TEMPLATE

SHORELINE COUNTERMEASURES MANUAL

TEMPERATE COASTAL ENVIRONMENTS

NATIONAL OCEANIC & ATMOSPHERIC ADMINISTRATION
HAZARDOUS MATERIALS
RESPONSE & ASSESSMENT
DIVISION

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Introduction

Shoreline countermeasures following an oil spill are a critical element in determining the ultimate environmental impact and cost resulting from a spill. As with most aspects of spill response, careful planning can significantly increase the effectiveness of treatment operations. Local response organizations need to develop mechanisms for identifying shorelines requiring treatment, establishing treatment priorities, monitoring the effectiveness and impacts of treatment, and for identifying and resolving problems as the treatment progresses.

The National Oceanic and Atmospheric Administration (NOAA) developed this manual as a tool for shoreline countermeasure planning and response by Regional Response Teams, Area Planning Committees, and State response agencies. The manual is presented as a template that can be tailored for each region or area.

Each section of the manual should be adapted to the specific environments, priorities, and treatment methods appropriate to the planning area. These elements provide the information needed to select cleanup methods for specific combinations of shoreline and oil types. Adapting and completing the template creates a better manual that meets the specific needs of the area. At a minimum, the shoreline environments and special resources need to be revised to reflect those found in the area of concern. Local information on shoreline types (discussed in Chapter 2) can be obtained from Environmental Sensitivity Index (ESI) atlases prepared by NOAA for most of the U.S. shorelines, including the Great Lakes. These atlases describe the shoreline types in each area; these descriptions can be used to replace those included in this template, if appropriate. The section on Special Considerations only lists those resource issues that are potentially of concern. Each region or area should identify those issues of greatest concern and provide guidance on how to best minimize impacts from oil spills. More importantly, the pre-spill process of adapting this manual should allow response agencies the opportunity to discuss and resolve shoreline treatment issues prior to a spill emergency. This tool also outlines a process of documenting and recommending cleanup options for a section of a shoreline after it has been oiled.

1 Decision Process Organization

A Shoreline Evaluation Process

The shoreline evaluation process requires a commitment of trained personnel to assess, evaluate, and communicate the impacts of oil on the shoreline, as well as to recommend countermeasures to mitigate adverse impacts. At most spills, a repetitive, detailed, and systematic survey of the extent and degree of shoreline contamination is needed for:

1. Assessment of the need for shoreline cleanup
2. Selection of the most appropriate cleanup method
3. Determination of priorities for shoreline cleanup
4. Documentation of the spatial oil distribution over time
5. Internally consistent historical record of shoreline oil distribution for use by other scientific surveys of intertidal and subtidal impacts

The organizational structure described in the following pages details a three-phase model for the On-Scene Coordinator (OSC) to use in establishing the shoreline evaluation process during an incident. During a small spill event, one team of individuals may be able to conduct all three phases of support.

On the other end of the spectrum, during a larger spill event, three or more separate teams would be required to conduct all three phases of support to the OSC. The products of the shoreline evaluation process for a larger spill would include the collection of the individual shoreline sketches noting the extent of oiling, the development of a database either in text matrix or graphics displaying the oil distribution on the shoreline, a record of the decision process from the initial assessment of oiling, and the monitoring to final evaluation of the countermeasures used.

1 Shoreline Assessment Group

Objectives

To determine location and extent of shoreline oiling, and effectiveness of implemented countermeasures.

Members

Three or four trained personnel prepared to evaluate a section of shoreline, equipped with proper protective gear and suitable transportation to and from the site. The assessment group should have representatives of the OSC, State, responsible party, and trustees. Trained volunteers may assist members of the group. Team members must have basic site safety training and training sufficient to complete the Shoreline Survey Evaluation Form (page 33). A person well-versed in oil spill control should be the team leader. The group leader should seek consensus, however, all areas of controversy or differences of opinion shall be documented and forwarded to the OSC. Specific recommendations for cleanup may be included under this phase of the assessment. Chapter 3 outlines the shoreline field evaluation process.

Products

During a small spill event, the products may be as simple as a field sketch illustrating the oil distribution on the impacted shoreline and photographic documentation. During more complex events, the completion of the Shoreline Survey Evaluation Form would be required to document the many details of the oil's distribution on complex shoreline features.

2 Shoreline Product Review Group

Objectives

Assure product quality of the Shoreline Assessment Group. Assure quality of the spill database.

During larger or complex spill events, the OSC may elect to establish a special quality assurance / quality control (QA / QC) team. The responsibility of this group is to insure that information from the Shoreline Assessment Group is accurate and consistently gathered. They will assure items of significance that may have been overlooked by the Shoreline Assessment Group are added to the assessment process from other data sources (i.e., in-house reports, maps, databases) such as culturally or archaeologically significant areas.

Significantly, the time-sensitive elements of the response may also be added to recommendations to the OSC by this team. For example, are there natural resources that are particularly sensitive to oiling at the time, or season, the spill is occurring? Is there a window of opportunity to conduct countermeasure operations to protect a turtle nesting season (remove the oil before they arrive) or terminate countermeasure activities to protect bird nesting areas (keep the responders away from nesting areas with live chicks)?

Members

The Shoreline Product Review Group should contain representatives from the OSC, State, land managers, and database managers, as appropriate. The State representative shall collect and forward special concerns submitted by local authorities. The NOAA Scientific Support Coordinator (SSC) team can assist in the design of the database to compile detailed data on oil distribution by shoreline segment.

Products

During more complex spill events, a database will be used to collect and summarize the Shoreline Evaluation Survey forms prepared by the field teams. The use of maps and other graphics to display the oil's distribution on the shoreline is critical in assisting the decision process. This display may be as simple as using colored markers on existing maps or charts. There should not be a requirement for a computer-generated display of the oil's distribution on the shoreline when lower technology displays will provide the same information to the Technical Advisory Group and the OSC. The NOAA SSC team can assist in the design of a visual display for a particular spill event by drawing pictures

representing oil distribution on representations of particular shorelines now available from National Ocean Survey (NOS) charts.

For more detailed statistical documentation, the use of a database to collect and summarize distances and extent of shoreline segments that are oiled may also be required. There should not be a requirement for the computer system to be both a combination of a visual and a data collection system when lower technology systems can provide the same information to the Technical Advisory Group and the OSC.

3 Technical Advisory Group

Objectives

Review and evaluate Shoreline Survey Evaluation forms to provide timely advice to the OSC for recommended treatment of oiled shorelines and priorities, including specific countermeasures. In addition, this group will consider the effects of proposed countermeasures. They may also suggest alternative or modified countermeasures and technologies to the OSC for experimental trials during a spill of opportunity.

Members

NOAA SSC, State representative, trustee(s), U.S. Coast Guard, and responsible party. The SSC will present group recommendations, including differing opinions, to the OSC. Participants in this group shall have the authority to commit their agencies to recommended actions. The level of staff participating on this team should have the authority to determine the final recommendations.

Products

One key product of the Technical Advisory Group is feedback to the Shoreline Assessment Group on treatment countermeasures that have been approved. The Shoreline Assessment Group will then be able to assess the effectiveness of this treatment method on the affected shoreline and make recommendations back through the Technical Advisory Group for any adjustments necessary to improve the efficacy of the cleanup. The form of the feedback may be as simple as a copy of the approved countermeasure or a work order. The copying of the graphics/charts, in which the oil distribution is displayed, would be another desirable form of feedback. Recommendations and authorized countermeasures should be copied to each team member.

B Termination of Countermeasure Activities

Objective

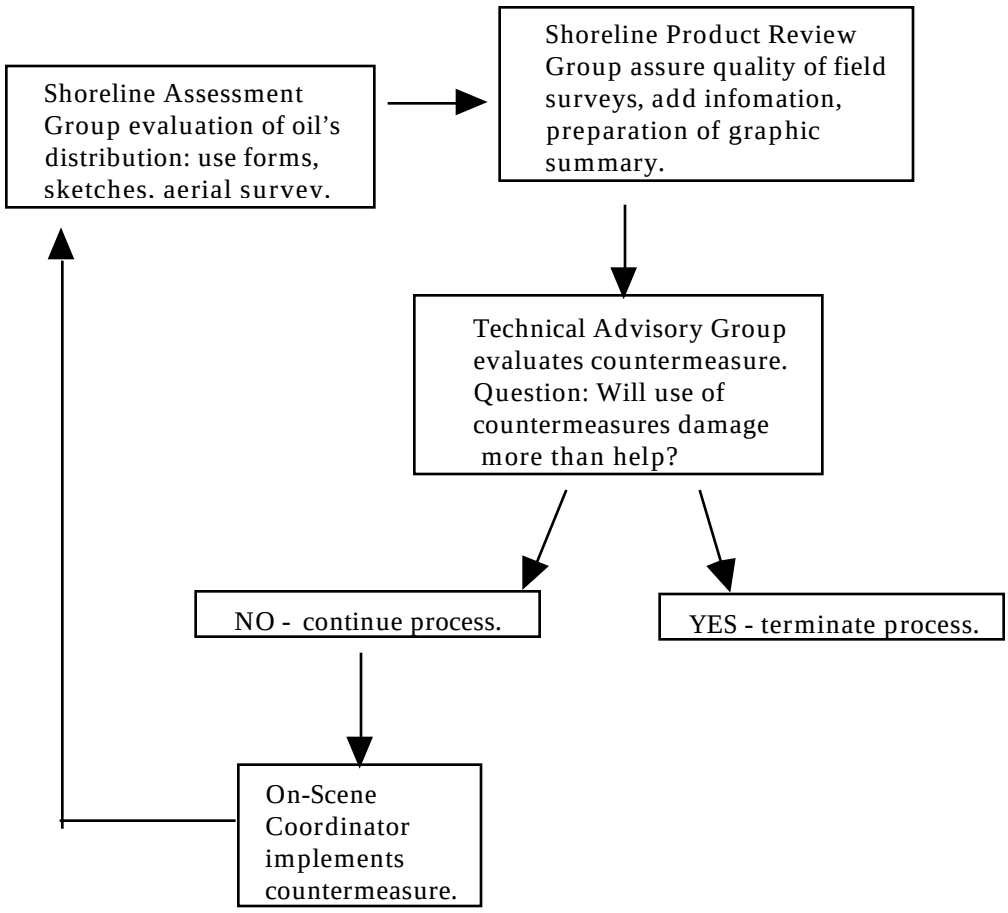
To reach agreement on the completion of each shoreline segment countermeasure activity.

Product

Completion of active shoreline countermeasures under the jurisdiction of the Federal Government is a decision of the OSC. Support of the OSC requires recommendations on shoreline countermeasures, and also recommendations on when to terminate response. The process of evaluating the results of countermeasures and the recommendation to terminate response activities requires a give and take of members with many different responsibilities and roles. A goal of the Technical Advisory Group is to determine if the continued use of a particular countermeasure will result in more damage to the environment than would occur as a result of terminating any active response measures.

Summary of the Decision Process

This section outlines the decision tree for evaluating activities. It is a cyclical process.



Summary products of the decision process, including the use of maps and other graphics to display the oil's distribution on the shoreline, is critical in assisting this cyclical decision process.

- This display may be as simple as using colored markers on existing maps or charts.
- For more detailed and statistical documentation, the use of a database to collect and summarize distances of shoreline segments that are, for example, heavily or lightly oiled, may also be required.
- The NOAA SSC team can present the visual and database information, including differing opinions of members, to the OSC.

- This report of the recommendations and countermeasures approved for use should be copied to each team member and collected for inclusion in the final OSC report as required.

2 Shoreline Types and Sensitive Resources

The type of shoreline, degree of exposure to waves and currents, and associated biological sensitivity are the main criteria for selecting appropriate treatment techniques. Prediction of the behavior and persistence of oil on intertidal habitats is based on an understanding of the coastal environment, not just the substrate type and grain size. The vulnerability of a particular intertidal habitat is an integration of the:

1) Shoreline type (substrate, grain size, tidal elevation, origin)
2) Exposure to wave and tidal energy
3) Biological productivity and sensitivity
4) Ease of cleanup

All of these factors are used to determine the relative sensitivity of shorelines. Key to the sensitivity ranking is an understanding of the relationships between: physical processes, substrate, shoreline type, product type, sediment transport, and product fate and effect. Thus, the intensity of energy expended upon a shoreline by wave action, tidal currents, and river currents directly affects the persistence of stranded oil. The need for shoreline cleanup activities is determined, in part, by the lack or slowness of natural processes in removal of oil stranded on the shoreline.

These concepts were used in the development of the Environmental Sensitivity Index (ESI), which ranks shoreline environments as to their relative sensitivity to oil spills, potential biological injury, and ease of cleanup. ESI maps have been prepared for most areas of the coastline of the United States. Generally speaking, areas exposed to high levels of physical energy, such as wave action and tidal currents, and low biological activity rank low on the scale, while sheltered areas with associated high biological activity have the highest ranking. The shoreline types used in this manual are the rankings, on a scale of 1 to 10, used on most ESI maps (NOAA, 1992). Each atlas has a legend that defines the shoreline ranking scale, describes the nature and distribution of each shoreline type in the area, predicts the behavior of oil on that shoreline type, and makes general cleanup recommendations. The

descriptions, predicted oil impact, and recommended response activity listed in the following sections were updated from existing ESI maps, based on NOAA (1992).

The shoreline ranking system provides a useful first step in the design of contingency plans because it identifies the priority areas that require maximum effort for protection and cleanup. With this document, Strike teams and contractors can focus their activities on environmental priorities, particularly during the first few hours and days of the spill. Based on numerous oil spill studies of shoreline characteristics, treatment, and oil impact, the matrices in Chapter 4 were formulated following the basic ESI shoreline types.

1a. Exposed Wave-Cut Cliffs

Description

- The intertidal zone is steep (greater than 30° slope), with very little width.
- Sediment accumulations are uncommon and usually ephemeral, since waves remove the debris that has slumped from the eroding cliffs.
- They are often found interspersed with other shoreline types.
- There is strong vertical zonation of intertidal biological communities.

Predicted Oil Impact

- Oil is held offshore by waves reflecting off the steep cliff.
- Any oil that is deposited is rapidly removed from exposed faces.
- The most resistant oil would remain as a patchy band at or above the high-tide line.
- Impacts to intertidal communities are expected to be of short duration.
- An exception would be where heavy concentrations of a light refined product (e.g., No. 2 fuel oil) came ashore very quickly.

Recommended Response Activity

- Cleanup is usually not required.
- Access can be difficult and dangerous.

1b. Seawalls And Piers

Description

- Seawalls and piers are particularly common in developed areas, providing protection to residential and industrial developments.
- They are also common along inlets, urbanized areas, and developed beachfront sites.
- They are composed of concrete and stone, wooden, or metal bulkheads and wooden pilings.
- Organisms, such as barnacles, shellfish, and algae may be common on pilings.
- Biota on concrete structures along the upper intertidal or supratidal zones is sparse.

Predicted Oil Impact

- Oil would percolate between the joints of the structures.
- Oil would coat the intertidal areas of solid structures.
- Biota would be damaged or killed under heavy accumulations.

Recommended Response Activity

- High-pressure spraying may be required in order to:
  - remove oil;
  - prepare substrate for recolonization of barnacle and oyster communities;
  - minimize aesthetic damage;
  - prevent the chronic leaching of oil from the structure.

2. EXPOSED WAVE-CUT PLATFORMS

Description

- The intertidal zone consists of a flat rock bench of highly variable width.
- The shoreline may be backed by a steep scarp or low bluff.
- There may be a narrow, perched beach of gravel- to boulder-sized sediments at the base of the scarp.
- The platform surface is irregular and tidal pools are common.
- Small accumulations of gravel can be found in the tidal pools and crevices in the platform.
- Pockets of sandy “tidal flats” can occur on the platform in less exposed settings.

- These habitats can support large populations of encrusting animals and plants, with rich tidal pool communities.

Predicted Oil Impact

- Oil will not adhere to the rock platform, but rather be transported across the platform and accumulate along the high-tide line.
- Oil can penetrate and persist in the beach sediments, if present.
- Persistence of oiled sediments is usually short term, except in wave shadows or larger sediment accumulations.

Recommended Response Activity

- Cleanup is usually not required.
- Where the high-tide area is accessible, it may be feasible to remove heavy oil accumulations and oiled debris.

3. Fine-Grained Sand Beaches

Description

- These beaches are generally flat, wide, and hard-packed.
- They are commonly backed by dunes or seawalls along exposed, outer coasts.
- Along sheltered bays, they are narrower, often fronted by tidal flats.
- Upper beach fauna are scarce.

Predicted Oil Impact

- Light oil accumulations will be deposited as oily swashes or bands along the upper intertidal zone.
- Heavy oil accumulations will cover the entire beach surface, although the oil will be lifted off the lower beach with the rising tide.
- Maximum penetration of oil into fine-grained sand will be 10 centimeters (cm).
- Burial of oiled layers by clean sand within the first few weeks will be less than 30 cm along the upper beach face.
- Organisms living in the beach sands may be killed either by smothering or by lethal oil concentrations in the interstitial water.
- Shorebirds may be killed if oiled, though they may shift to clean sites.

Recommended Response Activity

- These beaches are among the easiest beach types to clean.

- Cleanup should concentrate on the removal of oil from the upper swash zone after all oil has come ashore.
- Removal of sand from the beach should be minimal to avoid erosion problems; special caution is necessary in areas backed by seawalls.
- Activity through both oiled and dune areas should be severely limited, to prevent contamination of clean areas.
- Manual cleanup, rather than road graders and front-end loaders, is advised to minimize the volume of sand removed from the shore and requiring disposal.
- All efforts should focus on preventing the mixture of oil being pushed deeper into the sediments by vehicular and foot traffic.

4. Coarse-Grained Sand Beaches

Description

- These beaches are moderate-to-steep, of variable width, and have soft sediments.
- They are commonly backed by dunes or seawalls along exposed, outer coasts.
- Generally species density and diversity is low.

Predicted Oil Impact

- Light oil will be deposited primarily as a band along the high-tide line.
- Under very heavy accumulations, oil may spread across the entire beach face, though the oil will be lifted off the lower beach with the rising tide.
- Penetration of oil into coarse-grained sand can reach 25 cm.
- Burial of oiled layers by clean sand can be rapid, and up to 60 cm or more.
- Burial over one meter is possible if the oil comes ashore at the start of a depositional period.
- Biological impacts include temporary declines in infaunal populations, which can also affect feeding shorebirds.

Recommended Response Activity

- Remove oil primarily from the upper swash lines.
- Removal of sediment should be limited to avoid erosion problems.
- Mechanical reworking of the sediment into the surf zone may be used to release the oil without removal.

- Activity in the oiled sand should be limited to prevent mixing oil deeper into the beach.
- Use of heavy equipment for oil/sand removal may result in the removal of excessive amounts of sand; manual cleanup may be more effective.

5. Mixed Sand And Gravel (Or Shell) Beaches

Description

- Moderately sloping beach composed of a mixture of sand (greater than 20 percent) and gravel (greater than 25 percent).
- The high-tide berm area is usually composed of sand or fine gravel (pebbles to cobbles), whereas the lower part of the beach is coarser, with cobbles to boulders.
- Because of the mixed sediment sizes, there may be zones of sand, pebbles, or cobbles.
- Because of sediment mobility and desiccation on exposed beaches, there are low densities of attached animals and plants.
- The presence of attached algae, mussels, and barnacles indicates beaches that are relatively sheltered, with the more stable substrate supporting a richer biota.

Predicted Oil Impact

- During small spills, oil will be deposited along and above the high-tide swash.
- Large spills will spread across the entire intertidal area.
- Oil penetration into the beach sediments may be up to 50 cm; however, the sand fraction can be quite mobile, and oil behavior is much like on a sand beach if the sand fraction exceeds about 40 percent.
- Burial of oil may be deep at and above the high-tide line, where oil tends to persist, particularly where beaches are only intermittently exposed to waves.
- On sheltered beaches, extensive pavements of asphalted sediments can form if there is no removal of heavy oil accumulations, because most of the oil remains on the surface.
- Once formed, pavements are very stable and can persist for many years.
- Oil can be stranded in the coarse sediments on the lower part of the beach, particularly if the oil is weathered or emulsified.

Recommended Response Activity

- Remove heavy accumulations of pooled oil from the upper beach face.
- All oiled debris should be removed.
- Sediment removal should be limited as much as possible.
- Low-pressure flushing can be used to float oil away from the sediments for recovery by skimmers or sorbents. High-pressure spraying should be avoided because of potential for transporting the finer sediments (sand) to the lower intertidal or subtidal zones.
- Mechanical reworking of oiled sediments from the high-tide zone to the upper intertidal zone can be effective in areas regularly exposed to wave activity (as evidenced by storm berms). However, oiled sediments should not be relocated below the mid-tide zone.
- In-place tilling may be used to reach deeply buried oil layers in the mid-beach on exposed beaches.

6. Gravel Beaches and Riprap Structures

Description

- Gravel beaches are composed of sediments ranging in size from pebbles to boulders.
- They can be very steep, with multiple wave-built berms forming the upper beach.
- Attached animals and plants are usually restricted to the lowest parts of the beach, where the sediments are less mobile.
- Riprap structures are composed of cobble to boulder-sized rocks.
- Riprap structures are placed for shoreline protection and inlet stabilization.
- Biota on the riprap may be plentiful and varied.

Predicted Oil Impact

- Deep penetration and rapid burial of stranded oil is likely on exposed beaches.
- On exposed beaches, oil can be pushed over the high-tide and storm berms, pooling and persisting above the normal zone of wave wash.
- Long-term persistence will be controlled by the depth of penetration versus the depth of routine reworking by storm waves.
- On relatively sheltered beaches, formation of asphalt pavements is likely where accumulations are heavy.
- On riprap structures, deep penetration of oil between the boulders is likely.

- If oil is left uncleaned, it may become asphaltized.
- Resident fauna and flora may be killed by the oil.

Recommended Response Activity

- Heavy accumulations of pooled oil should be quickly removed from the upper beach.
- All oiled debris should be removed.
- Sediment removal should be limited as much as possible.
- Low- to high-pressure flushing can be used to float oil away from the sediments for recovery by skimmers or sorbents.
- Mechanical reworking of oiled sediments from the high-tide zone to the upper intertidal zone can be effective in areas regularly exposed to wave activity (as evidenced by storm berms). However, oiled sediments should not be relocated below the mid-tide zone.
- In-place tilling may be used to reach deeply buried oil layers in the mid-beach on exposed beaches.
- It may be necessary to remove heavily oiled riprap and replace it.

7. Exposed Tidal Flats

Description

- They are composed primarily of sand and mud.
- The presence of sand indicates that tidal or wind-driven currents and waves are strong enough to mobilize the sediments.
- They are always associated with another shoreline type on the landward side of the flat.
- The sediments are water-saturated, with only the topographically higher ridges drying out during low tide.
- Biological utilization can be very high, with large numbers of infauna and heavy use by birds for roosting and foraging.

Predicted Oil Impact

- Oil does not usually adhere to the surface of exposed tidal flats, but rather moves across the flat and accumulates at the high-tide line.
- Deposition of oil on the flat may occur on a falling tide if concentrations are heavy.

- Oil does not penetrate the water-saturated sediments.
- Biological damage may be severe, primarily to infauna, thereby reducing food sources for birds and other predators.

Recommended Response Activity

- Currents and waves can be very effective in natural removal of the oil.
- Cleanup is very difficult (and possible only during low tides).
- The use of heavy machinery should be restricted to prevent mixing of oil into the sediments.
- On sand flats, oil will be removed naturally from the flat and deposited on the adjacent beaches where cleanup is more feasible.

8. Sheltered Rocky Shores

Description

- They consist of bedrock shores of variable slope (from vertical cliffs to wide, rocky ledges) that are sheltered from exposure to most wave and tidal energy.
- The wider shores may have some surface sediments, but the bedrock is the dominant substrate type
- Species density and diversity vary greatly, but barnacles, snails, mussels, clams, periwinkles, amphipods, polychaetes, rockweed, and crabs are often very abundant.

Predicted Oil Impact

- On rocky shores, oil will adhere readily to the rough rocky surface, particularly along the high-tide line, forming a distinct oil band.
- Fractures in the bedrock will be sites of pooling and oil persistence.
- Even on wide ledges, the lower intertidal zone usually stays wet (particularly when algae covered), preventing oil from adhering to the rock surface.
- Heavy and weathered oils can cover the upper zone with little impacts to the rich biological communities of the lower zone.
- Where surface sediments are abundant, oil will penetrate into the crevices formed by the surface rubble and pool at the contact of the sediments and the surface.
- Where the rubble is loosely packed, oil will penetrate deeply, causing long-term contamination of the subsurface sediments.

- Fresh oil and light refined products have high acute toxicities that can affect attached organisms after even short exposures.

Recommended Response Activity

- Low- to high-pressure spraying at ambient water temperature is most effective when the oil is fresh.
- Extreme care must be taken not to spray in the biologically rich lower intertidal zone or when the tidal level reaches that zone.
- Cutting of oiled, attached algae is not recommended; tidal action will eventually float this oil off, so sorbent booms should be deployed.

9. Sheltered Tidal Flats

Description

- They are composed primarily of silt and clay.
- They are present in calm-water habitats, sheltered from major wave activity, and frequently fronted by marshes.
- Wave energy is very low, although there may be strong tidal currents active on parts of the flat and in channels across the flat.
- The sediments are very soft and cannot support even light foot traffic.
- There are usually large populations of clams, worms, and snails.
- Bird life is seasonally abundant.

Predicted Oil Impact

- Oil does not usually adhere to the surface of sheltered tidal flats, but rather moves across the flat and accumulates at the high-tide line.
- Deposition of oil on the flat may occur on a falling tide if concentrations are heavy.
- Oil will not penetrate the water-saturated sediments at all.
- In areas of high suspended sediments, sorption of oil can result in contaminated sediments that can be deposited on the flats.
- Biological damage may be severe.

Recommended Response Activity

- These are high-priority areas necessitating the use of spill protection devices to limit oil spill impact; deflection or sorbent booms and open water skimmers should be used.

- Cleanup of the flat surface is very difficult because of the soft substrate and many methods may be restricted.
- Manual operations and deployment of sorbents from shallow-draft boats may be helpful.

10a. Fringing and Extensive Salt Marshes

Description

- Marshes are intertidal wetlands containing emergent, herbaceous vegetation.
- Width of the marsh can vary widely, from a narrow fringe to extensive.
- They are relatively sheltered from waves and strong tidal currents.
- Resident flora and fauna are abundant and consist of numerous species.
- Marshes provide a nursery ground for numerous fish species.
- Bird life is seasonally abundant.

Predicted Oil Impact

- Oil adheres readily to marsh vegetation.
- The band of coating will vary widely, depending upon the tidal stage at the time oil slicks are in the vegetation. There may be multiple bands.
- Large slicks will persist through multiple tidal cycles and coat the entire stem from the high-tide line to the base.
- If the vegetation is thick, heavy oil coating will be restricted to the outer fringe, with penetration and lighter oiling to the limit of tidal influence.
- Medium to heavy oils do not readily adhere or penetrate the fine sediments, but they can pool on the surface and in burrows.
- Light oils can penetrate the top few centimeters of sediment and deeply into burrows and cracks (up to one meter).

Recommended Response Activity

- Under light oiling, the best practice is to let the area recover naturally.
- Heavy accumulations of pooled oil can be removed by vacuum, sorbents, or low-pressure flushing. During flushing, care must be taken to prevent transporting oil to sensitive areas down slope or along shore.
- Cleanup activities should be carefully supervised to avoid vegetation damage.
- Any cleanup activity must not mix the oil deeper into the sediments. Trampling of the roots must be minimized.

- Cutting of oiled vegetation should only be considered when other resources present are at great risk from leaving the oiled vegetation in place.

10b. Mangroves

Description

- Mangrove forests are composed of salt-tolerant trees that form dense stands with distinct zonation: red mangroves occur on the seaward exterior while black and white mangroves occur on forest interiors.
- The outer, fringing forests can be exposed to relatively high wave activity and strong currents; forests located in bays and estuaries are well-sheltered.
- Sediment types range from thin layers of sand and mud to muddy peat to loose gravel on limestone beachrock.
- Heavy wrack deposits in the storm swash line are very common.
- The topographic profile is generally very flat, and seagrass beds are common in shallow offshore areas.
- Attached to the prop roots are moderate densities of algae, snails, and crabs.

Predicted Oil Impact

- Fresh spills of light refined products have acute, toxic impacts to both trees and intertidal biota. These products will penetrate deeply into the forests, stopping only at the high-tide line, where sediment contamination may result.
- No. 2 fuel oil or fresh crude will have great persistence where it penetrates burrows and prop root cavities. Heavier oils tend to coat the intertidal zone, with heaviest concentrations at the high-tide line or storm wrack line.
- Heavy oils will coat the intertidal section of prop roots, resulting in defoliation and eventual death of the tree if significant coverage occurs.
- In sheltered areas, oil may persist for many years.

Recommended Response Activity

- Under light accumulations of any type of oil, no cleanup is recommended.
- If sheens are present, use sorbent booms to pick up the oil as it is naturally removed, being sure to change booms frequently.
- The only light refined product that usually requires cleanup is No. 2 fuel oil / diesel because of the potential for long-term sediment contamination.

- Heavy accumulations could be skimmed or flushed with low-pressure water flooding, as long as there is NO disturbance or mixing of oil into the substrate. If substrate mixing is likely or unavoidable, it is better to leave the oil to weather naturally.
- Oily debris should be removed, taking care not to disturb the substrate.
- Live vegetation should never be cut or otherwise removed.
- Sorbents can be used to remove wide heavy oil coatings from prop roots in areas of firm substrate and with close supervision.
- Under moderate to heavy accumulations of crude or heavy refined products, a detailed, site-specific cleanup plan will be required. The cleanup plan should be prepared by experienced personnel and include:
    1) General map of entire impacted area and locations of specific areas to be cleaned up.
    2) Detailed maps of each specific area showing the oil locations and type of cleanup to be performed at each location.
    3) Definition of each type of cleanup allowed.
    4) Specific restrictions to prevent further damage for each cleanup location.

Special Considerations

The above shoreline types may also have associated sensitive biological resources and human-use areas, which include:

Subtidal Habitats

- Submerged aquatic vegetation
- Kelp beds
- Coral reefs
- Worm beds

Birds

- Rookeries and nesting sites
- Waterfowl overwintering concentration areas
- High concentration migration stopovers
- High concentration resident bird colonies

Marine Mammals

- Migration corridors
- Population concentration areas

Terrestrial Mammals

- Concentration areas

Terrestrial Plants

- Threatened and endangered plants adjacent to the shoreline

Fish and Shellfish

- Anadromous fish spawning streams
- Sites important to beach- and kelp-spawning fish
- Estuarine areas that are important fish nursery areas
- Special concentration areas for estuarine and demersal fish
- Shellfish seed beds, leased beds, high concentration areas
- Crab, shrimp, and lobster nursery areas

Reptiles

- Marine turtle nesting beaches
- Alligator / crocodile concentration areas

Recreation

- High-use recreational beaches
- Marinas and boat ramps
- High-use boating, fishing, and diving areas

Management Areas

- Nature preserves and reserves
- Privately developed lands/facilities (Nature Conservancy Areas)
- Research natural areas
- State marine parks/Federal marine sanctuaries
- Wildlife management areas and refuges

Resource Extraction

- Commercial fishing areas, including finfish, crabs, and mollusks
- Water intakes
- Aquaculture sites
- Intertidal and subtidal mining leases
- Subsistence harvest sites
- Log storage sites

Cultural Resources

- Archaeological and other historically significant sites
- Native American reservations

3 Shoreline Mapping and Prioritization

Guidelines for Shoreline Surveys

At most spills, a repetitive, detailed, and systematic survey of the extent and degree of shoreline contamination is needed for:

1. Assessment of the need for shoreline cleanup
2. Selection of the most appropriate cleanup method
3. Determination of priorities for shoreline cleanup
4. Documentation of the spatial oil distribution over time
5. Internally consistent historical record of stranded oil distribution for use by other scientific surveys of intertidal and subtidal impacts

Though general approvals for use of shoreline cleanup methods are to be developed during planning stages, site-specific cleanup recommendations must be based on field data on the shoreline types and type and degree of shoreline contamination. Thus, shoreline surveys become a very important component of the decision-making process, and they must be conducted in a systematic manner. Also, repeated surveys are needed to monitor the effectiveness and effects of on-going treatment methods (any migration of beached oil, as well as natural recovery), so that the need for additional treatment or constraints can be evaluated.

Several methods of data collection can be used to obtain information on shoreline character and degree of oil contamination. For example, aerial surveys provide reconnaissance-level information that is necessary for broad scale evaluations, definition of the impacted area, and general characterization of the oiling conditions. During aerial surveys, observers should note presence of resources at risk that need immediate protection, recommendations for boom deployment sites, access points, or restrictions, etc.

Ground surveys provide detailed information necessary for site-specific decisions on shoreline treatment techniques. The methods and forms for ground surveys described here have been modified from those developed by Exxon and their contractors during the 1989

Exxon Valdez oil spill in Prince William Sound (Owens and Teal, 1990). These methods have been revised for application to specific regions, such as the Oil Spill SCAT Manual for the coastline of British Columbia (Environment Canada, 1992). Guidance on methods and forms for use in ground surveys are described in the following section.

Ground Surveys

The primary purpose of ground surveys is to collect information on the extent of oiling on various shoreline types and to feed this information into the decision-making process for shoreline cleanup. Thus, it is imperative that survey teams use consistent methods and terminology throughout the spill event. A series of forms have been developed as the basis for data collection and reporting. Field teams should conduct a training program so all members understand the objectives, methods, data forms, terms, etc., and to insure standardized application. The teams need to visit at least one site as a group so that their observations can be calibrated.

At a large spill, the scientific members of the Shoreline Assessment Team usually consist of the following:

> Oil Spill Scientist / Coastal Geologist (OG)—Should have at least B.Sc. degree in geology or physical geography and oil-spill experience, plus familiarity with shorelines of impacted area. Responsible for logistical / direction and detailed documentation (i.e., completion of Shoreline Survey Evaluation Form).
>
> Ecologist (ECO)—Should have degree in biology and oil-spill experience, plus familiarity with the local affected habitats and organisms. Responsible for characterization of the intertidal communities and assessing affects of oil or cleanup efforts.
>
> Archeologist (ARCH)—Usually an M.S.- or Ph.D.-level archeologist. Main responsibilities are identifying and updating archaeological and historical sites, and determining potential impacts of oiling or cleanup measures.

In addition to the core scientific group, the team also usually has representatives of: (a) operations group of the party responsible for cleanup; (b) the State government; (c) the Federal Government; and (d) the land owner or manager. At smaller spills or under emergency conditions, team members may have to assume more than one role.

Selecting and Naming Segments

The general approach is to divide the impacted area into segments, which are sections of the oiled shoreline for which detailed observations are recorded. The size of segments depends on the variabilities in degree of oiling and shoreline type. Boundaries of the segments should be defined where the shoreline geomorphology or degree of oiling changes significantly. However, it should be noted that new forms are completed for each segment, so the interval should not be so small that the number of forms required becomes unmanageable for the size of the spill. Segment lengths up to several kilometers would be acceptable for large spills, where smaller spills may have lengths in the hundreds of meters.

Numbering of the segments in a logical order helps location recognition. Usually an alpha-numeric code is employed, with two-letter abbreviations for the local area (e.g., CF for segments located along the Cape Fear River and BH for those on Bald Head Island), and numbers for each segment in the order it was surveyed. Thus, if Bald Head Island was divided into four segments, they would be designated as BH-1 through BH-4. The boundaries of the segments would be delineated on detailed maps.

The Shoreline Survey Evaluation Forms

For each segment, the Shoreline Survey Evaluation Form should be completed. Two versions of a Shoreline Survey Evaluation Form have been included in this manual. This section briefly outlines the methods to be used to complete the long form.

The Shoreline Terminology / Codes sheet lists the common terms and abbreviations to be used to describe the oil, sediments, and other features on the forms and sketch maps. The blocks on the Shoreline Survey Evaluation Form, where the codes are used, are indicated on the sheet. One member of the team, usually the OG, should be responsible for completing the forms, although all members collect the field data. The segment is walked and observations on the oiling conditions are recorded. It is very important to make accurate measurements or estimates of the dimensions of each type of oil. Areas containing surface oil are shown on a field sketch of the shoreline segment. The oiled sites, which are designated by letters, are described systematically by filling in Block 6 of the Shoreline Survey Evaluation Form. A blank sketch form is attached, and an example is included for illustration purposes.

Subsurface oil is investigated by digging trenches and recording measurements of the degree and depths of subsurface oil. Each trench is numbered, and the location of each trench should be shown on the sketch. A symbol is used to differentiate between oiled and clean

trenches (filled-in versus open triangle). The sketches are a very important component of the field survey data; they are better than photographs at depicting overall conditions. Sketches help reviewers put the tabular data on oiled area and type in perspective, thereby facilitating decision making. They provide documentation in a manner not achieved by photographs, videotapes, or statistics, and they allow ready comparisons over time.

The objective of the surveys should always be kept in mind: to collect the information needed by operations personnel and decision makers to formulate and approve shoreline treatment plans. An operations manager should be able to use the data to develop a detailed cleanup plan, including equipment and manpower needs, from these surveys. Government agencies should be able to use the data, along with natural resource information, to develop cleanup priorities, identify site-specific or temporal constraints, and approve the proposed cleanup plan.

The Comment section and sketch map will be important references for documentation of sensitive resources and impacts. The Comments section should highlight the information the field team considers to be very important to the shoreline treatment decision making. The Comments section is also where the field team makes treatment recommendations that would best remove the oil without causing further environmental damage, or identify specific constraints that should be incorporated into the cleanup plan.

Abbreviated Shoreline Surveys

Comprehensive surveys, as outlined above, are not always appropriate for smaller spills, or those that are relatively simple in oiling conditions. Yet, there is still the need for systematic observations and documentation of shoreline oiling conditions and cleanup progress. An abbreviated shoreline survey at smaller or less complicated spills would consist of:

- Trained team(s) with members from State and Federal response agencies, the cleanup contractor, and responsible party to document shoreline oiling conditions.
- Consistent terminology for description of oiling conditions and of shoreline features.
- Segmentation of the oiled areas into sections by shoreline type, degree of oiling, etc., and for which specific cleanup recommendations can be made.
- Field sketches to identify the area surveyed, record oil observations, identify sensitive areas to avoid, and utilize as the basis for a work plan by cleanup crews.
- Simplified forms for recording observations, making recommendations for cleanup, listing segment-specific restrictions, and generating summary statistics

on shoreline oiling conditions. The forms would also document team composition, samples, photographs, etc., for each segment.

The Shoreline Survey Evaluation Short Form was developed to meet the documentation requirements at smaller spills. The form contains space for recording measurements of the length and degree of shoreline contamination, but allows for textual descriptions of the oiling conditions. It is important that the standard terms be used in these descriptions and that specific features be shown on the field sketch. The Short Form also includes space for recording segment-specific considerations for cleanup operations. This section would include information on the location of areas that should be avoided or that require special care or restricted activities by cleanup crews. For example, the location of sensitive wildlife such as eagle nests would be noted in this section. Sites to be avoided, such as archeological sites or private property, would be delineated. Photographs and samples taken at the site would be recorded in the section for Other Comments.

Surface Oil Cover Summary

As the shoreline surveys are being completed, a rating system must be used to describe and summarize the surface oil conditions on the shoreline. These conditions are:

- Heavy
- Moderate
- Light
- Very Light

These ratings are assigned based upon the Oil Category Width and the Surface Oil Distribution, as defined on the sheet on Shoreline Oil Terminology / Codes. Following is an Initial Surface Oil Cover Matrix for use during spills.

Surface Oil Cover Matrix

		Width of Oiled Areas			
		Wide >6 m	Medium >3 - 6 m	Narrow >0.5 - 3 m	Very Narrow ≤0.5 m
Oil Distribution	Continuous 91 - 100%	Heavy	Heavy	Moderate	Light
	Broken 51 - 90%	Heavy	Heavy	Moderate	Light
	Patchy 11 - 50%	Moderate	Moderate	Light	Very Light
	Sporadic 1 - 10%	Light	Light	Very Light	Very Light
	Trace <1%	Very Light	Very Light	Very Light	Very Light

Shoreline Slope (Enter in Block 3)

Low	Less than 30 degrees
Medium	Between 31 and 60 degrees
High	Between 61 and 90 degrees
Vertical	Vertical or near vertical

Oil Category Width (Enter in Block 4)

(To be determined for each segment, depending on width of the intertidal zone)

W	Wide	> 6 m wide
M	Medium	> 3 m to ≤ 6 m
N	Narrow	> 0.5 m to ≤ 3 m
V	Very Narrow	≤ 0.5 m

Oil Distribution (Enter in Block 5)

C	Continuous	91 - 100%
B	Broken	51 - 90%
P	Patchy	11 - 50%
S	Sporadic	1 - 10%
T	Trace	<1%

Surface Oiling Descriptors - Thickness (Enter in Block 5)

PO	Pooled Oil (fresh oil or mousse > 1 cm thick)
CV	Cover (oil or mousse from >0.1 cm to <1 cm on any surface)
CT	Coat (visible oil <0.1 cm, which can be scrapped off with fingernail)
ST	Stain (visible oil, which cannot be scrapped off with fingernail)
FL	Film (transparent or iridescent sheen or oily film)

Surface Oiling Descriptors - Type (Enter in Block 5)

FR	Fresh Oil (unweathered, liquid oil)
MS	Mousse (emulsified oil occurring over broad areas)
TB	Tarballs (discrete accumulations of oil <10 cm in diameter)
PT	Patties (discrete accumulations of oil >10 cm in diameter)
TC	Tar (highly weathered oil, of tarry, nearly solid consistency)
SR	Surface Oil Residue (non-cohesive, heavily oiled surface sediments, characterized as soft, incipient asphalt pavements)
AP	Asphalt Pavements (cohesive, heavily oiled surface sediments)
NO	No Oil

DB Debris; logs, vegetation, rubbish, garbage, response items such as booms, etc.

Subsurface Oiling Descriptors (Enter in Block 6)

SAP	Subsurface asphalt pavement (cohesive)
OP	Oil-Filled Pores (pore spaces are completely filled with oil, to the extent that the oil flows out of the sediments when disturbed). May also consist of weathered oil such as a buried lens of asphalt pavement
PP	Partially Filled Pores (pore spaces partially filled with oil, but the oil does not flow out of the sediments when disturbed)
OR	Oil Residue (sediments are visibly oiled with black/brown coat or cover on the clasts, but little or no accumulation of oil within the pore spaces)
OF	Oil Film (sediments are lightly oiled with an oil film, or stain on the clasts)
TR	Trace (discontinuous film or spots of oil, or an odor or tackiness)
NO	No Oil (no evidence of any type of oil)

Shoreline Zone (Enter in Blocks 5 and 6)

SU	Supratidal (above normal spring high tide levels)
UI	Upper Intertidal
MI	Middle Intertidal
LI	Lower Intertidal

Sediment Types (Enter in Blocks 5 and 6)

R	Bedrock outcrops
	Gravel
B	Boulder (>256 mm in diameter)
C	Cobble (64-256 mm)
P	Pebble (4-64 mm)
G	Granule (2-4 mm)
S	Sand (0.06-2 mm)
M	Mud (silt and clay, < 0.06 mm)
AR	Riprap (man-made permeable rubble)
AW	Seawalls (impermeable)
AP	Man-made pilings

Sheen Color (Enter in Block 6)

B	Brown
R	Rainbow

S	Silver
N	None

SHORELINE SURVEY EVALUATION FORM Page __ of __

1 GEN	Segment Name: _____	Survey	Survey (use military time)	
	Segment ID: _____	Date: _____	Time: _____ to _____	
	Surveyed From: Foot / Boat / Helicopter	Weather: Sun / Clouds / Fog / Rain / Snow		

2 TEAM	Team No.	Operations:	
	OG :	State:	for:
	ECO :	Federal:	for:
	ARCH :	Land Manager:	for:

3 SHORE	Overall Classification for UITZ–select one	Sediment Beach:	Sediment Flat:	
	Bedrock: Cliff ___ Platform ___	Boulder-Cobble __ Sand __	Boulder-Cobble __ Sand _	
	Manmade: Permeable ___ Impermeable ___	Pebble-Cobble __	Pebble-Cobble __	
	Marsh/Wetlands	Sand-Gravel __	Sand-Gravel __	
	Secondary Shore Type:		Backshore Type:	

4 LAND	Geomorphology	
	Slope: Low ___% Med. ___% High ___% Vert. ___%	Wave Exposure: Low / Medium / High
	Estimated Segment Length: m	Total Estimated Length Surveyed:
	Access Restrictions:	

5 OIL	Oil Category Width:		Total Pavement: _____ sq.m	by _____ cm
	Wide ____ m	Very Narrow _____ m	Patties/Tarballs _____ bags	Oiled Debris? Yes/No
	Medium ____ m	No Oil _____ m	Debris/Amount: Logs _____	Vegetation _____
	Narrow ____ m	Unsurveyed _____ m	Trash _____	Other _____

6 SURFACE OIL

LOC	AREA LENGTH m	AREA WIDTH m	ZONE SU	ZONE UI	ZONE MI	ZONE LI	DIST	SURFACE OIL THICKNESS PO	CV	CT	ST	FL	TYPE FR	MS	TB	PT	TC	SR	AP	NO	SHORELINE SEDIMENT TYPE

Distribution (DIST): C = 100-91%; B = 90-51%; P = 50-11%; S = 10-1%; T = <1% Photo Roll # _____ Frames _____

7 SUBSURFACE

NO.	TRENCHES SU	TRENCHES UI	TRENCHES MI	TRENCHES LI	TRENCH DEPTH cm	OILED ZONE cm-cm	SUBSURFACE OIL CHARACTER OP	PP	OR	OF	TR	NO	WATER TABLE cm	SHEEN COLOR	SURFACE-SUBSURFACE SEDIMENTS	CLEAN BELOW Y/N

Sheen Color: B = Brown R = Rainbow S = Silver N = None

8 COMMENTS

SHORELINE SURVEY EVALUATION SHORT FORM

1	GEN	Segment Name: Segment ID:	Survey Date:	Survey Time: (use military time) to
		Surveyed From: Foot / Boat / Helicopter	Weather: Sun / Clouds / Fog / Rain / Snow	

2	TEAM	Team No.			
		Name:	for:	Name:	for:
		Name:	for:	Name:	for:
		Name:	for:	Name:	for:

3	LAND	Shoreline Types:
		Sediment Types:
		Access Restrictions:

Length of Shoreline for Each Oil Category

		Oil Distribution	Wide (>6m)	Medium (3-6m)	Narrow (0.5-3m)	Very Narrow (<0.5m)	No Oil	Total Estimated Segment Length
4	OIL	Continuous (91-100%)	m	m	m	m		
		Broken (51-90%)	m	m	m	m	__ m	m
		Patchy (11-50%)	m	m	m	m		
		Sporadic (1-10%)	m	m	m	m		

5 Description of oiling conditions (use standard terms/refer to sketch)
SURFACE OIL:

SUBSURFACE OIL:

6 Segment-specific considerations for cleanup operations
(sensitive wildlife areas to avoid, etc.)

7 Other Comments

SKETCH MAP

11/05/92

Segment Name_____
Segment No._____
Date_____
Names_____

Checklist

__North Arrow
__Scale
__Oil Distribution
__High-Tide Line
__Low-Tide Line
__Substrate Types
__Trench Locations

Legend

1Δ
Trench Number.
No Subsurface Oil

2▲
Trench Number.
Subsurface Oil

Sketch Map

4 Matrices of Recommended Countermeasure Methods by Oil and Shoreline Type

The matrices included in this chapter show which shoreline countermeasure techniques have been considered for the ten shoreline types described in Chapter 2. Four matrices have been constructed for the major categories of oil (very light, light, medium, heavy).

Countermeasure methods are described in Chapters 5 and 6. Countermeasures in Chapter 5 are traditional techniques that the OSC can use without any additional concurrence. However, the cutting of vegetation countermeasure should be used only during specific seasonal windows under specific conditions and with landowner approval. Countermeasures in Chapter 6 are described under a separate section called "Treatment Methods Requiring Regional Response Team Approval" and may be useful in certain situations. The matrices are a particularly dynamic component of the manual and should continue to be revised as the existing techniques are used and evaluated, and as both old and new techniques are refined.

Each matrix has a written explanation of how it is to be used as a countermeasure advisability matrix. The matrix is only a general guide for removing oil from shoreline substrates. It must be used in conjunction with the entire "Shoreline Countermeasures Manual" plus field observations and scientific advice. The countermeasures listed are not necessarily the best under all circumstances, and any listed technique may need to be used in conjunction with other techniques (including ones not listed herein). The Federal On-Scene Coordinator (FOSC) or the State OSC operating with the FOSC's authorization has the responsibility for and authority to determine which countermeasure(s) are appropriate for the various situations encountered.

Selection of countermeasure techniques to be used in each spill is based upon the degree of oil contamination, shoreline types, and the presence of sensitive resources. Extremely sensitive areas are limited to manual cleanup methods. It is important to note that the primary goal of countermeasure implementation is the removal of oil from the shoreline with

no further injury or destruction to the environment. The three categories of guidance used in the matrices are defined as follows:

R	Recommended	Method that best achieves the goal of minimizing destruction or injury to the environment
C	Conditional	Viable and possibly useful but may result in limited adverse effects to the environment
Shaded		Do not use

Shoreline Countermeasure Matrix

Very Light Oils (Jet fuels, Gasoline)

* Highly volatile (should all evaporate within 1 – 2 days)
* High concentrations of toxic (soluble) compounds
* Result: Localized, severe impacts to water column and intertidal resources
* Duration of impact is a function of the resource recovery rate
* No dispersion necessary

SHORELINE TYPE CODES

1 - Seawalls and piers
2 - Exposed wave-cut platforms
3 - Fine-grained sand beaches
4 - Coarse-grained sand beaches
5 - Mixed sand and gravel (or shell) beaches
6 - Gravel beaches and riprap structures
7 - Exposed tidal flats
8 - Sheltered rocky shores
9 - Sheltered tidal flats
10- Fringing and extensive salt marshes

COUNTERMEASURE	SHORELINE TYPES									
	1	2	3	4	5	6	7	8	9	10
1) No Action										
2) Manual Removal										
3) Passive Collection (Sorbents)										
4) Debris Removal										
5) Trenching										
6) Sediment Removal										
7) Ambient Water Flooding (Deluge)										
8) Ambient Water Washing										
a) Low Pressure (< 50 psi)										
b) High Pressure (< 100 psi)										
9) Warm Water Washing/Mod.-High Pressure										
10) Hot Water/High Pressure Washing										
11) Slurry Sand Blasting										
12) Vacuum										
13) Sediment Reworking †										
14) Excavation, Cleansing, and Replacement										
15) Cutting Vegetation										
16) Chemical Treatment †										
a) Oil Stabilization with Elastomizers										
b) Protection of Beaches										
c) Cleaning of Beaches										
17) In situ Burning of Shorelines †										
18) Nutrient Enhancement †										
19) Microbial Addition †										

† - Requires RRT approval
R - Recommended - may be preferred alternative
C - Conditional

Do Not Use

This countermeasure advisability matrix is only a general guide for removal of oil from shoreline substrates. It must be used in conjunction with the entire Shoreline Countermeasures Manual plus field observations and scientific advice. The countermeasures listed are not necessarily the best under all circumstances, and any listed technique may need to be used in conjunction with other techniques (including ones not listed herein). The Federal On-Scene Coordinator (FOSC) or the state OSC operating with the FOSC's authorization has the responsibility for and authority to determine which countermeasure(s) are appropriate for the various situations encountered. Selection of countermeasures is based on the degree of oil contamination, the shoreline type, and the presence of sensitive resources.

Shoreline Countermeasure Matrix

Light Oils (Diesel, No. 2 Fuel Oils, Light Crudes)

* Moderately volatile; will leave residue (up to 1/3 of spilled amount)
* Moderate concentrations of toxic (soluble) compounds
* Will "oil" intertidal resources with long-term contamination potential
* Has potential for subtidal impacts (dissolution, mixing, sorption onto suspended sediments)
* No dispersion necessary
* Cleanup can be very effective

SHORELINE TYPE CODES

1 - Seawalls and piers
2 - Exposed wave-cut platforms
3 - Fine-grained sand beaches
4- Coarse-grained sand beaches
5 - Mixed sand and gravel (or shell) beaches
6 - Gravel beaches and riprap structures
7 - Exposed tidal flats
8 - Sheltered rocky shores
9 - Sheltered tidal flats
10- Fringing and extensive salt marshes

COUNTERMEASURE	SHORELINE TYPES									
	1	2	3	4	5	6	7	8	9	10
1) No Action										
2) Manual Removal										
3) Passive Collection (Sorbents)										
4) Debris Removal										
5) Trenching										
6) Sediment Removal										
7) Ambient Water Flooding (Deluge)										
8) Ambient Water Washing										
a) Low Pressure (< 50 psi)										
b) High Pressure (< 100 psi)										
9) Warm Water Washing/Mod.-High Pressure										
10) Hot Water/High Pressure Washing										
11) Slurry Sand Blasting										
12) Vacuum										
13) Sediment Reworking †										
14) Excavation, Cleansing, and Replacement										
15) Cutting Vegetation *										
16) Chemical Treatment †										
a) Oil Stabilization with Elastomizers										
b) Protection of Beaches										
c) Cleaning of Beaches										
17) In situ Burning †										
18) Nutrient Enhancement †										
19) Microbial Addition †										

† - Requires RRT approval
R - Recommended - may be preferred alternative
C - Conditional

 Do Not Use

This countermeasure advisability matrix is only a general guide for removal of oil from shoreline substrates. It must be used in conjunction with the entire Shoreline Countermeasures Manual plus field observations and scientific advice. The countermeasures listed are not necessarily the best under all circumstances, and any listed technique may need to be used in conjunction with other techniques (including ones not listed herein). The Federal On-Scene Coordinator (FOSC) or the state OSC operating with the FOSC's authorization has the responsibility for and authority to determine which countermeasure(s) are appropriate for the various situations encountered. Selection of countermeasures is based on the degree of oil contamination, the shoreline type, and the presence of sensitive resources.

Shoreline Countermeasure Matrix

Medium Oils (Most Crude Oils)

* About 1/3 will evaporate within 24 hours
* Maximum water-soluble fraction is 10 – 100 ppm
* Oil contamination of intertidal areas can be severe/long term
* Impact to waterfowl and fur-bearing mammals can be severe
* Chemical dispersion is an option within 1 – 2 days
* Cleanup most effective if conducted quickly

SHORELINE TYPE CODES

1 - Seawalls and piers
2 - Exposed wave-cut platforms
3 - Fine-grained sand beaches
4 - Coarse-grained sand beaches
5 - Mixed sand and gravel (or shell) beaches
6 - Gravel beaches and riprap structures
7 - Exposed tidal flats
8 - Sheltered rocky shores
9 - Sheltered tidal flats
10- Fringing and extensive salt marshes

COUNTERMEASURE	SHORELINE TYPES									
	1	2	3	4	5	6	7	8	9	10
1) No Action										
2) Manual Removal										
3) Passive Collection (Sorbents)										
4) Debris Removal										
5) Trenching										
6) Sediment Removal										
7) Ambient Water Flooding (Deluge)										
8) Ambient Water Washing										
a) Low Pressure (< 50 psi)										
b) High Pressure (< 100 psi)										
9) Warm Water Washing/Mod.-High Pressure										
10) Hot Water/High Pressure Washing										
11) Slurry Sand Blasting										
12) Vacuum										
13) Sediment Reworking †										
14) Excavation, Cleansing, and Replacement										
15) Cutting Vegetation *										
16) Chemical Treatment †										
a) Oil Stabilization with Elastomizers										
b) Protection of Beaches										
c) Cleaning of Beaches										
17) In situ Burning †										
18) Nutrient Enhancement †										
19) Microbial Addition †										

† - Requires RRT approval
R - Recommended - may be preferred alternative
C - Conditional

 Do Not Use

This countermeasure advisability matrix is only a general guide for removal of oil from shoreline substrates. It must be used in conjunction with the entire Shoreline Countermeasures Manual plus field observations and scientific advice. The countermeasures listed are not necessarily the best under all circumstances, and any listed technique may need to be used in conjunction with other techniques (including ones not listed herein). The Federal On-Scene Coordinator (FOSC) or the state OSC operating with the FOSC's authorization has the responsibility for and authority to determine which countermeasure(s) are appropriate for the various situations encountered. Selection of countermeasures is based on the degree of oil contamination, the shoreline type, and the presence of sensitive resources.

Shoreline Countermeasure Matrix

Heavy Oils (Heavy Crude Oils, No. 6 fuel, Bunker C)

* Heavy oils with little or no evaporation or dissolution
* Water-soluble fraction likely to be <10 ppm
* Heavy contamination of intertidal areas likely
* Severe impacts to waterfowl and fur-bearing mammals (coating and ingestion)
* Long-term contamination of sediments possible
* Weathers very slowly
* Dispersion seldom effective
* Shoreline cleanup difficult under all conditions

SHORELINE TYPE CODES

1 -Exposed wave-cut cliffs
2 - Exposed wave-cut platforms
3 - Fine-grained sand beaches
4 - Coarse-grained sand beaches
5 - Mixed sand and gravel (or shell) beaches
6 - Gravel beaches and riprap structures
7 - Exposed tidal flats
8 - Sheltered rocky shores
9 - Sheltered tidal flats
10- Fringing and extensive salt marshes

COUNTERMEASURE	SHORELINE TYPES									
	1	2	3	4	5	6	7	8	9	10
1) No Action										
2) Manual Removal										
3) Passive Collection (sorbents)										
4) Debris Removal										
5) Trenching										
6) Sediment Removal										
7) Cold Water Flooding (deluge)										
8) Cold Water Washing										
a) Low Pressure (< 50 psi)										
b) High Pressure (< 100 psi)										
9) Warm Water Washing/Mod.-High Pressure										
10) Hot Water/High Pressure Washing										
11) Slurry Sand Blasting										
12) Vacuum										
13) Sediment Reworking †										
14) Excavation, Cleansing, and Replacement										
15) Cutting Vegetation *										
16) Chemical Treatment †										
a) Oil Stabilization with Elastomizers										
b) Protection of Beaches										
c) Cleaning of Beaches										
17) In situ Burning †										
18) Nutrient Enhancement †										
19) Microbial Addition †										

*† - Requires RRT approval
R - Recommended - may be preferred alternative
C - Conditional

 Do Not Use

This countermeasure advisability matrix is only a general guide for removal of oil from shoreline substrates. It must be used in conjunction with the entire Shoreline Countermeasures Manual plus field observations and scientific advice. The countermeasures listed are not necessarily the best under all circumstances, and any listed technique may need to be used in conjunction with other techniques (including ones not listed herein). The Federal On-Scene Coordinator (FOSC) or the state OSC operating with the FOSC's authorization has the responsibility for and authority to determine which countermeasure(s) are appropriate for the various situations encountered. Selection of countermeasures is based on the degree of oil contamination, the shoreline type, and the presence of sensitive resources.

5 Treatment Methods Not Requiring Regional Response Team Consideration

The following section lists and describes those techniques that have been approved by the Regional Response Team (RRT), Local Response Team, and/or the Area Committee. Methods and equipment currently in use for these approved shoreline treatment methods are described in some detail below. These methods, when used according to the guidelines in this manual, may be used on most sites as part of the OSC-directed response. It should be noted that some of these methods may require other authorizations or permits before work begins. Currently approved methods are:

1 No Action
2 Manual Removal
3 Passive Collection (Sorbents)
4 Debris Removal
5 Trenching
6 Sediment Removal
7 Ambient-Water Flooding (Deluge)
8a Ambient-Water/Low-Pressure Washing
8b Ambient-Water/High-Pressure Washing
9 Warm-Water/Moderate-to-High-Pressure Washing
10 Hot-Water/High-Pressure Washing
11 Slurry Sand Blasting
12 Vacuum
13 Sediment Reworking *
14 Sediment Removal, Cleansing, and Replacement *
15 Cutting Vegetation *

* May require special consideration

1. No Action

Objective

No attempt is made to remove stranded oil, to minimize impacts to the environment or because there is no proven effective method for cleanup.

Description

No action is taken. However, the OSC continues to monitor the incident.

Applicable Shoreline Types

Can be used on all shoreline types.

When To Use

If the shoreline is extremely remote or inaccessible, when natural removal rates are very fast, or cleanup actions will do more harm than leaving the oil to be removed naturally.

Biological Constraints

This method may be inappropriate for areas where high numbers of mobile animals (birds, marine mammals, crabs, etc.) use the intertidal zone or adjacent nearshore waters.

Environmental Effects

Intertidal — The same as the oil.

Subtidal — The same as the oil.

2. Manual Removal

Objective

Removing stranded surface oil with hand tools and manual labor.

Description

Removing surface oil and oily debris by manual means (hands, rakes, shovels, etc.) and placing in containers for removal from the shoreline. No mechanized equipment is used.

Applicable Shoreline Types

Can be used on all shoreline types.

When To Use

Generally used on shorelines where the oil can be easily removed by non-mechanical means. Most appropriate for light to moderate oiling conditions.

Biological Constraints

Foot traffic over sensitive areas (shellfish beds, algal mats, bird nesting areas, dunes, etc.) is to be restricted. May be periods when shoreline access is restricted (e.g., bird nesting, mammal pupping).

Environmental Effects

Intertidal — Minimal if surface disturbance by cleanup activities and work force movement is limited.

Subtidal — None.

3. Passive Collection (Sorbents)

Objective

Removal of oil by adsorption onto oleophilic material placed in the intertidal zone.

Description

Sorbent material is placed on the surface of the shoreline substrate allowing it to absorb oil as it is released by tidal or wave action. Oil removal is dependent on the capacity of the particular sorbent, energy available for lifting oil off the shoreline, and degree of weathering.

Applicable Shoreline Types

Can be used on any shoreline type, especially riprap and on intertidal vegetation.

When to Use

When the shoreline oil is mobile and transport of oil is expected on or off the site. The oil must be of a viscosity and thickness to be released by the substrate and absorbed by the sorbent. Often used as a secondary treatment method after gross oil removal, and along sensitive shorelines where access is restricted.

Biological Constraints

None, although this method can be slow, thus allowing oil to remain in critical habitats during sensitive periods of time.

Environmental Effects

Intertidal — None, except for the amount of oil remaining on the shoreline after the sorbents are no longer effective.

Subtidal — None.

4. Debris Removal

Objective

Removal of contaminated debris and logs.

Description

Manual or mechanical removal of debris from the upper beach face and the zone above high tide beyond the normal wash of waves. Can include cutting and removal of oiled logs.

Applicable Shoreline Types

Can be used on any shoreline type where safe access is allowed.

When to Use

When driftwood and debris is heavily contaminated and either a potential source of chronic oil release, an aesthetic problem, or a source of contamination for other organisms on the shoreline.

Biological Constraints

Disturbance to adjacent upland areas should be minimized. Foot traffic over sensitive intertidal areas (shellfish beds, algal mats, bird nesting areas, dunes, etc.) is to be restricted. May be periods when shoreline access is restricted (e.g., bird nesting, mammal pupping).

Environmental Effects

Intertidal — None.

Subtidal — None.

5. Trenching

Objective

Remove subsurface oil from permeable substrates.

Description

Dig trenches to the depth of the oil and remove oil floating on the water table by vacuum pump or super sucker. Water flooding or high-pressure spraying at ambient temperatures can be used to flush oil to the trench.

Applicable Shoreline Types

Can be used on beaches ranging in grain size from fine sand to gravel.

When To Use

When large quantities of oil penetrate deeply into permeable sediments and cannot be removed by surface flooding. The oil must be liquid enough to flow at ambient temperatures.

Biological Constraints

Trenches should not be dug in the lower intertidal when attached algae and organisms are abundant.

Environmental Effects

Intertidal — On gravel beaches, there may be a period of beach instability as the sediments are redistributed after the trenches are filled in.

Subtidal — None.

6. Sediment Removal

Objective

Removal of surface oiled sediments.

Description

Oiled sediments are removed by either manual use of hand tools or mechanical use of various kinds of motorized equipment. The oiled material must be transported and disposed of off-site.

Applicable Shoreline Types

Can be used on any shoreline with surface sediments. On rocky coasts, only manual removal is feasible. Equipment is to be used only on beaches, with special supervision to minimize sediment removal.

When to Use

When only very limited amounts of oiled sediments have to be removed. Should not be considered where beach erosion may result. Care should be taken to remove the sediments only to the depth of oil penetration, which can be difficult with heavy equipment.

Biological Constraints

Excavating equipment must not intrude upon sensitive habitats. Only the upper *INTERTIDAL* and supratidal areas should be considered *FOR SEDIMENT REMOVAL TO MINIMIZE DISTURBANCE OF BIOLOGICAL COMMUNITIES IN THE LOWER INTERTIDAL AND SUBTIDAL*. There may be site-specific constraints limiting placement of *EQUIPMENT* and temporary sediment storage piles. Replaced material must be free of oil and toxic substances. The washing must not change the grain size of the replaced material, either by removal of fines or excessive breakage of friable sediment. *SUCH OPERATIONS WOULD BE GENERALLY RESTRICTED IN FISH-SPAWNING AREAS. ADJACENT AREAS*

POTENTIALLY IMPACTED BY RELEASED OIL SHEENS MUST BE PROTECTED DURING OPERATIONS.

Environmental Effects

Intertidal — The equipment is heavy, and required support personnel is extensive. May be detrimental if excessive sediments are removed without replacement. All organisms resident in the beach will be affected, though the need for removal of the oil may be determined to be the best overall alternative.

Subtidal — Release of oil and fine-grained oily sediments to the water during sediment removal activities and tidal flushing of the excavated beach surface.

7. Ambient-Water Flooding (Deluge)

Objective

To wash surface oil and oil from crevices and rock interstices to water's edge for collection.

Description

A large diameter header pipe is placed parallel to the shoreline above the oiled area. A flexible perforated header hose is used during deluge of intertidal shorelines to better conform to their profiles. Ambient seawater is pumped through holes in the header pipes and flows down the beach face to the water. On porous beaches, water flows through the substrate pushing loose oil ahead of it (or floats oil to the water's surface) then transports the oil down slope for pickup. Flow is maintained as long as necessary to remove the majority of free oil. Oil is trapped by booms and picked up with a skimmer or other suitable equipment.

Applicable Shoreline Types

Beaches with sediments coarser than sand, and gently sloping rocky shorelines. Generally not applicable to mud, sand, vegetated, or steep rocky shorelines.

When to Use

On heavily oiled shorelines when the oil is still fluid and loosely adhering to the substrate; and where oil has penetrated into cobble or boulder beaches. This method is frequently used in combination with other washing techniques (low or high pressure, ambient or warm water).

Biological Constraints

Not appropriate at creek mouths. Where the lower intertidal contains rich biological communities, flooding should be restricted to tidal stages when the rich zones are under water, to prevent secondary oiling.

Environmental Effects

Intertidal — Habitat may be physically disturbed and smothered as sand and gravel components are washed down slope. Organisms may be flushed into lower tidal zones.

Subtidal — Oiled sediment may be transported to shallow subtidal areas, contaminating them and burying benthic organisms.

8a. Ambient-Water/Low-Pressure Washing

Objective

Remove liquid oil that has adhered to the substrate or man-made structures, pooled on the surface, or become trapped in vegetation.

Description

Low-pressure washing (<50 psi) with ambient seawater sprayed with hoses is used to flush oil to the water's edge for pickup. Oil is trapped by booms and picked up with skimmers or sorbents. Can be used with a deluge system on beaches to prevent released oil from re-adhering to the substrate.

Applicable Shoreline Types

On heavily oiled gravel beaches, riprap, and seawalls where the oil is still fresh and liquid. Also, in marshes and mangroves where free oil is trapped.

When to Use

Where adhered oil is still fresh and must be removed due to continued release of oil.

Biological Constraints

May need to restrict use of flushing to certain tidal elevations so that the oil / water effluent does not drain across sensitive low tide habitats. In marshes, use only at high tide and either from boats or the high-tide line to prevent foot traffic in vegetation.

Environmental Effects

Intertidal — If containment methods are not sufficient, contamination may be flushed into lower intertidal zone.

Subtidal — Oiled sediment may be transported to shallow subtidal areas, contaminating them and burying benthic organisms.

8b. Ambient-Water/High-Pressure Washing

Objective

Remove oil that has adhered to hard substrates or man-made structures.

Description

Similar to low-pressure washing except that water pressure is up to 100 psi. High-pressure spray will better remove oil that has adhered to rocks. Because water volumes are typically low, may require placement of sorbents directly below treatment areas.

Applicable Shoreline Types

Riprap and seawalls. Can be used to flush floating oil or loose oil out of tide pools and between crevices on riprap.

When To Use

When low-pressure washing is not effective for removal of adhered oil, which must be removed due to continued release of oil. When directed water jet can remove oil from hard-to-reach sites. To remove oil from man-made structures for aesthetic reasons.

Biological Constraints

May need to restrict use of flushing to certain tidal elevations so that the oil/water effluent does not drain across sensitive low-tide habitats.

Environmental Effects

Intertidal — Removes many organisms on the surface. May drive oil deeper into the substrate if water jet is improperly applied. If containment methods are not sufficient, contamination may be flushed into lower intertidal zone.

Subtidal — Oiled sediment may be transported to shallow subtidal areas, contaminating them and burying benthic organisms.

9. Warm-Water/Moderate-to-High-Pressure Washing

Objective

Mobilize thick and weathered oil adhered to rock surfaces prior to flushing it to the water's edge for collection.

Description

Heated seawater (ambient to 90°F) is applied at moderate to high pressure to mobilize weathered oil that has adhered to rocks. The warm water may be sufficient to flush the oil down the beach. If not, "deluge" flooding and additional low- or high-pressure washing can be used to float the oil to the water's edge for pickup. Oil is trapped by booms and picked up with skimmers or sorbents.

Applicable Shoreline Types

Gravel beaches, riprap, and seawalls that are heavily oiled.

When To Use

When the oil has weathered to the point that low-pressure washing with ambient water is not effective for removal of adhered oil, which must be removed due to continued release of oil. To remove oil from man-made structures for aesthetic reasons.

Biological Constraints

Must restrict use to certain tidal elevations so that the oil/water effluent does not drain across sensitive low-tide habitats (damage can result from exposure to oil, oiled sediments, and warm water). Should be restricted adjacent to stream mouths, tide pool communities, and similar rich intertidal communities.

Environmental Effects

Intertidal — Can kill or remove most organisms. If containment methods are not sufficient, contamination may be flushed into lower intertidal zones that would otherwise not be oiled.

Subtidal — Oiled sediment may be transported to shallow subtidal areas, contaminating them and burying benthic organisms.

10. Hot-Water/High-Pressure Washing

Objective

Dislodge trapped and weathered oil from inaccessible locations and surfaces not amenable to mechanical removal.

Description

Water heaters mounted offshore on barges or small land-based units heat water to temperatures from 90°F up to 170°F, which is usually sprayed by hand with high-pressure wands. Used without water flooding, this procedure requires immediate use of vacuum (vacuum trucks or super suckers) to remove the oil/water runoff.

With a deluge system, the oil is flushed to the water's surface for collection with skimmers or sorbents.

Applicable Shoreline Types

Gravel beaches, riprap, and seawalls that are heavily oiled.

When To Use

When the oil has weathered to the point that even warm water at high pressure is not effective for removal of adhered oil, which must be removed due to continued release of oil. To remove oil from man-made structures for aesthetic reasons.

Biological Constraints

Restrict use to certain tidal elevations so that the oil/water effluent does not drain across sensitive low-tide habitats (damage can result from exposure to oil, oiled sediments, and hot water). Should be restricted near stream mouths, tide pool communities, etc. Released oil must be recovered to prevent further oiling of adjacent environments.

Environmental Effects

Intertidal — All attached organisms in the direct spray zone will be removed or killed, and significant mortality of the lower intertidal communities will result even when used properly. Where the intertidal community is rich, the tradeoff between damage to the intertidal community from the hot-water washing versus potential damage from leaving the oil has to be weighed.

Subtidal — Oiled sediment may be transported to shallow subtidal areas, contaminating them and burying benthic organisms.

11. Slurry Sand Blasting

Objective

Remove heavy residual oil from solid substrates.

Description

Use of sandblasting equipment to remove oil from the substrate. May include recovery of used (oiled) sand in some cases.

Applicable Shoreline Types

Seawalls and riprap. Equipment can be operated from boat or land.

When to Use

When heavy oil residue is remaining on the shoreline, which needs to be cleaned for aesthetic reasons, and even hot-water wash is not effective.

Biological Constraints

Not to be used in areas of oyster/clam beds, or areas with high biological abundance on the shoreline directly below or adjacent to the structures.

Environmental Effects

Intertidal — Complete destruction of all organisms in the intertidal zone.

Subtidal — Possible smothering of subtidal organisms with sand. When the used sand is not recovered, introduces oiled sediments into the subtidal habitat.

12. Vacuum

Objective

Remove free oil pooled on the substrate or from the water's surface in sheltered areas.

Description

Use of a vacuum unit with a suction head to recover free oil. The equipment can range from small portable units that fill individual 55-gallon drums to large supersuckers that are truck-mounted and can lift large rocks. Can be used with water spray systems to flush the oil towards the suction head.

Applicable Shoreline Types

Can be used on any shoreline type if accessible. May be mounted offshore on barges, onshore on trucks, or as individual units on boats or ashore at low tide.

When to Use

When free, liquid oil is stranded on the shoreline (usually along the high-tide line) or trapped in vegetation that is readily accessible.

Biological Constraints

Special restrictions should be identified for areas where foot traffic and equipment operation should be limited, such as rich intertidal communities. Operations in wetlands are to be very closely monitored, with a site-specific list of restrictions.

Environmental Effects

Intertidal — Minimal impacts if used properly and minimal substrate is removed.

Subtidal — None.

13. Sediment Reworking

Objective

Rework oiled sediments to break up the oil deposits, increase its surface area, and mix deep subsurface oil layers that will expose the oil to natural removal processes and enhance the rate of oil degradation.

Description

Beach sediments are rototilled or otherwise mechanically mixed with the use of heavy equipment on gravel beaches. The oiled sediments in the upper beach area may also be relocated lower on the beach to enhance natural cleanup during reworking by wave activity (berm relocation).

Applicable Shoreline Types

Should be used only on beaches exposed to significant wave activity. Tilling-type activities work best on beaches with a significant sand fraction; large equipment can be used to relocate sediments up to boulder size.

When to Use

On beaches with significant amounts of subsurface oil, where sediment removal is unfeasible (due to erosion concerns or disposal problems); also where surface oil deposits have started to form pavements or crusts.

Biological Constraints

Could not be used on beaches near shellfish-harvest or fish-spawning areas, or near bird nesting or concentration areas because of the potential for constant release of oil and oiled sediments. Sediment reworking should be restricted to the upper part of the beach, to prevent disturbance of the biological communities in the lower intertidal area.

Environmental Effects

Intertidal — Due to the mixing of oil into sediments, this process could further expose organisms living below the original layer of oil. Repeated mixing over time could delay the reestablishment of organisms. Relocated sediments would bury and kill organisms. There may be a period of beach instability as the relocated sediments are redistributed.

Subtidal — There is a potential for release of contaminated sediments to the nearshore subtidal habitats.

14. Sediment Removal, Cleansing, and Replacement

Objective

To remove and clean oiled sediments, then replace them on the beach.

Description

Oiled sediments are excavated using heavy equipment on the beach at low tide. The sediments are loaded into a container for washing. Cleansing methods include hot water wash or physical agitation with a cleansing solution. After the cleansing process, the rinsed materials are returned to the original area. Cleaning equipment must be placed close to beaches to reduce transportation problems.

Applicable Shoreline Types

Sand- to boulder-sized beaches, depending on the limitations of the cleanup equipment. The beaches must be exposed to wave activity, so that the replaced sediments can be reworked into a natural distribution.

When to Use

Applicable on beaches with large amounts of subsurface oil, where permanent removal of sediment is undesired and other cleanup techniques are likely to be ineffective.

Biological Constraints

Excavating equipment must not intrude upon sensitive habitats. Only the upper and supratidal areas should be considered. Generally restricted in spawning areas. There may be site-specific constraints limiting placement of temporary sediment storage piles. Replaced material must be free of oil and toxic substances. The washing must not change the grain size of the replaced material, either by removal of fines or excessive breakage of friable sediments.

Environmental Effects

Intertidal — All resident organisms will be affected, though the need for removal of the oil may be determined to be the best overall solution. Equipment can be heavy, large, and noisy; disrupting wildlife. Transportation to site may entail aircraft, land vehicles, or barges, contributing to environmental disruption. There may be a period of beach instability as the replaced sediments are redistributed.

Subtidal — May release oil and fine-grained oily sediments into the water during excavation. This is a concern due to tidal flushing of beach sediments and exposed excavations.

15. Cutting Vegetation

Objective

Removal of oiled vegetation to prevent oiling of wildlife.

Description

Manual cutting of oiled vegetation using weed eater, and removal of cut vegetation with rakes. The cut vegetation is bagged immediately for disposal.

Applicable Shoreline Types

Marshes composed of emergent, herbaceous vegetation.

When to Use

Use when the risk of oiled vegetation contaminating wildlife is greater than the value of the vegetation that is to be cut, and there is no less destructive method to remove or reduce the risk to acceptable levels.

Biological Constraints

Strict monitoring of the operations must be conducted to minimize the degree of root destruction and mixing of oil deeper into the sediments. Access to bird nesting areas should be restricted during nesting seasons.

Environmental Effects

Intertidal — Removal of the vegetation will result in loss of habitat for many animals. Cut areas will have reduced plant growth for up to two years. Along exposed section of shoreline, the vegetation may not regrow, resulting in erosion and permanent loss of the habitat. Trampled areas (which are inevitable) will recover much slower.

Subtidal — Long-term impacts would include increased sediment load in the subtidal area as a result of increased erosion in the intertidal area.

6 Treatment Methods Requiring Regional Response Team Approval

Research and development is ongoing for both new and improved oil spill treatment methods. Various chemical and biological degradation techniques are currently being tested for effectiveness and toxicity, and they may be approved for use in certain situations. Methods considered to be of potential use in this area are described below.

- **16a** Chemical Oil Stabilization with Elastomizers
- **16b** Chemical Protection of Beaches
- **16c** Chemical Cleaning of Beaches
- **17** *In-situ* Burning of Shorelines
- **18** Nutrient Enhancement
- **19** Microbial Addition

16a. Chemical Oil Stabilization with Elastomizers

Objective

Solidify or gelatinize oil on the water's surface or a beach to keep it from spreading or escaping, and to speed recovery rate and efficiency.

Description

Chemical agent enhancing polymerization of the hydrocarbon molecules applied by semi-liquid spray or as a dry chemical onto the oil in the proper dosage. Depending on the nature and concentration of the polymerizing agent, the oil can be rendered viscoelastic, but still fluid, gelatinous, or semisolid. The primary purpose is to stabilize the oil, keeping it from spreading or escaping, causing oiling elsewhere. May reduce the solubility of the light (and more toxic) fractions, by locking them into the polymer. This reduces both air and water exposure. Depending on the beach type and equipment used, recovery may be enhanced.

Applicable Shoreline Types

Suitable on shorelines of low permeability where heavy oil has pooled on the surface, except vegetated shorelines.

When to Use

When heavy concentrations of liquid oil are on the substrate and adjacent water body, and physical removal can not be completed prior to the next tide so that the oil is likely to move to a more sensitive shoreline type. Should be used in conjunction with booming or other physical containment.

Biological Constraints

Not suitable for vegetated or riprap shore types. Should be avoided when birds or other wildlife that may be more adversely impacted by the congealed oil can not be kept away from the treated shoreline. The congealed oil may stick to vegetation and wildlife, increasing physical damage to both. On riprap the congealed oil may remain in crevices where it may hamper recovery and prolong the release of sheens.

Environmental Effects

May enhance the smothering effect of oil on intertidal organisms. Thus, the treatment should be considered only for heavily oiled beaches where smothering effects are already maximal. The congealed oil may stick to vegetation and wildlife increasing physical damage, such as impaired flight in birds or impaired thermoregulation in mammals and birds whose feathers or fur become oiled.

16b. Chemical Protection of Beaches

Objective

Pretreat shoreline to prevent oil from adhering to the substrate.

Description

Certain types of water-based chemicals, some of which are similar in composition to dispersants, are applied to beaches in advance of the oil.

Applicable Shoreline Types

Coarse- and fine-grained sand beaches, seawalls and piers (particularly piers or waterfront facilities that are of historical significance), eroding bluffs, wave-cut platforms, and riprap.

When to Use

When oil is projected to impact an applicable shoreline, particularly those that have high recreational or aesthetic value.

Biological Constraints

May not be suitable for nutrient-rich environments, particularly in confined waters. The toxicity of shoreline treatment products is reportedly much less than that of oil, but the toxicity of each product should be evaluated prior to consideration for use.

Environmental Effects

The long-term environmental effects of these procedures are unknown. A toxic effect of the chemical can be anticipated. Additionally, the nutrient load to nearshore and interstitial waters may lead to eutrophication. Whether the predicted reduced residence time of the oil on the beach will increase the survival rate for sessile and interstitial organisms is unknown.

16c. Chemical Cleaning of Beaches

Objective

To increase the efficiency of oil removal from contaminated areas.

Description

Special formulations, which can be characterized as weak dispersants, are applied to the substrate, as a presoak and/or flushing solution, to soften weathered or heavy oils to aid in the efficiency of flushing treatment methods. The intent is to be able to lower the temperature and pressure required to mobilize the oil from the substrate.

Applicable Shoreline Types

On any shoreline where deluge and water flushing procedures are applicable.

When to Use

When the oil has weathered to the point where it will not flow using warm to hot water. This approach may be most applicable where flushing decreases in effectiveness as the oil weathers.

Biological Constraints

Will require extensive biological testing for toxicity and water quality sampling prior to receiving approval for use. The concern is that the treated oil will be dispersed in the water column, and thus impact water column and subtidal organisms. Field tests will be required to show that use of a beach cleaner does not reduce overall recoverability of the oil. Use may be restricted where suspended sediment concentrations are high, adjacent to wetlands and tidal flats, and near sensitive subtidal resources.

Environmental Effects

If more oil is dispersed into the water column, there could be more oil sorbed onto suspended sediments and transferred to subtidal habitats, particularly along sheltered shorelines. Intertidal habitats might survive better, if cooler water temperatures are possible.

17. In Situ Burning of Shorelines

Objective

Removal of oil from the shoreline by burning.

Description

Oil on the shoreline is burned, usually when it is on a combustible substrate such as vegetation, logs, and other debris. Oil can be burned off of nonflammable substrates with the aid of a burn promoter.

Applicable Shoreline Types

On any shoreline type except tidal flats.

When to Use

Early in the spill event, after ensuring that the product is ignitable.

Biological Constraints

Should only be considered for use in the upper intertidal or supratidal zones since destruction of plants and animals from heat and burn promoters will be extensive. This technique is subject to restrictions and permit requirements established by federal, state and local laws. It should not be used to burn PCBs, wastes containing more than 1,000 parts per million (ppm) of halogenated solvents, or other substances regulated by the U. S. Environmental Protection Agency (EPA).

Environmental Effects

Little is known about the relative effects of burning oiled wetlands compared to other techniques or natural recovery. Burning may cause significant air pollution, which must be considered when weighing the potential benefits and risks of the technique. The combustion products may travel great distances before deposition.

18. Nutrient Enhancement

Objective

To speed the rates of natural microbial degradation of oil by addition of nutrients (specifically nitrogen and phosphorus). Microbial biodegradation is the conversion by microorganisms of dissolved and dispersed hydrocarbons into oxidized products via various enzymatic reactions. Some hydrocarbons are converted to carbon

dioxide and cell material, while others are partially oxidized and/or left unaltered as a residue.

Description

Nutrients are applied to the shoreline in one of several methods: soluble inorganic formulations that are dissolved in water and applied as a spray at low tide, requiring frequent applications; slow-release formulations that are applied as a solid to the intertidal zone and designed to slowly dissolve; and oleophilic formulations that adhere to the oil itself, thus they are sprayed directly on the oiled areas.

Applicable Shoreline Types

Could be used on any shoreline type where safe access is allowed.

When to Use

On moderately to heavily oiled shorelines, after other techniques have been used to remove as much oil as possible; on lightly oiled shorelines where other techniques are not effective; and where nutrients are a limiting factor in natural degradation. Potentially for the treatment of subsurface oil.

Biological Constraints

Not applicable in shallow water, poorly flushed, restricted embayments where nutrient overloading may lead to eutrophication, or where toxicity of nutrients, particularly ammonia, is of concern. There must be no risk of oxygen depletion. Use is to be restricted adjacent to stream mouths, tide pools, etc. Contact toxicity of oleophilic formulations may restrict areas of direct application. Bioassay test results should be carefully evaluated, as other chemicals in the formulations could be toxic to aquatic organisms.

Environmental Effects

Tests in Alaska showed that interstitial oxygen concentrations did not decrease to such an extent that it limited the supply of oxygen available to the bacteria. The fertilizer applications that increased nutrient concentrations and microbial activity did not harm the nearshore environment. About 99 percent of butoxyethanol, a toxic component of the Inipol formulation, (the fertilizer commonly used in Alaska) degraded to nontoxic compounds within 24 hours after Inipol treatments of cobble shorelines. Inipol was initially toxic to intertidal organisms directly contacted during application. Researchers also found no evidence that the nutrients released from the treated shorelines stimulated algal blooms.

19. Microbial Addition

Objective

To speed the rates of natural microbial degradation of oil by addition of nutrients and microbial products. Microbial biodegradation is the conversion by microorganisms of dissolved and dispersed hydrocarbons into oxidized products via various enzymatic reactions. Some hydrocarbons are converted to carbon dioxide and cell material, while others are partially oxidized and/or left untouched as a residue.

Description

Formulations containing hydrocarbon-degrading microbes and fertilizers are added to the oiled area. The argument is made that indigenous organisms will be killed by the oil, so new microbial species need to be added to begin the process of biodegradation. To date, microbial addition has not been shown to work better than fertilizer alone in field tests.

Applicable Shoreline Types

Could be used on any shoreline type where safe access is allowed.

Biological Constraints

Not applicable in shallow water, poorly flushed, restricted embayments where nutrient overloading may lead to eutrophication, or where toxicity of nutrients, particularly ammonia, is of concern. There must be no risk of oxygen depletion. Use is to be restricted adjacent to stream mouths, tide pool communities, etc. Bioassay test results should be carefully evaluated, as other chemicals in the formulation could be toxic to aquatic organisms.

Environmental Effects

Yet to be evaluated for full-scale field applications.

Appendix A

Guidelines For Treatment Operations

General Guidelines

Ensure familiarity and compliance with approved treatment methods, approved shoreline segment work plans, advisories, and special instructions. Restrict all access to wetlands and tidal flats, except with special authorization.

Conditions to avoid

- Treatment techniques (such as high pressure and hot water) that dislodge intertidal vegetation and invertebrates, e.g., mussels, barnacles, snails
- Clearing marshes and vegetated shorelines (the presence of algae does not characterize a vegetated shoreline)

Actions to encourage

- Boom off mud/grass flat adjacent to treatment areas to prevent further contamination.
- Boom off tidal creeks to prevent further contamination.
- Minimize impact to uncontaminated lower intertidal zones, including:
  - land crews during tides that cover the lower intertidal zone
  - avoid high-/low-pressure washing where possible
  - work heavily oiled upper beach zone hen lower intertidal zones are covered by high tides
  - employ sorbents along riprap and below oiled upper beach to protect lower intertidal zone from oiling

Ensure that all signs of human activity are removed when cleanup is completed. Ensure that all trash and wastes are removed daily:

- Oil trapped in booms must be picked up before the next tide cycle
- All food and associated trash must be removed each day to minimize attracting wildlife into contaminated areas

Guidelines Specific to Biological Resources

Advisories and special instructions may address:

- bird concentration areas (nesting sites, colonies, rookeries, etc.)
- live / dead animal collection policy
- protection of cultural resources
- marine mammal haulouts
- collection of eagle feathers and marine mammal parts
- cutting bull kelp
- cutting oiled fucus

Appendix B includes existing “best management practices” for specific issues addressed during previous spills, which can be used as the basis for developing regional guidelines.

Appendix B

Best Management Practices

Specialized Areas of Concern - National
(The following notices are provided as guidelines.)

Marine Mammal Notice
Collection of Eagle Feathers and Marine Mammal Parts
Protection of Cultural Resources
Cutting of Oiled Bull Kelp
Cutting of Oiled Fucus (Popweed)
Instruction for the Disposition of Dead and Live Wildlife

Marine Mammal Notice

(Developed by NOAA in 1989 during the *Exxon Valdez* oil spill.)

To reduce stress caused by unnecessary disturbance to marine mammal haulouts and improve the changes for wildlife survival, an aircraft advisory is issued for coastal areas affected by the spill. These advisories request that pilots stay at least one-half mile offshore and 1000 feet above ground level from areas of wildlife concentrations and critical habitats. These areas are shown on maps and distributed to pilots. The most critical areas to avoid are: (list critical areas).

No person, except an authorized government official, will approach, molest, or take a seal or sea lion, regardless of whether the animal is oiled, distressed, lethargic, or abandoned. This reminder is necessitated by the widespread activities of oil spill cleanup personnel in areas where seals and sea lions are giving birth to pups. Although casual and distant human/marine mammal interactions may not always be avoidable, they are, to varying degrees, harmful to the animal. The following explanation and guidance with respect to seal pups is offered in the interest of avoiding law violations and minimizing human-induced mortality among marine mammals.

Live seal pups are to be left undisturbed, whether or not they have oil on them. A pup not accompanied by an adult and/or appearing emaciated may not be abandoned. Females commonly leave their pups alone for extended periods during foraging trips. Newborn and young pups appear emaciated before acquiring fat through nursing. It is not possible to distinguish between a normal pup and one that is truly distressed. In the presence of humans, female seals may only approach their pups at night to nurse them, making determination of abandonment difficult to establish. True abandonment is unlikely, barring death or serious injury to the mother.

Pup deaths will greatly increase if oiled animals are picked up and subjected to the stress of handling, transport, and rehabilitation centers. Unlike sea otters and birds, external oiling does not adversely affect a seal's heat conservation ability or indicate a need for human assistance. Persons finding seals, sea lions, whales, or porpoises that appear to be in distress should contact NOAA Fisheries. Do not touch or closely approach these animals.

Collection of Eagle Feathers and Marine Mammal Parts

In response to inquiries about collecting eagle feathers and marine mammal parts by personnel involved in cleanup activities during a spill, the laws and regulations dealing with the collection and possession of such materials are summarized below.

Collection of Eagle Feathers: The Eagle Act (Public Law 95-616, 92 Stat. 3114, 16 U.S. Code 668) prohibits the collection and possession of any eagle parts, including feathers.

Collection of Marine Mammal Parts: The Marine Mammal Protection Act of 1972 (Public Law 92-522, 88 State. 1027, 95 Stat. 979, 16 USC 1372) generally prohibits the collection and possession of any marine mammal parts. Under 50 CFR 18.26, the collection of certain dead marine mammal parts is allowed, as follows:

a. Any bones, teeth or ivory of any (non-endangered) dead marine mammal may be collected from a beach or from land within 1/4 of a mile of the ocean. The term "ocean" includes bays and estuaries.
b. Marine mammal parts so collected may be retained if registered within 30 days with an agent of the National Marine Fisheries Service, or an agent of the U.S. Fish and Wildlife Service.
c. Registration shall include (1) the name of the owner, (2) a description of the article to be registered, and (3) the date and location of collection. Items so collected and registered must be retained in the ownership of the collector. The sale of such items is prohibited.

Protection of Cultural Resources

Shoreline cleanup operations have the potential for damaging important archaeological and cultural resources. Authorized shoreline cleanup procedures may uncover undiscovered archaeological features or artifacts. To assist in their identification, drawings of the types of artifacts that might be found in the intertidal zone and along the shoreline by cleanup crews are included. Cleanup personnel should be aware of the policy that anyone found vandalizing or appropriating cultural materials will be subject to full prosecution under the Archaeological Resources Protection Act. If response personnel find any cultural resources (fossils, archaeological or historical artifacts), the following steps should be taken immediately:

1. Leave the cultural materials in place at the site of discovery and mark with flagging tape.
2. Stop cleanup activities in the surrounding area.
3. Inform a designated state representative.

Cutting of Oiled Bull Kelp (Nereocystis luetkeana) as a Technique for Releasing and Recovering Trapped Oil

(Based on research by NOAA conducted during the *Tenyo Maru* oil spill, off the coast of Washington, 1991)

Although bull kelp is an annual, with much of a year's growth typically removed by seasonal storms, Dr. Sandra Lindstrom, a phycologist with the University of British Columbia, cautions that removal of the upper portion of the stipe removes the entire active reproductive area of the plant, which is located in the fronds. Bull kelp reproduces by the production of spore cases, which drop to the bottom and subsequently grow into the following season's plants. If cutting is to take place, it should be limited to the fronds, leaving a portion on the plant, which would permit it to nominally survive. Cutting the stipe effectively kills the plant.

Cutting kelp beds abruptly changes the light regime on the seafloor below. This may have implications in that growth of young kelp plants is light-mediated, and an increase in light reaching the bottom may result in earlier growth than would otherwise occur.

Secondary ecological impacts of kelp removal should be carefully considered before arriving at a decision about cutting the near-surface portions of plants. The canopy provided by the kelp stipes and blades represents important habitat for fish species such as greenlings and rockfishes (a study in California counted 23 species of fish in a bull kelp bed) and substrate for organisms that are important prey items for fish.

Should cutting take place, cutting the upper portion of the plants is preferable to removing the entire plant, and cutting only the blades and leaving the stipe intact is preferable to removing the gas-filled bulb. Decisions will necessarily balance removal of oil from the environment with direct impacts on the plants and alteration of significant nearshore habitat.

Commercial harvesting equipment similar to that routinely employed in California coastal waters is a possibility, but *Nereocystis* is substantially different in nature than *Macrocystis*. If they worked, such harvesting barges would cut through the stipe and kill the plant. Whether they are capable of cutting the stipe is not known. Support logistics for kelp cutting could be expected to be substantial as well: the large biomass of kelp

would require either vessels with considerable hold capacity, or barges on which the plants could be loaded.

Cutting of Oiled Fucus (Popweed)

(Developed by NOAA in 1989 during the *Exxon Valdez* oil spill)

The cutting of heavily oiled fucus still attached to the substrate in the intertidal zone is sometimes suggested during shoreline cleanup efforts. At issue is the benefit derived from removing a source of contamination compared with the costs to intertidal systems from fucus removal. Fucus defines the mid-intertidal zone and provides shelter and attachment for other animals. The spores, primarily the very small plants, are a sources of food for other animals. The plants are prone to breaking loose in exposed settings and may end up on the beach or in the water. The average half-life of fucus plants is six months, with the large, older overstory plants being up to five years old (in Prince William Sound).

Fucus is a particularly hardy species with respect to oiling. Mortality may occur as a result of the oil preventing photosynthesis from occurring, but it is extremely difficult to determine if a plants is dead or alive by looking at it when oiled. Reproduction in fucus is through the release of spores from buoyant reproductive receptacles that look like small air sacs located on the tips of the plant. The presence of mucus coming out of these receptacles when exposed during low tide indicates that the plant is fertile. Recruitment comes primarily from spores released by plants located no more that three to ten feet away and occurs quite readily as long as sufficient numbers of other fucus plants are in the area. In the absence of other fucus plants, drift spores do come along, but recruitment from this source is very haphazard and not at all guaranteed.

Cutting oiled fucus still attached to the rock is generally not recommended. Flushing (ambient water) and other cleanup techniques should be tried first. If it is deemed necessary to remove heavily oiled fucus to prevent redistribution to very sensitive resources, a sufficient number of mature plants should be left in the area to facilitate recruitment (in patches or fringe three to ten feet apart). If this is not done, recruitment may not take place. It is not necessary to leave the holdfasts when cutting plants.

Instruction for the Disposition of Dead and Live Wildlife

(Derived from the Wildlife Protection Guidelines, Alaska RRT, 1991)

Dead Animals

1. Collect all dead animals (except whale and other large forms), including scavenged carcasses, to discourage further scavenging in oiled areas.
2. Wear gloves when handling dead animals.
3. Use a shovel or spade to uncover and remove carcasses partially covered by sand, kelp, wood, or other debris.
4. Place carcasses in double plastic garbage bags. Place all animals from one beach in one bag, if possible. Close securely with masking tape.
5. Complete an animal collection form or provide the following information:
   - beach name or location where carcasses were recovered
   - date
   - name and address of collector
   - species, age, and sex of collected animals .

   If any of this information is not available or questionable, this fact should be recorded so that additional examinations of the animals can be conducted.
6. Place the form or list in a ziplock baggie and place the baggie outside the first garbage bag but inside the second. Bring the dead animals to a designated recovery site

Live Animals

Authorization for animal rescue must be given by the appropriate State or Federal agency prior to the rescue and rehabilitation of oiled wildlife. Long-handled nets, rags, or towels are recommended for capturing live, oiled birds. Wear gloves to keep from getting oiled. Do not wash oiled birds. It is more important to keep them warm. Place them in a covered cardboard box. It is okay to keep more than one bird and multiple species in the same box. Do not attempt to give birds fluids; they should be taken to a rehabilitation center as soon as possible. For live birds, the following information should be reported:

- beach name or location where animal was recovered
- date and name and address of collector
- species, age, and sex of collected animals

- condition of the animal

Do not attempt capture of live sea otters without prior authorization from the appropriate agency. Inexperienced people can cause otters additional injuries. In addition, otters may bite and cause infections. A bite from an otter may result in inflammation of the joints and inability to bend one's fingers. Live, oiled otters are to be reported to the designated agency contact for the spill.

Appendix C

NOAA Scientific Support Coordinators

For more information about developing and applying shoreline countermeasures, contact the appropriate NOAA Scientific Support Coordinator for your area.

District	Address	Phone
1 *Stephen Lehmann*	NOAA SSC HAZMAT First CG District (mer) 408 Atlantic Ave Boston, MA 02110	(w) 617-223-8016 (fax) 617-439-0468
1/5 *Ed Levine*	NOAA SSC HAZMAT Building 100, Box 2 Governors Island New York, NY 10004-5000	(w) 212-668-6428 (fax) 212-668-6370
2/9 *Bill Sites*	NOAA SSC HAZMAT c/o USCG Marine Safety Division AJC Federal Bldg. 1240 E. 9 St. Rm 2157 Cleveland, OH 44199	(w) 216-522-7760 (fax)216-522-7759
5 *Gary Ott*	NOAA SSC HAZMAT USCG RTC Yorktown (t-mer) Yorktown, VA 23690-5000	(w) 804-898-2320 (fax) 804-898-2296
7 *Brad Benggio*	NOAA SSC HAZMAT Miami Federal Build Rm 1123 51 S.W. First Ave, PO Box 83 Miami, FL 33130	(w) 305-530-7931 (fax)305-530-7932
8 *Ilene Byron*	NOAA SSC HAZMAT Cdr Eighth CG District (m-ssc) Hale Boggs Federal Bldg 501 Magazine St., Rm. 1341 New Orleans, LA 70130-3396	(w) 504-589-6271 (fax)504-589-4999
11 *Scott Stolz*	NOAA SSC HAZMAT 501 West Ocean Blvd. Rm 5110 Long Beach, CA 90802	(w) 310-980-4107 (fax) 310-980-4109
13/14 *Sharon Christopherson*	NOAA/HAZMAT 7600 Sand Point Way N.E. Seattle, WA 98115-0070	(w) 206-526-6829 (fax) 206-526-6329

District	Address	Phone
17 *John Whitney*	NOAA SSC HAZMAT Peterson Towers Bldg 510 L Street, Ste #100 Anchorage, AK 99501	(w) 907-271-3593 (fax) 907-271-3139

Glossary

Aerobic

Able to live or grow only where free oxygen is present.

Anaerobic

Able to live and grow where there is no air or free oxygen.

Annual

A plant that lives only one year or season.

Aromatic

Organic compounds containing any of a series of benzene ring compounds. They are unsaturated organic ring compounds with low boiling points and are generally toxic to aquatic life.

Benthos

The plants and animals that live in and on the bottom of a water body.

Berm

A wedge-shaped sediment mass built up along the shoreline by wave action. Sand berms typically have a relatively steep seaward face (beach face) and a gently sloping surface (berm top). A sharp crest (berm crest) usually separates the two oppositely sloping planar surfaces on top of the berm. Berms on sand beaches are eroded away during storms, thus a berm may not be present if the beach is visited shortly after a storm. On gravel beaches, however, steep and high storm berms are activated and refurbished during storms.

Biota

Animal and plant life characterizing a given region. Flora and fauna, collectively.

Booms

Both containment and absorbent booms are used for the collection, deflection, and containment of spreading oil. Containment booms are somewhat rigid structures extending both above and below the water acting as barriers to surface oil. Primary containment booms are usually deployed close to oiled shorelines to trap oil being flushed from beaches before it is collected. Secondary containment booms are deployed farther out to trap oil that leaks past primary booms. Absorbent boom is used along the shore-water interface to collect oil dislodged during treatment operations. It is important that absorbent boom be changed once the sorbent capacity is reached. Great care should be taken to seal the shore ends of booms so that no oil can get past. This is particularly difficult at rocky shorelines, or areas strewn with boulders and cobbles. The use of absorbent pads or other materials, such as "pom poms", can be effective sealants.

Brackish

Intermediate in salinity (0.50 to 17.00 parts per thousand) between sea water and fresh water.

Clam shell

A mechanical device mounted at the end of a crane that picks up soil or mud with a pincer-like movement.

Coagulating agent

Chemical additives applied to oil to form a more cohesive mass.

Contact period

The time required to maximize the efficiency of the sorbent or chemical agent or the time before plant or animal damage occurs.

Dispersant

Chemical agent used to disperse and suspend oil in water leading to enhanced biodegradation.

Distillate

A refined hydrocarbon obtained by collection and condensation of a known vapor fraction of the crude oil.

Drag line

A mechanical device that excavates or transports soil, using a container pulled over earth by cables or chains.

Dredge

A device used to remove sediment from the bottom of a water body.

Emulsification

The process by which oil is mixed with water.

Endless rope

A continuous rope-like oil sorbent device that is pulled across the surface of the water to pick up oil.

Erosion

The wearing away by action of water or wind of unprotected or exposed earth.

Estuary

Classic definition A drowned river valley that has a significant influx of fresh water and is affected by the tides. Most of the coastal water bodies in the mid-Atlantic region are estuaries (e.g., Chesapeake Bay, Delaware Bay).

Evaporation

The conversion of a fluid—including hydrocarbons—to a gaseous state.

Fast ice

Any sea ice that forms along and remains attached to the coast, or that forms between grounded ice bergs, or is attached to the bottom in shallow waters. May form *in situ* from seawater or by freezing of pack ice to the shore. It may extend a few meters to several hundred kilometers from the shore.

Fertilizer

A substance or agent that helps promote plant or seed growth.

Flash point

The lowest temperature at which vapors from a volatile liquid (e.g., oil) will ignite.

Flushing

Use of a water stream to make oil flow to a desired location or recovery device.

Fouling

Accumulation of oil or other materials, such as debris, that makes a device inoperative.

Free oil

See mobile oil.

Gelling agent

See coagulating agents.

Habitat

The chemical, physical, and biological setting in which a plant or animal lives.

Herding agent

Chemical agent that confines or controls the spread of a floating oil film.

Intertidal

The part of the shoreline that lies between high-tide and low-tide water levels.

Lagoon

A shallow, linear, and usually oblong water body, located parallel with and connected to a larger water body by one or more inlet channels.

Landfill

A dump that has progressive layers of waste matter and earth.

Marsh fringe

The edge of the marsh adjacent to the water.

Migration

Seasonal movement of a group of animals from one location to another.

Mobile oil

Oil that can refloat when water is applied (as in high tide).

Mobilization

Movement of oil caused by physical forces, such as gravity, tides, or wind. Mobility of oil is limited by its viscosity.

Mousse

A type of oil/water emulsion.

Non-persistent

Decomposed rapidly by environmental action.

Oil/water separator

A device for separating oil from water.

Oleophilic

A material that has affinity for oil.

Paraffin

The waxy saturated component of crude oil, having relatively high boiling point and low volatility. Any member of the methane series having the general formula $C_nH_{2n}+2$.

Penetration

Downward motion of oil into sediments from the surface driven by gravitational forces.

Perennial

Vegetation that continues to grow for several years.

Permeability

The degree to which fluids can flow through a substance. Measured in Darcys. Permeability is not equal to porosity. High porosity of a material does not insure high permeability. However, a substance cannot be permeable without having some degree of porosity.

Physiography
General term for the shape of the earth's surface.

Pooled oil
Oil thickness exceeds one centimeter. This need not be uniform.

Porosity
The volume of void spaces in a sediment mass, measured in percent.

Riprap
(a) A layer of large, durable fragments of broken rock, specially selected and graded, and thrown together irregularly or fitted together. Its purpose is to prevent erosion by waves or currents and thereby preserve the shape of a surface, slope, or underlying structure. It is used for irrigation channels, river-improvement works, spillways at dams, and revetments for shore protection. (b) The stone used for riprap.

Recontamination
Contamination by oil of an area that was previously cleaned.

Rhizome
A rootlike stem under or along the ground, ordinarily in a horizontal position, which usually sends out roots from its lower surface and leafy shoots from its upper surface.

Salt pan
A pool above high tide, "drained" only by evaporation so that salt is accumulated and concentrated.

Seine
A fish net that can be used to collect sorbent or debris.

Skimmer
A mechanical device that removes an oil film from the water surface.

Oil skimmers collect oil spilled on, or released to, the water's surface. They come in a wide range of shapes and sizes. Skimmers generally have a higher recovery rate than sorbents, providing enough oil is present to justify the costs for its use. Skimmers are usually

equipped with storage space for collected oil. Oil is herded to a collection point along a containment boom located close to shore yet in water of sufficient depth for the skimmer to function. Two types of skimmers currently in use are described below. Other types of skimmers are being tested for possible use at a later date.

Band, or "Rope," skimmers use an oleophilic material such as polypropylene. Oil is collected by a floating, continuous rotating band or "rope" drawn through an oil slick or along the water's edge of a contaminated area. Adhered oil is wrung from the band by a squeeze roller and collected in an oil sump. These bands are used in either static (stationary) or dynamic (towed) modes. Bands can be torn by solids or skimmed debris. Efficiency is high in calm waters, poor in choppy waters and waves.

Belt skimmers use an oleophilic belt mounted on the front of a small vessel. The oleophilic belt pushes the floating oil below the waterline. Oil not adsorbed by the belt is collected into a holding area located behind the belt. Oil carried up the belt is recovered at the top of the system by a squeeze belt or scraper blade. It is then pumped into a storage container. These skimmers can not operate in shallow waters or tight areas.

Slurry

A suspension of particles in water.

Solubility

The amount or fraction of a substance (e.g., oil) that dissolves into the water column, measured in ppm.

Solvent

A chemical agent that will dissolve oil.

Specific gravity

The measure of the density of a substance such as oil or sea water, usually determined at 20°C, compared to the density of pure water at 4°C. Thus, specific gravity varies slightly with temperature.

Sorbent

All sorbent materials work on the same principles—oil adheres to the outside of the material or sorbs into the material by capillary action. There are three basic types of sorbent materials: mineral based, natural organic, and synthetic organic. Currently, only synthetic organic sorbents are being used in the field in the form of booms, pads, and mops. Peat is currently in the testing and demonstration phase.

Stain

Oil that is visibly present but cannot be scraped off with a fingernail.

Substrate

The substance, base, or nutrient on which, or the medium in which, an organism lives and grows, or the surface to which a fixed organism is attached; e.g., soil, rocks, and water.

Substrate penetration

Vertical distance from surface to where oil has percolated into the substrate.

Subtidal

That part of the coastal zone that lies below the lowest low-tide level, so that it is always underwater.

Sump

A pit or reservoir that serves as a drain from which oil can be collected.

Supratidal

Above the normal high-tide line.

Tank barge

A barge for transporting liquids.

Tarballs

Lumps of oil (<10 cm in diameter) weathered to a high density semisolid state.

Tidal variation or range

The vertical distance between high and low tides.

Toxicity

The inherent potential or capacity of a material (e.g., oil) to cause adverse effects in a living organism (Rand and Petrocelli, 1985).

Viscosity

Flow resistance; referring to internal friction of a substance (e.g., oil) that is a function of the oil type and temperature.

Vacuum systems

Used to recover oil collected behind containment booms along the beach face and in the water during shoreline flushing operations. Where equipment access allows, vacuums can be used to remove pools of oil directly from shorelines and surfaces of heavily oiled rocks. Two vacuum systems currently in use are described below.

The first system is classified as a vacuum device, but requires a high-velocity air stream, @ 150 mph, to draw oil, water, and debris into the unit's collection chamber. Due to the 6- to 12-inch diameter of the inlet hose, it rarely becomes clogged by debris. The inlet nozzle should always be placed slightly above (never below) the fluid's surface. The distance at which it is held above the fluid is critical to limit the amount of water intake. This system is suitable for picking up weathered oil, tar balls, and mousse from water or shorelines, and to vacuum oil from skimming vessels, boomed areas, or debris-laden sites. The primary advantage is its ability to pick up oil of any viscosity and, where necessary, lift fluid more than 30 feet. The system can pick up and decant simultaneously. The main disadvantages are that it usually picks up a high water/oil ratio, and can be difficult to repair in the field.

The second system, barge-mounted vacuum trucks, use high-suction pumps and a cylindrical chamber capable of sustaining very low internal pressure, i.e., minus 12 psi. Vacuum is created in the chamber, and a 3- to 4-inch diameter hose is usually placed slightly below the surface of a floating oil slick, allowing a mixture of water and oil to enter the collection chamber. The position of the open end of the vacuum hose is critical. If it is placed too far down into the oil slick, recovered fluid will be mostly water; if not deep enough, air will be sucked into the system, and much of the vacuum will be lost. The primary advantages of the vacuum truck system are: it can recover fluid of nearly any viscosity; it has a rapid pickup rate of thick oil layers; and it can recover a wide variety of small debris. Primary disadvantages are its limited lift, no

more than 20 to 30 feet, and the length of time required to reestablish a vacuum if air enters the hose. As with the other vacuum, this one also picks up a high water/oil ratio.

Weathering
Natural influences such as temperature, wind, and bacteria that alter the physical and chemical properties of oil.

Weir
A vertical barrier placed just below the surface of the water so that a floating oil slick can flow over the top.

Wetlands (as defined by the Annotated Code of Maryland Title 9)
State wetlands: Lands below the mean high-tide line affected by the regular rise of tide.
Private wetlands: Lands bordering on state tidal wetlands, below the mean tide line subject to the effects of the regular rise and fall of tide. Lands able to support growth of wetland vegetation.

Lands transitional between terrestrial and aquatic systems where the water table is usually at or near the surface, and is at least periodically saturated with or covered by water (Cowardin et al., 1979).

Wrack
Accumulations of plant debris that is deposited at or above the high-tide line (e.g., *Spartina* or kelp debris).

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