Winter Oil Spill Recovery Tactical Guidance Document

Best Practice Guidelines for Preparedness and Response for Inland Frozen Waterways

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American Petroleum Institute

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Foreword

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Purpose of the Good Practice Guide

This is a field operations guide. It is not an educational or decision-making tool. This guide contains a set of operational checklists, tools, and references to assist in inland winter spill response (WSR) for oil releases.

Priorities for Oil Spill Response

— People: safety of response personnel and the public.

— Environment: prevention of negative effects on the environment, human health, and welfare.

— Assets: minimizing damage to structures and equipment.

— Relations: keeping customers, the community, and federal, state, and local government agencies informed.

Safety

Responder safety and health must never be compromised for tactical considerations.

WSR should only be conducted on and around ice if deemed safe to do so by qualified and experienced responders, with the goal to avoid health and safety impacts to responders, the public, occupied areas, roadways, etc. On-ice operations should not proceed without an acceptable ice evaluation and onsite, trained rescue personnel at the ready.

Intended Audience

This guide is intended for experienced response operations personnel having basic knowledge in WSR, but should also be used as a tool to prevent further damage to the environment. This guide is designed to be a personal walkthrough geared more toward a layman understanding of the necessary response tactics and consequences of WSR. Although widely applicable, this guide reflects research and experience in North America.

How to Use this Field Guide

A decision to implement WSR with appropriate local, state/provincial, and/or federal approvals should already have been made before field operations commence. The decision to pursue on-ice response should be made early in an incident, should consider responder safety and feasibility of implementation, and should include guidance from incident command to make best use of windows of opportunity.

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 included checklists provide guidance to develop operational arrangements to support WSR on location.

— The scale of the spill response and its tactics will significantly affect the potential hazards, permissions required, operational staffing, management structure, and intensity of any air or water quality monitoring.

This guide is intended to be incident scale-neutral.

— When encountering unfamiliar terms or acronyms, please refer to the glossary.

— Annexes provide additional detail on specific operational considerations.

Contents

Inland Winter Oil Spill Recovery

1 Safety

On-ice response activities should only commence after thorough ice evaluation and operational requirements of the recovery location are considered. Responder safety is paramount in all response work, and in WSR it is key for everyone's safety to employ a **"don't know, don't go"** attitude.

Working on ice can be very dangerous; ice thickness, quality, and the anticipated weight of response operations on the ice all need to be considered and constantly evaluated. A heightened sense of urgency to respond should never outweigh responder safety on ice. It is critical that the hazards of working in winter conditions, on ice, and with a potentially volatile product are noted for the sake of hazard elimination, or so that engineered controls or appropriate personal protective equipment (PPE) are put in place.

For the purposes of this guide, there will be no specific reference to government or company policies, nor all hazards associated with WSR. The focus will be on the larger picture and key safety equipment with which all responders should be familiar.

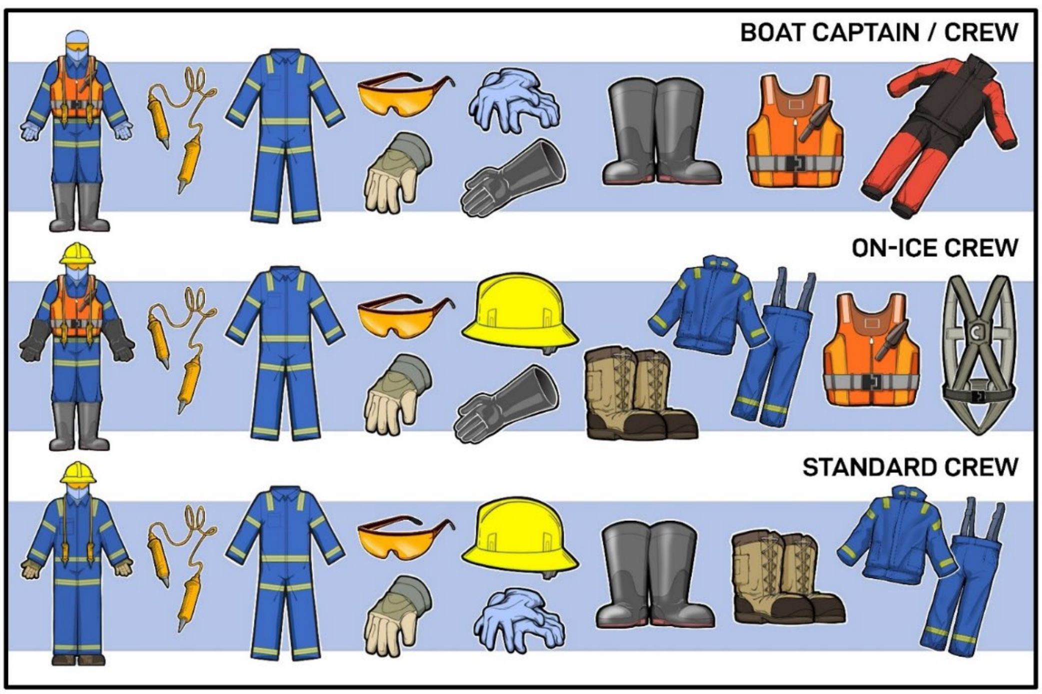
1.1 Safety Equipment and PPE

Different roles and work locations will require specific PPE to help ensure adequate protection. For the purposes of WSR, different scopes have been laid out below. These are not exhaustive, and there will be overlap based on the activity and comfort level with the ice assessment outcomes described later in this document.

When it comes to PPE, working in winter is a balancing act in terms of personal comfort and mobility, and PPE requirements can change based on the task. Dress in layers—including both moisture-wicking and insulating clothing—as well as outer wind-breaking and water/ice-repelling fire-retardant outer layers with high-visibility banding. Appropriate gloves, safety eyewear, and hearing protection for the conditions and tasks are essential for worker safety. Protective footwear should be steel or composite toe and shank, and be built of a material that is water-repellant and offers insulation. Traction aids are also highly recommended for anyone on the ice. Personal flotation devices (PFDs) are a must for anyone on the ice during assessment, whether working from vessels or near open water. Consideration should also be made for integrated flotation coats or immersion or dry suits depending on the task, conditions, and level of training. Responders are encouraged to have additional layers available onsite, as well as a change of clothes available. All efforts to build suitable onsite warming structures for personnel and equipment should be considered, and all areas of ice slotting should have barrier fencing in place to create work zones that are easily identifiable to match with the required PPE for authorized entry.

Any open-water locations that may be places for released oil to collect should be considered for air monitoring to protect responders and the public. Enclosed areas such as tents erected around skimming equipment are especially important for air monitoring, and respirators and intrinsically safe heating options may be needed based on the outcome of the monitoring. All the above considerations, and others, depending on the scope and site characteristics, are best captured in a thorough response-specific health and safety plan (HASP) that is created prior to initiating any work. This is a living document that should be updated and communicated as conditions and information changes to all who may be affected. It will also involve the inclusion of an ice safety plan and a rescue plan.

The figure below shows basic recommendations for PPE broken down by job functions. It is important to note that responders should always adhere to the company or contractor HASP and government guidelines if they are more stringent than the suggestions below.



Boat captain/crew: Site assessment and standby rescue operations

— standard PPE (fire-retardant coveralls, work boots, safety glasses, gloves, head covering), PFD/floater suit, hearing protection, ice awls.

On-ice responders: Initial ice assessment, ice slotting, oil recovery, or generally working near open water

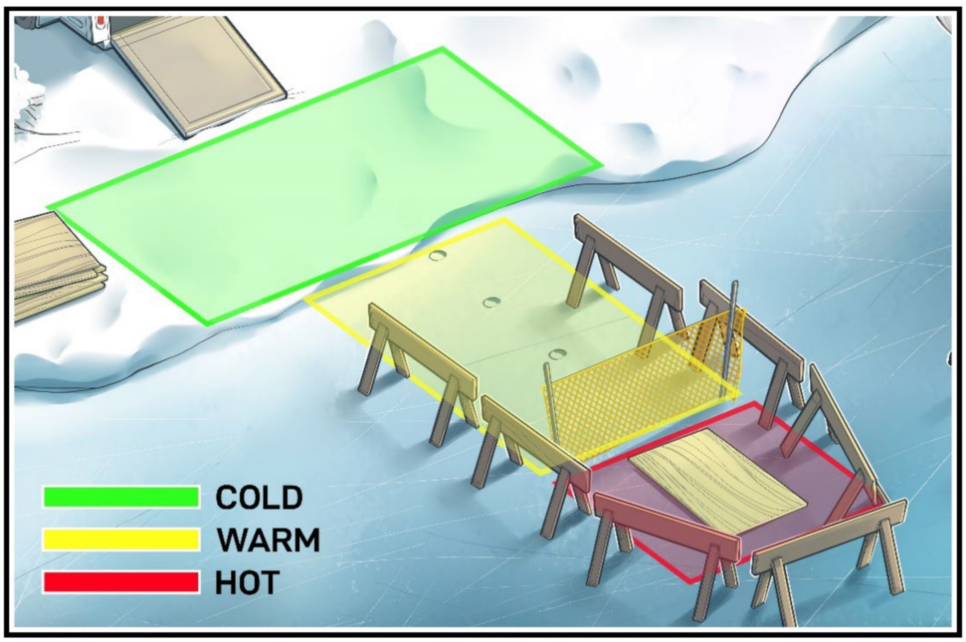
— standard PPE (fire-retardant coveralls, work boots, safety glasses, gloves, hard hat, head covering), PFD, rescue harness (front and back D-rings), life line, traction aids for footwear, hearing protection, and ice awls. Consideration for flotation suits or dry suits based on conditions, hazards, and availability.

Standard responders: Labor, equipment operators, consulting/sampling crews (after ice safety plan deems the work area and ice conditions safe and open water hazards are fenced off)

— standard PPE (fire-retardant coveralls, work boots, safety glasses, gloves, hard hat, head covering), traction aids for footwear.

1.2 Site Safety Considerations

This work is new to many individuals involved in a response. Care and attention should be taken by subject-matter experts (SMEs), experienced responders, incident management personnel, and safety/rescue personnel to help ensure all parties understand the risks, hazards, and tasks being asked of them. Knowing that the ice has been deemed safe and what load-bearing capacity for the given work area has been agreed upon is essential. A proper incident command system (ICS) should have been established; a designated location for safety and daily task briefing documents should also be established and reviewed by all participants at the start of a shift, or as individuals join the response. Designating zones within a worksite to clearly indicate the levels of PPE, safety considerations, and possible decontamination zones are vital to a safe and clean worksite.



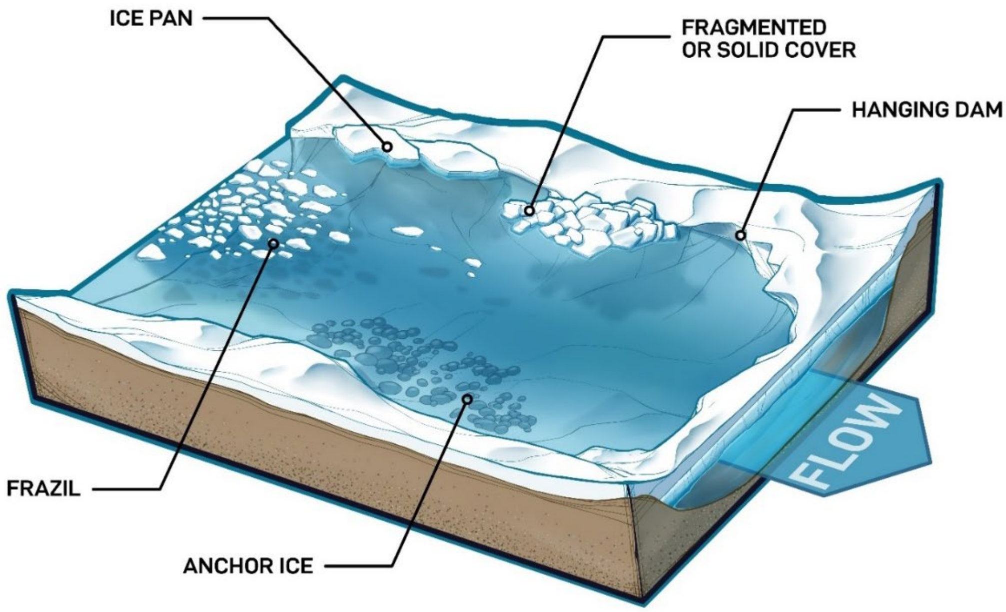
1.2.1 Ice Science

1.2.1.1 Ice Formation

The way that ice is formed on a river or a lake will affect its quality and thickness, and that will affect its load-bearing capacity. Several factors can influence ice formation, including wind that causes broken ice, the natural insulating ability of snow, the freeze/thaw cycle of a snow/ice interface, and debris frozen in the ice. Never assume that ice conditions will be uniform until a thorough ice assessment has been completed.

1.2.1.2 River Ice

River ice is formed through a variety of processes. Generally, supercooled river water forms ice crystals called frazil ice; these crystals freeze together to form pans, and these pans will become lodged and frozen to objects such as trees or solid shoreline ice (called anchor ice). This process repeats itself until the maximum surface area of the river is frozen over, or until the freezing cycle is impacted by the effects of current or a weather change. Areas with the highest river velocity will generally have the thinnest ice or open water.



1.2.1.3 Lake Ice

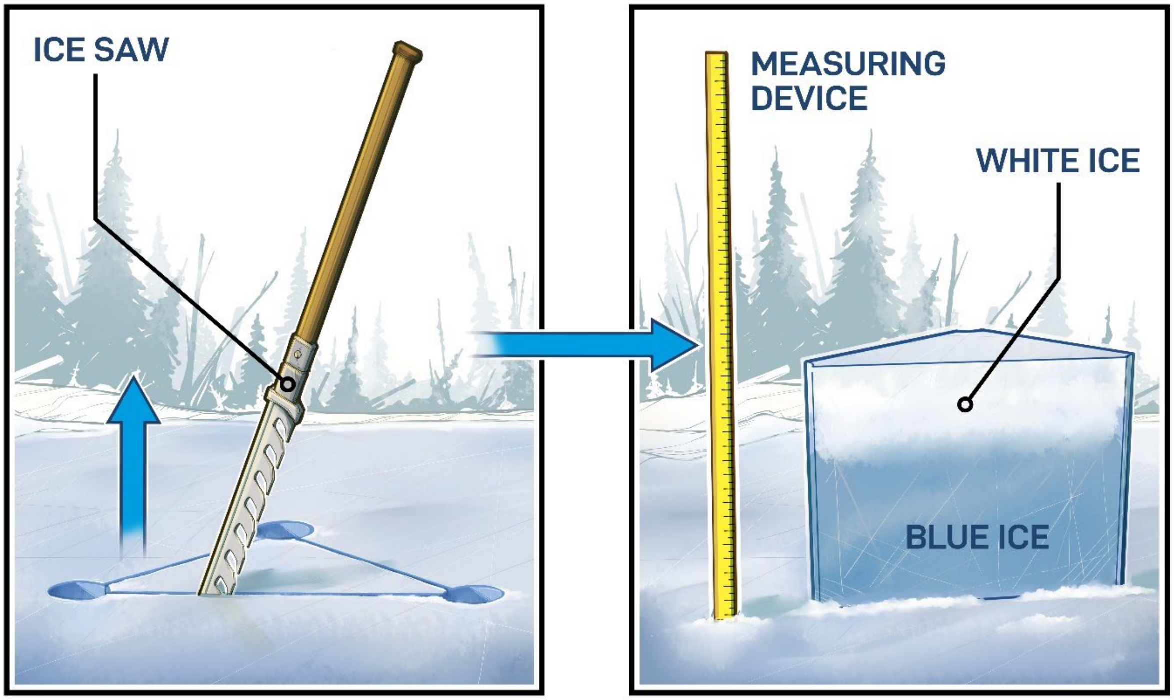
Ice on a lake tends to be more uniform as the formation is not influenced by current. Ice will freeze outwards from the shore until it is affected by wind or another weather factor, or until it covers the whole water surface. From there, it freezes downward from the water/ice interface to the maximum depth at which the ambient temperatures can cool the water to the freezing temperature (32˚F, 0˚C). Ice thickness on a lake is generally uniform, but it can be affected by the depth of insulating snow cover on top of the ice or the presence of any current due to springs/creeks or rivers.

1.2.1.4 Blue Ice

Sometimes referred to as clear ice, blue ice is generally transparent and contains little or no bubbles and debris. **This ice has the highest weight-bearing capacity whether in a river or a lake environment.**

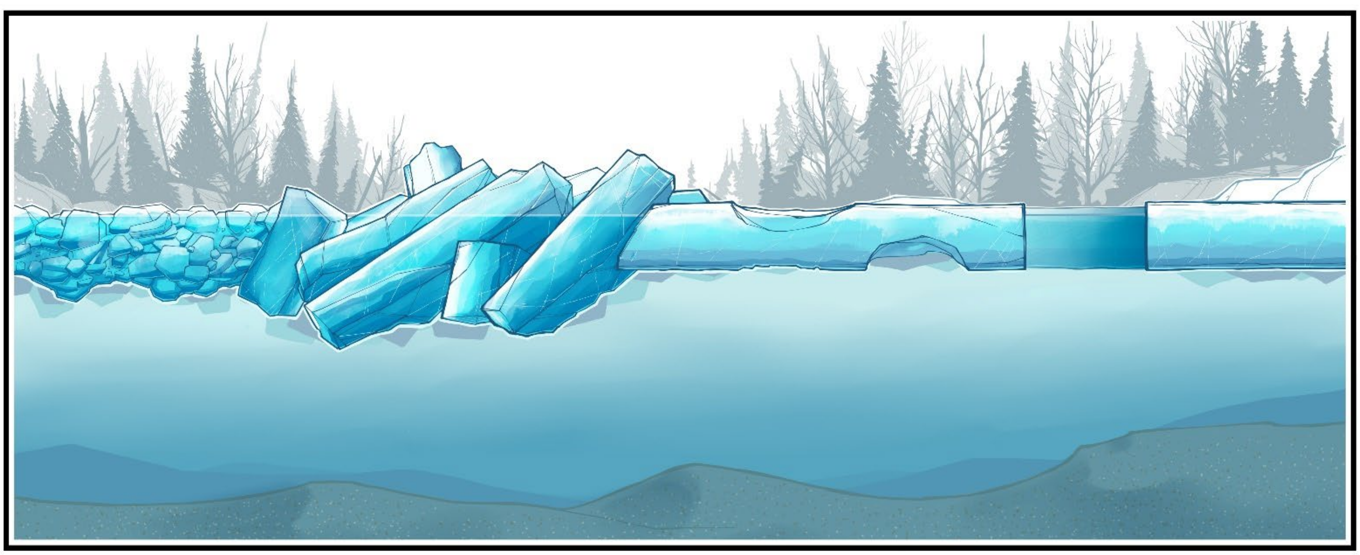
1.2.1.5 White Ice

Formed during less-than-ideal conditions, white ice is opaque due to air pockets and has a much less consistent structure. Generally formed by the freezing of water and snow at the surface (sometimes multiple times), **this ice has half the weight-bearing capacity of blue ice.**



1.2.1.6 Inconsistent Ice Sheet

An ice sheet that does not offer uniform ice conditions and quality is likely to be encountered, especially in river environments. Always utilize the least favorable conditions encountered in your anticipated work area as the deciding factor for load-bearing capacity and to determine your containment and recovery equipment and strategies. Always err on the side of caution; if you are unsure the ice sheet bears the quality or thickness required for response activities, consider an alternate location.



1.2.1.7 Open-water Areas on an Ice Sheet

Open water on a river ice sheet generally relates to the section of river with the highest current velocity. Open water allows for visual identification of released hydrocarbons at that location and, potentially, the opportunity to recover hydrocarbons if safe access allows (open water airboat deployment).

1.2.2 Visual Assessment

A visual assessment of the proposed work area will often point to areas of concern on the ice. Any areas that seem lower, where the snow has dropped, or where steam is present are signs of either open water or water on the ice due to snow load and/or cracks. These are areas of concern. You may also notice areas where the ice is built up higher than other areas. This is likely due to a water source flowing over ice. On a lake, it could be due to ice ridges caused by movement and failure of an ice sheet. Ice conditions in this area can be highly variable and should also be avoided during assessment and future work.

1.2.2.1 Cracks

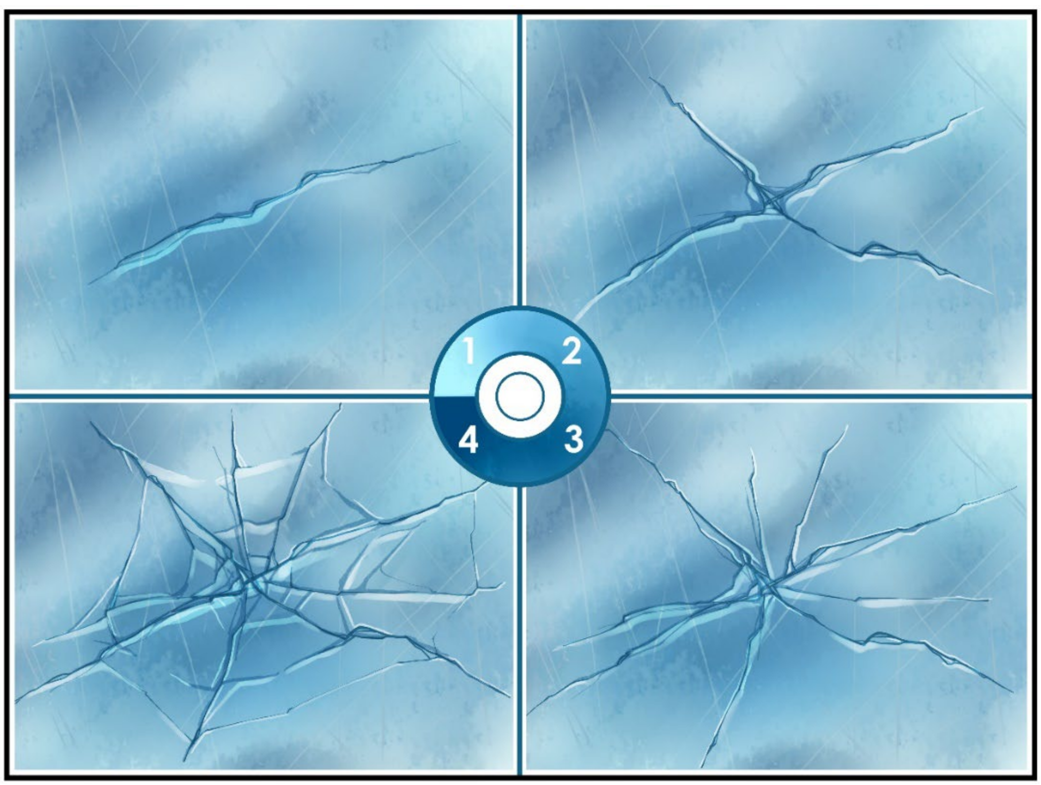
The following are signs of load-induced ice stress that could lead to ice failure.

1) lateral lines;

2) intersecting lateral lines (cross pattern);

3) additional intersecting lateral cracks (spider web);

4) intersecting lines have circular connected cracks.



Additional considerations:

— Wet cracks are a sign of continuity through the whole ice sheet and are more dangerous than dry cracks.

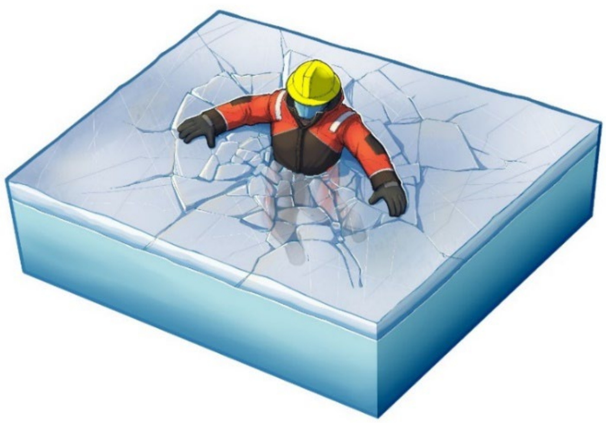
— Overlapping ice at cracks are signs of ice sheet movement due to rapid expansion or shifting.

1.3 Winter Hazard Awareness

Prior to initiating work, be sure that all individuals are briefed on site safety considerations, hazards, and procedures. Knowing what to do in the event of a fall through the ice is critical to worker safety. Understand the risks and always watch out for one another.

1.3.1 Cold-water Immersion

In the event a worker falls through the ice and is immersed in cold water, it is important to understand the body goes through four general stages that need to be recognized to ensure safety, increase the chances of full recovery, and avoid possible loss of life.



Cold Shock

This occurs immediately when a person enters the water. The body's first reaction to the cold water is an involuntary response to gasp for air. If a person gasps for air while still under water, this leads to the ingestion of cold water, which prompts coughing, a state of panic, and hyperventilation. It is extremely important to overcome the shock and focus on getting the victim's breathing under control. The ingestion of cold water can also contribute to a decrease in internal body temperature.

Cold Incapacitation

This stage starts when the muscles and nerves get so cold, they stop working. This stage typically begins between one and 10 minutes of entering the water, depending on the victim's body type, the water temperature, ambient conditions, and the protection factor of any clothing and PPE they may be wearing. This stage is a victim's opportunity to rescue himself or herself, or have the highest likelihood of being rescued because the victim still has mobility, awareness, and strength.

Hypothermia

During this stage, the body's core temperature starts to drop. This is the body's defense against cold; it stops spreading warm blood to the extremities in an act to protect the vital organs (brain, heart, and lungs). Mobility, speech, and brain function begin to be seriously affected as the body attempts to survive.

Circum-rescue Collapse

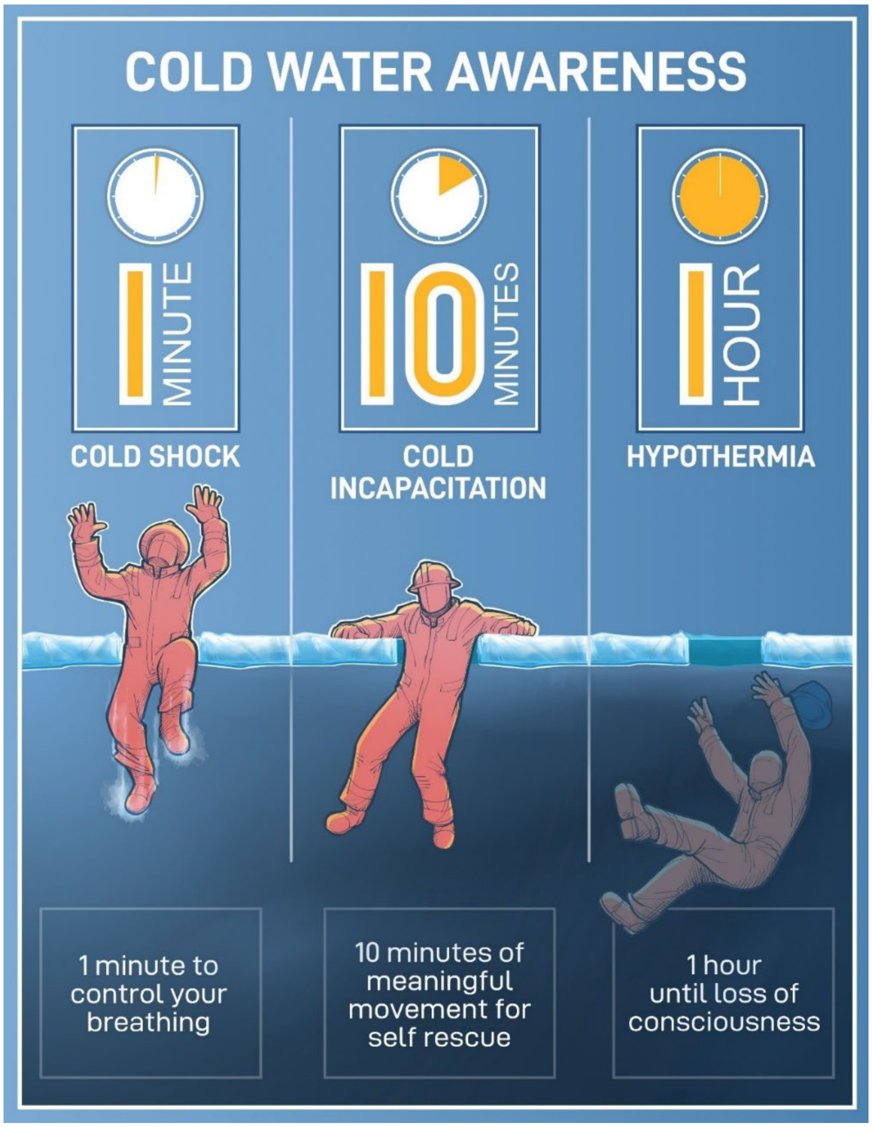
This stage is important to understand and diagnose. A hypothermic victim who has been rescued but is treated roughly or asked to physically exert themselves even a small amount is at risk of cardiac arrest. The heart has an extreme amount of stress placed on it already, and movement and changes in blood pressure cause movement of blood. The density differences in cold blood from the extremities and warmer blood from the core can lead to a heart attack.

1.3.1.1 1-10-1 Principle

— 1 minute to get breathing under control (managing cold shock);

— 10 minutes of meaningful movement (prior to cold incapacitation);

— 1 hour before unconsciousness due to hypothermia.



1.3.1.2 Hypothermia Considerations

Any person who has fallen into cold water or has been exposed to the elements for a sufficient period of time is susceptible to hypothermia. The symptoms of hypothermia can include shivering, loss of motor skills, and impaired brain function. If a hypothermic person is left untreated, loss of life can occur. If you encounter a suspected hypothermic victim:

— Protect the victim from the environment. Remove wet layers, then insulate their body with dry clothes, blankets, body heat, or a combination of these, if necessary.

— Handle the victim gently. Their nerves and muscles are in various stages of shutdown and movement and pressure can cause extreme pain.

— **Do not provide the victim with hot liquids.** Only offer lukewarm, non-alcoholic drinks, and only if the person is alert.

— Get medical attention immediately. There is a very specific sequence and timing to treating a hypothermic victim; this is best left to professionals.

1.3.2 Rescue

Before venturing out onto an ice sheet for the sake of assessment or response, a thorough ice safety plan must be completed. The response should not proceed without a plan in place and adequate resources allocated. This safety plan should include a list of designated personnel, rescue equipment, and staging location(s), and should be reviewed as part of the health and safety plan (HASP) prior to entry onto the ice sheet. Items that should be reviewed with all responders are the use of personal flotation devices (PFDs), self-rescue tools and tactics, harnesses and taglines, location and deployment of rescue resources, and procedures for sitewide notification of a rescue operation. Consideration should be given to hiring this service out to trained rescue professionals, such as local fire departments or health and safety management companies.

Some items of note for the rescue crew in relation to the operations:

— Rescue equipment should be deployed in the "ready" state at a pre-determined and well-marked location as close to operations as safely possible.

— All responders on the ice should be wearing a PFD and a tagline and harness until the ice sheet is assessed and deemed safe, or anytime they are working near open water on an ice sheet.

— A front attached tagline should be used; this method is the safest option for the assisted rescue of a victim because it helps pull a victim up onto the ice in the way the body naturally bends.

— For each responder on a tagline and harness, there should be a minimum of two rescuers manning that tagline.

— When an ice sheet is covering a moving body of water, always place rescue personnel on the upstream side of a tagged-off individual; this will provide the best recovery angle as it avoids pulling against the ice sheet lip and the current.

— In the event that a rescue is necessary, all work must immediately stop so that all available resources can be accounted for and all qualified individuals are available for activation should they be needed.

— Any rescuer involved in helping a victim that has fallen through the ice must place their safety above that of the victim; quick, unplanned reactions can result in the rescuer also becoming a victim.

1.3.2.1 Self Rescue

In the event that a responder breaks through the ice, there are several items that can be beneficial to their protection and increase the likelihood of self rescue. Should a responder break through or fall into open water on an ice sheet without a tagline and harness (or PFD), they need to focus on keeping their head above water and calm themselves so they can formulate a clear plan for extraction. Responders who fall through ice or fall into open water on an ice sheet should:

— call out for help upon steadying their head above water;

— keep their arms up and on the ice to spread out their weight and anchor themselves.

— extend their legs backwards and work to kick for propulsion while crawling forward toward shore and/or stronger ice.

— use ice picks (if available) to help pull themselves back up onto the ice (shown below).

Should a victim not be able to lift themselves onto the ice sheet during self rescue, be sure to prop their arms up on the ice sheet. A victim's arms may freeze to the ice, and this will prevent them from slipping out into open water or under the ice as an assisted rescue is enacted.

1.3.2.2 Assisted Rescue

A responder that breaks through the ice and is unable to rescue themselves will require support. This rescue will be implemented by the designated rescue team or any qualified responders who are able to immediately activate for this purpose. The safety of a rescuer cannot be compromised for the sake of a victim. All rescue personnel should be equipped with proper safety gear for the rescue; this could include PFDs, flotation suits, or dry suits with taglines and harnesses, and rescue equipment with support.

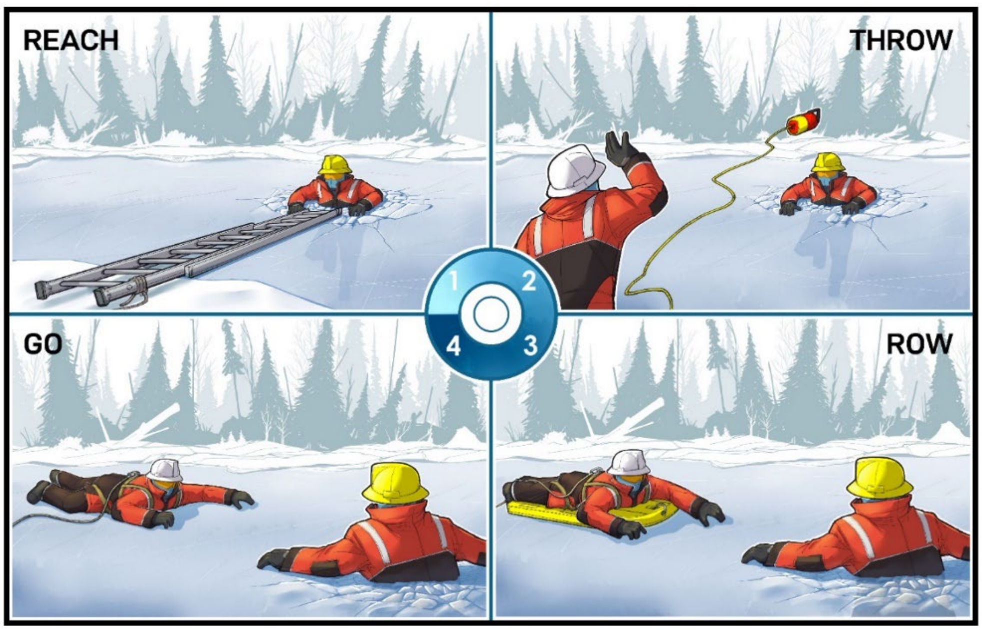
An unplanned assisted rescue gone wrong can increase the number of victims. A panicking victim is experiencing a surge of adrenaline and fear, and this can make them strong and dangerous. Even a rescuer of a larger physical stature than the victim should approach a rescue with caution and use the principles below in the order they are presented for their own safety, and to increase the likelihood of a successful assisted rescue.

1) **Reach:** Extend an object to the victim (rescue pole, ladder, or any sturdy solid object of significant length); this creates space between the rescuer and victim and is a fast response option.

2) **Throw:** If an item cannot be extended out to a victim due to proximity, attempt to throw an item securely tied to a line to the victim. Be sure to retain the free end of the line. Items such as a throw bag, life ring and line, tag line, etc. can be utilized. Be aware that a thrown object can strike a victim; always throw the item past the victim and allow the victim to go to the object and hold onto the object, or wrap their arms in the line.

3) **Row:** Should there be too much unsafe distance between the victim and their rescuer, consider using floating items that can support the weight of a rescuer and allow them to travel across ice and/or open water. Rescue sleds/sleighs of various configurations can support the rescuer's weight, be tagged off to shoreline support personnel, and include handles and lines to help a victim grab onto or be secure to the device for retrieval.

4) **Go:** Having a rescuer physically move through water to retrieve a victim should be a last-resort tactic. This should only be done by highly trained rescue personnel wearing the appropriate immersion-style suits with flotation and tag lines. A conscious, panicking victim in the water can be a potential hazard to a rescuer.



1.4 Ice Evaluation

Knowing that the ice sheet you intend to work on is safe for people and equipment is vital to any WSR. Without a safe ice sheet, no work can be implemented on the ice at that location. The load-bearing capacity of the ice sheet needs to be calculated for the work area. To do this, it is necessary to collect data on ice thickness and quality, water depth below the ice, and the expected weight of items that will be placed on the ice. Before any on-ice evaluation work begins, a thorough ice safety plan needs to be developed and reviewed with all personnel.

1.4.1 Calculating Load-bearing Capacity of an Ice Sheet

When a block of ice is pulled, an accurate measurement of blue ice vs. white ice will typically yield information to allow the calculation of weight-bearing capacity. Knowing the total thickness of blue ice and the total thickness of white ice (given a half value) allows for the calculation of ice thickness. The weight bearing capacity of the ice in your work area is established based on your effective ice thickness and the allowable risk rating you chose to apply to the calculation.

Gold's formula[1]:

$$P = A \times h^2$$

Where:

P = kilograms weight allowed;

A = amount of agreed-upon risk (3.5, 4, 5, 6);

h = effective ice thickness in centimeters.

— Effective ice thickness is defined as the total depth of clear ice and half the overall depth of white ice.

— Gold's formula is designed for use with metric units and risk factors. The table in Annex A shows rounded figures for weight-bearing capacity converted to US customary units (pounds) for easy reference.

It is recommended to stay in the low-risk category, so for Gold's formula, that works out to an "A" rating of 3.5 on rivers or 4 on lakes. This formula's results provide a weight-bearing capacity for an ice sheet over a radius of 100 ft (30 m).

You may exceed the low-risk category when water depth is shallow and when additional safeties are put in place, such as flotation on heavier equipment and on all personnel.

A reference sheet of Gold's formula calculations is available in Annex A.

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[1] Gold, L.W., 1971, "Use of ice covers for transportation," *Canadian Geotechnical Journal*, 8, p. 170-181

1.4.2 Ice Safety Plan

1) Site assessment

— Physical location and site description. Pertinent emergency response plan (ERP) information, i.e., muster points, rescue stations, on-scene command location, and contact numbers.

i) Safety controls

— Hazard elimination: Can the process be completed elsewhere, without on-ice work?

— Procedural controls: Can ice be accessed via a solid structure (walkways, bridges) or a floating structure (docks)? Special consideration should be given to air boats as a mobile safe-access platform.

— Administrative controls: Rescue plan, safety procedures, and roles during assessment, documentation of equipment weight.

— PPE (PFDs, flotation coats/suits, dry suits, harnesses with safety lines attached).

ii) Ice slotting strategy/location

— Ice assessment must be adjacent to the anticipated work area. Once the work area is determined, assessment needs to be completed and is only valid for a work area within a 100-ft (30-m) radius of the assessment location(s).

iii) Safety orientation confirmation

— Safety tickets/training.

— Operator training/procedure review.

— Proper equipment for the task.

— Review of all task- and site-related hazards to accomplish the initial ice assessment.

— Trained rescue personnel onsite, available and ready for immediate action.

iv) Ice-covered watercourse assessment

— Documentation of the assessment work.

— An example ice-covered watercourse assessment can be found in Annex C.

v) Site drawing

— Contains all pertinent information (flow direction, rescue station, muster).

vi) Additional information

An example ice safety plan is available in Annex B.

2 Establish a Work Area

2.1 Ice Assessment

Until safe load-bearing conditions are confirmed, it should be a requirement that all on-ice personnel wear required standard PPE and a PFD, and have a harness and tagline tended by crews on shore. As an ice assessment progresses further out onto the ice sheet, determinations of safe ice conditions for continued assessment can be made considering overall ice depth and the assumption that there is all white ice along the assessment path. Staying within a weight-bearing capacity sufficient for all resources on the ice minimizes tagline length for the purpose of continued assessment.

2.1.1 Equipment

In order to complete an initial ice assessment, you will need at least a two-person crew on the ice. The crew should be equipped as per the PPE list for the on-ice responders in Section 1.1. Alternatively, this is a great opportunity to utilize an airboat (if available) and have the crew complete the assessment from onboard.

Be sure that all items being taken onto the ice have been fueled and function-tested on the shore prior to on-ice operations. This helps ensure that the correct gear is in inventory and will function when the crews are called upon. The crew should venture onto the ice slowly and cautiously, testing the ice ahead of them with a long, solid-handled object with the following items in tow:

— sled to carry all items;

— long-handled ice chisel or pole;

— scoop shovel;

— ice scoop (ice-fishing style);

— ice auger (ideally a power auger—8-in. model preferable) that has been function-tested on shore;

— hand auger (6-in. or smaller model);

— ice handsaw; take two if available;

— ice anchors with carabiner handle (screw);

— length of rope for lifting blocks;

— ice tongs;

— measuring stick with bottom hook;

— measuring tape with a weight attached;

— flow meter (directional/velocity indicator for rivers);

— ice assessment data sheet, or communication to shore person acting as scribe.

NOTE During ice assessment, it is preferable to have the assessment team in harnesses with a D-ring on the front of the harness. Because this line is for rescue and due to the body's natural range of motion, if a person needs to be rescued after falling through ice, it is better to have the pressure pulling them forward up onto the ice instead of backwards up over the ice. While operating rotating equipment, a soft, overhand knot on the shoulder strap will keep the line over the responder's shoulder while augering.

2.1.2 Ice Assessment Procedure

1) Travel to the first ice-assessment location with all necessary equipment.

   a) Shovel snow from the immediate area.

   b) Visually inspect the surface ice and/or water on ice. Take note of cracks, defects, and debris in the ice.

   c) Record all information on the ice assessment form.

2) Drill the initial test hole.

   a) Use either a power auger or hand auger based on anticipated ice thickness and equipment availability.

   b) After drilling, clear away slush to expose the ice surface.

   c) If you anticipate encountering hydrocarbons below the ice, utilize a hand auger to avoid providing a source of ignition for product and vapors (that could escape and come in contact with hot exhaust from a power auger).

i) Measure ice thickness, water depth, and flow direction and velocity.

— Drill additional assessment holes on a tight pattern (rivers: 6-ft/2-m spacing; lakes: 10-ft/3-m spacing)

— If consistent ice depth is encountered, greater distance between holes can be considered, especially on lakes.

3) Drill three test holes in a triangle when you reach your anticipated work area radius.

a) In a triangle pattern, make a 1-ft cut across the ice block.

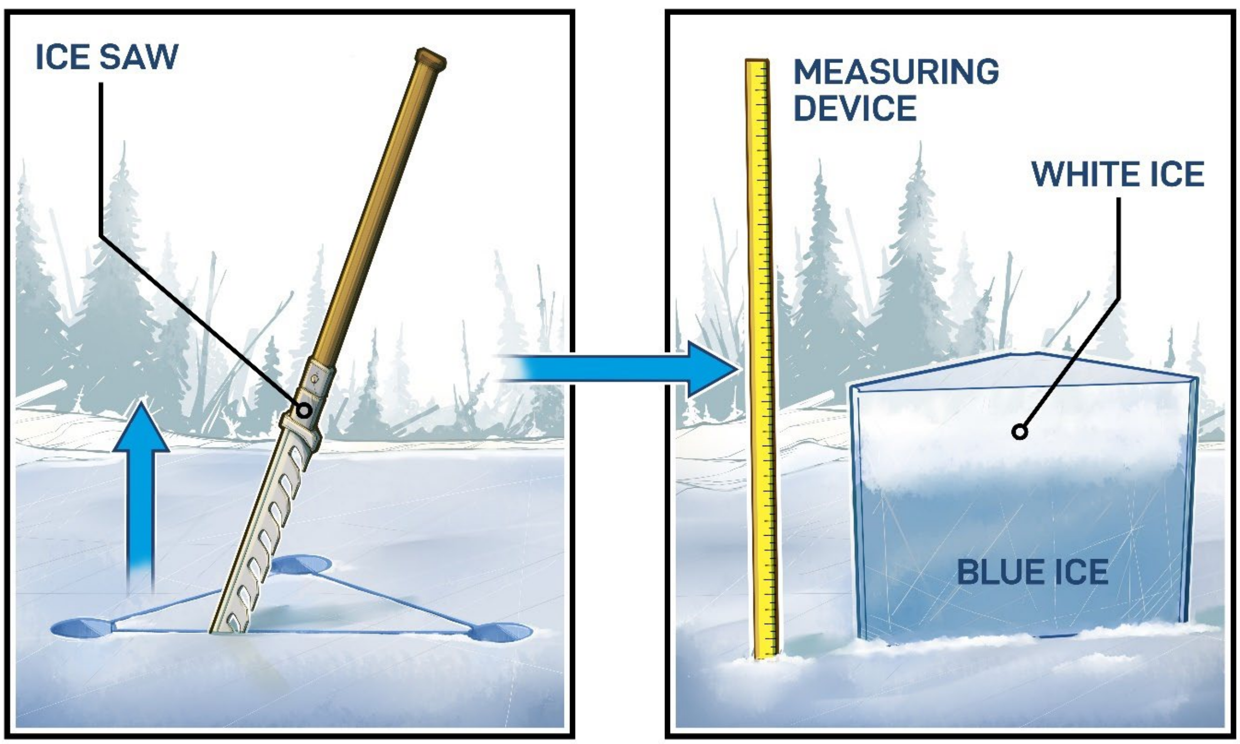
b) Install an ice anchor into the center block.

c) Cut the block free utilizing a handsaw (tapered inward cut).

d) Lift the block free with the ice anchor and line, or with ice tongs (two-person lift may be required).

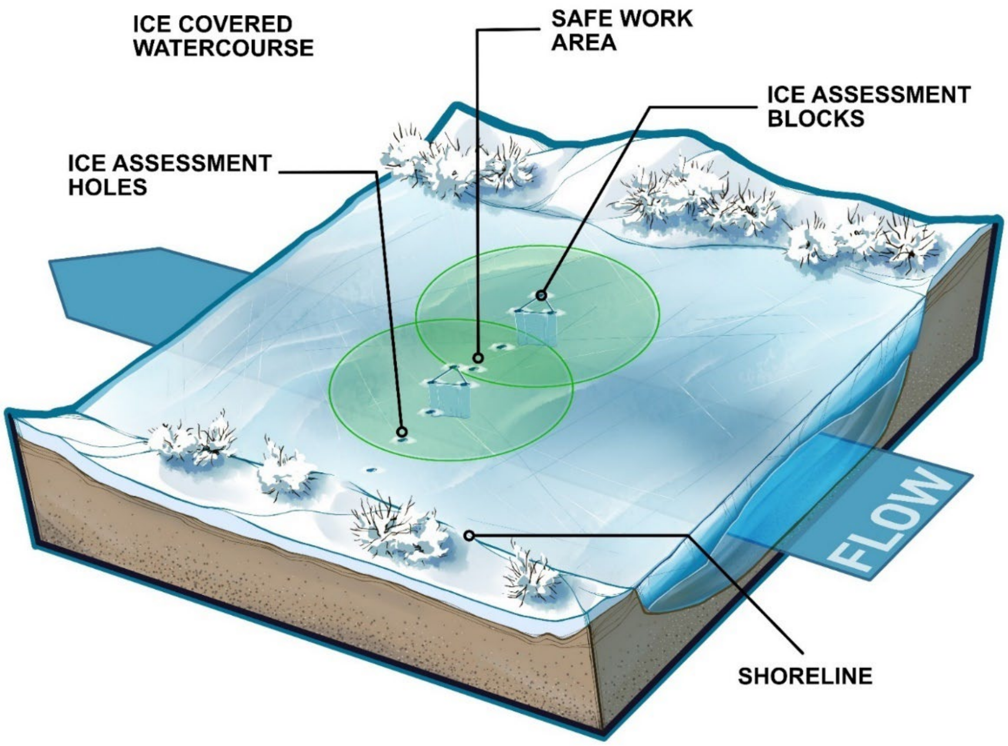
— It helps to push the block down and use the buoyancy to help lift the block free.

Once the block is free, clean it up, then measure the thickness of different ice types (blue vs. white). If you have properly trained chainsaw operators, you can bypass the auger and handsaw to cut an assessment block.



2.2 Work Area

Once an ice assessment has been completed and the information has been reviewed and entered into Gold's formula, the response team can begin formulating a recovery strategy based on the weight-bearing capacity of the ice sheet. The size of the required work area will dictate the number of assessment blocks that need to be pulled to ensure coverage of the work area.



2.3 Work Site Safety and Security

Preparation of the site for the upcoming work and supporting the efforts of responders in WSR is very important. Consideration should be made for items to support personnel [responders and incident command system (ICS) onsite roles], access, site security, and public protection and notification.

Personnel:

— office trailers (warm-up, lunch, ICS management);

— washcar facilities;

— communications (cell towers, satellite internet, private radio tower);

— consumables (trading post for PPE, tools, etc.).

Access and site security:

— access matting;

— signs and barricades for traffic and people;

— site preparation equipment (skid steers, loaders, excavators).

Public safety:

— traffic control (lights, signs, flagging crews);

— notifications (public awareness);

— local emergency personnel (police, sheriff, fire department).

2.4 Site Preparation for Ice Slotting

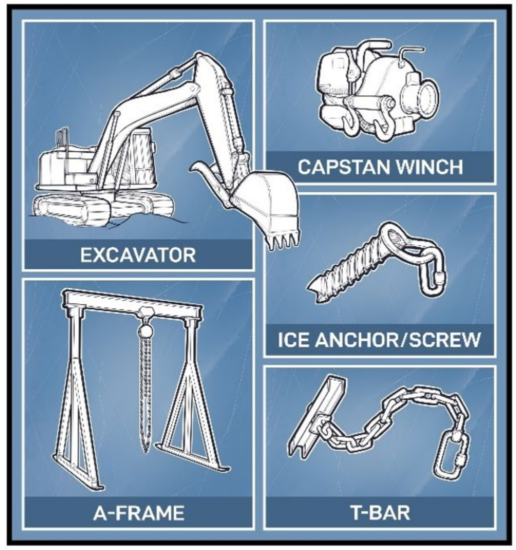
Once a location is chosen for containment and recovery and an ice evaluation and subsequent ice safety plan have been developed and implemented, the deployment site on land and the work area on the ice need to be prepared for operations. This means providing safe, all-weather access, equipment staging, and the removal of the snow from the work area on ice. Removing snow from the ice should be done with the resources that fall within the safe and established weight-bearing capacity of the ice sheet in the work area. Using equipment such as a skid steer will drastically increase your productivity, but it needs to be evaluated against the weight-bearing capacity. Keep in mind that until the snow is removed from the ice, you must include the snow weight in the load calculation in the work area, along with the equipment weight. Consideration should be made for moving the snow out of the work area (ideally onto land) to eliminate it from the allowable ice load.

Consider the appropriate training, procedures, and PPE required for these tasks. Items such as chainsaw chaps, hearing and face protection, and appropriate footwear and gloves must be made available.

3 Response Equipment

WSR requires specialized response equipment, supported by commonly used oilfield construction and site support equipment and tools. Many of the specialized equipment pieces have been adapted from more common uses, such as tree felling and ice climbing. You will need to know SMEs who have access to this equipment or have company- or cooperative-owned equipment through arrangements such as retainers, mutual aid agreements, or individual company ownership. Some of these items are difficult to procure on emergency notice, so it is highly recommended that you maintain a contact list of owners and locations in the event this equipment and services are required.

Support operations for containment and recovery during WSR can become intensive and large. Ensure that there is adequate space for equipment staging and operational needs. Heating, melting, storage, treatment/trucking, fueling, and repair and maintenance in winter-weather conditions all need to be considered, and these operations should not be hindered by or affect the ability of the incident management team to operate nearby.



Ice saw: A very sharp and aggressive opposing-tooth blade designed to cut through ice up to 30 in. in depth by hand.

Ice chainsaw: Designed to take an off-the-shelf large-bore chainsaw and mount it in an engineered cage system to provide added worker protection and better ergonomics. These saws should be used when the weight-bearing capacity of the ice sheet does not allow for larger and faster means of ice-slot cutting, such as excavators.

— All chainsaws used for ice-slotting operations should either be new and run without bar oil of any kind, or have the bar oil system cleaned and purged. No oil is necessary for ice cutting; it will only be a source of hydrocarbons to be detected in the waterway.

— Chains should be a skip-tooth design for the minimum bar size needed to cut through the ice.

— Be aware of the direction of the ice block bevel created by the saw; you should aim to create a slight inwards pyramid-shaped block.

Ice sled saw: Another chainsaw model, based around a sled design with a four-stroke motor and belt-driven system. These sleds have a lower center of gravity and have been found to be very reliable due to the higher-horsepower four-stroke motor utilized in cold weather. These designs are much quieter for those working in the immediate proximity of the saw, compared to two-stroke commercial chainsaws.

— Chains are recommended to be a skip-tooth design for the minimum bar size needed to cut through the ice.

— Be aware of the direction of the ice block bevel created by the saw; you should aim to create a slight inwards pyramid-shaped block

3.1 Other Equipment Considerations

All tools used for the cutting and handling of ice will experience freeze-ups and require maintenance and repairs; this is a simple fact of ice-slotting operations. Chainsaws and ice augers will require refueling multiple times a day; blades will require tune-ups; chains, bars, and augers will need to be thawed and tightened; and parts such as air filters and spark plugs will need to be replaced. Be sure to have multiple units working with backups available onsite, as well as a good selection of replaceable parts. Have a warm shelter on the shore to allow for small-equipment maintenance, thawing, and repairs. Always complete fueling of equipment on the shore inside of containment to avoid spills.

3.2 Ice Block Recovery

If the chosen slotting strategy calls for the recovery of ice blocks, be sure to have a recovery-and-storage plan in place. Handling ice blocks will require heavy lifting and/or assisted lifting equipment. Be sure to know what you have available onsite and who is trained to use it. Store ice blocks off the ice sheet if possible to avoid adding their weight to the bearing capacity of the ice sheet.

NOTE 1 sq. ft. of ice weighs approximately 57 lbs (26 kg).

Manual: If lifting equipment is not available, keeping blocks small and manageable is very important for worker health and safety. Utilize ice tongs, ice screws, rope, and two-person lifts.

Mechanical assist: Capstan rope winches or pulley systems utilized in tandem with ice screws and T-bar assemblies can help lift blocks or pull blocks out of the water. Cutting a ramp in the ice slot, as well as a secure anchor point and lash protection on the pull lines, should be considered.

Mechanical lift: If available, a mechanical “A-frame” with either chain or electric hoist capabilities will allow responders to lift large blocks in combination with a T-bar assembly.

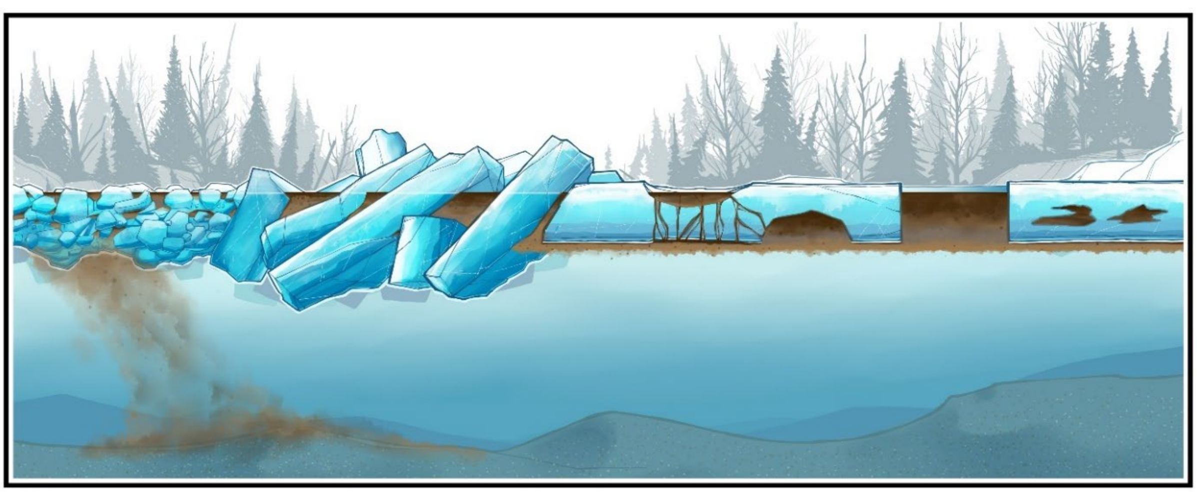
If an excavator cannot be used to rip open an ice slot, but it can reach from shore, it may speed up ice-slotting work and provide a lifting assist when used safely from the shoreline.

4 Watercourse Characteristics and Spilled Product Mobilization

4.1 Moving Water vs. Standing Water

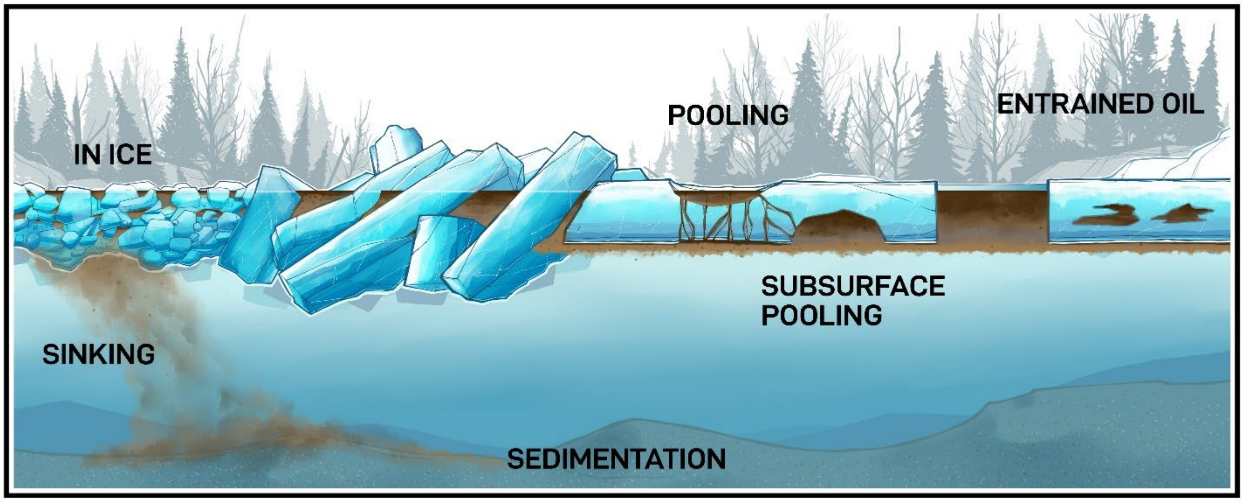
Hydrocarbons released under an ice sheet behave similarly to how they would in the summer, depending on the density or API gravity of the given product. All oils will see an increase in density when they are cooled (API gravity decrease), but unless the density increases above 1000 kg/m3 (API 10 or less), the oil will still float (with no other factors considered, such as deposition due to sediment load).

Oil and its associated light end vapors that are trapped under an ice sheet will still want to rise to the surface, but the nature of ice as a solid floating mass prevents this unless there is an opening in the ice (cracks, ice slots, open water due to temperature or current). WSR typically involves recovering oil at open-water areas, either natural or created by responders.



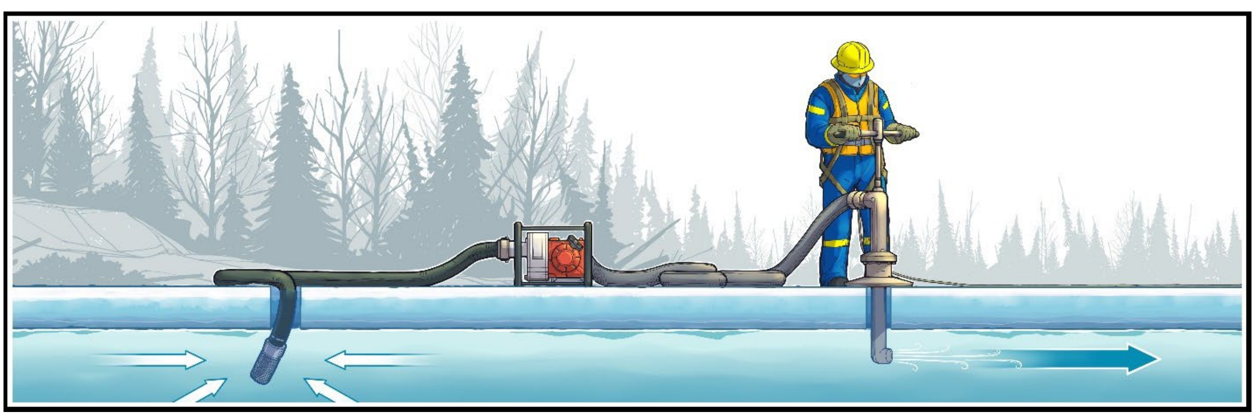
4.2 Oil Under Ice in Moving Water

Oil that is released under the ice in a moving water body will travel downstream with the current, just as it would in the summer; however, the speed of travel will be slower. Oil density will have increased, slightly slowing its movement, but the primary function slowing the downstream migration of oil is friction. Ice typically is not a static and level surface on the underside of a sheet. It is undulating in nature, so the oil has a longer path to travel and more friction to overcome in order to be moved downstream. Similar to open-water releases, oil will accumulate under ice is areas of slower current, such as back eddies and slower-moving sections. Typical response scenarios will experience product movement that is 20 % to 30 % slower than the average water-current speed, and there will likely be some impact remaining throughout the entire section of the release until it hits containment. The diagram below illustrates the principles discussed in this section so far.



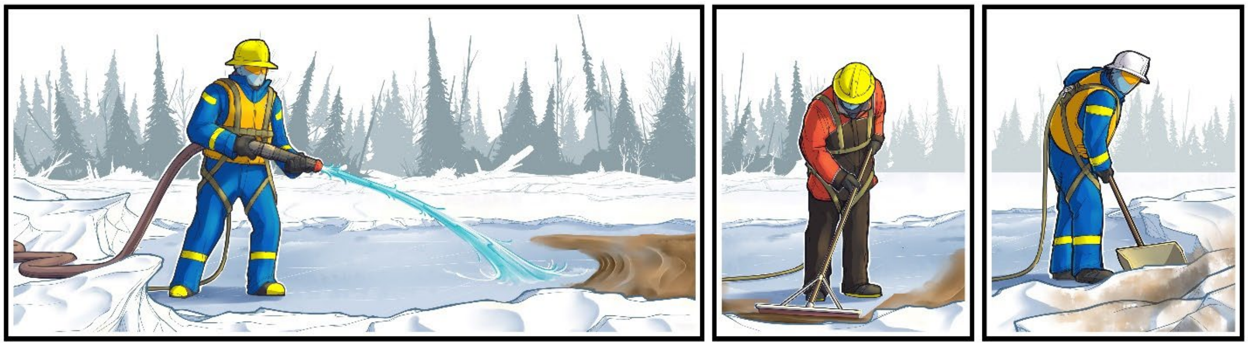
4.3 Oil Under Ice in Static Water (Lakes and Ponds)

Oil that is under ice in a lake or pond environment acts the same as it does in a river, but mobility is not a major issue due to lack of current. Oil in these scenarios needs to be treated much like open-water lake recovery, which involves containment around the point of entry (POE). In order to make the oil mobile, an artificial current needs to be enacted on the product to mobilize it toward the recovery locations.



4.4 Product on Ice

Dealing with oil on top of the ice is generally more of a standard cleanup, much like working on frozen ground. The key is to first know that you have a safe ice sheet to work on, then focus on collection efforts that will not drive the oil into the ice through cracks and application of heat. Shoveling, scraping with equipment, and low-pressure/low-volume flushing will mobilize oil to containment and recovery locations.



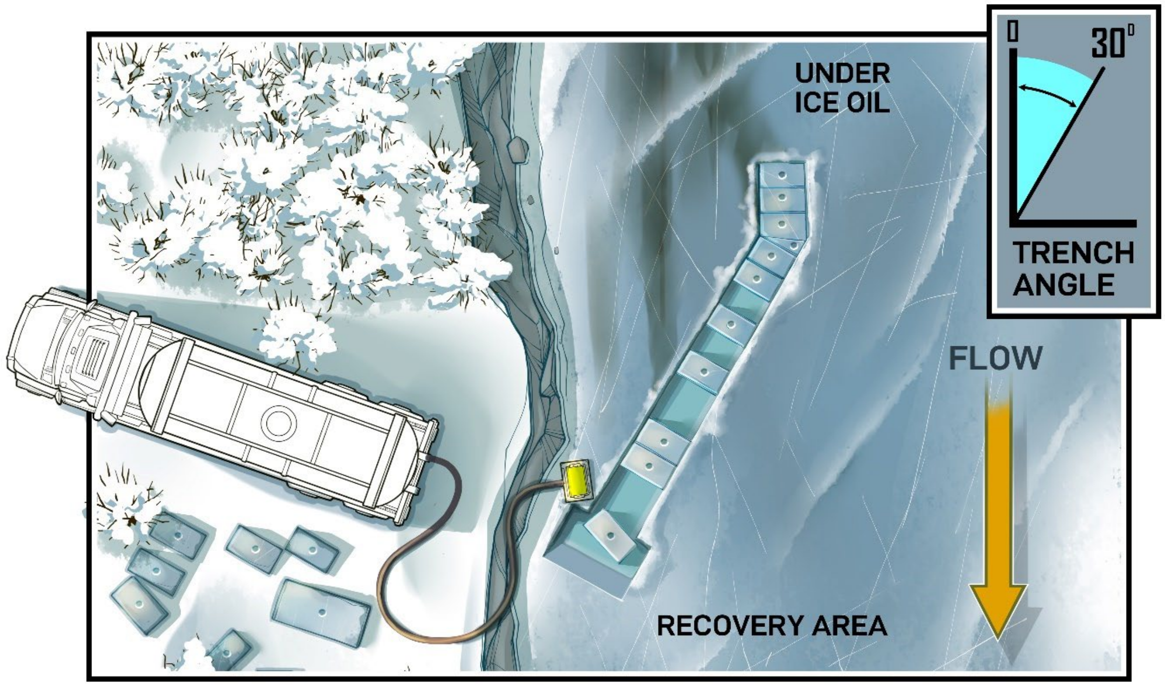
5 Containment and Recovery Tactics

5.1 Moving Water

Oil under ice acts similar to how it acts in open water; it migrates downstream due to current, following the faster water until it is trapped on the underside of the ice or in back eddies, or until it is able to surface in open-water areas. WSR on a river typically involves creating an open-water interception slot, more commonly referred to as a “J-slot.” These are laid out in areas with good access for containment and recovery, and in sections of river most likely to be the travel path for downstream migrating oil.

5.1.1 J-Slots

Utilizing a design very similar to how a containment boom is installed in the summer, a suitable containment and recovery point is selected and a location for the recovery method (skimmer, vacuum, and/or pump) is chosen. From that point, a slot is laid out on the ice surface using string, rope, or marking paint to allow for a design to be followed by the cutting crews.



5.1.1.1 Installation Steps

1) Select your access point for containment and recovery, and help ensure that a proper ice evaluation and ice safety plan have been developed and implemented.

2) Remove snow from the work area to subtract it from the weight-bearing capacity of the work area, and create a plain view of the ice to check for concerning ice surface characteristics (such as cracks) and create a flat working area.

3) Lay out and confirm the location of the recovery point close to shore (suitable water depth for a skimmer).

4) Mark out a J-slot outline, ensuring the angle to the current does not exceed 30° to the current and will be intersect the migration of released oil. At the end of the recovery angle, point the slot into the current to grab water velocity to aid in block removal and oil movement down to recovery.

    a) For safety reasons, do not exceed a 3-ft (1-m)-wide slot.

    b) The slot should be widest at the recovery end and slightly narrower the further upstream you go to allow blocks to be floated down toward shore if they are being recovered.

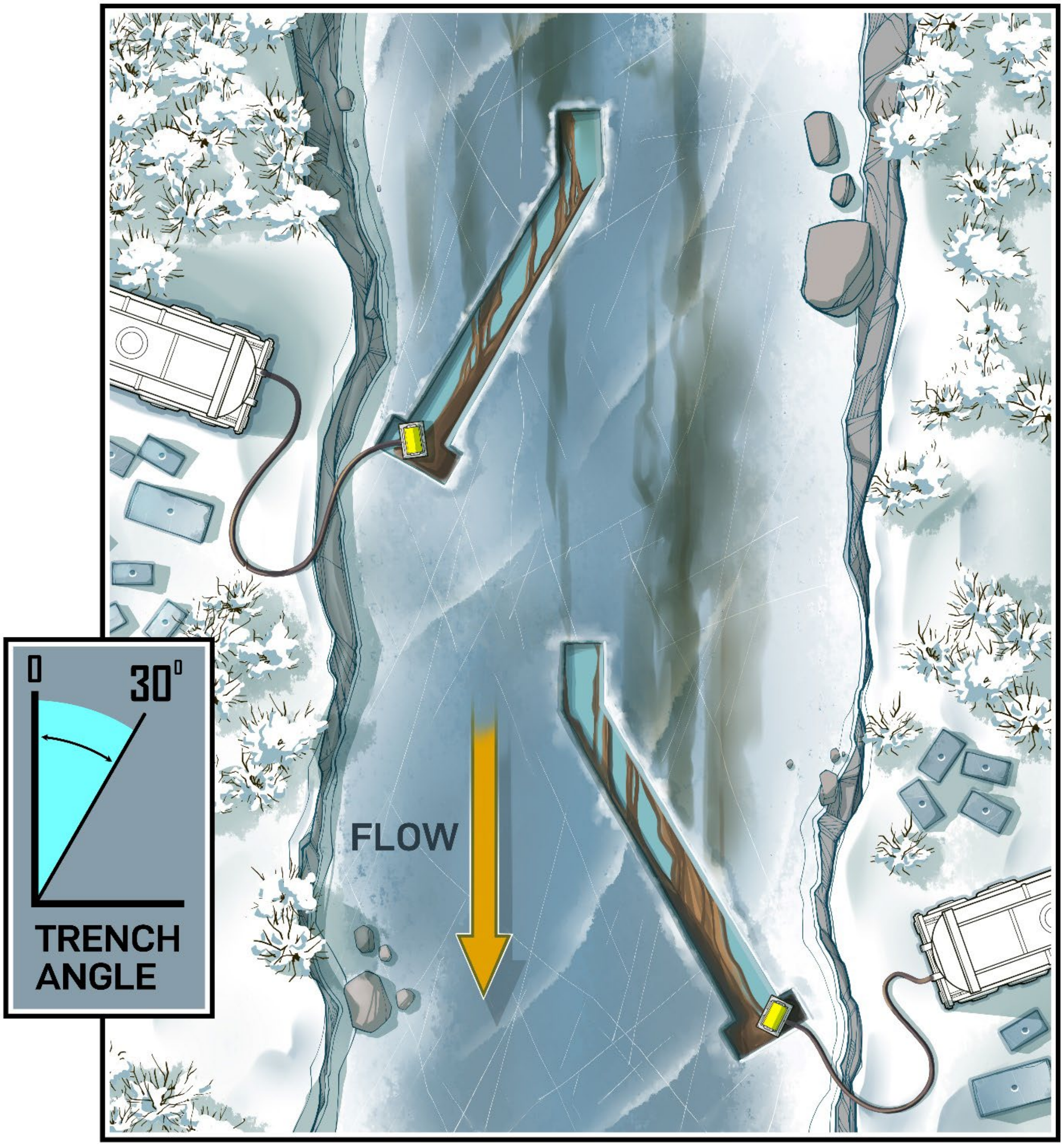
    c) Blocks can be pushed under the ice to save time, but help ensure they will not create an under-ice dam immediately downstream of the slot; this could lead to overflow being forced up onto the ice sheet.

5) Cut out the blocks using the tools selected for ice slotting based on the weight-bearing capacity of the ice sheet. Apply a small inwards bevel on the cut to allow for easy block extraction. Straight cuts typically lead to jamming issues with slush and debris.

    a) Blocks that need to be removed from the ice should be of a size that will allow for extraction by manual or mechanical lifting.

b) Use of ice screws, ice tongs, and drilling holes in the blocks before cutting to allow use of the T-bar assembly are all considerations.

6) Remove blocks systematically, starting at the largest downstream blocks to create a recovery point; blocks that are further upstream can then be cut free and floated downstream for extraction.

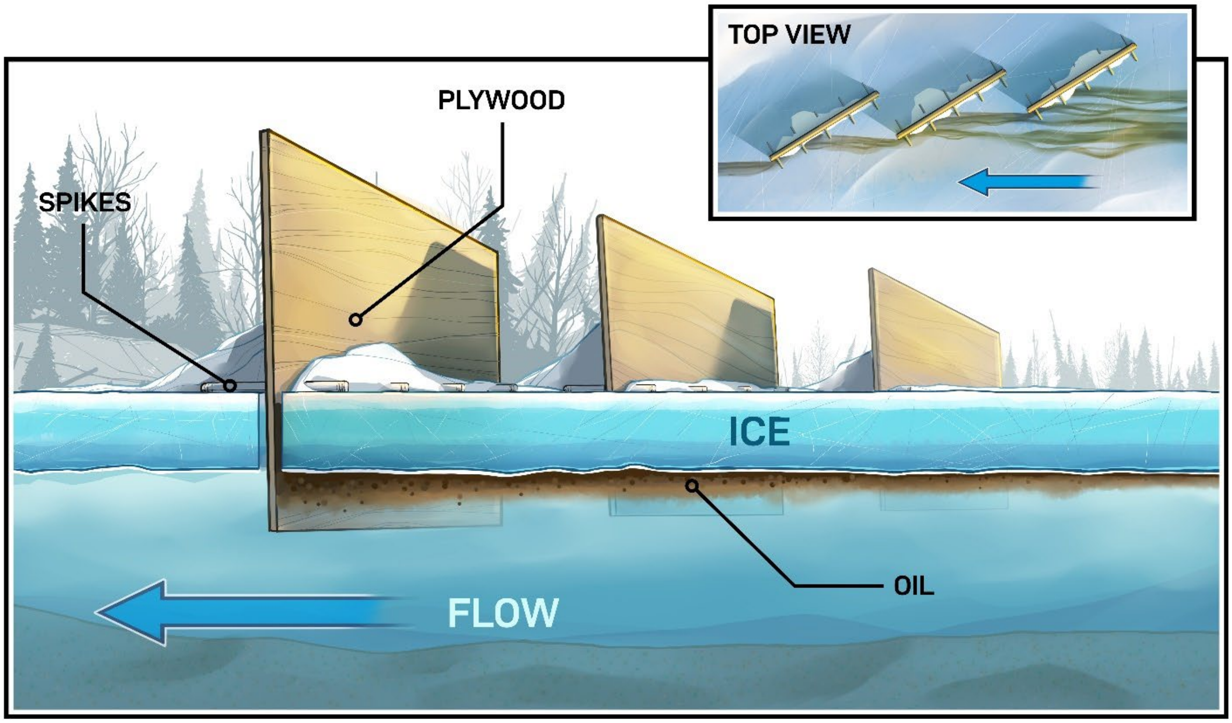


5.1.1.2 Considerations

It is recommended to only cut the recovery area out fully after all blocks are removed; this creates less of a hazard for responders. Once the slot is opened, it will need to be maintained to prevent freezing, and should be isolated with fencing or barricades for the sake of worker safety.

5.1.2 Deflection

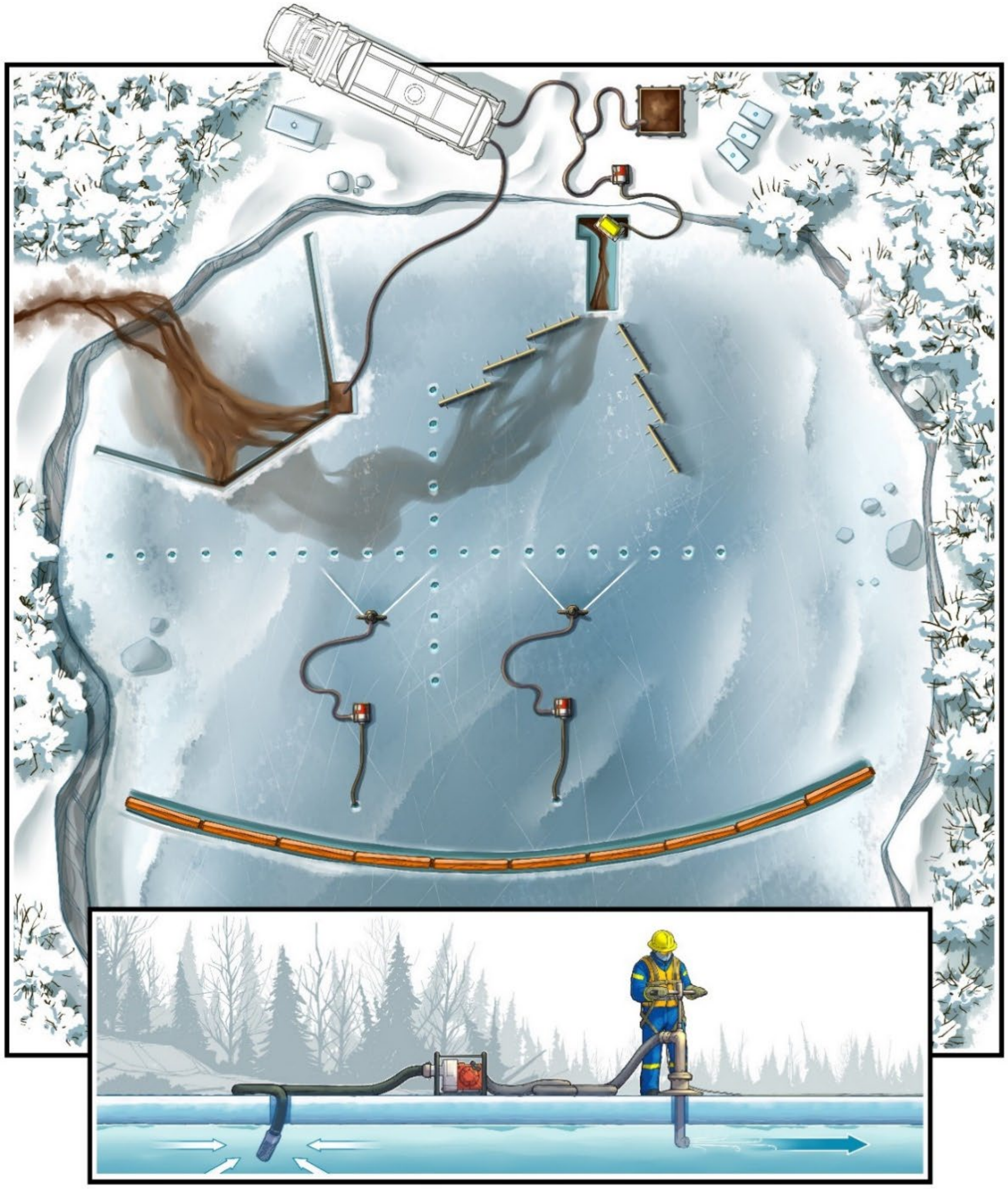
Installing deflection boards into the ice is a quick means of concentrating oil toward a collection point. Slots can be cut in the ice (as shown in the figure below) and boards with pegs can be inserted to a suitable depth below the ice to act as a containment boom skirt would in open water, gathering and directing oil toward a collection point.



5.2 Standing Water

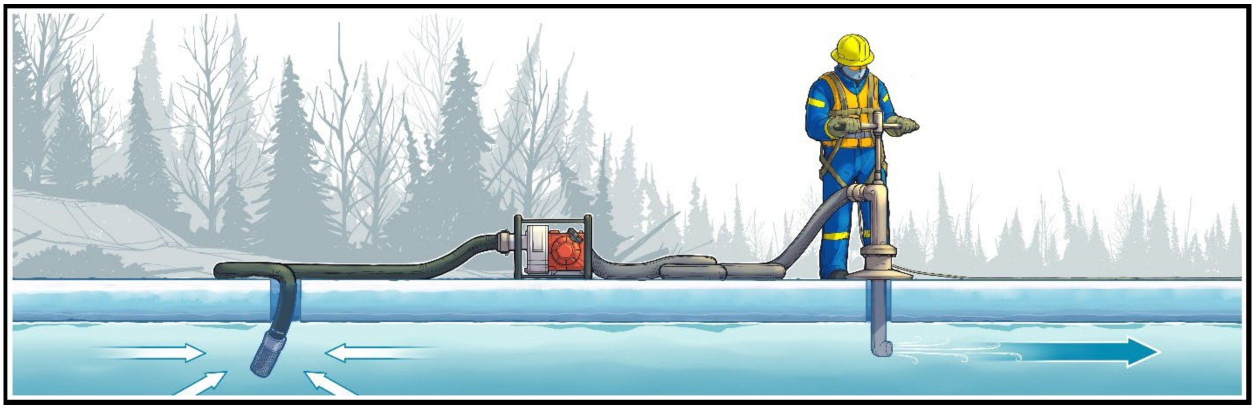
5.2.1 Containment

Physically containing and deflecting free product under ice can be done in several ways. Using plywood or poly sheeting hung just below the bottom of the ice acts like the skirt on containment boom, and is a simple and effective containment method. Overlap the sheets to create continuity and you can direct product toward recovery slots.



5.2.2 Mobilizing Product

Current needs to be created to allow for the movement of product under ice when a natural current is not available. Typical water pumps can be placed, along with a controllable discharge nozzle to direct the pumped water toward the oil and your nearby containment systems. Working systematically from the farthest reaches of contamination back toward your collection is the best approach.



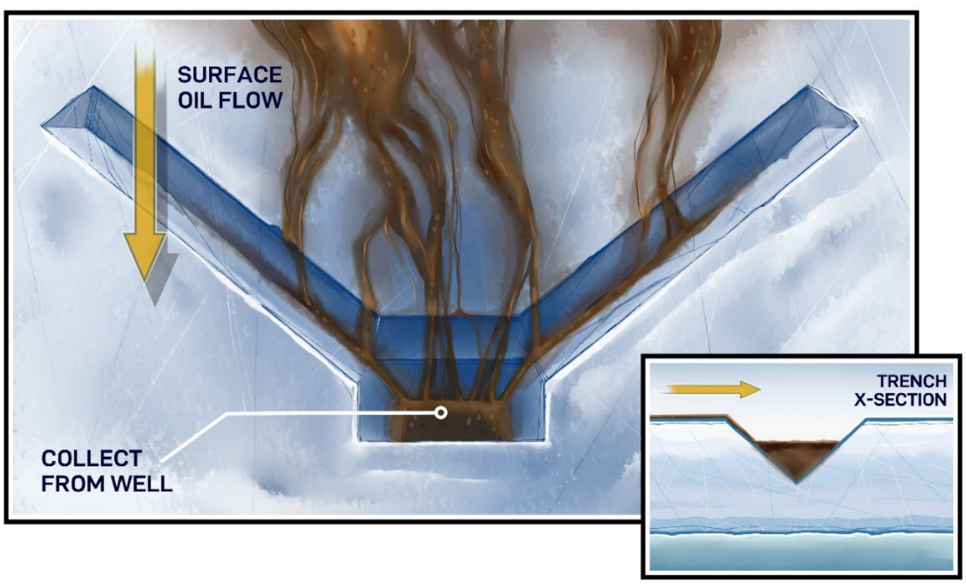
5.2.3 Product Collection

Oil will surface in product collection trenches, which allow for recovery via a multitude of options. Consideration should be given to the most efficient means (such as drum skimmers) to minimize waste recovery and the need for treatment and/or disposal.

5.3 Surface Oil

5.3.1 Recovery Trenches

Surficial oil collection trenches can be strategically placed in the ice to concentrate and allow for surficial oil recovery. Utilize chainsaws and ice augers to cut these structures according to containment and recovery plans in areas that have good solid ice that will not allow for oil movement beyond the structure.



5.4 Recovery Equipment Considerations

Recovery of oil in WSR can be very difficult—the oil will either be thicker due to temperature, emulsified, or dissipated to the point of only being noted as sheen and dissolved phase components. This means that recovery needs to be tailored to the situation. Skimming systems are extremely effective at recovering high volumes of oil, with little water volume, but the oil tends to act differently due to temperature. A multi-head skimmer such as a brush/drum/disc setup may need to be considered, or, alternatively, a weir skimmer if the majority of the product is only sheen. Vacuum equipment can also be utilized, but be aware that whatever system or combination of systems you use, freezing during operations is an ongoing issue. Steam generators, intrinsically safe electric line heaters, and ongoing manual monitoring and maintenance need to be sustained.

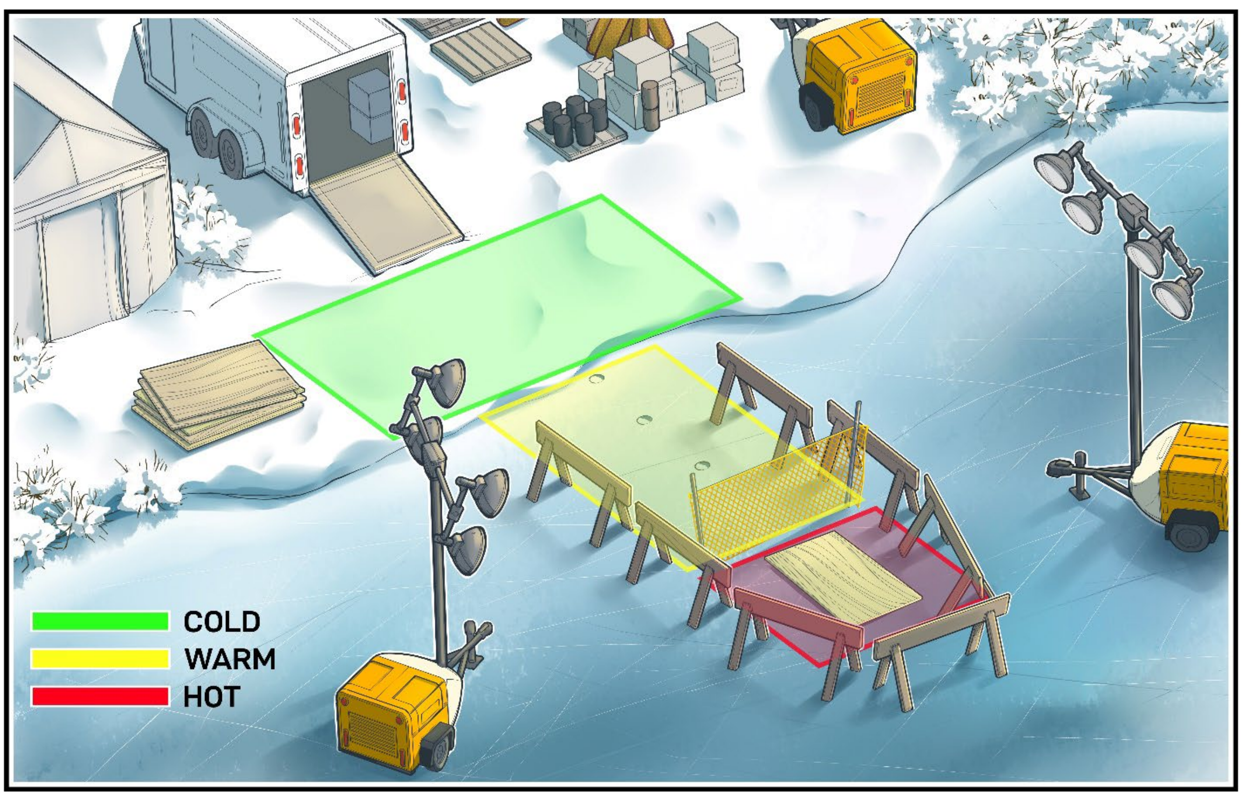
Where possible, the recovery area can be enclosed with temporary tents, etc., to allow for insulation and or addition of heat to aid in operations. Be sure to monitor the air in the location for worker safety and the selection of safe heating options.

6 Ongoing Site Maintenance/Security

Weather changes throughout a response, and the needs of onsite responders will change. The site should have safe access, staging, parking, and sufficient support facilities to allow for effective and efficient use of the responders' and SMEs' skill sets that meet the needs of the ongoing operation.

6.1.1 Site Security

Once a location has been set up and is slotted for anticipated or ongoing containment and recovery operations, responders and the incident management team should consider additional resources to maintain the location for operations, protect the location for safety reasons, and protect the public, wildlife, and personnel. Additional fencing around open water, protection for workers and the work area from extreme weather, and the establishment of decontamination and safety corridors are key. These operations could be 24 hours a day for a period, so support in the form of warm-up and washroom facilities, lighting, fencing, signage, and manned security need to be organized. Utilize ICS structure to support responders' requests and the suggestions of onsite SMEs.



6.1.2 Monitoring Conditions

6.1.2.1 Weather—Current and Forecast

Significant changes in weather can affect the load-bearing capacity of the ice sheet. It is important to assess the ice sheet based on the conditions and temperature changes to track the ice quality. Warming temperatures can cause ice to melt or become less solid, and rapid cooling temperatures can cause ice to become brittle and crack.

6.1.2.2 Ongoing Weather Evaluation

Knowing what weather is upcoming helps the incident management team determine goals for the immediate operational period. Priorities can be determined based on "weather windows" where required.

6.1.2.3 Ice thickness/Quality

Warming and cooling trends that last for several days can affect ice thickness and quality, especially in the cleared work area. Crews should evaluate ice for changes to quality and thickness that may prompt a change in allowable weight-bearing capacity.

7 Final Considerations

WSR is a rare experience for many responders. It is important to maintain a list of SMEs that can help guide and/or manage a response when situations like this occur. Focus on safety of personnel by assessing ice conditions and providing all necessary controls (engineered and PPE) for hazards that cannot be eliminated. Ensure that all responders know their roles and are properly trained and outfitted for the response prior to any work being done. Safety is key.

Annex A
(informative)

Gold’s Formula

See the Gold’s Formula table on the next page.

Gold's Formula

$$P = A \times h^2$$

P = Load in KG

A = Safety Factor for Lake or River

h = **Effective** Ice Thickness in cm

Effective Ice Thickness (h)		RIVER Low Risk Metric (A) = 3.5 Allowable Load (P)		LAKE Low Risk Metric (A) = 4 Allowable Load (P)		RIVER Tolerable Risk Metric (A) = 4 Allowable Load (P)		LAKE Tolerable Risk Metric (A) = 5 Allowable Load (P)		RIVER Substantial Risk Metric (A) = 5 Allowable Load (P)		RIVER Substantial Risk Metric (A) = 6 Allowable Load (P)		RIVER EXTREME RISK Metric (A) = 6 Allowable Load (P)		LAKE EXTREME RISK Metric (A) = 6 Allowable Load (P)	
Inches	cm	Lbs	Kgs	Lbs	Kgs	Lbs	Kgs	Lbs	Kgs	Lbs	Kgs	Lbs	Kgs	Lbs	Kgs	Lbs	Kgs
8	20	3087	1400	3528	1600	3528	1600	4410	2000	4410	2000	5292	2400	5292	2400	6174	2800
10	25	4823	2188	5513	2500	5513	2500	6891	3125	6891	3125	8269	3750	8269	3750	9647	4375
12	30	6946	3150	7938	3600	7938	3600	9923	4500	9923	4500	11907	5400	11907	5400	13892	6300
14	35	9454	4288	10805	4900	10805	4900	13506	6125	13506	6125	16207	7350	16207	7350	18908	8575
16	40	12348	5600	14112	6400	14112	6400	17640	8000	17640	8000	21168	9600	21168	9600	24696	11200
18	45	15628	7088	17861	8100	17861	8100	22326	10125	22326	10125	26791	12150	26791	12150	31256	14175
20	50	19294	8750	22050	10000	22050	10000	27563	12500	27563	12500	33075	15000	33075	15000	38588	17500
22	55	23345	10588	26681	12100	26681	12100	33351	15125	33351	15125	40021	18150	40021	18150	46691	21175
24	60	27783	12600	31752	14400	31752	14400	39690	18000	39690	18000	47628	21600	47628	21600	55566	25200
26	65	32606	14788	37265	16900	37265	16900	46581	21125	46581	21125	55897	25350	55897	25350	65213	29575
28	70	37816	17150	43218	19600	43218	19600	54023	24500	54023	24500	64827	29400	64827	29400	75632	34300
30	75	43411	19688	49613	22500	49613	22500	62016	28125	62016	28125	74419	33750	74419	33750	86822	39375
31	80	49392	22400	56448	25600	56448	25600	70560	32000	70560	32000	84672	38400	84672	38400	98784	44800
33	85	55759	25288	63725	28900	63725	28900	79656	36125	79656	36125	95587	43350	95587	43350	111518	50575
35	90	62512	28350	71442	32400	71442	32400	89303	40500	89303	40500	107163	48600	107163	48600	125024	56700
37	95	69650	31588	79601	36100	79601	36100	99501	45125	99501	45125	119401	54150	119401	54150	139301	63175
39	100	77175	35000	88200	40000	88200	40000	110250	50000	110250	50000	132300	60000	132300	60000	154350	70000
41	105	85085	38588	97241	44100	97241	44100	121551	55125	121551	55125	145861	66150	145861	66150	170171	77175
43	110	93382	42350	106722	48400	106722	48400	133403	60500	133403	60500	160083	72600	160083	72600	186764	84700
45	115	102064	46288	116645	52900	116645	52900	145806	66125	145806	66125	174967	79350	174967	79350	204128	92575
47	120	111132	50400	127008	57600	127008	57600	158760	72000	158760	72000	190512	86400	190512	86400	222264	100800
49	125	120586	54688	137813	62500	137813	62500	172266	78125	172266	78125	206719	93750	206719	93750	241172	109375
51	130	130426	59150	149058	67600	149058	67600	186323	84500	186323	84500	223587	101400	223587	101400	260852	118300
53	135	140651	63788	160745	72900	160745	72900	200931	91125	200931	91125	241117	109350	241117	109350	281303	127575
55	140	151263	68600	172872	78400	172872	78400	216090	98000	216090	98000	259308	117600	259308	117600	302526	137200
57	145	162260	73588	185441	84100	185441	84100	231801	105125	231801	105125	278161	126150	278161	126150	324521	147175
59	150	173644	78750	198450	90000	198450	90000	248063	112500	248063	112500	297675	135000	297675	135000	347288	157500

*METRIC FORMULA with Imperial Conversions Listed

* Allowable load is based on a 100' (30m) radius from point of ice assessment block

Annex B
(informative)

Ice Safety Plan

Name: ______________________________
Date: ______________________________
Time: ______________________________

SITE ASSESSMENT

Location (GPS coordinates, legal land description)				
Date (dd/mm/yy)	/ /	Time		
Current temperature				
Temperature variations last 24 hours				
Predicted temperature variations for next 24 hours				
Windchill				
Site access description (for responder vehicles/equipment)	Poor	Fair	Good	Excellent
Ice faults	Yes	No		
Pressure ridges	Yes	No		
Cracks	Yes (wet / dry)	No		

SAFETY CONTROLS

Muster point	
First aid station	
Medical facility	
Local hospital	
Warm-up facility	

ICE-CUTTING STRATEGY RESTRICTIONS

- Authorized personnel and equipment only on-ice: safety lead/lead responders
- Stationary loads: < 2 hours
- Personnel working within 6 ft (2 m) of ice slot must be secured with manned or anchored safety lines
- Buddy system for on-ice personnel
- Certification required: operating boat, chainsaws, etc.
- Secure site before leaving it unattended
- Other

  ____

SAFETY ORIENTATION

Leads to review with crews

- Hazard assessment for working on ice
- Safety controls
- Emergency communications and actions
- Ice cutting strategy restrictions

Verification Crew Briefings

Ice evaluation team	
Ice slotting team	
Ice rescue	
Air boat	

ICE-COVERED WATERCOURSE ASSESSMENT

Ice-Covered Watercourse Assessment Worksheet
Date:
Time:
Location:

Hole#	Units	1	2	3	4
Ice thickness	in. or cm				
Water depth	in. or cm				
Current velocity	km/hr or mi/hr				
Freeboard	in. or cm				

Hole#	Units	5	6	7	8
Ice thickness	in. or cm				
Water depth	in. or cm				
Current velocity	km/hr or mi/hr				
Freeboard	in. or cm				

Hole#	Units	5	6	7	8
Ice thickness	in. or cm				
Water depth	in. or cm				
Current velocity	km/hr or mi/hr				
Freeboard	in. or cm				

Site Diagram ***Recommended: 3-m spacing on rivers and 10-m spacing on lakes***

NOTE For rivers, indicate the direction of flow at each augered hole with an arrow on the surface.

SITE DRAWING

Ice thickness (in./cm): Draw in bore hole location and indicate thickness in inches and centimeters.

Ice Quality

- Indicate block location.
- Indicate thickness of:
  - white ice: ________________
  - blue ice: ________________

$P = A \times h^2$
A =
h^2 =

Effective ice thickness: ______________________

Weight-bearing capacity: ____________________

Risk tolerance: _____________________________

REFERENCE—GENERAL DESCRIPTION OF WORK

Objectives:

	Ensure safety of all workers, observers, and others who could be impacted both during and following the work.
	Identify the weight-bearing capacity of the ice sheet in the working area.
	Determine suitable risk tolerance for work required.
	Identify a containment and recovery strategy.
	Slot the ice with appropriate equipment.
	Debrief and document follow-up requirements and lessons learned.
	Secure the site.

Other: ______________________________

Typical Sequence of Events:

	Identify the equipment deployment site location.
	Hazard assessment and identification of safety controls and zones.
	Develop an ice safety plan.
	Crew orientations and specific hazard identification and safety controls.
	Placement of the ice rescue team.
	Ice assessment.
	Identify weight-bearing capacity and equipment requirements.
	Discuss risk tolerance and identify ice removal strategy.
	Slot ice and begin recovery operations.
	Install boom or dimensional lumber at the perimeter of the spills site to prevent lateral migration.
	Debrief.
	Identify follow-up.
	Site cleanup.
	Secure site and appoint someone to check on barricades.

Other: ______________________________

If this is a spill event, ensure that work policies and procedures are in line with the incident action plan and other relevant site-specific spill response plans.

REFERENCE—PERSONAL PROTECTIVE EQUIPMENT

ON-ICE WORKERS—RESCUE TEAM/ICE EVALUATION AND SLOTTING TEAM

- Minimum: PFD; floater jacket preferred.
- Initial ice assessment: harness and rope tended and anchored.
- Further assessment work, ice slotting, containment and recovery: developed as per initial ice assessment.
- Minimum 1-m distance from slots.
- Ice awls.
- Whistle.
- Appropriate outer work wear.
- Ice cleats if appropriate.
- Chainsaw safety equipment.
- Hearing protection (double protection required when operating equipment).
- Other ____

  ____

ON-ICE WORKERS—AIR BOATS

- Minimum: personal flotation device (PFD).
- Hearing and eye protection (double protection required when operating equipment).
- Warm outer work wear.
- Communications radio or pre-designated signals.
- Ice cleats.
- Other ____

  ____

OBSERVERS

- Follow company policy linked to PPE requirements.
- Appropriate outer cold weather clothing.
- Stay off ice unless escorted.

Other ____

____

Annex C
(informative)

Ice-covered Watercourse Assessment Worksheet

Ice-Covered Watercourse Assessment Worksheet
Date:
Time:
Location:

Hole#	**Units**	**1**	**2**	**3**	**4**
Ice thickness	in. or cm				
Water depth	in. or cm				
Current velocity	mi/hr or km/hr				
Freeboard	in. or cm				

Hole#	**Units**	**5**	**6**	**7**	**8**
Ice thickness	in. or cm				
Water depth	in. or cm				
Current velocity	mi/hr or km/hr				
Freeboard	in. or cm				

Hole#	**Units**	**9**	**10**	**11**	**12**
Ice thickness	in. or cm				
Water depth	in. or cm				
Current velocity	mi/hr or km/hr				
Freeboard	in. or cm				

Site Diagram ***Recommended: 3-m spacing on rivers and 10-m spacing on lakes***

NOTE For rivers, indicate the direction of flow at each augered hole with an arrow on the surface.