
- CONEX Trailer
- Porta Potty (2)

Table 5: Supplies and Mobilization/Demobilization Requirements

SUPPLIES

Treatment Process
- PES-51® (31 - 55 gallon drums)
- Sorbents - booms, pads, sweeps, snares
- Sorbent Pad Ringers (2)

Personnel Protection and Treatment
- Personnel Protection Equipment (17)
- First Aid Kits (2)
- Eye Wash Stations (2)

Miscellaneous
- Fuel
- Lubricants
- Field Radios (2)
- Field Supplies
- Office Supplies

MOBILIZATION AND DEMOBILIZATION

Off-Site Team - Anchorage to/from Seward

CONEX Trailer - Anchorage to/from Seward

Disposal of oily liquids and oily wastes

Assistant Program Manager San Antonio to/from Anchorage

Storage of Equipment and Supplies in Chenega if the two season option is selected

If the project were conducted in one season, all equipment, supplies and oily wastes would be returned to Seward for land shipment to Anchorage. If the project were conducted over two seasons, equipment and supplies needed for the second year would be stored in the CONEX trailer at a site nearby the treatment area, e.g. Chenega village.

G. COST ESTIMATES

1. One Season Project

If this project were conducted over one season, the total estimated cost for treatment of these candidate beaches would be $1,313,624. Table 6 shows the costs for the individual categories for a project conducted in one season. To demonstrate how each beach segment contributes to the overall costs, Table 7 shows the costs prorated across the seven beach segments. Appendix B contains further details on the costs for individual items that were used in developing these cost estimates.

2. Two Season Project

If it is decided to conduct this project over two seasons, it is recommended that LA-19A, LA-20B and LA-20C be treated in one season. In the second year, LA-15C, ER-20B, EV-37A and EV-39A would be treated. For a two season project, the total estimated costs for treatment would be $1,404,173. Table 8 shows the costs for the individual categories for a project conducted over two seasons. Appendix C contains further details on the costs for individual items that were used in developing these cost estimates.

IV. DISCUSSION AND CONCLUSIONS

Reconnaissance conducted during September, 1995 revealed that residual oil persists on all seven of the beach segments selected for this project. Each contained deposits of petroleum hydrocarbons that can be considered in a "mobile" from, e.g. surface and subsurface oil residues ranging from light to heavy and mousse. These forms are likely to be readily transportable during tidal cycles as well as when humans and other animal species tread on these surfaces. In addition, the tidal cycles can be expected to transport these forms into the Prince William Sound. Each site also contained deposits of petroleum hydrocarbons in what might be considered a more "stable" form, i.e. asphaltic pavement, tar patties and tar balls. These forms of residual oil are less likely to be physically displaced by the tidal cycles, but could be considered as an continual source of petroleum hydrocarbons that might be released through wave action, etc.

Results of the 1993 project on LA-19A revealed that the PES Shoreline Treatment Process can effectively remove residual oil from sediment on beaches that had been impacted by the *Exxon Valdez* oil spill four years earlier. PES anticipates that treatment of the seven beach segments evaluated

Table 6: Single Season Cost Summary[2]

COST CATEGORY	COST ESTIMATE
Personnel[3]	472,644
Equipment[4]	509,214
Supplies	94,192
Mobilization & Demobilization	9,200
Insurance[5]	22,366
Indirect Costs (15% of all categories except personnel)	95,246
Profit[6]	110,762
TOTAL	1,313,624

[2] Based on 68 days total field time.

[3] Includes labor costs, an estimate of fringe benefits and overhead for personnel.

[4] Includes equipment purchased and leased for this project.

[5] Includes Worker's Compensation and Sub-Contractor Coverage for the Prime only. Does not include General Liability or Auto Liability for the Prime which is included in Indirect Costs. Does not include project related insurance costs for subcontractors.

[6] For purposes of this Cost Estimate Project, profit was determined as 10% of all direct costs. In accordance with AS.36.30.370, profit on an actual contract would be negotiable.

Table 7: Prorated Individual Beach Cost Estimates for a Single Season Option

Categories	LA-15C	LA-19A	LA-20B	LA-20C	ER-20B	EV-37A	EV-39A	Subtotals
Work days	4	6	3	20	5	3	4	45
Prorated Days	6.0	9.1	4.5	30.2	7.6	4.5	6.0	68.0
% Total Days	9%	13%	7%	44%	11%	7%	9%	100%
Personnel	42,013	63,019	31,510	210,064	52,516	31,510	42,013	472,644
Equipment	45,263	67,895	33,948	226,317	56,579	33,948	45,263	509,214
Supplies	8,373	12,559	6,279	41,863	10,466	6,279	8,373	94,192
Mob/Demob	818	1,227	613	4,089	1,022	613	818	9,200
Insurance	1,988	2,982	1,491	9,940	2,485	1,491	1,988	22,366
Indirect Costs	8,466	12,699	6,350	42,332	10,583	6,350	8,466	95,246
Profit	9,846	14,768	7,384	49,228	12,307	7,384	9,846	110,762
TOTALS	**116,767**	**175,150**	**87,575**	**583,833**	**145,958**	**87,575**	**116,767**	**1,313,624**

Table 8: Two Season Cost Summary[7]

	COST ESTIMATE		
COST CATEGORY	YEAR ONE	YEAR TWO	Total Project
Personnel[8]	317,861	184,222	502,083
Equipment[9]	342,585	203,353	545,938
Supplies	93,160	1,033	94,193
Mobilization & Demobilization	8,600	8,000	16,600
Insurance[10]	16,007	8,768	24,774
Indirect Costs[11]	69,053	33,173	102,226
Profit[12]	77,821	40,538	118,359
TOTAL	925,087	479,086	1,404,173

[7] Based on total field times of 45 days in Year One and 26 days in Year Two.

[8] Includes labor costs, an estimate of fringe benefits and overhead for personnel.

[9] Includes equipment purchased and leased for this project.

[10] Includes Workers Compensation and Sub-Contractor Coverage for the Prime only. Does not include General Liability and Auto Liability for the Prime which is included in the Indirect Costs. Does not include project related insurance costs for subcontractors.

[11] Determined as 15% of all direct costs except for personnel which is already fully burdened.

[12] For purposes of this Cost Estimate Project, profit was determined as 10% of all direct costs. In accordance with AS.36.30.370, profit on an actual contract would be negotiable.

during this 1995 project will achieve comparable results to those that were obtained in 1993. In fact, lessons learned from the earlier project would be applied if treatment of these beach segments is approved. This would be likely to produce an even more effective treatment outcome.

Although not directly addressed in this project, the use of the airknife injection systems on these beach segments could enable the application of additional measures to enhance the degradation of the residual oil. Penetration into the subsurface by the airknife enable PES-51® to come into contact with the petroleum hydrocarbons and releases them for removal. In addition, any remaining petroleum hydrocarbons would be more bioavailable thereby enhancing the natural degradative process of the indigenous microflora. This biostimulation of the resident bacteria was noted in the 1993 project. Records of the treatments used at these beach segments in the past include reference to the use of Customblen and Inipol to stimulate the resident bacteria. Reports of these additions are generally accompanied by the statement, "...inadequate site preparation prior to fertilizer application"[13]. Should there be a decision made to provide additional stimulation to the indigenous bacteria by adding fertilizers, the airknife injection system provides a very effective application route that should achieve maximum benefits for the investment.

[13] ADEC Treatment Summaries for EV-37A, EV-39A, LA-15, and LA-20C

APPENDIX A - Summary of the Candidate Beaches Evaluated for Potential Treatment

SHORELINE RESTORATION - COST ESTIMATE PROJECT
SEPTEMBER 1995 RECONNAISSANCE SUMMARY
For
LA-15C on LaTouche Island

Treatment Area = 1,500 square meters

Treatment Time = 4 days

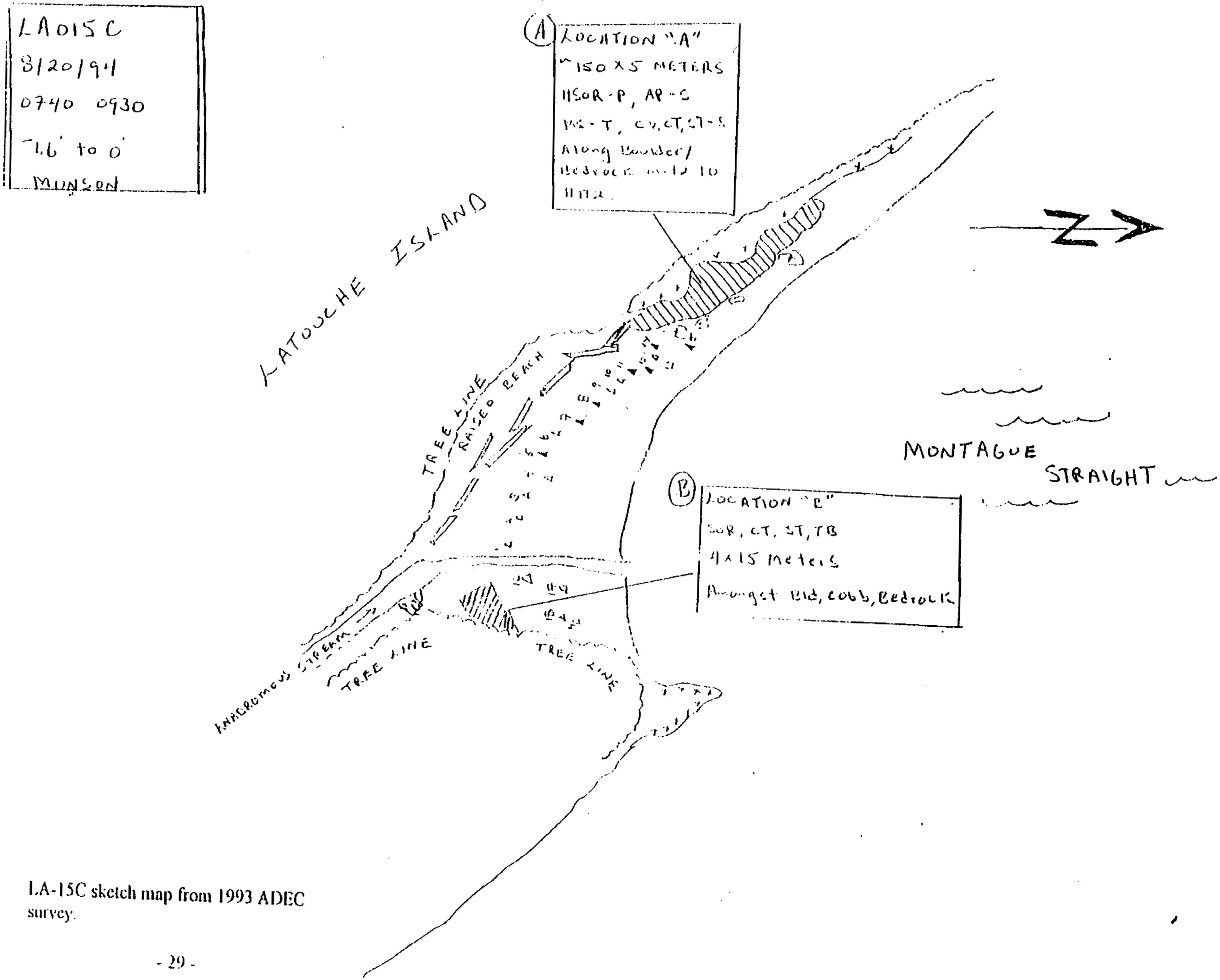
BEACH LOCATION: Northeast coast of LaTouche Island. See ADEC Sketch Map at the end of this summary.

BEACH DESCRIPTION: The eastern border of this beach is characterized by a boulder field and rock outcropping. There is an anadromous stream near the eastern border. The central portion is characterized by cobble armor over gravel sediment. The western portion is characterized by large boulders. The middle and upper intertidal zone was the focus of the 1995 ADEC/PES reconnaissance trip. Findings include sheen in water pools, mousse on the underside of small boulders, sporadic pockets of surface oil residue, and tar patties. This area of oil residue corresponds to location "A" on the 1993 ADEC survey map (see attached). Surface oil residue was also observed in the boulders that form the eastern border of this beach corresponding to location "B" on the 1993 ADEC survey map.

GENERAL APPROACH: Prior to treatment, the LA-15C would be surveyed to identify "hot spots" (areas of observable residual oil) based on data obtained in previous efforts. Those sites found to have visible asphalt pavement, mousse and oil residue on the surface and in the subsurface sediment would be marked to ensure treatment. Sediment samples would be obtained prior to and after treatment based on a schedule developed by the Alaska Department of Environmental Conservation. It is estimated that treatment of LA-15C would require two different settings of the double shoreline boom because of the separation in the areas to be treated and depending on the landing craft accessability. As warranted, an additional boom would be aligned along the stream and extended into the shoreline boom. A header hose flushing system would be placed above the upper intertidal zone to provide a constant flow of ambient temperature sea water across the area being treated. Four airknife injection systems would be used. Crews would proceed from the southern to the northern border of location "A", and then move to work in location "C" on the other side of the stream. Injections would be made down to at least 0.5 meters below the surface where feasible. PES-51® would be administered through the airknife to displace oil from the sediment. In spots where there is observable asphalt pavement and surface/subsurface oil residue around large boulders, injections would be made around their base to displace residue that may have seeped under these rocks. Direct flushing with ambient temperature sea water would begin after application of the biosurfactant. The density of injection sites would depend on the nature of the boulder surface and the presence of observable oil residue. Special attention would be paid to injections around the bases of large boulders where surface oil residue is observable. Whenever oil runoff is noted during injection and/or flushing, injections would be made in a more concentrated pattern to ensure maximum treatment of the subsurface. Oily runoff would be recovered by a combination of skimming in the boomed areas and the use of sorbent pads and sweeps in areas where skimming is not feasible. The oil recovered by skimming would be transferred to a holding tank and the water decanted off and returned to the sound. Treatment would be scheduled with the tidal cycles and proceed from the middle to the upper intertidal zones.

TREATMENT TIME: ADEC estimates a total area of 1,500 square meters could warrant treatment. Based on a coverage rate of 200 square meters per day per airknife injection system, one-half day for mobilization, one-half day for demobilization, and one-half day for resetting the booms once, it is estimated that the total work days would be up to four days for LA-15C. This estimate can be expected to change if this restoration is conducted in conjunction with other beaches. This change will be based on the need to include days for mobilization and demobilization to the site, crew rest, and delays due to inclement weather.

RECONNAISSANCE DATE: September 27, 1995



LA-15C sketch map from 1993 ADEC survey.

SHORELINE RESTORATION - COST ESTIMATE PROJECT
SEPTEMBER 1995 RECONNAISSANCE SUMMARY
For
LA-19A on LaTouche Island

Treatment Area = 3,700 square meters

Treatment Time = 6 days

BEACH LOCATION: North shore of LaTouche Island in Sleepy Bay. See ADEC sketch map at the end of this summary.

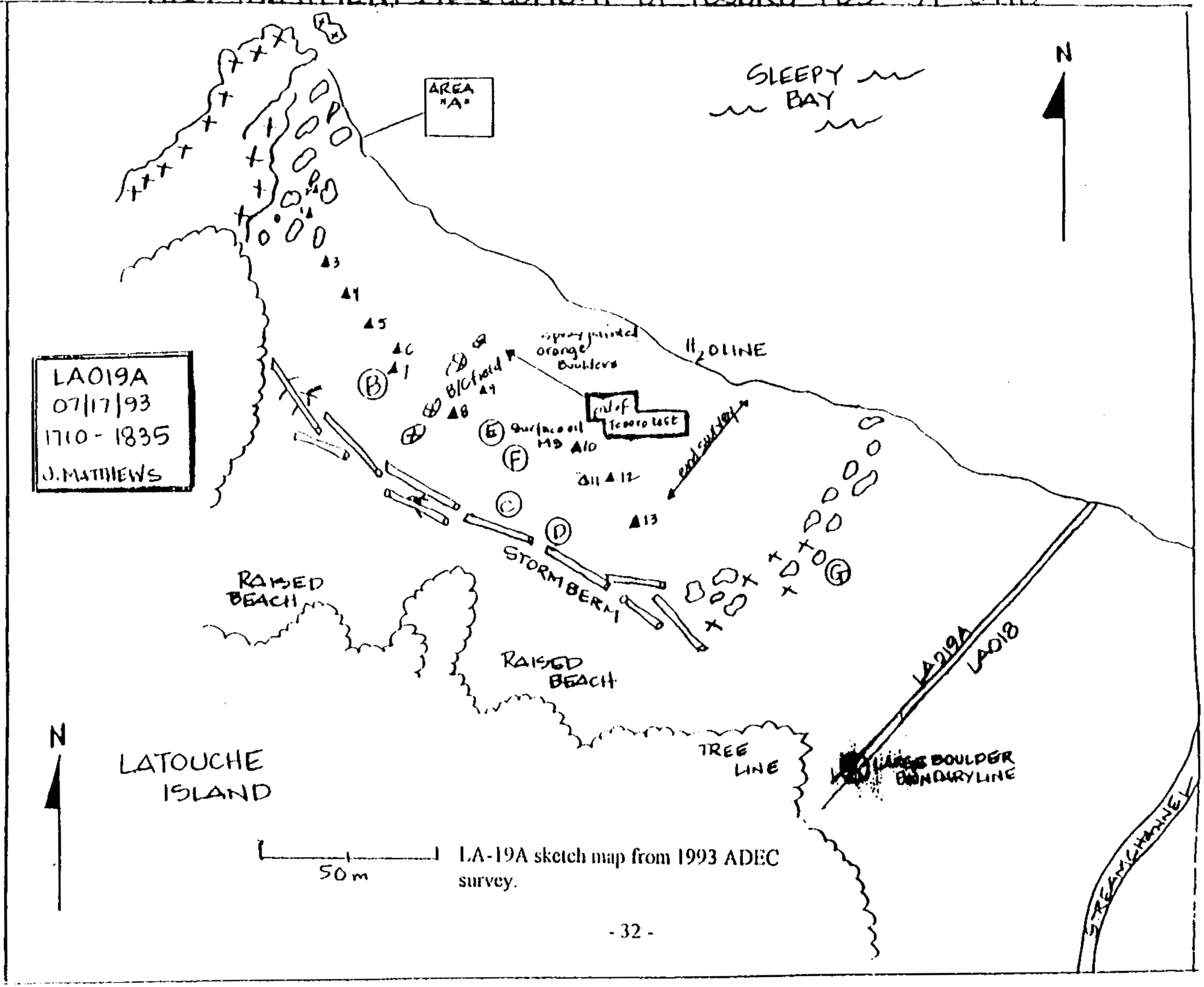
BEACH DESCRIPTION: The western border of this beach is a large boulder promontory. There are two rock outcropping on this beach dividing it into sections with the eastern most of these outcroppings being larger. An anadromous stream is east of this beach on LA-18. A segment of LA-19A was the site of a July 1993 project by PES in which a modified Airknife Injection System was used to penetrate to the subsurface prior to injecting PES-51® to displace residual oil. The treatment site was in the western portion of the beach between the large boulder border and the first rock outcropping. This site consisted of boulder armor over gravely sediment and was approximately 37 meters in length and 36 meters in width. A "reference" site (not treated) was located to the east of the rock outcropping. This site consisted of cobble over gravel sediment. Surveys taken prior to the 1993 PES project reported oil residue at several locations on both treatment and reference sites corresponding to locations "B", "C", "D", "E" and "F" on the 1993 ADEC map (see attached). In general, these sites were in the middle to upper intertidal zone. Surface oil residue was noted in the 1995 PES/ADEC reconnaissance trip in the area of the reference site. The 1993 ADEC survey also reported locations "G" and "H" on either side of the eastern most rock outcropping as containing asphalt pavement, mousse and surface oil residue among the boulders. Another location "A" along the western boulder border of the beach was noted to have patchy mousse.

GENERAL APPROACH: Prior to treatment, LA-19A would be surveyed to identify "hot spots" (observable residual oil) based on data obtained in previous efforts. Those sites found to have visible oil residue in the surface and subsurface sediment would be marked to ensure treatment. Sediment samples would be obtained prior to and after treatment based on a schedule developed by the Alaska Department of Environmental Conservation. The focus on this beach would be the areas outside that which was treated in the 1993 PES project. This area extends from the rock outcropping eastern border of the treatment site to the eastern most rock outcropping noted as location "G" on the 1993 ADEC survey map. It is estimated that treatment of LA-19A would require three different settings of the double shoreline boom because of the length of beach involved and depending on the landing craft accessability. As warranted, an additional boom may be aligned east of the treatment area and extended into the boomed shoreline to protect the stream on LA-18. A header hose flushing system would be placed above the upper intertidal zone to provide a constant flow of ambient temperature sea water across the area being treated. Four Airknife Injection Systems will be used. Crews will begin at the eastern border of the area to be treated and proceed westward. Injections would be made down to at least 0.5 meters below the surface where feasible. PES-51® will then be administered through the airknife to displace oil from the sediment. Direct flushing with ambient temperature sea water will begin after application of the biosurfactant. The density of injection sites would depend on the nature of the cobble/boulder surface and the presence of observable oil. Whenever oil runoff is noted during injection and/or flushing, injections would be made in a more concentrated pattern to ensure maximum treatment of the subsurface. In spots where there is observable surface/subsurface oil residue around large boulders, e.g. location "G" on the 1993 ADEC survey map, injections would be made around their base to displace any residue that may have seeped under these rocks. Oily runoff would be recovered by a combination of skimming in the boomed areas and the use of sorbent pads and sweeps in areas where skimming is not feasible. The oil recovered by skimming would be transferred to a holding tank and the water decanted off and returned to the sound. Treatment would be scheduled with the tidal cycles and proceed from the middle to the upper intertidal zones.

TREATMENT TIME: ADEC estimates a total area of 5,000 square meters could warrant treatment. Based on a coverage rate of 200 square meters per day per airknife injection system, one-half day for mobilization, one-half day for demobilization, and one-half day for resetting the booms once, it is estimated that the total work days would be up to eight days for this area. Based on the 1993 ADEC survey map, PES estimates that the area that warrants treatment is approximately 3,700 meters after excluding the area treated by PES in 1993. This would reduce the estimated total work days for LA-19A to six days. This estimate can be expected to change if this restoration is conducted in conjunction with other beaches. This change will be based on the need to include days for mobilization and demobilization to the site, crew rest, and delays due to inclement weather.

RECONNAISSANCE DATE: September 27, 1995

POST-TREATMENT ASSESSMENT OF TESORO PES-51 SITE



LA-19A sketch map from 1993 ADEC survey.

SHORELINE RESTORATION - COST ESTIMATE PROJECT
SEPTEMBER 1995 RECONNAISSANCE SUMMARY
For
LA-20B on LaTouche Island

Treatment Area = 1,000 square meters	Treatment Time = 3 days

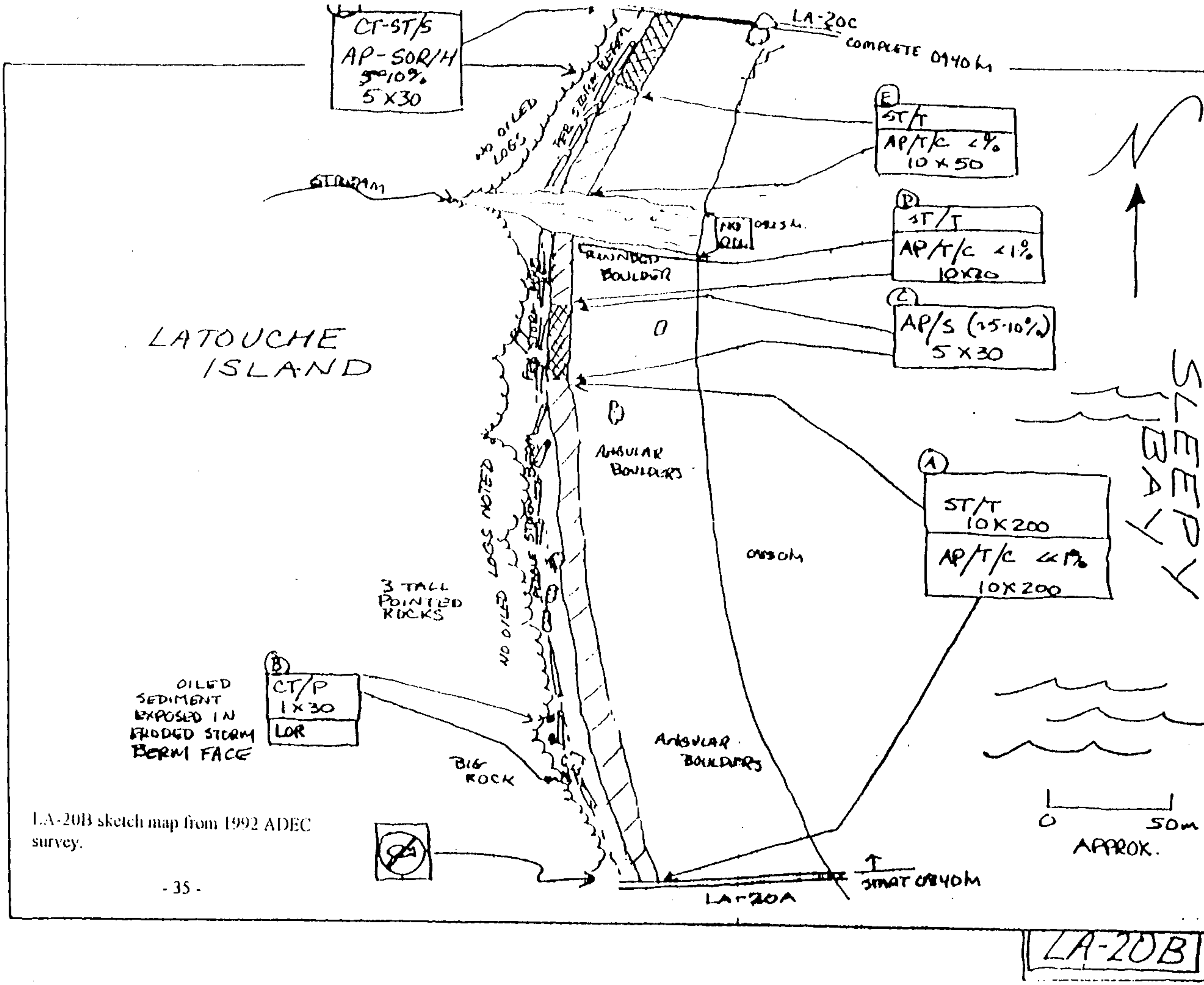
BEACH LOCATION: North end of LaTouche Island, west shoreline of Sleepy Bay. See ADEC sketch map following this summary.

BEACH DESCRIPTION: LA-20B is covered by a cobble/boulder armor over gravel sediment. The proportion of boulders to cobble increases from the southern to the northern border. A stream crosses the beach near the northern border as shown on the attached 1992 ADEC map. In general, patchy areas of surface and subsurface oily residue were found at several sites in the middle and upper intertidal zone of LA-20B. These sites were often found around large boulders. In general, these areas have both asphalt pavement and surface oil residue in the upper intertidal zone.

GENERAL APPROACH: Prior to treatment, LA-20B would be surveyed to identify "hot spots" (observable residual oil) based on data obtained in previous efforts. Those sites found to have asphalt pavement, mousse and other oil residue in the surface/subsurface sediment would be marked to ensure treatment. Sediment samples would be obtained prior to and after treatment based on a schedule developed by the Alaska Department of Environmental Conservation. It is estimated that treatment of LA-20B would require two different settings of a double shoreline boom because of the length of beach involved and depending on the landing craft accessability. As warranted, an additional boom would be aligned along the stream extending out into the boomed area of shoreline. A header hose flushing system would be placed above the upper intertidal zone to provide a constant flow of ambient temperature sea water across the area being treated. Crews would begin at the southern border of LA-20B and proceed towards the northern border. Four Airknife Injection Systems will be used. Injections would be made in the middle and upper intertidal zones down to at least 0.5 meters below the surface where feasible. PES-51® would then be administered through the airknife to displace oil from the sediment. Direct flushing with ambient temperature sea water would begin after application of the biosurfactant. The density of injection sites would depend on the nature of the cobble/boulder surface and the presence of observable oil. Special attention would be paid to injections around the bases of boulders where surface oil residue is observable. Whenever oil runoff is noted during injection and/or flushing, injections would be made in a more concentrated pattern to ensure maximum treatment of the subsurface. Oily runoff would be recovered by a combination of skimming in the boomed areas and the use of sorbent pads and sweeps in areas where skimming is not feasible. The oil recovered by skimming would be transferred to a holding tank and the water decanted off and returned to the sound. Treatment would be scheduled with the tidal cycles and proceed from the middle to the upper intertidal zones.

TREATMENT TIME: ADEC estimates a total area of 1,000 square meters could warrant treatment. Based on a coverage rate of 200 square meters per day per air knife injection system, one-half day for mobilization, one-half day for demobilization, and one-half day for resetting the booms once, it is estimated that the total work days would be up to three days for this area. This estimate can be expected to change if this restoration is conducted in conjunction with other beaches. This change will be based on the need to include days for mobilization and demobilization to the site, crew rest, and delays due to inclement weather.

RECONNAISSANCE DATE: September 26, 1995



LA-20B sketch map from 1992 ADEC survey.

SHORELINE RESTORATION - COST ESTIMATE PROJECT
SEPTEMBER 1995 RECONNAISSANCE SUMMARY
For
LA-20C on LaTouche Island

Treatment Area = 14,000 square meters	Treatment Time = 20 days

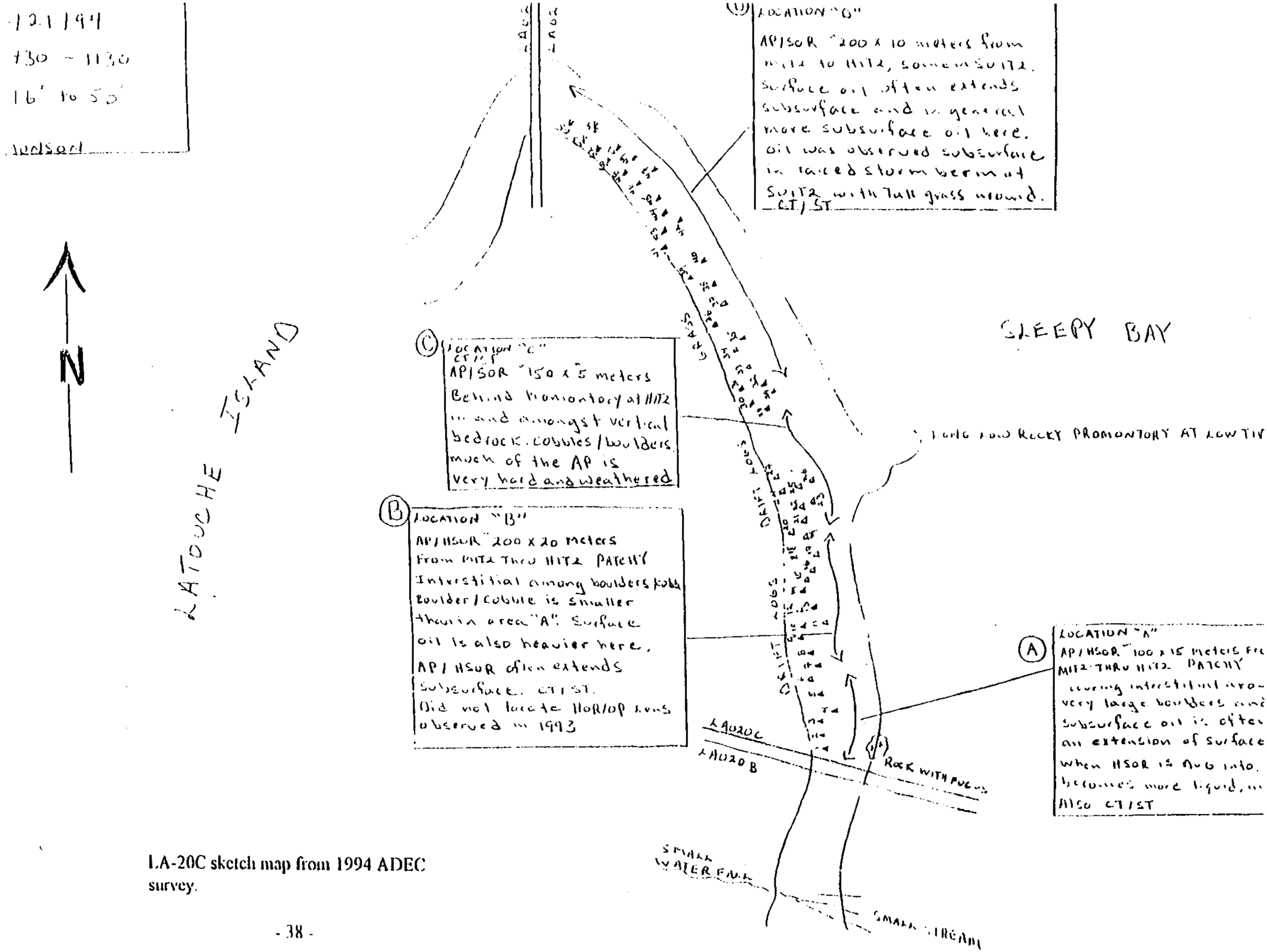
BEACH LOCATION: North end of LaTouche Island, west shoreline of Sleepy Bay. See ADEC sketch map following this summary.

BEACH DESCRIPTION: LA-20C is characterized by a boulder armor over vertically aligned shale bedrock and gravel sediment. There was a distinct oil odor in sporadic pockets of this beach. In general, patchy areas of surface and subsurface oily residue were found at several sites in the middle and upper intertidal zone of LA-20C, especially around large boulders. Sheen was also observed on water pools in the shale bedrock. The 1994 ADEC survey map (see attached) indicates an almost continuous band of residual oil along the upper and middle intertidal zone of LA-20C. In general, these areas have both asphalt pavement and heavy surface oil residue.

GENERAL APPROACH: Prior to treatment, LA-20C would be surveyed to identify "hot spots" (observable residual oil) based on data obtained in previous efforts. Those sites found to have asphalt pavement, mousse and other oil residue in the surface/subsurface sediment would be marked to ensure treatment. Sediment samples would be obtained prior to and after treatment based on a schedule developed by the Alaska Department of Environmental Conservation. It is estimated that treatment of LA-20C would require three different settings of a double shoreline boom because of the length of beach involved and depending on the landing craft accessability. A header hose flushing system would be placed above the upper intertidal zone to provide a constant flow of ambient temperature sea water across the area being treated. Crews would begin at the southern border of LA-20C and proceed towards the northern border. Four Airknife Injection Systems will be used. Injections would be made in the middle and upper intertidal zones down to at least 0.5 meters below the surface where feasible. PES-51® would then be administered through the airknife to displace oil from the sediment. Direct flushing with ambient temperature sea water would begin after application of the biosurfactant. The density of injection sites would depend on the nature of the boulder surface and the presence of observable oil. Special attention would be paid to injections around the bases of boulders where surface oil residue is observable. Whenever oil runoff is noted during injection and/or flushing, injections would be made in a more concentrated pattern to ensure maximum treatment of the subsurface. Oily runoff would be recovered by a combination of skimming in the boomed areas and the use of sorbent pads and sweeps in areas where skimming is not feasible. The oil recovered by skimming would be transferred to a holding tank and the water decanted off and returned to the sound. Treatment would be scheduled with the tidal cycles and proceed from the middle to the upper intertidal zones.

TREATMENT TIME: ADEC estimates a total area of 14,000 square meters could warrant treatment. Based on a coverage rate of 200 square meters per day per airknife injection system, one-half day for mobilization, one-half day for demobilization, and one day for resetting the booms twice, it is estimated that the total work days would be up to 20 days for LA-20C. The estimate can be expected to change if this restoration is conducted in conjunction with other beaches. This change will be based on the need to include days for mobilization and demobilization to the site, crew rest days and delays due to inclement weather.

RECONNAISSANCE DATE: September 26, 1995



LA-20C sketch map from 1994 ADEC survey.

SHORELINE RESTORATION - COST ESTIMATE PROJECT
SEPTEMBER 1995 RECONNAISSANCE SUMMARY
For
ER-20B on Elrington Island

Treatment Area = 1,500 square meters

Treatment Time = 5 days

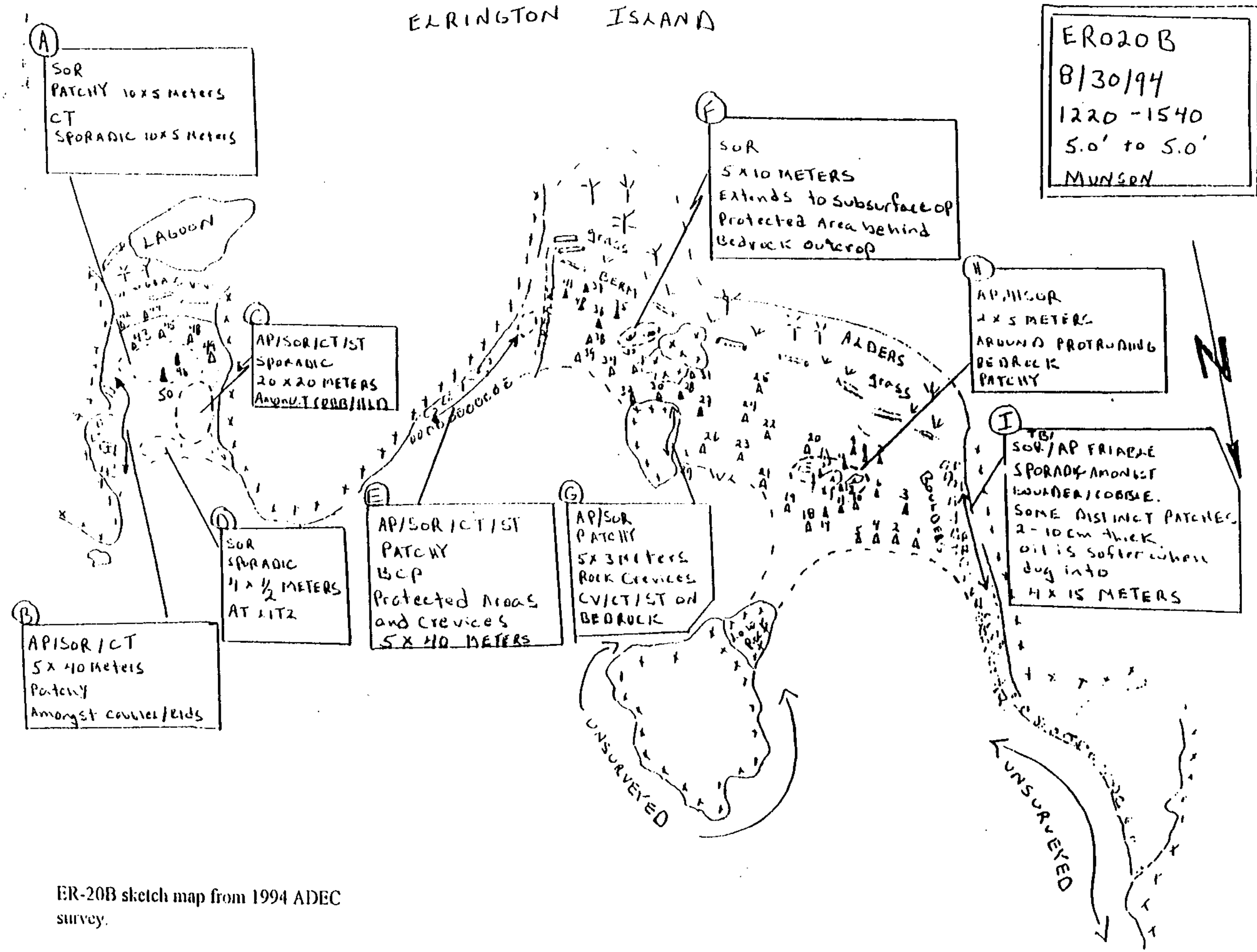
BEACH LOCATION: Northeast end of Elrington Island. See ADEC sketch map following this summary.

BEACH DESCRIPTION: This beach consists of two pockets. The West pocket beach is characterized by cobble over gravel/sandy sediment. The middle portion of this pocket has protruding bedrock and a rock outcropping that extends out into the water. A series of holes were dug west of the protruding bedrock at the middle intertidal zone level. Discoloration of the subsurface sediment was noted along with an oil odor. The holes filled with water and medium oil residue was noted. This corresponds to location "H" of the ADEC 1994 survey map (see attached) in which heavy oil residue and asphalt pavement had been noted. This survey also reported other locations (E, F, G, and I) that contained asphalt pavement and surface oil residue. The Eastern pocket beach is characterized by cobble and boulder over gravel sediment. Patchy areas of asphalt pavement and surface oil residue and subsurface oily sediment were observed in an area corresponding to location "C" on the 1994 ADEC survey map. This survey also reported other locations (A, B, and D) that contained asphalt pavement and/or surface oil residue. The lower to middle intertidal zone contained patches of small mussels and fucus.

GENERAL APPROACH: Prior to treatment, both pocket beaches would be surveyed to identify "hot spots" (observable residual oil) based on data obtained in previous efforts including the 1994 ADEC survey. Those sites found to have asphalt pavement and visible oil residue in the surface and subsurface sediment would be marked to ensure treatment. Sediment samples would be obtained prior to and after treatment based on a schedule developed by the Alaska Department of Environmental Conservation. It is estimated that treatment would require three different settings of the double shoreline boom, two for the western pocket and one for the eastern pocket, and depending on the landing craft accessability. A header hose flushing system would be placed above the upper intertidal zone to provide a constant flow of ambient temperature sea water across the area being treated. Four Airknife Injection Systems would be used. Crews will proceed across these pocket beaches in the middle and upper intertidal zone making injections down to at least 0.5 meters below the surface, possibly deeper if it is found that this will also produce oil runoff. PES-51® will be administered through the airknife to displace oil from the sediment. Direct flushing with ambient temperature sea water will begin after application of the biosurfactant. The density of injection sites would depend on the nature of the cobble/boulder surface and the presence of observable oil. Special attention would be paid to injections around the bases of boulders where surface oil residue is observable. Whenever oil runoff is noted during injection and/or flushing, injections would be made in a more concentrated pattern to ensure maximum treatment of the subsurface. Oily runoff would be recovered by a combination of skimming in the boomed areas and the use of sorbent pads and sweeps in areas where skimming is not feasible. The oil recovered by skimming would be transferred to a holding tank and the water decanted off and returned to the sound. Treatment would be scheduled with the tidal cycles and proceed from the middle to the upper intertidal zones.

TREATMENT TIME: ADEC estimates a total area of 1,500 square meters could warrant treatment. Based on a coverage rate of 200 square meters per day per airknife injection system, one-half day for mobilization, one-half day for demobilization, and one day for resetting the booms twice, it is estimated that the total work days would be up to five days for this area. This estimate can be expected to change if this restoration is conducted in conjunction with other beaches. This change will be based on the need to include days for mobilization and demobilization to the site, crew rest, and delays due to inclement weather.

RECONNAISSANCE DATE: September 26, 1995



ER-20B sketch map from 1994 ADEC survey.

SHORELINE RESTORATION - COST ESTIMATE PROJECT SEPTEMBER 1995 RECONNAISSANCE SUMMARY For EV-37A on Evans Island

Treatment Area = 1,100 square meters

Treatment Time = 3 days

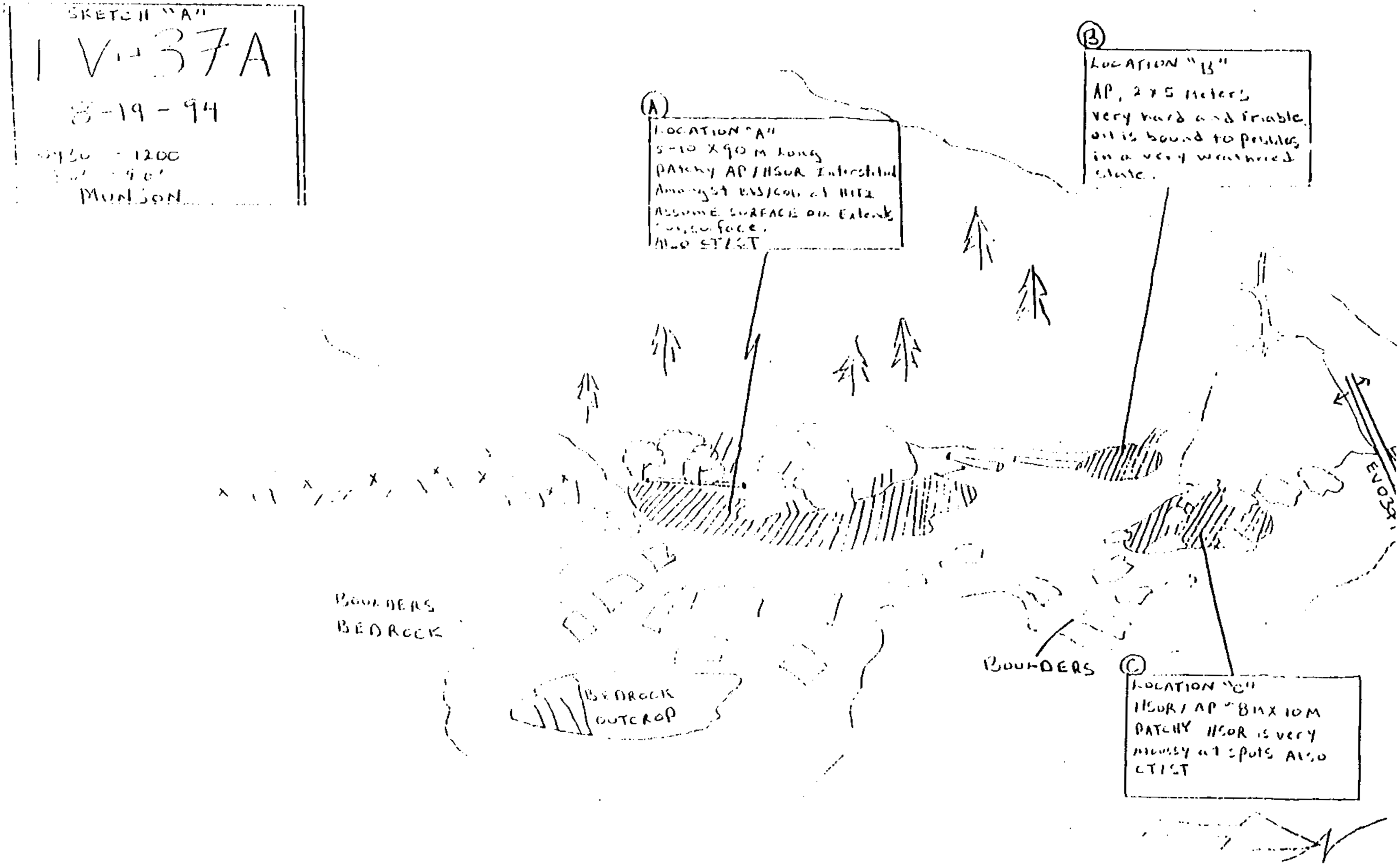
BEACH LOCATION: Northeastern end of Evans Island. See ADEC sketch map following this summary.

BEACH DESCRIPTION: This beach is characterized by large boulders over gravel sediment. Sporadic surface oil residue was found in surface and subsurface sediment at the base of large boulders in the upper intertidal zone corresponding to location "A" on the ADEC 1994 survey map (see attached). Holes dug at the base of large boulders below the rock promontory on the northern end of this beach in the middle intertidal zone had subsurface oily residue which produced sheen when the holes filled with water. Peat was found below the gravel sediment at a site that contained oil residue. The peat layer began approximately 6" below the surface. This site corresponds to location "C" on the ADEC 1994 survey map. This area is protected from wave action by the boulders in the lower intertidal zone. The 1994 ADEC survey reported another location "B" that is on the northern border of EV-37A in the upper intertidal zone and contains asphalt pavement.

GENERAL APPROACH: Prior to treatment, EV-37A would be surveyed to identify "hot spots" (observable residual oil) based on data obtained in previous efforts. Those sites found to have oil residue in the surface and subsurface sediment would be marked to ensure treatment. Sediment samples would be obtained prior to and after treatment based on a schedule developed by the Alaska Department of Environmental Conservation. It is estimated that treatment of this beach would require two different settings of the double shoreline booms because of the locations of the treatment areas and depending on the landing craft accessability. A header hose flushing system would be placed above the upper intertidal zone to provide a constant flow of ambient temperature sea water across the area being treated. This may not be feasible at location "A" because the area of oily sediment is up against large boulders at the upper limit of the upper intertidal zone. It should, however, be possible to deploy the header hose system above locations "B" and "C". Four Airknife Injection Systems would be used on this beach. Crews will proceed from one side of the beach to the other making injections down to at least 0.5 meters below the surface where feasible. PES-51® will then be administered through the airknife to displace oil from the sediment. Direct flushing with ambient temperature sea water begin after application of the biosurfactant. The density of injection sites would depend on the nature of the cobble/boulder surface and the presence of observable oil. Whenever oil runoff is noted during injection and/or flushing, injections would be made in a more concentrated pattern to ensure maximum treatment of the subsurface. In spots where there is observable surface/subsurface oil residue around large boulders, e.g. in locations "A" and "C" of the 1994 ADEC survey map, injections will be made around their base to displace any residue that may have seeped under these rocks. Oily runoff would be recovered by a combination of skimming in the boomed areas and the use of sorbent pads and sweeps in areas where skimming is not feasible. The oil recovered by skimming would be transferred to a holding tank and the water decanted off and returned to the sound. Treatment would be scheduled with the tidal cycles and proceed from the middle to the upper intertidal zones.

TREATMENT TIME: ADEC estimates a total area of 1,100 square meters could warrant treatment. Based on a coverage rate of 200 square meters per day per airknife injection system, one-half day for mobilization, one-half day for demobilization, and one-half day for resetting the booms once, it is estimated that the total work days would be up to three days for this area. This estimate can be expected to change if this restoration is conducted in conjunction with other beaches. This change will be based on the need to include days for mobilization and demobilization to the site, crew rest, and delays due to inclement weather.

RECONNAISSANCE DATE: September 27, 1995



EV-37A sketch map from 1994 ADEC survey.

SHORELINE RESTORATION - COST ESTIMATE PROJECT
SEPTEMBER 1995 RECONNAISSANCE SUMMARY
For
EV-39A on Evans Island

Treatment Area = 2,000 square meters

Treatment Time = 4 days

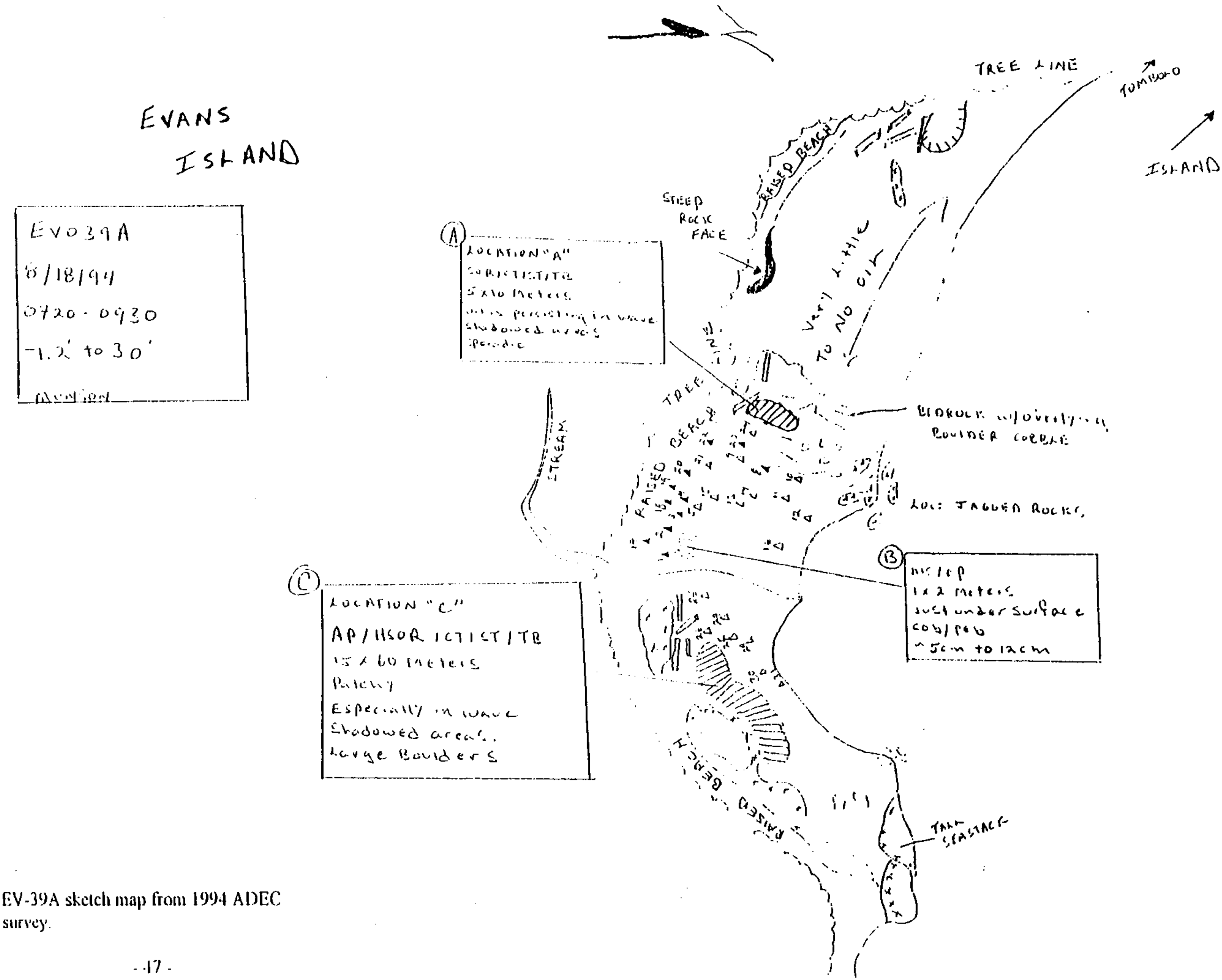
BEACH LOCATION: Northeastern end of Evans Island. See ADEC sketch map following this summary.

BEACH DESCRIPTION: The beach is divided into a southern and northern portion by a stream. The southern portion is characterized by boulder/cobble armor over gravel sediment with large rock outcroppings extending out into the water. Subsurface heavy oily residue was found in this area corresponding to a discontinuous band of asphalt pavement and heavy surface oil residue described in location "C" on the 1994 ADEC survey map (see attached). To the north of the stream, the first third of the beach is characterized by cobble over gravel sediment whereas the other two thirds consists of boulder/cobble armor over bedrock and gravel sediment . Tar patties were found on boulders on the northern portion of this beach roughly corresponding to location "A" on the 1994 ADEC survey map. Sheen was observed in small water pools around boulders lying below the large boulder outcropping in this area. Patches of mussels and fucus were observed in the lower intertidal zone at the northern border of this beach.

GENERAL APPROACH: Prior to treatment, EV-39A would be surveyed to confirm "hot spots" (observable residual oil) based on data obtained in previous efforts. Those sites found to have asphalt pavement and oil residue in the surface and subsurface sediment would be marked to ensure that they are included in the treatment. Sediment samples would be obtained prior to and after treatment based on a schedule developed by the Alaska Department of Environmental Conservation. It is estimated that treatment of this beach would require two different settings of the double shoreline booms depending on landing craft accessability. An additional boom could be aligned along the stream to deflect displaced oil into the boomed region of the shoreline. A header hose flushing system would be placed above the upper intertidal zone to provide a continuous source of ambient temperature sea water over the area being treated. Four Airknife Injection Systems would be used. Crews would proceed from the eastern border of location "C" making injections down to at least 0.5 meters below the surface where feasible. PES-51® would then be administered through the airknife to displace oil from the sediment. Direct flushing with ambient temperature seawater would begin after application of the biosurfactant. The density of site injections would depend on the cobble/boulder surface and evidence of surface and subsurface oil residue. In spots where there is observable surface/subsurface oil residue around large boulders, e.g. location "C" on the 1994 ADEC survey map, injections will be made around their base to displace any residue that may have seeped under these rocks. Oily runoff would be recovered by a combination of skimming in the boomed shoreline areas and the use of sorbent pads in areas where skimming is not feasible. Treatment would be scheduled with the tidal cycles and proceed from the middle to the upper intertidal zones.

TREATMENT TIME: ADEC estimates a total area of 1,125 square meters could warrant treatment. Based on a coverage rate of 200 square meters per day per airknife injection system, one-half day for mobilization, one-half day for demobilization, and one-half day for resetting the booms once, it is estimated that the total work days would be up to three days for this area. PES estimates that the total treatment area could be up to 2,000 square meters including the intervening area between location "A" and the stream. Several pits dug in this area were found to contain medium oil residue during the 1994 ADEC survey. This would increase the total work days to four days. These estimates can be expected to change if this restoration is conducted in conjunction with other beaches. These changes would be based on the need to include days for mobilization and demobilization to the site, crew rest, and delays due to inclement weather.

RECONNAISSANCE DATE: September 27, 1995



EV-39A sketch map from 1994 ADEC survey.

APPENDIX B - Details of Estimated Costs for Application of the PES Shoreline Treatment Process on the Candidate Beaches - One Season Project

PERSONNEL COSTS FOR A SINGLE SEASON OPTION

COST CATEGORY	PERSONS	HOURLY RATE	MAN-HOURS Pre-Field	MAN-HOURS Field[14]	MAN-HOURS Post-Field	ESTIMATED COST
"Off-Site" Personnel						
Project Manager	1	75/hr	80	724	80	66,300
Assistant Project Mgr.	1	65/hr	160	724	80	62,660
Administrative Assistant	1	25/hr	40	68	40	3,700
Equipment Operators[15]	2	48/hr		724		69,504
"On-Site" Personnel						
Work Crew Supervisor	1	40/hr		588		23,520
AKIS Operators	4	35/hr		588		82,320
Direct Flush Operator	4	35/hr		588		82,320
General Labor	4	35/hr		588		82,320
					TOTAL	472,644

[14] Based on a total field time of 68 days including four days for mobilization and demobilization, 45 work days, seven crew rest days and 12 days for delays due to inclement weather. Work days are considered to be 12 hour days. Off-site personnel were compensated for mobilization/demobilization, crew rest and inclement weather days on the basis of an eight hour day. On-site personnel were compensated on the basis of four hours per day for inclement weather days, but not for mobilization, demobilization and crew rest days.

[15] Responsible for operating, maintenance and handling of compressors, pumps and skimmers

EQUIPMENT PURCHASE AND RENTAL FOR A SINGLE SEASON OPTION

COST CATEGORY	UNITS	RATE	DAYS	ESTIMATED COST[16]
Airknife System	4	40/day	68	10,880
Compressor (250 cfm)	2	48/day	68	6,528
6" Water Pump for Deluge Header	1	40/day	68	2,720
6" Hose for suction (50 ft. section)	1	445/section		445
6" Hose for Deluge Header (50 ft. section)	4	445/section		1,780
4" Water Pump for Flushing	1	30/day	70	2,100
4" Hose for suction (20 ft. section)	1	300		300
4" Hose for flushing (300 ft. rolls)	8	175/roll		1,400
2" Trash Pump	2	250/each		500
2" Hose for suction (20 ft. section)	1	50/section		50
2"Hose for spot flushing (100 ft. + nozzle)	2	150		300
Skid Mounted Vacuum Skimming System and Storage Tank	1	150/day	68	10,200
VESSELS[17]				
Berthing Vessel (65 ft.)	1	3,500/day	68	238,000
Landing Craft (65 ft.)	1	2,800/day	68	190,400
Fishing Boat (34 ft.)[18]	1	375/day	45	16,875
Skiff (16 ft.)[19]	1	200/day	45	9,000
Booms (18 inches)	1000	$12.50/foot		12,500
Porta potty including supplies	1	$27/day	68	1,836
CONEX Trailer	1	50/day	68	3,400
		TOTAL		**509,214**

[16] Cost based on 68 days of total field time which includes four days for mobilization and demobilization, 45 work days, seven crew rest days, and 12 days for inclement weather.

[17] Included in the costs are the crews to operate these vessels.

[18] No payment for inclement weather and crew rest days.

[19] No payment for inclement weather and crew rest days.

SUPPLIES FOR A SINGLE SEASON OPTION

COST CATEGORY	UNITS	RATE	ESTIMATED COST
PES-51® 55 gal. drums + shipping[20]	31 drums	1757/drum	54,467
Personnel Protective Equip.[21]	17/persons	1350/each	22,950
Sorbents			
Booms (4" 40 lf. per bundle)	50	61/bundle	3,050
Pads (100 per bundle)	100	43/bundle	4,300
Sweeps (100 lf. per roll)	30	55/roll	1,650
Oil Snares (10 per box)	50	52/boxes	2,600
Fuel - Diesel	500	1.60/gal	800
Fuel - Gasoline	250	1.50/gal	375
Lubricants			100
First Aid Kits	2	75/each	150
Eye Wash Station	2	50/each	100
Sorbent Pad Ringer	2	125/each	250
Field Radio	2	200/each	400
Miscellaneous Field Supplies[22]	Est.		1,500
Miscellaneous Office Supplies	Est.		500
Printer/Fax/Telephones	Est.		500
Film/Video	Est.		500
		TOTAL	94,192

[20] PES estimates that the total surface area to be treated for the seven beach segments could be 24,800 square meters. It is estimated that one gallon of PES-51® will treat 15 square meters of surface, therefore 1,654 gallons will be needed or 31 - 55 gallon drums. For a purchase of this volume, PES-51® costs would be $1,600/each per drum. Shipping costs for 31 drums are $4,867 or $157/each. Therefore, total product costs would be or $1,757/each.

[21] Includes respirator, replacement cartridges (OVA), boots, gloves, goggles, rain suits, Tyvek coveralls, ear plugs and hard hat.

[22] Includes duct tape, drum pumps, gas cans, water jugs, toilet supplies, shovels, pry bars, garbage bags for oily wastes, storage drums for recovered oil, etc.

MOBILIZATION AND DEMOBILIZATION FOR A SINGLE SEASON OPTION

COST CATEGORY	UNITS	RATE	ESTIMATED COST
CONEX Trailer from Anchorage to Seward	2	$1,200/trip	2,400
Disposal			
Oily Waste		$75/drum	
Liquid Oil		$0.85/gal	
	Estimate		2,000
Assistant Program Manager - To/ from San Antonio and 14 days in Anchorage[23]	1	3,500	3,500
Off-Site Team from Anchorage to Seward and return	2	650/trip	1,300
		TOTAL	9,200

[23] Includes round-trip airfare, car rental, lodging and per diem for 14 days to cover 12 days prior to and two days after the field phase.

APPENDIX C - Details of Estimated Costs for Application of the PES Shoreline Treatment Process on the Candidate Beaches - Two Season Project

PERSONNEL COSTS FOR A TWO SEASON OPTION - YEAR ONE

COST CATEGORY	PERSONS	HOURLY RATE	MAN-HOURS Pre-Field	MAN-HOURS Field[24]	MAN-HOURS Post-Field	ESTIMATED COST
"Off-Site" Personnel						
Project Manager	1	75/hr	80	476	80	47,700
Assistant Project Mgr.	1	65/hr	160	476	80	46,540
Administrative Assistant	1	25/hr	40	45	40	3,125
Equipment Operators[25]	2	48/hr		476		45,696
"On-Site" Personnel						
Work Crew Supervisor	1	40/hr		380		15,200
AKIS Operators	4	35/hr		380		53,200
Direct Flush Operator	4	35/hr		380		53,200
General Labor	4	35/hr		380		53,200
					TOTAL	317,861

[24] Based on a total field time of 45 days including four days for mobilization and demobilization, 29 work days, four crew rest days and eight days for delays due to inclement weather. Work days are considered to be 12 hour days. Off-site personnel were compensated for mobilization/demobilization, crew rest and inclement weather days on the basis of an eight hour day. On-site personnel were compensated on the basis of four hours per day for inclement weather days, but not for mobilization, demobilization and crew rest days.

[25] Responsible for operating, maintenance and handling of compressors, pumps and skimmers

EQUIPMENT PURCHASE AND RENTAL FOR A TWO SEASON OPTION - YEAR ONE

COST CATEGORY	UNITS	RATE	DAYS	ESTIMATED COST[26]
Airknife System	4	40/day	45	7,200
Compressor (250 cfm)	2	48/day	45	4,320
6" Water Pump for Deluge Header	1	40/day	45	1,800
6" Hose for suction (50 ft. section)	1	445/section		445
6" Hose for Deluge Header (50 ft. section)	4	445/section		1,780
4" Water Pump for Flushing	1	30/day	45	1,350
4" Hose for suction (20 ft. section)	1	300		300
4" Hose for flushing (300 ft. rolls)	8	175/roll		1,400
2" Trash Pump	2	250/each		500
2" Hose for suction (20 ft. section)	1	50/section		50
2"Hose for spot flushing (100 ft. + nozzle)	2	150		300
Skid Mounted Vacuum Skimming System and Storage Tank	1	150/day	45	6,750
VESSELS[27]				
Berthing Vessel (65 ft.)	1	3,500/day	45	157,500
Landing Craft (65 ft.)	1	2,800/day	45	126,000
Fishing Boat (34 ft.)[28]	1	375/day	29	10,875
Skiff (16 ft.)[29]	1	200/day	29	5,800
Booms (18 inch)	1000	$12.50/foot		12,500
Porta potty including supplies	1	$27/day	45	1,215
CONEX Trailer	1	2,500		2,500
		TOTAL		**342,585**

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[26] Cost based on 45 days of total field time which includes four days for mobilization and demobilization, 29 work days, four crew rest days, and eight days for inclement weather.

[27] Included in the costs are the crews to operate these vessels.

[28] No payment for inclement weather and crew rest days.

[29] No payment for inclement weather and crew rest days.

SUPPLIES FOR A TWO SEASON OPTION - YEAR ONE

COST CATEGORY	UNITS	RATE	ESTIMATED COST
PES-51® 55 gal. drums + Shipping[30]	31 drums	1757/drum	54,467
Personnel Protective Equip.[31]	17/persons	1350/each	22,950
Sorbents			
Booms (4" 40 lf. per bundle)	50	61/bundle	3,050
Pads (100 per bundle)	100	43/bundle	4,300
Sweeps (100 lf. per roll)	30	55/roll	1,650
Oil Snares (10 per box)	50	52/boxes	2,600
Fuel - Diesel	300	1.60/gal	480
Fuel - Gasoline	175	1.50/gal	263
Lubricants			100
First Aid Kits	2	75/each	150
Eye Wash Station	2	50/each	100
Sorbent Pad Ringer	2	125/each	250
Field Radio	2	200/each	400
Miscellaneous Field Supplies[32]	Est.		1,500
Miscellaneous Office Supplies	Est.		300
Printer/Fax/Telephones	Est.		300
Film/Video	Est.		300
		TOTAL	**93,160**

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[30] PES estimates that the total surface area to be treated for the seven beach segments could be 24,800 square meters. It is estimated that one gallon of PES-51® will treat 15 square meters of surface, therefore 1,654 gallons will be needed or 31 - 55 gallon drums. For a purchase of this volume, PES-51® costs would be $1,600/each per drum. Shipping costs for 31 drums are $4,867 or $157/each. Therefore, total product costs would be or $1,757/each. It is recommended that all product be purchased in Year One and the quantity needed for Year Two stored at Chenega.

[31] Includes respirator, replacement cartridges (OVA), boots, gloves, goggles, rain suits, Tyvek coveralls, ear plugs and hard hat.

[32] Includes duct tape, drum pumps, gas cans, water jugs, toilet supplies, shovels, pry bars, garbage bags for oily wastes, storage drums for recovered oil, etc.

MOBILIZATION AND DEMOBILIZATION FOR A TWO SEASON OPTION - YEAR ONE

COST CATEGORY	UNITS	RATE	ESTIMATED COST
CONEX Trailer from Anchorage to Seward	1	$1,200/trip	1,200
CONEX Trailer Storage in Chenega	12 months	50/month	600
Disposal			
Oily Waste		$75/drum	
Liquid Oil		$0.85/gal	
	Estimate		2,000
Assistant Program Manager - To/ from San Antonio and 14 days in Anchorage[33]	1	3,500	3,500
Off-Site Team from Anchorage to Seward and return	2	650/trip	1,300
		TOTAL	**8,600**

[33] Includes round-trip airfare, car rental, lodging and per diem for 14 days to cover 12 days prior to and two days after the field phase.

PERSONNEL COSTS FOR A TWO SEASON OPTION - YEAR TWO

COST CATEGORY	PERSONS	HOURLY RATE	MAN-HOURS Pre-Field[34]	Field[35]	Post-Field	ESTIMATED COST
"Off-Site" Personnel						
Project Manager	1	75/hr	60	272	80	30,900
Assistant Project Mgr.	1	65/hr	100	272	80	29,380
Administrative Assistant	1	25/hr	20	26	40	2,150
Equipment Operators[36]	2	48/hr		272		26,112
"On-Site" Personnel						
Work Crew Supervisor	1	40/hr		208		8,320
AKIS Operators	4	35/hr		208		29,120
Direct Flush Operator	4	35/hr		208		29,120
General Labor	4	35/hr		208		29,120
					TOTAL	184,222

[34] Estimate less time needed for preparation for field phase.

[35] Based on a total field time of 26 days including four days for mobilization and demobilization, 16 work days, two crew rest days and four days for delays due to inclement weather. Work days are considered to be 12 hour days. Off-site personnel were compensated for mobilization/demobilization, crew rest and inclement weather days on the basis of an eight hour day. On-site personnel were compensated on the basis of four hours per day for inclement weather days, but not for mobilization, demobilization and crew rest days.

[36] Responsible for operating, maintenance and handling of compressors, pumps and skimmers

EQUIPMENT PURCHASE AND RENTAL FOR A TWO SEASON OPTION - YEAR TWO

COST CATEGORY	UNITS	RATE	DAYS	ESTIMATED COST[37]
Airknife System	4	40/day	26	4,160
Compressor (250 cfm)	2	48/day	26	2,496
6" Water Pump for Deluge Header	1	40/day	26	1,040
6" Hose for suction (50 ft. section)	1	445/section		445
6" Hose for Deluge Header (50 ft. section)	4	445/section		1,780
4" Water Pump for Flushing	1	30/day	26	780
4" Hose for suction (20 ft. section)	1	300		300
4" Hose for flushing (300 ft. rolls)	8	175/roll		1,400
2" Trash Pump	2	250/each		500
2" Hose for suction (20 ft. section)	1	50/section		50
2" Hose for spot flushing (100 ft. + nozzle)	2	150		300
Skid Mounted Vacuum Skimming System and Storage Tank	1	150/day	26	3,900
VESSELS[38]				
Berthing Vessel (65 ft.)	1	3,500/day	26	91,000
Landing Craft (65 ft.)	1	2,800/day	26	72,800
Fishing Boat (34 ft.)[39]	1	375/day	16	6,000
Skiff (16 ft.)[40]	1	200/day	16	3,200
Booms (18 inch)	1000	$12.50/foot		12,500
Porta potty including supplies	1	$27/day	26	702
CONEX Trailer (Purchased in 1996)	1			0
		TOTAL		**203,353**

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[37] Cost based on 26 days of total field time which includes four days for mobilization and demobilization, 16 work days, two crew rest days, and four days for inclement weather.

[38] Included in the costs are the crews to operate these vessels.

[39] No payment for inclement weather and crew rest days.

[40] No payment for inclement weather and crew rest days.

SUPPLIES FOR A TWO SEASON OPTION - YEAR TWO[41]

COST CATEGORY	UNITS	RATE	ESTIMATED COST
PES-51® 55 gal. drums + Shipping			
Personnel Protective Equip.			
Sorbents			
Booms (4" 40 lf. per bundle)			
Pads (100 per bundle)			
Sweeps (100 lf. per roll)			
Oil Snares (10 per box)			
Fuel - Diesel	200	1.60/gal	320
Fuel - Gasoline	75	1.50/gal	113
Lubricants			
First Aid Kits			
Eye Wash Station			
Sorbent Pad Ringer			
Field Radio			
Miscellaneous Field Supplies			
Miscellaneous Office Supplies	Est.		200
Printer/Fax/Telephones	Est.		200
Film/Video	Est.		200
		TOTAL	**1,033**

[41] Where feasible supplies would be purchased for the first season and then stored in the CONEX trailer in Chenega Village.

MOBILIZATION AND DEMOBILIZATION FOR A TWO SEASON OPTION - YEAR TWO

COST CATEGORY	UNITS	RATE	ESTIMATED COST
CONEX Trailer from Seward to Anchorage	1	$1,200/trip	1,200
Disposal			
Oily Waste		$75/drum	
Liquid Oil		$0.85/gal	
	Estimate		2,000
Assistant Program Manager - To/ from San Antonio and 14 days in Anchorage[42]	1	3,500	3,500
Off-Site Team from Anchorage to Seward and return	2	650/trip	1,300
		TOTAL	8,000

[42] Includes round-trip airfare, car rental, lodging and per diem for 14 days to cover 12 days prior to and two days after the field phase.

Appendix F
Summary of Chenega-area Shorelines and Oiling Status

This appendix shows oiling status and a summary of residents' concerns for beaches near Chenega Bay. The information was compiled by Alaska Department of Environmental Conservation and representatives of Chenega Bay. The map on the next page shows the oiling status of shorelines near Chenega Bay. The spreadsheet that begins on page F-3 summarizes the priority, oiling condition, probable treatment method, and community use of those beaches with significant surface or subsurface oil.

The priority for each beach was arrived at jointly by representatives of Alaska Department of Environmental Conservation and Chenega Bay. High priority shorelines are those beaches with significant community concern and a significant area of surface oil (AP, or SOR) or of subsurface oil (OP, HOR, or MOR). Medium priority shorelines are those with lesser amount of oil or community concern. Low priority areas are those with generally light coverage of residual oil.

Point Helen is rated high priority, but no treatment is recommended because additional treatment would be extremely difficult and perhaps infeasible.

TABLE F-1. CHENEGA AREA SUBDIVISIONS

Subdivision	Environmental Sensitivity	Community Concerns	Priority	Significant Surface Oiling	Significant Subsurface Oiling	Intertidal Location	No. of Sites	Square Meters	Treatment Method	Comments
BP 004 A	Anadromous Stream	Cultural area; Fresh water source; Base camp for near by hunting areas; Deer and seal hunting.	Unknown	Unknown	Unknown	Unknown	Unknown	Unknown	Unknown	Need to survey in 1995
ER 011 A	Fry Release	School related activities, including overnight field trips, plant and animal identification; Picnicking; Egg hunting; Seal and deer hunting; Chiton harvesting; Wood gathering.	Low	AP	AP	UITZ	6	N/A	No treatment recommended.	All sites manually broken up in 1994. Chenega residents observed scattered tarballs in summer of 1995.
ER 020 B	Mussel Bed	Popular picnic area; Large sea lion population; Whale foraging; Land otter dens; Chiton harvesting; Duck, deer and seal hunting; Pre-spill seal pupping area.	High	AP, SOR	OP,HOR,MOR	MITZ to UITZ	9	1430	Manual Removal, Manual and Mechanical Tilling with the tide, (PES-51 if necessary).	Subsurface oil appears to be decreasing with time. Site is within eye site of Chenega Bay.
EV 036 A	Mussel Bed	Subsistence set netting; Harvesting and cleaning catch; Commercial fishing; Duck egg gathering; Porcupine harvesting.	High	AP, SOR	MOR, HOR, OP	LITZ to UITZ	2	2300	Complex site to treat, not sure of treatment method at this time.	Majority of oil is beneath mussel bed. Difficult access, very low angle cobble/boulder beach. Mussel bed is intermixed with cobbles and boulders.
EV 037 A	None	Duck and seal hunting.	High	AP, SOR	MOR, HOR, OP	MITZ to SUIT	7	1724	Washing, PES-51	Majority of oil is AP and SOR between and under boulders at the high and supra intertidal zones.

TABLE F-1. CHENEGA AREA SUBDIVISIONS

Subdivision	Environmental Sensitivity	Community Concerns	Priority	Significant Surface Oiling	Significant Subsurface Oiling	Intertidal Location	No. of Sites	Square Meters	Treatment Method	Comments
EV 039 A	None	Duck and seal hunting; Land otter dens; Octopus harvesting.	High	AP, SOR	None	UITZ to SUITZ	3	1000	Washing, PES-51	A large area of soft and friable AP is present on the south part of this site. The AP is as much as 25 cm thick. Two other smaller and less concentrated areas of AP and SOR are also present in boulder and bedrock settings.
EV 050 C	Fry Release	Pre-spill popular school project camp-out area; Land otter dens; Chiton harvesting; Pre-spill black kelp harvesting; Candidate site for clam restoration project.	Low	AP, SOR	None	UITZ to SUITZ	3	164	Manual Removal, fall back treatment site in case of bad weather.	Very light coverage. Small amounts of AP and even smaller amounts of SOR were discovered at three locations in 1993.
EV 053 B	Fry Release	Black kelp and gumboot harvesting; Subsistence bottomfish and some shrimp; Duck hunting.	Low	AP, SOR	HOR, OP	MITZ to UITZ	3	100	Manual Removal, fall back treatment site in case of bad weather.	Very light coverage. Only minor amounts of AP and SOR were discovered in 1993. Two small areas of OP/Mousse were located under boulders.
EV 053 D	Fry Release	Black kelp and gumboot harvesting; Subsistence bottomfish and some shrimp; Duck hunting.	Low	AP, MS, SOR	HOR, OP	MITZ to UITZ	5	247	Manual Removal, fall back treatment site in case of bad weather.	Very light coverage.
EV 054 A	Fry Release	Black kelp and gumboot harvesting; Subsistence bottomfish and some shrimp; Duck hunting.	Low	AP, SOR	MOR	UITZ	8	435	Manual Removal, fall back treatment site in case of bad weather.	Very light coverage.

TABLE F-1. CHENEGA AREA SUBDIVISIONS

Subdivision	Environmental Sensitivity	Community Concerns	Priority	Significant Surface Oiling	Significant Subsurface Oiling	Intertidal Location	No. of Sites	Square Meters	Treatment Method	Comments
GR 103 C	Herring Spawning	Pre-spill, while enroute to Cordova or northern Montague Is. would successfully hunt for seal, "no luck out there anymore".	Medium	AP, SOR	None	UITZ to SUITZ	4	2530	Washing, PES-51	The greatest amount of AP and SOR at one location was found at this site in 1993. Location 'C' is a 20m by 100m area with over 50% coverage of AP and SOR trapped in vertical shale bedrock.
KN 405 A	None	Commercial fishing from Pt. Helen to Hogan Bay; Archeological.	High	SOR, MS	MOR, HOR, OP	MITZ to UITZ	2	1180 m lon	Difficult site to treat. No treatment recommended.	Extensive subsurface oil is buried deep beneath clean cobbles and boulders. One area of significant surface oil was found in 1993 as SOR/MS in an area 10m by 5m amongst cobbles and boulders in the MITZ.
LA 015 B	None	Duck, seal and bear hunting; Chiton harvesting.	Medium	AP, SOR	MOR, HOR, OP	MITZ to SUIT	5	1587	Washing, PES-51	Several locations of AP and SOR exist amongst boulders and cobbles in sporadic coverage. Several areas of HOR and OP were also observed under clean boulder and cobble surface sediments. Overall this site has significantly improved despite no treatment.
LA 015 C	Anadromous Stream	Duck, seal and bear hunting; Chiton harvesting.	High	AP, MS, SOR	MOR	MITZ to UITZ	2	1560	Washing, PES-51	One area has significant oil remaining. High concentrations of AP and SOR occur interstitially between large immobile boulders and bedrock. No significant subsurface oil remains at this site.

TABLE F-1. CHENEGA AREA SUBDIVISIONS

Subdivision	Environmental Sensitivity	Community Concerns	Priority	Significant Surface Oiling	Significant Subsurface Oiling	Intertidal Location	No. of Sites	Square Meters	Treatment Method	Comments
LA 015 D	None	Duck, seal and bear hunting; Chiton harvesting.	Medium to Low	AP, SOR	HOR, OP	UITZ	2	200	Washing, PES-51	Two small locations contain significant amounts of AP and SOR. Location 'A' is located in a low area behind a protective bedrock outcrop, between boulder and cobble. Location 'B' contains lesser amounts of AP and SOR and appears to have improved.
LA 015 E	Mussel Bed	Duck, seal and bear hunting; Chiton harvesting.	High	AP, SOR	MOR, HOR, OP	LITZ to SUITZ	6	850	Complex site to treat, not sure of treatment method at this time.	Majority of oil is beneath the mussel bed. Difficult access, rocky, low angle beach.
LA 019 A	None	Duck, Seal & Bear Hunting, Chiton Harvesting, Subsistence Bottom Fishing, Popular Wood Collecting Area, Berry Picking.	High	AP, MS, SOR	MOR, HOR, OP	MITZ to UITZ	1	3700	Washing, PES-51	The eastern 1/4 of the subdivision, is bordered by a prominent outcrop & large boulders. This natural border separated the site for the PES test. It has a concentrated area of AP/MS amongst boulders & cobbles. Subsurface oil coincides with surface oil.
LA 020 B	None	Duck, seal and bear hunting; Chiton harvesting; Subsistence bottom fishing; Popular wood gathering area; Berry picking.	High	AP, SOR	LOR	MITZ to UITZ	4	1000	Washing, PES-50	Cobble and boulder armor over gravel sediment, stream near northern border. Patchy areas of AP/SOR with lesser amounts of subsurface oil.
LA 020 C	None	Duck, Seal & Bear Hunting, Chiton Harvesting, Subsistence Bottom Fishing, Popular Wood Collecting Area, Berry Picking.	High	AP, SOR	MOR, HOR, OP	MITZ to UITZ	4	14,000	Washing, PES-51	Four large areas of significant oiling occur at this site. The oiling is primarily AP and SOR occurring in vertical shale and amongst boulders and cobbles. Subsurface oil is often an extension of surface oil.

TABLE F-1. CHENEGA AREA SUBDIVISIONS

Subdivision	Environmental Sensitivity	Community Concerns	Priority	Significant Surface Oiling	Significant Subsurface Oiling	Intertidal Location	No. of Sites	Square Meters	Treatment Method	Comments
LA 021 A	None	Fresh water; Wood gathering; Berry picking; Chiton harvesting.	High	AP, SOR	MOR, HOR	LITZ to UITZ	2	1500	Washing, PES-51	Oiling occurs as sporadic AP,SOR,CT,ST. Subsurface oil is coincident with surface oil. Unable to locate oil in 94. Survey/Treatment should occur at a tide level of 3.0' or lower.
LA 031 A	Anadromous Stream	Occasional wood gathering.	Low	MS,SOR	None	UITZ	2	8	No treatment recommended.	Two very small isolated locations.
SE 041 A	Seal Haulout Area	Seal harvesting.	Low	None	MOR	LITZ to UITZ	1	Unknown	No treatment recommended.	Essentially no surface oil. Central part of the platform still contained subsurface oil as LOR and MOR. At a more sheltered area, HOR was observed at 10cm. This site has improved significantly since 1991. Active sheening was observed at this site.

Appendix G
Estimated Cost of Shoreline Treatment Alternatives

The cost of conducting shoreline treatment is divided into treatment cost, monitoring cost, and agency management costs. This appendix provides an estimate of these costs for treating the beach segments outlined in Part 1B of the workshop report.

Treatment Cost

The Cost Estimate Project produced by Petroleum Environmental Services, Inc. that is contained in Appendix E provides a cost estimate for treating seven beach segments in the Chenega Area. Following the submission of the report, ADEC and Chenega-area residents revised the estimate of the areas proposed for treatment. This appendix extends the PES-estimate methodology to the additional beach segments. The appendix also includes estimates for agency project management, preparation (permitting, environmental analysis), and monitoring.

Assumptions. While the treatment technique will be tailored to the conditions and goals of individual beach segments, we assume that the cost will be approximately equal to or less than that of the PES Treatment technique used in Appendix E.

The conditions on two beaches, EV 36 and LA 15E, will require complex treatment because of the difficulty in landing boats and because their the oiling is relatively low in the middle intertidal areas. Thus, the cost estimate assumes that these beaches require twice the work time as other beaches of a similar size.

Work time for each beach (except EV 36 and LA 15E) is ½-day for mobilization, ½-day for demobilization, and ½-day for resetting the booms plus work time. Work time is assumed at 200 square meters per airknife system per day. Other cost assumptions are given in Appendix E, see especially page 54.

Cost assumptions made by ADEC (using the information provided in Appendix E) are below.

Personnel Cost		
Pre-field time; Mobilization and Demobilization	$37,252	per season
Field Time	$8,377	per work day
(For more detail on personnel cost, see Appendix E, page 54)	$1,913	per rest day
	$3,754	per weather day
Equipment		
Fixed Cost	$17,325	
Variable cost — per work day	$575	
Variable cost — per field day	$6,853	
(For more detail on equipment costs, see Appendix E, page 55)		

Supplies

Fixed Cost	\$39,725
Variable Cost — per square meter of beach	\$2.2/m^2

(For more detail on supply costs, see Appendix E, page 56)

Other Mobilization, Demobilization Costs (App E, page 57)	\$9,200

Insurance	\$22,366
Indirect Cost	15% of all categories except personnel
Profit	10% of all direct costs

(For more detail concerning insurance, indirect, and profit, see Appendix E, page 22)

Two-season Cost (i.e., the additional amount if the project was done in two seasons) is assumed to be approximately \$100,000.

Treatment Cost Conclusions. The table on the next page applies the assumptions above to the beaches identified jointly by Chenega and ADEC. These are grouped into four categories:

- high priority beaches
- medium priority beaches
- beaches that are high priority but complex to treat
- a contingency for unknown (for explanation see Part 3 of the Workshop Report).

The costs in the table do not exactly match those of Appendix E because of rounding.

Monitoring Cost

Monitoring is a necessary part of the total project costs. It may be necessary to monitor the physical, chemical, and biological effectiveness and impact of the treatment.

Physical monitoring involves before-and-after monitoring of the extent and location of oil on the treatment beaches. We expect to use the "qualitative, consistent" methodology used for previous shoreline assessments (as modified by the conclusions of Part 2 of the workshop). The objective of the physical monitoring is to document the presence and extent of residual oil before and after treatment. Expected monitoring involves one trip to each beach, before and following the treatment (one set of visits at the start of the project, and one the second year to finish). The estimated cost of a contract to supply ADEC with a geomorphologist familiar with the sites and methods is up to $25,000. The helicopter costs necessary to complete the monitoring is included in the agency management component of project costs.

Estimated Cost ≤ $25,000

Biological monitoring is necessary to document the effect on existing intertidal biota pre- and post-treatment effects. Complete documentation of the effect on all beaches is not necessary. Rather, monitoring would occur for particularly sensitive sites (if they exist), or for samples of typical sites from which it is possible to generalize. Currently, we have only a general notion of the probable cost, and so $100,000 is reserved for this purpose. Hopefully, the actual cost will be significantly less, but further work is needed to develop a realistic scope of work for biological monitoring.

Estimated Cost ≤ $100,000

Chemical Monitoring may be necessary to document the chemical composition of the residual oil before and after treatment. It is unclear whether significant amount of chemical analysis is needed. Until a final decision is made concerning the need and scope of chemical analysis, it seems reasonable to reserve $50,000 for this purpose.

Estimated Cost ≤ $50,000

Agency Management Cost

The treatment and monitoring costs exclude the costs necessary for permitting, completing the analysis required by the National Environmental Policy Act, selecting and monitoring the contractor, etc. Assuming that the NEPA analysis requires an environmental assessment (not an environmental impact statement), and that ADEC uses an on-site manager during the life of the contract, estimated project management costs are outlined in the budget attached to this appendix.

ADEC estimates that it will require approximately $243,700 to manage the project (the estimate is large enough to accommodate monitoring and treatment of all of the candidate beaches).

The major cost is the personnel cost to complete permitting and on-site management of the project (first year is 9 months; second year is 8 months half-time, four months full time; closeout year is two months). In addition, significant travel costs are required to reach the treatment sites and to support the monitoring efforts. Finally, this cost estimate assumes that the contractor providing the treatment provides a berth for the ADEC project managers.

Total Project Cost

The table below includes all of the project costs. If the Trustee Council decides to authorize additional shoreline treatment, the table assumes that at least the high priority sites will be treated. Thus, the project management and monitoring costs are added to those sites. Any additional sites are assumed to be incremental costs beyond the initial amount.

	High Priority	Medium Priority	Unknown	High Priority but Complex
Treatment Cost	$1,500,000	$140,000	$230,000	$300,000
Physical Monitoring	$25,000			
Biological Monitoring	$100,000			
Chemical Monitoring	$50,000			
Agency Management	$243,700			
Total	$1,918,700	$140,000	$230,000	$300,000
CUMULATIVE TOTAL	**$1,918,700**	**$2,058,700**	**$2,288,700**	**$2,588,700**

Appendix H
Glossary: Field Oiling Classification and Survey Terms

Surface Oil Types	Abbreviation	Definition
asphalt/pavement	AP	Heavily oiled beach sediments held cohesively together.
mousse/pooled oil	MS	Any oil/water emulsion with a thickness of more than 1 cm.
tar balls/tar patties	TB	Small, distinct oil deposits lying on top of the beach surface; possibly binding debris but typically not sediments.
surface oil residue	SOR	Significantly oil coated beach sediments in the top 5 cm; sediments do not form a cohesive layer; may be described as heavy or light.
cover	CV	Oil more than 1 mm to 1 cm thick.
coat	CT	Oil more than 0.1 mm to less than or equal to 1 mm thick; can be easily scratched off with fingernail.
stain	ST	Oil less than or equal to 0.1 mm thick; cannot be easily scratched off with fingernail.
film or sheen	FL	Transparent or translucent film or sheen.
oiled debris	DB	Any oiled debris or cleanup material stranded on a shore.

Surface Oil Distribution Classes	Abbreviation	Definition
continuous	C	Area or band with 91% to 100% oil coverage.
broken	B	Area or band with 51% to 90% coverage.
patchy	P	Area or band with 11% to 50% coverage.
sporadic	S	Area or band with 1% to 10% coverage.
trace	T	Area or band with less than 1% coverage.

Subsurface Oil Types	Abbreviation	Definition
oil pore	OP	Pore space are completely filled with oil resulting in oil oozing out of sediments-water cannot penetrate OP zone.
heavy oil residue	HOR	Pore spaces partially filled with oil residue but not generally flowing out of sediments.
medium oil residue	MOR	Heavily coated sediments; pore spaces are not filled with oil - pore spaces may be filled with water.
light oil residue	LOR	Sediments lightly coated with oil.
oil film	OF	Continuous layer of sheen or film on sediments - water may bead on sediments.
trace	TR	Discontinuous film; spots of oil on sediments; an odor or tackiness with no visible evidence of oil.

Surface and Subsurface Sediment Types	Abbreviation	Definition
. bedrock	R	
boulder	B	Greater than 256 millimeters.
cobble	C	64 to 256 millimeters.
pebble	P	4 to 64 millimeters.
granule	G	2 to 4 millimeters
sand	S	0.06 to 2 millimeters
mud/silt	M	Less than 0.06 millimeters.

Tidal Zones	Abbreviation	Definition
. supratidal	SU	Above the upper intertidal zone.
upper intertidal	UITZ	Upper 1/3 of active intertidal zone.
middle intertidal	MITZ	Middle 1/3 of active intertidal.
lower intertidal	LITZ	Lower 1/3 of active intertidal zone.