Great Lakes Oil in Ice Response Guide

Straits of Mackinac, Michigan, April 2, 2018. Image credit: NOAA

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Disclaimer
Great Lakes Oil in Ice Response Guide is a guidance document intended to support responders in planning and executing oil spill response operations in freshwater ice conditions. The recommendations and strategies outlined herein should be incorporated into each organization's standard operating procedures and best practices as appropriate.

Every effort has been made to ensure that the information provided is accurate, applicable, and up to date. However, response conditions vary, and professional judgment should be exercised in all situations. The authors assume no responsibility for any loss, damage, or consequences resulting from the use of this guide.

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This guide was prepared for the U.S. Coast Guard Great Lakes Center of Expertise (GLCOE) by Research Planning, Inc. (RPI) under contract to NOAA. The project team included Dr. Jacqueline Michel (Research Planning, Inc.); David Dickins (DF Dickins Associates, LLC); Chris Hall and Adam Kayser (Alaska Clean Seas); Jim Elliott and Mike Popa (T&T Group); and CWO Joseph Torcivia (USCG) as technical editor.

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Key Terminology

Stage of Ice Development

New/Thin Ice: Newly formed ice less than 2 inches thick. This is a general term including frazil ice, grease ice, slush and shuga.

- *Frazil:* fine plates of ice crystals suspended in the water.
- *Grease Ice:* later stage of freezing than frazil when the crystals have coagulated to form a soupy matt layer on the water surface.
- *Slush:* Snow that can appear as a viscous floating mass in water after a heavy snowfall into water at the freezing point.
- *Shuga:* Accumulation of spongy white ice lumps a few inches across – formed by grease ice or slush.

Thin Lake Ice: 2 to 6 inches thick

Medium Lake Ice: 6 to 12 inches thick

Thick Lake Ice: 12 to 28 inches thick

Very Thick Lake Ice: Greater than 28 inches – likely deformed ice

Ice Floe Size

Pancake Ice: No defining size, typically 1 to 6 feet in diameter – see Figures 2-6 and 2-5.

Small Cake/Brash: The wreckage of other forms of ice accumulating in the water as fragments less than 7 feet across.

Ice Cake: 7 to 65 feet

Small Floe: 65 to 325 feet

Medium Floe: 325 to 1,650 feet

Big Floe: 1,650 to 6,550 feet

Vast Floe: 1 ¼ miles to 6 ¼ miles

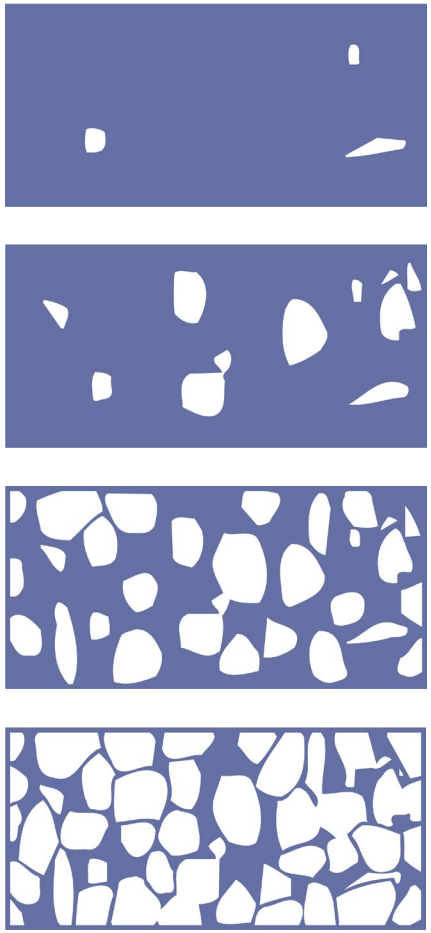
Giant Floe: greater than 6 miles

Fast Ice: Continuous sheet extending out from shore – no defining size, often deformed by wave and wind action. Figures 2-3 and 2-4.

Note: Refer to the *Key to Lake Ice Symbols* in Appendix A of the Technical Report for corresponding numeric codes used in ice charts to define Stage of Development, Floe Size and Concentration. Dimensions here are approximate, converted from metric to English Units.

Ice Concentration

Ice concentration is the area of water surface covered by ice expressed in tenths. For example, 1/10 = 10% coverage and 10/10 = 100% coverage of ice. See graphics below.

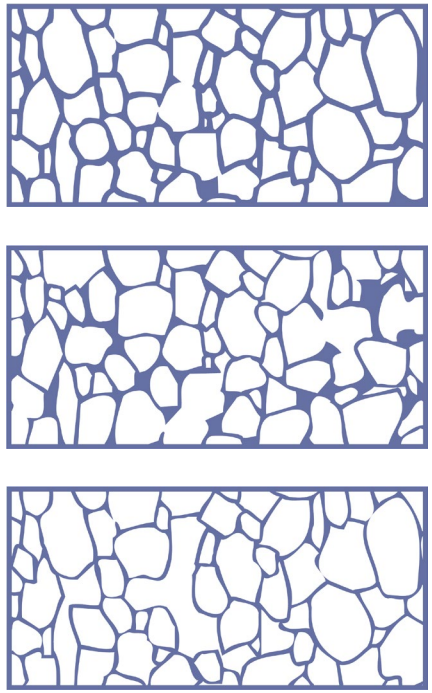


<1/10
Open water

1-3/10
Very open drift

4-6/10
Open drift

7-8/10
Close pack



9/10
Very close pack

+9/10
Very close pack

10/10
Compact/ Consolidated Ice

About This Guide

This guide is divided into two main parts:

- **Operations Guide** – Contains response checklists for different ice environments and tactic selection charts to help determine the most effective tactic for a given scenario.
- **Technical Report (TR)** – Provides in-depth information on each topic to support decision-making and execution.

How to Use This Guide:

1. **Determine Operational Need** – Use the guide flowchart to identify the appropriate response checklist.
2. **Develop & Execute a Response Plan** – Follow the selected checklist(s) and tactic selection chart to establish an effective plan.
3. **Reference Technical Details** – Use the Technical Report as needed for detailed guidance when developing and implementing the response plan.

These two documents are designed to be used together: The Operations Guide offers high-level guidance in the field; the Technical Report provides essential details for unfamiliar topics. Users are encouraged to employ the two sections together.

The Technical Report sections are:

- **Section 1 Introduction**
- **Section 2 Primer on Freshwater Ice in the Great Lakes Region**
- **Section 3 Ice Safety Best Practices and PPE for Responders**
- **Section 4 Logistics and Support**
- **Section 5 Oil Detection, Mapping, and Tracking, and Weathering**
- **Section 6 Tactics for Different Oil in Ice Scenarios**

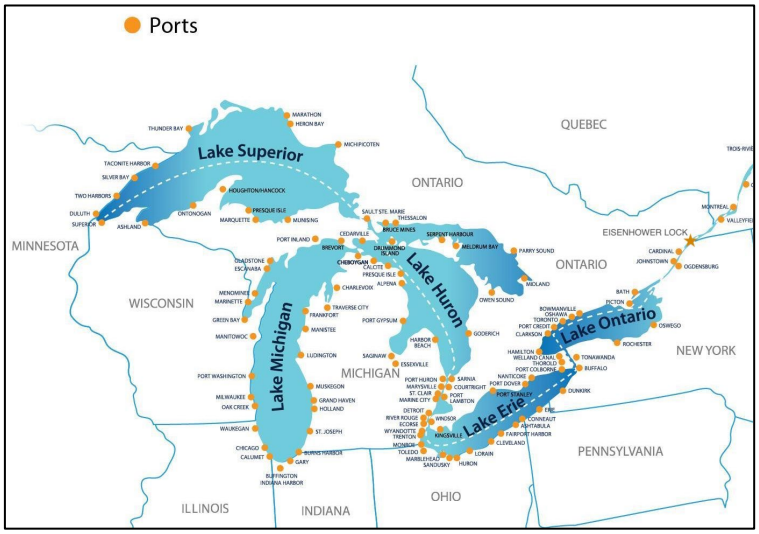
Objective

This guide provides foundational knowledge on oil-in-freshwater-ice tactics, safety, and logistics to support operations oversight and help responders develop appropriate response objectives and strategies.

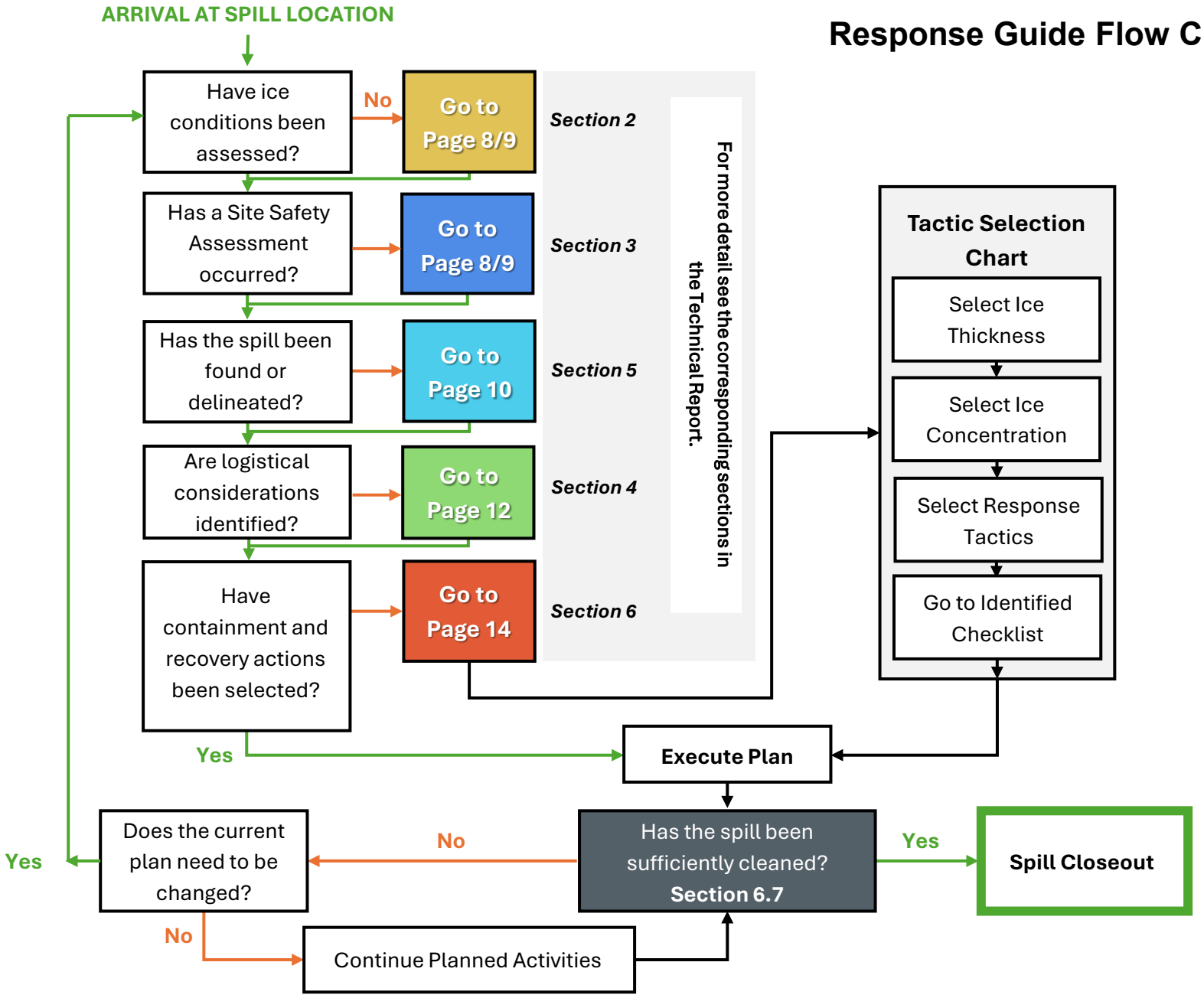
Several comprehensive publications cover the subject of oil in ice response, e.g., API 2024; Hansen and Fitzpatrick, 2017; Owens and Dickins 2015. This new guide builds on this material, as well as the results of many historical research studies on oil in ice response and presents findings that apply most directly to freshwater winter environments in the Great Lakes.

Great Lakes Region

This guide addresses responses to spills in ice conditions on the Great Lakes, Associated Navigable Rivers, and the St. Lawrence Seaway from Lake Ontario to the Eisenhower Lock.



Response Guide Flow Chart



Site Safety and Ice Access *(See TR Section 2 & 3 for more detail)*

Safety

- ☐ Develop incident site safety and health plan.
- ☐ Ensure entry to the spill site is controlled and compliant with entry guidelines.
- ☐ Perform a hazard assessment of the spill site, including a general hazard assessment, an assessment of materials released, and an assessment of the ice to ensure it can support operations. See TR Section 3
- ☐ Conduct atmospheric monitoring as part of the assessment. Best practice is continuous monitoring when able, until Safety determines it is not necessary.
- ☐ Ensure ice profiling and load calculations are completed prior to responders getting on ice. See TR Section 2.2
    - Ice profilers should have a PFD, harness, and be tethered to a safe location.
- ☐ Ensure required safety staff are present in the field to provide appropriate oversight.
- ☐ Clearly and visually define safe areas, unsafe areas, and transit routes on the ice.
    - Regularly inspect routes and work areas. Degradation can occur quickly over time. See TR Section 3
- ☐ Develop a rescue plan that addresses actions that will be taken if responders break through the ice. See TR Section 3
- ☐ Develop an Ice Safety Plan that addresses the specific hazards and mitigations for ice operations. See TR Section 3
- ☐ Ensure proper PPE is identified and in use. Some specific PPE that pertains to working on ice can include: See TR Section 3
    - Traction Devices
    - Personal Flotation Device (PFD)
    - Harness with tethered rope – This should be the outermost layer
- ☐ Coordinate early with Subject Matter Experts.
- ☐ Ensure all hazard mitigations are identified are implemented.
- ☐ Brief responders on safety plan. When any changes occur to the plan ensure responders are given an updated briefing.

USCG Subject Matter Expert (SME) Guidance

Oil spills in icy conditions are inherently dangerous and complex. Coordinate and communicate with appropriate Subject Matter Experts (SMEs) early and often to ensure a safe and best response. USCG members shall follow USCG District and Unit policies and guidance (see USCG SME and reference list as a starting point).

USCG internal SMEs for coordination (non-inclusive):

- District Response Advisory Team (DRAT)
- National Strike Force
- HSWL Safety Environmental Health Officer (SEHO)
- Ice Rescue Unit
- National Ice Rescue School

USCG internal guidance (non-inclusive):

- Boat Operations And Training (BOAT), Volume I COMDTINST 16114.32 (series)
- Cleveland SAR Plan D9 INST M16100.11
- Diving Program Manual COMDTINST M3150 (series)
- Ice Rescue Operations (IROPS) Tactics, Techniques, and Procedures (TTP) – CGTTP 3-50.1E
- Marine Environmental Response and Preparedness – COMDTINST 16000.14 (series)
- Rescue and Survival Systems Manual - COMDTINST M10470 (series)

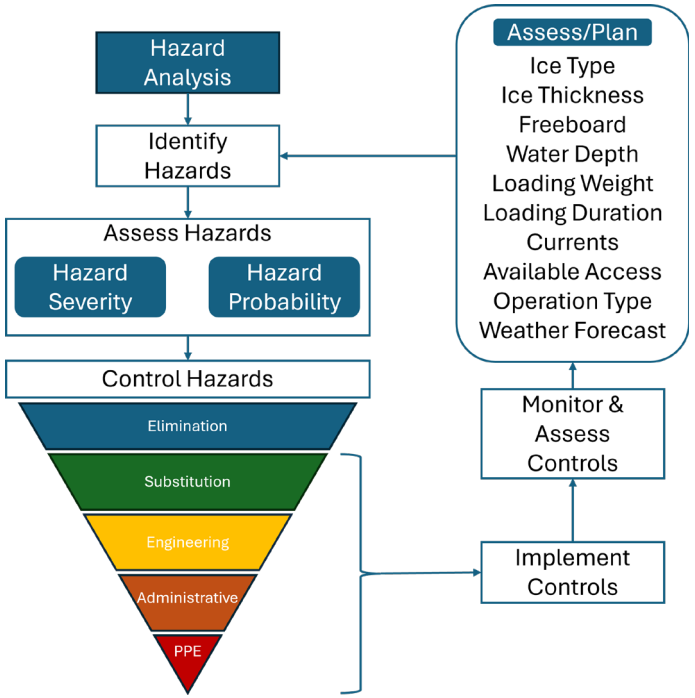
Personal Protective Equipment

Options

- Base layers
- Layered clothing to allow for insulating air between the layers
- Breathable, warm outer clothing
- Waterproof outerwear in wet conditions
- Flotation suits (as required for conditions and duties)
- Warm hat and face covering as necessary
- Safety glasses or goggles
- Hard hat
- PFD and safety harness (must be outermost layers)
- Warm, safety toe footwear
- Traction devices – must be worn over chemical resistant booties
- Warm work gloves and chemical resistant outer gloves
- Appropriate chemical-resistant clothing as outermost layer under flotation devices and safety harnesses
- Respirator

Government and industry personnel are reminded to follow their organization-specific PPE policies and guidance for cold weather and oil spill response operations.

PPE and Hazard Assessment



If ice operations are anticipated, developing and distributing a detailed Ice Safety Plan is a best practice. Components may include: (See TR Section 3 for more detail.)

- Identified hazards and controls
- Ice profiling process (assess ice quality and capacity)
- Weight, duration, and speed limitations
- Visuals: Profile grid map, travel routes
- Weather forecast
- Ice movement survey
- Required PPE

Surveillance and Tracking *(See TR Section 5 for more detail)*

- ☐ ***Use the tactic selection chart to choose the most suitable detection tactic.***
  - Multiple detection tactics may need to be utilized to detect oil in dynamic ice environments. Be prepared to utilize several.
  - It could be difficult to visually locate relatively colorless products like gasoline or diesel in ice. Near IR sensors may achieve better results for these products then optical systems.
  - Oil detecting canines may do better with products having more light ends.
  - If conditions are dynamic (continued release, spill product migration), conduct regular detection and tracking activities.
- ☐ ***Aerial – Better for large coverage areas but requires recurring flights. See TR Section 5.1***
  - Assign crewed/uncrewed air assets.
  - Assign trained aerial observer.
  - Fly over in established pattern.
- ☐ ***Ground – Better for stable thick ice. Can be done with minimal logistical support.***
  - Define areas to conduct detection in.
  - Ensure ice profiling is done in these areas and can support detection resources.
  - Conduct selected detection and tracking tactics and identify areas for safe access and equipment or personnel operations.
- ☐ ***Under Ice – Requires enhanced logistical support.***
  - These activities may involve the use of divers, hydrographic survey systems, or autonomous underwater vehicles (AUVs).
  - Ensure thorough ice profiling is conducted and confirm that all surface logistical support equipment is capable of being deployed and sustained safely.
  - AUVs, underwater cameras, and divers' helmet cameras enable surface personnel to observe subsurface operations and support tactical decision making.

Platform	**Airborne**				**On-ice**		**Below Ice**		
Sensor	GPR	Optical	FP	IR	GPR	ODC	Optical	FP	Acoustic
Exposed oil on ice	N/A				N/A			N/A	N/A
Snow covered oil on ice									
Oil under thin lake ice <~10 cm									
Oil under thicker lake ice									
Oil encapsulated by new ice									

Green = Likely; **Yellow** = Has Potential; **Red** = Not Likely; NA = Not applicable.
See Section 5.1 for a full explanation of these systems and their potential.

Sensors: Ground Penetrating Radar (GPR), Oil-Detecting Canines (ODC), Optical (cameras and radiometers), Fluorescence Polarization (FP), Thermal Infrared (IR), and Acoustic systems.

Performance Colors are based on field results and systems knowledge of the state of the art of the sensors.

Surveillance, Detection, Mapping and Tracking Tools *(See TR Section 5 for more detail)*

Crewed Aircraft
Good choice where aircraft assets and trained observers are available. May include remote-sensing capabilities. Fast survey speed.

Weather conditions may limit flying opportunities. Higher risk to responder personnel. Requires trained observers to be effective. Limited space for multiple observers. Cannot detect oil under ice.

Uncrewed Aircraft Systems (UAS)
Great choice where they can be operated safely. May include visual and IR sensors. Low risk to personnel. May permit more observers to see at the same time on monitors or livestream. Quick, near-real time data delivery.

Weather conditions may limit flying opportunities. Requires licensed Remote Pilots. Requires trained observers to interpret the imagery. May be required to maintain visual line of sight to operator. Cannot detect oil under ice.

Ice-strengthened GPS Tracking Buoys
Allows for around the clock tracking of oil in open water, broken ice, and compact ice. Can be placed on the surface above an area with oil under the ice to track its movement. New and custom-made buoys have been fitted with highly efficient power management, solar cells, cameras, and other sensors to enable extended deployments.

May need access to the broken ice area for deployment. May be difficult to retrieve if they encounter problems.

Ground Penetrating Radar (GPR)
Very effective tool to quickly profile the ice thickness and detect areas of oil under ice.

Requires trained personnel to interpret the data. Requires relatively uniform surface conditions, with enough ice for crews to work safely.

Autonomous Underwater Systems (AUVs), Underwater Lights and Cameras
Effective in detecting areas of oil under ice. Augers and electric drills can rapidly make many boreholes. Small underwater cameras can take pictures and video of conditions under ice. AUVs can detect sources of subsea releases, sunken vessels and other subsurface conditions.

Requires enough ice for personnel to be able to work safely. Logistical support equipment must be able to safely deploy and operate on the surface. Quick to deploy but large surveys take a long time.

Oil-Detecting Canines
Successful in detecting oil from long distances under snow and ice. Can cover large amounts of area in a short time.

Requires trained canines and personnel to detect oil.

Logistical Support Considerations *(See TR Section 4 for more detail)*

Logistics

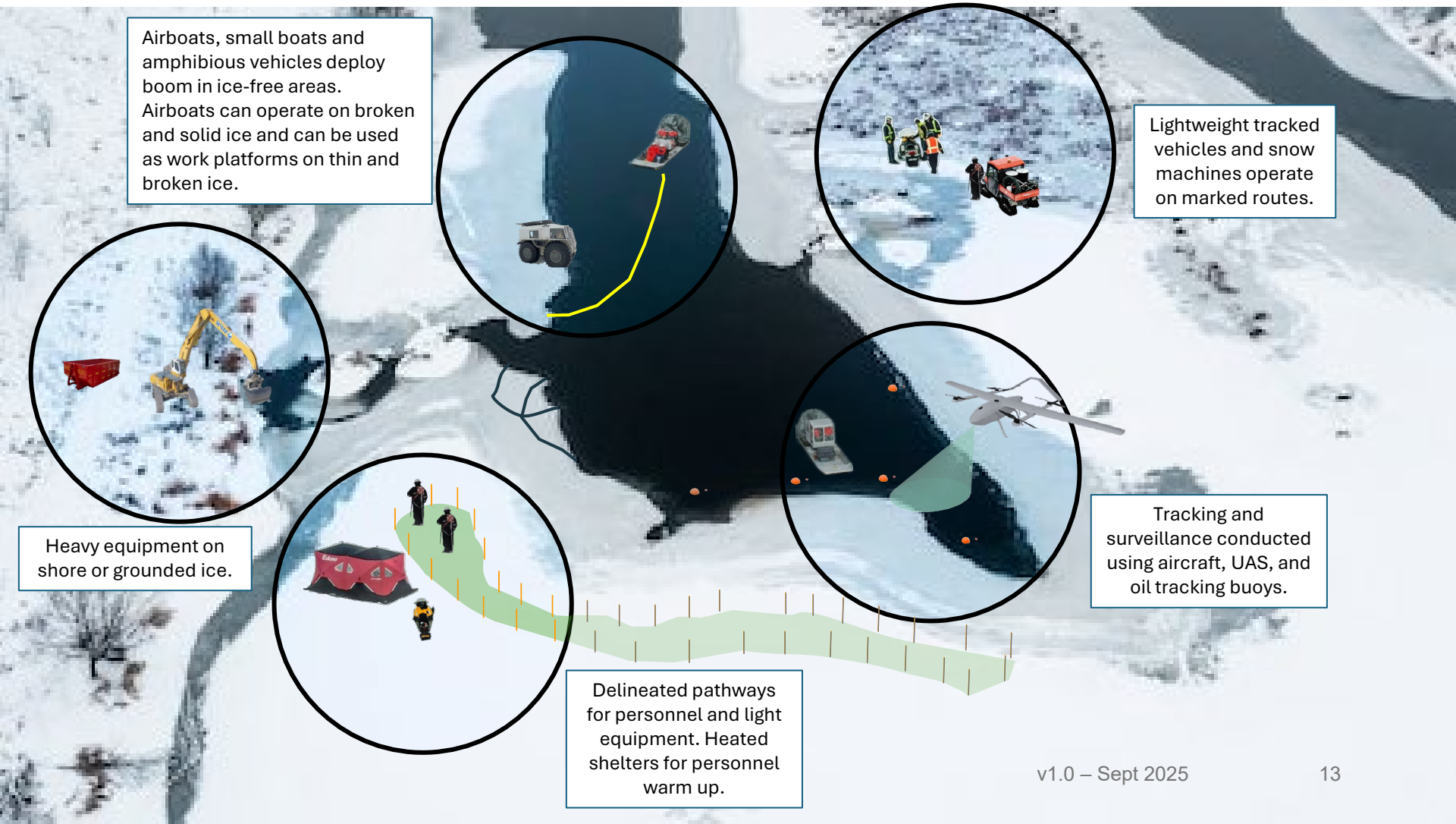
- ☐ Ensure communications are established to field locations.
- ☐ Lighter weight equipment is essential for safe operations conducted on ice.
- ☐ Determine what vehicles will be used to transit to the site. Can the ice support small tracked vehicles, snow machines, or will small boats and airboats be needed as work platforms?
- ☐ Site access can be accomplished via
  - Helicopter – Personnel and equipment can be transported via helicopter.
  - Amphibious vehicles allow for safe transition between water and ice and transit of thin ice.
- ☐ Identify warm-up facilities for personnel and equipment in the field.
- ☐ Staging should be as close to operations as possible. It may be necessary to set up staging on shore or on a nearby vessel.
- ☐ Used caution when storing waste on ice. Waste can quickly accumulate, adding a considerable amount of weight to the ice surface. Waste accumulation areas should be positioned off the ice if possible, and within secondary containment.

Vessel Based Logistics

- ☐ Determine vessel type with consideration to ice thickness, concentrations, and operational tasking.
  - Smaller vessels such as jon boats, hovercraft, and airboats may be used on ice.
  - Ice conditions heavily impact vessel maneuverability.
- ☐ Routes in more concentrated ice should be pre-planned when possible and will require ice-capable vessels to clear a path and/or break ice.
- ☐ Equipment/vessel icing from operations or surface spray will need to be addressed.
- ☐ Ensure adequate shelter space for responders available, especially in smaller vessels.
- ☐ Decontamination zones should be established on vessels.
  - Support zone may be internal vessel areas.
- ☐ Oil runoff from recovered equipment will need to be contained.
- ☐ Ensure appropriate storage for recovered product, proper placement and securement. Securing deck-mounted storage can use large amounts of deck space.
- ☐ Determine method and frequency required to offload recovered product.

Access for On-Ice Response Operations Overview *(See TR Section 4 for more detail)*

Considerations for ice access during spill responses. Heavy equipment may perform recovery operations from the shoreline and from thick or grounded ice. Small tracked vehicles and snow machines may operate on thinner ice if conditions allow. Personnel may be able to walk to recovery areas or provide support from shoreside for nearshore operations. Areas of open water and thin broken ice may be accessed using amphibious vehicles and jon boats/ airboats as work platforms. Ice-strengthened tracking buoys may be deployed in oil pockets by personnel on foot, from boats, and from helicopters.

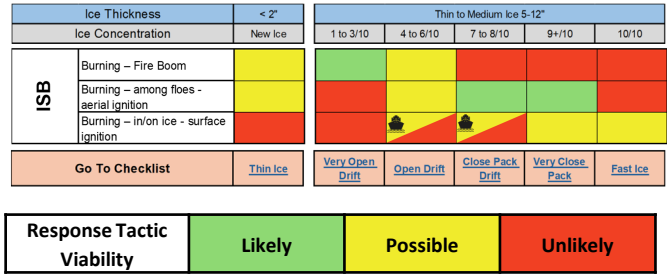


Tactic Selection Chart

- The colored “stoplight” chart is a preliminary guide to help in selecting the most appropriate (safe and effective) tactic for a given ice condition (concentration and thickness). The general terms **likely**, **possible,** and **unlikely** reflect the uncertainty involved in making a decision in the face of different operational factors – winds, temperature, vessel support, ice condition, distance from shore, oil type, oil thickness, waste disposal sites, etc.
- Ice in the Great Lakes is highly variable. Flexibility is key to selecting tactics that suit the conditions. Anticipate the need to change tactics.
- Tactics are focused on floating oils. Heavier products that are more likely to sink are also present in the region. Lower viscosity products will potentially begin to move under ice at a lower threshold current velocity and move at a higher rate once in motion. See TR Section 1.3 for more details about oil transported on the Great Lakes.

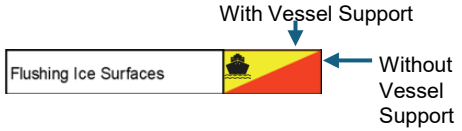
Using the Tactic Selection Chart

- As discussed in the Response Guide Flow Chart, first select the ice thickness and concentration found during your ice assessment. Tactics are listed along the left side for you to select from.
- For each ice condition there is a corresponding cell that describes that tactic’s viability.
- Select the tactics you wish to employ and follow the column down to find the corresponding checklist.



With or Without Vessel Support

Some cells are divided diagonally into two sections. The top half, marked with a vessel icon, shows tactic viability **with** vessel support. The bottom half shows viability **without** vessel support. If a cell is not divided, the tactic’s viability is the same regardless of vessel support.



GO / NO-GO Considerations

- **No personnel on floes without vessel or vehicle support due to potential pile-ups and rubble**
- **Working on ice offshore less than 12” thick with no vessel support creates an unacceptable risk to personnel**
- **Air temperatures above freezing for the last 24 hours can create areas of weak ice with reduced/unpredictable strength**
- **Water on the ice where responders are working could indicate potentially dangerous ice conditions**
- **Unprotected or non-participating populations downwind at less than a safe burn distance will prompt air quality concerns**
- **Winds greater than 19kt for In situ Burning will make it difficult to ignite and sustain burning**

Ice Tactics Selection Chart

Ice Thickness		New/Thin Ice < 6”	Medium Ice 6"-12”					Thick Ice 12" to 28"				
Ice Concentration		Any	1 to 3/10	4 to 6/10	7 to 8/10	9-9+/10	10/10	1 to 3/10	4 to 6/10	7 to 8/10	9-9+/10	10/10
Go To Checklist		New/Thin Ice	Very Open Drift	Open Drift	Close Pack/Drift	Very Close Pack	Compact/Fast Ice	Very Open Drift	Open Drift	Close Pack/Drift	Very Close Pack	Compact/Fast Ice
Detection Platforms	Satellite											
	Vessel Based - incl. IR											
	GPR/Drilling on Ice											
	Canines (ODCs)											
	AUV/ROV Under Ice											
	UAS - incl. IR	**Not Affected by ice Conditions – weather (winds, ceiling and visibility are the critical factors)**										
	Aircraft – incl. IR											
Containment & Recovery	Slots & Trenches											
	Boom & Skim											
	Natural Ice Containment											
	Barriers Under River Ice											
	Berming On Ice Near Shore											
	Bubblers & Skim Near Shore											
	Ice Removal											
	Flushing Ice Surfaces											
	Active Monitoring	**If not able to safely conduct containment or recovery, consider Active Monitoring. Go to Section 6.5**										
ISB	Burning – Fire Boom											
	Burning – among floes - aerial ignition											
	Burning – in/on ice - surface ignition											

New/Thin Ice Checklist - ≤6 inches

Ice Thickness		New/Thin Ice <6"
Ice Concentration		Any
Detection Platforms	Satellite	
	Vessel Based - incl. IR	
	GPR/Drilling on Ice	
	Canines (ODCs)	
	AUV/ROV Under Ice	
	UAS - incl. IR	Not Affected by Ice
	Aircraft – incl. IR	
Containment & Recovery	Slots & Trenches	
	Boom & Skim	
	Natural Ice Containment	
	Barriers Under River Ice	
	Berming On Ice Near Shore	
	Bubblers & Skim Near Shore	
	Ice Removal	
	Flushing Ice Surfaces	
	Active Monitoring	Note 1
ISB	Burning – Fire Boom	
	Burning – among floes - aerial ignition	
	Burning – in/on ice - surface ignition	

Vessel Legend:

With Vessel Support →  ← Without Vessel Support

Containment & Recovery - Options on thin ice are primarily restricted by the load-bearing capacity of the ice and what equipment it can support**.**

It is unlikely that personnel would be permitted to work on ice that is less than 2" thick without tethers, dedicated line handlers, and a stable work platform.

!! **Containment and recovery tactics should be deployed from a work platform, airboat deck, or shoreline/dock area.**

- ☐ Ensure personnel are briefed on Site Safety and Ice Safety plans.
  Ensure personnel have proper PPE to include traction devices, PFDs, and harness with tethered rope (this should be outermost layer).
- ☐ Use results from detection and tracking to determine where to deploy selected containment and recovery tactics.
- ☐ Determine safe route to containment and recovery area.
  - Determine method of transport. See TR Section 4.1
- ☐ Designate decontamination zones and establish decontamination facilities.
- ☐ Deploy and maintain containment. See TR Section 6.2
- ☐ Report containment updates.
- ☐ Ensure proper transport and storage capabilities for the recovered spilled product are available.
  - Options include portable tanks, bladders, pumps and hoses (in series).
  - Anticipate pumping to storage located on a vessel or on shore as ice will not support heavy loads.
- ☐ Deploy and maintain recovery. See TR Section 6.4
- ☐ Report quantity of spilled product recovered.
- ☐ If unable to recover due to conditions, conduct active monitoring until conditions improve. See TR Section 6.5

Other Notes and Considerations

- ☐ Bubbler systems may be effective in removing thin ice, particularly in marinas and dockside.
- ☐ Excavator buckets may be able to break up and remove thin ice if the machine can safely reach the ice.
- ☐ Continually assess the ice condition as containment and recovery activities continue. These activities can degrade ice, reducing its load bearing capacity. See TR Section 3
- ☐ If working from ice surface, ensure ice profiling is done in these areas and can support containment resources. See TR Section 2.2
- ☐ A heavy snowfall can submerge thin ice and create dangerous conditions.

New/Thin Ice Tactics: Advantages & Considerations

Natural Ice Containment

- Oil trapped in open areas between ice pieces may show slower rates of weathering and degradation.
- If open-water pockets in ice are filled with oil, they may be skimmed using rope mop skimmers if the vessels are able to get close enough to deploy them.

Booming

- Conditions at the edge of thin ice sheets may allow successful containment and recovery tactics. The area where booming and skimming activities will occur should have less than 3/10 ice cover to allow effective booming.
- Attempting to boom in higher concentrations than 3/10 may result in damage to boom, connectors, skimming systems, and hoses. Responders must maintain awareness of worsening ice conditions as weather, wind, and water conditions change.

Ice Removal

- Thin ice in a marina, near a shoreline, or near a dock may be removed using heavy equipment, such as clamshell buckets and excavators. Ice that is oiled should be placed in a lined secondary containment area for melting and oil recovery.
- Bubbler systems may also be deployed to remove ice from marinas, docks and collection areas. Bubblers will remove the need to stockpile the oiled ice blocks for further cleaning.

Skimming Systems

- Skimming in thin ice may be possible if areas of open water are created. Thin ice (<2 inches) will be too thin for this to work on; a vessel, work platform, dock, or shoreline must be available to work from.
- Even in thin ice, concentrations of 3/10 to 7/10 will be difficult to skim in. Special attention to potential damage to hoses and skimmer bodies getting caught on ice as they are positioned.

In Situ Burning

- Pools of oil on the surface of a solid sheet of thin ice may be burned if workers can access the area. A Helitorch may also be used, or a handheld igniter may be thrown into the pools from a small boat.
- Burning may also be accomplished in open leads in thin ice if the location can safely be accessed and the conditions are good for burning.
- In situ burning will require Unified Command and/or Regional Response Team approval.

Ice Thickness		Medium Ice 6"-12"	Thick Ice 12"-28"
Ice Concentration		1 to 3/10	1 to 3/10
Detection Platforms	Satellite		
	Vessel Based – incl. IR		
	GPR/Drilling on Ice		
	Canines (ODCs)		
	AUV/ROV Under Ice		
	UAS – incl. IR	Not Affected by Ice	
	Aircraft – incl. IR		
Containment & Recovery	Slots & Trenches		
	Boom & Skim		
	Natural Ice Containment		
	Barriers Under River Ice		
	Berming On Ice Near Shore		
	Bubblers & Skim Near Shore		
	Ice Removal		
	Flushing Ice Surfaces		
	Active Monitoring	Note 1	
ISB	Burning – Fire Boom		
	Burning – among floes - aerial ignition		
	Burning – in/on ice - surface ignition		

Vessel Legend:

With Vessel Support →  ← Without Vessel Support

Very Open Drift Ice Checklist

Containment & Recovery – Containment and recovery tactics in very open drift ice are similar to those used in open water for less than 3/10 coverage. Thin to medium thicknesses of ice in low concentrations will not be safe for personnel to walk on; however, they can use a vessel or a work platform to conduct recovery tactics. The primary concern is the excessive collection of ice as concentrations increase and the resulting failure of containment and recovery systems. **Tactics will be assumed to be executed from a vessel or shoreline only.**

!! **If burning tactics are selected, begin ISB approvals and prep as soon as possible as the window-of-opportunity to burn is limited.**

- ☐ Ensure personnel are briefed on Site Safety and Ice Safety plans.
- ☐ Use results from detection and tracking to determine where to deploy selected containment and recovery tactics.
- ☐ Determine safe route to containment and recovery area.
- ☐ Maintain continuous monitoring for potential changes in ice concentration.
- ☐ Designate decontamination zones on vessel or shore.
- ☐ Deploy and maintain containment. See TR Section 6.2
  - Be prepared to maneuver boom around ice floes.
  - Ensure ice collected in any boom does not overload the boom cables or buoyancy. Release contained ice periodically if needed.
- ☐ Report containment updates.
- ☐ Ensure proper transport and storage capabilities for the recovered spilled product are available.
  - Options include portable tanks, bladders, barges, and deck tanks.
  - As ice concentration and size increase cease using bladders as they may be damaged.
- ☐ Deploy and maintain recovery. See TR Section 6.4
  - Ensure skimmers are able to withstand ice forces.
  - Be prepared to regularly move skimmers often from one oil pocket to another.
- ☐ Report quantity of spilled product recovered.
- ☐ Transport and offload recovered product.
- ☐ If unable to recover due to conditions conduct active monitoring until conditions improve. See TR Section 6.5

Other Notes and Considerations

- ☐ Bubbler systems may be effective in removing light broken ice particularly in marinas and dockside.
- ☐ Excavator buckets may be able to break up and remove broken ice if the machine can safely reach the ice.
- ☐ Strong winds can break up and rapidly move ice floes away from the initial spill source.

Very Open Drift Ice Tactics: Advantages & Considerations

Natural Ice Containment

- Open-water areas between widely spaced ice floes will not sufficiently collect or pool oil to enhance recovery or burning operations.

Booming

- Booming and skimming operations should be possible within the same limitations as booming in open water.
- Personnel must remain vigilant to changing ice conditions and concentration.

Ice Removal

- Vessels may be designated to move drifting ice floes away from recovery areas.
- Bubbler systems may be useful if drift ice masses in natural collection areas. Excavators may also assist in in removing collections of drift ice if safe shoreline access is available.

Skimming Systems

- Skimming in very open drift ice should be possible with the same limitations as skimming in open-water operations.
- Vessel operators should maintain constant vigilance for changing ice conditions, which may become more restrictive to operations, create personnel safety hazards, or possibly damage equipment.

In Situ Burning

- Buring operations in very open drift ice will be conducted within the same parameters as burning in open water.
- Widely spaced drift ice floes should not interfere with in situ burning effectiveness.

Ice Thickness		Medium Ice 6"-12"	Thick Ice 12"-28"
Ice Concentration		4 to 6/10	4 to 6/10
Detection Platforms	Satellite		
	Vessel Based – incl. IR		
	GPR/Drilling on Ice		
	Canines (ODCs)		
	AUV/ROV Under Ice		
	UAS – incl. IR	Not Affected by Ice	
	Aircraft – incl. IR		
Containment & Recovery	Slots & Trenches		
	Boom & Skim		
	Natural Ice Containment		
	Barriers Under River Ice		
	Berming On Ice Near Shore		
	Bubblers & Skim Near Shore		
	Ice Removal		
	Flushing Ice Surfaces		
	Active Monitoring	Note 1	
ISB	Burning – Fire Boom		
	Burning – among floes - aerial ignition		
	Burning – in/on ice - surface ignition		

Vessel Legend:

With Vessel Support →  ← Without Vessel Support

Open Drift Ice Checklist

Containment & Recovery – Containment and recovery tactics open drift ice (4-6/10 coverage) may be possible. Maneuvering vessels safely in 4-6/10 ice concentration could be very challenging. Thin to medium thicknesses of ice in low concentrations will not be safe for personnel to walk on; however, they may be able to use a vessel or a work platform to conduct recovery tactics. The primary concern is the excessive collection of ice as concentrations increase and the resulting failure of containment and recovery systems.

Tactics will be assumed to be executed from a vessel or shoreline only.

!! **If burning tactics are selected, begin ISB approvals and preparation as soon as possible as the window-of-opportunity to burn is limited.**

- ☐ Ensure personnel are briefed on Site Safety and Ice Safety plans.
- ☐ Use results from detection and tracking to determine where to deploy selected containment and recovery tactics.
- ☐ Determine safe route to containment and recovery area.
- ☐ Designate decontamination zones on vessel or shore.
- ☐ Deploy and maintain containment. See TR Section 6.2
  - Ensure ice collected in any boom does not overload the boom cables or buoyancy. Release contained ice periodically if needed.
- ☐ Ensure proper transport and storage capabilities for the recovered spilled product are available.
  - Options include portable tanks, bladders, barges, and deck tanks.
  - As ice concentration and size increase cease using bladders as they may be damaged.
- ☐ Deploy and maintain recovery. See TR Section 6.4
  - Ensure skimmers are able to withstand ice forces.
  - Be prepared to regularly move skimmers often from one oil pocket to another.
  - Vertical rope mops suspended from vessel cranes and purpose-built brush skimmers on articulating arms may effectively recover oil from pockets between the floes.
- ☐ Report quantity of spilled product recovered.
- ☐ Transport and offload recovered product.
- ☐ If unable to recover due to conditions conduct active monitoring until conditions improve. See TR Section 6.5

Other notes and considerations

- ☐ Skimming operations may be conducted with skimming vessels alone, without towed boom.
- ☐ Most skimming operations will be hindered by thick ice in 4-6/10 concentrations.
- ☐ Strong winds can break up and rapidly move ice floes away from the initial spill source.

Open Drift Ice Tactics: Advantages & Considerations

Natural Ice Containment

- Oil trapped in open areas between ice pieces may show slower rates of weathering and degradation.
- If open-water pockets in ice are filled with oil, they may be skimmed using rope mop skimmers if the vessels are able to get close enough to deploy them.

Booming

- Booming and skimming operations may be possible within the same limitations as booming in very open drift ice.
- Personnel must remain vigilant to changing ice conditions and concentration.

Ice Removal

- Vessels may be designated to move drifting ice floes away from recovery areas.
- Bubblers and excavators may also assist in in removing open drift ice if safe shoreline access is available.

Skimming Systems

- Skimming in open drift ice may be possible; however: low oil encounter rate will be dictated by limited towing speeds and swath width. Free skimming vessels with belt skimmers or vertical rope mops suspended from a crane may be effective at skimming in the open areas between floes. Skimmer selection will be determined by the oil type, degree of weathering, and ability to access oil recovery areas.
- Ice may quickly build up on, or block oil flow to the skimmer head of weir, disc, or brush skimmers. Responders should keep skimmer heads free of ice to maintain encounter rate.
- Skimming vessels will need to maneuver between the floes.
- Vessel operators should maintain constant vigilance for changing ice conditions which may become more restrictive to operations, create personnel safety hazards, or possibly damage equipment.

In Situ Burning

- Concentrations of 6/10 or more will provide sufficient natural containment to create and maintain thick enough oil films on water to ignite and burn.
- As ice concentrations exceed 4/10, maneuvering the fire boom between floes becomes very difficult.

Ice Thickness		Medium Ice 6"-12"	Thick Ice 12"-28"
Ice Concentration		7 to 8/10	7 to 8/10
Detection Platforms	Satellite		
	Vessel Based – incl. IR		
	GPR/Drilling on Ice		
	Canines (ODCs)		
	AUV/ROV Under Ice		
	UAS – incl. IR	Not Affected by Ice	
	Aircraft – incl. IR		
Containment & Recovery	Slots & Trenches		
	Boom & Skim		
	Natural Ice Containment		
	Barriers Under River Ice		
	Berming On Ice Near Shore		
	Bubblers & Skim Near Shore		
	Ice Removal		
	Flushing Ice Surfaces		
	Active Monitoring	Note 1	
ISB	Burning – Fire Boom		
	Burning – among floes - aerial ignition		
	Burning – in/on ice - surface ignition		

Vessel Legend:

With Vessel Support →  ← Without Vessel Support

Close Pack/Drift Ice Checklist

Containment & Recovery – Containment, recovery tactics, and maneuvering vessels in close pack drift ice (7-8/10 coverage) may be very challenging. Traditional boom and skimmers could be damaged when deployed in 7-8/10 coverage.

Larger floes may support personnel operations when vessel support is available. Otherwise, tactics will be assumed to be executed from a vessel or shoreline only.

!! **If burning tactics are selected, begin ISB approvals and preparation as soon as possible as the window-of-opportunity to burn is limited.**

- ☐ Ensure personnel are briefed on Site Safety and Ice Safety plans.
  - Ensure personnel have proper PPE to include traction devices, PFDs, and harness with tethered rope (this should be outermost layer).
- ☐ Use results from detection and tracking to determine where to deploy selected containment and recovery tactics.
- ☐ Determine safe route to containment and recovery area.
  - Determine method of transport. See TR Section 4.1
- ☐ Deploy and maintain containment. See TR Section 6.2
- ☐ Report containment updates.
- ☐ Ensure proper transport and storage capabilities for the recovered spilled product are available.
  - Options include portable tanks, barges, and deck tanks.
- ☐ Deploy and maintain recovery. See TR Section 6.4
  - In situ burning is ideal in these ice concentrations.
- ☐ Report quantity of spilled product recovered.
- ☐ If unable to recover due to conditions conduct active monitoring until conditions improve. See TR Section 6.5

Other notes and considerations

- ☐ Aerial ignition of in situ burns among floes can be effective over large areas.
- ☐ If working from ice surface, ensure ice profiling is done in these areas and can support containment resources. See TR Section 2.2
- ☐ Strong winds can break up and rapidly move ice floes away from the initial spill source.

Close Pack/Drift Ice Tactics: Advantages & Considerations

Natural Ice Containment

- Oil trapped in open areas between ice pieces may show slower rates of weathering and degradation.
- If open-water pockets in ice are filled with oil, they may be skimmed using rope mop skimmers if the vessels are able to get close enough to deploy them.

Ice Removal

- Vessels may be designated to move drifting ice floes away from recovery areas.
- Excavator buckets may be able to break up and remove thin ice if the machine can safely reach the ice. They may also assist in in removing collections of open drift ice if safe shoreline access is available.

Skimming Systems

- Skimming in close pack drift ice may be possible; however: expect low oil encounter rate dictated by the limited ability to deploy boom. Free skimming vessels with belt skimmers, vertical rope mops suspended from a crane, and purpose-built brush skimmers on articulating arms may be effective at skimming in the open areas between floes. Brush skimmers are effective in recovering cold and viscous oil if placed in ice-free areas.
- Ice may quickly build up on, or block oil flow to the skimmer head of weir, disc, or brush skimmers. Responders should keep skimmer heads free of ice to maintain encounter rate.
- Skimming may be limited to mostly open-water or ice-free areas.
- Vessel operators should maintain constant vigilance for changing ice conditions which may become more restrictive to operations, create personnel safety hazards, or possibly damage equipment.

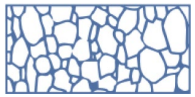
In Situ Burning

- Ice will provide sufficient natural containment to create and maintain thick enough oil films on water to ignite and burn.
- Fire booms should not be used in heavy concentrations of ice.
- Wind direction will tend to herd oil against ice edges and may shift oil concentrations as the winds shift.

Ice Thickness		Medium Ice 6"-12"	Thick Ice 12"-28"
Ice Concentration		9+/10	9+/10
Detection Platforms	Satellite		
	Vessel Based – incl. IR		
	GPR/Drilling on Ice		
	Canines (ODCs)		
	AUV/ROV Under Ice		
	UAS – incl. IR	Not Affected by Ice	
	Aircraft – incl. IR		
Containment & Recovery	Slots & Trenches		
	Boom & Skim		
	Natural Ice Containment		
	Barriers Under River Ice		
	Berming On Ice Near Shore		
	Bubblers & Skim Near Shore		
	Ice Removal		
	Flushing Ice Surfaces		
	Active Monitoring	Go to Section 6.5	
ISB	Burning – Fire Boom		
	Burning – among floes - aerial ignition		
	Burning – in/on ice - surface ignition		

Vessel Legend:

With Vessel Support →  ← Without Vessel Support



Very Close Pack Ice Checklist

Containment & Recovery – Containment and recovery tactics in very close pack ice are similar to fast ice and land-based tactics. Tactics are limited by ice load capacity and ice stability and size.

Tactics may be executed from on ice or shoreline. In areas of moving water (rivers) vessels should be used as work platforms.

‼ **If burning tactics are selected, begin ISB approvals and preparation as soon as possible as the window-of-opportunity to burn is limited.**

Ensure personnel are briefed on Site Safety and Ice Safety plans.

- Ensure personnel have proper PPE to include traction devices, PFDs, and harness with tethered rope (this should be outermost layer).

☐ Use results from detection and tracking to determine where to deploy selected containment and recovery tactics.

☐ Determine safe route to containment and recovery area.

- Determine method of transport. See TR Section 4.1

☐ Deploy and maintain containment. See TR Section 6.2

☐ Report containment update.

☐ Ensure proper transport and storage capabilities for the recovered spilled product are available.

- Options include portable tanks, bladders (on ice surface), pumps and hoses (in series).
- Ensure that ice conditions are constantly monitored if storage is located on ice. Otherwise transport to land/vessel.

☐ Deploy and maintain recovery. See TR Section 6

☐ Report quantity of spilled product recovered.

☐ If unable to recover due to conditions conduct active monitoring until conditions improve. See TR Section 6.5

Other notes and considerations

☐ Continually assess the ice condition as containment and recovery activities continue. These activities can degrade ice, reducing its load bearing capacity. See TR Section 3

☐ If working from ice surface, ensure ice profiling is done in these areas and can support containment resources. See TR Section 2.2

Very Close Pack Ice Tactics: Advantages & Considerations

Natural Ice Containment

- Smaller open-water areas between widely spaced ice floes may collect or pool enough oil to allow burning operations.

Berming and Barriers

- Berming on ice near shorelines is possible if the ice is thick enough.
- Barriers can be placed in river environments from vessels and shoreline if the ice is thick and stable enough.

Ice Removal

- Bubbler or steam systems may be useful if drift ice masses in natural collection areas. They can be less effective in unsheltered open areas.
- Excavators may also assist in in removing collections of drift ice from a vessel or along shorelines if safe access is available.

Slots and Trenches

- Possible on thicker, large floes with vessel support and along shorelines.
- If current is present angle the slots to the current like you would boom.

Skimming Systems

- Skimming systems may be able to operate in slots and trenches if stable work areas are available. Skimmer selection will depend on the type of oil, its degree of weathering, and the access to the oiled areas through slots, trenches, and open leads. Small vertical rope mops may be used from A-frames or portable gantries if access to open leads is limited.
- Responders working on the ice need to remain vigilant to moving and changing ice floes, pile-ups, and the presence of ice rubble.

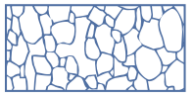
In Situ Burning

- Buring operations in open pockets in the ice can be conducted with Helitorches or handheld ignitors.

Ice Thickness		Medium Ice 6"-12"	Thick Ice 12"-28"
Ice Concentration		10/10	10/10
Detection Platforms	Satellite		
	Vessel Based – incl. IR		
	GPR/Drilling on Ice		
	Canines (ODCs)		
	AUV/ROV Under Ice		
	UAS – incl. IR	Not Affected by Ice	
	Aircraft – incl. IR		
Containment & Recovery	Slots & Trenches		
	Boom & Skim		
	Natural Ice Containment		
	Barriers Under River Ice		
	Berming On Ice Near Shore		
	Bubblers & Skim Near Shore		
	Ice Removal		
	Flushing Ice Surfaces		
	Active Monitoring	Note 1	
ISB	Burning – Fire Boom		
	Burning – among floes - aerial ignition		
	Burning – in/on ice - surface ignition		

Vessel Legend:

With Vessel Support → ← Without Vessel Support



Compact/Fast Ice Checklist

Containment & Recovery - Containment and recovery tactics on fast ice are limited by the load-bearing capacity of the ice and what equipment it can support.

Generally, thin to medium ice (5-12 inches) may support personnel with hand tools and light equipment, while medium to thick ice (12-28 inches) may be able to support some heavier equipment (tracked vehicles, skid steers).

!! **If burning tactics are selected, begin ISB approvals and preparation as soon as possible as the window-of-opportunity to burn is limited.**

- ☐ Conduct thorough ice profiling to ensure all areas have consistent, fast ice. Ensure personnel are briefed on Site Safety and Ice Safety plans.
  - Ensure personnel have proper PPE to include traction devices, PFDs, and harness with tethered rope (this should be outermost layer).
- ☐ Use results from detection and tracking to determine where to deploy selected containment and recovery tactics.
- ☐ Determine safe route to containment and recovery area.
  - Determine method of transport. See TR Section 4.1
- ☐ Deploy and maintain containment. See TR Section 6.2
- ☐ Report containment updates.
- ☐ Ensure proper transport and storage capabilities for the recovered spilled product are available.
- ☐ Deploy and maintain recovery. See TR Section 6
- ☐ Report quantity of spilled product recovered.
- ☐ If unable to recover due to conditions conduct active monitoring until conditions improve. See TR Section 6.5

Other notes and considerations

- ☐ Continually assess the ice condition as containment and recovery activities continue. These activities can degrade ice, reducing its load bearing capacity. See TR Section 3
- ☐ If working from ice surface, ensure ice profiling is done in these areas and can support containment resources. See TR Section 2.2

Compact/Fast Ice Tactics: Advantages & Considerations

Natural Ice Containment

- Oil collecting on and under the ice can be located with ROVs, underwater lights and cameras, and profiling holes. Marker paint on the surface of the ice can be used to mark the under-ice regions.
- Personnel must remain vigilant to changing ice conditions and concentration.

Berming and Barriers

- Berming on ice near shorelines is possible if the ice is thick enough.
- Barriers can be placed in river environments from vessels and shoreline if the ice is thick and stable enough.

Ice Removal

- Steam systems, de-icers, and bubblers can be used to keep pits and sumps ice free.
- Excavators may also assist in in removing collections of drift ice if safe shoreline access is available.

Slots and Trenches

- Possible on thicker ice and along shorelines.
- If current is present angle the slots to the current like you would boom.

Skimming Systems

- Skimming systems may be placed in slots and trenches cut into the ice. Skimmer selection will depend on the type of oil, its degree of weathering, and the access to the oiled areas through slots and trenches.
- Extended running in ice may require deicing skimming components or rotating units out to thaw. Steam systems can keep rope mops, brushes, and skimmer bodies ice-free and able to recover oil continually.

In Situ Burning

- Successful burning of oil mixed with snow on top of the ice may require mechanical intervention to concentrate the oiled snow before igniting.
- Oil under ice can be burned if ice cover is opened by cutting or drilling.

Ice Assessment Form

General Information

Date: _____

Time of Entry: _____

Location (General Area): _____

Weather Conditions: _____

Ice Observer/Team Lead: _____

Crew Members Present: _____

Nearest Safe Egress Point
(GPS or Land Feature): _____

Emergency Plan Reviewed with Team? (Y/N): _____

Environmental Conditions

Air Temperature (°F/°C): _____

Wind Speed & Direction: _____

Tide/Water Level Changes Observed: _____

Ice Movement Observed? (Y/N): _____

Estimated Time on Ice: _____

Site Drawing	
Water Source Name and #	

Non-Grounded Ice Evaluation Form

Work Description	Other Important Information

Competent person *(Name)*	Date	Ice Conditions *(Cracked, rotten, etc.)*	Borehold #	Temp *(°F)*	Freeboard *(in)*	Ice Thickness *(in)*	Water/unfrozen bottom material depth *(ft)*	Approved equipment type	Equip weight *(lbs)*	Distance to keep between equipment

This form must be completed daily by a competent person before no-grounded ice entry and use.
Keep a copy of this form on location.

Notes:

Photo: CIMSS and NOAA, January 25, 2022.