3.2.1d | Small Watercourses | Stream Dams | Water-Gate™

The Water-Gate™ dam is an open, self-filling barrier that, when in place, relies on the hydrostatic pressure differential axis to provide a bottom seal and to keep its mouth open. A small version of the Water-Gate weighs less than 30 kg (66 pounds) and can provide a water retention height of 35cm (14 inches) and span up to about 8m (26 feet).

Tips: - Tactic can cause possible upstream flooding in areas with flat topography.

- The boom in the diagram is to protect the dam from contamination.

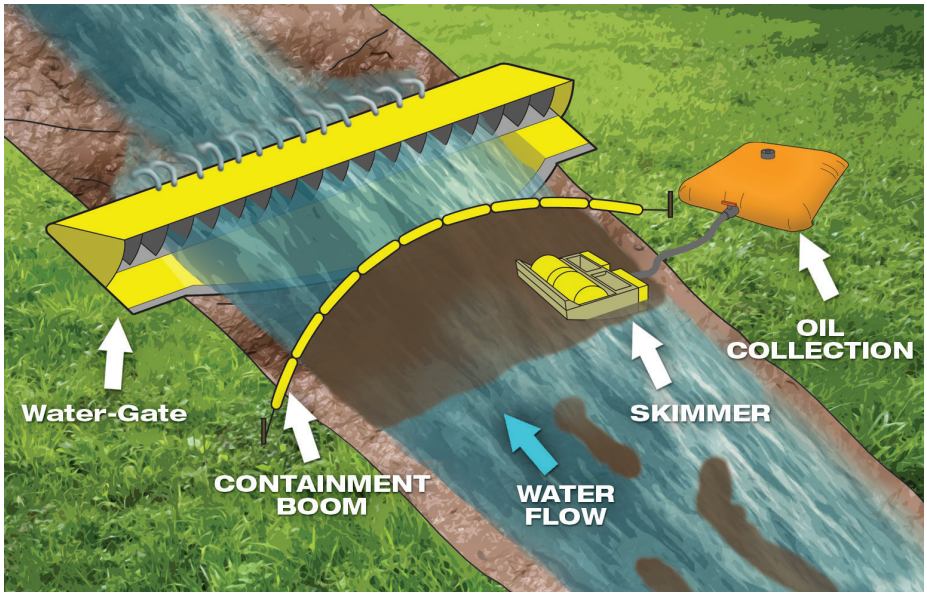


Diagram 3.2.1d Water-Gate

3.2.1 | Small Watercourses | Stream Dams

Water-filled dams and other forms of portable stream dams can be used to control the spread of a spill.

Call Before You Dig

Tip: Stream dams are more effective when used in near-zero current conditions.

Purpose: To contain and facilitate recovery of a water-borne spill from a ditch, creek or stream.

Application: Use in slow-moving shallow watercourses.

Environmental Considerations: Maintain control of damming materials to avoid introducing foreign substances into the watercourse. Handle and dispose of contaminated wastes in an approved manner. Tactic can cause possible upstream flooding in areas with flat topography.

Equipment Required: Water bags or other forms of mechanical stream dam devices, anchoring devices.

If significant amounts of product are expected, ensure recovery equipment is in place or en route.

Waste disposal bags and tags if sorbents are to be used.

Recovery Equipment Options: Sorbents, skimmer, pump, hoses, hose strainer, temporary liquid storage capacity, vacuum truck

Waste disposal bags and tags if sorbents are to be used

Operation:

1. Consider ground disturbance requirements before driving stakes/T-posts.

3.2.2 | Small Watercourses | Board Weir

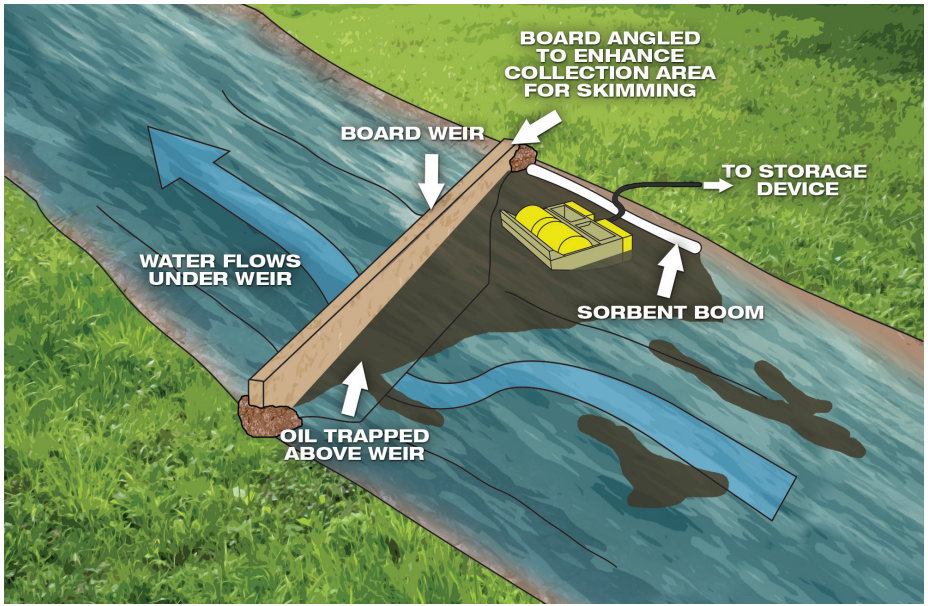


Diagram 3.2.2a Board Weir

3.2.2 | Board Weir

A board weir is an example of an underflow dam.

Call Before You Dig

Tips: - Downstream and upstream T-posts can be added for support and adjustment of the weir.

- Angle the board to create a recovery point. Protect the shoreline at the recovery point with boom.

- If sufficient recovery capacity is not in place at the board weir installation, the captured material can thicken and be lost beneath the board due to entrainment.

Purpose: To contain a spill in a water-filled ditch, creek or small stream for recovery.

Application: To stem the advance of oil in a small watercourse.

Environmental Considerations: Increased water velocity below the board may cause local erosion or scouring. Use erosion control measures to prevent excavated soil at edges from entering downstream water.

Equipment Required: Shovel(s), board of sufficient length to cross watercourse.

Recovery Equipment Options: Sorbents, skimmer, pump, hoses, liquid storage device or vacuum truck, as appropriate

Operation:

1. Place board in the water across the watercourse to prevent the advance of any surface-borne contaminants while leaving a gap below to allow the clean water to continue flowing. Dig the board ends into the banks and seal any gaps at the board ends with sorbents or mud.

3.2.3 | Culvert Block

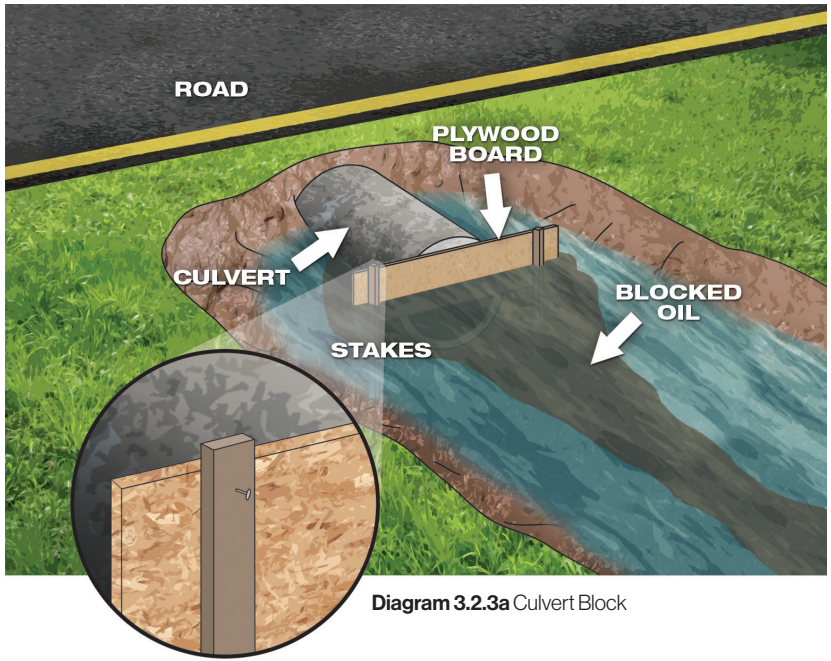


Diagram 3.2.3a Culvert Block

3.2.3 | Small Watercourses | Culvert Block

Culverts and other large diameter conduits that allow a watercourse to pass under or through obstacles present an opportunity for controlling the spread of oil. If water flows are sufficiently low, they can be blocked entirely with boards or plywood to contain oil above the culvert. In higher flow situations, partial culvert blocks can be installed to create underflow dams.

Tip: Board should not be permanently secured but made adjustable to account for water flow. Leave nails protruding to make it easier to adjust board level, if required.

Purpose: To stem the advance of oil in a watercourse.

Application: Where culverts are present.

Environmental Considerations: Manage board level to allow water to pass through culvert, reducing flooding on upstream side and maintaining downstream flow.

Equipment Required: Sheet of plywood, wooden stakes (2), sledge hammer, long nails, claw hammer.

Recovery Equipment Options: Sorbents, skimmer, pump, hoses, temporary liquid storage, vacuum truck.

Operation:

1. Place plywood sheet on UPSTREAM side of culvert. Secure in place with two stakes driven into bed of ditch, creek or stream.
2. Raise board sufficiently to allow passage of water under the board's lower edge. Secure in place by driving nails through stakes into plywood.
3. Monitor water levels to ensure sufficient flow is being allowed to pass beneath the culvert block. Adjust weir, as appropriate.
4. Sorbents may be required to be placed between rough culvert pipe end and the plywood to ensure a good seal.

3.2.4 | Small Watercourses | Filter Fence

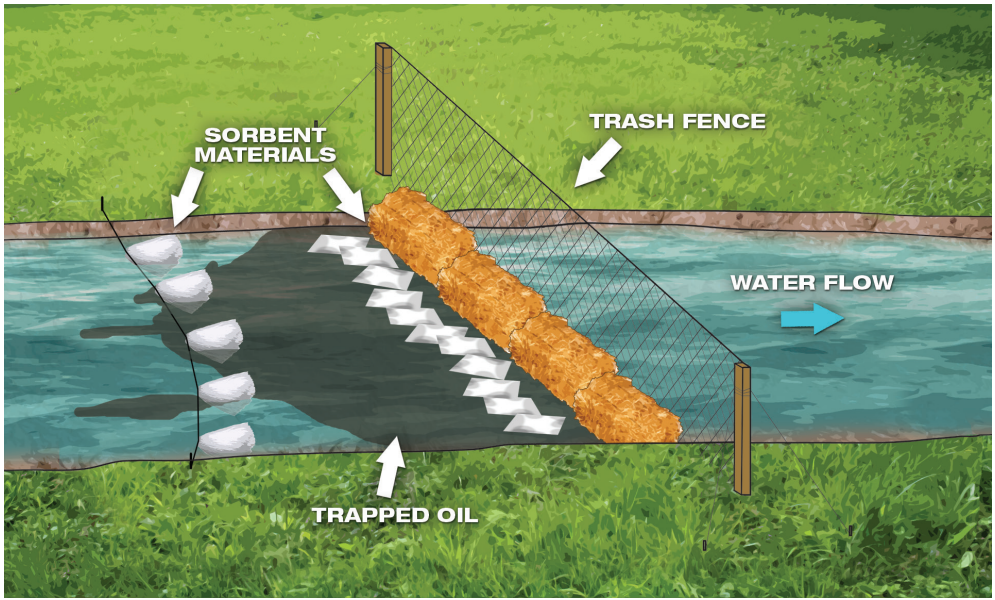


Diagram 3.2.4a Filter Fence

3.2.4 | Small Watercourses | Filter Fence

A filter fence can be used to contain oil in a moving watercourse because it offers a barrier to floating oil while allowing water to pass through.

Consider ground disturbance requirements before driving stakes/t-posts.

Tip: Board should not be permanently secured but made adjustable to account for water flow. Leave nails protruding to make it easier to adjust board level, if required.

Purpose: To contain and recover a water-borne spill from a ditch, creek or stream.

Application: Use in slow-moving shallow watercourses.

Environmental Considerations: Maintain control of damming materials to avoid introducing foreign substances into the watercourse. Monitor setup for possible trapped wildlife. Handle and dispose of contaminated wastes in an approved manner.

Equipment Required: Stakes/T-posts (2), sledge hammer/post driver (safety glasses /goggles), wire, wire staples, claw hammer, wire cutters, chicken wire (roll), hay/straw bales, sorbent booms, pom-poms or similar absorbent materials, waste disposal bags and tags, shovel(s). Waders, safety harness and line, and PFD may be required.

If significant amounts of product are expected, ensure recovery equipment is in place or en route.

Waste disposal bags and tags if sorbents are to be used.

Operation:

1. Firmly anchor stakes in ground; use guy wires if necessary. Central stream stakes may be required.
2. Affix chicken wire to stakes. Run wire stake-to-stake to support the chicken wire.
3. Place sorbent materials on upstream side of device. Monitor and replace sorbent as necessary. If significant amounts of product are expected, consider repeating several installations. Add sorbents on upstream side of the fence as necessary.

3.2.5 | Small Watercourses | Flexible Hose Siphon Dam

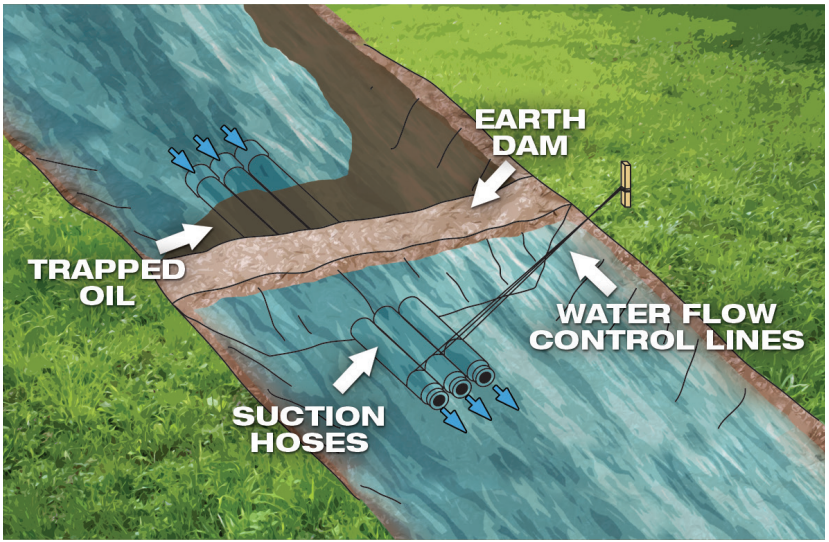


Diagram 3.2.5a Flexible Hose Siphon Dam

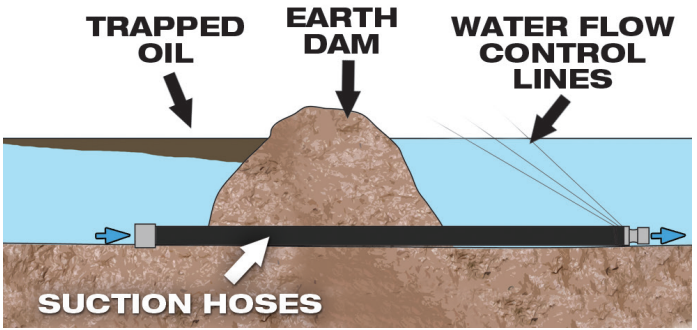


Diagram 3.2.5b Side View of Siphon Dam

3.2.5 | Small Watercourses | Flexible Hose Siphon Dam

A siphon dam or hose siphon dam is an example of an underflow weir. It provides a barrier to a spill moving on the surface, while allowing water to pass, preventing the dam from being over-topped.

Tips: - Siphon dams can also be constructed of soil or sandbag berms with angled hoses to carry water away.

- Install more hoses than necessary, as water may build up very quickly.

Purpose: To contain a spill in a water-filled ditch, creek or small stream for recovery.

Application: To stem the advance of oil in a small watercourse.

Environmental Considerations: Use appropriate damming materials so as not to cause further damage to the waterway through siltation. Maintain control of damming materials to avoid introducing foreign substances into the watercourse and increase siltation. Downstream water flow may be restricted.

Equipment Required: Shovel(s) or earth-moving equipment, suction hoses, rope and knife.

Recovery Equipment Options: Sorbents, vacuum truck or skimmer with hoses, pump and temporary liquid storage.

Waste disposal bags and tags if sorbents are to be used

Waders, safety harness and line plus PFD may be required.

Operation:

1. Fasten rope to the downstream end of each of the suction hoses and affix to shore anchor point.
2. Lay the suction hoses in parallel on the bed of the watercourse. Cover hoses with soil/fill sandbags, leaving the exposed downstream portion of the hoses longer than the upstream side.
3. By raising/lowering one or more hoses with the rope, the level of the water being retained by the structure can be effectively controlled.

3.2.6 | Small Watercourses | Sorbent Booms

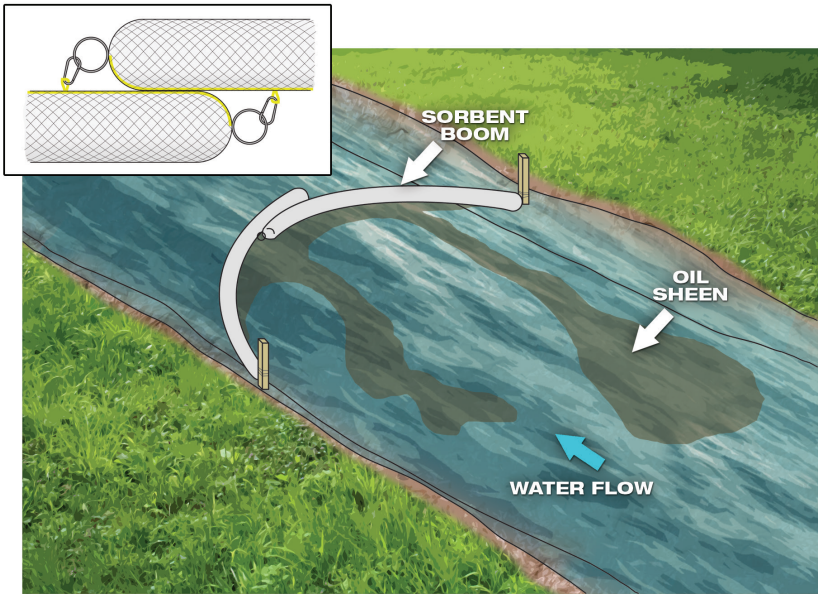


Diagram 3.2.6a Sorbent Booms

3.2.6 | Small Watercourses | Sorbent Booms

Sorbent booms are oleophilic (oil-attracting), lightweight and easily handled, installed and anchored, but are not designed for longterm use or harsh, high-current conditions. They should not be left unattended for long periods.

Tip: This tactic is less effective in faster flowing water.

Purpose: To contain and recover a spill in a water-filled ditch, creek or stream.

Application: Can be used as a containment boom liner, shore-line protection and for sheen management.

Environmental Considerations: Handle and dispose of contaminated wastes in an approved manner.

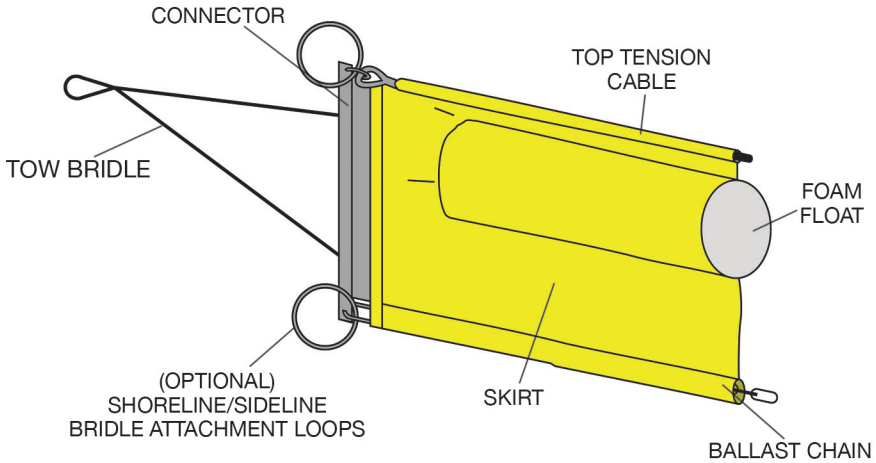
Equipment Required: "Hydrocarbon-only" sorbent boom or booms as appropriate. Stakes/T-posts, shore anchors or shoreline fixtures may be used to secure the boom(s). Rope, knife, waste disposal bags and tags. Waders, safety harness and line, and PFD may be required.

Operation:

1. Clip booms together in overlapping arrangement to achieve the required length. Affix to anchor points with rope.
2. If significant amounts of product are expected, consider several installations or additional hydrocarbon-only pads and/or pillows on the upstream side.
3. Monitor and replace the contaminated sorbents as necessary.

3.3.1 | Larger Watercourses | Floating Containment Boom

While materials and configuration may change from one manufacturer to another, floating containment booms share many of the same components and nomenclature. A typical, solid-flotation boom is illustrated in Diagram 3.3.1a.



3.3.1 | Larger Watercourses | Floating Containment Boom

Containment boom comes in an assortment of different sizes, identified by the overall height of the boom, or alternatively, by the diameter of the float and the depth of the skirt. ASTM[1] elects to classify boom by its overall height, and offers the following guidance for selecting boom that may be useful in inland water spill response:

Table 3.3.1a ASTM Guide for Boom Selection

Boom Property	Calm Water*	Calm Water - Current*
Overall height (range), mm(in)	150 to 600 (6 to 24)	200 to 800 (8 to 32)
Minimum gross buoyancy to weight ratio	3:1	4:1
Minimum total tensile strength, N(lbs)	6,800 (1,500)	23,000 (5,000)

Shallow skirts are advised for fast moving waters, because their reduced drag makes them easier to deploy and secure. Deeper skirts are advised where waves may be encountered.

The key to using boom to contain or redirect spilled oil is remembering that, regardless of the size selected, it will not retain oil when used in currents greater than about 3/4 of a knot (measured "normal to" or perpendicular to the plane of the boom itself). This is important and is illustrated in Diagram 3.3.1.a Maximum Boom Angles for Various Currents (on page 39). The maximum river currents consistent with 3/4 of a knot normal velocity are shown as a function of the angle the boom makes with the incident current.

* Calm Water = No waves and no current. Calm Water - Current = No waves with current.

[1] ASTM, F1523 - 94 (Reapproved 2013) Standard Guide for Selection of Booms in Accordance with Water Body Classifications. West Conshohocken, PA.

3.3.1 | Larger Watercourses | Floating Containment Boom

A boom stretched directly across the stream (90 degrees to the current) can only be expected to contain oil in currents up to 3/4 of a knot (0.86 mph or 1.39 kph), while a boom angled at 30 degrees can provide effective containment in twice that velocity.

Tip: It is Enbridge's recommended practice, when current is present, that boom not be installed at a degree greater than 45°.

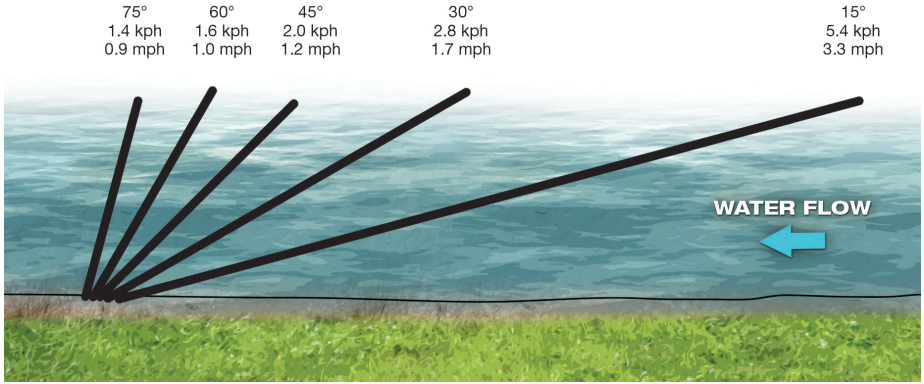


Diagram 3.3.1b Maximum Boom Anfles for Various Currents

3.3.2 | Larger Watercourses | Shore Seal Boom

The unique configuration of shore seal boom allows it to provide an effective barrier to control the spread of oil in the critical region where the water meets the shoreline. It is a floating barrier with integral water bags that provide an effective seal when grounded. A smaller tube is fitted into a larger tube. The larger outer tube is filled with water and the smaller inner tube is filled with air. Shore seal boom can adjust to fluctuating water levels.

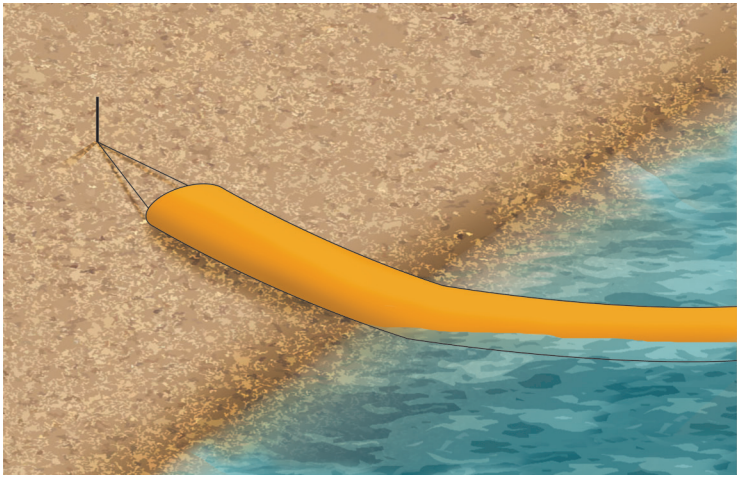


Diagram 3.3.2a Shore Seal Boom

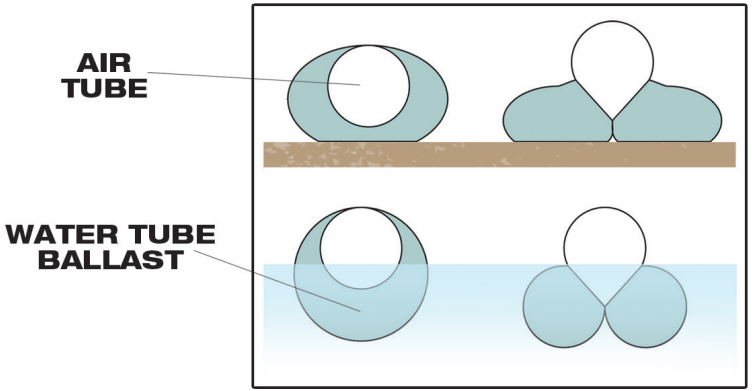


Diagram 3.3.2b Cross-Section of Shore Seal Boom

3.3.3 | Larger Watercourses | Deflection/Exclusion Booming

Sometimes the spread of a spill simply cannot be contained, particularly if it reaches moving water. This section discusses an alternative tactic for control of spills in moving water, which is to deflect or redirect the flow. This section also discusses the tactic of reverse containment, or exclusionary booming. Exclusion and deflection tactics are highly sensitive to watercourse velocity.

The goal of exclusionary booming is to prevent spilled product from entering particularly sensitive areas, in hopes of being able to deal with it somewhere downstream. The goal of deflection booming is to divert surface oil out of fast-moving surface waters to low-velocity backwaters or eddies where it can be contained and controlled for recovery. Natural, low-energy collection points may already be identified in a river system, but their location can change significantly with the season and fluctuating river flows.

Suitable backwaters for collection points are most easily identified by the presence of high concentrations of floating, stagnant debris. Where backwaters do not exist naturally, it may be necessary to create a similar low current environment by mechanical means, where the spill can be successfully recovered. A circus skimmer or similar device can be the least intrusive means of creating a suitable backwater.

The assumption is made that Control Points have been pre-selected and identified for the affected water body. A Control Point is a predetermined location from which spill containment and recovery operations may be conducted with the expectation of a high degree of success.

The Control Point information sheet may supply guidelines as to the optimum equipment and deployment techniques for that location, considering river flows. For larger releases, it is common for responders to mobilize to more than one Control Point simultaneously.

As with the selection of deflection/exclusion tactics, a critical issue in Control Point selection is the river speed to ensure the correct location is identified that permits adequate time for:

• Personnel and equipment mobilization • Travel to the location • Completion of the deployment, ideally in time to capture the leading edge of the spill in the river

While Control Point mapping may provide guidance as to the tactics to be employed at a Control Point, conditions at the time of the response and the available equipment will dictate the one(s) employed.

3.3.3 | Larger Watercourses | Deflection/Exclusion Booming | Estimating Stream Speed

There are a number of methods commonly used to identify river speed. The use of a stream speed meter and the manual stick in the stream technique are described below. Measure water flow speeds with flow meter or by the following:

1. Place two markers along shoreline 30.5 metres (100 feet) apart.
2. Throw a stick or other floating object into the river where the surface velocity appears fastest, approximately six metres (20 feet) upstream of the first marker.
3. Determine the time it takes the object to transit the distance between the two markers in seconds.
4. Use Table3.3.3a Stream Speed Estimating on page 42 to estimate water speed. This will aid in determining the proper boom angle and length, using Table 3.3.3b Boom Configuration and Length as a Function of Various Currents on page 53.

Tip: In all cases, the fastest flow of the water body must be selected for measurement. This provides planners with the most conservative basis for estimating resource requirements.

3.3.3 | Larger Watercourses | Deflection/Exclusion Booming | Stream Speed Table

Table 3.3.3a Stream Speed Estimating

Time for Object to Travel				
30m (100ft)				Current
sec	km/hr	m/s	mr/hr	ft/s
216	0.5	0.14	0.3	0.46
108	1.0	0.28	0.6	0.92
72	1.5	0.42	0.9	1.38
54	2.0	0.56	1.2	1.84
43	2.5	0.69	1.5	2.26
36	3.0	0.83	1.9	2.72
31	3.5	0.97	2.1	3.18
27	4.0	1.11	2.5	3.64
24	4.5	1.25	2.8	4.10
22	5.0	1.39	3.1	4.56
18	6.0	1.67	3.7	5.48

When the stream velocity has been determined, use Table 3.3.3b Boom Configuration and Length as a Function of Various Currents on page 43 to estimate the angle that deflection or diversion boom should make with the current and approximate length of boom required to avoid entrainment.

3.3.3 | Larger Watercourses | Deflection/Exclusion Booming | Estimating Boom Length

Table 3.3.3b Boom Configuration and Length as a Function of Various Currents

Angle Degree	Max Allowable River Current			Length of Boom Required per 100' of Span	
	kts	kph	mph	ft	m
90	0.8	1.4	0.9	100	30
75	0.8	1.4	0.9	104	32
60	0.9	1.6	1.0	115	35
45	1.1	2.0	1.2	141	43
30	1.5	2.8	1.7	200	61
15	2.9	5.4	3.3	386	118

3.3.3.1 | Larger Watercourses | Deflection/Exclusion Booming

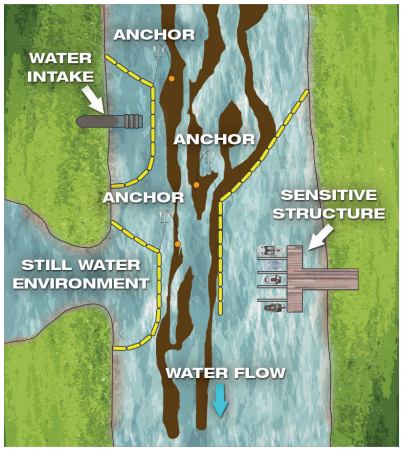


Diagram 3.3.3.1a Protection of Shoreline Resources by Exclusion Booming

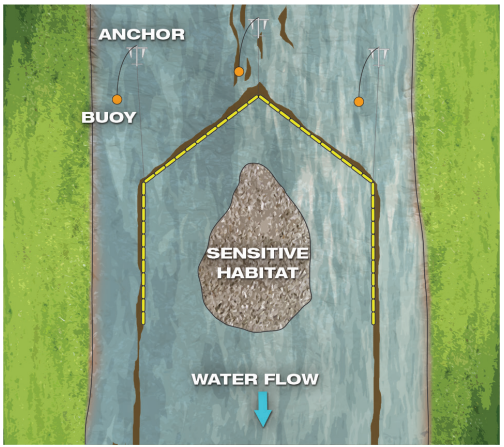


Diagram 3.3.3.1b Protection of In-Stream Sensitive Resources by Exclusion Booming

Oil is being excluded from the water intake and still water environment on the left side of Diagram 3.3.3.1a. At the same time, deflection booms are being used to divert any passing oil around the structure located on the right side of Diagram3.3.3.1a. Diagram 3.3.3.1b shows how a mid-stream sensitive resource can be protected using exclusion booming techniques. Note the use of anchors in the stream to hold the boom in the desired positions. Anchor deployment is discussed in Section 4.1.2 Anchor Deployment from Boat.

3.3.3.1 | Larger Watercourses | Deflection/Exclusion Booming

Call Before You Dig

Tip: Stream dams are more effective when used in near-zero current conditions.

Purpose: To prevent a waterborne contaminant from impacting a sensitive shoreline or in-stream resource.

Application: Where direct containment is not an option.

Environmental Considerations: Anchor deployment may disturb the stream bed ecosystem. Land-based anchor systems may disturb sensitive areas on shore. Avoid unnecessary disturbance.

Equipment Required: Boat, booms, tow bridle(s), sideline bridle(s), ropes, carabiners, anchor assemblies, shoreline anchor pins, sledge hammer/post driver. Consider boom marker lights for night operations.

Recovery Equipment Options: Laser rangefinder, boom marker lights for night operations. Use a post driver instead of a sledge hammer for safety!

Operation:

1. Identify sensitive area to protect.
2. Place the boom in an arc around the sensitive resource.
3. Affix anchor(s) as necessary to hold boom away from the resource. Anchor lines can be joined to boom at end connectors or at intermediate locations when sideline bridles are available.
4. Other than in areas with significant back eddies, the downstream end of the boom may be allowed to float free.
5. Pick up each "arm" and pull into the desired location. Attach sideline bridle and attach anchor while allowing the downstream portion of the boom to float free. Arms can be anchored at the downstream end, if required.
6. The anchor marker buoys on a line attached to the anchor crown permit it to be reset by dragging along the bottom to the new required location rather than raising it completely and redeploying.

3.3.3.2 | Larger Watercourses | Deflection/Exclusion Booming Cascade System Using Booms/Anchors

Deflection booming can be used to assist oil collection for recovery in high-current environments. If the current in the middle of the river is high, a boom stretched across the river will not contain the oil because the oil will ENTRAIN and pass beneath it. However, if booms are placed at an angle to the current, entrainment is reduced and the oil is deflected out of the heaviest current to low-velocity zones.

The illustration shows multiple short sections of boom being used in a CASCADE arrangement to move oil away from the lower bank to the collection area installed on the opposing bank. The illustration shows multiple short sections, because it is frequently easier to install than one long one.

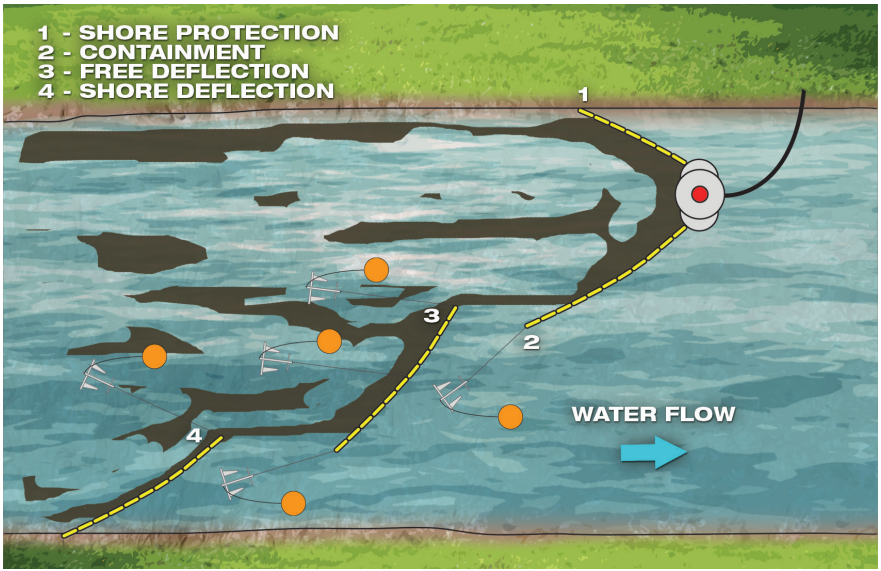


Diagram 3.3.3.2A Deflection/Exclusion Booming Cascade System Using Booms/Anchors

3.3.3.2 | Larger Watercourses | Deflection/Exclusion Booming Cascade System Using Booms/Anchors

Observe "No Anchor" Zones

Tips: - A three-way manifold will permit options for the distribution of recovered liquids coming from the skimmer without interrupting skimmer operations: direct to temporary storage tank, direct to vacuum or tank truck, or from temporary storage tank to vacuum or tank truck.

- The anchor marker buoy on a line attached to the anchor crown plate permits it to be reset by dragging it along the river bottom to the new required location, rather than raising the assembly completely and redeploying. It is also easier and safer retrieving an anchor, especially a Danforth or Davistype with movable flukes, by pulling it up by the buoy rope and lifting it into the boat by the stock.

Purpose: To deflect a spill across part or all of the water flow to a collection/recovery point.

Application: In wider and faster moving watercourses with shoreline access for recovery.

Environmental Considerations: Anchor deployment may disturb the stream bed. Avoid unnecessary disturbance.

Equipment Required: Workboat, boom, tow bridles, sideline bridles. If intermediate anchoring is required: ropes, anchor assemblies, shoreline anchor pin(s), if required.

Optional But Recommended: Laser rangefinder, three-way manifold, boom marker lights for night operations.

Recovery Equipment Options: Skimmer, pump, hoses, temporary liquid storage and/or vacuum/tank truck.

Operation:

1. Install the skimmer and booms (Booms 1 and 2) first and then work upstream.
2. Install deflection booms (Boom 3 followed by Boom 4, and so on).
3. Connect anchor assemblies to the boom by attaching the mooring line to the tow bridle at each end. Intermediate anchors can be attached using sideline bridles.
4. Deploy upstream end anchor assembly first; move downstream and deploy river bed anchor and marker buoy for the downstream end. Attempt to place the boom so that it forms a gentle curve or slight "J" with the section overlapping to feed the next downstream component.

3.3.3.3 | Larger Watercourses | Boom Deployment River Bed Anchor

Installing deflection booms and a skimming system to recover oil from a watercourse is traditionally done in stages. Components are laid out in groups for staged installation.

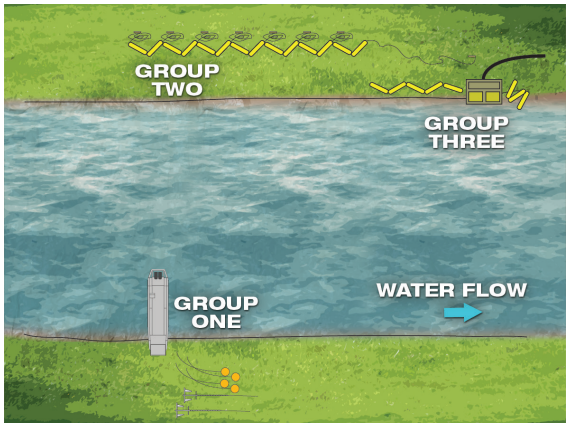


Diagram 3.3.3.3a Boom Deployment River Bed Anchor: Boat preparing to install ground tackle (Group One)

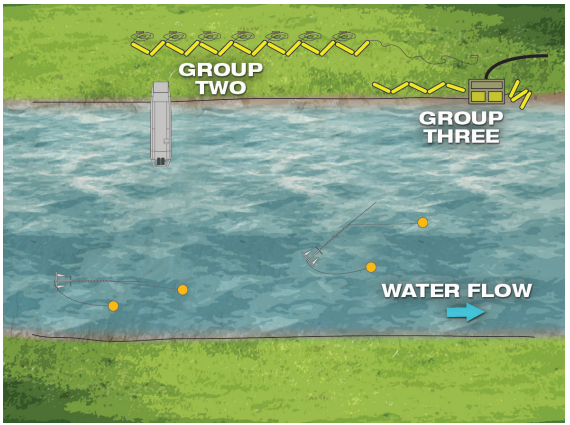


Diagram 3.3.3.3b Boom Deployment River Bed Anchor: Anchors installed. Boat preparing to secure diversion booms (Group Two) to installed anchors