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OIL SPILL: DECISIONS FOR DEBRIS DISPOSAL

VOLUME I

PROCEDURES MANUAL

by

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Contract No. 68-03-2200

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FOREWORD

When energy and material resources are extracted, processed, converted, and used, the related pollutional impacts on our environment and even on our health often require that new and increasingly more efficient pollution control methods be used. The Industrial Environmental Research Laboratory - Cincinnati (IERL - Ci) assists in developing and demonstrating new and improved methodologies that will meet these needs both efficiently and economically.

This two part report comprises both a user's manual for oil spill debris land disposal by land cultivation, sanitary landfilling, or burial, and a technical backup manual which includes the results of a literature search and four case studies. The report is intended to provide both the directions for oil spill debris disposal and the rationale behind them. Oil spill On-Scene Coordinators and local officials should find this report directly applicable for prior planning and during spill cleanup operations. For further information, please contact the Oil & Hazardous Spills Branch of the Resource Extraction & Handling Division.

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ABSTRACT

This report was prepared to guide persons responsible for disposing of oil spill cleanup debris in selecting suitable sites for debris deposition and in effecting proper disposal operations. A literature search and four case study investigations were conducted to verify the practicality and environmental acceptability of each disposal method described.

Project results are presented in two volumes and an introductory film.

The "Procedures Manual" (Volume I) is designed to be useful as both an office and field guidebook. Land disposal topics covered include site selection, disposal method selection, implementation of three alternative disposal techniques, site monitoring procedures, and possible correctional measures for environmental problems. All available disposal methods which may be employed when incineration or other processing is impossible or impractical were investigated prior to selection of the three recommended alternatives: land cultivation, burial, and incorporation into sanitary landfills with refuse. An outline for a training course on oil spill debris disposal is included in Volume I.

A 15 minute color training film was prepared as a companion to the Procedures Manual.

Supporting technical data is presented in an Appendix volume, "Literature Review and Case Study Reports" (Volume II). Volume II contains a summary of the current literature relating to physical and chemical interaction of oil and soil, biological degradation of oil spill debris, the relationship of oily waste disposal to vegetation, and oil spill debris disposal methodologies. Calculations are provided to indicate the theoretical limitations on degradation, evaporation, and other factors to verify data reported in the literature. Disposal cost estimates are also included. A bibliography of 67 pertinent references is provided.

Volume II also contains a description of four case studies conducted at sites that have accepted oil spill cleanup debris and/or oily wastes. The land cultivation disposal method was used to aerobically degrade the oil material at two

sites. Oil spill debris was buried with soils in specially constructed cells at the other two sites. Samples of oily material, surrounding soils, and local groundwater were analyzed for various constituents to determine the extent to which the disposal activities at each site impacted the environment.

This report was submitted in satisfaction of EPA Contract Number 68-03-2200 and describes work completed from June 1975 through January 1977.

CONTENTS

CONTENTS (continued)

CONTENTS (continued)

FIGURES

TABLES

* Tables with circled numbers are lists that highlight manual's instructions.

TABLES (continued)

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This manual and supporting literature and case study reports are the result of extensive cooperation between EPA, industry, university, and SCS personnel. The guidance and assistance of Mr. John Farlow, Project Officer, Industrial Environmental Research Laboratory (IERL) of U.S. EPA, Edison, New Jersey, is gratefully acknowledged. Also, Messrs. Robert Landreth and Dirk Brunner, MERL, Cincinnati, contributed to the project.

Other individuals participating in the project are listed below:

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SECTION 1

INTRODUCTION

PURPOSE AND SCOPE OF MANUAL AND SUPPORTING MATERIALS

Technologically sound disposal of oil spill debris is essential for minimizing the environmental damage from an oil spill. The purpose of this manual is to present the basic state-of-the-art (August 1976) procedures for properly disposing of debris collected as a result of oil spill cleanup activities.

Much research is underway on various topics related to this problem, and more is planned. Yet persons responsible for oil spill debris disposal must decide <u>today</u> how to dispose of the material. This manual is intended to provide guidance to decision-makers until the more detailed information on oily waste disposal being developed by the U.S. Environmental Protection Agency and others becomes available.

Incineration is often the most effective and desirable method of disposal. In those cases where incineration is impossible or impractical, land disposal should be considered. The subject of this manual is land disposal methods other than incineration. The manual addresses the following specific topics:

- Background of debris disposal practices and the need for a procedures manual;
- Selection of a suitable disposal method and site;
- Preparation and operation of the disposal site;
- Potential benefits and damages associated with each debris disposal method; and
- Procedures for detecting and correcting environmental problems.

This manual, designated as Volume I, is supported by Volume II, which contains a synopsis of the technical literature pertaining to land disposal of oily material, a discussion of four case study investigations, and other information relating to debris disposal procedures.

A 15 minute color narrated film highlighting debris disposal procedures has been prepared as a companion to this manual. The film is useful in introducing the problems and solution of oil spill debris disposal to officials responsible for implementing and overseeing disposal operations. Appendix A of this manual outlines the contents of a training course that incorporates the film and manual as classroom tools.

INTENDED AUDIENCE AND MANUAL USES

Anyone who has been or could be called upon to dispose of oil spill cleanup debris or to approve of debris disposal plans can make use of this manual. Such persons include representatives of local public works agencies, state and local pollution control organizations, federal emergency spill response team members, and oil spill cleanup contractor and cooperative personnel.

Proper disposal procedures help to ensure environmental protection. Use of this manual can assist officials in two basic areas:

- Developing a contingency plan for oil spill debris disposal, including selection of a site (or alternative sites) before the need arises, and
- Providing guidance to individuals responsible for disposing of oil spill debris after a spill has occurred.

OIL SPILL DEBRIS DISPOSAL: PROBLEMS AND PRACTICES

A common sight at oil spill cleanup activities is piles or bins full of oily solids, commonly referred to as oil spill cleanup debris or, simply, oil spill debris.

Usually, at least some oil spill debris remains to be disposed of after all recoverable oil is collected and the spill site is cleaned up. Depending upon the quantity of oil spilled, the cleanup method, and the spill location, large volumes of debris may require disposal. Debris volume from a single spill has ranged from less than several cubic meters (m^3) to over 40,000 m^3 (52,000 cu yd).

Debris solids may be composed of floatable debris (such as seaweed and wood); sorbent materials (such as straw or plastic foam); or sand, gravel, rocks, and dirt, depending on the location of the oil spill and the cleanup methods used. The oil itself may be very visible or so dispersed in the debris as to be almost invisible. For example, oil spilled in a water body will generally be contained in a small area by booms to facilitate removal by vacuum trucks, sorbents, or other methods. Any floating debris within the boomed off area will likely become coated with oil.

Oil spilled on land or washed onto shore may be collected by excavating the underlying soil and oil-coated vegetation along with the oil. Also, sorbents such as foam pads and porous beads may be used to soak up the oil. In either case, significant volumes of solid debris will be collected as a result of efforts to cleanup the water body or land area affected by the spill.

The collected mass of oil spill debris must be properly stored, transported, and disposed of to minimize the potential for further adverse environmental impacts. After all, an oil spill itself may cause significant damage. The subsequent cleanup and debris disposal efforts must be remedial, not sources of additional, more long-term environmental problems.

The specific impacts of oil in the environment are not fully known. Available information does indicate that oil should definitely not be allowed to enter a drinking water supply. Most waste oils, many crude oils, and some refined oil products contain heavy metals and other contaminants which have proven adverse health impacts. Of course, drinking water tainted with oil would be at the least aesthetically unpleasant. Oil and contaminants can be transported through soils to usable ground and surface water unless proper precautions are followed in oily waste disposal.

Past and Present Oil Spill Debris Disposal Practices

Management of oil spill debris has received relatively little attention in previous oil spill cleanup incidents. Removal of the spilled oil from a water body or land area is the primary goal of cleanup crews. All manpower efforts and equipment are generally committed to containing, collecting, and stockpiling the spilled oil. Also, many research efforts have been devoted to development of equipment and methods to improve the efficiency of oil spill cleanup. Consequently, increasingly sophisticated techniques have become available to remove oil spill debris, but the advancement of debris management and disposal methods has not kept pace.

The emergency nature of oil spill cleanup efforts has also contributed to implementation of less-than-adequate disposal practices. By the time cleanup efforts are underway and generating debris for disposal, the local population has probably been semi-traumatized by media coverage and by the shock of witnessing the local waters or landscape polluted by oil. A typical reaction by citizens and cleanup crews alike is to quickly remove all evidence of the spill to an "out-of-sight, out-of-mind" location. In this atmosphere, sufficient time or resources are not allotted to evaluate the suitability of alternative disposal sites in the area and to choose the one that offers the best conditions for environmental protection. Furthermore, most localities do not now have personnel available with sufficient knowledge of the particular factors that must be considered when selecting a disposal method or site for oil spill debris.

Various methods of oil spill debris disposal have been practiced:

- Landfilling with municipal solid waste at sanitary landfills and/or dumps located near the spill cleanup site;
- Burial at specially selected sites;
- Deposition on vacant land with little or no soil cover;
- Use in construction projects as a road base; and
- Land cultivation (also called landspreading, landfarming, and soil incorporation).

The debris disposal method used at a particular spill was dependent on many factors, including debris characteristics, availability of land, accessibility of existing sanitary landfills, degree of local regulatory control over waste disposal practices, and prevailing weather conditions. Some past debris disposal activities have been successful. Others may be sources of environmental problems including water contamination by oil, air pollution, and/or blighted landscapes. Examples of four relatively successful oil spill debris disposal activities are described as case studies in Volume II.

NEED FOR DISPOSAL GUIDELINES

EPA, Coast Guard, and other officials familiar with the problems of oil spill debris disposal have recognized the need for a concise delineation of proper disposal procedures. This Procedures Manual has been prepared to fill that need. Use of the manual should lead to the development of debris disposal contingency plans and help implement these plans in the event of an oil spill.

In 1975, 10,141 known oil spills totaling more than 57 million liters (14.5 million gal) occurred in the U.S. Oil spills are expected to become less frequent as spill prevention measures are implemented in response to EPA-administered regulations. Yet accidental spills due to human error and equipment malfunctions will always be with us. Spill cleanup will continue to generate oil spill debris that requires disposal. Implementation of the procedures in this manual will help to ensure that oil spill cleanup and subsequent debris disposal will be environmentally safe.

SECTION 2

SUMMARY

Oil spill debris, as discussed in this report, refers to oil or oily solids collected after an oil spill which cannot be used directly or after cleaning. These solids include, but are not limited to, floating organic materials such as seaweed, driftwood, or flotsam; land vegetation; naturally occurring, non-biodegradable, inorganic materials such as mud, sand, gravel, and boulders; and manufactured products used to clean up oil spills which may or may not be biodegradable. Proper disposal of this oil spill debris has been a problem in the past. This report addresses this problem and describes suitable land disposal and site selection methods.

REPORT ORGANIZATION

Section 3 of this manual discusses land disposal site selection considerations. Sections 4, 5, 6, and 7 discuss the various land disposal methods and the criteria for their selection, and Sections 8 and 9 deal with environmental considerations such as monitoring and correcting problems.

HIGHLIGHTS

- Section 3 deals with the selection of a land disposal site. Stress is placed on the importance of site selection before emergency need. Also discussed are the various site selection procedures and various arrangements necessary with site owners and regulatory agencies.

- Section 4 considers selection of land disposal methods. Available disposal methods are examined along with their compatibility with both debris types and landforms. Climatological considerations are also addressed.

- Sections 5, 6, and 7 examine the three land disposal practices deemed most acceptable for oil spill debris (from Section 4) and addresses these methods in terms of land area, equipment and personnel requirements, site preparation, disposal procedures, and potential problems and their solutions.

- Section 8 concerns site monitoring to ensure protection of the local environment. Potential problems and monitoring program development are stressed.

- Section 9 focuses on correcting any environmental problems encountered. The potential for ground and surface water contamination and degradation rates for oil at land cultivation sites are of primary concern.

SECTION 3

SELECTION OF A LAND DISPOSAL SITE

Procedures and information presented in this section provide guidance for the selection of a proper debris disposal site. The benefits of selecting a contingency disposal site prior to an oil spill event are emphasized, although the site selection procedures are also applicable during oil spill cleanup emergencies.

Site availability and procurement is generally the most critical factor in oil spill debris disposal planning. After a site is secured, the disposal method is selected to be compatible both with site conditions and debris characteristics. Site selection procedures are addressed first below, followed by a discussion of disposal method selection. Alternatively, where available land is plentiful, a disposal method could be selected and a site with features compatible to the method located.

IMPORTANCE OF DISPOSAL SITE SELECTION BEFORE NEED

Proper site selection is basic to safe oil spill debris disposal, and proper site selection can be assured only if it occurs through a rational planning process before a spill. Officials responsible for oil spill debris disposal must have a site available for deposition of the material.

In the past, selection of a disposal site for oil spill debris has often been neglected until an emergency situation arose. Location and use of a suitable site during the emergency of an oil spill cleanup is difficult and sometimes not even possible, because there is usually insufficient time, manpower, or resources to properly assess the attributes of alternative sites or to secure all necessary approvals to use a specific site.

Problems can arise if oil spill debris is disposed of at a hastily located or improperly situated site. Problems include:

- Environmental pollution - As reported in Volume II, information in the literature and field studies indicate that oily waste deposited on land may result in (among other things):

- Oil migration through soil;
- Groundwater contamination;
- Surface water runoff of oily material;
- Wash-out of disposal area due to floods; and
- Long-term effects on vegetation.

- Operational problems - For example, all-weather access roads must be available or readily constructable to ensure site usefulness during any climatic conditions. In more than one instance, oil spills have occurred at the time of or been caused by inclement weather.

- Social, institutional, and legal problems - Approval from local planning and pollution control agencies may be only provisionally granted, if at all, during the emergency to dispose of the debris. An adverse public reaction could result in prolonged disputes over the operation. Also, there may be insufficient time to arrange long-term agreements with landowners for indefinite use of the site for disposal.

To avoid these problems, it is highly desirable for local agencies to include a list of alternative sites that may be used for disposal of oil spill debris in all oil spill cleanup contingency plans. Table 1 suggests other pertinent items that would be useful in an oil spill cleanup contingency plan or a spill prevention, containment, and control plan. Depending upon the locations of potential oil spill events in a particular jurisdiction, the contingency disposal sites could be grouped according to the different areas the sites would best serve. Sites within each group would then be prioritized.

Recognition of the need for early designation of debris disposal sites will provide time for contingency planning to properly locate and evaluate alternative sites and to execute long-term site use agreements. The various possible environmental, operational, and other pitfalls associated with debris disposal may not be entirely eliminated, but they definitely will be minimized by early disposal site planning.

TABLE 1. MINIMUM INFORMATION ABOUT OIL SPILL DEBRIS DISPOSAL SITES FOR INCLUSION IN AN OIL SPILL CLEANUP PLAN

- Vicinity map showing all possible disposal sites and major access roads from areas of possible oil spills.
- List of local officials (phone nos.) with jurisdiction over solid and liquid waste disposal and water quality protection.
- List of site owners (phone nos.) and those owners of land over which site access may be required.
- List of industrial waste hauling firms in the area.
- List of heavy equipment rental companies or local governmental agencies with heavy equipment that may be useful for debris disposal.

SITE SELECTION PROCEDURES

Proper site selection is the most important decision to be made in planning for oil spill debris disposal. Whether the site is selected in advance of its actual need or during the rush of an emergency effort to find a disposal location, the same basic site location procedures should be followed:

1. Identify existing waste disposal sites.

2. Identify vacant land:

   - Use maps, aerial or ground reconnaissance;

   - Confer with large landowners/brokers.

3. Determine ownership:

   - For assessment of difficulties to secure;

   - For personal contract negotiations;

   - To determine whether public lands are preferred.

4. Gather background information.

5. Apply environmental criteria.

6. Evaluate suitability of each prospective site.

7. Select one or two sites for contingency use for debris disposal.

Location of Prospective Sites

An initial survey of potential debris disposal sites in the area should be the first step in locating a site or sites. This survey is facilitated by use of both a large-scale base map of the area and U.S. Geological Survey (USGS) topographical maps. The large map should show major roads, schools, military installations, residential neighborhoods, water bodies and recharge areas, and other significant land uses. The local county road department or planning agency could provide such a map. The USGS map is useful to indicate ground topography and general land use. All alternative sites identified should be marked on both maps to facilitate subsequent evaluation of their acceptability for debris disposal.

Prospective sites can be identified following various approaches. For example, ownership of land in the vicinity of sites can be determined by reviewing appropriate files of the local county assessor.

Alternatively or in combination with a map search, an aerial or ground reconnaissance of the area could indicate potential sites.

The use of existing municipal and industrial waste disposal sites should be considered first. Approval to use this land for waste disposal is already secured and the land is already dedicated to waste disposal uses. However, use of an existing waste disposal site may not be practical for various reasons, such as:

- The site(s) is (are) very far from the scene of spill cleanup;
- The site(s) may be unacceptable due to poor access roads; or
- The site(s) is (are) not approved for receipt of oily waste such as oil spill debris.

Thus, it is usually necessary to include for further evaluation at least two sites that are not presently used for waste disposal.

Another approach is to interview various major land holders or managers such as those listed on Table 2 to determine where suitable sites might be situated. Consultation with local planning officials can aid in location of prospective sites.

Any vacant plot of land near the expected source of oil spills should be considered. In the past, debris has been deposited on many different types of land, including a national recreation area, a state highway project, private property, military installations, and existing waste disposal sites.

When canvassing the local landowners, it should be emphasized that this is a preliminary survey to locate several alternative sites from which the one or two best suited ones will be selected.

Depending on the size of the study region and the number of individual areas where oil spill debris collection is expected, anywhere from three to six or more prospective sites should be located.

TABLE 2. LAND POTENTIALLY SUITABLE FOR AN EMERGENCY OIL SPILL DEBRIS DISPOSAL SITE

Type of Land	Local Contact
Government Property	
• Federal government	Representatives of local installations:
- Armed services land: + Military preserves + Communications installations + Weapons depots + Training camps	U.S. Army U.S. Navy U.S. Air Force U.S. Coast Guard General Services Administration
- Bureau of Land Management (BLM) property	BLM, U.S. Department of Interior
- National Forest land	U.S. Forest Service, U.S. Department of Agriculture
- National Park land	National Park Service, U.S. Department of Interior
• State and Local government	
- Excess highway property	Right of Way Office, State and County Highway Departments
- State Forest land	State Forest Department
- Recreational land such as parks	State Recreation Department, County Recreation Department
- Waste disposal sites, active or inactive	Local public works, sanitation, or health department
Private Property	
• Oil company property or leases	Oil company officials, BLM, U.S. Department of Interior
• Mining company property	State Dept. of Natural Resources
• Agricultural land	Grange, local industrial/agricultural realtors
• Industrial waste disposal sites	Industrial waste contractors
• Utility company property	Local utility officials

Site Selection Criteria and Data Sources

Once the sites are identified, basic background data on each should be gathered. Use of a concise form (see Appendix B) can facilitate data gathering and ensure that all pertinent information is obtained. Basic site information can be gathered from various sources such as those listed in Table 3.

In general, it is useful to judge the acceptability of alternative sites according to several criteria. These criteria can also be used as guides in selecting sites for consideration. Table 4 summarizes the most important factors to consider when searching for a prospective oil spill debris disposal site. These factors are stated in terms of criteria that should be met before debris is deposited on any site. Table 4 also shows examples of situations where criteria are and are not met. The basic rationale for these criteria are discussed below to further aid in selection of a suitable site.

Land Use Compatibility--

Any site considered for waste deposition must be compatible with surrounding land uses. Sites that otherwise offer ideal conditions for oil spill debris disposal may not be acceptable if they are in residential, recreational, or certain industrial areas. For example, debris disposal by land cultivation techniques would necessitate short-term, periodic mixing with tractors and other equipment. Noise and dust from such activities could disrupt a residential neighborhood. Also, burial of debris could alter landforms somewhat, making such disposal unacceptable in a park or recreation area dedicated to preservation of natural conditions.

On the other hand, it may be less difficult to locate a debris disposal site in or near a residential area than it would be for a sanitary landfill for mixed municipal refuse. Oil spill debris disposal is usually a short-term operation on the order of days or weeks at the most. If the debris were to be buried properly on well-suited land, the disposal operation may be tolerable even in high density areas and on agricultural land since most if not all visible and audible disruptions would be over quickly. Debris disposal sites located on prime land should not be discounted as long as environmental and public health standards can be met and proper monitoring procedures can be implemented.

Water Quality--

Oil is a potential water pollutant. However, not all land-deposited oil will contaminate an area's water. In fact, considering the present magnitude and past history of oil exploration, refining, and waste disposal, there have been

TABLE 3. SUGGESTED SOURCES OF BASIC DATA ON PROSPECTIVE OIL SPILL DEBRIS DISPOSAL SITES

For Data Concerning:	Check With:
Area base maps	• County road department
	• City, county, or regional planning department
	• U.S. Geological Survey (USGS) office or outlets for USGS map sales (such as engineering supply stores and sporting goods stores)
Site maps	• U.S. Department of Agriculture (USDA), Agricultural Stabilization and Conservation Service (ASCS)
	• Local office of USGS
	• County Department of Agriculture
	• Surveyors and aerial photographers in the area
Geology	• USGS reports
	• State Geological Survey reports
	• Professional geologists in the area
	• Geology Department of local university
Soils	• USDA, Soil Conservation Service (SCS)
	• USGS reports of area
	• Geology or Agriculture Department of local university
Hydrology	• Private and public suppliers of water
	• USGS water supply papers
	• State or regional water quality protection agencies
	• USDA SCS
	• State or federal water resources agencies
	• Local health department
Topography	• USGS topographic maps
	• USDA, ASCS
Vegetation	• County agricultural department
	• Department of Agriculture at local university
Land use	• City, county, or regional planning agency
Climate	• U.S. Weather Bureau
	• Nearby airports

TABLE 4. SUMMARY OF OIL SPILL DEBRIS DISPOSAL SITE SELECTION CRITERIA

Factor	Criteria
Land use	Planned use of the site for debris disposal should be compatible with on-site and adjacent land use.
	Disposal at an approved sanitary landfill usually meets this criteria fully. Debris disposal within a residential area may not be compatible.
Water quality	The site should not be a source of water pollution.
	Disposal on porous soil overlying potable groundwater or in an area subject to flooding would not meet this criteria. Sites that do not overlie groundwater or, if they do, have clayey soils present, are likely to offer the best protection for groundwater.
Location	Sites should be situated as closely as practical to the point(s) where oil spill debris is (or would expectedly be) collected or stockpiled.
Access	Existing access roads into the site should be of all-weather construction or such roads should be constructable in an emergency situation.
	A site that cannot be readily accessed is of little use. Access may be temporarily facilitated by placement of a gravel road or military lending mats.
Ownership	Publicly owned lands may ensure better long-term maintenance and acceptance of responsibility compared to private property which can readily change ownership.

relatively few documented cases of water pollution by oil. Yet it is important to ensure that oil from land-deposited spill debris does not become a source of water pollution.

Various physical conditions of a site determine its potential vulnerability to pollution:

- Soil characteristics;
- Subsurface hydrology;
- Geologic conditions; and
- Surface features, such as topography, surface water occurrence, and vegetation.

Of course, climatic factors such as precipitation, evaporation, humidity, and wind also influence the suitability of a site for receipt of oil spill debris. It is assumed, for the purposes of these guidelines, that the climatic conditions in any one area of potential oil spills are essentially the same for all possible alternative sites. Therefore, consideration of climatic differences will not usually be necessary when comparing acceptability of alternative sites.

Thorough consideration of the important geohydrologic and soil factors for each alternative disposal site may not be possible, especially if site selection has been postponed until an emergency site search is underway. It is therefore useful to briefly discuss the basic geohydrologic and soil features that should be assessed when considering any site for oil spill debris disposal.

The interrelationships between a site's soil, geological, topographic, and hydrologic features determine the potential for oil contamination of local waters. Figure 1 is an example of this interaction. Although many factors are important, knowledge of a few key physical conditions can make possible the rapid elimination of many poorly suited sites from consideration for debris disposal.

<u>Soil Conditions</u>--

Soil conditions at a debris disposal site are of primary importance. Even where potable groundwater underlies a site, available information shows that suitably graded soils can impede or eliminate downward migration of land-deposited oils. Conversely, loose soils will enable oil flow to occur.

For a basic determination of a soil's ability to impede oil flow, two types of data are desirable:

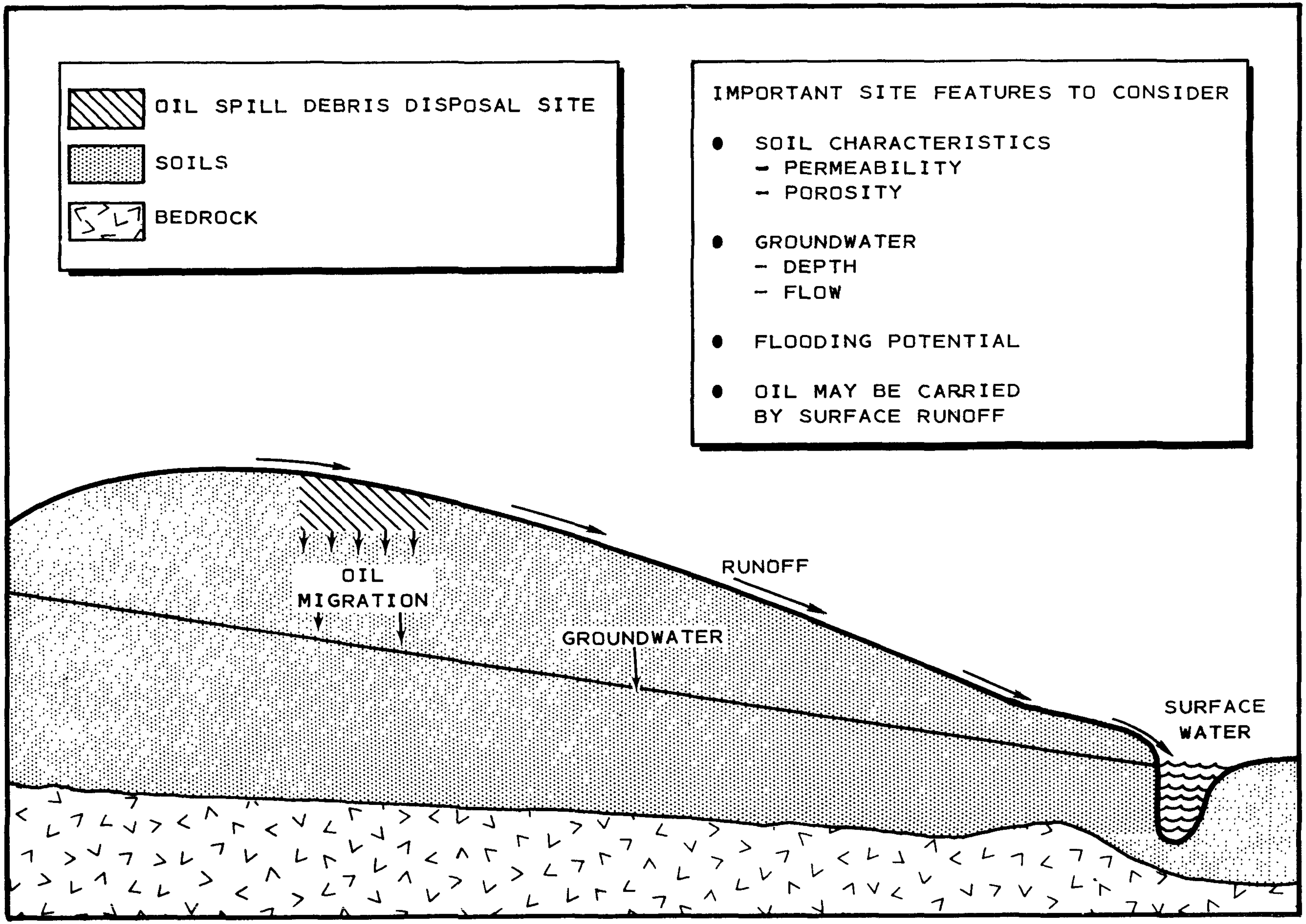

FIGURE 1. SCHEMATIC OF GEOHYDROLOGICAL AND SOIL CONDITIONS RELATED TO WATER CONTAMINATION POTENTIAL.

- Soil permeability, and
- Grain size distribution, which enables general classification of a soil as a sand, silt, loam, clay, etc.

In many areas, such information is available from the U.S. Department of Agriculture (USDA); Soil Conservation Service (SCS); or the local state, county, or university extension offices dealing with agricultural matters. The USGS may also have relevant soil data on file.

Available soil data may not describe site conditions to the extent necessary for judging its suitability for disposal. For example, USDA data usually pertains only to the uppermost 1.5 m (5 ft), while subsurface information to several meters or to groundwater is desirable in a disposal site survey.

Where available data is insufficient or lacking, soil sample tests may be beneficial. Such tests are routinely performed by professional soil or geological firms in the area. Also, these analyses can be run in the geology or engineering department of a local university. The USDA or state agriculture department representative in the area can assist in designating areas of representative sampling and depths so that valid data is obtained. The number of samples and depths will depend on time and economic constraints and the homogeneity of the site's soils.

Interpretation and Use of Soil Data--In general, a debris disposal site should have low permeability, fine grained soils, especially for debris burial or sanitary landfilling. These characteristics are common to clays and silts. The low permeability reduces the rate at which oil and/or an oil and water emulsion can move downward or laterally through the soil. Fine grained soils have a relatively high capacity for adsorption of oil because the overall surface area of such soil particles is significantly greater than for coarse grained soils like sands.

However, when land cultivating to promote rapid oil degradation is considered, a coarser grained soil would be more suitable to facilitate aeration of the oil.

Figure 2 indicates the permeability rates and relative adsorption properties associated with various soil types. Permeability values are usually reported in terms of cm per sec or gal per day. Soils with permeabilities of 10^{-6} cm per sec or less would likely be good barriers to oil migration.

Many contaminants are retained in soils by chemical and physical sorption onto the soil particle surfaces. Silts and

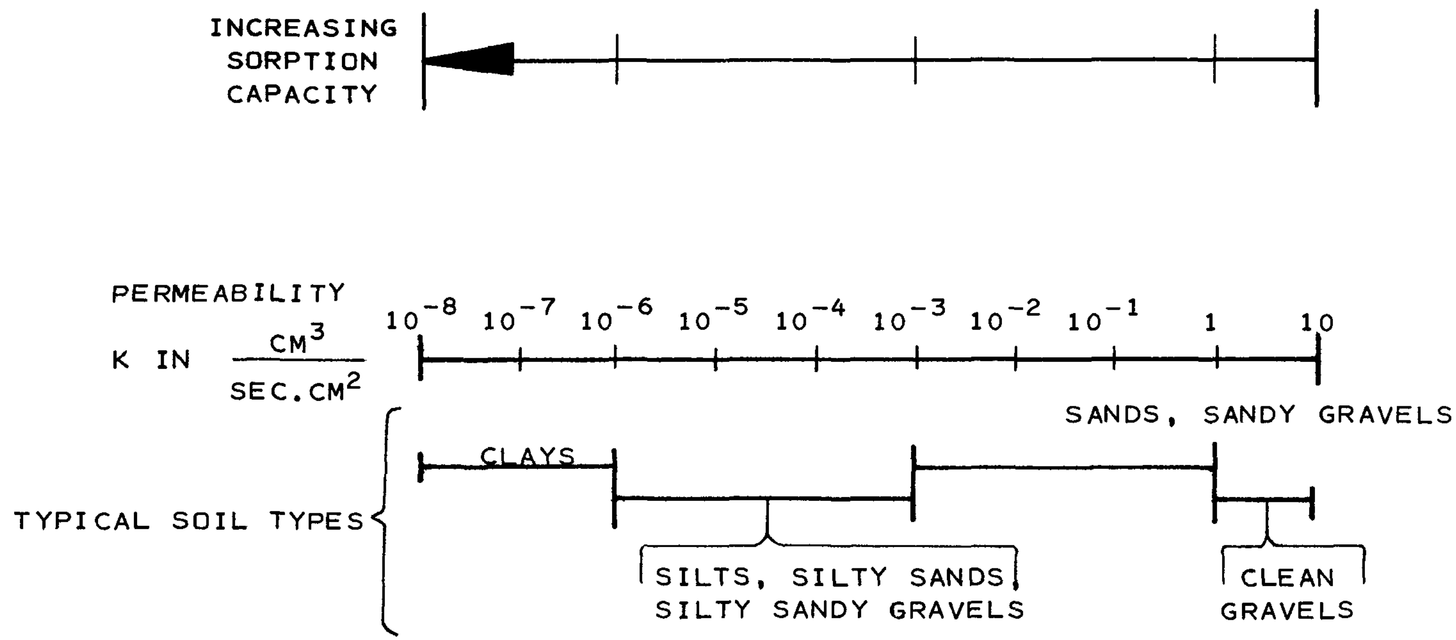

FIGURE 2. SOIL PERMEABILITIES AND SORPTIVE PROPERTIES OF SELECTED SOILS.

clayey soils tend to have a greater sorptive capacity than sands. Dense, consolidated impermeable soils and rocks permeable only in linear openings such as fractures tend to have poor sorptive capacities.

The depth of a site's subsoil is also an important consideration in judging the soil's value as a barrier to oil migration. For example, several hundred meters of relatively permeable coarse grained sand may provide a barrier as effective as 6 m (20 ft) of clay.

Prospective disposal sites that have poorly suited soils should not be hastily dismissed. Imported clayey and silt soils from nearby borrow areas or commercial outlets can be used effectively to create a barrier or liner. Synthetic liner materials include sheet plastic and rubber. However, the synthetics' long-term integrity in waste disposal uses has not yet been demonstrated (See Section 5, Receipt of Debris and Stockpiling).

Groundwater Hydrology--

Data on groundwater characteristics are also useful in evaluating the potential for oil contamination at any given site. The basic hydrologic information needed is:

- Depth to groundwater;
- Historical fluctuation in groundwater depth;
- Direction of groundwater flow; and
- Water quality characteristics.

Available information may be sufficient to define these parameters. Groundwater conditions in many areas are well-documented, especially if the local water supply is derived totally or in part from subsurface aquifers.

Determination of Groundwater Depth and Fluctuations--If groundwater levels at a prospective site have not been mapped, a review of logs and pumping records for wells in the vicinity is helpful. All records of water well depths in the area should be reviewed and documented. Well owners and operators can also provide information on historic fluctuations in groundwater depth. Only those wells within a radius of about 0.8 km (0.5 mi) of the prospective site should be investigated since the possibilities of aquifer continuity decrease with distance.

Further information concerning groundwater can be derived from a basic understanding of the site's vicinity. Generally, the water table lies deeper in regions of scarce rainfall (less than 12 cm or 5 in) than in humid regions. The depth to the water table tends to change with surface topography; it is deeper beneath interstream areas, shallower in lowlands, and it coincides with the surface of perennial streams. The water table is usually closer to the ground surface in relatively impermeable materials, such as clays, than in relatively permeable materials such as coarse sands. In dense unfractured rock, the water table may be absent or discontinuous.

It is important to determine if significant fluctuations in groundwater elevation occur. In some areas, natural or artificial groundwater recharge may raise the level into areas considered safe for disposal from a cursory investigation. Thus, data from water supply agencies as well as historical records of groundwater fluctuations must be checked.

Determination of Groundwater Flow Direction--Knowledge of the direction of groundwater flow is essential. Location of a debris disposal site upstream from a water supply well would be a less desirable practice than if the site were downstream, all other factors being equal. Also, installation of site monitoring wells must be based on accurate groundwater flow direction data.

If local water supply and other agencies' records are insufficient to determine flow direction at a prospective site, several rules of thumb may be used in developing this data. Groundwater moves in accordance with the hydraulic gradient, from points of high elevation to points of lower elevation. On a map of the site area, all wells should be located. The depth to groundwater in each well should be noted and the elevation of the groundwater surface with respect to sea level should be calculated. Approximate contour lines can be drawn on the map that connect wells of equal groundwater elevation. The direction of groundwater movement will be perpendicular to these elevation contour lines.

Where local well data are unavailable, it may be necessary to conduct a limited test drilling program to determine groundwater data. Test wells are also useful to help define subsurface soil and geological conditions.

Figure 3 illustrates how groundwater flow direction can be determined with three test wells. Ideally, the wells should be situated so that the site is encompassed within the triangle formed by the wells. In any case, the wells should be no more than 0.8 km (0.5 mi) apart. Knowing the elevation of three points on the groundwater surface plane, the direction of the plane's dip can be calculated and illustrated, as shown on Figure 3.

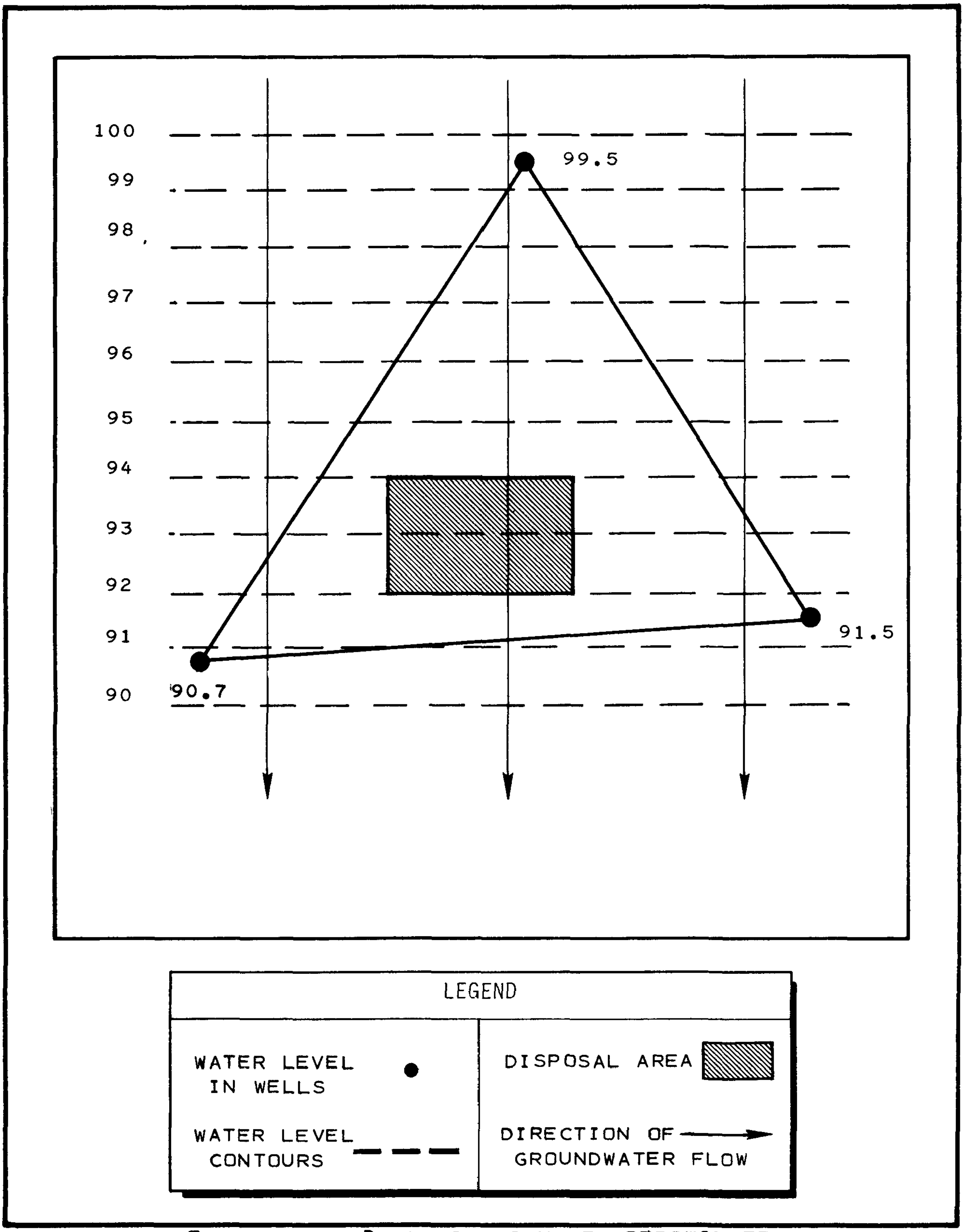

FIGURE 3. DETERMINATION OF APPROXIMATE GROUNDWATER FLOW DIRECTION.

Any exploratory wells placed at an alternative site should be cased with PVC pipe for possible later use in site monitoring. Soil samples should be retained for analysis.

Groundwater Quality--It should generally be preferable to locate a debris disposal site over a brackish (or otherwise unusable) groundwater rather than over potable water. Thus, basic information should be gathered concerning the water quality of underlying aquifers. This information can serve as water quality baseline data if the site is later used for disposal.

Local health departments and water companies usually have water quality records of all aquifers used for drinking water supply. These records should provide a sufficient basis upon which to compare the relative merits of alternative sites.

Depending on the extensiveness of the existing records, it may be desirable to analyze samples of the groundwater for selected constituents after designating a site for contingency disposal use. Water quality parameters of interest include:

- pH;
- Oil content;
- Organic acid; and
- Chloride.

Geological Conditions--

Geological conditions of interest in evaluating alternative disposal sites include:

- Landslide or slump potential, and
- Faults and seismic activity.

Landslide Potential--Observations of site topography and information on soil types can aid in evaluating the potential for sliding or land slumping at a site. A slide hazard would be expected if the site rests on a slope of more than 2:1 or is adjacent to the toe of such a slope. Investigation by a qualified engineering geologist would be useful in determining the slope stability if a site with such features were desirable for other reasons.

Potential for Seismic Activity--The location of active faults on or near the site and the historical record of seismic activity on these faults should be investigated. Such information can be obtained from the USGS or local geological firms who are familiar with the area. If the geological evidence indicates that movement has occurred recently or is a threat, the site may be unsuitable for oil spill debris disposal.

Surface Water, Topography, and Vegetation--

Surface topography and vegetation at and near a prospective disposal site can influence the potential for surface and groundwater contamination and vegetative damage from oily waste. For example, a debris disposal site located near a surface body of water could be subject to washout due to flooding, or runoff from the site could enter the water body. Precipitation runoff could be particularly detrimental if the land cultivation disposal method is used, since undegraded oil may be carried to a nearby lake or river. At sites where debris is buried, surface runoff may erode the cover soil, exposing debris and/or silting the downstream water body.

In evaluating the suitability of alternative sites, it is useful to determine what relative topographical positions they occupy. Seven different topographical positions or landforms are defined as:

- Upland crest
- Valley side
- Ravine
- Upland flat
- Terrace
- Upland valley
- Flood plain

Figure 4 illustrates the relative location of each type of landform. The general characteristics of these landforms and their suitability for debris disposal are discussed below, in order of their preference for debris disposal site location:

First preference: Upland crest, valley side, and ravine.

Second preference: Upland flat and terrace.

In all cases, it is expected that the disposal area will be protected either naturally or by design from washout and erosion due to surface runoff.

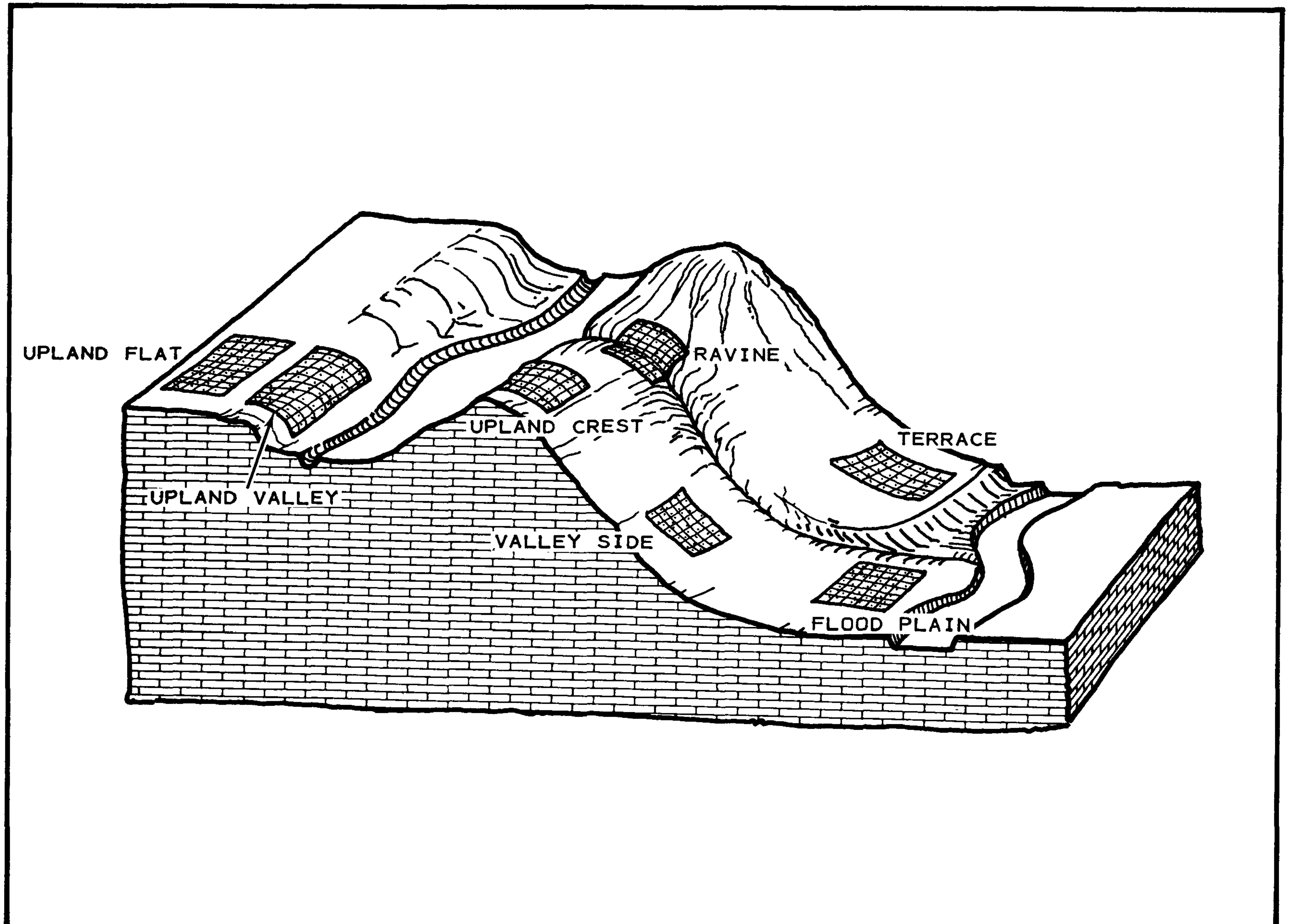

FIGURE 4. RELATIVE LOCATION OF VARIOUS LAND FORMS.

Upland Crest, Valley Side, and Ravine Landforms--Upland crest, the upper portions of ravines, and valley side positions generally are preferable locations for debris disposal sites because groundwater flow is usually away from them, and surface water occurrence is limited to directly incident precipitation and off-site runoff. The upper ravine and valley side positions require the diversion of surface water to reduce the amount of water entering and possibly infiltrating the site. Except in very impermeable materials or during extremely wet seasons, groundwater levels in these positions should lie well beneath the disposal area.

One drawback to disposal site location in these landforms is that they are often in groundwater recharge areas. As for every alternative site, the possibility of groundwater contamination should be investigated in terms of site soils and hydrology.

Upland Flat and Terrace Landforms--Suitability of upland flat and terrace topographic positions depends upon the depth to groundwater and soil characteristics. Upland flat areas with low permeability soils would generally be preferable, although groundwater may be close to the surface in these soils. In permeable materials, the water table should lie far below an upland flat position; yet permeable soils would transmit oil more readily than finer grained material. Obviously, the suitability of an upland flat disposal area is dependent on site-specific conditions.

Permeable soils usually underlie terraces, sometimes at very shallow depths. No surface expressions of groundwater should be present at or near a prospective disposal site to be located on a terrace landform. The likelihood of groundwater intersecting a terrace site increases as the site position approaches either the valley wall or the level of the modern flood plains. Also, disposal sites should not be situated in gullies or dry channels without provision of proper runoff diversion facilities.

Upland Valley and Flood Plain--In general, oil spill debris disposal sites should not be located in the flood plain of any surface water course. There have been many instances of water contamination from washed out waste disposal sites, including at least one oily waste disposal lagoon, because the sites were improperly situated in areas subject to flooding. Even provision of levees and dikes is no lasting solution since long-term dike maintenance is usually neglected, and a major flood may not occur until well after the disposal site has been used.

Site Location in Relation to Oil Spill Areas

A third major criterion is the site location with respect to areas where oil spill debris is expected to be generated and/or stockpiled.

Transportation of debris from the collection or stockpile area to the disposal site may represent a significant portion of overall cleanup costs, possibly more than the debris disposal operations. Also, oil may leak from the makeshift equipment often used to transport debris. Consequently, disposal sites should be as close as practical to the areas of expected debris generation to minimize costs and amount of oil spilled in transit.

On the base map of the region, areas of possible oil spill hazard should be noted. These would include, but are not limited to the following:

- Oil refinery complexes;
- Oil storage areas (e.g., tank farms and lagoons);
- Oil transportation facilities or transfer depots, such as pipelines, docks, railroad yards, and hazardous sections of highway;
- Major oil consumers, such as ship docks, electrical generating utilities, and major industries;
- Sensitive areas such as beaches, river or lake banks, and waterfowl areas.

Past experiences with spills in the area can help determine where to expect future spills. If the oil spill hazard areas are widely dispersed in the region, several disposal sites should be selected, and at least one contingency site selected to serve each major expected debris generation area.

Site Access

Existing access roads into the site should be of all-weather construction. If none exist, access roads should be easily constructable in an emergency situation.

Access roads serving existing sanitary landfills are usually adequate to handle all types of debris transport vehicles expected. Many other potential disposal sites are vacant land not presently served by improved or even dirt access roads from the service highway. A suitable access road into a debris disposal site should meet the following basic conditions:

- Width: Approximately 3 to 6 m (10 to 20 ft) depending on the volume of spill debris requiring disposal.

- Grade: Less than seven percent, especially if the debris delivery truck will be going upgrade while loaded.

- Bearing Capacity: Sufficient to carry a gross vehicle weight of about 32,000 kg (70,000 lb).

It is usually unnecessary to construct a new road into the site or improve existing ones prior to an oil spill emergency. However, access road preparation before hand may be in order if extensive work (requiring more than about one day) is needed.

Site Selection

The alternative site or sites best conforming to the four basic criteria should be selected for use. Major problems with any one site would be reason for its dismissal.

Application of the foregoing procedures will assure those responsible for site selection that all important factors were considered.

ARRANGEMENTS WITH SITE OWNERS AND REGULATORY AGENCIES

Once an environmentally acceptable site has been selected, it is necessary to negotiate an agreement for its use with the owner or manager. Several factors should be included in the site use agreement and resolved during negotiations:

- Procedures for site access during emergencies;

- Notification of intention to use site for waste disposal purposes;

- Responsibility for waste disposal permit fees, etc.;

- Responsibilities for site operation, cleanup, and maintenance; and

- Responsibilities for post-disposal monitoring (see Section 8).

Use of an existing sanitary landfill for oil spill debris disposal should present no problems, especially if the site is approved for receipt of oily materials. It may be necessary to obtain a variance of regulations from the responsible pollution control agency for disposal of debris into sites not so approved. The time to investigate such permit procedures is during the planning stages, not after a spill has occurred. Dumping fees for debris delivered to a landfill during an emergency should be discussed with site operators.

Planned use of a site not presently used for waste disposal must be carefully coordinated with the site owner and all regulatory agencies. A disposal site operational contingency plan should be developed and discussed with the landowner. He should be aware of how long the disposal operations would be likely to take, what environmental safeguards will be employed, and how the site will appear after cessation of operations.

Debris disposal rarely requires large land areas, so site purchase is usually not necessary. A lease arrangement may be worked out, or the landowner may contribute his land in exchange for a reduced property tax assessment or even in the spirit of civic cooperation. After all, the land need not be permanently dedicated for disposal, especially when land cultivating methods are employed.

SECTION 4

SELECTION OF A LAND DISPOSAL METHOD

After securing a site for oil spill debris disposal, it is necessary to decide what method of disposal to use. The decision will be based upon characteristics of the oil spill debris, the area's climate, and the landform of the available site.

AVAILABLE DISPOSAL METHODS

Three basic disposal methods are available:

- Land cultivation -- Oily wastes are spread on and mixed with soils to promote aerobic microbiological degradation.

- Landfilling with refuse -- Oil spill debris is incorporated into an active sanitary landfill along with municipal refuse or industrial wastes.

- Burial -- Oil spill debris is deposited into pits, trenches, or other depressions prepared for debris disposal. The excavated soil is used as intermediate and final cover over the debris.

Lagooning of debris may also be applicable under certain special circumstances, particularly if the debris is seeded with bacteria and mechanically aerated for long periods of time. Although oil drilling mud pits have been lagooned for some years, the results have not been reported in the open literature, and so the environmental attributes cannot yet be accurately predicted. Lagooning is not considered further in this manual.

Techniques for implementing each of the three disposal methods are described in Sections 5, 6, and 7. Table 5 summarizes their advantages and disadvantages.

Each disposal method is best suited for certain situations, depending upon debris characteristics, climate, and disposal features. If all contingency sites in an area are properly sited and operated sanitary landfills, the disposal

TABLE 5. ADVANTAGES AND DISADVANTAGES OF ALTERNATIVE DEBRIS DISPOSAL METHODS

Disposal Method	Advantages	Disadvantages
Land cultivation	- Oil is degraded, minimizing long-term environmental threat. - Land surface reusable for debris or other purposes. - Soil properties may be improved.	- Opportunity for oil volatilization, thus, increased air pollution. - Periodic plowing required; frequency depends on soil types. - Relatively costly. - Stockpiling at disposal site may be necessary. - Degradation may be slow in cold, wet climates. - May be impractical to implement during inclement weather. - Potential for plant uptake.
Landfilling with refuse	- Minimal equipment needs. - Relatively low initial cost. - Minimal site preparation. - Many landfills available.	- Land is dedicated to disposal indefinitely. - Influx of oil spill debris may overtax available equipment and personnel. - Long-term pollution potential (e.g., leaching). - Long-term monitoring desirable.
Burial	- Oil encapsulated, minimizes volatilization. - Operations complete relatively quickly. - Land surface can be returned to pre-disposal appearances.	- Land is dedicated to disposal indefinitely. - Oil remains undegraded for long periods with consequent long-term pollution potential (e.g., leaching). - Long-term monitoring desirable.

method to implement would most likely be landfilling with refuse. However, land cultivation or burial may be desirable in a given spill situation if, for example, the primary contingency site is a sanitary landfill located far from the cleanup site or the debris is well suited for land cultivation at a convenient site. Thus, it is important to be familiar with each alternative disposal method and the conditions under which it is applicable.

DISPOSAL METHOD COMPATIBILITY WITH VARIOUS TYPES OF DEBRIS

The characteristics of oil spill debris can vary significantly depending on the spill location, cleanup method, oil type, and other factors. Basic debris parameters important in selecting a compatible disposal method include:

- Size distribution of the debris solid matter collected during spill cleanup;
- Biodegradability of the debris constituents; and
- Oil content in the debris.

Table 6 presents a comparison between these characteristics of spill debris and the available disposal methods.

Debris Characteristics and Land Cultivation

Land cultivation is best suited for debris comprised of small particles such as oiled soils. The land cultivation method entails rototilling, discing or otherwise mixing the debris with site soils. Thus, land cultivated debris should not contain particles larger than about 15 cm (6 in) to avoid handling difficulties and ensure proper mixing. Vegetation such as seaweed, brush, or leaves that can be readily broken up and mixed with the soil can also be included in debris intended for land cultivation.

Debris with some large, bulky items can be land cultivated if the bulky items are segregated and either cleaned or disposed of at a sanitary landfill or a burial site.

The basic intent of land cultivation is to promote microbial degradation of the carbonaceous matter. Thus, land cultivation should not be practiced if noticeable amounts of inorganic, nondegradable items (such as plastics) are present in the debris, unless the land cultivation is to be at an existing landfill.

TABLE 6. APPLICABILITY OF DISPOSAL METHODS TO DIFFERENT TYPES OF OIL SPILL DEBRIS

	Debris Characteristic		
Disposal Method	Size of Solid Matter	Biodegradability	Oil Content
Land cultivation	• Debris should be relatively small in size, less than 15 cm (6 in) e.g., oiled soils. Some larger vegetation may be acceptable, such as seaweed or brush. • Bulky matter may be separated for landfill disposal	• Predominantly oils and soils are best. Non-degradable sorbents or inorganic trash should not be present.	• Land cultivation best suited for heavily oiled debris.
Landfilling with refuse	• No limitation on size.	• No limitation on materials.	• In general, no limitation on debris oil content. Regulation agencies may object to disposal of heavily oiled or high water content debris in a newer landfill where relatively little refuse is present to adsorb the liquids.
Burial	• In general, no size limitation. Bulky debris, such as poles, may pose operational problems. Also, disposal trenches may require widening to accommodate bulky items.	• No limitation on materials.	• No limitation on oil content as long as site conditions are acceptable.

Debris Characteristics and Landfilling or Burial

Virtually all types of oil spill debris can be disposed of by landfilling with refuse or burial alone. Proper site selection and preparation are needed to ensure that oil and/or water do not drain from debris.

DISPOSAL METHOD COMPATIBILITY WITH SITES IN VARIOUS LANDFORMS

Table 7 identifies site locations (illustrated in Figure 4) which are most suitable for each disposal method.

In general, land cultivation can be adapted to sites on all landforms except where slopes exceed about 6 percent. Ravines and upland valley sites may be unacceptable. Wherever a land cultivation site is situated on slopes of greater than about 4 percent, a runoff catch channel or basin should be installed downstream, especially in an area where heavy rainfall and high soil erosion potential are likely.

<u>As a last resort</u>, a land cultivation site may even be suitable in a flood plain. Oily material is a definite threat to water quality, but the land cultivation process will degrade oil into carbon dioxide gas, water, and cell matter within several years or sooner. Thus, the oil would pose a relatively short-term threat to water quality and <u>may</u> be acceptable in a flood plain. However, the risks of a flood occurring before the land cultivation operation has been completed and the possibility of heavy metals migrating to the waterway should be considered.

Debris disposal by landfilling or burial is well suited for any landform except flood plains and upland valleys. Oil contained in debris disposed of by these methods will remain undegraded for many decades. Thus, disposal sites located where flooding or washout potential is high present a threat to water quality.

CLIMATE CONSIDERATIONS IN SELECTION OF DISPOSAL METHOD

Degradation of oil by land cultivation proceeds best in warm climates with moderate precipitation and evaporation. The degradation process may stop when temperatures fall below freezing. However, because the practicability of land cultivation has been demonstrated in even very cold climates such as in northern Canada, this method should be considered applicable to all climates in the lower 48 states and Hawaii.

Sufficient moisture is required in the oil/soil mixture to support microbial activity at a land cultivation disposal site. Except in very dry areas, adequate moisture is usually naturally available. Land cultivation has been successfully

TABLE 7. SUITABILITY OF DEBRIS DISPOSAL METHODS FOR VARIOUS LANDFORMS

Disposal Method	Landform					
	Upland Flat	Upland Crest	Ravine	Valley Side	Terrace	Upland Valley and Flood Plain
Land Cultivation	X	X		X	X	(X)*
Sanitary Landfill	X	X	(X)+	X	X	
Burial	X	X	(X)+	X	X	

* Only in special cases where risks are acceptable.
\+ Only in arid areas.

employed in areas receiving less than 38 cm (15 in) of precipitation per year with more than 165 cm (65 in) of evaporation without providing additional moisture.

Land cultivation may be difficult or impractical to implement during periods of heavy rain or when snow covers the ground, and temporary stockpiling may be required (Section 5).

DISPOSAL METHOD SELECTION

The particular disposal method selected will depend upon the specific events surrounding an oil spill. Whenever possible, the land cultivation method should be considered as the first alternative to incineration since the oil will be degraded and thus present no long-term environmental problems. The landfilling and burial methods at appropriate sites are acceptable if properly implemented when land cultivation is not practical. Procedures for implementing each of these disposal methods are presented in Sections 5, 6, and 7.

SECTION 5

LAND CULTIVATION

Oil spill debris disposal by the land cultivation method (also called landspreading, landfarming, and soil incorporation) is accomplished by mixing the debris with soil to promote aerobic biodegradation.

Land cultivation has been practiced by oil refineries for many years. Often the same plots are regularly reused for disposal and degradation of oily waste. The method is also suitable on relatively level sites for oil spill debris that contains no bulky or nondegradable sorbent materials and no excessive concentrations of heavy metals.

LAND AREA REQUIRED

Area requirements for land cultivation of oil spill debris depend on many factors, including:

- Depth of spreading;
- Local climate;
- Concentration of oil in the debris;
- Type of debris;
- Oil characteristics;
- Volume of oil;
- Equipment used.

Available information derived from land cultivation of oily wastes from refineries can be used to estimate a land area needed for debris disposal by this method. The following hypothetical example shows how land area needs can be estimated:

<u>Given</u>:

- Debris type: Oily beach sand and seaweed.

- Oil content of debris: 1.0 to 1.5 percent. Oil content cannot be precisely determined without detailed analysis. A rough estimate can be calculated by dividing the total volume of oil spilled by the total volume of debris collected.

- Oil type: Fuel oil.

- Depth of mixing with soil: 10 cm (4 in).

- Climate: Moderate. For the purposes of debris disposal climate can be related to temperature extremes and duration of the growing season. A moderate climate would have an average growing season and a mean freeze-free period length of between 150 and 210 days per yr.

- Volume of oil collected with debris: 38,000 ℓ (10,000 gal).

- Empirical data on oil land cultivating: 0.43 to 0.70 m^2 of land per ℓ of oil (17 to 29 ft^2 per gal) is required for degradation.

<u>Then</u>:

About 2.1 ha (5.3 ac) ± of land is required for land cultivating all the debris. (10,000 x 23/43,560 = 5.3).

Land area requirements would increase with increasing oil concentrations and volumes, and would decrease with greater mixing depths and a warmer, more humid climate. Crude oil would require more area than refined oil products. In any event, it may be possible to stockpile a portion of the spill debris at the site and cultivate the entire mass in batches over an extended period, thereby reducing overall land area requirements.

EQUIPMENT AND PERSONNEL REQUIREMENTS

The number of equipment units and personnel required depends on the volume of debris to be disposed of, the area of the site, and the need for other duties such as traffic and unloading direction.

<u>Equipment and Facilities</u>

Land cultivation can be performed using almost any available heavy equipment unit capable of mixing oil with soil, such as:

- Track dozer or loader;
- Wheel dozer or loader; and
- Farm tractor.

Use of a rototiller, farm harrow, disc, or plow greatly aids in mixing the oil and soil. In some cases, oil is mixed with soil simply by the churning action of dozer tracks. A dozer blade or steel bar fixed to the equipment can spread the debris onto the soil. For most situations one tractor or dozer and one mixing device would be sufficient.

The site should be provided with portable sanitation facilities and drinking water. Also, fencing may be needed to keep people and livestock off the area.

Personnel

At least one equipment operator is necessary for each piece of heavy equipment used. Other personnel may be useful to spot debris delivery trucks at the proper dumping location and to direct traffic. It is usually advisable to have at least two persons at a disposal site at all times when work is going on so that one can aid the other in case of accidents.

PREPARATION FOR LAND CULTIVATION

A site to be used for land cultivation requires some preparation prior to receipt of the first load of debris.

Access Road Construction

An access road from the highway serving the site should be constructed to one end of the cultivation area. Land cultivation equipment and debris transport vehicles will use this road so it should be of suitable width, grade, and surface (e.g., gravel may be needed in the wet season).

Grading and Removal of Rocks and Vegetation

All boulders, logs, rocks, and other hard materials larger than about 15 cm (6 in) in diameter and any brush should be removed from the intended land cultivation area. These materials will inhibit proper soil/oil mixing. Grasses and low shrubs need not be removed. The site should be graded to a uniform one to two percent slope.

Scarifying the Soil

The surface soil should be scarified using conventional farm implements such as tillers, harrows, discs, or plows, shown in Figures 5, 6, 7, and 8. Depth of scarification depends on local climatic conditions. In northern, cooler areas, a shallow depth of 5 to 10 cm (2 to 4 in) is preferable. In the warmer, subtropic areas of the U.S., depths of 20 to 35 cm (8 to 14 in) are common for oily waste land cultivation at refineries.

Surface Drainage Diversion

Runoff diversion channels should be dug during site preparation. Depending on site conditions and the volume of runoff expected, half-round corrugated metal pipe may be preferable to unlined earthen channels.

Berm Construction

It is unlikely that oil spill debris would contain much excess liquid after being stockpiled and transported to the disposal site. As a precaution, however, it may be desirable to construct berms around the site to prevent water or oil from flowing from the disposal areas. Also, a basin on the downstream side would be desirable to contain any liquid run-off and siltation.

Additives

Most agricultural soils contain sufficient amounts of nutrients and moisture to support the growth of hydrocarbon-consuming microorganisms naturally present in the soil. However, the nutrient status is generally poorer in the soil at an oily waste disposal site compared to an agricultural soil due to continued additions of oily wastes into the soil. These wastes have high carbon:nitrogen (C:N) ratios and very low nitrogen content. As a result, the soil is invariably deficient in nitrogen. Furthermore, most soils are low in available phosphorus. Additions of nitrogen (as ammonium or nitrate) and soluble phosphorus (e.g., superphosphate) are necessary for the degradation of oily wastes at optimum rates. Since the optimum pH for the activity of a large number of soil microorganisms, including hydrocarbon-consuming bacteria, is near 6.8 to 7.2 (neutral), maintaining the pH in this range is advisable. Commercially available bacteria seeds are available to accelerate oil degradation, but there is no experimental evidence that seeding with bacteria is necessary.

To determine the levels of available nitrogen, phosphorus and other pertinent parameters in soil, representative surface samples (0 - 30.5 cm deep) should be taken from the disposal

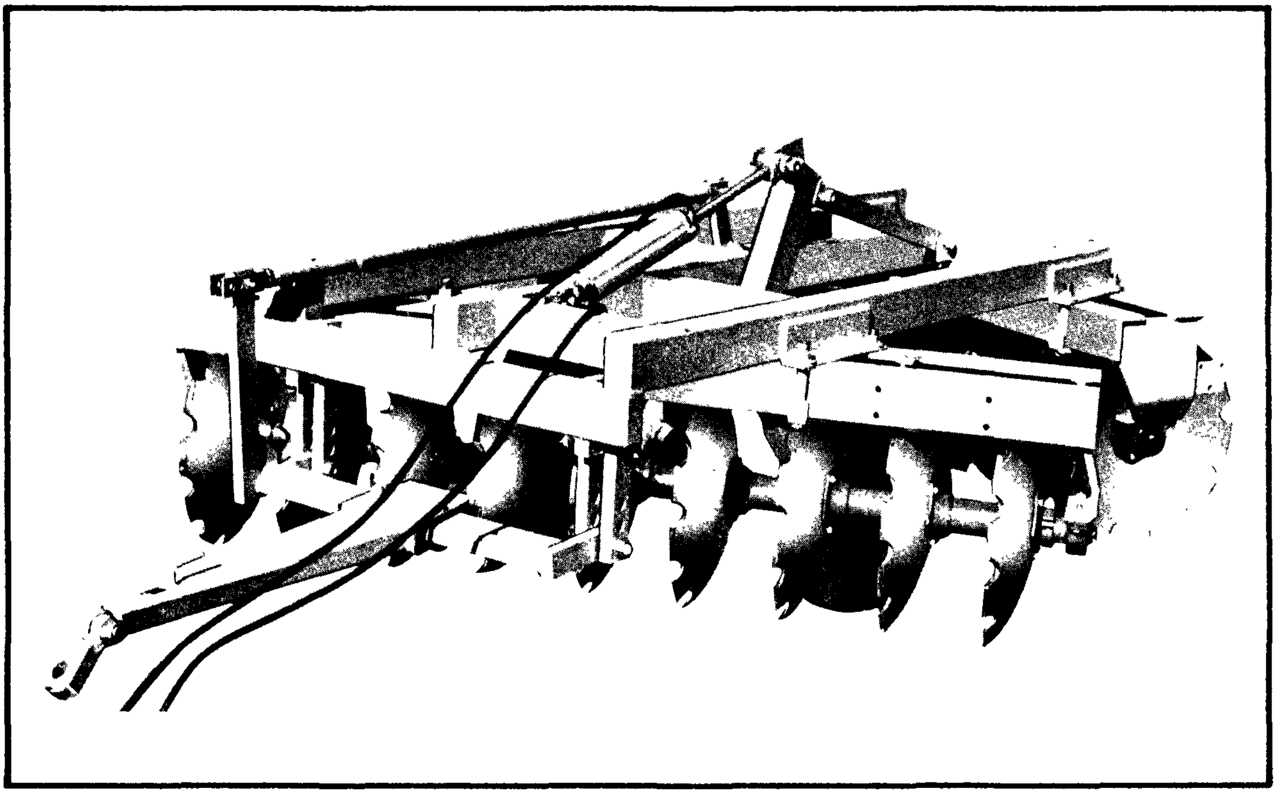

FIGURE 5. EXAMPLE OF DISC TILLER.

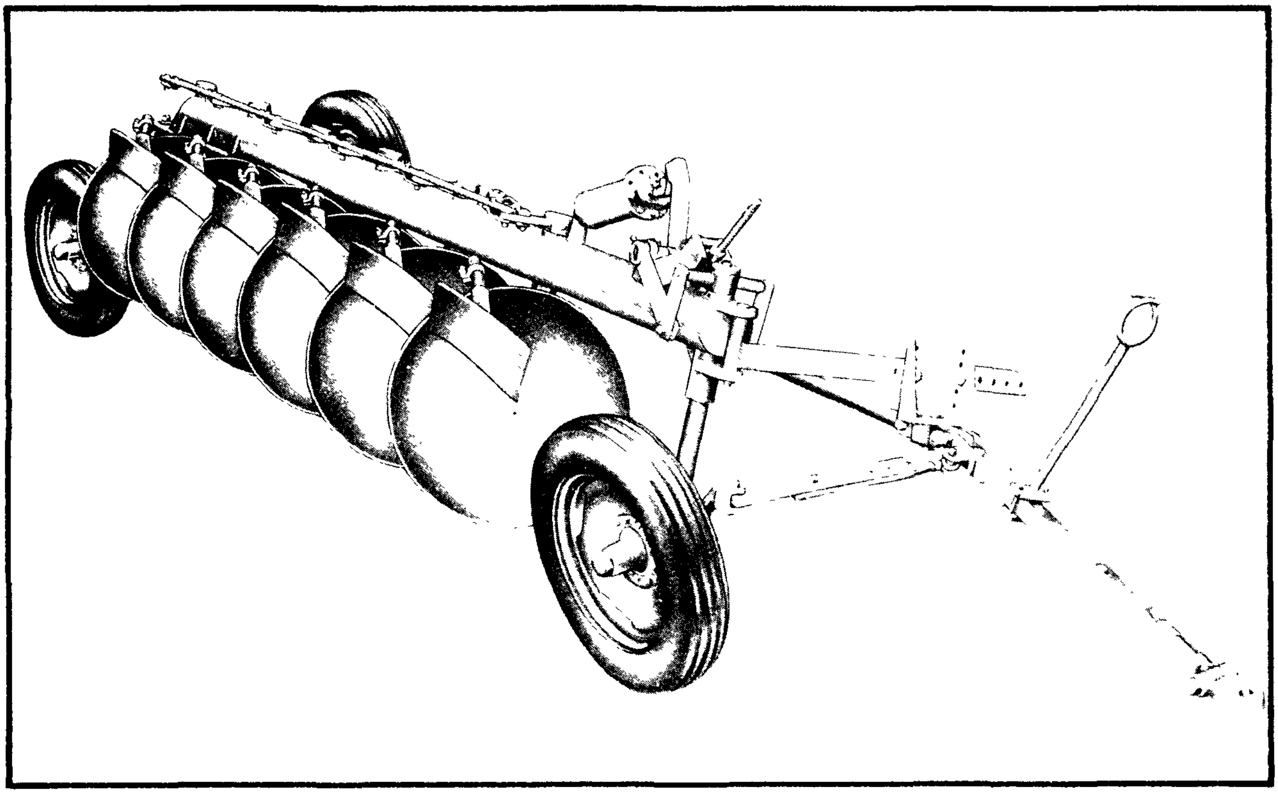

FIGURE 6. EXAMPLE OF DISC PLOW.

FIGURE 7. EXAMPLE OF DISC HARROW.

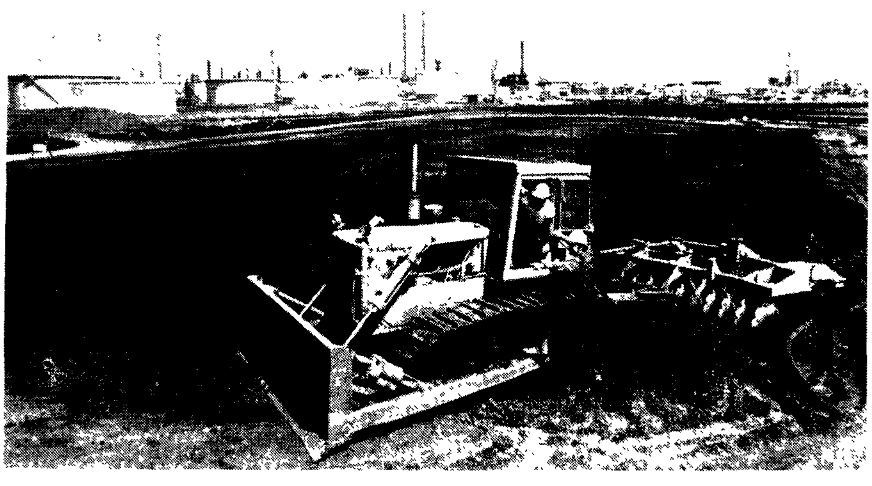

FIGURE 8. BULLDOZER PULLING DISC HARROW.

sites. Soil pH, nitrate-nitrogen or ammonium-nitrogen, total nitrogen, total organic carbon, and extractable phosphorus are determined by standard soil analytical methods. The nutrient status of the soil is then evaluated and a proper fertilization program is recommended. Generally, application of 56 to 90 kg/ha (50 - 80 lbs/ac) each of nitrogen and phosphorus a year should be sufficient to maintain favorable soil conditions for biodegradation of hydrocarbons.

If the soil is strongly acidic, the first step would be to apply lime to neutralize soil pH. Nitrogen and phosphorus fertilizers should be applied when the soil is relatively dry so they can be evenly incorporated into the soil. The disposal area should be kept aerobic by constant discing to increase microbial activity and to avoid denitrification and increased mobilization of some heavy metals (e.g., manganese and iron).

When to Prepare Site

Site preparation can usually be performed after deciding to land cultivate. However, if access road construction or other aspects of site preparation are expected to require more than one day, the contingency site should be readied prior to its actual need.

DISPOSAL PROCEDURES

There are five basic steps in implementing land cultivation of oil spill debris:

- Receipt of debris;
- Spreading and mixing with soil;
- Cleanup of site;
- Periodic recultivation; and
- Return of land to original use.

Receipt of Debris and Stockpiling

Debris delivered to the land cultivation site may be either deposited directly on the cultivation area or stockpiled nearby for later spreading. Direct deposit is preferable to eliminate double handling, but on-site stockpiling may be required if available equipment cannot properly cultivate all the debris as it is received or if insufficient land area is available to enable cultivating all debris in one batch.

The debris stockpile should be located near the spreading area, readily accessible to the landspreading equipment.

If the amount of debris is small, it may be left in dumpsters, garbage cans, 55 gal drums, or jiffy bags. If the amount is large, it should be placed on an impermeable liner, surrounded by an earthen berm and covered (to minimize runoff from precipitation). If the debris is very wet and the site soil is porous, it may be advisable to line the stockpile area with clayey or other fine-grained soils or a membrane liner to contain or impede the outward flow of oily liquids from the area. Liners may not be well suited for a stockpile area that is intended to be reused. Equipment operating in the stockpile area may inadvertently remove or puncture the liner with the debris.

Table 8 summarizes available information concerning membrane-type liners that may be applicable to oil spill debris stockpile areas. The polymeric membrane liners appear to have the greatest potential for containing oily wastes. Yet, as shown on Table 8, even these materials do not have extensive useful lives in the presence of hydrocarbons. Polychloroprene liners appear to offer the longest life (somewhere over 1 yr) while chlorosulfonated and regular polyethylenes are useful only for about one month at most, after which they begin to lose integrity and leak. Most liners degrade by swelling or hardening or will dissolve in the presence of many types of hydrocarbons. Asphalts, butyl rubbers, and ethylene propylene rubber are particularly subject to degradation and should not be considered for use at oil spill debris stockpiling areas.

Use of membrane liners generally requires subgrading and removal of angular objects that might puncture the liner material. If the debris itself contains sharp objects such as branches, a soil cover over the liner is required. Methods of installing the various liner materials vary depending on the type of liner and local conditions. Liners are generally shipped in large rolls and are placed in position in the field. Joints can be sealed by suitable adhesives or, in some cases, by heat treatment at the site.

Manufacturers specifications usually require certain liner section overlapping, installation temperatures, and other procedures.

Research and development into liner technology, including the integrity and longevity of membrane liners, is in its early stages. New liner materials are currently under development and further advances are expected. Consequently, it is best to consult manufacturers and U.S. Environmental Protection Agency representatives for up-to-date information on the availability and applicability of membrane liners for oil spill debris disposal stockpiling areas.

TABLE 8. SUMMARY OF DATA ON MEMBRANE LINERS POTENTIALLY USABLE FOR OIL SPILL DEBRIS STOCKPILE AREAS

Membrane type/material	Thickness avail. (mils)	Precautions		Est. installed cost range, $ per sq yd**
		Placement*	Expected Longevity+	
Polychloroprene (reinforced with polyester)	30	Exposable to sun	>1 yr	6.75-8.55
Thermoplastic polyester	7	Exposable	<1 yr	Experimental
Polyvinyl chloride (PVC)	10-30	Unexposable	<1 yr	1.17-2.16
Coal tar pitch and PVC	100	Unexposable	<1 yr	1.50-3.50
PVC reinforced with nylon	10-30	Unexposable	<1 yr	1.50-3.50
Chlorosulfonated polyethylene	20-45	Exposable	<1 mo	2.88-3.37
Polyethylene	10-20	Unexposable	<1 mo	0.90-1.56

* All liners require subgrade preparation by removal of sharp objects and rocks and may require a coarse soil base. Unexposable liners must be covered with soil to prevent damage by ultraviolet sunlight and atmospheric contaminants.

\+ Longevity data from Haxo, H.E., Evaluation of Selected Liners When Exposed to Hazardous Wastes. In: Proceedings of the Hazardous Waste Research Symposium, Residual Management by Land Disposal. EPA-60019-76-015, U.S. Environmental Protection Agency, 1976. p. 102.

** Cost of subgrade and soil cover not included. These additional costs can range from $0.10 to $0.50 per sq yd per ft of depth.

Spreading and Mixing with Soil

Thorough mixing of oil spill debris with the site soils is necessary to expose all oil to the available microorganisms and oxygen. There is no one correct procedure to spread and mix oily waste to promote degradation. Adaptation of the following general procedures to local soil, debris, and weather conditions and to equipment capabilities will be necessary.

Spreading Debris--

Debris should be spread in thin layers over a previously scarified soil. Layers of from 2.5 to no more than about 12 cm (1 to 5 in) will be adequate. If the debris contains materials up to about 15 cm (6 in), the spreading will be uneven but subsequent mixing should help disperse the oil.

As noted, debris with much material greater than 15 cm (6 in) will be difficult to spread and mix. Such large lumps and all bulky items must be removed to ensure proper land cultivation. Disposal by land cultivation is impractical if bulky items cannot be readily removed from the debris.

Weathering--

The layer of spill debris spread on the prepared land surface should be allowed to weather until it no longer appears wet or sticky. This may take several weeks in warm weather and much longer in the cold season.

In addition, mixing the debris into the soil should not be begun immediately after a rain, since equipment may become bogged down. It is preferable to wait until the soil has dried out reasonably well.

While the debris is weathering, an inspection should be made of all berms around the site to ensure that they properly contain any surface runoff from the site and to divert off-site runoff.

Mixing Debris with Soil--

Spill debris should be mixed into the soil using locally available equipment. The depth of mixing will depend on local conditions. Depths of 5.0 to 10 cm (2 to 4 in) in colder climates and 20 to 35 cm (8 to 14 in) in warmer climates should be adequate. Debris may be mixed to deeper depths in granular soils, shallower depths in silty or clayey soils.

Equipment used for pulling mixing devices can be track or wheel dozers or loaders, farm tractors, or any other type of suitable heavy equipment as shown in Figure 8. Rototillers, harrows, discs, plows, or dozer blades may be used for the actual mixing.

Tilling the soil and debris mixture should proceed systematically, similar to procedures used in normal agricultural soil preparation. For example, the debris and soil may be tilled using a disc harrow in one direction first then passing over the same plot again at right angles. Alternatively, the site can be plowed to mix the oil and soil. Plowing in one direction only is usually sufficient.

Sufficient mixing is achieved when the oil is dispersed in the soil so it is no longer visually recognizable as oil. No ponded liquid (water or oil) should be apparent. The number of repetitive passes required to achieve this condition depends on debris and soil characteristics. Usually at least two passes will be necessary. Sometimes more than five passes may be required.

Site Cleanup

After land cultivating all oil spill debris, the site surface should look like recently plowed farmland. All evidence of disposal activities should be removed, including bulky debris and cleared brush. Access roads should be left in place to enable subsequent mixing if necessary.

Subsequent Mixing Needs

It may be necessary to periodically re-mix the soil and debris to aerate the material and expose more oil to microbes. In general, when the surface of the land cultivation site appears gray, the material should be mixed again.

Re-mixing can be performed at varying intervals. Weekly tilling may be beneficial in the first month after initial land cultivation where once each six months may be adequate in the second year. In some cases, oil refinery waste land cultivation sites are plowed only once every two to four months year round until all oil is degraded.

Re-mixing is usually conducted for a period of six months to several years. The period depends on the degree of degradation and varies significantly with climate, season, oil type, and soil characteristics. The degree of oil degradation can be estimated by visual inspection. If no oil is visible after re-mixing, the process need not be continued.

Revegetation of the Site

A plot used for oil spill debris land cultivation can be kept available for contingency disposal use in the future, or it can be returned to the owner for other uses. In either case, grasses should be established to minimize erosion and improve site aesthetics.

Native grass or other vegetation may establish itself naturally, especially if nutrients have been applied to the area to promote biodegradation. Introduced vegetation such as crested wheat and rye grass have successfully grown from seed on cultivated sites. However, sown grass may not germinate during the first growing season.

While agricultural crops will grow on a cultivated site, the health effects of human or animal consumption of the resulting food products are not well defined. The effects will depend on many factors including crop type and oil characteristics. Until further information is available, it is safest to advise not to plant the area with crops intended for human or animal consumption, especially if the oil spill debris contained any heavy metals.

A land cultivation site is generally suitable as a foundation for building construction. However, if significant quantities of vegetative or organic matter other than oil was spread with the debris, more time is usually necessary for degradation of all organic debris components.

POTENTIAL PROBLEMS AND POSSIBLE SOLUTIONS

Various operational problems may be encountered during site preparation and land cultivation activities. Table 9 summarizes the possible problems and presents solutions that may be applicable. Environmental monitoring procedures for land cultivation and other disposal methods are explained in Section 8. Solutions to environmental problems are discussed in Section 9.

TABLE 9. LAND CULTIVATING OIL SPILL DEBRIS: POSSIBLE OPERATIONAL PROBLEMS AND SOLUTIONS

Possible Problem	Solution
• Inclement weather hindering site preparation and/or mixing	• Stockpile debris in prepared, diked area until weather improves.
• Difficulty in scarifying soils	• Rip soils with track dozer pulling double or single ripper blades prior to plowing or discing.
• Slow oil decomposition	• Till the oil/soil mixture more frequently.
	• Add fertilizers, such as urea and phosphates, or water.
• Erosion of land cultivated surface	• Regrade the surface to maintain no more than a 1 to 2 percent slope.
• Runoff of oily material	• Regrade the surface.
	• Improve earth berms.
	• Construct runoff catch basin downstream from the area.
• Odors	• Usually of short duration; accelerate mixing schedule to minimize exposure of odiferous matter.

SECTION 6

SANITARY LANDFILLING WITH REFUSE

Landfilling with refuse differs from both land cultivation and burial in that an existing sanitary landfill is used and few special arrangements need be made for disposal if the site has been properly prepared and operated.*

The selection of a site already approved and prepared for the receipt of wastes minimizes the need for pre-disposal activities. The oil spill debris is mixed with the ordinary refuse, which can act as an absorptive agent; the combined debris is then compacted at the site usually without special preparation of the subsoil or significant interruption of normal daily operations.

LAND AREA REQUIREMENTS

Most sanitary landfills generally have sufficient area and volume capacity to accept the volume of oil spill debris generated from even a large spill. A landfill's size could be considered adequate if it has capacity for the debris and at least 5 more years of wastes normally received. A problem might arise if the sanitary landfill site pre-selected as the debris disposal contingency area is nearing completion. Thus, the site may not have sufficient cover soil or remaining capacity to accept the debris. Sanitary landfills with adequate remaining life should be selected to avoid this problem. Also in the case of a large spill, several sanitary landfills may be needed to accommodate the debris.

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* See manuals and guidelines available on sanitary landfilling, such as, Brunner, D.R. and D.J. Keller. Sanitary Landfill Design and Operation. Report SW-65 ts, U.S. Environmental Protection Agency, Cincinnati, OH, 1972, and Sanitary Landfill, Manual of Practice No. 39, American Society of Civil Engineers, New York, 1976.

EQUIPMENT AND PERSONNEL REQUIREMENTS

Equipment Needs

Equipment normally employed at the sanitary landfill should also be sufficient for disposal of the oil spill debris. The optimum amount of debris which a landfill will accept will determine whether additional equipment or personnel are required. Arrangements can be made for the sanitary landfill operator to obtain the additional equipment and personnel needed for this increased volume of material.

Personnel

The normal contingent of employees at the selected landfill operation should be sufficient to handle oil spill disposal. No special preparation of the site is usually necessary, and disposal procedures are already established; as a result, the need for additional personnel or outside expertise will be minimal. If a significantly greater quantity of debris is expected than the normal waste loading at a sanitary landfill, additional personnel may be required.

As at any landfill site, certain tasks must be performed. A typical sanitary landfill team and their roles in managing oil spill debris is indicated below:

Title	Function
Site Coordinator..............	To oversee all on-site activities including metering of delivery vehicles, directing drivers to proper debris placement, and coordinating traffic.
Unloading Personnel...........	To assist with unloading debris from vehicles (e.g., using pitchforks or equipment such as forklifts).
Tractor Operator..............	To assure that oil spill debris is thoroughly mixed and compacted with refuse, and covered with soil.

SITE PREPARATION

Subsoil Preparation

No subsoil preparation is usually required for this form of disposal, unless normal sanitary landfill procedures at the site involve special precautions. It may be desirable to line the section of the sanitary landfill intended for debris disposal with fine-grained soils if the natural soils are relatively permeable. Local regulatory agency officials should be consulted prior to any subsoil work.

Traffic Control and Unloading of Debris

The projected increase of vehicular traffic at the sanitary landfill may require some adjustments in personnel allocations and vehicle routing. A systematic plan for unloading of oil spill debris should be formulated in advance in order to eliminate confusion.

It may be desirable to unload very wet oil spill debris at different locations on the site to ensure that any single area does not become oversaturated with water or oil.

Arrival of the debris at the fill will likely coincide with arrival of regular refuse vehicles. Thus, mixing of the refuse and debris can be conveniently accomplished and a minimum of mechanical mixing will be required.

When to Prepare Site

Burial with refuse at an existing disposal site does not generally require special land preparation prior to the actual receipt of the oil spill debris. All arrangements with the landfill owners should be planned at the time of site selection. It is, of course, desirable that a specific landfill be selected before the need for oil spill debris disposal arises. Therefore, operators of the contingency landfill should be notified as soon after an oil spill as possible and advised of the expected quantity of debris and of the anticipated time of debris delivery. This early warning should enable the operator to adjust his daily operations and to arrange for any additional personnel that may be required.

DISPOSAL PROCEDURES

Disposal of Oil Spill Debris

Disposal of oil spill debris at an existing landfill will require few special adjustments. The operator should follow EPA-approved or other accepted guidelines for landfill disposal operations. Oily wastes should be mixed with other refuse. Track dozers, wheel dozers, compactors, and other equipment normally used at a landfill will be adequate for mixing the refuse and spill debris.

As with standard sanitary landfill procedures, the oily debris/refuse mass will require proper covering at the end of each day. Ideally, the soil cover should have a high clay content to provide a relatively impermeable cap above the oily debris/refuse mixture. However, most available soil is sufficient as long as covered surfaces are graded to enhance runoff, minimize erosion, and prevent ponding. Cover thickness should be at least 15 cm (6 in). The amount of cover soil used should constitute roughly 20 percent of the total volume of refuse within the fill.

In sanitary landfilling the debris is sequestered under cover, greatly reducing or eliminating the possibility for aerobic microbial decomposition of oil. Sanitary landfilling necessitates longer term monitoring, but less site preparation (and none of the subsequent mixing) as compared to the land cultivation disposal method.

Site Cleanup

Normal cleanup procedures for the sanitary landfill should be followed. The refuse and oil spill debris should be covered, and all evidence of waste disposal activity should be removed. The landfill will most likely continue to receive refuse; therefore, no special site cleanup activities should be required. However, equipment used for mixing and spreading the oil spill debris may require steam cleaning to remove any buildup of oil or debris.

When all or portions of the landfill are decommissioned, care should be taken to ensure that the surface is properly graded and that planting to prevent cover soil erosion is completed promptly. As with land cultivation, no edible vegetation should be planted.

POTENTIAL PROBLEMS AND POSSIBLE SOLUTIONS

Several problems could arise during and after disposal of oil spill debris by landfilling with refuse. A summary of such problems and recommended solutions are listed in Table 10. Section 8 presents environmental monitoring procedures and Section 9 explains various possible solutions to potential problems in more detail.

Ignition of Oily Debris/Refuse

Although the probability of refuse/oil ignition is small, the potential does exist. If the oily debris has been stock-piled or stored for any length of time, dispersion of the volatile constituents will lessen the chance of ignition. Precaution should be taken against operating any equipment without proper spark arrestors or exhaust pipes in the oily debris/refuse disposal area.

TABLE 10. SANITARY LANDFILLING OIL SPILL DEBRIS: POSSIBLE OPERATIONAL PROBLEMS AND SOLUTIONS

Possible Problem	Solution
• Oil not absorbed by refuse Over-saturated mass Under-saturated mass	• More mixing with refuse until adequate mix is secured.
• Ignition of oily debris/refuse mass	• Extinguish flame: Prevent by installing spark arrestors on equipment and assuring they have mufflers above equipment.
• Leaching of oil into groundwater (groundwater flow through refuse)	• Reduce groundwater level by trenching or pumping. Excavate material and install liner.
• Leaching of oil into groundwater (vertical migration down through bottom)	• Dig up landfill and reseal bottom.
• Leaching of oil into groundwater (vertical infiltration of water from surface)	• Reduce percolation by improving cover material: slope surface to encourage runoff.
• Erosion of cover soil	• Place more cover soil; sown with grasses, and protect until grass grows.

Spontaneous combustion of buried oily wastes has not been reported. Sanitary landfills are usually anaerobic and thus would not present enough oxygen to support combustion.

SECTION 7

BURIAL

Burial of oil spill debris without refuse usually requires excavation or utilization of an existing pit or trench for disposal. In some cases, however, the oil spill debris can be contained within a berm mounded above ground and covered with soil, with little or no excavation involved. Burial above grade may be preferable since any lateral leakage can be readily observed without subsurface exploration. Figures 9 and 10 depict cross-sections of below- and above-grade debris burial sites. Alternative layering of oil spill debris and soil is usually employed in any burial disposal operations.

As in sanitary landfilling, the debris is sequestered under cover, greatly reducing or eliminating the possibility for aerobic microbial decomposition of oil. Burial may involve more site preparation and longer term monitoring but eliminates the subsequent mixing required of the land cultivation disposal method. See Section 3 for a discussion of site selection criteria.

LAND REQUIREMENTS

Land requirements for landfilling without refuse will depend upon:

- The volume of debris generated by the oil spill;
- The depth and lateral extent to which the site can be excavated; and
- The particular burial method selected.

Land characteristics at some sites may allow excavation equal to the volume of oil spill debris. At other sites, debris may be deposited level with the existing relief and covered. In such cases, land requirements will be determined not only by available land area, but by the height to which the debris can be mounded above grade. For example, local planning agency requirements may limit final grades at the site to a certain elevation to conform with adjacent land uses.

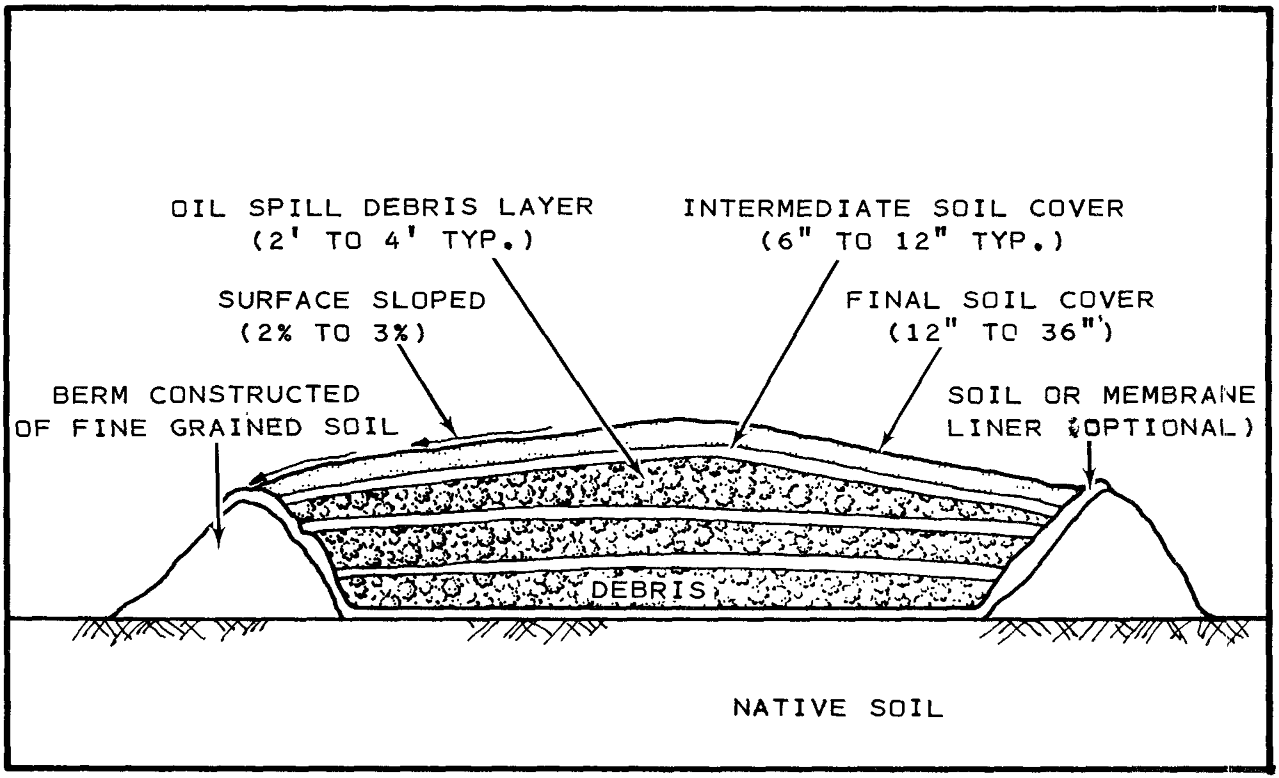

FIGURE 9. TYPICAL CROSS-SECTION OF AN ABOVE-GRADE DEBRIS DISPOSAL SITE.

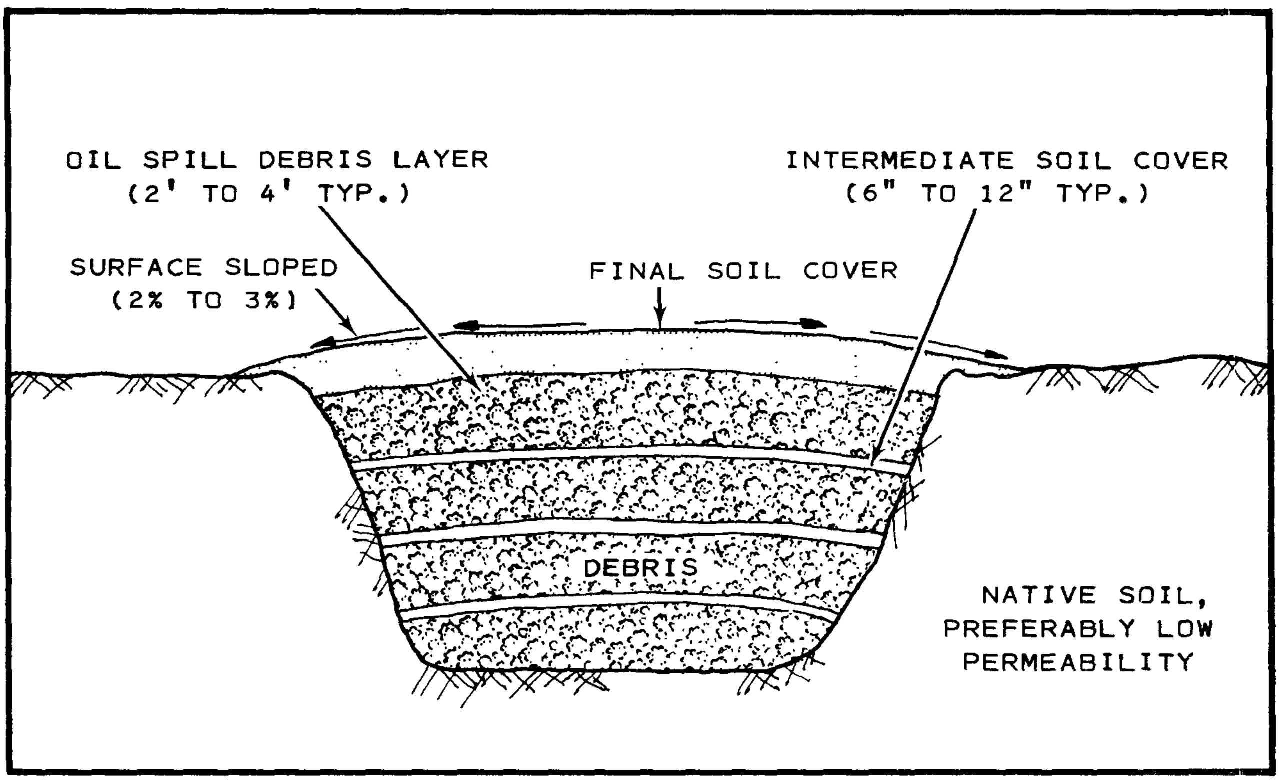

FIGURE 10. TYPICAL CROSS-SECTION OF A BELOW-GRADE DEBRIS DISPOSAL SITE.

EQUIPMENT AND PERSONNEL REQUIREMENTS

Equipment Needs

Heavy equipment will be required to prepare the burial disposal site and to receive, deposit, and cover the delivered debris. The types of equipment needed will depend upon the extent of excavation necessary and the distinctive geological and topographic features of the disposal site. If extensive excavation is required, equipment that can handle the types of soil or rock at the site will be needed. Useful equipment may include track dozers (equipped with one or two toothed rippers), backhoes, self-propelled scrapers, or bucket cranes.

Disposal operations involving above-grade mounding may require different equipment. Track dozers equipped with a bucket or graders would be appropriate for constructing any containment berms that may be required.

Track or wheel dozers would usually be adequate for placing the debris in the disposal trench or area. The same equipment can be used to apply intermediate and final cover and to grade the filled site surface.

Personnel

The number and tasks of personnel required will vary according to the quantity of spill debris, its rate of delivery to the site, and the disposal burial method chosen. In general, certain duties will need to be performed, whether by an individual or by a team assigned to a specific task. Necessary personnel categories and their tasks include:

Title	Function
Site Coordinator...............	To oversee all on-site activities including metering of debris, implementing proper disposal techniques, and coordinating traffic.
Unloading Personnel............	To assist in unloading debris from delivery trucks, either manually or using equipment.
Heavy Equipment Operator.......	To move debris from the unloading area, place it in the disposal area, cover it with soil, and grade the site surface after site completion.

PREPARATION OF SITE FOR BURIAL

Access Road and Drainage Control

Site access should be designed to fulfill the needs of the selected burial method. Expected truck types, traffic volumes, and routing of on-site vehicles should be considered in the design of access roads. Ramps and/or soil and oil spill debris stockpiling areas should be located near the disposal area to preclude extensive road development.

Drainage control should be a major feature of site preparation planning. Drainage patterns at the site and adjacent areas should be assessed to minimize surface runoff into the fill area. Natural drainage channels emptying onto the planned disposal area should be diverted so that the potential for runoff to infiltrate the fill is minimized. Drainage channels can be earth ditches, if low flows are expected. Lining with asphalt or gunnite may be necessary to handle higher flows. Half-round corrugated metal pipe is also used for drainage channels.

Trench Excavation

Burial of oil spill debris may require the use of excavated trenches. These excavations should be situated in the best possible position as determined during development of the debris disposal contingency plan. The trenches should not intersect groundwater or a permeable subsoil. Any runoff from off-site should be readily controllable. The disposal area should be easily accessible by vehicles delivering debris. Designing the trenches in this manner will contribute to the ease of disposal and guarantee minimal environmental hazards.

Subsoil Preparation

Burial of oil spill debris at suitable sites will not generally require special subsoil preparation. However, it may be desirable to prepare the subsoil at a site where soils would not otherwise be acceptable for debris disposal. For example, preparation of an above-grade burial site might include lining the bottom and sides with a fine-grained soil imported from off-site. This material would act to retard or eliminate outward migration of oil from the debris that is placed with soil liner enclosures. (See Volume II, Part 2, Section 4, Case Study Site D for an example of this type of burial site preparation.)

The need for a liner at a burial site, if any, will be determined not only by the nature of the spill debris, but also by geohydrological conditions at the disposal site. When evaluating suitable liner materials, the selective placement of indigenous and nearby fine-grained soils should be considered before synthetic membrane materials, as discussed in Section 5.

DISPOSAL PROCEDURES

Receipt of Debris from Delivery Vehicles

Transfer of oil spill debris from delivery vehicles to the disposal area may require special handling. In ideal circumstances, the vehicles will deposit the material directly into the trench or bermed area. Prevailing site characteristics, however, may require that the debris be mechanically removed from the vehicles and carried to the desired disposal location. The volume and arrival rate of delivery vehicles may require systematic traffic control so that stockpiled debris is stored near the actual disposal area. This way, subsequent movement, if any, will be minimal.

Spreading and Layering Debris

Oil spill debris can be spread and layered within a pit or trench with most track or wheel dozers or loaders. The total depth to which debris is spread will depend on the method of burial and on local topographic limitations.

It is usually best to layer the debris into the disposal trench or area. Each debris layer is compacted and then covered with an intermediate layer of soil. This process improves the overall compaction and prevents equipment from becoming mired in the debris.

The depth of each intermediate layer depends on the size of debris constituents. For beach sand and seaweed, without bulky items, one to two feet of debris should be adequate. Debris containing bulky brush or flotsam may necessitate use of deeper intermediate layers. An intermediate layer of soil may not be necessary if the equipment can operate satisfactorily on the uncovered debris. Plan procedures for wet weather in advance.

Site Cleanup

Cleanup procedures for oil spill debris burial sites are similar to those used for land cultivation disposal. All signs of disposal activities should be removed from the surface and surrounding areas. Any areas used for stockpiling should also be returned to their pre-disposal appearances.

Final Cover Soil and Revegetation of the Site

The final cover over the completed burial area may consist of soil excavated from the trenches, other on-site soils, or material imported from off-site. Low permeability soils are necessary to impede infiltration of precipitation. The cover soil should be compacted and graded to a three to four percent slope to further ensure minimum infiltration. Slopes greater than about four percent may tend to erode. A final cover depth of two to three feet is recommended.

Grasses should be planted over the burial site surface to inhibit erosion and improve site aesthetics. Grasses selected for cover plantation should:

- Germinate rapidly;
- Constitute a perennial strain; and
- Provide thick growth.

All vegetation should be protected until full grown. Edible crops should not be planted.

POTENTIAL PROBLEMS AND RECOMMENDED SOLUTIONS

The potential problems of burying oil spill debris without refuse are similar to those expected from the previously discussed debris disposal methods. Table 11 lists some potential problems and their recommended solutions; a more complete discussion will be found in Sections 8 and 9.

TABLE 11. BURIAL WITHOUT REFUSE: POSSIBLE OPERATIONAL PROBLEMS AND SOLUTIONS

Possible Problem	Solution
• Groundwater contamination	• Lower groundwater level by pumping or groundwater interceptor trenches. Excavate point source materials if necessary.
• Surface water contamination	• If contamination source is from groundwater, use measures as above. If source is from surface runoff, add more cover soil and/or improve surface water diversion facilities.
• Slumping of fill	• Place and compact additional cover soils.
• Cover grasses not germinating	• Re-sow and evaluate choice of grass and reasons for failure. • Fertilization or chemical soil adjustment may be required.

SECTION 8

MONITORING THE SITE FOR ENVIRONMENTAL PROTECTION

An oil spill debris disposal site may present the possibility of environmental problems as long as the oil and other waste materials are not thoroughly decomposed and pathways from the disposal area to off-site locations are present. Degradation may require hundreds of years or more for sites where oil is buried, or only several years at aerobic land cultivation sites.

Pathways for migration of oil spill debris constituents can be inherent at the site or may develop after completion of disposal activities due to natural causes or man-induced alterations to the disposal site and its environs.

Depending on the particular agreements developed during negotiation for use of a disposal site, it will be the responsibility of the agency coordinating oil spill cleanup operations, the landowner, another agency, or a combination of these groups to ensure that any environmental problems that do arise will be detected early enough to enable implementation of proper countermeasures. This section presents basic considerations for disposal site monitoring. Section 9 discusses available remedial actions should the disposal site monitoring program indicate that an environmental problem may be developing.

POSSIBLE ENVIRONMENTAL PROBLEMS

Any activity involving the disposal of a waste material on land will present potential environmental problems. Both short- and long-term pollution problems must be defined in order that a comprehensive monitoring plan may be formulated. An effective monitoring program will depend on the early recognition of these potential problems and the design of a system to facilitate their identification should they occur. It is essential to obtain background data prior to disposal.

Possible environmental problems to expect at an oil spill debris disposal site include the following:

- Surface runoff of oily materials;
- Surface settlement and ponding of surface water;
- Contamination of groundwater with constituents of the debris by:
  - Infiltration of groundwater into the debris, or
  - Leaching of debris constituents from the debris to groundwater; and
- Retarded oil degradation (at land cultivation sites).

The symptoms and possible impacts associated with these problems are briefly discussed below.

Surface Runoff of Oily Materials

Surface runoff of oil and other contaminants contained in spill debris is a particular problem at land cultivation sites where debris is purposely left on or near the surface to enhance oxygen contact. In some instances, runoff could possibly enter a debris burial or sanitary landfill area and exit as a surface leachate downgrade. In any case, contamination of surface waters could result from such runoff or leachate problems.

Surface Settlement and Ponding of Surface Water

Differential settlement of buried wastes at a sanitary landfill or burial disposal site may adversely alter surface drainage patterns or result in rupture of the cover soil. Either of these events could in turn allow surface waters to pond and facilitate infiltration into the debris. Also, operation of heavy equipment or other activities on the surface could create local depressions at any type of debris disposal site, thus impeding the runoff of surface waters.

Contamination of Groundwater

Leaching of water containing oil and/or other contaminants into groundwaters is a potential problem at most debris disposal sites. Surface water can infiltrate the debris mass and leach out the soluble constituents. Further migration of this polluted water, called leachate, through subsurface soils will remove some but not all contaminants. Any remaining materials will be added to whatever groundwater basin the leachate ultimately intersects.

A less probable potential hazard exists if subsurface waters infiltrate into sanitary landfill and buried debris. The long time span required for anaerobic degradation of sequestered oil spill debris makes this a particularly acute problem. Fluctuations in groundwater levels causing leaching of the debris may occur due to natural or man-caused events during the 100-yr plus oil degradation period estimated for burial and sanitary landfill disposal techniques. Groundwater basin characteristics could also change during this period, resulting in horizontal leaching of groundwater into the oil spill debris.

Retarded Oil Degradation (At Land Cultivation Sites)

Observation of the surficial oil and soil mixture at a land cultivation site may indicate that degradation is proceeding at a rate slower than originally anticipated. This delay may in turn affect scheduled reclamation plans for the site.

Contaminated Vegetation

Also, it may be that vegetation growing at a disposal site where the oily debris is not yet fully degraded could be inadvertently or purposely consumed by animals or humans. Because available information on the safety of such vegetation is meager, the safest course is to recommend that no animal or human food crops should be grown on waste disposal sites. If this recommendation is followed, monitoring of this vegetation is unnecessary.

DEVELOPMENT OF A MONITORING PROGRAM

The form and extent of the environmental monitoring to be implemented at a particular oil spill debris disposal site depends on the type of disposal operation and site geohydrological conditions. Also, requirements of all local regulatory agencies with jurisdictions covering water quality, environmental protection, and solid waste management should be met. Methods and sampling techniques for monitoring ground and surface waters and soils are discussed below.

Groundwater Monitoring

Basic hydrogeological features at the disposal site should be known from information gathered during the site selection process. In general, a groundwater monitoring program will entail placement of wells in the groundwater both upstream and downstream from the disposal site. Thus, at a minimum, knowledge of the following data is necessary for monitoring well design:

- Depth of groundwater and expected fluctuations;
- Direction of groundwater flow; and
- Quality of groundwater in area before disposal of debris.

Placement of Monitoring Wells--

When all available hydrogeological data has been evaluated and monitoring needs established, details of the design program can be specified. A groundwater monitoring system should detect as early as possible any contaminants that may be entering the aquifer and define the contaminated zones. This can be accomplished by a system of drilled wells both upstream and downstream from the site. Depth, placement, and number of wells will be determined by site-specific subsurface characteristics and monitoring objectives.

Based on subsurface hydrology, the first wells can be placed downgradient from the debris disposal area. Initially, two or three wells may be aligned perpendicular to the anticipated direction of contaminant movement from the disposal area. The wells should be situated as close as practical to the limits of debris deposit to ensure that any contamination that may occur is detected quickly. If one or more of these downstream wells detect any pollution, assessment of the degree of contamination in each well will aid in defining the limits of the contaminated zone.

At least one upstream well should be drilled to enable sampling of background groundwater quality.

Wells should be constructed of polyvinyl chloride (PVC) plastic pipe to minimize contamination of sampled water from pipe materials. The pipe diameter must be sufficient to accommodate sampling devices large enough to obtain a sufficient sample volume in a reasonable number of bails. All wells should be capped.

Depth of Monitoring Wells--

The depth of each monitoring well will be determined by site hydrologic characteristics. Vertical fluctuation of groundwater levels must be defined so that each well can be installed to extend into the aquifer throughout the year even in dry years. It is good practice to extend the well screen 1.5 to 3 m (5 to 10 ft) below the lowest expected level of the aquifer and several feet above the highest estimated level, as shown in Example B on Figure 11. Figure 11 also illustrates the problems that may be encountered if monitoring wells are not suitably screened.

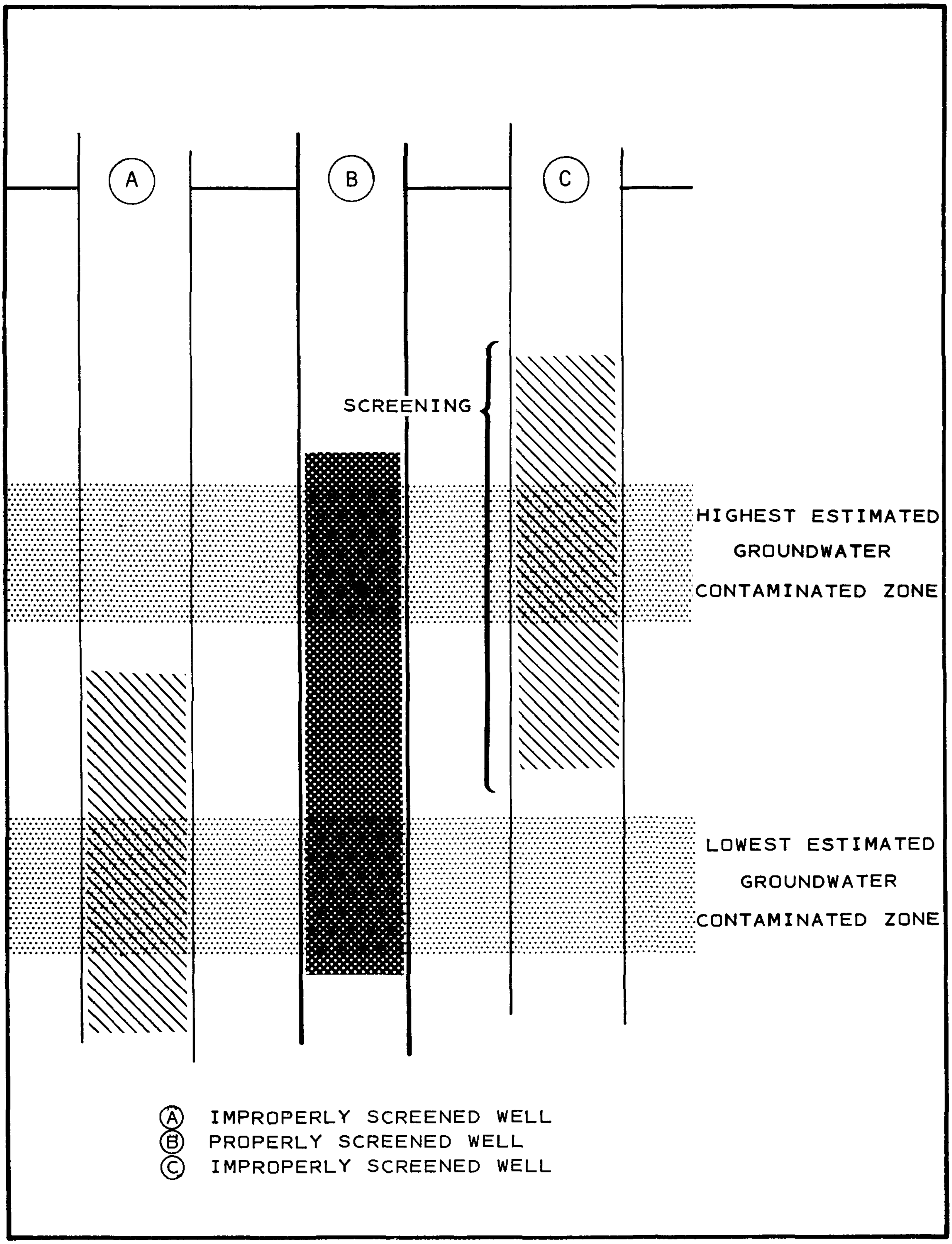

FIGURE 11. WELL SCREENING.

Surface Water Monitoring

Any body of surface water less than 300 m (1,000 ft) downstream from an oil spill debris disposal area should be periodically monitored to ensure water quality protection. Surface drainage patterns in the site's vicinity should be analyzed to assure that sampling stations are placed at the most likely points of contamination. Surface water samples should be taken as near to the disposal site as possible so that contamination can be detected before it spreads to a larger body of water (and becomes more diluted and harder to detect).

Monitoring of Land Cultivation Site

In addition to monitoring a land cultivation site for ground and surface water pollution, it may also be desirable to assess the extent of oil degradation occurring. Knowledge of the extent of degradation can help determine when the land is ready to be reclaimed for agricultural, industrial, or other purposes.

If such a program is desired, periodic sampling of surficial soil and oil mixtures should be planned. Also, it may be advantageous to obtain soil samples to a depth of several feet.

Sampling Procedures

The goal of careful sampling is to obtain representative soil and water samples from the disposal site. Sampling procedures should be designed to avoid altering the specimens in any way. Later samples should be taken from the same locations to provide continuity of data and results.

The following types of samples should be obtained from oil spill debris disposal sites as part of a routine monitoring program:

- Groundwater samples;
- Surface water samples; and
- Oil/soil samples (from the surface of land cultivation sites).

The depths and numbers of each type sample to be taken will be site-specific, depending on local regulatory requirements and site geohydrological conditions. Also, the frequency of sampling depends on local conditions. It is usually advisable to sample a new disposal site several times each year during the first two or three years after completion of disposal activities, since any liner leakage or oil migration would not be immediately detectable. As shown on Figure 2, permeabilities of fine-grained soils are 10^{-4} cm per sec or less. For a soil with permeability 10^{-4} cm per sec, contaminated water could move about 30 m (100 ft) in one year. If no contamination or other problems are detected during the first two or three year period, annual sampling should be sufficient thereafter.

In general, a land cultivation operation will require a short monitoring program on the order of several years, due to the relatively rapid degradation of hydrocarbons. Much longer time periods (tens and hundreds of years) may be necessary to monitor landfill and burial sites, where oil degradation will occur at a far slower rate, if at all.

During each sampling visit, personnel should both obtain the necessary samples discussed below, and observe and record general site conditions. Particular note of any abnormalities should be made, such as surface settlement at a burial site, ponded water, erosion, or oil sheens on any nearby waters. Photographs are useful in documenting observations made.

Sampling Equipment and Materials--

Table 12 summarizes the types of equipment and materials needed to sample and to properly store and transport the water and soil to the laboratory. Ice may be unnecessary if the laboratory will receive the samples within several hours of sampling. Laboratory personnel should be consulted in this matter.

Procedure for Groundwater Sampling--

Groundwater samples should be collected using a sampler constructed of inert materials such as polyvinyl chloride (PVC) pipe. A sampler of this type is illustrated in Figure 12. Whenever sufficient water is present, groundwater in the well should be pumped out or bailed for several minutes before taking samples. Sampling by pumping is preferred but bailing may be the only practical method of obtaining groundwater samples. In either case, the sampler should be rinsed in the field between samples with distilled water or with additional well water if enough is present. Water collected in the device should be emptied into precleaned glass bottles. Bottles should be prepared as follows: rinse bottles thoroughly with hot tap water and allow to cool; and rinse with 1:1 HCl (reagent grade), with cold tap water; and finally with double-distilled deionized water. Secure bottle caps to prevent any future contamination. Note that no detergents should be used to clean bottles, since the phosphorus content could affect sample analyses.

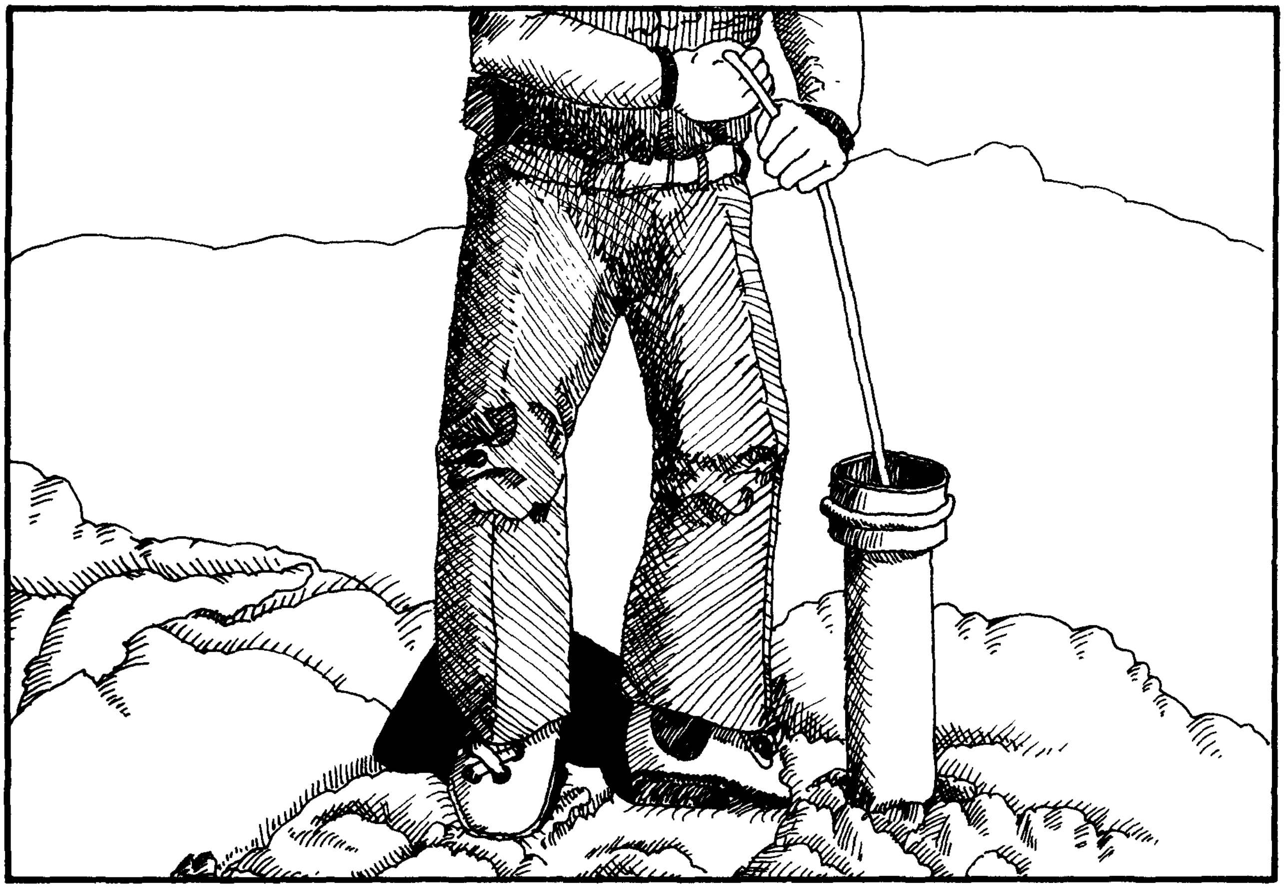

FIGURE 12. GROUNDWATER SAMPLER IN USE.

FIGURE 13. SOIL SAMPLES TAKEN FROM AUGER.

TABLE 12. BASIC EQUIPMENT AND MATERIALS REQUIRED FOR SAMPLING GROUND AND SURFACE WATER AND OIL/SOIL MIXTURES AT OIL SPILL DEBRIS DISPOSAL SITES

Water Samples

1. Glass bottles with caps for each water sample. Approximately 2 liter (1/2 gal) size is sufficient.

2. Water sampler to obtain samples. Sampler should be constructed of plastics to avoid contamination of sample.

3. Distilled water for rinsing sampler between sampling to avoid cross contamination.

4. Ice chest or box to contain sample bottles. Use of ice may be necessary if delivery to the laboratory will require more than a few hours.

5. Labeling tape for samples.

6. Waterproof marking pen.

Soil/Oil Samples (from the surface of land cultivation sites)

1. Rubber gloves.

2. Knife and trowel for sample trimming and digging.

3. Hand bucket auger (optional).

4. Plastic bags for storing sample. Plastic trash bags and ties are suitable.

5. Blank well log forms.

6. Labels and a waterproof marking pen.

Miscellaneous Items for All Sampling

1. Clipboard and pen to record field notes.

2. Map of disposal site to locate and/or record sampling points.

3. Camera and film.

Procedures for Surface Water Sampling--

Surface sampling should be conducted as for groundwater using inert sampling devices that can be rinsed in the field with distilled water. Samples should be taken from the surface of quiescent surface water nearest to the debris disposal area.

Procedures for Sampling Oil and Soil Mixtures at Land Cultivation Sites--

It is difficult to obtain samples of oil and soil mixtures that are "representative" of the entire cultivated surface area. Often, it is expedient and sufficient to designate a sub-area for grab sampling and to obtain all samples from that plot. Care should be taken to select a sampling area that does not exhibit signs of either excessive oil or lack of oil.

Rubber gloves and, if necessary, a clean trowel should be used when obtaining samples. Alternatively, soil and/or oil and soil mixtures can be taken from an auger used to drill groundwater wells as shown in Figure 13. About 2 kg (5 pounds) of the soil and oil mixture should be placed in a plastic bag and labeled. Double bagging is suggested to preclude breakage.

For a more refined approach, sampling by the cone and quartering technique developed in the mining industry may be employed. Basically, this method would involve mounding a mass of mixed oil and soil material into a cone shape several feet high. One quarter of the cone would be segregated and mixed thoroughly, after which another cone would be made. This process would continue until the desired amount of sample remains.

Laboratory Analyses to be Performed

The main purpose of monitoring an oil spill debris disposal site is to determine to what extent contaminants are leaving the site. Thus, the water and soil samples obtained during the monitoring program should be analyzed for the constituents known to be present in the original spill debris. Also, the concentration of any known intermediate by-product of decomposing debris material should be determined.

Table 13 shows the parameters that were analyzed during case study investigations of four oil spill debris disposal sites. This list was developed as part of a research effort and may be more extensive than necessary for a routine monitoring program aimed at assessing whether or not oil or other contaminants are causing environmental problems. Also, many

TABLE 13. WATER QUALITY AND SOIL PARAMETERS ANALYZED DURING INVESTIGATION OF FOUR OIL SPILL DEBRIS DISPOSAL SITES

Water and Soil Samples

- pH
- Organic acids
- Oil content
- Organic nitrogen
- Phosphate
- Lead
- Iron
- Chlorides
- Biological activity (plate count)
- Total extractable hydrocarbons
- Oil fractions, percent by weight paraffins, aromatics, and polar hydrocarbons

Soil Samples Only

- Moisture content
- Permeability
- Grain size distribution

of the parameters in Table 13 may not be related to the debris deposited at every site.

It is recommended that pH, oil content, and organic acids should be analyzed as part of a routine monitoring program. The solubilities of most elements, particularly trace metals, are known to be greatly influenced by pH. Low pH (strongly acidic conditions) increase the solubility and availability of toxic heavy metals (e.g., Cd, Ni and Zn), thereby facilitating their movement in the soil and aquatic environments. Hydrocarbon-consuming bacteria, on the other hand, are favored by pH's near the neutral range.

Data on oil content, in general, would indicate the extent of oil pollution and, if determinations are made over a period of time, rate of biodegradation. Accumulations of organic acids suggest incomplete decomposition of the hydrocarbons and an anaerobic environment. When present in high concentrations, the organic acids are harmful to plants and fish.

SECTION 9

CORRECTING ENVIRONMENTAL PROBLEMS

A properly designed monitoring system will enable the source and extent of any contamination to be readily detected. If contamination is found, measures to correct the problem should be taken by the parties responsible. Corrective actions should have two goals: (1) to remedy any damage that has already occurred; and (2) to prevent the pollution problem from recurring. It is helpful to briefly discuss possible alternative solutions to various debris disposal site pollution problems (summarized in Table 14).

GROUNDWATER CONTAMINATION

Once contamination of the groundwater has been detected, a determination of both the pollutant source and the extent of the affected area is necessary. Groundwater quality and use need to be considered in order to assess the consequences of contamination. Accurate information is essential to guarantee selection of appropriate and effective corrective measures. Once this information is assembled, alternative solutions can be considered.

Groundwater pollution from an oil spill debris disposal site can result from several events acting together or separately:

- Leaching of oil and other contaminants by infiltration of surface water through the debris;
- Drainage of the liquids contained in the debris itself; or
- Flushing of the debris materials by groundwater rising into the mass.

Vertical Infiltration

Vertical infiltration of waters from the surface into the debris may leach the deposited oil spill debris, transporting contaminants to the groundwater. Construction of diversion

TABLE 14. CORRECTING ENVIRONMENTAL PROBLEMS

Problem	Possible Solutions
A. Infiltration of groundwater into debris mass	1. Pump out groundwater to drain upstream area. 2. Construct diversion channels. 3. Construct peripheral subsurface drains to intercept groundwater flow. 4. Rebuild impermeable walls.
B. Leaching of oily matter from debris mass to groundwater	1. Intercept leachate with trench. 2. Pump out excess moisture from debris mass; either recycle pumped out water or remove for treatment at an approved facility. 3. Rebuild impermeable walls.
C. Surface runoff of oily materials from site	1. Install impoundment dikes or berms. 2. Improve upstream diversion channels. 3. Recycle runoff to debris disposal area (if quantity is small enough).
D. Ponding of water on surface of disposal site	1. Regrade surface; possibly apply more cover soil. 2. Establish vegetation to both increase evapotranspiration and reduce runoff velocities.
E. Impeded oil degradation at land cultivation site	1. Rototill or disc the soil/oil mixture more frequently. 2. Add nutrients or other amendments.
F. If above-noted remedial actions do not solve environmental problems, check further to be certain that debris disposal site is actually the source of detected contamination. If it is, removal of debris to another site may be last resort to positively curtail pollution threat.	

trenches to minimize the volume of water draining into the fill can prevent this problem, and should be included as part of effective site design. The effectiveness of drainage diversion trenches should be checked periodically and repaired when necessary. Proper site revegetation to minimize water accumulation and penetration will also reduce the possibility of vertical infiltration.

Infiltration can be caused by ponding of precipitation due to differential settling of the debris fill. Ponding can be prevented by regrading the surface to a three to four percent slope. Additional cover soil may be necessary when regrading. Again, plants with high transpiration rates can be planted at the site to reduce the amount of water available for infiltration.

A cracked or eroded portion of the cover soil may also allow precipitation to infiltrate directly into the fill. In the event of cover soil failure, it will be necessary to discover why such a failure occurred, though the addition of more cover soil over the problem area may provide an adequate solution. Use of a different type of cover soil may need to be considered, however, in order to prevent cracking and erosion in the future.

Leaching of Oily Matter from Debris Mass

Groundwater contamination may also be caused by leachate generated by the moisture present in the debris mass. A trench can be constructed to intercept leachate before it penetrates the aquifer, or excess moisture may be pumped out of the debris mass to reduce the volume of leachate available for groundwater infiltration.

When and wherever groundwater contamination occurs, appropriate remedial actions will necessarily be site-specific. If all other methods have failed, contaminated groundwaters can be pumped from the water table and treated appropriately. This procedure will require fairly accurate knowledge of the boundaries and degree of contamination of the leachate affected zone for efficient well placement. Where a shallow aquifer exists, an interceptor trench may provide an adequate solution. Figures 14 and 15 show several methods of pumping hydrocarbon wastes from this type of trench prior to treatment. Proper disposal site selection could preclude groundwater contamination problems that require costly pumping solutions.

Infiltration of Groundwater into Debris Mass

Contamination can result from the infiltration of groundwater into the fill caused by local mounding or areal changes

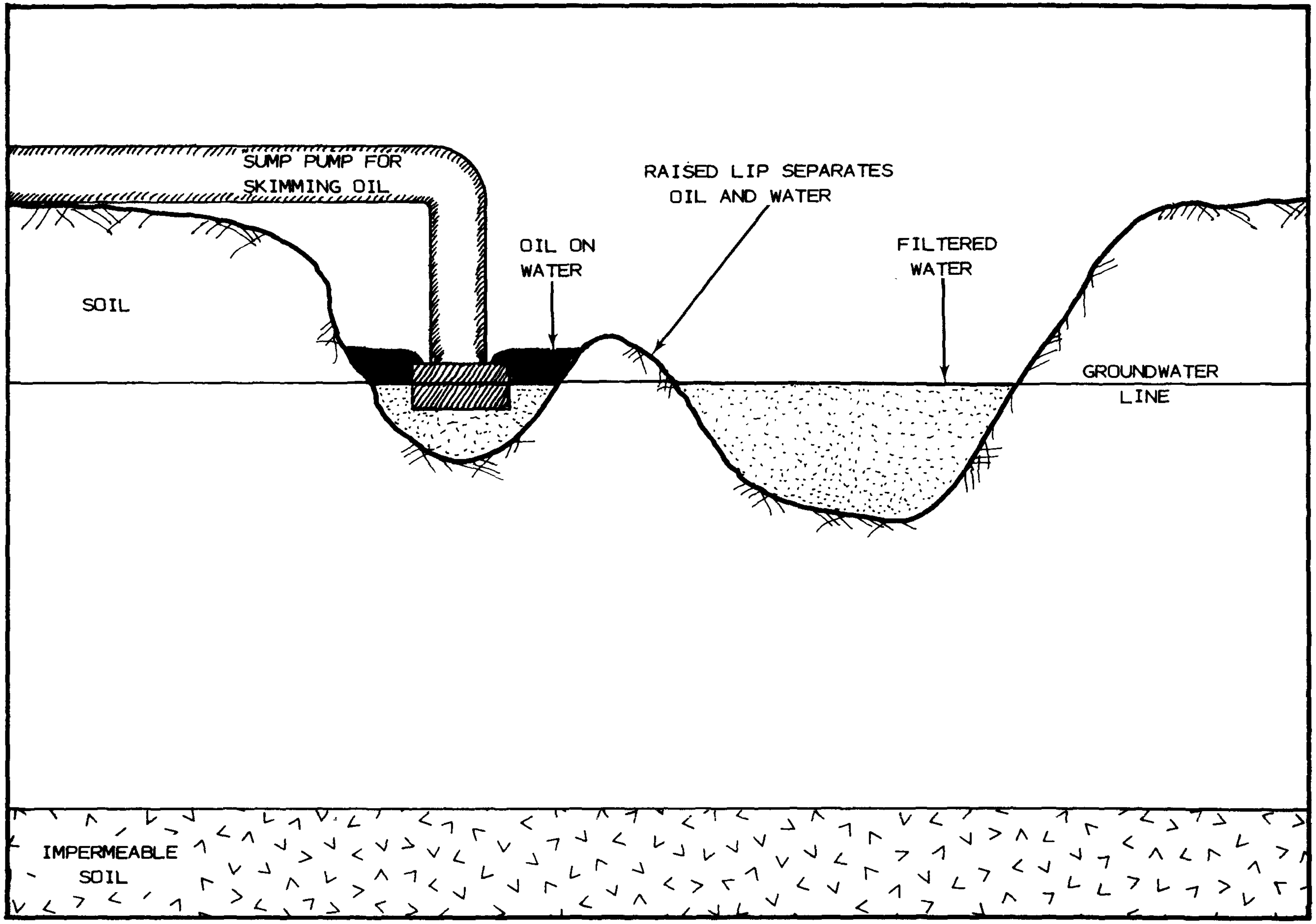

FIGURE 14. IMPROVISED FIELD SKIMMING DEVICES FOR SEPARATING OIL FROM WATER.

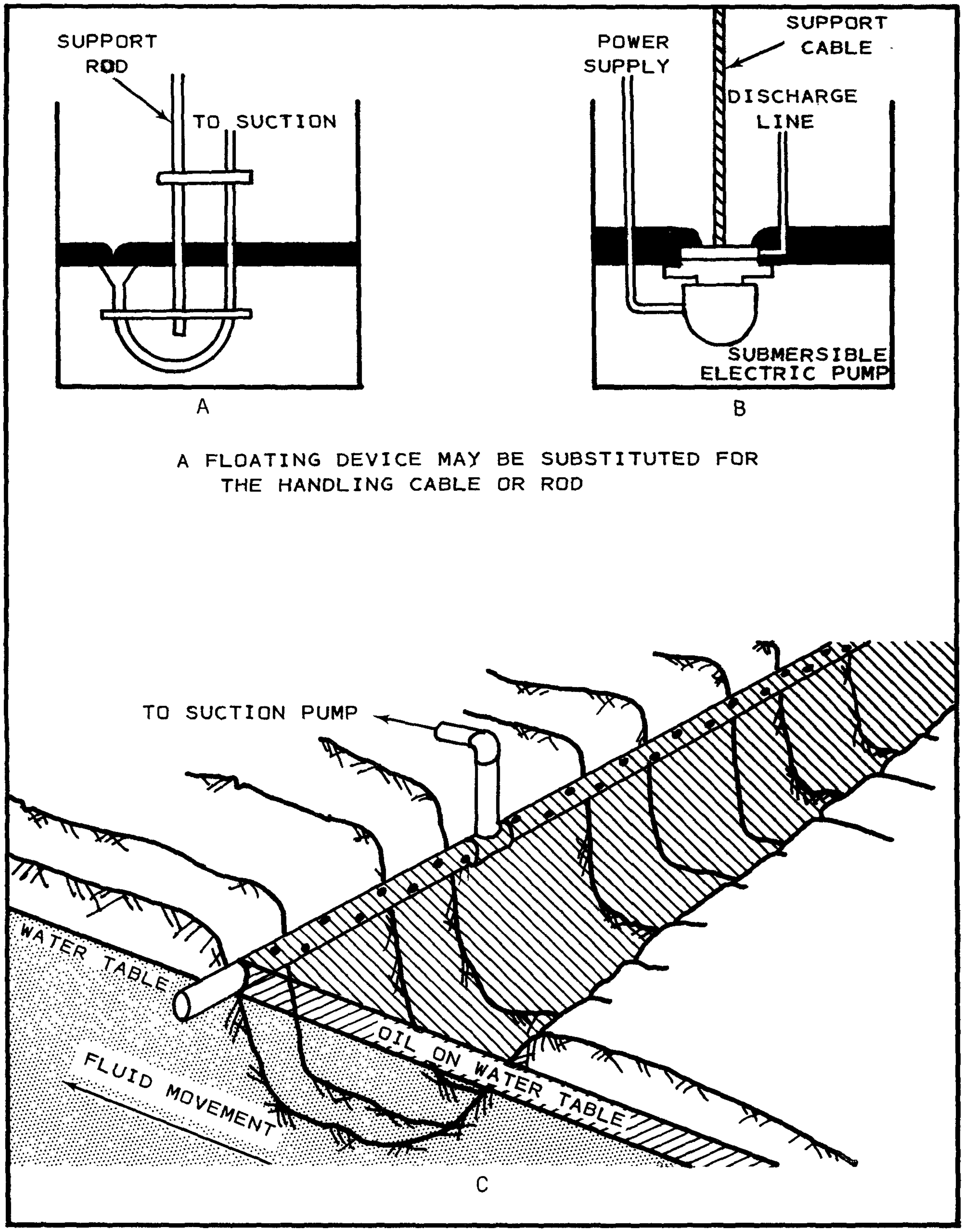

FIGURE 15. THREE SYSTEMS FOR SKIMMING WATER SURFACE IN DITCHES OR WELLS.

in the groundwater level. Pumping a short distance up gradient may lower the groundwater to a level no longer in contact with the filled material. Diversion channels may also provide a solution; such channels, lined with corrugated pipe, gravels, or screened PVC pipe, would transport water away from the fill, thereby preventing contamination. Peripheral subsurface drains to intercept groundwater flow offer a third alternative. These techniques are all intended to divert groundwater from the fill.

If, after implementing the remedial actions noted above, the monitoring system still indicates that groundwater pollution continues, more radical actions may be necessary. Excavation and removal of all oil spill debris from the offending site should be necessary only in the most extreme instances of groundwater contamination. Such measures would probably be needed only where inadequate site selection investigations failed to reveal the potential for contamination. The excavated debris could either be relocated or temporarily stockpiled until a low permeability soil can be installed in the disposal area.

SURFACE WATER CONTAMINATION

Surface runoff of oily materials from a disposal site presents another potential environmental hazard. Runoff can be impeded by the construction of dikes or berms to contain oily water within the site boundaries. Runoff could be recycled through the debris material if the groundwater is protected and if net annual evapotranspiration exceeds precipitation.

If contact between surface waters and oil spill debris is the source of contamination, replacement of cover soil at the points of contact is the most direct corrective measure. If erosion has caused the problem, a more thorough analysis and possible variation of soil type should be undertaken.

On-site surface waters are particularly undesirable in land cultivation operations, since cover soil is not utilized. Maintenance of upstream diversion trenches will reduce the flow of water into the area. Also, contour plowing (furrows ploughed perpendicular to dominant drainage patterns) will inhibit runoff from the land cultivation site. Collection of contaminated waters down gradient of the site offers a far less desirable alternative.

IMPEDED OIL DEGRADATION AT LAND CULTIVATION SITES

Impeded degradation of oil at land cultivation sites will prolong use of the site for disposal purposes and can present environmental problems such as readily available oil for surface runoff. More frequent tilling and discing, together with nutrient supplements, can accelerate the degradation rate of oil and thereby reduce the total time that the site poses an environmental pollution problem. Also, consideration may be given to seeding the land cultivation surface with commercially available, oil-degrading strains of bacteria.

OVERVIEW

The characteristics of any contamination problem at an oil spill debris disposal area will be site-specific; appropriate remedies naturally will have to be tailored to fit distinctive local features. If the above-noted remedial actions do not solve environmental problems, removal of the debris to another site will be the only means to positively curtail continuing pollution. Since removal and redeposition of the debris at another site would be very costly, it is best to confirm through an extensive monitoring program that the disposal site is actually the source of contamination before undertaking relocation of the debris.

The disposal of oil spill debris is a necessary part of oil spill cleanup programs. Until more detailed and in-depth knowledge of oily water disposal becomes available, use of the procedures presented here can aid in implementing proper disposal operations to ensure environmental protection.

Additional assistance and information on more recent developments may be obtained from your U.S. Environmental Protection Agency Regional personnel.

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APPENDICES

APPENDIX A

PRELIMINARY OUTLINE - OIL SPILL DEBRIS DISPOSAL TRAINING COURSE

I. Course Opening

   A. Introduce instructor(s) and course attendees

   B. Explain perceived need for course and course goals

   C. Distribute copies of manual

   D. Emphasize that questions and comments about personal experiences from course attendees should be encouraged by instructor.

II. Film

III. Description of Oil Spill Debris

   A. Chemical, physical, and handling characteristics

   B. Volumes expected/difficulties experienced in handling

IV. Instruction on Site and Method Selection

   A. Site selection criteria and their rationale

   B. Arrangements with site owner

   C. Selecting the method to match site conditions and debris characteristics

      1. Description of acceptable methods

         a. Land cultivation

         b. Landfilling

            (1) with refuse
            (2) alone

APPENDIX A (continued)

2. Discussion of site conditions and debris vs. methods applicable

V. Instruction on Site Preparation

A. Access roads, grading, facilities, etc.

B. Laying a liner, if required

1. Clay or soil additive

2. Artificial, e.g., plastic

C. Arrangements for equipment and qualified labor

VI. Instruction on Disposal Activities

A. Land cultivation

1. Land requirements

2. Personnel assignments

3. Equipment duties

4. Receipt of debris

5. Spreading techniques

6. Site cleanup

7. Requirements for subsequent rediscing.

8. Potential operational problems and suggested solutions

9. Guidelines for return of land to previous or other uses

10. Expected costs

B. Landfilling with refuse

1. Land/volume requirements

2. Locations for disposal

3. Equipment and personnel needs

APPENDIX A (continued)

4. Traffic control and unloading debris
5. Recommended filling procedures
6. Application of cover material
7. Cleanup/completion of disposal area
8. Potential problems and corresponding solutions
9. Expected costs

C. Landfilling without refuse or burying

1. Land requirements
2. Optional burying methods
3. Location of disposal area
4. Equipment and personnel needs
5. Receipt of debris
6. Filling methods
7. Covering methods
8. Site completion and cleanup
9. Potential problems and recommended solutions
10. Expected costs

VII. Instruction on Environmental Monitoring Procedures

A. Reasons for monitoring/potential environmental problems

B. Factors to be monitored

C. Monitoring techniques and rationale

D. Laboratory analyses of samples

VIII. Instruction on Correcting Detected Environmental Problems

APPENDIX A (continued)

IX. Overview and Course Conclusion

A. Solicitation of comments and questions from attendees

1. Comments based on personal experiences with oil spill debris disposal

2. Questions regarding practicality of suggested procedures

B. Refer attendees to Summary of Literature Review and complete bibliography for further related information

C. Request that attendees notify EPA of future oil spill debris disposal practices and problems encountered so that manual can be updated and improved

D. Course adjournment

APPENDIX B

EXAMPLE SITE SURVEY FORM

I. Site Background Information

____
(Disposal site name and address)

______________________ ______________________
City State Owner/Operator and Phone No.

______________________ ______________________
Investigator Date(s) of visit to site

Total site acreage ______________________________

Available on-site structures or facilities

Water	yes	no
Telephone	yes	no
Electricity	yes	no
Access Road	yes	no

Condition of on-site roads ________________________

____

Paved ______

Dirt ______

II. Geology

Any outcrops visible on site? yes no

Dominant geologic features on site? i.e., hill,

sink, depressions, etc. __________________________

____

Slope of land? 3^{o} ___ 5^{o} ___ 10^{o} ___ 15^{o} ___

APPENDIX B (continued)

On-site landslide or slippage potential ______________

____

____

Site geology: description of subsurface formations, depth to bedrock, etc. ______________________________

____

____

III. Soils

Permeability of on-site soils ________________________

Depth of soils _______________________________________

Soil horizons (i.e., sand 0-3', clay 3-10', etc.) ______

____

Sieve analysis results/soil classification ____________

____

IV. Hydrological Data

Groundwaters

Existence of aquifer beneath site? yes no

What kind? artesian _____

unconfined _____

Estimated depth to aquifer ___________________________

Quality of water - potable yes no

nonpotable yes no

Is nearby water used for -

irrigation yes no

drinking yes no

Direction of groundwater flow ______________________

Fluctuations in groundwater depth ____________________

Nearest wells using aquifer ______________________

Upgradient or downgradient of site ______________

Is site in either - discharge _____

recharge _____ area?

Are there on-site - springs? yes no

streams? yes no

ponds? yes no

lake? yes no

Surface Waters

Distance to nearby surface waters,

upgradient ____________________

downgradient __________________

Uses of these waters,

upgradient ____________________

____

downgradient __________________

____

V. Regional topographic description (rolling hills, flat, etc.) ____

____

Topographic category which best defines location

Upland flat __________________

APPENDIX B (continued)

Convex summit ____________

Ravine ____________

Valley side ____________

Terrace ____________

Does topographic expression lend to on-site flooding or ponding? ____________

VI. Land use

Previous use of land ____________

____

Present use of land ____________

____

Projected site use ____________

____

VII. Vegetation

Description of surrounding vegetation ____________

____

Description of on-site vegetation ____________

____

VIII. Climatological Data (Annual)

Evaporation data ____________

Transpiration data ____________

Rainfall ____________

Snow ____________

Temperature ____________

APPENDIX B (continued)

IX. Seismic Data

Presence of on-site fault ______________________________

Activity, if any, of fault ______________________________

X. Comments: ______________________________

____

____

____

INDEX

INDEX (continued)

TECHNICAL REPORT DATA
(Please read Instructions on the reverse before completing)

1. REPORT NO. EPA-600/2-77-153a	2.	3. RECIPIENT'S ACCESSION NO.
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15. SUPPLEMENTARY NOTES

A 15-minute color, 16 mm training film is also available.

16. ABSTRACT

This report was prepared to guide persons responsible for disposing of oil spill debris in selecting suitable methods and sites, and in carrying out effective, environmentally safe disposal operations.

Volume I is a procedures manual useful both in office and field. Topics covered include site selection and preparation, method selection, implementation of three alternative disposal methods, site monitoring requirements, and correctional measures for possible environmental problems. All available land disposal methods (other than systems employing incineration) were investigated prior to selecting the three recommended alternatives: land cultivation (also called landspreading), burial, and sanitary landfilling. An outline for a training course on oil spill debris disposal is also included.

Volume II presents a bibliography and a summary of the current literature relating to oily waste decomposition, migration through soils, and interaction with the environment. Calculations are provided to indicate the theoretical limitations on degradation. Case studies of two sites where the land cultivation disposal method was used to aerobically decompose the oily debris, and at two other sites where the debris was buried in specially constructed cells, are described and the effectiveness of each operation is evaluated.

17. KEY WORDS AND DOCUMENT ANALYSIS

a. DESCRIPTORS	b. IDENTIFIERS/OPEN ENDED TERMS	c. COSATI Field/Group
Waste disposal Refuse disposal Leaching Anaerobic processes	Biodegradation Oil spills Oil disposal Oil pollution Oil spill disposal Oil spill cleanup Disposal site monitoring	13B

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