DRAFT FOR DISCUSSION
ARCTIC AND WESTERN ALASKA
OFFSHORE RESPONSE CONCEPT OF OPERATIONS (CONOPS)

Introduction

This document was prepared as a read-ahead in support of the Arctic and Western Alaska Offshore Response **Concept of Operations (CONOPS)** Stakeholder Meetings scheduled for May 3, 4, and 5, 2023. Based on a review of various agency and industry lessons-learned documents and other reports following the Deepwater Horizon oil spill in 2010, this CONOPS strawman describes a general framework for rapidly organizing and responding to a Worst-Cast Discharge (WCD) incident in an offshore setting in both the Beaufort Sea and Cook Inlet. The goal of the CONOPS Stakeholder Meetings is to facilitate discussions between stakeholders to evolve this strawman into a realistic CONOPS for planning blowout scenarios in Cook Inlet and the Beaufort Sea. This document provides a realistic view of the unique oil spill response challenges and conditions that are characteristic of the Beaufort Sea, Cook Inlet, and Alaska in general. This preamble is included to identify and assess oil spill preparedness and response in Alaska as distinct from the lower 48, which Alaska only nominally resembles for a few months.

The CONOPS provides an offshore-based construct for employing multiple countermeasures in ways that will most effectively reduce oil contact with the environment. The overall goal of any oil spill response is to control the source as quickly as possible, minimize the potential damage caused by the accidental release, and employ the most effective response tools for a given incident and situation.

Underlying the CONOPS is the accepted practice of identifying the optimal mix of response strategies to maximize their effectiveness while minimizing ecological, socio-economic, and cultural impacts. This process is most recently described as a Spill Impact Mitigation Assessment (SIMA), the global industry approach to Net Environmental Benefit Analysis (NEBA) that incorporates socio-economic considerations. Ideally, the tool is used in the planning phase to pre-identify, or obtain pre-approval of, the best response options for representative planning scenarios. During a spill response, the Unified Command can conduct an expedited or qualitative SIMA to rapidly select the response option(s) that will yield the greatest overall environmental benefit. The intent of the SIMA methodology is to quickly obtain agreement among the various parties as to which response options will be most effective and result in the least overall impacts on the environment.

The SIMA process can be summarized in four stages:

1. Compile and evaluate data for relevant oil spill scenarios including fate and trajectory modelling, identification of resources at risk, and determination of feasible response options.
2. Predict outcomes/impacts for the 'no intervention' (or 'natural attenuation') option as well as the effectiveness (i.e., relative mitigation potential) of the feasible response options for each scenario.
3. Balance trade-offs by weighing and comparing the range of benefits and drawbacks associated with each feasible response option, including no intervention, for each scenario.
4. Select the best response option(s) to form the strategy for each scenario, based on the combination of techniques that will minimize the overall ecological, socio-economic, and cultural impacts and promote rapid recovery.

Decision making for implementing the CONOPS will still require an additional overlying comparative analysis that evaluates the environmental, cultural, social and economic tradeoffs in order to find the preferred balance of spill countermeasures for a given planning scenario or incident. Regardless, the use of the CONOPS as outlined in this document offers technical knowledge and experience-driven improvements for response planning involving blowout spills in the Alaskan environment.

CONOPS Purpose & Objectives

This CONOPS explains, in broad terms, the process and strategy involved in preparing for, responding to, and mitigating the impacts from a large offshore oil spill. To effectively manage a Worst-Case Discharge (WCD)-like incident, the CONOPS should clearly demonstrate a geographically and functionally layered, dynamic approach for deploying mitigation capabilities and strategies. A CONOPS also needs to be organized in a temporal sequence that reflects response priorities, the availability and deployment timelines of resources, and the evolving conditions on scene. To that end, this CONOPS is built around the creation of divisions and zones that can be customized and sequenced, as appropriate to most effectively address:

- The availability and phased arrival of response resources on scene
- Site-specific circumstances of the oil discharge and facility location
- The changing properties (weathering), distribution, concentration, and location of the discharged oil slick both spatially and temporally, and the subsequent impacts on mitigation strategies and response equipment to be used.

CONOPS Structure

This document excludes some elements which are integral to a spill response but are considered to be out of scope for this CONOPS. These elements include:

- Initial Notifications
- Search and Rescue
- Marine Firefighting

- Incident Investigation
- Site Safety Requirements
- Shoreline assessment (SCAT) and Treatment Strategies for Oil on Shore
- Authorization of Use Procedures for Alternate Response Technologies
- Wildlife Recovery Operations
- Decontamination, Waste Management, & Disposal

Deployment of Strategies & Capabilities

As soon as an incident occurs, the Responsible Party (RP) will initiate a response based on the deployment of capabilities outlined in the facility's Oil Spill Response Plan (OSRP) or Oil Discharge Prevention and Contingency Plan (ODPCP) and implement oil mitigation strategies generally consistent with the Arctic and Western Alaska Area Contingency Plan (ACP) and this CONOPS.

This CONOPS is organized in the following sections as described below:

- Temporal Phases of a Response
- Geographically-based Organizational Construct

The Geographically-based Organizational Construct is broken down into two separate sections for Cook Inlet and the Beaufort Sea due to the significant differences between these two regions (refer to Alaska Oil Spill Response Operational Factors for a summary of these differences). For oil spill response operations in Alaska, the Temporal and Geographical Construct of the CONOPS can be considered a "best-case" scenario as this structure may not be viable given the existing environmental, logistical, and technological challenges in the region.

Temporal Phases of a Response

A well blowout in any location is a continuous discharge of oil into the environment each day until the source is secured. A blowout response, therefore, must plan for strategies that deal with varying degrees of fresh and weathered oil over time, but for a specific location. As the incident evolves, critical events affect the offshore response and the geographic organization of the CONOPS. These inflection points can be used to identify the potential phases of the CONOPS over a 30-day planning period for a WCD discharge. The phases and corresponding inflection points are presented in Table 1. Implementation of these phases may vary greatly with time of year and location.

Table 1. Response phases with corresponding Inflection Points.

Response Phase	Inflection Point
Assessment	Arrival of surveillance and monitoring capabilities
Initial Response	Arrival of first mitigation resources (dispersant aircraft, oil spill recovery vessels (OSRVs))
Primary Removal Operations	Arrival of high-volume mechanical recovery (and ISB) assets
Expanded Source Control Operations	Arrival of assets for implementing temporary source control solutions

Post Discharge Removal Operations	Successful installation of temporary source control measures

Assessment – During the first phase immediately after initial notification, both the slick and the source are initially evaluated. Determinations are made about the potential severity and impacts, and resources needed for the response begin to mobilize. Assessment activities may include the actions of facility personnel, as well as the deployment of aerial and subsea observation and monitoring capabilities.

Initial Response – The initial response phase begins when the first response resources arrive at the scene. Generally, initial response resources on scene are likely to be OSRVs operating in the thickest oil near the source. If appropriate and authorized, dispersant aircraft may also be deployed in this phase.

Primary Removal Operations – This phase can be categorized by the arrival of larger, high-volume oil recovery response equipment operating in the freshest, thickest oil coming from the discharge area. This phase could also include the continued use of aerial dispersant operations and the start of ISB operations in thicker oil areas further away from the source.

Expanded Source Control Operations – The arrival of source control assets will trigger some significant changes in the response. Deploying source control assets for debris removal, deployment of the capping stack and, if necessary, flowback equipment will significantly expand the footprint of the Source Control Exclusion Division (SCED) and potentially reduce access to fresh oil for the primary removal assets.

Post Discharge Removal Operations – This phase begins once the source is secured through the implementation of temporary source control measures, such as a capping stack, and fresh oil is no longer being discharged. The response will shift focus to actions in areas further away from the source involving the recovery of oil that has weathered and spread into distributed, discontinuous patches of oil. High volume primary removal assets may be reassigned to these more distant divisions or demobilized.

Time parameters are not applied to the above phases due to the variations in source location, travel times, availability of resources, and other uncertainties.

The next section outlines the response operations that may be conducted in the various geographically-based divisions and zones of the CONOPS construct as the spill progresses through the various phases from assessment to post discharge removal operations.

Geographically-based Organizational Construct

Generally, spill response operations should follow a geographically-based operational pattern, starting at the spill source and expanding outward, as described below.

Source Control Exclusion Division (SCED)

The Source Control Exclusion Division (SCED) will be established around the location of the well blowout (or other discharge source type) for the duration of the event. As the response evolves it may be expanded to a larger size to accommodate source control vessels, equipment and actions that will occur on the damaged facility. Additionally, operators are required to pre-identify potential relief well locations and during the incident relief well locations will be chosen based on safety considerations with the intent to also minimize impacts to the on-water spill response. Relief well operations will have their own exclusion zones that can further expand the size of the SCED. The response should expand or contract the SCED to ensure that appropriate space is provided to source control assets. Any expansion of the SCED will likely reduce the recovery assets access to the freshest oil.

Assessment Phase

During the assessment phase, if there are personnel available on the facility, they will communicate known or probable causes of the discharge to the IMT. If facility personnel are not available, there may be ROV vessels (depending on the location) or other vessels at the source able to provide information to the IMT.

Initial Response Phase

As the incident shifts to the initial response phase, the priority will be to assess the status of any source control measures and take additional response actions, such as attempting to activate the Blowout Preventers (BOPs), remove debris, and shut in any other wells. Source control personnel will begin planning to reboard the facility if it was evacuated and available, as appropriate for the scenario.

Primary Removal Operations Phase

During the Primary Removal Operations Phase, additional resources, such as debris removal tools and shallow draft marine support will continue to arrive at the SCED, requiring further expansion of the exclusion zone. Simultaneous Operations (SIMOPS) will need to be activated with Mechanical Recovery as primary. Dispersants and In-Situ Burning will be considered on a case-by-case basis depending on the scenario and location.

Expanded Source Control Operations Phase

Major source control response assets will begin to arrive on scene. These assets may include:

- Debris Removal Tools
- Direct Intervention Vessels
- Flowback Vessels
- Recovered Oil Storage Vessels (as applicable)

At this phase in the response, the SCED will need to expand significantly, and SIMOPS will become significantly more complex. The length of time to arrive at this period of the response will depend significantly on the location of the spill and the season.

Post Discharge Removal Operations Phase

At this phase of the incident response, the source has been completely secured, and there is no additional discharge of oil. Many of the source control assets can begin to demobilize, and the SCED can be reduced in size.

Fresh Oil Removal Division (FORD)

Operations in this division will be focused on removing high volumes of fresh oil near the source and will expand and contract based on the situation, e.g., weather, the availability of resources and their efficiency in recovering or successfully treating the oil, and changes in the oil as it spreads, weathers, and is transported away from the discharge site. This zone may be divided into separate operational areas for skimming, in-situ burning, and aerial dispersant application operations, depending on the location of the incident. ISB and dispersant zones would include stand-off buffer areas to ensure proper separation from other activities and responder safety. Vessel dispersant operations will not be considered in this division due to their slow, lower oil-encounter rates in the offshore environment compared to aerial application, in addition to the shallow depths in these regions.

Assessment Phase

At the start of the response, surveillance aircraft and small OSRVs will be the first spill response assets arriving on scene. In certain scenarios, response equipment may have limited access during the initial phases of the incident due to activities such as search and rescue or firefighting. The OSRVs are likely to also be the initial assessment vessel on scene and will initiate air sampling to determine if the skimming operations in the vicinity of the discharge site can be performed safely.

Initial Response Phase

Once initial assessments are conducted, the OSRV(s) will begin recovering spilled oil near the source. During this phase, additional skimming resources will continue to mobilize and deploy to the site. The first mechanical recovery vessels arriving on scene are likely to have minimal onboard storage and will rapidly fill their storage tanks, so it is important that secondary temporary storage assets arrive on scene as quickly as possible. The capacity provided with the existing response tactic of using mini-barges to move recovered oil and water to shore may prove inadequate to deal with the volumes involved in a large-scale mechanical recovery operation. Where authorized and if appropriate, dispersant may be applied to the most concentrated oil slick areas during this phase.

Primary Removal Operations Phase

Further into the response and where appropriate and authorized, the FORD may be divided into operating zones for in-situ burning, aerial dispersant application, and mechanical recovery, with a safety corridor separating each area. At deep water locations, VOSSs and OSRBs provide significant operational value in the FORD due to their significant onboard storage.

During this phase of the response, dispersant aircraft could be operating. In-situ burning (ISB) assets will also begin arriving on-scene during this phase. ISB teams will need to begin collecting oil and conducting test burns. ISB should be assigned a zone that is down wind of the other response zones to ensure the smoke does not impact other operations and away from other facilities or shoreside assets to avoid impact to other operators and the public. Due to the potential for ISB and dispersant operations to impact the operations being conducted in the SCED, the skimming operations will normally be assigned to the area nearest to the SCED.

Each operating zone will require dedicated aerial support for the purposes of oil tracking and positioning equipment for oil removal operations. Given the need for persistent, localized, and wide-area oil tracking and surveillance, the possible operation of multiple dispersant spray and spotter aircraft, and frequent logistical flights, the response will need to be prepared to set up management structures to deconflict the significant air traffic throughout the offshore response. Aerial operations may be severely constrained by weather, and the Unified Command will require access to a suite of high-resolution radar satellites as well as satellite drifter buoys in ice-free zones to validate any trajectory modeling.

Expanded Source Control Operations Phase

As source control resources arrive on scene, the SCED will expand and may require assets in the FORD to relocate, potentially reducing their access to the most concentrated areas of oil. Zone assignments should be frequently reassessed to ensure that all resources are properly positioned over the slick footprint, have appropriate room to operate, and are deconflicted with each other and the SCED.

Post-discharge Operations Phase

Once the source is secured through the implementation of temporary source control measures, such as a capping stack, the response will shift focus to actions in areas further away from the source involving the recovery of oil that has weathered and spread into distributed, discontinuous patches of oil. High volume primary removal assets may be reassigned from the FORD to more distant zones in the WORD or demobilized.

Weathered Oil Removal Division (WORD)

As the oil spreads on the surface and is transported away from the source, it will become thinner and more discontinuous in nature, breaking up from large slick areas into smaller patches and windrows of increasingly weathered oil. These various patches of oil will become increasingly distributed across a large area and may be many miles apart. In Alaska, the size of the WORD will likely be smaller than the FORD in surface area due to the slower weathering of oil. The WORD will require a larger number of mechanical recovery resources, including towed containment booms, secondary storage, aerial observers for skimmer direction, and other support resources to meet the challenge. Skimming systems which are more maneuverable are better suited for recovering these streamers and windrows at the direction of aerial observers. It will likely be difficult to amass the number of mechanical recovery resources needed to manage the required operations in the WORD due to the Alaska Oil Spill Response Operational Factors mentioned at the end of this document.

Depending on the viscosity and other properties of the weathered oil, there may be an opportunity for ISB and dispersant operations to continue in the WORD. Given the limited onsite marine resources and lack of infrastructure, ISB or dispersant operations may be more effective than mechanical recovery in this phase. If so, separate operating zones would be established with safety separation corridors between them. In addition, natural recovery may be considered depending on the severity of the environmental conditions at the time of the incident.

As oil reaches the coastal areas, a Nearshore Mechanical Recovery Zone will need to be established. Since water depths of 20’ or less extend out several miles in both the Beaufort Sea and Cook Inlet, the vessels operating in the Nearshore Mechanical Recovery Zone must have drafts that allow them to maneuver and operate in shallow water. The skimming operations, however, will be similar to those conducted in the rest of the Division only with generally smaller skimmers and support vessels. Therefore, the vessels operating in this zone will also be more affected by sea and wind conditions. They must remain close to areas of safe haven and seek shelter should weather conditions deteriorate.

Primary Removal Through Post Discharge Phases of Operations

By the time the oil slick has moved beyond the recovery assets operating in the FORD, it will have broken up into more widely distributed patches, streamers, and windrows due to influence of the wind and currents. The oil will also have weathered and become more viscous in this division. Due to these natural processes, the oil will become increasingly difficult to locate and track. While there may be some slicks of oil that will continue to be burnable or dispersible, mechanical skimmers adapted to more viscous oils will likely be the primary removal countermeasure. Due to the spreading of the oil, it will be even more critical than in the FORD for these skimming assets to have enhanced encounter rates. Enhanced encounter rates can be achieved through skimming systems that can operate at increased speeds of advance, such as a current buster or rigid sweep arms, or through enhanced skimming tactics for oil collection that increase the effective swath width, such as vessels towing a U-shaped boom configuration with an open apex as shown in Figure 1. In Alaska, the WORD operations will be significantly impacted by the Alaska Operational Factors noted at the end of this document.

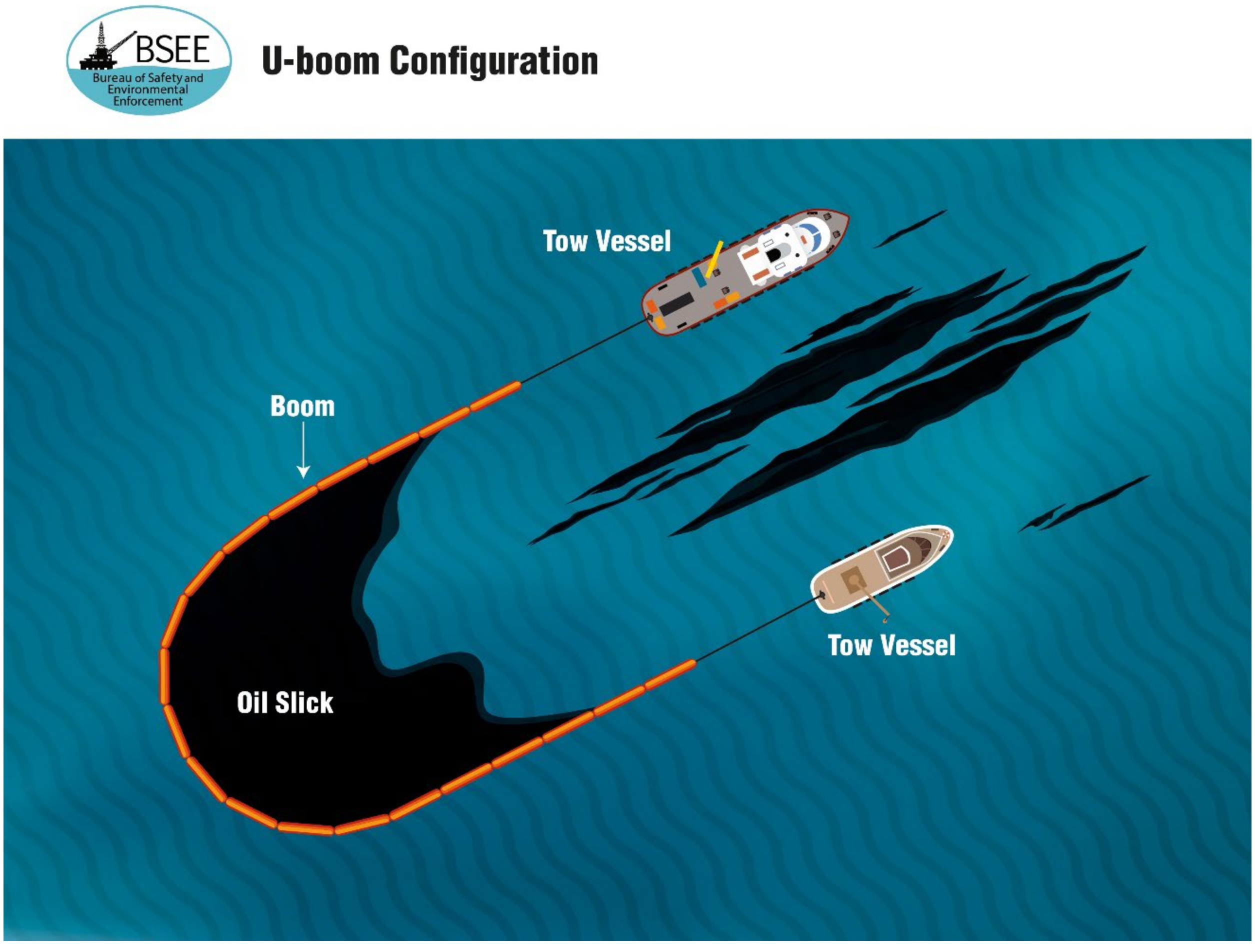

Figure 1. U-boom Configuration.

In addition to the large numbers of skimming resources required, there are other logistics issues associated with this strategic and tactical approach. Most OSRVs and Vessels of Opportunity (VOOs) will not have advanced X-Band Radar, Forward Looking Infrared (FLIR), or dedicated drones. Although spotting using aerial observation, remote sensing, and/or opportunistic vessel-based surveillance systems is critical to support these skimming and ISB groups, these capabilities may not be effective due to Alaska weather constraints. Refer to the **Alaska Oil Spill Response Operational Factors** for a brief summary of weather constraints on surveillance and monitoring including issues of interpreting satellite images to detect spills with and without ice.

Mechanical recovery assets operating in the Nearshore Mechanical Recovery Zone may encounter heavily weathered/emulsified oil and tarballs and may need to adapt their recovery techniques to include dip nets or other physical means of “grabbing” the oil for removal.

Shoreline Protection and Recovery Division (SPRD)

This document is intended to focus on offshore and nearshore operations and does not discuss shoreline protection or shoreline oil removal operations. These operations are critical to any coastal spill that experiences landfall where oil enters into bays and sounds or strands on shorelines. Information about operations that will occur in the Shoreline Protection and Recovery Division (SPCD) are well developed and can be found in the ACP, especially in the Geographical Response Strategies and Plans (GRS and GRPs).

CONOPS – Comparison Between Regions

This CONOPS is divided into two sections to address offshore responses in Cook Inlet and in Beaufort Sea. While the CONOPS for the Beaufort Sea (essentially nearshore rather than offshore) and Cook Inlet are similar in the temporal phases of response, there are significant geographical and environmental differences affecting all aspects of spill response planning, operational strategies, and decision making. A number of the key differences between these two regions are summarized below.

Comparing Cook Inlet and the Beaufort Sea

While CONOPS for the Beaufort Sea and Cook Inlet are conceptionally similar, this brief summary looks at some of the key differences between these two regions.

The North Slope at 70°N is a true Arctic environment while Lower Cook Inlet is 360 miles south of the Arctic Circle. Cook Inlet is characterized by large tidal fluctuations and strong currents reversing every 12 hours. In contrast, the North Slope experiences very small tides (inches vs. tens of feet) and relatively low currents, concentrated at the entrances separating the coastal lagoons from the open sea.

The marine environment is dramatically different between the two regions. The North Slope nearshore area out as far as 25 m water depth is covered in stable landfast ice for 8-9 months of the year. Sea ice is not a significant operational factor in Lower Cook Inlet. Winter temperatures are relatively mild in Lower Cook Inlet with an average low in January of only 18°F (e.g., Kenai) vs. -24°F in Prudhoe Bay. The lack of significant daylight for much of the winter on the North Slope severely constrains all aspects of oil spill response with the opposite true in summer. In contrast, Cook Inlet still has ~6 hours of daylight in December and January.

The configuration of Lower Cook Inlet forms an effective funnel where oil spills can move large distances very rapidly and readily strand and penetrate a complex mix of rocky pebble/cobble/sediment and highly permeable boulder shorelines to the east or west. Longshore oil transport is a major issue with the strong tidal currents. In contrast, the North Slope is a flat coastal plain dominated by sediments of relatively low permeability and backed by eroding, ice rich, low tundra cliffs. The nearshore Beaufort environment features a string of shifting barrier islands and protected inshore lagoons. Oil spills in this area are generally more predictable in terms of movement, fate, and effects.

In terms of infrastructure and proximity to major airports, ports and support vessels Cook Inlet clearly offers operational advantages over the North Slope, which is cut-off from marine access by sea ice for much of the year. Responding to a spill in Lower Cook Inlet will still have to deal with extensive and varied types of human use and year-round biological activity. On the North Slope any response decisions will have to consider threats to subsistence harvesting from spring to fall.

Clearly, any analysis of response viability and effectiveness for these two regions will produce very different results. They are both part of Alaska, but in many ways, they represent different worlds from an oil spill response point of view.

The next sections describe the CONOPS for the Beaufort Sea, both in an Open Water Scenario and in an Ice Scenario, and for Cook Inlet.

CONOPS – Beaufort Sea – Open Water Scenario

Figure 2 depicts the CONOPS divisions for the Beaufort Sea. Due to the prevailing currents in the region, the oil trajectory will likely be oriented to the west of the spill site. Therefore, the entire geographical laydown will be oriented to the west. The FORD will be larger than the WORD due to the relatively slow weathering of the oil in this area. Because of the close proximity to shore of all the potential sites in the Beaufort, the SPRD will extend the entire length of the oil trajectory.

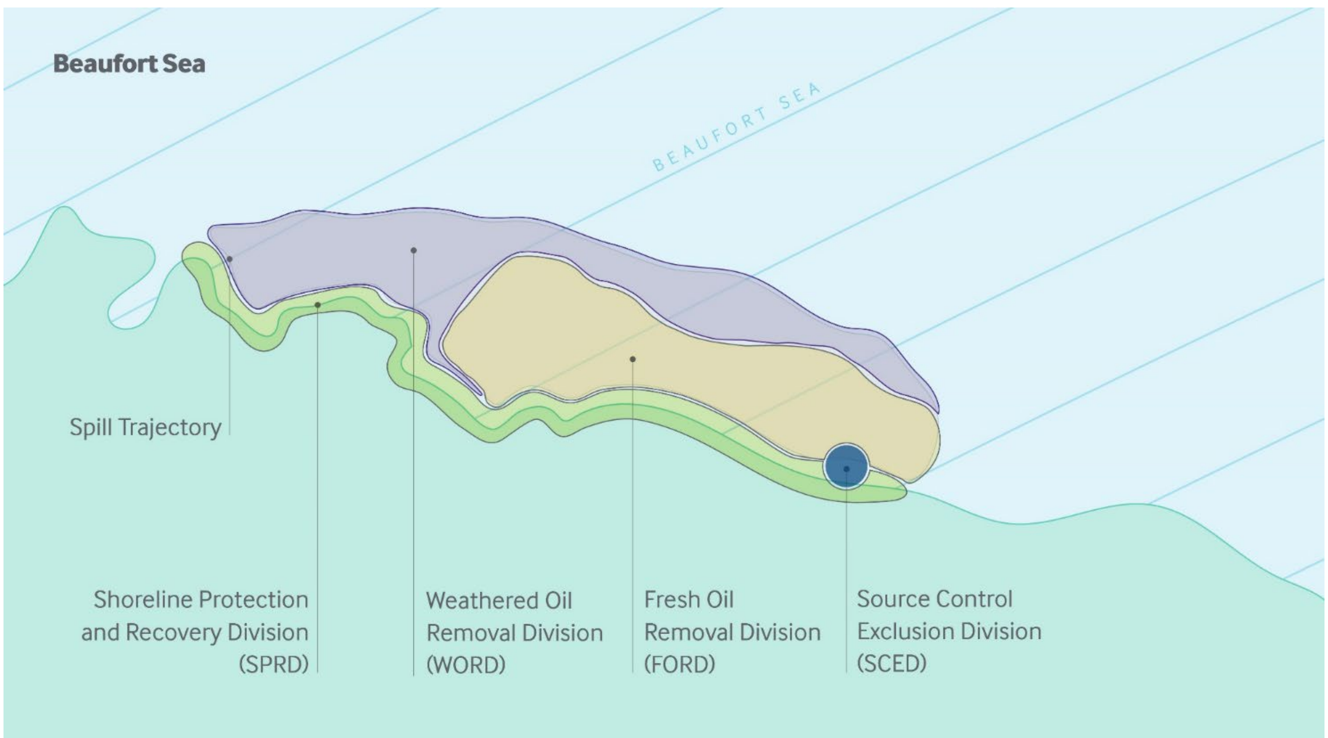

Figure 2. Possible Geographic Construct for Beaufort Sea.

Source Control Exclusion Division (SCED)

A possible configuration for the SCED is presented in Figure 3 for the Beaufort Sea. For the Beaufort Sea, the capping stack would be installed on the gravel island.

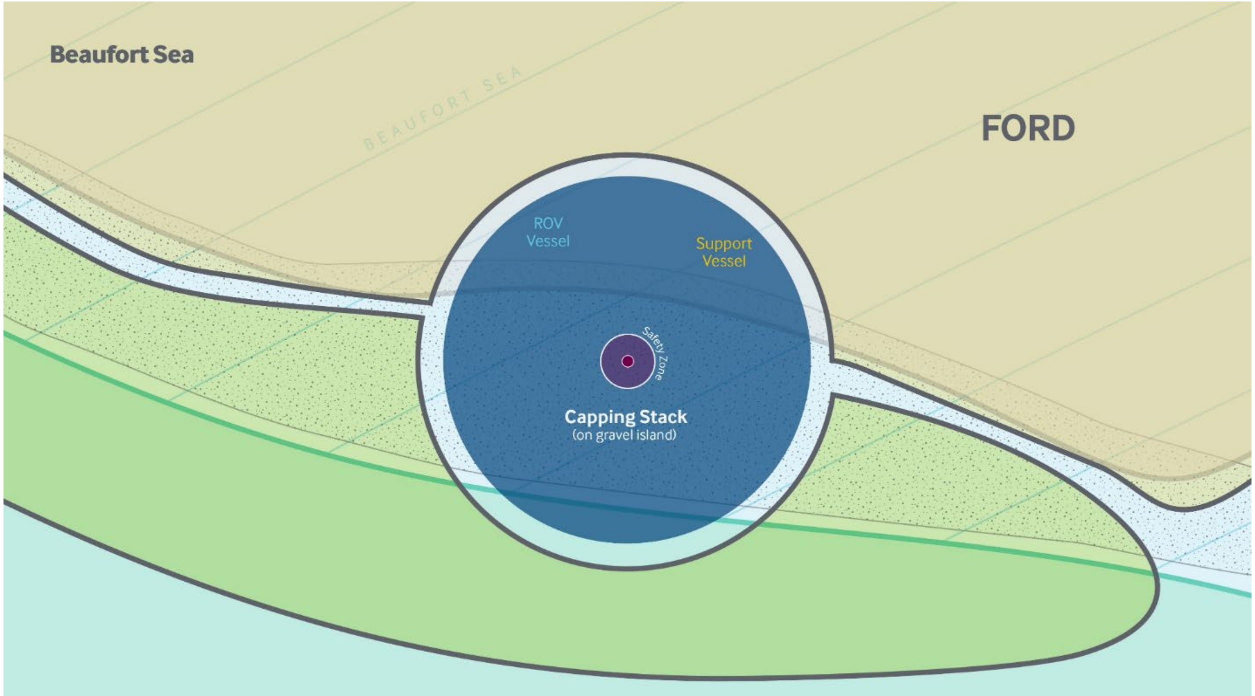

Figure 3. Possible SCED Configuration for the Beaufort Sea.

Assessment Phase

In the case of Beaufort Sea WCDs, all of the discharges from producing wells will be above surface resulting in either oil on water in summer, among ice at break-up, or on ice during winter. At the start of the response, surveillance aircraft and small oil spill response vessels (OSRVs) based at Prudhoe Bay will be the first spill response assets arriving on scene.

Initial Response Phase

In the Initial Response Phase, the priority will be to assess the status of any source control measures on the island and take additional response actions, such as attempting to activate the BOP(s), remove debris, and shut in any other wells on the production island.

Primary Removal Operations Phase

In the Beaufort Sea WCD scenarios, depth limitations will limit the operational utility of many conventional recovery vessels.

Expanded Source Control Operations Phase

Given the long distances from southern ports, it may take weeks to locate and reposition suitable vessels to the North Slope. Mobilization of non-ice strengthened vessels can only happen during the relatively short summer open water season. Water depth is a major consideration. Many vessels could have difficulty approaching the spill location or coming to shore to unload or resupply at West Dock or Oliktok.

Post Discharge Removal Operations Phase

Fresh Oil Removal Division (FORD)

A possible breakdown of the zones within the FORD is presented in Figure 4 for the Beaufort Sea. As noted above, it is expected that the FORD will extend to the west from the source due to the prevailing environmental forcing in the region. The FORD will also be relatively larger than the WORD in Alaska due to the slower weathering times in this northern area.

Figure 4. Possible configuration for the FORD in the Beaufort Sea.

Assessment Phase

Initial Response Phase

In Beaufort Sea, the temporary storage must rely on mini barges lightered on shore using vacuum trucks. This oil will then be transported for processing at onshore facilities. At present, there is insufficient on-site marine storage to deal with a 30-day WCD. Mobilizing assets from the Lower 48 could take 3 weeks or more.

Primary Removal Operations Phase

In the Beaufort Sea, large VOSS may not be feasible due to restricted water depths and lack of an unloading dock where normal displacement vessels can transfer oily waste. In addition, there are very few VOSS in the North Slope region. Shallow-draft OSRBs would be a more viable option in this area and can be staged in Prudhoe Bay.

Expanded Source Control Operations Phase

Post-discharge Operations Phase

Weathered Oil Removal Division (WORD)

A possible breakdown of the zones within the WORD is presented in Figure 5 for the Beaufort Sea. The WORD will extend to the west similar to the FORD due to the prevailing environmental forcing in the region.

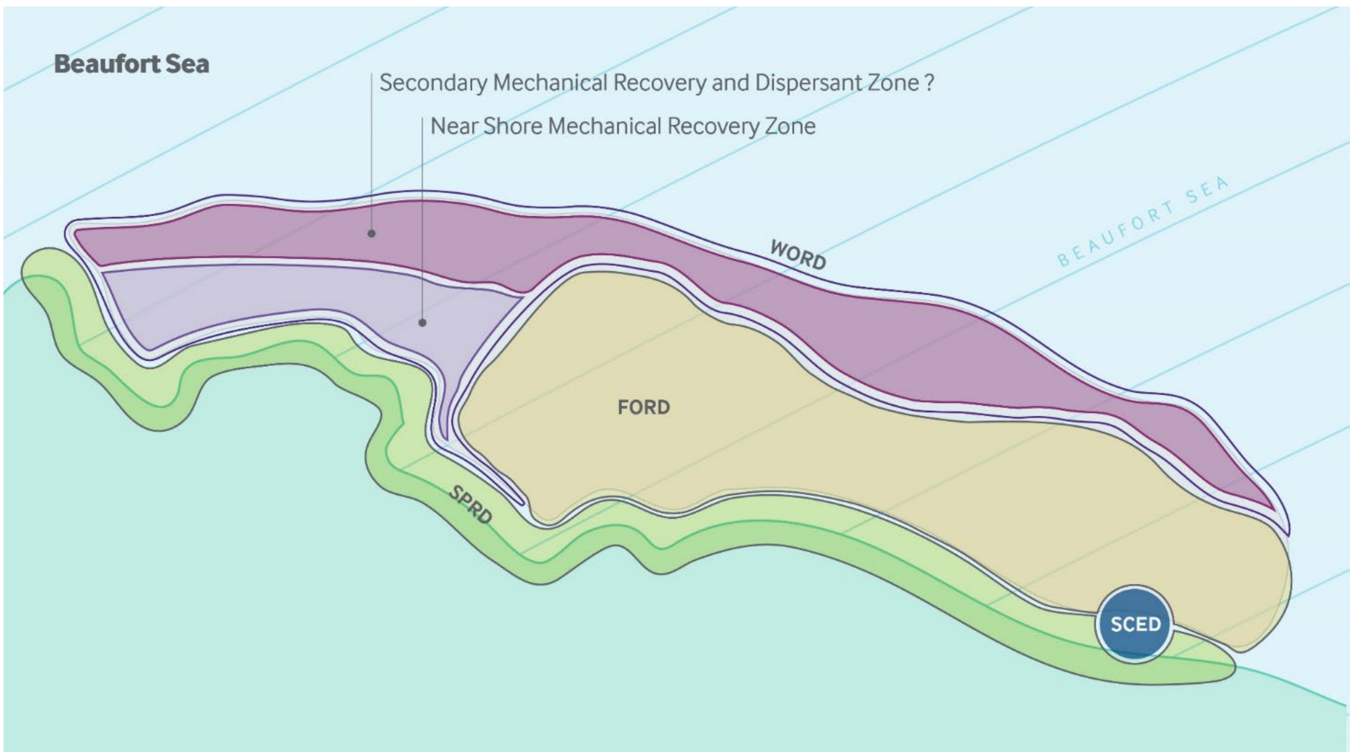

Figure 5. Possible configuration for the WORD in the Beaufort Sea.

Primary Removal Through Post Discharge Phases of Operations

Shoreline Protection and Recovery Division (SPRD)

CONOPS – Beaufort Sea – Ice Scenario

While the principles of response planning and spill management are universal, regardless of season, the processes of selecting and implementing different response strategies greatly depend on whether ice is present or not and its physical state at the time.

Examples of physical factors to consider are:

- Stability – Is the ice attached to shore (referred to as "fast)" and static, or drifting with wind and current?
- Ice concentration – What is the % area ice coverage? The ice coverage greatly affects the viability of conventional marine response as well as the use of burning and dispersants.
- Water depth – Is the sea ice free-floating or bottom-fast (resting on the seabed) as is typical in water depths less than 1.5-1.8 m (5-6 ft)?
- Thickness – Is the ice thick enough to safely support response crews and equipment?
- Ice roads – Is it possible to construct and maintain an ice road from shore to the spill site?
- Surface conditions – Is the oil adsorbed into dry snow on the surface or contained in melt pools on a melting ice sheet?

The process of oil weathering differs markedly for oil spilled among or on ice versus oil on water. The presence of ice implies low air and water temperatures and a relative lack of wave action, all factors that combine to significantly reduce rates of evaporation, natural dispersion, and, most importantly for many response actions, emulsification. Thicker oil slicks found under freezing conditions will undergo evaporation at a comparatively slower rate than with open water. Snow adsorbing into oil deposited on the surface will further slow the evaporation process. Norwegian studies comparing the evaporative loss under different levels of ice coverage showed that a light crude could lose as much as 30% in open water, 25% with 30% ice coverage, and 19% with 90% ice coverage – differences primarily attributed to greater oil slick thickness with greater natural containment in heavier ice. The relative lack of wave action with increasing presence of drift and pack ice greatly slows the formation of water-in-oil emulsions (mousse). In general, the slower weathering of oil in cold water and ice and snow environments increases the available windows of opportunity when oil can be recovered by skimmer systems, burned, or dispersed.

This section considers a generic winter scenario involving a WCD surface blowout from a gravel island production facility off the North Slope in water depths of ~5 to 15 m (15 to 45 ft). The purpose is to describe how oil spill response strategies would likely differ during freeze-up, winter and break-up, compared with the established suite of countermeasures used during open water. Rather than assuming that the blowout occurred at the onset of freeze-up and ceased after 30 days, the discussion is based on the fact that the spill could occur at any time between the start of freeze-up and end of break-up. In other words, there is always a supply of fresh oil as the various response options are reviewed as to their applicability throughout the ice season. This section does not deal with the issue of oil under ice because none of the WCDs developed as background to this CONOPS involve a large subsea release that would lead to oil being trapped under the ice.

Freeze-up

The transition from the first appearance of new ice nearshore to almost complete ice cover (80% or more by area) occurs rapidly within a relatively small range of variability from year to year (±8 to10 days). Grease (flexible layer of unconsolidated ice crystals), nilas, and new ice (up to 10 cm or 4 in thick) appear along the coast and lagoon areas near Prudhoe Bay typically in the first week of October. This thin ice nearshore becomes stable within a week. In deeper water seaward of the Barrier Islands, the first continuous sheet of new ice forms on average by mid-October. In the absence of significant snow cover, this ice grows very rapidly early in the season, reaching 30 cm (12 inches) by the end of October. At this stage, the thin fast ice (attached to shore) becomes relatively stable with a low probability of significant movement out to 10 m (30 ft) water depth, for example, in the vicinity of Northstar Island.

Oil spilled during freeze-up will initially be mixed with the newly forming ice in early October. This ice is still mobile and subject to widespread fracturing and rafting with the thin sheets riding over each other in response to wind action. Through these ice deformation processes, some of the oil deposited on the surface at this time could be redistributed and trapped between ice layers to remain inaccessible until the spring melt – (see break-up below).

Conventional advancing mechanical recovery operations are not feasible with new ice forming in freezing water. Advancing booms to collect oil under these conditions will rapidly build up a thick layer of slush and grease ice that effectively prevents oil from flowing to the skimmer head. Certain skimmer systems may be able to process some oiled slush, but the oil encounter rate drops dramatically while the water content of recovered product increases greatly. Most importantly, the risk to responders is greatly increased by working on the potentially slick decks of small work boats during freeze-up. A significant complicating factor for any oil spill response operations during freeze-up is the limited amount of daylight with less than 7 hours available at Prudhoe Bay by the end of October.

With the rapid transition from predominantly open water to continuous ice cover in October, dispersants become largely ineffective, except for possible small-scale applications using vessel mounted spray arms targeting isolated free-floating oil pockets within the newly forming ice. Some form of mechanical mixing, through directed prop wash for example, would then need to be applied to initiate and encourage dispersion (as tested in Norway in 2009). These types of localized small-scale operations would have little or no benefit in the case of a large-scale WCD. As with any dispersant application, the issue of gaining approvals in a timely manner by demonstrating a clear net environmental benefit presents additional challenges.

The operational and technical constraints imposed by a close to continuous ice cover at freeze-up prevent the effective use of mechanical recovery or dispersants. Eliminating these response strategies leaves in situ burning, either on the ice surface or at the wellhead (Intentional Well Ignition – IWI) as the only means of potentially removing significant volumes of oil from new ice surface during freeze-up in October. Once the new ice cover becomes relatively stable, oil could build up on the surface at a dramatic rate. For example, using the plume model predictions for the Liberty A - WCD scenario, the rate of oil deposition on the young ice surface could equal 1.5 cm/h (0.6 in/h) within 250 m (800 ft) of the island. When the ice becomes thick enough to sustain a dry stable snow cover, the oil falling out from the plume will saturate the snow and spread naturally at the snow/ice interface to reach an equilibrium thickness of approximately 4 cm (2 in). In the case where the ice surface is deformed with ridging, rafting, or ridges, the local equilibrium thickness could be much greater. Regardless, this level of oil layer thickness is more than sufficient to support very efficient combustion, potentially consuming over 70% of the available oil in any given burn.

Initiating burning in October before the ice is thick enough to support response crews or equipment, could be accomplished with a Helitorch or surface access with airboats or hovercraft. Any burning within the exclusion zone around the discharge point will need to consider the possibility of accidental wellhead ignition as well as exposure limits to VOCs for response crews.

A safer alternative might be to wait until the well is capped and the flow stopped before initiating large-scale burning in the vicinity of the facility. There is extensive experience in successfully burning oil pooled on solid ice even after the oil has been exposed to weathering for a month or more (Owens and Dickins, 2015).

Winter

The early winter period (November – December) is characterized by an expanding zone of fast ice increasing in stability as the ice thickens and becomes more able to resist early winter storms. During this period, the fast ice edge expands seaward to reach an average water depth of ~15 m (45 ft) in December. By this time, the average thickness of the fast ice is in the order of 75 cm (30 in). By late December, it becomes possible to start construction of ice roads to offshore locations like Northstar, a process of surveying and flooding that can take 6 weeks of round-the-clock work. Once the ice road is in condition to accept wheeled vehicles, offshore access becomes easier. Helicopters can land safely on the ice and response crews can begin to work with heavier equipment such as bobcats and loaders.

Unfortunately, in this period, daylight hours shrink to the point where there is less than 3 hours daylight from Nov 18 to Jan 25. Darkness combined with extreme cold temperatures makes extensive on-ice response operations very difficult to execute and sustain. During this time, serious consideration needs to be given to deliberate wellhead ignition, burning as much of oil at its source as possible. There is a strong argument for implementing this strategy regardless, at any time of year, with and without ice. Refer to the IWI Risk Benefit Model Worksheet available at ADEC Area Plan References and Tools – see selected references.

Without any removal of oil accumulating rapidly on the ice surface, the oil will spread laterally far outside of the deposition area predicted by the plume model. The contaminated areas will conform generally to the prevailing winds in orientation. Assuming an equilibrium thickness in the order of 4 cm (several inches), a winter WCD running for 30 days, could contaminate the surface of solid ice around the island to an overall area in the order of ~4 square miles. Although this seems huge, it is important to keep in mind that the equivalent spill on open water could potentially contaminate an area thousands of times larger. In spite of the lack of daylight, detection, tracking and monitoring is made much easier than in summer open water, by the containment provided by the ice cover. Heavily oiled snow on the surface is clearly visible and most of the oil (80%) will remain static within a radius less than two miles from the island for over 8 months. This contrasts with the challenge of trying to locate and follow rapidly spreading oil slicks and windrows on open water.

As the ice thickness builds up through mid-winter, reaching as much as 1.5 m (60 in) by March, offshore access becomes possible with heavy equipment like loaders, tandem dump trucks, and vacuum trucks using ice roads. Daylight constraints ease with over 13 hours of daylight available by the end of March. With thick oil films saturating snow on the ice surface, it should be possible to burn a significant portion of the oil, progressively igniting the upwind edges with torches from the surface or a Helitorch from the air. Dealing with the enormous volume and large contaminated area associated with a surface WCD will likely require multiple burns (hundreds) over a period of several months. It may be possible to mechanically collect the burn residue and transport it to shore by ice road but given the urgency of removing as much surface oil as possible prior to break-up, this may not be a priority.

In March and April, the ice roads are usually still in good condition, allowing potential access to the oiled ice area with heavy equipment, making use of the extended daylight. Mechanical recovery loaders and lined dump trucks can move some of the oiled snow to shore for disposal, but the logistics of this operation quickly become overwhelming for a WCD. For example, using a typical tandem dump capacity of ~14 m^3 (18 yd^3), it would take ~25,000 loads to transport just the oil volume accumulated over 30 days at 91,000 barrel per day (bpd) with an assumed evaporation of 20%. Moving just 10% of the oil and snow in March (assuming that the snow is 40% oil by volume) would involve ~25 trips an hour during daylight, over three weeks. This level of traffic with heavily loaded vehicles will require continuous maintenance of the ice road surface to heal cracks and areas where the road surface may spall away. Ice road repairs are feasible in February with extreme cold air temperatures but become more difficult moving into April and May. The increasing solar radiation with long daylight hours and warming temperature may prevent adequate freezing of the surface after spraying in late winter.

Many of the tactics developed for solid ice oil spill response are very difficult to scale up to deal with a surface WCD and extreme oil flow rates. This applies to mechanical response on solid ice tactics in the Alaska Clean Seas (ACS) Manual, showing for example, the use of snow berms to concentrate oil for mechanical recovery on the surface or to direct oil to trenches cut in the ice where it can be potentially recovered mechanically. While these strategies may prove effective with small batch releases in the order of 10s to 100s of barrels, it is difficult to envisage how they could be scaled up to cope with daily rates of oil deposition on the ice as much as 91,000 bpd called out in some of the WCDs used as the basis for this CONOPS. The Area Contingency Plan may be a more appropriate document to discuss responses to smaller spills and spills that might include oil under ice. These are cases where the specific on-ice mechanical recovery tactics presented in the ACS Manual could be applicable.

Beginning in May, shore access to the ice road can become problematic as a narrow band of melt water develops along shore in shallow water. After mid-May, wheeled vehicle access is usually not possible, although tracked vehicles and specialized low pressure tyred equipment, like Rolligons, can still operate into June at some locations if they can find access points from shore.

North Slope Rivers (Colville, Kuparuk, Sagavanirktok) overflow onto the sea ice beginning at the end of May. The overflood waters persist for several weeks and lead to open water corridors within the inshore lagoons and along the coast to the east of Prudhoe and off the Colville Delta.

By early June, melting snow on the offshore ice surface starts to create numerous melt pools with excess water draining through cracks and seal holes. Winds will herd oil remaining or deposited on the melt pools at this time into thickened patches. Surface access and working conditions on the ice become gradually more difficult moving into June, until at some point, the ice is too deteriorated to support safe operations with responders or heavy equipment. ACS has established guidelines for operating a wide range of equipment on ice at different times of the year, including late in the season.

Outside of the Barrier Islands in deeper water (5 to 15 m (15-45 ft), the fast ice remains stable and relatively static until the end of June or the first week of July on average. Continued offshore surface access during these last weeks of intact ice cover could use hovercraft, airboats or helicopters.

ISB is feasible and can still be highly effective during the period of ice melt and decay in May and June. As surface access to the oil becomes more difficult, aerial ignition will likely become the preferred option. Large-scale field tests in the Canadian Beaufort Sea involving hundreds of barrels of crude oil in 1974/75 and 1979/80) demonstrated that in multiple burns on the ice for in June, prior to break-up, could effectively remove ~65% of all the oil available on melt pools. In these experiments (some involving hundreds of barrels of oil) much of the oil had been exposed on the surface of melting ice for a month or more and had an opportunity to weather through evaporation before being successfully ignited.

Locating heavily oiled areas on the ice during the spring melt is facilitated by the significant temperature difference between clear melt water or snow and oil. Large-scale field experiments carried out in 1975 in the Canadian Beaufort showed that thick oil patches on the melting ice in June reached temperatures as high as +10°C by absorbing solar radiation. Infrared sensors will easily detect this level of temperature difference and could provide a visual map of the the most promising oil targets for in situ burning.

Break-up

Following the initial fracturing and movement in early July (vicinity of Northstar for example), the ice sheet deteriorates rapidly into increasingly thinner and smaller floes, leading to open water (defined as less than 10% ice cover) by late July in 5 to 15 m (15 to 45 ft) water depths.

Oil remaining on the ice from a winter blowout could accelerate the local ice melt process. Oil saturated snow has a much lower albedo than clean ice. The resulting increase in absorbed solar radiation will lead to an earlier appearance of melt pools on contaminated ice (as shown clearly in the Canadian experiments referred to above). The end result in those tests was that the oiled area became free of ice one to weeks earlier than the surrounding clean ice cover. Depending on the situation, this scenario could be advantageous if a large opening resulted, surrounded by still intact fast ice. Wind action could then cause the oil to collect in thick films along the still intact ice edge. This would provide an ideal opportunity to efficiently burn a high percentage (potentially over 80%) of the remaining oil on the water surface prior to natural break-up.

As the surrounding ice breaks up and becomes mobile, any oil remaining from being deposited on the solid ice surface in the winter will enter the water and rapidly drift and spread much like a fresh open water spill. One difference is that this oil will enter the water in a more weathered state (evaporated but not significantly emulsified). Viscous residue with a high specific gravity, left over from burning on the ice in winter will also enter the water and could sink, especially if it came in contact with sediment laden water.

Once the ice concentrations reduce to ~30% or less, setting boom for mechanical recovery or in situ burning becomes feasible again. Aerial dispersant applications can again be considered as a possible countermeasure, always subject to a SIMA analysis and adherence to published guidelines and approval processes (refer to Selected References)

CONOPS – Cook Inlet

Figure 6 depicts the CONOPS divisions for Cook Inlet. The FORD will extend on either side of the SCED due to the significant tidal fluctuations in this area. As in the Beaufort Sea, the FORD will also be relatively larger than the WORD due to the slower weathering times in this northern area. There will be two SPRDs due to the orientation of the inlet along both shorelines. With a maximum depth of 212 m in Lower Cook Inlet, this region would allow for application of dispersant, if authorized, and would allow for the use of larger draft vessels for mechanical recovery.

Figure 6. Possible Geographic Construct for Cook Inlet.

Source Control Exclusion Division (SCED)

A possible configuration for the SCED is presented in Figure 7 for Cook Inlet.

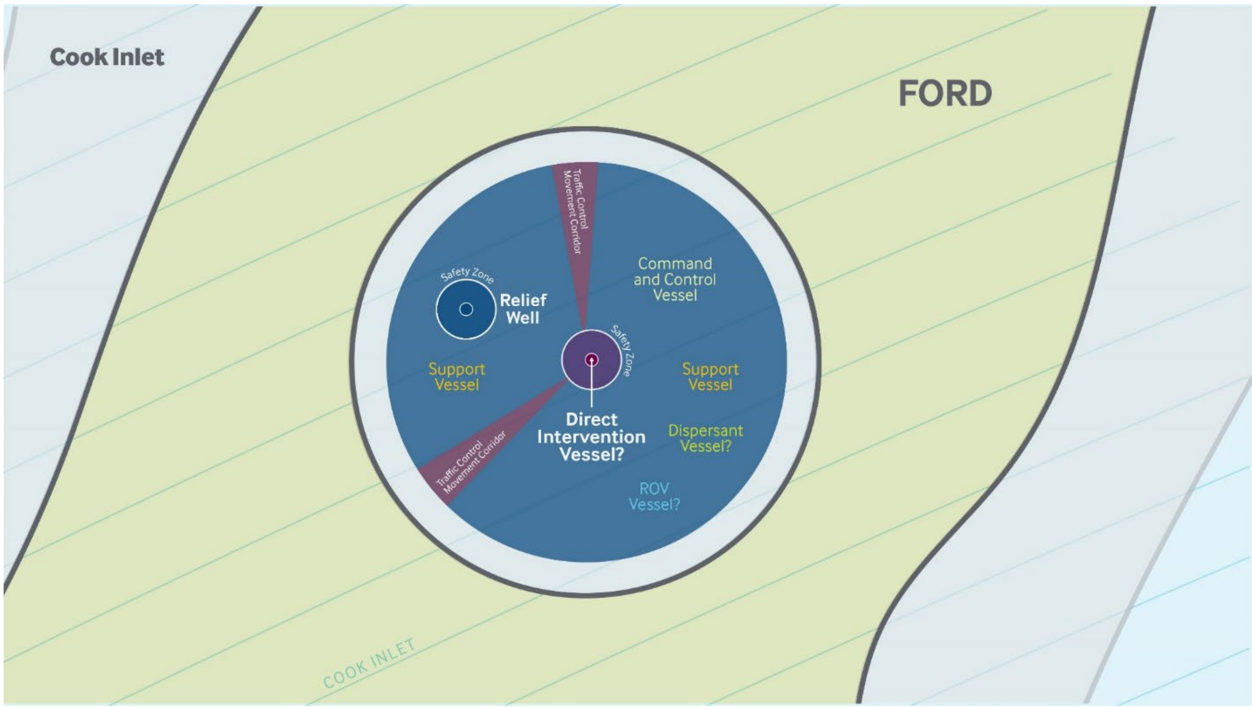

Figure 7. Possible SCED Configuration for Cook Inlet.

Assessment Phase

If personnel are on the facility in Cook Inlet, they will likely begin to take initial source control actions, such as using a jack-up rig with a BOP at the surface. Depending on the location of the incident, remotely operated vehicles (ROVs) could be a useful resource to assess the situation.

Initial Response Phase

Primary Removal Operations Phase

Expanded Source Control Operations Phase

Post Discharge Removal Operations Phase

Fresh Oil Removal Division (FORD)

A possible breakdown of the zones within the FORD is presented in Figure 8 for Cook Inlet.

The FORD will extend on either side of the SCED due to the large tidal fluctuations in this region.

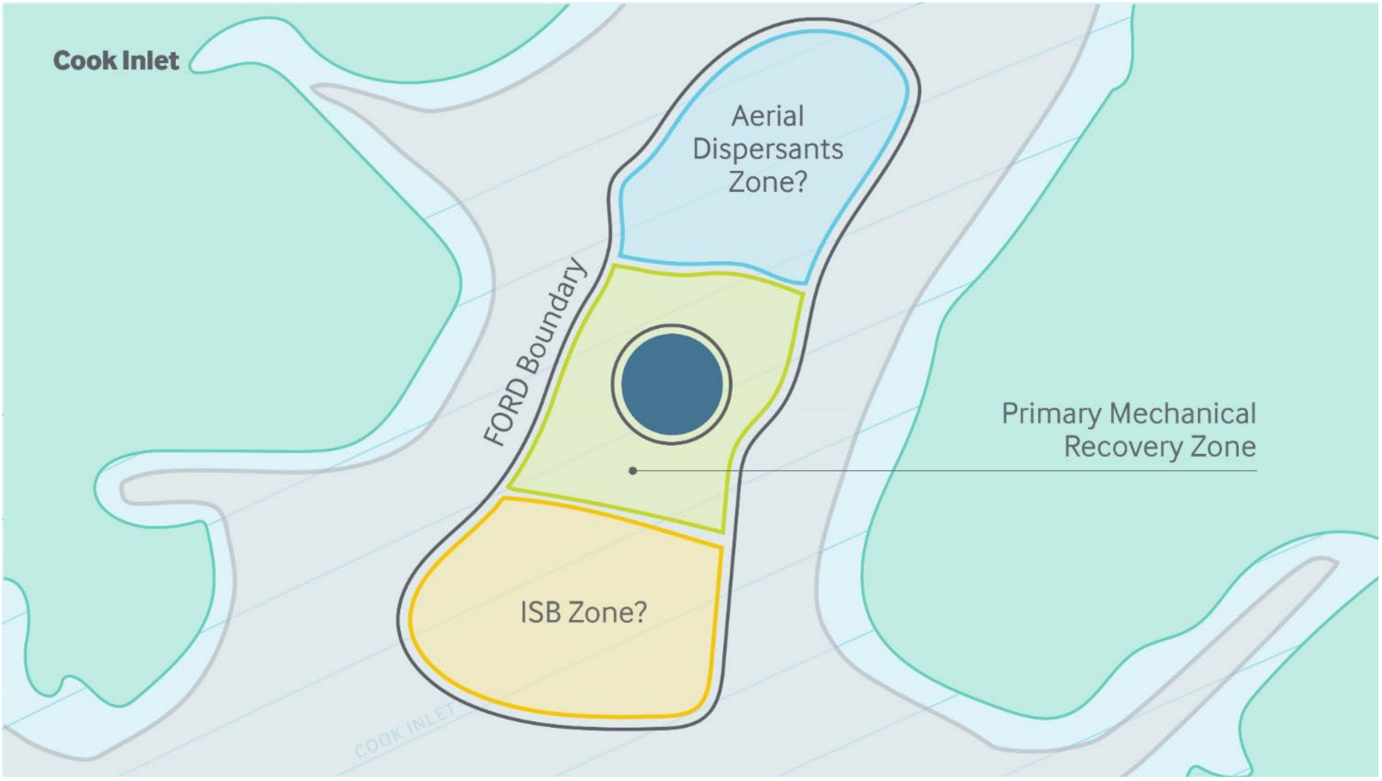

Figure 8. Possible configuration for the FORD in Cook Inlet.

Assessment Phase

Aerial and satellite assets would be used to assess the locations of freshest oil.

Initial Response Phase

Larger OSRVs would be used initially in the Primary Mechanical Recovery Zone to collect the freshest oil in the FORD in closest proximity to the SCED. Due to the tighter confines of the geography in the region, the Unified Command could potentially split aerial dispersant application and in-situ burning between the north and south zones in the FORD to separate the two operations and proceed with obtaining all required authorizations.

Primary Removal Operations Phase

The Primary Removal Operations Phase would involve OSRVs and other high efficiency advancing skimming systems as this region is ice-free through the year in the Primary Mechanical Recovery Zone. If authorized, aerial dispersant application and in-situ burning would begin in those zones.

Expanded Source Control Operations Phase

Post-discharge Operations Phase

Weathered Oil Removal Division (WORD)

A possible breakdown of the zones within the WORD is presented in Figure 9 for Cook Inlet. The WORD will extend north and south of the FORD due to the tidal fluctuations.

Figure 9. Possible configuration for the WORD in Cook Inlet.

Primary Removal Through Post Discharge Phases of Operations

The WORD will require a larger number of mechanical recovery resources, including towed containment booms, secondary storage, aerial observers for skimmer direction, and other support resources to meet the challenge. Skimming systems which are more maneuverable are better suited for recovering these streamers and windrows at the direction of aerial observers.

Shoreline Protection and Recovery Division (SPRD)

In Cook Inlet, the SPRD will extend on either shoreline to the east and west of the spill site due to the orientation of the geography. Shoreline clean-up will be a critical part of the response in Cook Inlet. These operations are covered in the existing ACP.

Alaska Oil Spill Response Operational Factors

This strawman CONOPS acknowledges important observations made in the National Research Council consensus report (2015), *"Responding to Oil Spills in the US Arctic Marine Environment",* Arctic oil spill response is challenging because extreme weather and environmental conditions, the lack of existing sustained communications, logistical, and information infrastructure, significant geographic distances, and vulnerability to Arctic species, ecosystems and cultures. Considering these factors and the seasonal limitations of different countermeasures in the Arctic, this report also concluded that *"response to a large offshore spill in the US Arctic is unlikely to rely only on mechanical containment and recovery because of its inefficiency".*

The **Alaska Oil Spill Response Operational Factors** review some of the realities of responding to a spill at sea in Alaska. These factors include constraints presented by the remote physical environment and the long supply chains that will largely determine the selection of viable response strategies. Oil spill response in Alaska is unique. Many of the conventional offshore response strategies applicable in the Lower 48 are either not practical or effective when applied to a remote area like the North Slope with sea ice present for a large part of the year. Given the lack of marine resources, particularly large vessels, restricted water depths, and lack of ports, response to a WCD in the Beaufort Sea will likely need to rely on large scale aerial delivery systems to initiate burning and/or apply dispersants over a broad geographic area. Either of these strategies will require agency approvals dependent on SIMA analysis.

Possible oil spill response countermeasures and tools for oil removal in Arctic conditions include biodegradation (including oil treated with dispersants), in situ burning (including the use of herders), mechanical containment and recovery, and detection and tracking. The oil spill response toolbox requires flexibility to evaluate and apply multiple response options, shifting from one to the other as conditions dictate (e.g., oil weathering, sea state, presence of ice, etc.). No single response technique will apply in all situations. In an actual incident, these countermeasures are also evaluated against the "no response" option of natural recovery, which may be the preferred alternative in some situations.

Oil spills in the Alaska region pose unique challenges due to the harsh and remote environment, limited infrastructure, and sensitive ecosystems. Responding to an oil spill in the Arctic requires advanced planning, specialized equipment, and coordination among various stakeholders where most of them will be located far from the incident location (i.e., at other coastal states in the U.S.). In addition, Alaska is home to some of the most pristine and sensitive ecosystems in the world, including sea ice, tundra, and marine and terrestrial wildlife.

The challenges of responding to an oil spill in Alaska can be broadly categorized into three main areas: 1) environmental conditions, 2) logistical issues, and 3) technological issues. The following discussion highlights many of the challenges for oil spill response in open water and ice. Although focused on WCDs occurring nearshore in the Beaufort Sea, many of the issues raised about the relative response effectiveness of different countermeasures also apply to Cook Inlet.

1. *Environmental Challenges*

In any spill, environmental factors such as marine weather (wave frequency/height, wind velocity, visibility, temperatures), will greatly impact the effectiveness of the response and choice of countermeasures. In the Arctic, these constraints are amplified by extreme temperatures, long periods of continuous ice cover, and limited daylight hours through much of the winter. Conversely, the extended daylight during the summer open water period greatly increases the operational time available to response crews, compared with lower latitudes.

Cold temperatures and the presence of ice affect all aspects of oil fate and behavior in the Beaufort Sea and, to a lesser extent, Cook Inlet. On the positive side, these two environmental aspects lead to slower weathering rates (including water uptake), which in turn can extend the applicability of dispersants and in situ burning beyond what is possible for spills in the Lower 48. The containment offered by ice can dramatically reduce the oil spreading rate and contaminated area, resulting in increased equilibrium thickness and more opportunities for effective burns. Thicker oil generally improves recovery effectiveness regardless of the countermeasure used.

In many respects, the presence of stable ice around a discharge site in the winter is a benefit for oil spill response and presents an easier case in terms of oil recovery than dealing with oil spreading in thin films over large expanses of open water in the summer. Ice can contain and isolate oil from the marine environment for many months, minimizing immediate impacts and providing valuable additional time for planning and executing a response when conditions become more favorable with daylight and warmer temperatures moving into the spring. This “deferred response” option is rarely, if ever, available in the case of open water spills. Keep in mind that the oil spill response benefits attributed here to the presence of an ice cover are specific to the case of spills on top of solid, stable ice surrounding a facility, such as a gravel island, and would not apply in the case of a subsea blowout under drifting pack ice further offshore.

When mobile ice during freeze-up and break-up preclude the effective use of traditional containment boom, the ice itself often serves as a natural barrier to the spread of oil, maintaining thick films for burning against ice edges or on top of the ice. At the same time, the interaction of individual floes can increase the natural mixing energy and promote successful dispersion., The contaminated area becomes dramatically smaller once stable ice forms in the nearshore Beaufort region around the sites selected as WCD scenarios. As an added benefit, the fringe of fast ice that envelops the Beaufort Sea coastline from early October to June acts as an impermeable barrier and prevents oil from entering and contaminating coastal areas throughout the winter.

In any offshore response, high-resolution mapping data is needed to guide or direct responders and air crews to the thickest oil. In the Beaufort Sea, frequent periods of poor visibility due to darkness, fog, and blowing snow (whiteouts) make visual surveillance and mapping extremely challenging. For much of the year, radar satellites are the only platforms potentially capable of imaging large slicks in open water without being blocked by clouds, fog, or darkness. With oil contained between floes, discriminating between smooth calm water, smooth new ice and oil on satellite images is extremely difficult due to the effective wave damping provided by the ice. Other airborne sensors such as Forward-Looking Infrared (FLIR) can be useful in detecting oil on water and ice, but marginal flying weather may preclude or limit the operational effectiveness of airborne platforms such as UAS), helicopters, or fixed wing aircraft.

Illustrating these operational challenges, Figure 10 is an aerial oblique photograph collected by a UAS operated from an icebreaker 20 miles north of Barrow AK on July 1, 2022. This image was collected approximately at 200 ft altitude and 300 ft from the vessel, where intense fog impeded the clear visualization of the vessel. Under these marginal flying conditions, aerial detection of oil on water, among ice or on top of the ice, could not be carried out by UAS or manned aircraft (fixed or rotary wing).

Figure 10. Example showing the difficulty of operating UAS (drones) In the Beaufort Sea and the challenges for detection of oil spills from aerial platforms during foggy conditions.

2. *Logistical Challenges*

The Arctic is a remote and sparsely populated region with limited infrastructure, including ports, airports, and roads. This can make it challenging to transport personnel and equipment to the spill site and to establish a base of operations, staging areas, and temporary waste disposal sites.

In the Beaufort Sea, extreme environmental conditions combined with lack of marine access for much of the year, restricted water depths, and absence of deep-water ports severely affects the viability of conventional open water response strategies that form the foundation of oil spill response in southern waters. The “offshore” WCD scenarios for the Beaufort Sea are all nearshore in water depths of ~ 8 to 20 ft and accessible only to the fleet of small workboats operated by Alaska Clean Seas and shallow draft tugs and mini-barges.

Mechanical recovery will always have an important role to play in responding to smaller spills, especially in areas where there is sufficient infrastructure and marine resources to support the need for lightering, storage, and disposal.

3. Technological Challenges

Technological challenges are mainly focused on the relative effectiveness of different countermeasures given the environmental and logistical constraints described.

Mechanical containment and recovery are generally preferred over other oil spill countermeasures because it removes oil from the marine environment, ideally followed by permanent disposal of the recovered oil onshore.

Cascading resources into the Beaufort Sea quickly from southern locations will need to rely on overland road transport and air cargo. The only vessels capable of moving recovered oil into shore are shallow draft tugs, small workboats and mini-barges that can access West Dock and Oliktok with water depths alongside of 8 to 10 ft. Resources should be required on scene before drilling due to these logistical challenges.

Large capacity barges able to handle the potential WCD volumes are not available on the North Slope. Securing, mobilizing and repositioning US-registered shallow draft tugs and barges from the closest major port (Seattle) would take at least three weeks and could only occur when the sea lane around Point Barrow to Prudhoe Bay is clear of ice. It is doubtful that the existing fleet of mini-barges in inventory on the North Slope could cope with the volume of oil and water likely to be collected in the early stages of a summer blowout.

Experience with using mechanical recovery on an unprecedented scale in the Deepwater Horizon response highlighted a key drawback of mechanical containment and recovery systems when confronted by a large, rapidly spreading oil slick: namely, the encounter rate is insufficient to allow the skimmers to achieve a significant percentage of their theoretical recovery capacity. This problem is amplified greatly by the presence of any significant ice cover. Field trials in Alaska and the Baltic have shown that ice concentrations greater than 3/10 (30% by sea area) significantly reduce the encounter rate of skimmer systems and force them to constantly deviate to avoid larger floes. The situation quickly becomes unworkable in higher ice concentrations.

There are two winter scenarios where mechanical recovery could be effective: (1) to remove small volumes of oil mixed with snow on the surface where ice roads can be constructed to access the site; and (2) to recover relatively small volumes oil pooled and trapped under solid ice that provides a safe working surface for personnel and equipment. The key word here is “small” (i.e., in the order of hundreds of barrels. For most WCD scenarios with flow rates potentially many tens of thousands of barrels per day, the logistics needed to recover oiled snow and transport to shore for disposal on land quickly become unworkable for large spills.

Questions have been raised concerning the adequacy of mixing energy between ice flows. On the Deepwater Horizon spill response, there was similar thinking which resulted in a temporary shutdown of the dispersant operation due to lack of wave height until the dispersant group were able to rebut that decision and restart the dispersant operation. In the 2014 International Oil Spill Conference paper, *"Does Wave Height Matter for Effective Surface Dispersant Application?" by* Huber et al., the authors noted trials in the Ohmsett test tank in New Jersey, test tanks in Norway and field trials with oil in ice in the Norwegian Barents Sea have shown that effective dispersion is possible even in relatively high ice concentrations, especially if aided by prop wash and mechanical mixing.

From freeze-up to break-up, a period encompassing approximately 9 months in the Prudhoe Bay area, there are limited response options available to deal with large volumes of oil either trapped between drifting floes or deposited on top of solid ice: dispersants in the case of open drift ice (<60% cover) or in-situ burning. See Figures 11 through 13 below. There may not be enough mixing energy between the ice floes. In the event dispersants and in-situ burning cannot be used, the oil can be tracked and collected after freezing or once water assets can mobilize safely. Oil can pool on water on ice. This oil can be collected using air boats.

Figure 11. C-130 Hercules from the Airforce Reserve Command's 910th Airlift Wing drops dispersant as part of the Macondo Response Effort (Wikipedia Commons)

Figure 12. Burning crude oil in slush between ice floes during the 1986 Canadian East Coast "Oil in Pack Ice" experiment. Ref. Buist and Dickins, 1987. Photo: D. Dickins.

Figure 13. Burning crude oil spilled into a field of small ice cakes concentrated in a fire-resistant boom, Norwegian Barents Sea 2009 (Potter et al, 2012).

If authorized and appropriate in a given scenario, in-situ burning can rapidly remove very large volumes of oil from the water surface with a series of small-scale task forces as were employed very effectively during the Deepwater Horizon response. One key advantage over mechanical recovery is the lack of any need to collect, store, lighter, and dispose of waste oil.

The existing shallow draft 48 ft Bay boats maintained by Alaska Clean Seas in Prudhoe Bay are capable of maneuvering and positioning fire boom. Alternatively, as proven in field trials in Norway in 2008/2016 and Alaska in 2015, non-toxic herder sprayed around slicks in very small volumes (tens of gallons) can rapidly thicken the oil to sustain ignition and enable effective (up to 90% removal) burns without using booms. In winter with thick oil on solid ice contained in a small area around the island, a Helitorch can be used to ignite the oil from the air. In the case of oil deposited in thick films on solid ice surrounding an artificial island, in-situ burning is the only response option with the potential to remove large volumes of oil. Numerous field trials in Alaska, Canada, and Norway over the past 50 years demonstrated the potential to efficiently burn fresh and weathered oil in thick films on bare ice or mixed with snow. Owens and Dickins (2015) summarize many of these experiences in an Arctic context. Refer to the Section "Beaufort Sea – Ice Scenario" for a further discussion of strategies to address volumes of oil on the ice surface from freeze-up to break-up.

There is approximately 17,000 feet of various size fire boom in all of Alaska. On the Deepwater Horizon spill response, approximately 23,000 feet of fire boom was utilized (Reference Al Allen, *"In-Situ Burn Operations During the Deepwater Horizon Oil Spill"* 2011). Teams of trained personnel were needed to operate the various ISB operations. In the case of an Alaska WCD, additional fire boom may need to be transported by air from the lower 48 to supplement and replenish the available inventory currently in State. Depending on the manufacturer, some fire boom deteriorates quickly after multiple uses and needs replacing

Dispersant use in Alaska and elsewhere has always been controversial. There is an extensive body of rigorous scientific evidence and experience from past spills around the world (including a ground-breaking experiment in the Canadian High Arctic in 1981). This knowledge base proves that the carefully considered use of dispersants can result in significant environmental benefits compared with other less effective options, even in shallow water and under Arctic conditions with mobile pack ice. Given the small swath width and slow rates of advance available with vessels, large-scale dispersant applications will need to rely on aerial delivery to cover the large areas potentially contaminated over time with a continuous, extended release. These airborne assets can be moved to the slope in a matter of hours, unlike other marine-based strategies that could take weeks.

Gaining permission to use non-conventional response strategies can take time and involve complex discussions with different stakeholders. Ideally this process should wherever possible be worked out ahead time to facilitate rapid approval in an emergency. There is an established Federal/State inter- agency (EPA, USCG, ADEC) set of guidelines governing safe operations and go/no go decisions for burning oil on water (Alaska Regional Response Team, 2008). Gaining agency approvals for dispersant use will require rigorous NEBA/SIMA analysis for the specific situation at the time, accompanied by full transparency and stakeholder engagement. Ref. ARRT Dispersant Use Plan for Alaska.

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