Shoreline Protection on Sand Beaches

Phase 2—Field Guide

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Field Guide for Shoreline Protection on Sand Beaches

Summary

- The behavior of oil washing onshore along sand beaches is dependent on the type and dynamics of the coastal setting.
- Under normal wave and tidal conditions, oil is deposited in the intertidal zone; however, during high wave-energy events and moderate storms, oil can be carried to the upper beach and deposited in berm runnels and at the base of dunes.
- During high wave and surge events generated by storms, dune systems may be eroded and oil carried over the beach into back-barrier lagoons and wetlands.
- Temporary containment of oil along open beaches involves construction of ridges of sand and boom deployment. More robust structures include armored baskets, rip-rap revetments, and gravel and sediment berms.
- Containment of oil at breaches and small ephemeral channels (typically less than 200 m wide and 1 m deep) can initially rely on hard boom and sand bag barriers, including Super Sacks, but the prevention of storm-induced incursions of oil requires the construction of bulkheads, rip-rap revetments or rock and sediment dams.
- Barricades across tidal channels prevent tidal exchange and likely would cause sediment deposition and a straightening of the shoreline, which may result in oil burial.
- Oil pooled adjacent to structures, particularly at barricaded channels, can be concentrated using sumps and removed with pumps or skimmers.

Introduction

Oil that reaches a sand beach following a spill onto water most frequently is deposited in the upper intertidal zone on falling tides. If water levels are high at the time oil washes ashore, due to spring tides or wind-induced surges, the oil can be deposited above the average high water level (HWL) in the supratidal zone or can be carried across the beach into low-lying backshore areas such as wetlands, lagoons, salt ponds or estuaries.

This Field Guide is based on the API report "*Shoreline Protection on Sand Beaches*" (2013, API Technical Report 1150-1) that describes:

- The form and processes that characterize sand beaches. Sand beach forms include beaches backed by dunes or terrestrial environments and barrier islands and spits that are backed by wetlands, lagoons, salt ponds or estuaries. Beach processes are a combination of wind, wave and tidal action.

- Conditions during which oil can be carried over a beach into the supratidal or backshore zones (see **Section 7: Definitions**).

- Strategies and tactics that can be used to intercept and contain oil as it washes over a beach.

- Response Considerations for the design and implementation of the shoreline protection strategies.

The "*Shoreline Protection on Sand Beaches*" report describes strategies and tactics that can be used on land across low-lying sections of a sand beach, such as shallow storm breaches, washover areas, and ephemeral channels. This Field Guide illustrates those shoreline protection options.

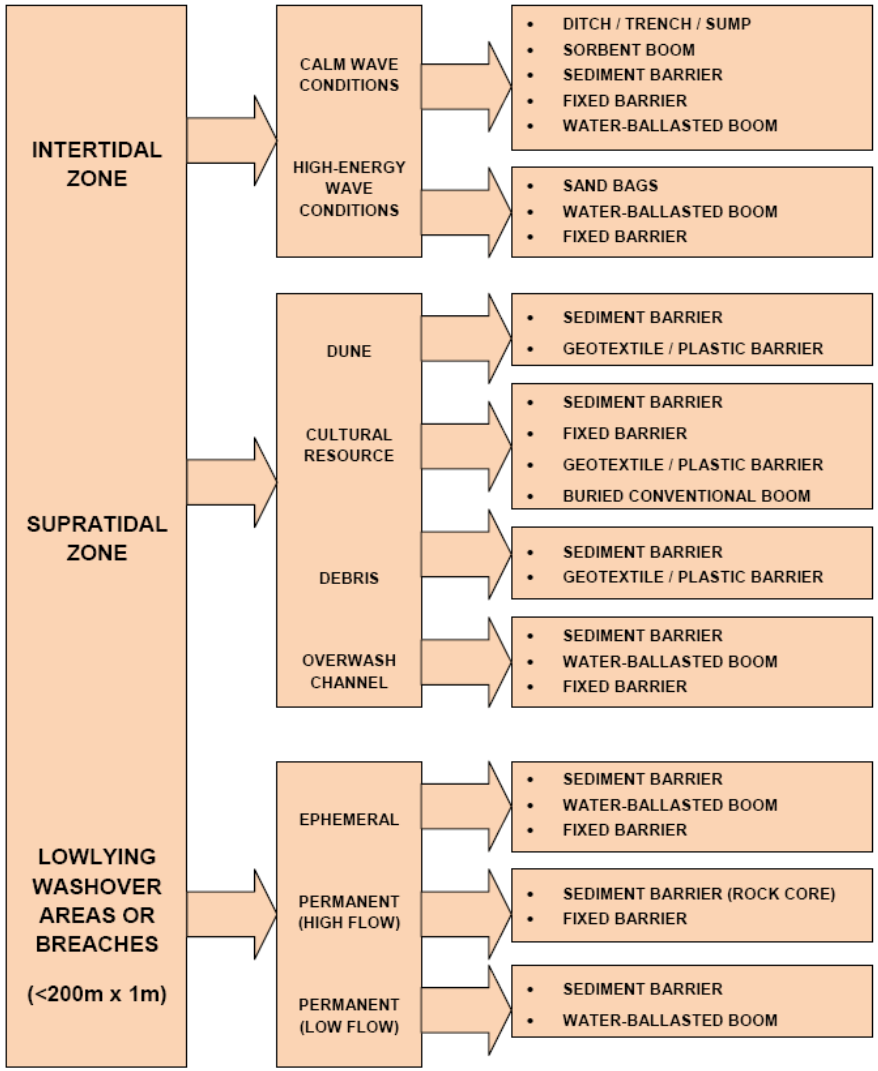
Response strategies associated with the containment and control of oil on nearshore waters at tidal inlets or in estuaries are the subject of a separate 2013 API report ("*Tidal Inlet Protection Strategies (TIPS) Field Guide*").

Three shoreline strategies to intercept or contain and control oil as it washes ashore are to:

a) Create fixed barriers (sand dikes, bulkheads, armored baskets, rip-rap revetments, sand and gravel dams, etc.),

b) Deploy moveable barriers or booms, and/or

c) Create sumps into which oil can flow for collection.



Sand Beach Protection Decision Guide

The Decision Guide is designed to assist with the selection of candidate Shoreline Protection Tactics for sand beaches.

The guide is organized in terms of location on the shoreline, existing or anticipated wave energy, feature of concern to be protected, and tidal channel or breach flow conditions.

The options presented are based on typical responder experience and are intended to provide a starting point in the identification of appropriate tactics.

Each situation is unique and must be assessed in consideration of the environmental conditions prevailing at the time of the response. Multiple or other related protection tactics, such as on-water recovery or diversion, may be appropriate to meet the needs of site-specific protection objectives.

The following tables describe eight generic Beach Protection Tactics and identify and summarize some of the key considerations in the selection of the most appropriate tactic(s).

Sand Beach Protection − Generic Tactics Descriptions

TACTIC	*DESCRIPTION*
FIXED BARRIERS AND DAMS	
Sediment Barriers or Dams	**Berms, ridges or sediment dams** are constructed, manually or mechanically, parallel to the water line to act as a barrier to water and oil washing over a beach. Generally, beach sediment would be used to construct this barrier, or material may be imported.
Sand Bags	**Sand bags** are used to create a barrier or dam. They may be filled on site with local sediment or with non-beach sediments. Typically canvas bags or sediment-filled, military-type, cellular fabric/wire mesh or armored baskets.
Geotextile or Plastic Barriers	**Flexible barriers** include a range of materials such as geotextiles, plastic sheets and silt screens, which are used to create a barrier or dam. They typically would be anchored and the base could be partially buried into the beach or, for some types of sensitive features, completely buried with sand.
Solid Barriers	Wood sheets, metal sheets, or other solid materials are used to create a barrier or dam. Solid barriers should have an underflow design where water flow/exchange is required. Can include a combination rubble and geotextile barrier.
MOVEABLE BARRIERS AND BOOMS	
Water-ballasted Booms	**Water-ballasted booms** include designs such as anchored, water-filled bladders or tubes or “shore-seal” boom that have an air chamber that sits on one or two water-filled tubes. Once deployed and anchored at the selected location, water is pumped into bottom chamber(s). For types with an upper air-filled bladder, this water acts as ballast when the boom is floating. When the boom is grounded, the flexible ballast chamber(s) follow the beach surface to form a seal. Alternatively the booms can be anchored so that they remain grounded on the beach surface and do not float.
Conventional Booms	**Conventional boom** is anchored on a beach with the skirt buried or partially buried in the sediment. Typically used to contain and control oil moving alongshore at the water line.
Sorbent Booms	**Sorbent boom** is constructed of a long, fabric sock (“sausage boom”) that encloses material that adsorbs oil but repels water. Unlike hard boom, sorbent boom does not have an attached skirt. **Snare boom** (or “sweep boom”) is constructed from a series of oleophilic polypropylene “pompoms” tied to a long line. Snare boom is anchored parallel to the water line to contain and adsorb oil on the water surface as it is washed ashore.
SUMPS	
Ditches or Trenches	**Collection sumps, ditches or trenches** are excavated, manually or mechanically, to collect oil as it washes ashore. Collection sumps can be installed independently or in conjunction with ditches or trenches and with one or more of the barrier and/or boom options.

Sand Beach Protection Tactics – Deployment and Durability

TACTIC	*LOCATION*	*DEPLOYMENT*	*DURABILITY*	*COMMENTS*
FIXED BARRIERS OR DAMS				
Sediment Barriers or Dams	At or above upper swash line. Berm crest.	Rapid (hours)	Short – hours/days	Can use on site materials. Can cover with plastic sheets. Easily washed out by waves. Can result in oil-sediment mixture.
Sand bags	At upper swash line. Channels and breaches.	Rapid (hours)	Days/weeks	Labor intensive.
Geotextile or Plastic Barriers	At the base of a dune or dune vegetation, on log lines, in shallow channels, or around man-made structures.	Rapid (hours)	Days/weeks	Can be labor intensive. Ineffective with strong wave action. Can be very effective.
Solid Barriers	Overwash or ephemeral channels.	Slow (days)	Weeks/months	Can be very effective.
MOVEABLE BARRIERS OR BOOMS				
Water-Ballasted Booms	At or above upper swash line.	Rapid (hours)	Days/weeks	Must be drained to move. Labor intensive. Ineffective with strong wave action. Anchors must be removed. Can cause sediment mixing which could result in buried oil.
Conventional Booms	Upper or mid-intertidal zone.	Rapid (hours)	Short – hours/day	Labor intensive. Ineffective with strong wave action. Anchors must be removed.
Sorbent Booms	Upper intertidal zone.	Rapid (hours)	Short – hours/day	Labor intensive. Requires frequent replacement of oiled sorbents. Ineffective with even small wave action. Anchors must be removed.
SUMPS				
Ditches or Trenches	At upper swash line.	Rapid (hours)	Short – hours/day	Easily washed out (filled in), must be carefully located or marked. Can result in buried oil. Ineffective in all but very small wave conditions.

Sand Beach Protection Tactics – Operational Considerations

TACTIC	*LABOR REQUIREMENTS/SAFETY*	*MONITORING/MAINTENANCE*	*WASTE MANAGEMENT*	*DEMOB ISSUES*
FIXED BARRIERS OR DAMS				
Sediment Barriers or Dams	• Standard equipment operating procedures • Site restriction during construction	• Regular inspection and maintenance recommended	• Impounded oil/oily sand should be recovered regularly • Berm material may be oiled and require removal/treatment (can be considerable)	• Feature must be removed and graded to original topography
Sand Bags	• Labor intensive • OSHA requirements	• Regular inspection and maintenance recommended	• Use local beach sand so clean sand can be returned to beach • Impounded oil/oily sand should be recovered on regularly • Bags and contents may be oiled and require treatment	• Sand bags must be removed and area graded to original topography
Geotextile or Plastic Barriers	• Moderate labor requirements • Smothering hazard • Access restrictions	• Regular inspection and maintenance recommended	• Geotextile and plastic should be segregated for disposal	• Minimal
Solid Barriers	• Moderate labor requirements	• Regular inspection and maintenance recommended	• Barrier materials should be segregated for disposal	• Barriers must be removed and area graded to original topography
MOVEABLE BARRIERS OR BOOMS				
Water-ballasted Booms	• Low to moderate deployment requirements • Must be drained to relocate	• Regular inspection, maintenance and repositioning may be necessary • Should be removed prior to storm activity	• Minimal – low	• Boom decontamination required • Anchors must be located and removed
Conventional Booms	• Moderate to high labor requirements for deployment (including skirt burial)	• Regular inspection and maintenance • Repositioning and re-anchoring may be necessary • Should be removed prior to significant storm activity	• Minimal – low	• Boom decontamination required • Anchors must be located and removed

TACTIC	*LABOR REQUIREMENTS/SAFETY*	*MONITORING/MAINTENANCE*	*WASTE MANAGEMENT*	*DEMOB ISSUES*
Sorbent Booms	• Low labor requirements for deployment	• Regular inspection, repositioning, re-anchoring • Change out required when sorbents are saturated or water loaded • Locations of sweeps should be precisely marked (e.g. by GPS or stakes) • Should remove prior to storm activity	• Dependent on amount of boom deployed	• Sorbent booms may become buried and difficult to locate and/or removed • Anchors must be located and removed
SUMPS				
Ditches or Trenches	• No trench entry • Restrict access while trenches are open, • Filled trenches may not support personnel or equipment (quicksand)	• Stake or GPS locations • Trenches may fill in and be hard to relocate • Remove collected fluids frequently • Monitor for trapped birds or animals	• Potential for oil burial • Significant oiled material can be generated if oiled trenches are buried	• Buried installations should be inspected for subsurface • Buried oil should be removed or treated in place • Backfill with excavated (clean material) or acceptable substitute • Surface should be returned to original topography

Sediment Barriers or Dams

Aerial views of low (1-m) sand ridge being constructed by a road grader above the swash line as oil washes ashore.

Sand ridge constructed seaward of beach houses. Note that wave uprush reaches to the toe of the ridge.

Sand dams across a shallow ephemeral tidal channel.

Sand Bags

"Super sacks" placed at the high water level across a low point in a barrier beach where waves can wash over into the backshore on spring tides or during storm surges.

Armored baskets placed along the highest elevation on a long, low sand barrier.

Geotextile or Plastic Barriers

Geotextile barrier held in place by imported rubble across a low section of a barrier beach.

Plastic sheet barrier on log piles above the intertidal zone (T/V *Exxon Valdez* response, Alaska).

Plastic sheet barrier on an historic property: 16th century Spanish fort and seawall (T/B *Morris J. Berman* response, Puerto Rico).

Solid Barriers

Solid sheet pile barrier under construction across a shallow channel. In the ground view at left, note oil in the lower half of the image. Hard booms, Super Sacks, and snare booms were deployed prior to completion of bulkhead construction.

Water-ballasted Boom

Water-ballasted (“shore-seal”) boom placed across the intertidal zone of a beach to prevent oil moving along shore. A length of sorbent boom (pink colored “sock boom”) is attached to the lower (intertidal) portion of the shore-seal boom (field trials on oiled beaches, Svalbard).

Water-ballasted boom anchored to form a barrier at the high water level. Note the low sand ridge on the landward side of the boom.

Conventional Boom

Conventional floating boom with skirt buried in the intertidal beach sediments to collect oil moving along shore (field trials, New Jersey).

Conventional solid floatation boom and water-ballasted (“shore-seal”) boom deployed at the high tide water level during an exercise (Port Angeles, WA).

Sorbent Boom

Sorbent (white) and snare boom (colored) booms placed at the high water level to collect oil as it washes ashore.

Snare boom placed in parallel in the upper intertidal zone to collect oil as it is washed ashore on a rising tide (T/B *Morris J. Berman* response, Puerto Rico).

Ditches, Sumps, or Trenches

Trench and sump system in the upper intertidal zone on a wide beach (T/V *Amoco Cadiz* response, France).

Trench being dug at the high water line to collect oil as it washes ashore on a rising tide (T/V *Estrella Pampeana* response, Argentina).

Response Considerations

The planning process that evaluates the potential consequences of a proposed protection strategy typically considers a broad range of issues to help planners and strategists ensure that actions are conducted in a responsible manner to minimize additional impacts to the environment, including human uses. Consultation with federal, state and local government agencies, as well as with environmental groups and land managers, is a key part of the process to identify potential consequences of proposed actions and strategic alternatives. For example, but without limitation:

- activities and potential impacts to Threatened and Endangered Species must be consistent with the Federal Endangered Species Act (ESA);

- federal legislation requires protection of Essential Fish Habitats

Some proposed strategies, such as a solid barrier across an active channel, may be submitted to the interagency Regional Response Team (RRT) for review and approval.

Construction of shore-zone protective berms and barriers should always be expected to have some effect on the environment and/or shore-zone processes, whether these actions are related to pedestrian traffic, use of machinery, or the physical presence of the berms and barriers. Some effects are likely to be negligible or very short lived (minutes to hours), whereas others have the potential to alter shore zone morphology or processes in a significant manner and have long-term (weeks to months) or permanent effects. In any event, it is fundamental that the planning of shore zone response actions considers the consequences of any proposed action in terms of the potential short and long term implications, and that monitoring be conducted to verify actual performance. A Net Environmental Benefit (NEB) analysis may be useful in the evaluation of proposed protection strategies.

Issues that should be considered during the design and selection of protection strategies and tactics include:

- **Sediment Transport**

- **Berm/Barrier Materials**

- **Tidal and Water Circulation**

- **Vegetation**

- **Wildlife and Fish Habitats**

- **Human Use**

- **Archaeological and Cultural Resources**

These considerations are described in the "*Shoreline Protection on Sand Beaches*" report. This list is not intended to be complete or exhaustive as each protection strategy is tailored to the local shore-zone character and processes and to the seasonality or other timing associated with habitat and human uses.

References

Accompanying reports are:

API 2013. *Shoreline Protection on Sand Beaches: Phase 1 - Final Report*, API Technical Report 1150-1, Washington DC, September, 35 pp.

API 2013. *Tidal Inlet Protection Strategies (TIPS)*, April, 57 pp.

General texts on beach form and processes:

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Hayes, M.O., 1979 Barrier Island Morphology as a Function of Tidal and Wave Regime. In: *Barrier Islands: from the Gulf of St. Lawrence to the Gulf of Mexico*. S.P. Leatherman, ed., Academic Press, NY, pp. 1–27.

Komar, P.D., 1998. *Beach Processes and Sedimentation* (Second Edition). Prentice Hall, Englewood Cliffs, NJ, 544 pp.

References that provide additional material related to beach protection strategies and tactics:

API, 2001. *Environmental Considerations for Marine Oil Spill Response*. American Petroleum Institute (API), National Oceanic and Atmospheric Administration (NOAA), U.S. Coast Guard (USCG), and U.S. Environmental Protection Agency (EPA). American Petroleum Institute Pub. No. 4706, Washington, DC.

Environment Canada, 2010. *A Field Guide to Oil Spill Response on Marine Shorelines*. Prepared by Polaris Applied Sciences, Inc. and S3 Environmental Inc., Ottawa, ON, 233 pp.

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NOAA, 2010a. *Characteristic Coastal Habitats: Choosing Spill Response Alternatives.* U.S. Department of Commerce, National Ocean Service, Office of Response and Restoration, Emergency Response Division, Seattle, WA, 85 pp.

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7 Definitions

beach
a sediment deposit along the shoreline built by waves and wind processes

barrier island or barrier spit
a wave-built accumulation of sediment extending above the *intertidal* zone that runs parallel to the coast and is typically separated from the mainland by a lagoon, bay, and/or wetland: the *backshore* zone often contains active and vegetated dunes

berm
a relatively flat, sandy platform created by wave and aeolian deposition above the *intertidal zone*: on coarse-sediment beaches there may be several parallel gravel ridges

intertidal zone
zone between the mean low tide water level (LWL) and the mean high tide water level (HWL) (see cover photograph): this zone is alternately underwater and exposed during each tidal cycle

supertidal zone
zone above the mean HWL that extends to the landward limit of marine processes: this zone is intermittently affected by tidal inundation and wave processes during periods of *spring* high tides or *surges caused by storms or strong onshore winds*

backshore zone
zone landward of the *supratidal* zone: a terrestrial zone that is only affected by marine processes during periods of exceptional high storm-driven water levels: includes wetlands, lagoons, ponds or rivers

neap and spring tides (astronomical):

- *Neap tides* occur twice during the lunar month when Earth, moon and sun are at right angles: this condition generates lower than average HWLs and higher than average LWLs and the least range between HWL and LWL

- *Spring tides* occur twice during the lunar month when Earth, moon and sun are aligned during new and full moons: this condition generates higher than average HWLs and lower than average LWLs and the greatest range between HWL and LWL

wind or storm surges (meteorological)
a rise in water levels along the shore generated by strong onshore winds and/or low atmospheric pressures: frequently, wind-driven waves are superimposed on the surge

overwash or washover
the landward transport of sediment into the *supratidal* or *backshore* zones during periods of elevated tides or storms: sediments (and oil) may be transported across a *barrier beach* into a wetland, pond or lagoon; in some instances, overwash may follow a channel that has cut through a low dune system

trafficability
the bearing capacity of beach sediments affects the ability for pedestrians and vehicles to travel across a section of beach and the speed at which vehicles can operate: the bearing capacity varies alongshore and across shore depending on sediment size, wetness and slope

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