Massachusetts Geographic Response Plan Tactics Guide

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I. INTRODUCTION

PURPOSE

The Massachusetts Geographic Response Plan (GRP) Tactics Guide provides a standardized oil spill response tactics manual that is intended to be a standard tactical reference for implementing geographic response plans (GRPs) in Massachusetts. It is available for use by the spill response community, including federal, state, local, industry, and spill response organizations throughout Massachusetts and in other regions of the northeastern United States, as applicable.

The information supports coastal GRP implementation and nearshore spill response in general by providing standard tactics and terminology. The standardization will facilitate mutual aid among response organizations and may improve resource ordering and allocation during a response. The manual also has value as a field guide and training aid for oil spill responders.

The tactics that are used in the Massachusetts GRP rely on standard mechanical response techniques. Mechanical response describes spill response methods where specialized equipment is used todivert, collect, and/or remove spilled oil from the environment. The Tactics in this manual are divided into three categories: Booming, Recovery, and Other.. Most tactics apply either to on-water or on-land spills, but there is some limited overlap where response methods may be used in either instance. In most cases, a combination of tactics from one or more of these categories will be used to accomplish the spill response objectives.

The tactics described here are not prescriptive or exclusive; spill planners and spill response organizations are free to develop and utilize other tactics or modify these tactics to meet their needs. These tactics are also intended to be flexible; spill responders should adjust or modify these tactics to meet the prevailing conditions that they encounter in the field.

The tactics in this guide were adapted from the Spill Tactics for Alaska Responders (STAR) manual, published by the Alaska Department of Environmental Conservation. A work group of spill response professionals adapted the tactics to the coastal Massachusetts operating environment through a collaborate process as part of the Cape and Islands GRP project led by the Massachusetts Department of Environmental Protection, the U.S. Coast Guard, the National Oceanic and Atmospheric Administration, and Massachusetts Coastal Zone Management.

OPERATING ENVIRONMENTS

The operating environment classification system used in this manual follows the system used in the World Catalog of Oil Spill Response Products – Eighth Edition.[1] The World Catalog in turn follows the standards of the American Society of Testing and Materials (ASTM), in particular F625-94(2000) Standard Practice for Classifying Water Bodies for Spill Control Systems.

Operating environments are not static; they describe on-scene conditions, which may change suddenly. In selecting response equipment and support systems, it is important to consider the potential for conditions to change suddenly. The following classification systems provide a general reference regarding the maximum operating limits of response equipment.

Equipment is rated to perform in one of the following operating environments:

Operating Environment	Significant Wave Height	Examples of General Conditions
Open Water	≤ 6 ft.	Moderate waves, frequent white caps
Protected Water	≤ 3 ft.	Small waves, some white caps
Calm Water	≤ 1 ft.	Small, short non-breaking waves
Fast Water	≤ 1 ft.	Small, short non-breaking waves with currents exceeding 0.8 knots, including rivers

NOTES:

The broken ice operating environment is not considered for the tactics listed in this manual, because on-water spill response operations will not usually be attempted in this region when sea ice is present.

[1] Potter, Steve, ed. 2004. World Catalog of Oil Spill Response Products. Ottawa, Ontario, Canada: SL Ross Environmental Research Ltd.

SAFETY CONSIDERATIONS

Each tactic lists specific safety and deployment considerations. However, there are a number of general safety considerations that apply to all oil spill response tactics and should be observed in implementing any of the Massachusetts GRPs:

- Daily weather evaluations are recommended, and should include distance to safe harbor, transit times and exposure of vessels.
- Vessel masters should have experience in the appropriate operating environment. Local knowledge is preferred.
- Vessels deploying response equipment shall be able to safely transit seas which exceed the equipment's operating limitation.
- Vessels, including skiffs, must have a minimum of two crew aboard.
- If possible, vessels in transit to/from an operation or staging area should transit in pairs.
- A communications schedule should be established and followed, between vessels in transit and the Operations Section or Radio Dispatcher.
- Extreme care should be used when taking strains on anchoring systems using the aft cleats of small vessels and skiffs.
- Response personnel should wear PPE as required by the incident-specific Site Safety Plan.

SITE ACCESS AND PERMITTING CONSIDERATIONS

Oil spill response tactics can alter or damage the natural environment and may also impact wildlife and historical or cultural resources. Therefore, before implementing any GRP tactics, due diligence should be followed to ensure that all local, state, and federal permits and permissions are acquired. These may include:

- Site access permission or agreement from private landowners.
- Compliance with permitting requirements.

LEGEND OF SYMBOLS

TACTIC SYMBOLS

The following symbols are used to represent the tactics described in this manual. These symbols will be applied to the GRP strategies to identify where each tactic may be applied to achieve the GRP protection priority.

- EB — Earthen Berms
- C — Containment Boom
- CB — Culvert/Outfall Blocking
- DF — Deflection Boom
- DV — Diversion Boom
- EX — Exclusion Boom
- MR — Marine Recovery
- FO — On-water Free-oil Recovery
- OR — On-land Recovery
- PR — Passive Recovery
- SR — Shoreside Recovery

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SECTION II – BOOMING TACTICS

GENERAL CONSIDERATIONS

Boom is a containment barrier used to intercept, control, contain, and concentrate spreading oil on water. Boom comes in a variety of forms and may be deployed in a number of possible configurations.

Boom Types and Classification Systems

Different types and sizes of boom may be referred to a by a variety of names, some of which may vary regionally. There are two major classification systems for selecting boom according to water body classification. This Tactics Guide uses the classification system developed by the American Society for Testing and Materials (ASTM), as it corresponds to the operating environment classifications used in this guide. The ASTM classification system divides boom into 4 categories, based on the operating environment in which it may be used:

- Calm water boom (sometimes referred to as "harbor boom")
- Fast water boom (calm water/fast current boom)
- Protected water boom
- Open water boom (sometimes referred to as "ocean boom")

The following table describes the properties of these four boom types.

Boom Property	Calm Water	Calm Water-current (fast water)	Protected Water	Open Water
Height (in)	6 to 24	8 to 24	18 to 42	36 to 90+
Minimum reserve buoyancy to weight ratio	2:1	3:1	3:1	7:1
Minimum total tensile strength (lbs)	1,500	5,000	5,000	10,000
Minimum skirt fabric tensile strength (lbs/in) 2TM=2 tension members; 1TM=1 tension member	2TM - 300 1TM - 300	2TM - 300 1TM - 300	2TM - 300 1TM - 400	2TM - 400 1TM - 400
Minimum skirt tear strength (lbs)	100	100	100	100

Tidal-seal Boom

Another category of boom, which does not fit into the above four categories, is also used for spill response in coastal areas. Tidal-seal boom is not currently stockpiled in Massachusetts, however its major characteristics are described briefly below since it may be appropriate

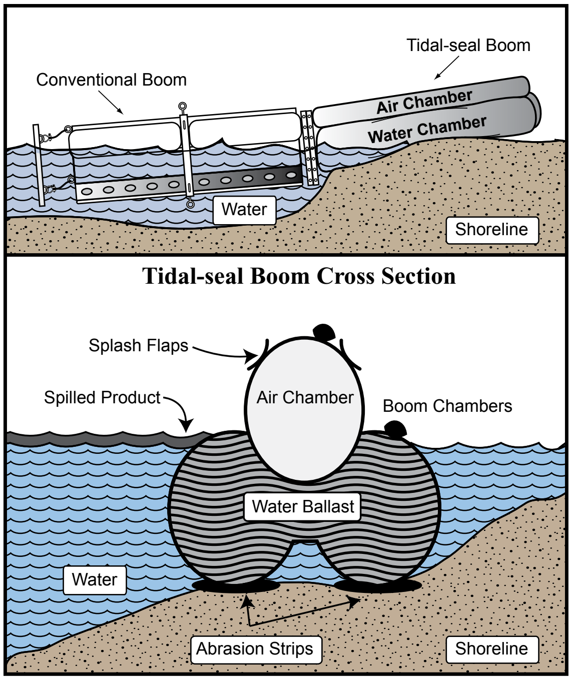


Figure B-1. Tidal-seal boom configuration.

for use in future Massachusetts GRPs.

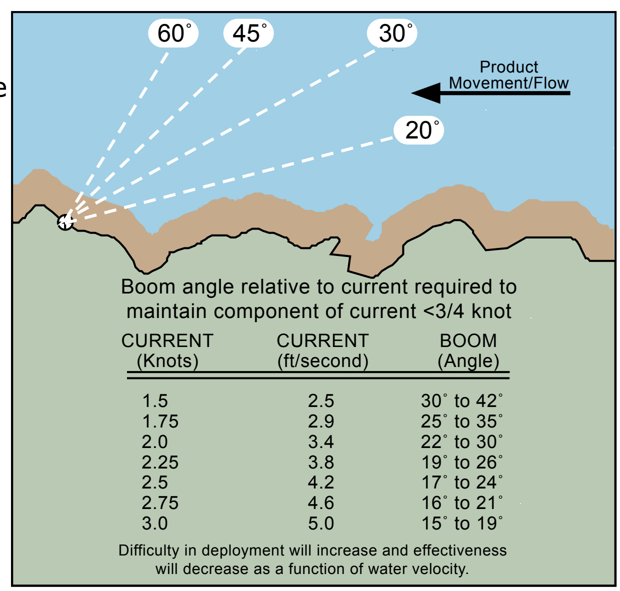
Tidal-seal boom may be used in boom arrays where the array contacts the shoreline to prevent oil from escaping. Tidal-seal boom typically contains three chambers as shown in Figure B-1. Two of the chambers are filled with water, and contact the shoreline in shallow water and shoreline areas. The third chamber is usually filled with air, and provides flotation as the water level rises. Tidal-seal boom should be used in areas with a smooth bottom of gradual slope and avoided where there are large rocks and sharp breaks in the bottom.

The Massachusetts GRP tactics do not use tidal-seal boom; instead sorbent materials can be placed next to or attached to conventional boom to hinder oil entrainment under the boom at the beach water interface. It is important that oiled sorbents be switched out at each tidal cycle.

Boom Angles

The booming tactics in this section and the strategies described in the Massachusetts GRPs require that boom be placed and adjusted to maximize efficiency. If boom is not deployed correctly, oil may entrain (escape underneath) the boom.

A key consideration in deploying boom is the boom angle, which is directly related to the velocity of the current. Figure B-2 may be used to select the appropriate boom angle to keep oil from entraining under the boom. Note that the angle relative to the current decreases rapidly as the current increases. Where currents exceed 3 knots, the boom must be almost parallel to the current to prevent entrainment. In currents exceeding 3 knots, a cascade of boom arrays may be used; the first boom array will slow the velocity of the slick allowing subsequent arrays to deflect the oil.



CURRENT (Knots)	CURRENT (ft/second)	BOOM (Angle)
1.5	2.5	30˚ to 42˚
1.75	2.9	25˚ to 35˚
2.0	3.4	22˚ to 30˚
2.25	3.8	19˚ to 26˚
2.5	4.2	17˚ to 24˚
2.75	4.6	16˚ to 21˚
3.0	5.0	15˚ to 19˚

Figure B-2. Boom angles for various current velocities.

Anchoring Systems

Boom is secured in place using standard anchoring systems. Anchor sizes will vary depending on the boom type and the operating environment.

Anchor systems must be selected based on the maximum stress that might be expected to occur on the boom array, considering stronger currents and winds than when the anchor is set.

The scope of the anchor line should be at least 3 times the depth of the water. If the anchor fails to hold try increasing the line scope to five times the depth of the water and/or double the length of the anchor chain. Finally, if additional anchor holding is required, anchors can be ganged or set in series.

Figure B-3 shows a typical boom anchoring system.

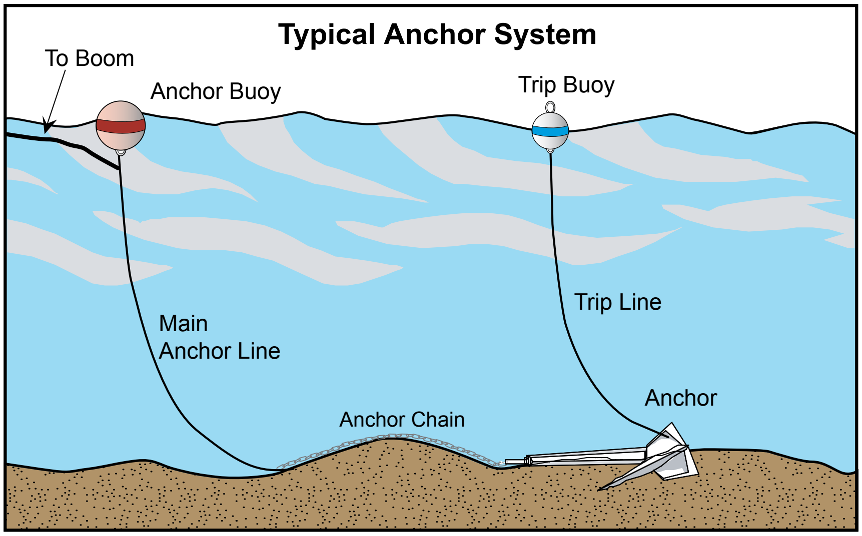


Figure B-3. Typical anchor system.

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DV DIVERSION BOOM

OBJECTIVE & STRATEGY

The objective of the Diversion Boom tactic is to redirect the spilled oil from one location or direction of travel to a specific site for recovery. For the purposes of maintaining consistent and clear terms, diversion is always associated with oil recovery, in contrast with the term deflection, which is used to describe the tactic where oil is redirected away from an area but not recovered.

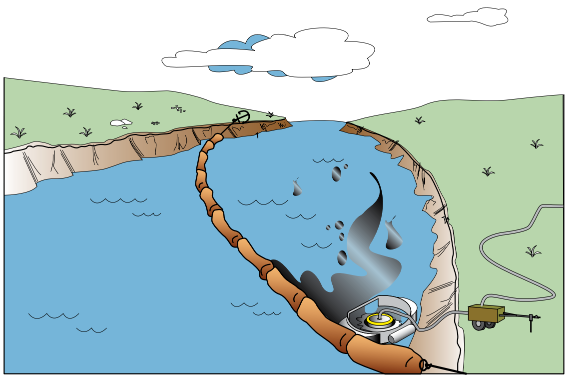

Figure DV-1. Diversion Booming with Marine Recovery.

TACTIC DESCRIPTION

The Diversion Boom tactic is for water-born spills where there is some current, usually from 0.5 to 3.0 knots. The boom is placed at an optimum angle to the oil trajectory, using the movement of the current to carry oil along the boom to a recovery location. The angle is chosen to prevent oil from entraining beneath the boom skirt. Oil can be diverted to a shoreline or away from a shoreline or shoal waters. This tactic is always associated with a recovery tactic, either Shoreside Recovery or Marine Recovery. Boom may be held in place by anchors, vessels, or a boom control device.

Boom Control Devices

An alternative to anchoring deflection boom on the offshore end are boom control devices. Boom control devices have the advantage of allowing continuous control over the angle and position of the boom. They can also allow the boom to be moved to allow a vessel or drifting debris to pass by without interfering with the diversion operation. One type of boom control device is a vessel, which continuously controls the offshore end of the boom. Controlling a diversion boom with a vessel takes considerable skill and a vessel suited for the purpose.

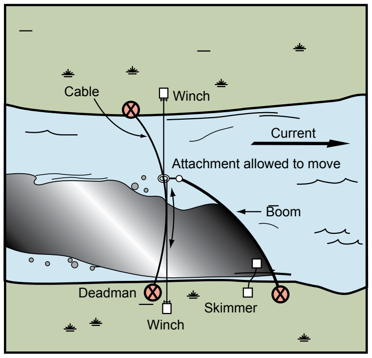

Figure DV-2. Diversion boom configuration using a trolley.

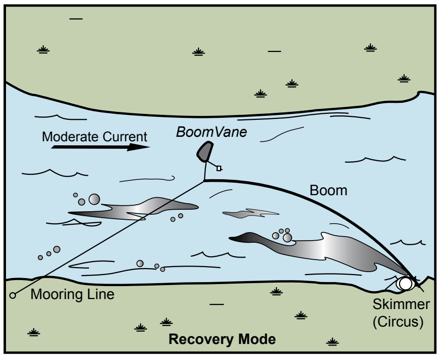

Figure DV-3. Diversion boom configuration using a BoomVane™.

Another type of boom control system is a trolley as shown in Figure DV-2. Trolleys require that a line be strung from one shoreline to another, thus they are mostly used in rivers. Trolleys may block a river to passage by vessels and they are susceptible to impacts from debris. A relatively new type of boom control device is built on the principle of a wing or rudder. Devices such as the Boom Vane™, allow the boom to be deployed and controlled from the shoreline (Figure DV-3). This decreases the need for vessels and anchor systems, while allowing superior control of the boom angle.

Operating Environments

Operating Environment	Diversion Booming Use	Considerations
Open Water	Rarely	Diversion Boom system components (vessels, boom and anchors) for open water operations should be able to deploy and operate in seas up to 6 feet and in winds of up to 30 knots. Open water systems are usually deep draft, operating at depths of greater than 6 feet.
Protected Water	Most common	Vessels, boom and anchors for protected water Diversion Boom systems should be able to deploy and operate in seas up to 3 feet and winds up to 25 knots. Protected water systems may be deep draft or shallow draft, depending on the water body.
Calm Water	Most common	Calm water diversion boom systems are composed of vessels, booms and skimmers that should be able to deploy and operate in seas of 1 foot and winds up to 15 knots. Calm water diversion boom systems typically work in depths as shallow as 3 feet.
Fast Water	Most common	Fast water diversion boom systems are designed to operate in moving water where the current exceeds 0.8 knots. This includes rivers and areas with significant tidal current. Vessels, boom and anchors used in tidal waters should be able to deploy and operate in seas up to 1 feet in winds up to 15 knots. Fast-water diversion boom systems are equipped with high-current boom and skimmers. ***Refer to USCG Fast Water Booming Guide for additional information.***

Deployment Configurations

There are many variations for deployment of Diversion Boom. Several configurations are described below, but responders should consider the actual conditions and modify their deployment accordingly.

SINGLE BOOM – DIVERT INSHORE

A basic diversion technique is to divert oil from a current to a recovery site along a shoreline (Figure DV-4). The recovery site is chosen where there

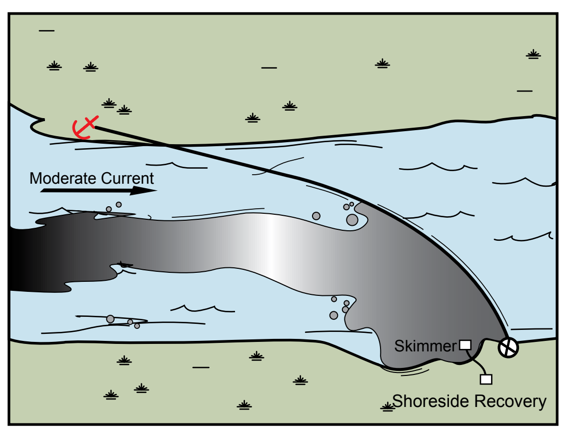

Figure DV-4. Single boom diversion configuration.

is minimal current (an eddy, quiet water, or collection beach) and a suitable recovery system can be deployed. In some cases, with approval, a trench can be dug to create a quiet skimming area. The boom is then anchored at the site and deployed at an optimum angle to the current and secured/anchored to divert the oil to the shoreline for recovery. The offshore end of the boom can be secured with an anchor in the water, an anchor on a far shore, a boom control device or with a vessel.

DIVERT OFFSHORE

A single boom can also be set to divert oil away from the shore or shoal water, where it can be recovered by On-water Free-oil Recovery or Marine Recovery Systems.

CASCADE

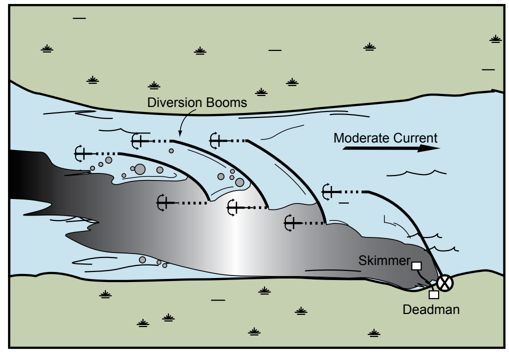

Figure DV-5. Cascade boom diversion configuration.

Several booms can be deployed in a cascade configuration when a single boom cannot be used because of fast current or because it is necessary to leave openings in the boom for vessel traffic, etc. (Figure DV-5) This configuration can be used in strong currents where it may be impossible to effectively deploy one continuous section of boom. Shorter sections of boom, when used in a cascade deployment, are easier to handle in faster water, thereby increasing safety and efficiency. Additional equipment will be required to set and maintain this system in comparison to the single boom configuration.

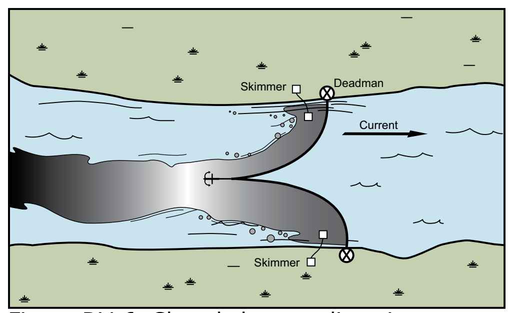

Figure DV-6. Closed chevron diversion configuration.

CHEVRON

Chevron boom configurations may be used in fast water. Two booms are deployed from an anchor in the middle of the stream/river and then attached to each bank (Figure DV-6). A closed chevron configuration is used to divide a slick for diversion to two or more recovery areas. An open chevron can be used where boat traffic must be able to pass (Figure DV-7). In the open chevron configuration the two booms are anchored separately midstream, with one anchor point up-stream or downstream of the other. An inverted chevron can also be used to funnel an oil slick to a marine recovery unit anchored mid-channel (Figure DV-8).

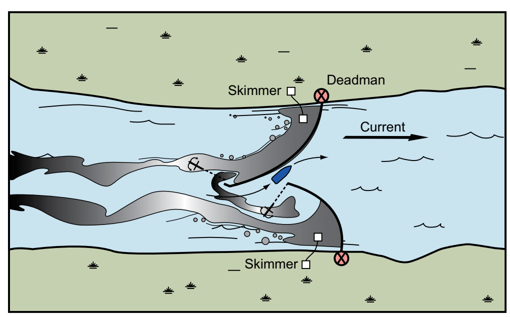

Figure DV-7. Open chevron diversion configuration.

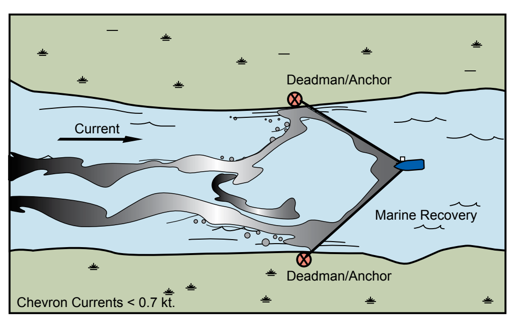

Figure DV-8. Inverted chevron diversion boom configuration.

DEPLOYMENT CONSIDERATIONS AND LIMITATIONS

- Extreme care should be given when selecting deadmans for the anchoring systems onshore.
- It may be useful to deploy back-up boom downcurrent from the primary boom array to catch oil that escapes the primary boom.
- For fast water deployments, consider adding a spotter/rescue person downstream for potential recovery of a casualty, i.e. overturned boat or man overboard.
- Anchor trip lines should be made of material strong enough to handle a moderate strain during boom reconfigurations. Responders normally used the trip line to reposition and reset the anchors.
- If the spill is in still water under calm conditions, consider Containment Booming.
- Boom control devices, such as the Boom Vane™, allow diversion booms to be set and retrieved from shore without a vessel. They also allow for continuous adjustment of boom angles.
- Do not assume 100% efficiency with one boom system.
- When deployed by vessels/crews of opportunity, remember that this tactic requires more training and skill than towing a U-boom.
- Readjust angles and widths between boom sections as necessary to meet changing conditions.
- Continuous monitoring of system efficiency is required.
- Planning for a marine environment should be based on average high tidal conditions.
- See Shoreside Recovery for methods to keep oil from contaminating beaches at recovery points.
- All screw pin shackles shall be seized with wire.
- Removal of boom may require additional personnel.

REFERENCES TO OTHER TACTICS

Other tactics associated with Diversion Boom include:

- Shoreside Recovery
- Deflection Booming
- Marine Recovery
- Containment Booming

EQUIPMENT AND PERSONNEL RESOURCES

Commonly used resources for this tactic include: vessels; boom; anchoring, mooring, or control systems; and response personnel. Configuration and specific resources required will be determined by site conditions, spilled oil type and volume, area of coverage, and resource availability. Resource sets may need to be refined as site-specific requirements dictate.

Typical Diversion Boom System

Typical Resources	Function	Quantity	Notes
Oil boom appropriate for operating environment	Divert and concentrate oil	Site-specific	Depending on configuration, currents, sea states, and oil concentration
Sorbent materials	Placed next to or attached to boom to hinder oil entrainment in inter-tidal zone	Site-specific, optional	Most commonly used on sand and gravel beaches with gradual slope; tidal-seal boom may also be used if available.
Medium anchor systems or shore-based anchors	Secure boom in selected configuration	Rule of Thumb - 1 anchor per 200 ft. of boom	Depending on configuration, currents, and sea states
Boom control devices	Controls boom angle	1 optional	Control devices are useful for adjusting the boom angle and avoiding debris
Recovery system	Remove oil	Site-specific	Select the appropriate recovery system for the situation, depending on configuration
Response vessels appropriate for boom size & operating environment. At least one vessel with a crane is recommended	Deploying/tending anchors and boom	2 to 4	Depending on configuration, currents, and sea states. Boom rollers and deck winches may also be useful when heavy response equipment is used.
Response personnel	Functions vary based on assignment	Varies depending on number of vessels, configuration, recovery system	All response personnel should have the appropriate level of OSHA training for their job assignments. Removal of boom may require more personnel than deployment.

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C CONTAINMENT BOOM

OBJECTIVE & STRATEGY

Containment Booming is a fixed-boom tactic. The objective is to corral spilled oil on the water, usually near the source, thus minimizing spreading and impacts to the environment. It is usually deployed in association with a recovery tactic, either Marine Recovery or Shoreside Recovery. Containment Booming is often associated with vessel-to-vessel or vessel-to-shore fuel or oil cargo transfers. This tactic can also be deployed for any oil spill migrating downstream or downhill to water or through water.

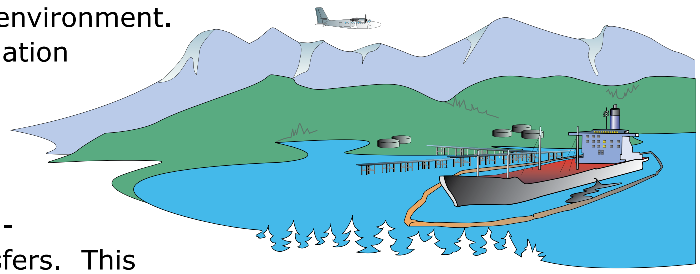

Figure C-1. Containment Boom deployed around a leaking vessel.

The general strategy is to:

1. Identify the location and trajectory of the spill or potential spill.
2. Select a deployment configuration that best supports the operating environment and available resources.
3. Mobilize to the location and deploy the tactic.
4. Place boom, using secure anchor system or mooring points.
5. Monitor the boom on an appropriate basis.
6. If oil collects in the boom, utilize an appropriate recovery tactic to remove it.

TACTIC DESCRIPTION

Containment boom systems are comprised of the appropriate oil boom for containment and concentration, and anchoring systems to hold the boom in place. There is considerable variation in how these systems are configured depending on the operating environment, type of oil, state of weathering, and available deployment platforms.

Operating Environments

Operating Environment	Containment Booming Use	Considerations
Open Water	Rarely	Containment boom systems may be difficult to deploy and maintain in the open water environment because of the high probability of fixed boom failure and the difficulty of anchoring in this environment. The On-water Free-oil Recovery tactic may work better in this environment, due to its inherent mobility.
Protected Water	Most common	Boom and anchors for protected water containment boom systems should be able to withstand seas up to 3 feet and winds up to 25 knots. Vessels deploying containment boom systems may be deep draft or shallow draft, depending on the water depth.
Calm Water	Most common	Calm water containment boom systems are composed of boom and anchors that can operate in seas of 1 foot and in winds up to 15 knots. Vessels deploying calm water containment boom systems typically work in depths as shallow as 3 feet.
Fast Water	Not recommended	Containment boom systems are not recommended for the fast water environment, where currents exceed 0.8 knots, because of the high probability of fixed-boom failure and the difficulty of anchoring in this environment. The Diversion Boom tactic may work better in this environment because of its ability to move oil into calmer water for recovery. Containment boom systems may work well in calm water adjacent to fast water to keep the oil from moving into the faster water. Examples of this include trapping oil in a slough or eddy until it can be recovered. ***Refer to USCG Fast Water Booming Guide for additional information.***

Deployment Configurations

Boom can be placed from shoreline to shoreline around a vessel at dock or around a spot where oil is running off the land into the water (See Figure C-2). This configuration can be used to trap oil in a natural collection point such as a slough, inlet, or backwater.

Boom is placed around an anchored vessel or underwater pipeline leak in a diamond or hexagon shape (See Figure C-3).

To some extent, boom angles can be used to deflect debris and concentrate oil into a suitable skimming pocket.

A second layer of containment boom, outside the primary boom, has two advantages:

1. It breaks the sea chop and reduces its impact on the primary boom,
2. It may capture oil that has escaped if the primary boom fails.

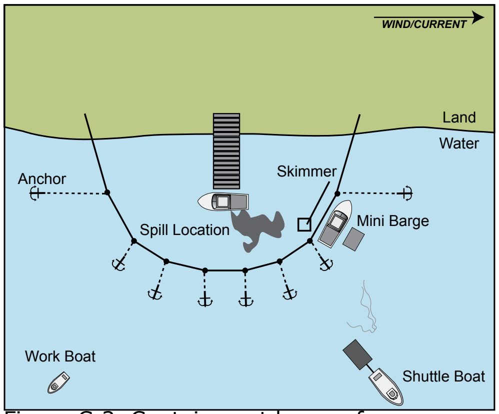

Figure C-2. Containment boom of a vessel at dock.

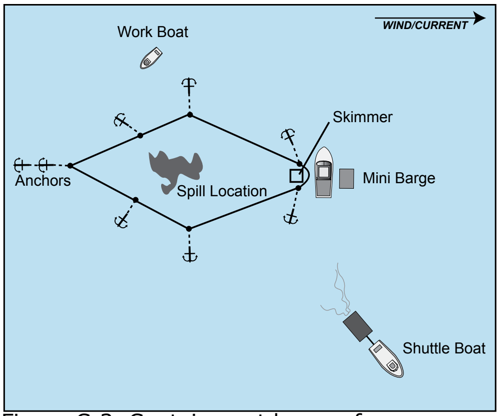

Figure C-3. Containment boom of a submerged pipeline spill.

DEPLOYMENT CONSIDERATIONS AND LIMITATIONS

- Anchor trip lines should be made of material strong enough to handle a moderate strain during boom reconfigurations. Responders normally use the trip line to reposition and reset the anchors.
- It may be useful to deploy back-up boom downcurrent from the primary boom array to catch oil that escapes the primary boom.
- It is often advisable to "line" the containment boom with sorbent materials (passive recovery) to recover the sheen and reduce decontamination costs.
- If the oil slick is moving, due to wind or current, consider containment at the source and ahead of the leading edge.
- If spill is moving in excess of 1 knot, or if the spill site is exposed to potential wave conditions greater that 2 feet, consider the Diversion Boom Tactic.
- Anchor vessels fore and aft, before deploying containment boom around them. Estimate the boom length at 3 times the vessel's length.
- Site conditions will influence deployment configuration options.
- Combinations of Containment Boom and Diversion Boom tactics are often used together to optimize success.
- Logistics for monitoring fixed boom should be considered.
- All screw pin shackles shall be seized with wire.
- Removal of boom may require additional personnel.

REFERENCES TO OTHER TACTICS

Other tactics associated with Containment Boom include:

- Shoreside Recovery
- Marine Recovery
- Passive Recovery
- Diversion Boom

EQUIPMENT AND PERSONNEL RESOURCES

Commonly used resources for this tactic include vessels, boom, anchoring or mooring systems, response personnel, and associated equipment and materials. Configuration and specific resources required will be determined by site conditions, spilled oil type and volume, area of coverage, and resource availability. Resource sets may need to be refined as site-specific requirements dictate.

Typical Containment Boom System Components

Typical Resources	Function	Quantity	Notes
Oil boom appropriate for operating environment	Contain and concentrate oil	Site-specific	Depending on configuration, currents, sea states, and oil concentration
Small anchor systems, moorings, or shore-based anchors	Secure boom in selected configuration	1 per 200 ft. of boom	Depending on configuration, currents, and sea states
Response vessels appropriate for boom size & operating environment.	Deploying/tending anchors and boom		Depending on configuration, currents, and sea states
Response personnel	Functions vary based on assignment	Varies depending on number of vessels, configuration, recovery system	All response personnel should have the appropriate level of OSHA training for their job assignments. Removal of boom may require more personnel than deployment.

EX EXCLUSION BOOM

OBJECTIVE & STRATEGY

Exclusion Booming is a fixed-boom strategy, with the objective of prohibiting oil slicks from entering a sensitive area.

TACTIC DESCRIPTION

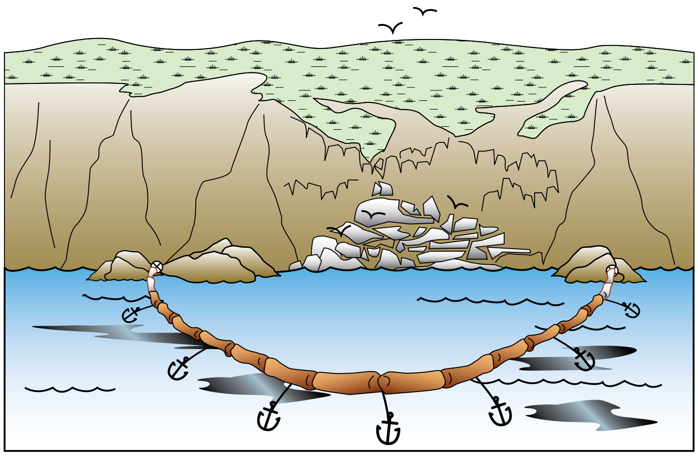
Figure EX-1. Exclusion Booming to protect a sensitive area.

This technique requires the area to be completely boomed off, forming a protective barrier. Conventional oil boom, tidal-seal boom, or a combination of each can be used to exclude spilled oil from a sensitive area. Typically, tidal-seal boom is deployed at the shoreline/ water interface on both shores and is secured/anchored into position. Conventional oil boom is then connected to the tidal-seal boom and is secured with additional anchor systems to form a barrier and to maintain shape.

This technique is most efficient in low current areas. Freshwater outflow from a river or stream may assist in maintaining boom configuration and pushing oil away from the area inside the boom.

The general strategy is to:

1. Identify the location and trajectory of the spill or potential spill.
2. Identify, prioritize, and select sensitive areas to be protected from impact.
3. Select a deployment configuration that best supports the operating environment and available resources.
4. Mobilize to the location and deploy the equipment.
5. Secure boom with anchor systems and/or mooring points.
6. Monitor the boom on an appropriate basis.
7. If oil contacts the outside of the boom, utilize an appropriate recovery system to remove it.

Operating Environment

Operating Environment	Exclusion Booming Use	Considerations
Open Water	Not recommended	Exclusion Boom is not recommended for use in the open water environment, because of the high probability of boom and anchor failure; consider On-water Free-oil Recovery, Diversion Booming, or Deflection Booming instead.
Protected Water	Most common	Vessels, boom and anchors for protected-water exclusion boom systems should be able to deploy and operate in seas up to 3 feet and winds up to 25 knots. Protected water systems may be deep draft or shallow draft, depending on the water body.
Calm Water	Most common	Calm water exclusion boom systems are composed of vessels, booms and skimmers that should be able to deploy and operate in seas of 1 foot and winds up to 15 knots. Calm water exclusion boom systems typically work in depths as shallow as 3 feet.
Fast Water	Not recommended	Exclusion Boom is not recommended for fast water operating environments; consider Diversion Boom or Deflection Boom tactics instead. ***Refer to USCG Fast Water Booming Guide for additional information.***

Deployment Configurations

Two configurations are described below, but responders should consider the actual conditions and modify their deployment accordingly.

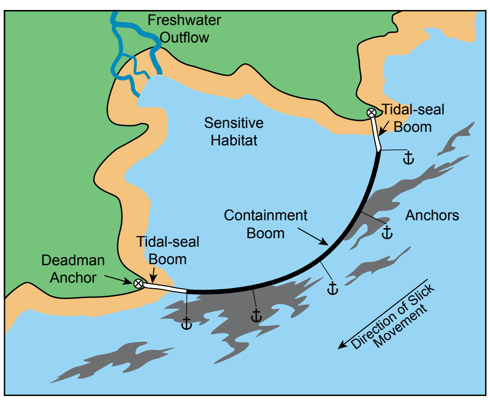

Figure EX-2. Exclusion booming configuration.

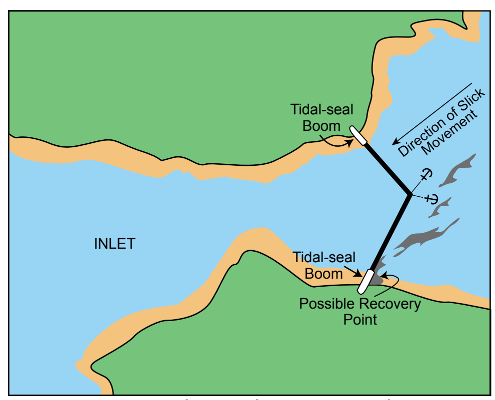

Figure EX-3. Exclusion booming with apex for exposed shores or currents.

DEPLOYMENT CONSIDERATIONS AND LIMITATIONS

- It may be useful to deploy back-up boom.
- Anchor trip lines should be made of material strong enough to handle a moderate strain during boom reconfigurations. Responders normally used the trip line to reposition and reset the anchors.
- Do not try to exclude oil from too large of an area; a single failure will result in contamination of the entire area. It is better to deploy more booms arrays covering smaller areas.

- Do not assume 100% efficiency with one boom system.
- Readjust anchors to maintain boom shape through tide cycles.
- Constant monitoring of system is required.
- Deployment planning should be based on average high tidal conditions.
- Expect boom failure where currents over 0.75 knots encounter the boom.
- A gate may be installed to allow vessels to pass.
- Sorbent materials such as pom-poms or snare on rope can be placed next to or attached to conventional boom to hinder oil entrainment under the boom at the beach water interface. Plans should be made to change out oiled sorbent on each low water tide cycle.

REFERENCES TO OTHER TACTICS

Other tactics associated with Exclusion Boom include:

- Beach Berms and Exclusion Dams
- Diversion Boom
- Deflection Boom

EQUIPMENT AND PERSONNEL RESOURCES

Commonly used resources for this tactic include vessels, boom, anchoring systems, and response personnel. Configuration and specific resources required will be determined by site conditions, spilled oil type and volume, area of coverage, and resource availability. Resource sets may need to be refined as site-specific requirements dictate.

Typical Exclusion Boom System Components

Typical Resources	Function	Quantity	Notes
Oil boom appropriate for operating environment	Exclude oil from sensitive area	Site-specific	Depending on configuration, currents, sea states, and oil concentration
Sorbent materials	Placed next to or attached to boom to hinder oil entrainment in the inter-tidal zone	Site-specific, optional	Most commonly used on sand and gravel beaches with gradual slopes; tidal-seal boom may also be used if available
Small anchor systems or shore-based anchors	Secure boom in selected configuration	Rule of Thumb – 1 anchor per 200 ft. of boom	Depending on configuration, currents, and sea states
Response vessels appropriate for boom size & operating environment. At least one vessel with a crane is recommended	Deploying/tending anchors and boom	2 to 4	Depending on configuration, currents, and sea states
Response personnel	Functions vary based on assignment	Varies depending on number of vessels, configuration, recovery system	All response personnel should have the appropriate level of OSHA training for their job assignments. Removal of boom may require more personnel than deployment.

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DF DEFLECTION BOOM

OBJECTIVE & STRATEGY

The objective of Deflection Boom is to direct spilled oil away from a location to be protected or simply to change the course of the slick. For the purposes of maintaining consistent and clear terms, "deflection" is used to describe the tactic where oil is redirected away from an area but not recovered, in contrast with the term "diversion", which is always associated with oil recovery.

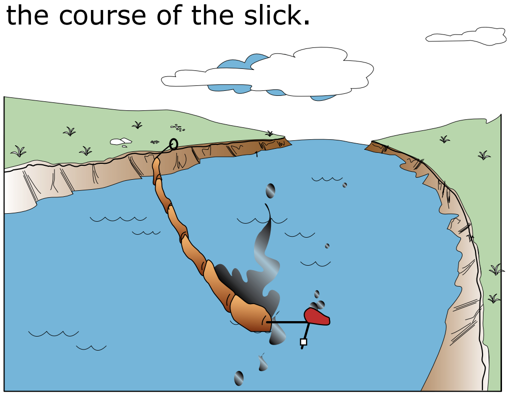

Figure DF-1. Deflection Booming.

TACTIC DESCRIPTION

The Deflection Boom tactic is for water-born spills where there is some current, usually from 0.5 to 3.0 knots. The boom is placed at an optimum angle to the oil trajectory, using the movement of the current to carry oil along the boom and then releasing it into the current again with a new trajectory. The angle is chosen to prevent oil from entraining beneath the boom skirt. Boom may be held in place by anchors, vessels, or a boom control device.

Deflection Boom may be used to temporarily avoid impacts to a sensitive area, but there is no recovery associated with the tactic, thus no oil is removed from the environment. For this reason, Diversion Boom or Free-oil Recovery is preferable to Deflection Boom whenever feasible. However, Deflection Boom may be more effective than Exclusion Boom at protecting a sensitive location, where currents over 0.75 knots exist.

The two alternatives for this tactic are Fixed Deflection and Live Deflection. In Fixed Deflection, boom is anchored to the shoreline or bottom. In Live Deflection, the boom is attached to vessels and held in position by the power of the vessels or one end of the boom is anchored and the other end held in position with a vessel. Live deflection is a very difficult tactic to execute. It should only be utilized where fixed deflection cannot be achieved, usually because deep water precludes anchoring.

The general strategy is to:

1. Identify the location and trajectory of the spill or potential spill.
2. Identify, prioritize, and select sensitive areas to be protected from impact.
3. Select a deployment configuration that best supports the operating environment and available resources.

4. Mobilize to the location and deploy the tactic.
5. Place boom using secured anchor systems, mooring points, vessels, boom control devices, etc.
6. Monitor and adjust the boom on an appropriate basis.

Boom Control Devices

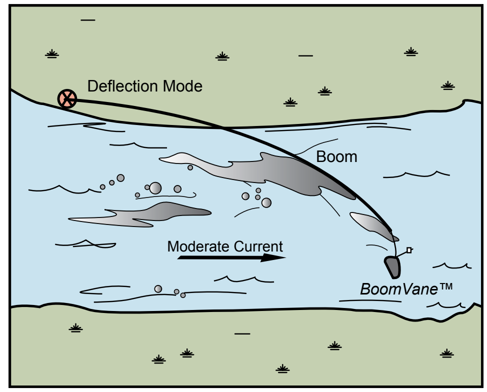

Figure DF-2. Using the BoomVane™ in deflection mode.

Boom control devices may be used as an alternative to anchoring deflection boom on the offshore end. Boom control devices have the advantage of allowing continuous control over the angle and position of the boom. They can also allow the boom to be moved to allow a vessel or drifting debris to pass by without interfering with the deflection operation. One type of boom control device is a vessel, which continuously controls the offshore end of the boom. Controlling a deflection boom with a vessel takes considerable skill and a vessel suited for the purpose. Another type of boom control system is a trolley. Trolleys require that a line be strung from one shoreline to another, thus they are mostly used in rivers. Trolleys may block a river to passage by vessels and they are susceptible to impacts from debris. A relatively new type of boom control device is built on the principle of a wing or rudder. Devices such as the BoomVane™, allow the boom to be deployed and controlled from the shoreline (Figure DF-2). This decreases the need for vessels and anchor systems, while allowing superior control of the boom angle.

Operating Environments

Operating Environment	Deflection Booming Use	Considerations
Open Water	Not recommended	Fixed deflection boom systems are not recommended for the open water environment because of the high probability of fixed boom failure and the difficult of anchoring in this environment. The Live Deflection Booming and On-water Free-oil Recovery tactic may work better in this environment, due to their inherent mobility.
Protected Water	Most common	Boom, anchors and vessels for protected water deflection boom systems should be able to withstand seas up to 3 feet and winds up to 25 knots. Vessels deploying deflection boom systems may be deep draft or shallow draft, depending on the water depth.
Calm Water	Most common	Calm water deflection boom systems are composed of boom and anchors that can operate in seas of 1 foot and in winds up to 15 knots. Vessels deploying calm water deflection boom systems typically work in depths as shallow as three feet.
Fast Water	Most common	Fast water deflection boom systems are designed to operate in moving water where the current exceeds 0.8 knots. This includes rivers and areas with significant tidal current. Vessels, boom, and anchors used in tidal waters should be able to deploy and operate in seas up to 1 feet and in winds up to 15 knots. Vessels, boom, and anchors used in river waters should be able to deploy and operate in waves up to 2 feet and in winds up to 15 knots. ***Refer to USCG Fast Water Booming Guide for additional information.***

Deployment Configurations

There are many variations for deployment of Deflection Boom. Several configurations are described below, but responders should consider the actual conditions and modify their deployment accordingly.

SINGLE BOOM

Boom is deployed from a site at an optimum angle to the current and anchored to deflect the oil away from a location.

CASCADE

Several booms are deployed in a cascade configuration when a single boom cannot be used because of fast current or because it is necessary to leave openings in the boom for vessel traffic, etc. This configuration can be used in strong currents where it may be impossible to effectively deploy one continuous section of boom. Shorter sections of boom used in a cascade deployment are easier to handle in faster water, thereby increasing efficiency. Additional equipment may be required to set and maintain this system as compared to the single boom configuration.

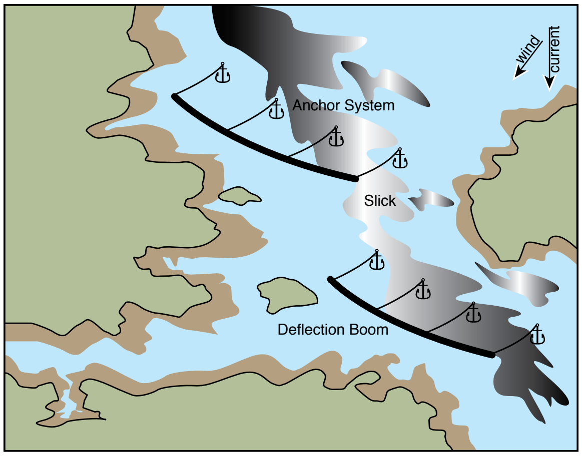

Figure DF-3. Deflection booming, fixed cascaded array.

LIVE

Booms are held in position by vessels. It takes practice and considerable skill in vessel handing to execute this effectively.

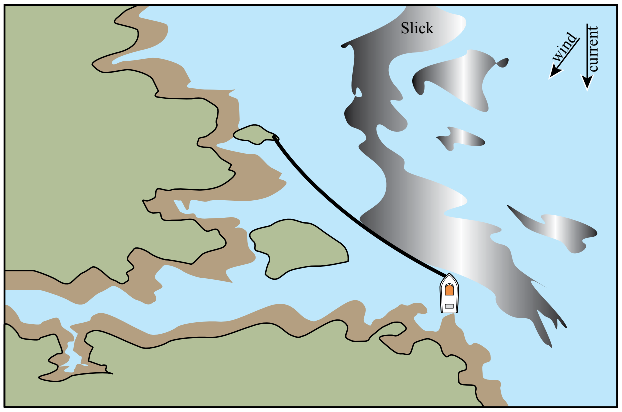

Figure DF-5. Deflection booming, half-live.

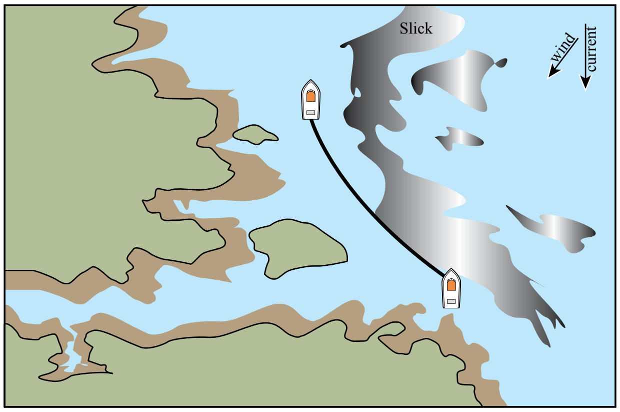

Figure DF-5. Deflection booming, live.

DEPLOYMENT CONSIDERATIONS AND LIMITATIONS

- Anchor trip lines should be made of material strong enough to handle a moderate strain during boom reconfigurations. Responders normally used the trip line to reposition and reset the anchors.
- Depending upon the boom array, consider deploying back-up boom to collect any oil that escapes primary boom.
- Calm/Protected water boom (6” x 24” / 18” x 42”) are most commonly used for this tactic.
- Do not assume 100% efficiency with one boom system.
- Readjust angles and widths between boom sections as necessary to meet changing conditions (tides, currents, and winds).
- Constant monitoring of system efficiency is required.
- Deployment planning should be based on average high tidal conditions.
- All screw pin shackles shall be seized with wire.
- The type of bottom and slope needs to be considered when selecting anchoring systems for fixed systems.
- Sorbent materials such as pom-poms or snare on rope can be placed next to or attached to conventional boom to hinder oil entrainment under the boom at the beat water interface. Plans should be made to change out oiled sorbent on each low water tide cycle.
- Removal of boom may require additional personnel.

REFERENCES TO OTHER TACTICS

Other tactics associated with Deflection Boom include:

- Diversion Boom
- Containment Boom

EQUIPMENT AND PERSONNEL RESOURCES

Commonly used resources for this tactic include vessels; boom; anchoring, mooring, or control systems; and response personnel. Configuration and specific resources required will be determined by site conditions, spilled oil type and volume, area of coverage, as well as resource availability. Resource sets may need to be refined as site-specific requirements dictate.

Typical Deflection Boom System Components

Typical Resources	Function	Quantity	Notes
Oil Boom appropriate for operating environment	Deflect oil slick	Site-specific	Depending on configuration, currents, sea states, and oil concentration
Small anchor systems, boom control devices, or shore-based anchors	Secure boom in selected configuration	Rule of Thumb – 1 anchor per 200 ft. of boom	Depending on configuration, currents, and sea states
Response vessels appropriate for boom size & operating environment At least one vessel with a crane is recommended	Deploying/tending anchors and boom	2 to 4	Depending on configuration, currents, and sea states
Response personnel	Functions vary based on assignment	Varies depending on number of vessels, configuration, recovery system	All response personnel should have the appropriate level of OSHA training for their job assignments. Removal of boom may require more personnel than deployment.

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SECTION III – RECOVERY TACTICS

GENERAL CONSIDERATIONS

Recovery of oil contained or concentrated with boom or natural barriers is accomplished using a skimming or recovery system that removes oil and water from the surface and transfers the recovered liquids to secondary containment, where the oil and water can eventually be separated for disposal.

On-water Skimmer Systems

On-water oil recovery requires at least one portable skimming system. The typical portable skimming system includes:

- Skimmer with pump and power pack
- Hose (suction and discharge with fittings)
- Oil transfer and decanting pump(s)
- Repair kit (tools and extra parts)

Like booms, there are many models of skimmers, but all fall into one of three categories:

Weir skimmers draw liquid from the surface by creating a sump in the water into which oil and water pour. The captured liquid is pumped from the sump to storage. The operator can usually adjust the working depth of the weir, controlling the liquid recovery rate. Weir skimmers can recover oil at high rates, but they can also recover more water than oil, especially when the oil is in thin layers on the surface of the water. This creates the need to separate the water from the oil and decant the water back into the environment. Otherwise, the recovered water will take up available storage volume. Weir skimmers are best employed where oil has been concentrated into thick pools or where there are very large volumes of oil and recovered liquid storage capacity. Avoid using centrifugal pumps to transfer liquids recovered by a weir skimmer, as this will cause the oil and water to emulsify; use a diaphragm pump instead. Figure R-1 shows several varieties of weir skimmer.

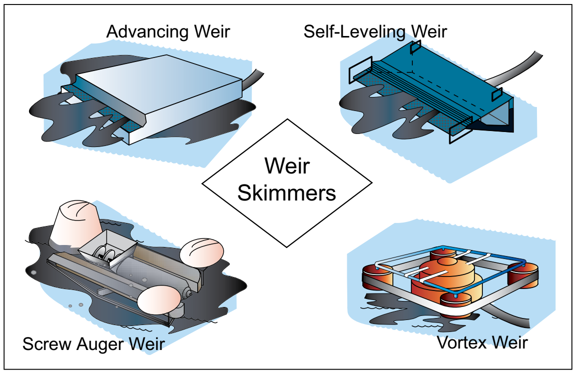


Figure R-1. Various types of weir skimmers.

Oleophilic skimmers pick up oil that adheres to a collection surface, leaving most of the water behind. The oil is then scraped from the collection surface and pumped to a storage device. The collection surfaces in oleophilic skimming systems include rotating disks, brushes and drums, or continuous belts or ropes. Belt, brush and rope skimmers can be used in any type of oil, while disk and drum skimmers are best in fresh oil. Oleophilic skimmers do not recover oil as fast as weir skimmers, but they have the advantage of recovering very little water. Oleophilic skimmers may be used where oil is very thin on the surface. Figure ?? shows several varieties of weir skimmer.

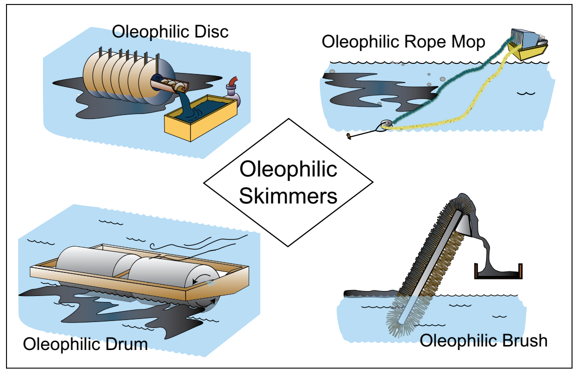


Figure R-2. Various types of oleophilic skimmers.

Suction skimmers use a vacuum to lift oil from the surface of the water. These skimmers require a vacuum pump or air conveyor system. Like weir skimmers, suction skimmers may also collect large amounts of water if not properly operated. Most suction skimmers are truck mounted and work best on land. However, suction skimmers for the marine environment have been made by converting fish pumps to oil recovery purposes, or loading a vacuum truck on a vessel. Figure R-3 shows several varieties of weir skimmer.

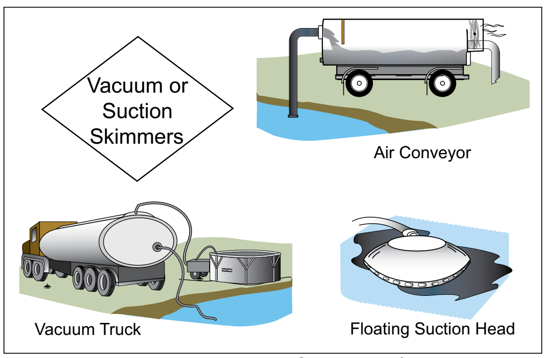


Figure R-3. Various types of vacuum/suction skimmers.

On-land Removal Systems

Typical equipment used for oil removal on-land consists of earthmoving equipment from shovels to heavy machinery, skimmers/ vacuums or sorbents, associated hoses (suction and discharge with fittings), and repair kits (tools and extra parts). The primary methods of collecting oil that has not entered the subsurface is through the use of sorbents or skimming systems. There are a variety of sorbents and skimmer systems available.

- Sorbents may be used in different configurations, such as loose or continuous materials. In cold weather environments oil can be incorporated with snow, using it as a sorbent material. Continuous material can be booms, pads, mops, pom-poms, etc. Loose materials are smaller particulates such as peat moss. Sorbents are spread over a spill and then removed with a vacuum or by raking and collecting. Sorbents should be minimized for larger spills due to the considerable solid waste stream that is produced. See the Passive Recovery tactic for further description.
- Suction skimmers use a vacuum to lift oil from a surface. These skimmers require a vacuum pump or air conveyor system. Suction skimmers may also collect large amounts of water and debris if not properly operated. Most land-based suction

skimmers are truck-mounted and require road access nearby the spill site, although trailer-mounted systems are available that may allow access to more remote sites. See the On-Land Recovery tactic for further description.

- Oleophilic skimmers may also be used in situations with adequate amounts of pooled oil or if the oil has pooled on water. Some manufacturers have adapted brush systems that can be mounted on the buckets of front-end loaders or excavators for land based recovery ("bucket skimmers"). Oleophilic skimmers an be used in any type of oil and where oil is very thin on the surface of pooled water; they are useful for land-based recovery.

Primary Storage Systems

Primary storage for recovered oil and water is an important component of both on-water and on-land recovery systems.

Primary oil storage devices for the marine environment can be tanks, bladders, drogues, or barges. There are two categories of portable oil storage devices to choose from: onboard storage and towable on-water storage. Onboard oil storage systems can be on deck or below deck, but both types are subject to numerous US Coast Guard regulations and should only be used when approved by a Coast Guard inspector. Towable on-water storage is the preferred method for Marine Recovery. Towable on-water storage devices include: barges, bladders, drogues, and open storage devices. Figures R-4 through R-7 show a variety of on-water storage devices.

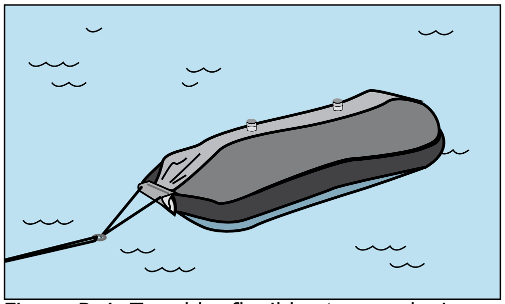


Figure R-4. Towable, flexible storage device.

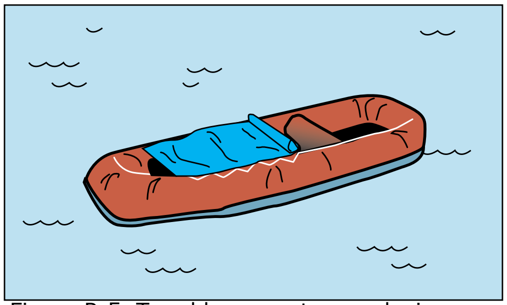


Figure R-5. Towable open storage device.

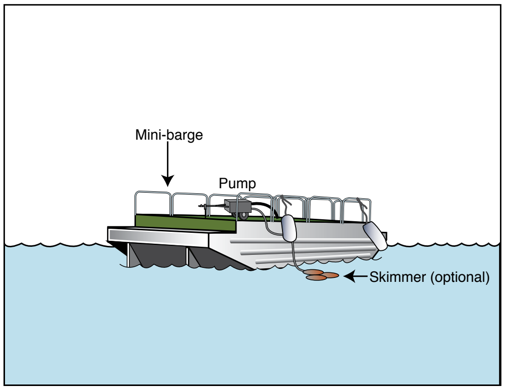


Figure R-6. Towable Mini-barge storage device.

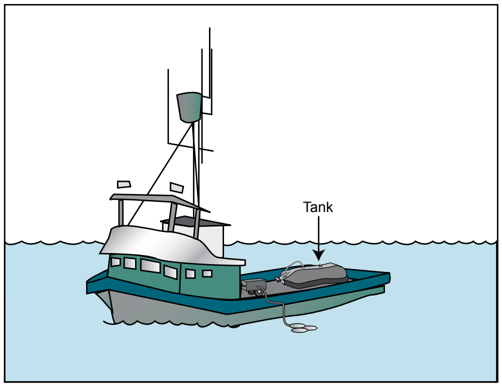


Figure R-7. Deck tank primary storage device.

On land, primary oil storage can be provided by tank trucks, portable tanks, or lined pits. Tank trucks are mobile and do not require additional transfer of recovered fluids in the field, but they are usually limited to road access.

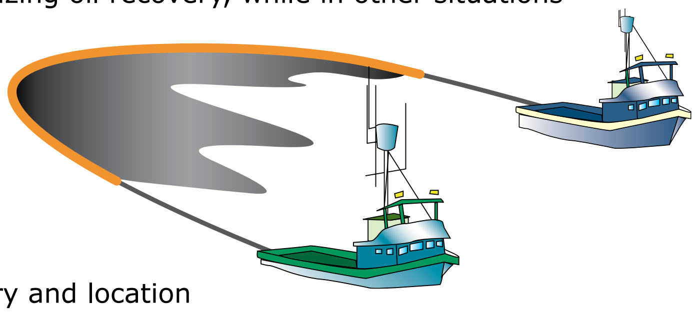
Portable tanks can be quickly set up in remote locations, but usually cannot be moved when they contain oil, thus requiring additional transfers.

Lined pits are the least preferred primary storage system, because building them may require soil disturbance and necessitate additional oil transfers. Lined pits are good choices for oiled debris and soils.

FO ON-WATER FREE-OIL RECOVERY

OBJECTIVE & STRATEGY

The objective of the Free-Oil Recovery tactic is to contain and recover spilled oil on the water, thus minimizing impact to the environment. In some situations, the Unified Command may task the free-oil recovery team with maximizing oil recovery, while in other situations the objective may be to maximize protection of a sensitive area by encountering oil that is on a trajectory to impact that area.



The general strategy is to:

1. Identify the trajectory and location of the spilled oil by performing over-flight surveillance and trajectory analysis.
2. Select a deployment configuration that best supports the operating environment and available resources.
3. Mobilize to a location downstream and upwind of the slick and deploy free-oil recovery teams.
4. Encounter the oil and concentrate it in oil containment boom.
5. Recover the oil with available skimming systems.
6. Store the recovered fluid in a primary storage device, until it can be transferred to secondary storage.

TACTIC DESCRIPTION

Free-oil recovery systems are comprised of vessels with oil boom for containment and concentration, skimming systems for recovery, and primary storage devices for temporary storage. There is a great variation in the way these systems are configured depending on the operating environment, type of oil and state of weathering, and the available deployment platforms. Examples of skimming systems and primary storage devices may be found in the Marine Recovery tactic.

Operating Environments

OPEN WATER

Free-oil recovery system components (vessels, boom, and skimmers) for open water operations should be able to deploy and operate in seas up to 6 feet and in winds up to 30 knots. Vessels deploying, towing, and tending the boom should be able to safely transit seas which exceed the boom's operating limitation. Open water free-oil recovery systems are usually based on large vessels with high volume skimmers and large primary storage devices, such as barges (see Figure FO-1). In many cases, the components of these systems are dedicated to oil spill response. Open water systems are usually deep draft, operating at depths of greater that 6 feet.

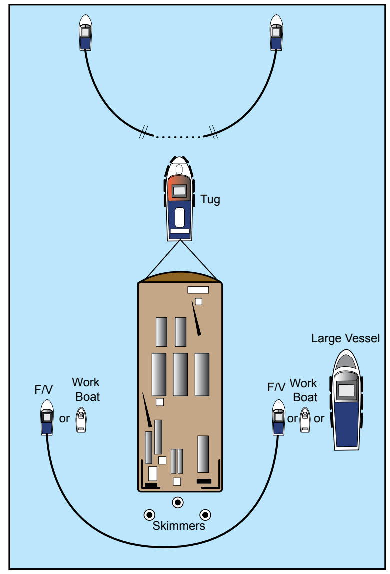


Figure FO-1. Open water barge-based free-oil recovery system.

PROTECTED WATER

Vessels, boom and skimmers for protected water free-oil recovery systems should be able to deploy and operate in seas up to 3 feet and in winds up to 25 knots. Vessels deploying, towing, and tending the boom should be able to safely transit seas which exceed the boom's operating limitation. Protected water free-oil recovery systems are often based on vessels of opportunity, such as fishing vessels, fitted with portable skimmers and primary storage devices. Protected water systems may be deep draft or shallow draft, depending on the water body.

CALM WATER

Calm water free-oil recovery systems are composed of vessels, booms and skimmers that should be able to deploy and operate in seas of 1 foot and in winds up to 15 knots. Vessels deploying, towing, and tending the boom should be able to safely transit seas which exceed the boom's operating limitation. Calm water free-oil recovery systems are usually based on small fishing vessels, work boats or skiffs fitted with portable skimmers and primary storage devices. Calm water free-oil recovery systems typically work in depths as shallow as 3 feet.

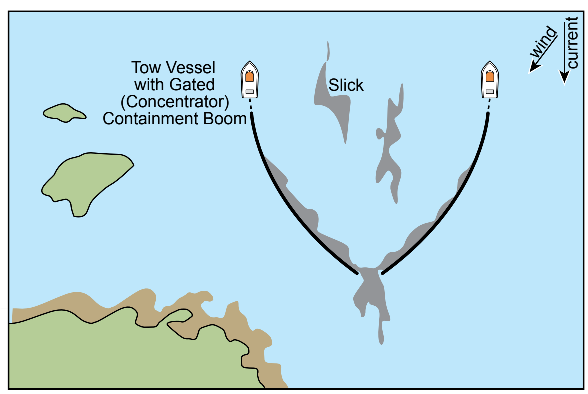


Figure FO-2. Gated U-boom concentrator boom, towed in front of free-oil recovery system.

FAST WATER

Fast water free-oil recovery systems are designed to operate in moving water where the current exceeds 0.8 knots. This includes rivers and areas with significant tidal current. Vessels, boom, and skimmers used in tidal waters should be able to deploy and operate in seas up to 1 foot and in winds up to 15 knots. Vessels, boom, and skimmers used in river waters should be able to deploy and operate in waves up to 2 feet and in winds up to 15 knots. Vessels deploying, towing, and tending the boom should be able to safely transit seas which exceed the boom's operating limitation. Fast water current free-oil recovery systems are equipped with high-current boom and skimmers. These systems are usually deployed from small vessels or skiffs.

BROKEN ICE

Free-oil recovery in broken ice may be difficult to deploy and operate because of ice interfering with the boom and skimming system. Free-oil recovery systems deployed in broken ice should be highly maneuverable, utilizing vessels that can safely operate in ice. Sometimes, ice leads can act to contain and concentrate oil so that a Marine Recovery system can be used for collection. Oleophilic rope skimmers are preferred over brush or weir skimmers in broken ice, because ice tends to clog weir and brush skimmers. Skimming system efficiency is generally reduced in broken ice.

Deployment Configurations

There are three typical deployment configurations for Free-Oil strike teams.

U-BOOM CONFIGURATION

The U-Boom System consists of vessels towing boom in a "U" configuration concentrating spilled oil into the back of the pocket formed by the boom (see Figure FO-3). This technique can also be used solely for oil concentration by leaving an opening secured by chain in the apex of the boom (see Figure FO-2). This is referred to as a "gated U–Boom." Typically, combinations of these configurations are used to enhance concentration and containment effectiveness. The spilled oil is then collected with a recovery device (skimmer), typically deployed by an additional vessel, and stored in a primary storage device.

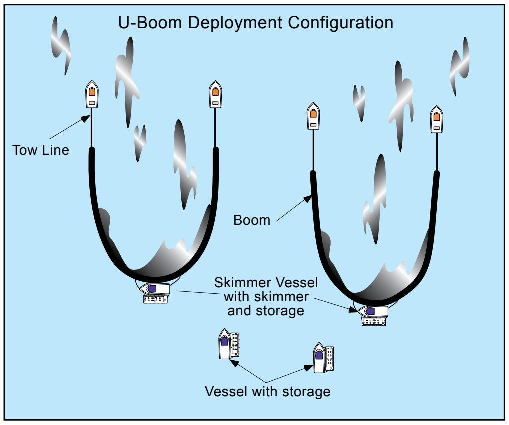


Figure FO-3. U-boom configuration.

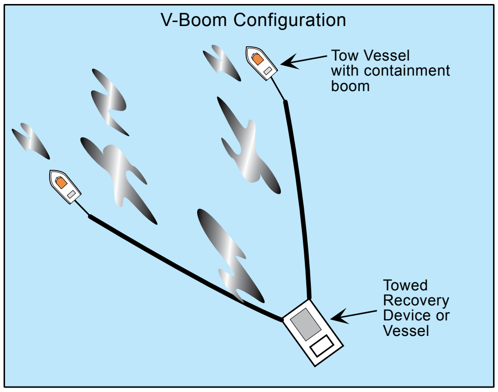


Figure FO-4. V-boom Configuration.

V-BOOM CONFIGURATION

The V-Boom Configuration consists of vessels towing boom and a recovery device (skimmer) in a "V" configuration (see Figure FO-4). The spilled oil is concentrated by the boom toward the back apex where a skimmer is located for oil recovery. Typically, these recovery systems are designed with a limited amount of storage built in and are either offloaded frequently or are augmented with additional storage devices and transfer systems.

Sec III. RECOVERY TACTICS

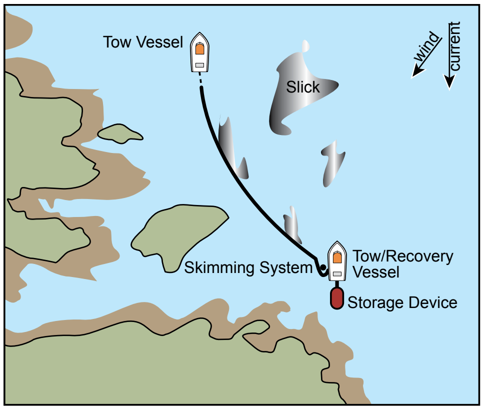


Figure FO-5. J-boom configuration.

J-BOOM CONFIGURATION

The J-Boom Configuration consists of vessels towing boom in a "J" configuration, concentrating the spilled oil for recovery into the back of the pocket formed by the boom (see Figure FO-5). The rear towing vessel is outfitted with a recovery device (skimmer) for deployment along the vessel side where the apex of the boom is formed. The oil is then collected with the skimmer and stored in a primary storage device, such as a mini barge. This system is often utilized in place of the U-Boom system, when the response is limited by the amount of vessels available, when maneuverability is not as critical, and when the oil is concentrated in windrows.

BOOM CONTROL AND ENHANCED RECOVERY DEVICES

Recent improvements in boom control devices, such as the Boom Vane™, allow a single vessel to deploy and control a U-Boom system (Figure FO-6). Enhanced recovery devices, such as the Current Buster™, allow for greater speed of advance for the boom system and concentrate oil to a deeper depth for more efficient collection (Figure FO-7). These configurations can improve system efficiency and reduce the costs of operation, however, they may limit the maneuverability of the recovery system.

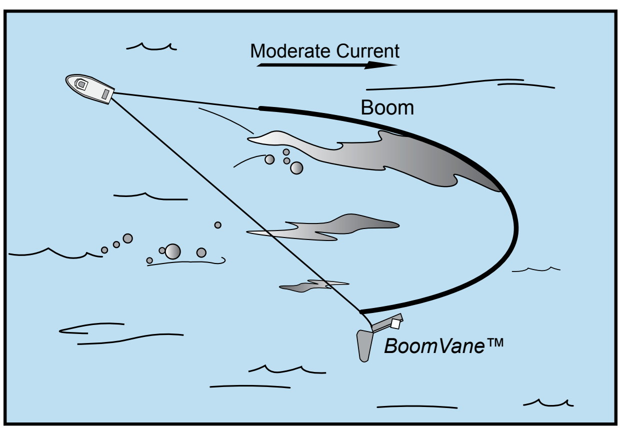


Figure FO-6. Free-oil recovery using a BoomVane™ to control one end of a U-boom.

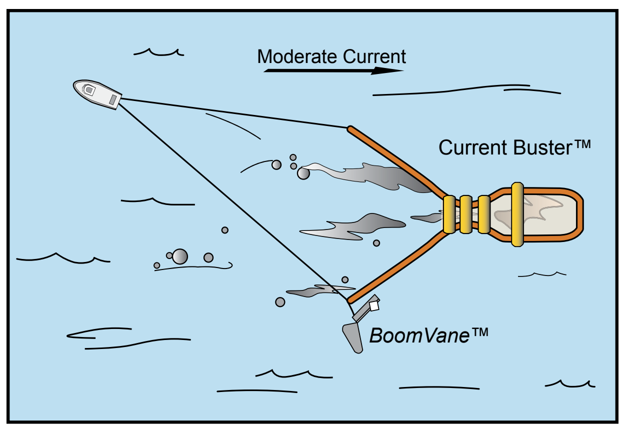


Figure FO-7. Free-oil recovery using a BoomVane™ to control one end of a Current Buster™.

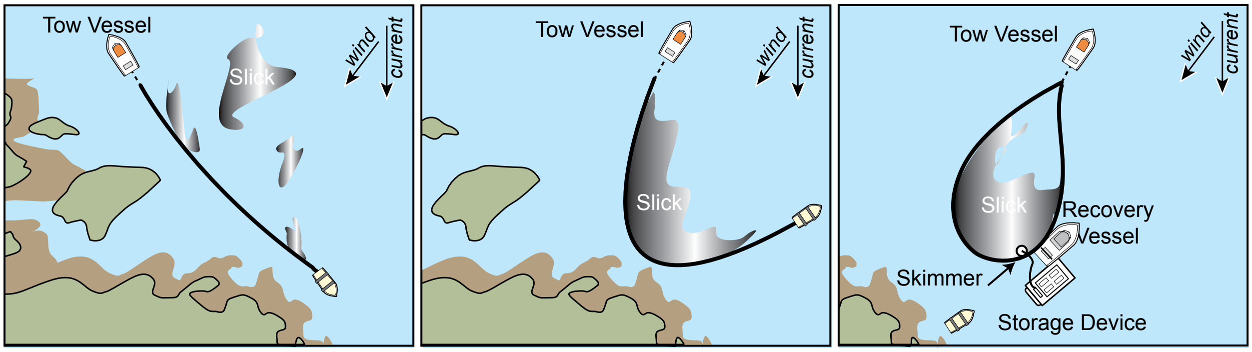


Figure FO-8. Nearshore trapping, boom-towing boats collect oil then tow the trapped oil to deeper water for recovery.

NEARSHORE TRAPPING

Shallow draft vessels can be used to capture oil in shallow water by encircling it and slowly dragging the slick into deep water. A marine recovery system is then used to remove the oil (see Figure FO-8).

DEPLOYMENT CONSIDERATIONS AND LIMITATIONS

SAFETY

- Daily weather evaluation is recommended, and should include distance to safe harbor, transit times and exposure of vessels.
- Vessel masters should have experience in the appropriate operating environment and tactic. Local knowledge is preferred.
- Vessels setting and tending the boom should be able to safely transit seas that exceed the boom's operating limitation.
- If possible, vessels in transit to/from an operation or staging area should transit in pairs.
- A communications schedule should be established and followed, between vessels in transit and the Operations Section or Radio Dispatcher.
- Vessels, including skiffs, must have a minimum of two crew aboard.
- Response personnel should wear PPE as required by the incident-specific Site Safety Plan.

DEPLOYMENT

- Site conditions may influence deployment configuration options.
- Combinations of Free-oil Recovery and Diversion tactics are often used together.
- Combinations of configurations may optimize recovery.
- Procedures and permits for decanting recovered water should be considered.

- Open water systems, typically operate two 12-hour shifts per day. Other systems typically operate one 12-hour shift per day.
- Logistics for oil transport and disposal should be considered.

REFERENCES TO OTHER TACTICS

Other tactics associated with On-water Free-oil Recovery include:

- Marine Recovery
- Diversion Boom

EQUIPMENT AND PERSONNEL RESOURCES

Commonly used resources for this tactic include vessels, boom, skimmers, primary storage devices, and personnel. Configuration type and quantity of strike teams required will be determined by site conditions, spilled oil type and volume, area of coverage, and resource availability. Resource sets may need to be refined as site-specific requirements dictate.

Typical On-water Free-oil Recovery System Components

Typical Resources	Function	Quantity	Notes
Oil boom, > 42" height	Contain and concentrate oil	1,000 to 3,000 ft.	Depending on configuration and oil concentration
Skimming system(s), open water	Remove concentrated oil	1 minimum	Type and capacity of skimmer depends on oil type, oil weathering state, and operating environment
Enhanced recovery device	Concentrate oil	1 optional	Type and capacity of skimmer depends on oil type, oil weathering state, and operating environment
Primary storage device	Store recovered fluid	2 times the effective daily recovery capacity of the skimming system(s)	Typically large barges or bladders are used for open water systems
Decanting system	Removing recovered water	1 optional	Permit is required to decant
Response vessel appropriate for on-scene conditions and equipment being deployed	Platform for skimming and handling oil storage device	1	Depending on configuration, currents, and sea states
Response vessel appropriate for on-scene conditions and equipment being deployed	Boom towing	1 to 4	Depending on configuration, currents, and sea states
Response Personnel	Functions vary depending on assignment	Varies depending on recovery system and hours of operation	Response personnel must have the appropriate level of OSHA training for their assigned position.

ON-LAND RECOVERY

OBJECTIVE & STRATEGY

The objective of On-land Recovery is to remove free-oil from the land's surface and transfer it into primary storage, while minimizing impacts to the environment. This tactic does not include the removal of sub-surface oil or oiled soil/gravel.

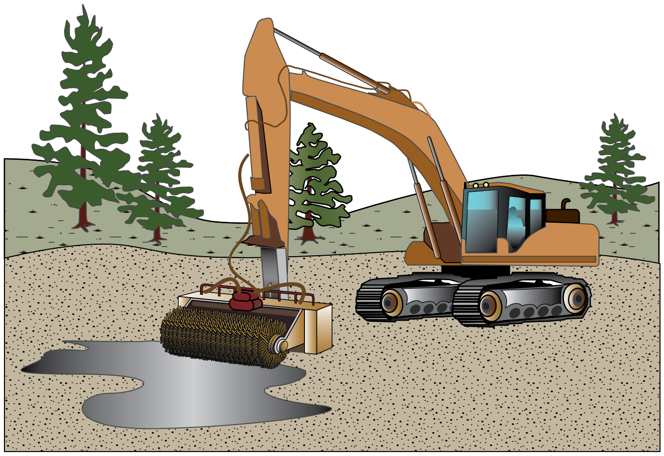


Figure OR-1. On-land recovery using a bucket skimmer attached to an excavator.

On-land Recovery is usually deployed in association with containment tactics such as earthen berms.

The general strategy is to:

1. Identify the recovery site and assess the site conditions.
2. Determine the appropriate recovery and storage systems based on oil type and site conditions.
3. Mobilize and deploy equipment to recover and store the oil at the designated recovery site.
4. Man and monitor the system as appropriate.
5. Store and transfer recovered oil and debris according to an approved waste management plan.

TACTIC DESCRIPTION

If oil spilled on land has not penetrated the surface, it will move to and pool in the lowest part of the landscape. Responders should seek to minimize the spread of oil and remove pooled oil. This can be achieved through immediate recovery of the oil, containment using existing land depressions, or by mechanically creating pits, trenches, dikes, berms, or dams. Where oil has incorporated in the surface materials, mechanical removal will be necessary using hand tools and/or heavy machinery. In both situations on-land recovery is comprised of a removal system, oil storage system, and associated vehicles and personnel. Differing types of recovery systems and primary oil storage devices are available for a variety of oils in numerous operating environments.

Operating Environments

The On-land Recovery tactic is used to collect oil in a variety of terrestrial environments. These include snow/ice, marsh, and other lands. The strategies described here should be adapted to the environment encountered.

SNOW/ICE

On-land recovery operations in snow should utilize the sorbent properties of the snow. Use the snow to create containment berms and dikes and, if conditions are predicted to remain below freezing, incorporate heavily oiled snow with lightly oiled snow to create a "mulch-like" consistency for removal. For small spills, use hand tools to remove the oiled snow and small containers for transfer. For larger spills, where access is available, use front-end loaders and dump trucks for removal and transportation to disposal sites. If the snow will not remain solid when handled, remove with a vacuum skimmer or move to a lined pit for temporary storage.

If the oil is frozen in place, a trimmer may be used to break up the surface and ready it for loading. If these activities create safety concerns or risk more harm to the environment, stabilize the area, create berms, and otherwise prepare for recovery operation with vacuum systems when break-up occurs.

MARSH

Marsh environments present challenges for operations due to their sensitivity. Plywood or similar material may be used to establish foot and ATV routes to the site. Initial response should be to remove the oil on the surface with vacuum systems. When conditions permit, the area can be flushed downslope into natural depressions or containment structures. Oil then can be removed via shallow skimming or vacuum systems. Another option is to construct a berm around the spill with soil, sand bags, or boom. The content inside the berm is then flooded and the oil is removed either by skimming or passive recovery.

OTHER LANDS

Removal techniques on other lands differ depending on the permeability of the soil. In porous, large-grain, well-drained soils, thin oil may immediately drain and become a sub-surface plume. Such plumes will move down through the sediment, contaminating the soil matrix until it reaches the water table or an impermeable soil layer. This manual is not intended to deal with such sub-surface contamination. An oil contamination remediation project is usually required for the sub-surface component of land-based spills.

In other cases the permeability of the soil or the volume or viscosity of the oil is such that all or part of the oil remains at the terrestrial surface. In these cases, quick removal of the oil and contaminated surface soils is recommended, unless the response would cause more environmental damage than the oil contamination itself. Responders should define the oil plume, anticipate its movement, and consider using berms, dikes, dams, trenches, or pits to contain and concentrate oil for recovery. Consider using an artificial water table to float the oil for recovery. Recovery tactics are discussed below.

Deployment Configurations

Typical configurations are shown below, but responders should consider the actual conditions and modify their deployment accordingly.

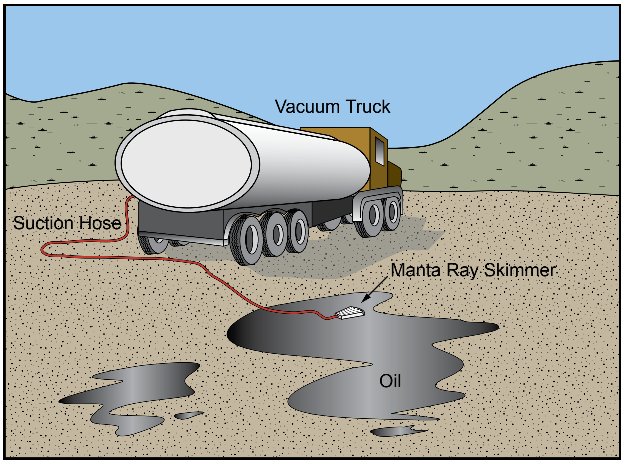


Figure OR-2. Oil recovery using a suction skimmer.

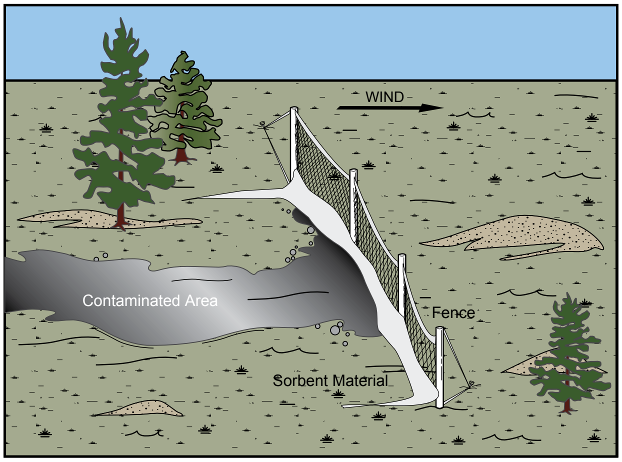


Figure OR-3. Oil containment and removal using sorbent material.

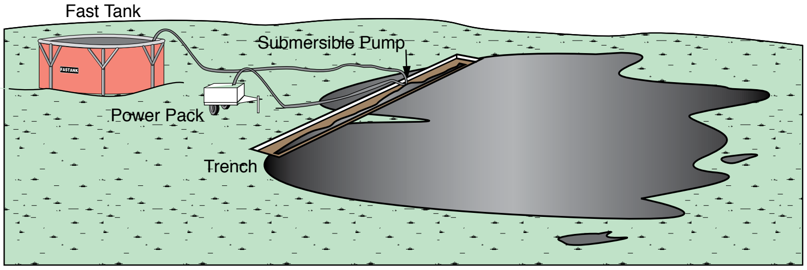


Figure OR-4. On-land Recovery using trench containment, submersible pump, skimmer, and portable storage tank.

DEPLOYMENT CONSIDERATIONS AND LIMITATIONS

- A spotter should be used around heavy equipment.
- Do not excavate materials if these activities will create more damage than the spilled oil.
- Lightly oiled snow contains 0.3 bbl per cubic yard of snow.
- Constant monitoring of system efficiency is required.
- Procedures to decant should be considered; a permit is usually required to decant.

REFERENCES TO OTHER TACTICS

Other tactics associated with On-land Recovery include:

- Earthen Berms
- Underflow Dams
- Passive Recovery

EQUIPMENT AND PERSONNEL RESOURCES

Resources for On-land Recovery have been defined as a recovery system, a storage device, associated vehicles, support personnel, equipment, and materials. Quantity of units required will be determined by operating environment, site conditions, and resource availability.

Typical On-land Recovery System Components

Equipment	Function	Quantity	Notes
Hand tools, front-end loader, backhoe, trimmer, scraper	Move soils and/or snow into berms, recover oil and oiled debris	Varies	Depending on site conditions and oil volume
Vacuum skimmer, oleophilic skimmer	Remove oil and oil/slush mixtures	1	Includes power pack, hoses, fittings, and rigging
Plywood	Create access path to the site	Optional	Use from established access to site
Pump	Provide water for flushing actions	Optional	High flow, low pressure is required
Trucks, ATV with trailers, front-end loaders, or excavators	Digging containment structures and removal of contaminated materials from the recovery site	Varies	Depending on site conditions
Response Personnel	Function varies depending upon assignment	1	All personnel must have the appropriate level of OSHA training for their job assignment.

MR MARINE RECOVERY

OBJECTIVE & STRATEGY

The objective of Marine Recovery is to remove spilled oil that has been diverted or collected at a suitable recovery site accessible from the water. Marine Recovery is similar to Open-water Free-oil Recovery, but does not include a containment/boom system. Marine Recovery may be used individually or in conjunction with other tactics. When it is used in conjunction with other tactics, fewer personnel may be required.

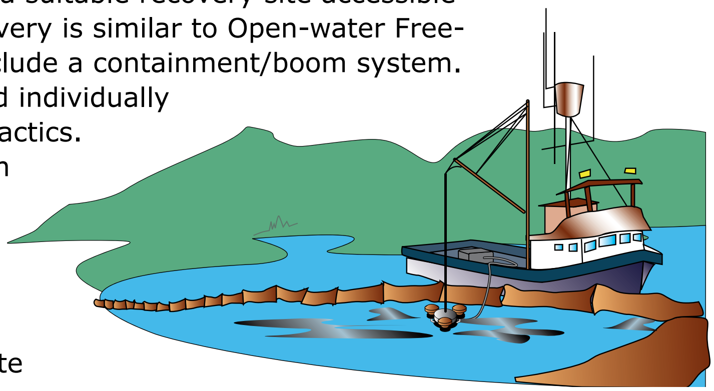


Figure MR-1. Marine Recovery.

The general strategy is to:

1. Identify the recovery site and assess the site conditions.
2. Determine the appropriate recovery and storage systems based on available equipment, oil type, site conditions, and deployment vessel capabilities.
3. Mobilize and deploy equipment to recover and store the oil from the designated recovery site.
4. Man and monitor the system as appropriate.
5. Store and transfer recovered oil and oily water according to an approved waste management plan.

TACTIC DESCRIPTION

Marine recovery systems are comprised of a skimming system, oil storage system, and associated vessels and personnel. Numerous types of recovery systems and primary oil storage devices are available to recover a variety of oils in various operating environments. Recovery system efficiency varies depending on oil type and encounter rates.

Operating Environments

The following table summarizes the considerations for using Marine Recovery in each of the following environments:

Operating Environment	Marine Recovery	Considerations
Open Water	Common	Marine recovery system components (vessels, skimmers, and storage devices) for open water operations should be able to withstand seas up to 6 feet and winds up to 30 knots. For safety, vessels should be able to transit higher seas from the recovery location to protected waters especially if towing a primary oil storage device.
Protected Water	Most common	Vessels, skimmers and storage devices for protected water marine recovery systems should be able to withstand seas up to 3 feet and winds up to 25 knots. Vessels deploying marine recovery systems in the protected water environment may be deep draft or shallow draft, depending on the water depth.
Calm Water	Most common	Calm water marine recovery systems are composed of vessels, skimmers, and primary storage devices that can operate in seas of 1 foot and in winds up to 15 knots. Vessels deploying calm water marine recovery systems typically work in depths as shallow as 3 feet.
Fast Water	Most common	Marine Recovery in fast water is difficult and not recommended if it is possible to divert the oil into calm water. Fast water marine recovery systems are designed to operate in moving water where the current exceeds 0.8 knots. This includes rivers and areas with significant tidal current. An oil concentrator/accumulator device, such as a Current Buster™ or River Circus™, may be useful for recovery systems in fast water. Vessels and skimmers used in tidal waters should be able to deploy and operate in seas up to 1 feet and in winds up to 15 knots.Vessels, boom, and skimmers used in river waters should be able to deploy and operate in waves up to 2 feet and in winds up to 15 knots.Fast water marine recovery systems are usually deployed from small vessels or skiffs. ***Refer to USCG Fast Water Booming Guide for additional information.***

Deployment Configurations

Typical configurations are shown below, but responders should consider the actual conditions, and modify their deployment accordingly.

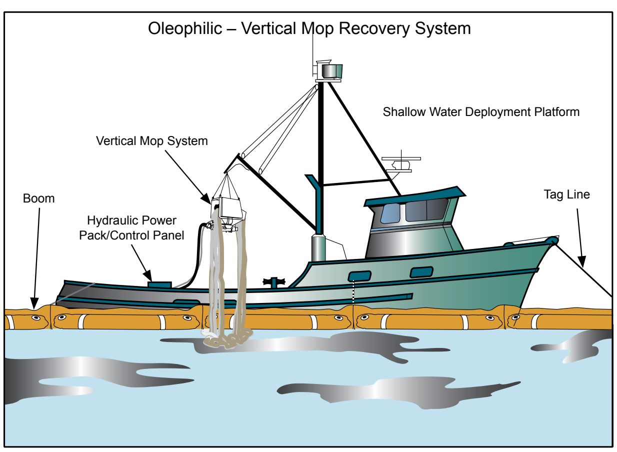


Figure MR-2. Vertical mop recovery system.

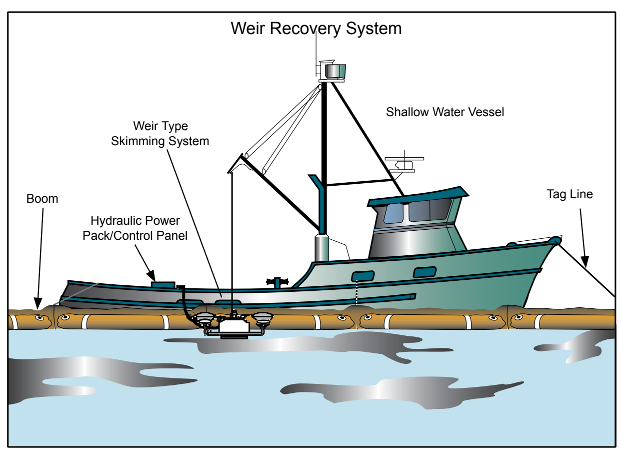


Figure MR-3. Weir recovery system.

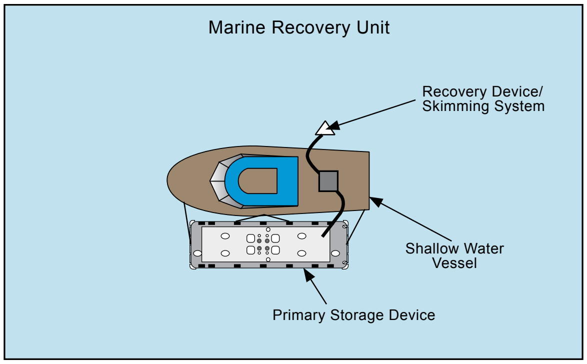


Figure MR-4. Typical Marine Recovery System

DEPLOYMENT CONSIDERATIONS AND LIMITATIONS

- Consider vessel stability when placing equipment and recovered liquids onboard any vessel.
- Vessel master should use extreme caution when maneuvering primary storage devices around submerged or sharp objects.
- Vessels setting and tending the skimmers and storage devices should be able to safely transit seas which exceed the operating limitations of the equipment.
- Water depth and oil type may influence equipment options.
- Recovery vessels should coordinate closely with other Recovery and Booming units.
- Constant monitoring of system efficiency is required.
- Procedure to decant should be considered; a permit may be required to decant.

REFERENCES TO OTHER TACTICS

Other tactics associated with Marine Recovery include:

- Diversion Boom
- Shoreside Recovery

EQUIPMENT AND PERSONNEL RESOURCES

Commonly used resources for this module have been defined as a recovery system, a storage device, and a deployment vessel along with the associated support personnel, equipment, and materials. Quantity of units required will be determined by operating environment, site conditions, and resource availability.

Typical Marine Recovery System Components

Typical Resources	Function	Quantity	Notes
Skimming system appropriate for operating environment	Remove oil	1	Includes power pack, hoses, fittings, and rigging
Primary oil storage system(s)	Store recovered oil	2 times the effective daily recovery capacity of the skimming system(s)	Depending on configuration, currents, and sea states
Decanting system	For removing recovered water	1 minimum	Permit is required to decant
Response vessel appropriate for on-scene conditions and equipment being deployed	Platform for skimming and handling oil storage device	1	Depending on configuration, currents, and sea states
Response Personnel	Functions vary depending on assignment	Varies depending on recovery system and hours of operation	Response personnel must have the appropriate level of OSHA training for their assigned position.

SR SHORESIDE RECOVERY

OBJECTIVE & STRATEGY

The objective of Shoreside Recovery is to remove spilled oil that has been diverted to a designated recovery site accessible from the shore. Shoreside Recovery is usually deployed as part of another tactic, such as Diversion Boom strategy. When deployed in conjunction with another tactic, fewer personnel may be required.

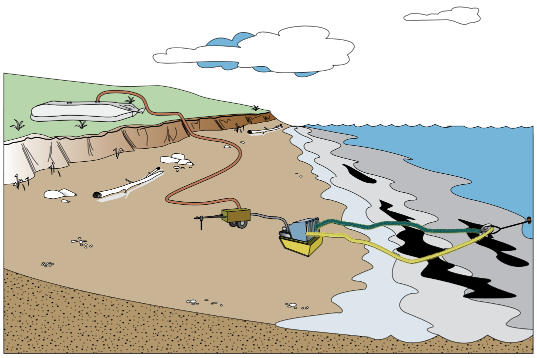


Figure SR-1. Shoreside Recovery.

The general strategy is to:

1. Identify the primary recovery site.
2. Assess site conditions and access routes.
3. Determine the appropriate recovery and storage systems based on oil type, access, and deployment restrictions.
4. Mobilize and deploy equipment to recover and temporarily store the oil from the recovery site.
5. Take precautions to minimize contamination of the shoreline at the collection site.
6. Man and monitor the system as appropriate.
7. Store and transfer recovered oil and oily water according to an approved waste management plan.

TACTIC DESCRIPTION

Shoreside recovery systems are comprised of a skimming system, oil storage system, and associated personnel. Shoreside recovery systems can be deployed from land access routes (roads, beaches, all-terrain vehicles), water access (marine vessels), or air access (helicopter). Access to the recovery site and the oil type will influence/dictate the options of equipment to be used.

Skimming Systems

Shoreside recovery requires at least one portable skimming system to remove spilled oil. The typical portable skimming system includes:

- Skimmer with pump and power pack
- Hose (suction and discharge with fittings)
- Oil transfer and decanting pump(s)
- Repair kit (tools and extra parts)

Recovery Location

Selection of a shoreside recovery location is critical to the success of this tactic. A recovery site should be in calm water with minimal currents. One option is to construct a quiet recovery spot by excavating a recovery lagoon or trench in the shoreline (Figure SR-2). However, a permit may be required to perform such an excavation. Commercial oil recovery enhancement devices, such as the River Circus™ and Current Buster™, are also available to provide a quiet recovery impoundment.

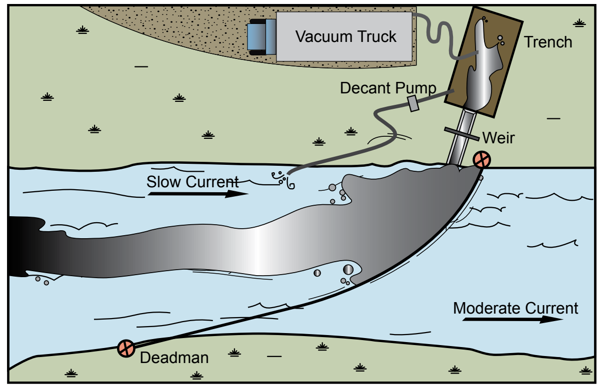


Figure SR-2. Shoreside recovery unit skimming lagoon.

The site must have enough level ground to set up and operate a power pack and portable tanks. Sites with road access are preferred, but if not available, the site must have some other suitable access. Shelter, food and water for the response crew must also be considered in selecting a site.

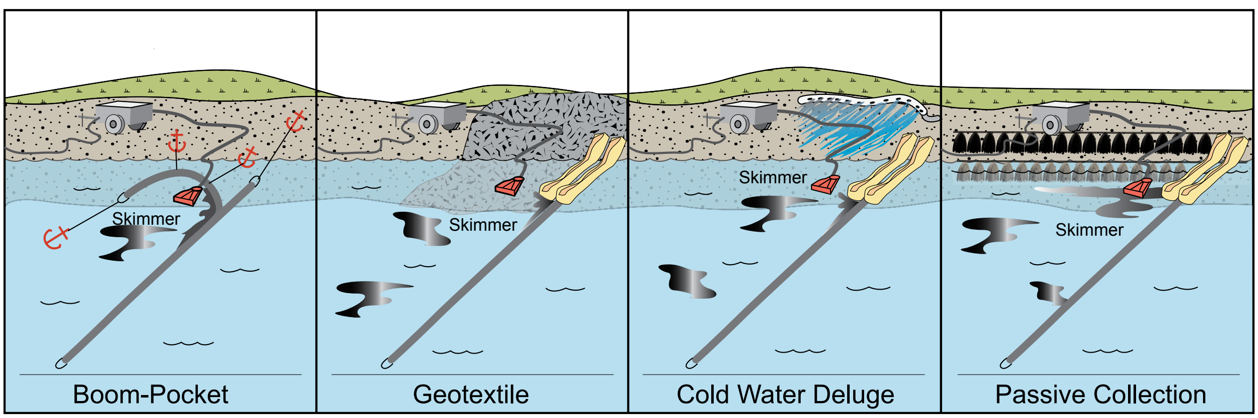


Figure SR-3. Methods to keep oil from contaminating collection beaches.

It is important to minimize shoreline contamination at the recovery site. If possible, oil should not be allowed to contact the inter-tidal zone or shoreline. Oil contamination can be avoided by constructing a boom-pocket in the water off the shoreline, covering the shore with a geotextile at the recovery location, using a cold-water deluge to keep the collection location wetted, or using passive materials to collect the oil prior to its reaching the shoreline (Figure SR-3). If oil does reach the beach, efforts should be taken to avoid pushing the oil down into the substrate. Do not walk on oiled muddy soils and avoid driving or operating equipment on oiled surfaces.

Operating Environments

The following table summarizes the considerations for using Shoreside Recovery in each of the following environments:

Operating Environment	Marine Recovery	Considerations
Open Water	Not applicable	
Protected Water	Possible in calm conditions	Shoreside Recovery can be deployed in areas considered protected water, but it is only feasible to operate from shoreline in calm conditions. In some cases, oil can be diverted from protected water into calm water for recovery.
Calm Water	Most common	Calm water shoreside recovery systems are composed of skimmers that can be deployed and operated in seas of 1 foot. Wind is normally not a limiting factor for shoreside recovery. If vessels are used to transport and support the recovery system, they should be able to safely transit seas up to 3 feet and winds up to 20 knots.
Fast Water	Common	Shoreside Recovery is often deployed in areas considered fast water, but oil is usually diverted from high current areas into calm water for recovery. ***Refer to USCG Fast Water Booming Guide for additional information.***

Deployment Configurations

Typical configurations are shown in the diagram below (Figure SR-4), but responders should consider the actual conditions, and modify their deployment accordingly.

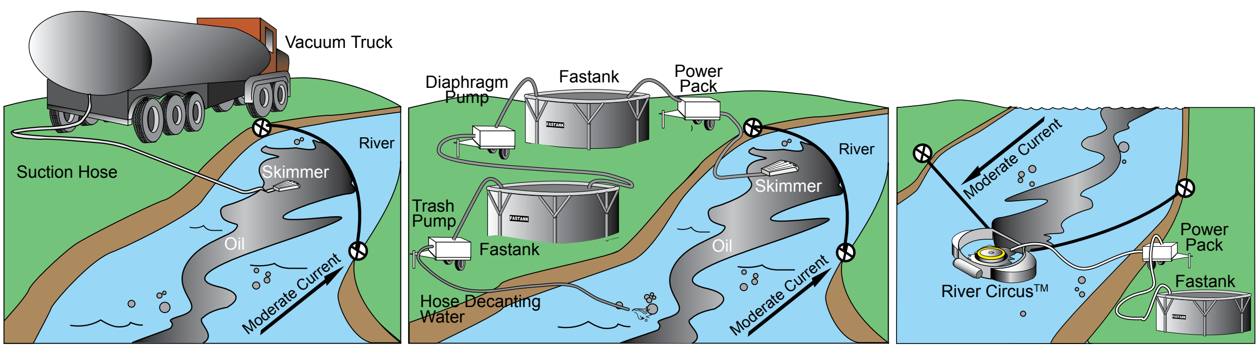


Figure SR-4. Shoreside Recovery deployment configurations.

DEPLOYMENT CONSIDERATIONS AND LIMITATIONS

- If mobilizing by water, consider vessel stability when placing equipment on deck.
- Access and oil type will influence equipment options.
- Team leader should coordinate closely with diversion booming units.
- Constant monitoring of system efficiency is required.
- Where access is restricted, system efficiency should be increased to minimize excess waste/water, and decant options should be reviewed.

- A transfer pump may be required to move oil from storage to vacuum truck or other mobile storage.
- May need to request a permit to decant free water from storage back into recovery area.
- Identify and order resources needed to sustain 24 hr operations, such as portable bathroom, warm-up tents, and lighting.
- Walking boards should be used to control traffic and minimize impact to uplands vegetation.
- A lay down area should also be identified for oily and non-oily solid waste.

REFERENCES TO OTHER TACTICS

Other tactics associated with Shoreside Recovery include:

- Marine Recovery
- On-land Recovery
- Diversion Boom

EQUIPMENT AND PERSONNEL RESOURCES

Resources for Shoreside Recovery have been defined as a recovery system, a storage device, deployment vehicle/vessel along with the associated support personnel, equipment, and materials. Quantity of units required will be determined by operating environment, site conditions and resource availability.

Typical Shoreside Recovery System Components

Typical Resources	Function	Quantity	Notes
Skimming system appropriate for operating environment	Remove oil	1	Includes power pack, hoses, fittings, and rigging
Primary oil storage system(s)	Store recovered oil	Depends on logistics of transporting recovered liquids, recommend a minimum of at least the daily recovery capability of the skimming system	May be part of a truck mounted system, such as a vacuum truck
Decanting system	Removing recovered water	1 optional	Permit is required to decant
Truck or truck or ATV with trailer	Deploy system to recovery locations accessible by road system	1 or more	Locations accessible by road system
Response Personnel	Function varies depending upon assignment	Varies depending on recovery system and hours of operation	All personnel must have appropriate level of OSHA training. Shoreside recovery personnel may be part of Diversion Booming Team.

PR PASSIVE RECOVERY

OBJECTIVE & STRATEGY

The objective of the Passive Recovery tactic is to remove spilled oil by collecting it in a sorbent material. The sorbent material and associated oil are then removed from the environment and disposed of according to an approved Waste Management Plan.

TACTIC DESCRIPTION

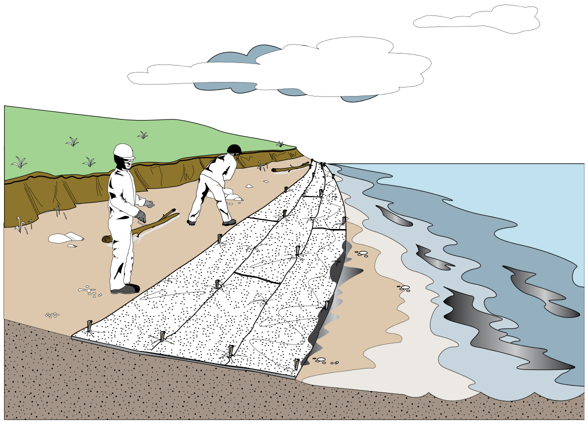


Figure PR-1. Passive Recovery.

Passive Recovery is performed through the process of adsorption on sorbent materials, such as sorbent pads, rolls, and boom; pom-poms (oil snare); and natural products. Sorbent boom and pom-poms are made from substances like polypropylene, a synthetic material that is oleophilic (oil-attracting) and hydrophobic (water-repelling). When left in an oily water mixture, they can collect many times their own weight in oil while collecting very little water. Their effectiveness depends on the type of oil, how they are placed, and the environmental conditions at the recovery site. The tactic is usually deployed by anchoring rows of sorbent boom or oil snare along the shoreline or in the intertidal zone. A variation for marine mammal haulouts is accomplished by broadcasting natural sorbent material, such as peat moss or sphagnum moss, on the haulout sites (Figure PR-4).

The general strategy is to:

1. Identify the trajectory of the spilled oil and select areas to be protected. Identify natural collection sites where floating debris is usually found.
2. Evaluate access restrictions and select appropriate deployment vehicles.
3. Mobilize and deploy personnel with tools and materials.
4. Secure sorbents with anchors or stakes.
5. Monitor the sorbent on a regular basis for oil content and security of the anchor systems.
6. Replace saturated sorbents as necessary.
7. Store and dispose all recovered sorbents according to the waste management plan.

Passive Recovery can be deployed along shorelines prior to impact to reduce the quantity of oil that might otherwise impact sensitive habitats. The tactic can also be applied to shorelines that have already been oiled to help keep the re-mobilizing oil from refloating and migrating to other non-impacted shorelines. Passive recovery can also be used to line the inside of containment or exclusion boom as an effective collection technique. Likewise, passive recovery can be used with diversion boom in cases where small amounts of oil are anticipated. Sorbents can be used with tidal-seal boom or fences to create an adsorption barrier. In all cases, the sorbent material must be monitored after each tide and replaced as necessary.

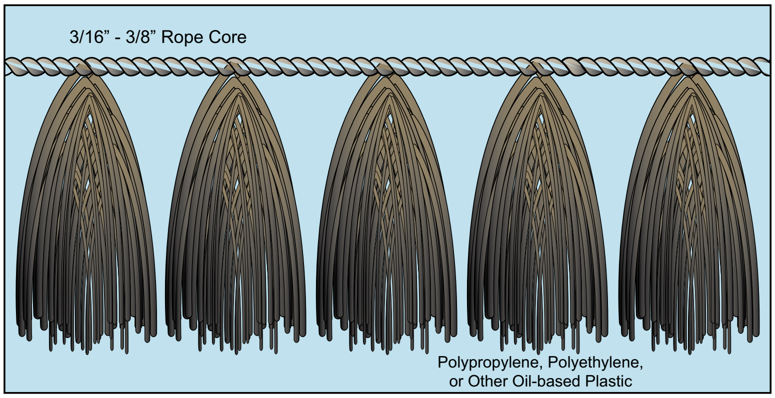


Figure PR-1. Snare line.

Fibrous polypropylene sorbents, such as pads, rolls, and sorbent boom, work well on non-persistent oil such as diesel. These sorbents can recover approximately 15:1 oil to sorbent by weight. Polypropylene strips, such as pom-poms, work best in persistent oil and may recover up to 20:1 oil to sorbent by weight. Natural material, such as peat, are effective sorbents, but are difficult to recover from the environment once oiled.

Passive recovery operations can produce a significant solid waste stream; all wastes generated must be measured, stored, and disposed of according to an approved Waste Management Plan. Logistical support for this waste stream should be mobilized early in the spill event. One way to reduce solid oily wastes is to wring out oil from the sorbents and reuse them.

Access to selected areas may be accomplished from the water, land, or air. Deployment from the water usually involves using shallow water platforms such as landing craft and skiffs. Access from a land-based response utilizes trucks, ATV’s, or other four-wheel drive vehicles, while access from the air may be possible by helicopter.

Passive Recovery is often combined with debris removal, where concentrations of driftwood and other debris are relocated or removed from a likely impact area. The impact area is typically the area between the low and high tide lines in marine areas or the present waterline of the inland water body.

Operating Environments

Operating Environment	Marine Recovery	Considerations
Open Water	Not recommended	Passive Recovery is not recommended in the open water operating environment due to the likelihood of losing sorbent materials.
Protected Water	Common	Consider placing sorbents from the shoreside in the protected water environment. Sorbent materials and anchors for protected water passive recovery systems should be able to deploy and operate in seas up to 3 feet and winds up to 25 knots. Vessels setting and tending the sorbents should be able to safely transit seas which exceed the sorbent's operating limitation. Sorbent arrays must be monitored often, due to the forces applied on the anchor systems by wind, currents, and waves.
Calm Water	Most common	Calm water passive recovery systems should be able to deploy and operate in seas of 1 foot and winds up to 15 knots. Vessels setting and tending the sorbents should be able to safely transit seas which exceed the sorbent's operating limitation. Calm water passive recovery systems may be based on small fishing vessels, work-boats, or skiffs. Calm water passive recovery systems typically work in depths as shallow as 3 feet.
Fast Water	Possible	Passive recovery systems are not usually effective in fast water environments, but are often utilized where the currents slow to calm water conditions. ***Refer to USCG Fast Water Booming Guide for additional information.***

Deployment Configurations

Typical configurations are shown below, but responders should consider the actual conditions, and modify their deployment accordingly.

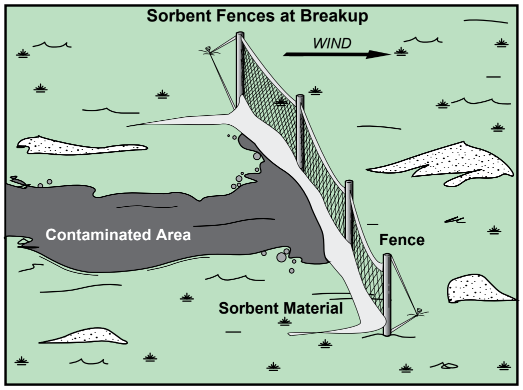


Figure PR-2. Sorbent fence at break-up.

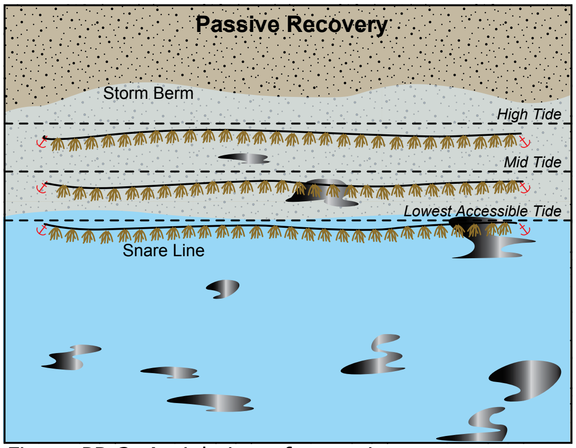


Figure PR-3. Aerial view of a passive recovery general configuration.

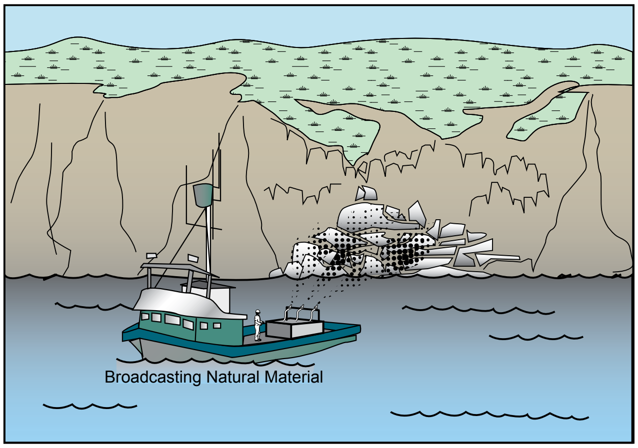


Figure PR-4. Marine mammal broadcast passive recovery.

DEPLOYMENT CONSIDERATIONS AND LIMITATIONS

- Shoreline access may influence deployment platform options.
- Passive recovery materials require periodic tending and replacement.
- Logistics for solid waste transport and disposal need to be considered.
- Contact National Marine Fisheries Service (NMFS) before disturbance of marine mammals.

REFERENCES TO OTHER TACTICS

Other tactics associated with Passive Recovery include:

- Diversion Boom
- Containment Boom

EQUIPMENT AND PERSONNEL RESOURCES

Commonly used resources for this tactic have been defined as personnel with tools, transportation, and sorbent materials. Quantity of units required will be determined by site conditions and resource sets may need to be refined as site-specific requirements dictate.

Typical Passive Recovery System

Typical Resources	Function	Quantity	Notes
Sorbent boom, typically 8″ diameter by 10′ long	Collect non-persistent oil	Site-specific	Best for diesel and non-weathered crude oil
Pom-poms attached to a line, typically in 50′ lengths	Collect persistent oil	Site-specific	Best for weathered crude, Bunker C, IFO, and other persistent oils
Anchor systems, small	Secure sorbent in selected configuration	1 system per 200′ of boom/line	Use in sub-tidal collection
Anchor stakes	Secure sorbent in selected configuration	1 stake per 100′ line	Use on land and in inter-tidal areas
Hand tools: rakes, pitchforks, shovels, sledge hammer	Deploy anchor, stakes, etc.	Site-specific	
Oily waste bags and duct tape	Storage of recovered sorbent materials	4 to 8 bags per 100′	
Deployment vessels	Deploy system to recovery locations accessible from the marine environment	1 or more	Locations with marine access
ATV with trailer	Deploy system to recovery location at an off-road location	1 or more	Locations with ATV access
Helicopter	Deploy system to recovery location at an off-road location	1 or more	Locations with a helicopter landing zone
Trucks and other 4-wheel drive vehicles	Deploy system to recovery location accessible by road	1 or more	Locations with road access
Response Personnel	Varies based on assignment	Varies depending on deployment platform and extent of operations	All response personnel must have OSHA certification appropriate to their job level

SECTION IV – OTHER TACTICS

GENERAL CONSIDERATIONS

In addition to booming and recovery, other tactics may be used alone or in combination with other tactics.

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BB EARTHEN BERMS, UNDERFLOW DAMS AND CULVERT BLOCKING

OBJECTIVE & STRATEGY

The objective of Earthen Containment, Underflow Dams and Culvert Blocking is to contain spilled oil and limit spreading of oil slicks, thus excluding spilled oil from impacting sensitive resources by constructing a barrier from natural materials, in the case of earthen containment, and/or other readily available materials for culvert blocking. Beach berms and exclusion dams are embankment structures built-up from the existing terrain (Figure BB-1), placed to contain and accumulate oil for recovery. These barriers can serve to:

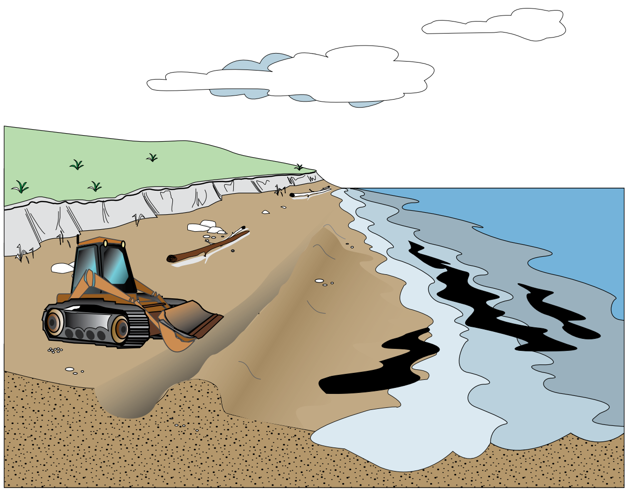

Figure BB-1. Beach berm construction.

- Contain and stabilize a contaminated area.
- Contain or divert oil on water or oil that has potential to migrate.
- Create cells for recovery.
- Use natural depressions to act as containment areas for recovery.

Dams are typically deployed at the mouths of inlets, lagoons, or streams to exclude oil from entering the area as the tide rises. Berms and dikes are used to prevent oil from entering the upper inter-tidal zone or over washing the storm berm and impacting sensitive habitat behind the storm berm. The tactics may be deployed in conjunction with a recovery tactic such as Passive Recovery or Shore-side Recovery. Culvert or outfall blocks are used to prevent oil from flowing in either direction through an existing water outfall or culvert. Berms, dikes and dams are most effective when they are deployed prior to the spill impacting an area.

The general strategy is to:

1. Identify the location and trajectory of the spill or potential spill.
2. Select a configuration that best supports the operating environment and available resources.
3. Identify, locate and mobilize equipment and personnel to the location.

4. Construct dike, berm or dam using local materials and ensure it does not leak using plastic or geotextile lining.
5. Monitor the containment structure to ensure that it remains intact.
6. If oil collects on or behind the berm or dam, utilize an appropriate recovery tactic to remove it.

TACTIC DESCRIPTION

This tactic involves building an embankment perpendicular to the flow of the oil slick or around a contaminated area. Dike, berm, and dam structures can be constructed with a wide variety of materials including: soil, gravel, snow, sand bags, oil boom, timbers and logs. Selection of the construction material depends on the operating environment, location, available materials, and whether the structure is to be temporary or permanent. The containment area should be lined with an impermeable membrane, such as plastic sheeting, to keep oil and oily water from leaking or migrating into the soil. The structure may include a method to regulate flow, such as a weir or spill way. Dikes, berms, and dams can be built by manual labor or with earth-moving equipment depending on the location and available resources. Dams are used to exclude the migration of water and oil into an area, as shown in Figure BB-2. Dikes, berms, and dams can cause significant impacts to the environment. If time allows, the Operations Section Chief should consult with the Environmental Unit Leader before authorizing the construction of any dike, berm or dam.

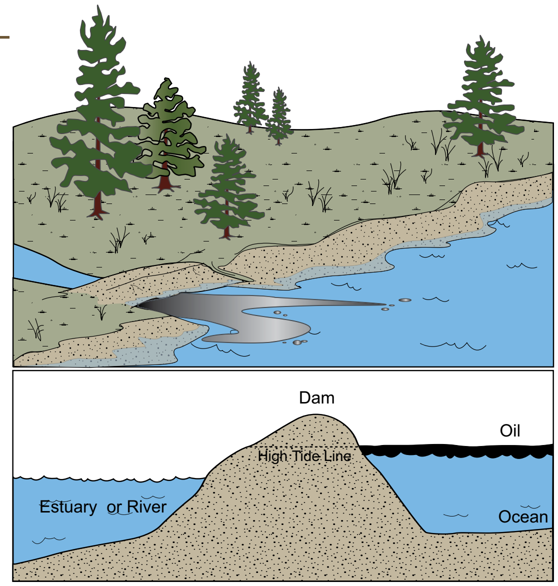

Figure BB-2. Exclusion dam construction.

If there is a constant water out-flow of the area, consider the use of an underflow dam (Figure BB-3). Measures should also be taken to ensure the dam is not breached or undermined by surf activity or currents. These systems are configured depending on the operating environment, type of beach, type of oil, the state of weathering, and available equipment.

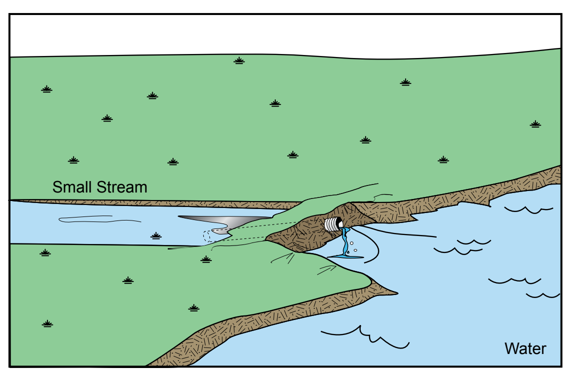

Figure BB-3. Underflow dam configuration.

Operating Environments

Earthen containment and underflow dams are utilized in the shoreline operating environment.

Beaches are broken down into 2 types:

- steep inclined beach – fine or course grained substrate
- low angled beach- fine or course grained substrate

STEEP INCLINED SHORELINE

It is difficult to build and maintain a dam or berm on a steeply inclined fine-grain shoreline; especially with wave action exceeding 1 foot. These high energy beaches are typically very mobile.

Dams deployed to exclude cuts on steep shoreline should be evaluated regarding the force of the water current entering the lagoon or backwater.

LOW ANGLED SHORELINE

Deployment of Earthern Berms and Underflow Dams on low angled shoreline works best if the wave height is less than 3 feet.

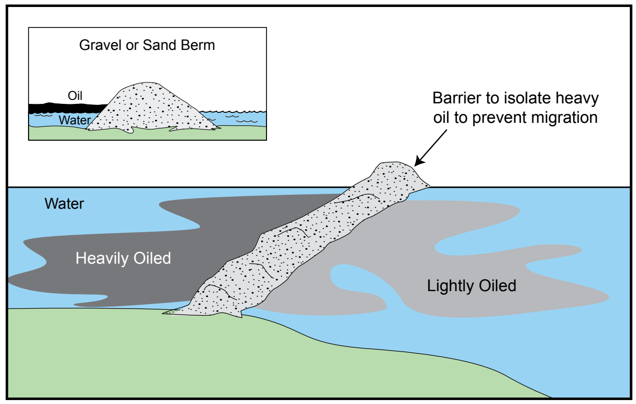

Figure BB-4. Berm configuration.

Deployment Configurations

There are many deployment configurations for dikes, berms, and dams. A few examples follow.

BERMS

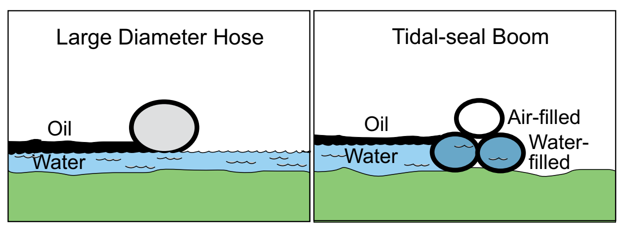

Figure BB-5. Using boom to form a berm

A containment berm can be constructed of available materials such as earth, gravel, or snow. Use earth-moving equipment or manual labor to construct the berm. Form the materials into a horseshoe shape ahead of the flow of oil. Use plastic sheeting to line the walls of a soil berm to prevent oil penetration. Sandbags filled with sand or other heavy material also make excellent containment barriers.

DAMS

An underflow dam can be used when there is too much water flow to allow for a complete blockage of a drainage channel. The dam is built of earth, gravel, or other barriers such as sandbags or plywood sheets. Wherever possible, line the upstream side of the dam with plastic sheeting to prevent erosion and penetration of oil into the dam material.

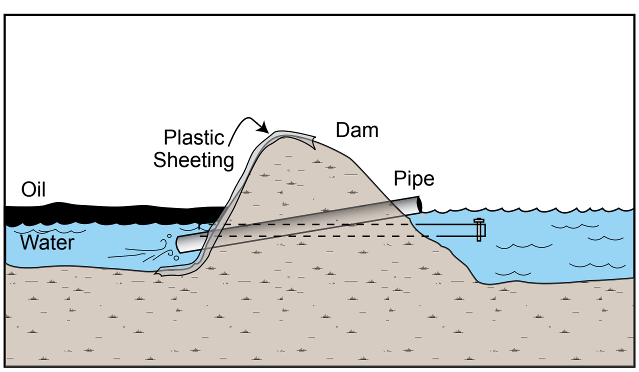

Figure BB-6. Underflow dam.

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Underflow dams use inclined culverts or pipes to move water downstream while leaving the spill contained behind the dam. The capacity of the pipe(s) should exceed the stream flow rate. It may be necessary to use pumps to remove water behind a dike. Valves or culvert plugs can also be used to control flow rate.

Pipes must be placed on the upstream side of the dam, with the elevated end on the downstream side. Make sure that the upstream end of the pipe is submerged and below the oil/water interface. The height of the elevated downstream end of the pipe will determine the water level behind the dam.

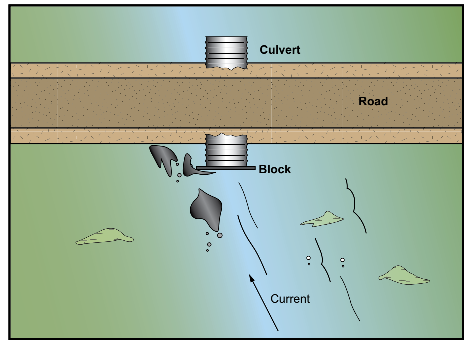

Figure BB-7. Using a roadway as a dike.

EXISTING ROADS

Roadways that are built up above the terrain can be used as dikes. However, road construction usually allows for natural drainage through culverts or bridges. These drainage structures must be controlled to turn the road into a barrier.

CULVERT BLOCKING

A culvert can be blocked using sheet metal, plywood barriers, or inflatable culvert plugs. Use a full block only when the culvert will be blocked for the entire cleanup operation, if the oil floating on the water will not contaminate additional soil, and if blocking the water flow will not threaten the road. Otherwise, an adjustable weir or culvert plug should be used.

Plywood and/or sandbags can also be used as culvert blocks, but are more labor-intensive and pose a higher potential for injury. A wood block may require a headwall with kickers oriented to support the boards or plywood. Place the blocking materials over the upstream end of the culvert. Plastic sheeting over the outside of the block will prevent oil penetration. Some Massachusetts GRP sites may have equipment or plywood pre-positioned to facilitate culvert blocking.

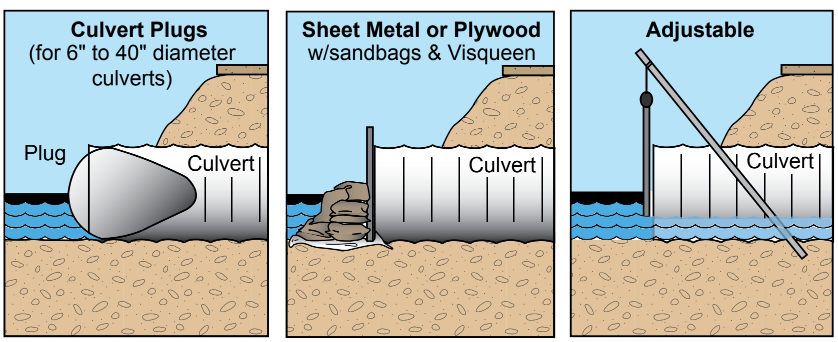

Figure BB-8. Culvert blocking options.

EARTH MOVING EQUIPMENT

A bulldozer, road grader, or front-end loader drives around the spill with its blade angled towards the spill, pushing earth or snow into a berm. Once the perimeter has been covered with an initial berm, shore-up areas as necessary.

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SNOW

Because of the absorbent quality of snow, it makes an excellent berm for both containment and recovery. A snow berm can be strengthened by spraying it with a fine water mist that forms an ice layer on top of the snow. A snow berm is built around the areas of heaviest oiling to contain oil or diesel spilled to ice in winter.

MESH FENCE

Plastic mesh fencing may be used to quickly construct an underflow dam system. The mesh fencing is placed across the drainage and held in place with stakes. Absorbent boom, oil boom, plywood, or even dry dead grass can be placed on the upstream side of the fencing. Running water will find its way under the barrier fence, but oil floating on top of the water will be trapped. The advantages of this system are that it is lightweight and mobile.

DEPLOYMENT CONSIDERATIONS AND LIMITATIONS

- During operation of heavy equipment a spotter should be present to ensure safe operations.
- Do not excavate materials if activities will cause more damage than the spill.
- Consult with the Environmental Unit to determine if permits are required before constructing a dike, berm or dam.
- A plastic liner or sheeting can be used on the walls of the soil or gravel embankments to inhibit spill penetration into the soils or gravel.
- Removal and disposal of oiled construction materials should be considered prior to deployment.
- Check berms and dams periodically for leakage and integrity, replace eroded materials, and continually monitor the water/oil interface. Valved pipes, pumps, or a number of siphons may require periodic adjustment to compensate for minor changes in stream flow.
- If sufficient underflow cannot be maintained, or if excessive overflow occurs, additional dams downstream may be required.
- Damming a stream mouth may block fish passage. Dams should be removed immediately when no longer needed.
- Sandbags are labor-intensive and should be the last consideration.
- Evaluate the out-flow potential of streams behind exclusion dams to avoid wash-out of culverts or dams. Construct an underflow dam, if necessary.

REFERENCES TO OTHER TACTICS

Other tactics associated with Earthen Berms and Underflow Dams include:

- Culvert Blocking
- Cold-water Deluge

EQUIPMENT AND PERSONNEL RESOURCES

There are too many variations of Earthen Berms and Underflow Dams to be specific on equipment and personnel resources.

Typical Earthen Berms and Underflow Dams Resources

Typical Resources	Function	Quantity	Notes
Bulldozer, road grader, front-end loader, excavator	Construct dikes, berms, or dams	Site-specific	Depending on configuration
Dump truck	Optional - for moving construction materials	Site-specific	Depending on configuration, currents, and sea states
Soil, gravel, sand, or snow	Material for embankments	Site-specific	May be available on-site or may have to be transported to the location
Culvert	Optional for underflow dam	Site-specific	Sized to be capable of handling surface water flow
Culvert plug, weir, or blocking materials	Optional to control flow through underflow dam	1 per culvert	
Plastic sheeting or other impermeable membrane	Liner to prevent the embankment from leaking	Site-specific	Care must be taken when placing the sheeting to maintain its integrity
Response Personnel	Function varies according to assignment	Varies based on quantity and configuration of eqipument.	All response personnel must have appropriate level of OSHA training for their job assignment

CWD COLD-WATER DELUGE

OBJECTIVE & STRATEGY

The objective of Cold-water Deluge is to use high volume/low pressure water flow to wet the surface of a shoreline segment. If there is no previous oil impact, the wetting will prevent oil from adhering to the shoreline. Flooding the beach segment may actually raise the water-table, thus lifting any oil from the sediment. Cold-water Deluge is most effective when deployed before oil impact. If oil has impacted a shoreline segment, Cold-water Deluge may be used as a clean-up technique. In this case the oil is washed down slope to the water and recovered.

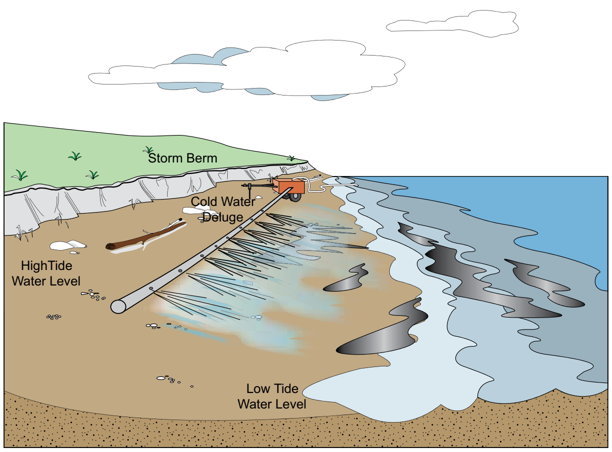

Figure CWD-1. Cold Water Deluge in protection mode.

The general strategy is to:

1. Identify the location and trajectory of the spill or potential spill.
2. Select equipment and a configuration that best supports the operating environment.
3. Deploy equipment and personnel to the location.
4. Set up equipment and begin operations.
5. Utilize an appropriate recovery tactic if oil has impacted the shoreline and is being remobilized.
6. Monitor the pumps and water flow to ensure that sufficient flow is maintained.

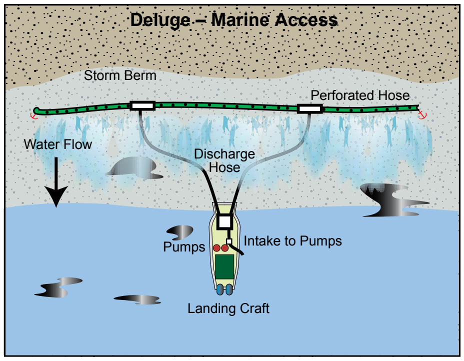

Figure CWD-2. Aerial view of a deluge configuration marine access.

TACTIC DESCRIPTION

Cold-water deluge systems consist of high volume/low pressure pumps, intake hoses, perforated discharge hoses or pipes and associated hardware. Generally a large diameter perforated header hose/pipe is laid parallel to the water at the high tide line. Using high volume/low pressure pumping systems, a large amount of ambient seawater is then pumped through the hoses and washed down the beach. These systems are configured depending on the operating environment, type of beach material, type of oil, the

Sec IV. OTHER TACTICS

state of oil weathering, and available equipment.

Operating Environments

Cold-water Deluge is used in the Shoreline operating environment.

Deployment Configurations

Cold-water Deluge is recommended for use on beaches with a substrate courser than sand and on low angled rocky shorelines. In clean-up mode, boom is deployed around the flooded area to ensure that oil is captured for recovery.

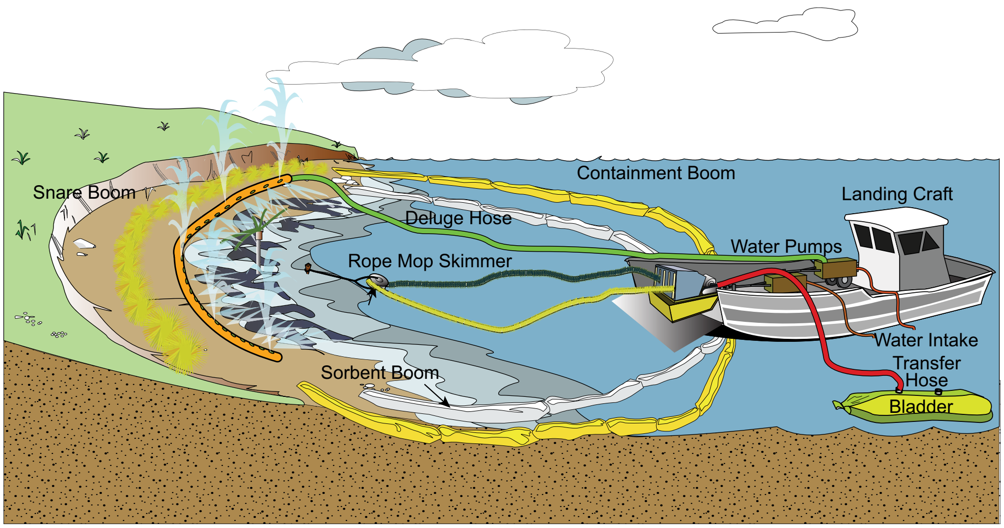

Figure CWD-3. Cold-water Deluge in clean-up mode.
Note: Other shoreline clean-up tactics are not included in this manual, but the Cold-water Deluge tactic can be converted to a shoreline clean-up tactic by adding containment boom, a wash-down system, and a marine recovery system.

DEPLOYMENT CONSIDERATIONS AND LIMITATIONS

- Consideration should be given to surf.
- On beaches with rich inter-tidal areas, deluge should be used during periods when the rich area is submerged.
- Cold-water Deluge is generally not recommended for fine grained sand, mud, vegetated, or steep rocky shorelines.
- Remobilized oil should be recovered during operations.

REFERENCES TO OTHER TACTICS

Other tactics associated with Cold-water Deluge include:

- Shoreside Recovery
- Marine Recovery
- Diversion Boom and Recovery

EQUIPMENT AND PERSONNEL RESOURCES

Resources for the Cold-water Deluge tactic include pumps, suction hose, discharge hose, perforated header hose/pipe, and response personnel. Configuration and specific resources required will be determined by site conditions, spilled oil type and volume, area of coverage, and resource availability. Resource sets may need to be refined as site-specific requirements dictate.

Typical Cold-water Deluge System Components

Typical Resources	Function	Quantity	Notes
Pumps and power pack	Moving seawater	Site-specific	Depending on configuration and length of beach
Suction hose	Moving ambient seawater to the pump	Site-specific	Depending on configuration and distance from water to high tide line
Discharge hose	Moving ambient seawater from the pump to the perforated header	Site-specific	Depending on configuration and distance from water to high tide line
Perforated hose or pipe	Supply water along the length of the beach	Site-specific	Depending on the length of beach being addressed
Response vessels appropriate for the operating environment and assignment	Platform for equipment and pumps; transportation to beach	Varies depending on configuration and size of area	
4-wheel drive vehicles and/or ATVs with trailers	Transport equipment to site	Varies depending on access and terrain	
Response personnel and vessel/vehicle operators	Function varies depending upon assignment	Varies depending on access type (land or water) and configuration	All response personnel must have the appropriate level of OSHA training for their job assignment

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SECTION VI: APPENDICES

Appendix A. Glossary
Appendix B. Acronyms
Appendix C. Spill Volume Estimator
Appendix D. Legend of Icons Used on Most Masschusetts GRP Maps

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A. GLOSSARY

Anchor Systems:

Large Anchor System – A large anchor system cannot be deployed by hand, thus requires the use of a crane or boom to lift and deploy. Typically, any anchor over 50 pounds is considered a large anchor.

Small Anchor System – A small anchor system can be deployed by hand, without the aid of a boom or crane. Typically, any anchor less than 50 pounds is consider a small anchor.

Application Rate – Refers to the volume of sprayed product divided by the surface area covered by the spray and is usually expressed in liters/hectare or gallons/acre.

Branch – ICS organizational level based on functional or geographic responsibility. A Branch is below a Section and above a Division or Group in an ICS organization chart.

Broken Ice – An operating environment where a body of water has incomplete coverage of ice. Broken ice varies from less than 10% coverage to greater than 90% coverage. Oil spill response operations in broken ice are generally limited to less than 70% coverage.

Buddy System – An arrangement in which persons are paired for mutual safety or assistance.

Calm Water – An operating environment where the sea state is usually less that 1 foot and currents are less than 0.8 knots. Includes waters that are very sheltered from wind and waves or very small bodies of water. This is the least demanding operating environment for water borne oil spills.

Cold Zone – A zone in the site layout of a spill response. The Cold Zone is also called the Support Zone and is free of oil contamination. Support facilities, staging areas, warm-up trailers, command posts, etc. are located in the Cold Zone.

Competent Person – An individual with the skill, knowledge, practical experience and training to enable him/her to assess the risks arising from work activities involving substances hazardous to health.

Coverage Rate – Refers to the surface area covered by the spray divided by the length of time required to spray it. It is usually expressed in hectares/hour or acres/hour.

Decant – To remove free-water from an oil/water mixture by drawing the water off the bottom of the oil/water interface.

Decontamination Plan – A plan approved by the Unified Command for the removal of oil contamination from personnel and equipment.

Demobilization Plan – A plan approved by the Unified Command for the orderly and timely demobilization of resources no longer needed in the oil spill response.

Division – ICS organizational level based responsibility for a defined geographic area or function. A Division is usually assigned to a specific area, such as the Gulf of Alaska Division or the Yukon River Division. A Division is below a Branch and above a Task Force or Strike Team.

Dispersant – A chemical formulation containing surface active agents (surfactants) that lowers the surface tension between oil and water and facilitates the breakup and dispersion of oil into the water column in the form of finely divided droplets to allow for natural biodegradation.

Emulsification – A process by which oil forms an emulsion or "mousse" consisting of many small droplets of water incorporated into the oil.

Encounter Rate – For dispersant applications, refers to the area of oil that can be sprayed in a specific time. This can be calculated as the ship or aircraft spraying speed multiplied by the width of the spray deposits on the surface. For mechanical recovery applications, it is area of oil that is contained in a specific time. This is calculated as the width of the boom opening times the speed of advance.

Environmental Unit – ICS organizational category that is part of the Planning Section. The Environmental Unit is responsible for: the identification and prioritization of environmentally sensitive areas to be protected; wildlife response; acquiring permits for dispersant, in-situ burning, and land access; and shoreline assessments.

Fast Water – An operating environment where the sea state is usually less that 1 foot but the current exceeds 0.8 knots. Fast Water includes rivers, streams and marine waters with moderate to strong tidal currents.

Flash point – The temperature at which a liquid gives off sufficient vapor to ignite in the presence of an open flame.

Geographic Response Strategy (GRS) - GRS are site-specific spill response methods used to protect sensitive coastal environments from the deleterious effects of petroleum or other hazardous substance spills. GRS provide first responders with specific guidance for a rapid deployment of pre-identified actions to protect priority sensitive sites.

Geotextile – A manufactured fabric material, usually woven from Polyester or Polypropylene, used in earth construction projects. Geotextile is oleophilic and will act as a passive recovery material, while allowing water to pass through the fabric. Geotextile can be used to protect a shoreline or soil from oil contamination at oil recovery locations.

Group – ICS organizational level-based responsibility for a particular function, such as Non-mechanical Operations Group, Wildlife Recovery Group, or Shoreline Protection Group. A Group is below a Branch and above a Task Force or Strike Team.

Hot Zone – A zone in the site layout of a spill response. The Hot Zone is also called the Exclusion Zone and is where oil contamination is found. The Hot Zone perimeter is established by the Safety Officer. Site safety assessment and site entry criteria are applied to the Hot Zone in order to prevent the spread of contamination, and to ensure the health and safety of responders and the public.

Incident Commander – The individual responsible for the management of all incident operations.

Intermediate Storage – Secondary or tertiary storage for oil, recovered liquids, and oily solid wastes collected from a recovery operation. Storage devices that receive wastes from primary storage or other intermediate storage devices, such as a rigid tank that is filled from a vacuum truck or a tank truck filled from a portable tank.

Marsh – A wetland operating environment that is considered sensitive to disturbance from oil spill response activities. Marshes are low-lying, waterlogged land that are poorly drained and difficult to cross on foot or vehicle. Care must be take in oil spill operations to minimize the disturbance of marshes and prevent introducing oil below the surface.

Mousse – An emulsified mixture of water in oil. Mousse typically has a thick consistency compared with fresh oil, and can incorporate up to 75 percent water into the oil, increasing apparent oil volume by up to four times. Colours can range from red, orange or tan to dark brown. Mousse can be easily confused with algal scum collecting in convergence lines, algae patches, or kelp. See also emulsification.

Open Water – An operating environment where the sea state can reach 6 feet and moderate waves and white caps may occur. Includes open waters that are not sheltered from wind and waves. This is the most demanding operating environment for water borne oil spills.

Operations Section – ICS organizational category responsible for all operations directly applicable to the primary mission of the incident.

Operations Section Chief – The individual responsible for executing all field operations approved by the Unified Command. The Operation Section Chief reports directly to the Incident Commander.

Payload – Refers to the total amount of dispersant carried by the aircraft or ship.

Preapproval – The state of being accepted for use as a spill treatment agent in a particular location without further bureaucratic authorization procedures under the conditions set forth by the responsible authorities.

Preauthorization – Same as preapproval.

Primary Storage – The initial storage for oil, recovered liquids, and oily solid wastes collected directly from a recovery operation. The initial storage once the oil, oily liquid, or oily solid waste is picked-up, such as a mini-barge associated with a skimming vessel or a portable tank associated with a shore-side recovery tactic.

Protected Water – An operating environment where the sea state can reach 3 feet and small waves and white caps may occur. Protected Waters have limited shelter from wind and waves. Protected Water falls between Open Water and Calm Water in the classification scheme.

Safety Officer – A member of the Command Staff responsible for monitoring and assessing safety hazards or unsafe situations, and for developing measures to ensure personnel safety.

Sheen – A very thin layer of oil (less than 0.003 millimeters in thickness) floating on the water surface. Sheen is the most commonly-observed form of oil during the later stages of a spill. Depending on thickness, sheens range in color from dull brown for the thickest sheens to rainbows, grays, silvers, and near-transparency in the case of the thinnest sheens. Natural sheens can result from biological processes.

Site Safety Plan – A plan prepared by the Safety Officer and approved by the Unified Command that establishes safety procedures and practices for the incident.

Slick – Oil spilled on the water, which absorbs energy and dampens out surface waves, making the oil appear smoother (or slicker) than the surrounding water.

Solid Ice – An operating environment where a body of water has complete coverage of ice. Spill response activities may occur on Solid Ice only after it is determined that the ice is of sufficient thickness to safely support response personnel and equipment.

Sortie – Refers to each dispersant application run.

Spreading – The thinning out of an oil slick onto the surface of water.

Staging Area – Location where incident personnel and equipment are available for tactical deployment. Can serve as a check-in location for equipment and personnel reporting to the incident.

Staging Area Manager – The individual responsible for overseeing and managing the Staging Area. The Staging Area Manager reports to the Operations Section Chief.

Streamers – A narrow line of oil, mousse, or sheen surrounded on both sides by clean water. Streamers result from the combined effects of wind, currents, and/or natural convergence zones. Heavier concentrations are often present in the centre, with progressively lighter sheen along the edges. Streamers are also often called “fingers”, “ribbons”, or “windrows”.

Strike Team – An ICS operations team that consists of the same kind and type of resources with common communication and leader.

Supervisor – The individual responsible for the command of a Division or Group.

Tar ball – Oil weathered into a pliable ball up to approximately 30 cm. Sheen may or may not be present.

Task Force – A group of resources with common communications and a leader assembled for a specific mission.

Tundra – An operating environment that is considered sensitive to disturbance from oil spill response activities. Tundra has permanently frozen subsoil. Tundra is often waterlogged land that is poorly drained and difficult to cross on foot or vehicle. Care must be take in oil spill operations to minimize the disturbance of tundra that can cause melting of the subsurface ice and permanent damage to the ecosystem.

Unified Command – A command team that allows all parties responsible for the incident to manage the incident by establishing a common set of objectives and strategies. This is accomplished without relinquishing agency responsibility, authority, or accountability. The Unified Command is comprised of the Responsible Party Incident Commander, Federal On-Scene Coordinator, and State On-Scene Coordinator and may also include a Local On-Scene Coordinator.

Unified Plan – The State/Federal contingency plan for Alaska, officially titled Alaska Federal/State Preparedness Plan for Response to Oil & Hazardous Substance Discharges/Releases (Unified Plan).

Warm Zone – A zone in the site layout of a spill response. The Warm Zone is also called the Contamination Reduction Zone and is where decontamination activities occur. The Warm Zone allows for an orderly transition from the Hot Zone to the Cold Zone. Workers shed contaminated clothing and equipment and personnel are decontaminated in the Warm Zone.

Waste Management Plan – A plan approved by the Unified Command that establishes waste management practices and procedures for the incident.

Waste Management Specialist – An individual with the skill, knowledge, practical experience and training to enable him/her to assess the character of a waste or hazardous material and determine the proper handling and disposal methods.

Weathering – The chemical and physical changes that occur once oil has spilled, including spreading, evaporation, dissolution, photo-oxidation, dispersion, biodegradation, and emulsification.

Windrows – Oil or sheen oriented in lines or streaks in the direction of the wind. Windrows typically form early during a spill when the wind speed is at least 10 knots (5.1 meters per second). Sheen is the form of spilled oil that most frequently windrows.

B. ACRONYMS & ABBREVIATIONS

to be developed

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C. ESTIMATING AMOUNT OF SPILLED OIL

SPILL VOLUME ESTIMATION

Oil in or on Soils

- It is difficult to estimate the amount and extent of subsurface pollution from hydrocarbons spilled and trapped in soil.
- Hydrocarbons in soil may exist in three phases:
  - As vapors within the pore spaces
  - As residual liquid attached to or trapped between soil particles
  - As dissolved components of oil in moisture surrounding soil particles
- Generally, oil retention increases with: decreasing grain size, poorer sorting of soils, and increasing oil viscosity.
- Oil retention of initially water-saturated soils is generally lower than initially dry soils.
- The "retention capacity" factor for different types of soils provides an estimate of volume of liquid retained per unit pore volume. The following are rules of thumb for retention capacity of soil types:

	Silt	Sand	Gravel
Crude Oil & Other Persistent Oils	12% - 20%	4% - 13%	0% - 5%
Diesel	7% - 12%	2% - 8%	0% - 2%
Gasoline	3% - 7%	1% - 5%	0% - 1%

Oil on Ice and Snow

- Field experience and data from actual spills indicate that oil-holding capacities of ice and snow range as high as 1,600 barrels per acre.
- Equations for estimates:

  $V (bbl) = (4.14 \times 10^5) \times A (mi^2) \times t (in.)$

  $V (bbl) = 647 \times A (acres) \times t (in)$

  $V (bbl) = (1.48 \times 10^{-2}) \times A (ft^2) \times t (in.)$

  $V (gal) = 42 \times V (bbl)$

  V = Volume of oil spill

  A = Area of oil slick or contaminated zone

  t = Thickness of oil slick or contaminated zone (with snow, t = equivalent oil thickness)

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Oil on Water

- Oil Color – The BONN Agreement Oil Appearance Code (BAOAC) Oil Layer Thickness Estimates:

CODE	Description	Layer Thickness Interval (μm)	Litres per Km^2
1	Sheen (silvery/grey)	0.04 - 0.30	40 - 300
2	Rainbow	0.30 - 5.0	300 - 5,000
3	Metallic	5.0 - 50	5,000 - 50,000
4	Discontinuous true oil colour	50 - 300	50,000 - 200,000
5	Continuous true oil colour	More than 200	More than 200,000

- Equations for estimates:

V (bbl) = 4.14×10^5 A (mi^2) x t (inches)

V (bbl) = 647 A (acres) x t (inches)

V (bbl) = 1.48×10^{-2} A (ft^2) x t (inches)

V (gal) = 0.624 A (ft^2) x t (inches)

V = Volume of oil spill

A = Area of slick at thickness t

t = Thickness of oil slick

Encounter Rate Calculations

- Calculations used to estimate the amount of oil moving past in a stream, entering a collection boom, or in a windrow/patch of oil.

EnR (gpm) = 37 x W (ft) x V (ft/sec) x t (in)

EnR (bbl/hr) = 53.33 x W (ft) x V (ft/sec) x t (in)

EnR (bbl/day) = (1.28×10^3) x W (ft) x V (ft/sec) x t (in)

W = Width of oil swath

V = Velocity in feet per second (1 knot = 1.68 ft/sec)

t = Thickness of oil slick

ESTIMATING SPILL SOURCE VOLUMES AND FLOW RATES

Leak Rate Calculations

One drop/second = 1 gallon per day

Thin stream breaking to drops = 24 gallons per day

Small stream (about 1/8 inch) = 84 gallons per day

Large stream (about 1/4 inch) = 936 gallons per day

A simple rule of thumb is to divide 10,000 by the number of seconds it takes to fill a five-gallon pail.

Estimates for Capacity

- Pipeline per linear foot
  - For volume in gallons per foot: square the inside diameter (in inches) and multiply by 4 percent (0.04)
  - For volume in barrels per foot: square the inside diameter (in inches) and divide by 1,000
  - To find the volume of a pipeline in barrels per mile: square the inside diameter (in inches) and multiply by 5.13
- For vertical cylindrical tanks:

V (gal) = 0.0034 d (in.) x d (in.) x h (in.)

V (gal) = 5.88 D (ft) x D (ft) x H (ft)

d = diameter in inches

D = diameter in feet

h = height of liquid in inches

H = height of liquid in feet

NOTES:

The National Oceanic and Atmospheric Administration publishes an observer's guide that contains more information on estimating oil spill volumes.

Information in this Appendix was taken from the Alaska Clean Seas Technical Manual Vol. 1, and the BONN Agreement Oil Appearance Code (BAOAC).

D. LEGEND OF ICONS USED ON MOST MASSACHUSETTS GRP MAPS

to be developed