7. RIVER RESPONSE

Spill prevention is paramount to environmental management for this Project. Prevention and mitigation measures planned for the project include: pipelines burial depths greater than 2 m below stream crossings, 24-hour manned automated monitoring, leak detection systems, visual monitoring, and emergency shut down systems for production, storage, and transportation systems. Spill response conexes will be pre-positioned at key stream crossings. In addition, the system will be inspected regularly by ground and aerial patrols for signs of leakage or unauthorized encroachment along the land easement that might affect overall system integrity. Other items that may require attention, such as soil erosion, water course changes, road and stream crossings, and the re-growth of brush and trees over the pipeline itself will also be monitored.

Despite best management practices an incident may occur, in which case the objective of the oil spill response is to assure that actions are compatible with the balanced environmental, social, and economic needs of the community. The response strategy includes all viable techniques to reduce damage from a spill but conducted from using NEBA principles. No oil spill response option would be ruled out or limited in advance.

This section provides an overview of containment, recovery and treatment options for a spill of oil onto streams and rivers. Site specific response strategies and tactics will be identified in each ASOSRP.

7.1. Introduction

Spills of oil to streams and rivers require immediate response action to stop the source of the discharge and to limit the spread of material. Immediate response actions and notification procedures are outlined in Section 2. Attention must be paid to fire and safety hazards. Spill response in rivers often involves the removal of slicks that have been transported downstream, sometimes for long distances. Response some distance from the release point might be required if source control operations either are not feasible or safe to conduct, particularly if there are fire and/or explosion concerns. Slicks may be contained at their source in larger coastal rivers during slack tide or very low flow conditions. In some cases, it might be possible to deploy boom downstream from transfer points to intercept slicks.

The NEBA approach (see Section 1.3.1) accepts that some cleanup or treatment responses have the potential to cause a negative impact on the environment; however, they may be justifiable because of overriding benefits, such as protecting local sensitive populations or water users, and/or the avoidance of further impact. For example, the option with the greatest net environmental benefit to protect down stream water users and aquatic habitat may be to burn oil on water and accept certain by-products of the process, such as smoke and possible loss of vegetation in a limited area, instead of opting for mechanical containment and recovery where containment may be only partially effective.

Site-Specific Conditions

There are a number of river crossings ranging from relatively small rivers, i.e., Nya and Loulé to larger, more significant rivers such as the Mbéré. The flows in the rivers vary considerably depending on the season (dry vs. wet) and there is occasional flooding. The maximum rainfall in the Chad region falls in August, and July–September are generally the wettest months of the year. In Cameroon, the Project area traverses five climatic and hydrologic regions with varying wet and dry seasons. Regionally, there is a decrease of about 46 percent in the mean annual rainfall from the coastal area near Kribi to inland areas near Meiganga. Seasonal

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rainfall, river flow rates and water levels are discussed in the EA documents developed for Chad and Cameroon. River flow and water levels are also discussed in Section 4.1.4, Fate and Effects of Spilled Oil — Rivers.

Figure 7-1. Example River Crossing

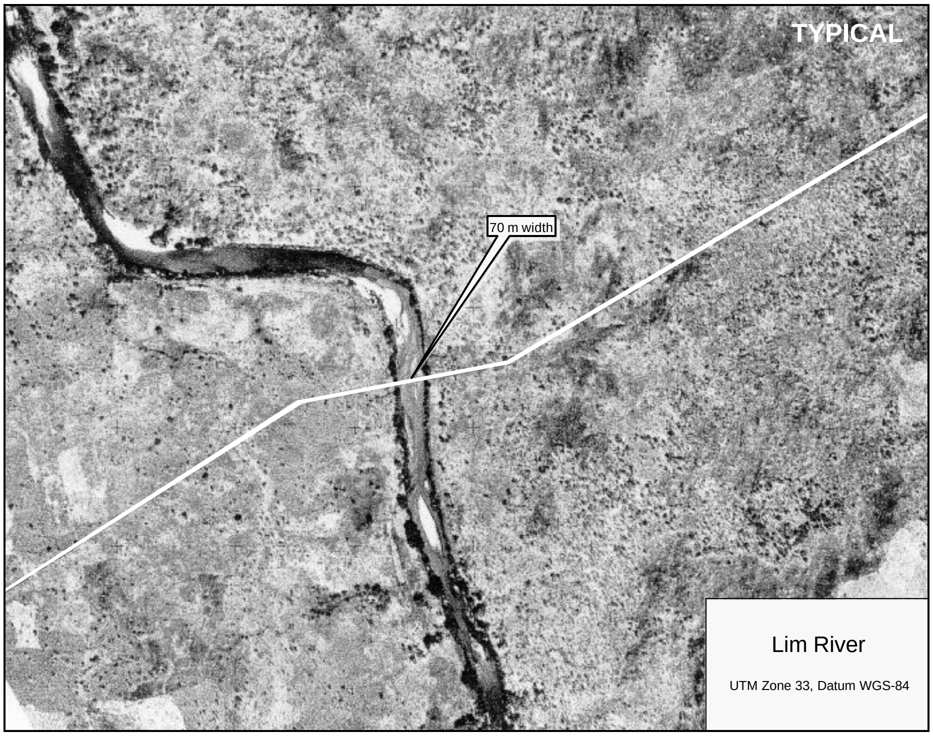


Table 7-1 lists the major river crossings where mechanical recovery or *in-situ* burning techniques might be used.

Table 7-1. Major River Crossings

River	Pipeline Kilometer
Loulé	2
Lim	140
Mbéré	178
Mbéré	324
Mba	432
Pangar	487
Mouyai	529
Lom	539
Sesse	585
Yong	608
Tede	709
Afamba	811
Nyong	907
Lokoundje	946
Mougue	994
Lokoundjé	1,007
Kienké	1,062

7.2. Assessment and Monitoring

The volume of oil spilled can be estimated using various methods, and then combining the results (see Chapter 5 for details). With possible pipeline spills into rivers, these methods include:

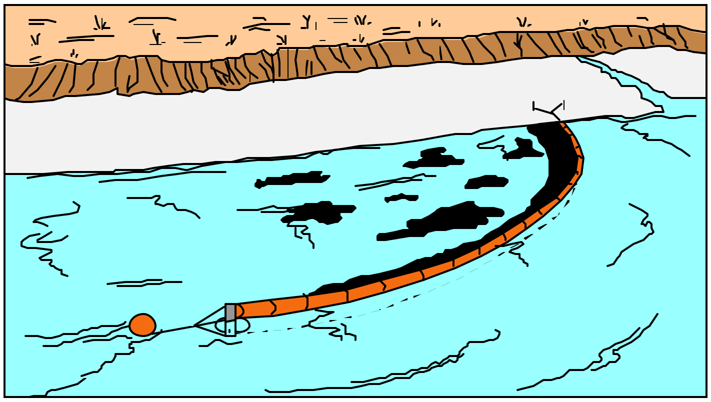
- ongoing electronic measurements of the rate of flow through a pipeline and the duration of spill before shutoff,
- the color and size of, and distance traveled by, the slick,
- correlation of slick color and thickness using ground-truthing methods, and
- surveillance of the spills from aircraft and vessels.

7.3. Containment

Various commercially available booms have been specially designed for operation in rivers. These river booms feature both top and bottom tension members that provide vertical stability (and improved oil deflection capability) in relatively high current, i.e., up to approximately 1 m/s (2 knots). They have relatively high reserve buoyancy and are fabricated from durable fabrics. Such booms can be effective in a coastal river where there is uni-directional flow. In a large coastal river with reversing tides, repositioning a boom can be difficult and time-consuming.

When current speeds exceed 0.4 m/s (0.7 knots), it is necessary to angle the boom (including river booms) to reduce the current relative to the boom (Figure 7-2; see also Table 6-6). Angling the boom also allows oil to be diverted to shore where it can be collected.

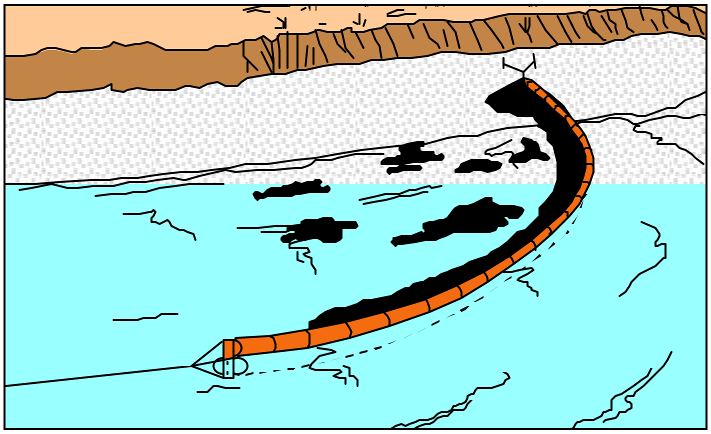
Figure 7-2. River Booming (Exxon, 1992)



Deploying angled booms might not be practical if the river is too wide to effectively divert slicks or if there is insufficient time to set up booms.

In intertidal areas, or at riverbanks where water levels may be expected to fluctuate, shore-seal booms (Figure 7-3) can be deployed to ensure that a seal is maintained at the waterline as the water level rises and falls. They can be used on mud or sand flats but do not form an effective seal on rough or rocky shorelines.

Figure 7-3. Shore-Sealing Boom Use on Rivers with Varying Water Levels (Exxon, 1992)



Shore-sealing booms function through water-filled lower and air-filled upper chambers that automatically adjust to changing water levels (see Figures 9-6 and 9-7 in Section 9, Shoreline Protection). The shore-end of the shore-seal boom is fixed while the water-end floats and is usually connected to a conventional boom.

When deploying shore-seal booms, the final position should be known before the boom is placed and anchored since redeployment is difficult, if not impossible, once the heavy water-filled chambers have settled on the shore. Also, the water chambers of the boom must be fully filled or water will collect in the lower sections leaving the more highly elevated sections (toward the shore) only partially full or empty.

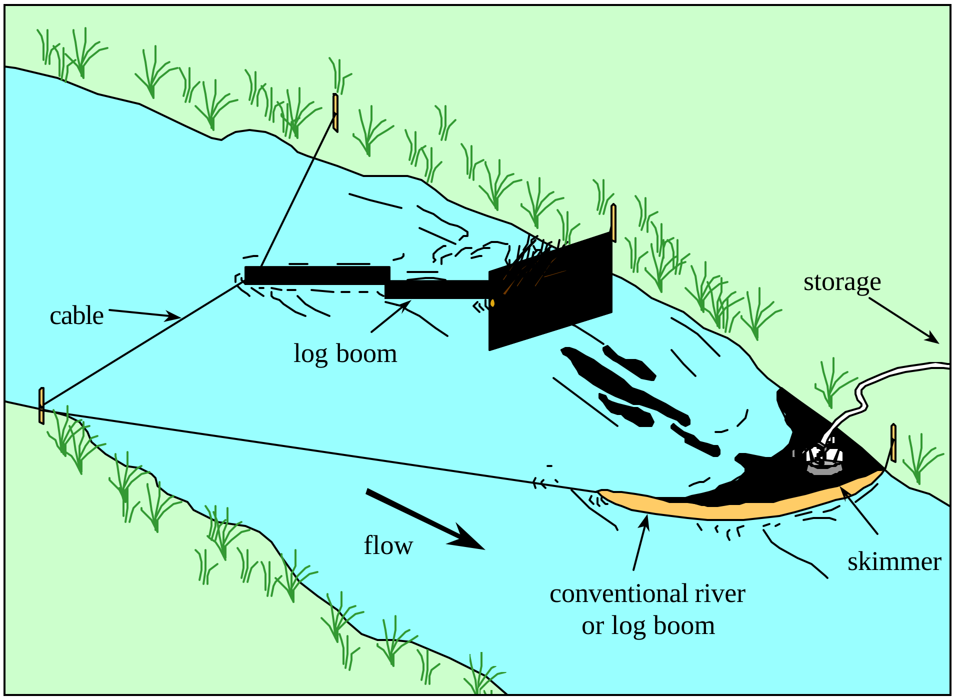
Sites with boulders, sharp protrusions, rip-rap, or other features that will puncture the boom or prevent tight sealing resulting in oil leaking under the boom when the tide changes should be avoided. Shore-sealing booms require regular monitoring once deployed since currents, wind and waves can move and/or twist them. Damage to the fabric can also result as the boom grounds and chafes in the intertidal zone.

Islands, channels and embayments can be used effectively to enhance response operations:

- Islands can act as natural barriers.
- Booms and channels can be used together to divert slicks and to protect resources.
- Oil can be directed to embayments for collection.
- Circular current patterns or eddies that commonly occur in river embayments can be used to facilitate oil collection.

Logs can also be deployed to deflect oil from an area requiring protection, or to a skimmer for concentration and recovery. They can also be used to deflect or contain debris upstream of a collection boom operation (Figure 7-4). They can be deployed either singly or in multiple patterns.

Figure 7-4. Log Boom Barrier

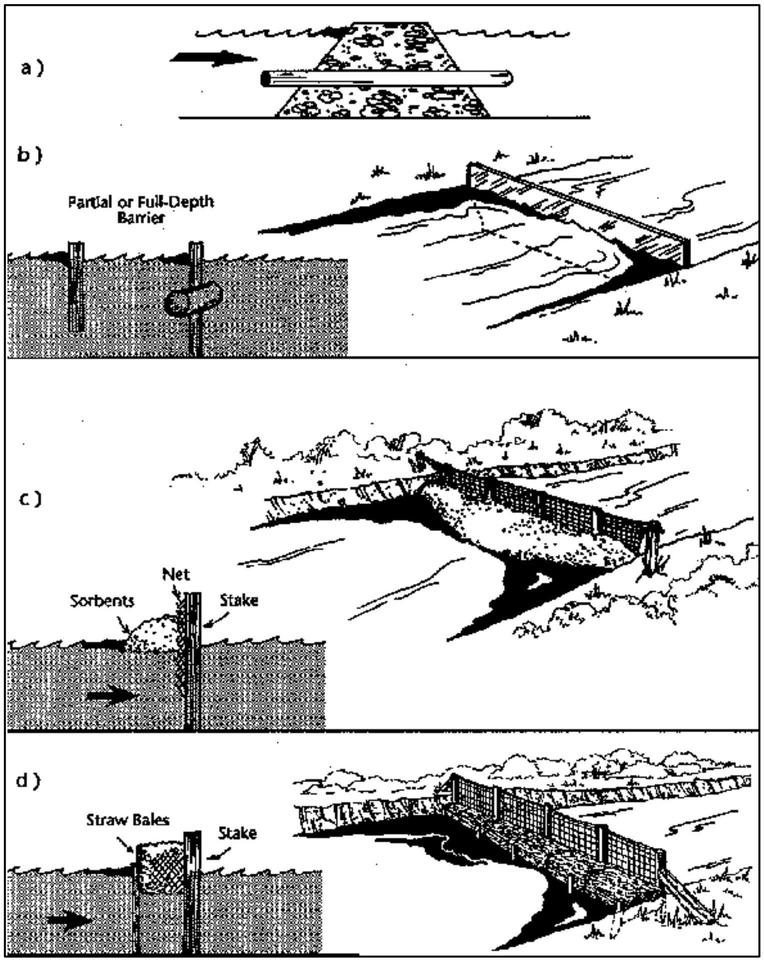


River channel barriers can also be fabricated from available materials such as boards, fencing or nets, and sorbent materials (Figure 7-5). Usually, the width and depth of the channel and the water velocity control the selection and design of practical and effective methods. The time available to deploy equipment or to construct barriers can limit the effectiveness of this approach.

In areas where river or tidal flow is not an issue, blocking a channel, canal, or ditch without culverts or pipes can result in ponding from the backup of rainfall and allowance should be made for possible flooding. Where necessary, water flow can be maintained using underwater pipes or underflow techniques (Figure 7-5a). The design of single or multiple pipes and siphons should factor in the lowest anticipated water level, flow volumes, and the potential for oil to build up against the dam and become entrained with the water that passes through the pipe system.

In intertidal channels or where water levels may change, barriers should be designed to allow for the rise and fall of the water level and for current reversal.

Figure 7-5. Channel Barriers (after CONCAWE, 1983)



7.3.1. Booming Submerged Oil

The containment, redirection and recovery of heavy, viscous oils in rivers is generally difficult because the oil can submerge and be transported along or just above the river bed.

Submerged oil cannot easily be located due to its movement and to masking by suspended sediment.

Trawl or other netting systems are sometimes used to collect submerged oil; however, nets can trap debris and are likely impractical to use in rivers. As a result, these booms have a low probability of efficient oil capture of spills originating from pipelines that reach river systems in Chad or Cameroon.

7.3.2. Wet Season Response

Priority response operations during the wet season may require a combination of channelized river response techniques described in the section as well as techniques conventionally used for on-land response (see Section 8). Containment in shallow water settings will be possible through the construction of berms and barriers placed at strategic locations where access allows. Deeper water operations may utilize combinations of barriers and boom to redirect oil to recovery sites. Concentrated oil will be removed using small skimmers. *In-situ* burning may be an option for those areas that are flooded, have restricted access, and where there is minimal tree cover.

Higher water levels or flood conditions also may increase the amount of logs and debris flowing downstream that could interfere with containment boom and barrier operations.

7.3.3. Dry Season Response

During the dry season, river water levels and flow rates would generally be lower allowing more time to implement control operations. Containment in shallow water settings will be possible through the construction of berms, dams and barriers placed at strategic locations where access allows. Berms and dams can be easily constructed using earth-moving equipment. With lower flow rates, channel-blocking techniques would be more viable.

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Figure 7-6. **Decision Guide for Inland Water Containment Techniques (modified from Exxon, 1992)**

Type of Water Body			
Lake or Pond (see Section 6)	Amount of Oil Contamination	Minor sheen	Sorbent Booming
		Moderate to major visible slick	Containment Booming
Rivers or Large Streams greater than ½ meter deep	Water Current Speed	Less than 0.5 m/s (1 knot)	Containment Booming or Exclusion Booming
		Between 0.5 and 1 m/s (1 and 2 knots)	Single Diversion Boom
		Greater than 1 m/s (2 knots)*	Multiple Cascading Diversion Booms
Small Streams less than 10 meters wide and greater than ½ meter deep	Water Current Speed	Less than 0.5 m/s (1 knot)	Sorbent Barrier or Containment Booming
		Between 0.5 and 1 m/s (1 and 2 knots)	Single Diversion Boom
		Greater than 1 m/s (2 knots)*	Multiple Cascading Diversion Booms
Shallow Rivers or Streams less than ½ meter deep			Barriers, Berms or Dams on Stream Bed

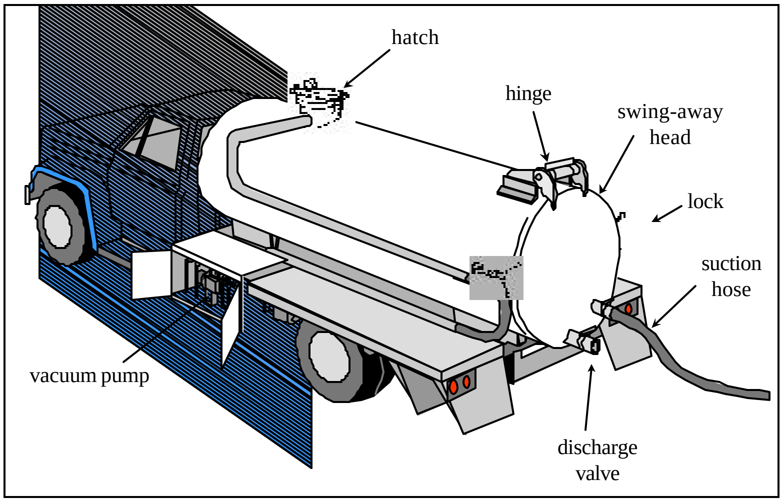
* If current speed exceeds 3 knots, booming should be attempted at an alternate location where currents are slower.

7.4. Mechanical Recovery

Mechanical recovery might be possible in areas where oil naturally accumulates or is easily diverted to a collection area with booming techniques. Such areas, e.g. back eddy and quiet water embayments, are common in meandering rivers or streams. They can also occur where a narrow channel widens or a river turns in an oxbow and currents are reduced. In some cases, such areas are also created during a spill by earthmoving equipment where the advantages of creating an oil collection point outweigh the disturbances caused by altering the terrain.

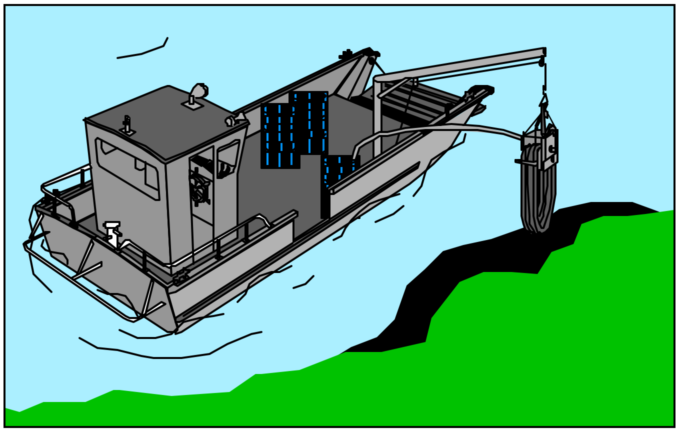
Small, oleophilic skimmers (disc, drum, brush and rope mop units) and vacuum or air conveyor trucks (see Figure 7-7) can be readily deployed from shore where there is access to a river and oil collection is possible. Floating platforms can also sometimes be used on larger rivers as operational bases from which recovery capability is deployed.

Figure 7-7. Vacuum Truck (Exxon, 1992)



Water-based working platforms, i.e., shallow-draft boats (see Figure 7-8) or barges are useful when equipment cannot be readily set up on shore.

Figure 7-8. Work Boat Deployment in a River (Chen, 1998)



7.4.1. Pumps

Pumps will be needed for spill response operations in rivers to support oil recovery, i.e., to transfer oil, water and emulsions (see also Section 6.4.2). Recovered liquids typically need to be transferred:

(1) from a skimmer to an interim storage device,

(2) from interim storage to storage/separation vessel or truck, and

(3) from vessel or truck to a final storage/disposal facility.

Preplanning the transfer of recovered oil is critical to ensure the continuity of OSR operations. Transfer equipment must be selected to suit the quantities and types of liquids being moved. Although a wide range of pumps can be used for fresh, non-emulsified oils, as oil weathers, mixes with water and becomes more viscous, transfer becomes more difficult and pump options can become limited. Careful consideration must therefore be given to each specific transfer situation, particularly in the case of long-term mechanical recovery operations when, over time, oil weathers, viscosity increases, and debris is collected.

Generally, spill cleanup does not require pumps with extreme capabilities. The head through which the pump must push liquid is usually about 2 to 6 m (6 to 20 ft) and suction lift from skimmer to pump is often much less than that (i.e., only a few feet or about a meter). In some cases a large head is required, especially when oil is pumped from a skimmer to a large, unballasted barge or storage vessel. In this case the head required may be 10 m (30 ft) or more.

Some pumps are not suitable for oil spill work for the following reasons:

- They neither self-prime nor maintain prime when the skimmer rolls.
- Suction capacity is limited.
- Pumping capacity decreases even with slight increases in oil viscosity.
- Cavitation occurs in warm or high viscosity oil.
- Emulsification of oil and water occurs.
- Debris blocks the pumping mechanism.
- Damaged is caused by running dry.

Four pumps that are both suitable and commonly used for spill cleanup are:

- centrifugal,
- peristaltic,
- screw/auger, and
- reciprocating (diaphragm).

The characteristics of these pumps are described in detail in Chapter 6.

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7.4.2. Temporary Storage

Since oil recovery operations may not be conducted near permanent waste storage facilities, temporary storage options must be considered as part of the response planning process for rivers. The type and number of storage devices required for rivers will most likely be more limited than that required for offshore operations. This will depend on the size of the spill and the expected need for mechanical recovery systems. Storage capacity may be achieved by drawing on various resources already available or by purpose-built storage units procured to meet specific needs.

Generally, storage will be required to facilitate the ongoing collection, containment and transfer of oily wastes. Two possible applications of temporary storage include:

1) Medium-capacity storage to contain liquid recovered by one or more skimmers.
2) Smaller land-based storage for collecting wastes generated from riverbank cleanup and small, land-based oil recovery operations.

Types of Temporary Storage Devices

There are many temporary storage options. Commercial products specifically designed for oil spill response are detailed in the *World Catalog*. One should also consider other general purpose devices to meet temporary storage requirements. Examples of both categories of storage devices are indicated below, and are described in detail in the *Exxon Oil Spill Response Field Manual*, 1992 (Figure 7-9).

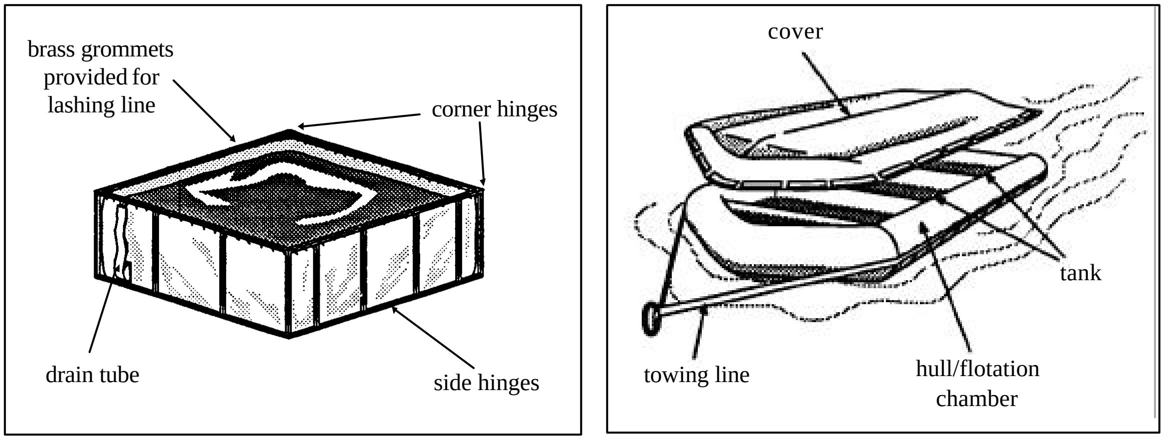
Barges — Small barges offer temporary storage capability for river and open water spill response but are sometimes difficult to procure within the first few hours of spill response. Operations will consider the pre-arranged use of various barges that can negotiate the river systems of concern.

Towable Tanks — Flexible, towable tanks are purpose-built storage units designed for small and medium size spills. They have less potential application to spills in rivers.

StationaryTanks — Typically used for on-shore temporary storage of both oily liquid and solid wastes, some stationary tanks can also be mounted on vessel decks for water-based cleanup operations. There is a wide range of options to choose from although commonly used devices include:

- Purpose-Built
  - open, (frame-based) pools
  - open, inflatable pools
  - collapsible, (pillow-type) tanks
- General Purpose
  - deck barge with deck tanks
  - 55-gal oil drums
  - vacuum or air conveyor truck
  - tank truck
  - pick-up or dump truck
  - “containers of opportunity” (e.g., livestock tanks, fish boxes, garbage skips, etc.)
  - plastic swimming pools
  - plastic trash bags or “super sacs”
  - plastic-lined earthen pit or dike

Figure 7-9. Land-Based Storage (left) and Floating Storage (right) (Chen, 1998)



Factors Affecting Storage Selection

The factors that will be considered when determining temporary storage needs are the same as those for offshore response operations listed in Section 6.5. All storage needs for spills into rivers will be determined in relation to likely cleanup sites that are associated with spill control points. Establishing storage sites near riverbanks or in floodplain areas must be considered carefully during the wet season on rivers that have the potential to flood or overflow their banks as storage devices may be swept away or storage areas flooded during high water.

7.5. In-situ Burning in Rivers

Spills into rivers might involve *in-situ* burning at downstream locations where the ignition and combustion of oil could be carried out safely, i.e., without jeopardizing population centers, facilities, forests, etc. Such locations include coves, bays, bends and other sites where spilled oil would accumulate. These locations are usually pre-designated and pre-approved for burning operations. Log boom could be deployed in a diversionary mode to deflect oil into a relatively quiet water area for ignition adjacent to the riverbank (Figure 7-10). Careful consideration must be given to the selection of burn sites that are appropriately located (including the river mouth) and to positioning personnel and equipment prior to, during, and following boom deployment and oil ignition, possibly requiring backup booming and fire-control equipment near each site.

The advantages and limitations of *in-situ* burning and basic burning theory are discussed in Section 6.7.

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Figure 7-10. *In-situ* Burning in a River