MECHANICAL PROTECTION GUIDELINES

MECHANICAL PROTECTION GUIDELINES

Dr. Jacqueline Michel[1]
Dr. Sharon Christopherson[2]
Cdr. Frank Whipple[3]

[1] RESEARCH PLANNING, INC., COLUMBIA, SOUTH CAROLINA
[2] NATIONAL OCEANIC & ATMOSPHERIC ADMINISTRATION
[3] U.S. COAST GUARD NATIONAL STRIKE FORCE

JUNE 1994

CONTENTS

FIGURES

TABLES

INTRODUCTION

The main objective of shoreline protection is preventing or reducing the environmental effects of spilled oil. This manual emphasizes providing guidance to Area Committee members on how best to employ mechanical protection methods, such as booms and barriers, when designing workable protection strategies.

The Oil Pollution Act of 1990 (OPA 90) directed that Area Committees be established to plan for a coordinated community response to an oil discharge or hazardous substance release. For areas under U.S. Coast Guard jurisdiction, Area Committees are designated for each coastal Captain of the Port zone. The U.S. Environmental Protection Agency (EPA) is in charge of inland Area Committee development, and has designated each EPA Region as an Area and the Regional Response Teams (RRT) as the Area Committees.

There are many components to Area Contingency Plans that need to be addressed by Area Committees. This manual provides a framework for the planning requirements specified in the Commandant Notice 16471, Annex E, Area Assessments, and focuses on the Notice's Appendix IV, Protection Strategies and Appendix V, Identification of Sensitive Areas. It also can be used by facilities who must prepare Response Plans for Marine Transportation-Related Facilities. These plans identify sensitive areas and set guidelines for protecting these resources during a spill.

Specifically, the objectives of this manual are to:

- Provide guidelines for identifying and prioritizing areas with sensitive habitats, fish and wildlife resources, and human-use resources. We include sample formats for mapping and describing sensitive areas that optimize maps' operational usefulness;
- Describe the types of shoreline protection measures available to protect sensitive resources, emphasizing the limits and requirements of each protection measure. Where mechanical shoreline protection response actions are not feasible, Area Committees should consider alternative protection methods;
- Provide guidance on developing site-specific protection strategies, including equipment and logistics needed, operational constraints, and physical conditions at the site. Charts and tables are included as tools for developing the most feasible and successful strategies; and

- Encourage continuity among Area Plans to facilitate exchange of information and use by Regional and National Response Teams.

The manual is intended to support planning; it does not address spill response or shoreline cleanup issues. For guidance in these areas, NOAA (1993) has prepared a shoreline countermeasures manual.

Although Area Committees must eventually plan for discharges of both oil and hazardous substances, the emphasis here is on oil spills and shoreline protection. Similar equipment and strategies are used to control and recover nearly all types of oil products. In contrast, the range in types and behavior of hazardous substances is too great to address in a single manual.

The planning process is as important as the final plan. Area contingency planning provides the opportunity for cross-training among a variety of response organizations. The success of the plan depends on the participation of the response community, as well as of local resource experts who are likely to be involved in a spill. For example, response contractors who understand the basis for setting protection priorities can make better decisions in the field to fine-tune the response to the environmental conditions of each spill. Resource managers who understand performance limitations and logistical requirements of equipment in their areas can participate more effectively in developing workable response strategies. There is no benefit for resource managers to recommend booming strategies in locations where boom is operationally unfeasible or has a high likelihood of failure. However, when operations and natural resource personnel work together, feasible strategies can be developed to protect sensitive resources.

Finally, it is important to note that developing the plan is only the first step. You should field-check each priority site and revise the protection plan as necessary. The response community should be thoroughly trained in both scientific and operational aspects of the protection methods. In addition, you must test and refine protection plans to make sure that they are workable and effective. Developing Area Plans is a multi-step process: plan, train, exercise, and revise.

Identifying Potential Spill Sources

Because identifying sensitive resources and developing protection strategies are predicated on the location and probable trajectory of a spill, it is important to understand the most likely spill scenarios. Oil spill risk characterization includes analyzing the types and volumes of oil products stored and transported in the area and historical spill patterns.

Transportation systems and patterns include waterborne, rail, highway, and pipeline. The U.S. Army Corps of Engineers publishes annual reports on waterborne commerce of the United States for all ports and navigable waterways. These reports list the vessel freight traffic by major commodity types, including specific petroleum types, and summarize temporal trends in freight traffic. The Coast Guard keeps records of bunkering notifications. State port authorities can also provide data on the types and frequencies of oil and hazardous cargoes passing through their jurisdictions. These data can be used to generate statistics on the frequency of shipments by oil type to identify the most commonly handled products. Ports with Navy facilities should review traffic patterns with local Navy representatives to identify products and volumes related to Naval shipping and storage operations.

Data on rail transportation of oil are difficult to obtain because the only sources on types, frequencies, and volumes are railroad companies, which generally do not have such information readily available. Highway oil transportation patterns are also difficult to obtain because there are numerous trucking companies and many possible routes. However, the locations where transportation spills could affect coastal resources, namely at bridges and waterfront rail yards, can be readily identified. Usually, the potential spill amounts from rail and highway transportation are relatively small compared to marine transportation. In contrast, the potential spill amount from pipelines is highly variable, depending on the pipeline diameter, flow rate, spacing between shut-off valves, and type of leak detection system in place. This information on pipelines is available from each pipeline operator.

Because oil production wells can be very numerous in both onshore and offshore regions, point locations or groups of wells should be determined. There are incomplete data available on pipelines from wells, especially in older fields. However, the oil companies operating the wells can be contacted to provide information.

Storage and transfer facilities are required to determine worst-case discharges from the facility as part of their facility response plans, which are submitted to the Coast Guard for the transportation-related portion of the facility, and to EPA for the non-transportation portion. The criteria used to define a worst-case discharge from facilities are listed in 33 CFR Part 150, §154.1029. These worst-case discharge scenarios are the best source for assessing the risk of oil spills from facilities. Likewise, vessel response plans require planning for the worst-case discharge from a vessel, defined in §155.1020 as the discharge of the vessel's entire oil cargo in adverse weather. If the facility and vessel response plans are not available, Area Committees should get input from industry participants in the planning process. Other facilities besides storage and transfer facilities should be evaluated for their potential for spills (e.g., shipyards).

The spill history for the area should also be reviewed to help select sites for the spill scenarios. National sources of historical spill data include:

U.S. Department of Transportation Hazardous Materials Information System (HMIS)	Coast Guard Marine Pollution-Marine Safety Information System (MSIS)	EPA Emergency Response Center Notification System
provides location only at the municipality level	provides location by latitude/longitude	tracks spills reported to the National Response Center

State agencies also maintain spill records. All of these possible sources should be investigated because there is no single source that contains all historical spill information. The spill history is used to generate statistics to estimate the average spill size. However, some minimum spill volume should be used to calculate the average spill size. Between 1977 and 1990, the Coast Guard tracked approximately 105,000 oil spills in coastal and navigable waters, including the Great Lakes and inland regions. Ninety-five percent of these spills were less than 1,000 gallons and 74 percent were less than 50 gallons. Because Area Committees focus on planning for larger spills, historical petroleum spills greater than 1,000 gallons should be evaluated in terms of their location, cause, product type, and volume as part of the risk assessment database.
Once all the available information on potential spill sources and historical spills has been compiled, the data should be reviewed to discern trends and devise spill scenarios. Plot the location of potential sources (facilities, pipeline, and rail crossings, for example)

onto maps to identify potential problem areas. Plot locations of past spills onto separate maps to identify spatial patterns. Through such graphical representation of the historical spills and potential sources, the Area Committee can identify and rank high-risk areas. Figures 1 and 2 are examples of two different ways to show the distribution of historical spills, for a bay and a river. Simple statistical summaries of the spill history should be generated by source, oil type, volume, and location. Figure 3 shows a sample plot of the spill size versus number of spills for all spills greater than a minimum volume. Figure 4 shows pie charts for the spilled oil type and cause. Such plots are useful aids in developing appropriate spill scenarios in an area.

Vessel Operating Parameters and Environmental Conditions

Maritime operators familiar with the area, such as harbormasters and pilots, should help evaluate the operational considerations for vessel traffic in the area, to identify hazards associated with the following:

Areas of high currents or wave conditions

Narrow channels with strong tidal currents, river-entrance bars, river crossings, and harbor entrances are sites where tides, waves, and river currents can create conditions hazardous to ship operations.

Congested areas

In congested traffic routes, there is increased risk of collision at the entrances to ports, narrow straits, or under bridges. Risk is often reduced by traffic separation zones or speed restrictions.

Draft constraints

The Area Committee should identify areas where decreased maneuverability of deep-draft vessels could possibly account for an increased risk of spills due to groundings or collisions. Also, zones of shoaling can increase groundings.

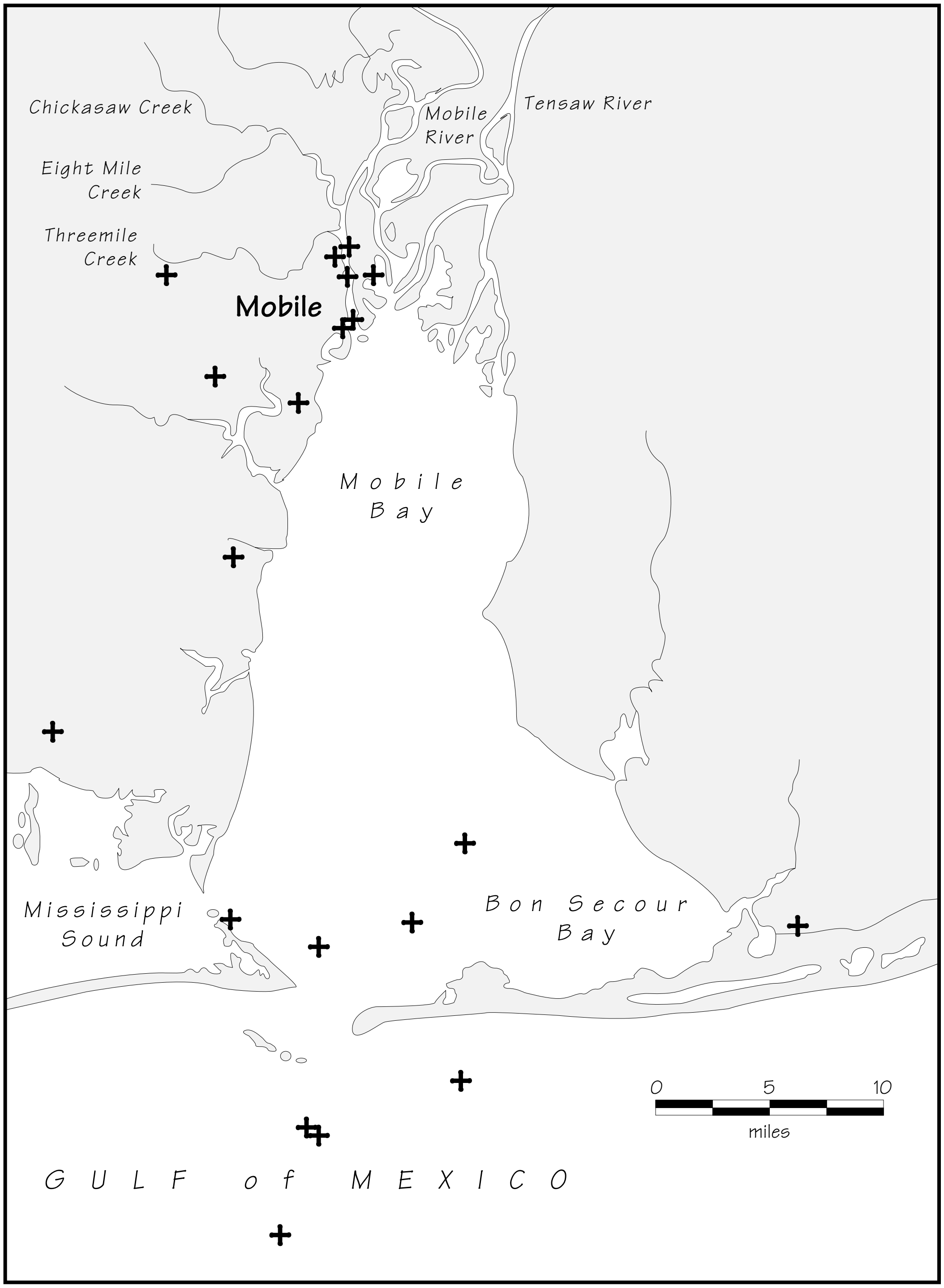


Figure 1. Example plot showing the spatial distribution of spills. Data are for Mobile Bay, for the period 1982-1986 for spills greater than 500 gallons. It can be seen that historical spills tend to cluster in two locations: near the entrance to Mobile Bay and in the harbor. The trajectory and impact of spills in each of these general areas are likely to be very different.

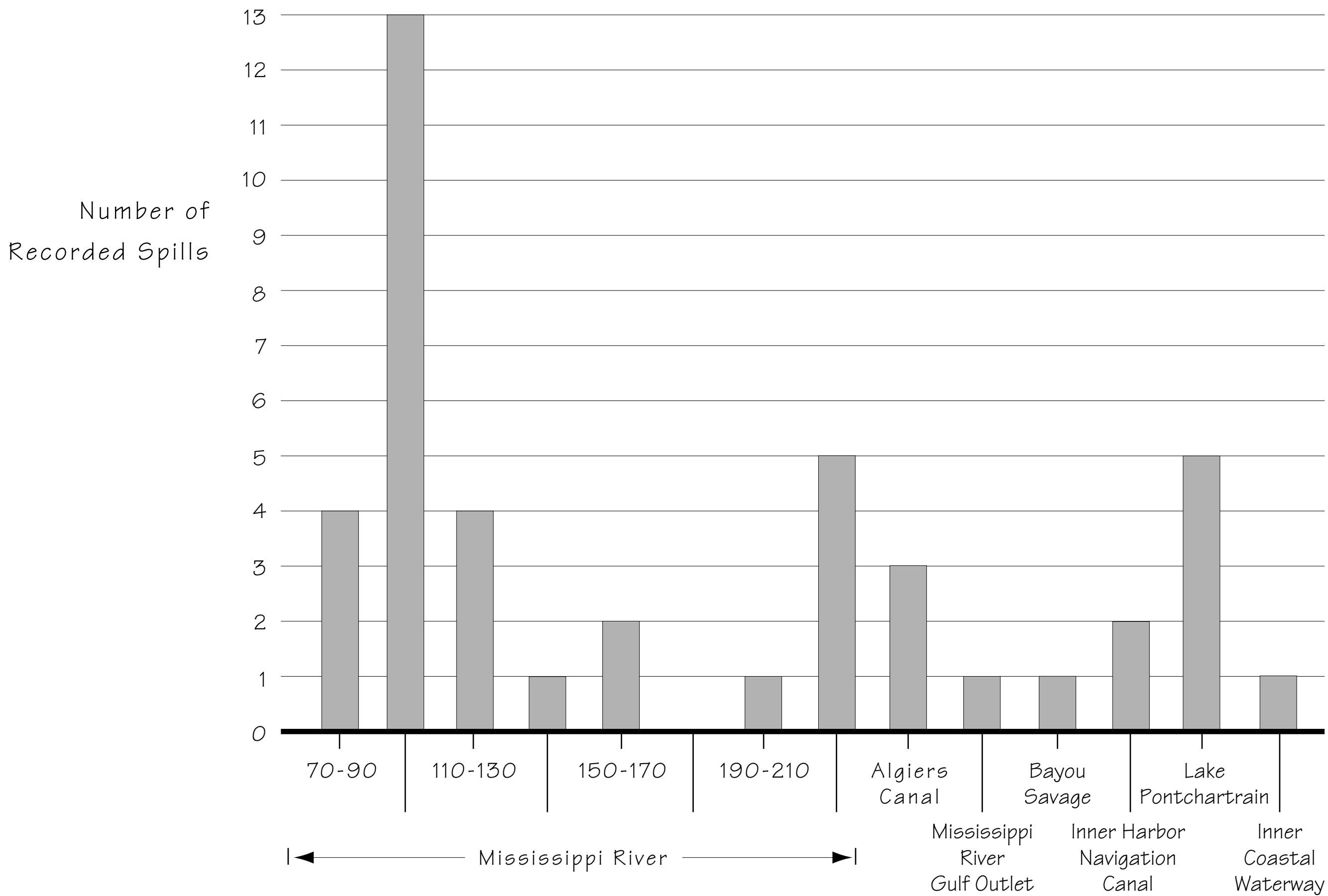


Figure 2. Example plot showing historical spill patterns by river mile. Data are for petroleum spills over the period 1985-1989 along the Mississippi River, from Baton Rouge (river miles 90-110) to the Gulf of Mexico. Based on these data, spills are more common in the river than in adjacent waterbodies, and spills can occur anywhere along the river. There is a higher frequency of spills near Baton Rouge and Lake Pontchartrain. These areas might be considered as sites for the worst-case spill scenario.

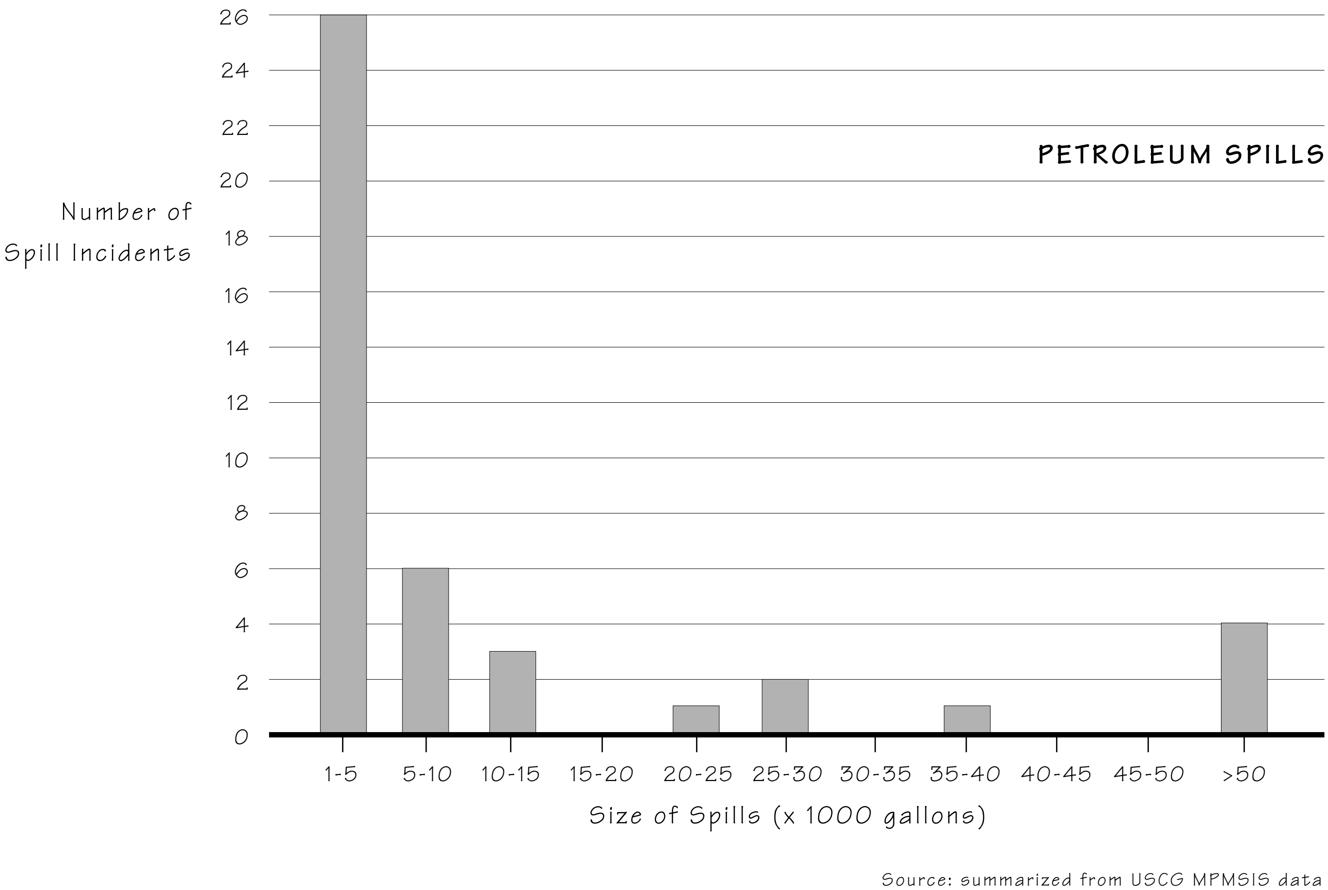
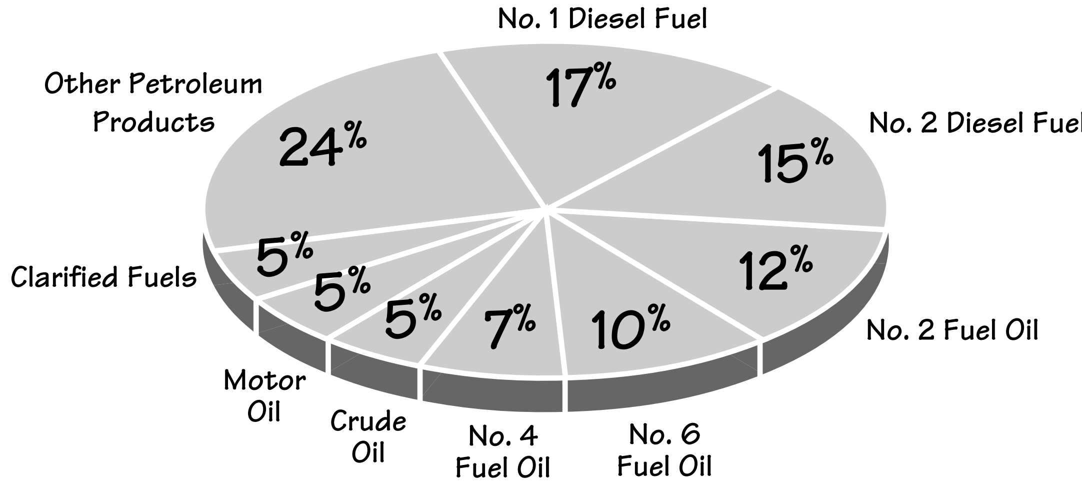


Figure 3. Example plot showing historical spill frequency by size. Data are for petroleum spill incidents greater than 1,000 gallons over the period 1980-1990 for the Philadelphia Captain of the Port zone. Small spills are much more common, and large spills may be more likely to result from a limited number of sources. Both location and size of historical spills should be considered in evaluating the type, amount, and location of protection equipment.

TYPE of PETROLEUM SPILLED



CAUSE of PETROLEUM SPILLS

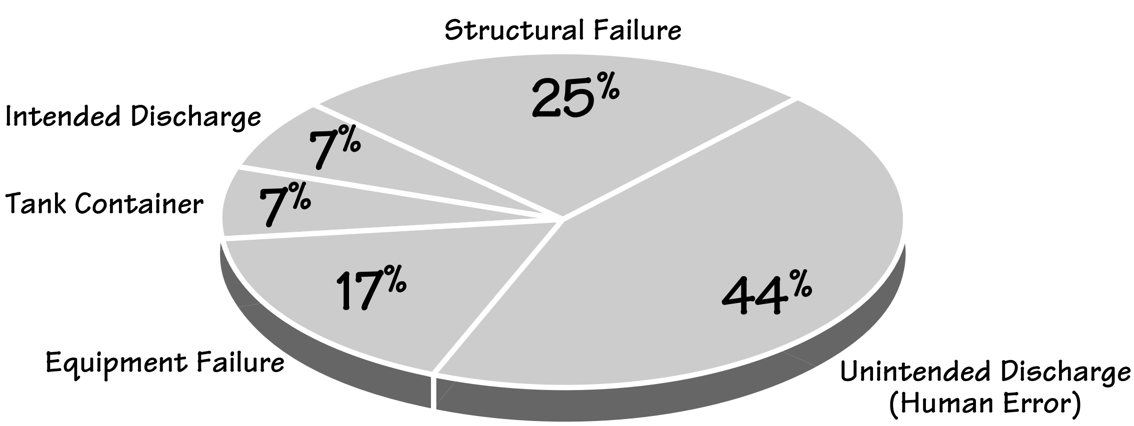


Figure 4. Example pie charts showing spilled oil types and causes (as a percentage of total number of incidents). Data are for petroleum spills greater than 500 gallons for the period 1980-1990. Refined products are more commonly spilled, and lighter products are likely to be spilled, compared with heavy products

.

Bottom substrate

Groundings are more likely to result in a discharge in areas with rocky substrates than in softer substrates such as sand or mud.

Lightering being conducted in the area

Ships carrying oil from other countries often are unable to use U.S. port facilities due to their size or draft limitations. Thus, cargo must be offloaded at sea or in anchorage. This increases the amount of traffic and should be investigated in the zone, even if the lightering area is outside of the designated area boundaries. Bunkering of vessels at anchor from barges is also a potential source of spillage.

Seasonal considerations

Time of the year may dictate the type of cargoes carried (e.g., increased shipments of heating oil in early winter), the priority of sensitive areas, and the type of weather or water conditions expected in a particular geographic region (e.g., low water/floods on rivers, ice, reduced visibility, hurricanes, or winter storms).

Oil Properties Important to Risk Assessment and Planning

The physical and chemical properties of oil greatly affect how it will behave on the water surface, its persistence on the water and when stranded, the degree and mechanisms of toxicity, and the effectiveness of containment and recovery equipment. Some of the most important properties include the following:

Specific gravity is the density of the oil relative to water. Fresh oils with a specific gravity less than 1.00 will float; any oil with a specific gravity greater than 1.00 for fresh water and 1.03 for seawater will tend to sink. While most fresh oils have a specific gravity less than 1.00, spilled oil can reach these higher densities through weathering, emulsification, sorption onto suspended sediments, and incorporation of sediments during stranding on the shoreline. The petroleum industry uses another measure of the gravity of an oil, called "API gravity." An API gravity of 10 is equal to a specific gravity of 1.00. Oils with a high API gravity are lighter, whereas oils with an API gravity below 10 have the potential to sink.

Volatility is an indicator of the amount and rate of loss of the light fractions of a spill through evaporation. Highly volatile oils pose significant explosion and inhalation risks to responders. However, evaporation is a very important mechanism for removing the oil from the water or shore, lessening the amount of oil to be recovered.

Flash point is the lowest temperature of a liquid at which its vapor is given off in sufficient quantities that the vapor/air mixture is in the flammable range.

Viscosity is a measure of the ease of flow, either on the water surface or penetrating into sediments. Kinematic viscosity is measured in centistokes (cSt), with 2,000 cSt considered to be moderately viscous and the point at which dispersants become marginally effective, and 10,000 cSt highly viscous. The kinematic viscosity of diesel fuel at 15°C is about 5 cSt, whereas Bunker C can range from 1,000 cSt and up. Oil viscosity decreases with higher temperatures and increases as a function of weathering. Viscosity is one of the factors to be considered in evaluating dispersant effectiveness and mechanical recovery and entrainment. Pumping of viscous oil can be very difficult and slow, affecting lightering operations

Pour point is the temperature above which the oil will flow. Below this temperature the oil becomes semi-solid, making recovery from the water surface more difficult using standard equipment. The oil congeals into tarballs, produces less sheen, and generates less of a dampening effect on the water surface, making it difficult to keep track of the oil.

Emulsification, the process by which oil is mixed with water, is particularly important, because emulsions can contain up to 70 percent water, tripling the volume of "oil" to recover. Emulsions decrease the recovery rate of many skimmers and the effectiveness of alternative techniques such as in-situ burning. Emulsions weather slowly, so they are more persistent on the water and shoreline. Formation of stable water-in-oil emulsions (mousse) depends on the composition of the oil. Some oils are well known for their tendency to form strong emulsions (Kuwait and La Rosa crudes) or weak emulsions (South Louisiana crude and No. 2 fuel oil).

The *water-soluble fraction* is the component of oil that dissolves in water. As rule of thumb, 1-1.5 percent of the fraction of oil that evaporates has the potential to dissolve in the water. Total aromatic hydrocarbons constitute 35-80 percent of the water-soluble fraction of crude oils. The aromatic fraction is of concern because this fraction has the greatest acute toxicity to water-column organisms.

Oil can be divided into five general types with the following properties:

Group I: Very Light Refined Products (e.g., gasoline, naphtha, solvents, Avgas 80/100)

- Very volatile and highly flammable (flash point near 100°F/40°C);
- High evaporation rates; complete removal by evaporation is likely;
- Low viscosity; spread rapidly to a thin sheen;
- Specific gravity less than 0.80; float on water;
- High acute toxicity to biota; can cause localized, severe impacts to water-column and intertidal resources
- Will penetrate substrate, causing subsurface contamination;
- Recovery usually not attempted because of fire hazards; and
- Exclusion booming of sensitive areas must be completed rapidly.

Group II: Diesel-Like Products and Light Crude Oils (e.g., no. 2 fuel oil, jet fuels, kerosene, marine diesel, West Texas crude, Alberta crude)

- Moderately volatile (flash point varies from 100 to 150°F/40-65°C);
- Light fractions (up to two-thirds of the spill volume) will evaporate;
- Low to moderate viscosity; spread rapidly into thin slicks;
- Specific gravity of 0.80 - 0.85; API gravity of 35 - 45, so slicks will float on the water surface, except under turbulent mixing conditions;
- Moderate to high acute toxicity to biota; product-specific toxicity related to type and concentration of aromatic compounds in the water-soluble fraction;
- Will coat and penetrate substrate; some subsurface contamination;
- Stranded oil tends to smother organisms; and
- Containment/recovery from the water is most effective early in the response.

Group III: Medium Oils and Intermediate Products (e.g., North Slope crude, South Louisiana crude, intermediate fuel oils, lube oil)

- Moderately volatile (flash point higher than 125°F/≈52°C);
- Up to one-third will evaporate;
- Moderate to high viscosity;
- Specific gravity of 0.85 - 0.95; API gravity of 17.5-35;
- Variable acute toxicity, depending on amount of light fraction;
- Can form stable emulsions;
- Will coat and penetrate substrate; heavy subsurface contamination likely;
- Stranded oil tends to smother organisms;

- Recovery from the water and shoreline cleanup is most effective early in the response.

Group IV: Heavy Crude Oils and Residual Products (e.g., Venezuela crude, San Joaquin Valley crude, Bunker C, no. 6 fuel oil)

- Slightly volatile (flash point greater than 150°F/65°C);
- Little product loss by evaporation (usually less than 10-15 percent);
- Very viscous to semi-solid; may become less viscous when warmed in sunlight;
- Specific gravity of 0.95 - 1.00; API gravity of 10 - 17.5; so slicks will float initially and sink only after weathering or incorporating sediment;
- Low acute toxicity relative to other oil types;
- Form stable emulsions;
- Little penetration of substrate likely;
- Stranded oil tends to smother organisms; and
- Recovery from the water and shoreline cleanup difficult during all stages of response.

Group V: Very Heavy Residual Products

- Very similar to all properties of Group IV oils, except that the specific gravity of the oil is greater than 1.0 (API gravity less than 10). Thus, the oil has a greater potential to sink when spilled.

OPA 90 Spill Scenario Requirements

Area Committees are required to develop three oil-spill scenarios to prepare their response strategies:

Most probable discharge: This scenario is based on the size of the average spill in the area. When determining the most probable discharge, any unusually large spill that would skew the value should not be included when calculating the average. Alternatively, the median rather than the mean spill volume could be used. The most probable type of spilled product can also be determined from the spill history. Product type is particularly important in determining the persistence of spilled oil and the effectiveness of recovery strategies. The spill history should be evaluated to determine if there are temporal trends (e.g., decreasing spill volumes since change of a power plant from oil to natural gas) that should be factored in.

Maximum most probable discharge: This scenario is based on the largest recorded spill size for the area. The maximum most probable discharge will take into account such factors as the size of the largest recorded spill, traffic flow through the area, hazard assessment, risk assessment, seasonal considerations, spill histories, and operating records of facilities and vessels in the area. The spill histories (including potential spills) are particularly important in identifying likely spill locations and type of product likely to be spilled, unless there have been major changes in petroleum transportation patterns in the area.

Worst-case discharge: For vessels, this scenario is based on discharge of the vessel's entire cargo; for facilities, the largest foreseeable discharge; for both vessels and facilities, catastrophic product loss under adverse weather conditions.

These spill-planning scenarios can be a useful test of mechanical protection plans, especially where oil spill trajectories are available for specific scenarios. These trajectories can be used to estimate the location of likely shoreline impacts and the associated protection strategies. They can also be used to help select equipment-staging areas. Oil trajectories can be determined using the output of NOAA's On-Scene Spill Model (OSSM), models run by other groups, or simple calculations based on average currents and wind conditions for the scenario.

Delineating Sub-Areas

Most planning areas are large and include diverse habitats, resources, likely spill sources, and trajectories. Thus, to facilitate prioritizing, most Area Committees subdivide their Areas into logical risk sub-areas and some develop Geographical Response Plans for these sub-areas. These sub-areas should be delineated based on the likely spill sources, analysis of the short-term trajectory under both typical and worst-case conditions, and nature of the sensitive areas to be protected. With smaller sub-areas, it is easier to rank sensitive areas and identify optimum locations for staging of equipment. Even large bays can be divided into separate sub-areas, particularly if there are distinct differences in oil spill risk, likely source of a spill, circulation patterns, and the distribution or type of sensitive resources.

Identifying Sensitive Resources

Resources are considered sensitive to oil spills because they are: 1) of environmental, economic, or cultural importance; 2) at risk of coming in contact with spilled oil; and 3) likely to be affected once oiled. Sensitive resources can usually be identified using existing databases of oil sensitivity for aquatic and marine resources developed from many case histories and extensive research. However, setting protection priorities requires value judgments and difficult trade-offs by the Area Committee, a group with its own diverse interests and values.

For planning purposes, sensitive resources potentially at risk from oil spills can be divided into three categories:

- Habitats
- Fish and wildlife resources
- Human-use resources

Table 1 lists the sub-categories of resources that have been found to be most sensitive to oil spills. For shoreline habitats, many Area Committees use the shoreline rankings on Environmental Sensitivity Index (ESI) maps to identify habitats and assign a priority classification. The ESI ranking is based on the physical and biological character of the different coastal types, which in turn control the persistence of stranded oil, severity of impact, and ease of cleanup. Table 2 lists the ESI rankings for all shorelines throughout the U.S. The highest-priority habitats generally include vegetated wetlands (ESI=10) and tidal flats (ESI=9). Lowest priority includes the high-energy shoreline habitats (ESI=1 and 2). Of the beaches, gravel beaches are ranked highest because of the likelihood of deep penetration, difficulty of cleanup, and long-term persistence. Subtidal habitats, such as coral reefs and seagrass beds, are deemed sensitive when they are used by oil-sensitive species or are themselves sensitive to oil spills. A detailed discussion of the basis for habitat sensitivity rankings is provided in NOAA (1992, 1993).

Table 1. Sensitive biological and human-use resources.

Resource Category	Sub-Category	Comments
Habitats	Shoreline types	ESI or other geomorphological class
	Submerged aquatic vegetation	All types of subtidal grass beds
	Kelp beds	
	Coral reefs	
	Worm beds	
Fish and Wildlife Resources		
Marine Mammals	Whales	Seasonal use areas; migration routes
	Dolphins	Population concentration areas
	Sea lions	Haulouts
	Seals	Haulouts
	Sea otters	Population concentration areas
	Manatees	Population concentrations areas
	Walruses	Haulouts
Terrestrial Mammals	Water-associated species (e.g., otter, beaver, mink)	Concentration areas
	Endangered species	Important habitats, as identified by resource agency
Birds	Waterfowl	Nesting/concentration areas; wintering/migration areas
	Seabirds	Rookeries; wintering concentration areas
	Shorebirds	Nesting sites; migration stopover sites; wintering concentration areas
	Wading birds	Rookeries; important forage areas
	Gulls/terns	Nesting sites
	Raptors	Nest sites; important forage areas
	Other migratory species	Nest sites; important migration stopover sites; wintering concentration areas
	Endangered species	Important habitats, as identified by resource agency
Fish	Anadromous fish	Spawning streams
	Beach spawners	Spawning beaches
	Nursery areas	Areas for all nearshore species; areas of unique concentrations
	Endangered species	Important habitats, as identified by resource agency
Shellfish	Mollusc	Seed beds; leased/abundant beds
Crustaceans	Shrimp	Nursery areas
	Crabs	Nursery areas; high concentration sites
	Lobster	Nursery areas; high concentration sites

Table 1. Sensitive biological and human-use resources, cont.

Data Element	Sub-Element	Comments
Reptiles/Amphibians	Water-associated species (e.g., sea turtles, alligators)	Nursery areas; high concentration sites
Plants	Endangered species	Important habitats, as identified by resource agency
Human-Use Resources		
Recreation	Beaches	High-use recreational beaches
	Marinas	
	Boat ramps	
	Diving areas	
	Boating/fishing	High-use recreational areas
	State parks	
Management Areas	Marine sanctuaries /national parks	
	Wildlife refuges	
	Preserves/reserves	Areas of special biological concern
Resource Extraction	Subsistence	Designated subsistence harvest sites
	Commercial fisheries	Concentration areas
	Water intakes	Industrial; drinking water; irrigation
	Aquaculture sites	Water intakes/pens/ponds
	Other resource extraction sites (e.g., log storage)	
Cultural	Archaeological sites	
	Native lands	Culturally important sites/reservations
	Historical sites	Water-associated sites

For fish and wildlife resources, the emphasis is on habitats where:

- Large numbers of animals are concentrated in small areas, such as bays, where waterfowl concentrate during migration or overwintering;
- Animals come ashore for birthing, resting, or molting, such as marine mammal haulouts and pupping areas;
- Early life stages are present in somewhat restricted areas or in shallow water, such as anadromous fish streams and turtle-nesting beaches;
- Habitats are very important to specific life stages or migration patterns, such as foraging or overwintering;
- Specific areas are known to be vital sources for seed or propagation;
- The species are on Federal or state threatened or endangered lists; or
- A significant percentage of the population is likely to be exposed to oil.

Human-use resources of concern are listed as the last four elements in Table 1. Areas of economic importance, like waterfront hotels, should also be considered when establishing resource protection priorities. Human-use resources are most sensitive when:

- Archaeological and cultural sites are located in the intertidal zone;
- Oiling can result in significant commercial losses through fouling, tainting, or avoidance because of public perception of a problem;
- The resource is unique, such as a historical site; or
- Oiling can result in human health concerns, such as tainting of water intakes and subsistence fisheries.

Table 2. Summary of the various ESI ranking scales used throughout the United States, ranked from least (ESI = 1) to most (ESI = 10) sensitive.

ESI No.	Shoreline Type
1	Exposed rocky cliffs
	Exposed vertical seawalls made of concrete, wood, or metal
2	Exposed wave-cut platforms in bedrock
	Scarps in clay with associated wave-cut platforms
	Exposed bluffs in unconsolidated sediments with associated wave-cut platforms
3	Fine-grained sand beaches
4	Coarse-grained sand beaches
5	Mixed sand and gravel beaches
	Mixed sand and shell beaches
6	Gravel beaches
	Riprap
7	Exposed tidal flats
8	Sheltered vertical rocky shores
	Sheltered bedrock ledges
	Sheltered rubble slopes
	Sheltered solid man-made structures, such as bulkheads
9	Sheltered tidal flats
	Sheltered low banks
10	Salt-water marshes
	Fresh-water marshes (herbaceous vegetation)
	Fresh-water swamps (woody vegetation)
	Mangroves

Many references can be used to identify sensitive resources, including ESI atlases, state and Federal resource inventories, resource management plans, and Environmental Impact Statements. ESI maps have been prepared for the entire U.S. coastline; these maps show the distribution and seasonality of oil-sensitive fish and wildlife, human-use resources, and shoreline sensitivity, mostly on U.S. Geological Survey 7.5-minute topographic maps. State and local resource management plans for specific areas can provide detailed information on the size or relative importance of local populations, which is critical when assigning protection priorities. The knowledge of local resource managers is particularly important to include, since they often have access to unpublished data and are intimately familiar with the area's resources.

Prioritizing Resources at Risk

Establishing site-specific resource protection priorities is a very difficult but critical task. Effective response during the early hours of a spill is essential to reduce the potential spill damage. First responders must be able to deploy protection equipment immediately after a spill occurs. When protection priorities are established and tested in advance, response times can be significantly reduced.

The specifics of a particular spill and the temporal and spatial variations in important resources can alter protection priorities. Once local resource experts are activated during a spill, they can fine-tune pre-established protection priorities. Valuable time is lost, however, if you do not establish initial priorities in advance.

Resource priorities are usually divided into three classes, as follows:

A = Highest priority: protect first
B = Protect after A areas
C = Protect after B areas

Each Area Committee may have a different set of criteria for ranking its sensitive resources. Resource prioritizing is an iterative process, best achieved through open discussion and consensus-building among all interested parties before a spill. It requires considering a wide range of factors, including resource value, likelihood of the resource coming in contact with oil under the spill scenarios, and the relative duration of impact.

Assuming that all the resources being considered are sensitive and valuable, the prioritizing process should address those likely to be oiled, that is, those that have a high risk of exposure. Often, there are highly sensitive resources in locations that are not likely to be threatened from an oil spill (e.g., above annual high-water levels; not directly connected to an open water body where spills are likely; inland eagle nests). These areas might be listed with a lower priority for protection in the plan, even though they are highly sensitive.

The relative ability of the resource to recover once oiled is another important prioritizing guideline. Generally, resources are considered sensitive if they are likely to endure long-term impacts resulting from exposure to oil spills. Therefore, when prioritizing sensitive resources, those that are likely to require longer periods of recovery should receive a higher rating. For example, sheltered, interior marshes that have little exposure to natural removal processes should have higher priority than more exposed marshes. Species that are already stressed by other factors or are undergoing long-term declines should also have a higher priority.

Ranking criteria can include relative size, number of individuals present, and importance to the resource or local population as a whole. Sometimes these rankings can be numerically defined. For example, a major harbor seal haulout (priority A) would be those sites with more than one hundred animals typically present. Alternatively, major resources can be defined as those representing a percentage of the local resource, such as the anadromous streams that contribute to the majority of the annual escapement. Finally, characteristics of priority areas would include those that serve numerous functions in the natural community. For example, a wetland area may serve as a nursery for fish, as habitat for endangered species, and be heavily used by birds. These areas provide excellent quality in the ecosystem. However, for many resources, there is no quantitative basis for ranking. In these cases, the knowledge and expertise of the resource managers form the basis for these value judgments.

The priority of a site can change seasonally, because of changes in the distribution of natural resources or their sensitivity. In particular, seasonal sensitivity will vary with the presence of large concentrations of migrating or overwintering birds, or when early life stages are in shallow waters or concentrated in susceptible habitats, such as intertidal spawning beds. Such seasonal influences on site priority include:

Presence/absence of sensitive animals. In areas where the habitat is not particularly sensitive, such as open water or rocky shores, protection priorities will be a function of when the animals are present. For example, waterbodies that can contain large numbers of migratory waterfowl would be sensitive only during migration periods, and, in the event of a spill, only if the waterfowl were actually present or soon to arrive.

However, if the habitat is susceptible to long-term impacts, the site may keep its priority. For example, some anadromous fish spawning habitat is sensitive even when the adult fish are absent and there are no eggs or larvae present, because contamination is likely to persist and affect the value of the habitat.

Life history of the sensitive resources. Early life stages are usually the most sensitive to oil spill impacts, both directly and indirectly. Nesting adult birds can survive light oiling but even small amounts of oil will greatly reduce egg-hatching success. Also, response disturbances, such as foot and equipment traffic, can drive parents from the nesting area, leading to nest abandonment or hatchling starvation. Thus, site priorities may increase when eggs or young are present.

Habitats do not usually show strong seasonal differences in sensitivity. Wetland vegetation is more likely to be affected if oiled during the growing season, but the seasonal differences are not large enough to change the protection priority on the basis of the vegetation alone. However, the likelihood of being oiled can vary seasonally, e.g., ice protection of shorelines or isolation of an area during low-water periods.

The prioritizing process consists of the following activities. First, the sub-committee working on resource priorities should prepare lists of the types of resources to be considered under each priority ranking. (Use the list of resources in Table 1 as a start.) Update these initial lists throughout the process, so that the final list for each priority can be included in the area plan.

Second, the sub-committee needs to compile information on the distribution of sensitive resources, management status, location of critical habitats for species of concern, habitat quality, and habitat use by sensitive resources. Using maps and resource information, identify and locate sensitive areas on an overview map. Give each site a number and use a worksheet similar to that shown in Table 3 to record available information on the site. All resources can be mapped together, or separate workgroups can be formed to address different groups, e.g., fish/shellfish, birds, or mammals. At the end of this step, locate all of the sensitive resources on maps, and summarize on a worksheet the specific sensitive resources present and to be protected. Sites with multiple resources and functions should become obvious. Guidelines should emerge as to the important considerations in setting protection priorities in the area. The workgroup should write down these candidate guidelines for prioritizing as they are proposed.

Third, in addition to the fact that the resource is sensitive, two other factors are extremely important in setting priorities: the likelihood that the resource will be impacted during an oil spill and the duration of the impact. Likelihood of impact is a function of the following: geographic position of the resource relative to likely spill sources/trajectories; position relative to the water surface and intertidal zone, inasmuch as most oils float or come ashore along the high-water line; and percent of time spent on the water surface or exposed during low water. For example, seaducks are usually more susceptible to oiling than dabbling ducks, because dabbling ducks are usually concentrated in shallow ponds that are not directly connected to open water; and subtidal seagrass beds are much less susceptible than intertidal wetlands. The likelihood of impact can be ranked on a relative scale, such as:

- Low: Resource present in water depths greater than ten meters, on land above the normal spring high tide level, or in isolated waterbodies.

- Medium: Resource present in water depths of one to ten meters, spends most of its time away from the water, or in locations which oil slicks from likely spill scenarios will take one to two days to reach.

- High: Resource present in the intertidal zone, spends most of its time on the water surface, or is located in close proximity to likely spill sources.

The likelihood of direct impact of the resources at each site is described on the worksheet, including the reason for each ranking.

Another consideration in setting protection priorities is the ability of the resource to recover once oiled. Although difficult to quantify, resource recovery can be ranked on a relative scale for the resources in the area or sub-area. Duration of impact is a combination of both persistence of oil in a habitat and the ability of the resource to recover once the oil effects are gone. Thus, areas exposed to physical processes that speed natural removal of oil from the habitat usually have shorter impacts than those sheltered from such processes. Also, certain types of resources can recover more quickly from the acute toxic effects of exposure (e.g., phytoplankton) than other resources (e.g., 20 years for a mangrove forest to grow to maturity). A recommended ranking system for living resources is listed below. A different ranking will be required for non-living resources, such as cultural resources.

Table 3. Worksheet for identifying priority protection sites.

Site No.	Site Name	Specific Sensitive Resources	Likelihood of Direct Impacts	Seasonality				Duration of Impact	Res Pri	Other Considerations
				Sp	Su	F	W			

- Low: Resource restabilizing or repopulating will likely occur within six months.
- Medium: Resource restabilizing or repopulating will take 6-12 months.
- High: Resource restabilizing or repopulating is likely to take more than 12 months.

The seasonal distribution of the resource is very important information, particularly if it may change the protection priority of a site or resource. For example, a site may be of high priority only during winter months, when large flocks of overwintering waterfowl are present or only during summer months in areas of high recreational use. Other sites will be of high priority year-round. Document on the worksheet any seasonal changes in site sensitivity, or in the likelihood or duration of impact.

Other considerations for the resource that would affect the priority ranking might include overall quality of the habitat and its potential to serve as a source for recruitment and recolonizing (e.g., seed beds in a large shellfish-producing area), public use, or some unique feature of the habitat that makes it more sensitive than similar habitats.

All of the data collected and recorded up to this point are used to reach consensus on the initial priority of each sensitive area, which is recorded on the worksheet and encoded on the maps. Maps are very important tools that can assist in the prioritizing process. Maps of sensitive areas color-coded by protection priority identify problem areas, potential inconsistencies, and missed sites. Stretches with large numbers of "A" priority sites should be re-evaluated to refine the rankings. Protection methods or feasibility should not be a factor in ranking at this time; the ranking should be based strictly on resource sensitivity. Detailed maps will be needed in the final plan to show the location of priority areas (as discussed in Section 5). However, a larger overview map of each area or sub-area is much more valuable during prioritization to show spatial patterns and omissions. These overview maps can be used during the final prioritizing process when specific protection methods are recommended for each site.

It should be noted that, during actual spill events, the priority of a site does not change except for when the resource manager determines that the sensitive resource to be protected is not present (e.g., the waterfowl have already migrated). Even if an "A" priority site is not in the threat zone of a spill, it still remains an "A" site. However, only those sites likely to be impacted by the oil spill are to be protected.

Existing methods and technology used in protecting resources from oil spilled on the water are based on three principles:

1. Oil has a density less than water and floats. Under turbulent conditions, the oil can be physically dispersed in the water column and not exist as a surface slick;
2. Oil has properties that attract it to some materials and displace it from others; and
3. Oil is a compound that undergoes rapid changes once spilled into water. Evaporation, dilution, and emulsification can rapidly change oil properties, requiring different methods of shoreline protection and recovery as the spill progresses.

The three principles of mechanical protection are containment, deflection, and exclusion. *Containment* consists of deploying a boom or other barrier to hold the oil in place, with oil recovery the main objective. *Deflection* consists of diverting moving oil either away from a sensitive area without any attempt to recover the oil at that site, or toward a containment site where recovery of the oil is more feasible. *Exclusion* consists of placing either temporary or permanent barriers to prevent oil from reaching an area; usually there is no attempt to recover the oil.

Recovery is the actual removal of the oil, which is achieved by skimmers, sorbent material, and manual pick-up. All spills require a combination of methods, technologies, and tactics to minimize or eliminate the threat. Each method has its limitations and must be employed within certain criteria or operational guidelines.

This section includes a brief discussion of mechanical shoreline protection methods, limitations in their use and performance, general protection tactics, oil recovery methods, alternative protection methods, and guidelines for selecting protection methods for specific physical settings.

Shoreline Protection Methods

Shoreline protection technology has not greatly changed or improved over the last ten to fifteen years. The basic methods are open-water recovery, floating booms, and solid barriers. Each of these is briefly described below.

Open-Water Recovery

Open-water recovery includes using skimmers on oil slicks and netting systems for tarballs and highly viscous oils. Skimming of uncontained slicks can consist of either self-propelled skimming vessels or towed skimmer units. Storage capability and time needed to offload are very important considerations in determining the effectiveness of oil recovery by skimmers. Historically, skimming efforts have recovered only 10-30 percent of the spilled oil. Skimming systems employing winged or towed booms increase the encounter rate with oil and improve overall collection of the oil. Frequently, skimming is the only option in areas with very strong currents and water too deep to anchor booms. Skimmers are most effective on thick slicks or areas such as convergence zones where the oil tends to accumulate in thicker concentrations. If the spilled oil emulsifies, skimmer performance usually decreases significantly.

In areas of shallow water or strong currents, it may be possible to collect or corral the oil and bring it to deeper water or low-current areas that have better skimmer access and higher recovery rates. Towing speeds of the corralled oil must not exceed 0.7 knots; otherwise, the oil will be lost by entrainment under the boom. Towing should be with the direction of the current to reduce the relative speed of the oil and boom through the water.

For spills where the oil is highly viscous or has formed tar balls, netting systems may enhance oil recovery. Using technology adapted from the fishing industry, a net is either moored or towed, allowing the oil to be collected and recovered.

Booms

Boom deployment is by far the most common method of protection. Booms are essentially devices placed on the water surface to form a floating barrier to oil slicks. All booms are manufactured using five elements: flotation, skirt, ballast, longitudinal strength member, and connector/anchoring points (Figure 5).

The flotation system provides buoyancy to keep the boom afloat. The freeboard is the above-water area that prevents oil from splashing over the top. In many booms, the flotation system and freeboard are combined. The skirt provides the area below the water's surface (draft) to prevent or limit oil passing under the boom. Combined, the freeboard and skirt comprise the barrier that prevents or reduces oil passage. Ballast weights maintain the boom in as near-vertical position as possible. The longitudinal strength member is the element that allows long sections of boom to be deployed without separation, normally by using high-strength boom material, chain, or wire rope capable of withstanding loads created by currents, wind, towing, and positioning of the boom. The last element is the connector and anchor points, which allow anchoring of the boom or connection to another length of boom. Booms are usually fabricated in 50 to 100-foot sections and need to be connected into the appropriate lengths. It should be noted that the many different kinds and brands of boom on the market do not always have compatible connections.

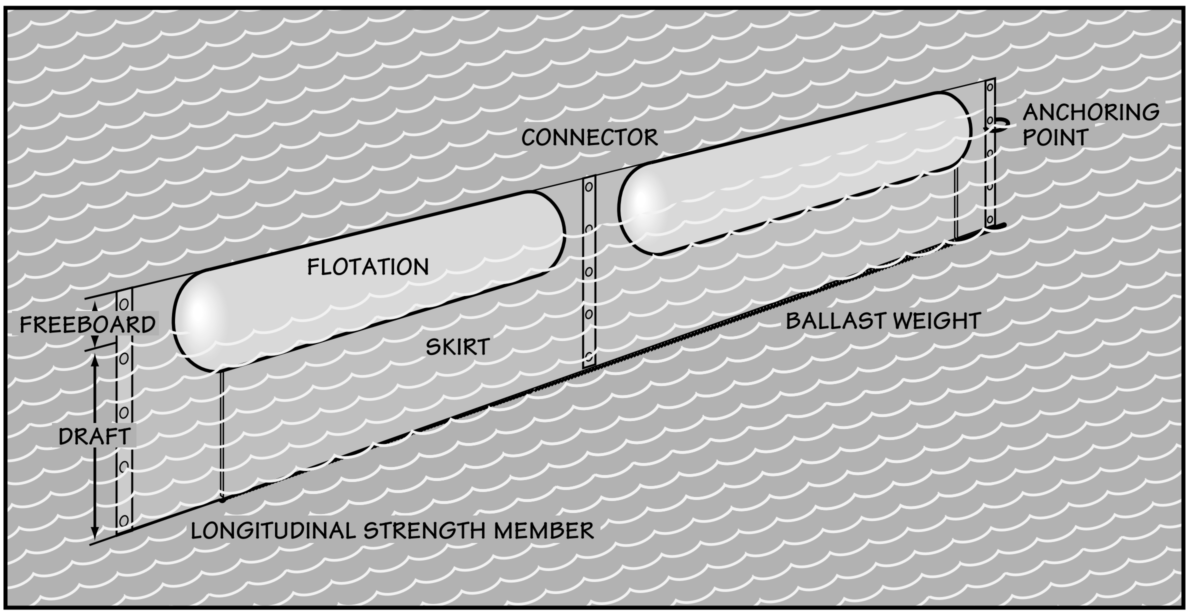


Figure 5. Major elements of standard boom.

Boom is manufactured for many different applications, and in many different shapes and sizes. There are four basic application types: shallow-water boom, inland or river boom, harbor boom, and open-water boom. The specifications for each are listed below and briefly discussed in the following sections. When booming, bigger is not always better; the larger the boom, the more it will be subject to currents and wind. Sorbent boom is also discussed, although it is generally not used as a stand-alone barrier to oil. Although not discussed here, there are also special-purpose booms such as fire boom for in-situ burning and fence boom for more permanent installations. Collected oil should be removed as soon as possible to prevent entrainment and loss of oil. Additionally, boom plays an important role in recovery operations where skimmers are used.

BOOM SIZE CHART

SERVICE	FREEBOARD (inches)	DRAFT (inches)	SEA CONDITION wave height
Shallow-water	0 and above	< 6	calm
Inland/river	4-10	6-12	< 1 foot
Harbor/Great Lakes	10-18	12-24	< 3-4 feet
Open-water	> 18	> 24	< 6 feet

Effective boom deployment depends on many factors, including working with shorter lengths of boom that are more manageable; positioning the boom correctly during the first attempt; and sealing the shoreline end of the boom so that the oil cannot get past at high water or under the boom when a gap forms between the boom and water surface, such as on a steep river bank or beach on a falling tide. Once deployed, boom must be regularly maintained, including checking for wear and tear, ensuring that anchor lines are secure, repositioning anchors where there is excessive boom deformation, and repositioning the boom when currents change or the boom is ineffective.

Shallow-water Boom

Shallow-water boom is designed for deployment in very shallow water where traditional boom may foul on the bottom during low water levels. This boom's special features allow it to conform to the substrate, so that it can continue to act as a barrier to oil during changing tides or lower water levels. Some use ballast tubes that are filled with water and actually can lay on the bottom to provide a seal against oil passage (Figure 6). Shallow-water boom is also effective in higher-current areas because the shallow skirt minimizes the drag in the current. Shallow-water boom is also known as "Texas boom," or "intertidal boom."

Inland Boom

Inland boom is the smallest conventional boom and is designed for deployment in very shallow water; note that the draft is only 6-12 inches. It is normally deployed in more protected waters where there is little to no wave action.

Harbor Boom

Harbor boom is medium-sized boom that has a deeper draft than does inland boom, but still requires protected waters where wave heights or wind conditions do not cause splashover. Often, it is difficult to estimate whether actual site conditions will be calm enough to deploy this type of boom.

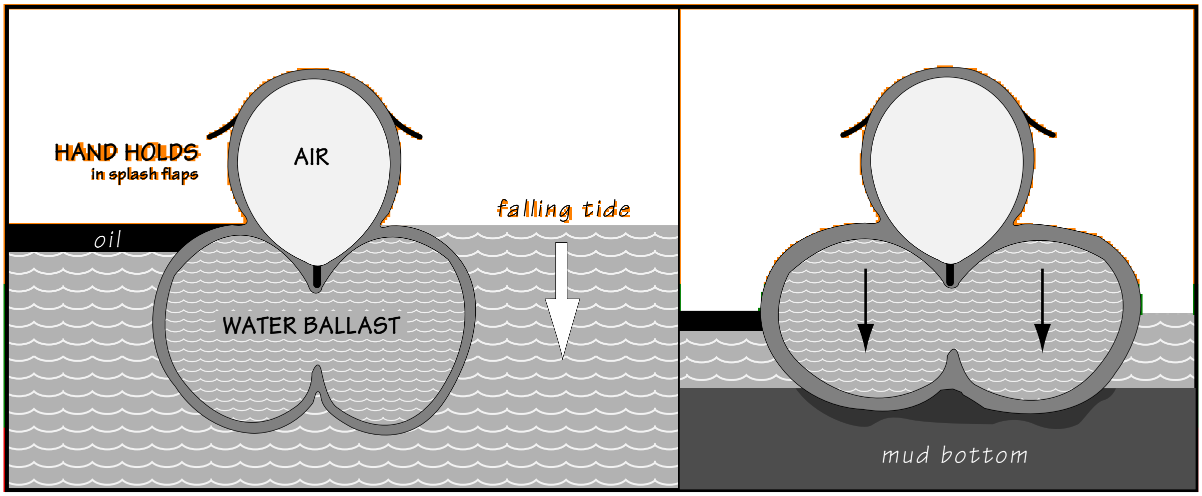


Figure 6. Cross-section sketch of one type of shallow-water boom.

Open-water Boom

Open-water boom is the largest of all boom and required in any offshore situation or when prevailing sea conditions dictate maximum protection. This boom size requires mechanical equipment for deployment, boats to position or maintain the boom, and multiple anchors for proper positioning. These booms are capable of generating very high loads when moored in even moderate currents, requiring substantial support vessels and highly skilled personnel.

Sorbent Boom

Sorbent boom is designed primarily to absorb or adsorb oil although it can act as a protective measure against thin oil sheens under very quiet water conditions. Circular sorbent boom (also called "sausage" boom) readily rolls over in any current, making it an ineffective barrier to flowing oil. Sausage booms are most effective with low-viscosity oils, such as diesel fuel. Snare boom (pom-poms tied onto a line) is effective as a sorbent of more viscous oils under higher wave and current conditions. In any current, sorbent boom can contain only the thinnest sheens. It can be used alone to keep sheens away from marshes and tidal flats where water depths are too shallow for booms. When used with conventional boom, sorbents can be placed outside of the boom to pick up small amounts of escaping oil (primarily sheen), or inside the boom to sorb small amounts of contained oil.

Solid Barriers

Solid barriers are structures constructed across a feature to prevent oil and/or water passage. They can be permanent structures, such as flow gates or locks, or temporary structures, such as dams or trenches. It may be necessary to allow for water passage, depending on the water flow rates and volumes or downstream water needs. In general, solid barriers are most effective where the area to be protected is narrow with low water volumes and currents, such as small streams and creek mouths.

Earthen Barriers or Berms

Earthen barriers or berms are built across sensitive areas to prevent entry of contaminants or to divert oil toward collection areas for containment and recovery. An earthen barrier placed across a sheltered beach or ephemeral tidal inlet will provide good protection; they are less effective where wave activity or strong currents can erode them. Methods of water passage or circulation, such as pumps, may have to be developed to maintain water quality (e.g., dissolved oxygen, temperature) or minimum flow volumes when the barrier cuts off water flow or exchange.

Dams (Underflow and Overflow)

A dam is an earthen barrier with a mechanism that allows for passage of clean water while containing the oil. An underflow dam allows water to flow through the bottom of the dam and floating oil to accumulate on the water surface behind the dam. Piping is normally run under or through the dam to let clean water through. Because low water volume is the most critical factor in selecting underflow dams, this method is only effective in small creeks.

Overflow dams are designed to generate a low-flow pool of water behind the dam, making it easier to divert and recover the oil. They are effective with larger volumes of water because the water does not have to flow through restricted piping.

Improvised Barriers

Improvised barriers have been developed out of necessity and the ingenuity of response personnel when more traditional methods were not available. These barriers can take any shape or form and can be made with anything, ranging from chain-link fencing with hay bales to fishing nets strung out with lumber or boards as the fence. Booms have been made out of logs in some areas. Improvised barriers are most commonly used along small creeks in inland areas.

Trenches

Trenches may be used to hold or divert oil temporarily to an area to prevent it from contaminating a more sensitive site. Trenches can be dug at rivers' edges to divert oil to containment areas. Trenches placed near the high-tide line along sheltered beaches and exposed tidal flats can trap the oil. However, they should not be used on exposed beaches because they will fill with sand and heavily contaminate sediment. If there is time, trenches should be lined to prevent sediment and groundwater contamination.

Flow Gates/Tide Gates

Various waterbodies may have flow gates to control water movement. Flow gates may be manipulated to decrease water currents in selected channels so that booms and skimmers are more effective; contain oil within a drainage boundary by temporarily closing the gate; keep oil from being transported into sensitive areas, especially in tidal areas where tide gates are common; and divert oil to a less sensitive area.

Locks

Locks are permanently installed in many river and lake systems to allow the passage of vessels. When closed, locks may be considered the ultimate boom because they effectively block the passage of oil and debris. However, closing locks also means stopping vessel traffic, which may provide an additional operational problem.

Other Mechanical Protection Measures

Air and Water Streams

Air and water streams may be used to herd or push floating oil toward recovery devices or away from sensitive sites. This technique is not considered a primary protection method but is a tool to enhance collection. Plunging water jets are used to create an oil barrier and are particularly effective in high-current areas. Plunging water jets incorporate high-pressure, high-volume water directed perpendicular to the direction of oil flow.

Bubble Barriers

Bubble barriers use air bubbles rising to the surface to cause a counter-current at the water's surface. Perforated piping installed along the bottom carries the forced air. A bubble curtain is generated as the air rises to the surface. This method is only effective in protected areas or harbors where there is limited current, and may be used where obstructing traffic is a concern.

Shoreline Protection Limitations

Limitations to the use and performance of shoreline protection methods can be divided into three general categories: properties of the spilled product, physical and environmental conditions, and logistical constraints.

Spilled Product Properties

The properties of the spilled product will influence the selection and effectiveness of methods for shoreline protection. Response plans for very light refined products such as gasoline may consist primarily of short-term protection strategies of sensitive areas until the product completely evaporates. They must also take into account explosion potential, human health, and environmental toxicity. In contrast, a heavy fuel oil spill is more likely to reach shorelines and to require strategies for long-term cleanup. Medium crudes tend to emulsify into a viscous fluid, making the oil difficult to pick up with standard types of equipment.

Physical and Environmental Conditions

Physical and environmental conditions control the feasibility of mechanical protection methods. Area Committee members need to evaluate how these conditions will affect the selection, deployment, and performance of protection strategies at each site.

Current

Strong currents are probably the greatest single limitation to the effectiveness and performance of most protection strategies. Oil on the water surface will move at the same velocity and direction as the current. Where floating oil being transported by a current encounters a boom placed perpendicular to the current, the oil begins to accumulate against the freeboard area of the boom. If the current velocity or towing speed normal, or perpendicular, to the boom is over 0.7 knots, the oil that has accumulated against the boom may pass under it. This is called "entrainment." Fast currents may also cause oil to splash over the boom top. In most coastal settings, currents are caused by tidal changes whose alternating directions also complicate boom deployment.

Figure 7 shows the deployment angle of the boom required for increasing current velocities. These angles result in an effective current velocity at the boom of less than 0.7 knots. In most channels subject to currents, boom should not be placed straight across the channel, perpendicular to flow. Even where currents are relatively weak, oil will collect at a pocket in the boom that usually forms in the middle of the channel, the area of strongest flow (in straight channels). In most cases, the oil should be deflected to the shoreline where it can be more easily recovered.

BOOM ANGLES FOR VARIOUS CURRENTS

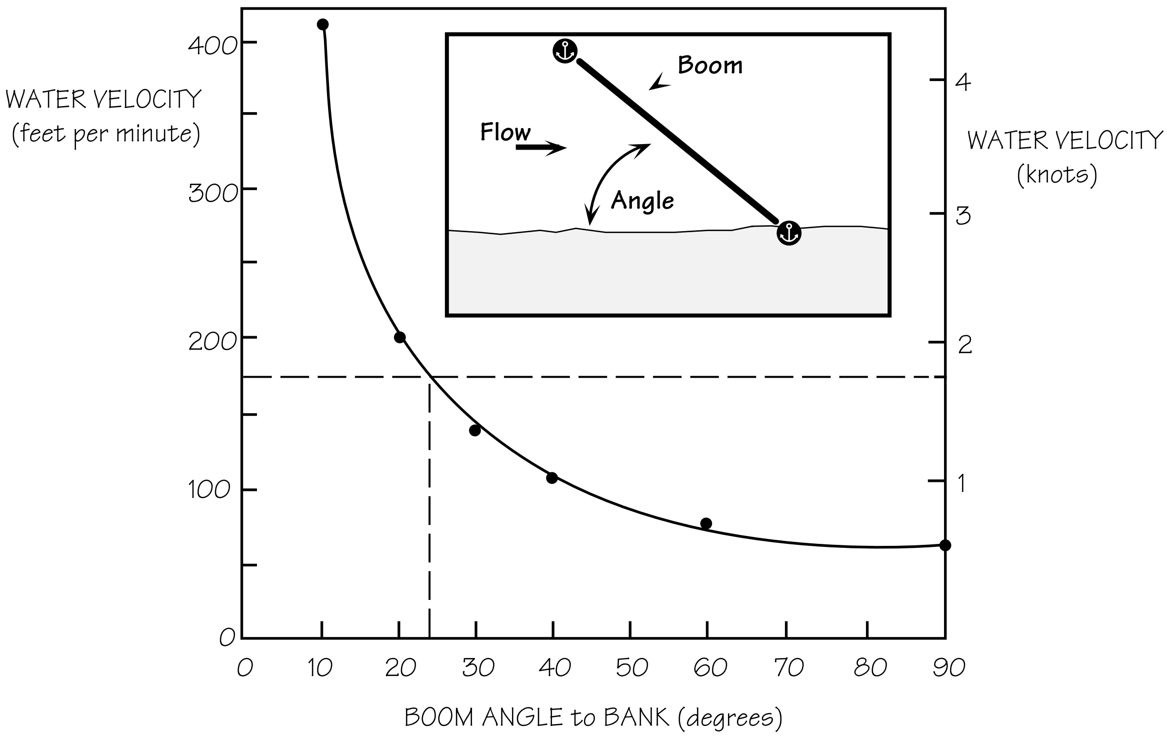


Figure 7. Plot of the maximum angle for boom deployment at increasing current velocities.

Waves

Both swells and short-period waves affect the usefulness of protection methods by causing uneven surface areas that may hamper efforts to contain or direct floating oil. Once the boom begins to move erratically, performance drops rapidly. Further, the safety risk to personnel working in rough seas is a major concern.

Short-period waves can severely limit the effectiveness of protection methods by splashing oil over booms, eroding barriers, and damaging equipment. Waves can cause problems even in some bays and estuaries with large effective fetches of open water, especially during storms. Shallow-water boom is totally ineffective and harbor boom effectiveness diminishes greatly at wave heights greater than two to three feet, especially nearshore. Large waves can be quite unpredictable and pose significant risks to response personnel operating boats on the water and equipment on the shore.

Tidal Effects

All U.S. coastal areas are subject to tidal fluctuations that create strong tidal currents, especially those areas with tidal ranges exceeding six feet (for example, the Georgia Bight, New England, and Alaska). These currents shift direction every six hours, except for the Gulf Coast. However, they may not have the same velocities on opposing tides or even ensuing tides in the same direction of flow, particularly in areas with a strong diurnal inequality such as the West Coast. Therefore, in order for a booming protection strategy to be effective, the responder must be able to change the boom configuration every six hours and be prepared to deal with drastically differing local topography and water levels as the tides shift. The danger of losing collected oil as the tide changes is also a problem. Thus, timing is extremely critical in these operations. The operators must study the tidal conditions carefully and be intimately familiar with local intertidal topography and nearshore bathymetry in order to deal effectively with the ever-changing tidal stages.

Wind

Winds cause oil slicks to move at a speed equal to about three percent of the wind speed. Rapidly changing wind directions mean that responders have to attempt to move booms continually to meet the shifts in the oil's movement, which decreases the effectiveness of the booms. Wind can also push against the freeboard area of the boom, possibly causing the boom to tip over or otherwise lose effectiveness.

Water Depth

Water depth affects the type of response equipment that can be deployed. Many types of protection strategies use vessels and anchoring systems that require relatively deep water for operation. However, deep water in high-current areas can create anchoring problems. Shallow-water areas are usually among the most difficult to protect because of access restrictions, equipment that is too heavy or big for manual deployment, or other complications.

Water Volume

Water volume will be a concern where responders are considering employing dams, trenches, flow gates, or fixed barriers along rivers and small tidal inlets and creeks. Larger water flows restrict the number of strategies that may be practical and those that do work require close monitoring. Planners should also consider sudden changes in water volume, such as increased runoff from heavy rainfall.

Debris/Broken Ice

Free-floating debris and ice can clog skimmers, fill up the catchment area behind booms, and increase the drag on booms (especially logs). Large amounts of debris or ice can change the shape of the boom, making it less effective or causing it to fail.

Logistical Constraints

There are many logistical constraints in the proper and timely deployment of protection strategies. They generally fall into the categories of equipment, personnel, training, and support.

Access

Sites with limited access may require building roads and using vessels and helicopters to transport equipment and workers to the site. Often, limited access requires using an alternative protection method. Exceptionally high tides and flood water levels in rivers also affect site access. In coastal settings with significant tides, responders need to be familiar with high-water levels created by spring and storm tides, and should not rely on access routes at elevations below those levels.

Bulky and Heavy Equipment

Much of the equipment used for oil-spill response is bulky and heavy. Movement to a deployment site requires large trucks and other material-handling equipment. Logistical issues must be carefully thought out to reduce deployment time and decrease downtime. The large size of the equipment and common need for deployment in less-than-favorable conditions create a high risk of injury. Deployment of such equipment may cause further damage to the environment by extensive physical disruption and mixing the oil into the sediment, especially in areas without roads or other means of access.

Towing of Equipment

Barriers such as booms are commonly deployed into the water at a convenient location and towed to their intended position for the protection strategy. However, many factors can affect a vessel's ability to tow a barrier, including water that is too shallow or current that is too fast, or unfamiliarity of the crew with the shoreline. Towing the barrier requires special boat-handling skills to avoid damage and to ensure proper positioning. Under optimum operating conditions, boom should not be towed in sections longer than 1,000 feet. The boom may need to be doubled when longer lengths must be towed or positioned. Currents, wind, or seas may dictate either shorter lengths of boom or higher-powered vessels to accomplish the same task.

Positioning of the Equipment

In order for a protection strategy to work, response equipment must be placed exactly where planned, in its correct configuration, and where it will require the least amount of maintenance. The response team must be well-organized and efficient, especially in dynamic coastal waters (e.g., with 500-1,500 feet of boom and anchors ready, for deployment in a one- to three-knot current). Otherwise, the current may move the boom into an unacceptable position. Repositioning boom is very difficult.

Equipment Tending

All types of shoreline protection methods require tending to compensate for changing conditions (e.g., wind, tides, currents, and vessel traffic) and movement of the oil. Barriers usually do not function properly over long periods of time. Therefore, responders may have to move equipment around continually to maintain effective protection.

Required Personnel

In the initial phases of most spills, there is a finite number of personnel who are trained spill responders with appropriate operational experience and safety training. The limited number of personnel immediately available for deploying and operating equipment may limit the method of protection itself, as well as the time required for deployment.

The larger the spill, the more properly trained personnel and support equipment are required. Larger spills also take larger management organizations to provide direction. If a response is to continue 24 hours per day, two to three times as many personnel will be required because of the need to have trained, professional responders available. It is also necessary to have a pool of trained workers from which relief personnel can be drawn to prevent burnout and safety lapses.

Another consideration is that 29 CFR 1910.120 requires all employers to provide safety training for their employees involved in basic response and cleanup. Planning to have enough trained personnel available for spills is very difficult and costly, considering the unpredictable and episodic demand for such personnel.

Equipment Resources

The amount of equipment available, however, is a known quantity. Equipment can normally be brought in from another location, but the delay may limit protection options because of the time to get the equipment to the spill scene. Because time is usually the limiting factor, rather than the actual amount of equipment, response organizations cache equipment near potential spill locations. However, there will still be delays in placing the equipment in the water and in towing equipment to the deployment site.

Decontamination of Equipment and Personnel

All the equipment taken to the spill must be returned and cleaned or disposed of. Thus, appropriate decontamination chemicals need to be available. In addition, personnel decontamination stations, and clean eating and break areas need to be established and maintained.

Channel Traffic

Maintaining shipping or other kinds of vessel traffic through navigation channels or waterways during a spill response is a difficult consideration because there are usually economic and political pressure to re-establish normal operations as soon as possible. However, deploying booms and skimmers or constructing recovery sites can conflict with such traffic for several days. Also, passage of deep-draft vessels through the waterway can suddenly change water level and flow or create wakes, causing booms to fail.

Recovery and Storage Capability

To lessen the chance of additional oiling, the spilled product must be recovered from the water surface as soon as possible. The lack of recovery and storage capability in remote areas due to inaccessibility is a difficult problem that requires extensive planning and strategy development. Environmental operating conditions (water depth, channel width) may require specialized recovery devices and may limit storage capacities.

Disposal of Contaminated Materials

In addition to oiled sediment, water, and vegetation, spills generate a lot of contaminated cleanup material, including sorbents, debris, and clothing. Interim storage and permanent disposal options have to be defined. Disposal of contaminated materials to landfills simply moves the pollution from the shoreline to another site. Accordingly, the work plan should include provisions for reducing the volume of material to be disposed of in landfills and should address options such as recycling, using waste oil in road asphalt, and removing excess liquid from the waste oil.

Darkness

In past spills, oil recovery and equipment deployment ceased when darkness fell and resumed at first light. Response personnel had to anticipate conditions to be encountered the next day. Current trends are towards round-the-clock operations that require additional logistical consideration for lighting systems and methods to track the oil.

Power

Power is a consideration for many protection methods. For example, power is needed to operate open-water boom reels, lighting systems, air/water systems, overflow dams, flow gates, and locks. Should power be lost, the entire operation could be severely curtailed.

Fuel

Fuel is required by boats, tractors, trucks, vehicles, skimmers, and pumps. Fuel shortages can limit the effectiveness of the response. Identify in advance adequate vessel, aircraft, and equipment refueling stations.

Matrix of Protection Methods versus Operational Limits

The matrix in Figure 8 summarizes how a particular protection method will be impacted by the operational limitations discussed above. After selecting viable protection methods, the planning team should use the matrix to ensure that all considerations and impacts are being taken into account. The matrix is particularly useful during site visits to verify the protection strategy. Used as a checklist, the matrix provides a general overview of the effect of each limitation on response methods when actually deployed. Because the matrix represents general guidelines, each case will require careful consideration by experienced spill response equipment specialists.

Note

The impact ratings assume that each protection method will be employed in the manner for which it was designed. For example, shallow-water boom is designed for very shallow water; the matrix reflects those limitations typical in shallow-water areas.

Should the boom be used in a deep-water situation, the matrix impact rating may be inaccurate. The impact ratings are defined as follows:

Heavy Impact: Planners should review these limitations first to determine whether they may be overcome through planning. "Heavy" impact does not mean the method cannot be employed. On the contrary, it means that, when correctly planned, the method will be more effective. At times, heavy impact may require pre-constructing facilities, pre-staging equipment, or other techniques that will increase the likelihood of success of the strategy. When pre-planning cannot help the planning group overcome the limitation, the team should select another approach or use alternative protection methods.

Moderate Impact: Often, these impacts do not require advance equipment mobilizing or pre-construction of special facilities. "Moderate" impact implies that responders need to be aware of the special limitation and be prepared to carry out the preplanned method in its entirety.

Low Impact: Planners need to identify these impacts for the response community and ensure that enough quantities of the proper equipment are on hand to perform the protection method with ongoing operations.

Not Applicable: This rating indicates that this particular operational limit should not affect the performance of the protection method when it is employed appropriately.

PROTECTION METHODS *versus* OPERATIONAL LIMITS

	Spilled Product Properties	Access	Current	Swell	Wave Conditions	Tidal Effects	Wind Conditions	Water Depth	Water Volumes	Debris/Broken Ice	Bulky or Heavy Equipment	Towing of Equipment	Positioning of Equipment	Equipment Tending	Required Personnel	Equipment Resources	Cleanup of Contaminated Equipment	Channel Traffic	Recovery and Storage	Darkness	Power	Fuel
Open-water Skimming	H	L	L	H	H	-	M	-	-	H	H	M	H	H	M	H	M	L	-	H	M	M
Netting Systems	H	L	M	M	M	L	L	L	L	H	H	H	H	H	H	H	H	M	H	M	L	.L
Shallow-water Boom	L	H	M	-	-	H	M	M	L	M	-	-	H	M	M	M	L	L	M	M	-	-
Inland Boom	L	M	M	-	-	M	M	L	M	M	L	L	H	M	H	M	M	M	M	M	-	-
Harbor Boom	M	L	L	L	M	L	L	M	M	M	M	M	M	H	H	H	M	H	H	M	-	L
Open-water Boom	H	M	L	M	H	-	L	-	H	M	H	H	H	H	H	H	H	L	H	L	M	L
Sorbent Boom	M	L	M	-	-	M	M	L	-	H	-	-	L	L	L	L	-	L	M	M	-	-
Earthen Barriers	-	M	M	M	M	H	L	M	M	L	H	-	-	-	L	L	-	-	M	L	-	M
Underflow Dams	L	H	H	-	-	-	-	H	H	L	L	-	M	M	L	L	L	-	M	L	L	L
Overflow Dams	L	L	H	-	L	L	-	H	H	H	L	-	M	M	L	L	L	-	M	L	L	L
Trenches	H	M	H	-	H	H	L	-	L	L	H	-	-	M	M	M	L	-	M	L	-	L
Flow Gates	-	-	M	-	-	-	-	-	M	L	-	-	-	L	L	-	L	-	L	-	L	-
Locks	L	-	L	-	-		-	-	L	L	-	-	-	L	L	-	L	H	L	-	L	-
Air or Water Streams	L	-	H	-	H	L	H	L	-	L	-	-	M	L	L	L	-	-	M	L	L	L
Bubble Barriers	L	-	H	-	H	L	H	L	-	H	-	-	-	-	-	-	-	-	H	-	L	-
Improvised Barriers	L	M	L	-	L	H	L	H	H	M	L	-	L	L	M	H	L	L	H	M	-	-

H = HEAVY IMPACT   M = MODERATE IMPACT   L = LOW IMPACT   - = NOT APPLICABLE

Figure 8. Matrix showing how protection methods can be impacted by operational limitations and thus require consideration during planning activities.

Matrix of Protection Methods versus Support Equipment

In planning for protection strategies, Area Committees should think in terms of "systems." Protection strategies such as deflection booms, earthen barriers, or open-water skimming usually require specific support equipment and logistics. The matrix in Figure 9 provides planners with a brief guide to the amount of support equipment necessary to support each protection method. Identifying support equipment needs is critically important, for two reasons:

1. Logistically attempting to conduct more activities than a particular site is able to handle becomes an ALL STOP scenario during a response. Planners must continually keep in mind that a method must be properly and safely carried out. Understanding the support equipment required will help planners assess a particular site's suitability.

2. There is always the potential for deployment and maintenance of a selected protection method to damage a site physically, even when used properly.

In Figure 9, support equipment is designated using the following terms:

Required: In most cases, support equipment will be needed to employ this particular protection method effectively. The equipment identified below highlights only the major categories of support equipment and may not be inclusive.

Optional: The identified support equipment is not normally mandated and will require careful consideration by the planning group. At times, need for the equipment will be dictated by a particular system available through contractors in an area or at the decision of the planning group.

Note

This manual cannot describe support measures for every system in existence. However, the matrix does give the planning group the ability to foresee support needs for various protection methods. It is clear from the matrix, for example, that larger or more mechanized equipment requires more support equipment.

PROTECTION METHODS *versus* SUPPORT EQUIPMENT

	Shovels / Rakes	Cranes / Forklifts	Tractors / Trailers	Bulldozers	Backhoes	Boats	Anchors / Chain	Line / Wire Rope	Compressors	Prime Movers (hydraulic)	Pipe	Hose / Nozzles	Sorbent Pads / Rags	Tool Box	Ships	Pumps
Open-water Skimming	-	R	R	-	-	O	O	R	O	R	-	R	R	R	R	R
Netting Systems	-	R	R	-	-	O	-	R	-	O	-	-	-	R	-	-
Shallow-water Boom	R	-	-	-	-	O	R	R	-	-	-	-	-	O	-	-
Inland Boom	R	-	-	-	-	R	R	R	-	-	-	-	O	O	-	-
Harbor Boom	O	-	O	-	-	R	R	R	-	-	-	-	O	R	-	-
Open-water Boom	-	R	R	-	-	O	R	R	O	O	-	-	R	R	R	-
Sorbent Boom	R	-	-	-	-	O	-	R	-	-	-	-	-	O	-	-
Earthen Barriers	O	-	O	R	R	-	-	-	-	-	-	-	-	R	-	-
Underflow Dams	R	-	-	O	O	-	-	-	-	-	R	-	-	O	-	-
Overflow Dams	R	-	-	O	O	-	-	-	-	-	O	-	-	O	-	-
Trenches	R	-	-	-	R	-	-	-	-	-	-	-	R	-	-	-
Flow Gates	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Locks	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Air or Water Streams	-	-	-	-	-	O	-	-	O	-	O	R	-	-	-	R
Bubble Barriers	-	-	-	-	-	-	-	-	R	-	O	O	-	-	-	R
Improvised Barriers	R	-	-	O	O	-	-	R	-	-	-	-	O	O	-	-

R = REQUIRED ***O = OPTIONAL***

Figure 9. Matrix showing the support equipment needed for the various protection methods.

Natural Resource Constraints

There are many site-specific, secondary natural resource constraints on implementing and maintaining protection strategies that need to be incorporated into the overall protection plan. Secondary natural resource constraints fall into the following categories:

Minimizing human activity disturbance. Certain animals are very susceptible to impacts caused by humans in the immediate vicinity, particularly during nesting or pupping periods. For example, birds can abandon eggs or young if the disturbance reaches intolerable levels. Therefore, certain areas may be designated as off-limits during response or protected with an exclusion zone during the breeding season. Often, minimum elevation and distance restrictions are set for aircraft operations; the conditions under which these restrictions might be implemented should be identified in the plan. For example, vessel traffic can be excluded from sensitive areas or restricted to specific corridors through sensitive areas. The normal periods during which such restrictions might be enforced should also be specified.

Minimizing physical disturbances while implementing protection strategies. Crews deploying and maintaining protection methods can physically disrupt shoreline and nearshore habitats during activities such as setting and repositioning anchor points, particularly when they are placed onshore; digging into sediments to excavate dikes or trenches; and transiting to and from sites in shallow water where the motor prop can cut into benthic habitats such as seagrass beds. Even foot traffic around soft-sediment sites can trample vegetation and mix oil into the substrate, increasing the impact to the habitat. Site-specific restrictions should be included in the protection plan.

Controlling access to and release of information about the location and nature of sites likely to be affected by increased public recognition, in terms of vandalism or poaching. Many agencies are concerned about the publication of information on some resources, such as archaeological sites, eagle or peregrine falcon nests, and endangered plants. The concern is that such publication can result in increased visitation or vandalism because of their designation in public plans or during protection activities. Such areas can be flagged without indicating their exact location and nature of concern. Workers must receive strict instructions not to disturb readily recognized archaeological or cultural resources (e.g., fossils and artifacts). Some sites will be sensitive enough to require the presence of a monitor during all response activities to prevent either inadvertent or deliberate damage to particular resources.

General types of natural resource restraints. There are many general types of constraints on access and activities that should be included in the plan. Examples include restricting access to sensitive habitats to minimize trampling of vegetation, tide pool fauna, or particularly rich intertidal communities; restricting physical disturbance of the stream bottom in spawning reaches of streams; and using low water pressures in areas of fine-grained sediments to minimize erosion and high suspended sediment loads.

General Shoreline Protection Tactics

Booming Tactics

Figures 10-11 show common tactics for containment, deflection, and exclusion booming. These tactics are the building blocks for developing protection strategies. Guidelines for successfully deploying these tactics are summarized for each figure.

Containment Booming

The key to successful containment booming is understanding current speed and direction, and how they change over time, so that the effective current at the boom does not exceed 0.7 knots. Figure 10 shows two types of containment booming.

1. Teardrop or Donut (Figure 10a)

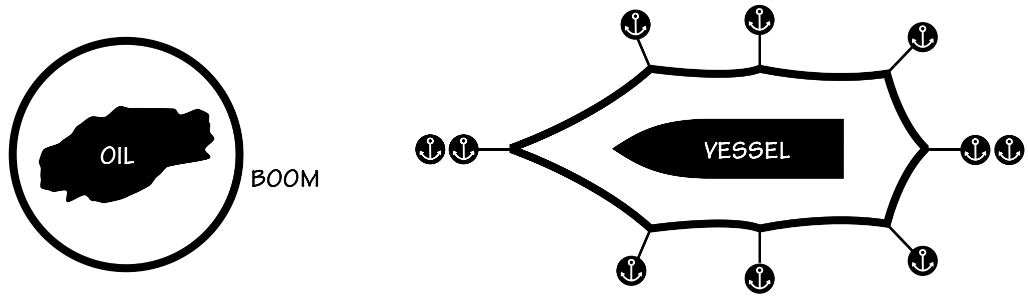
- Often used in areas with very strong currents and deep water, which make holding the oil in place nearly impossible.
- Thick slicks are collected and enclosed in boom, which drifts with the currents.
- Skimmers go to the contained oil to recover the oil as it drifts.
- To collect the oil in shallow water, it may be necessary to corral the oil and bring it to deeper water or low-current areas with better skimmer access.

2. Ship Containment (Figure 10b)

- When anchoring boom around the ship, leave space between the two for oil accumulation.
- Multiple anchors improve the holding capacity and the configuration of the boom; boom pushed against the hull will be completely ineffective.
- The bow of an anchored ship will face into the prevailing wind or current and shift accordingly. Booming must account for vessel swing.
- Large lengths of boom (2,000-5,000 feet) are often required for ship containment.

- Boat/manpower-intensive; requires highly skilled personnel. Access/egress to ship must be coordinated.

Containment Booming



a donutb ship containment

Figure 10 . Examples of containment booming configurations.

Deflection and Exclusion Booming

Deflection booming requires exact placement and securing. The most common failures result from placing boom at the wrong angle for the current speed and improper anchoring so that the boom sags and a pocket forms. The pocket orients perpendicular to the flow at the point of highest current speeds, and usually results in boom failure by entrainment.

Exclusion booming is effective only where the currents are relatively weak, otherwise entrainment under the boom is likely. Even so, deflection booming can be added as a backup in come cases. Multiple booms should be used to ensure effectiveness. It is imperative that the boom is well sealed to the shoreline to prevent leakage. Figure 11 shows examples of deflection and exclusion booming.

1. **Cascade to Collection Points (Figure 11a)**

- Used to deflect oil from areas of strong currents, such as the center of channels, toward an area of weaker currents for enhanced recovery.
- High currents require small angles and, thus, long boom lengths. To reduce the strain on the longitudinal member, use shorter lengths in an overlapping configuration.
- There must be adequate overlap between boom sections.
- Use multiple anchors to handle heavy strains in strong currents.

- Anchoring points, collection sites, and boom configuration will change with shifts in tidal current and wind directions, and so must be regularly tended.
- Use two to three booms to collect oil that is entraining under upstream booms.
- Sites for collection along the shore must have access for personnel and equipment. These collection sites should have impermeable substrates to minimize the extent of site contamination.
- Create or find collection points (trenches) to speed removal of accumulated oil from the water surface.

2. Chevron (Figure 11b)

- The boom is anchored in the middle of the channel, with the oil deflected towards recovery sites on both banks.
- This tactic allows the smallest boom angle in the center, where the currents are highest, and deflection to shore where currents are low.
- Use chevron booming where the current flows only in one direction.

3. Deflection (Figure 11c/d)

- Used to deflect oil away from a sensitive area without attempting recovery because of inadequate access, high currents, or other limitations.
- Can be used to exclude even gasoline from sensitive areas or ignition sources.
- Under tidal conditions, the oil might approach from opposite directions because of reversals of tidal current flow, requiring complex deployments and anchoring.
- Plans need to include eventual recovery of the oil.

4. Exclusion (Figure 11c/d)

- Need to maintain a tight configuration against the shoreline.
- There should be no sagging in the boom to prevent pocket formation.
- Used in marinas, harbors, and canals where currents at the entrance are very weak.
- Riprap structures may be permeable to oil and thus may need to be lined.
- With narrow entrances and good access, multiple booms are usually deployed to improve success.

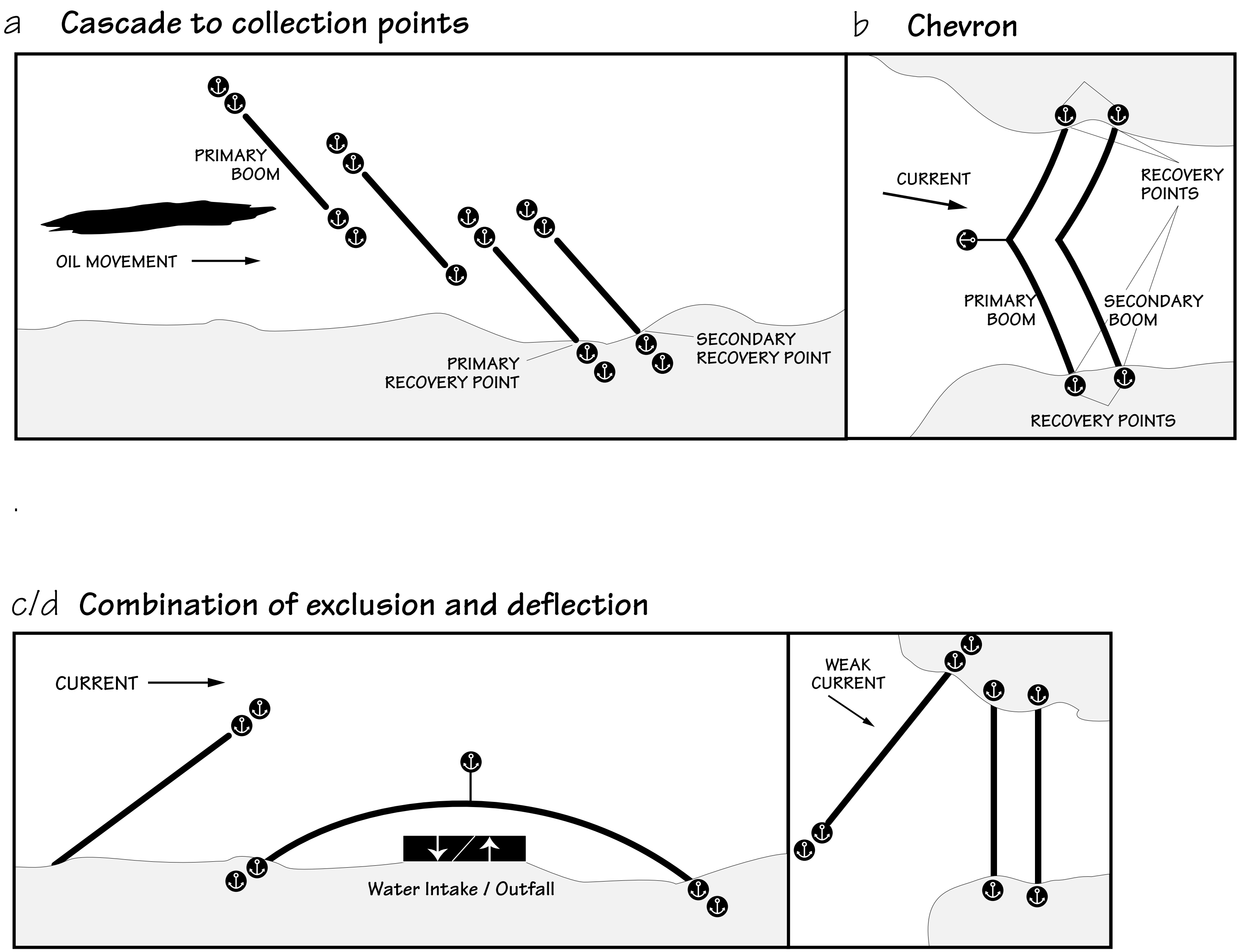


Figure 11. Examples of deflection and exclusion booming configurations.

Overview of Oil Recovery Methods

Recovering oil on the water is limited to skimmers, sorbents, and manual recovery. Recovering floating oil would appear to be an easy task: oil floats on water so all that is required is a means to gather the floating oil. In fact, recovering floating oil is one of the most difficult operations to perform. Effective recovery leaves less oil to be deposited on the shoreline. Skimming oil off the water surface frequently collects large amounts of water, which increases the volume of product to handle. Skimmers may operate independently, be mounted on vessels, or may be completely self-propelled. Skimmers are classified in five different categories: weir, suction, centrifugal, submersion, and sorbent or oleophilic skimmers.

Key factors in selecting appropriate skimmers are the amount of debris present, the viscosity of the oil, and the water depth. Figure 12 is a skimmer selection and employment checklist. Area Committees should match up skimmer requirements with their proposed protection strategies and work with response organizations to determine whether their equipment and capabilities are adequate to meet protection requirements.

Sorbents are not primary oil cleanup techniques but are used mainly during final cleanup or when small or trace amounts are being removed. They are used in areas that are inaccessible to skimmers and where heavy equipment may cause excessive damage. Sorbents are measured by how much oil they will recover in weight compared to the weight of the material. The most efficient sorbent can sorb nearly 20-25 times its weight in oil. Overuse of sorbents can generate a large disposal problem because most used sorbent material is placed in landfills, although some areas have approved incineration. Recycling of sorbents should be done whenever possible.

Manual recovery involves using hand equipment to recover oil, primarily with rakes and shovels to lift tarballs or tarmats from the substrate or water surface. Heavy or weathered oil can sometimes be recovered by hand, depending on its viscosity. The recovered oil is bagged for later disposal. Manual removal is not considered a primary means of removing oil from the water and it is used most often in shoreline cleanup.

SKIMMER SELECTION AND EMPLOYMENT CHECKLIST

1. Amount of oil to recover
   - ❑ Correct number of skimming systems
   - ❑ Logistics to support each additional skimming system
   - ❑ Thickness of the oil

2. Type of oil to recover
   - ❑ Product viscosity
   - ❑ Weathering
   - ❑ Emulsification
   - ❑ Sheens versus heavy oil concentrations
   - ❑ Contamination with spill response chemicals

3. Debris
   - ❑ Size - clogs skimmer head and pumps
   - ❑ Type - paper, wood, trash, and brush
   - ❑ Amount

4. Water depth
   - ❑ Skimmer underwater profile
   - ❑ Floating skimmer
   - ❑ Anchoring system
   - ❑ Changes in water depth

5. Collected water
   - ❑ Sufficient holding capacity/interim storage
   - ❑ Decanting capability
   - ❑ Reducing the collection through more efficient oil containment

6. Current
   - ❑ Velocity
   - ❑ Direction (does the direction change?)
   - ❑ Cross-currents
   - ❑ Heavy impact on skimmer maneuverability

7. Logistics
   - ❑ Skimmer location
   - ❑ Transportation arrangements
   - ❑ Skimmer contractual arrangements
   - ❑ Fuel
   - ❑ Nighttime operational requirements

8. Heavy equipment
   - ❑ Cranes/forklifts
   - ❑ Vessels/boats
   - ❑ Equipment contractual arrangements
   - ❑ Location

9. Skimmer size
   - ❑ Location suitable for small or large skimmer
   - ❑ Personnel handling requirements
   - ❑ Physical ability to get skimmer from storage area to the site

Figure 12. Checklist for selecting and deploying skimming systems.

10. Wind
    - ❑ Velocity - high or low, moves the oil and the skimmer
    - ❑ Direction - will the direction change on location?
    - ❑ Creates wave action detrimental to skimming

11. Maneuvering skimmer
    - ❑ Self-propelled skimmers need room to maneuver
    - ❑ Non-self-propelled skimmers need to be maneuvered into the oil
    - ❑ Changing anchoring positions

12. Qualified operators
    - ❑ Past oil spill experience
    - ❑ Local availability
    - ❑ Time to arrive on scene
    - ❑ Area familiarization

13. Shoreline type
    - ❑ Sand, mud, gravel, rock, or cliffs
    - ❑ Ability to support skimmer operational needs
    - ❑ Damage to associated shoreline from response personnel

14. Containment efficiency
    - ❑ Maximum efficiency with thick oil contained in a barrier
    - ❑ Reduce the water intake
    - ❑ Other limitations impact efficiency

15. Access
    - ❑ Roadways available to site
    - ❑ Helicopter sling-loading required
    - ❑ Boat/ship access only
    - ❑ Building or construction required for access
    - ❑ To temporary storage device
    - ❑ To shoreside discharge location with recovered oil

Figure 12., cont.

The skimmer selection and employment checklist should be used during field verification. After areas have been examined and equipment requirements laid out, various spill scenarios can be used to determine whether a particular skimmer will work in a given situation.

Alternative Protection Methods

Because of the many operational, logistical, and environmental limitations, mechanical methods cannot protect all sensitive shorelines. In those areas where these methods do not work, the only alternatives will be taking no action at all or using non-mechanical methods that are usually implemented away from the shore in open water. All chemical countermeasures require RRT consultation.

Chemical Dispersants

Chemical dispersants are specially formulated compounds designed to reduce the oil-water interfacial tension and allow the oil to break into small droplets that mix into the water column. Dispersants are normally used in offshore waters to prevent oil from moving into sensitive environments. They may work when other protection strategies are most likely to fail, that is, in conditions of strong currents and high waves. Dispersant application by aerial spraying is limited by high winds, fog, and darkness. Effectiveness drops rapidly with time after the initial release of the oil. The tradeoffs between increasing oil concentration in the water column and removing oil from surface water will have to be evaluated.

Herding Agents

Herding agents are products that push or compress oil slicks on the water surface. They have low solubility and volatility, and must have a spreading pressure greater than the target oil. Application rates are very low (1-15 gallons per lineal mile). They are most effective on thin films and low-viscosity oils. Weather and sea conditions must be calm, with no breaking waves, low currents, and no rainfall. Their optimal use may be in harbors to control slicks under docks and piers and in water too shallow for booms. Commercially available products vary widely in their aquatic toxicity.

Solidifiers

Solidifiers are usually organic polymers that mix with oil and turn it into a rubber-like solid or gel. The most limiting factor is the amount of product needed to solidify a given volume of oil; current solidifiers require application rates of 1 to 200 percent. The solidifier must be mixed into the oil, making it more difficult to treat emulsified, thick, or heavy oils. There is also concern about inconsistent application rates and resulting areas of liquid, semi-solid, and solid oil. Available products are insoluble and have very low aquatic toxicity, thus the greatest environmental concern will be the ability to recover the solidified oil from the water surface.

Shoreline Pre-Treatment Agents

These products prevent oil from adhering to a shoreline. There are two sub-classes: film-forming agents and wetting agents. However, currently there are no commercially available products for oil-spill applications. There would be concern about contact toxicity and smothering since these products would be applied directly on clean substrates. This category does not include products that are dispersants.

Burning

Burning spilled oil produces the highest potential rate of oil removal. Whether the oil is burning due to the casualty or being ignited in situ, the results are worth considering. Oil must be a minimum of two millimeters thick to maintain a burn on the water surface. Otherwise, the cooling effects of the water below will extinguish the flame. The tradeoff between creating an air plume of soot and combustion by-products and leaving the oil on the water surface needs to be evaluated.

Hazing

Hazing is the intentional use of mechanical devices to generate loud noises to prevent wildlife from coming in contact with floating or stranded oil. However, the devices have a very limited period of effectiveness because wildlife quickly acclimate to them. Hazing should be coordinated with local fish and wildlife representatives to ensure that greater harm is not being done to animals than would happen with no action. In addition, responders must be aware of the chance that they could actually haze animals away from their habitat and into another oiled area.

Operational Restrictions and Modifications

Altering vessel patterns and operational procedures may be a viable option to reduce risk to environmental areas that cannot be adequately protected with mechanical means. This can be achieved through local councils, port safety committees, and international agencies, such as the International Maritime Organization (IMO). These efforts could include traffic rerouting, establishing exclusion zones, modifying or restricting operational procedures (such as requiring booms), limiting bunkering during seasonal coral spawning, and requiring pilots and tugboats to guide vessels into port in high-risk areas.

Permanent Structures

Permanent structures are intended as preventive measures to eliminate or reduce the impact of a spill in advance of the actual incident. Some structures could be staging areas for response equipment deployment, some for isolating the potential source, and others for isolating the sensitive area to be protected. These structures might include permanent booms at piers, permanent boom anchor points and rollout mounted booms, and tide gates or permanent barriers erected around a potential spill source.

No Action

No action should be considered when the response is likely to cause more injury to the resource than would the oil alone. An example would be a marine mammal pupping area where any physical disturbance might either drive the animals into the water (and the oil) or cause the mothers to abandon the young.

Protection Methods for Specific Physical Settings

Determining the most effective protection methods for a particular setting may not relate directly to either the presence of sensitive resources or the priority of the area. Rather, it may depend on the physical setting of the sensitive area. For example, the sensitive resource being protected could easily be a nesting endangered species or a public swimming beach. However, if both are located on open exposed beaches the options are limited to those technologies available for protection of open exposed beaches. Below are brief general descriptions and guidelines for selecting protection strategies for the thirteen physical settings listed. These same settings are used in the protection methods versus physical setting matrix in Figure 13. Feasible protection methods are indicated, either as viable or conditional, for each physical setting. *Viable* methods are those most likely to be effective under normal physical conditions at a site. *Conditional* methods are those that may be effective under optimum conditions but site-specific constraints may render the method ineffective or cause more harm than the anticipated benefit. Dashes indicate methods that are not applicable to that physical setting. Figure 13 is not a cookbook; it is intended to provide planners a starting position when considering protection methods.

Open Water

Open-water habitats include offshore areas along the coastline, the Great Lakes, and large bays. They are characterized by frequent high waves, moderate currents, and deep water. The water surface itself may have sensitive resources such as large flocks of waterfowl, concentrations of marine mammals, and kelp beds. Feasible protection methods include open-water skimming, netting, and booming.

- Open-water skimming is most effective on thick oil early in the spill before the oil spreads into thin slicks and over large areas.
- Responders should take full advantage of natural convergence zones where the oil tends to concentrate, even large distances from the source. Some convergence zones are quite stable and form in the same location, whereas others are more variable due to changing tidal and wind conditions.

- Aerial observations are essential to direct skimmers.

Often, mechanical protection is not possible because of high waves, strong currents, or a spilled product that rapidly evaporates or naturally disperses. Thus, alternative protection methods may need to be considered, such as in-situ burning and dispersants. Otherwise, no action is the only alternative.

Open Exposed Shorelines

Open exposed shorelines occur along the outer coast and the Great Lakes where there is sufficient fetch to generate large waves. The shoreline may be composed of sand, gravel, rock, seawalls, or a combination of types. These areas might have high priority for protection because of the presence of large marine mammal haulouts or seabird nesting sites. Feasible protection methods include open-water skimming, netting, booming, earthen barriers, and trenches.

- Where there are large waves and strong currents, deploying boom in the nearshore zone will not keep oil off the shore.
- In less exposed areas, such as on lakes or during periods of relative calm water, wave heights may be small enough to use deflection boom anchored to the shoreline to deflect oil onto sandy beaches where it can be recovered.
- Earthen berms can provide very temporary protection for resources at or above the high-tide line on exposed beaches, such as turtle nests; however, the berm is likely to be eroded by waves during the next period of significant wave activity.
- Trenches may be possible on sandy substrates to trap or direct large amounts of oil heading toward sensitive areas when there are no other oil recovery options.
- No action is the only option when physical conditions render protection ineffective. Alternatives to reducing the amount of oil coming ashore include in-situ burning and dispersants.

PROTECTION METHODS *versus* PHYSICAL SETTING

	Oil Recovery		Floating Barriers					Solid Barriers						Other		
	Open-water Skimming	Netting	Shallow-water Boom	Inland Boom	Harbor Boom	Open-water Boom	Sorbent Boom	Earthen Barrier	Underflow Dam	Overflow Dam	Trench	Flow Gate	Locks	Air / Water Streams	Bubble Barrier	Improvised Barrier
Open-water	V	C	-	-	C	V	-	-	-	-	-	-	-	-	-	-
Open Exposed Shoreline	V	C	-	-	C	V	-	C	-	-	C	-	-	-	-	-
Sheltered Shoreline	C	C	C	V	C	C	-	V	-	-	C	V	-	C	C	C
Rivers and Banks	C	-	V	V	C	-	-	C	-	-	C	-	C	-	-	C
Entrances	V	C	-	C	V	V	-	-	-	-	C	-	-	-	-	-
Salt Water Marshes and Creek Mouths	-	-	V	C	-	-	C	V	C	C	C	C	-	-	-	V
Freshwater Marshes and Swamps	-	-	V	C	-	-	C	C	C	-	C	-	-	-	-	C
Tidal Inlets	C	-	V	C	C	-	-	C	-	-	-	-	-	-	-	-
Intermittent Creeks	-	-	V	C	-	-	C	V	C	C	C	C	-	-	-	V
Streams	-	-	V	C	-	-	C	C	C	C	C	-	-	-	-	C
Vegetated Shorelines	-	-	C	V	C	-	C	-	-	-	-	-	-	-	-	-
Sand / Mud Flats	C	-	V	C	C	-	C	C	-	-	-	-	-	-	-	C
Submerged Habitats and Resources	C	-	C	C	C	C	-	-	-	-	-	-	-	-	-	C

V = VIABLE METHOD   C = CONDITIONAL METHOD   - = NOT APPLICABLE

Figure 13. Matrix showing viable protection methods for various physical settings.

Sheltered Shorelines

Sheltered shorelines occur on the inside of barrier islands, in bays and estuaries, or along lakes and rivers. The substrate can range from mud to sand to bedrock. Sheltered shorelines do not have large fetches of open water for waves to build across, although water currents can be locally strong. Nearshore water depths are variable. The sheltered character of the shoreline may vary seasonally with storm wind patterns. Feasible protection methods include open-water skimming, netting, booming, trenches and earthen barriers on beaches, flow gates, improvised barriers, and bubble barriers.

- Shoreline access is often a problem, from both land and water.
- Large areas will require many sections of boom, which can be difficult to deploy and maintain in proper configuration.

Rivers and Banks

Rivers are characterized by high-flow channels and river banks typically composed of muddy, organic-rich sediments. Terrestrial vegetation containing threatened and endangered species, and wildlife use by birds and terrestrial mammals, make rivers potential areas for priority protection. Rivers pose a very difficult situation to responders because of high flow rates in the channel, turbulent mixing, and heavy debris loads. Furthermore, many rivers flood several times a year, drastically changing the physical characteristics of the river as well as the location of possible sensitive areas. Such seasonal water-level changes must be considered and incorporated into the plan. Feasible protection methods include skimming, booming, earthen barriers, locks, trenches (with booms), and improvised barriers.

- Deflection booming away from high-flow areas to low-flow areas is the most efficient countermeasure.
- Take advantage of natural collection points where the oil tends to accumulate anyway.
- Shore-based access is often limited; sites need to be identified that have access and where recovery operations can be established.
- Clay banks are preferred containment sites because the clay minimizes sediment contamination during recovery operations.
- Use trenches to divert oil off the water surface to recovery equipment.
- Plan for large amounts of debris in the river and in collection sites.

- Use lines tied to banks on smaller rivers, rather than anchors to secure boom; line allows better control of boom and angle.
- Air or water streams can be used to direct oil toward collection and recovery sites.
- Use the shortest skirted booms possible where currents are strong.

Entrances

Entrances connect semi-enclosed water bodies to larger tidal waterbodies such as an ocean, bay, or estuary. They are characterized by reversing tidal currents, large open areas with complicated water-circulation patterns, and highly variable water depths ranging from intertidal shoals to deep channels. These areas can be sensitive themselves because of the presence of waterfowl, or they can lead to more sensitive, sheltered habitats. Feasible protection methods include open-water skimming, netting, booming, and digging trenches on shore. Alternative strategies include in-situ burning and using dispersants in deep water. The complexity of these areas often requires equally complex booming strategies devised for the specific sites and refined through field testing.

Saltwater Marsh Creek Mouths

Saltwater marsh creeks typically have muddy banks that are exposed during low tide; water floods into the vegetation at high tide. Tidal channels can be numerous in extensive marshes, and they are the focus of protection because they lead to extensive sheltered marshes where oil persistence and impacts are greatest. The larger creek channels can have surprisingly strong tidal currents. Feasible protection methods include various types of deflection and exclusion booming, depending on tidal current velocities, earthen barriers, overflow and underflow dams, flow gates, and improvised barriers.

- The soft, muddy substrate may cause anchor points to fail; visit the site to verify the best anchoring locations.
- It may be difficult to seal the boom to the shore to prevent leakage at high tide; response personnel may have to go a long distance to find a good anchor point.
- With potentially long distances, boom handling and deploying is often a serious problem.
- Constantly alternating tidal currents and water levels in coastal settings require regular tending of boom.
- Earthen barriers (use sandbags if sand is available) can often fail because of strong tidal currents.

- Earthen barriers may require water circulation to maintain water temperature and dissolved oxygen at specified levels.
- Sorbent boom can be used to protect vegetation from thin sheens.
- Deflection to collection points is likely to fail in large channels with strong tidal flow where exclusion or deflection is the lone preventive method.
- Physical disturbance to the substrate by foot traffic can be severe.

Freshwater Marshes and Swamps

Freshwater marshes and swamps are flat, vegetated areas of standing water with few well-defined channels. Marshes are vegetated wetlands dominated by grasses; swamps are dominated by woody vegetation. Water levels vary seasonally with freshwater discharge; those near the coast may be under some tidal influence. A special type of freshwater swamp includes backwater lakes that occur along major rivers and are isolated from the main current but still hydrologically connected to the river at higher water levels. Connecting channels can be narrow, shallow, numerous, and poorly defined. Feasible protection methods include booming, earthen barriers, underflow dams, trenches, and improvised barriers.

- Deflection/exclusion booming can be effective because currents are typically slow.
- Consider the potential for reversing water flow directions during flooding conditions.
- It may be difficult to close all connections along rivers when water levels are high or under flooding conditions.
- Slow water currents may require air and water streams to push oil flow toward collection and recovery sites.
- Access is often difficult and limits use of recovery equipment.
- Expect large amounts of debris to accumulate.
- When barriers are used, water quality should be monitored.
- Physical disturbance to the substrate by foot traffic can be severe.

Tidal Inlets

Tidal inlets are narrow channels connecting the open ocean to interior bays and wetlands that are subject to reversing tidal currents. The inlet size and current rates are controlled by the volume of water, called the *tidal prism*, that flows in and out of the inlet during a tidal cycle. In the main inlet channel, the currents often reach one to two knots during some stage of the tidal cycle. Some inlets have maximum currents of three or more knots, rendering boom ineffective in the main channel. There may also be multiple channels. Inside the tidal inlet, wetlands and tidal flats dominate, making it difficult to locate appropriate sites for oil containment and recovery. Feasible protection methods include open-water skimming in the deeper channels, booming tactics where the currents are slower, and sediment barriers where the inlets are small and freshwater flow rates are very low.

- Place deflection boom at low angles to the flow to minimize entrainment; use multiple sections of boom rather than long sections.
- Responders may need to deploy booms landward of the main inlet channel where current velocities drop.
- Locate sandy substrates with good access as sites for oil deflection and recovery.
- Small inlets with minimal freshwater outflow may be effectively closed with a sediment barrier; monitor water quality.
- Protecting very difficult inlets requires delineating primary, secondary, and tertiary lines of defense.
- Because inlets can change shape and location rapidly, strategies may need to be modified at the time of the spill.

Intermittent Creeks

Intermittent creeks are characterized by a shallow stream bed that can completely dry up seasonally. The sediments are often composed of sand or gravel. Feasible protection methods include booming, earthen barriers, underflow and overflow dams, trenches, flow gates, and improvised barriers. Strategy selection will depend on the presence or absence of water flow.

- Place barriers diagonally across the creek rather than perpendicular to the bank.
- In a dry stream bed with gravelly sediments, trapped oil can penetrate deeply into the gravel (up to tens of feet).
- Watch for rapid changes in stream flow that can wash out dams and barriers.

Streams

Streams always have running water in the channel or bed, although the flow rates can vary seasonally. The banks can be steep or flat and are often natural and composed of riparian vegetation, rather than manmade materials such as seawalls and riprap.

Feasible protection methods include booming tactics, earthen barriers, overflow and underflow dams, trenches, and improvised barriers.

- Response will be driven by location of access points, such as at bridges or parks.
- Containment will be most effective where the slope is gentler and the flow rates slower.
- Take care to minimize contamination of stream-side sediments.

Vegetated Shorelines

Many embayments and other sheltered areas have large areas of vegetated shoreline. The vegetation can be fresh- and saltwater marshes, mangrove swamps, or low banks of terrestrial vegetation. The nearshore areas are usually shallow, limiting access for booming or other protective methods. Booming is the only feasible protection method.

- Responders should take extreme care to avoid trampling vegetation/substrate.
- In tidal settings, a combination of both shallow-water and inland booms may be needed.

Sand/Mud Flats

These flats consist of accumulations of sand or mud that are exposed at low water levels and completely submerged during high water levels. They occur at the mouths of tidal inlets and next to many shoreline types in bays and estuaries. Sandy flats usually indicate strong tidal currents and/or wave activity; however, muddy flats do not always indicate weak currents. Booming is the only feasible protection method.

- Shallow water and shoreline access are major operational limitations.
- Responders may need a combination of both shallow-water and inland booms, especially where waves may cause entrainment.

Submerged Habitats and Resources

Submerged habitats include all areas below low-low water level, sensitive habitats such as submerged aquatic vegetation and coral reefs, and human-use resources such as water intakes and fish pens. These areas are extremely difficult to protect because of their open nature. Most water intakes should have an internal contingency plan that includes water-quality monitoring, closure when slicks are near the intakes, temporary alternate sources of water, and increased carbon filtration of the raw water. Feasible protection methods include open-water skimming, booming, and improvising barriers.

- Booms are only effective where wave heights are small and water depths are appropriate for anchoring.
- Responders may need to give special consideration to heavy oils or oil mixed into the water column attached to debris or sediments.

Steps for Developing Site-Specific Protection Strategies

When developing Appendix V, Sensitive Areas, Area Committees complete two very important components of the area plan: identifying sensitive areas and developing specific response strategies to protect these sensitive areas. Developing the site-specific protection strategies is another iterative process as the committee evaluates the feasibility of various strategies. Before working on the strategies, the committee should have identified and initially prioritized sensitive resources (see Chapter 2). All priority areas should be listed in tabular form and pinpointed on work maps. The committee should have compiled available information on the physical and environmental conditions on each site.

The process can be divided into a series of steps.

Step 1. Identify the following information for each site:

- Nautical charts, for water depths, bathymetry, and navigation information
- Topographic maps, for access points, topography, and demographics
- Water velocities, average and maximum
- Average and storm wave heights and direction
- Tidal range, for neap and spring tides
- Seasonal changes in water levels
- Shoreline types
- Lists of sensitive resources present
- Potential spill sources

Step 2. Summarize the resources being protected at the site. For example, a priority site is an extensive marsh system that is connected by a series of channels to an open bay. Channels are the primary conduit for an oil spill in the bay to enter the marsh during all but extreme water levels. Protect the marsh by focusing on preventing oil from entering the channels during flood tide.

Step 3. Determine the physical setting of the actual protection site. In this example, it is a saltwater marsh creek mouth.

Step 4. Using the matrix for weighing viable protection methods versus physical setting, list the "recommended" and "conditional" protection methods for the site. For saltwater creek mouths, consider using shallow-water boom and earthen barriers.

Step 5. Evaluate the feasibility of employing each listed method at the site. Use the matrices on operational limits (Figure 8) and support equipment (Figure 9) for each method and recovery device, as well as the available information on site conditions and resources. Consider each of the limitations for the specific site, realizing that many decisions are made based not on information from a report, but on the knowledge, experience, and judgment of the committee members. Thus, it is very important to have resource and response community members present. Select the most appropriate protection method or combination of methods. If no mechanical actions are feasible, then consider alternative protection strategies.

Step 6. Develop the full, site-specific response strategy. Describe the strategy in detail so that the committee's intent is very clear. Include specific actions to follow or avoid. For example, if diversion booming is recommended, specify collection points. If special conditions at the site were noted during the evaluation, they should be included here so that responders implementing the strategy can benefit from the work of the committee.

Step 7. Field-verify and revise the protection strategy through site visits. Each priority site should be visited to determine that the site is properly located on maps and classified, the proposed protection strategy is feasible, and that access and anchor points are properly located. Figure 14 is a suggested checklist of actions to be completed during the site visit. It is likely that, for some high-priority sites, the only possible protection strategies will be deemed to be of low feasibility during field verification. The committee will have to consider alternative methods and/or prevention strategies for these sites. Field verification of each site does not have to be completed prior to submitting the Area Plan, but key sites (those of highest priority and the most questionable protection strategies) should be visited within the first year, and subsequent sites visited within the first five years. It is important to verify the plans at different conditions of tide, water level, discharge rates, etc.

Step 8. Submit the protection strategies to the Area Committee for approval, both for an individual site or updates to sub-areas. The final products are:

1. Feasible protection strategy for priority sites;
2. Alternative approaches for low-feasibility sites; and
3. Consideration of alternative protection methods.

Formats for presentation of these products are described in Section 5.

FIELD VERIFICATION CHECKLIST

Site Name ______________________________ Site No. ______Date______________

Survey Team Members____

- ☐ Is the site properly located on the map?
- ☐ Has the name of the site changed?
- ☐ Verify latitude/longitude if GPS is available.
- ☐ Are the physical settings of the site correct?
- ☐ Are all the shoreline types listed?
- ☐ Verify presence of sensitive resources listed for the season of the visit.
- ☐ Are other sensitive resources present?
- ☐ Evaluate whether the protection strategy is appropriate.
  - Check feet of boom needed for currents and width at the site.
  - Are the anchor points accessible at high/low tide or water levels; will they hold?
  - Is water depth compatible with protection strategy?
  - Are natural collection sites identified?
- ☐ What logistics are available on-site?
- ☐ Verify the possible staging areas. Are the directions correct?
- ☐ Verify the possible access points. Are the directions correct?
- ☐ Verify operational response limitations.
- ☐ Verify resource protection limitations.

Figure 14. Checklist of actions to be completed during field-verification visits to priority protection sites. The checklist should be used with the site summary sheet and map of the site from the area plan.

Presentation of Work Products

The Coast Guard guidance for identifying sensitive areas in Appendix V, Annex E of the Area Contingency Plan specifies that sensitive areas be mapped out with as much detail as possible using the information from sensitivity and protection strategies. The plan should include the following information, at a minimum:

- Maps showing the location of the prioritized areas;
- Summary sheets that describe each area (both sensitive resources and protection strategies);
- Detailed sketches of priority sites showing site-specific information on protection method, access, anchor points, location of sand bars, etc.

Each of these types of information is discussed in the following section.

Maps of Sensitive Areas

Maps show both the location of sensitive areas and their priority. The most cost-effective maps are black-and-white, page-sized (8.5 x 11 inches). Color and larger-format maps are more readable, but are not widely used because of the initial cost of reproduction and the difficulty of rapidly reproducing or transmitting them with standard office equipment, such as photocopiers and facsimile machines.

If possible, maps at various scales should be used to display the information in the plan most effectively. Two types of maps should be considered: location maps and protection priorities maps. You need a *location map* of the entire area or region covered by the plan to show the area of concern, the division of any sub-areas, and the location of more detailed maps. Figure 15 shows a sample map containing all of the necessary information on a location map:

- The boundaries of the area covered by the plan;
- Location of the area map on a state map;
- Map scale and north arrow;
- Map source; and
- Area covered and key for more detailed maps

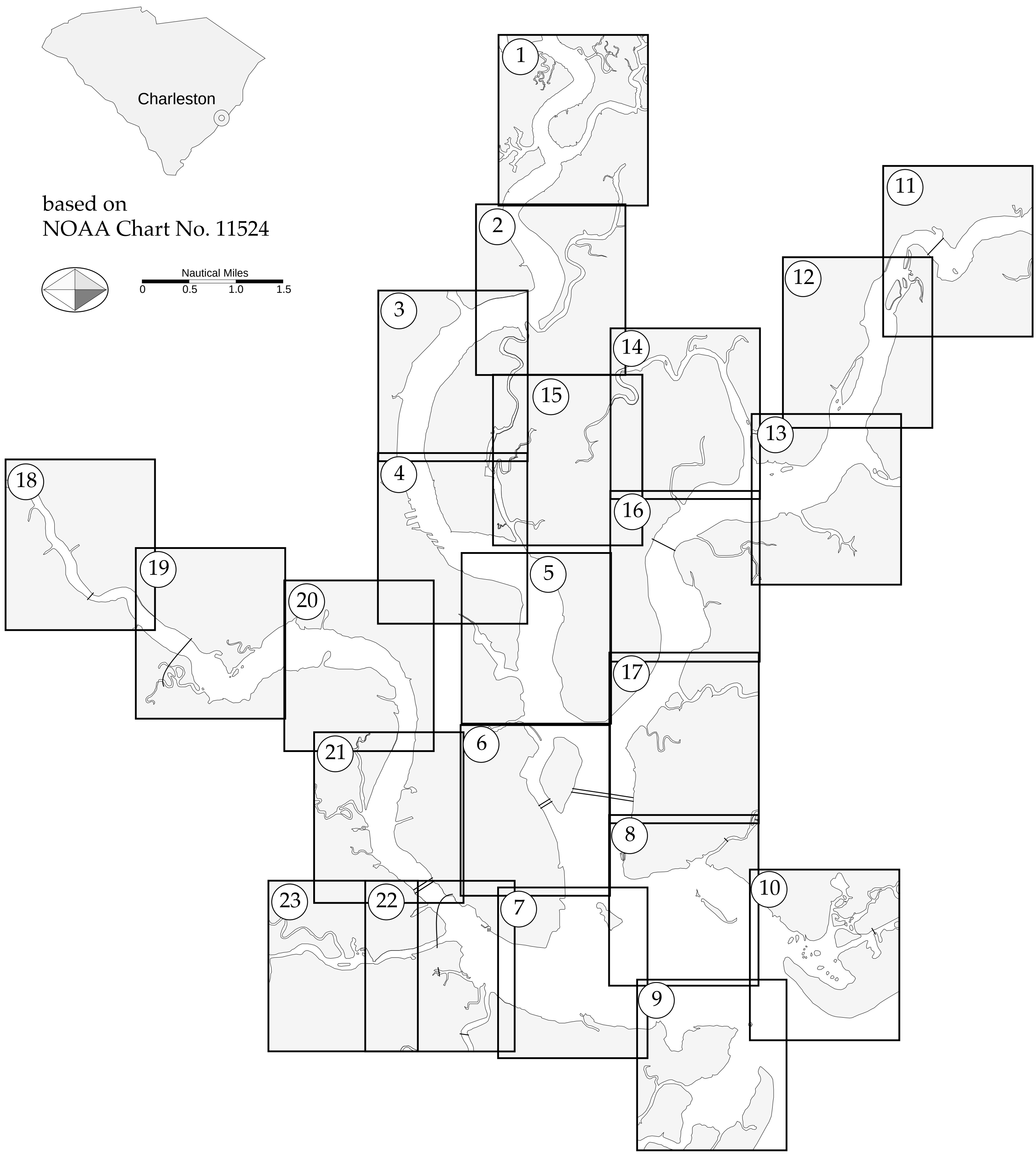


Figure 15. Sample location map showing the necessary information.

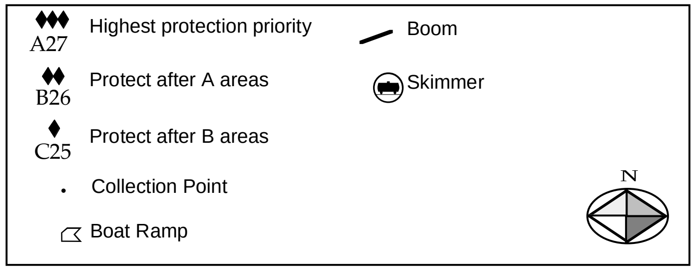
Protection priorities maps show the location of priority protection areas. Use standard base maps, such as NOAA charts or U.S. Geological Survey topographic maps, because they are commonly used by response agencies and provide detail missing on other maps. Also, shoreline and other types of information are distributed in digital format for these maps, which the Area Committee can use with readily available mapping software to generate their own computer maps. If the Committee decides that the base maps will be the original 1:24,000-scale USGS topographic map (7.5-minute quadrangle), but reduced to page size, the scale of the reduced map becomes 1:64,800 when the map is 8.5 x 11 inches, and about 1:80,000 when room for a legend is added. If this scale is not appropriate, it may be better not to reduce the whole map to page size, but instead cut the original map into page-sized sheets. The objective is to keep the area covered by the map or the map scale tied to a recognizable format, because computer-generated maps will necessarily lack much of the detail shown on printed maps. The response plan maps should have:

- Map name and number;
- Map base (and computer file name if in digital format);
- Latitude/longitude tick marks;
- Scale (e.g., 1:24,000) and distance ruler;
- Date published by the Area Committee (to facilitate updating);
- Legend for all symbology used on the map; and
- North arrow.

The protection priorities maps should be kept relatively simple and emphasize the location and priority of the protection priority areas (Figure 16 is a sample map). Shoreline sensitivity or the distribution of sensitive resources should not be included on these maps. Each priority area should be marked with a symbol and unique code that is linked to tables or summary sheets with detailed information (discussed in the next section). The symbol indicates the protection priority. The priority area code includes an identification number; the priority should be included in the code (e.g., A12 represents an “A” priority site with identification number 12). The map provides a visual summary of the areas requiring protection and their priority. They do not provide detailed information on specific protection configurations.

COTP Savannah

Map 4
prepared by NOAA



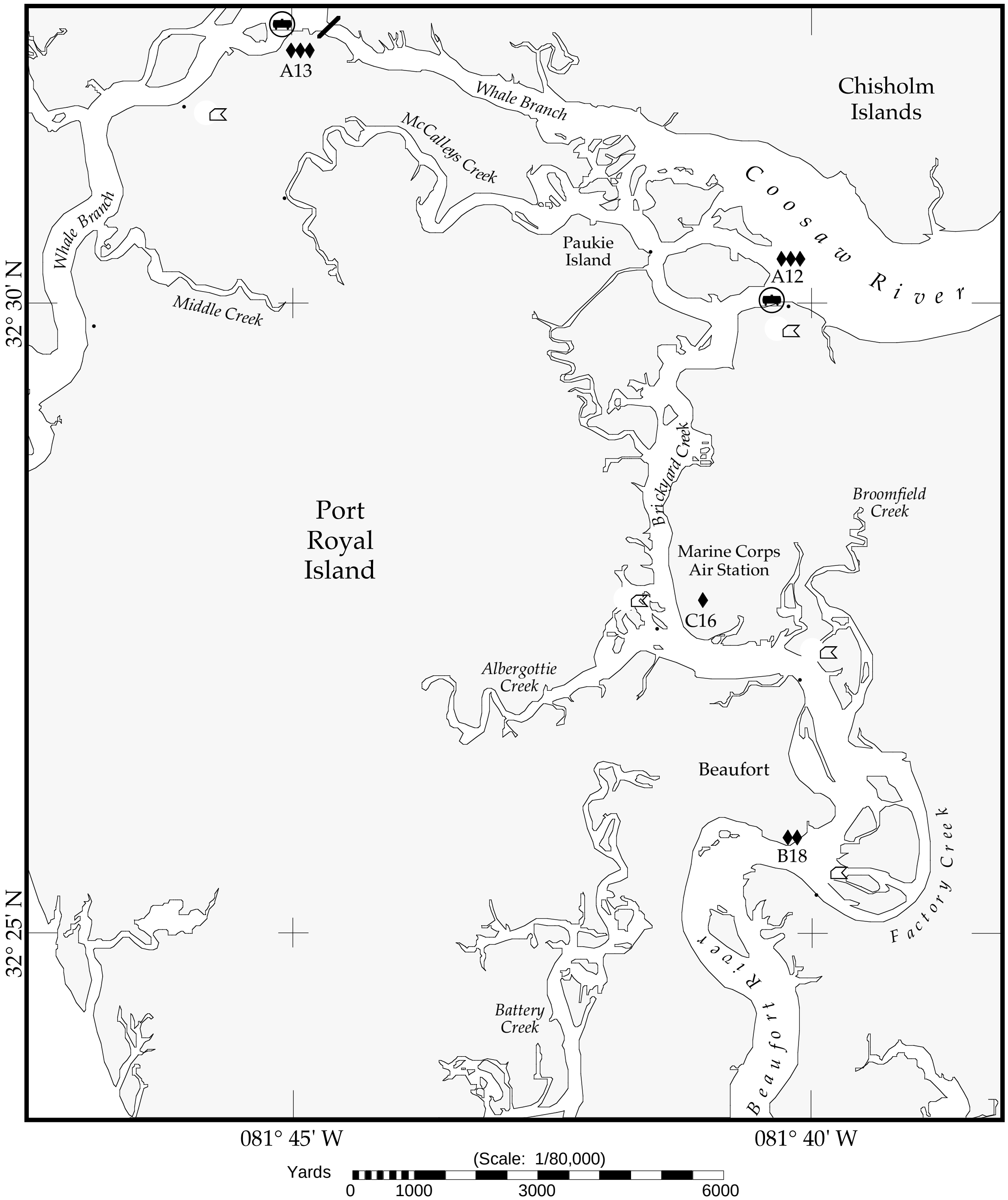


Figure 16. Sample map from COTP Savannah, Port Royal Island area, showing priority protection areas.

Site Summary Sheets

Site summary sheets contain text descriptions of sensitive resources and response strategies. Figure 17 is a sample sheet. Data to be included in these summaries include:

Map Number: Refers to the map in the published plan where the priority site is located. Each map should be numbered sequentially.

Site No.: Refers to the site number shown on the map. Number the sites in logical order on the map, at least at first. However, the initial numbers are likely to change during the process.

Site Name: The site name should be very descriptive and accurately represent its location on the map and in the field.

Latitude/Longitude: These coordinates should be carefully measured from detailed maps for the center point of the site.

Date Entered: The month/day/year that the sheet was initially completed.

Date Updated: The month/day/year that any information on the sheet was changed.

Local Expert/Land Manager Contact: List local experts so that you can contact them during a spill for information on the resources that are actually present or to provide more detail during planning. For example, the regional wildlife biologist would know if the piping plovers have completed nesting and have dispersed, and thus no longer need protection at that site. This is a good reason for including their specific expertise. The listed experts should be the most knowledgeable local contact, someone who is very familiar with the site and/or resource. Include the land manager contact to provide access permission, directions, special restrictions due to current conditions, and resource information.

Site Description: This section of the sheet includes identifying the physical settings at the site, using whatever terminology is in use in the area. List the shoreline types present using the ESI terminology if appropriate.

SITE SUMMARY SHEET

MAP NO._____ **SITE NO.**________ **NAME**____________________ DATE ENTERED: ________ LATITUDE: _________________ LONGITUDE:_________________ DATE UPDATED: ________		
LAND MANAGER/CONTACT	EXPERTISE	PHONE

SITE DESCRIPTION

PHYSICAL SETTINGS:

SHORELINE TYPES:

SENSITIVE RESOURCES TO BE PROTECTED

PROTECTION STRATEGIES

EQUIPMENT REQUIREMENTS:

STAGING AREAS:

ACCESS POINTS:

OTHER:

RESPONSE LIMITATIONS

OPERATIONAL:

RESOURCE PROTECTION:

REVIEWED BY: FOSC _________ SOSC _________ FED/TRIBE_________OTHER _______

Figure 17. Site summary sheet to be completed for each protection priority site.

Sensitive Resources to be Protected: List all of the specific sensitive resources at the site, emphasizing the basis for sensitivity. Note any seasonal variations in presence or sensitivity of the resources. Sample text would include "heron rookery, ± 100 nesting pairs, May-September." The information should be correct, concise, and informative to the resource manager who will be able to revise priorities quickly based on conditions during a spill event, and to the responder who will know what is to be protected at the site.

Protection Strategies: This section should include a clear description of the type of protection to be used at the site, in preferred order of use if more than one strategy is applicable. The description should include the intent (e.g., exclusion, diversion), method (e.g., booming, underflow dams), location (e.g., ten feet inside the channel, at the north end of the seawall), and any specific collection points.

Equipment Requirements: List the equipment needed to complete the protection strategy, such as the type and feet of boom, and number of anchors, boats, bulldozers, pipe, and pumps.

Staging Areas: List facilities or locations that can provide necessary services, such as parking, work spaces, storage, security, power, and sanitation.

Access Points: For water-based response strategies, list the nearest boat ramp or hoist, including details such as size and construction. For land-based response strategies, provide directions to the shore from major roads. Be sure to identify locked gates and private property; provide contact phone numbers.

Other: Examples of other information that can be provided are:

Response Limitations–Operational: Use the checklist in Figure 18 to generate site-specific operational conditions that may affect the success of protection strategies. The objective is to give the responder site-specific information to implement the protection strategy effectively. It is important to identify the conditions under which the proposed strategy will not work.

Response Limitations–Resources: Use the checklist in Figure 18 to generate site-specific constraints on crews working at the site that will minimize disturbances to the site.

Site Name ______________________________ No. _____ Date ___________

Water Conditions

☐ Water current: <1 knot____ 1-2 knots ____ 2-3 knots ____ >3 knots____

☐ Flow direction:____

☐ Wave height: Average ____ feet Storm ____ feet

☐ Tidal range: Neap ____ feet Spring ____ feet

☐ Non-tidal water changes (describe): _________________________________

☐ Water depths: Maximum ____ feet Minimum ____ feet

☐ Describe variations in water depth: _________________________________

Access

☐ Possible by: Vehicle ____ Boat ____ Foot ____ Helo ____

☐ Land access restrictions:____

☐ Water access restrictions, at high tide: ________________________________

☐ At low tide:____

☐ Nearest staging area: ____

☐ Nearest boat ramp:____

☐ Vessel traffic restrictions:____

Other

☐ Describe:____

Figure 18. Operations limitations checklist.

Detailed Sketches of Priority Protection Areas

Produce detailed site sketches for all priority areas where you have developed and ground-truthed protection strategies. These sketches are usually plan-views drawn at a scale proportionate to the size and complexity of the site. Figure 19 is an example of a detailed site sketch. Note that the site sketch includes:

- Site name, number, and location (descriptive and map number);
- Date prepared;
- Tidal conditions during the site visit;
- North arrow;
- Scale bar;
- Legend for all symbols and abbreviations used on the sketch;
- Protection methods used;
- Access points;
- Anchor points; and
- Collection areas (primary and alternative)

You should also briefly describe or explain the protection strategies shown on the map. These detailed protection strategies should only be developed by a team of experienced response and resource personnel. All of the available information on currents, water levels, wave energy, and sediment transport patterns should be compiled and reviewed. A site visit is necessary to field-check access, locations for anchor points, current velocities, and other site-specific features that affect the design and logistical requirements for site protection. It may be necessary to install permanent anchor points at some locations.

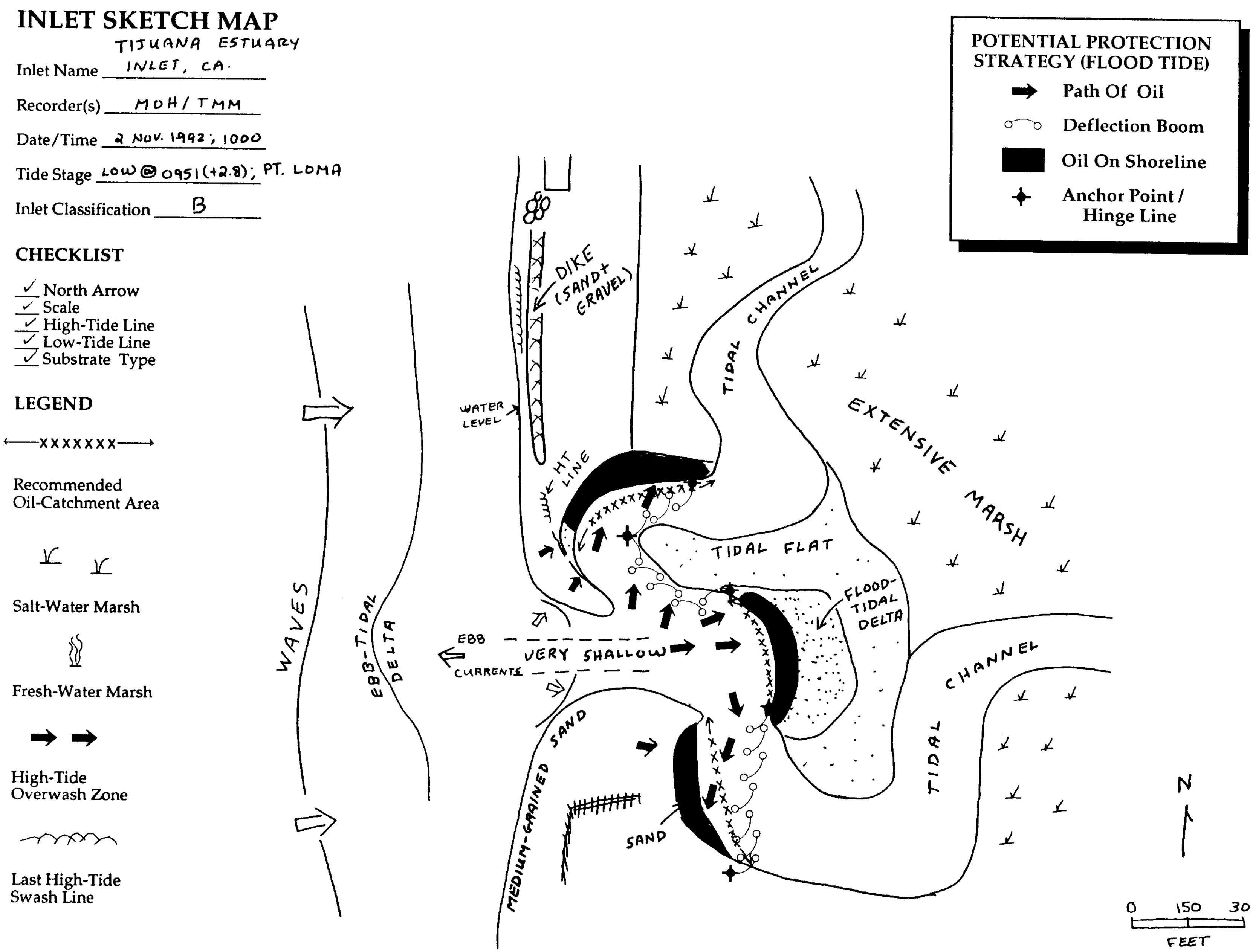


Figure 19. Sample site sketch showing recommended protection strategy.

6 PLAN VALIDATION

1. *Match protection strategies with three OPA 90 scenarios: most probable, maximum most probable, worst-case*

Validation of the plan includes identifying equipment shortfalls and optimizing staging areas according to the three scenarios outlined in OPA 90. The procedure is to run each scenario, identify priority areas at risk within the specified time periods, then total up equipment requirements.

2. *Plan, train, exercise and revise*

Conduct field exercises to test and refine the protection strategies, particularly where site conditions are close to the operational limitations of the equipment. Field-test the protection strategies as an integral component of the regular exercises and drills being conducted in each area. Facilities, response contractors and co-ops, and others should be encouraged to test the protection strategies in the plan during any field exercises they conduct. Poorly designed or unfeasible protection strategies must be revised and re-tested to verify their performance.

RECOMMENDED REFERENCES

American Petroleum Institute. 1985. *Oil Spill Cleanup: Options for Minimizing Adverse Ecological Impacts*. API Publ. No. 4398. Washington, D.C. 110 pp.

Code of Federal Regulations. 1992. Title 40, Part 300, National Oil and Hazardous Substances Pollution Contingency Plan. Washington, D.,C.: U.S. Government Printing Office.

Exxon. 1990. *Valdez Oil Spill Technology, 1989 Operations*. Houston: Exxon Production Research Company.

Exxon. 1992. *Oil Spill Response Field Manual.* Fourth Printing. Houston: Exxon Production Research Company. 193 pp.

Oklahoma State University. 1993. *Field Operations Guide*. Report ICS-420-1. Stillwater, Oklahoma: Fire Protection Publications.

Fingas, Mervin F., Wayne S. Duval, and Gail B. Stevenson. 1979. *The Basics of Oil Spill Cleanup, with particular reference to Southern Canada*. Ottawa, Ontario: Environmental Emergency Branch, Environmental Protection Service, Environment Canada. 155 pp.

IMO. 1988. *Manual On Oil Pollution*, Volumes 1-4. London: International Maritime Organization.

International Tanker Owners Pollution Federation Ltd. 1988. *Response to Marine Oil Spills*. New York: State Mutual Books. 125 pp.

National Conventioneer. 1993 Oil Spill Conference and Instrumentation Equipment and Supplies Exposition. Pittsburgh: Publishers for Conventions, Inc.

NOAA. 1992. *Shoreline countermeasures manual template for temperate coastal environments*. Seattle: Hazardous Materials Response and Assessment Division, National Oceanic and Atmospheric Administration.

NOAA. 1993. *Guidelines for developing digital environmental sensitivity atlases and databases.* Seattle: Hazardous Materials Response and Assessment Division, National Oceanic and Atmospheric Administration.

National Response Team. 1990. *Oil Spill Contingency Planning, National Status. a Report to the President*. Washington, D.C.: U.S. Department of Transportation and U.S. Environmental Protection Agency.

Tramier, B. 1981. *A field guide to coastal oil spill control and clean-up techniques*. Report No. 9/81. The Hague, The Netherlands: CONCAWE. 112 pp.

Texas A & M University. *Oil Spill Control Course*. Galveston: Occupational Environmental Safety Training Division, Texas Engineering Extension Service.

Schulze, Robert and Harry L. Hoffman, eds. 1993. *World Catalog of Oil Spill Response Products*. Elkridge, Maryland: World Catalog. 592 pp.

INDEX

C

H

I

J

K

L

M

N

O

P

R

S

T

U

V

W