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Spill Containment And Clean-up Course
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SPILL CONTAINMENT AND CLEAN-UP COURSE

Sector: Mining/Oil/Energy

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Reference Material

1989

Northwest Territories Renewable Resources
Pollution Control Division

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1.0 INTRODUCTION

1.1 PURPOSE AND SCOPE

This course manual for spill containment and clean-up has been prepared by the Government of the Northwest Territories -- Department of Renewable Resources. The Department of Renewable Resources has a mandate to monitor spill containment and clean-up activities in the Northwest Territories and to provide education and training programs aimed at achieving effective spill response and clean-up measures.

Due to the sparsity of the population and the diversity of activities in the Territories, a number of government agencies and industries can be called upon to provide direction and guidance in the event of a spill. In an effort to coordinate spill response, the Department of Indian Affairs and Northern Development maintains a 24-hour telephone line manned by staff with technical background and experience in spill procedures.

The purpose of this manual is to provide the technical and practical background needed for effective spill response in the Northwest Territories, recognizing the unique conditions that exist here.

Special conditions in the Northwest Territories dictate a unique approach to spill response. In particular, the severity and wide variations of climate, the sparsity of population and resource activities, and the pristine and sensitive nature of the environment require special consideration. In addition, the remoteness and wide separation of communities, and the problems associated with access and travel also provide unique factors that must be addressed in the development of spill response programs for the NWT.

The approach and content provided within this manual has been prepared with the following workshop participants in mind:

* Community based spill response personnel;
* Local municipal, regional, and territorial government officials;
* Barge and truck operators; and
* Government petroleum distribution contractors.

This manual provides the background needed for spill response by presenting information on the characteristics, properties and hazards of spilled materials, by providing suggested response, clean-up and site restoration actions, and by discussing the potential public health and environmental effects. Emphasis is directed to spills of petroleum products.

1.2 BACKGROUND

In recent years, mining and oil exploration activities, community growth, and construction have generated an increase in the transportation, storage and use of hazardous materials in the Territories. As a result, accidental spills of these materials have occurred. Their effects on the sensitive northern environment are of increasing concern. It is recognized that an effective program for preventing, responding to, and cleaning up such spills will minimize impacts to the environment and to public health.

Approaches to spill prevention and response may be found in several technical references; however, these in general, do not focus on the specific conditions in the Territories. Reference to northern conditions found in these documents has been extracted and forms a basis for the information presented in this manual.

The participant will learn to control spills of petroleum and other products by using available equipment and materials in a safe and effective manner.

This course has the following specific objectives:

1. Learn proper response procedures stressing personal and public safety*.

2. Practice spill control in the field on simulated problems.

3. Understand the behaviour of petroleum products under various conditions and the hazards associated with them.

4. Learn the importance of prevention and planning regarding potential problems.

5. Review and discuss case studies of spills that have occurred in the N.W.T.

2.0 SPILL EXPERIENCE IN THE NORTHWEST TERRITORIES

2.1 REPORTING REQUIREMENTS

The 24 hour spill report line is a telephone line dedicated for reporting spills or potential spills to government departments in the Northwest Territories. **All spills or potential spills of hazardous materials must be reported through the (403) 920-8130 telephone number.** Having a single point of contact for notifying government simplifies the reporting of spills and ensures that a coordinated investigation is undertaken by the appropriate government agency.

The Department of Renewable Resources maintains computer stored statistics on reported spills. To provide a focus for the content and approach of this manual, statistics on spills reported during the period of 1981 -- 1988, which have occurred in the Northwest Territories are summarized in this section.

2.2 STATISTICS ON PREVIOUS SPILLS

2.2.1 Material Types

The majority of hazardous materials spilled in the Northwest Territories are petroleum products. Petroleum products account for 84% of spills; chemicals 4%, wastewater including mine and mill tailings and sewage 9% and drilling muds 1%. Spills by material types and number of spills reported for the period of 1981 -- 1988 are presented in Figure 1.

Inspection of Figure 1 shows that the predominance of petroleum product spills are of fuel oil. Fuel oil accounts for 58% of the spills of petroleum products. 2% of petroleum product spills involve gasolines, unrefined crude oils, lubricating oils, waste oils and others. A total of 4.9 million litres of petroleum was spilled during the period of 1981 - 1988. Approximately 70% of these spills were on land and 30% involved either marine or fresh water.

NOTE Further discussion of spill statistics in this manual shall include spills of petroleum products only.

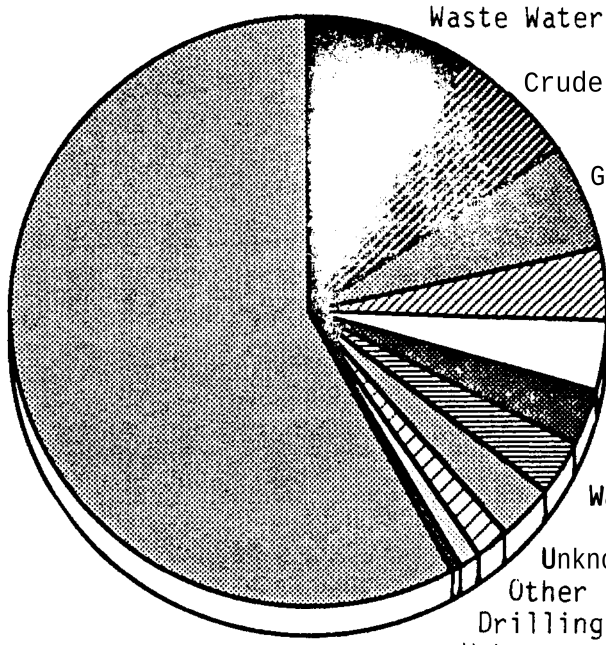
2.2.2 Spills By Location

The majority of petroleum product spills occur in the Fort Smith and Inuvik Regions. Fort Smith Region accounted for 34% and Inuvik Region for 39% of reported spills of petroleum products during the period 1981 -- 1988. Spills

FIGURE 1

HAZARDOUS MATERIALS SPILLS IN THE N.W.T.

BY THE NUMBER OF SPILLS REPORTED 1981 - 1988



Commodity	Number of Spills	% of Spills
Fuel Oil (heating, diesel,aviation)	538	58
Crude Oil	62	7
Gasoline	51	6
Other Oil (hydraulic, bunker, asphalt)	39	4
Waste Oil (slops, sludge)	30	3
Unknown Oil	28	3
Lubricating Oil	23	3
Sub-Total - Petroleum Products	771	84
Waste Water (mine/mill tailings, sewage)	86	9
Chemicals (PCB's, pesticides, acids, ferric sulphate, sodium fluoride, zinc bromide)	36	4
Other	14	2
Drilling Muds	10	1
Unknown	3	<1
Total	920	10(J

in the Inuvik Region are due primarily to the intensive petroleum exploration activities in the Beaufort Sea and the production and transportation of petroleum and petroleum products in Norman Wells. Spills in the Fort Smith Region are largely associated with bulk transportation of fuel on highways and spills associated with barge transport and unloading operations. The Baffin Region accounts for 11% of reported spills of petroleum products, Keewatin Region 8% and Kitikmeot Region 8%. All regions experience spills associated with the supply and storage of fuel in communities.

2.2.3 Spills By Facility Type And Transportation Mode

Spills by facility type and transportation mode for the period 1981 - 1988 are presented in Figure 2. Transportation between and vehicle distribution within communities accounts for 30% of reported spills. The means of transportation from which spills occur, in order of decreasing frequency, are trucks, marine vessels, aircraft, other means of transportation and trains. Stationary storage tanks account for 30% of reported spills and pipelines, including hoses, 22%. When one assumes that the majority of pipelines are associated with stationary storage tanks, the largest proportion of reported spills occur at fuel storage facilities.

2.2.4 Spills By Parties Responsible

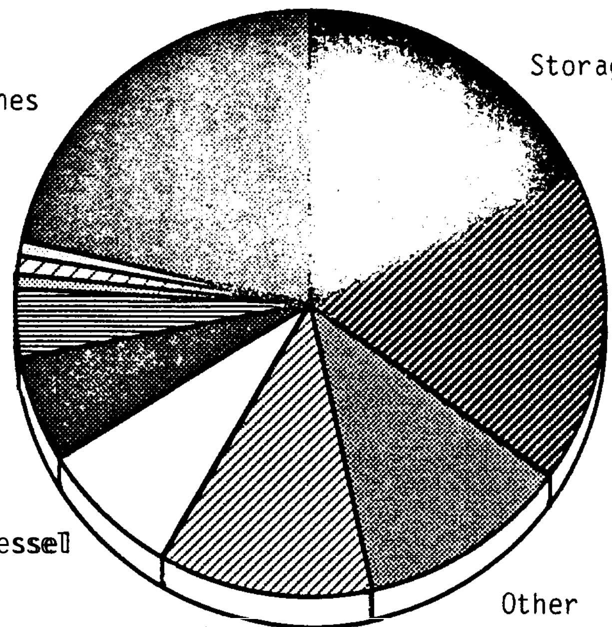
Figure 3 presents reported spills by sectors of the economy. As previously discussed in section 2.2.3 the transportation industry accounts for 23-30% of reported spills of petroleum products. Petroleum companies whether in the exploration, refining, or storage phases of operation account for 24% of reported spills. The various levels of government account for 24% of reported spills; Territorial Government and its contractors and Federal Crown Corporations formerly including NCPC account for 10% and 7% of the total spills respectively because of their involvement in fuel storage for community heating and energy requirements. Mining companies account for 11% of reported spills as all companies maintain fuel storage facilities at their sites.

2.2.5 Spills By Contributing Factors And Type Of Failure

Spills of petroleum products maybe dueto the failure of a component containing the product, failure of the entire vessel or vehicle, human error, climatic factors, intentional acts of vandalism or acts of God. Evaluation of contributing factors and types of failures for spills reported during the period 1981 - 1988 is represented in Figure 4.

FIGURE 2

PETROLEUM PRODUCT SPILLS IN THE N.W.T.
BY FACILITY TYPE AND TRANSPORTATION MODE 1981 -1988

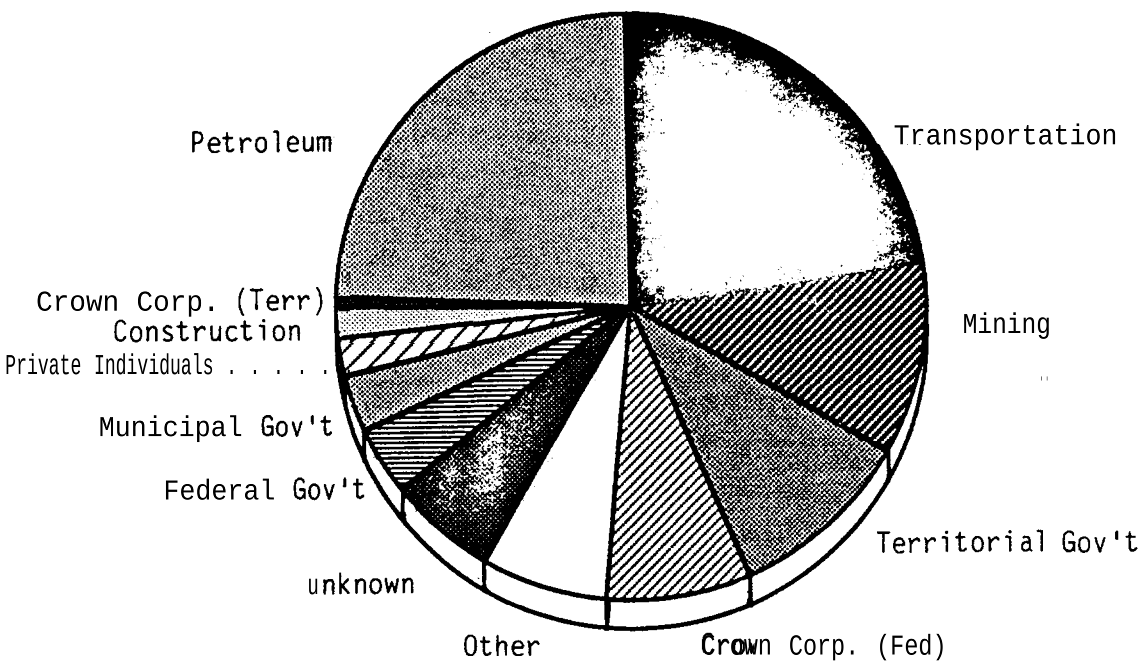


Source	Number of Spills	% of Spills
Pipelines (pipes, hoses, nozzles)	204	22
Storage Tanks - bulk (>4000 litres)	169	18
Storage Tanks - day tanks (<4000 litres)	108	12
Sub-Total - Storage Tanks	277	30
Truck (tankers, drums on trucks)	163	18
Marine Vessels (barges, drums on vessels)	69	8
Aircraft (drums/tanks on aircraft)	35	4
Rail Train	2	<1
Other (cat trains)	1	<1
Sub-Total - Transportation	270	30
Other (oil wells, sewage lagoons, tailings ponds)	109	12
Unknown	55	6
Natural Seepage (Norman Wells area)	5	<1
Total	920	100

Human error and failure of materials and equipment account for 25% and 34% of reported spills respectively. The failure of materials and equipment can, however, sometimes be a result of human error -- ie. not conducting regular maintenance inspections. Stricter adherence to recognized fuel transfer procedures, regular maintenance and inspections and training of operators can result in fewer spills attributed to human error and failure of materials and equipment. Climatic factors account for 7% of reported spills and vandalism 3%. Three percent of all spills were intentional.

FIGURE 3

PETROLEUM PRODUCT SPILLS IN THE N.W.T.
BY SECTORS OF THE ECONOMY 1981 - 1988

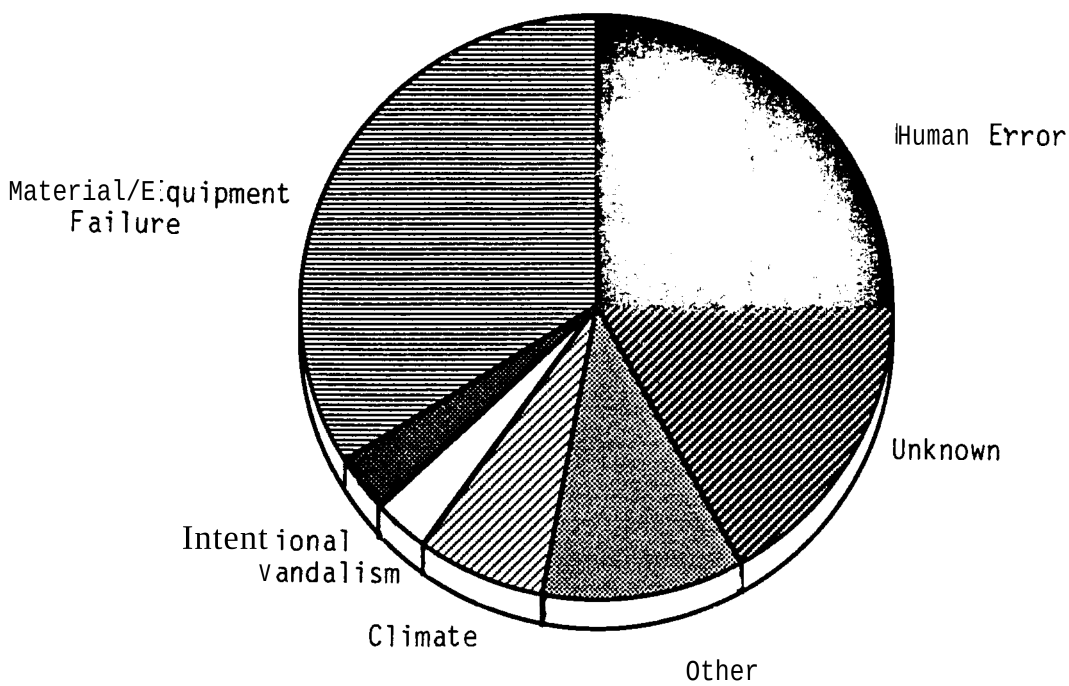


Sector	Number of Spills		% of Spills	
Petroleum (commercial bulk fuel storage, oil explore/refine facilities)		222		24
Transportation (transport, loading/offloading)		211		23
Mining		104		11
Territorial Gov't (DPW, POL contractors)	96		10	
Federal Crown Corporations (NCPC)	54		7	
Federal Gov't (DND, MOT, INAC)	33		4	
Municipal Gov't	32		3	
Territorial Crown Corporations (NWTPC)	5		≤1	
Sub- total - Government		220		24
Other (community Co-ops, contractors)		68		8
Unknown		53		6
Private Individuals		22		2
Construction		20		2
Total		920		100

FIGURE 4

PETROLEUM PRODUCT SPILLS IN THE N.W.T.

BY CONTRIBUTING FACTORS AND TYPE OF FAILURE 1981 - 1988



Factor	Number of Spills	% of Spills
Materials and Equipment Failure (weld/ joint failure, corrosion)	254	34
Human Error	173	25
Unknown	155	17
Other (power failures, tanks falling over, lines hit by vehicles)	105	11
Climatic factors (storm, fire, flood)	64	7
Vandalism	26	3
Intentional	25	3
Total	920	100

3.0 PROPERTIES AND CHARACTERISTICS

3.1 OIL CHARACTERISTICS AND BEHAVIOUR

3.1.1 Characteristics

Crude oil and its refined products are complex mixtures of hydrocarbons (compounds composed of hydrogen and carbon only) and nonhydrocarbons (compounds containing small amounts of sulphur, oxygen, and nitrogen compounds as well as other trace elements). Refined products are derived through processes called catalytic cracking and fractional distillation. The resultant products possess different physical and chemical properties which will determine how they will move if they are spilled, how they will affect organisms, including man, and how fast they will degrade or disappear from the environment. Several key definitions follow.

Specific Gravity

Specific gravity (S.G.) is defined as the ratio of the mass of a substance to the mass of an equal volume of water. The specific gravity of water is 1.0, while most oils are less than 1.0 (which means they will float).

Generally, oils with low specific gravities have low viscosities (see definition below), low adhesion properties, and emulsify with water easily. Oils with high specific gravities have high viscosities, high adhesion properties and limited tendencies to emulsify.

Viscosity

Viscosity is a measure of a fluid’s resistance to flow. The greater the viscosity, the less readily it flows. Gasoline has a low viscosity and bunker oil has a high viscosity. Oils become less viscous with increasing temperature or more viscous with decreasing temperature. Low viscosity oils tendto form emulsions readily. Viscosity will determine the rate of spreading of a slick, its penetration into the ground and the ability of pumps to remove oil from the surface.

Volatilitv

The volatility is a qualitative measure of the tendency of a solid or liquid to pass into the vapour state. Generally, low carbon number hydrocarbons (methane, ethane, etc.) are extremely volatile and quickly pass into the gaseous state (volatilize) when exposed to the air. Gasoline contains a high proportion of volatile compounds. Bunker fuels contain limited volatiles because they are removed during the refining process.

Flash Point

Flash point is the lowest temperature at which a particular oil will ignite, that is, the flash point is an indication of the oil's volatility. Gasoline has a flash point of less than-40 C; most arctic crude oils will ignite, but the flash points are high. Diesel oil is difficult to ignite but will burn readily once the flash point is reached. Bunker and heavy fuel oils are difficult to ignite at ordinary atmospheric temperatures.

Volubility

The volubility of a substance indicates its tendency to dissolve in a solvent, commonly water. Low volubility is typical of many petroleum products. However, compounds within each product exhibit some volubility. This has a bearing on the toxicity of the particular product to aquatic organisms. Miscibility is the degree to which a substance is capable of mixing with water without separating into two phases. Gasoline is not miscible in water.

The following table (Table 1) compares the previously discussed parameters for several petroleum products. Note in this table that in going from gasoline to #6 fuel oil, that specific gravity, flash point and viscosity increase corresponding to the greater fraction of heavier hydrocarbons within the product.

TABLE 1

COMPARISONS OF PHYSICAL CHARACTERISTICS OF CRUDE OILS AND SOME REFINED PETROLEUM PRODUCTS

	Specific Gravity (15 c)	Viscosity cs units	Flash Point (c)
Crude Oil	0.8-0.95	20-1000	Variable
Gasoline	0.65-0.75	0.5-1	-40
Kerosene	0.80	2-5	55
#1 Fuel Oil (furnace, stove, diesel)	0.807	2-4	46
#2 Fuel Oil (furnace, stove, diesel)	0.840	10-15	53
#4 Fuel Oil (plant, heating)	0.9	50	60
#5 Fuel Oil (Bunker B)	0.95	100	65
#6 Fuel Oil (Bunker C)	0.98	300-3000	80

3.1.2 Movement on Land

Introduction

Several factors influence the extent and rate of movement of oil on land. These include the type of oil product spilled, its viscosity, pour point and temperature. Other equally important factors include the presence of snow, types of soils, vegetation and season of the year.

Snow

The nature of the snow cover is dependent upon terrain conditions. In forested areas, such as the taiga, the snow may be quite light, fluffy and deep, whereas on the tundra, wind action may compact the snow and make it hard and dense. This will affect the penetration of spilled oil.

Snow is a very effective absorbent for oil having the ability to contain more than 50% oil by volume, depending upon the nature of the snow. Light, fluffy snow will absorb more oil than will hard, dense snow. Hard, dense snow can also act as an effective physical barrier; therefore it should be used whenever possible for dyking and containing oil spills.

Oil can also flow for considerable distances under snow cover without being seen from above.

Soils and Vegetation

The movementof oil through soils and rocks is complex and largely unpredictable. The topography will determine the direction of oil flow and the shape of the spill. Movement downward will depend on the type of overlying soil, vegetation and the presence of impervious layers of clay or permafrost.

Soils and rocks consist of small fragments or grains, which, when compacted together, form small openings or pores. Interconnected pores allow a material to be permeable to fluids such as oil and water. Clay, silt or shale have very small pores which are not extensively interconnected and act as barriers to oil movement. In the treeless tundra, the mineral soil is overlain by 20 to 30 cm of organic detritus such as mosses, sedges, and lichens. In the taiga, the organic detritus layer may be 30 to 100 cm deep. Mineral soils generally have a very high absorptive capacity for oil, especially in the late summer when the frost level and water table are low.

The organic mat overlying the permafrost in the tundra and taiga regions has a high insulating value and any modification to its thermal properties by oil may cause an increase in thaw depth, possibly leading to thermocarst conditions.. The tree canopy in the taiga forest reduces the solar radiation reaching the ground. If this canopy is destroyed by oil spreading or burning, a significant increase in the active layer depth may result. Care in clean-up and protection methods must be taken to ensure that this overlying vegetative mat is not disturbed and that the use of heavy machinery is limited. Thermocarst problems may be more environmentally damaging than the oil itself.

The extent of vertical oil penetration will be controlled by the absorptive capacity of the ground. Table 2 presents some rough estimates of absorptive capacities for various soils. The absolute values are less important than the relative differences. Note that the finer the soil, the greater the absorptive capacity; the exception being clay and shale which will absorb very little. Tundra will typically absorb 60 L/m* of crude oil.

TABLE 2

ABSORPTIVE CAPACITY OF VARIOUS SOILS AND VEGETATIONS

Soil Texture	Oil Absorptive Capacity (l/m^3)
Stone -- coarse gravel	5
Gravel -- coarse sand	8
Coarse -- medium sand	15
Medium -- fine sand	25
Fine sand -- silt	40

(Modified from Deslauriers et al., 1982)

Low viscosity oils will produce the fastest rate and greatest depth of penetration into the soil. In seasonally frozen soil or permafrost, the rate of oil penetration will be very slow and will proceed only through melting caused by the oil as it spreads over the frozen soil. Many soils in the Northwest Territories permit fast water movement. This means oil spilled in such areas would be difficult to contain.

If the amount of product spilled is not large, or the water table is low, the oil will be absorbed during its descent, and will leave behind a trail of relatively immobile material in a roughly vertical column. Rainfall may cause further downward movement of the oil and leach out water soluble components. If the main body of the liquid slug reaches the water table, there could be significant pollution. The rate of downward movement depends primarily on product spilled and the permeability of the soil layers. Figure 5 illustrates possible shapes of oil spreading.

Viscous fuel oils and some crudes will not penetrate the soil to a great depth and the rate of movement is slow. Movement of the slug will continue until it is either absorbed by the soil (or tundra), is stopped by an impermeable layer (clay, permafrost), or it reaches the ground water (Figure 6). The spilled oil

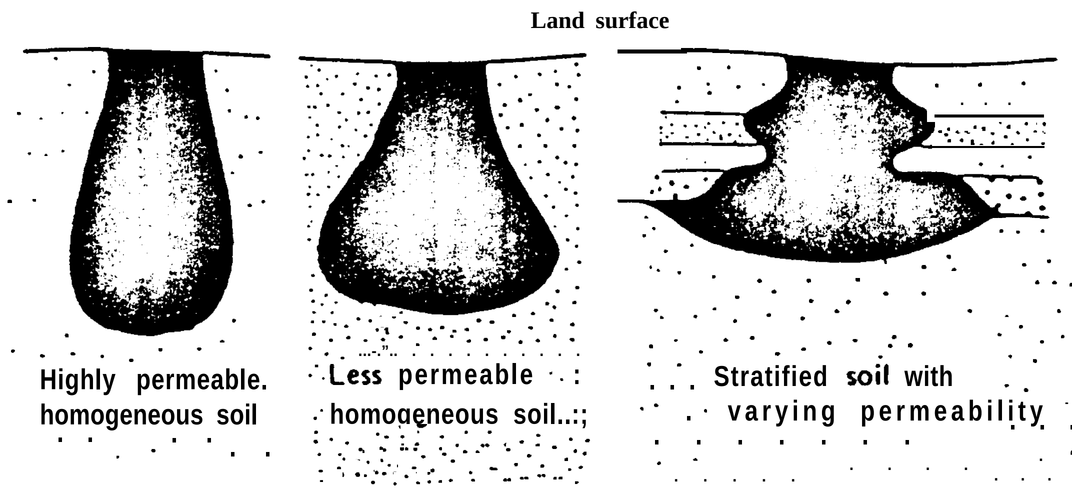


FIGURE 5
THEORETICAL CONTAMINANT SPREADING CONES
(Basic 1983)

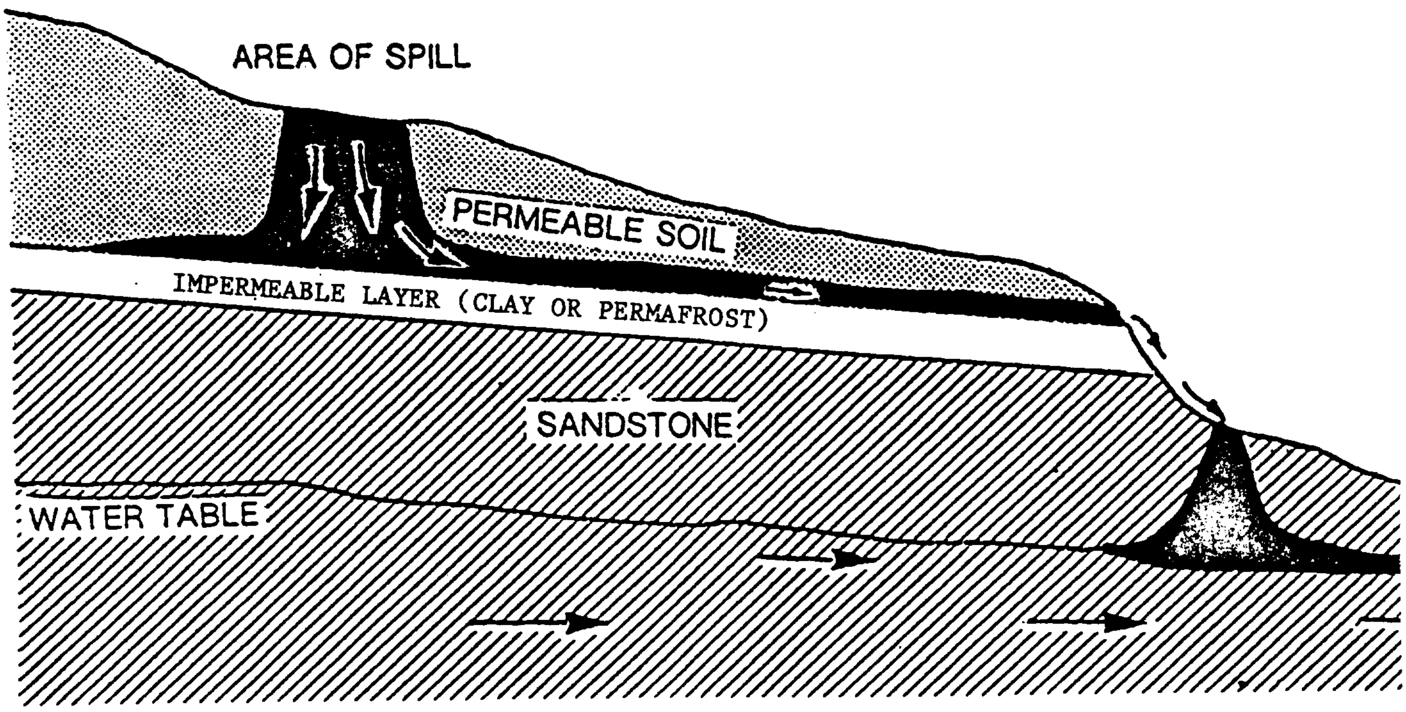


FIGURE 6
POSSIBLE PATH OF CONTAMINATION MIGRATION
(Basic, 1983)

may move along the top of the permafrost layer until it finds its lowest level, but it will not sink into the permafrost layer as long as the soil is completely saturated (dry frozen soils can be penetrated by oil whose temperature is above the pour point).

The shape and spreading rates of the oil slug will vary with subsoil variations and time. Forty to seventy percent (40 - 70%) of the final spread extent can be reached within 24 hours of the spill; 60 - 90% in one week. Spreadingcan continue for long periods especially if the product reaches groundwater. This may lead to chronic contamination of groundwater supplies and may eventually result in pollution of surface waters.

3.1.3 Movement on Water/Ice

Oil on Water

Oils spilled on water will spread rapidly. The behaviour of the slick formed will depend on the type of oil spilled, the temperature, wind velocity, waves and current. Its persistence will be governed by the same factors which affect the weathering of the oil. Table 3 relates surface water appearance to the approximate quantity of oil per km^2. This is very approximate and depends on temperature, water quality, type and age of the oil.

Water-in-oil (chocolate mousse) or oil-in-water emulsions may form and create additional clean-up problems by increasing the volume of material to be recovered. These emulsions can also be difficult to pump.

Oil on or Under Ice

Oil spilled onto ice will spread laterally depending upon ice surface irregularities and viscosity of the oil. The presence of pores and fractures in the ice and oil viscosity will dictate vertical movement through or into the ice block. The rate of absorption of solar energy and hence the rate of ice melting can be increased by the presence of oil in or on the ice surface. This ice melting may eventually cause oil trapped in ice to migrate to the surface of melt water, making it available for recovery. (Figure 7).

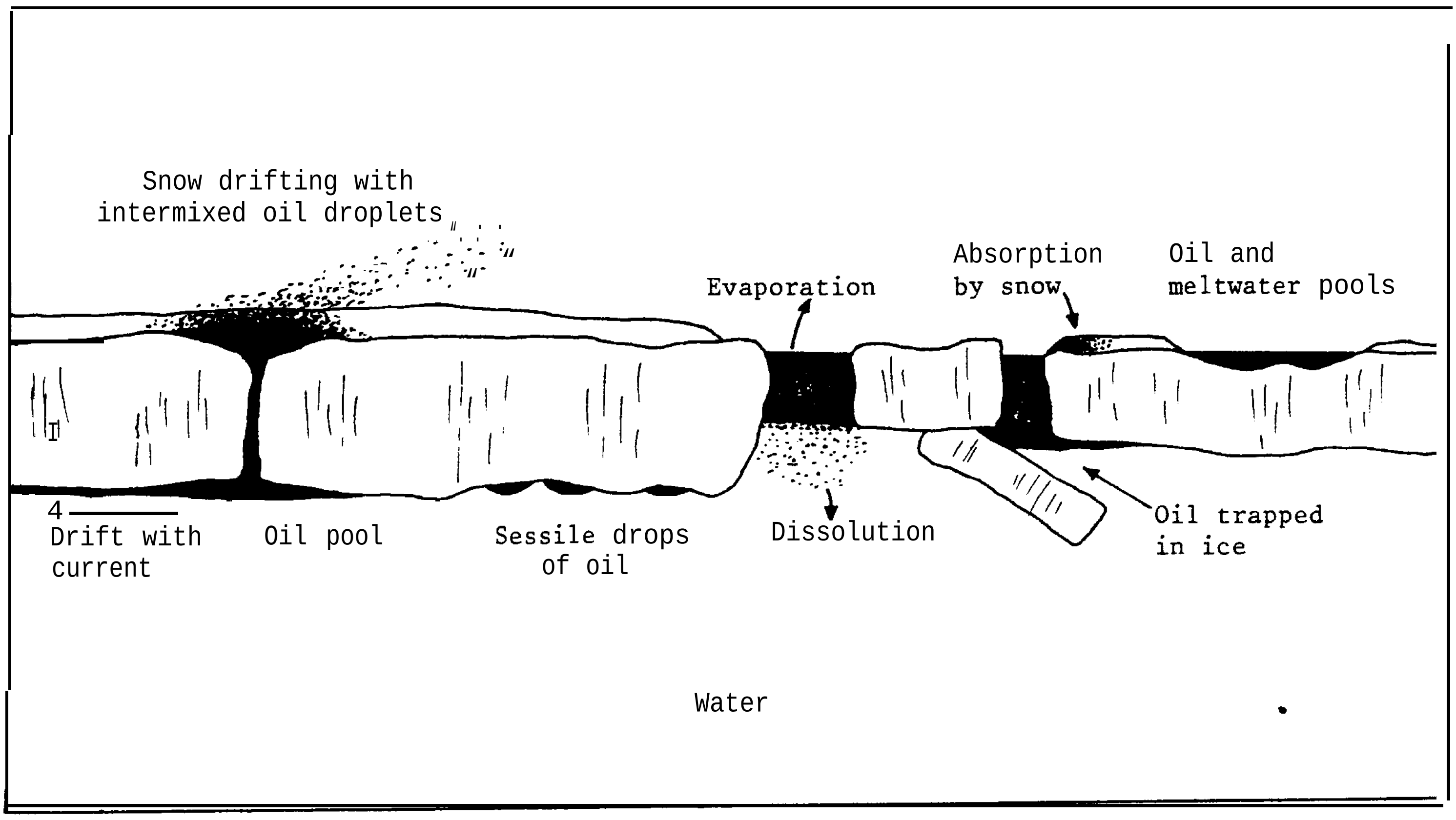


FIGURE 7

BEHAVIOUR AND FATE OF OIL IN HATER

TABLE 3
SURFACE WATER APPEARANCE

Approximate Quantity of Oil		Appearance
Gallons/ sq.mile	Litres/ km^2	
25	45	Barely visible under very good light conditions
50	90	A visible silvery sheen on the water surface
100	180	First traces of colour are observable
200	360	Bright bands of colour
665	1165	Colours becoming dull
1330	2330	Colours are much darker

3.1.4 Seasons and Oil Movement

Spills in the winter present the least problems; snow is present to absorb the oil and frozen ground prevents downward movement. Frozen conditions can provide a solid base for heavy equipment operation while protecting the fragile active layer.

Spring is the worst season for an oil spill because the oil is prevented from being absorbed into the water-logged ground and is forced to flow over a wide area, assisted by flowing melt water. The spilled product can be quickly carried away and climatic conditions make it difficult to contain. As in the summer, heavy equipment and excessive manpower must be avoided on the active layer.

In summer the soil's active layer is characterized by a steadily increasing depth of thawed soil. The thaw depth reaches its maximum by late August or early September. In the event of an oil spill in summer, the oil will flow over the terrain, flowing downhill over the surface and penetrating downward into the soil until it reaches groundwater, an impervious layer of clay or rock, the frost level or permafrost.

Figure 8 illustrates predicted spill areas occupied by spilled oil during the different seasons. Too many factors make the absolute values unreliable; it is the relative differences between seasons that is of consequence.

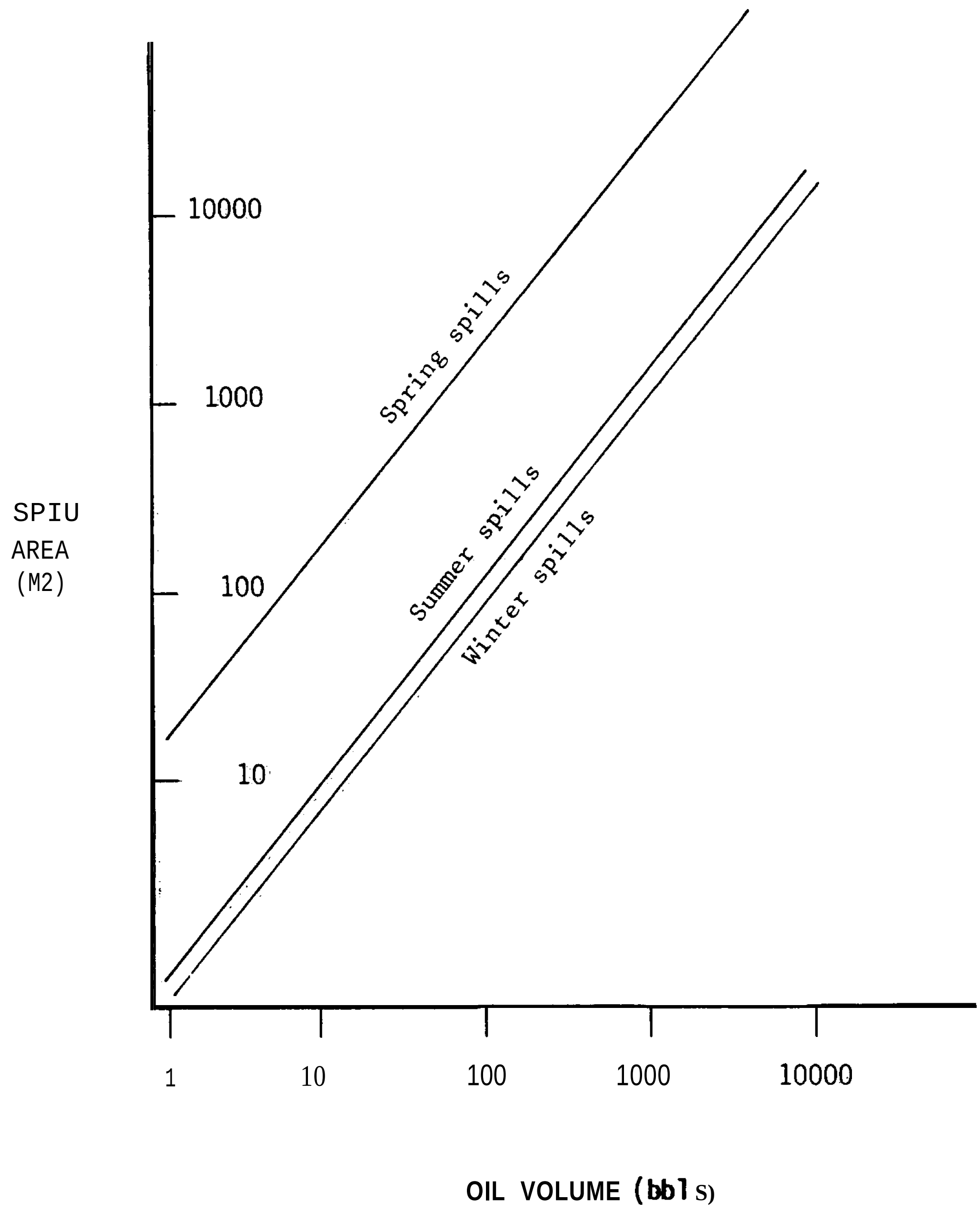


FIGURE 8
PREDICTED OIL SPILL AREAS

3.1.5 Weathering

Weathering describes the ultimate fate of spilled oil in the environment. Weathering induces a progressive series of changes in physical and chemical proper ties of the oil, and begins as soon as the oil has been spilled. The rate of weathering depends on the various factors involved which include: evaporation, dissolution, oxidation, microbial degradation and emulsification. These are all natural processes and depend on site conditions and the type of oil spilled. Light crudes and gasolines weather faster than heavy crudes or fuel oils. This is mainly because light oils have a higher proportion of volatile fractions and thus a higher rate of evaporation.

Evaporation

The rate of evaporation of an oil is influenced by its temperature, water turbulence, wind and oil spill spreadingor surface area exposed. The lighter components in the oil are generally more volatile and will evaporate faster than heavier components. As evaporation proceeds less volitive components remain. The remaining fraction - a residue - is more viscous and has a higher specific gravity than the original oil. This residue may become so dense that it may sink in water, but this usually only occurs when other materials such as clay or silt are present to allow the residue to adhere to them.

Crude oil may lose 25% of its total volume within one day; Nos. 2, 4 and 6 fuel oils may lose 13%, 3% and 2% of their total volume at 23 C in 40 hours, respectively. Gasoline may lose 50% of its original volume within 7 -8 minutes at 20 C. Generally, the more volatile an oil, the greater the fire hazard.

Oxidation

Oxidation is a term used to describe the chemical combination of oxygen with hydrocarbons. Oxidation occurs at an air-oil interface and therefore will proceed more quickly when the oil is spread out. Oxidation is a slow process in comparison to other weathering processes.

Biodegradation

Several species of bacteria, fungi and yeasts oxidize hydrocarbons by using these compounds as food energy. These organisms are generally found everywhere, but are more common in areas of chronic oil spills.

The rate of biodegradation is highly dependent on temperature, decreasing with lower temperatures. Consequently, under freezing temperatures, biodegradation is extremely slow.

Biodegradation is the principle upon which land cultivation of oil and oil debris is based. Spills left unrecovered will eventually become reduced through biodegradation.

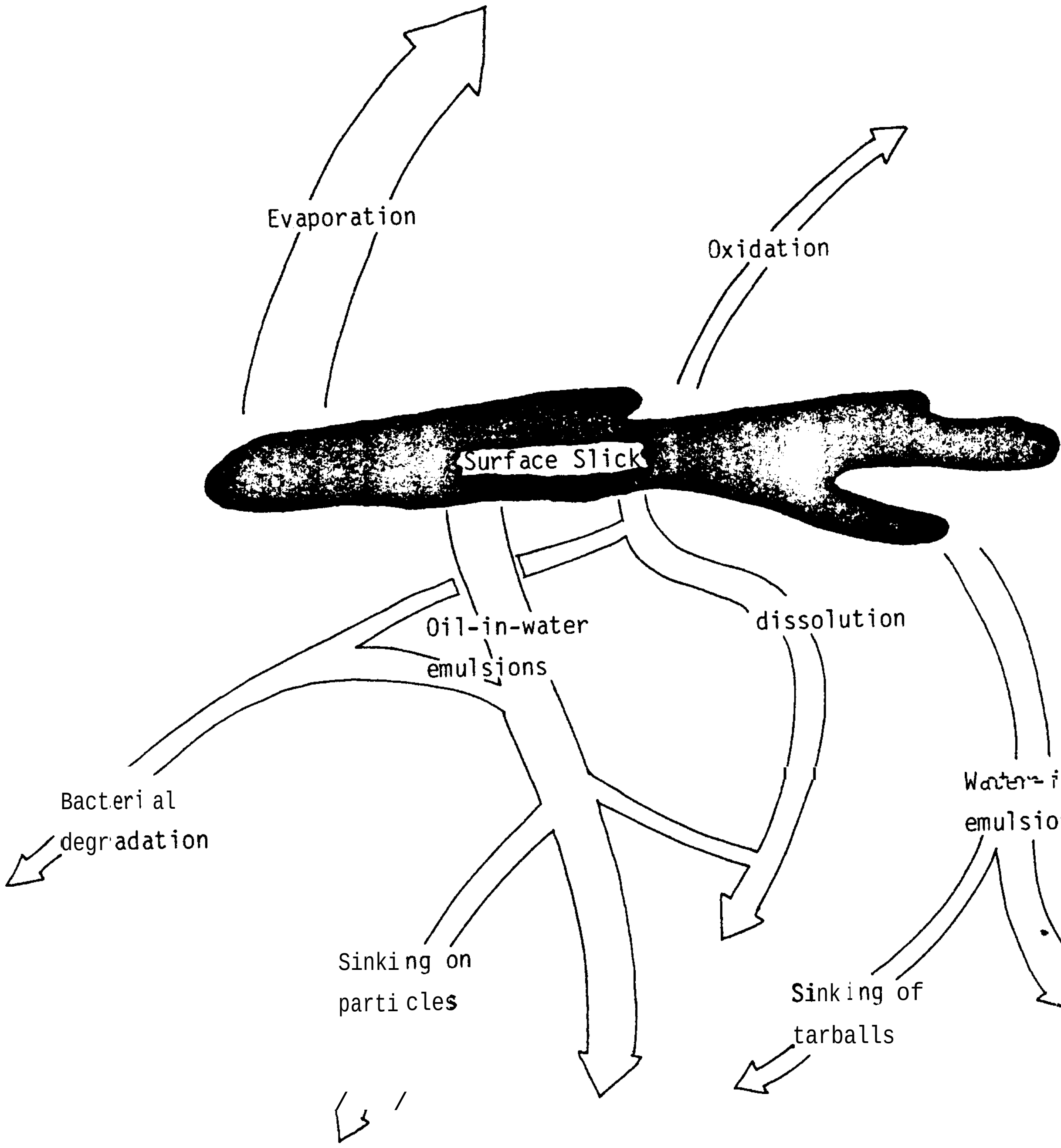
Emulsification

This term describes the mixture of one liquid in another. An emulsion is not one mixture dissolved in another; it is a mixture of small droplets - often microscopic. With respect to oil, two types of emulsions can occur, an oil-in-water emulsion or a water-in-oil emulsion. Either type of emulsion can persist for months or years. Stable emulsions refer to those emulsions that persist.

"Chocolate mousse" is a water-in-oil emulsion. It is brown in color and greaselike in consistency. It can form from wind and wave action. Further weathering of these emulsions may be very slow because the surface area open to chemical and biological reactions is relatively small.

Dissolution

Soluble hydrocarbons and nonhydrocarbons in oil will dissolve in water through the process of dissolution. Most hydrocarbons have limited volubility, but several sulphur, nitrogen and oxygen compounds present in oil (nonhydrocarbons) exhibit significant solubilities. Oxidation and microbial degradation of oil also tend to produce water soluble compounds.



Chemical and bacterial degradation on bottom

FIGURE 9

MAJOR PROCESSES BY WHICH OIL IS WEATHERED

4.0 RESPONSIBILITY FOR CLEAN-UP AND RELEVANT LEGISLATION

4.1 RESPONSIBILITY

4.1.1 Responsibility of-the Polluter

The responsibility for the costs of response and clean-up to ensure environmental protection lies with the owner or controller of the product spilled. This responsibility includes the provision of all personnel, equipment and resources for response clean-up, disposal and site restoration.

The owner or controller is also responsible for reporting all spills to the 24-hour spill-report line. Informing government agencies in this manner ensures that both the polluter's and the government's legislative responsibilities are fulfilled and that c-lean-up proceeds in an environmentally sound manner.

4.1.2 Government Responsibilities

Government works under the principle that the owneror controller bears the primary responsibility for spill response and clean-up actions. Government agencies are responsible for initiating an evaluation of the spill event and monitoring of the clean-up activities to ensure protection of people, property and the environment and for- providing technical advice on clean-up where required.

Active, government participation in spill clean-up is not provided as a service for those responsible for the spill. It may be provided, however, under the following conditions:

a) the party responsible does not respond,
b) the party responsible does not have the available resources for immediate response, or
c) the actions being taken are not adequate to ensure public safety and environmental protection.

If government undertakes these actions, reasonable costs for use of government staff and resources are recovered from the party responsible by normal billing methods or, if necessary, by legal actions.

The primary responsibility of government is to enforce its own legislation pertaining to environmental authorities.

4.2 RELEVANT LEGISLATION

Legislation relating to spill response and clean-up in the Northwest Territories may be enforced through various Acts and regulations. Both the Federal and Territorial governments have legislation relating to oil and hazardous material spills.

The government agencies most frequently involved in spill response in the Northwest Territories are:

* Department of Renewable Resources, Government of the Northwest Territories

* Indian and Northern Affairs Canada

* Environmental Protection Service, Environment Canada

Less frequent spills involving radioactive materials, atmospheric emissions of hazardous materials orspil ls which threaten community and public health may require involvement by other government agencies.

Legislation applicable to spill response and clean-up is summarized in Table 4.

4.3 JURISDICTIONAL RESPONSIBILITY

In order to provide a clear understanding of which government agency has the lead role in spill response for specific situations and to avoid jurisdictional overlap, a working agreement has been reached (NAP, 1985) and is summarized in Table 5.

TABLE 4
LEGISLATION TO SUPPORT GOVERNMENT RESPONSE TO SPILLS

GOVERNMENT AGENCY	LEGISLATIVE AUTHORITY
Government. of the Northwest Territories	Environmental Protection Act Transportation of Dangerous Goods Act Commissioner's Land Act Pesticide Act
Indian and Northern Affairs Canada.	Northern Inland. Waters Act and Regulations Arctic Waters Pollution Prevention Act and Regulations Territorial Lands Act and Land Use Regulations Public Lands Grants Act and Regulations Department of Indian Affairs and Northern Development Act
Environmental Protection Service, Enviro.nment. Canada	Fisheries Act, Section 33 Ocean Dumping Control Act
Canada Oil & Gas Lands Administration	Canada Oil and Gas Act Canada Oil and Gas Drilling Regulations
Department. of Transport	Canada Shipping Act and Oil Pollution Prevention Regulations Navigable Waters Protection Act
Atomic Energy Control Board	Atomic Energy Control Act
EmergencyPlanning Canada	
Department of National' Health and Welfare	Public Health Act

TABLE 5

JURISDICTIONAL RESPONSIBILITY FOR GOVERNMENT RESPONSE TO SPILLS IN THE N.W.T.

SPILL INCIDENT	LEAD AGENCY
1. Spills on Territorial Land[1]	INAC (Indian and Northern Affairs Canada)
Except:	
a) Spills at Federal Facilities[2] not permitted under Federal or Territorial legislation.	EPS (Environment Canada)
b) Spills at oil and gas exploration and production facilities which affect the integrity or safety of the operation.	COGLA (Canadian Oil and Gas Lands Administration)
c) Spills in National Parks.	EPS
2. Spills on Commissioner's Land[3] (i.e. Territorial Highways[4], communities)	GNWT (Government of the N.W.T.)
Except:	
a) Spills at Federal Facilities not permitted under Federal or Territorial legislation.	EPS
b) Spills at oil and gas exploration and production facilities which affect the integrityor safetyof the operation.	COGLA
c) Spills at facilities permitted under Federal legislation.	INAC
3. Spills on Water[5]	INAC
Except:	
a) Spills at Federal Facilities not permitted under Federal or Territorial legislation.	EPS
b) Spills at oil and gas exploration and production facilities which affect the integrityor safetyof the operation.	COGLA
c) Spills from ships.	CCG (Canadian Coast Guard)

TABLE 5 (continued)

FOOTNOTES:

1) Territorial Land means lands in the Northwest Territories that are vested in the Crown or of which the Government of Canada has power to dispose.

2) Federal Facilities means any facility such as DEW Line Stations, High Arctic Weather Stations, -Research Centres and-Research Ships, operated directly or indirectly by the following agents of the Crown.
   a) Department of Communications;
   b) Department of Fisheries and Oceans;
   c) Department of Indian Affairs and Northern Development
   d) Environment.Canada
   e) Energy, Mines and Resources;
   f) National Health and Welfare;
   g) Department of National Defence;
   h) Transport Canada;
   i) Department of Public Works;
   j) Department of Justice (RCMP)
   k) Canada Post.;
   1) Crown Corporations, such as CN, CBC, CMHC, Petro Canada, Freshwater Fish Marketing Corp and-formerly NCPC and NorthwesTel.

3) Commissioner':s L-and means 'lands in the Northwest Territories transferred by Order-in Council-to the Government of the Northwest Territories.

---9 4) Territorial -highways include #1 -- #8, access roads and land portions of winter roads-that do not require a federal permit; eg. Jean Marie River, Lac La Martre, and Norman Wells.

5) Water means inland and arctic waters as defined in the Northern Inland Waters Act and Arctic Waters-Pollution Prevention Act. In cases where a spill on land enters water, the lead government response shall remain with the agency with responsibility for land spills.

5.0 SPILL RESPONSE

Spill response consists of a series of steps which are meant to allow the clean up of the spilled product without endangering people, property or the environment. The steps which should be taken when responding to a spill are:

a) identify the product spilled;

b) assess the dangers and hazards associated with the spill;

c) stop the flow at the source, if safe to do so;

d) take actions to contain the spilled product;

e) report the spill to the 24 hour spill report line; and

f) clean up the spill.

5.1 SPILL PRODUCT IDENTIFICATION

An immediate identification of the material spilled is required upon arrival at the spill site. Identification provides a basis for making assessments of the dangers and hazards to the environment, the public and response personnel.

In the majority of cases, identification of the spilled product is made immediately through information received from the driver or captain, through familiarity with storage facilities, or from local knowledge of material uses. In the event that immediate identification is not possible the following procedures should be followed. These procedures should also be used to confirm the identity of known materials.

Placards and Product Identification Numbers

Transport Canada's Training Section - Transportation of Dangerous Goods has developed a consistent and uniform approach for product identification. Nine classes of dangerous goods are defined and are uniquely identified by placards and product identification numbers (PIN) mounted on the containers or vessels in which the materials are shipped or stored.

Shipping Documents

One or more of the following documents may be available in the vehicle or at the shipper's office:

1) Hazard Information Emergency Response Forms;
2) Air Waybills and Manifests; or
3) Manifests required under the Transportation of Dangerous Goods Act.

Location and Container/Vessel Type

The majority of spills in the Northwest Territories are petroleum products. These products are commonly transported by barge or truck in bulk or in 45 gallon drums. The routes, schedules and container or vessel types for these products are often known through local knowledge and familiarity.

For stationary sources, location of the source may provide for identification of the product.

IF THE PRODUCT CANNOT BE IDENTIFIED, ASSUME THAT THE MATERIAL IS DANGEROUS. Do NOT ATTEMPT TO IDENTIFY BY SMELLING OR TOUCHING THE MATERIAL.

5.2 ASSESSMENT OF DANGERS AND HAZARDS

The assessment of the type of material spilled and the magnitude and conditions of the spill provides a basis for identifying the hazards and the dangers inherent in controlling the spill. These assessments will be critical in preventing loss of life and personal injury, in ensuring public safety, and developing a plan for approaching the spill site. The identification of hazards and dangers associated with controlling and handling hazardous materials are discussed in Appendix 6.

Personal protection and safety are of utmost importance in approaching the spill site. These are outlined in Appendix A.

5.3 SECURE THE SOURCE

Once the product has been identified and the dangers and hazards to the response team and the public have been assessed, further risk may be minimized by preventing additional loss of material. If the entire contents are already lost, the immediate action is to contain the spill on site.

Time is of critical importance in securing a leaking source. The response team should be prepared, upon arrival on site, to quickly assess the situation and be prepared with the necessary tools and equipment to secure the source.

5.3.1 Specific Actions for Securing the Source

The reasons and causes of spills in the Northwest Territories are discussed in Section 2. Human error is a significant factor for many of the spills reported.

The first assessment to be made in proceeding to secure the source is to identify the leak. Potential routes of leakage are:

* open valves;
* overflow;
* orifice leak, (puncture, rupture); or
* vessel failure (fire, explosion).

General procedures for securing the source for various natures of leaks or failures are given in Table 6.

TABLE 6
PROCEDURES FOR SECURING THE SPILL SOURCE

NATURE OF LEAK/FAILURE	SUGGESTED ACTION
Discharge from tank due to overflow	1. Stop flow into tank by closing supply valves or pump. 2. If overflow is from fuel expansion, remove some fuel from the tank lay transferring to another vessel.
Discharge from tank due to open valve or pipe.	1. Close valve upstream from discharge point. 2. If no valve is present, transfer contents to another vessel.
Discharge due to orifice leak	1. Transfer contents to another vessel. 2. Patch utilizing techniques described in Figure 6. 3. If leak is from a small vessel (ie. barrel), realign to have level of liquid below leak point.

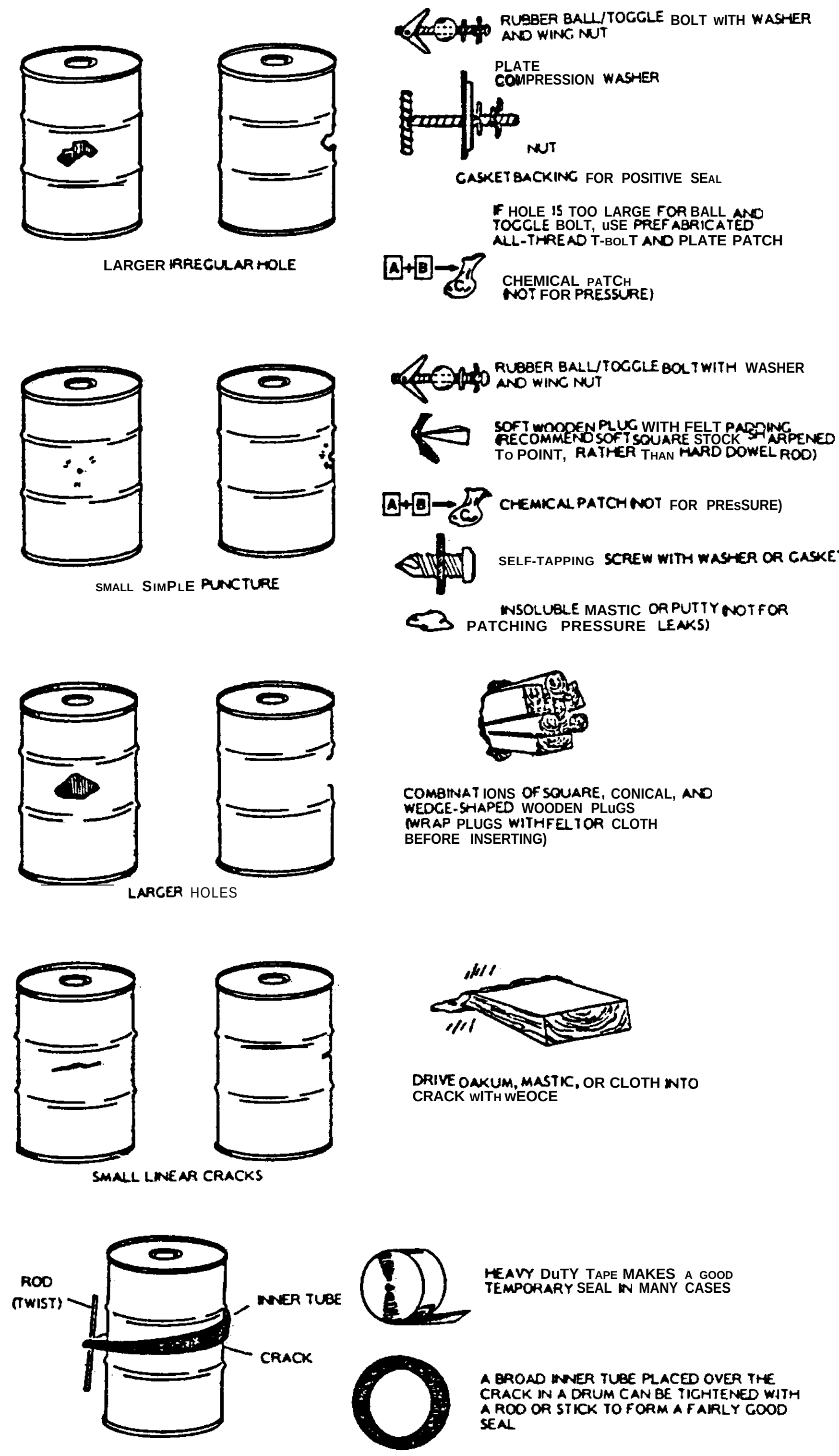


FIGURE 10

TECHNIQUES FOR PATCHING AND STABILIZING LEAKING CONTAINERS

5.4 SPILL REPORTING

In the Northwest Territories, all spills of petroleum products and other hazardous materials must be reported. A telephone line dedicated for this service is maintained in Yel lowknife and is known as the

24-HOUR SPILL REPORT LINE: (403) 920-8130

This telephone line was initiated jointly by Indian and Northern Affairs (INAC) and the Government of the Northwest Territories (GNWT) in 1979. The Water Resources Divisionof INACmaintains the telephone services and GNWT provides for the printing and supply of spill report forms.

The purposes of reporting a spill through this telephone service are:

1. To provide a uniform and consistent approach to spill response in the Northwest Territories.

2. To assist field personnel in responding to the spill, in undertaking proper site assessments, and in identifying recovery and disposal methods.

3. To elicit technical backup from personnel in various government agencies in the Territories and from specialized firms and organizations in Canada.

4. To dispatch (when needed) personnel and equipment to the spill site.

5. To provide technical information on material properties, response and site restoration procedures, as required.

6. To monitor the progress of response and clean-up actions.

7. To provide a central clearing house or command post for progress of spill response actions.

5.4.1 Reporting Procedures and Information Needs

The reporting of spills in the Northwest Territories requires the reporting of specific information on spills of oils and other hazardous materials. A spill report form is available for these purposes and a sample copy is provided in Figure 11. Spill report forms are available from the Government of the Northwest Territories, Department of Renewable Resources. The procedure for reporting is:

1. Fill out spill report form as completely as possible before contacting the 24 hour spill report line. If incomplete information is available., the spill line should be contacted regardless.

2. Report immediately to the 24 hour report line (403)920-8130. Collect telephone calls can be made by informing the operator that you wish to report a spill.

3. Where telex is available, follow up immediately by sending a telex copyof the spill report: Telex 034-45623.

4. RCMP or Renewable Resources communications may be used if other means are not available.

The information specifically needed when reporting a spill is:

a) Report Date and Time of Spill
The written report should be prepared as soon as possible after the spill event to ensure completeness.. Reporting the time of spill will determine the measures and approaches which may be used for response; the greater the period of time the less that can be done to contain and control the spilled material.

b) Location and Map Coordinates (if known) and Direction of Spill Movement
Be specific and accurate. The potential for the spill discharging to water should be reported.

c) Party Responsible
The party who allowed or caused the spill to occur, be it industry, a government agency or a member of the public. If available the operations supervisor's name should be reported.

d) Product Identification and Quantity Spilled
The material should be positively identified. If the material is not known, assistance should be requested. An estimate of the spill quantity should be made. Identification of container type (tank truck, barge, etc.) will assist in providing an estimate of the magnitude of the spill. Product names should be reported correctly, ensure correct spelling.

e) Cause of Spill
Identify the general incident category (truck overturn, barge grounding, tank overfill, pipeline rupture, etc.) causing the spill.

f) Spill Terminated or Continuing

Is the spilled material continuing to leak from the source? If spill is of a continuing nature, assistance can be provided to identify options for securing the source.

g) Extent of Contaminated Area

Estimate the land or water area covered by the spill. This will assist in determining the potential environmental effects and types of measures needed to contain the spill.

h) Factors Affecting Spill Recovery

Factors such as manpower and equipment availability, temperature, wind, snow, ice, terrain, buildings, etc. will require consideration when undertaking an effective spill response program.

i) Containment Measures

Is containment by natural or artificial means? Provide information on how the spill has been contained so that assessments maybe made regarding the need for further actions.

j) Response Actions to Date

Provides information on the actions that have already taken place to contain, recover, clean-up or dispose of spill material.

k) Request for Assistance

Provides information on additional manpower and equipment needs, fire response, medical aid, safety equipment requirements, etc.

1) Hazards and Dangers

Potential hazards and dangers must be identified so that emergency measures may be taken or public warnings made.

m) Comments and Recommendations

Provides for additional comments and information not given in other sections.

"Reported by:"

Self-explanatory

"Reported to:"

Usually the person manning the 24 hour spill report line.

Northwest Territories

SPILL REPORT

(Oil, Gas or Other Materials, i.e. Hazardous Chemicals, etc.)

24-Hour Report Line
Phone (403) 920.s130

A	Report Date	Date and Time of Spill if Known
B	Location and Map Coordinates (if known) and Direction if Moving	
C	Party Responsible	
D	Product Spilled and Estimated Quantities (Provide Metric Volumes/Weights if Possible)	
E	Cause of Spill	
F	Is Spill Terminated or Continuing	
G	Extent of Contaminated Area	
H	Factors Affecting Spill or Recovery Temperature, Wind, Snow, Ice, Terrain, Buildings, etc	
I	Containment - Naturally, Booms, Dykes or Other, No Containment	
J	Action, If any, Taken or Proposed to Contain, Recover, Clean-up or Dispose	
K	Do You Require Assistance	If so, What Form
L	Hazard to Persons or Property or Environment Fire. Drinking Water, Threat to Fish or Wildlife	
M	Comments and/or Recommendations	

Reported by	Position, Employer, Location	Telephone
Reported to	Position, Employer, Location	Telephone

FIGURE 11

SPILL REPORT FORM

5.4.2 Follow-up Reporting

During or following actions taken to clean-up a spilled material, follow-up reports should be phoned to the 24-hour spill report line outlining any new information which becomes available. The" spill report form should be used to sup ply the follow-up information; supply new information only. Notify the 24-hour spill report line when clean-up has been completed.

5.5 CONTAINMENT

5.5.1 Containment To Minimize Clean-Up Operations

Prompt and effective containment of spill movement is necessary to reduce spill clean-up and site restoration work and to minimize potential environmental and public health risks.

Containment measures may be broadly categorized into two groups: land based and water based. The options available make use of a wide range of materials including straw, chicken wire, and snow fencing to commercial sorbents and booms.

Effective containment will result from prompt action, selection of proper methods, advance planning (prior to spill occurrence) and proper use of equipment.

5.5.2 Land Containment Methods

Land spills are generally more easily dealt with than spills that have reached a waterway. Efforts should be made to prevent or stop spilled product from entering water.

Land containment of spills is generally achieved by minor earthworks such as trenches and earth dams or dykes. Under northern conditions, where earth is frozen for most of the year, snow can be used for temporary containment and can also be used as a sorbent material.

Trenches

Trenches may be used to intercept and hold all types of hazardous materials but are practical only under summer conditions. In areas of continuous permafrost, the depth of excavation will be limited by the depth of the active layer. In the northern arctic, the thaw depth by the end of summer is about 0.5 - 1.0 metres while in the southern arctic it ranges from 1.0 - 2.0 metres. When water is present in excavated trenches, it should be assumed that contamination will result and will eventually discharge to surface waters. A synthetic membrane liner may be placed on the bottom and sides of the trench. For petroleum products water flooding will separate spilled material from the bottom of the trench and will assist in material recovery.

Trenches may be effective in intercepting subsurface flows (as shown in Figure 12). Under arctic conditions, the flow of contaminants below the ground surface will generally be limited to a 1 - 2 metre depth. Relatively shallow trenches strategically placed downslope of the spill will be effective in intercepting both surface and subsurface migration of spilled materials. This method is effective in preventing subsurface contamination of water and eventual discharge to streams and other water bodies.

The use of this approach may result in permafrost degradation and thermocarsting. Subsequent erosion may complicate site rehabilitation measures.

The materials and equipment needed for trench construction are:

* backhoe, loader, dozer
* shovels, picks
* synthetic membrane liners

Dams/Dykes for Impoundment

Earth or snow dams constructed across ditches or swales may be used to contain a spill and stop its flow. The entire flow of the spilled material and any surface drainage may then be contained.

Construction materials which can be used include earth, wood, sandbags, and snow. The dam or dyke should be lined with plastic sheeting to make it impermeable to the spilled product. In the winter, water may be sprayed on snow dams or dykes forming ice to make it impermeable.

The dam dimensions and location must take into account the volume of material to be retained. Deep ditches or swales require narrow dams. Care should be taken to ensure that dam configuration is adequate to contain the entire spill volume. Insufficient capacity may result in overtopping and failure.

Dams and Weirs for Impoundment and Separation

For ditches or swales with flowing water or for small streams, it may be necessary to allow water flow to continue and to retain the lighter-than-water liquids. These methods apply only to spills of petroleum products which readily separate from water.

Water bypass or underflow dams may be constructed on small, slow flowing ditches or streams. An earth dyke is constructed stopping the flow of water and spilled products in the ditch. Water is then allowed to continue down the ditch by piping water from below the level of the hazardous liquid as shown in figure 10. It should be noted that the pipe is inclined to prevent the spilled liquid from dropping too far and discharging through the piping. The discharge end should not be inclined above the level of the dam since overtopping and failure will result.

Weirs may be effectively and easily used in ditches and at culverts. Materials commonly used such as plywood, lumber and sheet metal may be placed to completely or partially block culvert entrances. These barriers may be suspended from stakes on either side of culvert openings and raised or lowered to maintain the desired water level while retaining the oil. For fast flowing streams, oil can be entrained in the water and then flow under the weir. Figure 11 illustrates the useof weirs.

Recovery of material collecting behind dams and weirs may be made with the use of solvents, skimmers, or by direct suction. Containment and recovery operations must be monitored to ensure that the system's capacity to retain contained material is not exceeded. Special attention should to be given to positioning the weirs culverts as leakage is a potential problem.

5.5.3 Water Containment Measures

Water containment measures generally include the use of booms or barriers. Unless the entire flow of contaminated water can be stopped by damming, these methods are limited to the containment and recovery of materials that will readily separate from and float on water. For materials which will readily mix with water, efforts should be directed at stopping the material from entering water, ensuring public health and safety (i.e. protection of water intakes, prevention of explosion and fire, etc.), taking quick action in stopping the release at the source, and monitoring the progress and effects of these materials on the environment.

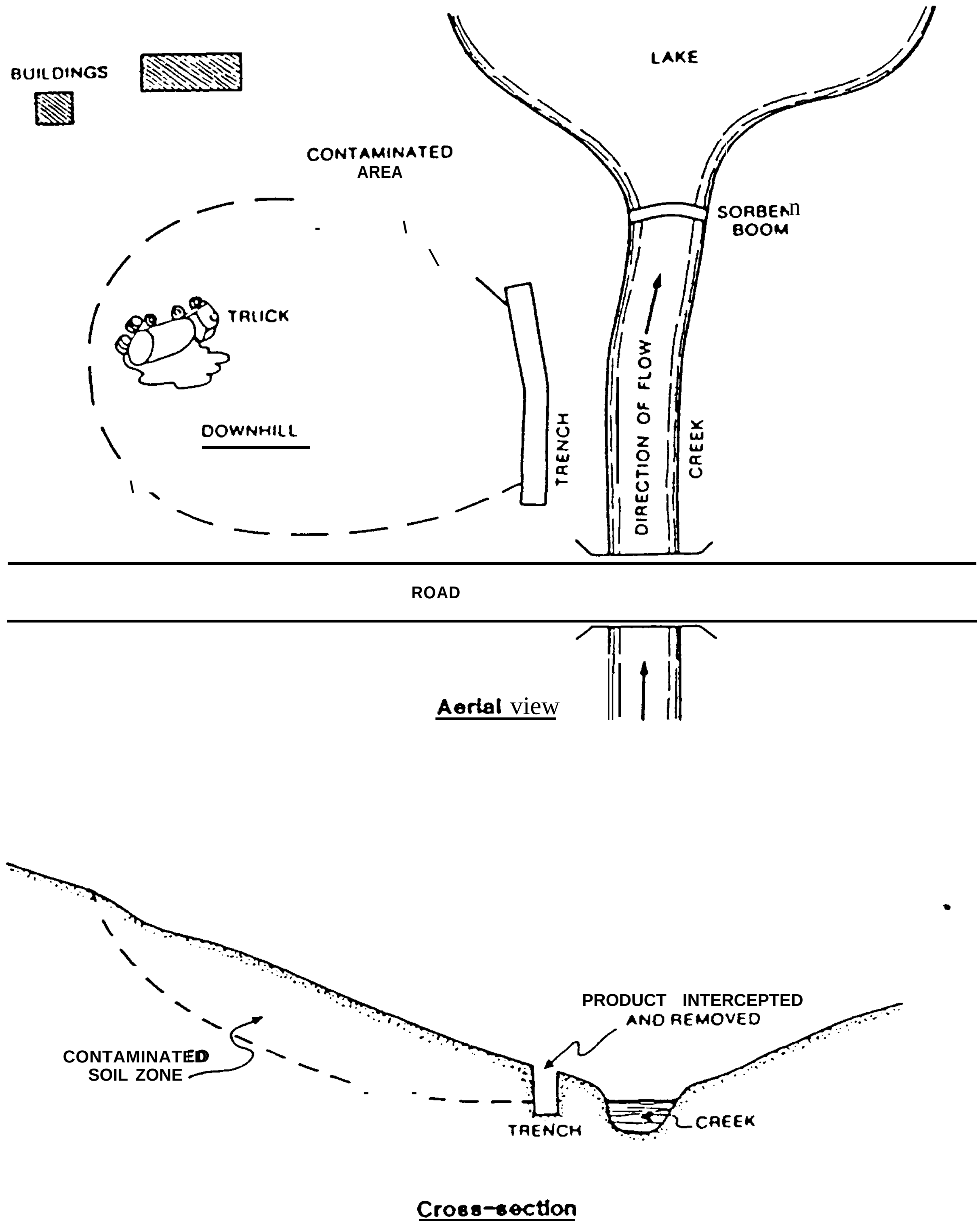


FIGURE 12

TRENCHES TO INTERCEPT OVERLAND/SUBSURFACE FLOW
(DILLON, 1983)

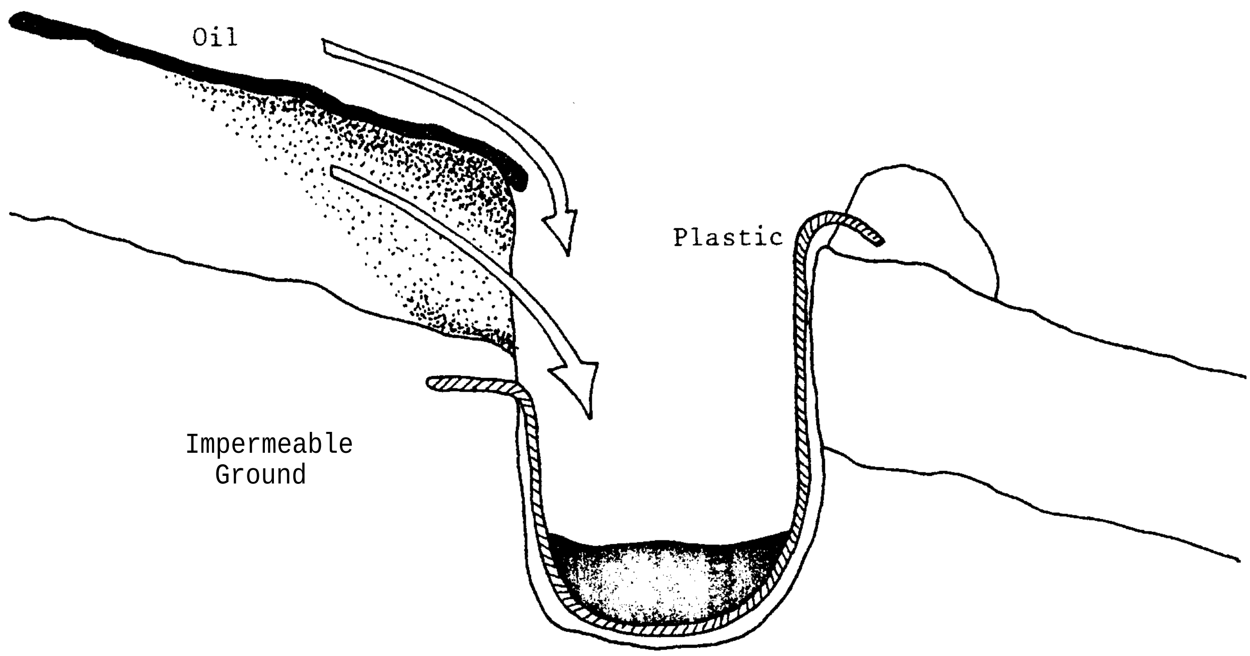


FIGURE 13

DETAIL OF INTERCEPTOR TRENCH

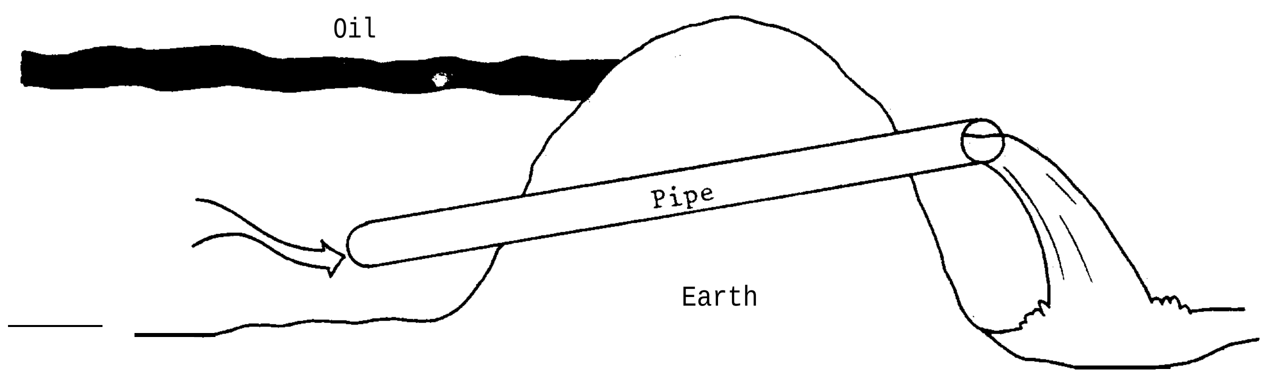


FIGURE 14

WATER BYPASS [UNDERFLOW) DAM

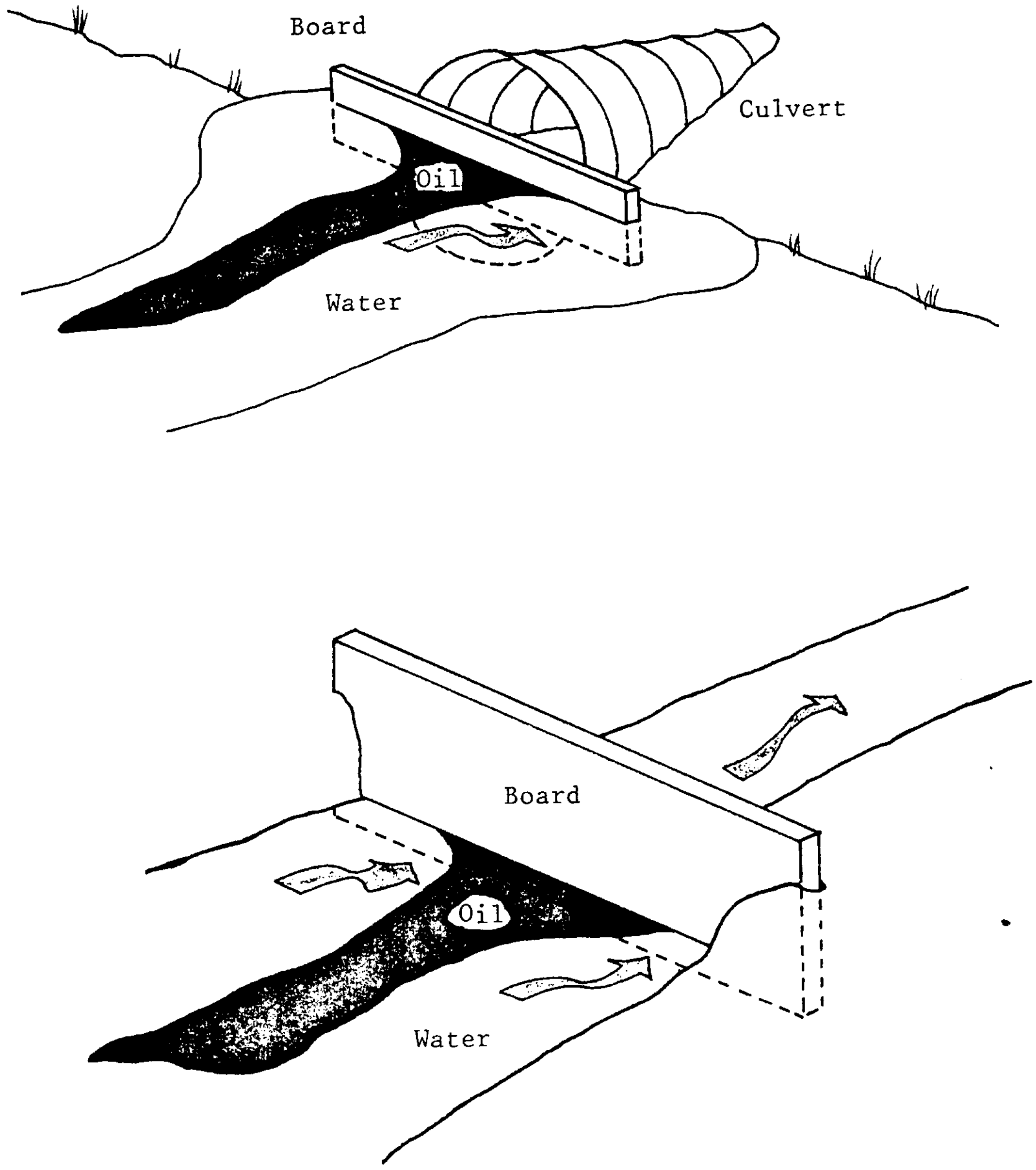


FIGURE 15

CULVERT AND EARTH DAM WEIRS

Areas where there is a high likelihood for accidental spills or which must be protected from contamination should be assessed as part of an advance planning program for spill containment.

The specific locations for water containment measures are dependent on the type of water body (stream, lake, river or pond), climatic conditions, equipment and personnel availability, volume of spill and spill material properties.

Certain materials such as gasoline or other volatile or flammable petroleum products have high risk of fire or explosion. For these materials, containment and evaporation (without recovery) or in-situ burning may be a preferred approach.

Fixed Barriers - Snowfence and Sorbent Barrier

Snowfence and sorbent barriers (Figure 16) may be used in streams with soft beds into which stakes can be driven. These methods are limited to summer conditions.

A snowfence barrier is installed to span the width of a stream less than 1 m deep and anchored at both ends with steel or wooden stakes. Stakes are driven into the stream bottom at 1 to 2 m intervals (supporting braces may be needed for strong currents). Straw bales or commercial sorbents are placed on the upstream side. Sorbent floats against the upstream side but must be replaced before it sinks. The barrier should be angled against the current for shore side collection. Multiple snowfence barriers can provide backup against potential losses from upstream barriers. Net or chicken wire barriers (Figure 17) can be constructed in the same way. For stronger currents, these are more practical since water can flow through more easily.

Floating Booms

a) Commercial Booms

The type and size of boom will depend on the specific location and conditions at which the boom is to be used. The general principles in using a boom are:

* To contain a spill of floating liquid or debris;
* To deflect or divert material to a defined area so that it may be recovered; and
* To protect sensitive areas from contamination.

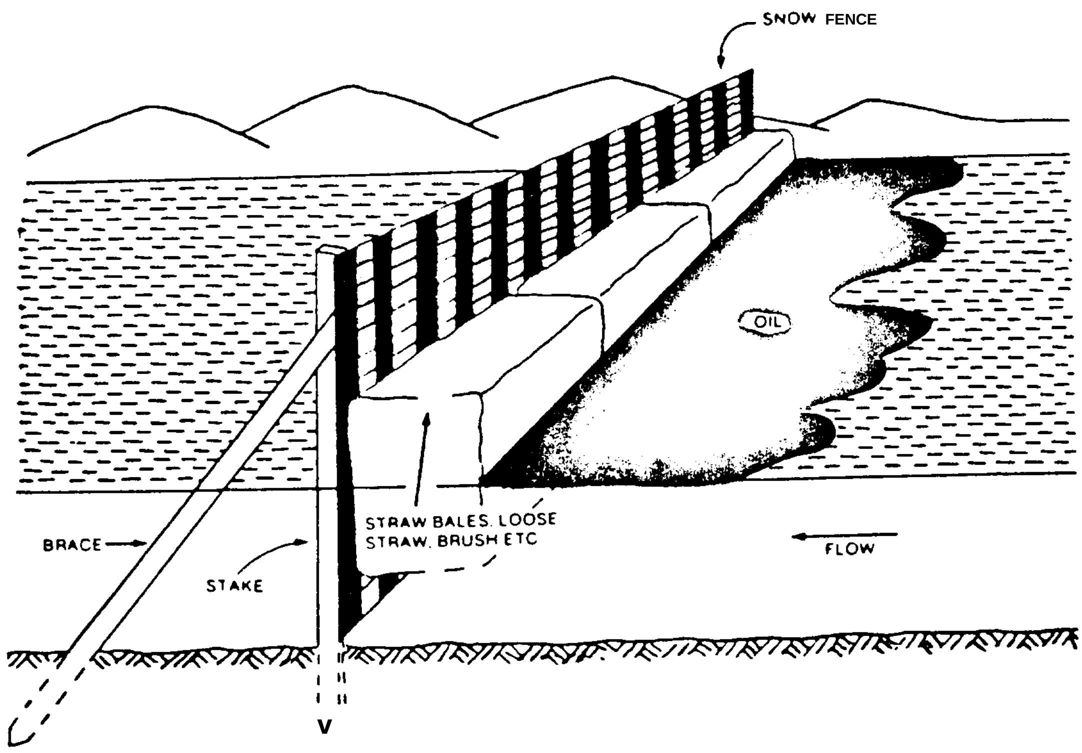


FIGURE 16

<u>SNOWFENCE AND SORBENT BARRIER</u>
(DILLON, 1983)

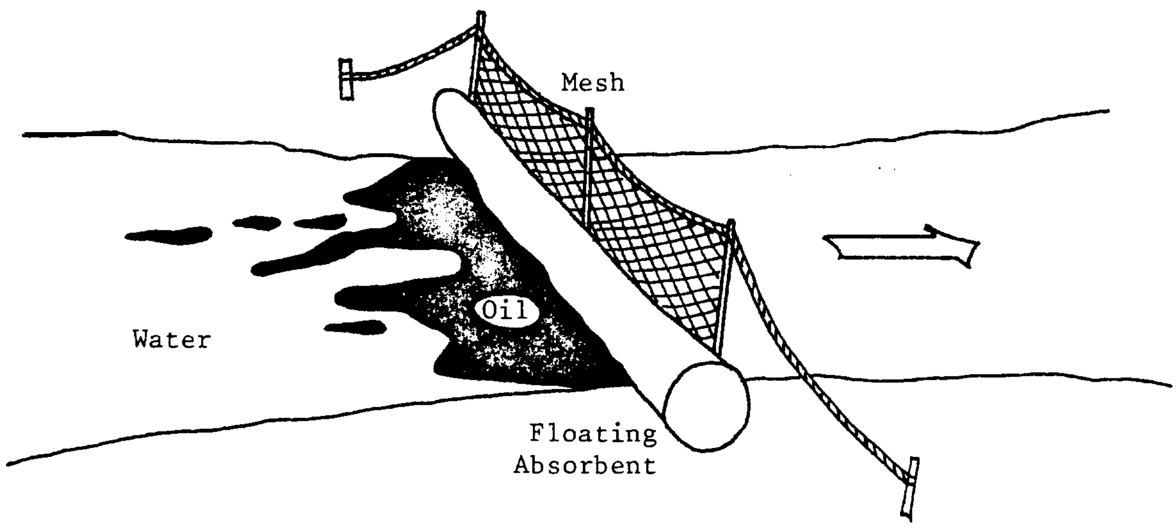


FIGURE 17

NET AND SORBENT BARRIER

The four basic components of commercial booms (Figure 18a) include flotation, skirt, ballast and tension members. Flotation maintains the boom on thesurface of the water; the skirt is designed to prevent contained material from escaping under the boom; the ballast keeps the boom in a vertical position; and a tension member provides directional orientation and holds the boom together. Boom failure can result from high winds, strong currents or large waves. The componentsof a boom anchoring assembly are shown by Figure 18b.

Boom deployment is a critical consideration. The angle of the boom relative to flow direction must be related to water flow velocity in orderto achieve effective containment. This relationship is described by Figure 19.

Several booms arranged in parallel maybe necessary to contain all the oil (or other floatable material). These should be spaced to allow for particles which may escape the first boom to float to the surface and be contained by the next boom. In addition, the use of several booms permits the removal of a boom for cleaning. (Figure 20).

b) Improvised Booms

Improvi sedbooms maybe constructed from awidevariety of materials readi ly available in most communities. Basical ly anything that will float and form a barrier can be used to contain floating spilled product.

Wooden Booms constructed from logs, railroad ties, telephone or power poles, trees or lumber can be used to deflect floating material to shore orto keep floating material within a contained area. Individual sections are connected together by rope, chain or wire. A seal around the joints to prevent leakage can be attempted by wrapping with plastic sheets or burlap. (Figure 21).

Wooden or other floating booms can be used to contain the spilled material itself or the sorbent containing the material. They can also be used upstream of sorbent booms to improve the efficiency and longevity of the sorbent material.

Inflated fire hose or styrofoam can also be used as improvised booms.

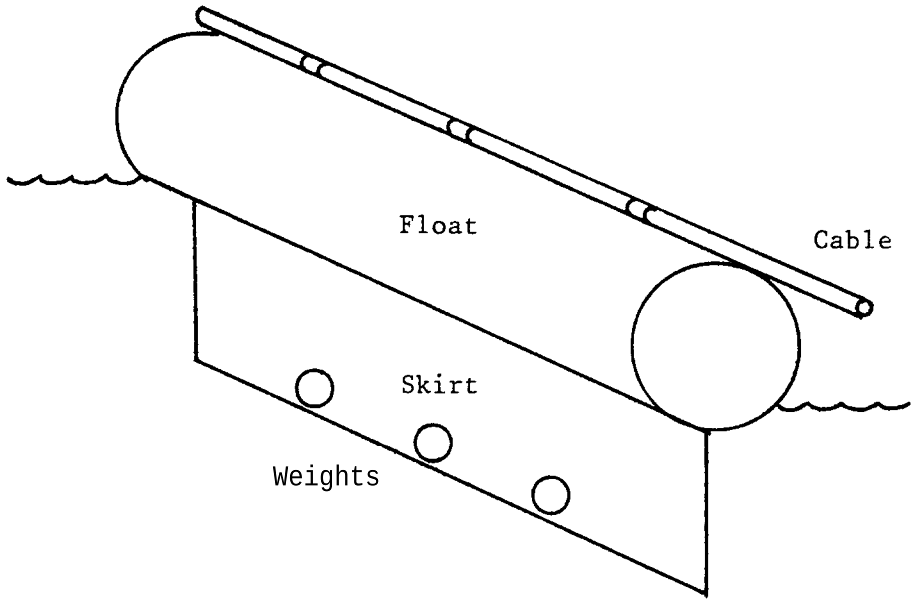


FIGURE 18a

BASIC COMPONENTS OF A COMMERCIAL BOOM

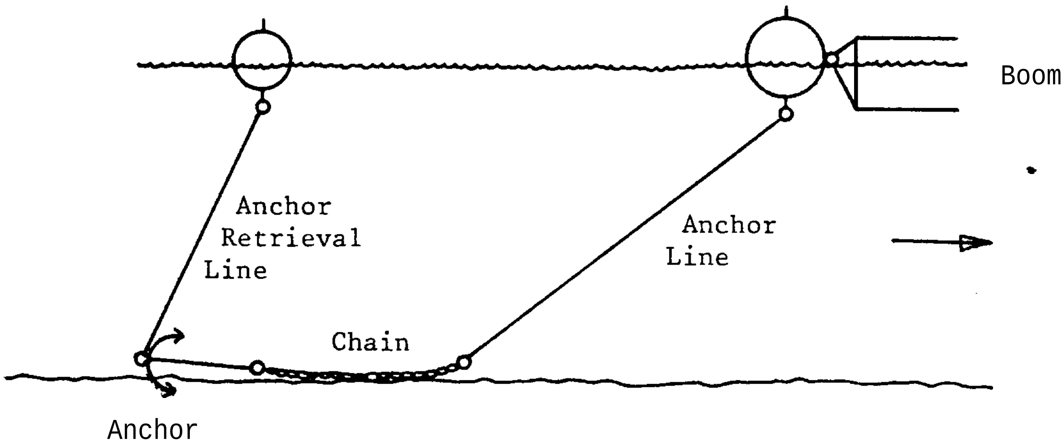


FIGURE 18b

BASIC COMPONENTS OF A BOOM ANCHORING ASSEMBLY

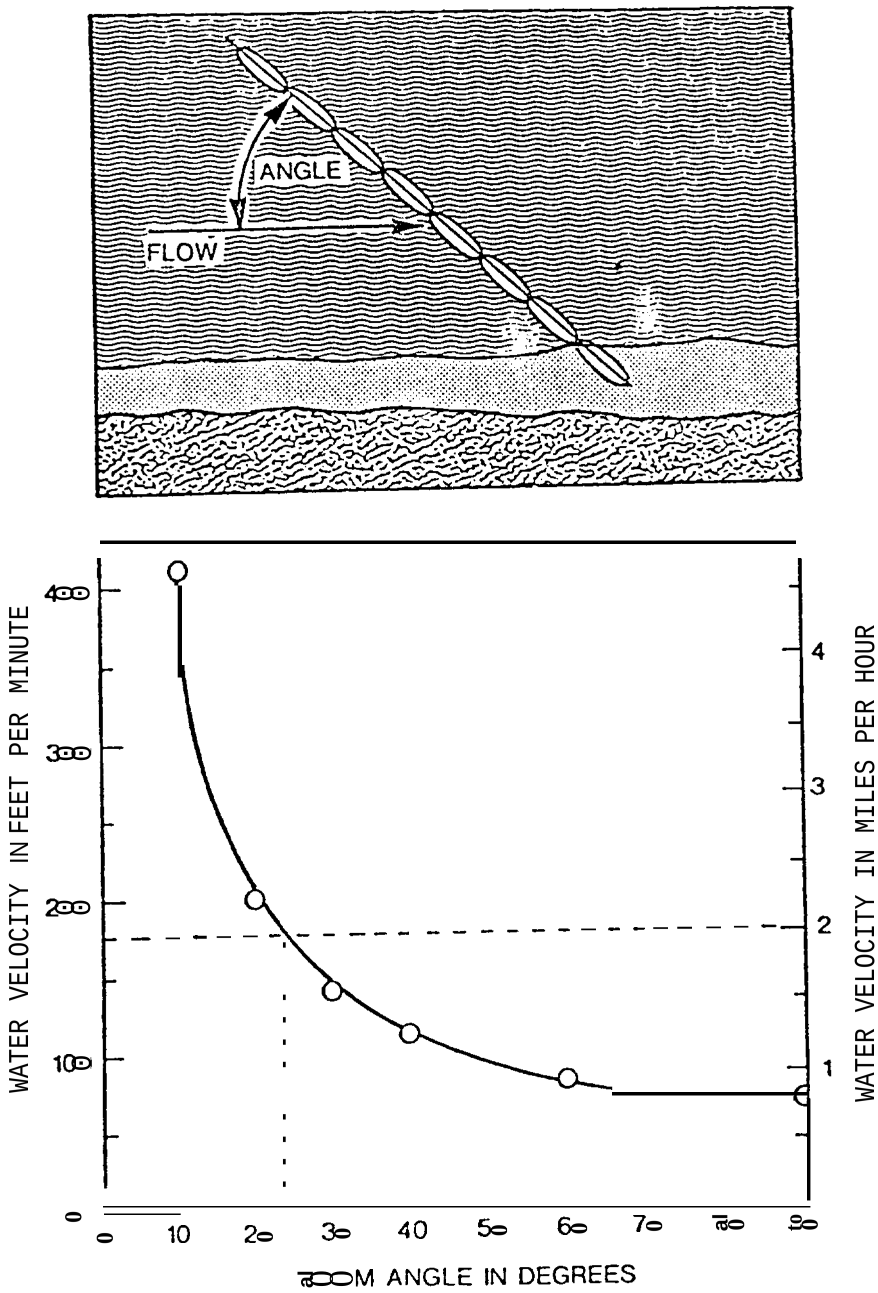
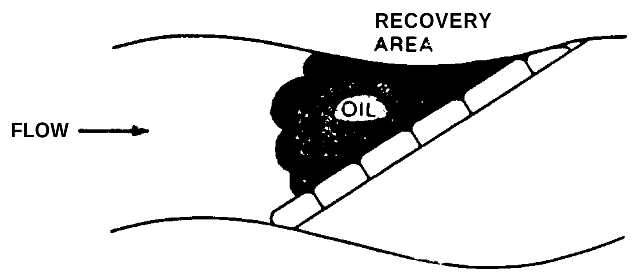


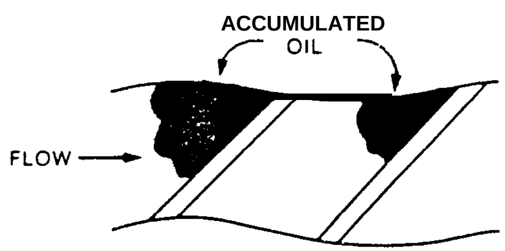
FIGURE 19

BOOM ANGLE DEPLOYMENT VS WATER VELOCITY

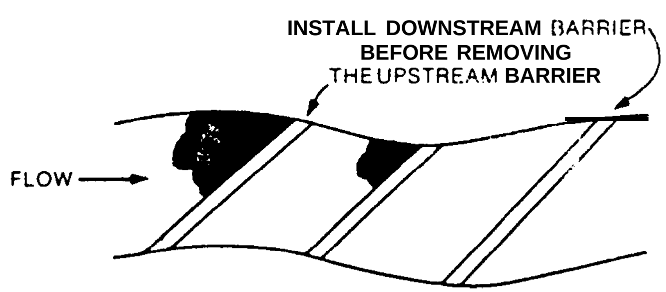
(EMU, 1979)



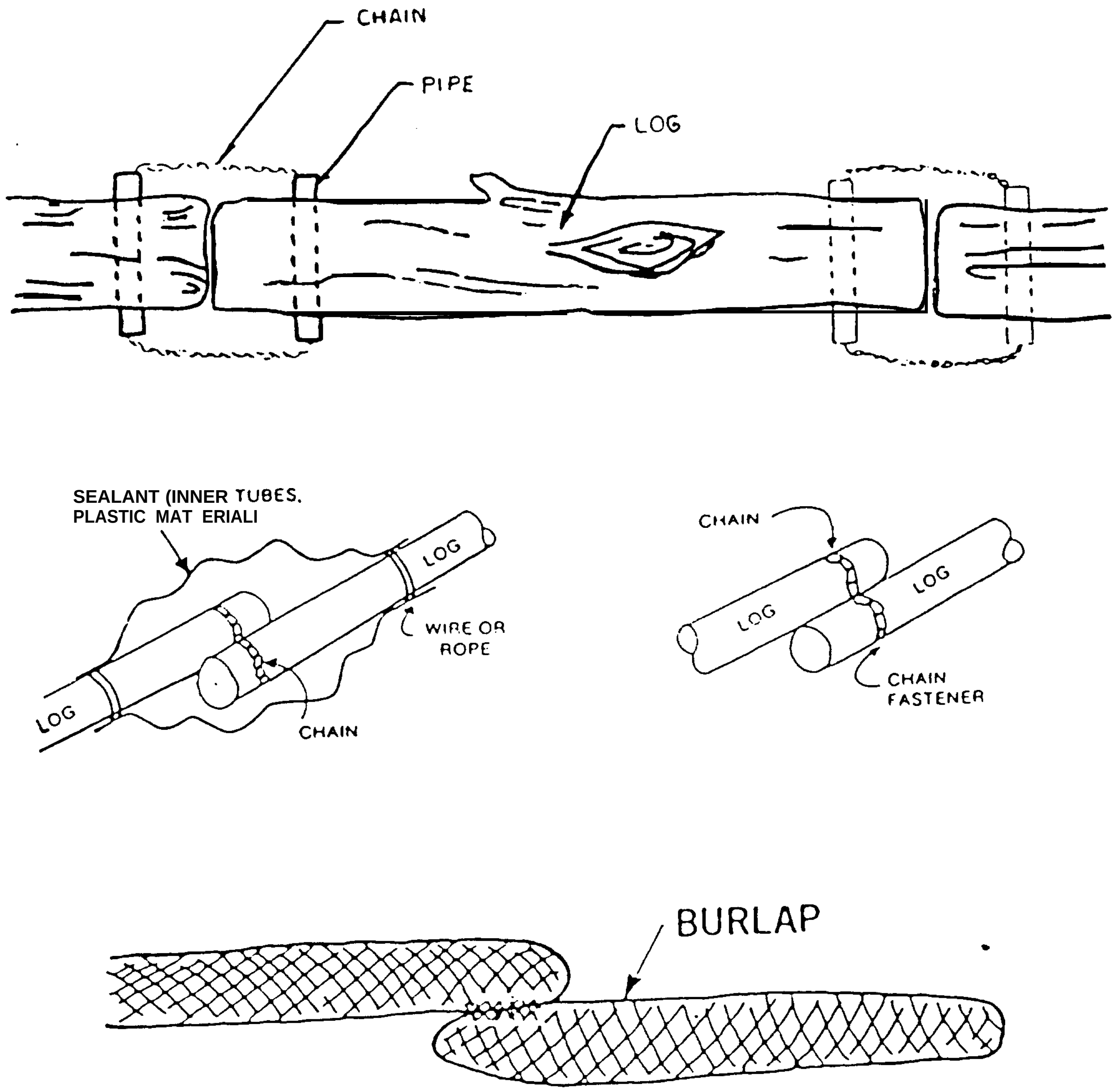
RECOVERY
AREA
OIL
FLOW



ACCUMULATED
OIL
FLOW



INSTALL DOWNSTREAM BARRIER
BEFORE REMOVING
THE UPSTREAM BARRIER
FLOW



STYROFOAM LOGS IN BURLAP

FIGURE 21

VARIOUS MEANS OF CONNECTING WOOD OR STYROFOAM BOOMS
(KENNEDY et al, 1981)

Chicken wire and sorbent booms (figure 22) are applicable to narrow streams with weak currents or still waters. Fishing net can replace chicken wire if the wire is not readily available. This boom is a combination containment and recovery boom. A suitable length and width of chicken wire is rolled up with commercial or natural sorbents in the form of a "jellyroll" or "sausage". Buoyant material should be used within the boom otherwise it will sink after several hours. Rope or wire is used to hold the sections in place. Natural sorbents include straw and evergreen boughs. Commercial sorbents have greater capacity to absorb oil and other petroleum products, they last longer, and they can be re-used. Foam sections have good sorbent capacity and excellent buoyancy.

Several booms can be placed in parallel for more effective containment and to permit the replacement and cleaning of alternate booms. Multiple booms will also reduce the risk of downstream water contami nation if an improvised boom rolls over. When removing booms, there exists a potential for the absorbed oil to be expelled back into the watercourse, therefore care is advised in this operation.

Figure 23 illustrates a potential placement of improvised booms. Note the upstream log booms placed for either directing oil or containing debris that might otherwise damage or interfere with the makeshift sorbent boom.

5.5.4 Containment Under Ice

All possible attempts should be made to avoid oil from entering ice covered waters as no easy method exists for containment and recovery of oil under ice.

Ice slotting may be used in rivers or streams when current speeds are slow, less than 0.5 meter/second. A trench is cut into the ice using a chain saw or "ditchwitcher" machine at an angle to the current to deflect and concentrate oil which passes through the area. Because of the thickness of ice cover encountered during northern winters, cutting and removal of ice blocks is often difficult. Loaders or backhoes may be needed to lift blocks out of the slot. Alternately, backhoes may be used to push blocks down. Oil which accumulates in the ice slot may either be pumped out, absorbed or burned in place. Figure 24 demonstrates ice slotting techniques.

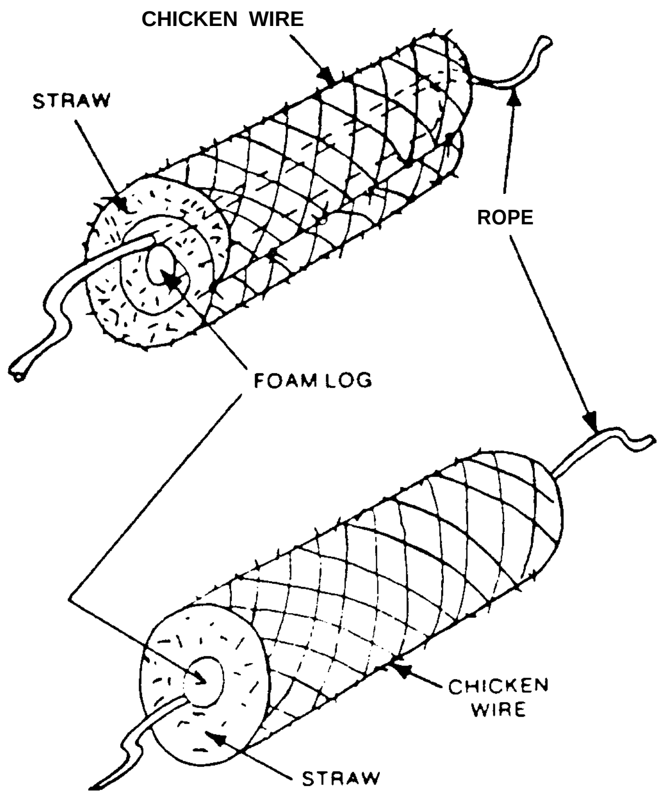


FIGURE 22

JELLYROLL AND SAUSAGE ROLL IMPROVISED SORBENT BARRIERS
(KENNEDY et al, 1981)

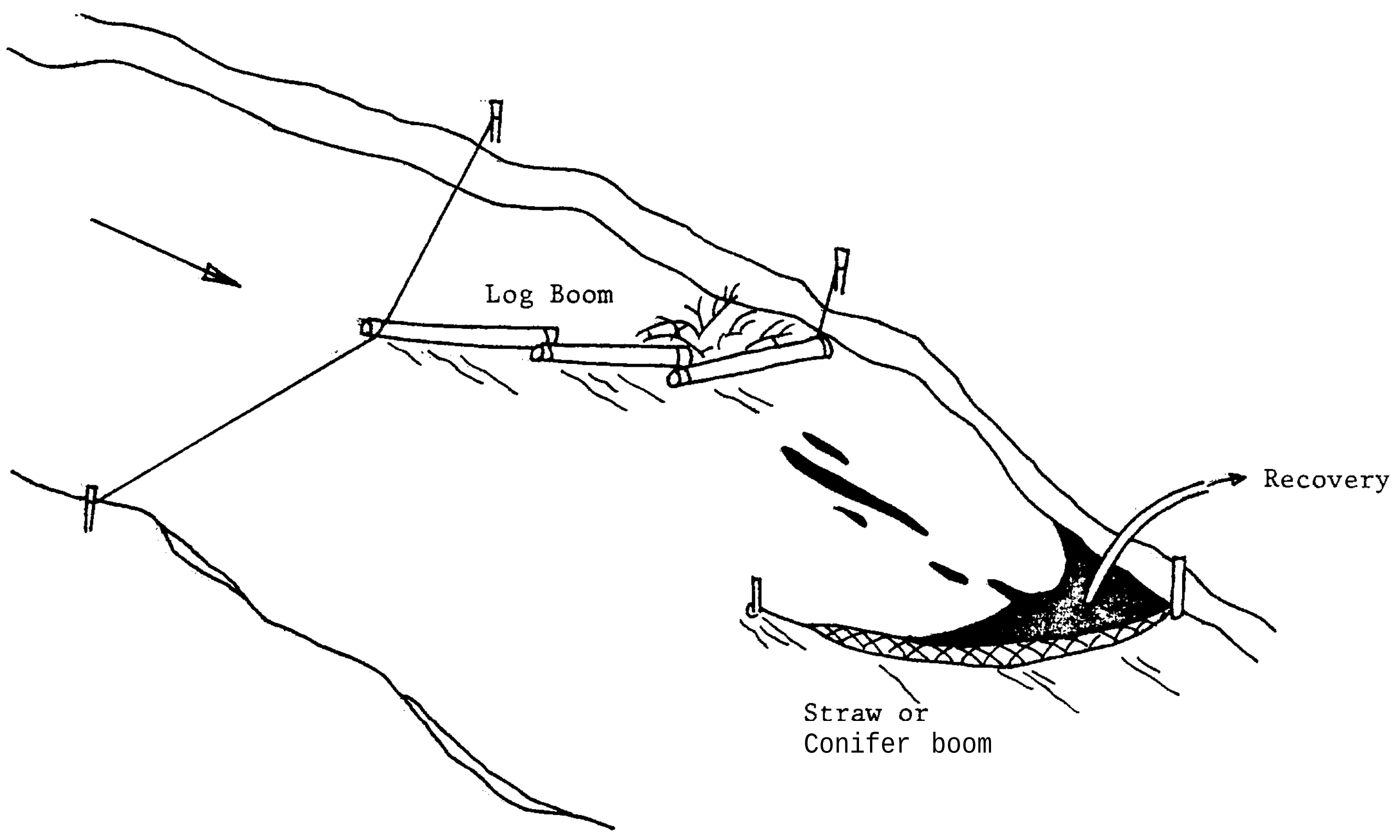
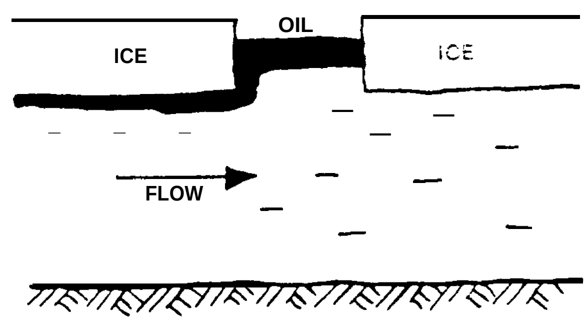


FIGURE 23

POSSIBLE SCHEMES FOR BOOM ATTACHMENT AND DEPLOYMENT
(EMO, 1979)



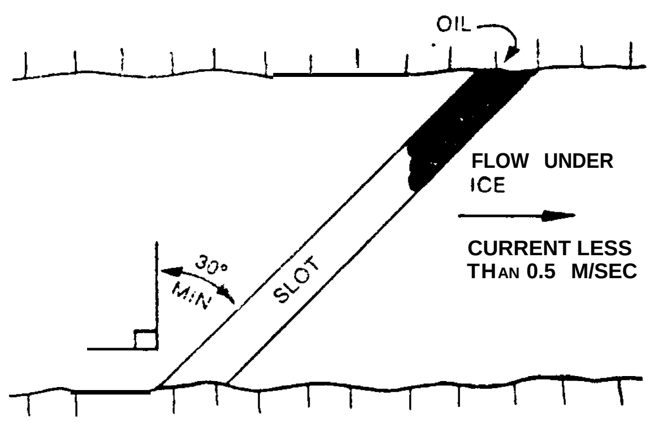


FIGURE 24

ANGLED ICE SLOT FOR OIL DEFLECTION AND RECOVERY
(KENNEDY et al, 1981)

Vertical barriers in ice (example plywood) may be used to deflect oil under ice in slow moving deep waters. Ice conditions must allow support for the necessary personnel and equipment.

Vertical barriers are put in place by cutting trenches in ice at an angle to current flow, inserting the plywood barriers and allowing them to freeze in place. (Figure 25). Chain saws can cut slots into ice upto 0.5 metre thick. The location of the oil slick may be monitored by drilling observation holes with an ice auger.

5.6 RECOVERY

Prompt removal of the spilled material from the spill site is required to reduce and/or eliminate any potential dangers and hazards to the public and to the environment. Recovery methods generally include suction, mechanical removal and the use of sorbent material.

A water spray mist may be used to herd the spilled material to specific areas to assist recovery.

5.6.1 Direct Suction Equipment And Techniques

Direct suction methods include the use of vacuum trucks, portable pumps or shop vacuums.

Vacuum or portable pumps can be used to directly recover materials from damaged containers or from thick slicks on water. Shop vacuums (in particular those of large capacity) are suitable for small spills if a power source is available. Commercial skimmers are available for attachment to vacuum sources. These skimmers serve to "skim" floating product from the water surface while reducing the amount of water recovered.

Suction screens may be required to prevent hose plugging by floating debris and to prevent pump damage.

Care should also be taken to prevent the uptake of water in order to minimize the final volume of material which requires disposal and to prevent emulsification of oil and water. Once removed from the water body, however, water and oil can be separated using gravity separation. Valving on vacuum trucks can be used for water/oil separation or a drum separator may be readily constructed using a 45 gallon drum and hardware as shown in figure 26.

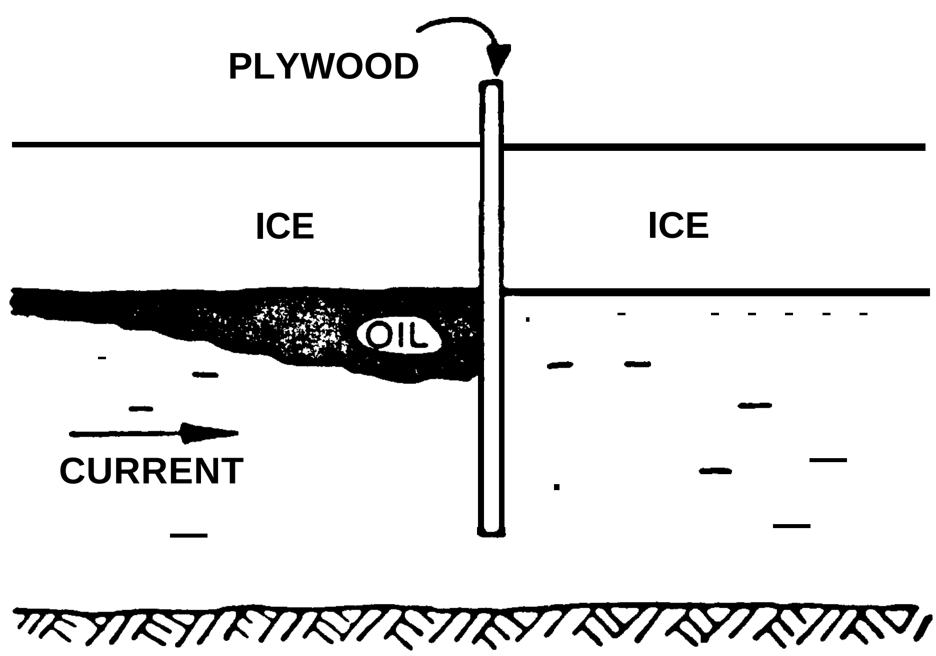


FIGURE 25

PLYWOOD BARRIER IN ICE
(KENNEDY et al, 1981)

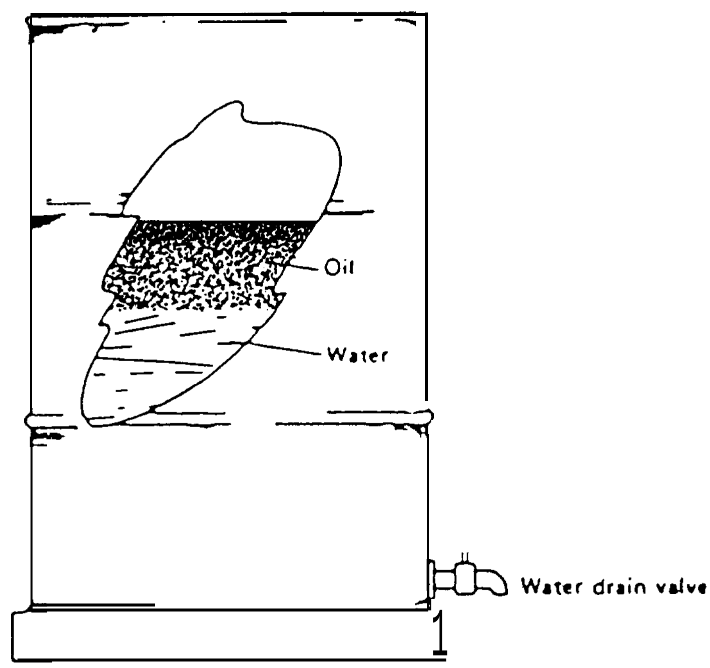


FIGURE 26

IMPROVISED OIL-WATER SEPARATOR DRUM

CAUTION: All containers used for the recovery of flammable materials must be grounded because of the potential for static-electricity buildup.

5.6.2 Manual and Mechanical Recovery

Manual recovery by use of handtools (cans, buckets, shovels, rakes) is an effective means of recovering spilled product from small spills or from areas that are inaccessible to larger equipment. Though labour intensive and time consuming, it is often the only method of recovery available and in some cases, is the preferred method as it causes the least damage to the area.

Mechanical recovery using heavy construction equipment can be used in some cases for recovery and loading of material for disposal. Caution must be used when operating such equipment around a spill site. In some instances, more damage could be produced from the operation of the equipment than from the spilled product. Escaping petroleum vapours maybe present and pose the dangerof explosion and fire.

5.6.3 Use of Sorbent Material

Sorbents are materials that soak up oil either by absorption or adsorption. They are commonly used for final cleanup and recovery of small amounts of oil or to remove oil in places which are inaccessible to other means of recovery. They are effective in recovering thin as well as thick layers of oil; however, large volumes of material is often required.

Snow and soil can be used as effective sorbent materials for a variety of oi s. When mixed, the oil in snow or oil in soil mixture can be shove" led or picked up using construction equipment and taken to a suitable disposal si e.

5.7 STORAGE

The destruction or disposal of materia s from a spill site may not be immediately practical. Storage is required if a suitable location for disposal cannot be found, if climatic conditions do not permit disposal at the time of cleanup, if the selection of a disposal option requires further assessment, or if transportation to a disposal/destruction facility is dependent on the availability of a suitable transportation vehicle.

Storage options generally consist of containers, barrels, drums, tanks or pits. The specific type of storage unit needed is dependent on the volume of recovered material, the degree of contamination with water or soil, the properties of the spill material, and the duration of storage required.

5.7.1 Vehicle Storage

Vehicles generally suited for the storage of recovered materials and which are available at many locations in the NWT include:

* tank trucks and vacuum trucks
* dump trucks
* flat bed trucks
* sled-mounted tanks
* transport trailers

Many communities in the Northwest Territories depend on the use of water trucks and vacuum trucks for the supply of water and the removal of sewage. Due to the severe climatic conditions and frequent and regular use of this equipment, the service life of these vehicles is generally limited to five years, or less. These vehicles are replaced on a regular basis and used vehicles are stored at sites designated near the communities. These vehicles are no longer useful for their original purpose. The tanks on these unused vehicles may be useable for the storage of liquids from spills.

Tank trucks typically have capacities ranging from 7.8 to 24.6 m^3 while vacuum trucks typically hold 3.8 to 17.0 m^3. Tank trucks have the potential for separating oil and water mixtures by drawing off a bottom layer through valving.

Flat bed trucks and transport trailers are suitable for carrying 45-gallon drums and barrels.

5.7.2 Open-Topped Tanks

Open-topped portable tanks such as plastic lined swimming pools may be quickly assembled on firm, level ground. The capacities range from 1 m^3 to 20 m^3. They may be fed by several hoses at once and can store liquids and solid debris. These should be used only for short-term storage when storing oils and other petroleum products.

The majority of spills in the Northwest Territories are petroleum products and container corrosion will not be a concern in most cases; however, consideration should be given to flammability, explosiveness and security.

5.7.3 Pits and Other Land Dependent Storage

These methods employ terrain and earth works to contain recovered liquid and may be upgraded using synthetic or natural liners to avoid soil and site contamination. Because of the requirement to alter topography, these are limited to sum mer conditions when the active layer is sufficiently deep to provide excavation volume and material for berming. The methods most commonly used include natural land features, ditches, pits, lagoons, and trenches.

Temporary storage sites should be prepared and selected to minimize groundwater contamination. Sites should not be located next to gullies, streams or on the sides of hills, but rather in flat areas. Highly porous or water saturated soils should be avoided for use as temporary storage sites.

Although natural clays may provide an adequate barrier to subsurface migration, these materials are scarce in the Northwest Territories. Synthetic membrane liners such as plastic sheeting may be used for lining storage facilities; however, when storing petroleum products, consideration should be given to liner degradation and the potential for failure.

5.7.4 Drums and Barrels

Temporary storage of liquid may be accomplished using tanks, drums and barrels which are available in all communities.

5.8 DISPOSAL

Disposal or destruction of recovered materials is ultimately needed to eliminate the risk of further contamination from recovered material.

A wide range of materials are recovered from spill sites in the NhIT and a wide range of disposal methods may be considered. Disposal does not mean merely re-locating the problem. No decision, except under emergency conditions, should be made until approval has been obtained from appropriate government agencies. The 24-hour spill report line should be used to initiate such requests and a followup report should describe the disposal method used.

Techniques for the disposal of recovered oil and debris vary widely, but can be categorized into four basic options;

* salvage and recycle,
* mechanical incineration,
* on-site burning and
* natural recovery (biodegradation) [last option].

Factors that determine the most suitable technique for disposal are equipment availability, properties of the recovered product, spill volume, amount and type of debris and impact of disposal techniques on the environment.

Disposal techniques cannot always be pre-planned. The response team should, however, be familiar with the available disposal alternatives in the event that a spill occurs. Companies and/or communities should be encouraged to prepare a proper disposal site.

Whatever the disposal method employed, groundwater must not be polluted -- either by the material being disposed of, or by its decomposition products.

5.8.1 Salvage and Recycle

Salvage and recycling is the desirable disposal technique whenever local conditions permit. Techniques include direct reuse or injection into a pipeline.

Recovered diesel and lubricating oil may be reused directly as a low-grade heat"ing fuel . Unpaved roads may be oiled to reduce traffic dust; however, authorization from appropriate regulatory authorities must be received prior to this being undertaken.

Pipeline injection may be used under certain circumstances for disposal of oil discharged from a pipeline. For example, discharged oil that has pooled along the pipeline may be reinfected at a nearby pump station, pipeline valve assembly, or directly at the spill site, with the field installation of a "T". Techniques for heating the oil to reduce its viscosity may be required before reinfection. Heating may be achieved by transferring the viscous oil into a warming tank.

Another problem to be considered with pipeline reinfection is that of separating the oil from water that may have been collected with it. An effective approach for dealing with this problem involves the use of an oil/water separator. The remaining oil could then be reinfected directly into the pipeline (assuming it is free of debris). A mechanical separation technique can be used to separate the debris from the oil. The oil could be contained in a storage tank before being reinfected into the pipe.

5.8.2 Mechanical Incineration

Mechanical incineration is a good method of eliminating recovered oil. If burning can be controlled, smoke and ash are reduced since oil will burn at a high tempera"ture. The residue left after incineration can be disposed at a landfill site.

Several types of incinerators have been designed for disposal of recovered oil and debris including flare burners, open-pit incinerators, rotary kilns and stoker-type incinerators. These are specialized equipment, however, and few are presently operating in the Northwest Territories.

5.8.3 On-Site Burning

In some remote areas, on-site burning of oil and contaminated debris may be a practical and acceptable disposal technique. In unpopulated areas, the smoke resulting from such burns may cause less environmental damage than the disturbance of the area from conventional recovery methods. Conventional recovery equipment may also not be readily available in remote locations.

On-site burning of oil and contaminated debris requires **prior approval and-advice** from appropriate regul**atory agencies.**

On-site burning should only be carried out in open, unpopulated areas where there is no possible danger of the fire spreading. Also, oil must not be ignited unless all personnel and equipment are a safe distance from the area.

There are benefits and risks associated with on-site burning which must be considered when making the disposal technique decision. An advantage of on-site burning is that it:

Removes the last small quantities of surface oil that cannot be picked up.

Disadvantages include:

* Increases probability of root death by heating;
* Increases the movement of toxic elements of the oil;
* Increases the possibility of forest fires;
* Can cause smoke damage to nearby buildings and property; and
* May encourage oil spreading and kill above-ground vegetation.

Oil on frozen water bodies can be burned using mass burning techniques. The residue and oil not burned can then be scooped up using scrapers, dozers, dump trucks, and finally with brooms and shovels and loaded into trucks.

Burning can also be considered when oil penetration has been prevented due to low permeability of the soil surface (frozen or compacted mineral soil) or when the water table is at the surface. Residue can be removed the same way as on ice but great care must be taken to protect area vegetation.

The worst areas to consider burning is where islands of vegetation exist or where the surface has a moss cover into which the oil has penetrated to more than eight or ten centimetres.

5.9 FINAL CLEAN-UP AND RESTORATION

Every reasonable effort must be made to clean-up a spill site to pre-spill conditions. To effect final clean-up and restoration, activities may include:

* Natural Assimilation or Revegetation
* Replacement of Soil.

5.9.1 Natural Assimilation (Biodegradation) and Revegetation

Oil can be degraded naturally by microorganisms under proper conditions of temperature and nutrients. The biodegradation of oil spilled onto soils may be enhanced with the application of fertilizers. Tilling the affected soil to increase the exposure of the soil organisms and oil to oxygen can also be beneficial. Before considering leaving oil in place, the following factors should reconsidered;

* The oil should remain in the upper 15 cm soil layer;
* The oil must not affect groundwater;
* Proximity to drinking water, surface water supplies;
* Short or long-term health hazards;
* Disturbance to vegetation or permafrost from clean-up activities versus disturbance from no actions taken;
* The oil will not interfere with property use; and
* The oil will not spread or otherwise contaminate the environment further.

The utilization of natural assimilation to treat, in whole or in part, soils affected by spilled oils requires prior concurrence of environmental authorities.

A considerable amount of natural assimilation also takes place on oil spilled on surface water. Thin sheens of oil left after oil recovery operations may disappear naturally within days. Warm temperatures, wind and wave action will accelerate oil degradation and natural assimilation on water.

Research has found that many plant communities will naturally regenerate. For instance, various willows and birches are tolerant to spilled oil if the oil does not penetrate the soil surface and kill the root systems. In one study, total plant recovery was found to be between 20% and 55% after the first season in an arctic willow-birch plant community. There is merit in leaving the spilled oil and preventing additional disturbance through clean-up activities.

5.9.2 Replacement of Soil

The grass on the upper layer of soil may have to be removed if these have been contaminated with oil or chemicals. Reasons for removal of this material may include:

* soil restoration and prevention of groundwater contamination;
* elimination of odours or hazardous fumes; and
* aesthetic reasons.

When contaminated material is being removed, regulatory agencies should be contacted in regard to acceptable disposal sites. In some instances, it will be necessary to replace contaminated soil with clean soil. Sensitive areas in the tundra should be left untouched.

TABLE 7
DISPOSAL ALTERNATIVES

METHOD	APPLICATION
Salvage and Recycle	The preferred fate of any material that can be recovered.
Mechanical Incineration	A practical method of disposal. Can achieve close to 100% combustion, does not leave undesirable residues. Transportable units are available which can burn 50-50 water-oil mixtures. Transportable unit can burn 50 to $80 m^3$/day.
On-Site Burning	Best for oil on ice. Can achieve about 70% combustion. To be most effective, spill should be less than 24hours old, 0.5 cm thick, and winds 1 1/2 to 2 km/h. Residue must be scraped up immediately after burn. Burning on land increases depth of spill penetration and combustion is difficult. Caution is needed to keep fire under control. Can cause crusting where oil has penetrated a moss cover or wet areas. Kills all above-ground vegetation. On water, it is best if the slick is fresh and thick. Wicking agents may be used to help support combustion. Utmost care must be exercised in preventing hazards to life and property. Government supervision, consultation, or approval is necessary for any on-site burning.
Natural Recovery (biodegradation)	Rate and extent of microbial degradation is limited by temperatures and lack of nutrients. Application of nitrogen and phosphorus fertilizers can assist. Maybe considered for sensitive areas, such asmuskeg, where disturbance from clean-up activities could cause more harm than the spilled oil. Government agencies should be consulted before decision to allow natural recovery is made.

(IPL Spill Contingency Plan, December 1984)

Equipment for the removal of contaminated soil includes front-end loaders and small dozers.

The primary concern of any restoration is the prevention of environmental deterioration through accelerated erosion. In cold regions, where permafrost is pre sent, minimizing alterations to soil thermal regimes and the melting of permafrost are important objectives of restoration.

6.0 PREVENTION AND PLANNING

6.1 SPILL PREVENTION

6.1.1 Need For Prevention

An increased frequency of hazardous material spills in the NWT is expected as a result of community growth, increased exploration and production and construction activities. The reasons and causes for hazardous material spills are dis cussed in Section 2. Manyof these spills are attributable to direct human error (fatigue, lack of training, etc.) and indirect human error (fire, explosion, equipment failure).

Spill prevention or the stopping of a spill before it occurs, falls into two categories, prevention "before the fact" and prevention "after the fact". Prevention before the fact is determination of potential causes of spills and implementing preventive measures to ensure that a spill does not occur. Prevention after the fact is determination of the causeof the spill and implementing measures to prevent its reoccurrence. Remember:

THE COST OF ACTING TO PREVENTA SPILL IS ALHAYS LESS THAN THE COST OF REACTING.

A spill prevention program would reduce the frequency of spills occurring in the Territories. To be effective, however, the program must be useful, practical, meaningful, cost-effective, reach large numbers of people, be accepted by the people reached and be consistent with the overall task. The cost of implementing such a program is considered small compared to the cost of response, clean-up and monitoring or spills.

6.1.2 Prevention Strategies

Effective spill prevention begins with an awareness of a potentially hazardous situation. Some of the methods or strategies that could be employed to initiate this awareness are:

A) Educate operators as to the hazards and consequences of spills and the methods of transfer, transportation and storage. This maybe achieved through seminars, drills, practices and scenarios.

B) Develop check lists. Checklists outline the potentially hazardous areas of an operation to maintenance inspectors and operators, and thus, go hand-in- hand with inspections and quality control. Encourage the use of log books during regular inspections.

During the development of prevention checklists, the following areas Of spill causes require consideration:

1. Natural Causes (heavy rains, snow, ice, high winds);
2. Equipment Failure (improper equipment, poor maintenance and condition of existing equipment); and
3. Human Error (carelessness, neglect, deliberate acts).

The following list (Basic, 1983) outlines some of the specific causes of spills which occur at bulk storage facilities. Examination of such causes is desirable when developing spill prevention checklists or strategies.

* Spills due to overfilling of tanks.
* Rupture of tanks.
* Leaks in pipes, valves, pumps, fittings, and other equipment.
* Leaks in containment dykes.
* Inadequate secondary containment systems.
* Oil flow from dyked area through open dyke valve.
* Piping and tank damage by collision with mobile equipment.
* Spills from water drawoff from tanks.
* Spills from tank bottom cleanout and sludge disposal.
* Poor maintenance of pipes, valves, pumps, fittings and other equipment.
* Spills from line flushing.
* Spills from pipe and tankage changes.
* Spills from underground storage tanks.
* Possible sabotage.

C) Incorporate anti-spill devices such as drip pans, interceptor drains, high-level sensors and one-way valves.

D) Develop an effective reporting system within facilities, municipalities and governments, for reporting potentially hazardous situations.

6.2 CONTINGENCY PLANNING

6.2.1 Need for Planning

Contingency planning is the development of a high level of preparedness which allows for efficient response to spill situations. In this manner, actual or potential health hazards and damage to property and the environment are reduced and clean up costs are minimized.

Contingency planning should be carried out at all levels of government and industry. An overall contingency plan for the Territories provides a framework upon which to base planning at the community level and to provide a basis for coordinating the roles of various government agencies and industry. Territorial wide contingency planning for all the potential spill scenarios which could occur considering all the potential approaches and organizations involved is, by necessity, general.

Detailed contingency plans can, however, be made for each facility or activity. Each contingency plan should clearly identify to the personnel the procedures for reporting and response, list the resources, personnel and equipment available, and define procedures for response and clean-up.

A contingency plan is a written outline of procedures to be followed in response to spills of oil or other hazardous materials. Distribution of a well thought-out plan to personnel who are likely to be involved in spill response and monitoring will result in a faster and more effective response. The contingency plan provides the following benefits:

Identifies the procedures for reporting the spill and includes the names, locations and telephone numbers of personnel who may be contacted for assistance.

Describes the immediate actions which should be undertakento secure and contain the spill.

Lists the locations and types of manpower, equipment and resources available for material recovery and clean-up.

- Provides general technical guidance to assist site personnel in assessing hazards and risks to workers and to the public.

- Identifies the location of areas which must be protected such as community water supplies, streams, lakes.. .

- Identifies the location and adequacy of facilities (landfills, lagoons, sewage treatment plants) and sites which may be suitable for the disposal of spill clean-up material.

The Territorial Government supports the development of local contingency plans and the pollution Control Division will provide assistance in the development of community specific spill contingency plans.

6.2.2 Plan Development

Each contingency plan must be designed for a specific facility or activity. No two situations are identical; therefore, no two contingency plans should be identical.

There are, however, basic underlying guidelines which can be applied to contingency plan development. Two concerns must be addressed in any plan:

1. Public and Occupational Safety
   The dangers and hazards of handling the spilled material must be clearly understood by all personnel, and the safety of workers and the public, must be the first concern. Appendix A deals with these concerns.

2. Environmental Protection
   A general rule in spill response is that quick and effective actions are needed to contain spilled material and prevent its flow to water bodies where potenti al environmental impacts are greatest. Methods for such actions are discussed in Section 5.

A set of contingency plan guidelines - or “check list” has been developed by a joint government-industry forum, the Consortium on Spill Training which identifies pertinent contents of a contingency plan. These guidelines provide a foundation for development of such a plan and are presented in Table 8.

TABLE 8

CONTINGENCY PLANNING CHECK LIST

1. Notification and Alerting Procedure

(a) Notification List - Office and home telephone numbers

* Company: (i) Local Management
  (ii) Local Spill Team
  (iii) Regional Management
* Local co-operative members and alternatives
* Local clean-up contractors
* Government - Notification and Assistance
  * Federal
  * Territorial
  * Municipal

(b) Reporting Procedures

* What is to be reported and with what urgency?
* To whom is it reported?
* By whom is it reported. Use fan-out call list system to reduce the number of calls any one person must make
* Method of reporting - verbal or written

2. Specific Analysis of Plant Layout and Operations

* Always assume the worst (eg. product escapes plant site)
* Where could spill occur?
* How much product could be spilled?
* Where would spilled product go?
* How could it be contained and recovered?
* What equipment and manpower would be required and where would they be obtained?
* Are specific action steps outlined for the most probable or most serious incidents which might occur?

TABLE 8 [Continued]

3. Equipment Inventory List

* Identify own on-site equipment and exact location of it.
* Identify local co-op equipment, location of it and procedures to obtain.
* Identify back-up equipment - nearest company facilities and co-operatives, mobile vans, with procedures to obtain
* Identify equipment or services available from governments
* Obtain written schedule of charges or contract, in advance, from local contractors for men, materials and equipment, and commitment on availability.

4. Equipment Readiness

Establish routine procedures and responsibility for spill equipment stored on site:

* inspection
* maintenance
* physical presence inventory
* equipment loaned to others

5. Waste Disposal

Identify means of disposal of recovered product and contaminated debris

* location of disposal site
* method of transport
* waste disposal contractor
* Means of holding or accumulating product or debris pending disposal (open headed drums, buckets, tanks).
* Obtain approval, preferably in writing, of plans to dispose of recovered product and debris from all appropriate government agencies.
* Consider possibility and consequences of leaching if material is to be buried in ground, or on-site burning used.

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APPENDIX A

PERSONAL AND PUBLIC SAFETY AT THE SPILL SITE

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PERSONAL AND PUBLIC SAFETY AT THE SPILL SITE

A.1 Product Identification

The correct safety procedures at a spill site will depend on the physical and chemical properties of the spilled product. Therefore, the spill product must first be identified. Means to do this includes recognizing the container structure, identifying placards, asking the driver of the vehicle, checking for papers within the vehicle or contacting the manufacturing or transportation company. Procedures for product identification are outlined in Section 5.1

Once the product is identified, information must be obtained on its characteristics and the appropriate safely precautions to take. It is recommended that a copy of the Manual for Spills of Hazardous Materials, (EPS, 1984) be consulted. This manual is available from the Environmental Protection Service of Environment Canada. Two hundred and twenty listings of hazardous chemicals are compiled therein. Some of the information presented for each chemical is:

- identification characteristics;
- human health data;
- fire extinguishing agents;
- reactivity with other chemicals;
- immediate response actions;
- protective clothing and equipment;
- first aid; and
- response actions.

If possible, product hazard information should be cross referenced with another source to ensure correctness of information. Some other sources include:

1. Transport Canada CANUTEC (Phone: (613)996-6666) or the CANUTEC reference book Dangerous Goods Guide to Initial Emergency Response, 1986.
2. The 24-hour spill report line [Phone: (403) 920-8130].

In the event that material identification cannot be **made, it should be assumed that the material is dangerous and under these circumstances, response actions should not be attempted.**

Table A.1 is taken directly from the Manual for Spills of Hazardous Material and presents gasoline as an example.

T

EXAMPLE OF EPS N

G

IDEN

common synonyms

Petrol, Automotive Fuel
A V-Gas
leaded contains tetraethyl lead
lead-free may contain other compunds

observable Characteristi

Colorless (or dye red, pu
Typical gasoline odour.

Transportation and Storage Information

Shipping State: Liquid.
Classification: Flammable liquid.
Inert Atmosphere: No requirement.
Venting: Open (flame arrester) or pressure-vacuum.
Pump Type: Standard.

Label(s): Red and white la
Class 3.2, Group Il.
Storage Temperature: Ar
Hose Type: Standard.

Physical and Chemical Characteristics

Physical State (20°C, 1 atm): Liquid.
Volubility (Water): 1 to 100 ppm/100 mL water.
Molecular Weight: Mixture of materials.
Vapour Pressure: 300 to 600 mm Hg (20°C)
Boiling Point: 40 to 200°C.

Floatability (Water): Flo
Odour: Gasoline (0.25 ppr
Flash Point: -43°C (c.c.)(
-38°C (c.c.) up to 100 oct
Vapour Density: 3 to 4
Specific Gravity: 0.75 to

HA

Human Health

Symptoms: Inhalation: vapours cause rapid breathing, excitability, staggering, h convulsions, coma. Ingestion: gastrointestinal irritation, dizziness, fatigue, loss eyes - watering, stinging and inflammation.
Toxicology: Moderately toxic by inhalation.
TLV® -300 ppm; 900 mg/m^3.
Short-term Inhalation Limits -500 ppm; 1 500 mg/m^3 (15 rein).

LC50 - No information.
LC_{Lo} - Inhalation: man =
Delayed Toxicity - No in

Fire

Fire Extinguishing Agents: Foam, carbon dioxide, dry chemical. Water may be containers.
Behaviour in Fire: Flashback may occur along vapour trail.
Ignition Temperate: 280°C, up to 60 octane; 456°C, up to 100 octane; 440°C, 100 to 130 octane (aviation grade); 471°C, 115 to 145 octane (aviation grade).

Burning Rate: 4 mm/min.

Reactivity

With Water: No reaction.
With Common Materials: Can react vigorously with oxidizing materials.
Stability: Stable.

TABLE A. 1 (cont'd)

Environment

Water: Prevent entry into water intakes and waterways. Harmful to aquatic life. Fish toxicity: 90 ppm/24 h/juvenile American shad/TLm/freshwater; 91 mg/L/24 h/juvenile American shad/TLm/saltwater; 5 to 40 ppm/96 h/rainbow trout/TLm/freshwater; BOD: 8%, 5 days.
Land-Air: No information
Food Chain Concentration Potential: None.

EMERGENCY MEASURES

Special Hazards

FLAMMABLE.

Immediate Responses

Keep non-involved people away from spill site. Issue warnings. "FLAMMABLE". Call Fire Department. Eliminate all sources of ignition. Notify manufacturer. Dike to prevent runoff. Shut off leak, if safe to do so. Notify environmental authorities.

Protective Clothing and Equipment

Protective clothing as required.

Fire and Explosion

Use foam, dry chemical or carbon dioxide to extinguish. Water may be ineffective and cause fire to spread, but may be used to cool fire-exposed containers. Flashback may occur along vapour trail.

First Aid

Move victim, out of spill area to fresh air. Call for medical assistance, but start first aid at once. Inhalation: If breathing has stopped give artificial respiration; if laboured, give oxygen. ingestion: give water to conscious victim to drink; do not induce vomiting. Contact: skin - remove contain inated clothing and wash affected areas with plenty of warm water; eyes - irrigate with plenty of water. If medical assistance is not immediately available, transport victim to hospital, doctor or clinic.

ENVIRONMENTAL PROTECTION MEASURES

Response

Water

1. Stop or reduce discharge if safe to do so.
2. Contact manufacturer or supplier for advice.
3. If possible, contain discharge by booming
4. If floating, skim and remove
5. Notify environmental authorities to discuss disposal and cleanup of contaminated materials.

Land-Air

1. Stop or reduce discharge if safe to do so.
2. Contact manufacturer or supplier for advice.
3. Contain spill by diking with earth or other barrier.
4. Remove material with pumps and vacuum equipment and place in appropirate containers
5. Adsorb residual liquid on natural or synthetic sorbents.
6. Remove contaminated soil for disposal.
7. Notify environmental authorities to discuss disposal and cleanup of contaminated materials.

Disposal

1. Contact manufacturer or supplier for advice on disposal.
2. Contact environmental authorities for advice on disposal.
3. Incinerate (approval of environmental authorities required).

A.2 Public Safety Considerations

The safety of curious on-lookers, concerned citizens or others not directly involved with the response action must be ensured. Keep them at a safe distance. Some factors that may help determine the required safe distance are:

- the area needed to permit the movement of the response team;
- the area covered by product; and
- the possibility of wind carrying flammable or toxic vapours.

Discourage volunteers from assisting in the cleanup operations unless their safety is ensured; they may not have the proper training or clothing.

A.3 Personal Safety Considerations

No matter how severe the situation becomes, it is vital that the personnel be protected from the working environment by having the knowledge and skills necessary to protect themselves.

The following information is by no means complete, but serves only to point out some of the more obvious safety precautions.

- Wear appropriate protective clothing.
- Warm clothing and food supplies should always be kept at the spill site if long hours of work are going to be required.
- Wear clothing properly. Tuck pantlegs into boots to prevent tripping and avoid torn or ragged clothing, loose clothing, neckties and finger rings.
- Lift objects by using leg muscles rather than back muscles. Keep back straight and bend knees. If necessary get help.
- Avoid getting chemicals on skin. Use plenty of water to wash.

A.4 Rescue And First Aid

- Have a good working knowledge of rescue and first aid procedures.
- Use approved breathing apparatus if you suspect the presence of poisonous or asphyxiating gases.
- Always have a fully-stocked first aid kit on hand for all spill response operations.

- Develop a first aid record book for recording injuries. Emergency telephone numbers should be on hand.

First aid care can reduce the potential for infection from cuts and prevent shock or unnecessary loss of blood if an accident occurs.

The following general procedures should be followed when rescuing or reviving a spill victim:

- Wear a breathing apparatus if dangerous gases are suspected.
- Remove the victim immediately to a safe area with fresh air.
- Keep the victim at rest and give oxygen if it is available.
- If the victim is not breathing, start mouth-to-mouth artificial respiration immediately.
- If the victim's mouth is contaminated with the spilled material, either clean his/her mouth or cover it with a piece of gauze to protect yourself from the spilled product.
- If oil or other material is lodged in the victim's mouth, remove it.
- If the victim has been contaminated with the spilled material, wash him/her with soap and water.
- Check the victim's eyes carefully for possible contamination. If spilled material has entered his/her eyes, wash them thoroughly with clear water.
- Call an ambulance or the fire department for a respirator and transportation to a hospital and consult medical personnel.

A.5 Fire Control

Many petroleum products are very flammable and must be handled properly. The following are some immediate considerations when working with flammable products:

- Spill teams must be advised of the product's flammability.
- If in doubt about the flammability of a product, assume it is and act accordingly.
- Do not attempt to extinguish large fires with portable fire extinguishers; retreat upwind to a safe position.

The following actions will help prevent, control or extinguish a fire:

- Eliminate all possible sources of ignition;
- Eliminate oxygen - cover with sand, tarpaulins, wet blankets or inert gases such as CO_2.
- Eliminate the fuel supply - close open valves, remove fuel source.
- Cool or eliminate the heat source - use water to cool tanks. Foam is the most effective means of controlling large petroleum fires.

A.6 Hazards In Confined Areas

Many petroleum product vapours are heavier than air; therefore, they tend to flow and accumulate in low places such as holes, pits, trenches, basements, inside dykes or under piers or wharfs. People entering such areas without the appropriate personal protective equipment are highly at risk due to the toxic nature of the vapour or because the atmosphere has become deficient of oxygen.

The immediate action upon determining the presence of a toxic or hazardous gas in a confined area is to:

- Seal off the area.
- Eliminate ignition sources.
- Ventilate the area.

A.7 Site Specific Factors

Local conditions may either intensify or reduce the hazards associated with a spilled product. Such factors as discussed below may impose additional restrictions to the response action.

Weather

- Wind increases dispersal of vapours and toxic gases and restricts access downwind. Approach an accident scene from upwind, but be aware that wind direction can change.
- Rain or snow can dilute materials, cool potential reactants and suppress wind dispersion of vapours. Rain can create slippery conditions, disperse product into the environment.

- High temperatures can increase volatilization, chemical reaction rates, and the risk of explosion. Low temperatures can increase viscosity of liquids and slow reactions.
- Winter conditions require warm clothing and can cause frostbite or exposure problems.
- Equipment is subject to freezing and malfunction at very low temperatures. Under extreme conditions, equipment should be left running. Respiration units may malfunction due to regulator or exhalation valve icing, especially if left at ambient temperatures between uses.
- Ice thickness must be tested for support of equipment and machinery.

Wreckage Litter

- Exercise care around torn and twisted metal to avoid tearing or cutting protective clothing or snagging breathing apparatus hoses.
- Cuts or lacerations can be infected with product and lead to systemic poisoning.

Miscellaneous

- Downed power lines can cause fires, explosions or shock hazards.
- High speed traffic, swift currents, thin ice, etc., are other Possible hazards.

APPENDIX B

PROPERTIES AND HAZARDS
PETROLEUM PRODUCTS

APPENDIX B

PROPERTIES AND HAZARDS OF PETROLEUM PRODUCTS

The hazardous quality of certain products results from the interaction of these materials with man and the environment in three basic ways:

- the properties of the material may render it toxic;
- the material may be highly reactive with other materials; and
- the spill material may be flammable when exposed to ambient conditions.

This section discusses these three properties of hazardous materials.

B.1 Toxicity

The toxicity of a substance refers to its ability to produce injury or damage to a living organism. In terms of their effects on humans, the relative hazards of a substance are described as:

- Unknown - used when there is no information available.
- Non-toxic - assigned to materials which cause no harm under conditions of normal use.
- Slightly toxic - substances which can produce changes in the human body but which will disappear (with or without medical treatment) after exposure is stopped.
- Moderately toxic - material which may produce irreversible or reversible changes to the human body - but which will not threaten life or produce serious permanent physical impairment.
- Highly toxic - can threaten life or cause permanent physical damage.
- Toxic - assigned to those chemicals which have insufficient data to rate them more accurately. They should be assumed to be "highly toxic" without more information.

Toxicity of materials within each of these relative hazard ratings is often described in terms of the duration of exposure and number of exposures required to produce the toxic effects.

- Acute -- exposure in seconds, minutes or hours, in one or a few doses.
- Subacute -- exposure of up to 90 days, in several doses.
- Chronic -- prolonged exposure with absorption or inhalation into the body.

Some substances may produce chronic illness or effects even though the exposure was acute.

The toxic effects of hazardous materials are often subdivided on the basis of the site of action in or on the body.

- Local effect -- indicates the point of action occurs at the point of contact. This may be the skin, mucous membranes, eyes or other areas.
- Systemic effect -- indicates the point of action is at a location other than the site of contact.

The main factors used in evaluating the toxic effect of a hazardous material to an individual are dosage and route of exposure. Each individual may have a different response to a hazardous material depending on his or her physical condition and susceptibility. The response may be immediate or arise slowly through the material or substance having accumulated or persisted in the body.

B.2 Dosage

Threshold Limit Value

The threshold limit value (TLV) represents the maximum concentration to which most workers can be repeatedly exposed to durinq a 40 hour week without adverse affect. The values are applicable to conditions of low concentrations exposed to over a prolonged period of time and have limited application to brief exposure, high concentration situations often encountered at a spill site. The TLV does, however, assist to indicate the relative toxicities of the rated material; the lower the TLV, the higher the toxicity.

A TLV has been assigned to many substances but not all. When absent, this may indicate that information on its toxicity is not available and not that the substance is non-toxic. If unsure of a substance's toxicity, assume it is toxic and take appropriate precautionary measures until informed otherwise.

Lethal Dose 50 and Lethal Concentration 50 Values

Lethal dose 50 value (LD_{50}) is the acute lethal dose required to kill 50% of a population of lab animals. The LD50 value is expressed as either oral (ingestion) or a dermal (skin contact) dose.

Lethal concentration 50 (LC_{50}) value is the acute lethal concentration in air required to kill 50% of a population of lab animals who inhale it into their lungs.

A low LD_{50} or LC_{50} value indicates high toxicity.

Individual Susceptibility

Individuals respond differently to potentially harmful substances. Effects will depend on age, sex, weight, general physical condition, and the intake of other medication.

Cumulative Effects

Some toxic materials may be retained or built up in the body depending on the level and duration of exposure. Clean up of materials with this potential should be considered in terms of repeated exposure to them.

B.3 **Routes of Exposure**

The routes of exposure to toxic materials are through inhalation, ingestion or penetration of the skin or mucous membranes and are a function of the physical state and properties of the material spilled.

Inhalation

Inhalation is a common route of exposure in spill situations involving volatile products and the actual hazard is often underestimated. Extremely low concentrations of some vapours and gases can be rapidly absorbed by the lungs and may result in severe injury or death.

Skin Penetration

Relatively few substances are absorbed in dangerous amounts through the skin and its film of oils and sweat if the skin is intact (no cuts or scrapes). Open wounds greatly reduce the effectiveness of skin as a barrier.

Contact with some solvents, such as gasoline, may cause skin rash and associated itching, burning, cracking and possible secondary infection by destruction of skin proteins. it is best to minimize skin contact with those materials.

Ingestion

Poisoning may occur through ingestion of contaminated drinking water supplies or foodstuffs, failure to wash hands thoroughly before eating, or swallowing inhaled toxic particles. The practice of common sense and normal hygiene will minimize exposure by this route.

B.4 Flammability

Each flammable substance has concentrations of its vapour in air above or below which it will not burn. The minimum concentration of a flammable vapour which will allow ignition is the Lower Flammable Limit (LFL) and the maximum concentration which will still ignite is the Upper Flammable Limit (UFL). The difference between the two is the flammable range. These limits are also called the Lower and Upper Explosive Limits (LEL and UEL).

A flammable gas-air mixture below its LFL is too lean to burn, while one above its UFL is too rich; dangerous gases are those with a low LFL and a wide flammable range.

LFL and UFL concentrations are given in % of gas in air by volume.

° Examples:

Gasoline	1.4 - 7.6%
Propane	2.1 - 9.5%
Acetylene	2.5 - 82.0%

B.5 Flash Point - Fire Point

The lowest temperature at which a flammable liquid will vapourize to form a flammable mixture with air is known as the flash point. The Flash Point is that temperature at which ignition first occurs but combustion (burning) is not continuous.

Substances are classified as combustible if their flash points are between 38°C-93°C (100"F - 200°F) and flammable if below 38°C (100"F).

Examples:

Gasoline	-43°C
Propane	-104"C
Acetylene	-17.8°C

As a liquid is heated above its flash point a temperature is reached at which enough vapour is given off for sustained combustion. This temperature is known as the Fire Point and is usually 15 - 25°C (30 - 50°F) above the flash point. At still higher temperatures and in the absence of sources of ignition, a value is reached at which the vapour spontaneously ignites. This is called the Auto-ignition Temperature, or simply the Ignition Temperature. Example: gasoline 280°C.

APPENDIX C

CASE STUDIES

APPENDIX C

CASE STUDIES

C.1 Heating Fuel Spill - Frobisher Bay

On May 22nd, 1984, heating fuel was observed in a drainage ditch in the Iqaluit area of Frobisher Bay. The fuel was migrating along a roadside drainage ditch and eventually could have entered a stream which lead to the ocean.

The source of the leak was located, excavated and repaired by Baffin Building Systems on May 23rd. Investigation revealed that the leak had originated from a fitting leak in an underground pipe leading from an aboveground storage tank. 9000 litres of heating fuel were estimated to have leaked from the fitting prior to its repair.

The N.W.T. Housing Corporation, after discussions with Renewable Resources, agreed to proceed with a cleanup on May 23rd and clean-up plans were prepared. The Town was to use one of their sewage trucks to remove the pooled heating fuel for disposal. The Ministry of Transport was to assist by providing a dump site where disposal by open burning could take place. There was, however, a delay in the sewage truck arriving at the site. On the evening of May 23rd, the fire department took action without consultation with other parties. Several thousand gallons of water was used to flush the heating oil from around houses in the area. Heating oil was now running down the drainage ditch and onto the sea ice of Koojesse Inlet.

Immediate action was now required. Renewable Resources requested the involvement of the Regional Emergency Response Committee to act as a coordinating force. This action mobilized the resources of local, Territorial and Federal government departments.

Once initiated, the response and clean-up actions consisted of:

- establishing a command post for effective communications and coordination of response actions.
- making arrangements with local town officials and industry for procuring equipment (vacuum truck, loader, dump truck, backhoe etc), materials (commercial sorbents, sorbent booms), men, and arranging for disposal of the recovered fuel.

- constructing a containment dyke (using sand, plywood and PI astic) at the spill location;
- digging a ditch at the spill location to direct the mixture of oil and water into one area in order for peat moss and commercial sorbents to soak up the fuel ;
- building a dyke at the drainage ditch at the main culvert just above the stream entrance;
- placing sorbent booms on the shore ice to contain the fuel and prevent it from reaching the open water;
- placing sorbent materials (snow, earth, peat moss, commercial sorbents) at the fuel concentration sites (eg. at berms and barriers);
- digginq a hole at the spill site to collect oil and allow the sewage truck to draw off the fuel; and
- removing contaminated soil, snow and sorbents from the areas for disposal;

Although response and cleanup was effective once begun, several factors contributed to the fuel spillage and subsequent drainage to the stream and ocean. - Regular monitoring of fuel levels in the storage tank and monitoring the rate of fuel consumption would have led to early detection of the leak. A lack of communications existed between the parties involved which resulted in the fire department's actions.

C.2 Diesel Fuel Spill - Ingraham Trail (North of Yellowknife)

On April 6th, 1984, the fifth wheel of a tanker carrying 30,800 litres of diesel fuel separated from the truck. The separated trailer ran into a roadside ditch, overturned and fuel leaked from the hatch covers. An estimated 15,900 litres of fuel escaped before the tanker could be turned upright.

The RCMPolice were immediately contacted by the trucking company personnel. They arrived on the scene shortly thereafter and then contacted the Pollution Control Division of the Government of the NWT. Government of the NWT representatives arriving upon the scene reported that the following actions had already been taken by the trucking company personnel:

- A front end loader, empty pump off tanker, portable centrifugal trash pump and six trucking company personnel were at the spill site.

- A snow trench lined with the polyethylene had been constructed under the middle four hatch covers. The rear hatch cover was not leaking but the front cover was leaking slightly. Limited quantity of polyethylene did not allow for catching the front leak.

Spilled diesel was collecting at the bottom of a slope in the ditch approximately 30 metres from the overturned tanker. A drainage ditch perpendicular to the road led southward into a swamp area. Diesel fuel had migrated approximately 50 metres along the drainage ditch when environmental authorities arrived.

Trucking company personnel were instructed to contain the diesel fuel in the drainage ditch and to restrict its further migration. In the drainage ditch, two polyethylene lined dykes were constructed a few meters beyond the migration zone. They were approximately 2.5 metres wide, 0.5 metres high, 2 metres apart along the ditch and constructed with a 0.3 metre toe.

In the meantime, an attempt was made to pump off the remaining fuel using the portable centrifugal pump, but it could not be made to operate. A second pump had to be sent for to remove the rest of the diesel fuel. The diesel fuel was pumped off and the truck was turned upright and removed.

Once the tanker had been cleared away, on site burning of the spilled diesel was started. This resulted in fuel and meltwater overcoming the snow dikes in the drainage ditch and migrating to the swamp.

Following the burn, diesel fuel was observed seeping from the roadside ditch and walls of the drainage ditch towards the swamp. Commercial sorbent was placed *in* the drainage ditch to remove fuel from the runoff water's surface. Also, twig dykes were constructed in the drainage ditch. Once ignited, these twig dykes visibly delayed the passage of diesel and residue and acted as burning wicks to burn the collected material.

Diesel fuel and residue was recovered from the swamp surface by sweeping the surface with absorbent material and by manual skimming. Cleanup of the spill site continued for approximately one month.

Although the response actions undoubtedly prevented some diesel fuel from entering the swamp, preplanning and alternative actions would have increased the efficiency of the overall cleanup activity.

- The operating condition of the centrifugal pump was unknown prior to useage. The additional time required to obtain a second pump resulted in unnecessary diesel fuel leaking from the tanker.
- Allowance should have been made in the drainage ditch dyke construction for meltwater from the burning operations. Alternatives to on-site burning (eg. mechanical or suction removal) should have been considered.
- Construction of by-pass or underflow dams in the drainage ditch would have increased diesel and residue collection efficiency.

C.3 Gasoline Spill - Yellowknife

On December 5th, 1985, a B-train tanker truck containing 47,000 litres of unleaded gasoline was traveling through an industrial area of Yellowknife when it stopped for a vehicle on the road. In an attempt to move around the vehicle, the truck drove toward the side of the road, the roadside bank gave away and the truck rolled onto its side. Gasoline started to spill from the hatch covers into the ditch.

The RCMP, local fire department and the 24-hour spill report line were immediately contacted. GNWT environmental representatives arriving upon the scene reported that the RCMP, fire department and spill response crew and equipment were present. Response equipment consisted of two front end loaders, an empty pumpoff tanker, pump and hoses, roll of polyethylene, hatch cone covers and assorted hand tools.

Prior to transfer of gasoline to the waiting tanker, both tankers were grounded to eliminate build up of electrical charges and the fire department was prepared with foam fire suppressant. Hatch cone covers were utilized to reduce spillage from the hatch covers during pumpoff. They were also utilized to stop spillage from hatch covers which continued to leak after attempts were made to close them. A polyethylene lined trench was constructed underneath the leaking hatch covers of the front tanker. Approximately 450 litres of gasoline was collected in the polyethylene lined trench and transferred to the waiting tanker.

Once offloading of the gasoline was completed, the tanker was righted and a front end loader proceeded to remove contaminated snow from the ditch. According to metered estimates, 740 litres of gasoline was spilled.

This accident could have been avoided by 'the driver having the patience to wait for the stopped vehicle to move. Response was, however, prompt and carried out in a safe manner. The response crew was trained in spill response and had ready access to response equipment. A minimum of product was spilled with the result being minimal threat to public safety or the environment.

C.4 Hydrochloric Acid Spill - Norman Wells

On July 31, 1984 a loader was workina within the hydrochloric acid bulk storage facility dyked compound of Dowell Chemical at Norman Wells. The loader backed into one of the storage tanks, punctured it and 85 barrels of 34% hydrochloric acid were discharged onto the ground.

The bulk storage facility is located east of the Townsite. The facility is surrounded by chain-link fencing with offices and storage sheds within the fenced compound. A compacted clay core dyke surrounds the storage tanks on three sides with the fourth uphill side having no dyke.

Immediately after the discharge of acid began, the loader operator notified the facility manager that a spill had occured. The manager directed all unauthorized and untrained people to stay away from the area, the containment dyke be inspected to ensure impermeability and initiated the emergency response plan. A spill report was filled out and the 24 hour spill report line contacted.

A soda ash solution (a base) was prepared by Dowell Chemical staff and added to the spilled acid to neutralize the solution. A vacuum truck subsequently pumped out the neutralized chemical and disposed of it at a nearby disposal injection well.

A satisfactory resolution to what could have been a serious problem was achieved by the company maintaining an effective emergency response plan and suitable response equipment and neutralizing chemicals on site. Facility pre-planning (eg. construction of a suitable containment compound) resulted in a minimum of environmental damage occuring.

C.5 SODIUM FLUORIDE SPILL - FORT SMITH

A shipment of 14 bags of granulated sodium fluoride (NaF) was being delivered to the water treatment plant in Fort Smith on June 18, 1981. During the delivery, a bag fell out of the back of the truck and onto the road. The bag was broken

broken open by vehicle traffic and the material spread over a small area of road surface. The missing bag was not noticed by either the driver or the receiver when the load was delivered. Sodium fluoride is used to fluoridate domestic drinking water supplies.

A local resident collected and disposed of most of the spilled material into the garbage. On June 22nd, some children were playing in the affected area when a two-year-old boy apparently consumed some of the spilled material, the child was taken to hospital later that day after violent vomiting had started. The child died that night after being wrongly treated as having eaten calcium chloride, a chemical used on roads for dust suppression.

The bag of sodium fluoride was labelled :Harmful - Keep Away from Food Stuffs" but was not label led "poisonous". Laws existing at the time did not require hazardous labelling of sodium fluoride during road transportation.

This fatal incident was the result of oversights and carelessness on the part of persons involved. The driver of the truck should have ensured that the load was secured to avoid shifting and loss of product during transport. The loss of the bag should have been realized by either the driver or receiver by careful examination of the shipping and purchase documents. Although the local resident believed he was assisting the situation, he acted without identifying the product . Identification would have ensured that clean-up was completed and would have assisted medical staff during treatment of the child. Any of these actions would have avoided this tragedy.

C.6 Heating Oil Spill - Rankin Inlet

A three-year modification and upgrading of the bulk fuel storage facility at Rankin Inlet began in 1986. By the summer of 1987, the contractor and consultant had lined and seamed half of the compound and completed some of the berm construction.

To allow testing of a tank, the P-50 stove oil had to be transferred to another tank. On August 3rd, the transfer began and continued through the night. During the operation, at approximately 2:00 a.m., the receiving tank was overfilled, resulting in a spill estimated by the contractor to be 1,000 -- 5,000 litres. This initial estimate seemed reasonable as there was little oil visible on the ground and no sign of seepage through the berms; however, subsequent measuring of the fuel in the tanks revealed a loss of 46,000 litres.

Clean-up operations began and the contaminated soil was removed. A sump was installed to intercept migrating fuel. Unseamed liner was removed to allow evaporation of the lighter fractions. A decision was made to bring in an environmental consultant to advise and direct the clean-up operations.

Following extensive investigation, the consultant determined the fuel flowed off the lined portion of the compound and onto the unlined sandfill which it infiltrated. The fuel had migrated beyond the bermed compound. More contaminated soil was removed to the landfill site where unsuccessful attempts were made to burn off the fuel. Recovery wells were constructed and operated until freeze-up to intercept and recover the fuel from the subsurface soil. To date, 7,000 litres have been recovered and an estimated 8,500 litres collected with the excavated soil.

Factors contributing to the spill included:

- The tank being emptied contained approximately 2,200,000 litres whereas the receiving tank had a 1,300,000 litre capacity;
- Transfer operations continued throughout the night with the contractor's foreman on site. The foreman was sleeping in his truck during the transfer, using an alarm clock to wake himself periodically to check the tanks. On his last check before the spill, he estimated one hour of pumping was required to fill the receiving tank. He set his alarm for 40 minutes, but when he awoke, he found the tank overflowing.

C.7 Heating Oil Spill - Chesterfield Inlet

On June 30, 1987, a spill of P-50 heating fuel occurred at the Chesterfield Inlet bulk fuel storage facility. A common practice had been to stand on a 25 mm bypass/relief line in order to reach a main valve. The repeated stress eventually caused the line to break, resulting in a spill of 330,000 litres of fuel. At the time, there was approximately 0.3 metres of water in the bottom of the compound. The volume of product involved and the presence of the water caused some of the lost product to overflow the liner at one corner of the compound. The fuel migrated to a nearby lake and rendered the water, normally used for wash water, unfit for a period of time. Although the compound liner was 20 years old, its integrity did not suffer as a result of contact with the fuel. There was no loss through the berm. Approximately 300,000 litres were recovered by pumping product from inside the berm back to the tanks.

Factors contributing to the spill included:

- The poor practice of standing on the relief line, thereby stressinq it and eventually causing its failure.
- Maintenance of the facility should have included the pumpinq out of melt-water in the spring. The berm was unable to contain the entire spill as the volume of the berm had been significantly reduced by the water. As a result, an overflow of the liner occurred. Fortunately, the majority of the fuel was contained due to the integrity of the liner, therby avoiding a potentially disastrous spill.

APPENDIX D

ENVIRONMENTAL EFFECTS OF PETROLEUM ON PLANTS, ANIMALS AND MAN

ENVIRONMENTAL EFFECTS OF PETROLEUM ON PLANTS, ANIMALS AND MAN

D.1 INTRODUCTION

The effects of a spill of petroleum on the environment are varied and depend on:

° the type of plant or organism present and their behavior patterns;

° the type of crude oil or oil product spilled;

° the topography and geology of the area; and

° the season of the year.

D.2 EFFECTS ON PLANTS AND ANIMALS

The fluidity of water favours the transport of spilled petroleum over a larger area than does land spills. **Once a spill reaches a water course it is difficult to contain; if the petroleum has a specific gravity greater than one (by the weathering process), containment may be impossible.**

The following categories outline the consequences of oil pollution.

D.2.1 Systemic Poisoning

Lighter hydrocarbons are relatively poisonous to many forms of animal life when swallowed or absorbed through the skin. Toxicity increases in this-order: paraffins, naphthenes, olefins, aromatics. Generally, the heavier hydrocarbons are not toxic, but some are cancer causing (carcinogenic). Many of the oxygen, nitrogen and sulfur derivatives of hydrocarbons are toxic, soluble in water, and can cause taste, odour and fish tainting problems.

Organisms living on or in sediments at the bottom of freshwater or marine bodies of water may be affected when oil sinks. The sediments are the final sink for most contaminants that enter the aquatic environment and once the oil reaches the sediments it may remain there for a long time, exposing organisms to a potentially chronic source of hydrocarbons.

When the tanker Torrey Canyon was wrecked off the south coast of England in 1967, massive quantities of oil dispersants were used to disperse the oil. It was found that much more marine life died from the dispersants than would have been the case if no dispersants had been used.

D.2.2 Asphyxiation

Plants and animals respire by exchanging gases across a surface; in the case of fish across gill tissue. Oil can coat this surface and block the transfer of gases which can result in death. During oil spills asphyxiation is a danger to plant life and some forms of animal life.

D.2.3 Starvation

Algae and plankton provide food for larger animals in a process which describes the food chain. Man is at the top of many food chains. Laboratory studies indicate that algae and plankton can be killed by oil films. Widespread destruction of any group of organisms may result in widespread starvation of all species higher in the food chain. Birds can be so damaged by oiling that their feeding habits are disrupted (for example, heavily oiled birds cannot fly); or they may be driven from the area where their food is located.

D.2.4 Drowning

A bird has buoyancy because of air trapped in its feathers. This air is displaced by oil and the bird sinks and drowns. Diving birds are most severely coated by oil on the water.

D.2.5 Exposure

Air trapped in fur or feathers is an excellent insulator, preserving body heat of aquatic birds and animals. When oil and water displace this air, body heat is lost so that, in cold weather, the victim dies of exposure.

D.2.6 Predators

Reduced mobility or weakness due to oiling increases creatures' vulnerability to predators.

D.2.7 Stress

Oil damages skin, eyes and nasal passages of animals, causing stress and decreasing their ability to avoid predators. Stress leads to internal infection and shock; death usually follows.

D.2.8 Rehabilitation and Recovery

Efforts have been made to clean and rehabilitate severely oiled birds, but few of the treated birds survive. They usually die of stress.

Contaminated areas will gradually recover, but oil can persist for many years in sediments and marshes making complete recovery a slow process. When annual temperatures are low, as in the N.W.T., recovery time could run to a hundred years or more and irreversible damage is possible.

The following points should be borne in mind when treating oiled animals:

- If any wildlife is affected by a spill, the Renewable Resource Officer should be notified;
- Animals killed by the spill should be collected and destroyed to prevent other animals from eating the contaminated organisms;
- Personnel engaged in gathering the affected animals should remain between the slick and the animals to avoid driving them into the affected areas;
- Gravel bars should be especially protected because they are fish spawning areas;
- Treatment of oil-soaked waterfowl should be carried out by government or wildlife authorities who are familiar with proper procedures; do not use ordinary detergent to clean birds;
- If an oil spill occurs in an area of high waterfowl population, steps should be taken to scare the birds away until the spill can be cleaned up.

D.3 EFFECTS ON MAN

D.3.1 Food

Adult fish are generally not affected by the heavy ends of crude oil, but their rate of reproduction and growth can be reduced. Gasoline, diesel and the light ends of crude oils may be directly toxic. Fishing gear may be fouled. Fish flesh can be sufficiently tainted as to be unmarketable. Extensive damage may be inflicted on shellfish, mussels and shrimps and have serious economic consequences for commercial fishermen.

Dangerous hydrocarbons may be introduced into the food chain and be potential sources of cancer.

D.3.2 Water Supplies

Inland spills on the ground can penetrate to the water table where the oil may be carried to surrounding springs and wells. Many soils in the north are particularly conducive to rapid pollutant migration. Petroleum products may penetrate to the top of the permafrost layer and migrate along the surface to watercourses or groundwater sources. Domestic water supplies are very sensitive to oil spills because of odour and taste problems associated with petroleum.