Massachusetts Department of Environmental Protection

MASSACHUSETTS Geographic Response Plan Tactics Guide

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This guide was developed by Nuka Research & Planning Group, LLC. under a contract with MassDEP's Marine Oil Spill Prevention and Response Program.

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I. INTRODUCTION

PURPOSE

The Massachusetts Geographic Response Plan (GRP) Tactics Guide provides a standard tactical reference for implementing geographic response plans (GRPs) for oil spill response in Massachusetts. It is available for use by the spill response community, including federal, state, local, industry, and spill response organizations throughout Massachusetts.

The information supports coastal marine GRP implementation and nearshore spill response 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 to divert, collect, and/or remove spilled oil from the environment. All tactics are intended for marine oil spill response in coastal waterways. In most cases, a combination of tactics will be used to accomplish the spill response objectives. The tactics included in this guide are geared specifically toward the equipment and first responders available through the MassDEP Marine Oil Spill Program. These tactics are intended to be implemented by local first responders during the initial phases of an oil spill response. The GRP tactics are protective in nature; they are intended to be used to protect priority areas from oil spill impacts.

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 collaborative process as part of the Cape and Islands GRP project led by the Massachusetts Department of Environmental Protection (MassDEP), the U.S. Coast Guard, the

National Oceanic and Atmospheric Administration, and Massachusetts Coastal Zone Management.

The tactics in this guide are intended for spills of floating oils. GRP tactics are never to be used for spills of gasoline or similar, highly refined products, because of safety and human health risks. Incidents involving spills of hazardous substances, hazardous materials, or other non-petroleum chemicals into the marine environment can sometimes be mitigated utilizing equipment and tactics outlined in this guide. However, due to the potential hazards associated with these types of incidents, responders must first consult with local fire departments, MassDEP and the U.S. Coast Guard prior to utilizing the tactics outlined in this guide. It is important to identify all potential health and safety hazards associated with the type of material spilled.

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 (Potter 2004). 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

The Massachusetts GRP Tactics Guide contains tactics that are appropriate for use in the protected water and calm water environments only.

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.

LEGEND OF SYMBOLS

TACTIC SYMBOLS

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

GRP Tactics

BB	Beach Berm
CB	Culvert Block
DV	Diversion Booming
PR	Passive Recovery
DF	Deflection Booming
	Exclusion Booming
SR	Shoreside Recovery
FO	Free-oil Recovery
TG TG	Tide Gate
	Boat Ramp

Other symbols used in Mass GRPs

	Beach Berm Material
	Protected-water Boom (Flood Tide)
	Protected-water Boom (Ebb Tide)
	Snare or Sorbent Boom
	Booming Strategy Developed by Other Agency
	Seasonal Booming Tactic
L	Lock
	Outfall
MD	Mosquito Ditch
	U.S. Coast Guard Station
	Boston Harbor Co-op Response Trailers
	Boston Harbor Co-op I-Beams
	Pump Station
HB	Hurricane Barrier
	Water Intake
	Permanent Attachment
	Access Point
S	Staging Area
	Response Trailer
	Washover Area
	Lighthouse

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 Components

Figure B-1 shows the typical components of boom. The portion of the boom above the water surface is referred to as the sail and usually includes a flotation mechanism; the portion below the surface is referred to as the skirt. A tension member (such as a piece of cable) of greater strength than the fabric prevents the fabric from tearing under stress. Some sort of ballast, such as chain or weights, is attached to the bottom of the fabric to keep the boom vertical in the water. Flotation material keeps the boom afloat. There are several different designs and methods of flotation. Floats may be rigid or flexible. Inflatable air chambers may be used to provide flotation. Freeboard is the vertical height of a boom above the water line. The freeboard prevents oil from washing over the top of the boom. If there is too much freeboard, however the boom may be pushed over in high winds. The skirt prevents oil from being swept underneath the boom. End connectors are used to connect sections of boom together. Since there are many different types of boom, there are many different end connectors, but the connectors for the boom stored in the MassDEP spill response trailers are universal.

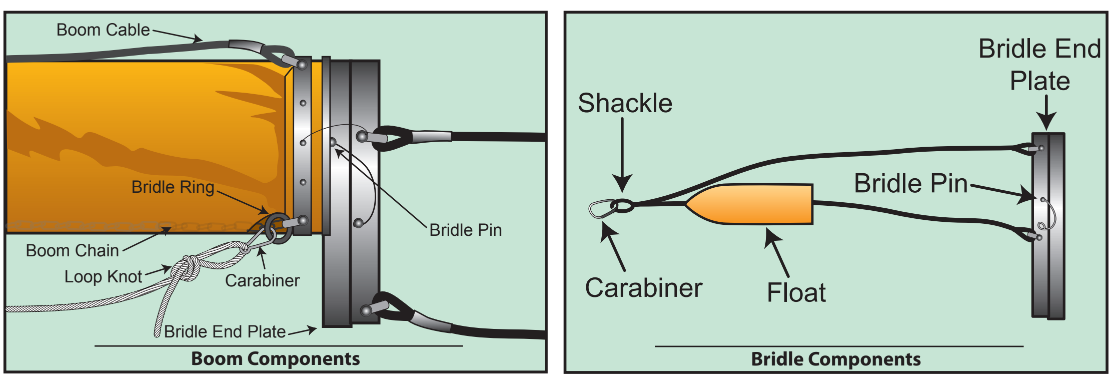

Figure B-1. Boom Components and Bridle Components.

Boom Types and Classification Systems

Different types and sizes of boom may be referred to 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 four 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

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) and the boom may sustain damage or fail.

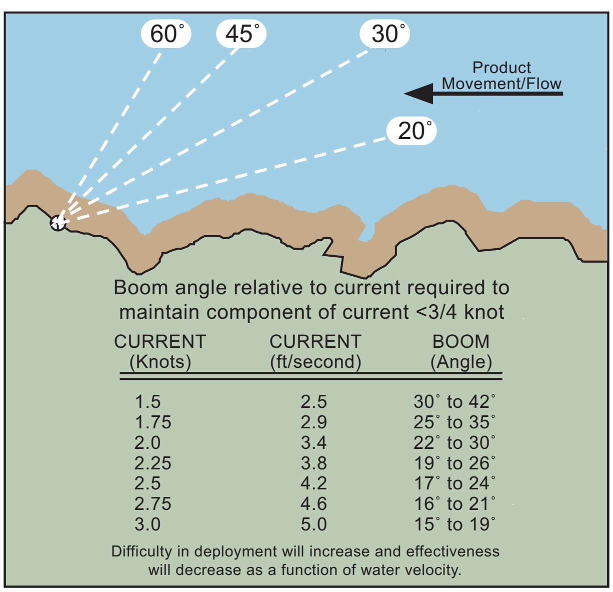

Figure B-2. Boom angles for various current velocities.

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 three knots, the boom must be almost parallel to the current to prevent entrainment. In currents exceeding three 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.

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 three times the depth of the water. If the anchor fails to hold, responders should 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.

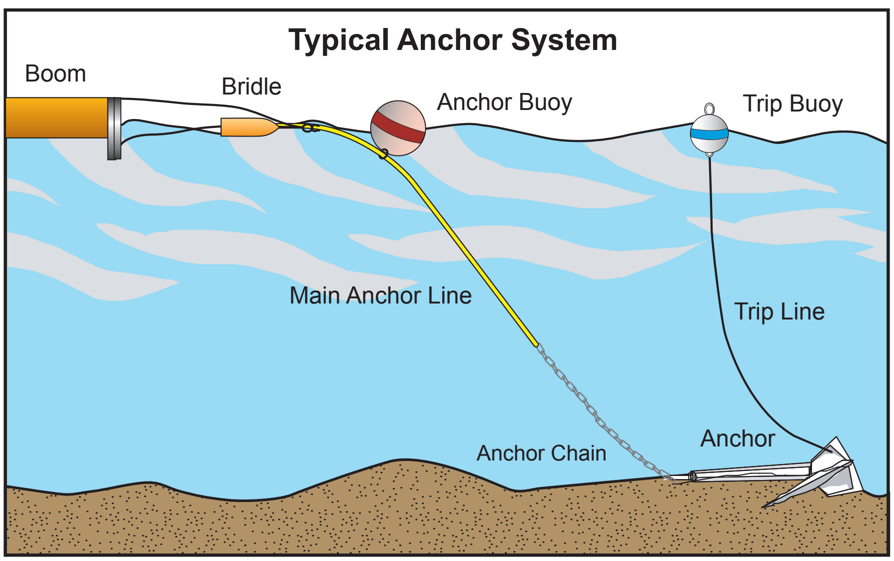

Figure B-3. Typical anchor/boom/bridle configuration system.

Towing and Setting Boom

Most of the booming tactics in the Massachusetts GRPs will require responders to tow boom from a boat ramp or dock to the deployment site. Towing boom requires experienced vessel operators. It is also important that the vessel be appropriately powered to manage the amount of boom being towed. Figure B-4 provides a rule-of-thumb reference to make sure that a vessel is appropriately powered to tow boom to a deployment site, at various towing speeds. Vessels towing boom should operate slowly and should have at least one crewmember in addition to the operator, to keep an eye on the boom. Particular care should be taken in areas with navigational hazards such as fishing floats or mooring buoys. For the purpose of Massachusetts GRP boom deployment, 200 feet of boom is suggested as the maximum amount to be towed by a vessel at one time whenever possible.

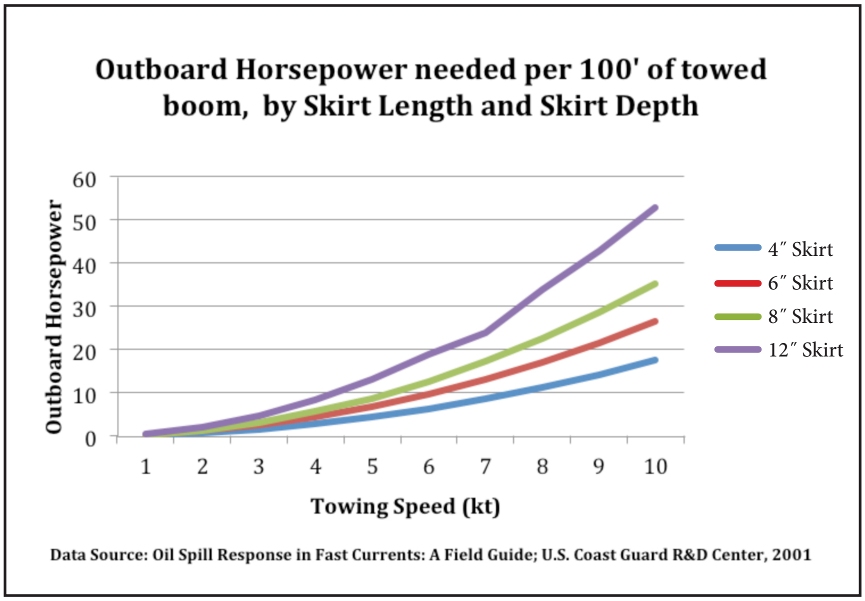

Figure B-4. Rule-of-thumb reference to make sure that a vessel is appropriately powered to tow boom to a deployment site.

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.

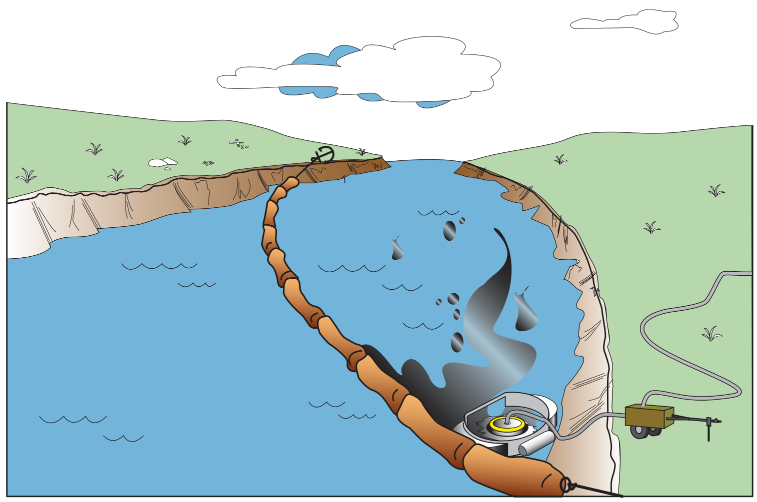

Figure DV-1. Diversion Booming with Marine Recovery.

TACTIC DESCRIPTION

The Diversion Boom tactic is for water-borne 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 (see Figure B-3). Oil can be diverted to a shoreline or away from a shoreline or shoal waters. This tactic is always associated with a recovery tactic, typically Shoreside Recovery. Boom may be held in place by anchors, vessels, or a boom control device.

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 foot and 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. (Hansen and Coe, 2001)***

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 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.

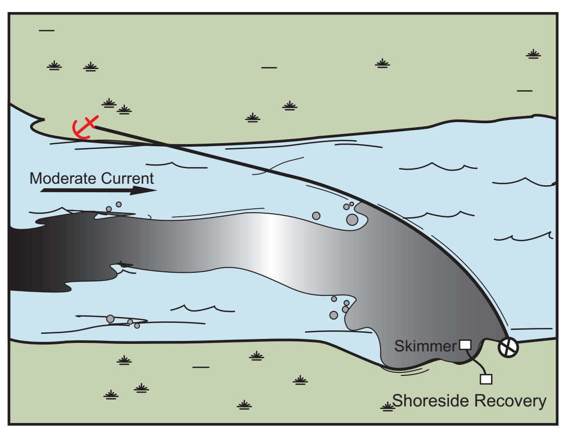

Figure DV-4. Single boom diversion configuration.

DIVERT OFFSHORE

A single boom can also be set to divert oil away from the shore or shoal water, where it can be recovered On-water Free-oil Recovery or Marine Recovery Systems. This tactic requires experienced spill response personnel and is not utilized in the Massachusetts GRPs.

CASCADE

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.

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). This tactic requires experienced spill responders with marine skimmers, and is not utilized in the Mass GRPs.

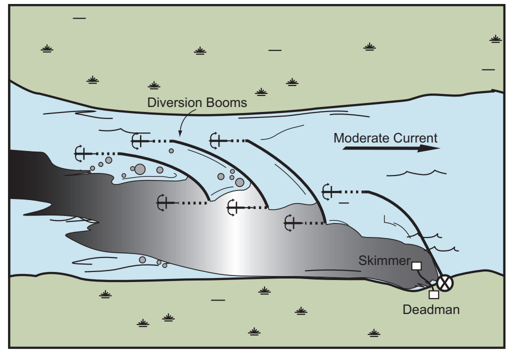

Figure DV-5. Cascade boom diversion configuration.

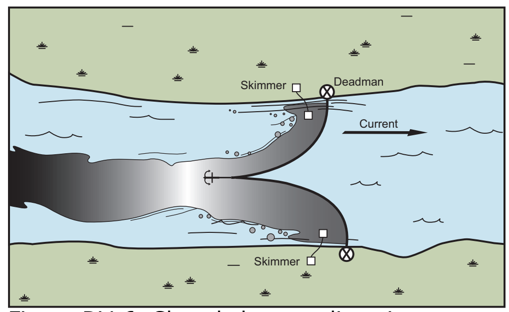

Figure DV-6. Closed chevron diversion configuration.

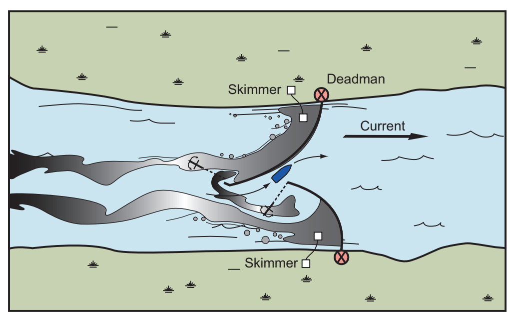

Figure DV-7. Open chevron diversion configuration.

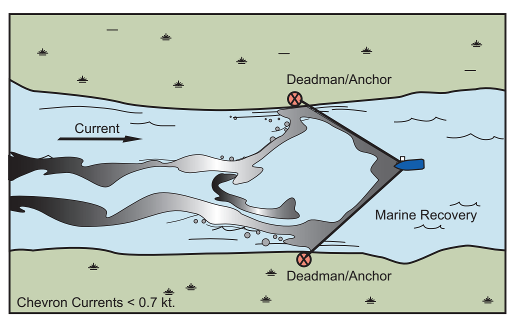

Figure DV-8. Inverted chevron diversion boom configuration.

DEPLOYMENT CONSIDERATIONS AND LIMITATIONS

- Extreme care should be taken when selecting onshore anchoring systems.
- It may be useful to deploy back-up boom down current 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 (see Figure B-3) 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.
- If the spill is in still water under calm conditions, consider Containment Booming.
- Do not assume 100% efficiency with one boom system.
- 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 tidal conditions.
- See Shoreside Recovery for methods to keep oil from contaminating beaches at recovery points.
- Removal of boom may require additional personnel.

REFERENCES TO OTHER TACTICS

Other tactics associated with Diversion Boom include:

- Shoreside Recovery
- Deflection Booming
- 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
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	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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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.

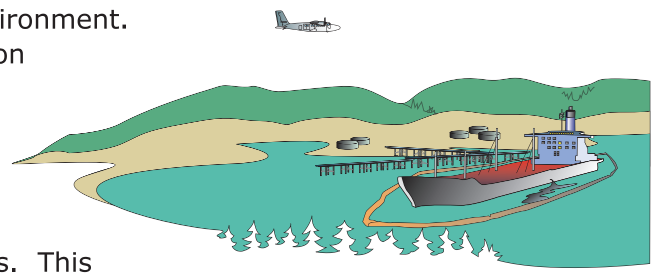

Figure C-1. Containment Boom deployed around a leaking vessel.

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 an 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.

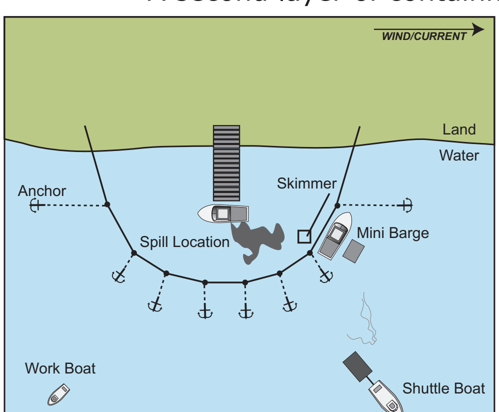

Figure C-2. Containment boom of a vessel at dock.

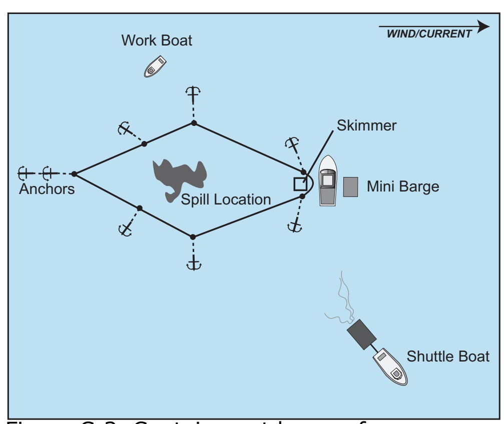

Figure C-3. Containment boom of a submerged pipeline spill.

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 one knot, or if the spill site is exposed to potential wave conditions greater that two feet, consider the Diversion Boom Tactic.
- Anchor vessels fore and aft, before deploying containment boom around them. Estimate the boom length at three 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.
- Removal of boom may require additional personnel.

REFERENCES TO OTHER TACTICS

Other tactics associated with Containment Boom include:

- Shoreside 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	Varies	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

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.

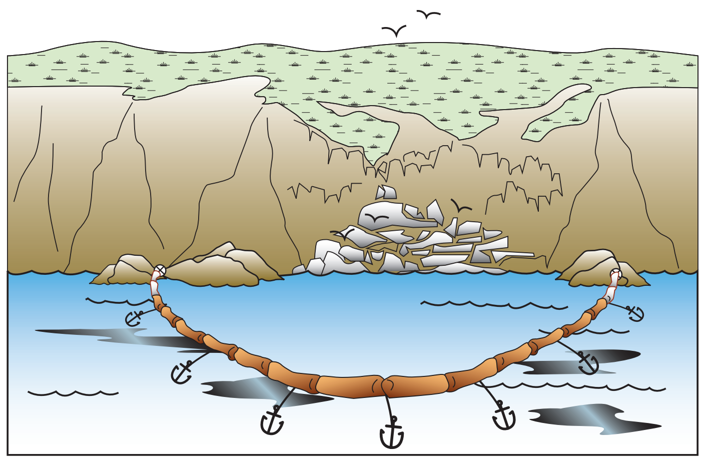
Figure EX-1. Exclusion Booming to protect a sensitive area.

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. (Hansen and Coe, 2001)***

Deployment Configurations

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

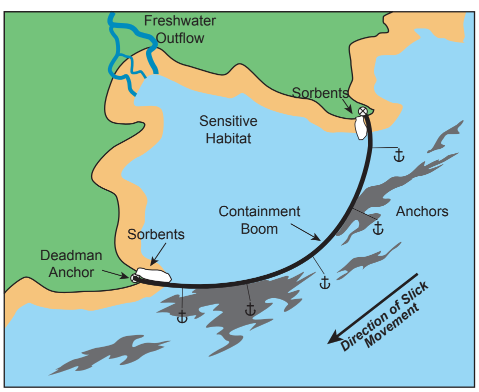

Figure EX-2. Exclusion booming configuration.

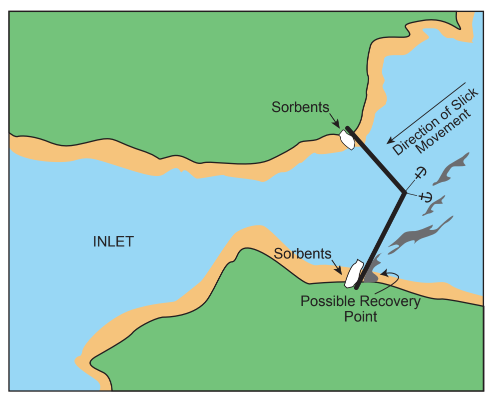

Figure EX-3. Exclusion booming with apex for exposed shores or currents.

DEPLOYMENT CONSIDERATIONS AND LIMITATIONS

- It may be useful to deploy back-up boom.
- Anchor trip lines (see Figure B-3) 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.

- 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 boom 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 tidal conditions.
- Expect boom failure where currents over 0.75 knots encounter the boom.
- A gate (open section of boom) 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
- 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.

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.

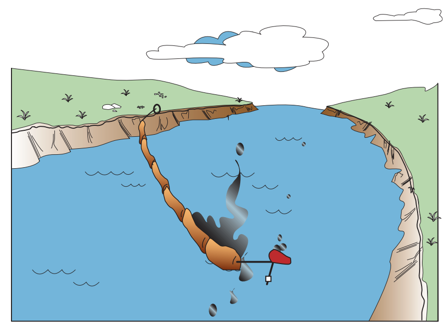

Figure DF-1. Deflection Booming.

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 (see Figure B-3). 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 and is not utilized in the Mass GRPs.

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

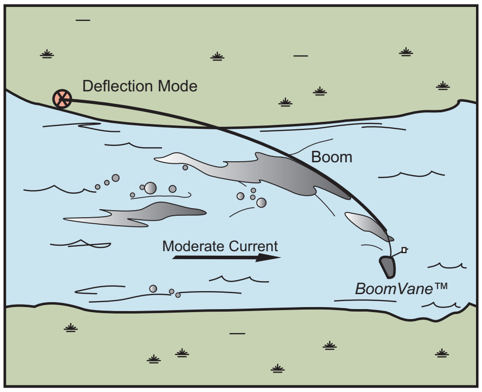

Figure DF-2. Using the BoomVane™ in deflection mode.

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. (Hansen and Coe, 2001)***

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. As depicted in figure DF-3, it is important to ensure that the trailing end of each boom segment overlap the leading end of each successive boom segment as you move downstream to ensure that oil does not escape between boom segments.

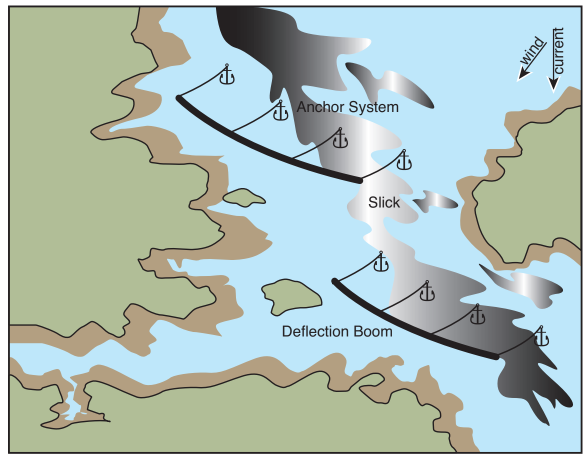

Figure DF-3. Deflection booming, fixed cascaded array.

LIVE

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

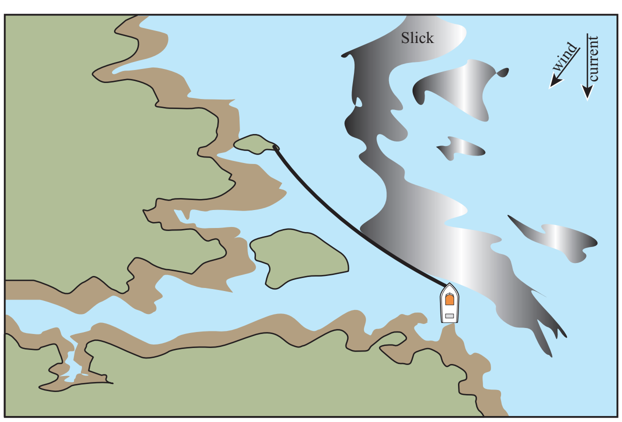

Figure DF-5. Deflection booming, half-live.

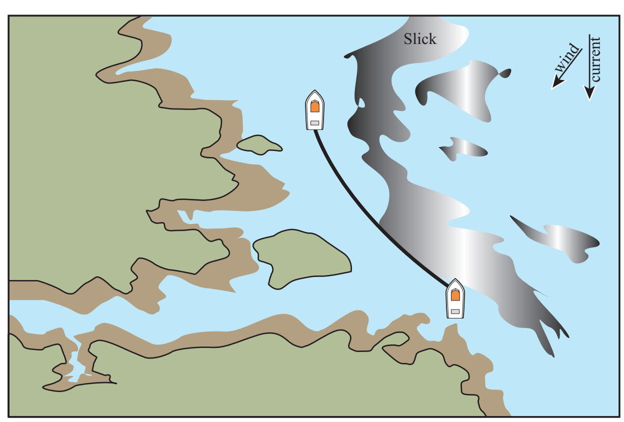

Figure DF-5. Deflection booming, live.

DEPLOYMENT CONSIDERATIONS AND LIMITATIONS

- Anchor trip lines (see Figure B-3) 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.
- Depending upon the boom array, consider deploying back-up boom to collect any oil that escapes primary boom.
- Calm/Protected water boom 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 tidal conditions.
- 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)
- Temporary storage device
- Repair kit (tools and extra parts)

Like boom, 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 sometimes 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.

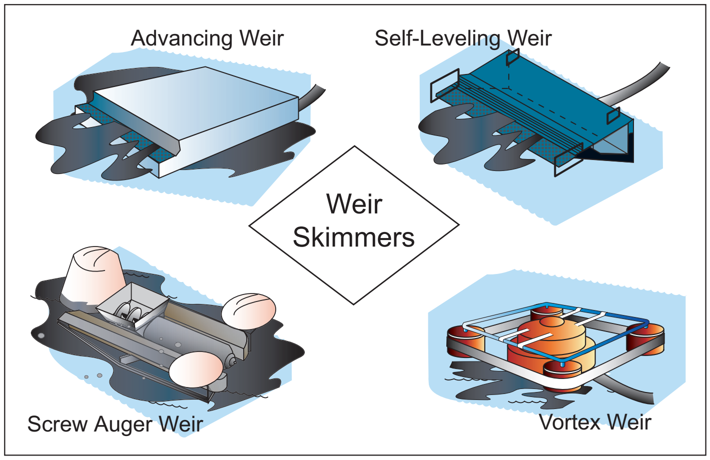

Figure R-1. Various types of weir skimmers.

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 R-2 shows several varieties of oleophilic skimmers.

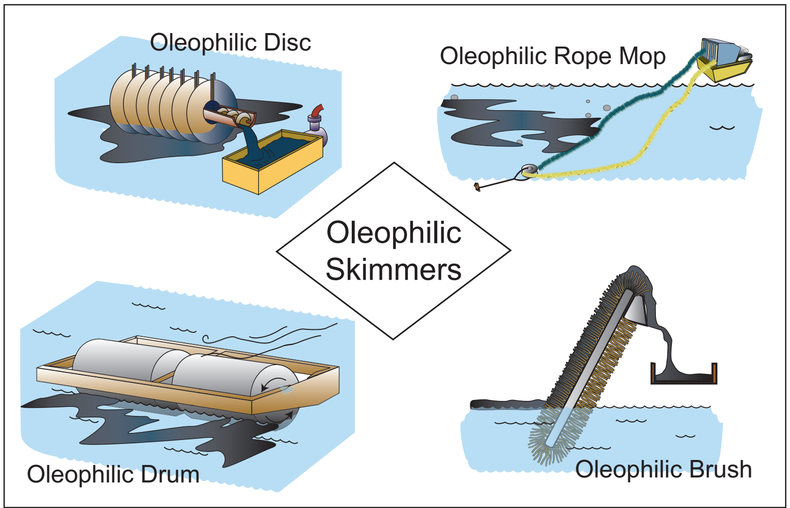

Figure R-2. Various types of oleophilic skimmers.

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 vacuum/suction skimmers.

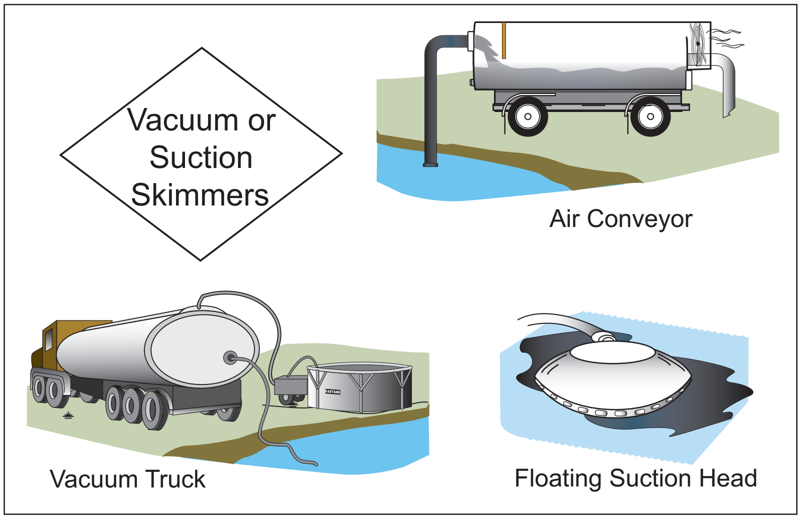

Figure R-3. Various types of vacuum/suction skimmers.

Temporary Storage Devices

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

Temporary 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.

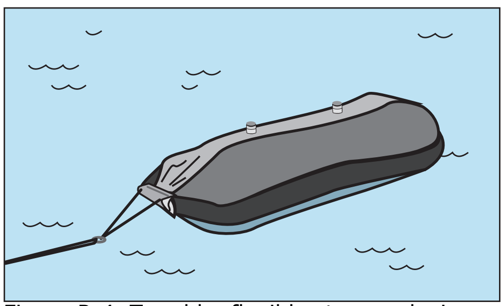

Figure R-4. Towable, flexible storage device.

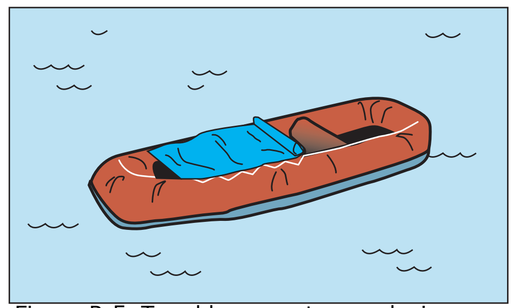

Figure R-5. Towable open storage device.

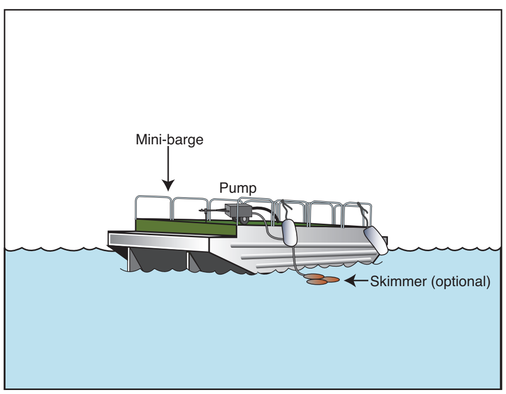

Figure R-6. Towable Mini-barge storage device.

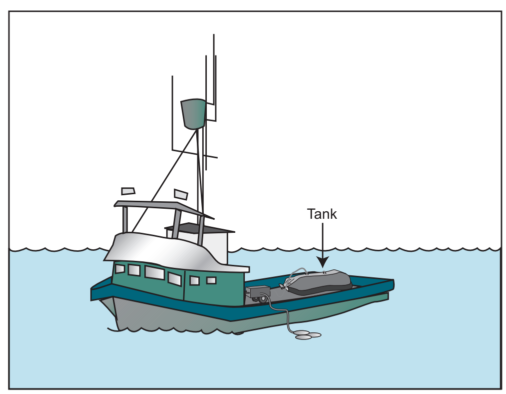

Figure R-7. Deck tank primary storage device.

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, but may require additional permitting.

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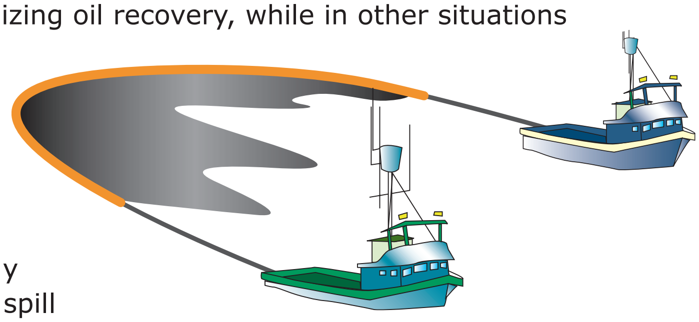
FO ON-WATER FREE-OIL RECOVERY

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.



Free-oil recovery is typically performed by experienced spill responders. It is shown in many of the Mass GRPs to emphasize the importance of removing floating oil wherever feasible. However, free-oil recovery would not be undertaken by local first responders.

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 temporary 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 temporary storage devices. 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 temporary 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 six 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 temporary 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 than six feet.

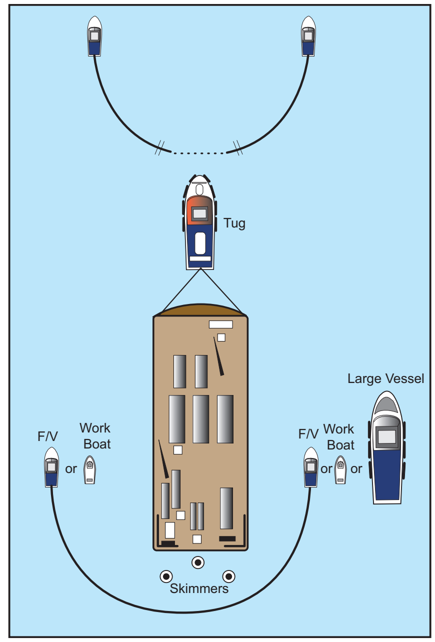


Figure FO-1. Open water barge-based free-oil recovery system.

PROTECTED WATER

Vessels, boom and skimmers for protected water free-oil recovery systems should be able to deploy and operate in seas up to three 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 temporary 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, boom and skimmers that should be able to deploy and operate in seas of one 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 temporary storage devices. Calm water free-oil recovery systems typically work in depths as shallow as three feet.

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 one 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 two 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 free-oil recovery systems are equipped with high-current boom and skimmers. These systems are usually deployed from small vessels or skiffs.

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-2). 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-3). 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 temporary storage device.

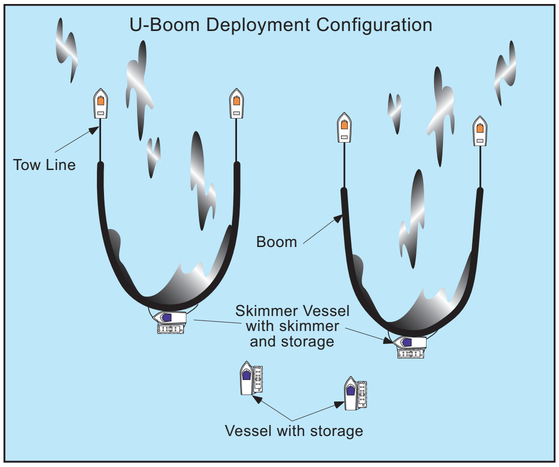


Figure FO-2. U-boom configuration.

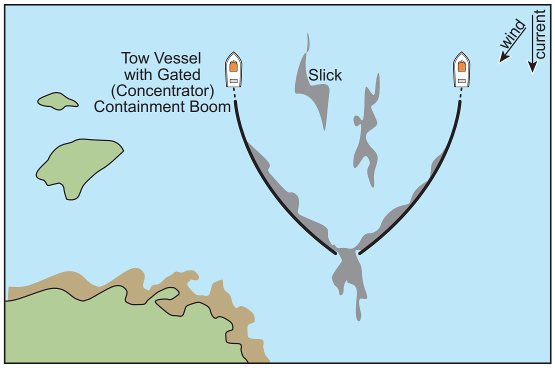


Figure FO-3. Gated U-boom concentrator boom, towed in front of free-oil recovery system.

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.

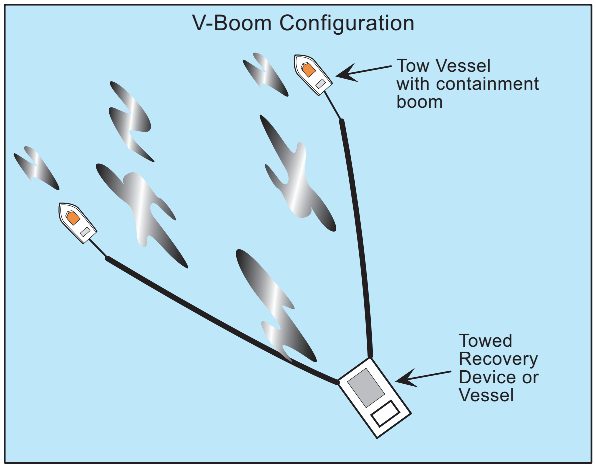


Figure FO-4. V-boom Configuration.

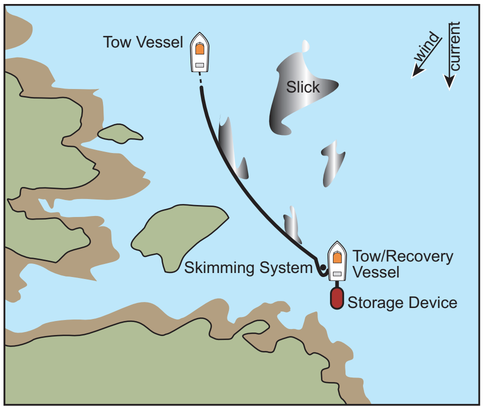


Figure FO-5. J-boom configuration.

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 temporary 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 number 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.

NEARSHORE TRAPPING

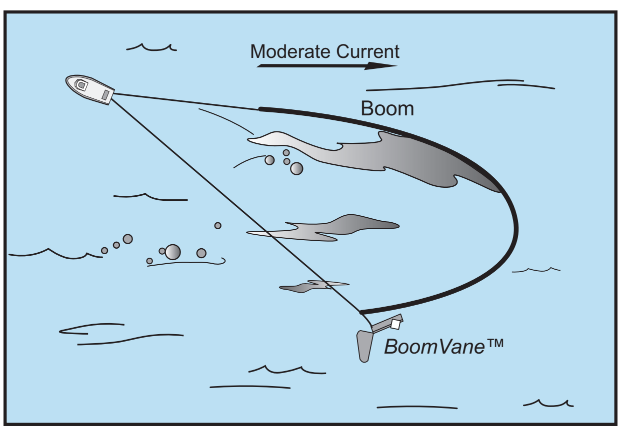


Figure FO-6. Free-oil recovery using a BoomVane™ to control one end of a U-boom.

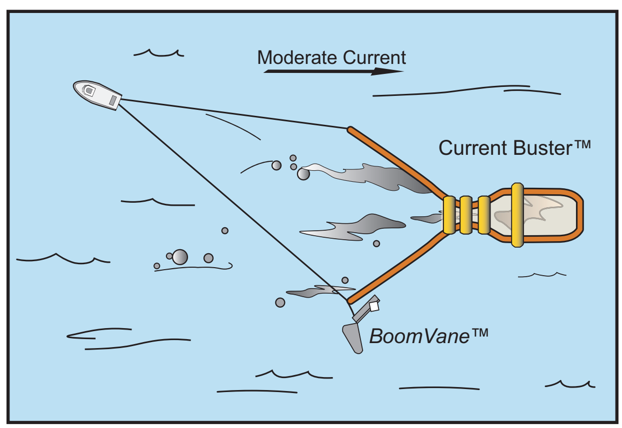


Figure FO-7. Free-oil recovery using a BoomVane™ to control one end of a Current Buster™.

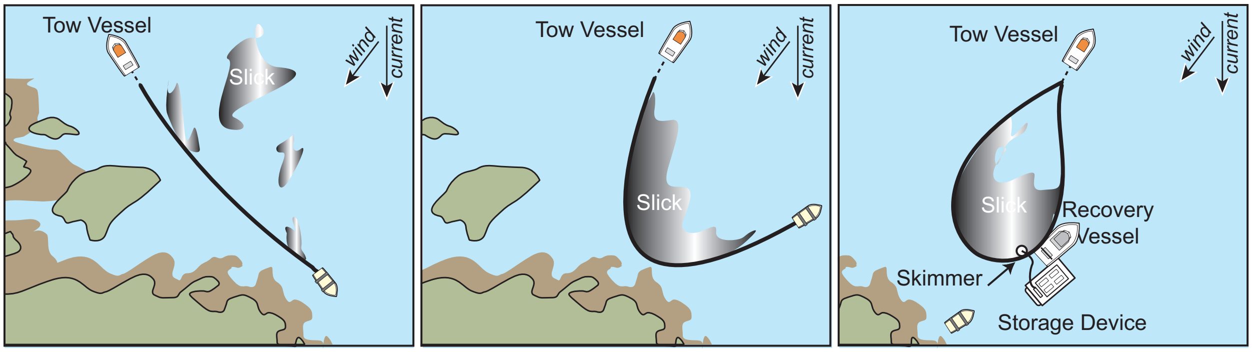


Figure FO-8. Nearshore trapping, boom-towing boats collect oil, then tow the trapped oil to deeper water for recovery.

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, temporary 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, appropriate size for operating environment	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.

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.

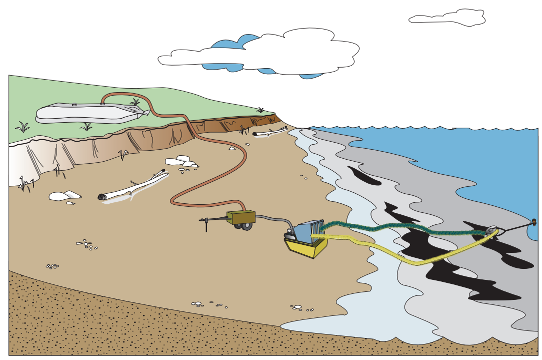


Figure SR-1. Shoreside Recovery.

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.

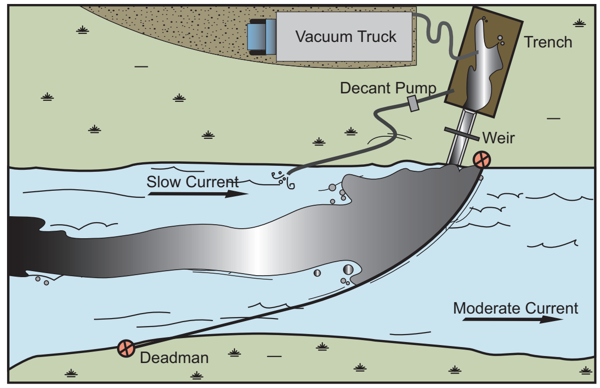


Figure SR-2. Shoreside recovery unit skimming lagoon.

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.

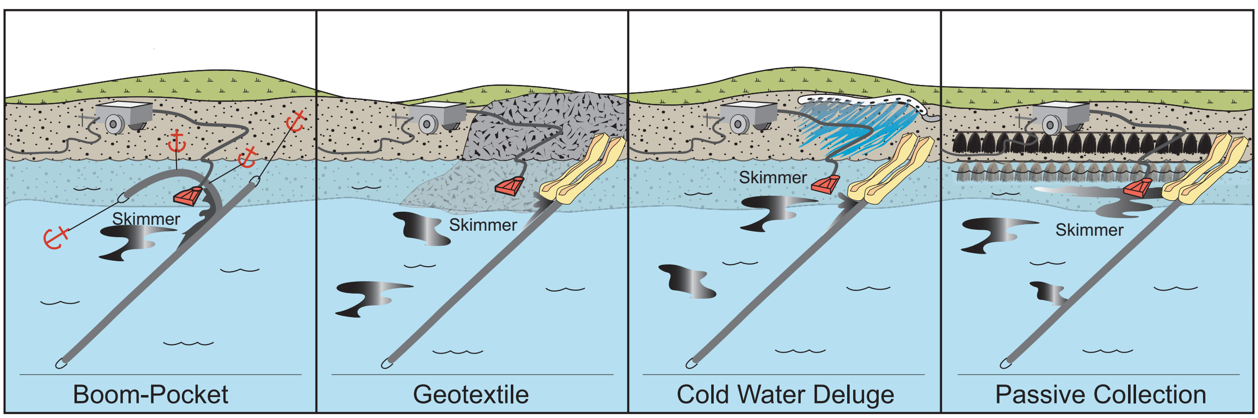


Figure SR-3. Methods to keep oil from contaminating collection beaches.

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, 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. (Hansen and Coe, 2001)***

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.

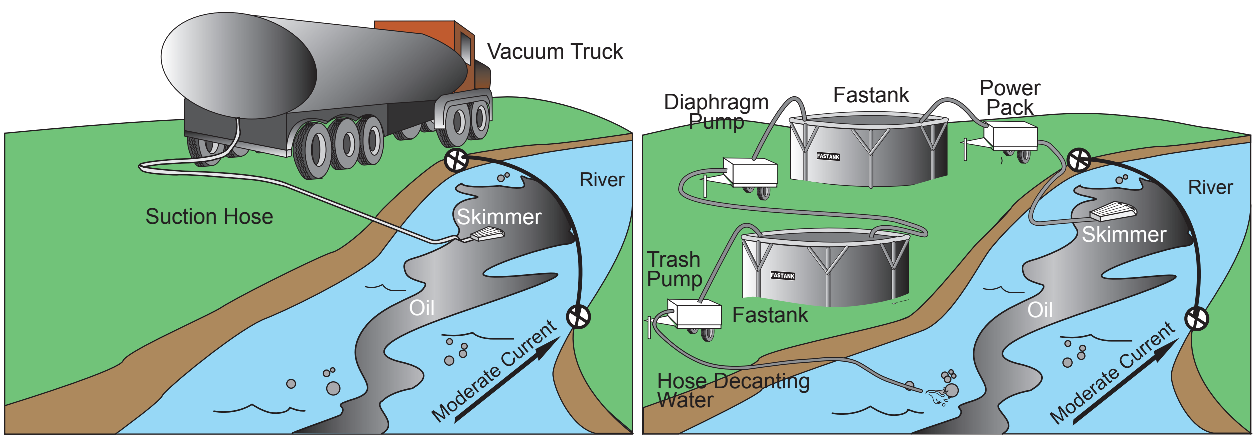


Figure SR-4. Shoreside Recovery deployment configurations.

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.
- Walking boards should be used to control traffic and minimize impact to upland 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 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

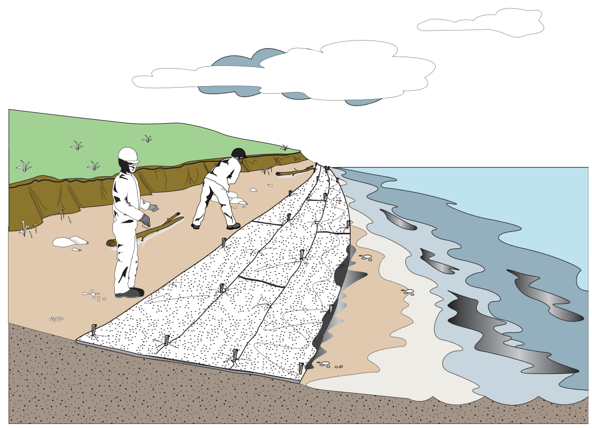


Figure PR-1. Passive Recovery.

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. Natural sorbent materials, such as peat moss or sphagnum moss, may also be used.

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 sorbents 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 encounter 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.

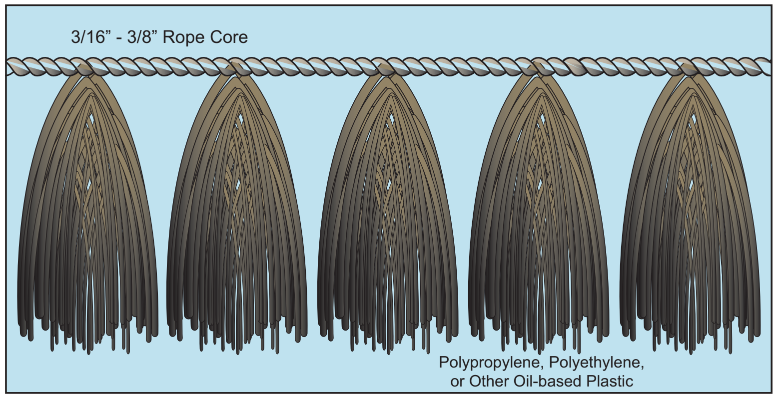


Figure PR-1. Snare line.

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 materials, such as peat, are effective sorbents, but are difficult to recover from the environment once oiled.

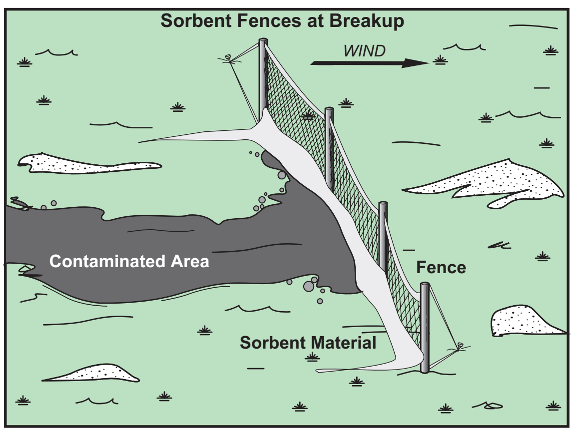
Passive recovery operations can produce a significant solid waste stream; all wastes generated must be measured, stored, and disposed of according to an approved Waste Management Plan. Logistical support for this waste stream should be mobilized early in the spill event. One way to reduce solid oily 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, ATVs, 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 operate in conditions that exceed the sorbent's effective application parameters. 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 operate in conditions that exceed the sorbent's effective application parameters. 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.(Hansen and Coe, 2001)***



Deployment Configurations

Typical configurations are shown in figures PR2 to PR4, but responders should consider the actual conditions, and modify their deployment accordingly.

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

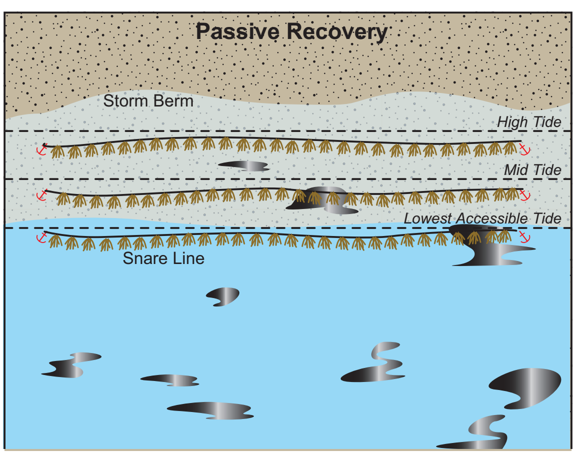


Figure PR-3. Aerial view of a passive recovery general configuration.

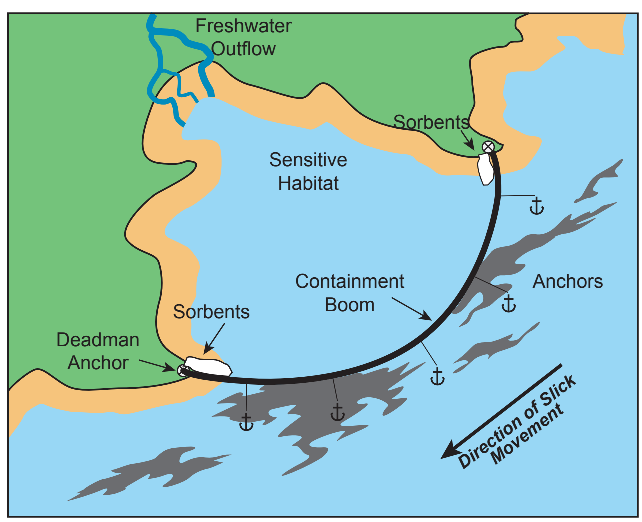


Figure PR-4. Marine mammal broadcast passive recovery.

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 – BERMS, DAMS and BARRIERS

GENERAL CONSIDERATIONS

In addition to booming and recovery, tactics that use hard physical barriers to close off waterbodies may be used alone or in combination with other tactics.

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BB BEACH BERMS, DIKES AND DAMS

OBJECTIVE & STRATEGY

The objective of Beach Berms and Underflow Dams is to limit spreading of oil slicks into small inlets or coastal ponds by constructing a barrier from natural beach materials. Beach berms are embankment structures built-up from the existing terrain (Figure BB-1), placed to exclude oil from entering coastal ponds or inlets, or contain and accumulate oil for recovery. These barriers can serve to:

- Exclude oil from entering coastal ponds or wetlands by blocking inlets.
- Close off washover areas to prevent oil from entering coastal ponds.
- Create cells for recovery.
- Use natural depressions to act as containment areas for recovery.

Figure BB-1. Beach berm construction.

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 Shoreside Recovery. Berms 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 and secure any permits or permissions necessary to move beach materials.
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: beach sediments, 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.

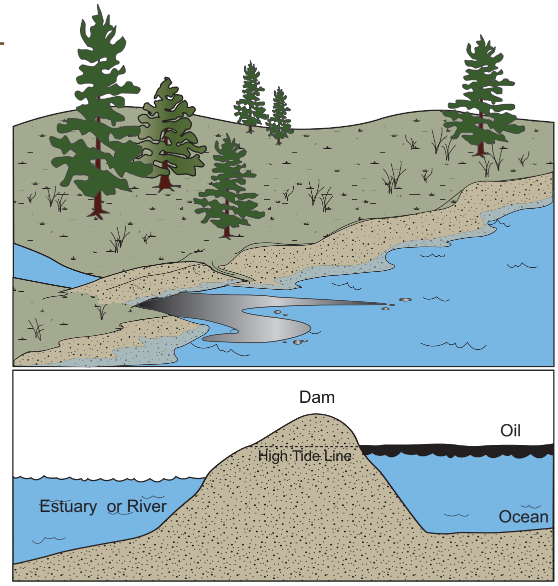

Figure BB-2. Exclusion dam construction.

Dikes, berms, and dams can cause significant adverse impacts to the environment and may not be appropriate for all areas. The Unified Command should consult with the Environmental Unit Leader before authorizing the construction of any dike, berm or dam. Special care should be taken when considering this tactic for dune areas during bird nesting activities.

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.

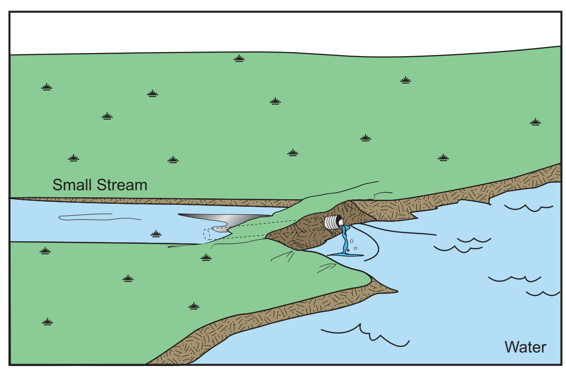

Figure BB-3. Underflow dam configuration.

Operating Environments

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

Beaches are broken down into two types:

- steep inclined beach – fine or coarse grained substrate
- low angled beach- fine or coarse 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 one 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 Earthen Berms and Underflow Dams on low angled shoreline works best if the wave height is less than three feet.

Deployment Configurations

There are many deployment configurations for dikes, berms, and dams. The descriptions below provide general information on how physical barriers are constructed and utilized in oil spill response. Figures BB-4 through BB-7 are merely representative depictions of these methods. Understanding that there is sometimes flexibility in deployment configurations, responders should utilize this information to determine the best materials and methods to apply based on site characteristics and any limitations or constraints.

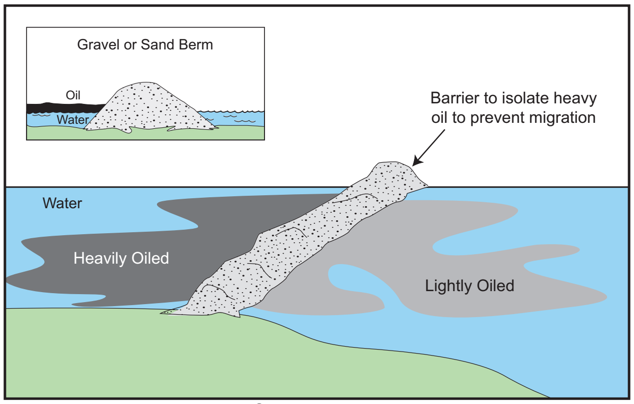

Figure BB-4. Berm configuration.

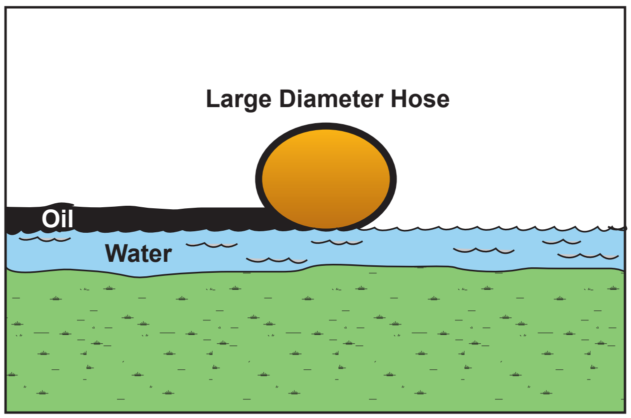

Figure BB-5. Using boom to form a berm

BERMS

A containment berm can be constructed of available materials such as beach sediments, 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.

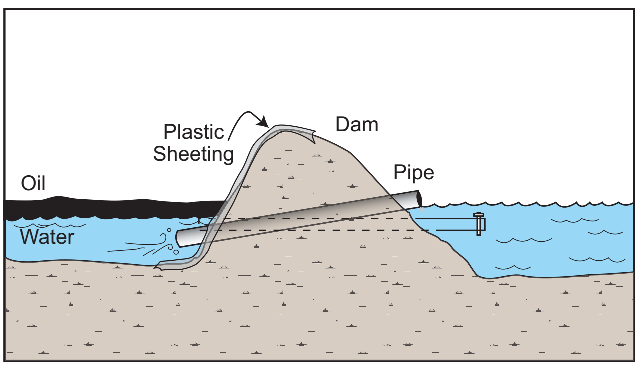

Figure BB-6. Underflow dam.

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.

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.

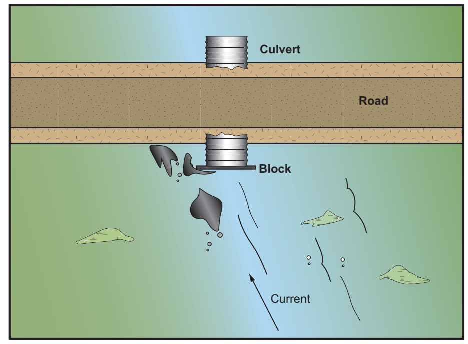

Figure BB-7. Using a roadway as a dike.

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.

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.

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 Beach Berms, dams and dikes include:

- Shoreside Recovery
- Passive Recovery

EQUIPMENT AND PERSONNEL RESOURCES

There are too many variations of berms, dikes and 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
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 equipment	All response personnel must have appropriate level of OSHA training for their job assignment

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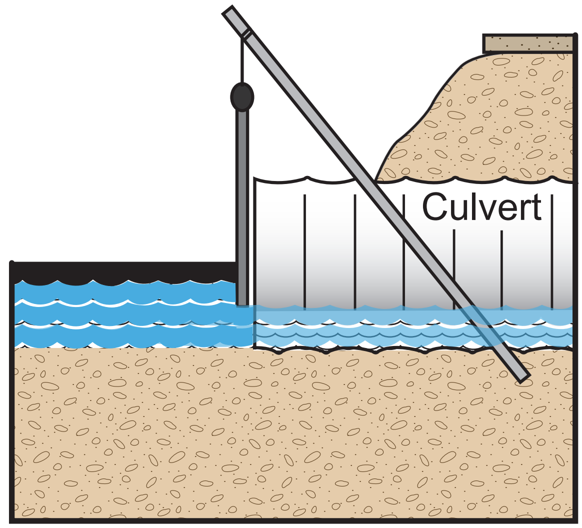
CB CULVERT BLOCKING

OBJECTIVE & STRATEGY

The objective of 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 to block a culvert or outfall. Culvert blocking prevents oil from traveling through a culvert or outfall.



Culvert blocking is typically done to close off the flow of water and oil through an outfall pipe or culvert. In the case of a culvert that is in place to allow a waterbody to flow (either directionally or tidally) under a roadway or other barrier, blocking the culvert may keep contamination from spreading inland from a coastal spill, or from entering coastal waters in the event of a spill upstream from the culvert. Outfalls typically flow in a single direction (from inland sources to coastal waters); blocking or plugging an outfall may prevent oil from inland sources (e.g. road spill) from traveling to marine waters.

The tactic may be deployed in conjunction with a recovery tactic such as Passive Recovery or Shoreside Recovery.

The general strategy is to:

1. Identify the source and trajectory of the spill or potential spill.
2. Determine whether closing off an outfall or culvert will prevent the migration of the oil to sensitive areas.
3. Identify, locate and mobilize equipment and personnel to the location.
4. Block culvert or outfall using plug, plywood, sandbags, or other available materials.
5. Monitor the culvert block to make sure that it remains intact. In the case of a culvert or outfall that flows from an inland source to open waters, make sure that the block does not cause flooding or other issues upstream.
6. If oil collects on or behind the blocked culvert, utilize an appropriate recovery tactic to remove it.

TACTIC DESCRIPTION

This tactic involves placing materials inside a culvert or outfall pipe to block flow in either direction. Materials used may include inflatable culvert plugs, plywood or similar sheeting, sandbags, or other impermeable barriers.

Operating Environments

Culvert Blocks are utilized in the shoreline operating environment.

Deployment Configurations

There are many deployment configurations for culvert or outfall plugs.

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 CB-1 shows examples of culvert blocking options.

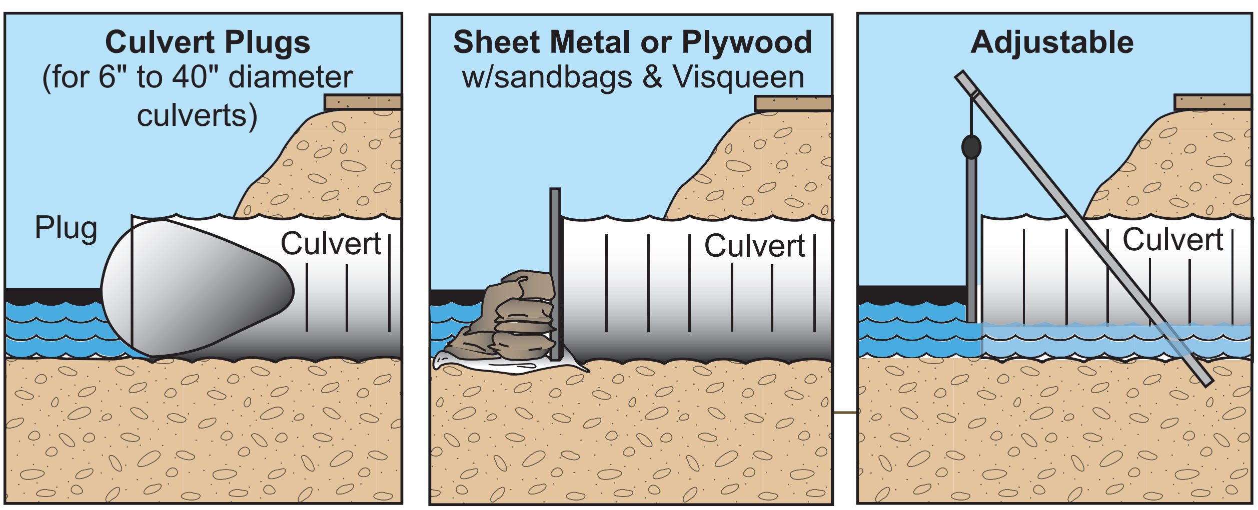


Figure CB-1. Culvert blocking options.

DEPLOYMENT CONSIDERATIONS AND LIMITATIONS

- Consult with the Environmental Unit and with local Public Works departments to determine if permits are required when blocking culverts or outfalls.
- Knowledge of the culvert or outfall diameter is important. Ensure that the selected method for plugging or blocking is the appropriate size.
- Removal and disposal of oiled construction materials should be considered prior to deployment.
- Dams should be removed immediately when no longer needed.
- Sandbags are labor-intensive and should be the last consideration.
- Evaluate the out-flow potential behind plugs or barriers to avoid wash-out of culverts or outfalls. Construct an underflow dam, if necessary.

REFERENCES TO OTHER TACTICS

Other tactics associated with Culvert and Outfall Blocks include:

- Underflow Dams
- Shoreside Recovery
- Passive Recovery

EQUIPMENT AND PERSONNEL RESOURCES

There are too many variations of Culvert and Outfall plugs to be specific on equipment and personnel resources. Massachusetts Spill Response Trailers contain 24” inflatable culvert plugs and air compressors.

Typical Culvert Blocking Resources

Typical Resources	Function	Quantity	Notes
Culvert plug, weir, or blocking materials	Optional to control flow through culvert or outfall pipe	1 per culvert	
Response Personnel	Function varies according to assignment	Varies based on quantity and configuration of equipment	All response personnel must have appropriate level of OSHA training for their job assignment

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TG
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HB

TIDE GATES, LOCKS and HURRICANE BARRIERS

OBJECTIVE & STRATEGY

The objective of Tide Gates, Locks and Hurricane Barriers is to use existing barrier structures that are designed to control the flow of water to prevent oil from migrating past the barrier. Tide gates, locks and hurricane barriers are all structures that exist in coastal New England; they were not designed for oil spill response, but they may have value during a spill to control the flow of oil into sensitive areas.

On-water free oil recovery, passive recovery, or shoreside recovery may be used in conjunction with this tactic to remove floating oil contained by the barrier.

The general strategy is to:

1. Identify the location and trajectory of a spill.
2. Identify tide gates, locks or hurricane barriers in the spill trajectory.
3. Coordinate with the local agency or organization that controls the tide gate, lock, or hurricane barrier to determine whether the barrier could be closed to minimize spilled oil movement.
4. Close the tide gate, lock, or hurricane barrier to prevent the migration of oil beyond this barrier.
5. Line the barrier with sorbent materials or hard boom if feasible, to minimize the contamination of the barrier.
6. If oil collects at the tide gate, lock or hurricane barrier, use an appropriate recovery strategy to remove it.
7. Coordinate reopening of the tide gate, lock or hurricane barrier with the local agency or organization that controls its operation.

TACTIC DESCRIPTION

This tactic involves closing a tide gate, lowering a hurricane barrier, or closing a lock on a waterbody to prevent floating oil from traveling past the barrier. There is little specialized equipment or action required to deploy this tactic; instead, coordination with the agency or organization that has the authority to operate the tide gate, lock or hurricane barrier is required.

Operating Environments

Since tide gates, hurricane barriers and locks are fixed structures, operating environments are not a strong consideration. Other considerations, such as water levels in rivers and marshes, may be the determining factor as to whether the tactic can be used.

Deployment Configurations

There are many different types of tide gates, locks, and hurricane barriers located throughout coastal Massachusetts.

TIDE GATES

Tide gates are typically used in New England to manage tidal waterflow into estuaries or marsh areas, to control water levels, and sometimes to prevent coastal flooding. There are many different potential configurations for tide gates. Some tide gates are “flaps” that automatically close on an incoming tide. Others are controlled through manual or automated open/close mechanisms that allow local resource managers to open or close the tide gate based on local conditions. A tide gate may be a single flap or door or multiple flaps/doors. In some areas, one or more door or flap is inoperable, making the tide gate functionally more similar to a culvert. Figure TG-1 shows an example of a tide gate.

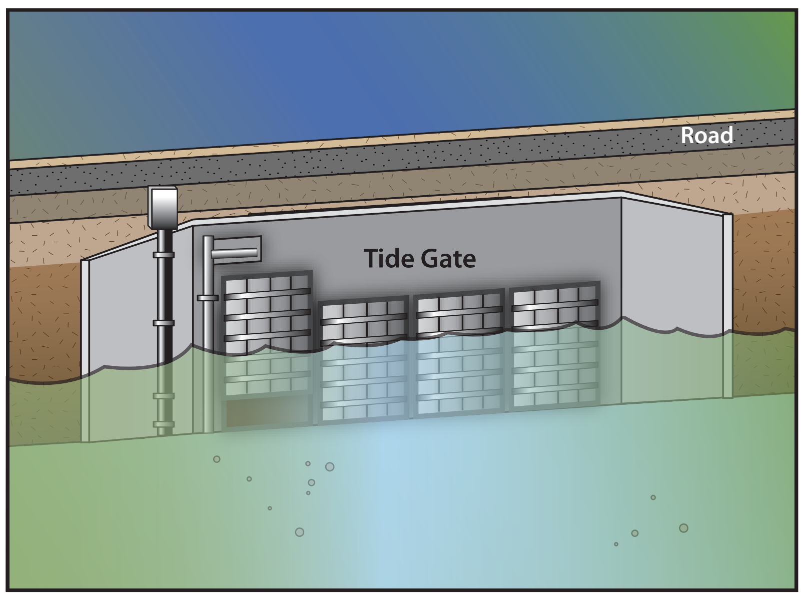

Figure TG-1. A tide gate example.

Closing a tide gate to prevent an oil slick from migrating behind the gate may be a very effective spill response option, particularly when the tide gate controls access to rivers, estuaries, and marshes or wetlands. However, local officials must be included in the decision-making. Closing a tide gate may have unwanted negative consequences, such as causing localized flooding. In such cases, the Unified Command should coordinate with local officials to determine whether to implement the tactic. Once tide gates have been closed, the decision to re-open them will also require close coordination. Massachusetts GRPs that include tide gate tactics list contact information for the local agency or official in charge of tide gate operations.

LOCKS

Locks are used on river systems or canals to raise and lower boats when water levels differ between segments. Lock systems use a series of dams or barriers. Vessels traveling through a lock are typically isolated in a chamber between the two segments with different water levels, and water is then pumped into or out of the chamber to raise or lower the water level before the boat is released into the river segments. Since locks are pre-existing barriers, they may have a function in spill response to prevent floating oil from moving past the lock system. Figure TG-2 shows an example of a lock system.

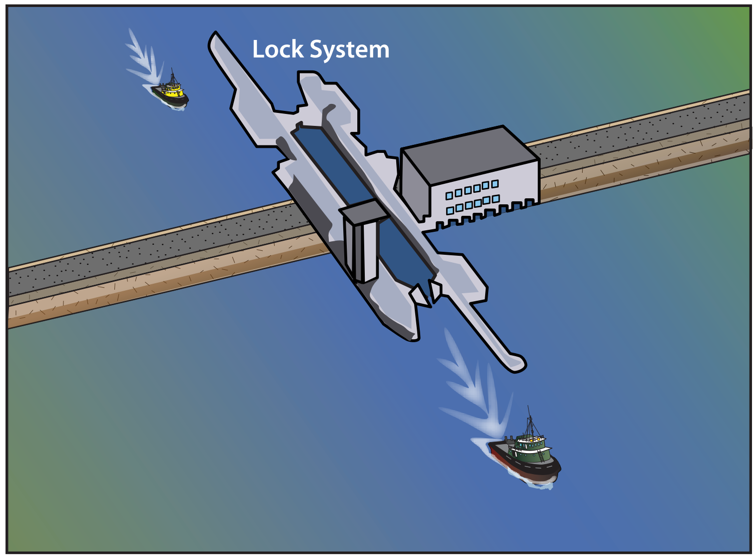

Figure TG-2. A lock system example.

Closing a lock to prevent oil movement may provide an effective spill response tactic; however it may have impacts on vessel movement along the river or waterway. Prolonged closure of a lock may impact navigation. Like the tide gate tactics, using locks as an oil spill barrier requires a consensus decision between the Unified Command and the local officials or agency that controls the lock operations. Massachusetts GRPs that include locks list contact information for the appropriate local official or agency.

HURRICANE BARRIERS

Hurricane barriers are structures that have been put in place to protect harbors, inlets, or embayments from storm surge and waves during hurricanes and coastal storms. Hurricane barriers function similarly to tide gates, but on a much larger scale. Hurricane barriers involve a system of gates, dikes, and pumps that can be used in the event of a storm to minimize damage from coastal flooding, waves, and storm surges. Figure TG-3 shows an example of a hurricane barrier.

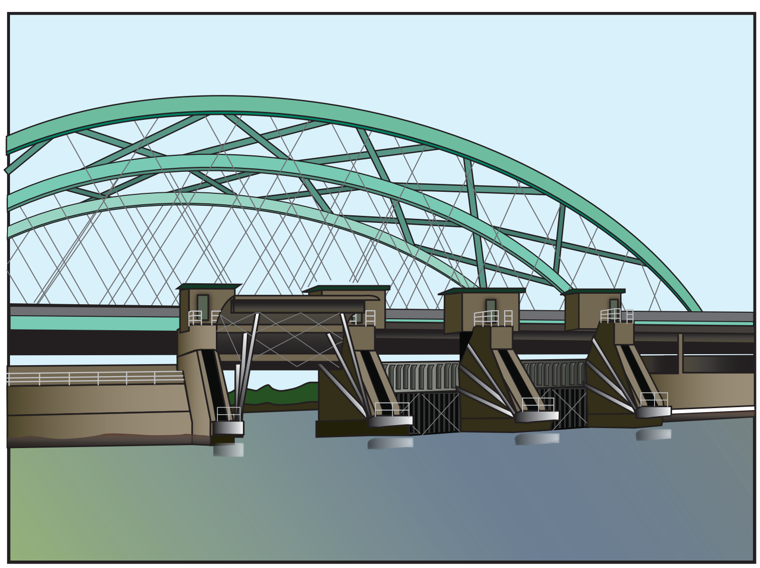
Figure TG-3. An example of a hurricane barrier.

Hurricane barriers typically limit the opening area across a wider river or inlet, so even without closing the barrier, it will stop passage of oil along most of the waterbody. Closing a hurricane barrier in the event of an oil spill would be a significant effort and would likely only be considered in the case of a significant spill. Hurricane barriers often protect areas of high commercial value, which may or may not be particularly environmentally sensitive. However, if the spill scenario were such that closing the hurricane barrier could minimize adverse impacts, then this tactic could be valuable. Like the other types of manmade barriers, closing a hurricane barrier would require close coordination between the Unified Command and local officials. Massachusetts GRPs where hurricane barriers are located include contact information for the agency or organization that controls the hurricane barrier operation. Closing a hurricane barrier could have the effect of shutting down an entire port.

DEPLOYMENT CONSIDERATIONS AND LIMITATIONS

- This tactic requires close coordination with local officials.
- If the barrier is used to stop the movement of oil, it may require decontamination and cleaning prior to re-opening.

REFERENCES TO OTHER TACTICS

Other tactics associated with Culvert and Outfall Blocks include:

- On-water free-oil recovery
- Shoreside recovery
- Passive recovery

EQUIPMENT AND PERSONNEL RESOURCES

No special equipment or resources are required, since closing these barriers would typically be done by a local official or agency.

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SECTION VI: APPENDICES

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A. GLOSSARY

Anchor Systems:

Large Anchor System – A large anchor system cannot be deployed by hand, requiring 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.

Apex - The pointed end or tip of something.

Bridle - A span of chain, wire, or rope that can be secured at both ends to an object and slung from its center point. For the purposes of booming, a bridle is typically connected at the end of a length of boom to tow it or secure it to an anchor assembly or to a shore side connection point.

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

Bunker C - A high viscosity residual fuel oil commonly used in the marine industry. Also commonly known as Number 6 fuel oil.

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.

Cascade - A succession of stages, processes, operations, or units. In terms of booming configurations, cascade booming is represented by several separate lengths of boom deployed in a successive, overlapping fashion in a downstream direction to divert or deflect oil.

Chevron - Any V-shaped pattern or device. IN the context of this guide, used to describe a booming configuration.

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.

Decant – To remove free-water from an oil/water mixture by drawing the water from below 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.

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

Encounter Rate – The 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.

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.

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

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 areas that are poorly drained and difficult to cross on foot or vehicle. Care must be taken in oil spill operations to minimize the disturbance of marshes and prevent introduction of 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. Colors 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.

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 shoreside recovery tactic. Often referred to as a temporary storage device (TSD).

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.

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.

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.

Sorbent - a material that sorbs another substance; i.e. that has the capacity or tendency to take it up by either absorption or adsorption.

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.

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

Sump - tank used for collecting and storing a liquid (as water or oil).

Tensile - of or relating to tension; “tensile stress”; “tensile pull”.

Tidal Seal Boom - A shore seal boom having a buoyancy chamber and a ballast chamber employed to contain oil within a confined area.

Trip Line - a light rope used in on-water booming to free (and sometimes tow) an anchor.

Trolley - A boom control method wherein a line is suspended above the water and secured on opposite sides of a water body with additional lines attached to the boom via a pulley or other device allowing for adjustment of the boom from shore.

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

Weir - Any control or barrier used to permit or restrict the flow of a liquid. Weir skimmers function by allowing the oil floating on the surface of the water to flow over a weir. The height of the weir may be adjustable.

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 forms windrows.

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B. ACRONYMS & ABBREVIATIONS

GRP	Geographic Response Plan
STAR	Spill Tactics for Alaska Responders
ASTM	American Society for Testing and Materials
USCG	United States Coast Guard
DV	Diversion
C	Containment
EX	Exclusion
DF	Deflection
FO	Free Oil
OR	On-land Recovery
ATV	All Terrain Vehicle
OSHA	Occupational Safety and Health Administration
MR	Marine Recovery
SR	Shoreside Recovery
PR	Passive Recovery
NMFS	National Marine Fisheries Service
IFO	Intermediate Fuel Oil
BB	Beach Berms
MassDEP	Massachusetts Department of Environmental Protection
NIOSH	National Institute for Occupational Safety and Health
NOAA	National Oceanic and Atmospheric Administration
bbl	Barrel (1 barrel of oil equals 42 U.S. gallons)

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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:

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

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

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

  $V\ (\text{gal}) = 42 \times V\ (\text{bbl})$

  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)

Oil on Water

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

CODE	Description	Layer Thickness Interval (m)	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).

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