Vancouver Energy
Operations Facility Oil Spill Contingency Plan

EFSEC Application for Site Certification No. 2013-01
Docket No. EF131590

Appendix F
Response Techniques and Guidelines

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APPENDIX F
RESPONSE TECHNIQUES AND GUIDELINES

F.1 SHORELINE PROTECTION GUIDANCE

Shoreline protection procedures are conducted to prevent oil impact to shoreline and reduce the impact on wildlife. Mechanical methods, such as use of boom and skimmers are the preferred methods. These methods can be used to control or contain floating oil slicks on the water away from marshes. Sorbents are effective on mudflats when placed on the shoreline before oil contacts the shore. A description of shoreline types is presented in **Figure F.1**. Specific shoreline protection and cleanup measures, for areas possibly impacted by a potential spill from the Facility, are discussed in this subsection. Additional information may be obtained from the *Northwest Area Contingency Plan*. The Vancouver Energy recognizes CRCI as their primary response contractor and will defer to their expertise in assessment, clean-up methodology, and provision of trained personnel.

F.2 SHORELINE AND TERRESTRIAL CLEANUP

F.2.1 General

In the event that terrestrial areas do become oiled, cleanup operations should be undertaken to minimize the environmental effects of the oil**.** Before terrestrial and shoreline cleanup plans are implemented they require Unified Command approval. Assessment teams comprised of personnel from the appropriate agencies, Company personnel, and consultants can be utilized to determine the most appropriate cleanup method.

In most instances, cleanup efforts are not subject to the same time constraints as containment, recovery, and protection operations. As a result, better planning and greater attention to detail are possible. The exception is where there is a high probability of stranded oil becoming mobilized again and migrating to previously unaffected areas. In this case, implement cleanup operations as soon as possible. If time does permit, consider the following items in detail.

- Documentation of the location, degree, and/or extent of oil conditions
- Evaluation of all environmental, cultural, economic, and political factors
- Selection of optional cleanup technique
- Mitigation of physical/environmental damage associated with cleanup operations
- Cost-effectiveness
- Net environmental benefit assessment

The shoreline or terrestrial oil conditions can range from those which require immediate and thorough cleanup to lightly oiled areas where no cleanup may be the most environmentally sound option. Factors that influence technique selection and whether or not cleanup will be required include:

- Oil type and amount
- Sensitivity
- Substrate or shoreline type
- Intrusive nature of the candidate techniques
- Shoreline accessibility
- Exposure

Therefore, before initiating cleanup activities, an assessment of the net environmental benefits of a proposed cleanup operation should be performed for all affected shorelines.

F.2.2 Cleanup Technique Selection

Shoreline

In the event the techniques recommended above do not apply to a particular spill situation at the Facility, other techniques should be considered for implementation. The other techniques that may be applicable are generally dependent on the following.

- Oil type
- Oiling conditions/degree of impact
- Environmental, safety, and political considerations
- Unusual circumstances the may be present at the time of the spill

Therefore, the following guidelines can be used to identify the most appropriate cleanup technique(s) for that situation.

The selection of an appropriate shoreline cleanup technique is primarily dependent on the following factors:

- **Substrate type** – Finer grained sediments typically require different techniques than coarse grained sediments and sediment type can affect trafficability (i.e., ability to traverse the area without losing traction) for heavy equipment.
- **Oil conditions** – Heavier oil conditions and larger areas may require more intrusive or mechanical methods, whereas lighter conditions may not require any form of cleanup.
- **Slope** – Heavy equipment use may not be appropriate on steeper or unstable banks.
- **Shoreline sensitivity** – Intrusive techniques may create a greater impact than the oil itself.
- **Penetration depth** – Significant penetration can reduce the effectiveness of several techniques.

FIGURE F.2 includes a shoreline cleanup technique selection guide.

These figures should only be used as a guide to identify the most appropriate techniques based on a limited number of factors and not a definitive list of techniques that can be used for selected situations.

A number of other factors can influence technique selection and result in techniques other than those identified in the figures as the most appropriate for a given situation. Final selection of cleanup techniques should be conducted in consultation with the state and federal OSCs, the appropriate natural resource trustees, if applicable, and the particular landowner(s) or manager(s) prior to implementation.

Figure F.1. Description of Shoreline Types

TYPES	ESI #	DESCRIPTION	PREDICTED OIL IMPACT	RECOMMENDED CLEANUP ACTIVITY
Exposed Rocky Cliffs	1A	• The intertidal zone is steep (greater than a 30° slope), with very little width. • Sediment accumulations are uncommon and usually ephemeral, since waves remove the debris that has slumped from the eroding cliffs. • They are often found interspersed with other shoreline types. • There is a strong vertical zonation of intertidal biological communities.	• Oil is held offshore by waves reflecting off the steep cliff. • Any oil that is deposited is rapidly removed from exposed faces. • The most resistant oil would remain as a patchy band at or above the high-tide line. • Impacts to intertidal communities are expected to be of short duration. • An exception would be where heavy concentrations of light refined product (e.g. No. 2 fuel oil) came ashore very quickly.	• Cleanup is not usually required • Access can be difficult and dangerous.

Exposed Sea Walls and Piers	1B	• Seawalls and piers are particularly common in developed areas, providing protection to residential and industrial developments.
		• They are also common along inlets, urbanized areas, and developed beachfront sites.
		• They are composed of concrete and stone, wooden, or metal bulkheads and wooden pilings.
			• Oil would percolate between the joints of the structures.
			• Oil would coat the intertidal areas of solid structures.
			• Biota would be damaged or killed under heavy accumulations.
				• High-pressure spraying may be required in order to:
				  • Remove oil;
				  • Prepare substrate for recolonization of barnacle and oyster communities;
				  • Minimize aesthetic damage;
				  • Prevent the chronic leaching of oil from the structure.

Exposed Wave-Cut Platforms	2	• The intertidal zone consists of a flat rock bench of highly variable width. • The shoreline may be backed by a steep scarp or low bluff. • There may be a narrow, perched beach of gravel- to boulder-sized sediments at the base of the scarp. • The platform surface is irregular and tidal pools are common. • Small accumulations of gravel can be found in the tidal pools and crevices in the platform. • Pockets of sandy “tidal flats” can occur on the platform in less exposed settings. • These habitats can support large populations of encrusting animals and plants, with rich tidal pool communities.	• Oil will not adhere to the rock platform, but rather be transported across the platform and accumulate along the high-tide line. • Oil can penetrate and persist in the beach sediments, if present. • Persistence of oiled sediments is usually short term, except in wave shadows or larger sediment accumulations.	• Cleanup is usually not required. • Where the high-tide areas is accessible, it may be feasible to remove heavy oil accumulations and oiled debris.

Figure F.1. Description of Shoreline Types (continued)

TYPES	ESI #	DESCRIPTION	PREDICTED OIL IMPACT	RECOMMENDED CLEANUP ACTIVITY
Fine/Medium-Grained Sandy Beaches	3	• These beaches are generally flat, wide, and hard-packed. • They are commonly backed by dunes or seawalls along exposed outer coasts. • Along sheltered bays, they are narrower, often fronted by tidal flats. • Upper beach fauna are scarce.	• Light oil accumulations will be deposited as oily swashes or bands along the upper intertidal zone. • Heavy oil accumulations will cover the entire beach surface, although the oil will be lifted off the lower beach with the rising tide. • Maximum penetration of oil into fine-grained sand will be 10 centimeters (cm). • Burial of oiled layers by clean sand within the first few weeks will be less than 30 cm along the upper beach face. • Organisms living in the beach sands may be killed either by smothering or by lethal oil concentrations in the interstitial water. • Shorebirds may be killed if oiled, though they may shift to clean sites.	• These beaches are among the easiest beach types to clean. • Cleanup should concentrate on the removal of oil from the upper swash zone after all oil has come ashore. • Removal of sand from the beach should be minimal to avoid erosion problems; special caution is necessary in areas backed by seawalls. • Activity through oiled and dune areas should be severely limited, to prevent contamination of clean areas. • Manual cleanup, rather than road graders and front-end loaders, is advised to minimize the volume of sand removed from the shore and requiring disposal. • All efforts should focus on preventing the mixture of oil being pushed deeper into the sediments by vehicle and foot traffic.
Coarse-Grained Sand/Gravel Beaches	4	• These beaches are moderate-to-steep, of variable width, and have soft sediments. • They are commonly backed by dunes seawalls along exposed outer coasts. • Generally species density and diversity is low.	• Light oil will be deposited primarily as a band along the high-tide line. • Under very heavy accumulations, oil may spread across the entire beach face, though the oil will be lifted off the lower beach with the rising tide. • Penetration of oil into coarse-grained sand can reach 25 cm. • Burial of oil layers by clean sand can be rapid, and up to 60 cm or more. • Burial over one meter is possible if the oil comes ashore at the start of the disposition period. • Biological impacts include temporary declines in faunal populations, which can also affect feeding shorebirds.	• Remove oil primarily from the upper swash lines. • Removal of sediment should be limited to avoid erosion problems. • Mechanical reworking of the sediment into the surf zone may be used to release the oil without removal. • Activity in the oiled sand should be limited to prevent mixing oil deeper into the beach. • Use of heavy equipment for oil/sand removal may result in the removal of excessive amounts of sand; manual cleanup may be more effective.

Figure F.1. Description of Shoreline Types (continued)

TYPES	ESI #	DESCRIPTION	PREDICTED OIL IMPACT	RECOMMENDED CLEANUP ACTIVITY
Mixed Sand and Gravel Beaches	5	• Moderately sloping beach composed of a mixture of sand (greater than 20%) and gravel (greater than 25%). • The high-tide berm area is usually composed of sand or fine gravel (pebbles to cobbles), whereas the lower part of the beach is coarser, with cobbles to boulders. • Because of the mixed sediment sizes, there may be zones of sand, pebbles, or cobbles. • Because of the sediment mobility and desiccation of exposed beaches, there are low densities of attached animals and plants. • The presence of attached algae, mussels, and barnacles indicated beaches that are relatively sheltered, with the more stable substrate supporting a richer biota.	• During small spills, oil will be deposited along and above the high-tide swash. • Large spills will spread across the entire intertidal area. • Oil penetration into the beach sediments may be up to 50 cm; however, the sand fraction can be quite mobile, and oil behavior is much like on a sand beach if the sand fraction exceeds about 40%. • Burial of oil may be deep at and above the high-tide line, where oil tends to persist, particularly where beaches are only intermittently exposed to waves. • On sheltered beaches, extensive pavements of asphalted sediments can form if there is no removal of heavy oil accumulations, because most of the oil remains on the surface. • Once formed, pavements are very stable and can persist for many years. • Oil can be stranded in the coarse sediments on the lower part of the beach, particularly if the oil is weathered or emulsified.	• Remove heavy accumulations of pooled oil from the upper beach face. • All oiled debris should be removed. • Sediment removal should be limited as much as possible. • Low-pressure flushing can be used to float oil away from the sediments for recovery by skimmers or sorbents. High-pressure spraying should be avoided because of potential for transporting the finer sediments (sand) to the lower intertidal or subtidal zones. • Mechanical reworking of oiled sediments from the high-tide zone to the upper intertidal zone can be effective in areas regularly exposed to wave activity (as evidence by storm berms). However, oiled sediments should not be relocated below the mid-tide zone. • In-place tilling may be used to reach deeply buried oil layers in the mid-beach on exposed beaches.
Gravel Beaches	6A	• Gravel beaches are composed of sediments ranging in size from pebbles to boulders. • They can be very steep, with multiple wave-built berms forming the upper beach. • Attached animals and plants are usually restricted to the lowest parts of the beach, where sediments are less mobile.	• Deep penetration and rapid burial of stranded oil is likely on exposed beaches. • On exposed beaches, oil can be pushed over the high-tide and storm berms, pooling and persisting above the normal zone of wave wash. • Long-term persistence will be controlled by the depth of penetration versus the depth of routine reworking by storm waves. • On relatively sheltered beaches, formation of asphalt pavements is likely where accumulations are heavy.	• Heavy accumulations of pooled oil should be quickly removed from the upper beach. • All oiled debris should be removed. • Sediment removal should be limited as much as possible. • Low- to high-pressure flushing can be used to float oil away from the sediments for recovery by skimmers or sorbents. • Mechanical reworking of oiled sediments from the high-tide zone to the upper intertidal zone can be effective in areas regularly exposed to wave activity (as evidence by storm berms). However, oiled sediments should not be relocated below the mid-tide zone. • In-place tilling may be used to reach deeply buried oil layers in the mid-beach on exposed beaches.

Figure F.1. Description of Shoreline Types (continued)

TYPES	ESI #	DESCRIPTION	PREDICTED OIL IMPACT	RECOMMENDED CLEANUP ACTIVITY
	6B	• Riprap structures are composed of cobble to boulder-size rocks. • Riprap structures are placed for shoreline protection and inlet stabilization. • Biota on the riprap may be plentiful and varied.	• On riprap structures, deep penetration of oil between boulders is likely. • If oil is left uncleaned, it may become asphalted. • Resident fauna and flora may be killed by the oil.	• It may be necessary to remove heavily oiled riprap and replace it.
Exposed Tidal Flats	7	• They are compose primarily of sand and mud. • The presence of sand indicates that tidal or wind-driven currents and waves are strong enough to mobilize the sediments. • They are always associated with another shoreline type on the landward side of the flat. • The sediments are water-saturated, with only the topographically higher ridges drying out during low tide. • Biological utilization can be very high, with large numbers of infauna and heavy use by birds for roosting and foraging.	• Oil does not usually adhere to the surface of exposed tidal flats, but rather moves across the flat and accumulates at the high-tide line. • Deposition of oil on the flat may occur on a falling tide if concentrations are heavy. • Oil does not penetrate the water-saturated sediments. • Biological damage may be severe, primarily to infauna, thereby reducing food sources for birds and other predators.	• Currents and waves can be very effective in natural removal of oil. • Cleanup is very difficult (and possible only during low tides). • The use of heavy machinery should be restricted to prevent mixing of oil into the sediments. • On sand flats, oil will be removed naturally from the flat and deposited on the adjacent beaches where cleanup is more feasible.
Sheltered Rocky Shores	8A	• They consist of bedrock shores of variable slope (from vertical cliffs to wide, rocky ledges) that are sheltered from exposure to most wave and tidal energy. • The wider shores may have some surface sediments, but the bedrock is the dominant substrate type. • Species density and diversity vary greatly, but barnacles, snails, mussels, clams, periwinkles, amphipods, polychaetes, rockweed, and crabs are often very abundant.	• On rocky shores, oil will adhere readily to the rough rocky surface, particularly along the high-tide line, formed a distinct oil band. • Fractures in the bedrock will be sites of pooling and oil persistence. • Even on wide ledges, the lower intertidal zones usually stays wet (particularly when algae covered), preventing oil from adhering to the rock surface. • Heavy and weathered oils can cover the upper zone with little impacts to the rich biological communities of the lower zone. • Where surface sediments are abundant, oil will penetrate into the crevices formed by the surface rubble and pool at the contact of the sediments and the surface. • Where the rubble is loosely packed, oil will penetrate deeply, causing long-term contamination of the subsurface sediments. • Fresh oil and light refined products have high acute toxicities that can affect attached organisms after even short exposures.	• Low- to high-pressure spraying at ambient water temperatures is most effective when the oil is fresh. • Extreme care must be taken not to spray in the biologically rich lower intertidal zone or when the tidal level reaches that zone. • Cutting of oiled, attached algae is not recommended; tidal action will eventually float this oil off, so sorbent booms should be deployed.

Figure F.1. Description of Shoreline Types (continued)

TYPES	ESI #	DESCRIPTION	PREDICTED OIL IMPACT	RECOMMENDED CLEANUP ACTIVITY
Sheltered Tidal Flats	9	• They are composed primarily of silt and clay. • They are present in calm-water habitats, sheltered from major wave activity, and frequently fronted by marshes. • Wave energy is very low, although there may be strong tidal currents active on parts of the flat and in channels across the flat. • The sediments are very soft and cannot support even light foot traffic. • There are usually large populations of clams, worms, and snails. • Bird life is seasonably abundant.	• Oil does not usually adhere to the surface of sheltered tidal flats, but rather moves across the flat and accumulates at the high-tide line. • Deposition of oil on the flat may occur on a failing tide if concentrations are heavy. • Oil will not penetrate the water-saturated sediments at all. • In areas of high suspended sediments, sorption of oil can result in contaminated sediments that can be deposited on the flats. • Biological damage may be severe.	• These are high-priority areas necessitating the use of spill protection devices to limit oil spill impact; deflection or sorbent booms and open water skimmers should be used. • Cleanup of the flat surface is very difficult because of the soft substrate and many methods may be restricted. • Manual operations and deployment of sorbents from shallow-draft boats may be helpful.
Fringing and Extensive Salt Marshes	10A	• Marshes are intertidal wetlands containing emergent, herbaceous vegetation. • Width of the marsh can vary widely, from a narrow fringe to extensive. • They are relatively sheltered from waves and strong tidal currents. • Resident flora and fauna are abundant and consist of numerous species. • Marshes provide a nursery ground for numerous fish species. • Bird life is seasonably abundant.	• Oil adheres readily to marsh vegetation. • The band of coating will vary widely, depending upon the tidal stage at the time oil slicks are in the vegetation. There may be multiple bands. • Large slicks will persist through multiple tidal cycles and coat the entire stem from the high-tide line to the base. • If the heavy vegetation is thick, heavy oil coating will be restricted to the outer fringe, with penetration and lighter oiling to the limit of tidal influence. • Medium to heavy oils do not readily adhere or penetrate the fine sediments, but they can pool on the surface and in burrows. • Light oils can penetrate the top few centimeters of sediments and deeply into burrows and cracks (up to one meter).	• Under light oiling, the best practice is to let the areas recover naturally. • Heavy accumulation of pooled oil can be removed by vacuum, sorbents, or low-pressure flushing. During flushing, care must be taken to prevent transporting oil to sensitive areas down slope or along shore. • Cleanup activities should be carefully supervised to avoid vegetation damage. • Any cleanup activity must not mix the oil deeper into the sediments. Trampling of the roots must be minimized. • Cutting of oiled vegetation should only be considered when other resources present are at great risk from leaving the oiled vegetation in place.

Figure F.1. Description of Shoreline Types (continued)

TYPES	ESI #	DESCRIPTION	PREDICTED OIL IMPACT	RECOMMENDED CLEANUP ACTIVITY

Mangroves	10B	• Mangrove forests are composed of salt-tolerant trees that form dense stands with distinct zonation: red mangroves occur on the seaward exterior while black and white mangroves occur on forest interiors.
		• The outer, fringing forests can be exposed to relatively high wave activity and strong currents; forests located in bays and estuaries are well-sheltered.
		• Sediment types range from thin layers of sand and mud to muddy peat to loose gravel on limestone beachrock.
		• Heavy wrack deposits in the storm swash are very common.
		• The topographic profile is generally very flat, and seagrass beds are common in shallow offshore areas.
		• Attached to the prop roots are moderate densities of algae, snails, and crabs.
			• Fresh spills of light refined products have acute, toxic impacts to both trees and intertidal biota. These products will penetrate deeply into the forests, stopping only at the high-tide line, where sediment contamination may result.
			• No. 2 fuel oil or fresh crude will have great persistence where it penetrates burrows and prop root cavities. Heavier oils tend to coat the intertidal zone, with heaviest concentrations at the high-tide line or storm wrack line.
			• Heavy oils will coat the intertidal section of prop roots, resulting in defoliation and eventual death of the tree if significant coverage occurs.
			• In sheltered areas, oil may persist for many years.
				• Under light accumulations of any type of oil. No cleanup is recommended.
				• If sheens are present, use sorbent booms to pick up the oil as it is naturally removed, being sure to change booms frequently.
				• The only light refined product that usually required cleanup is No. 2 fuel oil/diesel because of the potential for long-term sediment contamination.
				• Heavy accumulations could be skimmed or flushed with low-pressure water flooding, as long as there is NO disturbance or mixing of oil into the substrate. If substrate mixing is likely or unavoidable, it is better to leave the oil to weather naturally.
				• Oily debris should be removed, taking care not to disturb the substrate.
				• Live vegetation should never be cut or otherwise removed.
				• Sorbents can be used to remove wide heavy oil coatings from prop roots in areas of firm substrate and with close supervision.
				• Under moderate to heavy accumulations of crude or heavy refined products, a detailed, site-specific cleanup plan will be required. The cleanup plan should be prepared by experience personnel and include:
				  ◦ General map of entire impacted area and locations of specific areas to be cleaned up.
				  ◦ Detailed maps of each specific area showing the oil locations and type of cleanup to be performed at each location.
				  ◦ Definition of each type of cleanup allowed.
				  ◦ Specific restrictions to prevent further damage for each cleanup location.

Figure F.2. Shoreline Cleanup Technique Selection Guide

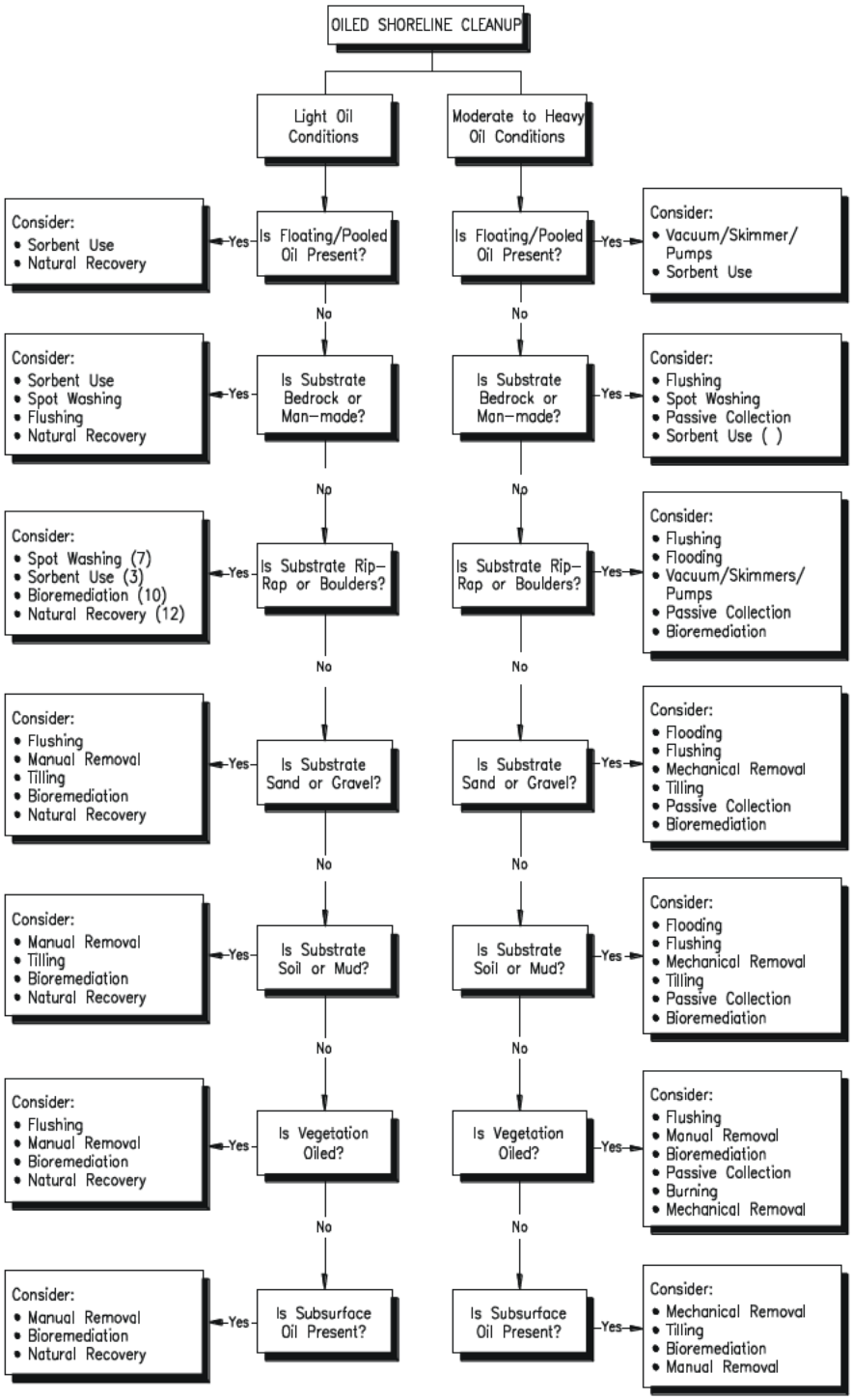

Figure F.3. Shoreline Protection Methods[2]

ON-WATER	METHOD	APPLICABILITY
EXCLUSION BOOMING	• Deployed across or around oil • Oil removed from water surface	• To protect small bays, harbors, inlets or river mouths • Currents less than 0.5 m/s
DIVERSION BOOMING	• Deployed at an angle to approaching oil • Diverts oil away from sensitive areas	• Where currents are greater than 0.5 m/s
CONTAINMENT BOOMING	• Deployed around oil • Oil removed from water surface	• Current less than 0.5 m/s • Not applicable for large slicks
SORBENT BOOMING	• Deployed across approaching oil • Oil absorbed by boom	• Quiet waters • Can be recycled and reused • Small slicks
DISPERSION AGENTS	• Reduce surface tension of oil by application of chemicals • Oil is then dispersed more rapidly into the water	• Requires permission of regulatory agencies • Increases oil mobility, therefore, stranded oil has greater potential to penetrate beach sediments
COLLECTION AGENTS	• Increase surface tension of oil by application of chemicals • Oil is prevented from spreading	• Decreases oil mobility, therefore, stranded oil has a reduced capacity to penetrate beach sediments
ONSHORE	**METHOD**	**APPLICABILITY**
SORBENTS	• Applied manually or mechanically to the beach before oil is stranded • Oil/sorbent is then removed manually or mechanically	• Prevents penetration of oil into substrate • Sorbent pads preferable to loose-fiber materials for ease of collection • Synthetic products have higher absorption capacity than natural materials • Can be recycled and reused • Usually a labor-intensive method
SURFACE TREATMENT AGENTS	• Applied to shore zone before oil is stranded • Prevents oil from adhering to the substrate	• Applicability and effectiveness not yet fully assessed • May be difficult to apply on long sections of shore • Oil must be flushed from the shore and agent removed if it does not degrade naturally
COLLECTION AGENTS	• Applied along water line before oil is stranded • Reduces natural dispersion of oil	• Reduces area of shoreline contamination • Reduces penetration into beach
DIKES AND/OR DITCHES	• Ditch up to 1.0 m deep dug parallel to shore at upper limit of wave action • Sediment removed used to build dike on landward side of the ditch • On pebble-cobble beaches can fill ditch with sorbents to collect oil and prevent oil penetration	• Prevents oil being washed onto the backshore • Can be constructed mechanically along long beach sections • Ditch acts as a collector of oil which can be removed with buckets, hand pumps, or vacuum pumps
DAMS	• Used for shallow streams where booms cannot be deployed	• Acts as a boom for exclusion of oil • Can be constructed to allow water to flow through dam
VISCOUS	• Applied manually to the beach, rock jetties, etc.	• Excellent with heavier oils • Can be recycled and reused • Reduces penetration into rocks

[2]Breuel, A. 1981. Oil Spill Cleanup and Protection Techniques for Shoreline and Marshland and Marshlands. Park Ridge, New Jersey, Noyes.

Figure F.4. Response Options for Oil or Substances with Physical and Chemical Properties Similar to Oil

	PROTECTION					CLEANING/MIXING				REMOVAL/DISPOSAL				ONSHORE DISPERSION				
ENVIRONMENT	DITCHES/DIKES	DISPERSANTS ON WATER	SINKING AGENTS	HERDING/GELLING AGENTS	BOOMS/SKIMMERS	BRACH CLEANING MACHINES	BURNING	MIXING	NATURAL CLEANING	MANUAL REMOVAL	MECHANICAL REMOVAL	VACUUM PUMPING	VEGETATION CROPPING	DISPERSANTS ON CROPPING	HIGH PRESSURE FLUSHING	LOW PRESSURE FLUSHING	SAND BLASTING	STEAM CLEANING
1. SEA GRASS BEDS		x	#	o	+				+	x			x	x		o		
2. MANGROVES		+		o	+		#		o	o	#	o	x	+	x	+		
3. MARSHES				o	+		#		+	#	#	o	x	o	#	+		#
4. SHELTERED TIDAL FLATS				o	+			#	+	o	#	o		x	#	+		
5. RIVER BANKS	o			o	+		x		+	+	o	o				o		
6. OYSTER REEFS				o	+				+			o		x		o		#
7. EXPOSED TIDAL FLATS	o	x		o	+				+					x				
8. DREDGE SPOIL BANKS	o			o	+			o	+	o	o							
9. BAY MARGINS	o			o	+	o		o	+	o	o	+				o		
10. 11. OPEN SAND BEACH	+			o		+	#	o	+	+	+	+		o	#	o		
12. MAN-MADE SHORE				o	+		x		+	o				o	o	o	o	o
13. EROSION SCARPS									+	+	x	+			x	o		
TIDAL INLETS		o		o	+				+									
LAGOONS BAYS			#	o	+				+		o							

KEY: + PREFERRED o OPTIONAL x NOT ADVISABLE # AVOID

Figure F.5. Summary of Shoreline and Terrestrial Cleanup Techniques

TECHNIQUE	DESCRIPTION	PRIMARY LOGISTICAL REQUIREMENTS[1]	USE LIMITATIONS[2]	POTENTIAL ENVIRONMENTAL EFFECTS
Removal				
1. Manual Removal	Hand tools (scrapers, wire brushes, shovels, cutting tools, wheel barrows, etc.) are used to scrape oil off surfaces or recover oiled sediments, vegetation, or debris where oil conditions are light or sporadic and/or access is limited.	Equipment Misc. hand tools Personnel 10-20 workers	• Poor access • Highly sensitive areas	• Sediment disturbance and erosion potential • Trampling of vegetation and organisms • Foot traffic can work oil deeper into soft sediments
2. Mechanical Removal	Mechanical earthmoving equipment is used to remove oiled sediments and debris from heavily impacted areas with suitable access.			
2a. Bulldozer/Front-end Loader	Used to recover moderately to heavily oiled sediments using a bulldozer to push sediments into piles for pickup by front-end loader. Front-end loader may work alone to recover sediments directly.	Equipment 1 bulldozer 2 front-end loaders Personnel 2-4 workers plus equipment operators	• Very poor trafficability • Limited access • Highly sensitive areas • Light or sporadic oil conditions	• Removes upper 2 to 12 inches of sediments • Removes shallow organisms but recolonization is typically rapid • Excessive sediment removal can cause erosion
2b. Backhoe	Used to recover surface or subsurface oiled sediments on flat or steeply sloped areas by scooping up sediments and placing directly into dump trucks or in piles for subsequent removal.	Equipment 1-2 backhoes 4-6 dump trucks Personnel 2-4 workers plus equipment operators	• Limited access • Highly sensitive areas • Unstable slopes • Light or sporadic oil conditions	• Removes minimum of 6 to 12 inches of sediments • Removes shallow organisms but recolonization is typically rapid • Can cause erosion and slope instability
3. Sorbent Use	Sorbents are applied manually to oil accumulations, coatings, sheens, etc. to remove and recover the oil.	Equipment Misc. hand tools Misc. sorbents Personnel 2-10 workers	• Poor access • Highly sensitive areas • Heavy oil conditions	• Sediment disturbance and erosion potential • Trampling of vegetation and organisms • Foot traffic can work oil deeper into soft sediments

Figure F.5. Summary of Shoreline and Terrestrial Cleanup Techniques (continued)

TECHNIQUE	DESCRIPTION	PRIMARY LOGISTICAL REQUIREMENTS[1]	USE LIMITATIONS[2]	POTENTIAL ENVIRONMENTAL EFFECTS
4. Vacuums/Pumps/ Skimmers	Pumps, vacuum trucks, skimmers are used to remove oil accumulations from land or relatively thick floating layers from the water.	Equipment 1-2 50- to 100-bbl vacuum trucks w/hoses 1-2 nozzle screens or skimmer heads Personnel 2-6 workers plus truck operators	• Poor access • Thin oil accumulations or light sheens • Highly sensitive shoreline areas • Excessive suction lift required	• Typically does not remove all oil • Can remove some surface organisms, sediments, and vegetation
Washing				
5. Flooding	High volumes of water at low pressure are used to flood the oiled area to float oil off and out of sediments and back into the water or to a containment area where it can be recovered. Frequently used with flushing.	Equipment 1-5 100- to 200-gpm pumping systems 1 100-foot perforated header hose per system 1-2 200-foot containment booms per system 1 oil recovery device per system Personnel 6-8 workers per system	• Highly permeable substrate • Highly sensitive areas • Poor access • Highly weathered oil or thin films or coatings • Typically does not remove all oil	• Can impact clean downgradient areas • Can displace some surface organisms if present • Sediments transported into water can affect water quality
6. Flushing	Water streams at low to moderate pressure, and possibly elevated temperatures, are used to remove oil from surface or near-surface sediments through agitation and direct contact. Oil is flushed back into the water or a collection point for subsequent recovery. May also be used to flush out oil trapped by shoreline or aquatic vegetation.	Equipment 1-5 50- to 100-gpm/ 100-psi pumping systems with manifold 1-4 100-foot hoses and nozzles per system 1-2 200-foot containment booms per system 1 oil recovery device per system Personnel 8-10 workers per system	• Highly permeable substrate • Highly sensitive areas • Poor access • Highly weathered oil or thin films or coatings • Typically does not remove all oil	• Can impact clean downgradient areas • Will displace many surface organisms if present • Sediments transported into water can affect water quality • Hot water can be lethal to many organisms • Can increase oil penetration depth

Figure F.5. Summary of Shoreline and Terrestrial Cleanup Techniques (continued)

TECHNIQUE	DESCRIPTION	PRIMARY LOGISTICAL REQUIREMENTS[1]	USE LIMITATIONS[2]	POTENTIAL ENVIRONMENTAL EFFECTS
7. Spot (High Pressure) Washing	High pressure water streams are used to remove oil coatings from hard surfaces in small areas where flushing is ineffective. Oil is directed back into water or collection point for subsequent recovery.	Equipment 1-5 1,200- to 4,000-psi units with hose and spray wand 1-2 100-foot containment booms per unit 1 oil recovery device per unit Personnel 2-4 workers per unit	• Poor access • Highly sensitive area • Safety hazard from high pressure water stream • Relatively soft or unconsolidated substrates	• Will remove most organisms if present • Can damage surface being cleaned • Can affect clean downgradient or nearby areas
In Situ				
8. Passive Collection	Sorbent/snare booms or other sorbent materials are anchored at the waterline adjacent to heavily oiled areas to contain and recover oil as it leaches from the sediments.	Equipment 1,000-2,000 ft sorbent/snare boom 200-400 stakes or anchor systems Personnel 4-10 workers	• Poor access • High currents/waves • Lightly oiled sediments • Oil removal process is slow	• Significant amounts of oil can remain on the shoreline for extended periods of time
9. Sediment Tilling	Mechanical equipment or hand tools are used to till light to moderately oiled surface sediments to maximize natural degradation processes.	Equipment 1 tractor fitted with tines, dicer, ripper blades, etc. or 1-4 rototillers or 1 set of hand tools Personnel 2-10 workers	• Poor access • Heavily oiled area • Highly sensitive area • Oil can be mixed deeper into substrate	• Significant amounts of oil can remain on the shoreline for extended periods of time • Disturbs surface sediments and organisms
10. In Situ Bioremediation	Fertilizer is applied to lightly or moderately oiled areas to enhance microbial growth and subsequent biodegradation of oil.	Equipment 1-2 fertilizer applicators 1 tilling device if required Personnel 2-4 workers	• May cause algal bloom and short-term water quality problems • Heavily oiled areas	• Significant amounts of oil can remain on the shoreline for extended periods of time • Can disturb surface sediments and organisms

Figure F.5. Summary of Shoreline and Terrestrial Cleanup Techniques (continued)

TECHNIQUE	DESCRIPTION	PRIMARY LOGISTICAL REQUIREMENTS[1]	USE LIMITATIONS[2]	POTENTIAL ENVIRONMENTAL EFFECTS
11. Log/Debris Burning	Oiled logs, driftwood, vegetation, and debris are burned to minimize material handling and disposal requirements. Material should be stacked in tall piles and fans used to ensure a hot, clean burn.	Equipment 1 set of fire control equipment 2-4 fans 1 supply of combustion promoter Personnel 2-4 workers	• Local air quality regulations • Close proximity to populated areas • High wind conditions • Heavy precipitation	• Heat may impact local near-surface organisms • Substantial smoke may be generated • Heat may impact adjacent vegetation
12. Natural Recovery	No action is taken and oil is allowed to degrade naturally.	None required	• Heavy oil conditions • Highly sensitive shorelines • High oil remobilization potential	• Oil may persist for significant periods of time • Remobilized oil or sheens may impact other areas • Higher probability of impacting wildlife

1 - Per 1,000 feet of shoreline or oiled area. Potential sources of equipment are provided in Section 5.0.
2 - In addition to fire and explosion hazard.

Figure F.6. Summary of Shoreline Cleanup Techniques by Surface Type

Note: The appropriate government agencies must be consulted prior to implementing shoreline clean-up techniques.

TYPE OF SURFACE CONTAINING SPILL	RECOMMENDED CLEAN-UP TECHNIQUES	ACTIONS TO AVOID
Sand	Use vacuum skimmer and sorbents to clean up pools of free flowing oil. Use shovels to remove and place oiled sand into plastic bags or 55-gallon drums.	Do not let people or equipment travel over oiled sand. Do not bury oil sand.
Pebble or Gravel	If heavily oiled, use water spray and front-end loader to remove oiled material. If lightly oiled, use water spray and detergents to wash oil films off gravel and pebbles.	Do not place oiled gravel or pebbles in streams or offshore areas.
Snow	Use shovels to place oiled snow in 55-gallon drums.	Do not place oiled snow in wetlands or offshore areas. Make sure that drums do not have holes in them.
Concrete or Asphalt	Use vacuum skimmers and sorbents to clean up oil. Wash surface with water. Remove oil between cracks.	
Wetlands	Consult Ecology, EPA, or other agencies for permits to work on wetlands. If cleanup will cause excessive damage to wetlands, request agency approval to leave oil in place.	Do not operate vehicles or heavy equipment on wetlands. Do not disturb nesting areas.
Marshes	Use booms to control oil movement. Use a low pressure water spray to herd oil to areas where it can be recovered with skimmers and sorbents. Seek agency input as to whether oil should be left in place to prevent environmental damage that could result from clean-up operation.	Do not block entrance to marsh with berms or dams. Do not use heavy equipment.
Harbors and Streams	Use booms to prevent oil from spreading. Use skimmers to clean up oil slicks.	Avoid creating waves which may cause oil to spread. Do not use dispersants or chemicals to remove oil from water surface.