ENVIRONMENTAL EMERGENCY BRANCH
ENVIRONMENTAL PROTECTION SERVICE
PACIFIC AND YUKON REGION

GUIDE TO THE PREPARATION OF SHORELINE PROTECTION AND CLEANUP MANUALS

Regional Program Report: 81-17

By

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The Environmental Protection Service has developed an aid to oil spill response planning with this Guide To The Preparation of Shoreline Protection and Cleanup Manuals. The format was initially prepared for the Environmental Emergency Group of E.P.S. by Dr. Ed Owens of Woodward-Clyde Consultants of Victoria, British Columbia. Scientific authority for the project was provided by Mr. Wish Robson, formerly of the Environmental Protection Service and by Mr. Steve Pond, Environmental Emergency Coordinator for the Pacific and Yukon Region of Environment Canada. This guide is intended for the use of government agencies and private corporations concerned with environmental protection, oil spill response and the cleanup and restoration of oil contaminated shorelines. It is hoped that these organizations will take the opportunity of reviewing this method for possible inclusion in their own contingency plans.

ABSTRACT

This regional guidebook summarizes the results of a pilot study conducted in 1981 to research and develop a format and technique applicable to the preparation of shoreline protection and cleanup manuals. The report first describes the rationale for such a project and then examines the individual components and their systematic arrangement. Following the introduction, two sample formats are depicted for consideration.

The first employs a series of maps at various scales, each accompanied by a text or legend which describes the regional, operational and tactical steps required to implement an oil spill response. The second, employs a coding system which numerically identifies individual shoreline types and keys that code number to a series of tables which describe the countermeasures techniques, accessibility, land use, ownership and constraints appropriate to that site. Countermeasures practices and decision guides referenced to the coding scheme are then provided in the following section.

Each format identifies sites and areas of potential disturbance and priorizes them according to their sensitivity to impact from oil spills. Factors considered in the assignment of priorities are based on biological, physical and social parameters. Finally, the use of aerial video-tapes in contingency planning and cleanup operations is discussed in an appendix to the report.

RÉSUMÉ

Ce manuel de marche à suivre au niveau régional, se réfère aux résultats d'une étude pilote effectuée en 1981, dédiée à la recherche et au développement d'un format et d'une technique se rapportant à la préparation de manuels sur la protection et le nettoyage de la zone littorale. Premièrement le rapport décrit la raison d'être d'un tel projet et ensuite il en examine les parties constituantes individuelles ainsi que leur arrangement systématique. Faisant suite à l'introduction, deux échantillons des formats sont décrits pour votre considération.

Le premier échantillon consiste à des séries de cartes à différents échellons, chacun s'accompagnant d'un texte ou d'une légende décrivant des étapes régionale, opérationnelle et de tactique nécessaire pour rendre effectives les réponses aux déversements d'huile. Le deuxième consiste à un système de codage identifiant numériquement différents types de zones littorales individuelles et relie le système de code numérique à des series de tableaux décrivant des techniques de contre-measure, d'accessibilité, d'emploi de terrain, de droit de propriété and de contraintes s'appropriant à ce site.

Chaque format identifie et classe les régions et les sites les plus aptes à être pertubés, par ordre de priorité de sensibilité face à l'impact d'un déversement d'huile. Les facteurs considérés dans le classement par ordre de sensibilité dans ce travail, sont les paramétres biologiques, physiques et sociaux. Enfin, il y a discussion de l'utilisation des video-cassettes aériennes dans les études sur les measure d'interventions d'urgence et les opérations nettoyage dans un appendice au rapport.

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1.0 INTRODUCTION

This guide to the preparation of shoreline protection and cleanup manuals has been prepared by the Environmental Protection Service, Pacific and Yukon Region, for the use of other government agencies and industrial concerns. It is based on work performed during 1980 and 1981 by Woodward-Clyde Consultants of Victoria, B.C. and the Environmental Emergency Branch of E.P.S. It is also derived from the oil spill manual prepared by B. Worbets for the Arctic Petroleum Operators Association, entitled Shoreline Oil Spill Protection and Cleanup Strategies: Southern Beaufort Sea, (1979) and other manuals.

Two alternative formats have been assembled within this report for the consideration of potential users. Neither format should be construed as an exact model to duplicate; corporate requirements, local conditions, information quality and the circumstances for which a manual is written will all dictate some variance from the formats presented herein. There are, however, certain key elements common to both examples which offer potential improvements to contingency planning. Chief among these is the use of different map scales to achieve different goals and the organization of information in discrete data sets.

A shoreline protection and cleanup manual can be a valuable addition to the arsenal of tools available for oil spill response. It provides a basis for organizing much of the resource material collected by organizations concerned with protection of the environment from petroleum related activities. In essence, it examines the primary features of the physical and biologial environment and provides advice on how they can be protected, cleaned and rehabilitated.

We believe that the oil spill shoreline protection and cleanup manuals described in this guide are an advance over previous contingency planning systems in the way they use "sensitivity" information to determine what protective cleanup techniques should be applied to a particular geographic unit. The manuals have an additional planning benefit in that they identify potential operational and tactical activities. These actions can therefore be assessed and approved by the appropriate regulatory authorities long before they may be needed. This will undoubtedly reduce communication problems during an actual spill response. Although two alternative methods of constructing a manual are described, they have three essential common features.

A manual should include three sets of information, each of which contributes to spill response. The first, concerning assessment of potential impact, has been assigned to a Regional Map Series. The primary function of this map series is to provide an overview of a large coastal area, its general shoreline character and sites or areas of environmental sensitivity. It is unnecessary, at this level of detail, to describe that sensitivity, only to flag it for future reference further on in the manual. A small scale map of 1:250,000 or less is therefore adequate for this purpose.

The second task, that of organizing response in a particular area, has been assigned to the Operational Map Series. Owing to the need to provide greater detail for the information set that makes up this series of maps, a scale of 1:50,000 has been used. Again, the use of this particular scale is not strictly necessary; the choice depends upon the amount of physical and logistical data that requires depiction. A populated, resource-rich coastline may require a larger scale while an isolated, uniform coast could be mapped at a considerably smaller scale (1:100,000 or less). The availability of base maps may be the sole criterion in some districts. In most of Southern Canada, the 1:50,000 topographic maps are the most convenient.

The final task, that of depicting specific cleanup and protection techniques for use at sites of unusual sensitivity, has been assigned to a Tactical Map Series. Here, the need for a high resolution of detail on such places as harbours, lagoons, estuaries and the like, necessitates the use of very large scales. The sample shown in Figure 2.3, page 22, is 1:8,000 but as with the other map series, the choice of scale is entirely dependent on the amount of detail required.

By adopting a system such as this, the manual user will be able to quickly assess the potential impact of a spill, (regional maps), determine how a response should be organized (operational maps) and implement the protection and cleanup of individual, high priority areas (tactical map). Among its several advantages, it provides a well-structured approach to oil spill response, it sorts data into well-defined information sets and it removes the need to map every coastal area at the same large scale, regardless of environmental significance.

The first format, section 2.0, is an example from a pilot study (conducted by the Environmental Emergency Branch) on the southwest coast of Vancouver Island during 1980 and 1981. Its primary departure from the recommendations of Woodward-Clyde Consultants is in its use of a textual format as opposed to one relying on reference codes. Each component in the operations and tactical map series is therefore self-contained, requiring no reference to other sections of the publication. This is advantageous in that it can be readily understood. Its main disadvantage is that the information load each map component can handle is somewhat limited.

The Woodward-Clyde proposal is provided in section 3.0. This approach to the preparation of shoreline protection and cleanup manuals is similar to the format presented in 2.0 insofar as map scale and information sets are concerned. The Woodward-Clyde countermeasures manual, however, includes a distinct and separate component. Briefly, each homogenous coastal strip is assigned a numerical description. This code is then referenced to several tables which detail physical conditions, environmental concerns, protection techniques and the like. The advantage of this scheme is that a great amount of information can be placed on a single map and legend sheet. Its primary drawback is that the user must look elsewhere to decode the system.

This format was employed in part, to prepare a Shoreline Protection and Cleanup Manual for the south-west coast of Vancouver Island as an in-house pilot project of the Environmental Emergency Branch. This manual, currently under review, incorporates many of the recommendations made in the Woodward-Clyde report. The purpose of this paper is to explain how someone else can prepare a contingency planning manual. It also explains the use of video taping as an effective, cost-efficient tool in the preparation of a manual.

2.0 EPS CONCEPT

The pilot study, carried out in 1980, resulted in the preparation of a shoreline protection and cleanup manual for the southwest coast of Vancouver Island, British Columbia. Various formats were devised for presentation of data accumulated during the research phase of the project. It became apparent that a single series of maps, drawn to a uniform 1:50,000 scale, was too inflexible to have much value. Apart from the difficulty of incorporating both environmental data and countermeasures on the same map sheet, it was apparent that the complexity of some sites was such that the 1:50,000 map series would not permit a detailed description sufficient for their protection. Similarly, other areas were so straightforward that to map them at a fine scale was considered unnecessary.

The solution to this problem was to adjust the scale of maps to correspond to the sensitivity of each site and to consign countermeasures procedures and resource sensitivities to a text. Map space was therefore freed up to contain only that information considered most useful to the manual user. The general layout of the manual consists of three types of maps; a regional series which gives a general overview of the area and its main sites of environmental sensitivity, an operational series which provides greater detail with respect to shorelines, countermeasures and resources and a tactical series at greatly expanded scale which focuses in on individual sites of significant human or biological importance.

2.1 Regional Map Series

The first thing required, should a large spill occur, is an overview of the situation. The On-Scene Commander will want to know where the oil is, where it is moving, its speed and where it will impact shorelines. These are real-time information requirements that cannot be pre-determined. Potential environmental impacts can, however, be predicted in advance, as can the availability of access routes, logistics, equipment, manpower, currents, bathymetry, shoreline type and the like. Information requirements for regional maps have been listed on Table 2.1. For the purpose of this initial overview, the manual should contain what has been designated a Regional Map Series. A scale of 1:250,000 is sufficiently detailed to provide essential data which can be assimilated at a glance. Scales of up to 1:1,000,000 may be appropriate in some circumstances. Figure 2.1, page 14, is a regional map example. A map of this scale may be sufficient to cover a whole study area or it may form part of a series that covers an entire coastline. If the path of approaching oil slicks can be predicted with a reasonable degree of accuracy, reference to this map will indicate what resources lie in the path of the oil, the degree of concern that should be expressed in the protection of those resources and whether or not a seasonality factor enters into the interpretation of sensitivity. Each regional map can also provide a general shoreline description to indicate what kind of coast is threatened, a key map to locate it relative to other coastal areas and a legend that identifies resources at risk in a simplified fashion. The regional map does not proffer any advice on response, but is an excellent method of informing the On-Scene Commander of potential problem areas.

The priorities assigned to such sites have been deliberately kept simple. They do not depend on an elaborate numbering scheme nor do they result in situations where an unacceptable impact has been overlooked due to its incorporation as a component in a larger total. Simply stated, an area of primary concern year round is one where the impact of oil will cause a prolonged, deleterious effect on the resources in question. An extensive shellfish bed is one example. An area of primary concern seasonal, is one where contact with oil will have a pronounced effect during certain times of the year but not at others. A seabird colony and herring spawning ground are examples. An area of secondary concern is one where contact with oil is believed to have only a short term impact or where oil will rapidly dissipate through wave and weather action. Response in such an area is desirable, provided that primary sensitivity sites have been adequately protected. There is sufficient scope in this method to provide for sites of tertiary concern, but this level has not been employed owing to the absence of criteria sufficiently detailed to allow for fine discrimination between resources of equal sensitivity.

TABLE 2.1: REGIONAL MAP INFORMATION REQUIREMENTS

Biological

- seabird/waterfowl nesting, feeding, roosting and migration areas
- marine mammal colonies, haulouts, breeding grounds and foraging areas
- intertidal and benthic shellfish grounds
- fish spawning and feeding areas
- estuaries, lagoons and mudflat environments
- highly productive inter-tidal areas
- marine vegetation
- seasonality factors influencing all of the above

Physical

- general shoreline character

Human

- townsites, settlements and residential areas
- marine oriented economic activities
- industrial and commercial waterfront
- Indian Reserves
- parks, ecological reserves and recreational waterfront
- archaeological and historical sites
- unique aesthetic phenomena

2.2 Operational Map Series

The second component of the oil spill manual concept deals with the Operational Map Series. These maps have been drawn to a scale of 1:50,000 and are intended to collectively provide full coverage of the study area. Reference to the Regional Maps will have isolated the general area of the spill impact. By turning to the appropriate operational maps which cover the impacted area, the on-scene commander will find a diverse array of information (Table 2.2) that will be useful in implementing his field operations. The 1:50,000 scale allows for a greater degree of definition for such parameters as shoreline classification, access points, bathymetry, topography, boom deployments, sacrificial beaches, current directions and velocities, logistics and the like. Each operational map is accompanied by a legend which identifies additional resource material and countermeasures, as well as a text which discusses spill response, shoreline protection, cleanup, access and the resources most likely to be impacted by either the spill or by cleanup operations. Figure 2.2, page 17, is an example of how this operational map series might appear.

2.3 Tactical Map Series

The Tactical Map Series is not intended to provide full coverage of the study area but only those sites or areas that warrant an intensive response. In general, each site identified on the regional map series as being of primary concern should be covered with a tactical map to highlight important physical and logistical factors. The E.P.S. manual for the south west coast of Vancouver Island departed considerably from the consultants recommendations as to how a tactical map should be prepared. The E.P.S. view was that a well prepared map accompanied by a textual description on shoreline cleanup and protection provided sufficient detail and was easy to understand. Figure 2.3, page 22, is an example of how this map series was treated.

The Woodward-Clyde recommendations appeared better suited to the site-specific preparation of contingency planning manuals rather than a method

TABLE 2.2: OPERATIONAL MAP INFORMATION REQUIREMENTS

Physical

- shoreline classification
- current directions and speed
- nearshore bathymetry; backshore topography
- wave and weather climate
- potential staging areas and marine access points

Logistical

- roads, trails and shoreline access points
- beach trafficability
- docks and marine support facilities
- food, fuel and lodgings; communications and transportation facilities
- potential staging areas, launch ramps, barge landings
- suitable helicopter or seaplane landing sites

Countermeasures

- spill response alternatives which reflect the advantages and constraints imposed by local conditions prevalent in the area under discussion
- protection techniques suitable to the meteorological and oceanographic conditions present
- cleanup suggestions appropriate to the character of the shoreline in each area
- rehabilitation methods to coincide with the type of cleanup techniques employed

Resource Material

- identification of marine charts, topographical maps, aerial photographs, video tapes and other information that may be useful to the on-scene commander
- potential oil collection points, burning sites and disposal sites.

TABLE 2.3: TACTICAL MAP INFORMATION REQUIREMENTS

Physical Data

- shoreline description: type, slope, energy exposure, sediment transport, trafficability
- nearshore bathymetry and topography
- currents and circulation of marine waters
- low-energy debris accumulation areas (areas where oil may also accumulate)

Logistical Data

- marine and terrestrial access points
- waterfront land status/ownership
- communications and transportation facilities
- docks, airstrips, helicopter pads, float plane landings etc.
- oil and oily debris disposal or burning sites
- references to appropriate marine charts, topographical maps, aerial photographs, video tapes, etc.
- staging areas, field headquarters, accommodations
- equipment and manpower resources

Countermeasures

- boom deployments, channel widths, sacrificial beaches
- protection and cleanup recommendations
- identification of areas or sites that may be sensitive to human impact during cleanup operations; e.g. archaeological sites, salt marshes, unstable beaches
- sources of replacement material for excavations
- environmental constraints on equipment capability; inherent site-specific advantages that may augment the efforts of response teams.

that could be used to embrace the complexities of a long coastal strip. Their proposal had considerable merit in that it reduced the task of identifying countermeasures to a system of tagging discrete sections of coast with a code that related to a response guidebook at the end of the manual. Each tactical map was therefore accompanied by a legend which listed separate codes for access, resources, ownership, land-use, protection strategies, cleanup strategies and countermeasure constraints. Detailed information requirements are listed in Table 3. In addition, tactical charts covering the same area were employed to depict tidal currents, boom orientations, oil accumulation areas and logistic data.

The primary problem with this system is that although it is extremely precise, it does not lend itself to fast and easy interpretation. Moreover, its dependability relies on a fairly exact knowledge of beach types, water circulation, land status and the like. This knowledge is available for only a few well-studied sites on the Pacific Coast. Chapter 3 illustrates the Woodward-Clyde recommendations.

2.4 Shoreline Video Taping

An invaluable aid to the preparation of the Shoreline Protection and Cleanup Manual were the low altitude, oblique angle video tapes that had been taken over the south-west coast of Vancouver Island in the summer of 1980. This footage was shot during an exceptionally low tide during which much of the intertidal zone was well exposed to the camera. By fortuitous circumstance (on this coast at least), the weather was clear and calm, and the sun was at a good angle for taking high resolution shots of shoreline detail.

The video tapes were provided to Dr. J. Harper of Woodward-Clyde Consultants of Victoria, initially for the purpose of establishing a series of maps and coding sheets characterizing the different shoreline types to be found in the area. This essential information was incorporated into the manual, but after reflection, it was decided that the tapes themselves would provide an excellent reference to the users of the manual. The tapes were subsequently dubbed with a sound track describing this coast and the ways and means by which it could be protected or cleaned up. (Woodward Clyde, 1981)

Videotaping is relatively inexpensive, depending primarily on the cost of the airplane or helicopter used as the shooting platform. Standard ¾" Sony equipment was used to record the twenty minute cassettes that formed the raw footage. The recordings were made from an altitude of approximately 400 feet, at a speed of 70 to 80 knots, from a position 300 yards off the beach. The camera was hand held to reduce the effect of the aircraft's vibration, at an angle of 45° off the course of the aircraft. As zooming in tended to exaggerate any movement of the camera, this was avoided except when passing narrow inlets or bays that the aircraft could not enter. Details on time, speed, altitude, location and height were continuously entered into the video logbook. This is especially important when taping extensive lengths of remote shoreline where recognizable landmarks are few and far between. It is also advisable to take at least two persons on the taping crew- one to hold the camera and the other(s) to keep a flight log, tend the equipment, change tapes, change batteries, monitor the tape and coordinate the pilot and the cameraman.

Once taped, the video cassettes can be used as a permanent and continuous record of the shore zone. They can be edited, spliced with maps and slides, dubbed with visual characters for map references and dubbed with an audio track describing the coastline as it passes across the television monitor. Their availability to other interested parties lessens the need for single purpose overflights of study areas in that they can fulfill more than one purpose. While one user may refer to them for oil spill planning purposes, another may find them excellent for shoreline classification, mapping or monitoring of coastal processes.

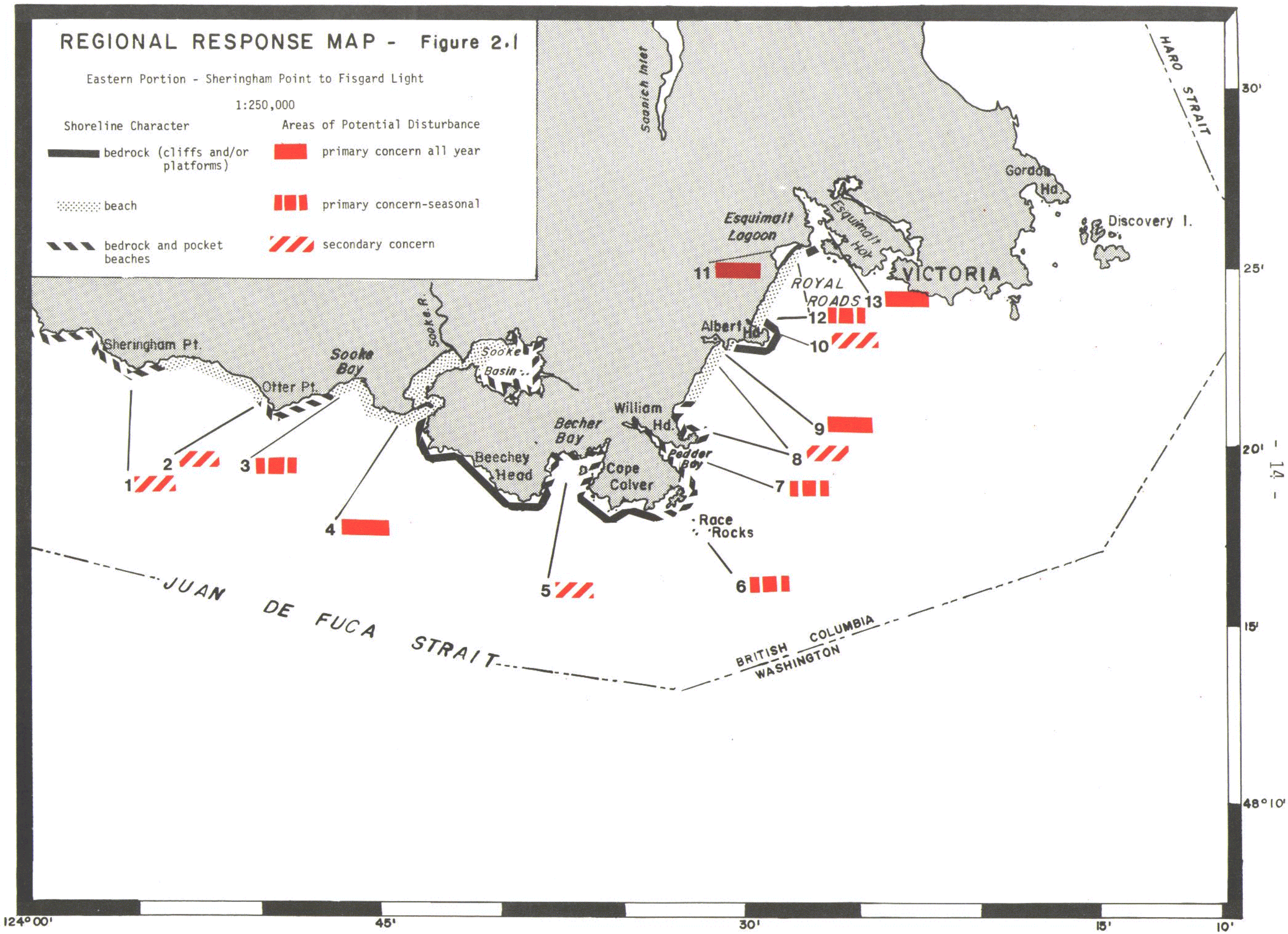
Unlike vertical aerial photographs, video tapes taken at an oblique angle to the shoreline, are more readily interpreted and provide a greater degree of detail to the viewer. As tapes are continuous, they provide better coverage than still photographs or slides at little extra cost.

Similar surveys have been conducted on the coasts of Newfoundland, Labrador, the Northwest Passage, the Beaufort Sea, and northern and central California.

For those individuals or organizations interested in conducting their own video-taping program, the article, "Shoreline Aerial Video-Tape Surveys for Spill Countermeasures", by E.H. Owens and G. Robilliard in the September-October, 1980 edition, (vol. 5) of the Spill Technology Newsletter has been included at the end of this report. Demonstration tapes can be viewed at the Pacific Region office of the Environmental Emergency Branch, Kapilano 100 Park Royal, West Vancouver, B.C. or through Woodward-Clyde Consultants Ltd., 16 Bastion Square, Victoria, British Columbia.

FIGURE I

Sample Regional Response Map


REGIONAL RESPONSE MAP - Figure 2.1
Eastern Portion - Sheringham Point to Fisgard Light
1:250,000
Shoreline Character
bedrock (cliffs and/or platforms)
beach
bedrock and pocket beaches
Areas of Potential Disturbance
primary concern all year
primary concern-seasonal
secondary concern
HARO STRAIT
Discovery I.
Gordon Hd.
VICTORIA
Esquimalt Hbr
Esquimalt Lagoon
ROYAL ROADS
Albert Hd.
Saanich Inlet
Sooke R.
Sooke Basin
Sooke Bay
Sheringham Pt.
Otter Pt.
William Hd.
Becher Bay
Pedder Bay
Beechey Head
Cape Colver
Race Rocks
JUAN DE FUCA STRAIT
BRITISH COLUMBIA
WASHINGTON
1
2
3
4
5
6
7
8
9
10
11
12
13
124°00'
45'
30'
15'
10'
48°10'
20'
25'

Regional Response Map - Sheringham Point to Esquimalt Harbour

1:250,000

1. Sheringham Point/ French Beach
   - provincial park at French Beach
   - productive inter-tidal shelves; harbour seals
   - lighthouse and weather station at Sheringham Point

2. Otter Point/ Gordons Beach
   - residential and recreational beach use
   - archaeological sites
   - recreational salmon fishing - juvenile salmon

3. Sooke Bay
   - residential and recreational area; Indian Reserve
   - seabird and waterfowl wintering area
   - prawn, shrimp and geoduck fishery
   - small log booming area in Sooke Bay

4. Sooke Harbour/ Sooke Basin
   - oyster aquaculture; shellfish, crab, prawns, shrimp and herring spawn locations.
   - seabird wintering area and migratory bird stop over
   - commercial and recreational marine facilities
   - extensive log booming and barge activities
   - fish processing plants; marine industries
   - residential and recreational shoreline use
   - townsites at Sooke, Milnes Landing, and Saseenos
   - several important estuaries
   - large Sooke River salmon escapement
   - Indian Reserve at Sooke River Delta

5. Becher Bay
   - marinas, launch ramps; log booming and storage
   - Indian Reserve and residential shore use
   - wintering area for seabirds and waterfowl

6. Race Rocks
   - ecological reserve; sea lion and seal haulout
   - bird colony and roosting area
   - diverse and abundant inter-tidal and sub-tidal biota
   - light house and weather station

7. Pedder Bay
   - estuary; shellfish and crab; squid spawning
   - seabird and waterfowl wintering area
   - recreational marina; Lester Pearson College

8. Weirs Beach/ Wittys Beach
   - recreational beach use in summer

9. Wittys Lagoon (Metchosin)
   - Bird Sanctuary; saltmarsh environment, shellfish
   - recreational and residential area

10. Albert Head Lagoon
    - bird sanctuary; greatest disturbance in spring and fall
    - recreational beach activities

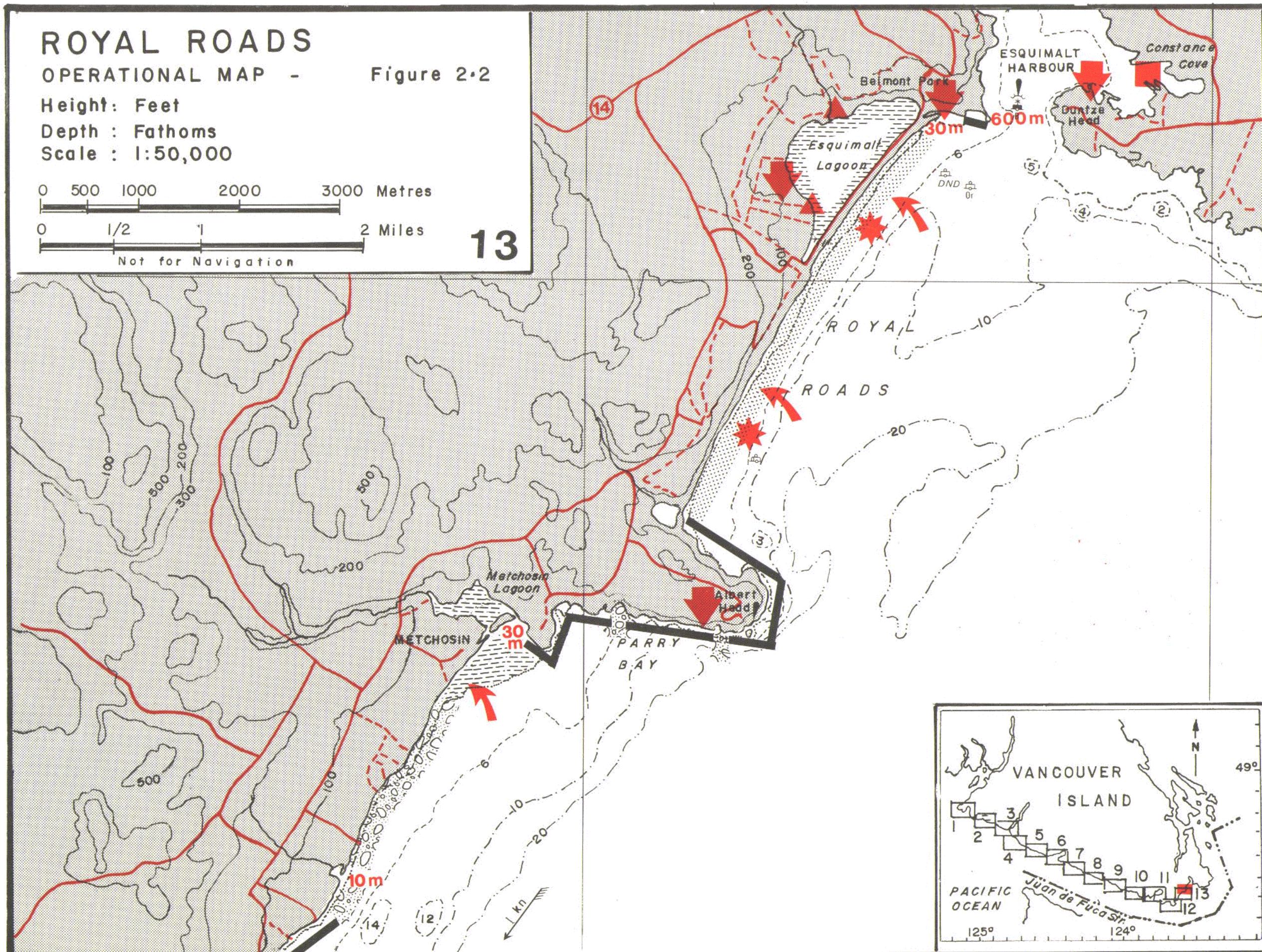
11. Esquimalt Lagoon
    - important bird sanctuary; prime sensitivity during spring and fall; less sensitive during summer and winter
    - mud flats and marsh vegetation; clam beds
    - aesthetic and recreational beach activities
    - residential areas; Royal Roads Military College

12. Esquimalt Spit Beach (seaward side)
    - extensive beach use during summer but popular recreation site year round.

13. Esquimalt Harbour
    - major naval base; graving dock
    - commercial, recreational and industrial marine facilities
    - log booming, barging and lumbering activities

FIGURE 2

Sample Operational Map


ROYAL ROADS
OPERATIONAL MAP - Figure 2·2
Height: Feet
Depth : Fathoms
Scale : 1:50,000
0 500 1000 2000 3000 Metres
0 1/2 1 2 Miles
Not for Navigation
13
ESQUIMALT HARBOUR
Constance Cove
Duntze Head
Belmont Park
Esquimalt Lagoon
30m
600m
DND
ROYAL ROADS
Albert Head
PARRY BAY
Metchosin Lagoon
METCHOSIN
30 m
10 m
48°25'
123
3°25'
VANCOUVER ISLAND
PACIFIC OCEAN
Juan de Fuca Str.
N
49°
125°
124°
1 kn

Legend

Shoreline Classification

- Bedrock cliff
- Rock platform
- Mixed sediment
- Sand
- Tidal Flats
- Sequence of rocky headlands and pocket beaches

Access

- Road
- Trail
- Docking facility
- Launch ramp
- Staging area
- Float plane landing
- Helicopter pad
- Marine access

Resource material

Hydro. charts	3422/3448/3413
Topo. maps	92 B/5 92 B/6
Video tape	#7

Countermeasures

- Boom deployment — metres (m)
- Sacrificial beach
- Oil collection point
- Oil burning site
- Oil disposal site

Operational Map 13 - Royal Roads

Spill Response

Southeast winds may make offshore response impractical but during calm weather or mild westerly conditions, the operation of boats and other floating cleanup applicances should pose no problems for the on-scene commander. As oil slicks are likely to approach from the south on flood tides, response crews should have sufficient time to prepare for recovery, dispersion and protection operations. As fouling of shorelines in this map area is certain to result in public demand for meticulous cleanup, the on-scene commander must decide early that his containment and recovery equipment is either sufficient to control oil slicks or that intensive aerial and marine application of dispersants is his only chance to prevent severe shoreline contamination. The consequences of either option are profound and must be weighed with an appreciation for environmental and social repercussions.

Protection

Metochosin Lagoon and Esquimalt Lagoon are highly sensitive environments that should be fairly simple to protect. Approximately 50 metres of inshore boom will be sufficient to prevent oil from entering either place. A more effective strategy may be to dam their entrance channels with locally available fill until the threat of contamination has passed. This technique requires that a sub-surface culvert be installed to allow clean water to pass back and forth on tidal changes to maintain water temperature and quality.

Esquimalt Harbour should be protected with approximately 600 metres of boom at the entrance. As weather conditions and vessel traffic will likely make it impossible to simply install a continuous length of boom, special boom configurations will be required to permit vessel movement. Diversion and cascade modes are recommended. Extensive beaches north and south of Albert Head probably warrant protection but they may be more useful as sacrificial beaches which can be cleaned or replaced at the termination of the cleanup operation. Trench and dyke emplacements at the mid-tide level may prevent oil from reaching upper beach levels and facilitate oil collection. This technique is not effective when waves are high enough to erode earthworks.

Cleanup

The cleanup of sandy beaches between Fisgard Light and Albert Head will be fairly straight forward. Graders and elevating scrapers can pile the oiled sand into windrows which can be removed by scrapers or front end loaders. This beach has sufficient bearing capacity to permit access to large-tire vehicles.

The rocky foreshore around Albert Head will likely require manual cleaning with water or steam hoses, sand blasters or scraping tools. The headland is impassable but good access to other sites on this map makes its trafficability unnecessary.

Metchosin Lagoon is a muddy environment on either side of the barrier spit. Both foot and vehicular travel should therefore be discouraged. Oil removal below the high tide line should be done with low pressure water flushing. Sandy super-tidal areas are appropriate for moving machines along the beach.

The mixed sediment beach south of Metchosin Lagoon may pose more complex problems for cleanup crews. If oil contamination is light, flushing with copious amounts of salt water may float oil out of cobble beaches for collection at the water's edge. Heavily contaminated beaches will likely require excavation with front end loaders, bulldozers or clamshell drag lines. Excavated material should either be cleaned or land filled in an appropriate location. Excavated beaches should be restored with clean, compatible material.

Access

Road access to shorelines is excellent throughout this map area although permission from private owners in the Metchosin Lagoon area will be required. The sandy beaches north and south of Albert Head are sufficiently stable to permit passage by heavy equipment, particularly at low tides. If necessary, landing barges will encounter few difficulties placing cleanup equipment ashore in the few sites where road access is not available.

Resources

Metchosin and Esquimalt Lagoons are low energy salt marsh environments with many estuarian characteristics. Theyare excellent habitat for diverse aquatic organisms and a haven for a variety of seabirds and waterfowl. Esquimalt Lagoon has been designated as a federal bird sanctuary.

Open seaward beaches are reported to have clam populations while offshore, dungeness crabs and geoduck clams are found. Squid spawn on beaches south of Metchosin Lagoon during February, and smelt spawn is also reported in this area. Juvenile salmon are frequently encountered off Albert Head and Duntze Head during spring and summer.

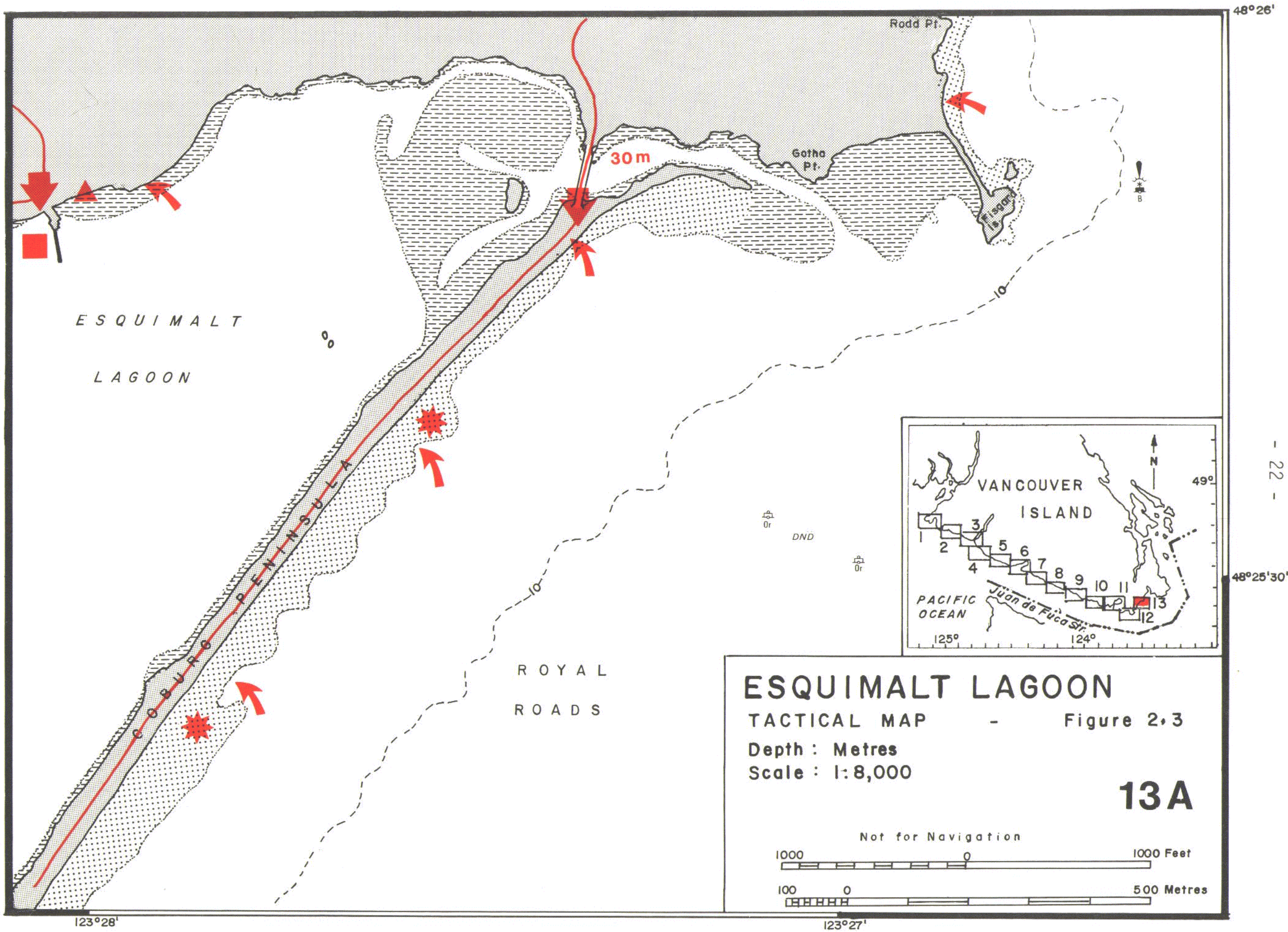
The natural beauty of this area has made it attractive to sightseers, beach goers and residential users. Metchosin and Esquimalt Lagoons have park and beach facilities as does Fort Rodd Hill Park at the western side of the entrance to Esquimalt Harbour.

Albert Head is owned by the Department of National Defence but public access is permitted. Much of the waterfront land south of Metchosin Lagoon is privately owned and the uplands over Esquimalt Lagoon are part of the Royal Roads Military College. Duntze Head, at the eastern entrance to Esquimalt Harbour is owned and utilized by the Department of National Defence.

The large sand and gravel operation at the southern end of Royal Roads is owned by Construction Aggregates Lt. If large amounts of fill are required to build dams or replace contaminated beaches, this facility, with its barge loading conveyor ramp, is the place to acquire such material.

FIGURE 3

Sample Tactical Response Map


48°26'
48°25'30"
123°28'
123°27'
Rodd Pt.
Gotha Pt.
Fisgard Is.
30 m
ESQUIMALT
LAGOON
COBURG PENINSULA
ROYAL
ROADS
DND
10
VANCOUVER
ISLAND
PACIFIC
OCEAN
Juan de Fuca Str.
N
49°
125°
124°
1
2
3
4
5
6
7
8
9
10
11
12
13
ESQUIMALT LAGOON
TACTICAL MAP - Figure 2.3
Depth : Metres
Scale : 1:8,000
13A
Not for Navigation
1000 0 1000 Feet
100 0 500 Metres

Legend

Shoreline Classification

- Bedrock cliff
- Rock platform
- Mixed sediment
- Sand
- Tidal Flats
- Sequence of rocky headlands and pocket beaches

Access

- Road
- Trail
- Docking facility
- Launch ramp
- Staging area
- Float plane landing
- Helicopter pad
- Marine access

Resource material

Hydro. charts	3417/3422/3413
Topo. maps	92 B/6
Video tape	# 7

Countermeasures

- Boom deployment — metres (m)
- Sacrificial beach
- Oil collection point
- Oil burning site
- Oil disposal site

Tactical Map 13 A - Esquimalt Lagoon

Protection

Esquimalt Lagoon is protected by a long sand spit except at its northern end where a twenty metre wide channel allows ocean water to pass during tidal changes. If offshore remedies have not been effective in preventing the approach of oil slicks, this channel should either be boomed or dammed to avoid oiling of the lagoon. Damming this narrow channel is likely to be the most effective method of protection, provided that allowance is made for the exchange of water during tide changes, either by constructing a valved, sub-tidal culvert under the dam or by pumping clean sea water directly into the lagoon. It may be unwise to do this if an excessive amount of oil has impacted the seaward side of Coburg Peninsula, due to hydrocarbons in the water column which may taint or distress biota within the lagoon. Conversely, if seawater is not kept in circulation through the lagoon, oxygen depletion or temperature changes may prove harmful to organisms. It is, therefore, important that the on-scene-commander expedites the removal of oil from the adjacent area in order to reopen the lagoon channel as soon as possible.

Cleanup

Cleanup of sandy beaches on the seaward side of Coburg Peninsula should be practical with the use of heavy equipment such as graders, scrapers and front end loaders. The bearing capacity of this beach should be sufficient to permit the passage of tyred vehicles. The use of tracked vehicles should be discouraged as they tend to grind oil deep into beach sediments.

Should oil enter Esquimalt Lagoon, cleanup will require a great deal of caution and care. Substrates within the lagoon are extremely sensitive to human and vehicular traffic which can cause oil to be mixed in with the fine grain sediment mud flats. Removal of oil from this environment may best be accomplished by flushing oil with low pressure water into collection areas. Once an area has been satisfactorily cleaned it should be protected from recontamination as other areas are subsequently flushed. Shallow draft floating platforms may provide the most effective work stations for operations in inaccessible areas of the lagoon, while limiting foot traffic.

3.0 WOODWARD-CLYDE CONCEPT - SPILL RESPONSE MANUAL

Contingency planning for oil pollution involves a number of components and steps that include:

- recognition of potential pollution sources,
- identification of damage that might be caused,
- identification of environmental factors that characterize the area, and
- organization of response in terms of coordination, assignments, and responsibility.

These criteria (IMCO, 1978, and Garnett, 1978) can be used to obtain the necessary information base from which the response organization and a set of response actions can be developed.

The actual layout or format of a contingency plan may vary, depending upon the nature of the potential threat and upon the character of the area to be covered. In each case there exists, however, a common information set which is required to develop response actions. Environmental data is essential in terms of evaluation of:

- the fate of spilled oil
- the effects of the spilled oil
- the deployment of countermeasure resources
- the effectiveness of countermeasure techniques

Certain elements of the information set are not predictable (e.g., the physical and chemical character of the oil, the volume of the spilled oil, air temperature, wind and wave conditions). It is possible, however, to obtain and organize a large proportion of the information set as part of spill response planning. In addition, it is possible to identify that data which is required at the time of a spill event (e.g., Robilliard et al, 1980). These two types of information can be categorized simply on the basis of the rate at which the parameter changes. Bedrock geology, rock platform width, sediment types, and so on, will remain essentially unchanged through time. Although these parameters are subject to change, the rates of change are slow. Other more variable parameters, such as beach slope, wave height, and wind direction, can only be identified by reconnaissance surveys at the time of a spill. Some measure of the range of values or of the average conditions (e.g., monthly wave height and period averages) can be obtained to provide guidelines for expected environmental conditions.

The purpose of this pilot study is to define and describe information that can be obtained as part of oil spill contingency planning, and that would be used to develop response actions. This study is oriented towards the physical rather than the biological character of the shore zone, so that the emphasis throughout is on:

- the fate and mechanical dispersion of stranded oil,
- the planning of shoreline countermeasure logistics,
- the physical character of the shore zone, and
- the evaluation of appropriate shoreline protection or cleanup techniques for different sections of coast.

The information is presented in a format that is intended for discussion purposes. This recommended format has been developed with a specific set of objectives in mind, so that no one single map scale or set of tables is applicable for all cases. Certain planning objectives must consider large areas in order to develop decisions for the deployment of resources to high priority areas. Such regional "strategical" decisions require a very different information base from "tactical" decisions that relate to actual cleanup operations on individual beaches. With these different objectives in mind, three sets of maps are presented, each at a different scale and each depicting a different set of information. These maps are derived primarily from the information set presented in Section 2 of this study.

The specific objectives of each of these sets of maps are identified in Table 3.1 . It is important to note that the most detailed maps series (1:16,000) is developed initially, and that subsequent map series are derived from this first set. The order in which the maps are presented and discussed is the reverse to that in which they were prepared. Spill response strategies are developed initially at a regional scale. The evaluation of an actual response action increases in detail and decreases in aerial coverage to the level at which a site-specific countermeasure is implemented.

TABLE 3.1 Objectives and Characteristics of Spill Response Maps

SCALE	MINIMUM SIZE OF MAPPED FEATURES	OBJECTIVE	FEATURES
1:16,000 (tactical maps)	15 m	• to indicate the type of adverse impact that could be expected and recommend appropriate countermeasure actions • to provide site-specific information for the implementation of protection or cleanup operations	• minimum length of mappable units ∿50 m • detailed information presented for actual response actions • usually only developed for coastal units that would require a high-priority response
1:50,000 (operational maps)	50 m	• to identify areas or sections of coast where a spill would have an adverse impact • to identify the nature and timing of the potential impact	• minimum length of mappable units ∿150 m • data organized to identify physical, biological, logistical information on a unit-by-unit basis • accompanying tables provide details on data and on time element of potential impact
1:250,000 (strategy maps)	250 m	• to identify regions of primary concern in the event of a spill where a response action would probably be required and would be a high priority	• minimum length of mappable ∿1000 m • no site-specific data • indicates general (physical) shore-zone character and locations of parks, wildlife sanctuaries, and settlements • provides a guide to the potential level of concern

The discussion of regional strategies (Section 3.1) provides recommended information requirements to identify areas of primary concern. For area-specific planning (Section 3.2), the scale (1:50,000), the format, and the data requirements alter to permit greater levels of detail with respect to the nature and timing of potential impacts. The implementation of response actions requires further, site-specific, details which are presented in this pilot study at a scale of 1:16,000 (Section 3.3). These tactical maps should be supplemented by reconnaissance surveys at the time of a spill, and the information requirements for both pre-spill and real-time surveys are discussed in Sections 3.2.2 and 3.3.2 The methods and techniques which could be implemented are described in detail in Section 3.4 to provide information on the suitability of these response actions for different shoreline types and environmental conditions.

The map scales used in this study are designed to be appropriate for other locations or sections of coast. It may be necessary, however, to adopt different scales depending upon the size of the area or the length of coast in question. For example, strategical maps for the entire coast of British Columbia or Newfoundland and Labrador may be more effective at a scale of 1:1,000,000 or even 1:5,000,000 to provide a broad regional picture of the high priority areas. Similarly, for greater detail of specific sites such as Vancouver Harbour (Burrard Inlet) or Toronto Harbour it may be preferable to prepare detailed tactical maps of scales in the order of 1:5,000 for short sections of shoreline. The actual scales that are used are not intended to be fixed. Map scales are dependent on the purpose of the mapping project and as such should vary to meet changing objectives or changing dimensions of project areas.

The primary recommendation that is presented in this study is that different scales or levels of detail are required to meet a series of different objectives within a spill response manual or an oil spill contingency plan. Access parameters and data on the bearing capacity of intertidal sediments are only necessary at detailed site-specific scales (>1:20,000). By contrast, the regional distribution of wildlife sanctuaries is best displayed on regional maps (<1:100,000) that identify the locations of coastal sections that would require a high response priority.

This concept of defining specific objectives and preparing the information base to meet these objectives, in tabular or map format, is crucial to the improved presentation of relevant data.

Often in the past data or information have been gathered and organized on a topical basis (e.g. the distribution of physical shoreline types; the location of mammal haulouts; etc.) with little or no reference to the timing of natural cycles, such as migratory or breeding cycles, or to the selection of practical countermeasures that takes into account logistic or environmental constraints at the time of a spill. Consideration of a problem on a logical basis defines the nature of and level of detail of the information that is necessary to answer specific strategical or tactical questions. By this approach the On-Scene Coordinator or a Task Force is not inundated with a large volume of material which must then be filtered to locate or isolate the required information set.

No set of rules can be developed for response actions as decisions must be made that are appropriate to a set of conditions at the time of a spill. There are questions, therefore, which can only be answered at the time of an incident. The objective of pre-spill planning is to obtain and organize data or information that is unlikely to change over short time periods (months/years). This information base, combined with data collected by reconnaissance or site surveys at the time of the spill incident, is designed to provide the necessary inputs for the response decision-making process.

The approach presented in this section provides one method by which relevant information can be presented at different levels of detail to answer different questions that would be asked during a spill response operation. The methodology presented here focuses primarily on the concepts rather than on individual details and should be discusses with this factor in mind. The data and information presented in the examples have not been verified or checked, as this report is intended to be a discussion document rather than an actual response manual.

3.1 REGIONAL STRATEGY MAPS

3.1.1 Introduction

A primary question that must be asked at the time of a spill event is: "Will there be a major impact on man's activities or on particular species or habitats?", or more simply, "Will there be a problem?."

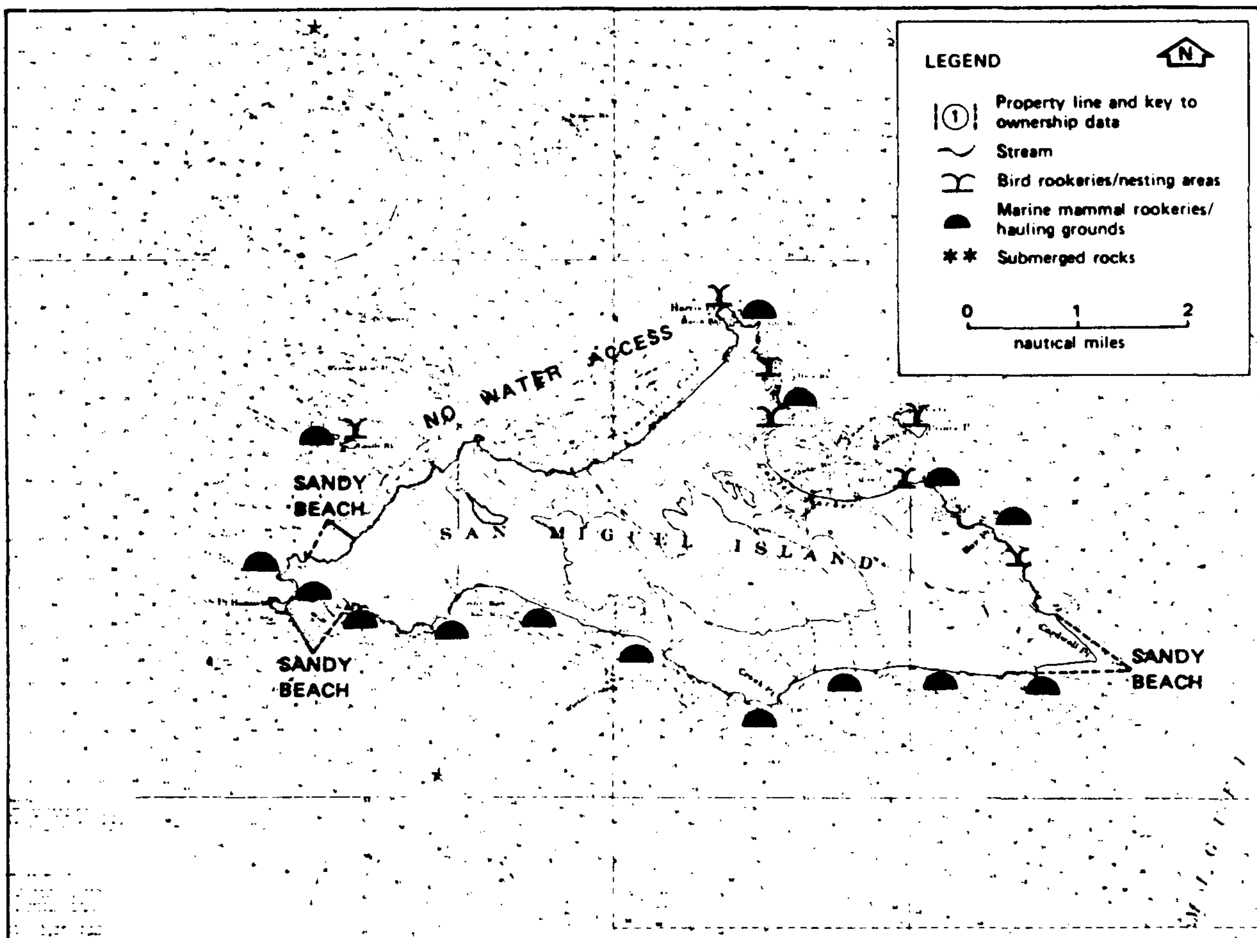
A knowledge of the character of the threat (e.g. volume of oil; location and movement of oil) and of the threatened feature(s) (e.g., location and status of migratory species; location of commercial or recreational elements that could be affected) is necessary to answer this initial question. A broad picture of the distribution of coastal sections where the threat poses a serious concern is required to analyze this question, except for small spills, which are restricted to a small area or to only a few (<10) kilometers of coast.

A number of mapping systems for spill strategy or countermeasure planning have been developed in recent years. In particular the "Oil Spill Vulnerability Index" developed at the University of South Carolina defined sensitivity to oil spills ("vulnerability") in terms of approximately 10 repetitive shoreline types (Hayes et al., 1976). The actual number and character of the shoreline types varies from area to area. One example of this approach, at a scale of 1:140,000 is given in Figure 3.1 and Table 3.2.* This approach has since been developed to include biological parameters and is referred to as an "Environmental Sensitivity Index" (Hayes et al., 1980). The ESI index code for one study is given in Figure 3.2.* Worbets (1979) developed a numerical sensitivity ranking system that involved human, biological and geological parameters in the analysis. This series of maps, at a scale of 1:150,000, includes information on access and logistics for countermeasures. The maps are characterized by a colour code to identify shoreline types and by plastic overlays to define sensitive areas.

* not shown

A recent example of a strategy map, prepared by Woodward-Clyde Consultants (1978), at a scale of 1:100,000 is given below . The information provided in this example indicates the general character of the area in terms of the shoreline types, access and ownership. The primary emphasis, however, is on the potential disturbance of the biological community. This information is plotted on a hydrographic chart and is described more fully on an accompanying text. This countermeasures map provides a variety of information that is related to the implementation of response actions.

Initial strategy decisions should be related to the identification of high priority areas for response actions and to the deployment of available equipment and manpower resources on a regional basis. These decisions require a regional information base at a scale that is sufficiently general to compare adjacent sections of coast. For the pilot study coast, which is approximately 250 km in length, a scale of 1:250,000 is considered appropriate in terms of the level of detail required to display the information



San Miguel Island (scale - 1:100,000): (from Woodward-Clyde Consultants, 1978).

3.1.2 Objectives and Conceptual Approach

The objective of a series of regional strategy maps is to identify potential problem areas or sections of coast. This information is designed to assist in the development of decisions related to identification of where response actions are likely to be needed and to identify the nature of the possible disturbance. At this regional scale an effort is made to minimize the level of detail of information that is presented on the maps. The primary purpose is simply to locate potential problem areas and to indentify the timing of possible adverse effects. The timing element is considered on a very general basis, and a differention is made between those sections of coast where the adverse effects would likely occur at all times of the year and those sections of coast where the adverse effects would probably be limited to specific time periods during each year.

The definition of an adverse effect relates primarily to biological communities and human activities. At this scale sensitive sites or habitats that are likely to be affected are identified. These might include wild-life sanctuaries, reserves, and habitats of rare or endangered species. The identification of potential disturbances with respect to man's activities would involve the distribution of coastal settlements, parks, and subsidence activities (e.g. oyster leases, water intakes). Other types of information may be depicted on these regional maps, for example the location of permanent airstrips or of docking facilities such as wharves and jetties. Major road access characteristics can be depicted if the information is plotted on topographic maps. This road access information is not designed to identify whether specific access of the shore zone itself is available, but only to indicate that there are roads in the general area of the coastal zone.

The approach taken for the regional strategy maps, as presented in the example in Section 3.1.3, is to use topographic map sheets that have been cut into smaller sheets which can be easily inserted into a three-ring binder with an 8½" X 11" format. Relatively little information data is presented on these regional strategy maps. The physical shore-zone character, derived from more detailed maps indicates the general character of the coastal zone in terms of the presence or absence of sediments and rock.

The location of parks, reserves, or sanctuaries, settlements, airstrips, and docking facilities could be shown by symbols or patterns. Areas of primary concern in terms of possible disturbances that could be caused by spilled oil are identified at 4 different levels (Table 3.2).

TABLE 3.3 Levels of Concern for Regional Strategic Response Planning

1. *primary concern:*
   countermeasure response necessary for all types of spills at any time of the year
2. *primary concern:*
   at certain times of the year only
3. *secondary concern:*
   countermeasure response likely to be necessary at certain times of the year
4. *tertiary concern:*
   no known potentially serious biological or human activity disruptions: countermeasure response probably not required

The areas of primary concern are identified on the basis that there would likely be a severe disruption either of habitat or of man's activities, irrespective of the type of oil and volume of the spill or of the time of year. On these sections of coast it is likely that a protection or cleanup response would be required. Within these primary areas a lower level subdivision is identified on the basis of a potential disruption of habitat or of man's activities for all sizes of spills and for all types of oils, but only at certain times of year. At this second level of concern it is necessary to take into account cycles of biological activity (for example, breeding seasons, migratory species, growth cycles) and the seasonality of man's activities (for example, the recreational use of an area or the timing of commercial activities that may be related to biological cycles).

At the secondary level of concern the expected or potential impact of the oil is considered to be less serious. No specific criteria are presented at this time for identifying serious or non-serious concerns. The sections of coast regarded as being of secondary concern would perhaps be identified by default, as they would not be areas of either primary or tertiary disruption. In the latter case, the identification procedure for sections of coast of tertiary concern is based upon the fact that there are no known potentially serious disruptions for either biological or human activity in an area or on a given section of shoreline. On these sections of coast there is unlikely to be a disruption of biological or human activities, and these would probably be sections of coast where no response actions would be likely.

Identification of areas of primary concern provides, for a decision maker, the location of those sites to which equipment and personnel would likely be directed immediately at the time of a spill situation. At this strategical level the development of broad-scale response actions requires a knowledge only of the location of sites of concern, not a knowledge of the nature of the problem itself. The approach taken is simplistic but directs attention immediately to sites or areas where protective countermeasures would be required.

3.1.3 Strategical Map Example

The objective of a regional strategy map is to identify areas of sites of concern. The map is designed to provide a rapid indication of where countermeasure resources might be required for shoreline protection actions to mitigate potential disturbances from a known threat. The information presented on the map (Fig. 3.1) shows the general physical shore-zone character (in black-and-white) and the areas of concern (in red). The base is a topographic map so that information on the location of settlements and primary roads may be obtained. No attempt is made to provide an accurate resolution of areas or sites as this is precluded by the map scale.

Once an area of concern has been identified and is threatened by an oil spill it is necessary to determine how the oil would disturb biological or human activities. This involves reference to the more detailed (1:50,000) set of maps described in Section 3.2. From the example given in Figure 3.1 it is clear that the areas of primary concern on this map are located on the coast between Sooke Harbour and Cadboro Bay. Seven areas would be of primary concern at any time of the year, for any size of spill, and for any type of oil. No areas or sites of primary or secondary concern occur on the coast to the west of the entrance to Sooke Harbour.

The relevant data and information are presented on a 1:250,000 topographic map and a set of accompanying notes. The map identifies sites or areas of concern, and the black-and-white pattern outlines the physical shore-zone character. Some indication of the regional shore-zone character is of great value in planning at this level, as both biological habitats and response actions are, to a large degree, governed by the physical environment (Owens, 1977b).

The general area of concern is located on a map, but the precision is limited at this scale, as the smallest size of feature that can be identified is in the order of 250 m. Greater detail on the exact areal boundaries, and on the timing and nature of a possible disturbance, is given on the operational map series.

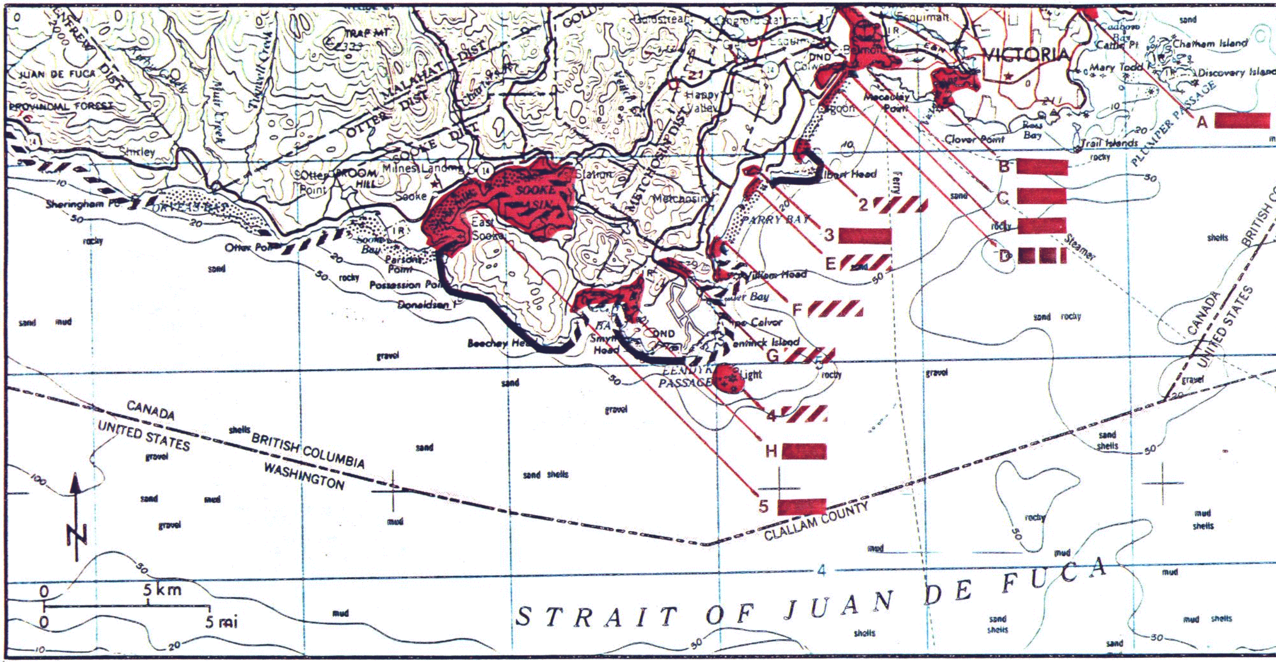
The strategy maps present a minimal level of information. The relevant data are screened so that only the results of a study are presented, rather than the reasons or explanations. The basic data set from which the results are derived may be very detailed, but this knowledge is not required for regional planning.

3.1.4 Summary

Strategy planning involves the identification of areas or sites of concern on a regional scale. The level of detail required for this phase is not great, as the emphasis is on the identification of concerns rather than on the explanation of the nature of the possible disturbance. The information is required for regional planning to deploy equipment and resources over relatively large sections of coast (>100 km).

The approach presented in this pilot study is to define areas or sites of primary and secondary concern in terms of disturbance to biological species or habitats, and to human activities. A time element is included for those areas or sites defined to be of primary concern, to indicate if the threat should be considered serious at all times of the year, or only during specific time periods.

Sample Regional Strategy Map



LEGEND

Physical Shoreline Character

- bedrock outcrops (cliffs and/or platform)
- beach
- small-scale repetitive sequence of bedrock and sediment or sediment veneer beaches

- Areas/sites of potential disturbance described on opposite page
- sections of tertiary concern; no known potentially serious biological or human activity disruptions
- sections of secondary concern
- sections of primary concern; at certain times of the year only
- sections of primary concern; year round

REGIONAL SPILL STRATEGY MAP - 1: 250,000

<u>Sites/Areas of Potential Biological Disturbance</u>

1. <u>Esquimalt Lagoon</u>
   - bird sanctuary; supports large number of a wide variety of waterfowl, seabirds, and shorebirds - especially during the migratory seasons
   - extensive eelgrass beds and, near the entrance, clam beds
   - human use high for aesthetic purposes (bird watching; beach walking)
   - numerous permanent dwellings and Royal Roads Military College front onto lagoon shore
2.
   - small bird sanctuary
   - some resident birds in summer and winter, but disturbance would be greatest during spring/fall migratory seasons
3. <u>Witty's Lagoon</u>
   - bird sanctuary; primary disturbance would be to migrating waterfowl and seabirds in spring and fall, and to resting species in winter
   - also supports clams, crabs, eelgrass and a salt marsh
4. <u>Race Rocks</u>
   - provincial ecological preserve
   - sea lions (northern and California); harbour seals; some seabirds, a very abundant and diverse intertidal/subtidal fauna and flora
5. <u>Sooke Harbour/Sooke Basin</u>
   - oyster aquaculture sites; herring spawning areas; crab, clam and shrimp areas; waterfowl stopover during migration
   - several marinas; log-booming area; fish processing plants; numerous recreational/commercial shoreline facilities
   - north shore heavily populated

<u>Sites/Areas of Potential Disturbance to Human Activity</u>

A. <u>Oak Bay/Cadboro Bay</u>
   - recreational areas; marinas, yacht clubs, aquarium (sea-water intake)
   - residential area; beaches heavily used in summer; high aesthetic value year round

B. <u>Victoria Harbour</u>
   - numerous industrial, commercial and recreational faciltles including docks, marinas, wharves and ferry terminal
   - aquarium has a sea-water intake
   - biological preserve around the breakwater

C. <u>Esquimalt Harbour</u>
   - major naval base; graving dock; lumber mills; log-booming areas; several commercial and recreational facilities

D. <u>Esquimalt Spit Beach</u>
   - high-use recreational beach in summer months

E. <u>Witty's Beach</u>
   - recreational beach in summer months

F. <u>Weir's Beach</u>
   - recreational beach in summer months

G. <u>Pedder Bay</u>
   - marina and recreational boat-launching ramp

H. <u>north Becher Bay</u>
   - marinas and launching ramps
   - log booming areas

Figure 3.1 Strategy map for the Victoria-Sooke area.

3.2 OPERATIONAL MAPS

3.2.1 Introduction

Decisions regarding the exact nature of response actions for a given section of coast must be taken at a more detailed scale than the regional strategy maps. At this level of detail, the primary questions are: "What is the distribution of oil on the section of coast?" and "What is the nature of the disturbance of a species/habitat or of a human activity, for the volume and type of oil on the shoreline?".

The knowledge base for the development of operational decisions requires information on the exact nature of the biological disturbance or of the disturbance to human activities. It is not adequate to simply define the areas of concern. Information that explains how the oil affects a habitat, a species, or a subsidence activity is necessary in order to determine the degree of concern and the level of the disturbance.

At this level of detail it is also necessary to identify a time element. Certain biological activities or human activities may be variable in time, and therefore the severity of the disturbance may also vary on a monthly or seasonal basis. A particular example would be the use of a habitat or section of shoreline by a migratory species. It is necessary to identify that section of coast which is used by that species, and to indicate the usual time periods of occupancy. It is also important at the time of the spill to undertake a reconnaissance survey to identify if in fact that migratory species has occupied that section of shoreline at the time of the incident. Many instances are documented where the timing of a migration or the location of stopover areas changes from year to year.

Operational planning is related to the identification of specific threats on specific sections of shoreline. Some assessment is required to define the potential severity of the disturbance. For the pilot study coast, a scale of 1:50,000 is considered appropriate in terms of the level of detail and of the information base necessary to answer the primary questions (Table 3.1; page 27

The format developed for this pilot study to present the operational level information is to (a) display on maps the spatial aspects of a potential disturbance, and to indicate the general level of severity, and (b) describe the timing elements and the actual nature of the disturbance for different habitats, species or activities in a series of tables and notes. In addition, the physical shore-zone character is depicted on the maps in terms of six repetitive shoreline types. The number and character of these shoreline types may vary from area to area.

A key element of this series of maps is the tabulation of the level of disruption or disturbance with time (month of the year). Once a site or area has been identified in terms of the existance of a threat from spilled oil, the location is displayed on a 1:50,000 map. The area is coded on the map by a number (for a biological disruption) or a letter (disturbance of human activity) that relates to text or tabular information, and by a pattern that indicates primary, secondary or tertiary levels of concern (Table 3.2). The accompanying tables indicate, for each identified location, the expected level of disruption by species or by activity for each month of the year. Thus, the spatial and temporal components are related to an evaluation of the expected severity, or level of concern, associated with an oil spill threat. Further information that describes the nature of the disturbance is provided in the notes or text that accompany the map and tables.

The evaluation of possible biological disturbance is again related to three levels of concern. At the tertiary (or lowest) level, the expected disturbance is minimal, the species is absent, or the activity is suspended. The primary levels of concern are associated with long-term species or habitat disturbance, and with the disruption of rare or endangered species. The time element here is taken to be greater than one year for recovery of a species or habitat; the most serious level of concern has a recovery time element of longer than 5 years.

The potential disturbance of human activities also relates to the three levels of concern. The most serious level of disturbance would involve a large proportion of the resident population. A recent example of this type of threat occurred in 1980 at the Hasbah 6 blowout in the Arabian

Gulf. The closure of power plants and desalination plants by oil contamination through water intakes would have affected the health and safety of the populated areas, as well as having a major disruptive effect on all commercial activities. At less serious levels of concern (secondary) the disturbance could involve closure of aquaculture or harvesting areas; for example, clam or oyster beds that provide income for one or only a few families. The scale of concern is therefore related directly to the degree to which human health and safety are disturbed, the level of economic disruption, and to the size of the population body that would be affected by the spill. Commercial activities, upon which a large number of families depend for income, clearly would be more threatened that would recreational facilities, such as bathing on a sandy beach, from which little or no income is derived. At the tertiary level of concern, the disruptive effects of spilled oil are not considered significant from a health and safety standpoint, nor in terms of economic losses.

The mapped distribution of repetitive physical shoreline types is supplemented by information on the wave climate, wave-energy levels at the shoreline, tidal range, and the character of the tide. For this study, these data can be obtained directly from the coding sheets (Section 2.3). A knowledge of wave climate and of the levels of wave energy provides background knowledge for evaluation of the expected persistence of oil that is stranded, both within and above the normal limits of wave activity (Owens, 1978). The seasonality of energy levels, or the preeminence of swell versus storm waves, provides information on the timing of beach cycles that control the erosion or burial of oil stranded on beaches (Owens, 1977a). Similarly, in ice-infested waters it is important to identify the open-water season and the timing of shore-fast ice growth and decay cycles. Tidal range and tidal character (the latter refers to diurnal, semi-diurnal, or mixed cycles) control the distribution of wave energy across the shore zone, and also affect the distribution of stranded oil. All of these physical environmental factors are significant in an assessment of the expected distribution and persistence of oil that reaches the shoreline.

The implementation of mitigating countermeasures is a response to the threat of potential damage. Operational planning involves consideration of the nature and severity of a potential disruption and of the rates of natural cleaning of stranded oil. There are many sections of coast where the threat of disruption is not great and where rates of mechanical dispersal could be high. For such sections, the operational planning decision may be to let the shoreline processes remove the oil, and to focus resources where they could be used to greater advantage.

The preparation of these pre-spill operational maps is intended to identify the expected disturbance of a species, habitat or activity. At the time of a spill, a reconnaissance survey must be carried out to identify that the mapped element is actually present on a section of coast. This is particularly important for migratory species or seasonal activities, but can also apply more generally; for example, a marina or aquaculture area may be inactive or out of business. The type of data and information requirements for operational planning are outlined in Table 3.3 (c.f. Table 3. 6, p. 52). Real-time surveys determine the actual presence (or absence) and abundance of an element, after that element has been identified from the pre-spill analysis or survey.

From an operational standpoint, temporal variability is a critical consideration. Of special significance are the migrations of fish and numerous sea birds, waterfowl, and shorebirds. A site may be occupied by large numbers of a vulnerable species, but may be highly sensitive during only a few weeks each year, when the site is occupied. Similarly, a marsh system is more or less disturbed at different periods during the year, depending upon the growth phase of various plant species and upon the presence of water-associated birds and estuarine-dependent larval fish or shellfish. During the rest of the year, these habitats may be much less disturbed by an oil spill (Owens and Robilliard, 1981b). The importance of the timing of a spill cannot be understated. Elmgren _et al._, (in Kineman _et al._, 1980) note that the _Tsesis_ incident occurred, in the Baltic in October 1977, at a time that was least critical in terms of aquatic biota and human activity. Had the spill occurred during a different season, the impact may have been substantially different. Pre-spill mapping for contingency plans must take into account these temporal variations, not only in the distribution of flora and fauna, but also in the frequency of man's activity.

TABLE 3.3 Examples of Information and Data Requirements for Operational Planning (after Owens and Robilliard, 1981a)

Pre-Spill Studies

Spill Factors:

- nature of potential threat
- probable type of oil
- maximum spill volume

Physical Factors:

Shoreline character

- sediments; morphology
- beach cycles
- backshore character
- nearshore character

Shoreline processes

- winds; waves; tides; currents
- wave climate; storm frequency
- ice cycles

Biological Factors:

Species/habitat relationships

- breeding/feeding/molting cycles
- resident or migratory patterns

Population parameters

- abundance and cycles

Rare or endangered species

- distribution, abundance, and activity cycles

Reserves or protected areas

- location; species

Human Factors:

Commercial or recreational activities

- distribution and character of activity
- timing of activity
- level of economic/manpower activity

Real-Time Spill Surveys

Spill Factors:

- volume of oil
- type of oil
- physical and chemical character of oil
- location of oil
- spill trajectory (if on water)

Physical Factors:

- meteorological conditions
- oceanographic conditions
- regional weather pattern and prognosis
- stage of beach cycle

Biological Factors:

- species distribution and abundance
- stage of biological cycles (breeding, molting, etc.)
- location of mobile or migratory species

Human Factors:

- actual commercial activities
- actual recreational activities
- potential disturbance of commercial/recreational species present in or entering an area
- potential threat to public safety or health

3.2.3 Operational Map Examples

(a) Parry Bay area

The objective of the map and text of tables at this scale is to provide specific information on the nature of the disturbance in both time and space. Text material is presented in a note or tabular format, rather than as a narrative, in order to enable the user to rapidly identify separate relevant pieces of information.

The map (Fig. 3. 1) ndicates the location of sites or areas of primary and secondary concern. These sites or areas are described in a series of notes (Fig. 3. 1 that provide information on the specific nature of a disturbance and on the species, habitats or activities that would be threatened. The actual level of concern and the timing of the concern for each important species, habitat or activities is indicated graphically on a separate set of tables (Tables 3.4 and 3. 5).

Additional information on the regional character is provided in the notes (Fig. 1.9b). This information briefly describes some of the physical characteristics and human activities of which the user should be made aware before assessing the potential effects of a spill and the expected fate and persistence of stranded oil, and before development of an operational plan for the area.

On this map sheet, only one area of primary concern is identified. This is a sheltered lagoonal environment, with wide, intertidal flats exposed at low tide, that is enclosed by a large barrier spit. The primary disturbances at this location would be to (i) migratory waterfowl in spring and fall, (ii) vegetation (eelgrass and salt marsh) during the spring-summer growing season, and (iii) clams at all times of the year. With this level of information, an operational plan could be developed rapidly to mitigate the potential disturbance from an oil spill. The key element of this example is that detail is provided only for those sections of shoreline where that information would be required. For these sections, the level of detail must be adequate to determine the nature and the potential severity of disturbance in both time and space.

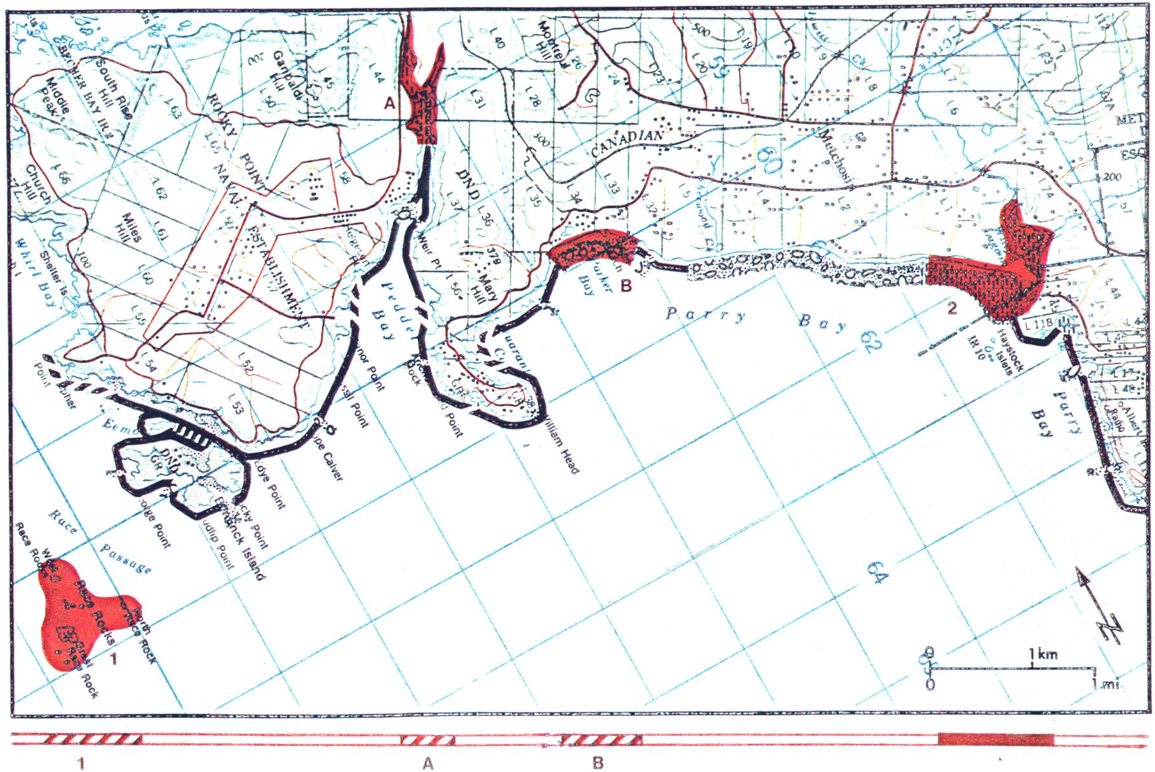


Figure 3.2 Operational map for Parry area
Physical shoreline character legend: Figure 2.2 page 17
Biological human disturbance legend: Tables 3.5 and 3.6 .

(a) Sites/Areas of Potential Biological Disturbance

1. Race Rocks

- federally protected ecological preserve
- abundant and diverse subtidal/intertidal fauna and flora
- sea lion, harbour seal haulout area
- numerous seabirds, in particular cormorants
- high-intensity use by scuba divers
- recreational fishing (salmon, rock cod, ling cod)
- intertidal organisms would be disturbed, possibly eliminated; in particular the red and green algae and the invertebrates in the mid/upper intertidal zone and on protected rocky shores; recovery period <5 yrs.
- mammals could suffer slight disturbance by oil; but if oil concentrations are high they would probably leave the area
- disturbance of shorebirds would depend on timing and local meteorological conditions (potential disturbance greatest during calm conditions in spring and fall; least during storm conditions in winter months)
- recreational users would avoid area if it became contaminated; no major disruption of human activities

2. Witty's Lagoon

- bird sanctuary: both residential and migratory species
- waterfowl and seabirds would be severely disturbed during spring/fall migration periods
- clams, eelgrass and salt marsh components would be subject to severe disturbance throughout year
- eelgrass and salt marsh areas less susceptible to disturbance during fall and early spring (non-growing seasons) depending on the oil type, volume of oil and countermeasure actions
- crab and fish disturbance would be seasonal; but is considered a secondary concern

(b) Sites/Areas of Potential Human Activity Disturbance

A. Pedder Bay

- marina and boat-launching area
- recreational activities could be disturbed; but no primary reasons for concern
- no biological reasons for concern

B. Weirs Beach

- recreational use of beach in summer
- no biological reasons for concern

(c) Physical Environment

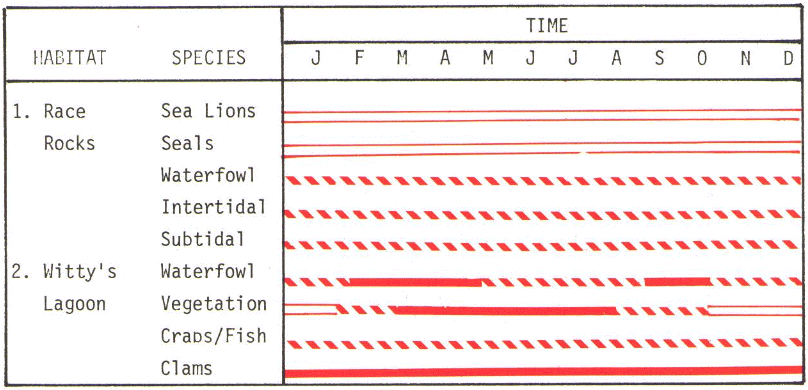
- mixed coast of beaches, bedrock outcrops, and sheltered embayments or lagoons
- log debris common on beaches in upper intertidal and supratidal zones
- east-facing coast exposed to storm-generated waves out of east and south
- maximum fetches approximately 50 km to the east/southeast and 20 km to the south
- storm frequency and wave-energy levels greatest in winter months
- shore-zone sediment transport south to north on beaches (i.e. towards Witty's Lagoon)
- tidal range 1.8 m (3.1 m at spring tides)
- mixed semi-diurnal tides

(d) Cultural Environment

- populated area; residential use in eastern half of map area
- shore-zone in western sections is primarily a restricted area (Dept. of National Defence, and federal penitentiary)
- public roads provide access to coastal sites or to adjacent backshore areas in most sections

Figure 3.4 Notes to accompany Parry Bay area operational map.

TABLE 3.5 Potential Biological Disturbance for Parry Bay Map Area



Objective: identify time span when an area may be used by important species and estimate the potential adverse effects

Tertiary concern — species absent or unlikely to be affected except by a major (1 M gal) spill

Secondary concern — minor or short-term habitat or species disruption: recovery potential 1 yr

Primary concern — serious or long-term species or habitat disruption: recovery potential 1-5 yrs

— serious disruption, >5 yrs; rare or endangered species; rookery or calving area

TABLE 3.6 Potential disturbance of human activities for Parry Bay Map Area

		TIME											
AREA	ACTIVITY	J	F	M	A	M	J	J	A	S	O	N	D
Pedder Bay	Marina												
B. Weir's Beach	Recrea-tional beach												

Objective: identify timing and severity of a potential disturbance for different human activities

Tertiary concern — no disturbance to recreational or commercial activities

Secondary concern — moderate disturbance, in terms of money or time, of man's activities, but no hazard to health or safety of inhabitants

Primary concern — serious disturbance that would (a) affect large portions of the population; (b) have a substantial economic impact; or (c) be hazardous to public health and safety

3.2.4 Summary

Operational plans involve the identification of sites or areas where a spill could cause disruption of biological species or habitats, or of human activity. Two important elements at this level of detail are to define the nature of the potential disturbance, and to describe variations in the severity of the effects in time. These latter, cyclic, variations are primarily related to seasonal aspects of biological habitats or activities. Lindstedt-Siva (1977) describes some aspects of potential biological disturbances, but to date no comprehensive discussion of the potential disruption to human activities has been prepared.

Previous studies at 1:50,000 scales of the physical shore-zone character (Bornhold et al., 1979) and of spill-related information (Canada, Dept. of the Environment, 1976; see also Hum, 1977) provide a useful data base for the preparation of operational maps. The primary emphasis at this level of detail in this pilot study is to focus on the nature of the problem, rather than to present information on logistics or on the implementation of countermeasures. The minimum size of a mappable feature at this scale is in the order of 50 m, which does not provide sufficient detail for site-specific planning.

The preparation of an information base to define and assess the nature of a potential concern involves both pre-spill studies and real-time surveys. Data on the exact nature of the threat, on meteorological/oceanographical conditions, and on the distribution and abundance of mobile species, cannot be obtained prior to a spill event.

The examples presented to illustrate the approach include a map that identifies the location and areal extent of possible concerns, both biological and human, and a set of notes that provide more detail for each location identified on the map. Tables indicate the timing and possible level of disturbance for each habitat, species, or activity. This approach, therefore, combines relevant information on the location, timing, nature, and on the degree of concern for sections of coast threatened by an oil spill.

3.3.1 Introduction

The response decisions taken at the regional and operational scales described in Sections 3.1 and 3.2 define areas of concern and specific sections of shoreline where a response action would be implemented. After decisions have been made at the regional strategy and the operational planning levels, a response action can be implemented by asking the following question: "What can be done to mitigate the disturbance of a species, or habitat, or of man's activities?". The operational planning decisions define which sections of shoreline are to be protected or cleaned, whereas the tactical level involves identification of how appropriate countermeasures are to be implemented.

The development of a tactical plan for the implementation of shoreline countermeasures must include specific information concerning logistics, access, and environmental constraints (e.g. sediment types, sea-state conditions). Evaluation of the efficiency and effectiveness of available countermeasures must also consider the effects of the technique(s) to ensure that the actions do not incur an unacceptable disturbance or damage themselves. In many instances, countermeasure actions have been known to cause more damage than that which resulted from the oil spill.

A suitable tactical plan would include the identification of command-post locations, staging areas and specific information, for example, on suitable booming locations. The map scale required to identify this detailed information, that might include access points, land use, and land ownership, would vary from site to site depending on the size of the area in question. In the example chosen for this pilot study, Sooke Harbour, a scale of 1:16,000 is considered appropriate. More detailed scales (e.g., 1:5,000) may be required for smaller sections of coast, such as a shoreline adjacent to a fuel dock or a water intake system. At this detailed tactical scale the primary emphasis is to document and display information that relates to the actual implementation of countermeasures (Table 3.1; page 27)

3.3.2 Objectives and Conceptual Approach

The decision to protect of clean up an area much consider how that countermeasure action can be implemented. Once the problem is identified (i.e., the threat and the concern are known), the solution is governed by available countermeasure options, in terms of equipment and manpower resources, and by environmental parameters such as accessiblity, sea state, and sediment bearing capacity that constrain the implementation of chosen option.

At this tactical level of spill response actions, it is possible to obtain and organize a large proportion of the relevant information base prior to a spill event. Operational factors such as the location of airports, docks, and wharves; the designation of temporary staging and permanent disposal sites; access points to the shore zone; and the trafficability or bearing capacity of the intertidal and backshore sediments can all be documented as part of contingency planning. Information on the availability and type of equipment and manpower resources for spill response can also be obtained during pre-spill surveys (Table 3.6). It is unlikely that this basic set of information will change considerably over relatively short periods of time (i.e., months or years). Examples of this type of information, presented at a more general scale, are given in the operational section (Figs. 3.5 to 3.8, and Tables 3.4 to 3.7).* The tactical implementation of spill countermeasures must involve consideration of meteorological and oceanographic factors at the time of the event. Real-time reconnaissance surveys are necessary to determine the exact distribution, volume, and character of the oil. This information set will be different for each spill incident, and is dependent upon local environmental conditions that change continuously through time. As with operational planning (Section 3.2), the required information base for the tactical implementation of countermeasures involves both pre-spill and real-time surveys. An outline of information requirements for tactical decisions is given in Table 3.6 .

*not shown

TABLE 3. 6 Examples of Information and Data Requirements for Tactical Maps.

Pre-Spill Studies

Environmental Factors:

- shoreline character and sediment bearing capacity
- nearshore bathymetry
- backshore morphology
- low-energy areas (potential oil accumulation areas)

Logistical Factors:

- shoreline access
- shore-zone ownership
- distances to logistic bases (airstrips, wharves, etc.)
- approved disposal sites
- suitable temporary staging areas
- suitable command-post locations
- personnel resources
- equipment resources

Tactical Constraints:

- geologic
- biologic
- human activities

Real-Time Spill Surveys

Spill Factors

- location of oil
- character of oil
- depth of oil penetration
- thickness of oil

Environmental Factors:

- air temperature
- winds and waves
- nearshore currents
- predicted tide stages and heights
- cone index values
- distribution of debris or logs

Logistical Factors:

- access permission
- availability of communications support
- availability of manpower and equipment resources

Tactical Constraints:

- oceanographic
- meteorologic

Evaluation of the efficiency and effectiveness of proposed countermeasure actions must involve consideration of the potential disturbance to the geological environment, the biological environment, and to human activities that might result from the protection or cleanup methods themselves. For example, the movement of equipment or personnel through a vegetated dune area could cause serious disturbance of the stabilizing vegetation that might result in the formation of dune blowouts and in erosion (see Section 3.4.3.2). Similarly, the use of equipment or other countermeasure techniques in marshes could destroy both the vegetation cover as well as the habitats. The deployment of booms across harbour or marina entrances could interfere with commercial and recreational boat traffic, and these factors must be considered when developing countermeasure options. In certain instances, the optimal protection or cleanup actions may cause more damage or more disturbance than the oil spill itself. In these situations, it may be necessary to select alternative, perhaps less efficient or less effective countermeasure actions, in order to avoid such damage or disturbance.

A primary emphasis in this pilot study is to segregate information sets so that specific questions can be answered in terms of the development of different levels of response actions. For this pilot study, the information that relates to the actual implementation of countermeasures is presented at the detailed, 1:16,000 scale, tactical level which is described in this section. The purpose of tactical maps is to describe limitations, constraints, or favourable factors that influence the implementation of spill countermeasures. At this scale and level of detail, it is also possible to suggest or to recommend appropriate response actions. Figure 3.3 is an example of a series of recommended response actions that have been identified on a base map that is a hydrographic chart. In particular, this response map indicates sites where booming could be effective to protect areas where biological or human disturbance might result from the spilled oil.

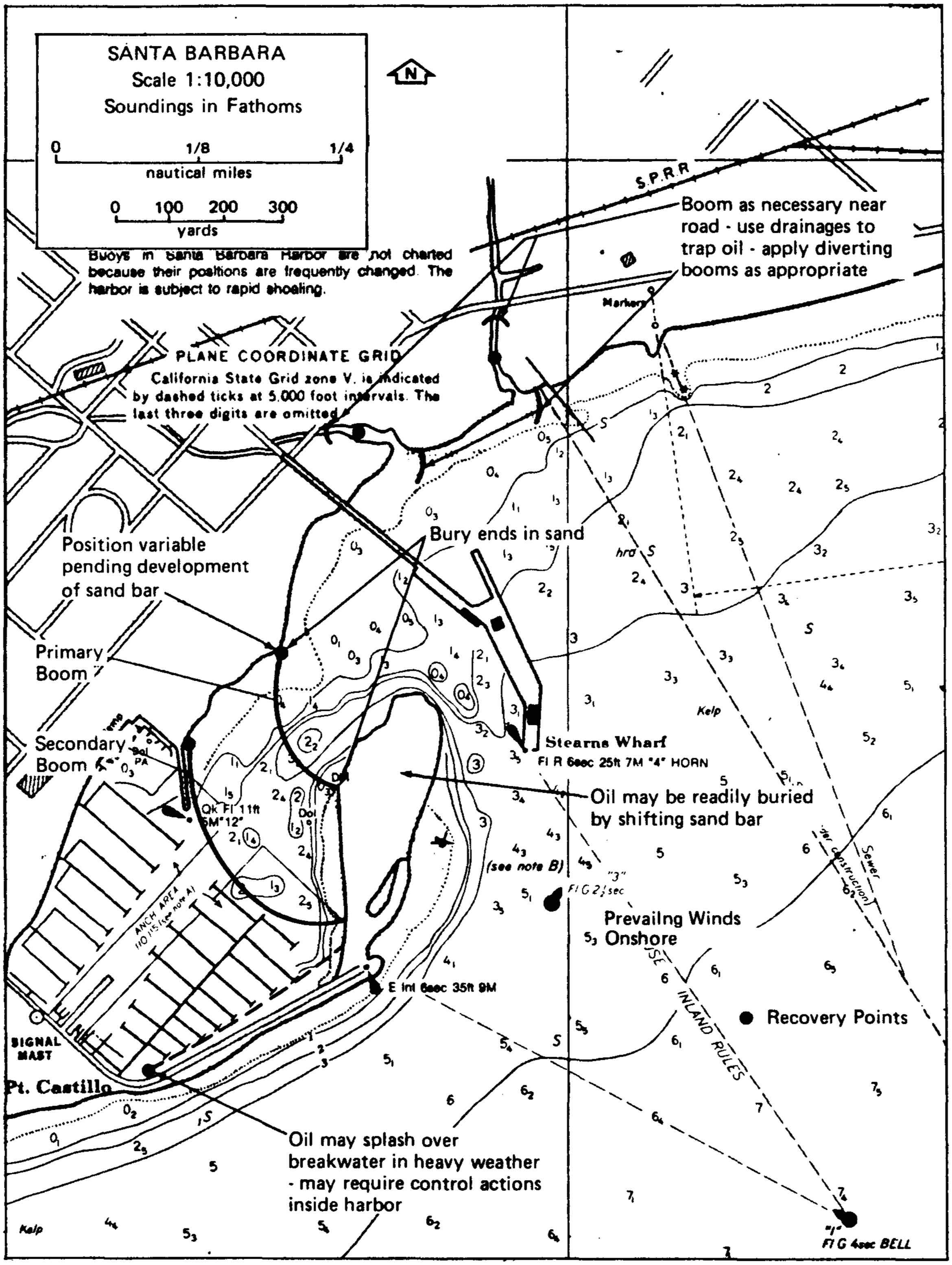


Figure 3.3 A detailed response map of Santa Barbara Harbour.

3.3.3 Tactical Maps Example

The area of Sooke Harbour and Sooke Basin has a well-developed geological, biological and countermeasures data base (Bornhold et al., 1979; British Columbia, 1980; Canada, Dept. of Environment, 1976). These studies present information at scales as detailed as 1:50,000, but this level of detail is not adequate for the planning or implementation of site-specific countermeasure actions. The tactical response maps should be of sufficient detail to identify features less than 50 m in size (see Table 3.1, page 27), and should contain a range of disparate information (Table 3. 4). The approach recommended in this pilot study is to present a series of maps, tables, and charts in order to present all of the necessary information.

The first map (Fig. 3.5) displays only relevant physical shore-zone and biological information. A greater level of detail on each of the physical shoreline units can be obtained by reference to the coding sheets and coding scheme presented in Sections 2.2 and 2.3.* The biological data is identified in terms of the distribution of species or habitats and further information, particularly on the timing of cycles would be obtained from the operational map series for that site or area (e.g., Table 3.4, page 47). A table that identifies a series of tactical parameters is keyed to the individual map units (Fig. 3.5). These parameters are coded (Table 3. 8) so that a relatively detailed information level can be used to describe each shoreline unit. In this example only 5 of the 10 map units are described in the table. Information on operational access, ownership and land-use are provided and appropriate protection and cleanup techniques are identified. Constraints on countermeasure actions are included as these must be evaluated before any action is implemented. The selection of appropriate countermeasures can involve the application of decisions guides (Section 3.4.2, page 63 ; and Section 3.4.3.1, page 83). The accompanying countermeasures manual (Section 3.4) includes information on the primary uses of available techniques and the effects that use of a technique might have on the geological and biological environment. This manual should be consulted during the evaluation and selection process for countermeasure actions.

* not shown

The area of the tactical map is covered by a hydrographic chart at a scale of 1:12,000 (Fig. 3.6). The bathymetric information presented on the charts is of great importance to tactical planning, and in particular to small-craft operations and to boom deployment. Superimposed on the hydrographic chart is data that relates to ebb- and flood-tidal currents (obtained by drogue measurements; D.P. Krauel, pers. comm.); possible boom deployment locations and configurations; shore-zone access locations; and possible staging areas (see legend of Fig. 3. 7). Oceanographic studies have determined areas where oil would likely accumulate during periods of calm winds (D.P. Krauel, pers. comm.).

The remaining maps and charts for Sooke Harbour and Sooke Basin (Figures 3.15 to 3.18) provide relevant information for the entire area. The data on the tidal circulation pattern (see Fig. 3.18) which indicates a predominant clockwise flow in Sooke Basin throughout most of the tidal cycle is of particular importance. On the flood tide a small counterclockwise back eddy is associated with this gyre in the northwest corner of the basin (fig. 3.14c). Current data plotted on the charts indicate that maximum velocities occur off Whiffen Spit (4 knots or 2.0 m/s) and at Billings Spit (3 knots or 1.4 m/s). Elsewhere within the channels drogue studies indicate that maximum currents are in the order of 0.5 to 1.0 m/s (1 to 2 knots). Operational data for the implementation of an action must also consider the timing of tide stages and the predicted water-level elevations (Table 3.11).

The tactical maps are presented here in a page-size format. For an area such as Sooke Basin it would be more appropriate to use a single map or chart, at the same scale as presented here, in order to effectively plan for the implementation of countermeasures actions. The key element of the tactical maps is that there is a large volume of information that is required and that this information is also very detailed and site specific. The preferred approach to display the data is to use more than one map (in this case a map and a chart) and a coded table rather than attempt to combine all of this disparate information on a single map.

3.3.4 Summary

The relevant information for tactical planning and/or decisions is presented at an appropriate level of detail on a set of maps, charts and tables. The objective of this scale of data presentation is to be site-specific. Once a problem (or concern) is identified the next series of actions relate to the evaluation of how a mitigating response can be implemented. This process requires a knowledge of environmental and logistical parameters as well as an understanding of factors or constraints that may limit the appropriateness or effectiveness of particular techniques.

The level of detail that is necessary to achieve the desired data base involves ground surveys and the use of detailed vertical aerial photographs (scale 1:10,000) and low altitude colour videotapes. The latter are of great value in preparation of the maps and can also be used to provide an audio-visual commentary on shoreline character and on appropriate spill countermeasures (Owens and Robilliard, 1980). From the air photos and videotapes it is possible to identify features on the ground with dimensions in the order of 5 m.

The pre-spill studies provide a large proportion of the necessary data base. This information must be supplemented at the time of a spill by meteorologic and oceanographic data as well as by details of the nature of the threat itself (i.e., the spill size and the physical and chemical properties of the oil). Detailed pre-spill studies could probably be developed only for areas where either the level of concern or the probability of a spill would be high.

OPERATIONAL ACCESS	Land	L_1	Heavy vehicle access by road
		L_2	Vehicle access possible by construction of temporary route
		L_3	Pedestrian access only
		L_4	No pedestrian access
	Sea	S_1	Dock, wharf or marina
		S_2	Water-depths >1 m at low tide
		S_3	Very shallow, or reefs, or kelp
		S_4	Exposed, potentially dangerous approach
	Air	A_1	Fixed wing backshore access
		A_2	Float plane
		A_3	Rotary blade aircraft
		A_4	No aircraft access
OWNERSHIP		C	Private: commercial
		F	Federal
		M	Local government
		P	Provincial
		R	Private: non-commercial
LAND-USE		a	Agricultural
		c	Habitation (seasonal)
		i	Industrial - commercial
		if	Industrial - forestry
		o	Unused
		p	Habitation (permanent)
		r	Recreation
RECOMMENDED COUNTERMEASURE TECHNIQUES	protection:		see Table 3.8 ; page 64
	cleanup:		see Table 3.9 ; page 91
COUNTERMEASURE CONSTRAINTS *		1.	Potential damange to dune vegetation
		2.	Sediment removal could cause backshore (cliff) retreat
		3.	Sediment removal could cause beach retreat
		4.	Anticipated low bearing capacity of sediments; or extensive log debris
		5.	Potential habitat damage
		6.	Operations limited to mid- or low-tide periods
		7.	Booms limited by strong nearshore currents
		8.	Booms would interfere with boat traffic
		9.	Pack ice would limit boom effectiveness

* These are examples, and the list is not intended to be complete

Figure 3. 4 Codes for tactical information.

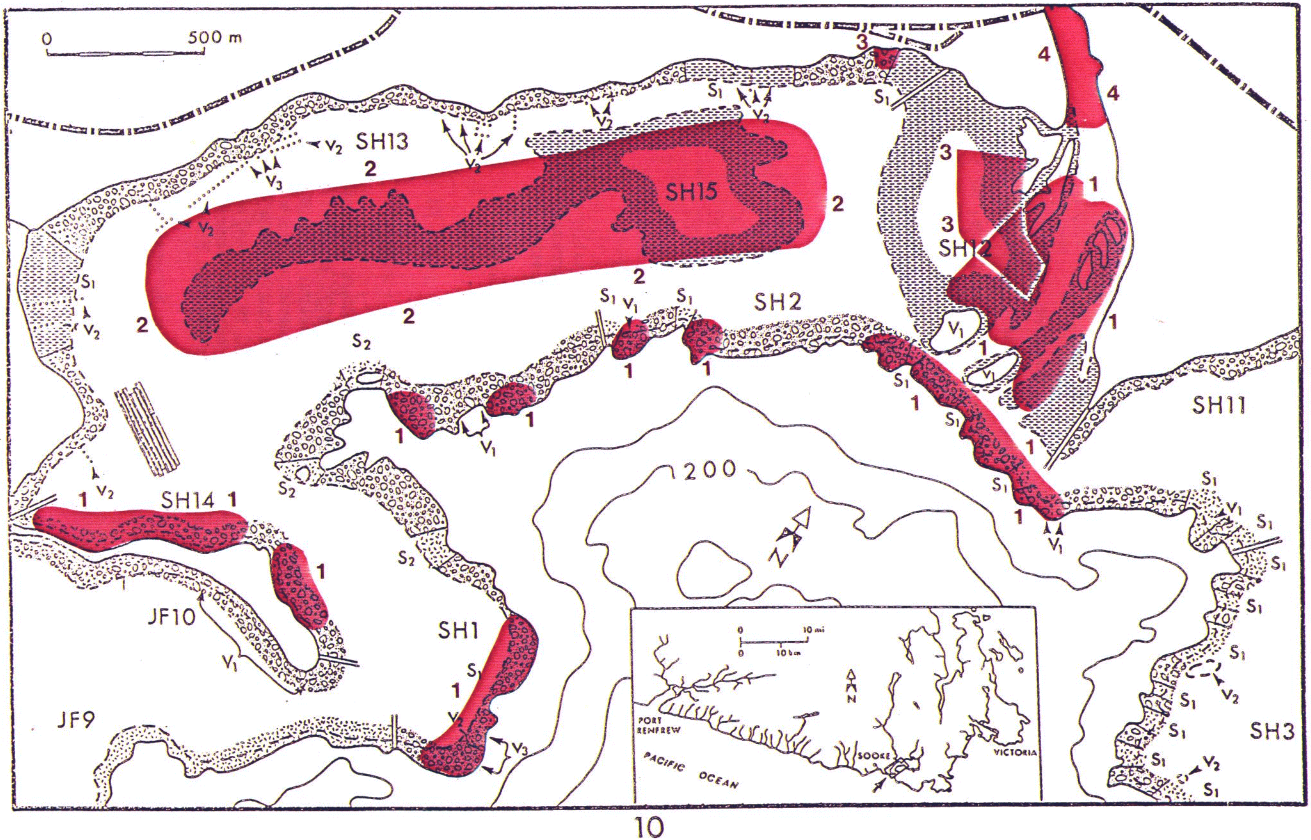


Figure 3.5 West Sooke Harbour tactical map.

PHYSICAL SHORE-ZONE CHARACTER:

BIOLOGICAL CHARACTER

1 clams

2 Dungeness crabs

3 oyster leases

4 salmon spawning route

5 herring spawning

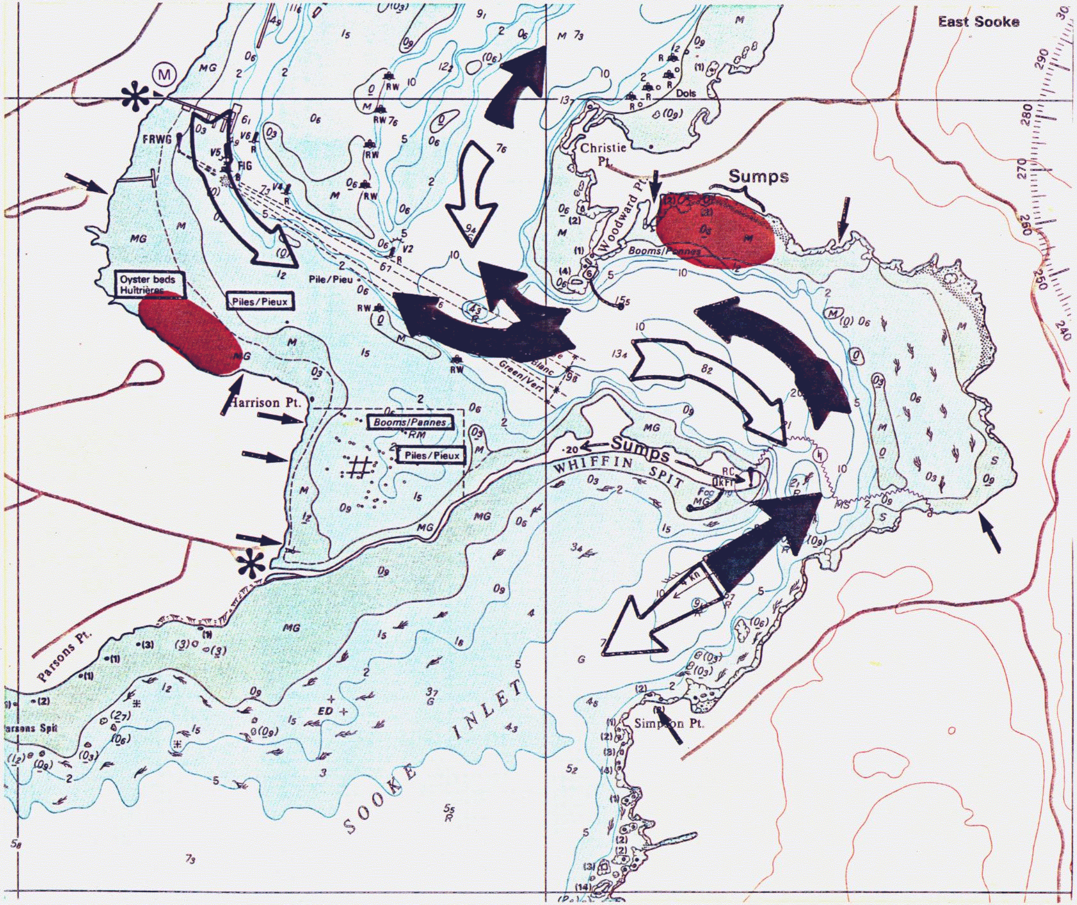
6 shrimp

TACTICAL PARAMETERS (see code sheet page 58).

PARAMETER \ LOCATION (unit)	JF 9	JF 10	SH 1	SH 13	SH 15
Access	$L_2 - L_3$	L_1	$L_2 - L_3$	L_1/S_1	S_3
Ownership	R	P	R	C/R	F
Land-Use	p	r	p	i/p	o
Recommended Countermeasure Techniques	(b) 8,11,13,16 23	(b) 4,5,12,23	(b) P, S_1 } 4,5,12; S_2 8,11,13,16	(b) 4,5,12	(b) 4,5,12,23
Countermeasure Constraints	6	3,4	3,4	2,4,6,7	4,5,6,7

Figure 3.5 West Sooke Harbour tactical map and notes.

Legend is given
on Figure 3.7
page 62



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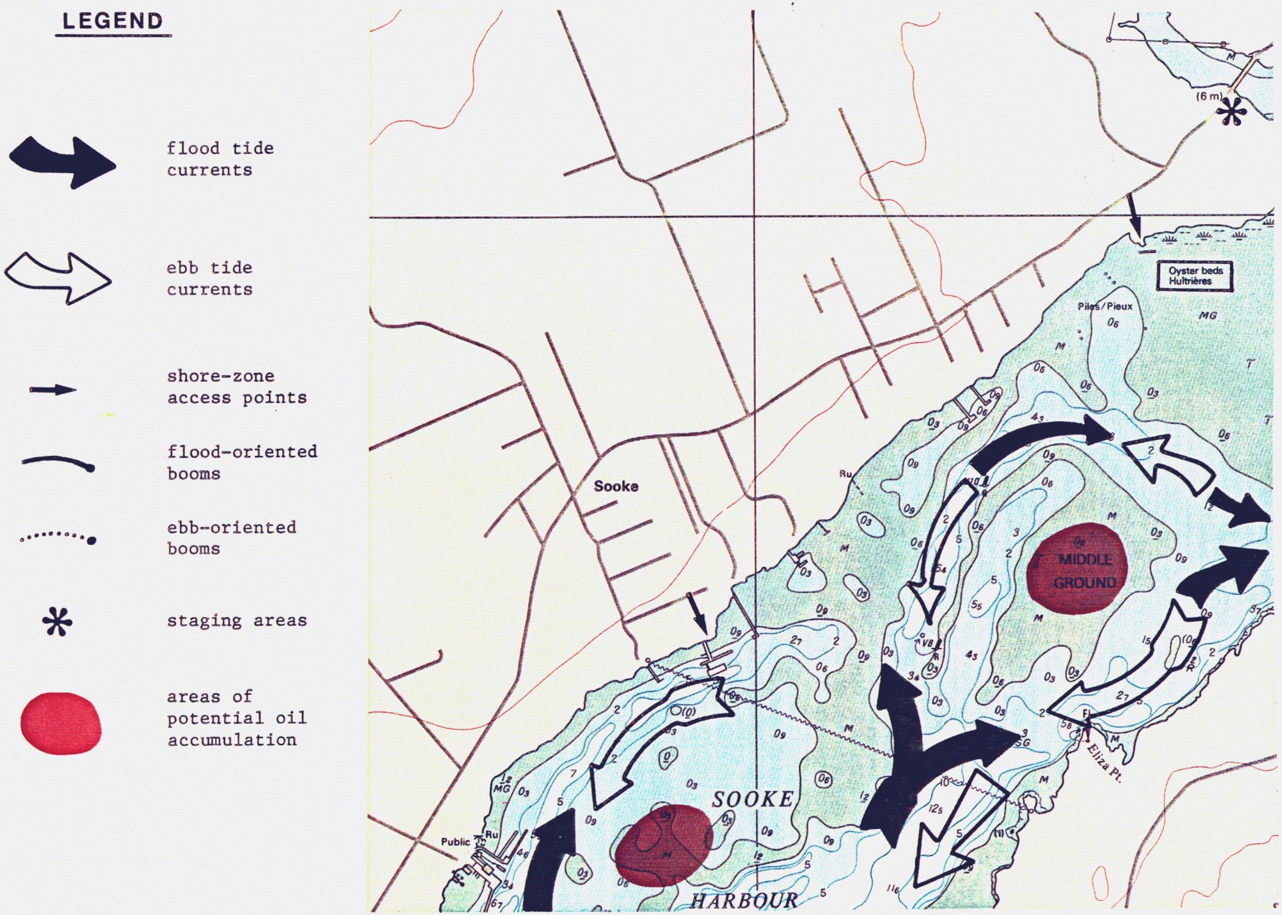

Figure 3.7 Tactical chart - Sooke Harbour. Legend applies to Figure 3.6

3.4 COUNTERMEASURES MANUAL

3.4.1 Introduction

The implementation of a countermeasure action involves the evaluation of available and applicable methods in order to select the most appropriate protection or cleanup technique(s). In this section a series of decision diagrams provide an approach by which appropriate response actions can be selected. Each of the protection or cleanup techniques that are applicable to the pilot study area are described individually. Much of the material presented in this section is derived from Foget _et al_., (1979).

3.4.2 Shoreline Protection Methods

The principle shoreline protection methods are described in Table 3.7 . Selection of an appropriate protection technique(s) for a shoreline or water area depends on the following factors:

- water body character (bay, tidal channel, open coast)
- presence and type of ice
- water current velocity
- coastal configuration (e.g., inlet, harbour entrance, straight coast)
- water depths
- sea state
- volume of oil

Figure 3. 8 presents a decision guide that has been designed to (a) help evaluate those factors that affect the use of a protection technique and (b) select the appropriate technique(s) for the collection of oil on nearshore waters.

TABLE 3- 7 Shoreline Protection Methods

OFFSHORE	METHOD	APPLICABILITY
(a) EXCLUSION BOOMING	• excludes oil from specific areas	• to protect small bays, harbours, inlets or river mouths • currents <0.5 m/s, wave height <25cm
(b) DIVERSION BOOMING	• deployed at an angle to approaching oil • diverts oil away from sensitive areas • oil removed from water surface	• where currents >0.5 m/s, and wave height >25 cm
(c) CONTAINMENT BOOMING	• deployed around oil • oil removed from water surfaces	• current >0.5 c/s • not applicable for large slicks
(d) SORBENT BOOMING	• deployed across approaching oil • oil absorbed by boom	• quiet waters • small slicks
ONSHORE	**METHOD**	**APPLICABILITY**
(e) SORBENTS	• applied manually or mechanically to the beach before oil is stranded • oil/sorbent is then removed manually or mechanically	• reduces penetration of oil into substrate • sorbent pads preferable to loose fibre materials for each of collection
(f) DYKES AND/OR DITCHES	• ditch up to 1 m deep dug parallel to shore at upper limit of wave action • sediment or snow removed used to build dyke 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
(g) BERMS	• keeps oil from upper intertidal area	• prevents oil from being washed into the backshore
EXPERIMENTAL	**METHOD**	**APPLICABILITY**
DISPERSANTS (water)	• sprayed directly on slick surface • facilitates 2 or 3 dimensional breakup and dispersion of slick	• requires permission of regulatory agencies • light to medium fluid oils • best suited in areas where natural dilution rate of dispersed oil is great
SURFACE COLLECTORS (water)	• applied as a spray between slick and shoreline • oil must be recovered	• effective use requires low wind and wave activity • most effective on sheens or thin slicks
SURFACE TREATMENT AGENTS (onshore)	• applied to shore zone before oil is stranded • prevents oil from adhering to and penetrating into 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
SURFACE COLLECTORS (onshore)	• applied along water line before oil is stranded (as a spray)	• applicability and effectiveness not yet fully assessed

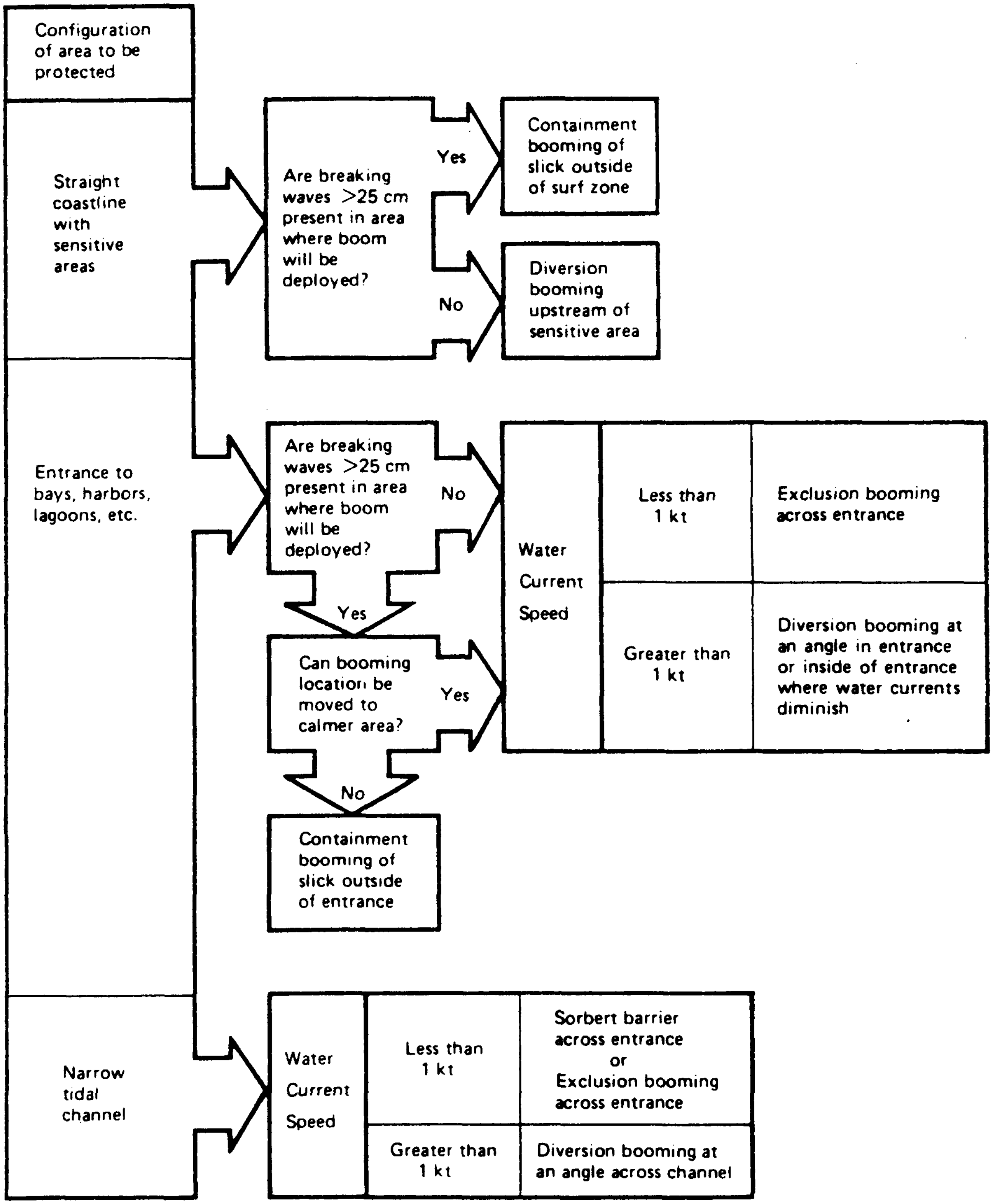

Figure 3.8 Protection decision guide for coastal waters (from Foget *et al.*, 1979).

The principle techniques can be subdivided into those which: (1) can be used on the surface of the water, (2) are used on the shoreline, and (3) are still considered experimental (Table 3.7). In the latter case, the techniques have not been proven to be effective in large-scale spills. The primary shoreline defence is to contain and collect oil on the water surface before it becomes stranded. It is preferable to collect the oil on the open sea rather than in the nearshore environment. Containment adjacent to shorelines is generally difficult because of wave action (breakers and longshore current). Booms that are deployed through a surf are rendered ineffective by waves breaking over them and can be damaged by the surf action.

The techniques for containing spills on open water adjacent to shorelines are the same as those employed to contain open-water spills further from shore (Fig. 3.9) and only techniques that are peculiar to shoreline containment and protection (i.e., diversion and exclusion booming) are discussed here.

3.4.2.1 Boom deployment for shorelines and protected waters.

(a) Diversion booming. Diversion booming is useful for the protection of sensitive areas. It is likely that a spill headed toward a sensitive area can be diverted to another shoreline location that is less sensitive and/or more easily cleaned up. In addition, diversion booming should be used where the water current is greater than 1 knot. At water velocities greater than 1 knot containment booms tend to become inefficient; oil will flow beneath the skirt, rendering the boom relatively ineffective. Diversion booms should be deployed at an angle closest to the leading edge of the approaching oil slick to deflect oil toward the shore. Figure 3.10 shows the optimum angle of boom deployment for various current speeds. Two methods of diversion booming can be used during containment operations.

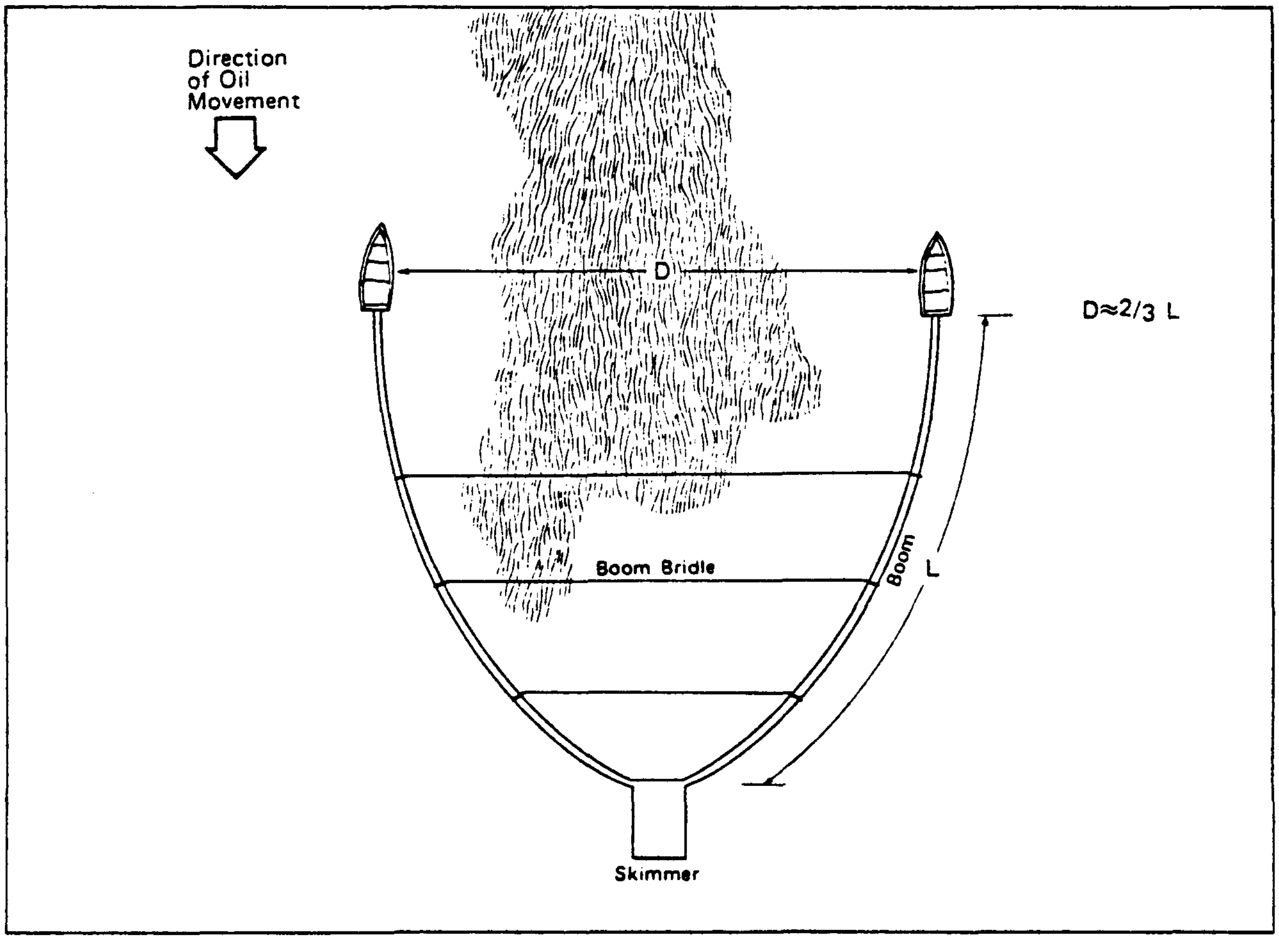

Figure 3.9 Boat, boom and skimmer relationship.

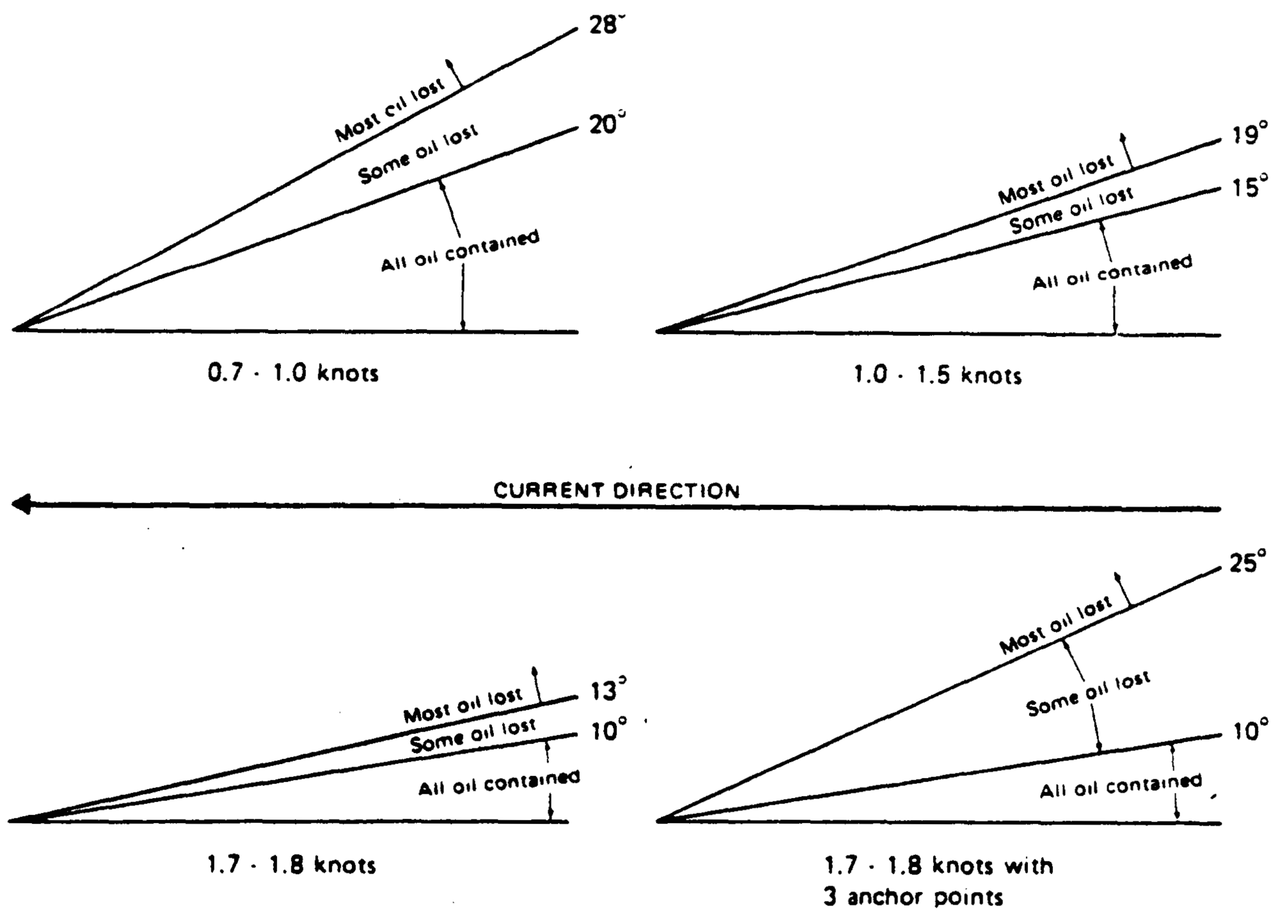

Figure 3.10 Boom deployment angles.

The first method of diversion booming involves the use of two lengths of boom; a shoreline boom and a diverting boom (Fig. 3.11). The shoreline boom is deployed parallel to the shore away from the surf zone and secured at both ends and along its length as required. The diverting boom is attached to the downwind end of the shoreline boom and the free end attached to a vessel. The diverting boom should be angled to deflect the approaching slick into the vee of the two booms. A skimmer can then pick up oil contained in the vee and pump it to a floating storage vessel outside the boom. The attached ends of the booms can also be secured to a skimmer at the vee of the booms, as shown in Figure 3.9 . This method of diversion booming can be effective in protecting sensitive shorelines and in preventing shoreline contamination, thereby eliminating potential shoreline cleanup problems.

The second method of diversion booming can be used on shorelines where little or no surf is present. One end of the diverting boom is anchored to the shoreline and the free end is angled by the vessel as shown on Figure 3.12 . The advantage of this method is that is can be set up in less time with less equipment. A disadvantage is that the shoreline must be cleaned up. A variation on this method is to use two or more booms to deflect the oil onto the shoreline (Fig. 3.13). This method of cascading deflection booms is preferred for high currents (>1.5 knots) as stress on the booms is reduced.

The length of boom required for diversion booming will depend on the width of the approaching slick and/or the area of shoreline to be protected. The angle at which the boom should be deployed depends primarily on the current speed. As the current increases, the free end of the boom should be moved toward the direction from which the wind is blowing.

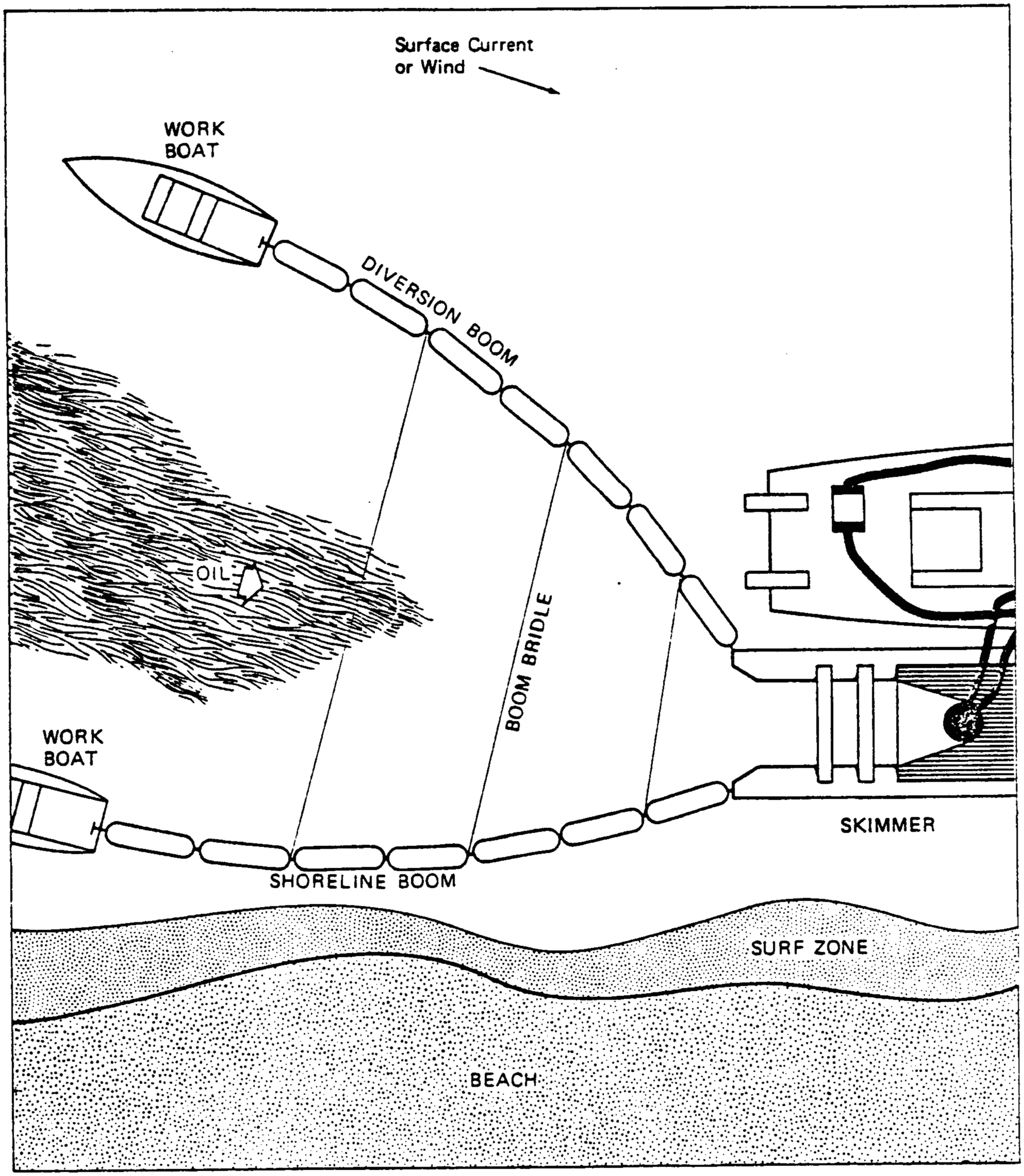

Figure 3.11 Protecting sensitive shoreline with two booms.

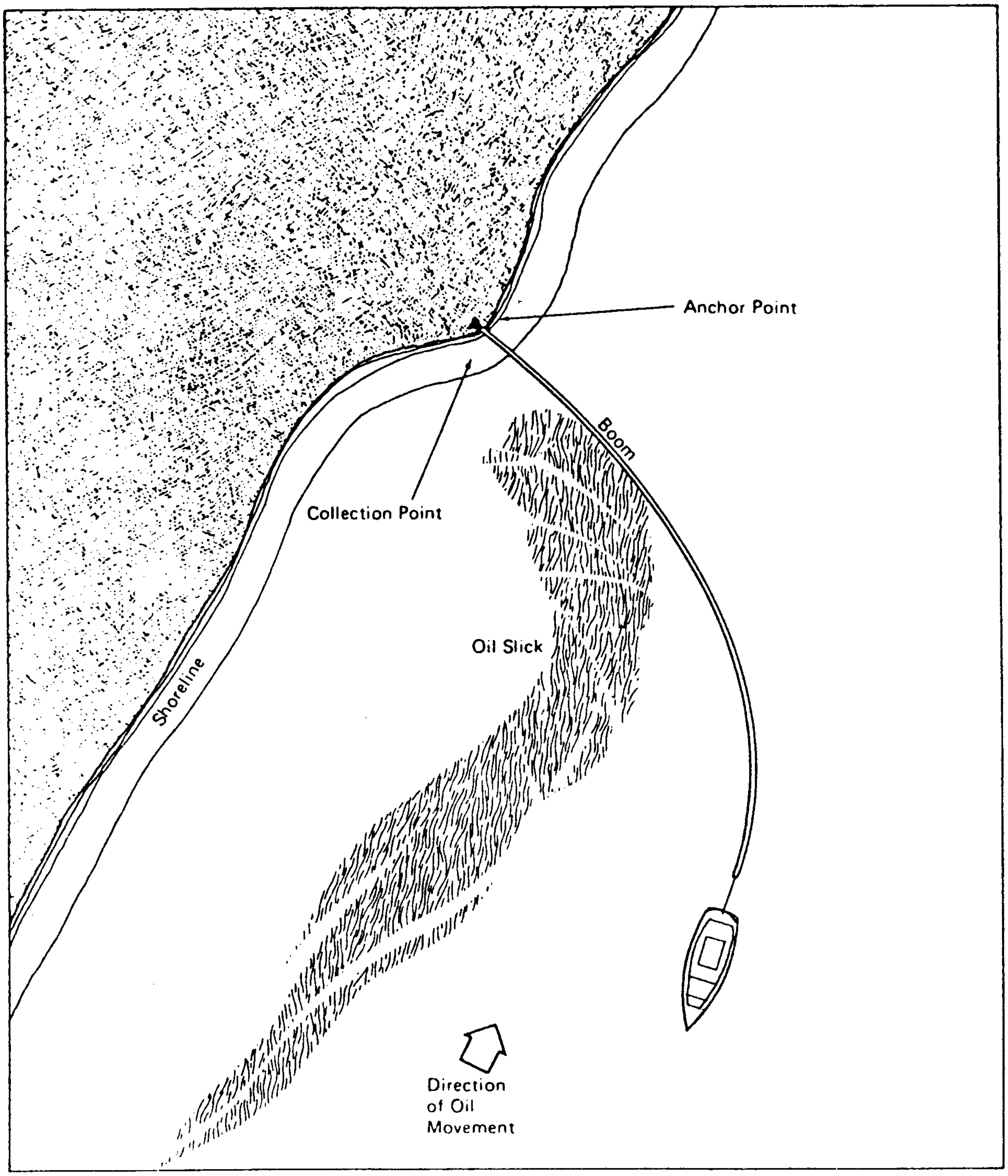

Figure 3.12 Diversion booming along shoreline.

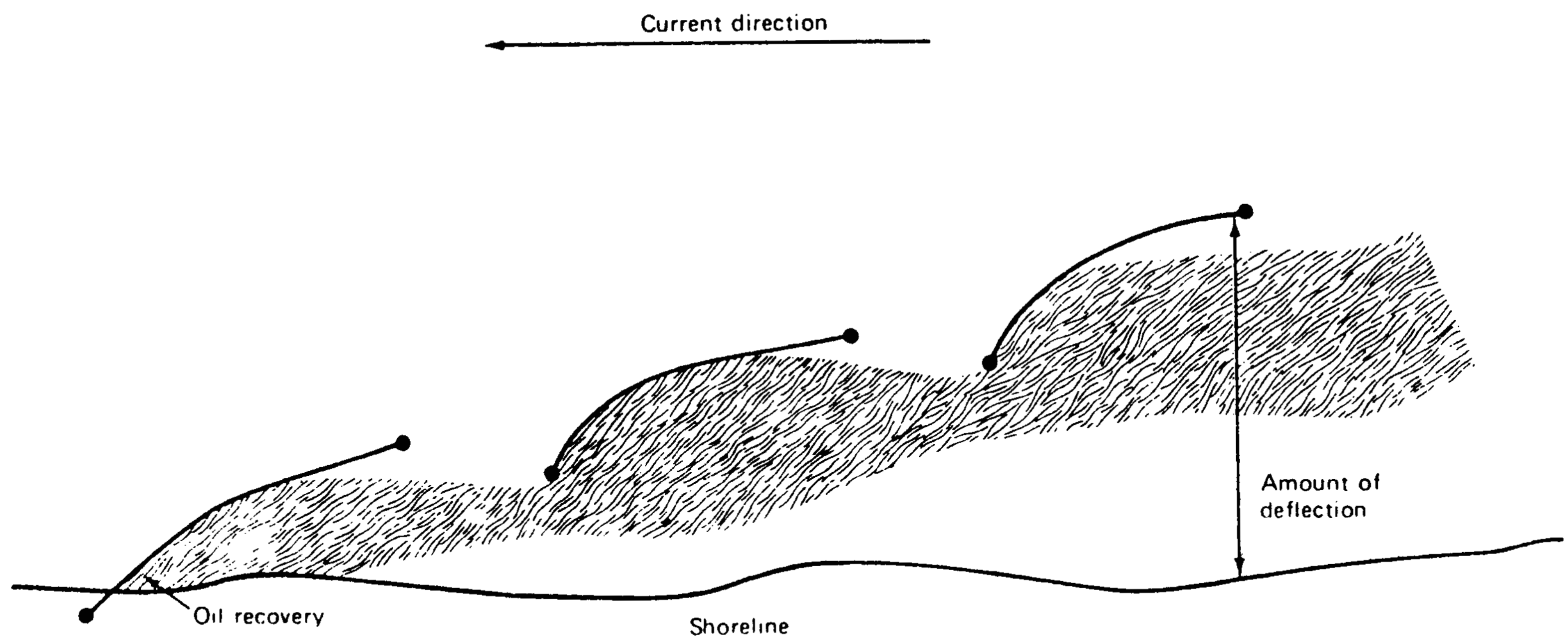

Figure 3.13 Placement configuration of 3 lengths of boom (cascading deflection booms).

(b) Exclusion booming. Exclusion booming involves deploying the boom in a static mode, i.e., placing or anchoring the boom between two or more stationary points. This method is used primarily to prevent oil from entering harbours and marinas, breakwater entrances, and inlets. Many of these entrances or channels have tidal currents exceeding 1 knot or waves breaking in the opening. Under these conditions, booms should be placed landward from the entrance in quiescent areas of the channel, harbour, or inlet. Exclusion booms should also be deployed, when possible, at an angle with the wind to a shoreline to guide oil to an area on the shoreline where a vacuum truck or skimming equipment can recover the oil. Figure 3.14 shows typical exclusion booming deployment for inlets.

Exclusion booming of harbours or inlets may require that a small work boat be stationed at the upstream end of the boom to open the boom for boat traffic entering or leaving the harbour.

A flexible curtain-type boom is recommended for shoreline use. This type of boom will react more favourably to the fluctuations in water level (tide cycle) than the fence-type booms.

3.4.2.2 Boom deployment and shore attachment

Operations in the nearshore should not be attempted during periods of high waves. Generally several hundred feet of boom will be required per location for shoreline containment and protection activities. A boom can be deployed from the shoreline using a small work boat by securing one end of the boom onto the shore and the other end is then towed in position by the work boat. The boom should be positioned so that the boom ends are above the high-tide line. This will enable the boom to act as a barrier throughout the entire tide cycle. Sorbent materials (booms, sheets, or rolls) can be placed around the boom in the intertidal area of the shoreline connections to prevent oil from

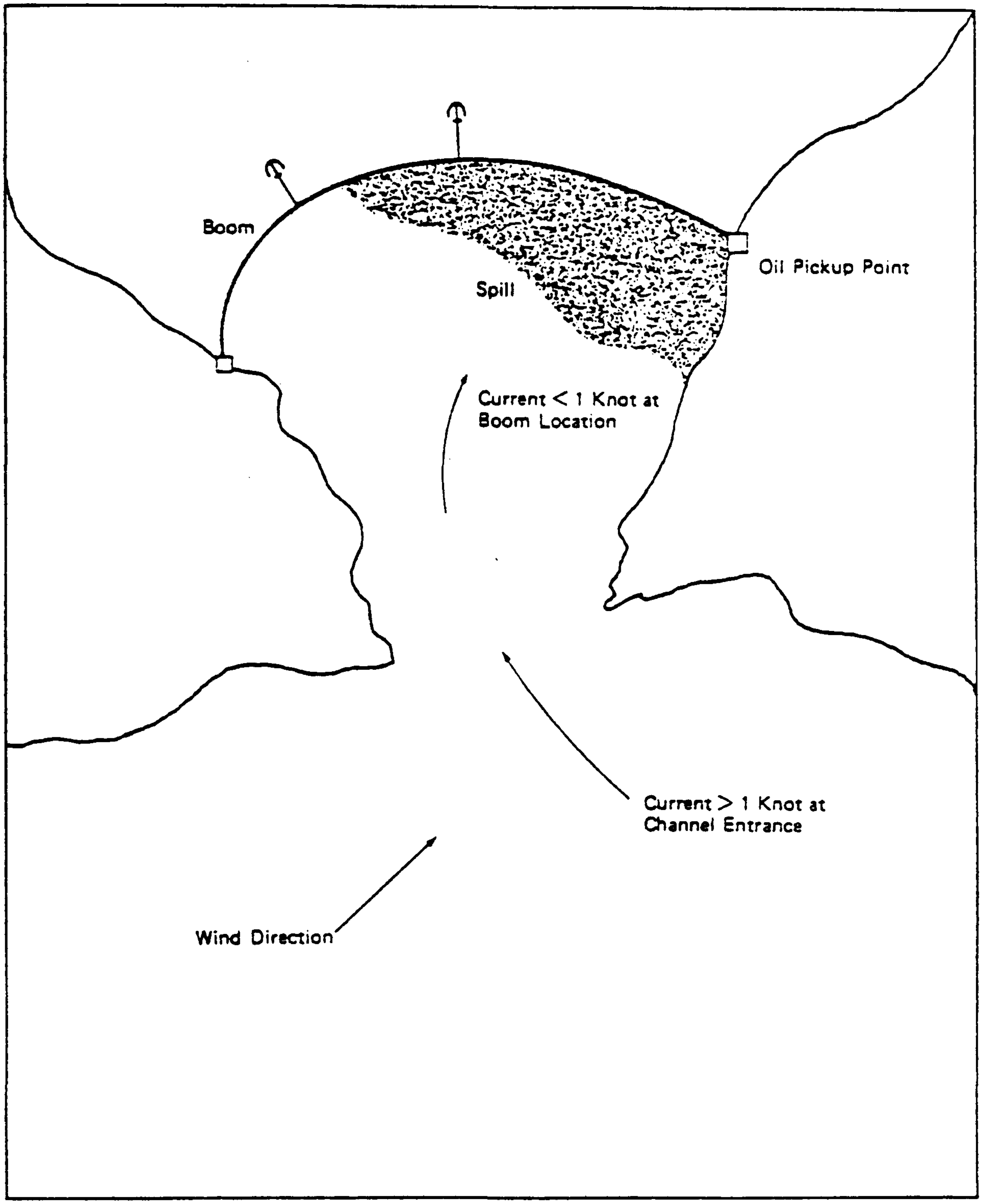

Figure 3.14 Exclusion booming at inlet with high channel currents.

seeping through at these junctions, or the boom skirt can be buried or sandbagged.

The boom end cable can be attached to a fixed point on shore, such as a piling, a sea wall, a block of concrete with an eye bolt, or a piece of heavy equipment. If there is no structure on shore on which to secure a boom, a simple boom anchor is a large concrete block with an eye bolt on the top side. Because of the weight, which could be more than 1 ton, this type of anchor could only be used in locations where there is ready access for lifting equipment to place the anchor point. Also, the onshore anchoring device can be a screw anchor or a dead-man. A dead-man is an anchoring device that is buried at right angles to the direction of maximum force (pull in this case). For example, a log about 12 in. in diameter and about 6 ft. long can be buried at least 4 ft. deep. A cable sling can be attached to the log and, in turn, the boom to the sling. If there is no timber available, a large (250 lb) Danforth Anchor can be buried in a similar fashion.

3.4.2.3 Exclusion of oil from wetlands

A variety of methods are acceptable for controlling the entrance of oil into, or movement within, wetlands. These methods including damming, booming and use of permeable barriers.

(a) Damming. Some small creek mouths are seasonally closed by sand bars. These bars tend to erode away during winter and storm conditions. If a bar is present, its height should be inspected to determine if it is sufficient to contain high water and waves. If inadequate, heavy equipment may be used to increase its height.

If water is flowing in any of the smaller estuarine entrances, damming may or may not be possible. If flow velocity is low successful damming is likely. Impounded water will percolate through the sand. Temporary closures of these areas should not cause environmental effects. Damming of perennially open estuaries is not feasible.

The two primary types of dam construction appropriate for oil spill containment are: (1) the complete blocking of an actual or potential drainage course (a blocking dam), and (2) the blocking of oil flow while permitting water to continue downslope (an underflow dam).

Blocking dams should be constructed only across drainage courses which have little or no water flow. The dam can be constructed from several types of materials including earth, sandbags, and sheets of metal or wood, or from any materials that blocks flow. The dam can be built across the drainage course to form a holding pond or reservoir to contain the oil and water. Water trapped behind the dam can be pumped out by placing the suction (intake) hose at the base of the dam on the upstream side, leaving oil trapped behind the dam for subsequent removal. The discharge (outlet) hose should be placed on the downstream side. Trapped water can also be moved across the dam with one or more siphons.

An underflow dam can be used (Figs. 3.15 and 3.16) for waterways with higher stream-flow rates. If the dam is to be effective, the surface of the oil must always be below the lip of the dam, and the oil/water interface must be above the top of the underflow opening. To maintain the proper level, it is necessary to remove some of the water, usually through horizontal valves or inclined pipes, as illustrated.

The underflow dam can be constructed by placing pipes of appropriate size on the stream bed and building an earthen or sandbag dam over the pipe across the waterway. The diameter of the pipe will depend on the flow rate of the stream and the

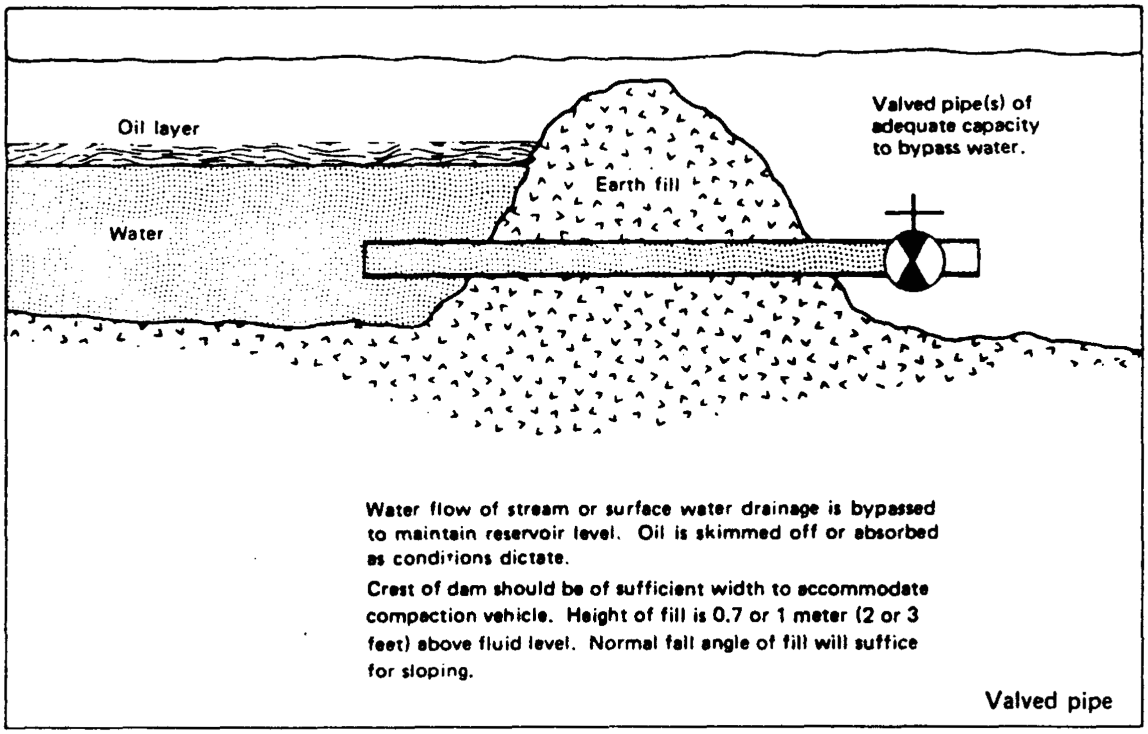

Figure 3.15 Water bypass dam with valved pipe.

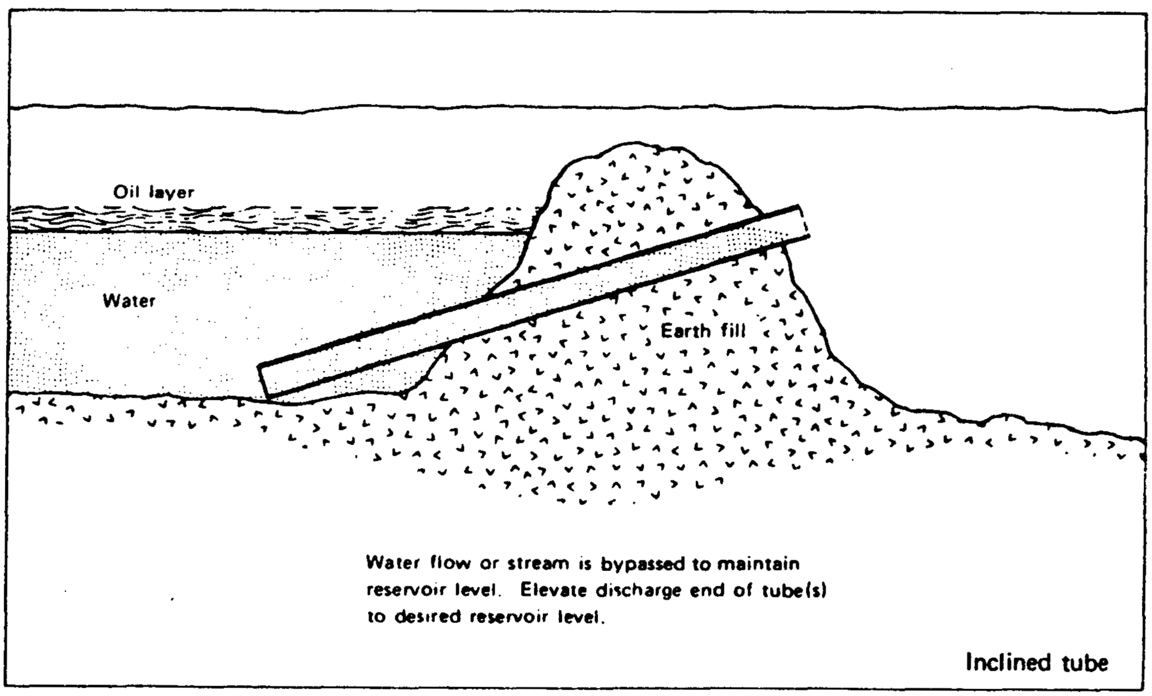

Figure 3.16 Water bypass dam with inclined tube.

depth of the water behind the dam. For example, a 60 to 76 cm (24 to 30 in.) diameter pipe will have sufficient capacity for a flow rate of up to 850 litres (30 cu.ft.) per second. If time does not allow for pipe diameter calculations, a diameter larger than that required will control flow if it is inclined at the proper angle or if a valve is used. A pair or series of dams may be required downstream if sufficient underflow cannot be maintained.

(b) Booming. Conventional booms have been successful in controlling the entrance of oil into estuaries. Placement of the booms, however, is critical. Currents in entrance channels may often exceed the performance capabilities of booms. Placement should, therefore, be attempted on the landward side of the entrance where current velocities drop. Sand bars commonly form in this area and these should be avoided in booming. Any deployment in a lagoon mouth situation will require constant monitoring and removal of accumulated oil and debris.

If oil threatens or enters the wetland interior it may be excluded or contained with conventional booms if depths are adequate. As currents in tidal channels are commonly high, diagonal positioning of the boom is necessary. Diagonal booming also responds well to reversing tidal currents. Double booming of critical areas provides a good measure of safety.

(c) Permeable barriers. Oil can be excluded from interior areas or contained with permeable barriers constructed on site. Permeable barriers offer the advantages of non-interference with flow, conformance with bottom configuration, and response to tidal variation. Double barriers are required because of tidal reverses. A diagram of a typical permeable barrier fabricated by placing sorbent material between fencing is shown in Figure 3.17. Although a variety of screen and mesh fencing is available, heavier materials are recommended. When

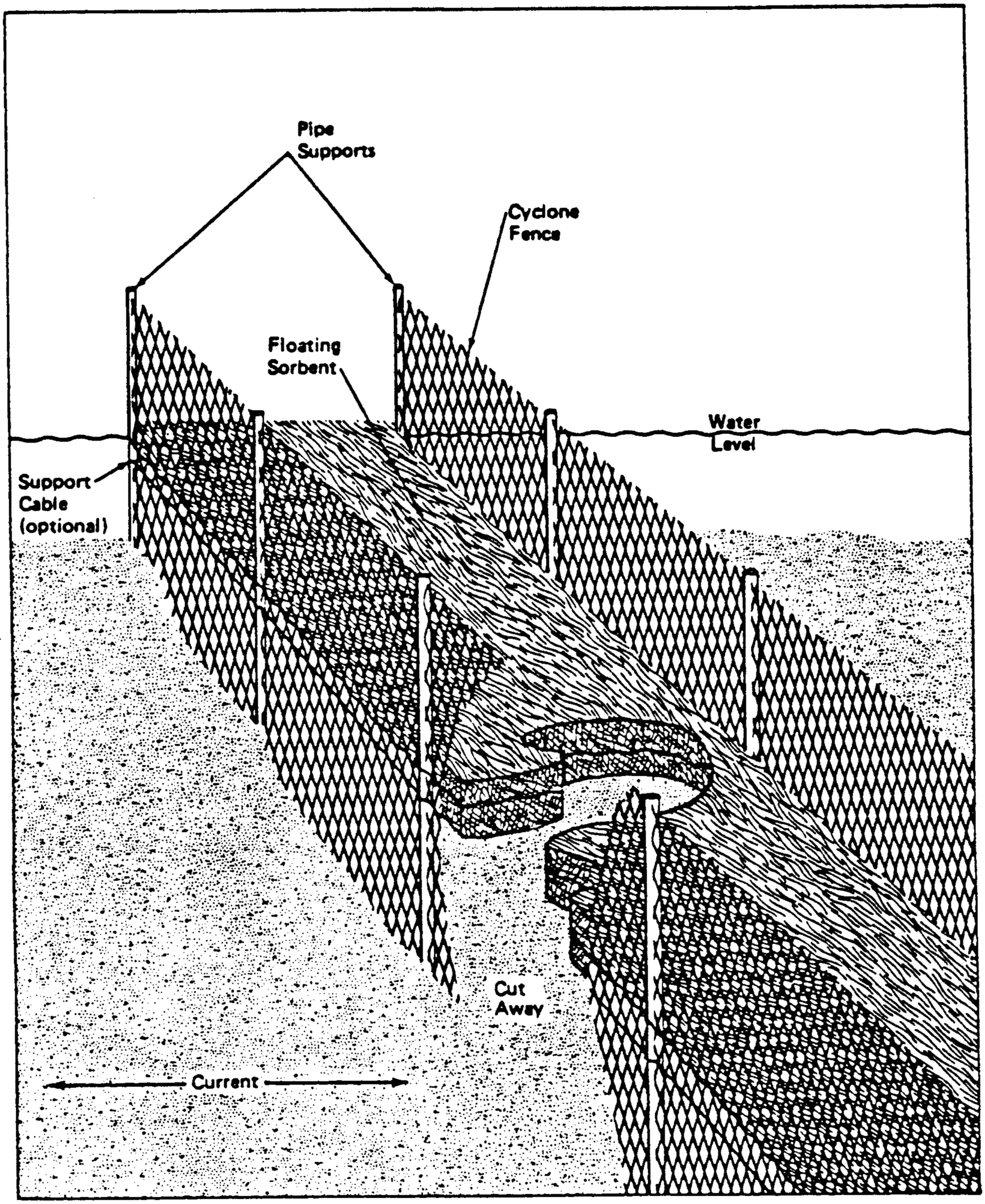

Figure 3.17 Typical permeable barrier.

subjected to high currents and debris, lighter material, such as chicken wire, will probably fail.

3.4.2.4 Onshore methods

The selection of onshore protection can be considered, even though only a few methods are practical. The applicability of the available methods for the major shoreline types is given in Table 3.8 .

TABLE 3.8 Onshore Protection Methods and Shoreline Types

SHORELINE TYPE	ONSHORE PROTECTION METHOD(S)
ROCK MAN-MADE	• sorbents may be useful on low angle slopes
MUD	• sorbents could be effective if collection can be achieved without mixing oil/sorbent into uncontaminated muds
SAND PEBBLE	• ditch/dyke system could be used to protect backshore • sorbents could prevent or reduce penetration and facilitate the removal of oil
COBBLE BOULDER	• no available effective onshore protection • retrieval of sorbents is difficult • ditch/dyke system is too permeable but could stop oil from washing over into the backshore or could be used in conjunction with sorbents
MIXED SEDIMENTS	• can be treated in the same manner as sand/pebble beaches
MARSHES	• loose sorbent can be blown into the marsh edge along channels • dykes across the marsh channels could prevent oil from penetrating into the backshore marsh areas

The configuration of a typical ditch-dyke system is depicted in Figure 3.18 . This method is used primarily on sandy or gravel low-energy beaches to protect the upper intertidal and backshore area from oil contamination. It is especially useful during spring tides or storm surges when the water level extends above the normal high-tide level for a short period of time. Oil deposited during this time usually persists until the next

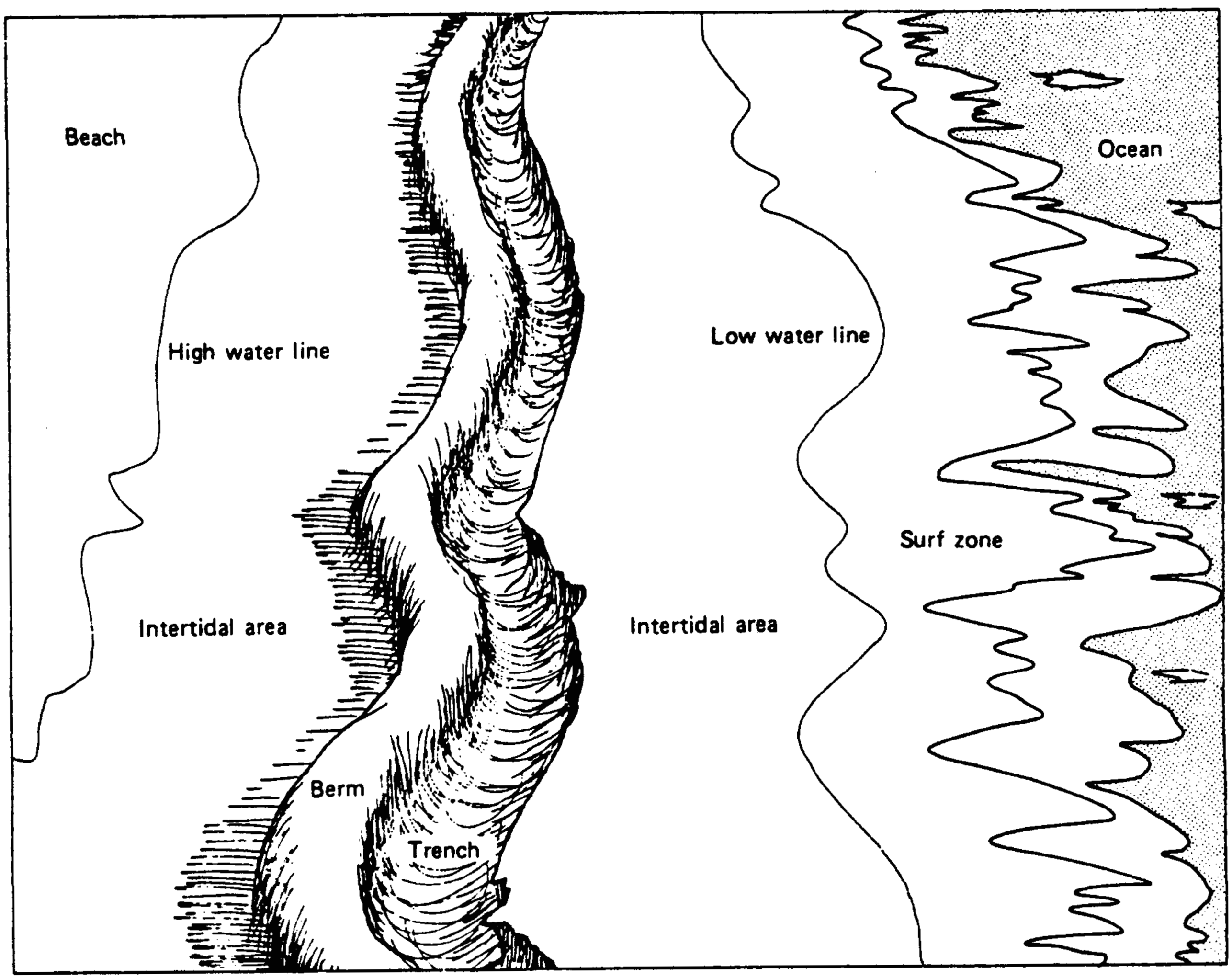

Figure 3.18 Ditch-dyke system.

tide of equal magnitude. The dyke should be approximately 2 m wide and 0.75 to 1.0 m high, but these dimensions are dependent on the maximum height of the incoming tide.

Construction of the dykes is achieved by operating a motor grader parallel to the water line along the upper intertidal area. The blade is set at an angle to cast a windrow to one side as the motor grader moves down the beach. Several passes are usually required to attain the optimum dyke height. Bulldozers fitted with angled blades can be operated in the same manner; if fitted with a straight blade, they can be used to push material up the beach into a pile forming a dyke with successive, adjacent piles. A trench on the seaward side of the dyke would also assist in trapping oil that comes ashore on each wave for subsequent removal. Trench-cutting machinery that sidecasts the excavated material can be used to form a ditch-dyke system, although this technique is usually slower than the use of bulldozers or graders.

Observations of tidal action on constructed dykes indicate that the dykes could successfully protect backshore areas for at least one tidal cycle, and possibly two, assuming no large storm waves or winds occur.

3.4.3 Shoreline Cleanup Methods

The physical and biological characteristics of the contaminated shoreline will determine appropriate cleanup techniques. For example, most techniques that are applicable on sandy beaches would not be used on rock cliffs; and motorized cleanup equipment should not be used in salt marshes because of potential damage to vegetation and habitat.

If oil contamination is extensive, heavy equipment is more efficient and effective for cleanup than manual labour.

Manual or "hand" cleanup is effective against light shoreline contamination, in the final stage of cleanup, and where heavy equipment access to a shoreline is not available. Some kinds of earthmoving equipment can be used to clean up beaches composed of material ranging in size from silt to cobbles. Pressurized spraying equipment is most effective for cleaning rock and boulder beaches, boulder barricades, rocky cliffs, and man-made structures. Small oil skimmers, hose flushing, and sorbents should be used in salt marshes.

3.4.3.1 Selection of appropriate cleanup methods

The choice of effective and efficient cleanup countermeasures is dependent on a number of factors. These include:

- type of substrate
- amount of oil contamination
- depth of oil penetration into sediments
- type of oil
- trafficability of equipment in the shore zone

A series of decision guides is presented that allows the evaluation of these factors for a given shoreline and the selection of the preferred cleanup technique. Figure 3.19 presents a key to these decision guides (Figs. 3.20 through 3.22).

The procedure for using the decision guide is as follows:

1. Use Figure 3.19 (Key to Decision Guides) to determine which of the other three decision guides is applicable for the cleanup of each shoreline in question. Enter with the type of substrate that is contaminated and follow the guide, answering the questions where appropriate.

2. Enter the decision guide selected (Figs. 3.20 to 3.22) and answer the questions for each shoreline section that requires cleanup. The guide will lead to one or more cleanup techniques listed first. If the first technique cannot be used because of lack of equipment or access to shoreline, then the next technique should be considered.

3. Information on each technique is given in Table 3.9 and the number in parentheses refers to the number of the cleanup technique in that table. Instructions on how to use the cleanup technique are given below.

Once a cleanup technique has been selected for a particular shoreline area, the impacts of that cleanup technique and the implementation requirements should be assessed. If the impacts of the technique are unacceptable or the technique cannot be implemented, then the next preferable technique listed should be chosen or consideration should be given to leaving the shoreline area to natural recovery.

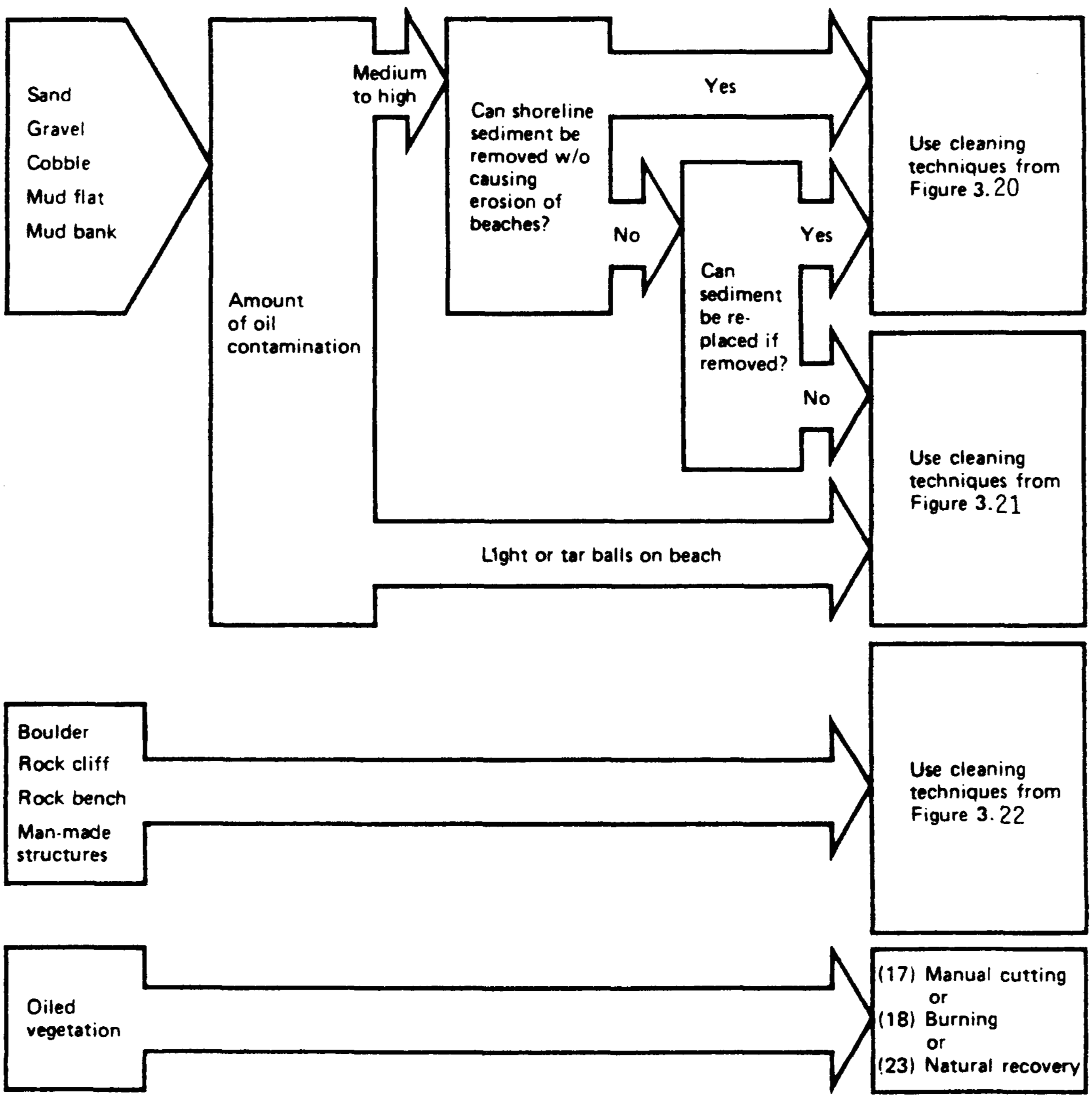

Figure 3.19 Key to decision guides.

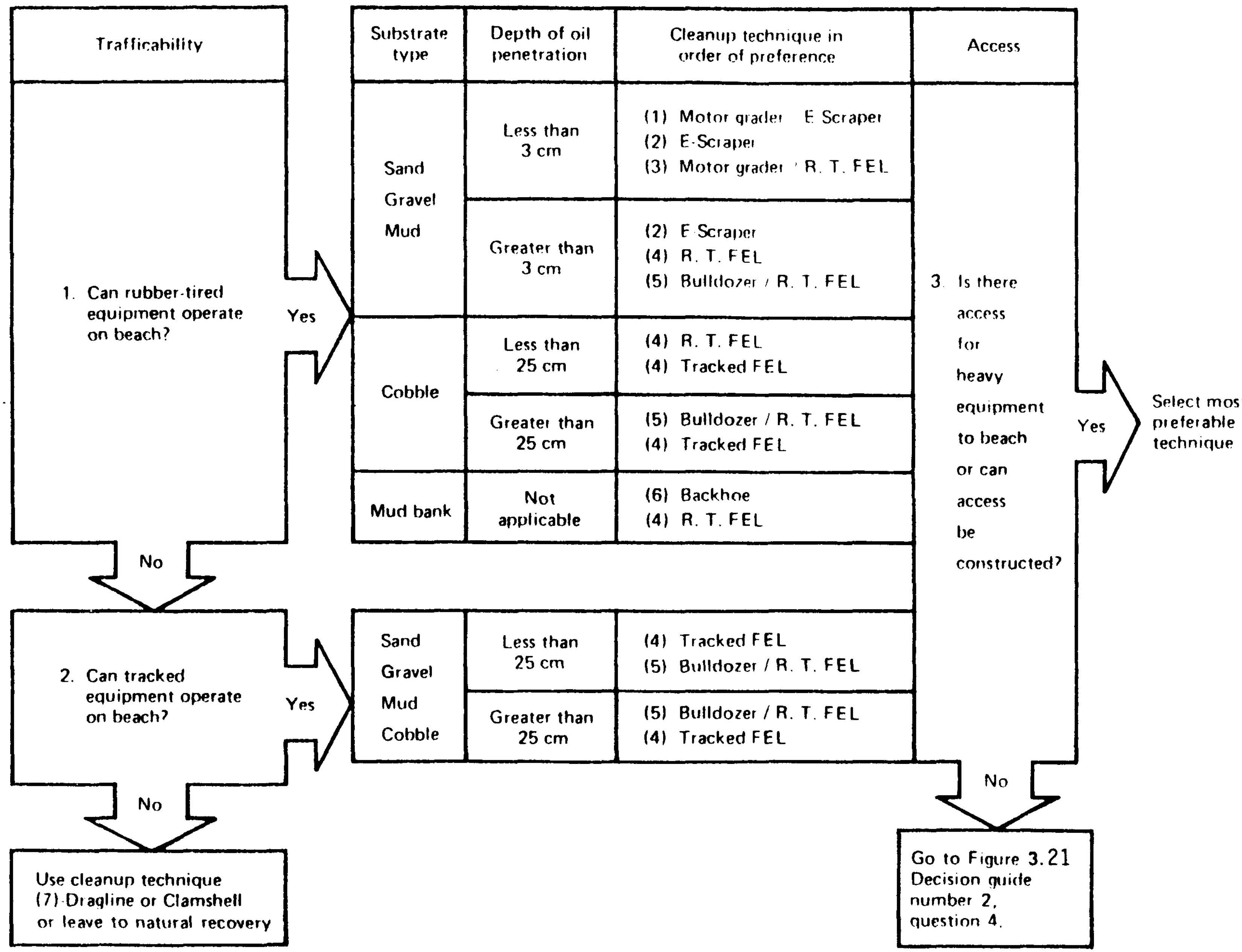

Figure 3.20 Cleanup decision guide number 1. (FEL = front-end loader; RT = rubber-tired)

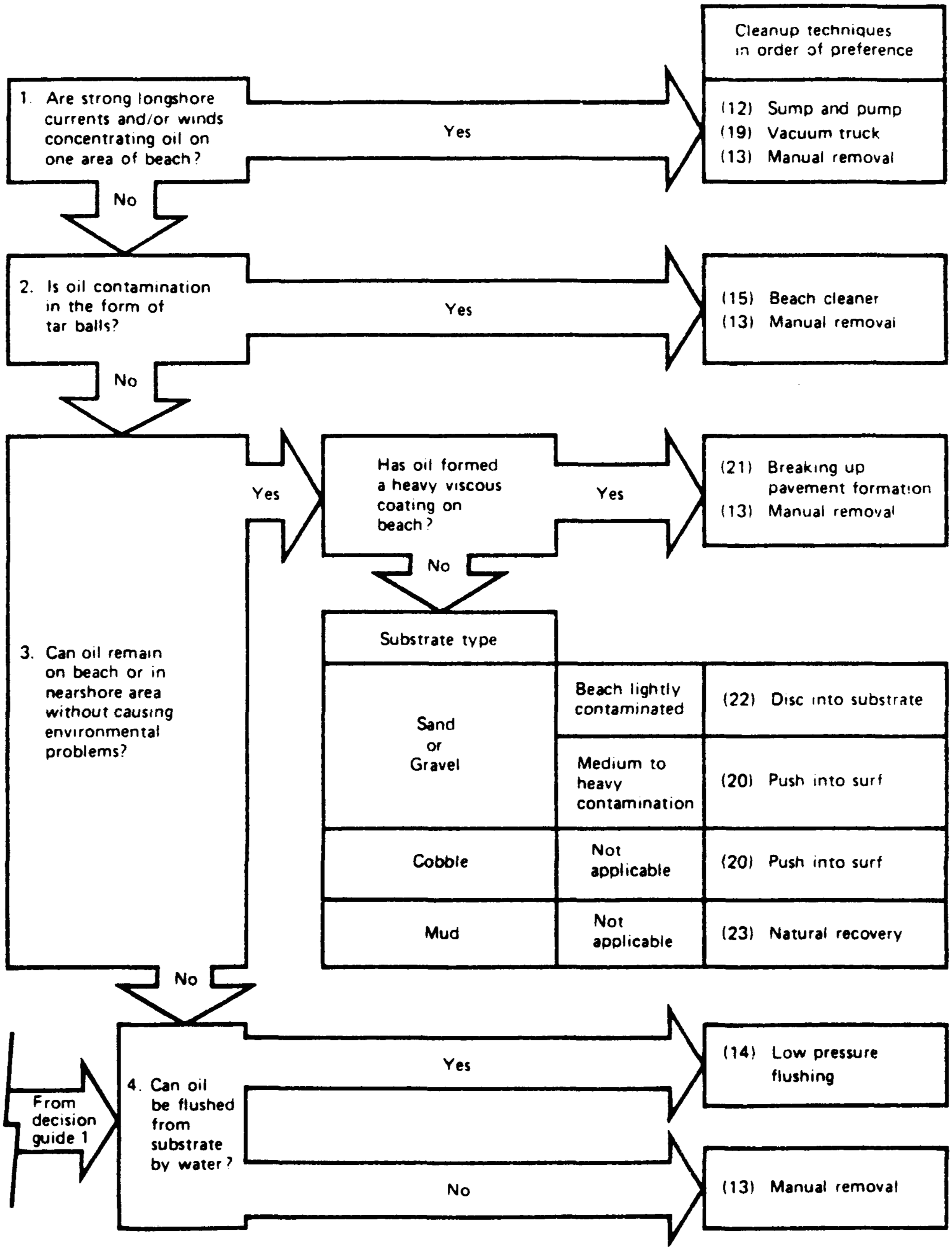

Figure 3.21 Cleanup decision guide number 2.

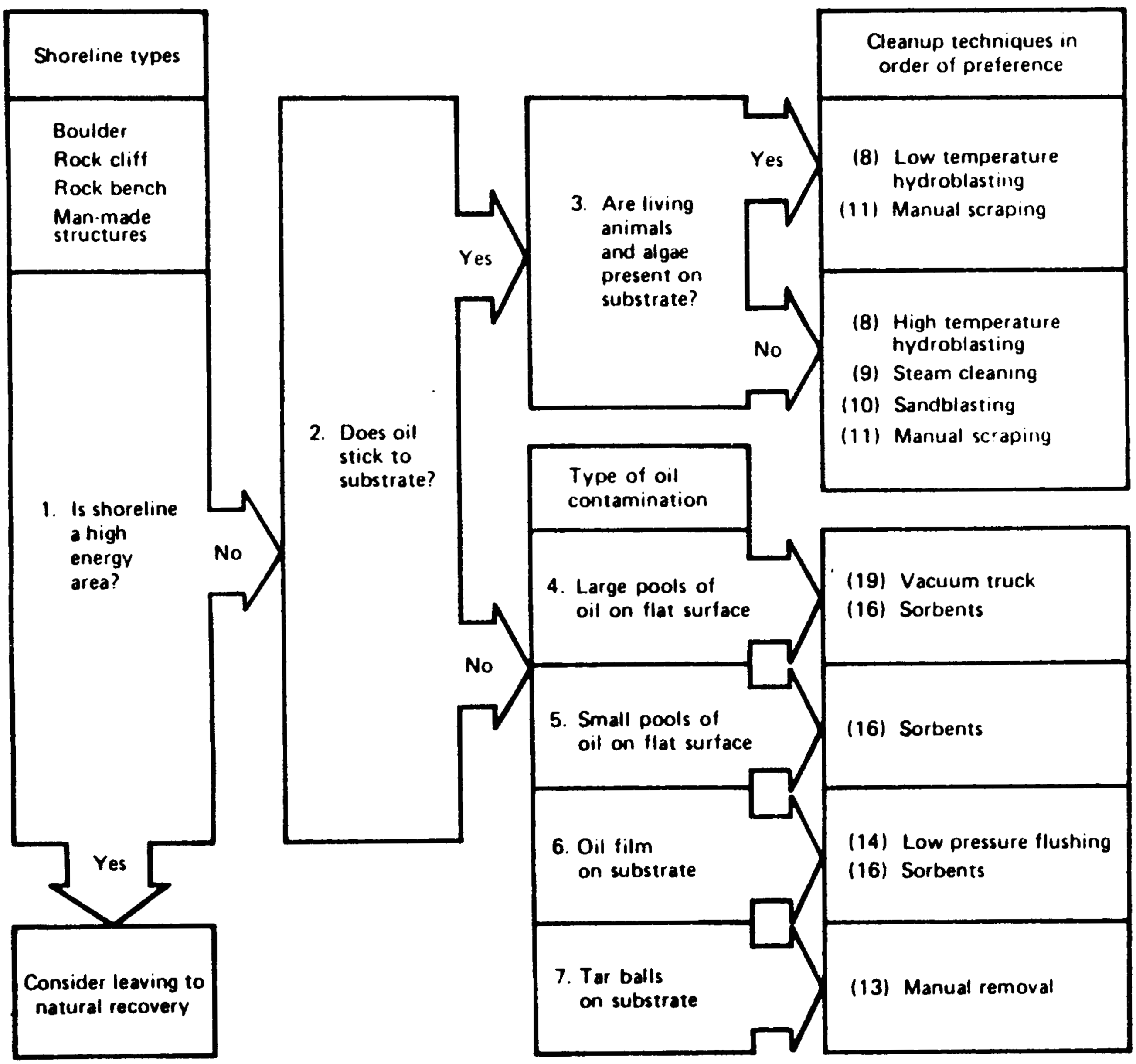

Figure 3.22 Cleanup decision guide number 3 for boulder, rock or man-made shores.

3.4.3.2 Geological impact of cleanup

The two primary geological problems that can occur from cleanup are related to sediment removal and dune disturbance.

The removal of any sediment from the shore zone reduces the total volume of beach sediments. This is not a problem if the sediments are in abundance or if natural processes can replace the sediment. If excessive amounts of sediments are removed (>50 cm depth) or the volume of beach sediment is small, beach retreat can follow as the waves attempt to reestablish an equilibrium. In particular, sheltered or pocket beaches usually have relatively little sediment and low sediment resupply rates and, therefore, are very susceptible to damage by sediment removal. The effect of beach retreat is either: (1) a general landward movement of the beach, if the beach is wide or if it is backed by a marsh or lagoon, or (2) backshore erosion if the beach is backed by cliffs or dunes. In cases where a narrow beach is backed by cliffs of unconsolidated sediments, erosion can be rapid until the shore zone establishes a new equilibrium with the waves.

<u>In all cases, the cleanup operation should aim to remove as little beach material as possible.</u> To achieve this the oil should be removed as soon as is practical after a spill to prevent burial or greater penetration of the oil into beach sediments. If large-scale removal is necessary, it is advisable that the material be replaced by an equal volume of the same size sediment. Replacement of sediment on pebble, cobble, or boulder beaches is particularly important as natural sediment replacement rates are very slow.

Dune systems can be severely damaged if personnel and equipment destroy the dune vegetation that naturally stabilizes the sand. The trampling or removal of the vegetation can cause serious erosion if "blowouts" (removal of sand by wind action) develop before the vegetation can restabilize the sand. If access across a dune system is necessary, personnel or vehicles should be restricted to as few routes as possible and mats can be used to improve traction as well as to reduce the damage level.

3.4.3.3 Shoreline cleanup techniques

The available shoreline cleanup techniques are described briefly in Table 3.9 . Detailed procedures for those methods most applicable to the pilot study coast are described in more detail in this section. It is important that an in-field evaluation of performance should be continually reviewed to ensure the efficiency of the cleanup technique. For example, at a particular field site it may be determined that tracked vehicles are actually mixing significant quantities of oil into the sediments, such that the oil is penetrating to greater depths than would have occurred naturally; in this case, an alternative cleanup technique should be selected.

The number given to each cleanup method in Table 3-9 is shown in brackets following the technique description title in text (pages 95 to 119).

TABLE 3-9. Shoreline Cleanup Methods

Cleanup Technique	Description	Primary Use of Cleanup Technique	Technique Requirements	Physical Effect of Use	Biological Effect of Use
1. Motor grader/ elevating scraper	Motor grader forms windrows for pickup by elevating scraper	Used primarily on sand and gravel beaches where oil penetration is 0 to 3 cm, and trafficability of beach is good. Can also be used on mudflats.	Good trafficability. Heavy equipment access.	Removes only upper 3 cm of beach.	Removes shallow burrowing polychaetes, bivalves, and amphipods. Recolonization likely to rapidly follow natural replenishment of the substrate.
2. Elevating scraper	Elevating scraper picks up contaminated material directly off beach.	Used on sand and gravel beaches where oil penetration is 0 to 3 cm. Can also be used on mudflats. Also used to remove tar balls or flat patties from the surface of a beach.	Fair to good trafficability. Heavy equipment access.	Removes upper 3 to 10 cm of beach. Minor reduction of beach stability. Erosion and beach retreat.	Removes shallow and deeper burrowing polychaetes, bivalves, and amphipods. Restabilization of substrate probably slow; recolonization likely to follow natural replenishment of substrate; reestablishment of long-lived indigenous fauna may take several years.
3. Motor grader/ front-end loader.	Motor grader forms windrows for pickup by front-end loader.	Used on gravel and sand beaches where oil penetration is less than 2 to 3 cm. This method is slower than using a motor grader and elevating scraper but can be used when elevating scrapers are not available. Can also be used on mudflats.	Good trafficability. Heavy equipment access.	Removes only upper 3 cm of beach.	Removes shallow burrowing polychaetes, bivalves, and amphipods. Recolonization likely to rapidly follow natural replenishment of the substrate.
4. Front-end loader; rubber-tired or tracked	Front-end loader picks up material directly off beach and hauls it to unloading area.	Used on mud, sand, or gravel beaches when oil penetration is moderate and oil contamination is light to moderate. Rubber-tired front-end loaders are preferred because they are faster and minimize the disturbance of the surface. Front-end loaders are the preferred choice for removing cobble sediments. If rubber-tired loaders cannot operate, tracked loaders are the next choice. Can also be used to remove extensively oil-contaminated vegetation.	Fair to good trafficability for rubber-tired loader. Heavy equipment access.	Removes 10 to 25 cm of beach. Reduction of beach stability. Erosion and beach retreat.	Removes almost all shallow and deep burrowing organisms. Restabilization of the physical environment slow; new faunal community could develop.
5. Bulldozer; rubber-tired front-end loader	Bulldozer pushes contaminated substrate into piles for pickup by front-end loader.	Used on coarse sand, gravel, or cobble beaches where oil penetration is deep, oil contamination extensive, and trafficability of the beach poor. Can also be used to remove heavily oil-contaminated vegetation.	Heavy equipment access. Fair to good trafficability for front-end loader.	Removes 15 to 50 cm of beach. Loss of beach stability. Severe erosion and cliff or beach retreat. Inundation of backshores.	Removes all organisms. Restabilization of substrate and repopulation of indigenous fauna is extremely slow; new faunal community could develop in the interim.

TABLE 3- 9 (cont'd.)

6. Backhoe	Operates from top of a bank or beach to remove contaminated sediments and loads into trucks.	Used to remove oil contaminated sediment (primarily mud or silt) on steep banks.	Heavy equipment access. Stable substrate at top of bank.	Removes 25 to 50 cm of beach or bank. Severe reduction of beach stability and beach retreat.	Removes all organisms. Restabilization of substrate and repopulation of organisms is extremely slow; new faunal community could develop in the interim.
7. Dragline or Clamshell	Operates from top of contaminated area to remove oiled sediments.	Used on sand, gravel, or cobble beaches where trafficability is very poor (i.e., tracked equipment cannot operate) and oil contamination is extensive.	Heavy equipment access to operating area. Equipment reach covers contaminated area.	Removes 25 to 50 cm of beach. Severe reduction of beach stability. Erosion and beach retreat.	Removes all organisms. Restabilization of substrate and repopulation of indigenous fauna is extremely slow; new faunal community could develop in the interim.
8. High pressure flushing (hydro-blasting)	High pressure water streams remove oil from substrate where it is channeled to recovery area.	Used to remove oil coatings from boulders, rock, and man-made structures; preferred method of removing oil from these surfaces.	Light vehicular access. Recovery equipment.	Can disturb surface of substrate.	Removes some organisms and shells from the substrate, damage to remaining organisms variable. Oil not recovered can be toxic to organisms downslope of cleanup activities.
9. Steam cleaning	Steam removes oil from substrate where it is channeled to recovery area.	Used to remove oil coatings from boulders, rock, and man-made structures.	Light vehicular access. Recovery equipment. Fresh water supply.	Adds heat (> 100°C) to surface.	Removes some organisms from substrate but mortality due to the heat is more likely. Empty shells remaining may enhance repopulation. Oil not recovered can be toxic to organisms downslope of cleanup activities.
10. Sandblasting	Sand moving at high velocity removes oil from substrate.	Used to remove thin accumulations of oil residue from man-made structures.	Light vehicular access. Oil must be semi-solid. Supply of clean sand.	Adds material to the environment. Potential recontamination, erosion, and deeper penetration into substrate.	Removes all organisms and shells from the substrate. Oil not recovered can be toxic to organisms downslope of cleanup activities.
11. Manual scraping	Oil is scraped from substrate manually using hand tools.	Used to remove oil from lightly contaminated boulders, rocks, and man-made structures or heavy oil accumulation when other techniques are not allowed.	Foot access. Scraping tools and disposal containers.	Selective removal of material. Labour-intensive activity can disturb sediments.	Removes some organisms from the substrate, crushes others. Oil not removed or recovered can be toxic to organisms repopulating the rocky substrate or inhabiting sediment downslope of cleanup activities.

TABLE 3- 9. (cont'd.)

Cleanup Technique	Description	Primary Use of Cleanup Technique	Technique Requirements	Physical Effect of Use	Biological Effect of Use
12. Sump and pump/ vacuum	Oil collects in sump as it moves down the beach and is removed by pump or vacuum truck.	Used on firm sand or mud beaches in the event of continuing oil contamination where sufficient longshore currents exist, and on streams and rivers in conjunction with diversion booming.	Heavy equipment access. A longshore current present.	Requires excavation of a sump 60 to 120 cm deep on shoreline. Some oil will probably remain on beach.	Removes organisms at sump location. Potentially toxic effects from oil left on the shoreline. Recovery depends on persistence of oil at the sump.
13. Manual removal of oiled materials	Oiled sediments and debris are removed by hand, shovels, rakes, wheelbarrows, etc.	Used on mud, sand, gravel, and cobble beaches when oil contamination is light or sporadic and oil penetration is slight, or on beaches where access for heavy equipment is not available.	Foot or light-vehicular access.	Removes 3 cm or less of beach. Selective. Sediment disturbance and erosion potential.	Removes and disturbs shallow burrowing organisms. Rapid recovery.
14. Low-pressure flushing	Low pressure water spray flushes oil from substrate where it is channeled to recovery points.	Used to flush light oils that are nonsticky from lightly contaminated mud substrates, cobbles, boulders, rocks, man-made structures, and vegetation.	Light vehicular access. Recovery equipment	Does not disturb surface to any great extent. Potential for recontamination.	Leaves most organisms alive and in place. Oil not recovered can be toxic to organisms downslope of cleanup.
15. Beach cleaner	Pulled by tractor or self-propelled across beach, picking up tar balls or patties.	Used on sand or gravel beaches, lightly contaminated with oil in the form of hard patties or tar balls.	Moderate to heavy vehicular access. Good trafficability.	Disturbs upper 5 to 10 cm of beach.	Disturbs shallow burrowing organisms.
16. Manual sorbent application	Sorbents are applied manually to contaminated areas to soak up oil.	Used to remove pools of light, nonsticky oil from mud, boulders, rock, and man-made structures.	Foot or boat access. Disposal containers for sorbents.	Selective removal of material. Labour intensive activity can disturb sediments.	Foot traffic may crush organisms. Possible ingestion of sorbents by birds and small animals.
17. Manual cutting	Oiled vegetation is cut by hand, collected, and stuffed into bags or containers for disposal.	Used on oil-contaminated vegetation.	Foot or boat access. Cutting tools.	Disturbs sediments because of extensive use of labour; can cause erosion.	Removes and crushes some organisms. Rapid recovery. Heavy foot traffic can cause root damage and subsequent slow recovery.

TABLE 3-9. (cont'd.)

18. Burning	Upwind end of contaminated area is ignited and allowed to burn to down-wind end.	Used on any substrate or vegetation where sufficient oil has collected to sustain ignition; if oil is a type that will support ignition, and air pollution regulations so allow.	Light vehicular or boat access. Fire control equipment.	Causes heavy air pollution; adds heat to substrate, can cause erosion if root system damaged.	Kills surface organisms caught in burn area. Residual matter may be somewhat toxic (heavy metals).
19. Vacuum trucks	Truck is backed up to oil pool or recovery site where oil is picked up via the vacuum hose.	Used to pick up oil on shorelines where pools of oil have formed in natural depressions, or in the absence of skimming equipment to recover floating oil from the water surface.	Heavy equipment access. Large enough pools on land or thick enough oil on water for technique to be effective.	Some oil may be left on shoreline or in water.	Removes some organisms. Potential for longer-term toxic effects associated with oil left on the shoreline. Recovery depends on persistence of oil left in the pools.
20. Push contaminated substrate into surf	Bulldozer pushes contaminated substrate into surf zone to accelerate natural cleaning.	Used on contaminated cobble and lightly contaminated gravel beaches where removal of sediments may cause erosion of the beach or backshore area.	Heavy equipment access. High energy shoreline.	Disruption of top layer of substrate; leaves some oil in intertidal area. Potential recontamination.	Kills most of the organisms inhabiting the uncontaminated substrate. Recovery of organisms usually more rapid than with removing substrate.
21. Breaking up pavement	Tractor fitted with a ripper is operated up and down beach.	Used on low amenity cobble, gravel or sand beaches or beaches where substrate removal will cause erosion; or where thick layers of oil have created a pavement on the beach surface.	Heavy equipment access. High energy shoreline.	Disruption of sediments. Leaves oil on beach.	Disturbs shallow and deep burrowing organisms.
22. Disc into substrate	Tractor pulls discing equipment along contaminated area.	Used on nonrecreational sand or gravel beaches that are lightly contaminated.	Heavy equipment access. Fair to good trafficability. High energy environment.	Leaves oil buried in sand. Disrupts surface layer of substrate.	Disturbs shallow burrowing organisms. Possible toxicity effects from buried oil.
23. Natural recovery	No action taken. Oil left to degrade naturally.	Used for oil contamination on high energy beaches (primarily cobble, boulder, and rock) where wave action will remove most oil contamination in a short period of time.	Exposed high energy environment.	Some oil may remain on beach and could contaminate clean areas.	Potential toxicity effects and smothering by the oil. Potential incorporation of oil into the food web. Potential elimination of habitat if organisms will not settle on residual oil.

(a) Motor grader and front-end loader (3)

This method is used on sand and gravel beaches where oil penetration is less than 2 to 3 cm and trafficability is good. It can also be used on mud flats if trafficability permits. Windrows are formed by a motor grader and the front-end loader removes the windrows and transfers the material to the unloading area (Fig. 3.23). For specific operating procedures of the loader itself, refer below to the description of front-end loaders. Operating procedures for front-end loaders working with a motorized grader are listed below. Several front-end loaders are needed to remove windrows formed by a single grader.

1. Use 4-in-1 type bucket if available.
2. Operate tractor in first gear while loading.
3. Fill bucket only 1/2 to 2/3 full to minimize spillage while scraping.
4. Minimize traffic over oil-contaminated area when using tracked loader.

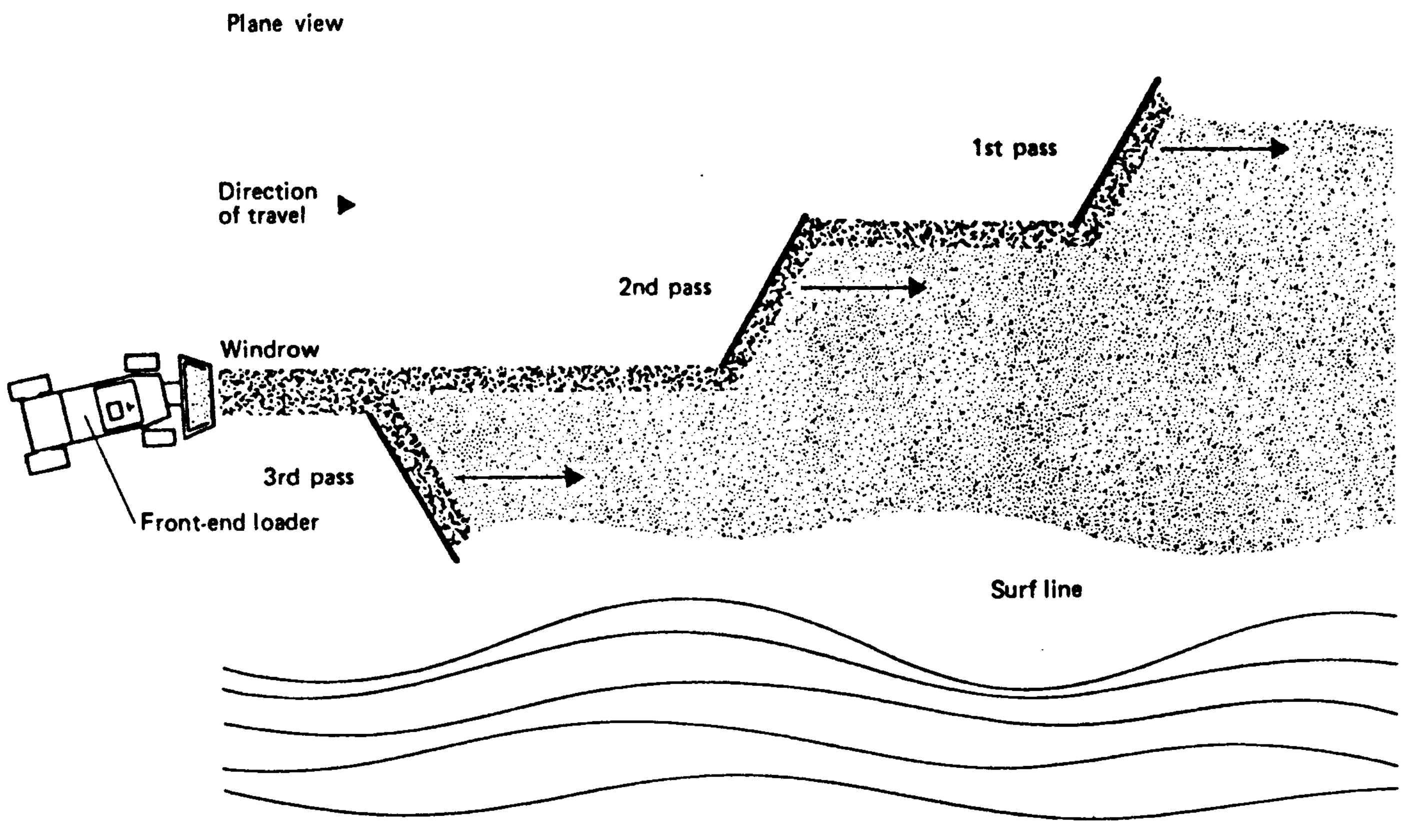

Figure 3.23 Motor grader/front-end loader operational sequence.

(b) Front-end loader (rubber-tired or tracked) (4)

Front-end loaders are used on mud, sand, or gravel beaches when trafficability is poor and when oil penetration is light to moderate. Front-end loaders are designed for digging and loading, and for limited transport of material. Buckets are made in different sizes and weights for different kinds of materials and work conditions. Buckets for wheeled and crawler tractors range from 1/4 to 10 yd^3. Figure 3.24 illustrates the operational sequence for this equipment.

Front-end loaders equipped with slot buckets, which allow loose sand to fall through the slots, should be used to remove large quantities of oil-contaminated debris such as kelp and driftwood. Previous beach-restoration experience indicates that front-end loaders should be used primarily for loading material into trucks from stockpiles or from windrows formed by motorized graders.

When the front-end loader is used alone the operational procedures are:

1. Use 4-in-1 type bucket if available.
2. Operate tractor in first gear while loading.
3. Position bucket flat on beach for loading loose material.
4. Position bucket at slight downward tilt for digging and skimming.
5. Load bucket most easily by moving tractor forward.
6. Fill bucket only 1/2 to 2/3 full to minimize spillage while loading
7. Minimize traffic over oil-contaminated area when using crawler loader to avoid oil being ground into substrate.

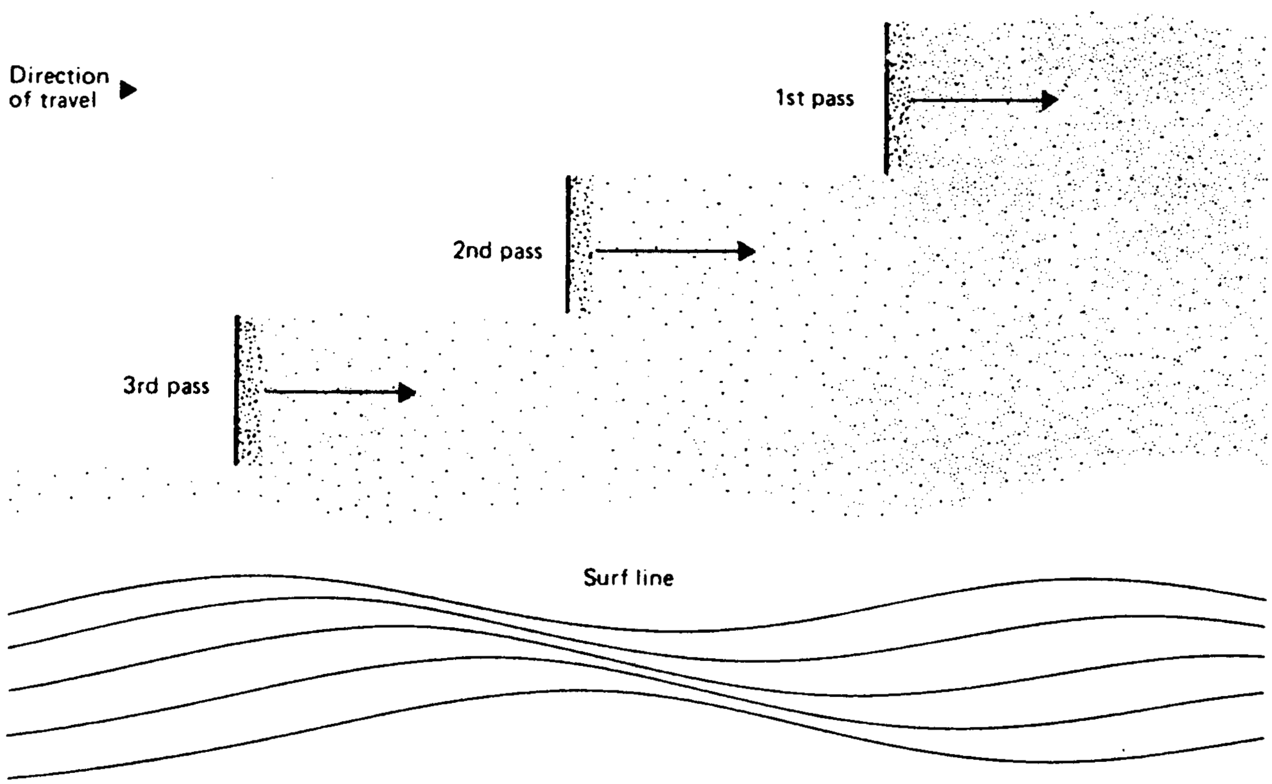

Figure 3.24 Front-end loader operational sequence.

(c) Bulldozer/front-end loader (rubber-tired) (5)

This equipment is used primarily on coarse sand, gravel, or cobble beaches where oil penetration is deep, contamination extensive, and trafficability poor. It can also be used to remove heavily oil-contaminated vegetation.

For those situations described above when no other techniques are applicable, the bulldozer/front-end loader combination is an acceptable method. The bulldozer is utilized to push the contaminated material into piles for pickup by the front-end loader (Fig. 3.25). The sequence of operational procedures for a bulldozer follows:

1. Begin at low-tide line of the beach using a universal or straight type blade. If there is a longshore current the bulldozer should be at the up-current end of the contaminated area.
2. Dozer is operated in first gear.
3. Contaminated material is pushed up the beach perpendicular to the tideline and onto an area with suitable trafficability to operate a front-end loader.
4. The cut depth should not exceed the depth of oil penetration.
5. Material should not be pushed beyond the contaminated area to avoid spoiling uncontaminated areas. A road may have to be constructed for the front-end loader to gain access to the stockpiled material.
6. Dozer is returned to starting point by back-tracking on cleaned area and repositioned so that the second cut will overlap the first cut slightly.
7. The procedure is repeated along the beach (Fig. 3.25).
8. Rubber-tired front-end loaders operate at the backshore side of the contaminated area to pick up the stockpiled sediments and transfer them to dump trucks for disposal.

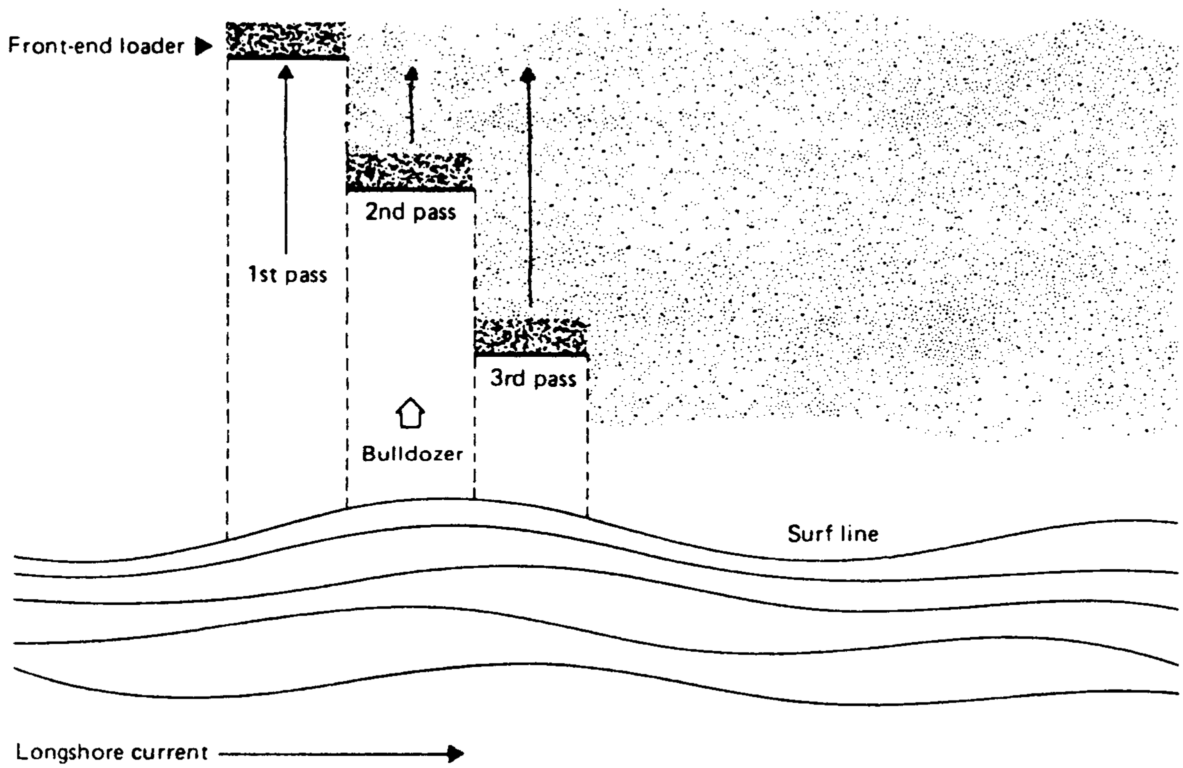

Figure 3.25 Bulldozer/front-end loader operational sequence.

(d) Backhoe (6)

A backhoe is used to remove oil-contaminated sediment (primarily mud or silt) on steep banks where other types of equipment are unable to operate.

The oil sediment is removed by positioning the backhoe at the edge of the bank, extending the boom down the bank, and scraping the surface layer into the bucket as the boom is retracted. The contaminated material is stockpiled or loaded directly into dump trucks and hauled away for disposal. The sequence of operational procedures for the backhoe is as follows:

1. Backhoe is positioned at the top of the bank facing downhill.

2. The boom is extended to the lower edge of the contaminated area or as far downhill as possible.

3. The edge of the bucket is placed in the sediment about 25 to 50 cm deep and moved up the bank, scraping the sediment into the bucket.

4. When the bucket reaches the top of the bank or becomes 2/3 full it is levelled and the material is stockpiled or placed directly into a dump truck.

5. Several slightly overlapping cuts should be made to clear a path approximately 3 to 6 m (10 to 25 ft.) wide.

6. Backhoe is then repositioned to begin cleaning a path adjacent to the previous path (Fig. 3.26).

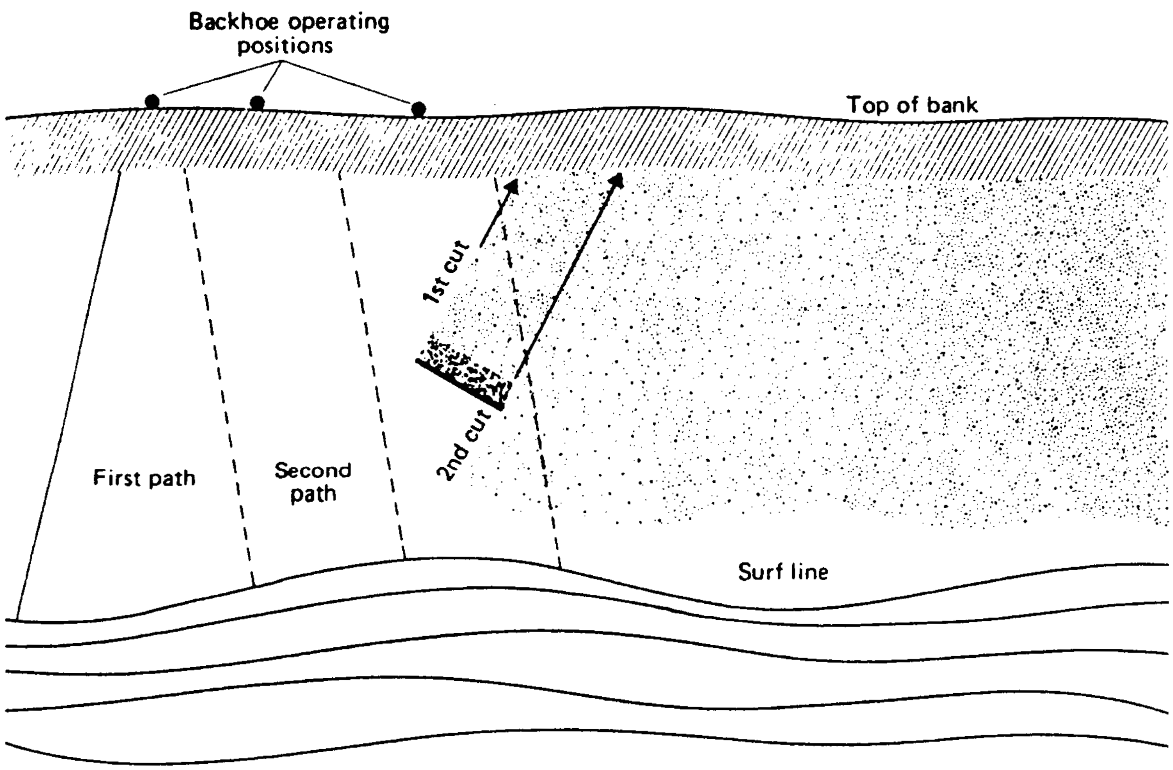

Figure 3.26 Backhoe operational sequence.

(e) Dragline or clamshell (7)

This equipment is used on sand, gravel or cobble beaches where trafficability is very poor and oil contamination and penetration is extensive. Although this method is quite slow and inefficient, it can be used on shorelines where trafficability excludes the use of tracked equipment.

The dragline or clamshell is operated along the upper edge of the contaminated area or as close to it as trafficability of the sediments will permit. It may be necessary to construct an access road from which equipment can operate. The specific operating procedures for a dragline are:

1. If a longshore current is present, begin at the up-current end of the contaminated area.
2. Operate from backshore edge of contaminated area.
3. Position boom * for maximum reach or enough reach to cover the contaminated area.
4. Drop the bucket to the beach and pull back toward the crane to scoop up the sediment.
5. Tilt bucket back when 2/3 full **, swing around, and load the collected sediments into a dump truck, or deposit in a stockpile.
6. Swing the bucket back and continue the cut or start a new cut adjacent to, and slightly overlapping, the previous cut.

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* The boom may have to be of considerable length should the contaminated area be of excessive width.

** The bucket is only filled to 2/3 capacity to avoid spillage.

If a clamshell is used, then the following procedures are followed:

1. The crane and boom are positioned as before and the open clamshell is dropped onto the beach surface.

2. The clamshell jaws are shut, scooping oiled material into the bucket portion.

3. The clamshell is raised and swung around to a dump truck or stockpile where the clamshell is opened, spilling its contents.

4. The clamshell is returned to a spot on the backshore side of, just barely overlapping, the previous cut.

The procedure is repeated until a pass is completed across the contaminated area. The crane is moved slightly and a new pass is started adjacent to the previous one. Figure 3.27 graphically displays the cleaning pattern for both types of equipment.

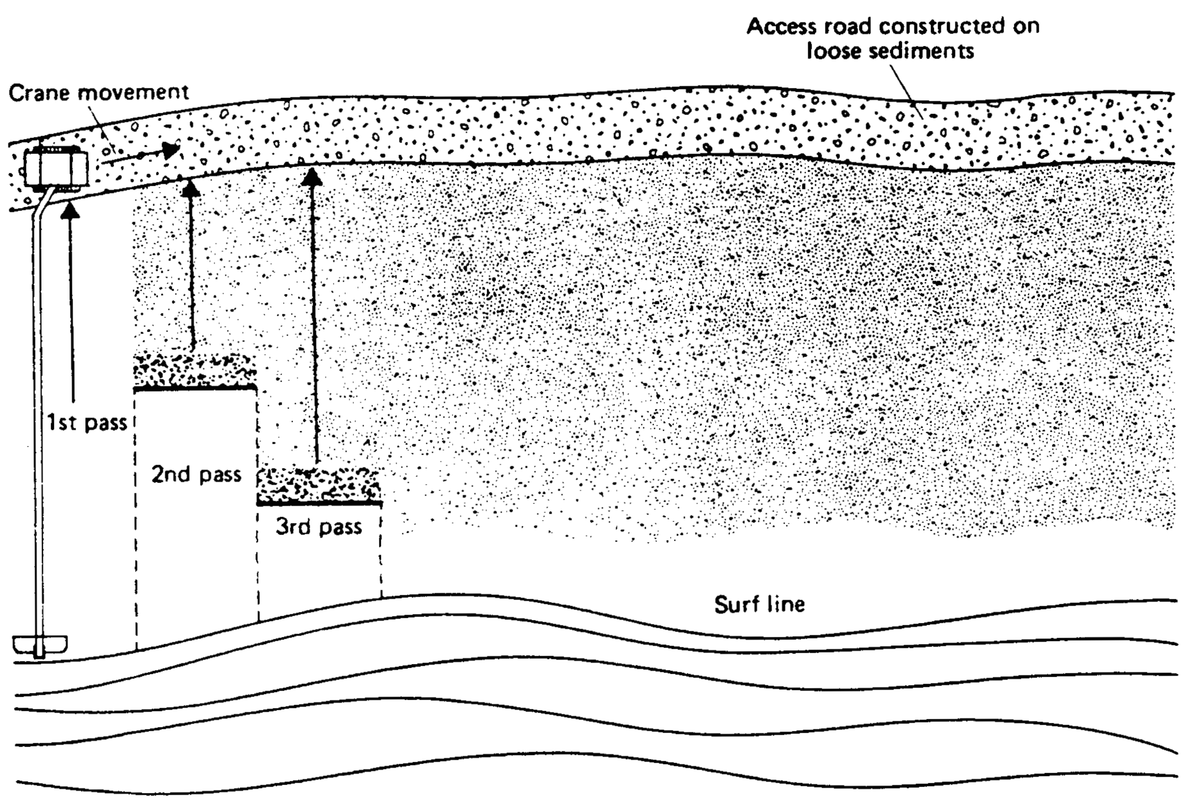


Figure 3.27 Cleaning pattern for dragline or clamshell technique.

(f) High-pressure flushing (hydroblasting) (8)

Hydroblasting has proved to be the most efficient method of removing oil coatings from boulders, rock, and man-made structures. Hydroblasting is safest within a boomed area next to the waterline, but it can be used effectively in the upper intertidal zone if proper steps are taken to contain the runoff water and oil.

Hydroblasting uses a high-pressure water jet that removes oil from almost any surface. The water is often heated close to boiling for increased effectiveness. The water jet should be used only by trained personnel. Too strong a jet will remove all plant and animal life and may also damage man-made surfaces.

When the hydroblast jet drives oil from a surface the oil then adheres to another surface or forms a slick on top of the water. The oil must be prevented from contaminating other rocks, gravel, silt, or sand, and this is best achieved by letting the water and oil form a pool or letting the oil re-enter the water. Specific operating procedures for hydroblasting are:

1. If the oil is to be channeled into the water or there is a possibility of it re-entering the water, containment booms should be anchored beyond the surf zone, or close to the shore when used on inland waterways.

2. Flushing should begin at the highest point, working downslope. It should be conducted at high tide or timed so the lowest point is cleaned at low tide and the oil recovered before the tide rises and recontaminates the area.

3. Plastic sheets should be placed over adjacent surfaces to prevent further contamination and to direct the flow of water and removed oil to the desired area.

4. Berms or ditches can be constructed or booms used to further channel the oil and water into collecting pools or, in some cases, back into the surf or waterway.

5. Pumps, vacuum trucks, or shoreline skimmers can be used to transfer the collected oil to suitable containers for disposal.

(g) Steam cleaning (9)

This method is used for removing oil coatings from boulders, rock, and man-made structures. The steam raises the temperature of the adhered oil, thereby lowering its viscosity and allowing it to flow off a surface. However, since living plants or animals attached to a surface would be unlikely to survive the high temperatures of steam cleaning, this process is not usually recommended for surfaces that support living plants or animals.

Steam cleaning euqipment uses a high-pressure steam jet that will remove oil from almost any surface. It drives oil off one surface onto another, requiring that precautions be taken to avoid recontamination of previously unaffected areas. Specific operating procedures for steam cleaning are:

1. When used on shorelines the oil should be prevented from re-entering the water by surrounding the working area with containment booms, which concentrate the removed oil for pickup by skimmers or vacuum equipment.

2. Cleaning should begin at the highest point of contamination working downslope and be done at high tide or timed so the lowest point is cleaned at low tide and the oil recovered before the tide rises and recontaminates the area.

3. Plastic sheets should be placed over adjacent surfaces to prevent further contamination and to direct the flow of removed oil to a collection point.

4. Berms or ditches can be constructed to further channel the oil into collecting pools or back into the water.

(h) Sandblasting (10)

This method is used primarily to remove thin accumulations of oil residues from man-made structures. Sandblasting also removes any vegetation or animals inhabiting the surface and should not be used where repopulation may take considerable time, or where other techniques are available.

Sand is applied to the structure surface at high velocity using sandblasting equipment. The oil is removed from the substrate by the abrasive action of the sand. The result is an accumulation of sand, oil, and surface material in the area near the operation. This should be removed and transported to a disposal area. In most cases the sand used cannot be taken from a nearby shoreline as it must be screened to obtain the proper size. Specific operating procedures for sandblasting are:

1. Blasting should begin at the highest point of contamination and work down to the base of the structure.

2. Operations should be done at low tide to clean as much of the structure as possible.

3. Removal of the accumulation of spent sand, oil residues, and surface material is generally performed manually with shovels and wheelbarrows. Should the quantity become large, front-end loaders may be used.

(i) Sump and pump/vacuum (12)

This technique is used primarily on firm sand or mud beaches in the event of continuing oil contamination. For a coastal shoreline with a longshore current, a sump is dug in the intertidal zone with a berm built from the excavated material extending from the back of the sump into the surf on the lowest side of the sump. The current moves the oil down the beach where it is intercepted by the berm and channeled into the sump. A vacuum truck or trash pump is used to remove the oil and water from the pit or sump. The specific procedures for constructing and operating the sump and pump are:

1. Dig a rectangular sump at some point down-current from the contaminated area approximately 1 to 2 m (3 to 6 ft.) deep at the back end sloping upward toward the surf.

2. The sump should be constructed at low tide and situated so the back end is located just above the high-water mark extending 1/2 to 2/3 the distance across the intertidal zone.

3. The berm should be of sufficent height to be above the water level at high tide and run from the back end of the sump, alongside, and down to the lower intertidal area angling slightly up-current.

4. A suction hose from a vacuum truck or trash pump is operated manually to collect oil from the surface of the sump.

(j) Manual removal of oiled materials (13)

Manual removal is used on mud, sand, gravel, and cobble beaches when oil contamination is light or sporadic and penetration is slight, or where heavy equipment access is not possible. Manual removal may also be used when heavy equipment use is deemed harmful to the environment.

The equipment required for this work includes rakes, shovels, hand scrapers, plastic and burlap bags, buckets, and barrels. Oiled vegetation, debris, and sediments are collected by manual labourers and placed in bags for removal and disposal. Supervisors should be placed in charge of groups of workers with a foreman for each group. The procedures for manual removal are:

1. Wear protective gloves, boots, and hand cream.
2. Cut and/or collect contaminated material into small piles.
3. Do not rake vegetation.
4. Fill plastic or burlap bags half full with material from piles.
5. Place filled bags on plastic sheets above high-water line.
6. Bags may be removed manually, by vehicle, airlifted by helicopter, or loaded onto small boats or barges from shoreline or makeshift docks.

The rate for manually cleaning a shoreline area depends on the number of workers used, their productivity, the method of removal of contaminated materials, and the degree of contamination. If a shoreline area has sporadic contamination it can be cleaned much faster than if it is heavily contaminated. The more workers used, the faster an area can be cleaned. Helicopter, vessel, or vehicle removal of collected materials is fast and effective, whereas manual removal of collected materials is very slow and labour-intensive.

(k) Low-pressure flushing (14)

Low-pressure flushing is used to remove light, non-sticky oils from lightly contaminated mud substrates, cobbles, boulders, rocks, man-made structures, and vegetation. Low-pressure flushing will not disturb the substrate to any great extent but does present the threat of recontamination of unaffected areas if runoff from the flushing operation is not properly channeled and collected.

Test flushing should be done in each situation to determine the suitability of this technique. Flushing systems of any size may be assembled, although small portable units are generally most useful. Direct application of the water stream to the oiled substrate is not necessarily desired as erosion or damage to the flora and fauna may result. Bathing the substrate will generally float oil off the surface without any adverse effects. Oil can then be channeled into collection areas for removal. Procedures for low-pressure flushing are:

1. Containment booms should be anchored just past the surf zone or near the shore on inland waters if there is a possibility of the oil re-entering the water.

2. Flushing should be completed and oil recovered at low tide to avoid recontamination of the intertidal zone by the rising tide.

3. Begin flushing at the highest contaminated point and work downslope toward the water.

4. The runoff is channeled by berms, ditches, or booms into contained areas or sumps where it can be removed by vacuum trucks, pumps, or sorbents. If used on inland waters with little or no current, it may be washed back into the water within the confines of a containment boom and herded toward a collecting point with water jets.

5. Shoreline characteristics, winds, and currents should be used to advantage.

(1) Dispersants

The type of equipment used to apply dispersants to shorelines varies with the type of dispersant, the type and amount of oil contamination, and the application technique selected.

Hydrocarbon-base dispersants are generally required to treat viscous or weathered oil. They dissolve or soften coatings to permit their removal by flushing, high-pressure blasting, steaming, or by natural wave action which may be sufficient. To accomplish this loosening, only light applications of dispersant should be made, together with a suitable reaction period before flushing or additional dosage is attempted. Areas with limited contamination can usually be treated with a backpack or hand-held garden sprayer fitted with a single, wide-angle nozzle to produce a coarse spray. Larger areas require a stationary or mobile high-volume pump with dispersant tank capable of serving one or more spray lances with long hoses.

Water-base dispersants can be applied by several different methods. The extent of contamination, the type of substrate, availability of euqipment and desired effect determine the proper method. Water base dispersants can be used to (a) directly assist in removal of oil, or (b) prevent the re-formation of slicks where the removal mechanism is primarily mechanical. Generally, small contaminated areas can usually be treated with a backpack or hand-held garden sprayer containing a premixed solution of dispersant and sea water. After a suitable reaction period, the treated area may require supplementary flushing. Larger areas are more efficiently treated with spray lances or fire hoses. If the oil coating is viscous, water-base dispersant can be injected into a high-pressure water washing stream (hydroblaster).

In all cases, unless oily runoff is collected, the shoreline treatment should be limited to periods just prior to high tide, when there is the most rapid dilution of treating agent and removed material.

(m) Burning (18)

Burning is used on coastal or inland substrates and vegetation where sufficient oil of a proper type has collected to sustain ignition. Consideration must also be given to the potential environmental damages resulting from burning and to the potential for igniting adjacent backshore trees.

The feasibility of burning should be determined by test ignition of an oiled area away from the actual site. Relatively high temperatures may be required for ignition, but once ignited the fire must be self-sustaining to be effective.

Specific operational procedures for burning are:

1. A plan that provides for safe, controlled burning should be prepared.
2. If the area is very large, it may be necessary to section it off with fire breaks to ensure controlled burning.
3. The fire is started on the upwind side of the contamination area or section. A combustion promoter or flame thrower may be required initially to sustain ignition until sufficient heat is generated to maintain the burning.
4. The fire would be allowed to burn until exhausted or until it reaches a barrier.

(n) Vacuum trucks (19)

A vacuum truck is best used to pick up oil which has collected in pools on the shoreline, but can also be used to skim relatively thick layers of oil off the surface of the water. The latter use is somewhat inefficient, as rather large quantities of water are usually collected along with the oil. This techniques is, however, invaluable in the absence of skimming equipment. When vacuum trucks are used to pick up oil which has formed pools in shoreline depressions a screen should be placed over the suction nozzle to prevent any debris that can cause serious and expensive damage from entering the vacuum truck system. Finer-mesh screens should be used for light oils such as kerosene, while coarse screens are needed for heavy oils.

If used to collect oil from a water's surface, the same procedure is used with the addition of booms or some means of concentrating the oil to increase the ratio of oil to water collected.

(o) Push contaminated substrate into surf (20)

This technique is used primarily on lightly contaminated cobble and gravel beaches where removal of sediments may cause erosion of beach or backshore area, or where acceleration of oil degradation rather than cleanup is preferred.

Bulldozers are used to push the contaminated layer of sediments into the lower intertidal area where wave action and increased cobble or gravel movement will remove the majority of the oil from the sediments and accelerate degradation rates. The sediments are returned to the beach within a relatively short period of time through natural wave and tidal action. Specifically, the sequence of operational procedures is as follows:

1. Preferably this operation is carried out at low tide to avoid the equipment operating in the water.

2. If a longshore current is present, cleaning should begin at the up-current end of the contaminated area.

3. The bulldozer is operated in first gear, cutting to a depth not exceeding that of oil penetration.

4. Starting from the backshore side, the oiled sediment is pushed straight into the lower intertidal area.

5. The dozer is returned to starting point by backtracking on cleaned area.

6. Dozer is repositioned for second pass which should run adjacent to, and slightly overlapping, the previous run.

7. Figure 3.28 displays the cleaning pattern for pushing contaminated substrate into the surface.

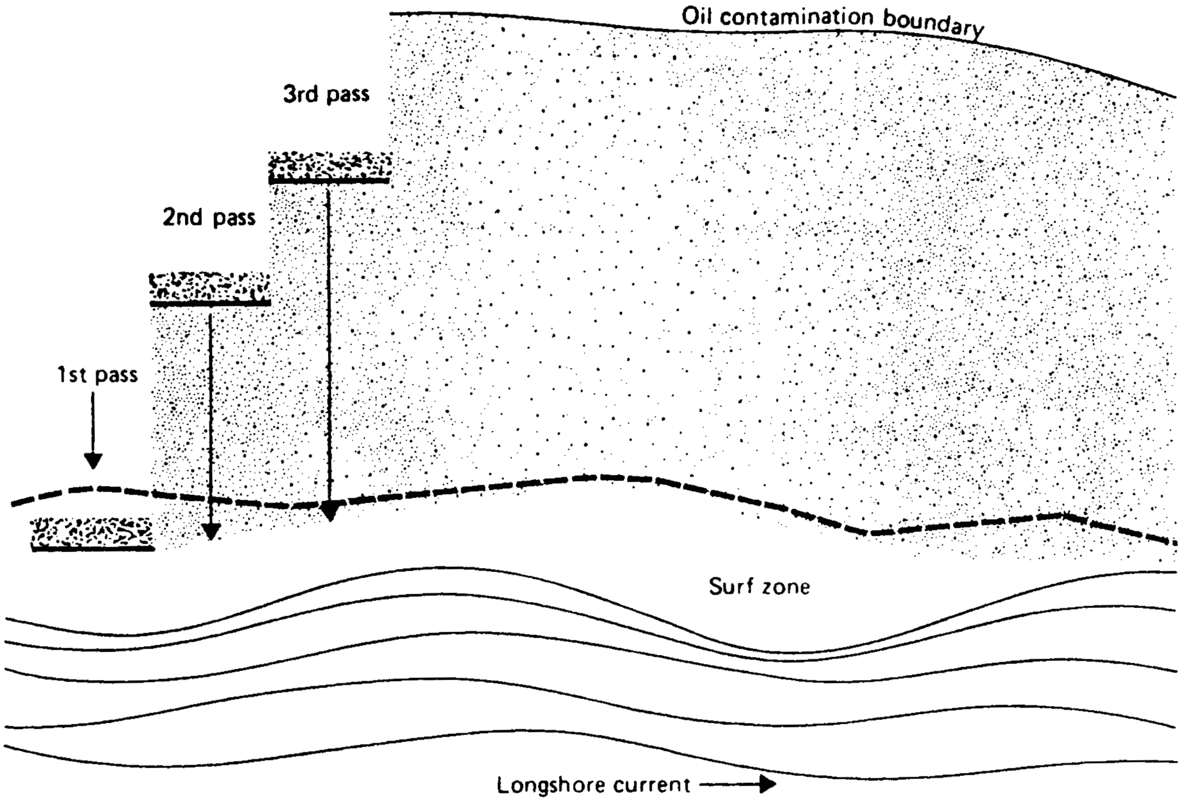


Figure 3.28 Cleaning pattern for pushing contaminated substrate into surf.

(p) Breakup of pavement (21)

This method can be used on high-energy, cobble, and on gravel or sand beaches where thick layers of oil have created a pavement on the beach surface and substrate removal will cause erosion. It should be used only on remote or low-priority beaches because this technique leaves the oil on the beach to degrade naturally.

The oil pavement is broken up by a tracked bulldozer or front-end loader fitted with a ripping apparatus on the rear of the tractor. The ripper consists of two or three large, curved teeth which are dragged through the pavement by the forward movement of the tractor. The specific sequence of operating procedures are:

1. Operate the tractor in first gear at 1.6 to to 3.2 km/hr (1 to 2 mph).
2. Set the rippers to a depth slightly below the pavement thickness.
3. Begin ripping along the backshore edge of the pavement-covered area, operating parallel to the surf line.
4. Continue to end of contaminated area or approximately 200 to 300 m in distance.
5. Tractor is turned around and repositioned to rip a path in the opposite direction adjacent to the previous one.
6. Figure 3.29 illustrates the ripping pattern to be used in pavement-covered areas.

Tracked vehicles or tractor-drawn rakes, ploughs and hoes can be used to breakup a pavement in the absence of ripping apparatus.

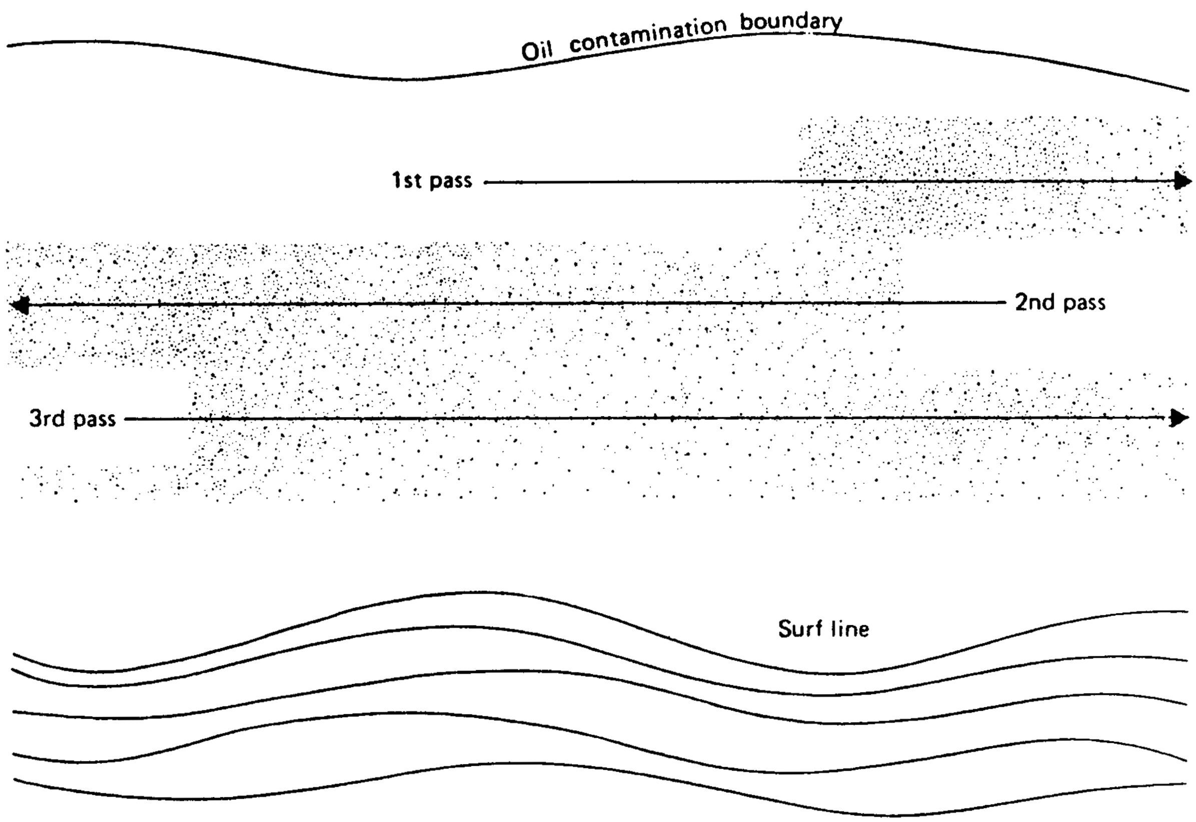


Figure 3.29 Cleaning pattern for breakup of pavement.

(q) Disc into substrate (22)

This technique is used on non-recreational sand or gravel beaches that are lightly contaminated and are of moderate to good trafficability. Although this technique is very fast and efficient, the oil is not removed but buried into the top layer of sediments and left to degrade naturally.

The oil is disced into the substrate using a tracked loader or tractor towing a discer. This discing equipment is the same as that used for tilling agricultural fields. The specific operating procedure for discing into the substrate is:

1. Begin along the backshore edge of the contaminated area.
2. Operate the tractor in second gear and continue to the end of the contaminated area or approximately 200 to 300 m in distance.
3. The tractor is turned around and a new path started adjacent to, and slightly overlapping, the previous one. Figure 3.30 displays the cleaning pattern for discing.

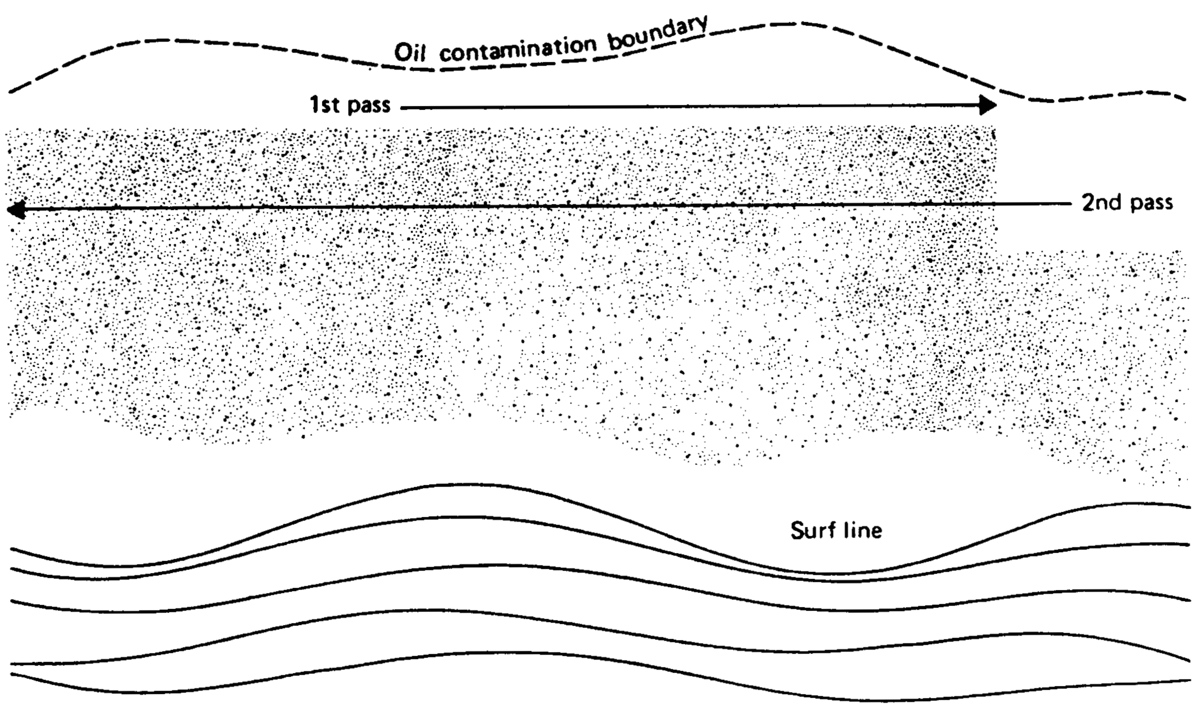


Figure 3.30 Cleaning pattern for discing into substrate technique.

3.4.4 Disposal of Material

Handling recovered oil and oil-contaminated materials can pose both immediate and long-range problems. Oil/water mixtures can be separated in treatment tanks and recovered oil then sent to a refinery. Disposal of contaminated debris is more difficult. In most cases, contaminated wastes should not be burned. They can, however, be buried safely on land in approved disposal sites if correct procedures are followed. It is often advisable during waste handling, transfer, or storage to prevent contamination by covering the area of operation with plastic sheets.

Disposal can pose several problems. In particular, it is often necessary to locate on-site storage before transportation of oil and contaminated material to the final disposal sites. In most oil spill situations, recovered material is stored for a short period of time at a local site, while arrangements are made for a final disposal site.

Several disposal methods are available. They include oil and water separation, burial, and natural degradation. The specific disposal method selected depends on the nature of the oil-contaminated material and the location of the spill.

3.4.4.1 Oil and water separation

The majority of the oil and water separation can be performed at existing treatment and separation facilities located at refineries or oil production sites. However, if the spill is minor and/or occurs at a considerable distance from any such facility, the following techniques can be used to provide oil/water separators for field use. These separators might also be utilized locally to remove a portion of the water so as to reduce the bulk of the oil/water mixture before transporting it for final separation.

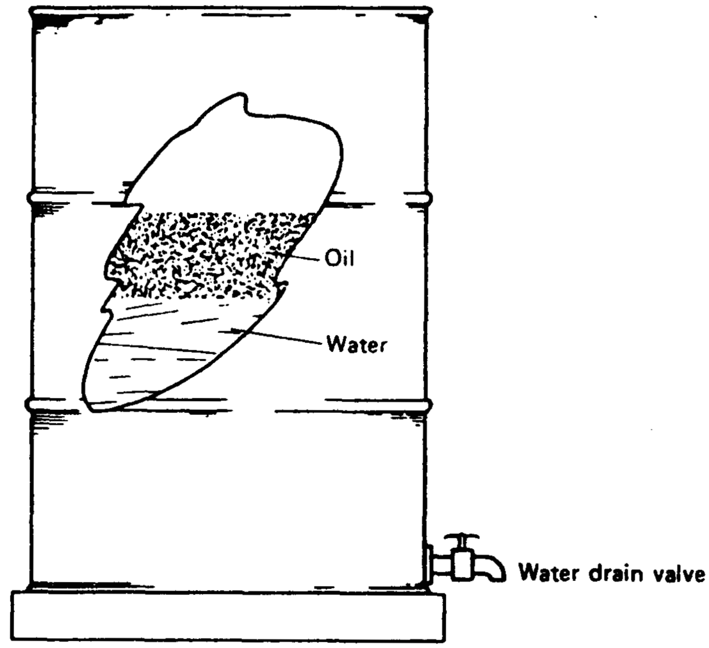
Effective oil/water separators can be constructed under field conditions to further recover oil from oil/water mixtures. Fifty-five gallon drums or sheet metal welded together into a 4 x 5 x 4-foot transportable container can be used as separators, after being fitted with a bottom draining pipe with valve. The oil/water mixture would enter the container from the top, be allowed to settle, and water then drained off the bottom through the drain pipe. The oil can be pumped from the vat to a storage tank or tank truck (Fig. 3.31 A.).

A second method can be used to remove oil from a natural or excavated sump pit. A 55-gallon drum fitted with a small pump and hose and a 4- x 18-inch slot cut from the top third is suspended upright into the sump pit, positioned such that the bottom of the slot remains just below the surface of the oil layer. Oil flowing into the drum is then pumped into a storage tank or tank truck (Fig. 3.31 B.).

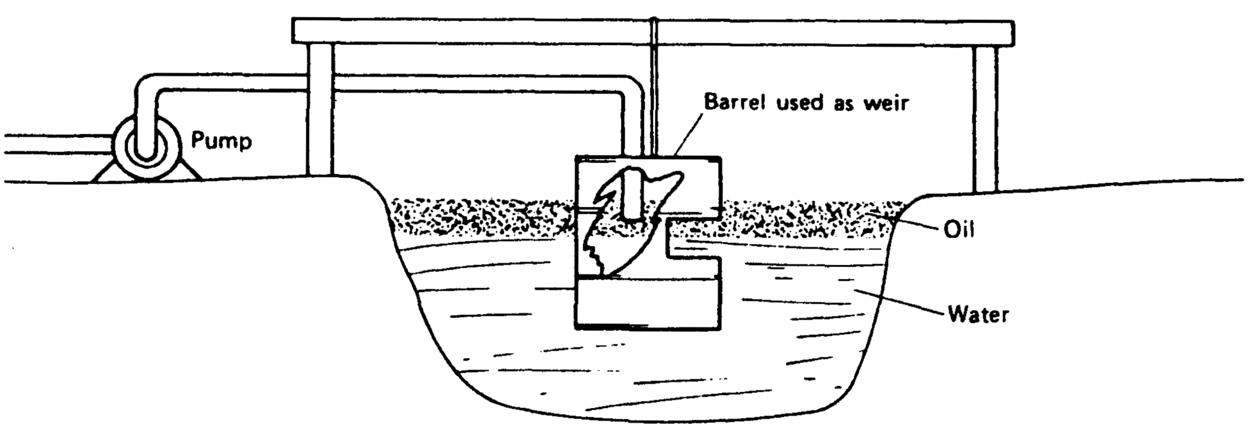
A drum or any portable tank can also be used to provide oil/water separation. If water in oil emulsions are recovered, chemical de-emulsifiers can be added to the separator tanks to aid in breaking the emulsions and providing more effective water/oil separation.

3.4.4.2 Temporary waste storage sites

In the event of any shoreline cleanup operation, establishing a temporary oily waste disposal site close to the cleanup operation is very important. The purpose of a temporary storage site is to provide a location to accumulate oily sediment and debris removed during shoreline cleanup operations until a final disposal site can be located, approved, and arrangements made for its use. The temporary storage sites should be located in an area with good access to the shoreline cleanup operation and to nearby streets and highways. Good



A. 55-gal drum oil/water separator.



B. 55-gal drum and sump oil/water separator.

Figure 3.31 Field oil-water separation techniques.

storage site locations should be flat areas such as parking lots (paves or unpaved) or underdeveloped lots adjacent to the shoreline.

Temporary storage sites should be selected and prepared to minimize contamination of surrounding areas from leaching oil. Therefore, storage sites should not be located on or adjacent to ravines, gullies, streams, or the sides of hills, but on flat areas with a minimum of slope. Once a location is selected, certain site preparation is usually necessary to contain any leaching oil. An earth berm should be constructed (Fig. 3.32) around the perimeter of the storage site. If a paved parking lot is used, earth would have to be imported from nearby areas; if an unpaved surface is used, material can be excavated from the site itself and pushed to the perimeter, thereby forming a small basin. Entrance and exit gaps should be left in the berm to allow cleanup equipment access to the site. If the substrate of berm material is permeable, plastic liners should be spread over the berms and across the floor of the storage site in order to contain any possible oil leachate.

A front-end loader should be stationed at each storage site to distribute the dumped oily material evenly and to load trucks removing the material to final disposal.

3.4.4.3 Transport

Transporting oiled material to a final disposal site is usually done with dump and tank trucks. The material is loaded into the trucks at the point of removal or temporary storage and transported to an approved dump site. The trucks typically have capacities of 10 yd^3 or 20 yd^3. To prevent oil leakage during transport, the truck beds should be lined with plastic sheeting.

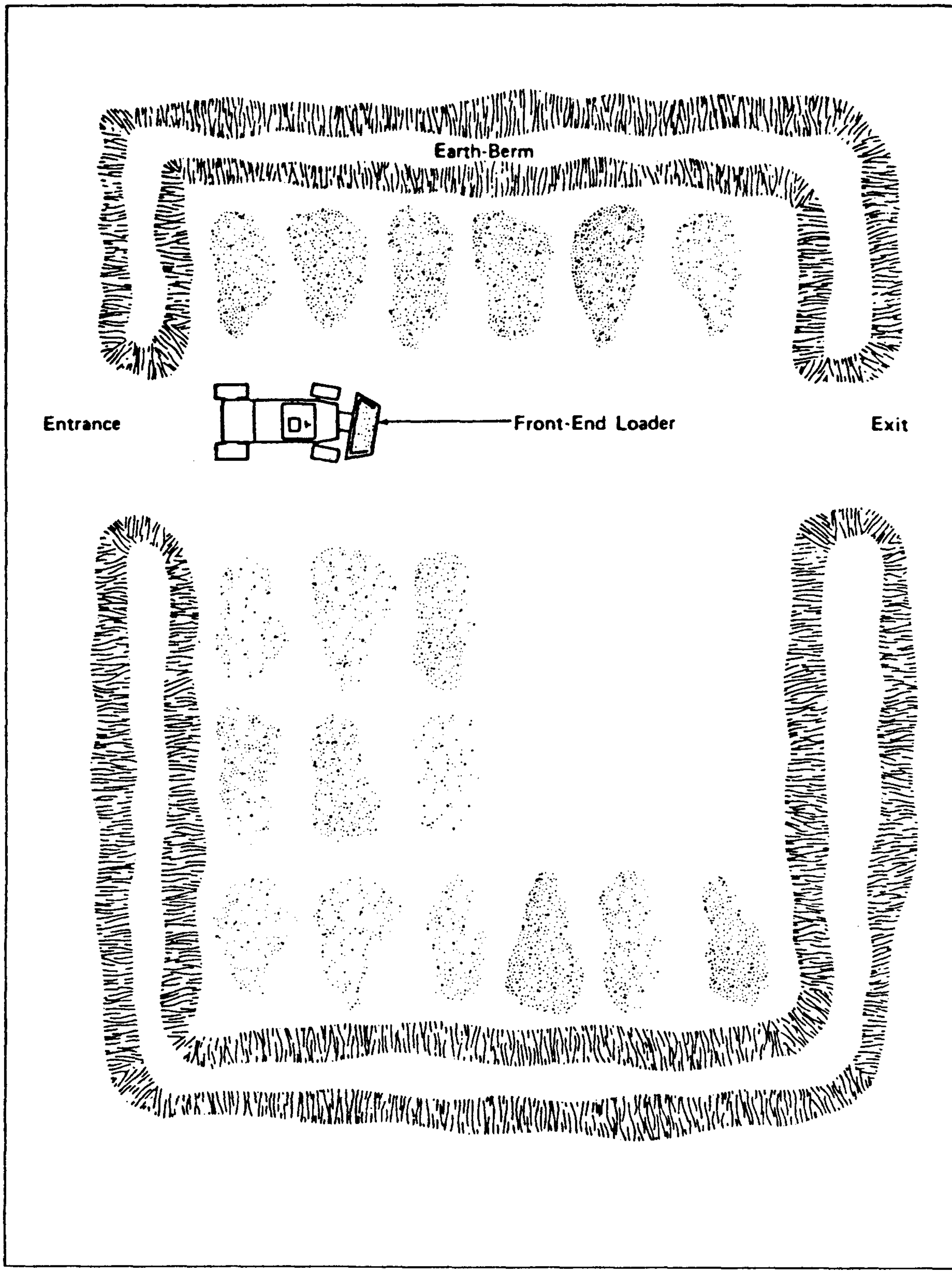


Figure 3.32 Suggested configuration for a temporary waste storage site.

In more remote areas transportation may involve the use of boats to remove material. Again care should be taken to ensure that spillage or leakage is avoided by the use of plastic bags or liners in all cases.

4.0 SUMMARY

Contingency planning is dependant upon the availability of relevant information and must take into account a wide range of disparate information. The actual response to a spill situation and the initiation and implementation of countermeasures is dependent upon a series of factors that will be unknown until the incident occurs. Despite these limitations, the analysis of information and the preparation of relevant data sets in an organized manner can be of considerable benefit. Without pre-spill studies the response activities are made more difficult, due to the lack of relevant information, and the response timing would be delayed until essential data are gathered. Pre-spill studies are of particular benefit during the initial response period when little or no time is available to gather relevant information or to organize that information so that it may be of value to the decision makers.

The primary objective of this study has been to consider the types of information and the levels of detail that are necessary to adequately respond to spill incidents by the implementation of mitigating countermeasures. Efficient and effective response actions can be taken if the available relevant information is filtered and organized in a logical manner. The principle that underlies the suggested series of spill response maps is that answers to different questions require different types and levels of information. Identification of the primary questions enables the information base to be compartmentalized. In this manner, it is possible to provide discrete levels and types of information in separate formats. The questions identified by this study are:

- where does/will a problem occur and where will a response action be required?
- what is/will be the nature of the problem?
- how can an action mitigate that threat?

These primary questions are considered to be respectively strategical, operational, and tactical in character and are considered at different levels of detail or scales. The use of different maps is based on the premise that different sets of information can be displayed at different scales. The scale chosen is determined by the smallest size of a feature that must be legible or identifiable on the map. Thus, different spill response questions require different map scales to present different information or data sets. A characteristic feature of the three sets of response maps presented here is that the volume of information as well as the level of detail, increases as the questions become more specific. At the most detailed level, more than two maps and a coded table are required to legibly display all of the necessary information at the desired level of detail. This is in marked contrast to the relatively simple regional strategy maps.

Initially the questions that should be asked are relatively generalized and regional in character. These relate to a definition of where the threat (spill) is likely to have a serious effect by disturbance of biological species or habitats, or of human activities. For this initial response, the level of detail that is required is low. The primary objective is to simply locate and define areas or sites of concern and to indicate briefly the nature of that concern. These are sites or areas where a response action, either to protect or cleanup a shoreline, would probably be necessary in the event of a spill. In this pilot study, the objective is achieved by the use of topographic maps at a 1:250,000 scale. The strategy maps identify regions of concern where a countermeasure response would likely be required. No sitespecific data are presented, as the minimum size of feature that can be identified is 250 m, and the minimum length of a mappable unit is in the order of 1 km. The general physical character of the shoreline is indicated by a pattern. The nature of the potential disturbance to biological species or habitats, or to human activities, is described briefly in note form on an accompanying table. These sites or areas of concern are identified so that initial resource deployment decisions can be made at a regional scale. Once an area has been identified and is threatened by a spill, more detailed information is required to assess the nature of the potenial disturbance.

The development of a response plan involves evaluation of operational parameters that focus on the nature of the problem or potential problem. Information that would be required to make these evaluations is presented at a scale of 1:50,000. The element of time with respect to biological and human activity cycles is of particular concern at this level of detial. Operational maps and supporting tables or notes indicate the possible timing and nature of the disturbance, but a real-time spill reconnaissance or an on-site survey is also necessary to determine if, in fact, the concern is valid. The objective of prepared operational maps is to define and describe the spatial and temporal components of threatened elements. This information is presented, in this pilot study, as a map and tables. In addition, an evaluation of the possible severity of the disturbance is indicated both spatially and temporally. The maps (1:50,000) provide information on the physical shoreline character and define the boundaries or limit of areas or sections described in more detail in the notes or tables. At this scale, the minimum length of a mappable unit is in the order of 150 m, and the smallest size feature that can be identified is 50 m.

The development of a specific course of action to mitigate the threat involves a detailed set of data that is site- or area-specific. The tactical scale proposed for the pilot study area has been adopted in order to present relevant parameters that would be considered during an evaluation of the way in which an appropriate countermeasure could be implemented. These tactical maps and notes, at a scale of 1:16,000, indicate site-specific physical and logistical information and identify possible operational constraints. Such maps would probably be developed only for sections of coast where response actions would be highly likely, that is, areas or sites of primary concern. The primary tactical response would be to describe a solution to a problem. Appropriate response protection or cleanup actions can be suggested or recommended but these suggestions must be considered in the light of environmental and spill conditions at the time of the incident. As with decisions that are made at the operational level, reconnaissance or on-site surveys are necessary to supplement the pre-spill studies with information that cannot be obtained prior to the event. At this level of detail, it is possible to identify individual features that are approximatley 15 m in size and to map units that are in the order of 50 m in length. In this pilot study, the tactical maps present local information on the physical and biological character of an area. Relevant information on access, nearshore currents, potential boom deployment sites and staging areas is provided on detailed tables or hydrographic charts.

Each of the spill response maps contains information at different scales or levels of detail. Similarly the information base that is required to prepare each of the three different maps varies in both the degree of detail and the degree of accuracy. The strategy maps are the most generalized and could be prepared from map or aerial photograph interpretation and from available information. Tactical maps, on the other hand, can only be prepared from detailed information that has been checked in the field. In this study the inital process began by development of a detailed data base for the physical shore-zone analysis. The coded sheets and maps (1:10,000 scale) provided the basis from which the more generalized maps were prepared. By this approach, a high level of accuracy is maintained even though the pictorial information becomes more generalized and less site-specific.

The collection, storage and retrieval of detailed shore-zone information can best be achieved by a logical and systematic approach. The method adopted for this study involves a detailed analysis using information obtained from maps, charts, vertical aerial photographs, and oblique colour videotapes that is coded at a scale in the order of 1:50,000. For this study, 39 separate items were coded. The physical shore-zone character was summarized in terms of eight repetitive shoreline units that typify the study area. These shoreline types were mapped at a scale of 1:16,000, in part to present the physical character of the shore zone, but also to indicate the boundaries of the units defined in the coding sheets. This approach provides a great level of detail combined with a high level of accuracy.

The coding and mapping system is designed to be flexible, both in terms of the actual information and the scale of analysis or map. This study focusses on the detailed physical shore-zone analysis of a rocky ocean coast. The system can be adapted to include biological parameters, to describe arctic or tropical coasts, to river or lacustrine environments and to more general scales. The coded sheets and maps are accompanied by a text narrative that describes some of the more general features of the coast. This regional description is most appropriate when used with the 1:50,000 or 1:250,000 scale maps. The use of three scales in the physical shore-zone analysis is intended to illustrate the levels of details, or conversely of generalization, that are associated with the different scales.

A set of edited and annotated, low-altitude, colour videotapes was prepared for the pilot study area as part of this project. These videotapes are intended to complement the manual and provide a complete coverage of the intertidal zone of the coast. The primary purpose for the tapes is to provide a continuous visual image of the coast for use in planning, training, and in the actual implementation of spill countermeasures. The set of tapes and an accompanying manual form a separate, but closely related, part of the pilot study.

The physical shore-zone analysis presented and described in this study is intended for a variety of uses. The application of this data would be necessary to plan the implementation of countermeasures. The development of a series of maps that use the same (physical) data base is intended to provide meaningful sets of information that would be necessary to answer specific questions during a spill response. Identification of the information requirements, in terms of a series of questions, enables the available data to be screened an to be organized in a manner such that the user is not inundated by a large volume of relevant, but unorganized, information.

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APPENDIX I
SHORELINE AERIAL VIDEO-TAPE SURVEYS FOR SPILL COUNTERMEASURES

The collection and presentation of environmental information relevant to oil spill contingency planning and countermeasure implementation has focussed to date primarily on the preparation of maps. Depending upon map scales and upon the quality of the information, these maps are a basic and an important tool for both general planning and for site-specific activities. The recent development of a technique using low-altitude (100 m), oblique colour video-tape recording (VTR) adds a very valuable component to the analysis and presentation of shoreline information. Although the method is not itself new (for example: the entire coast of the Canadian Great Lakes was video-taped in the mid-70s by the Shore Damage Survey at CCIW in Burlington), the application and refinement of the technique to contingency planning and spill countermeasures is a new development.

Sources of Information for Shoreline Survey

The traditional methods for mapping physical and general biological shoreline characteristics have been based primarily on: (i) vertical aerial photography, (ii) ground surveys, (iii) low-altitude oblique colour photography, and (iv) topographic maps. These four techniques are usually used in combination. Air photos and maps provide continuous information but often lack detail for small-scale mapping, except where available at scales less than 1:50,000. Conversely, ground surveys and low-altitude oblique photography can provide considerable detailed information but lack continuity. It is rarely possible to survey entire sections of coast on the ground due to constraints of time, money and shoreline access. Even the most prolific photographer rarely averages more than one or two photographs or slides per kilometer during surveys longer than 10 km. On an aerial reconnaissance of the Canadian Great Lakes in 1978 one of the authors (Owens) took approximately 1,800 slides for 9,000 km; an average of one slide for each 5 km. Similarly, in a recent aerial survey of the Beaufort Sea and the Northwest Passage coasts, 2,450 slides were taken for a 4,800 km section of coast (approximately one slide for each 1.9 km).

Topographic maps provide only a general indication of physical shoreline characteristics (i.e., relief, general morphology) and are best used as a base for displaying mappable data obtained from other sources.

As a result of these limiting factors, it is necessary to sacrifice either complete accuracy or continuity in coastal mapping. This does not imply that mapping using these methods singly or in combination is inaccurate, but rather that the mapping is only as good as the information base. In preparing maps for contingency planning or for countermeasure operations, the use of VTR surveys in combination with the existing survey techniques, can significantly improve the information base.

Advantages of VTR Surveys

The advantages of low-altitude colour VTR surveys are that:

a) the information (image) is continuous,
b) shoreline characteristics can be mapped directly from tapes, and
c) the tapes can be used as an audio-visual technique for users to view a section of coast.

Video-tapes alone are valuable, as are vertical aerial photos or oblique colour photographs. The best available information source for coastal mapping involves the use of combination of maps, vertical aerial photographs, oblique photographs and ground truthing, as well as a VTR system.

A distinct advantage of a VTR system over photography (either still or movie) is that the recorded image can be viewed in real time on board the aircraft. It is therefore possible to monitor the quality (colour and clarity) of the image and the framing of the picture during the flight. In addition the capability to view tapes following a flight (in a hotel room) allows an on-site review and critique. Thus it is possible that sections of poor coverage (due to turbulence, poor lighting etc.) can be resurveyed the following day or before leaving the study area. This real-time replay potential also alleviates the tenseness of the first viewing of slides or movies to see if anything came out after one has been back from a field trip for a week or two!!!

From a geological viewpoint, the combination of VTR plus traditional information sources is a significant step forward in methodology. By providing a continuous coverage of the coast this method overcomes the bias that a still photographer may introduce into the frequency of pictures taken and into the choice of the location of photographs. Shorelines change through time, inlets open or close, spits grow and cliffs erode, so that resurveys can update the information base. Continuous coverage of the coast also provides an excellent means of locating exact site of a still photograph or of identifying the exact dimensions of shore-zone features. (We still have numerous slides of interesting features taken "some were between Cape A and Point B"). In the system which we have used on recent surveys our equipment has been modified to allow the cameraman and the still photographer to record observations simultaneously (and in synchrony with video) onto the tape using headsets and microphones. This audio commentary has proved very valuable during subsequent viewing and editing of the tapes.

From a biological viewpoint, video-tapes are also a valuable information source (again in combination with other sources). The primary advantage is the continuous record of the along-shore and across-shore cover of the supra-tidal and inter-tidal zone by dominant sessile or sedentary species. From the tapes, the specific location of each biotic community type can be mapped and correlated with physical characteristics, such as exposure and substrate. In particular, zones where one community changes to another can be identified and mapped. From this information an estimate of the area dominated by specific communities on a section of coast can be obtained. In cases where it is possible to obtain VTR coverage during different times of the year, seasonal comparisons of the spatial distribution can be made. Similarly if a section of coast is disturbed (e.g., by an oil spill) a comparison of an area could be made before and after the disturbance.

The primary advantage of biological information is in providing an accurate estimate of the relative size and distribution of communities (provided that the dominant biotic forms are distinguishable from the substrate). These estimates of spatial distributions are considerably more precise and accurate than those which could be obtained from a discontinuous record such as slides, in-flight field notes, or spot ground surveys. In order to determine the abundance, size-frequency, species composition and other population and species parameters for an observed community, ground truth is an essential component of a biological survey. By combining both information sets, the population parameters for whole section of coast can be estimated.

The geomorphological (or geological) and biological information obtained from a VTR survey can be directly applied to:

(a) identify and map the physical shore-zone character,
(b) identify and map specific shoreline features (e.g., inlets, marshes, etc.),
(c) identify and map biotic communites,
(d) locate migratory species at a given time (e.g., inlets, marshes, etc.),
(e) evaluate shoreline accessibility by land, sea and air.

All of these are important aspects in developing either shoreline maps or contingency plans at regional and local scales.

A second major use for video-tapes, particularly in remote or inaccessible areas, is that the tapes can be easily viewed by an on-scene coordinator and his staff at the spill headquarters. This would be particularly valuable if logistics or poor visibility preclude a reconnaissance of a given section of coast. Many users find that video-tapes are more "realistic" than vertical photography as well as having the advantage of providing the continuity that slides lack.

The primary uses and advantages of VTR surveys for spill technology are therefore related to the provision of:

(1) geological and biological shoreline information for pre-planning, and
(2) logistics and accessibility information for determining countermeasure feasibility and accessibility during a spill.

In addition, during a spill a VTR survey would provide a real-time display of the extent and degree of shoreline contamination.

Limitations of VTR Surveys

Although the use of a continuous low-altitude record provided by video-tapes is a significant contribution to shoreline studies and spill operations, it is not a panacea. The principal limitations are:

(a) As a survey tool the tapes are only as good as the cameraman and pilot and as the interpreter. Poor flying conditions, (for example, turbulence or poor light conditions), can result in a poor video record.

(b) Even from a slow moving stable aircraft, such as a helicopter, it is not always possible to determine the specific sediment characteristics or biotic communities. On the basis of VTR alone, in general it is not practical to identify other than the visually dominant species in a community or to estimate their size and abundance. However, these limitations are also true for vertical or oblique photography.

(c) The only primary difference between the VTR approach and still or movie photography is that the VTR approach requires two people in the aircraft in addition to the pilot. The cameraman is kept occupied with taping; a second person is required to change and mark tapes and to record location information. This is not strictly a limitation or disadvantage as the second person also doubles as a photographer for oblique colour slides.

(d) As an office system the tapes require a modest outlay (playback and colour monitor), which is a more expensive system than a slide or movie projector.

(e) Some care must be exercised in storing or handling the tapes as they are magnetic and can be destroyed if exposed to a strong magnetic field.

(f) The use of ½" tapes is also limited by the incompatibility of different video-systems; i.e., one set of tapes cannot be viewed on all playback machines. However, we use ¾" tapes which are compatible with all existing ¾" playback or recording machines. It is an easy task to copy between ½" and ¾" systems.

These limitations are relatively minor and those related to the actual data collection or to the quality of the recorded data, (a) and (b), are ones which can be overcome by experience and planning.

The cost of obtaining and editing or annotating tapes is higher than if photography is used, but the data base that is obtained is more continuous and comprehensive. In most aerial surveys, the costs of the equipment and film or tapes are significantly lower than the cost of the aircraft and comprise a small part of the total cost, though they are the only product.

Discussion

Recent uses of the video system for shoreline surveys have proven its value as one of the important tools available for shoreline mapping and for contingency planning and spill response decisions. When used in conjunction with other available shoreline information and when combined with existing maps or cleanup manuals, the tapes provide a valuable perspective and a continuous record.

To date the method has been applied successfully for federal and provincial agencies to sections of the coasts of Vancouver Island and of the Gulf Islands in British Columbia for shoreline mapping. As part of Petro-Canada's involvement in the E.A.M.E.S. project, the northeast coast of Baffin Island and of eastern Lancaster Sound was taped to provide an information base on the character of the shorelines. Edited tapes have been provided for Dome Petroleum Ltd. for spill countermeasures along the coasts of the Canadian Beaufort Sea and the Northwest Passage between Amundsen Gulf and Lancaster Sound. In these latter cases the (proprietory) tapes were prepared for approximately 5,000 km of shoreline to include a continuous audio description of: (a) the shoreline character, and (b) appropriate spill countermeasures. The tapes were edited into shore (10-15 minutes) segments for ease of retrieval and replacement and to facilitate the location of specific sections of coast.

A further application of the VTR system, presently in progress, is for an oil spill risk and impact analysis on the coasts of central and northern California. In this study two VTR surveys (winter and summer) are scheduled to contribute to the information base for mapping at scales of 1:24,000, 1:250,000 and 1:1,000,000 of: (a) biophysical shore-zone characteristics, and (b) areas where potential oil spill impacts would cause significant disturbance of the natural environment. This detailed survey of 1,200 km of coast will involve aerial VTR helicopter surveys at low tides.

The VTR approach has to date been used for: (a) physical and biophysical coastal mapping, (b) shore-zone characterization, (c) spill impact assessment, and (d) spill countermeasure identification. These and other different uses can all be derived from the same set of tapes so that once a VTR survey has been completed the tapes can be edited and annotated for a variety of requirements. This flexibility can extend from mapping or planning projects outlined above to training workshops, to defining the extent of stranded oil, or to defining seasonal and long-term shoreline changes.

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