Swift Water Spill Response Guide

Good Practice Guidelines for Initial Spill Response Management and Operational Tactics

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American Petroleum Institute

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Introduction

This field operations guide is not an educational or decision-making tool. This guide contains a set of operational tools and references to assist in the response to spilled oils on inland swift waters, which are waters traveling at speeds greater than 2.5 mph.

Priorities for oil spill response:

— people—safety of response personnel and the public;

— environment—prevention of environmental, human health, and welfare effects;

— assets—minimizing damage to structures and equipment.

People

Responder safety and health should never be compromised for tactical considerations. Likewise, swift water spill response (SWSR) should be conducted to maximize safety around water and health impacts to responders, the public, and the surrounding areas of a spill.

Intended Audience

This guide is intended for experienced response operations personnel having basic knowledge in spill response. For general guidance on spill response, it is encouraged that you review basic spill response materials prior to utilizing this guide. The functionality of this guide is designed to be a personal walkthrough geared towards an understanding of the necessary response tactics and consequences of swift water spill response.

How to Use This Field Guide

A decision to use SWSR with appropriate local, state, and/or federal approvals should already have been made before field operations commence.

Operations managers should use this guide to develop timely plans, brief personnel, and manage operations. Environmental staff should ensure that operational plans conform to any permission requirements or permit conditions.

The scale of the spill response and its tactics will determine the potential hazards, permissions required, operational staffing, management structure, and intensity of any air quality monitoring. This guide is intended to be incident scale-neutral.

When encountering unfamiliar terms or acronyms, please refer to Section 7, Terms and Definitions.

Swift Water Spill Response Guide

1 Safety

1.1 Safety Equipment and Personal Protective Equipment

The first priority during an emergency response is the protection of human health and safety. This applies to the responders attempting to contain the release. In the following section, we will discuss the appropriate personal protective equipment for initial responders. Most responses create a heightened sense of urgency necessary to combat and minimize the potential impact to the environment. However, it is very important that this does not create an unsafe workplace. All releases will have differing hazards associated with them, so it is vitally important to review the safety data sheets (SDS) of spilled materials to ensure responder safety. It is also important to make sure that regulatory and company standards are followed. Safety is the first priority; serious injuries and loss of life cannot be remediated.

For the purposes of this guide, we will not dissect government regulations or all hazards associated with spill response. We will cover the main and key pieces of safety equipment that all responders should be familiar with. This begins with personal protective equipment (PPE). Each operational scope will require a different combination of PPE to protect personnel. When we talk about swift water spill response (SWSR), three initial work scopes have the largest significance:

1) On-water crews: will be working from the confines of a response vessel;

2) Shoreline crews: will be spending a majority of their response time within close proximity of the watercourse;

3) Standard crew: the response team workers who will be more than 10 feet from the water.

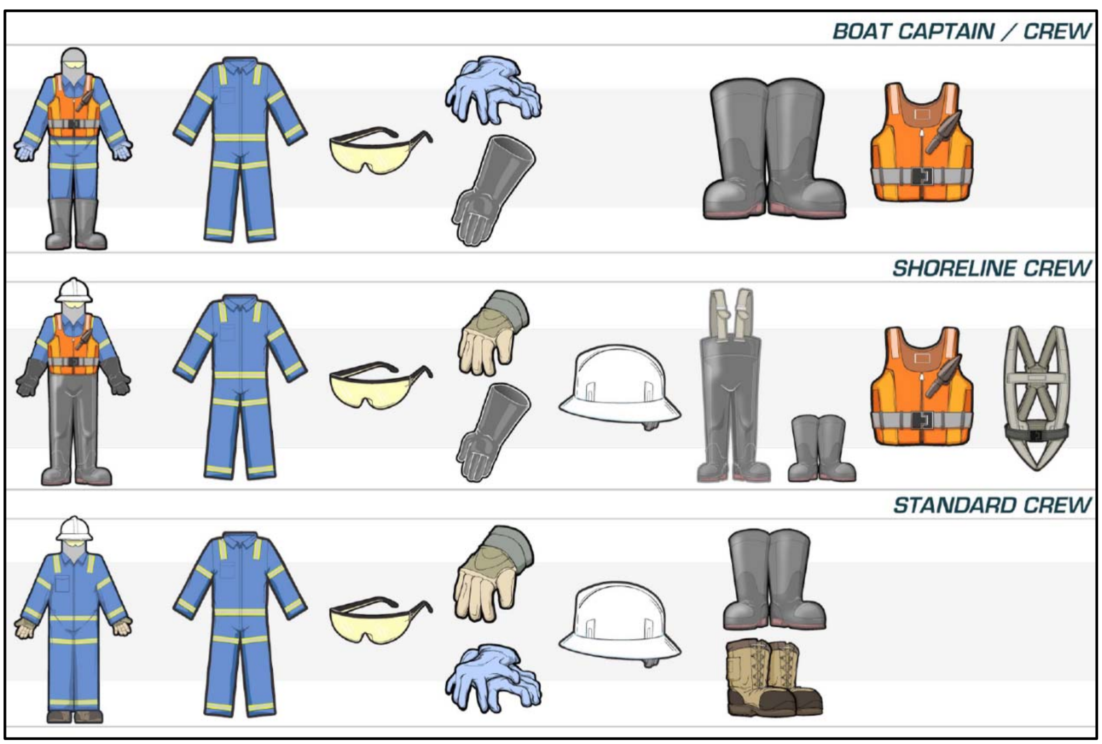

Figure 1—Personal Protective Equipment

The base layers for the responders will vary based on site temperatures; however, the exterior shells should always be fire-retardant coveralls with high-visibility banding. Eye protection should always be worn, and varying types may be required based on work scope. Gloves are also required, especially for the responders who will be frequently performing manual handling tasks. Foot protection should be steel/composite toe that is easy to decontaminate. High-ankle support is also strongly recommended for those who may be working on uneven shoreline terrain. Personal flotation devices (PFD) are a must for anyone working on the water or within 10 feet of the water's edge. Note that this location can change over the course of the response giving rising/falling water lines. There are several different types of PFDs, so ensure you choose the correct one based on your work scope. Hard hats are recommended for shoreline and standard crews where no overhead hazards exist. However, hard hat use is not recommended for those on a vessel, unless chinstraps are worn to guarantee hardhats cannot come off and become a hazard. Helmets should be considered when working in swift water. Also, harnesses may be considered for shoreline crew.

Air monitoring equipment should be used by safety personnel to ensure that flammable vapors do not become a point of concern. The makeup of the spilled material will determine the level of concern posed by toxic or flammable vapors, and the SDS should be consulted. Additionally, local and regional governments should be consulted during air monitoring to ensure an efficient use of resources, as well as enable communication of this information to the public.

Fire and explosion hazards are most prevalent during the initial response, so it is strongly recommended that no work operations occur until proper monitoring equipment is available. This is extremely important because watercourses are found in lowland areas due to their topographical makeup. This can create toxic or flammable areas that may not be as obvious as the spill footprint. Respirators may also be necessary depending on the released product and volume. If you ensure that time is spent creating a response-specific health and safety plan (HASP), you will be able to address the unique hazards present. Hazard assessment should always be treated as an ongoing process with continuous reevaluation to ensure the safety of personnel and the public.

1.2 Site Safety

Taking the time to conduct daily field-level safety meetings will lead to a healthy and open dialogue on-site. This is also a great time to discuss hazards that other crews may have previously encountered, or to discuss safe work practices. This "tailgate" is meant to be a concise forum for all responders to voice their concerns or good work practices. It provides supervisors the opportunity to ensure that workers are familiar with site hazards for the day's operations. It also affords the opportunity to draw up the containment strategies on a whiteboard or trailer if they have not been already. The delegation of tasks can then be conveyed and goals reaffirmed to promote success.

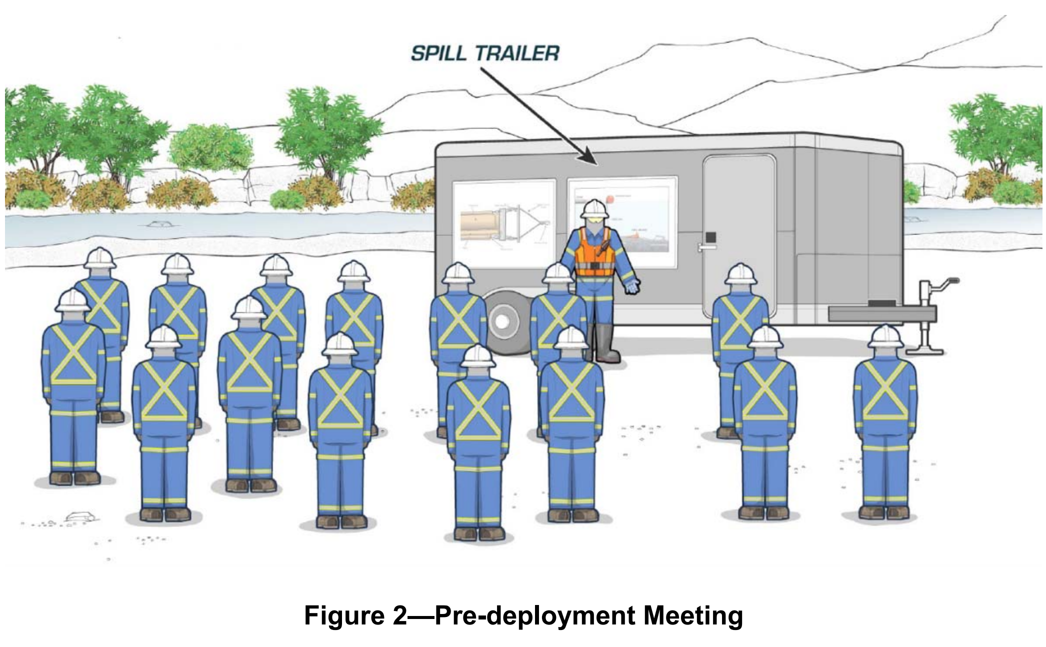

Figure 2—Pre-deployment Meeting

2 Site Evaluation

This section examines site variables responders should consider when choosing containment and recovery sites.

2.1 Access

Having instantaneous access to the anticipated control point is certainly beneficial, and is sometimes identified in a contingency plan. However, this is not always possible. Some responses are going to dictate that access has to be creative and positioned based on the specific considerations during a spill. If this is required, it is extremely important to evaluate the consequences of forging a road to the shoreline. Over the next few pages, we will discuss low-impact techniques and why they should always be considered when developing control point access. The driving factor for determining whether special access should be built should be a net environmental benefit analysis (NEBA). By building this analysis, you will decide whether the further impact to the environment is justified by the access it will afford. This analysis will need input from all stakeholders and the responsible party. Extreme rutting (see Figure 3) will limit access of vital response equipment and make the control point ineffective. As the first responder, you should challenge yourself to maintain as small of a footprint as reasonably possible for an effective response.

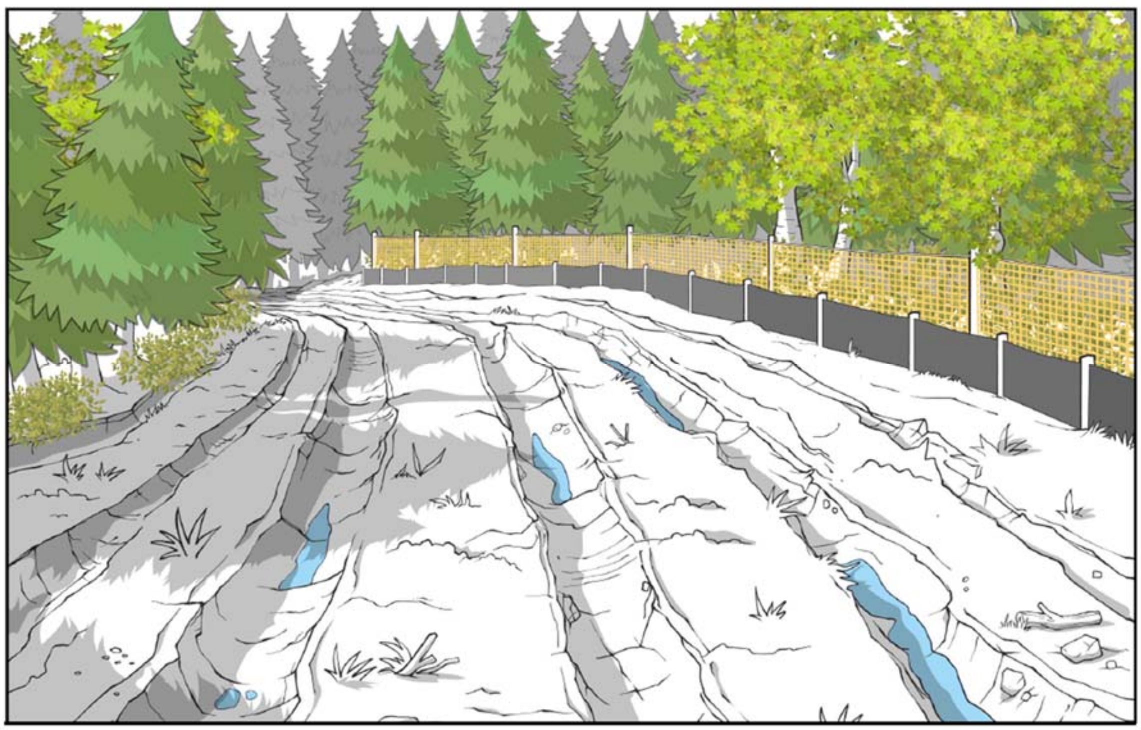

Figure 3—Extreme Rutting Limiting Access

Oftentimes, the best access methods for a particular event will not always be readily available. This should not be a deterrent to finding a location that provides exemplary containment conditions. Easy access should be viewed as a luxury and not a necessity. Optimal containment conditions should be your priority for SWSR. Minimal impact equipment can be brought in to negate/minimize an expanding footprint. Matting and pallets (see Figure 4) are inexpensive supplements that can be reused at different locations. They allow frequent traversing with less damage. This is important if the response occurs as seasons are changing, which will make it hard to maintain adequate access. Not every control point will require as much attention to the detail of the access, as roads may be erected with minimal damage or already be present. However, for locations that will become crucial for the entire response, the benefit of a detailed and thorough access plan is more than just environmentally cohesive; it can become the cornerstone for maintaining continuous progress.

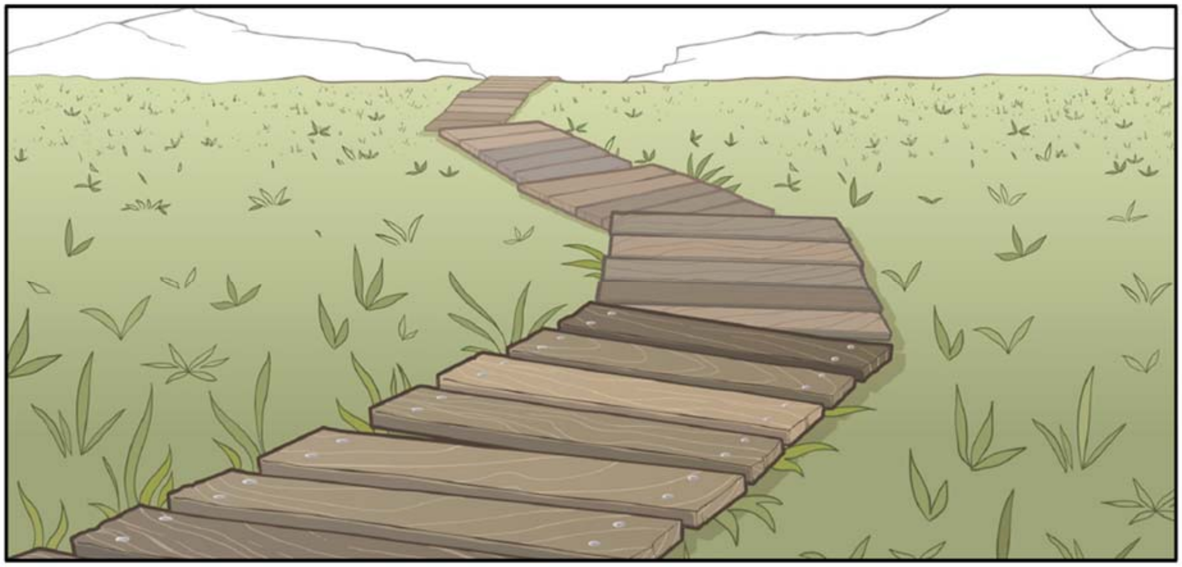

Figure 4—Boarding and Pallets

2.2 Staging Area

The logistical backbone of a successful control point location is the staging area. This encompasses not only having the necessary equipment but keeping it organized and quickly accessible. The next few pages will break down the design and strategy for staging-area configurations, as well as the necessary management mentality to promote response success. During an initial response, recovery locations are important, but staging areas become important after the initial response. The resources will need to be housed at a convenient location to allow for effective and efficient deployment of resources. Depending on the magnitude of the response, this can be as simple as one local field office or as complex as several adjacent fields spread out along the river system. Some responses may require moving the staging area several times during the response.

The size of a staging area is almost always underestimated because it is hard to know the full work scope immediately following the release, and only over the duration of a response can the correct size and type of staging area be designed. However, there are several consistencies that can be templated to ensure that the response will be able to function if the staging area needs to be increased. The first consistency is duration of necessity. It is important to build the staging areas to outlast the operational scope; the infrastructure necessary to protect the equipment and surrounding wildlife is crucial to establish early. The next step is ensuring the topsoil can handle the amount of anticipated site traffic. This may mean moving the topsoil temporarily and/or bringing in matting. Both are options that should be considered for practicality and effectiveness. The next consideration is to establish a traffic plan or flow for equipment arriving and leaving the site. The one entrance and one exit system ensures that everything arriving is not only checked in immediately, but also is in the right place. One exit helps eliminate theft or accidental misappropriation.

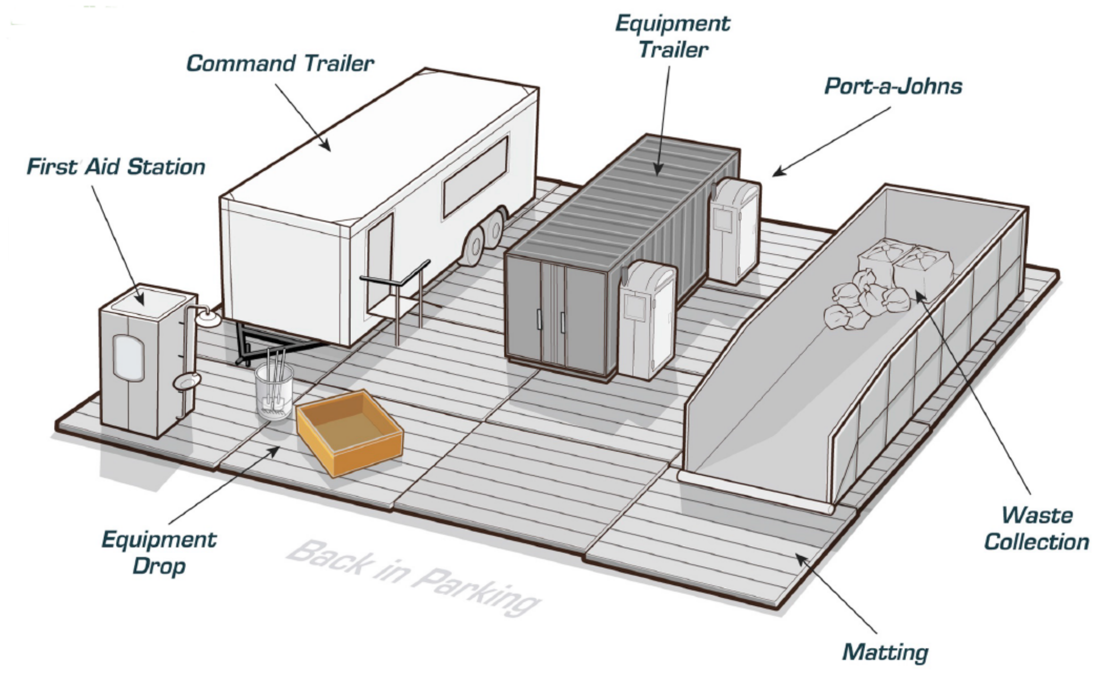

Figure 5—Staging Area Example

Initially, the most common resources will be focused on containment and recovery. However, it is very important that as the ancillary resources come in, they do not get in the way or bury important pieces of containment. Depending on the size and scope of the response, it can be beneficial to use the staging area for waste management. This will streamline logistics and shrink the response footprint. The staging area design and functionality will simplify response equipment tracking while also helping to ensure response effectiveness, so it is important to utilize good midpoints between control points and less important to ensure the staging area is located directly adjacent to response operations on the watercourse.

For the staging area and recovery site, the best way to promote success is by establishing a functional work area. Over the next few pages, we will highlight the appropriate design for swift water spill response. Figure 6 illustrates work areas that will lead to successful product recovery. These feature open access points for mechanical equipment, bare or minimally vegetated banks, and very little slope. The trick is to utilize equipment that will enhance the response efforts or be able to spot variables that will be too much of an obstacle and warrant moving the work area upstream or downstream. During the initial response, playing defense and securing containment ahead of the leading edge is as vital as isolating the source. Using Figure 6 as a template on how to design a work area, discuss whether it will be more beneficial to cut down overgrown vegetation or install pallets along the shoreline to minimize impact, as was considered when looking at site access. This stable work area will allow for efficient equipment usage on site. Another good practice is that if matting is installed, it should allow for a vacuum truck to drive all the way to the shoreline for recovery rather than having to utilize additional hosing or a fast tank. These subtle improvements will allow for the response to handle changing weather patterns that have traditionally caused further impact or a worsening loss of containment. This development of adequate infrastructure also ensures that other traditionally menacing variables can be maintained at the control point.

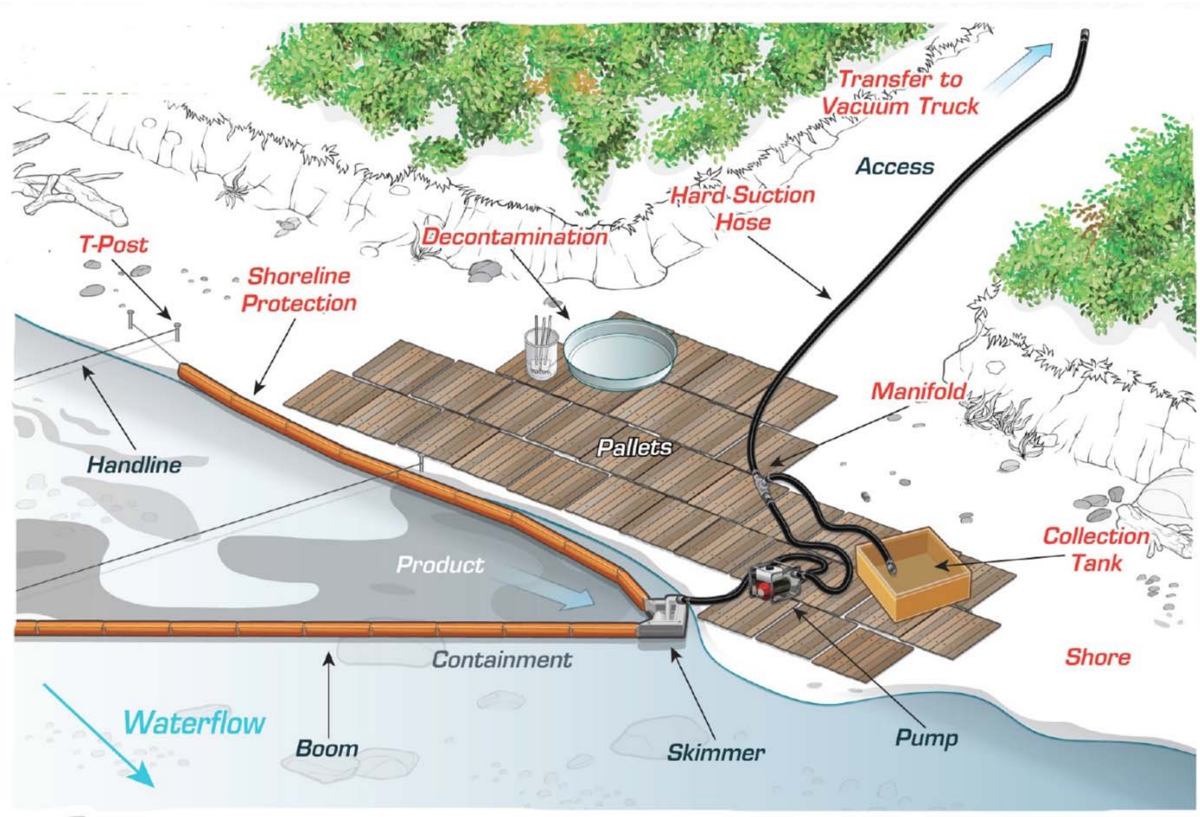

Figure 6—Work Area Example

Another best practice is to provide sufficient room for decontamination or, at a minimum, ensure that the impacted equipment doesn't leave the site between use. This is important as it pertains to hand tools and PPE. If every responder is taking equipment back to the staging area for decontamination at the end of every work cycle, the spill footprint will slowly grow every day and will require additional remediation along access paths. All resources should be utilized to their maximum extent prior to being brought back to the staging area or prior to decontamination. The best example of this is shoreline protection boom. This is the segment of containment boom that runs upstream from the recovery equipment along the work area. This is important because the goal of a containment configuration is to force the released impacts to a recovery point. Accumulating more product at this location than what would typically be deposited based on the hydrology is preferred. This cause and effect leads to a greater potential to impact the shoreline adjacent to the work area. The shoreline protection boom ensures that this does not happen and that the product stays within the containment configuration until it is extracted mechanically.

2.3 Boat Launch

When choosing a control point location, having an onsite boat launch will drastically expedite the response efforts. Be aware that a boat launch is only a few stabilized mats away from being created at any site. For swift water spill response, vessels are pivotal in all phases of the response effort. The initial response phase is no different; without boats, the response efforts are limited to very few tactical strategies. Locating all of the permanent boat launches should be done prior to a response during contingency planning. If not, you will be forced to rely on local knowledge and online information. For swift water spill response, utilize boat launches located as close to their work area as possible. This helps cut down on unnecessary travel time. It is also highly recommended that public launches be photographed and their conditions be well documented. This will help track the wear caused by the influx of response vessels. It is also important during the initial response phase to have someone visually inspect and collect records of decontamination for all of the vessels heading into the water. Introducing an invasive species to a sensitive area should be avoided. This will also assure you are not introducing more contamination into the site.

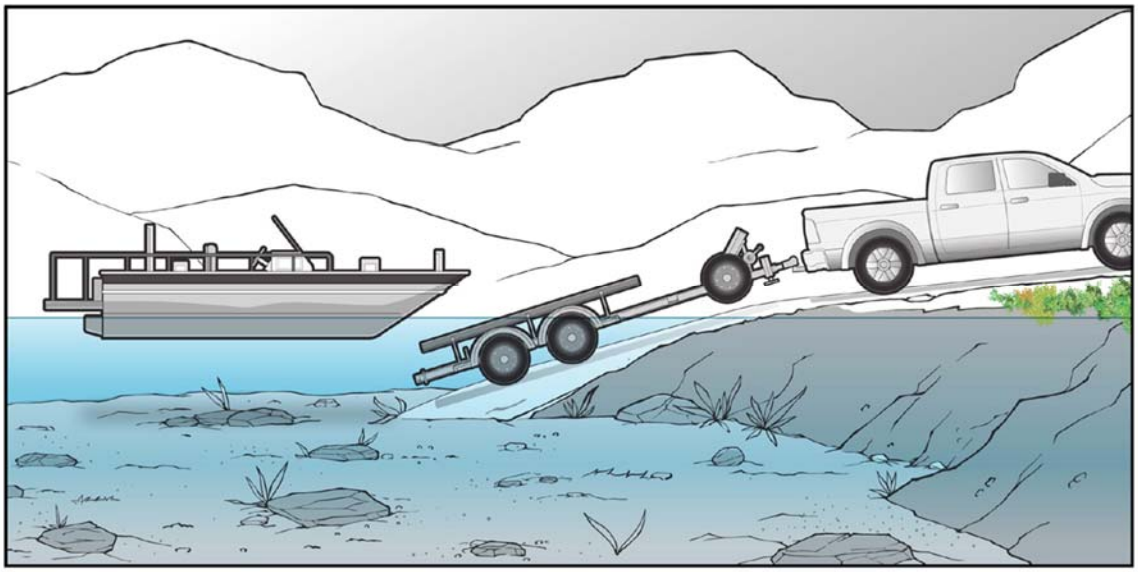

Figure 7—Boat Launch

2.4 Vegetation

Site vegetation can offer many clues on key factors of a response. This can be something as simple as recognizing an over-bank flood plain or as complicated as soil chemistry. There are many advantages to recognizing the vegetation on site and along the watercourse. For example, identifying the vegetation and the root-zone it inhabits can be useful when looking for natural anchor points for containment landlines. The vegetation will also tell you when you are approaching sensitive receptors, such as wetlands located in flood plains along major river systems. As a responder, the challenge of minimizing personal impact, as well as the overall magnitude of the spill, directly depends on your personal knowledge and familiarity with these plant species. Understanding that the local vegetation provides clues about how it can be utilized during the response is sufficient enough.

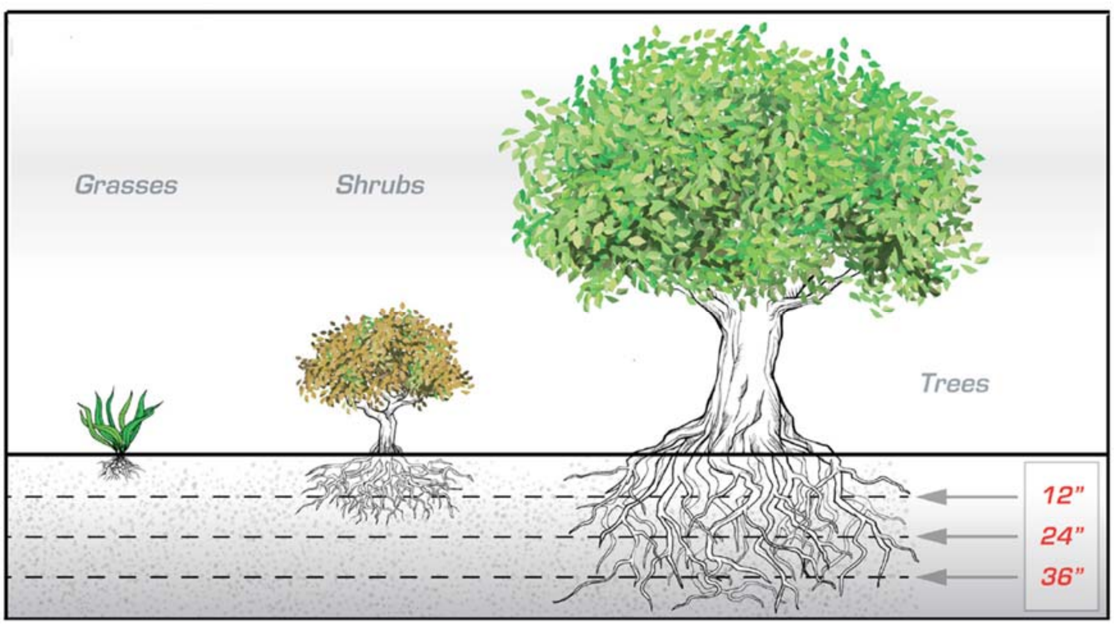

Figure 8—Vegetation

2.5 Shoreline Composition

Shoreline composition is significant on the front end of a response due to its ability to shape containment efforts, but it also plays a larger role in SCAT programs following containment. Shoreline composition is shaped by the hydrology present, and it is important to remember that watercourses are fed by the massive network of surrounding watersheds. A predominantly slow river could turn into a swift water course, depending on the season. Clues on whether this has happened in previous years are located on the shoreline; infrastructure used for transporting products is likely to fail during these floods.

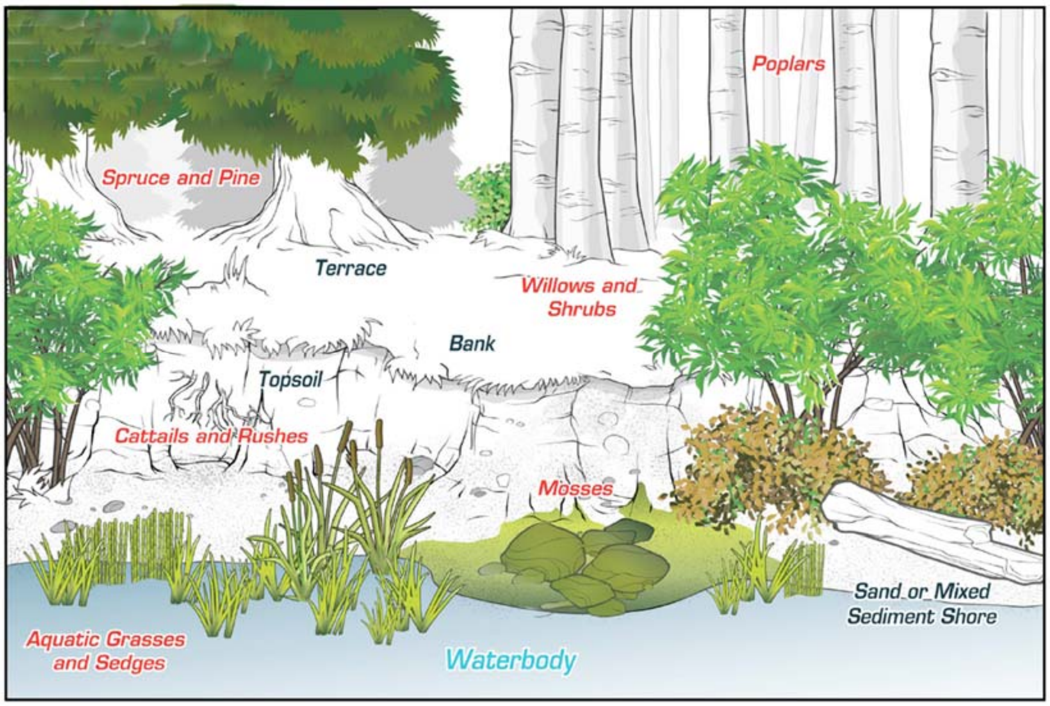

Figure 9—Shoreline Composition

As water velocity increases, erosion increases, which leads to varying shoreline profiles. This should influence containment, recovery, and access strategies. In addition to water velocity giving clues regarding shoreline profiles, it will also be an indicator as to what should be expected for riverbed substrate. For example, if you have bedrock shorelines, the watercourse will most likely be moving very swift and require different containment strategies and anchor systems. This substrate tends to experience very little erosion during the time frame of a response. However, a sediment cliff or mud/clay bank that is not filled with large vegetation with deep root zones or complex root networks is significantly more likely to erode during the response and carry a higher turbidity concentration. These two factors will drastically change the scope of materials required for a successful response. As the water level fluctuates, questions arise about whether the impacted banks will maintain composition and hold the impacts along the shoreline, where they can be accessed and remediated. In contrast, they could erode rapidly, releasing the previously stranded contaminant back into the watercourse. These are factors that should be considered as a part of your shoreline and watercourse assessment.

Shorelines can also be indicators of the wildlife present along the shoreline and in the watercourse. It is very important to develop a wildlife plan as soon as reasonably possible and to ensure that responders are aware of any dangerous wildlife present. Sweet aromatic hydrocarbons tend to attract certain species and must be addressed immediately. If dangerous wildlife is encountered, it should be reported to the safety officer for inclusion in the safety plan for the response.

3 Watercourse Characteristics

All watercourses are constantly changing due to hydrological dynamics. However, some rivers experience dramatic changes in as little as a few hours. From the rerouting of sand bars in a braided channel to the complete shift of channel stability, ever-changing river systems present a litany of variables to consider during response. In the following section, we will deconstruct the hydrology that shapes SWSR.

Similar to site analysis, the watercourse breakdown consists of several important factors: current velocity, riverbed composition, flow pattern, water depth, watercourse width, and obstructions, among others. This section will focus on the aforementioned variables.

Current velocity affects boom angles, recovery equipment, responder capabilities, and anchoring. Note that this document is for swift water spill response, so for the purposes of this guidance we define swift water as moving faster than 1.5 mph. Figure 10 very clearly shows a wandering channel. We know that as the topographical gradient becomes steeper, the current velocity becomes faster. The shoreline substrate acts as the pendulum wall, and the more structural support, the quicker that refraction occurs. If the shoreline walls are silt and clay, refraction will become elongated and erode much faster. This means that the fastest moving section of the water is on the outside of the bends in the river/stream. The inverse is also true, in that the inside of the riverbend will have a slower current velocity and will have larger eddies, which have the potential to be utilized for product recovery. These naturally occurring eddies will also be ideal locations to begin collecting product that has pushed outside of the main laminar flow. These locations, depending on the river speed, tend to be shallower and laden with sediment. These factors are shaped by the current speed, and faster speeds should be treated with extreme caution, with only trained professionals operating vessels or working within proximity to the watercourse.

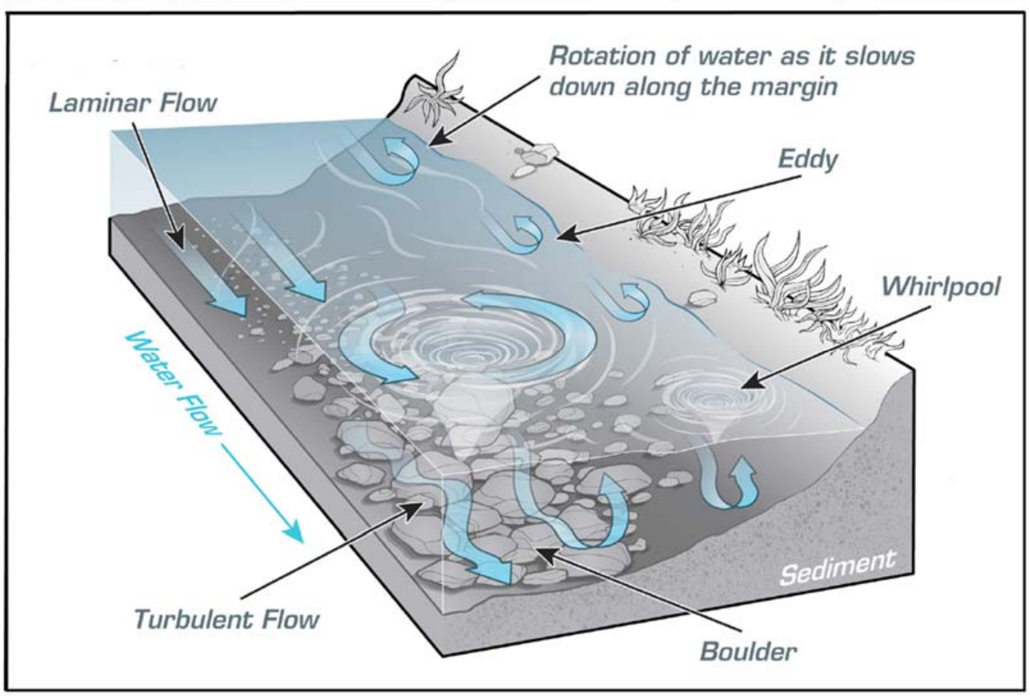

Figure 10—Watercourse Characteristics

3.1 Current Velocity

As the watercourse changes from high speeds to lower speeds, we will see many different types of river channel characteristics. Recognition of these characteristics will result in the pivoting of a tactical response to better tailor the equipment needs. For example, sandbars will have heavy to high impact if they are located in the spilled product’s path. However, that does not always mean it should be designated as the highest priority for recovery or restoration. As always, during the initial response, achieving containment and isolation of the source is a higher priority. Once that is completed, water-level fluctuation should be considered. If the water level is going to rise prior to having developed the appropriate recovery strategy, the watercourse will wash the impacts downstream to one of the eddies, and responders should plan accordingly.

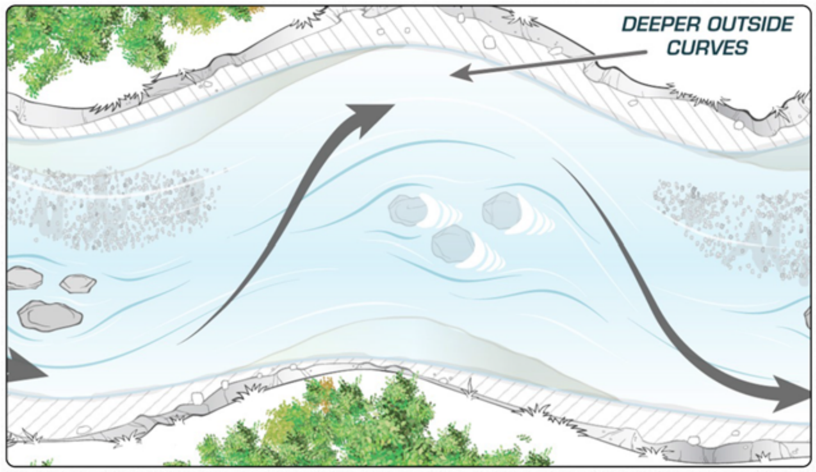

Figure 11—Current Velocity

The main questions that need to be considered on site pertaining to current velocity are:

1) During standard water levels, will the current velocity be manageable with the response equipment readily available?

2) Are there hydrological anomalies within the work area that are going to cause problems for the anticipated work area or personnel safety?

3) Is the current along the shoreline at a velocity that is agreeable to modern equipment?

If you can answer yes to these questions, you should be able to develop reliable tactics in watercourses with swift water.

3.2 Riverbed Composition

The most hidden watercourse characteristic is the riverbed substrate, which is important as responders consider the anchoring ability of equipment. Keen compression and identification will prevent failed containment-anchoring attempts, which will maximize crucial time and resources early in the response. In this section, we discuss the varying substrates responders will encounter during swift water spill response. Unlike the previously mentioned variables, the watercourse substrate is one that can be difficult to spot with the naked eye. There are several clues, like shoreline composition, turbidity levels, and current velocity, that are helpful; however, you will not know for sure until you begin setting anchors. There is a chronological order when we start to analyze the speed of the watercourse and the river substrate present to better enable this process. We will work our way from the slower-moving watercourses to faster watercourses.

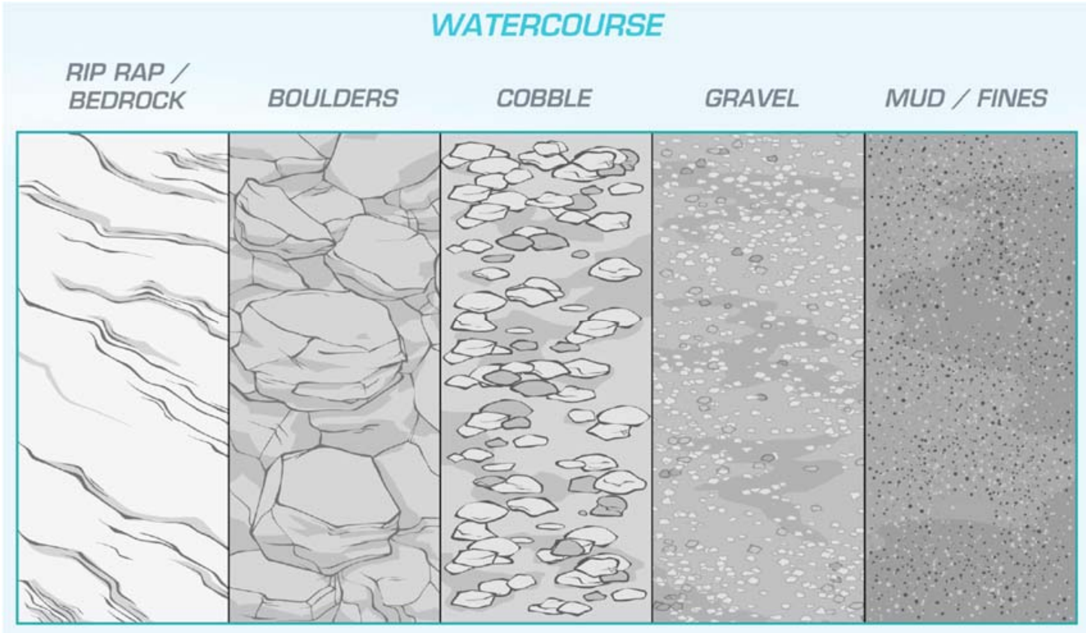

Figure 12—Riverbend Substrates

We begin with silt, mud, and fines substrates. These are typically on the slower end of the current-velocity spectrum because their presence means that the laminar flow is slow enough for these materials to deposit on the bottom of the river. Gravel and cobble must be washed in from upstream and deposited in the mid-range velocity areas, and tend to be located in and around riffles. Like the mud/fines, these areas are relatively easy for responders to contain as long as there is sufficient water depth for conventional booming strategies. Boulder and large rock substrates are more predominant after a significantly steep elevation gradient has been plateaued. These large rocks can render traditional tactics ineffective because they aren't always submerged. Finally, the substrate associated with the fastest-moving portions of water flow is the rip rap to bedrock substrate. This is because the water has eroded or removed any other substrate materials. These watercourses are consistently located within or at the bottom of mountain ranges.

All of these substrates offer unique challenges and will require specific tailoring for a successful deployment configuration.

3.3 Flow Pattern

Often, a boom configuration fails to provide complete containment. This is because responders do not know how to visualize the impact of the on-site hydrodynamics. This can lead to incorrect equipment usage and tactical failure.

In Figure 13, you will see that the release point occurred on the right descending bank (RDB) and the impact is being held by the hydrodynamics present onsite. Can we contain this release with only tactics at one site? Recall the discussion about the expected velocity changes over the course of the river, and its desire to find the path of least resistance while also keeping hydraulic pressure on certain areas of a watercourse.

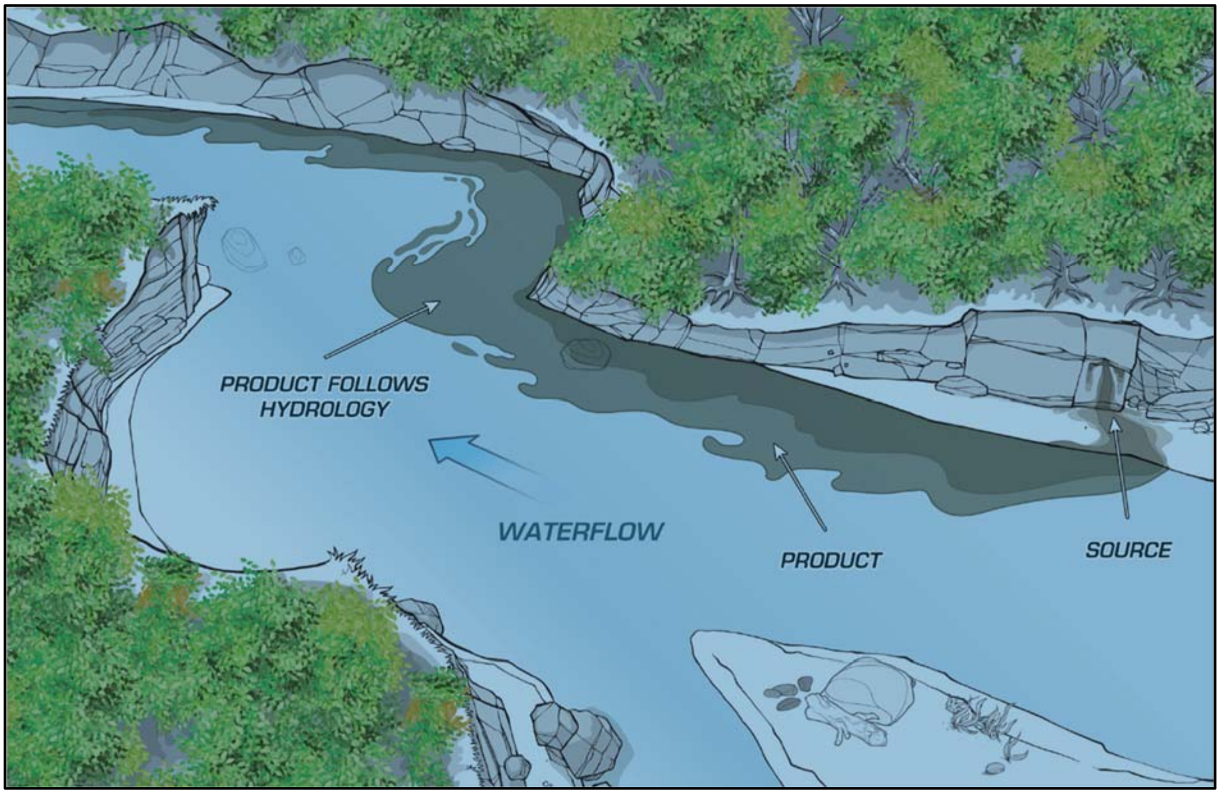

Figure 13—Initial Product Path

3.4 Water Depth

Insufficient water depth drastically changes containment, recovery, and operational tactics. For some HCAs located on swift watercourses, the fluctuation of being navigable in a vessel to inoperable in the same vessel is only a few months. However, a lower water level doesn't mean the product will be less mobile. Often, these lower water levels can cause more impact to exposed sandbars, shoals, and many other watercourse features.

As you can clearly see in Figure 14, the two converging watercourses have drastically different characteristics. The dominant watercourse illustrates a laminar flow. The smaller watercourse acts as sediment deposit with many braided channels. The response tactics will vary dramatically between the two because of different depths and velocities.

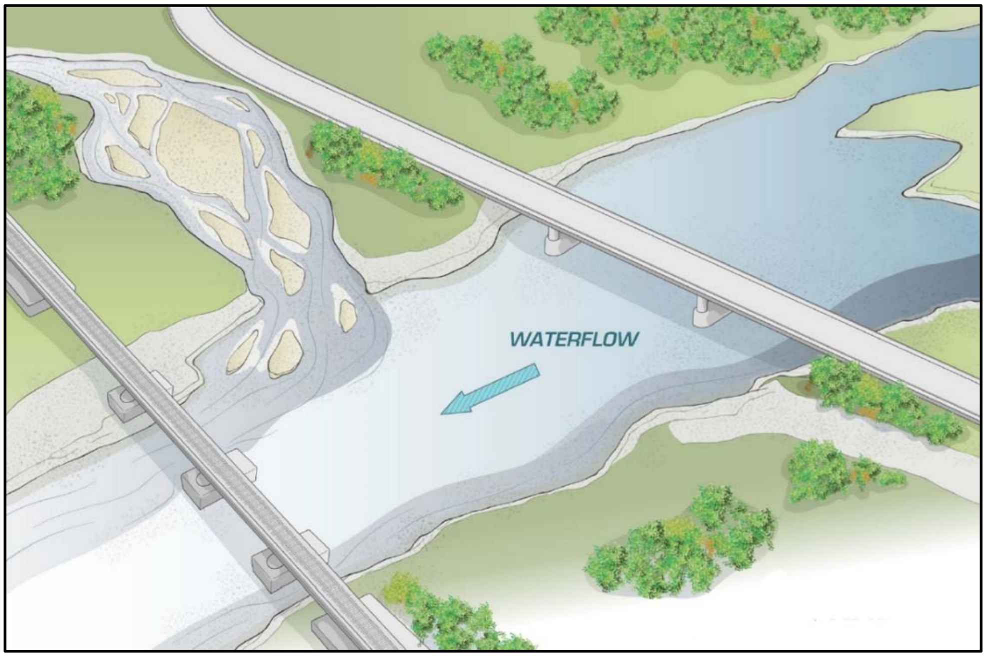

Figure 14—Braided Channel Characteristics

3.5 Watercourse Width

Preemptively choosing control point locations gives responders a head start on the response, not only from a logistical standpoint but also as it pertains to tactics. The caveat is that because of the dynamic nature of a river system, especially a swift watercourse, the watercourse will never be the same as it was during the field visit. Although it may appear to be the same, subtle nuances will alter the response strategy. It is clear that watercourses with larger widths will likely have islands throughout the channel, whether exposed or not. The key decision to make is whether these islands or sandbars need to be protected or are valuable resources better used at a different location. Weather forecasts should be consulted to ensure that containment can be maintained if the water level is expected to fluctuate. Evaluating the vegetation on the islands should be completed, as this could aid in the response. Larger and heavily rooted vegetation increases stability. Islands with little to no vegetation should be monitored, but will more often than not be destroyed as the water levels change. Also, several pieces of deflection boom can protect entire sections of river.

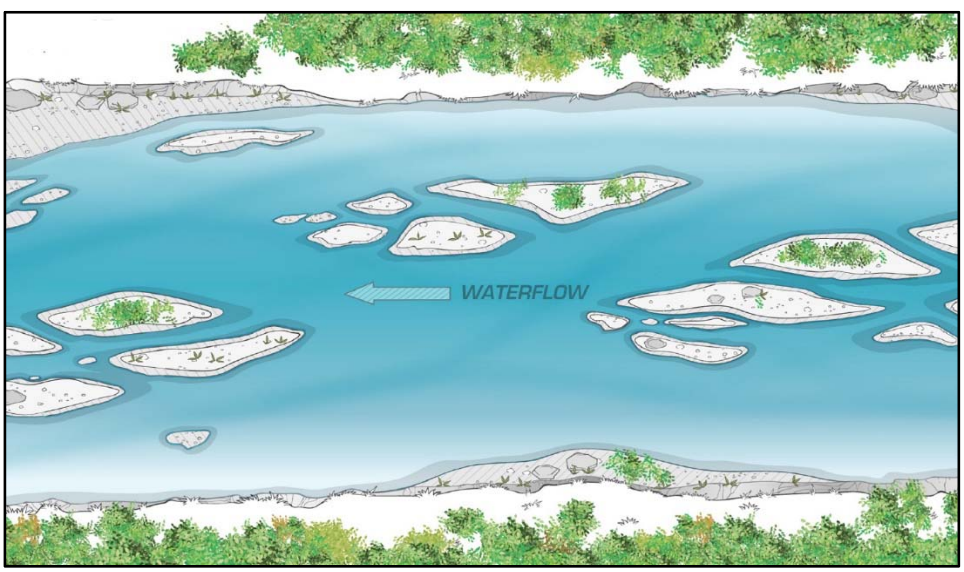

Figure 15—Efficient Boom Placement

3.6 Obstructions

One of the highest-risk tasks that will be completed during swift water spill response is operating a vessel in the river system. Many obstacles in a river are obvious to spot, but some obstructions cannot be spotted by an untrained eye. Basic river boat operations (beam upstream, no tie-off points, capsizing, etc.) will be discussed in the following section; however, this is not a complete discussion of vessel operation and safety in swift water, and boat operators are encouraged to have extensive training in this area.

Responders should be aware that on-water response work can be dangerous. Large debris can be transported through the entirety of a river during a response and can complicate containment configurations, as well as the safe operating procedures necessary to maintain a safe work zone. As you can see in Figure 16, woody debris can act as a natural collection point. The trapped product will become stranded and, if left there long enough, will become weathered and emulsified due to the continuous movement of the river, and may emit a persistent sheen. If access allows, it is suggested that responders boom downstream of these locations and slowly begin removing the woody debris with heavy equipment. Regulations may determine whether woody debris can be treated and put back into the environment or disposed of.

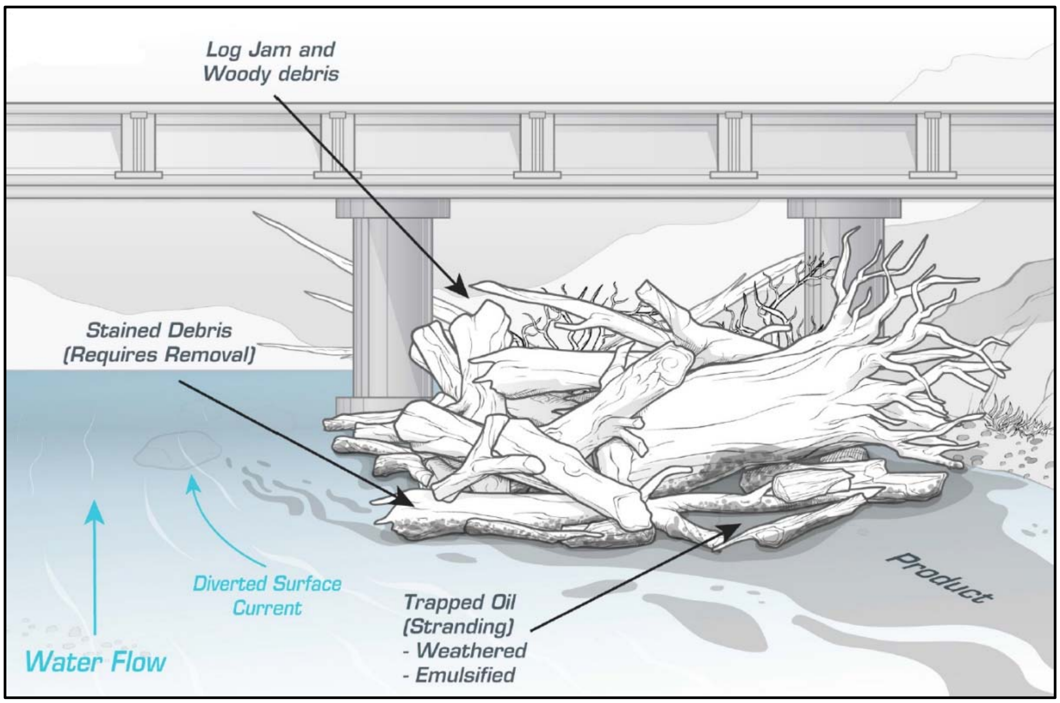

Figure 16—Watercourse Debris

Obstructions can also create safety hazards for the vessel operators. To the untrained eye it can be very hard to spot these obstructions. Using Figure 16, note that the channel is easy to locate because of the shoreline curvature. Whenever you find yourself in an unfamiliar portion of river, look to the shoreline for clues; wandering and meandering channels will follow the pendulum hydrology, while laminar channels will follow the main channel. Obstacles may also be underwater, and additional training may be required to act safely when encountering these issues.

Vessel safety is crucial to ensuring response success. Unfortunately, rivers contain dangerous natural and man-made debris. Vessels of all types can easily get entangled in, overturned by, and stuck on any of these objects. Also, sharp and jagged edges of debris can damage vessels. Scouting out a route on the river can prevent putting responders in danger. Response vessels should contain a first aid kit, buoyant heaving line or throw bag, a bailer/bilge pump, fire extinguisher, and a whistle or sound signaling device.

Vessel captains should conduct a vessel inspection and thorough safety briefing for all passengers prior to leaving the shore. This briefing should cover water safety basics, as well as a detailed set of safety concerns based on the river and site characteristics, weather, and other mitigating factors.

4 Response Equipment

4.1 Containment Equipment

Knowing what type of containment boom to use is just as important as knowing how to use it. In the following section, we will elaborate on the components of river boom and why the design should remain consistent for continuity and efficiency purposes. Every component in the booming apparatus has structural limits, from the anchor to the hand bridles. Every part has to have a minimum working capacity to ensure nothing in the series fails. This section will discuss additional supplemental equipment that can and should be utilized during swift water spill response.

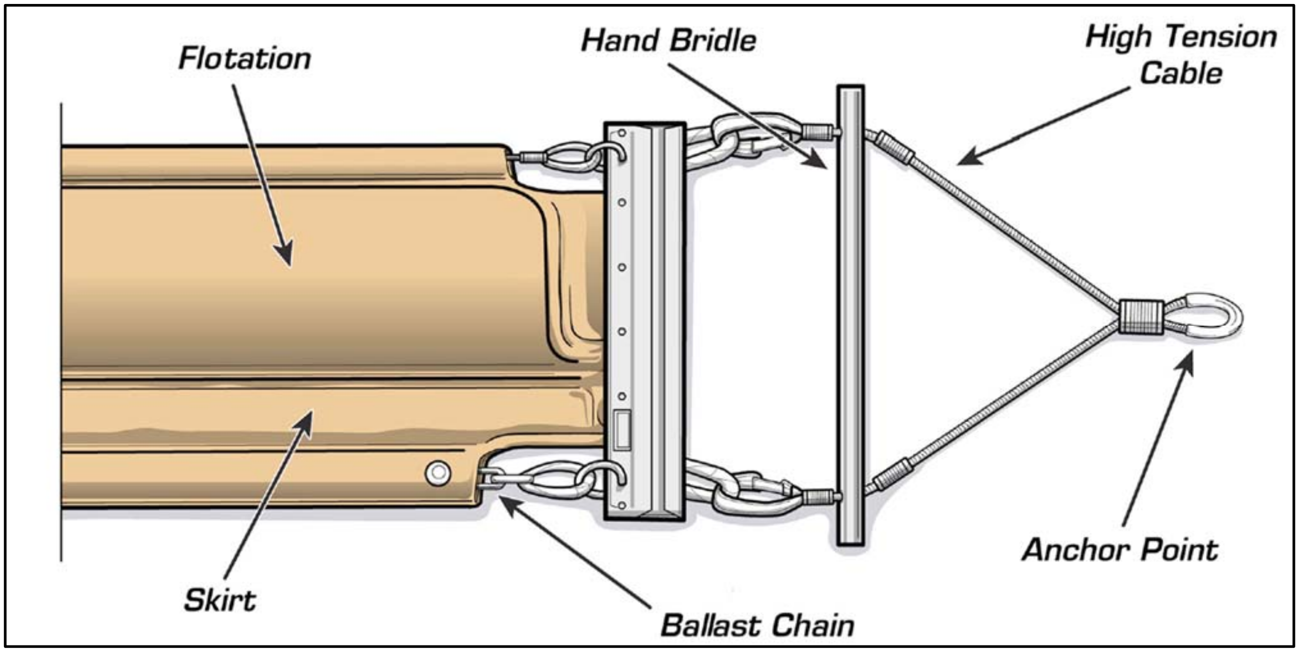

Figure 17—Supplemental Response Equipment

During swift water spill response, it is important to have the proper equipment for the response location. Containment boom that is too small won't be able to hold up with faster currents, and boom that is too large will not be able to stay down in the water due to the damming effect it has. In most cases, the ideal boom size will be 6" x 6" hard containment boom. Running along the top of the boom should be a high tension steel cable to ensure that you can achieve the necessary angle without destroying the boom. Below the cable is a 6" float that is designed to maintain enough buoyancy to allow for the lower portion, known as the skirt, to sit in the top 6 to 8 in. of the water column. A heavy chain should run through the bottom of the skirt. The connectors at each end should be made with marine-grade aluminum to ensure they are strong, but are still light enough to float. The connector styles vary from manufacturer to manufacturer and will need to be evaluated prior to arriving at the staging area for consistency. For SWSR, it is also important to source boom with extra loops to use for hand line bridle connection points. Make sure to inspect the containment boom regularly for wear and tear. For river systems, the containment booms allow you to move product from the opposite shoreline and lead it to you by damming and redirecting the top 6 to 8 in. of water, where contaminants are most likely to be present.

Another piece of equipment to consider for swift water spill response is a boom deflector. In the right conditions (straight laminar flow), boom deflectors can work well to use the river's current to push the boom to the desired location. Another piece of equipment to consider is the paravane, which connects to the most-upstream section of containment boom. The paravane is a small section of aluminum float, often shaped like the boom. Its purpose is to keep the containment boom afloat and to minimize the wear and tear from the constant friction created by the moving water coming downstream.

Selecting the most efficient recovery equipment for swift water spill response is based on the watercourse current velocity. In the following section, we will examine why it is important for equipment caches designated for swift water river systems to have weir-style skimmers, and how they can be misused, leading to the collection of more water than product. The Pedco skimmer was designed to be self-adjusting based upon the current speed manipulating the front of the trough and causing it to lower and gather product and water. It should be connected to either a peristaltic pump or connected directly to a vacuum truck. Once the unit is hooked up, controlling the pump's discharge rate will guide the depth of impacts being skimmed from the surface. The Pedco typically comes in two sizes: 4 ft and 2 ft. These units are ideal for watercourses moving more than 3 mph. If the watercourse moves any slower, the unit will not operate to its full potential.

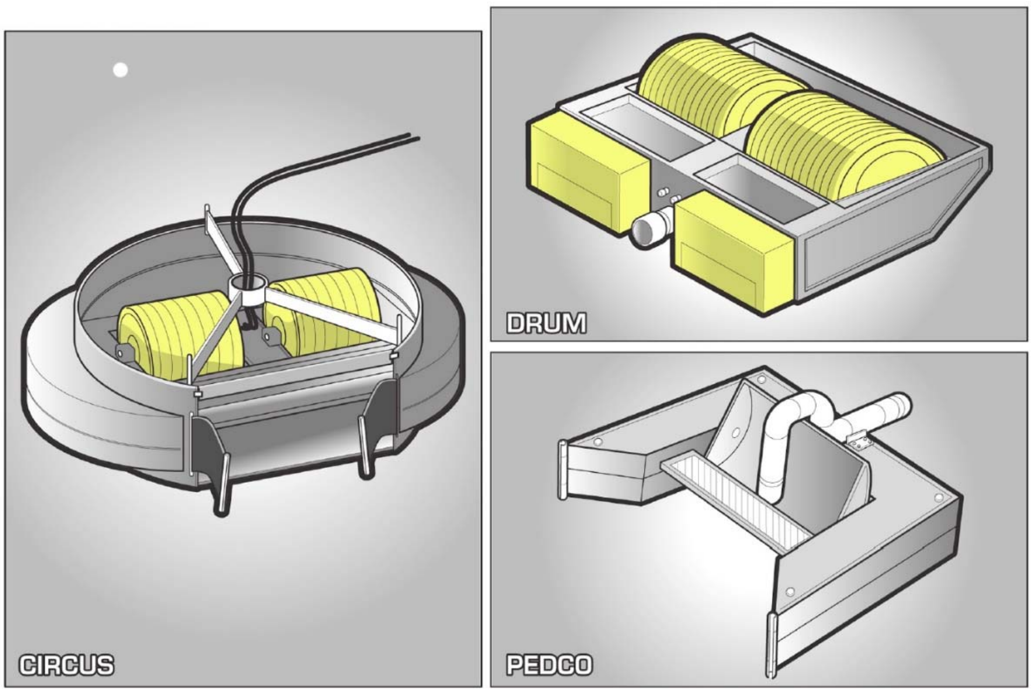

Figure 18—Types of Skimmers

Drum/oleophilic skimmers are designed with materials that attract hydrocarbons and repel water. Different variations include discs and brushes, however, for SWSR, the main unit of interest is the drum skimmer, which is designed for working in stagnant water to about 1.5-mph current speeds. If the water is moving faster than 1.5 mph, the unit may not work properly. Similar to the weir-style skimmer, it is are designed to be emptied with suction line, but powered with either a hydraulic power pack or a pneumatic system. The power source causes the drums to rotate, and the adhered product is wiped off on top and into the onboard reservoir. The advantage of this unit is that it is hydrophobic, meaning it will collect mostly hydrocarbons.

The next piece of skimming equipment most practical for SWSR is the circus-style skimmer. The design allows the impacted water to flow down the containment and into the unit. It will then rotate in the chamber, and the oil is collected by either two counter-rotating drums or a self-adjusting weir skimmer positioned in the center of the chamber. These units are also powered by separate diesel power packs. They are meant for speeds as slow as 0.25 mph and as fast as 3.5 mph.

5 Anchoring

The best rule to live by when it comes to anchoring is: If your anchor fails, your containment fails.

Muds and fines are typically laden with sediment and require minimal effort to lock the anchor system in place. The recommended anchors for this substrate are the traditional Danforth and SARCA. The Danforth's steel flukes are large and wide to allow for good penetration into the substrate. The SARCA is designed to plow into the substrate with relative ease because of the roll bar. The trick for all of these anchor configurations is to ensure that you use as much ballast chain as reasonably possible. A ballast chain between ¾ and ½ inch will make sure that the anchor fluke stays as low to the riverbed as can be.

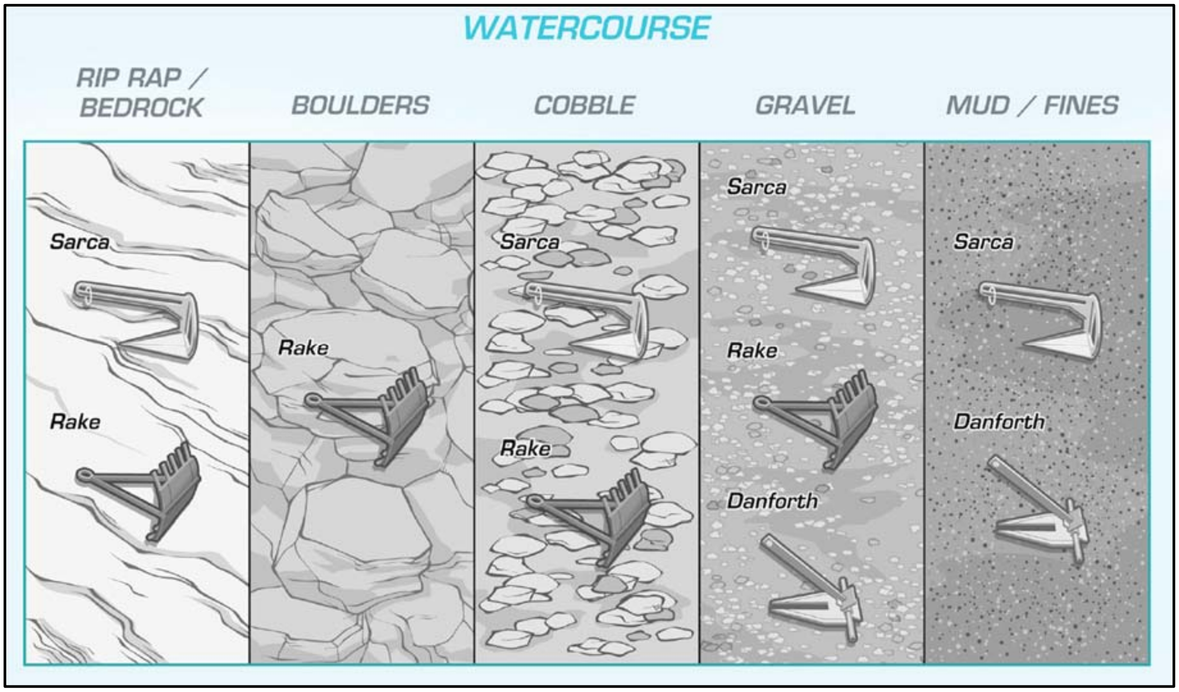

Figure 19—Anchor Choices

Gravel substrate uses a rake anchor. A rake anchor has two shanks that run away from the rake section. The rake section of the anchor is designed to bite into the boulder, cobble, gravel, and bedrock. Handling larger anchoring units can be dangerous. All crew on the vessel should be trained to eliminate any risk during deployment. All anchor equipment should be staged at the front of the vessel to ensure no person is tangled upon deployment.

It is important to talk about how to deploy anchors safely beyond basic lifting ergonomics. Responders should never put themselves between the anchor, ballast chain, or rode line. Becoming entangled in either the ballast chain or rode line can lead to a life-threatening situation. To ensure safety, it is important to stage all of your anchoring equipment at the front of the vessel. Starting with your primary anchor, the ballast chain should be stacked so that the primary end attached to the anchor is on top. Then, the rope should be positioned in a similar fashion. This will provide a safe way to deploy the anchor and allow the weight of the anchor to pull the chain and rope over the bow, giving responders a safe distance from the moving parts while allowing the captain of the vessel to keep the bow facing upstream for added control. In case of entanglement, a safety knife should be within reach, to allow for quick cutting of the anchor line.

After the anchor(s) has been deployed, the vessel captain should allow the current of the river to move the vessel downstream until the rode line is taut. Then, additional power in reverse may be necessary to truly lock the anchors into place so containment boom can be attached.

5.1 Shoreline Anchoring

Shoreline anchors are used for different facets of the containment strategy—from the top end of a shore-to-shore configuration, at nearly every recovery anchor point, and all of the hand lines in between. The type of shoreline will determine which anchoring system is most appropriate. For example, sandy beaches may require use of a Danforth or SARCA anchor. For very rocky substrate, an extra rake anchor reversed so that it is facing the direction of pull, but dug in behind several large rocks, may be effective.

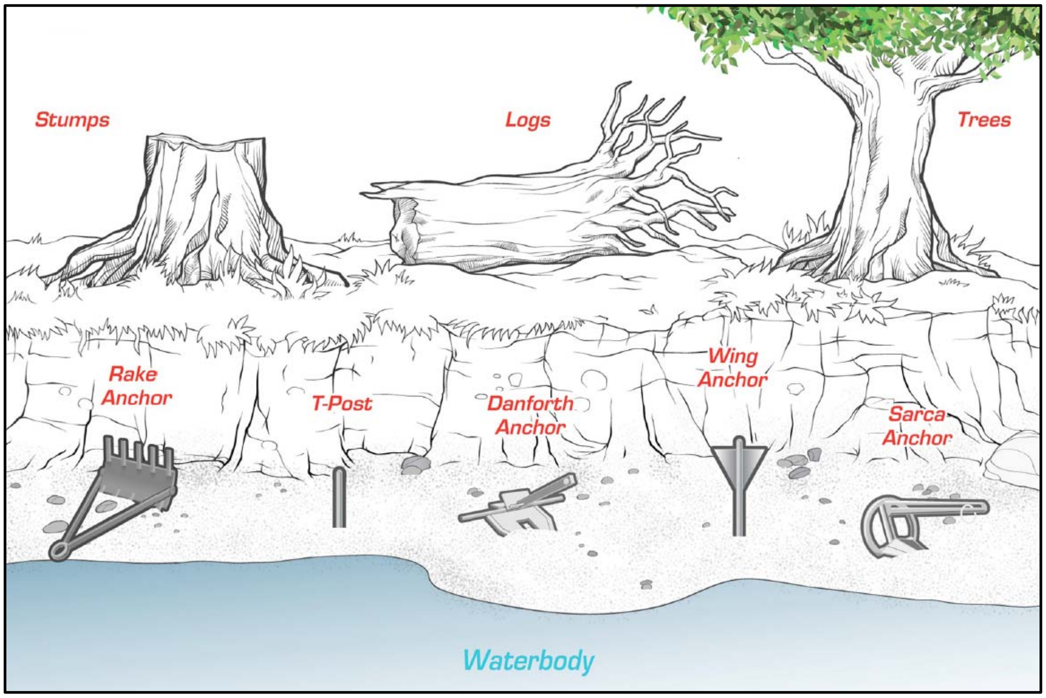

Figure 20—Shoreline Anchoring Methods

The most common types of shoreline anchors are T-posts, drive pins, wing anchors, and auger-type anchors. These anchors work best in a heavy sediment load because they are easy to lock into place and are extremely reliable. Another consideration is to look for natural anchors. Depending on local regulations, large trees can be utilized to simplify shoreline anchoring even more. Make sure that you are picking a tree large enough to handle the stress caused by boom tension.

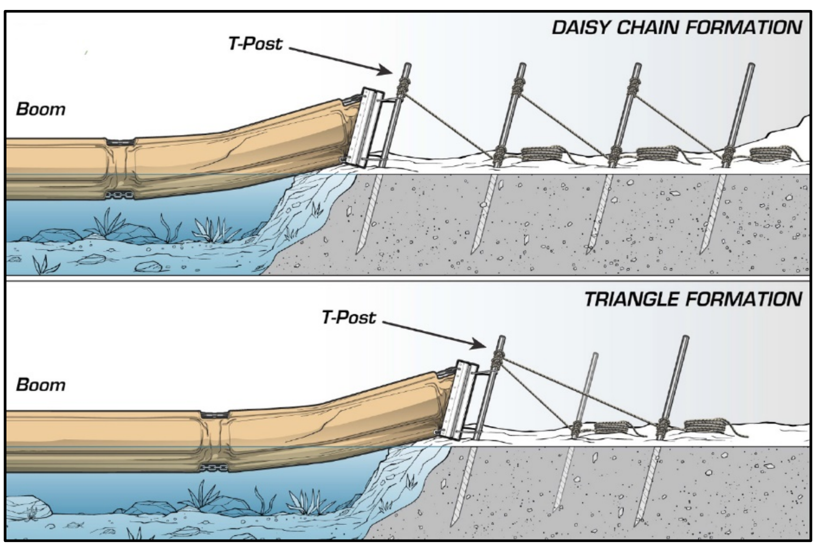

Figure 21—T-Post Boom Installation

A quick and cost-effective way to create reliable shoreline anchors is to utilize T-posts in a series. This series may be known as a daisy chain or triangle formation. A daisy chain is formed by installing four T-posts in the ground with a slight lean opposite the direction of where the boom is pulling. The posts are then connected in a series from the top to bottom. This provides the structural integrity of all four T-posts. The triangle formation only requires three T-posts organized in the shape of a triangle, where the front of the triangle is facing the boom and the two secondary posts are offset to the outside, with one section of rope securing the top of the forefront post to the bottom of the secondary posts.

5.2 In-stream Anchoring

Locking in anchors can become more challenging in fast current conditions when the bottom is a mud or fine substrate. The best method of deployment is to drop over the primary anchor and then float back until the ballast chain starts to take a holding lead. Then, release the second anchor and all of the necessary rode line to get to the top end. Wrap the rode line around one of the front tow posts while facing upstream. Allow the river current to float you back until you feel the anchors secure. Then, have a deck hand pick a stationary point on the shoreline to use as your frame of reference as you slowly give the vessel reverse throttle; make sure you have not moved from your fixed point. Depending on the substrate, this may take a few attempts, or you may get it locked right away. Once this is complete, pitch the hand line and buoy into the water so the secondary vessel pulling the containment boom can attach it.

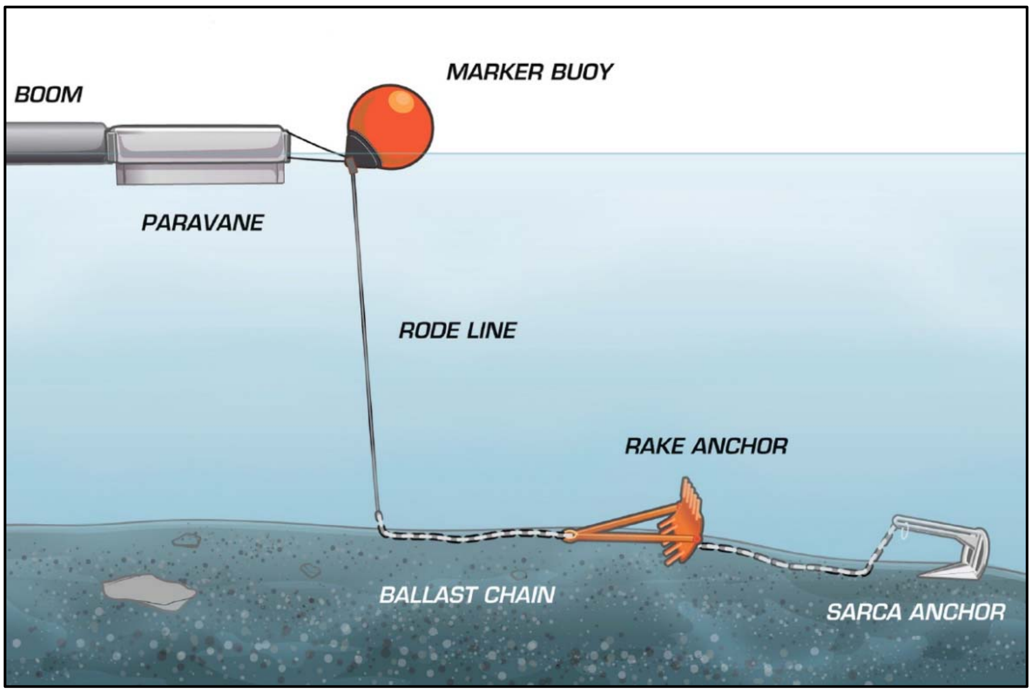

Figure 22—Tandem Anchor Systems

5.3 Boom Deployment Device

The boom vane is designed to simplify and expedite containment boom deployment. The intent of the design is to be able to deploy boom without a fixed anchoring point or without the assistance of vessels. By action of the current flowing through the main wings, the boom vane can swing off a mooring line and into the water. Proper usage depends on adjusting the mooring line and length of boom to the river current. Deployment can involve wading partially into the water to deploy the boom vane and using guide ropes, both of which can present safety hazards. Boom vanes are designed for different water depths, so consult the manufacturer for the proper sizing.

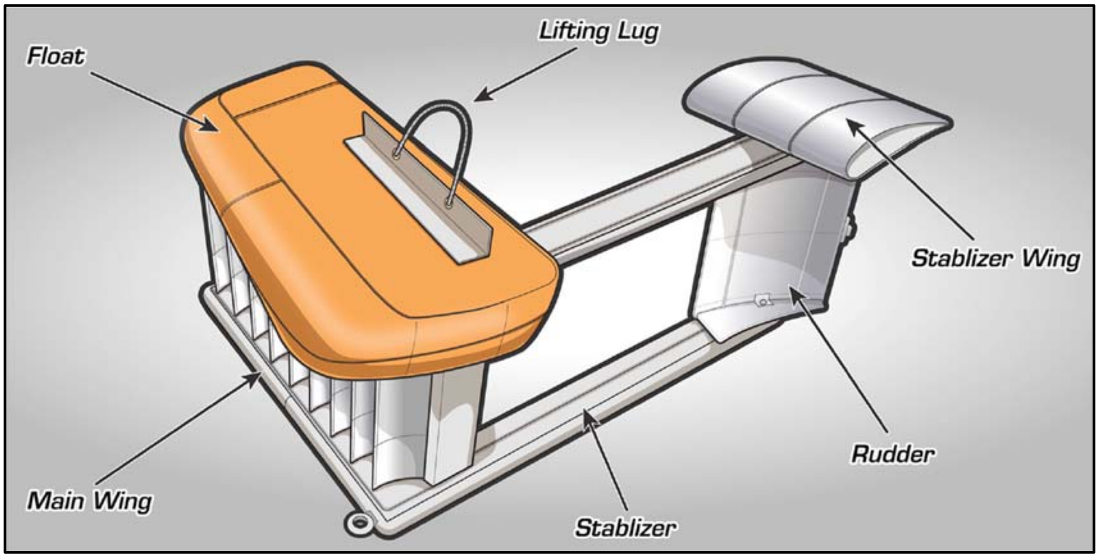

Figure 23—Boom Deployment Device Parts

Proper boom deployment can encompass proper boom anchoring, shoreline protection, shoreline anchoring, and skimmer selection. In the following section, we will discuss booming strategies including boom angle, hand lines, chevrons, and cascading systems.

6 Containment Tactics

6.1 Boom Angles

Installing containment booms at the proper angle is one of the most important parts of achieving containment. As in Figure 24, there are extremely detrimental effects to not following the simple 10- and 30-degree rule. In Figure 25, the boom was run out and across the watercourse. It was completely perpendicular to the river system, which was moving around 2 mph. In this case, even if it we manage to keep containment, all of our recoverable materials are in the center of the channel, where they are difficult to recover. Also, because we are perpendicular to the river, the product has a significant chance to slip under the boom and escape (also called entrainment). Because of this, at 2 mph, boom angles should be a maximum of 30 degrees.

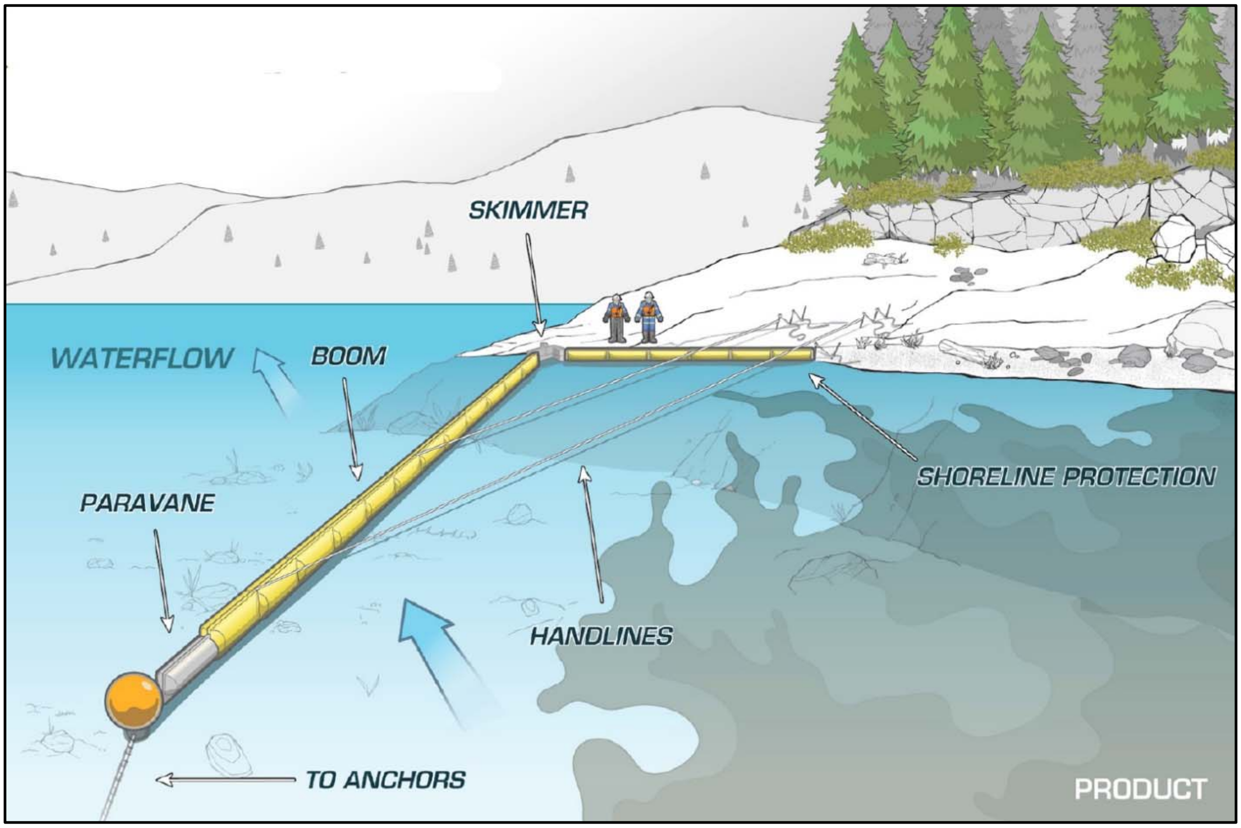

Figure 24—Check with In-stream Anchors

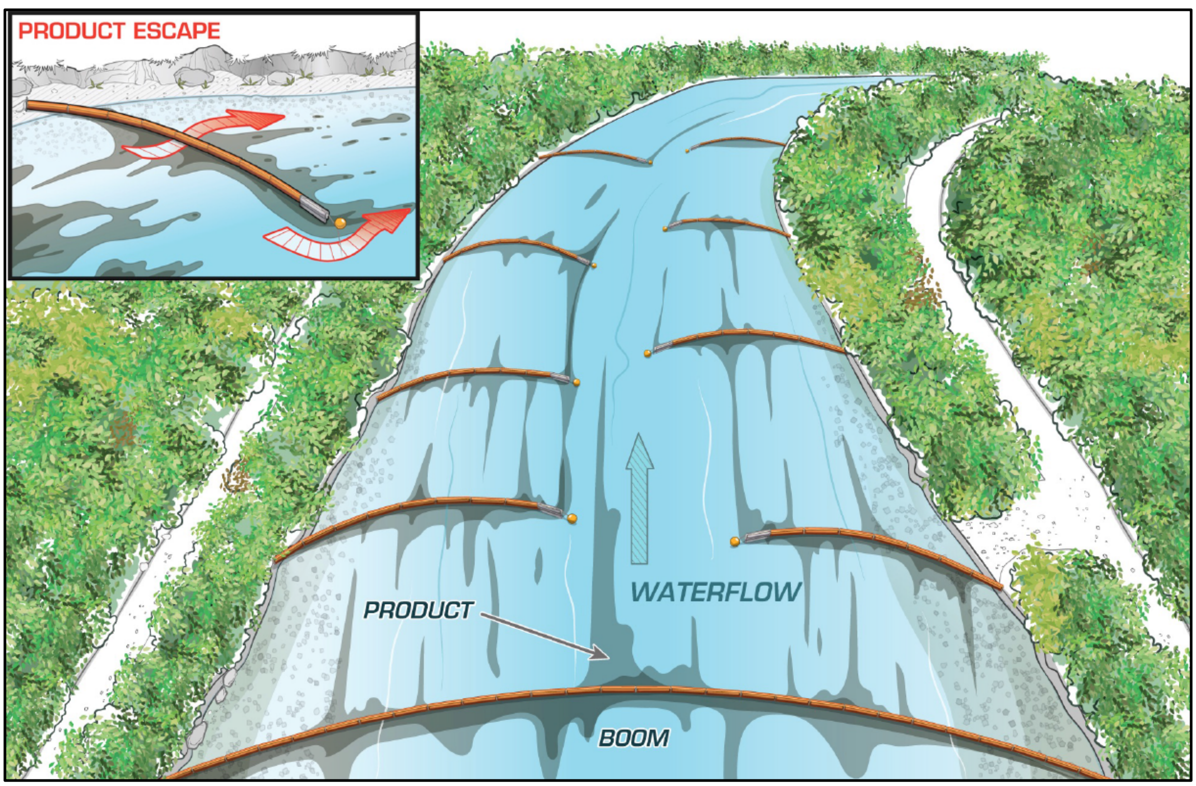

Figure 25—Poor Containment Tactics

For any water spill response, the general rule is, the faster the water, the smaller the boom angle. To determine the appropriate angle for deploying containment boom, first determine the river velocity. This can be done through an Internet search, or by walking next to the shoreline and knowing that an average walking pace is about 3 mph. If the river velocity is 2.5 mph or less, you should base your containment configuration angle at no more than 30 degrees to ensure that no product is traveling under the boom. A water speed greater than 2.5 mph would require a boom angle of around 10 degrees.

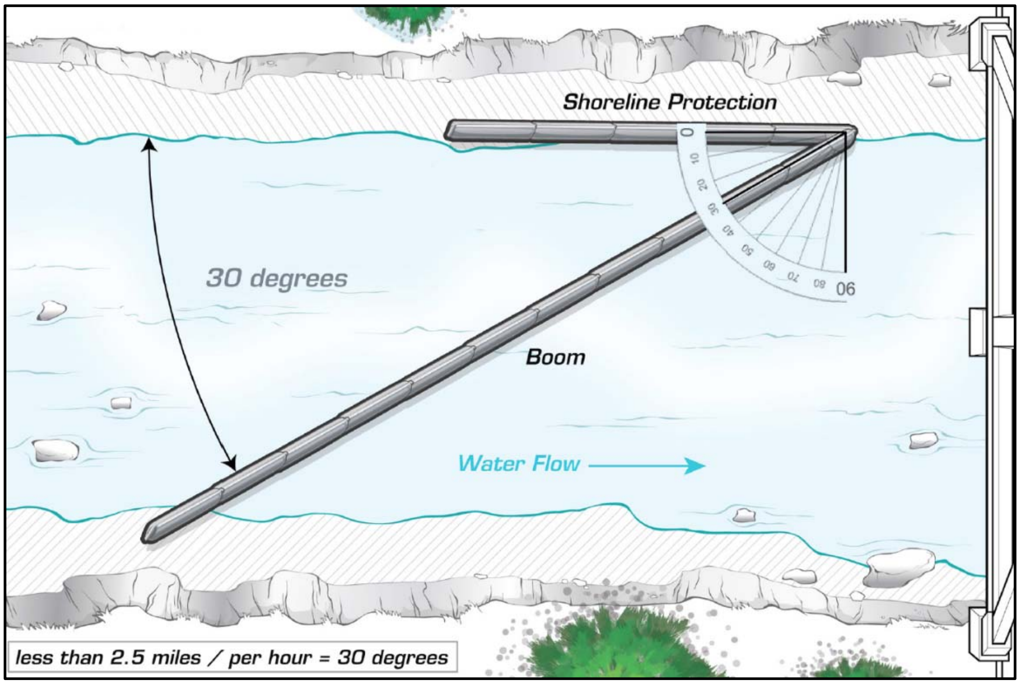

Figure 25a—Boom Angle (30 degrees)

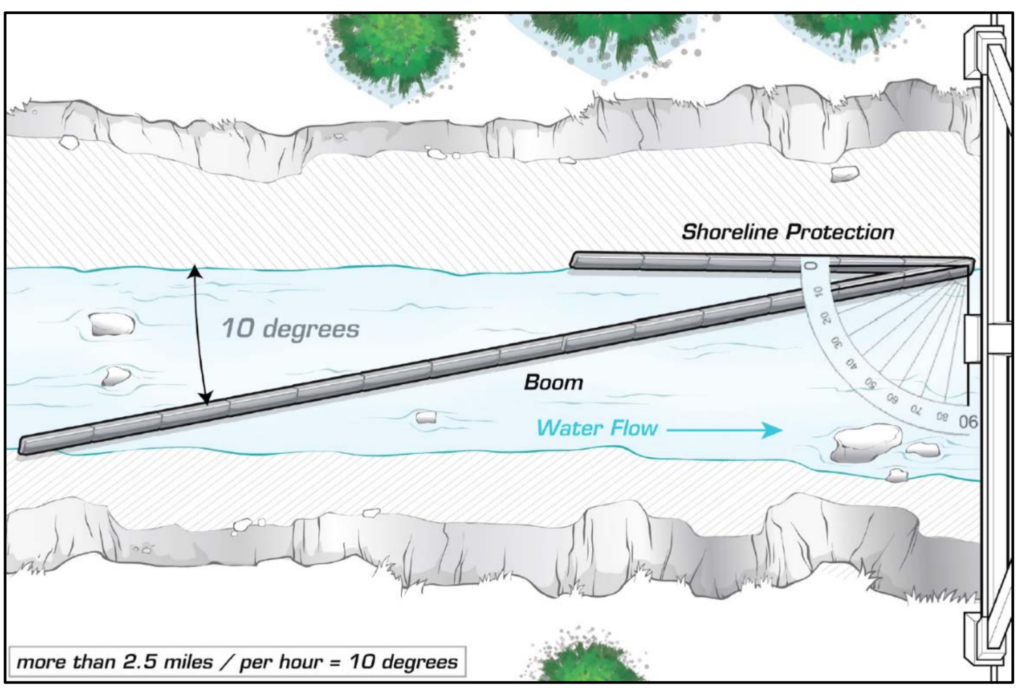

Figure 25b—Boom Angle (10 degrees)

The faster the water, the smaller the boom angle required—and the more equipment required in terms of boom length and control lines. Swift-moving water generates a lot of force, and containment boom restrains that force. This force can be strong enough to pull crew members or even pickup trucks into the water if they are attached to the boom when it is being deployed.

6.2 Hand lines

Hand line ropes are designed to help negate the hydraulic forces that impact the containment boom configuration. A preferred approach is to determine the length of hand lines to be used prior to boom deployment. River speed will dictate how many hand lines will be necessary, with increasing speeds requiring more because there is a greater force being exerted on the boom. Using rope reels can be an easy way to run hand lines from the boom to the shoreline. A common error made during this step is running hand lines upstream or straight across from their initial attachment point, which can cause inconsistencies in the boom angle and create vortices that will pull the impacted material under the containment boom, making it ineffective. When pulling the hand lines to your shoreline anchor, there are two methods to consider. The first is to pull them all at a similar angle to different locations up and down the shoreline, and the other is to pull them to one single point near the recovery equipment. Both styles are equally effective and will depend on siting.

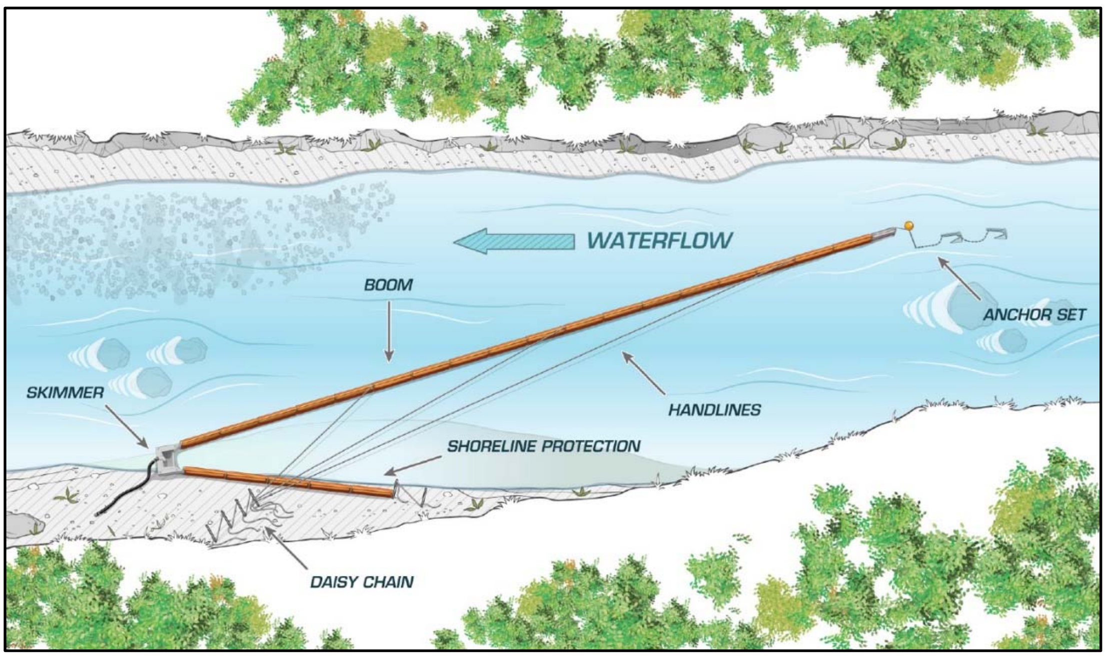

Figure 26—Hand line Positioning

It should be noted that in SWSR, the higher the current, the harder it is going to be to pull the hand lines in by hand. In Figure 27, the top image portrays two responders pulling by hand while the third uses the tree to act as a brake to slow the kinetic energy. Responders can tie a half-hitch in the line between the boom and the anchor point and run the tail through the loop that is created to use it like a secondary pulley to lighten the load. Another method is to use mechanical advantage, especially as it pertains to working around the shoreline and other rip rap. Figure 27 depicts one responder using a capstan winch, which can multiply a responder’s efforts.

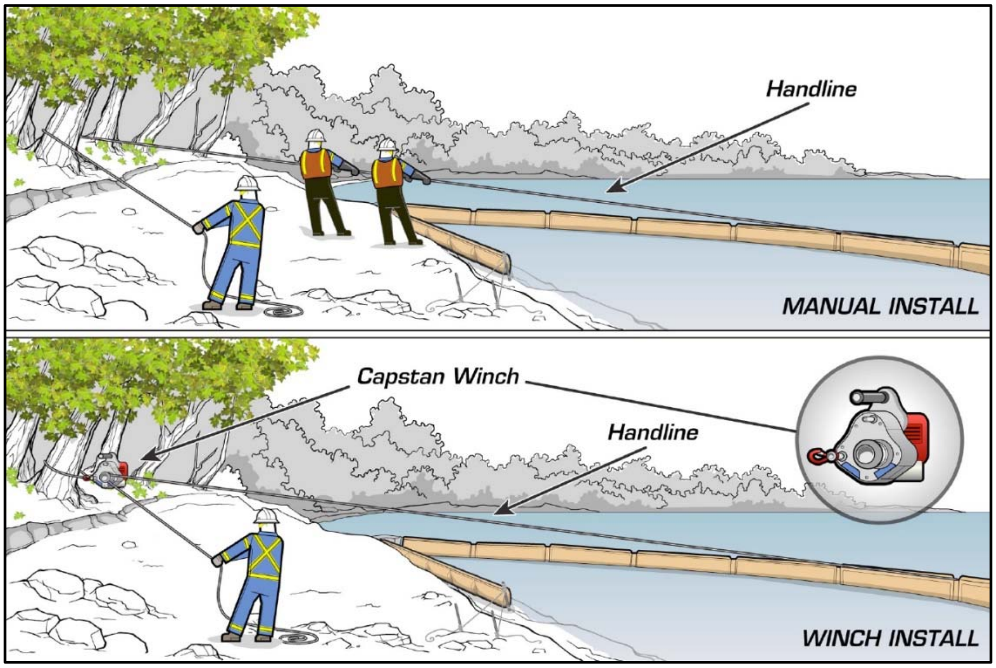

Figure 27—Hand line Installation Techniques

6.3 Implementation Strategies

6.3.1 Closed Chevron

The closed chevron configuration can be used on swift water bodies with significant wind-driven movement, or immediately upstream of outflows on large bodies of water to direct product-recovery areas. They are more traditionally designed to stop free product on the surface or large watercourses with moderate to strong currents while still allowing fresh water to continue downstream. They are also used to divide an oil slick into two recovery areas on wide and straight water bodies.

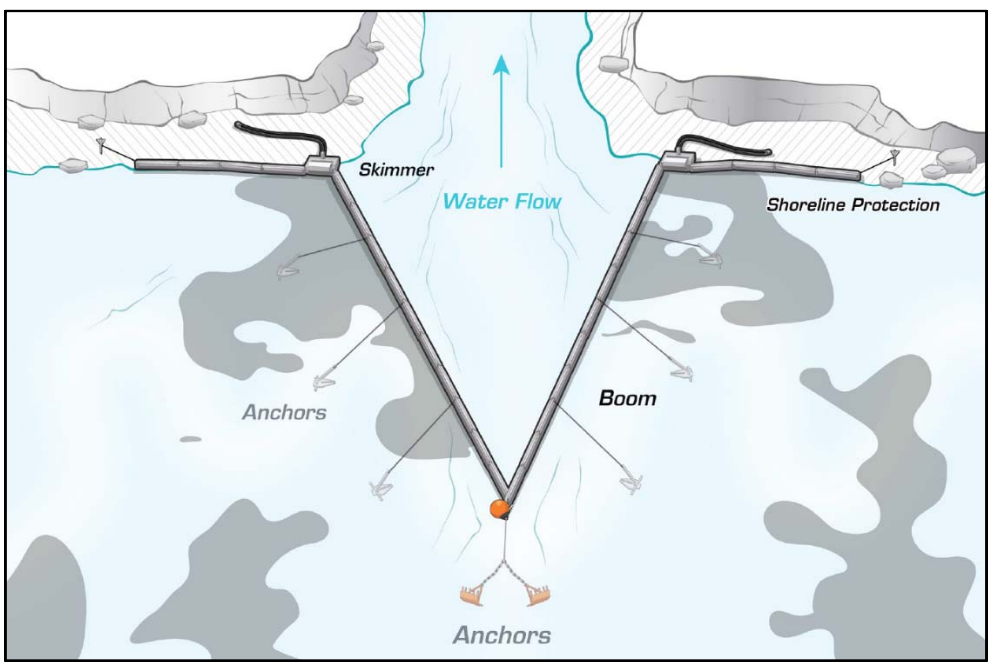

Figure 28—Closed Chevron Configuration

For installation, identify select areas to protect from the spill's impact. Use a boat crew to set anchors and deploy the boom. Deploy two strings of boom from the anchors in a "V" formation and attach them to the shoreline, using hand lines from the shore to secure the correct boom angles. Anchor boom to shore using shoreline pins, and screw anchors into trees and rock or other natural features capable of withstanding the tension.

It is ideal to install on the straightest laminar flow available to eliminate any underflow or overflow issues. One of the challenges of this configuration is that it can be difficult for novice vessel operators to cross the boom. All boat operators should have the appropriate training for the task at hand.

6.3.2 Shore to Shore

Shore-to-shore containment configuration can be used in most average-sized watercourses, depending on flow rate. First, identify, prioritize, and select the area for recovery. Then, using a range finder or other measuring device, calculate the total amount of containment boom required for this deployment based on current speeds and watercourse width. Using shoreline anchoring tactics, create anchoring points, then run hand lines to the work shoreline adjacent to the recovery area. Lay the boom along the channel on the near side of the channel. Anchor the tail of the boom, then pull the head across to prevent developing a belly in the boom, which can result in the entrainment of oil.

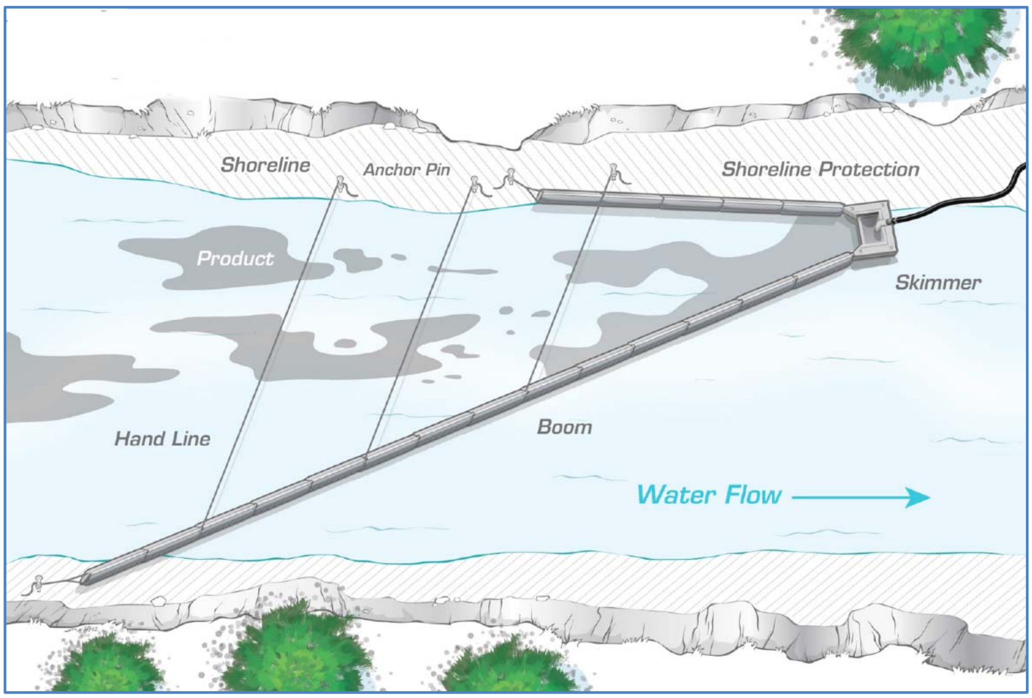

Figure 29—Shore-to-shore Configuration

Anchoring boom above a steep bank may result in a gap between the water and the boom. In these cases, either the bank has to be cut (after appropriate notifications) or the anchor point should be moved to a more appropriate location that guarantees a good seal between the boom and the shoreline.

Deep water may require waders or john boats to aid in the skimming.

6.3.3 Cascading

Deflection or diversionary boom is used to move free product in a certain direction. It can be used to stop free product on the surface of small to medium sized watercourses with moderate to fast currents while allowing fresh water to continue downstream. A combination of these types of boom are known as cascading boom.

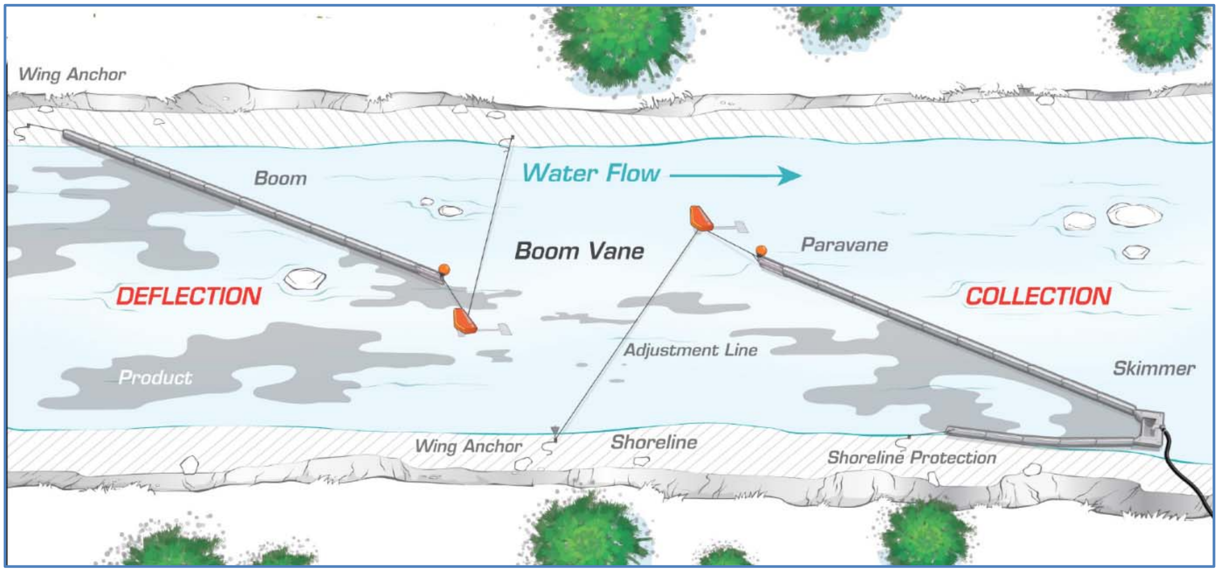

Figure 30—Deflection/Collection Configuration

Responders should first identify, prioritize, and select areas to be protected from impact and maximize recovery. Then, responders should angle the boom based on the current speed. Utilize this configuration to deflect product to the recovery area. Anchor boom and/or boom strings above the high-water mark on the bank to protect against a fluctuation in water levels. Anchor boom to shoreline pins, screw-in anchors, or natural anchors. Multiple independent strings of boom may be required to effectively move product toward a shoreline collection point.

Boom installation is often referred to as a “checkmark configuration” due to the acute angles between long boom and shoreline protection. Deploy oil skimmer at the apex of the boom, where product collects toward the shoreline. Utilize the appropriate number of hand lines to secure the configuration.

6.3.4 Trolley Line

Trolley line boom deployments are used to stop free product on the surface of small to medium sized watercourses with moderate to strong currents where bank-to-bank deployment is not feasible and in-stream anchors can’t be used (i.e., when there is no boat access or a boom vane is not available).

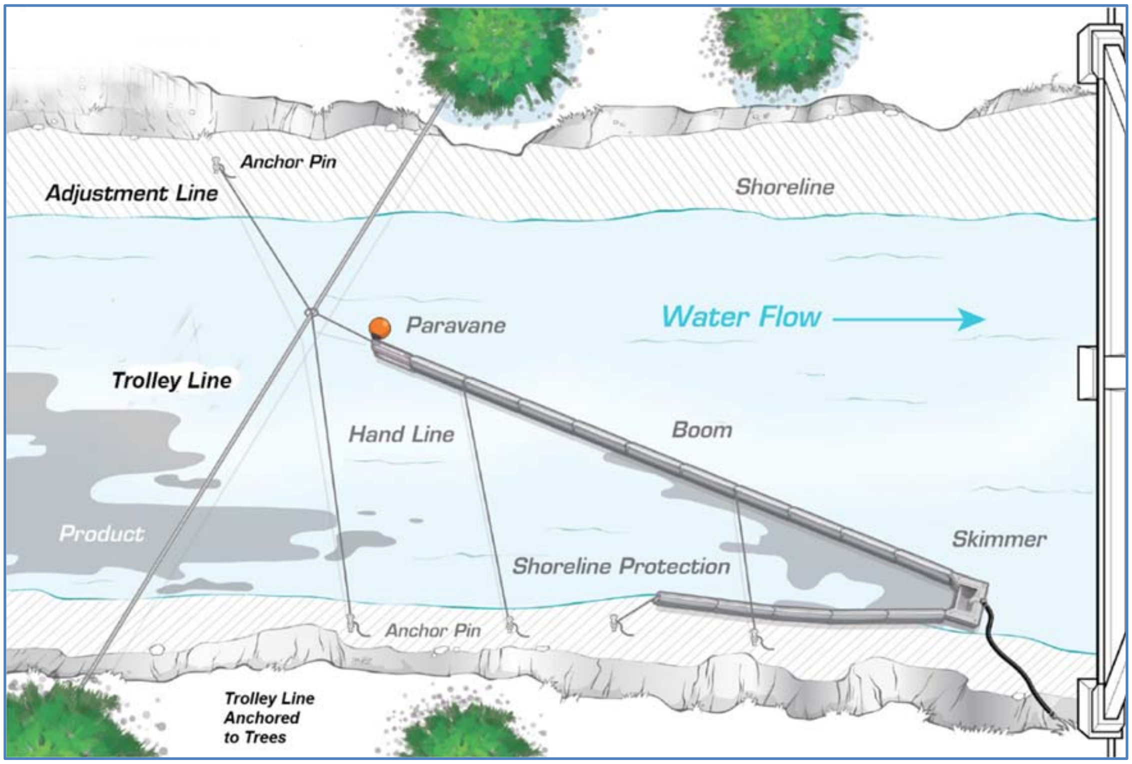

Figure 31—Trolley Line Configuration

Identify, prioritize, and select areas to be protected from impact. Then, anchor the trolley line to shore using shoreline pins, screw-in anchors, or trees and rocks. The trolley line should be installed using a come-a-long or similar device to ensure that it is taut. The trolley line should be installed at a slight angle with the near side being upstream of the far shore. This will allow for adjustable boom angles. The angle of the boom should follow the 10-degree-and-30-degree rule based on current velocity. Deploy the oil skimmer downstream at the end of the boom.

This technique requires the supervision of a subject-matter expert or sufficient training on deployment before it can be installed by field crews. Install in areas where the current is more laminar.

7 Terms and Definitions

7.1
air monitor
A mechanical piece of equipment designed to monitor constituents within the ambient atmosphere. This ensures responders are breathing pollutant-free air.

7.2
bed rock
River substrate in little to no sediment present due to erosion.

7.3
boots
Personal protective equipment designed to protect the responder's feet, most commonly containing a steel toe for added protection.

7.4
boulders
Large rocks that are typically worn smooth due to erosion.

7.5
cascade
A series of steps that renegotiate contaminants from one side of the river system to the other.

7.6
cascading open check configuration
A containment configuration created utilizing multiple containment configurations, most often used on very wide watercourses or rivers with hard-to-access shorelines.

7.7
closed chevron configuration
A containment configuration where an apex is created in the river system utilizing two arms that run back to the shoreline and achieve complete containment with one continuous configuration.

7.8
cobble
A natural medium-to-large stone deposited outside of critical flow.

7.9
Danforth anchor
The most common fluke-style anchor readily available for an emergency situation.

7.10
deflection open check configuration
A containment configuration designed to minimize the amount of containment boom necessary to contain an entire river system. It is also utilized where access is limited.

7.11
eye protection
Coverings that protect the responder's eyes from being poked or from indirect contact with released fluids.

7.12
fire retardant coveralls
Personal protective equipment designed to minimize the dangers of burns and direct contact with released fluids.

7.13
gloves
Covering for the hands, designed to protect the wearer from cuts, cold weather, or direct contact with recovered fluids.

7.14
gravel
Small-to-medium rock deposited outside of critical flow.

7.15
laminar flow
Type of fluid (gas or liquid) flow in which the fluid travels smoothly or in regular paths, in contrast to turbulent flow, in which the fluid undergoes irregular fluctuations and mixing.

7.16
mud flat
A low-profile shoreline with minimal vegetation and constant erosion issues.

7.17
mud (clay) bank
A shoreline with very little structural integrity, often reshaped by rain or flood events.

7.18
oleophilic
Having or relating to a strong affinity for hydrocarbons.

7.19
open check configuration (boom deployment method)
A containment configuration designed to capture bulk released fluid on one shoreline. It may be paired with other configurations to achieve complete containment. This can be created utilizing a boom deployment device.

7.20
open chevron configuration
A containment configuration in which two open checks supersede the centerline of the river and achieve complete containment without traversing the entire water column.

7.21
personal flotation device (PFD)
A piece of personal protective equipment worn around the chest and designed to aid in buoyancy.

7.22
pin anchor
Straight metal bar/dowel designed with a pointed end to allow for easy installation.

7.23
pools
A calm section of a river created from an eddy line.

7.24
rake anchor
An anchor that has fingerlike spikes and a trough, designed to burrow and scoop surrounding aggregate.

7.25
rapids
The fast and most turbulent part of a river system.

7.26
riffle
A rocky or shallow part of a stream or river with turbulent water.

7.27
rip rap
Medium-to-large stone and often man-made concrete structures.

7.28
sand bar
A type of sediment deposit area in which a stable work area is created due to the accumulation of eroded sand.

7.29
SARCA anchors
Anchors designed to self-right underwater and create a pumping action that is intended to drive them deeper into the substrate.

7.30
screw anchor
A rapid deployment anchor designed with a large threaded flight pattern so users do not need to pound it into the ground.

7.31
sediment cliff
A large shoreline bank with vertical topography. It is created from millions of years of erosion.

7.32
shoal
A naturally submerged sand deposit often on the downstream side of obstructions in rivers.

7.33
shore-to-shore configuration
A containment configuration in which the entire span of a river is contained utilizing one continuous containment boom.

7.34
silt (mud/fines)
Sediment that has been eroded upstream and allowed to move through the river system until it finds a depositional area.

7.35
T-post
A metal post traditionally used for fencing; readily available at most hardware stores.

7.36
trolley line configuration
A containment configuration that is designed to utilize the current speed, shoreline anchors, and a pair of lines to dictate the boom angle and deployment position.

7.37
undercut bank
A shoreline that has a false floor with little to no sediment underneath it. It is created from erosion, and can be very dangerous and detrimental to response efforts.

7.38
waders
Waterproof personal protective equipment designed to be worn up to the chest and with a personal flotation device.

7.39
wing anchor
A shoreline anchor in which a pin has been welded to a flat metal triangle. It is designed to create more surface area resistance.

7.40
wooded upland
A characterization of the vegetation along the watercourse. This botanical development is often very helpful during deployments, but may hinder large equipment access.

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