APPENDIX 6

EVALUATION OF DEVICES FOR CLEANUP OF OIL SPILLS
AND THEIR APPLICABILITY TO PUGET SOUND

Control of an oil spill encompasses two phases, namely, containment and cleanup. This appendix concerns itself with the latter aspect. Devices for oil spill cleanup are broadly classified into four groups - mechanical, chemical, chemo-mechanical and biological.

Under each group, there are various techniques for removing oil from water. Examples of such include sinking, evaporating, dispersing, recovery, and biodegradation. Because of the possible adverse consequences of sinking and dispersing, these two techniques are not fully developed in this appendix.

For each group, evaluation of commercially available devices is presented, including manufacturers and prices, where available.

A. Mechanical Cleanup

1. Introduction

This rather controversial aspect of an extremely controversial issue should be divided into three classifications:

a. Collection of the spilled oil and subsequent mechanical recovery.

b. Sinking of the oil and recovery by suction devices.

c. Mechanical removal of the oil from the water.

Vast amounts of data are available; thus, the problem is not the quantity but the quality of the information. The data supplied could best be described as inconsistent. Specifications supplied by vendors did not correspond with research laboratory test results; which, in turn, differed from information supplied by salvage masters and others directly involved with oil spills.¹

Before beginning a discussion of how the various devices work, it is admitted that they all work. Each proponent of a particular device can legitimately claim a measure of success. But if these devices do pick up oil, why do most knowledgeable people disregard mechanical recovery as a practical answer to the problem? The answer is probably twofold:
a. Lack of concentrated effort;  
b. Time lag.

Slide presentations of the Santa Barbara$^2$ and San Fransisco$^3$ spills point out the lack of concentrated effort in this area. Visualize a projection screen which shows miles of oil stringers and slicks. The moderator then points out a device the size of a pin head which is attempting to clean up this oil. This problem does not lend itself to the efforts of individual entrepreneurs. As an illustration of the type of effort and capabilities necessary to solve this problem, it is pointed out that private industry took 19 years and hundreds of thousands of dollars to develop and market Minute Rice. The Government took approximately three and one half years from idea to delivery for the atom bomb. This is not to say that another Manhattan Project is required to develop a mechanical cleanup device, but that the effort must be on the order of magnitude of the problem involved.

When certain experts were questioned regarding the effectiveness of a device, the usual answer was that the device was not used or the results were inconclusive. As the situation exists today, most skimming devices have to be transported many miles and, in some cases, reassembled at the spill site. It is hours, sometimes days, before these devices begin to attempt the cleanup. As a result of this time lag, much of the oil is on the beach. The oil that remains on the water bears little resemblance to the substance these devices were designed to pick up.

2. State of the Art

Pacific Northwest laboratories of the Battelle Memorial Institute performed a series of tests on mechanical cleanup devices. Most of the data herein presented is a result of their research.$^4$ The Battelle report is important because it represents the efforts of an independent research group — an unbiased third party. Of even greater importance is their consideration of sensitivity factors (wind, waves, debris, etc.) in rating various devices. But, like
all information concerning oil cleanup devices, the Battelle report is at times vague and inconsistent.

An operational description of the devices currently available follows. Special attention will be drawn to those devices available in the Puget Sound area. 5

a. The Weir Skimmer

Several of these skimmers are in use. All of these skimmers have an adjustable lip which must be located at just below the water level. The weir can be advanced or the polluted water can be brought to the lip by flushing or drawing with a boom. Many of the devices employ a centrifugal pump with suction at the lip to draw the slick.

Norfolk Skimmer - 600 GPH oil: The Norfolk Naval Shipyard skimmer separates the oil from the water by gravity. The oil and water are drawn into a small diffusion box with numerous holes. After separation, the oil is stored in a tank, (10,000 gal. cap.), and the water passes out the bottom.

Such a device is available at the Puget Sound Naval Shipyard. Recent information indicates that the device is no longer operable. This converted LCM is self-propelled and is currently used as an all purpose barge to carry absorbents which can be mechanically retrieved.

Battelle rated this type of skimmer extremely high. The device, however, was given a "U" rating for sensitivity to environmental factors, i.e., rendered inoperable by five foot waves and 20 knot winds.

French Technocean Skimmer: This device is not yet operational. Similar in concept to the Norfolk skimmer, this device, however, is self-propelled. It is designed to operate in reverse when picking up oil. The bow of the vessel is standard and the stern section is "v" shaped. The point of the "v" is an intake valve which automatically adjusts to the water level. The vessel will treat 13,000 cu.yds./hr. of oil and water and store the same amount.
of oil. (Inflatable) Draconi barges are also carried aboard for oil storage. Technocean, 45 Boulevard Haussman, Paris, France.

**Slick Sled:** Inverted column of water open to sea at the bottom, supported by pontoons. The entrance to the raised column is an inclined, horizontal funnel which permits the craft to skim the undisturbed surface of the oil. The oil rises to the top of the inverted column, displacing water at the bottom - thence overboard. Water Pollution Control, Inc., 2035 Lemoine Avenue, Fort Lee, New Jersey.

**Waterwisser - Shell Oil:** Forty-seven foot self-propelled barge has attached vee booms in front making an effective 65 foot sweep. Storage capacity 20 tons.

**Union Oil Skimmer:** Portable device suitable for use on a YP or other such auxiliary vessel. The device utilizes two self-priming centrifugal pumps. The pumps take suction from a trough. The trough receives the oil-water mixture after it passes over the lip.

This device was used in Santa Barbara. It was most effective at cleaning up stringers and removing thick slicks. Maximum rating is 25 bbls/day.

**b. Suction Devices**

One of the most easily obtained devices consists of one or more vacuum trucks on a barge. This design is not for use as a skimmer, but can be used in conjunction with "v" booms to obtain a similar effect. This appears to be the most readily available device in Puget Sound area. The trucks are available from: Airo Company, 2103 E. 112th, Tacoma, Washington; Christel Septic Service, 5626 Waller Road, Tacoma, Washington; A-1 Sanitary, Puyallup, Washington; or Ryan & Haworth, Lynnwood, Washington.

**Rheinwerft Oil Removal Unit:** Small devices useful for harbor operation. These units consist of three floating pontoons. A well is centrally located and receives the oil-water mixture.
One pump lowers the water level and a second pump removes the oil. No operating statistics are available. This device requires that the oil be pumpable. Debris will render the unit inoperable. Made in Germany, by Mainz-Mombach.

**Esso Recovery:** This converted LCM is equipped with four suction devices and a Victor Oily Water Separator.

**Buda I:** Similar in size to the Esso Revocery. Two suction devices feed a four tank oily-water separator. This self-propelled vehicle is equipped with a debris catcher. Made by Marine Pollution Control Corp., 9010 Roselawn Avenue, Detroit, Michigan.

**Slickskim Oil Recovery Device:** Similar in design to the other vehicles. Slickskim includes a skimmer head, suction hose, hose bridge and discharge hose. Supposedly operates in rough water by automatically positioning the floating suction head and utilizing a boom to contain the slick. Made by Slickbar, Inc., Saggatuck, Connecticut.

Manufacturers ratings:
1) Model 60 - max. 86 bbls/hour
2) Model 160 - max. 254 bbls/hour

c. Oleophilic Devices

The workings of such devices are analogous to sponge in water; that is, the fluid is absorbed by the material which is then removed into a container.

**Floating Oil Skimmer:** Floating discs in series are rotated. Oil is removed from the water surface. Scrapers remove the oil from the discs and the oil is stored in tanks. The device is highly sensitive to environmental factors and is adequate for use on minor spills. Made by Centri Spray Corporation, 39001 Schoolcraft, Livonia, Michigan.

**Oil/Water Separator:** Plastic cylinders in series. This device is similar in principle to the floating disc. Highly sensitive to environmental factors. Rate of removal is not deemed adequate for spills greater than 2700 gallons. Does not seem to be
highly sensitive to oil viscosity; however, the manufacturer recommends different cylinders based on the following parameters:
   i) Maximum oil viscosity.
   ii) Minimum pumping temperature.
   iii) Head pressure.
   iv) GPH.

Made by Surface Separator Systems, Inc., 103 Mellor Avenue, Baltimore, Maryland.

MV "Port Service": Owned by Port of Baltimore. Designed by Surface Separator Systems. This vehicle has been highly publicized. It is similar in design to their floating skimmer. Recovery rates are given as 200 to 500. Highly sensitive to environmental factors. These devices require less carrying capacity than other devices because only 5% of water by volume is picked up.

Mop Cat: Catamaran capable of sweeping a 15 foot swath and reclaiming oil at 1.2 to 3 knot. Revolving drum of hydrophobically treated polyurethane foam. The drum is squeezed free of oil by a metal strip, the oil falls into a sump and is pumped to a container. It supposedly operates in two foot waves. Made by Worthington Corporation, Pioneer Products Division, Livingston, New Jersey.

Oil Eater: Continuous belt of oil absorbing material is rolled from a free wheeling pivot extended ahead of the bow of a barge to an elevated roller/scaper and back. The device is capable of recovering 480 bbls/day. The device is operable in 5 foot waves and 20 mph winds. Belt life is 80-100 hours. Made by Bennett International Services, Inc., 5645 Topanga Canyon Boulevard, Woodland Hills, California.

Straw and Straw Recovery: Wheat straw is one of the most readily available absorbents. It will absorb five times its weight in oil. One of the best ways to distribute the straw is the straw mulcher stationed on a barge. Each mulcher is capable of distributing forty-eight tons per day. Approximately 3,000 tons will be required for a 50,000 bbl spill.
A clam shell on an open barge (scow) is capable of picking up tremendous amounts of straw and oil fouled debris.

Several commercial vehicles are available for this purpose. One commonly seen on the East Coast is called the Water Witch. This vehicle is small and maneuverable. It has a pitch fork type device powered by power cylinders on the bow.

3. Cleanup Methods Readily Available on the Sound

Puget Sound offers little in the way of mechanical cleanup devices. If a spill should occur before more devices are available, the use of jury rigs (e.g. wheat straw, mulchers, clam shells, etc.) is recommended.

Pac-Mar\textsuperscript{6} has a commercially distributed vehicle similar to the oilevator. The device is capable of being air lifted to the site and is equipped with 1000 feet of plastic boom.

The Puget Sound Naval Shipyard has a skimmer barge similar in design to the Norfolk Naval Shipyard skimmer. Recent reports indicate that this device is no longer operable and is now being used as a personnel and absorbent carrier.

There are numerous vacuum trucks in the area. These trucks should be placed on barges and used as stationary skimmers.

It is estimated that to handle a 50,000 barrel spill, the following items would be required:

a. 3,000 tons of wheat straw.

b. 20 mulchers on barges (480 tons/day cap.).

c. 12 clam shell cranes on barges.

d. 20 tugs.

e. 20 oilevators.

f. one suction-weir type skimmer (Chevron).
B. Chemical Cleanup

The purpose of this section is to evaluate the various chemical agents that can be used in the cleanup of oil spills in Puget Sound region. These agents employ the use of chemicals which, by their own action, will remove the oil from water. Unfortunately, there is, at present, a deficiency of objective quantitative data by which to judge the effectiveness and toxicity of the chemicals. Consequently, this discussion can only serve to collate the available information and outline recommendations and conclusions based on the present state of the art of chemical cleanup agents and procedures.

The main types of chemical agents are as follows:

1. Dispersants.
2. Combustion promoters.
3. Biological degrading agents.
4. Beach cleaners.
5. Miscellaneous types.

Perhaps the most widely used chemical agents in the past have been the dispersants. Dispersants cause the formation of oil-in-water emulsions or solutions and thus break down the oil slick and speed up the biodegradation process. Also, dispersants can prevent oil from adhering to surfaces. The effects of dispersants on marine life are usually harmful to some degree and can be disastrous. As a result, the use of dispersants is not recommended by the State of Washington. For this reason, this discussion does not dwell at length on chemical dispersants. But, a more thorough treatment of dispersants, as well as the other types of chemical agents discussed here, is available.

Combustion promoters also have been moderately successful in certain cases. These agents act as a wick enabling the oil agent to sustain combustion until all the oil is burned. However, there are several problems inherent in the use of this particular type of agent. The burning causes air pollution and can present a danger to human life. In addition, the burning agents do not work effectively in windy or rainy conditions - weather conditions common to Puget Sound. Consequently, the potential use of burning agents in the Puget Sound area seems to be extremely limited.

The various beach cleaners are usually of the dispersant or sorbent (discussed later in this appendix) type with the associated advantages and
and disadvantages of each type. The effectiveness of these agents has not been established satisfactorily at this time.

A new type of chemical agent is currently under investigation and shows a great deal of promise. Monomolecular surface films have been used in experimental conditions to prevent the spreading of oil and reduce the oil slick in area. These agents consist of fatty alcohols, glycerol esters of fatty acids, and similar substances. Since the concept of reducing an oil slick to manageable size is an attractive one, the developmental progress of this product should be followed with interest.

Because of the wealth of marine life in the Puget Sound region and the possible harm to this marine life from chemical cleanup agents, it is recommended that any chemical agent introduced into the marine environment be removed.

C. Chemo-Mechanical Cleanup

Chemo-mechanical agents include those chemical materials which, after application on oil spill, must be recaptured physically from the spill site. Within this category of cleanup devices are sinking agents and sorbents.

1. Sinking agents

Even though sinking agents have proved effective in removing some relatively small oil spills from the surface of the water this method is not recommended for the Puget Sound region. There are two primary reasons for this:

a. the oil would be harmful to any marine life living on the sea floor, and

b. the oil may surface at some later time.

Sinking does not eliminate the oil problem from water, it only temporarily removes it from the surface. After sinking, the oil will contaminate the bottom of the Sound, and most probably will damage the biological species which live on the sea floor. Also, the oil will tend to dissolve into the sea water over a period of time. This is especially critical in the Puget Sound area due to the extensive tidal current system which would tend to spread the contamination over a large area.
A final disadvantage of using sinking agents is the virtual absence of development of recovery devices for recapturing the oil soaked sinking agent.

2. Sorbents

The second type of chemo-mechanical agent, the sorbent, is the one that appears to be the most useful for actual oil spills in the near future. For this reason, the bulk of this discussion will include an analysis of the various types of sorbents currently on the market. Because of cost and availability, straw has been the most commonly used sorbent material in the past. The main problem in using straw and other sorbent materials is that there is as yet no effective way to pick up large quantities of the oil-sorbent product. Also, there is a tendency for a portion of the sorbed oil to drain from some sorbents during harvesting operations. This drainage is usually not accounted for in the manufacturer's effectiveness data so the dosage and effectiveness data supplied by the manufacturers should be viewed with skepticism.\(11,17\) Disposing of the sorbent-oil product can also be a problem in some cases.

However, given these limitations, it is still believed that sorbents are the best type of chemical agent with which to deal with oil spills in Puget Sound. This is due to the fact that sorbents have the capability of removing the bulk of the oil from the marine environment with little damage to marine life. The newer synthetic sorbents such as polyurethane, polystyrene and styrofoam look particularly promising since they have a very large capacity for absorbing oil and there is a possibility of reclaiming the oil and agent after harvesting.\(15,18\) The oil is reclaimed usually by the mechanical pressing or heating of the sorbent-oil product.

Floating sorbents include a great number of different natural and synthetic materials which have an affinity for petroleum products and do not have an affinity for water. Sorbents are normally employed as part of a recovery system to prevent slick spreading and facilitate recovery of the petroleum product. A list of the different types of sorbents is included in this section.
Sorbents Evaluation

Sorbents can be grouped into three different groups:

1. Commercial bulk materials (non-foam) $.30/gallon oil.
2. Straw, $.03/gallon oil.
3. Polymer foams, $.15/gallon oil.

A. Commercial bulk materials such as perlite, vermiculite talc, shredded bark, peat moss. The cost of commercial bulk materials is typically $100 to $250/ton and will absorb three or more times their own weight of oil so the approximate cost is $.30/gallon of oil.

B. Straw is almost universally available at about $30/ton. It is assumed to absorb five times its own weight of oil and therefore the cost is approximately $.03/gallon of oil.

C. The employment of "soft" polymer foams (polyurethane, polypropylene, polystyrene, and polyethylene), from which oil can subsequently be recovered, is of great potential if systems for broadcasting the sorbent and efficiently recovering it from the water surface become available. Polyurethane foam can theoretically absorb in excess of 90% of its volume and over 100 times its weight in oil. The cost of polyurethane is approximately $.75/lb, and one pound will typically absorb about five gallons under field conditions making the cost about $.15/gallon. Some foams can be reused if the oil is squeezed out, but the extra operation and handling facilities might make this method cumbersome.

In the Puget Sound area care must be taken in the use of sorbents. Due to the high currents and wind states, equipment should always be available to handle the sorbent-oil mixture; otherwise this mixture will cause a pollution problem in itself, which might be harder to clean up than the original oil spill by itself.

It might be beneficial to work out a system specifically designed for the Puget Sound area (sorbent-boom combination) that can handle the high currents that exist in the area. Such a system might be sorbents in conjunction with nets, fences, flow through curtains, fir booms, etc. (see Part B of Section III of this report).
A chart listing the sorbents that have possible use in the cleanup of oil spills in Puget Sound is shown in Table 6-1. The parameters in the chart were chosen so as to give an indication of each agent's relative cost and effectiveness. Unless otherwise noted in the Comments column, it can be assumed that the sorbent can be applied manually or by mechanical blowers or mulchers and that the sorbent-oil product can be picked up manually, with the aid of nets or screens or with any of the common mechanical devices currently on the market. The data in the chart includes only those sorbents which are believed to be potentially effective in environmental conditions that are typical of Puget Sound. A list of the manufacturers of these products along with the manufacturers' addresses is also included.
### TABLE 6-1: COMMERCIAL A VAILABLE SORBENTS

<table>
<thead>
<tr>
<th>Sorbent</th>
<th>Manufacturer or Distributor</th>
<th>Chemical Composition</th>
<th>Price per lb.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Agglomoweb</td>
<td>Collins &amp; Aikman Corp.</td>
<td>Polypropylene Fiber web</td>
<td>$0.54 FOB N.C.</td>
</tr>
<tr>
<td></td>
<td>Roxbord, North Carolina 27575</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bibbipol</td>
<td>Bibby Chemicals Ltd.</td>
<td>Polyurethane Foam</td>
<td>By Quantity $0.84-$0.51</td>
</tr>
<tr>
<td></td>
<td>8 Stanley St.</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Liverpool, L1 6EZ England</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Capillardamin</td>
<td>U.F. Chemical Corp.</td>
<td>Urea Formaldehyde Foam</td>
<td>By Quantity $0.40-$1.20</td>
</tr>
<tr>
<td></td>
<td>37-20, 58th St.</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Woodside, N.Y.11377</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ekarperl</td>
<td>Grefco Inc.</td>
<td>Water Repellent Aluminum Silicate</td>
<td>$0.18</td>
</tr>
<tr>
<td></td>
<td>630 Shatto Pl.</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Los Angeles, Calif.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Emtal XT-1</td>
<td>Englehard Minerals</td>
<td>Tale Stearate modified</td>
<td>$60/ton in carload lots</td>
</tr>
<tr>
<td></td>
<td>Chemical Corp.</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Meno Park, N.J.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3M Brand Oil</td>
<td>3M Company</td>
<td>Polymeric fiber</td>
<td>-</td>
</tr>
<tr>
<td>Absorbing</td>
<td>Industrial Special Products Dept.,</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Microfibers</td>
<td>3M Company</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>St.Paul, Minnesota</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Oil Blotter</td>
<td>Birtiner Equipment Co.</td>
<td>Carbamide urea Foam</td>
<td>$4.00</td>
</tr>
<tr>
<td></td>
<td>2200 Hancock St.,</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>P.O. Box 385</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Gretna, La.70053</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Oil Gobbler</td>
<td>Polymer Research Corp.</td>
<td>Proprietary</td>
<td>$0.50 FOB Brooklyn</td>
</tr>
<tr>
<td></td>
<td>2186 Mill Ave.</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Brooklyn, N.Y.11234</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Perlite King</td>
<td>Filter Media Co.</td>
<td>Silicone treated Perlite</td>
<td>$2.50/4 cu.ft/bag</td>
</tr>
<tr>
<td>SRD-32</td>
<td>P.O. Box 19156</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Houston, Texas 77024</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mistrion Vapor</td>
<td>Cyprus Mine Corp.</td>
<td>Talc</td>
<td>4c-8c per lb. in carload lots</td>
</tr>
<tr>
<td></td>
<td>UNTSO Sierra Division</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Box 1201</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Trenton, N.J.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Dosage Rate</td>
<td>Applicable to All Oil Types</td>
<td>Recovery Possible for Oil Agent</td>
<td>Comments</td>
</tr>
<tr>
<td>-------------</td>
<td>----------------------------</td>
<td>-------------------------------</td>
<td>----------</td>
</tr>
<tr>
<td>1:143</td>
<td>Yes</td>
<td>Yes</td>
<td>-</td>
</tr>
<tr>
<td>1:84</td>
<td>Not effective on high viscosity oils.</td>
<td>Yes</td>
<td>Can be produced from 2 aqueous solutions.</td>
</tr>
<tr>
<td>1:5</td>
<td>Yes</td>
<td>No</td>
<td>Can be harvested by suction hoses.</td>
</tr>
<tr>
<td>2:1 gallon oil</td>
<td>Yes</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>1:20</td>
<td>Less effective for heavier oils at low temperature.</td>
<td>Yes</td>
<td></td>
</tr>
<tr>
<td>1:50</td>
<td>Yes</td>
<td>Yes</td>
<td>-</td>
</tr>
<tr>
<td>1:50</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>N/A</td>
<td>Less effective on lighter oils.</td>
<td>No</td>
<td>Perlite may be recovered by burning, though its use is then limited to soil conditioning.</td>
</tr>
<tr>
<td>2-3 parts agent to each pt. oil</td>
<td>Not effective on Bunker C or heavy fractions</td>
<td>No</td>
<td>Must be agitated.</td>
</tr>
<tr>
<td>Sorbent</td>
<td>Manufacturer or Distributor</td>
<td>Chemical Composition</td>
<td>Price per lb.</td>
</tr>
<tr>
<td>-----------------</td>
<td>-------------------------------------</td>
<td>----------------------</td>
<td>-----------------------</td>
</tr>
<tr>
<td>Powdered Pine Bark</td>
<td>American Modoc, Inc.</td>
<td>Shredded fibers</td>
<td>$5/100 lb. bag</td>
</tr>
<tr>
<td>Scott Industrial Foam</td>
<td>Wilshire Foam Products, Inc.</td>
<td>Complete line of open and closed celled foams</td>
<td>$.50 per board ft.</td>
</tr>
<tr>
<td>Sorbent Type C</td>
<td>Clean Water, Inc.</td>
<td>2 types clay with Binder and Perlite</td>
<td>By Quantity approx.$.22 FOB N.J.</td>
</tr>
<tr>
<td>Stepanpol RM 15</td>
<td>Stephan Chemical Co.</td>
<td>Polyurethane foam</td>
<td>$.53 liquid</td>
</tr>
<tr>
<td>Straw</td>
<td></td>
<td>Wheat straw</td>
<td>$.015</td>
</tr>
<tr>
<td>Strickite</td>
<td>Strickman Industries, Inc.</td>
<td>Proprietary white granular solid</td>
<td>$.42 FOB N.J.</td>
</tr>
<tr>
<td>Typar</td>
<td>E.I. du Pont de Nemours, Inc.</td>
<td>Polypropylene porous fabric</td>
<td>$1.00 delivered</td>
</tr>
<tr>
<td>Tyvek</td>
<td>E.I. du Pont de Nemours, Inc.</td>
<td>Polyethylene porous fiber</td>
<td>$1.00-$1.10</td>
</tr>
<tr>
<td>Vermiculite</td>
<td>California Zonalite Co.</td>
<td>a porous, granular silicate</td>
<td>$1.00-$1.65 per 4 cu.ft. bag</td>
</tr>
</tbody>
</table>

480
<table>
<thead>
<tr>
<th>Doseage Rate lbs. agent: lbs. oil</th>
<th>Applicable to All Oil Types</th>
<th>Recovery Possible for Oil Agent</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>2:7</td>
<td>N/A</td>
<td>N/A N/A</td>
<td></td>
</tr>
<tr>
<td>1:5</td>
<td>N/A</td>
<td>N/A N/A</td>
<td></td>
</tr>
<tr>
<td>approx. 1:6</td>
<td>Yes</td>
<td>No No</td>
<td>Used product suitable for highway road beds.</td>
</tr>
<tr>
<td>1:60</td>
<td>Yes</td>
<td>Yes Yes</td>
<td>Foam made by mixing liquid components. Five minutes cure time before shredding.</td>
</tr>
<tr>
<td>1:5</td>
<td>Yes</td>
<td>No No</td>
<td></td>
</tr>
<tr>
<td>1:10</td>
<td>Yes</td>
<td>Yes Yes</td>
<td>Can be put in porous fabric tubes for containment of spills.</td>
</tr>
<tr>
<td>1:10</td>
<td>Yes</td>
<td>Yes Yes</td>
<td>Use on belt type recovery machine or tow behind vessel.</td>
</tr>
<tr>
<td>1:10</td>
<td>Yes</td>
<td>Yes No</td>
<td>Also available in loose fiber form.</td>
</tr>
<tr>
<td>1:3</td>
<td>N/A</td>
<td>N/A N/A</td>
<td></td>
</tr>
</tbody>
</table>
D. Biological Cleanup

In most waters, and particularly in areas where frequent small oil spills occur, there are a population of microorganisms that are able to degrade oil. "Organisms known to attack hydrocarbons number in the thousands." The microorganisms are selective, and may degrade only a certain type of hydrocarbons, but generally they break down several kinds. The hydrocarbons utilized first are the simple type short chains, then the longer chained and the branched hydrocarbons are used. The cyclic and aromatic hydrocarbons are the most resistant to microbial attack and the most toxic to aquatic life.

A substantial amount of the hydrocarbons can be transferred to protein by the microorganisms. The fraction is determined by the type of organism, the oxygen available, sufficient nitrogen in form of NH$_3$ or NO$_3$, phosphorus available and the type of hydrocarbon used. An estimate of the protein fraction is 25-35% of the original carbon content. This protein is then incorporated in the natural food chain, as the predators take care of the microorganisms.

The rate at which the degradation of hydrocarbon occurs is temperature dependent. Some microorganisms are active even at a temperature of 0°C., but the activity is very slight. As an illustration of the effect of temperature, it has been found that some organisms decompose seven times as much paraffin at 55°C. as at 22°C.\[7\]

After the recent oil spill in San Francisco Bay, it was roughly estimated that about one-half of the escaped oil was recovered. The remaining portion had sunk or been emulsified, and was impossible to recover. This part was left for natural microbial decomposition.

It is conceivable that the use of microorganisms, as an aid in oil spill cleanup, would be valuable in lessening the strain on marine flora and fauna. Research is already being done by several firms, but the information is proprietary. The procedure is to spread a mixture of fertilizer (ammoniumsulphate, etc.) and dried bacterial culture. The culture should be adjusted to the particular oil of the spill. The cleanup will proceed in the same manner as before to recover as large portion as possible. The remaining oil would be subject to a much faster and more complete breakdown than before. The addition of microbes will lower the dissolved oxygen of the water, but this could be corrected by introducing air to the water through perforated hoses.
The public information about this kind of "treatment" is not very complete, and Zobell's words from 1946 ring very true today, 25 years later: "It is an anomalous situation that the petroleum industry, praiseworthy for its many outstanding scientific and technological achievements, has devoted so little attention to the effects of microorganisms on petroleum or its products." But, through the efforts of individual firms without connection with the industry, some progress is being made.
E. Endnotes for Appendix 6


5. Puget Sound Tug and Barge Company, and Pac-Mar Services, Puget Sound Oil Spill Response Plan, (a list of cleanup devices is included), April 1, 1971.


7. David Hoult, Oil on the Sea, 1969, p.35.


19. Principal sources of data include Battelle's compendium and the Dillingham report on oil spills.
APPENDIX 7

CRITIQUE OF COAST GUARD CONTINGENCY PLAN

In the aftermath of the April 1971 spill at Anacortes, Washington, criticisms are being voiced from a multitude of quarters as to what should be done to prevent another occurrence and what was done incorrectly in respect to cleanup of the pollutant. If one is able to take a position comparable to that of detached objectivists it will be readily apparent that the concentrated efforts to correct the error factor that resulted in a spill are only clouding the issue, primarily because of the very low probability of a spill happening in the same fashion in the future. Also, the criticisms of what should have been done to handle the spill serve the same purpose in many respects. The effort here is not to judge but to evaluate a system approach that is presently the primary modus operandi for handling oil spills. However, it must be recognized that our present systems have come from drawing boards and very limited experience, not from the long-term experience and practice that is so beneficial to the development of a societal, regulatory and protective service. Also, with our massive and sophisticated technology, oil handlers still are baffled and forced to treat oil spills with primitive technology. Furthermore, for those experts of the Torrey Canyon, the Arrow, and other spills, let it be duly recognized that a spill in Puget Sound waters is different than a spill in the Gulf of Mexico or off the coast of California and a spill on inland waters is different than a spill on open waters. The efforts of many to create a world-encompassing plan of attack to handle all oil spills leads to generalizations that provide little in the way of concrete assistance on the working level. Therefore, this critique is geared to the evaluation of the United States Coast Guard plan as it relates to Puget Sound, an inland body of water, and the existing resources of the Puget Sound region. The section numbers in the sequel refer to the U.S.C.G. Plan (1).

Sections 105.6, 105.7, 105.8;

MINOR/MODERATE/MAJOR APILL DEFINITION

These sections treat degree classifications in regard to spillage in terms of gallonage or barrels with little consideration of toxicity and solubility of particular pollutants. Possibly a more sophisticated classification procedure should be developed where the classification is a function of
two factors or more. A matrix chart could be developed that will classify spills by considering amounts, types, and chemical characteristics. Such an approach would serve to refine the input to those responsible and key a greater response from those who are operationally oriented as to clean up rather than scientifically oriented. The people, most of them, who clean up a spill are not spill experts, biologists, or chemical engineers. Many are bargemen, crewmen, dock workers, and supervisory personnel. All efforts must be made to provide these people with the tools to make adequate evaluations so that all concerned do have full opportunity to meet the demands of the occasion.

Sections 1212, 1213, 1214;

MINOR/MODERATE/MAJOR SPILL RESPONSE

As was seen in the Anacortes spill initial response the spill was classified as minor and not requiring immediate inspection or mobilization. The plan states that when in doubt treat as a spill of consequence. True, the Coast Guard had no reason to doubt the validity of their initial report in the Anacortes incident. However, due to an error mobilization for the handling of a major spill was delayed by precious hours. It is recommended that a review be made of the practicality of inspectors coming only from Seattle on all spills. When considering the human element involved and the propensity not to respond to a minor spill in the darkness of early morning hours and the compounding that may take place due to the reporting of inaccurate or incomplete information a follow-up plan of verification on all but the most miniscule spill would be advantageous. Now, if, with the cooperation of other agencies and other Coast Guard facilities, there was a stand-in On Scene Commander (OSC), who would be called upon to go directly to the scene of the spill upon notification by the Sub-Regional Response Center (SRC) or the Regional Response Center (RRC), and verify the information the less than adequate procedures that now exist might be properly reinforced. As in the case of the Anacortes spill, with the information of 82 Fuel Oil and of 5,000 gallons, the Coast Guard could have contacted their stand-in OSC (from State Fish & Game, Department of Defense, Health Education and Welfare, Department of Transportation, United States Coast Guard, or any other designated representative) who would have gone immediately to the site and talked with the shore and launch facilities to ascertain the
true nature of the spill. Upon verification of original data and/or acquisition of additional or different data the stand-in OSC would have reported to the proper SRC or RRC thus instituting adequate response or allaying fears and doubts. This approach could be used for all spills using aircraft, launches, or autos. The only criteria that must be met is cooperation by agencies that all derive support from public tax dollars and that all have mutual interests.

Section 1500;

COMMUNICATIONS

Consideration should be given to the utilization of a private communications facility. At present, the Coast Guard carries the burden of notifying all concerned agencies. In turn, all of the various agencies have their own ways they wish to be notified. Recognizing that there is a certain amount of friction between segments of the government on the national and state levels as well as within these levels, the idea of a 24-hour seven-day-a-week service by a neutral party seems most advantageous. The task then would be for the informer of a spill to notify the Coast Guard who would then notify the central communications service so that they might notify others. By using a private answering service each agency could institute its own procedures for receiving notification as well as making timely adjustments and requests. This would be all possible because such a service would be geared to meeting the varying demands of many customers. Also, cost would be minimal. At present many of the agencies do not have the funds to maintain twenty-four hour service on all days. By using the central communications service approach costs would be shared by all giving full service at minimum expense. Furthermore, there would be a buffer between agencies thus reducing the friction that must increase during times of stress and crisis.

In addition, to make sure that verifications are made by the service to all concerned, a random number table could be used by each agency as a code source. When the agency is notified, the answering service would request a verification code that they would record and that could be double checked when questions arise. One code number could be assigned for each day.

This system also provides the conditions more conducive to double checks and verifications, thus reducing the human error factor. It also provides
multiple channels for communications and could greatly facilitate the installation of temporary on-site communications facilities. Without a doubt, the people involved in spill reporting and cleanup are not trained communicators and few of their budgets provide for hiring a full-time communicator. The central communications service idea provides for on-tap communications expertise as well as communicators experienced in dealing with those that often provide communications facilities; private companies.

Section 2503.20;

FUEL OIL GRADE

This section should be expanded to take into account the fact that all refined products are not the same and that they should be treated differently. Mention should be made of the increased solubility and toxicity of the more refined products, especially in light of the fact that the bulk of the petroleum products shipped on the waters of Puget Sound are refined.

Section 2511.1-1;

REMOVAL

Consideration here should be made of specific and unique beach types. The implications are that where a highway exists or some other access heavy equipment can be used for cleanup. The danger involved is that beaches and shorelines vary in richness of life forms and terrains. Some are sandy and sterile, very conducive to dumping a spill and cleaning up with front end loaders. Others are rocky and veritable habitats of life, not conducive to the equipment nor the technique. The OSC should verify the ecology of a shore before he authorizes or institutes dumping or cleanup techniques. This aspect of the problem re-emphasizes the dire need for baseline information and levels of safeguard priority. The most feasible approach to the mammoth task of determining such information would be a joint venture of national, state, and local agencies as well as industry to finance and manage such a study. The thought of all working together may frighten many but the result if all do not work together and share the burdens together will be that all will lose.

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Section 3110;

CRITICAL WATER USE AREAS

In this section the Coast Guard should reconsider their priorities and criteria for ordering the sites. Reference might be made to the Puget Sound and Adjacent Waters Task Force Report. The ports of Seattle and Tacoma have great value with respect to capital goods that are replaceable through the use of our society's factors of production. The idea here is that damage to these areas would be more easily repaired and possible to repair. Also, these areas in terms of environment are already adversely affected by heavy shipping, shore facilities, sewage, motor boating, and other pollutants. On the other hand, the Anacortes region, rich in biota, is extremely susceptible to oil pollution damage that cannot be repaired through the use of the factors of production. Furthermore, there is strong evidence that the natural environment of the North Puget Sound Region might very well be, potentially, the most valuable part of Puget Sound from purely an economic point of view. This will come to pass if projections are correct and tourism becomes the number one industry of the Pacific Northwest and the major contributor of jobs and income to the state's economy.

In essence, the priorities of this section might very well be reversed. If they had been in a more meaningful order at the time of the Anacortes spill, even 5,000 gallons of #2 Fuel Oil would have elicited a greater concern and response on the part of all concerned.

Section 3160.1;

SCIENTIFIC ADVISORY GROUP

The plan calls for a team of experts ready to mobilize in the event of a spill. In the plan three faculty members of the University of Washington are listed as the Puget Sound Region team. Yet, a group of students under the auspices of Professor Juris Vagners are doing more, apparently, to monitor the Anacortes situation than the Coast Guard. Furthermore, after interviewing representatives from the Environmental Protection Agency, Washington State Department of Ecology, and the United States Coast Guard there was no mention of utilization of the stated standby team. As was stated by R.E. Hammond in Commandant Notice 3010, the responsibility of the Coast Guard is ongoing and they have the responsibility to monitor all oil activity. The implication here is that the oil is active in the water and that the Coast Guard should utilize its scientific team during and after a spill to organize monitoring of the impact of oil on the
environment. Having an ongoing responsibility, the Coast Guard should monitor oil far beyond the immediacy of the spill.

TRAINING MANUAL AND TESTING TOWARDS CERTIFICATION

The National Safety Council now has a program used by most large companies and government agencies; the Defensive Driving Course. It might be worth considering a similar conceptual plan for oil spill prevention, containment, and cleanup. The plan would be very practical, as costs would be spread over all of the users rather than with a central point such as the limited Coast Guard budget. Initially, the Coast Guard could prepare a manual for training purposes or a course, that would cover such areas; Oil Spill Laws and Liabilities, Types of Oil and Their Performance under Varying Weather and Sea State Conditions, Prevention of Oil Spills, and Notification and Implementation of Cleanup Operations. Actually, four levels of instruction could be developed that would cover the requirements from the workers position through that of the OSC. Then, in conjunction with the Coast Guard coordinated educational program, industry, agencies, and private sectors could be encouraged to send a representative for training to the Coast Guard, at a nominal cost to help spread the burden, and then back to his sponsor to administer training programs to other members of his firm or agency. Along with the above efforts, the Coast Guard could authorize certification as to competence in oil handling and spill conditions. Again, a program that is not new but one that is successful in other areas, and might well be so here given the same crucial criteria as the communications service center and Spill Response section: cooperation.

Section 3130;

EQUIPMENT AND SERVICES

Another area where the plan is not fully followed when it should be is in equipment and services. For example, the plan calls for a firm commitment of personnel, equipment, and supplies. However, it appears that the commitment is less than firm. First, personnel are only specified for the Coast Guard by site and how many men the site. In reality, not all can respond to a spill. Of the sixteen men at the site, what is a skeleton crew? Agencies did not submit quantities or types of personnel available. If the report included even a range of personnel such as 3-5 biologists from
Fish & Game or five men from the Lopez Island Coast Guard Station, the
tasks of the OSC and the Spill Cleanup Coordinators would be greatly
facilitated. In the plan, equipment and supplies are mentioned. The
list seems most comprehensive though it is less than firm. A range of
prices is not set and a range of quantities available is not stated.
Somehow the OSC must be able to gauge his resources and his capabilities
if he is going to be able to most effectively meet the challenges of a
spill in Puget Sound waters.

GENERAL COMMENTS

The contingency plan seems most adequate at the upper levels of
responsibility. It is clear who is to contact who, how they are to do
it and when. In fact, if anyone who is confined to RRC or above follows
the clear guidelines he cannot get into trouble. However, for those who
must actually cope with the problem on an operational level the picture is
not so clear. For instance, under what conditions does an OSC take full
charge of cleanup and what are the legal liabilities when he does so.
The comments have been to the effect when the "spiller's efforts at clean-
up are grossly inadequate." What is "grossly?" What is "inadequate?"
The OSC is left out on a limb where action will seldom be praised and
more often than not detrimental because it belongs in the legislature
rather than the position of OSC. However, there should be common guide-
lines that he can follow. If the OSC has complete authority and responsi-
bility should he take-over control? Then how far will he be backed; i.e.
what is the breadth of complete authority and responsibility. If the OSC,
as an advisor, recommends the closest and most adequate supply of hay or
equipment for cleanup does he have to worry about the petty arguments
after the fact about the Coast Guard recognizing or catering to a specific
product or supplier? In essence, the OSC is sitting on a hot box of
issues that leave him little room for anything but doing as little as
possible. Such negative incentive can only serve to hamper rather than
encourage resourcefulness, creativity, and positive and immediate action
that may be discounted after the fact but appropriate at the time under
the circumstances. In summary, there should be a section specifically
relating to the position of OSC that specifically states the do's and don'ts of the position and the official Coast Guard position, should difficulties follow. There should also be adequate reference to the specifics of a spill in respect to ordering of equipment and supplies, mobilizing resources, and coordinating efforts in the field.
Endnotes for Appendix 7

1. U. S. Coast Guard, Seattle Coastal Region Oil and Hazardous Materials Pollution, Contingency Plan, 1 December, 1970.

2. Oil spill incident at Texaco Refinery, Anacortes, April 26, 1971, involving the discharge of approximately 242,000 gallons of #2 diesel oil into Guemes Channel during the loading of a United Transportation barge.