In-Situ Burning Guidance for Safety Officers and Safety and Health Professionals

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Purpose of Report

This report is intended to support the Incident Safety Officer and other safety and health professionals involved or having responsibilities in the incident response during oil spill responses (OSR) where the strategy of controlled in-situ burning (ISB) can be used. ISB is an effective response countermeasure for oil spills on land (including wetlands), on water, and in ice and snow. This Guide presents the process of anticipating, recognizing, evaluating and controlling the hazards associated with ISB for a Safety Officer or other health professional to consider during an incident as a part of the National Incident Management System / Incident Command System (NIMS / ICS) planning cycle.

ISB has been used less frequently than other techniques such as booms and skimmers or oiled soil removal. Consequently, familiarity with the pros and cons of ISB might be limited. Extensive practical and operational experience has been gained from ISB efforts to the Deepwater Horizon OSR in 2010.

This document is available from the API Publications at www.api.org.

In-situ Burning Guidance for Safety Officers and Safety and Health Professionals

1 Introduction

1.1 Background

ISB is an effective response countermeasure for oil spills on land (including wetlands), on water, and in ice and snow. Past spill responses, such as the Deepwater Horizon oil spill response (OSR) in 2010, and academic research, have provided Safety Officers and safety and health professionals much needed data in the areas of response worker safety issues, response worker and community exposure potentials, smoke plume modeling and air monitoring as it relates to ISB. This information, as well as the lessons learned from these responses, has been incorporated into this document (i.e. "the Guide") in an effort to capture and share this expanding knowledge base. Additionally, other API documents, including, but not limited to, *In-Situ Burning: A Decision-Maker's Guide to In-Situ Burning* (API, 2005), *Field Operations Guide for In-Situ Burning of Inland Oil Spills* (API, 2015a), *RP 98: Personal Protective Equipment Selection for Oil Spill Responders* (API, 2015b), and *Risk Communication for In-Situ Burning: The Fate of Burned Oil* (API, 2004) should all be reviewed as they complement this Guide.

1.2 Purpose and Scope

The Guide is intended to support the incident Safety Officer (SOFR) and other safety and health professionals involved or having responsibilities in the incident response during oil spills where the strategy of controlled *in-situ* burning (ISB) can be used. Typically, oil spill response operations, including those involving ISB, are conducted using the organization structure prescribed by the National Incident Management System Incident Command Systems (NIMS/ICS) (DHS, 2009). The SOFR is position appointed as part of the Command Staff. As stated in NIMS/ICS guidance, the SOFR's function "is to develop and recommend measures for ensuring personnel safety and to assess and/or anticipate hazardous and unsafe situations." (DHS, 2009). This would include operations relating to ISB if this response action is selected for use during an oil spill.

The SOFR, along with the Incident Commander and other Command Staff, participate in the daily NIMS planning cycle. This a process is template for strategic, operational, and tactical planning used to develop Incident Action Plans (IAPs) designed to address many issues relating to the oil spill, including mitigation measures such as ISB. The SOFR participates in the process to help ensure that operations are conducted in the safest manner possible. Typically, during the pre-tactics and tactics meetings, the SOFR meets with the Operations Section and other members of the command to discuss the options for strategies and tactics. As the tactics are being outlined in the Form ICS-215, the SOFR works on the abbreviated JSA, Form ISC-215A. Additionally, a more formal JSA can be developed by the SOFR with the Operations Section. Formal JSAs provide greater detail and can be used to support decisions made while completing an ICS-215A. Having a solid understanding of ISB operations will allow the SOFR to follow along as the tactics are described. However, it is imperative that the Safety Officer ask questions when there is not a clear understanding of the operations being discussed.

Many SOFRs and safety and health professionals have not been involved with ISB operations and might find supporting such operations challenging without some basic understanding as to how ISB is performed and what potential hazards and risks could be associated with it. The Guide is meant to supplement the SOFR's and safety and health professional's training and education so that ISB site health and safety plans and control measures can be developed when and where they are needed in a timely manner[1]. The Guide uses industrial hygiene principles to aid in the identification and management of potential hazards associated with ISB and focuses on the process of anticipating, recognizing, evaluating and controlling (AREC) the hazards associated with ISB, a process the SOFR can use to effectively fulfill their role within of the NIMS / ICS planning cycle. The content of the Guide is intended to be useful to SOFRs and safety and health professionals who might not be formally educated or certified as industrial hygienists.

Due to ISB being a time sensitive operation (i.e., becomes less feasible and effective over time due to natural weathering of the spilled oil), there will be limited opportunity to learn the operations and understand the potential risks before being called upon to develop a site health and safety plan (HASP) or develop safe work practices. In the Guide are tools which a SOFR can use to assist in assessing risks associated with ISB, developing comprehensive safety messages and HASPs, and communicating safety options to the Operations and Planning Sections.

The Guide provides a list of relevant and often-cited reference materials as well as supplemental Performance Qualification Standards (PQS) that incident SOFRs can follow to document their experience and knowledge of ISB. The Guide also provides three supplemental tools intended to support safety professionals during a response:

— an example ISB Health and Safety Plan (HASP) (**Appendix A**),

— example Job Safety Analyses (JSAs) (**Appendix B**); and

— risk communication information presented as Frequently Asked Questions (**Appendix C**).

Response scenarios addressed in the Guide and Appendix material include inland (i.e. on-land and wetlands), near shore (i.e. < 4.8 kilometers from the coast) and offshore (i.e. > 4.8 kilometers from the coast) ISB of petroleum hydrocarbon oils. Because safety concerns overlap considerably for each of these scenarios, one general example of a HASP is included in **Appendix A**. Within the example HASP are sections which can be added, modified or removed based on the location and type of ISB. Performing site-specific JSAs is a key step in building an accurate and actionable HASP. The example JSAs in **Appendix B** include a variety of tasks/scenarios. These documents are not substitutes for developing safe work practices, performing a JSA, or preparing a health and safety plan that is specific to a site and oil spill response (OSR) task. The FAQs in **Appendix C** are examples of questions or concerns which may arise from the public during an ISB and which the SOFR may familiarize themselves in order effectively communicate with the ISC Public Health lead and other members of Incident Command/Unified Command (IC / UC).

1.3 Assumptions and Limitations

It is assumed that SOFRs and safety and health professionals using this Guide possess core competencies in their field and in OSR in general. It also assumes the incident response is being managed using the NIMS / ICS system and that the SOFR will have the standard ICS roles, responsibilities and authorities associated with the SOFR position.

This Guide does not provide an all-inclusive primer on OSR, ISB, or how to perform the duties of a SOFR within NIMS/ICS; rather, its purpose is to aid in anticipating, recognizing, evaluating and

[1] This guide does not include the physical hazards associated with an oil spill response as this area has already been well researched and documented. This exclusion is not to diminish the risks created by generic hazards such as thermal stress, fatigue, ergonomics, slips, trips and falls, noise, drowning, motor vehicle operations and workplace violence. These have all been found to create the highest risks for responders. Information covered by this guide is intended to improve a safety professional's understanding of ISB and assist in building ISB site specific health and safety plans to supplement a Site Safety Plan.

controlling hazards associated with ISB. It is not possible to expect all risk to be eliminated; therefore, a SOFR needs to work with the IC/UC and Operations Section Chief to determine an acceptable level of risk for ISB operations. The SOFR and/or safety and health professionals will then work with the ISB Burn Group Supervisor (Burn Boss) to assess the hazards and develop control measures that are both feasible and practicable.

The key to any spill response success, no matter the position held, is preparation. The Guide, if used to prepare for a spill, should allow SOFRs and safety and health professionals to understand safety and health issues relevant to ISB and make decisions at the pace dictated by the NIMS / ICS planning cycle.

2 Performance Standards for Safety Officers and Support Safety Personnel

The SOFR for an ISB operation is the person who works within the NIMS / ICS system to ensure that recognized safe practices are followed by all personnel throughout the burn operation. The SOFR should have the training and/or experience to: analyze the personnel safety hazards related to ISB, understand the safety consequences of specific tactical operations proposed for the location where the spilled oil is situated and with the equipment to be used, assess safe vehicle, vessel and boom usage, enforce vehicle and vessel safety and personal protective equipment (PPE) usage, evaluate PPE needs and availability, evaluate air quality impacts for workers, and effectively assist the ISB Burn Boss. The SOFR may consult with Technical Experts (including, but not limited to, Industrial Hygiene, Air Monitoring, Weather Forecasting or Fire Fighting experts) in order to establish safe work practices.

SOFRs and other safety and health professionals assigned to support ISB operations need to come prepared. Preparation could follow many paths, but a strong foundation (not necessary relating to ISB operations) includes:

— Being able to recognize, evaluate, and control the hazards associated with OSRs,

— Being able to assess and prioritize health and safety risks,

— Being able to communicate the risk to stakeholders, responders and the public,

— Understanding the hazards of spilled oil and combustion by-products produced by burning of oil,

— Being able to gather, produce, analyze and distribute safety information, as required

— Being able to gather situational information and supply it to other members of the incident command structure

— Being qualified as a NIMS/ICS Safety Officer and having at least NIMS/ICS-200 Level training (see *API Selection and Training Guidelines for In-Situ Burn Personnel*).

SOFRs, in order to support operations, are preferred to have a working knowledge of ISB operations and the hazards associated with it before they arrive on-site and also be capable of demonstrating competency in a variety of operational areas. Competencies are the behaviors which encompass the desired skill, knowledge and abilities that lead to a successful ISB operation. There are no regulatory requirements for serving as a SOFR or safety support staff during an ISB. However, API's *Selection and Training Guidelines for In-Situ Burn Personnel* (i.e. *ISB Selection and Training Guide*, API, in preparation) contains PQS information for a variety of ISB positions, including the SOFR, which may be used to help identify qualified personnel to serve in the SOFR or safety support staff roles. Additional certification opportunities that may be useful for the SOFR are available from the Federal Emergency Management Administration (ISC 404) and the National Fire Protection Association (NFPA 1521 Fire Department Safety Officer; NFPA 472 Hazardous Materials Safety Officer). For convenience select PQS information listed in the ISB Selection and Training Guide which are applicable to ISB SOFRs has been included below in a shortened form (**Figure 1** to **Figure 4**). Readers are encouraged to review the *ISB Selection and Training Guide* for greater detail on specific PQS topics.

Competency Area #1: Oil Spill Hazards Control

Requisite Knowledge	Requisite Skill
Identify Hazards to Oil Spill Responders Involved in ISB	
Understand concepts relating oil types, physical properties of oil and oil residue, flammability, behavior of oil in the environment, emission of volatiles from oil, production of combustion byproducts from burning oil and properties / use of oil dispersants.	Use reference materials to identify hazards associated with tasks associated with ISB response tactics.
Understand Exposure Limits to Oil Constituents, Combustion Byproducts and Spill Control Agents	
Understand basic toxicological principles such as exposure routes, dose-response and acute vs. chronic effects. Understand the toxicological properties of oil constituents, combustion byproducts and spill control agents. Understand terminology associated with chemical exposure limits (i.e. measures of airborne concentration (ex. ppm), types of exposure limits (ex. TLV-TWA, TLV-STEL, IDLH).	Anticipate and ensure control of chemical hazards associated with oil constituents, combustion byproducts and spill control agents.
Analyze the Behavior of Spilled Oil in Various Operational Environments	
Understand how oil behaves in each operational environment associated with an oil spill.	Be able to obtain information on local weather conditions and predict the influence of changing conditions on the spilled oil.
Identify Conditions Conducive of Successful ISB of Spilled Oil in Various Operational Environments	
Understand limiting conditions that affect ISB success in operational environments associated with an oil spill	Be capable of assessing appropriate distance from public receptors, worker safety, environmental conditions, tactics to contain the oil and maintain a minimum thickness of oil for ISB, suitability of vessels and equipment, ability to contain and limit burning to a target location, adequacy of personnel training, permissions and permits from regulatory authorities and consent of responsible party.

Figure 1—ISB SOFR PQS Competency Area #1

Competency Area #2: Planning the ISB Response

Requisite Knowledge	Requisite Skill
Identify and Evaluate Tactical Options for ISB of Spilled Oil in Various Operational Environments	
Understand fire break construction and fire boom positioning techniques and use of existing topographical or geographical features to facilitate ISB in different operational environments. Understand positioning of personnel to maintain safe positions and unimpeded exit routes.	For a given operational environment, be able to identify equipment, vehicles, vessels and personnel that will but suitable for a safe and effective ISB.
Equipment Capabilities, Quantities and Safe Operating Practices in Various Operating Environments	
Understand vehicle and vessel size, maneuverability and power supply needs. Understand vessel or personnel mobility requirements for ISB ignition, fire boom deployment and recovery (if applicable), fire suppression (if applicable), on-scene command and operational surveillance. Understand equipment and fire boom selection criteria as well as advantages and disadvantages of available equipment in regards to suitability to task. Understand safe operating procedures and safe positioning personnel in relation to equipment operation.	Be able to evaluate safety and health hazards associated with the position of equipment, vehicles or vessels to perform safe and effective ISB in the applicable operational environment.
Timeline for Daily ISB Operations	
Understand expected deployment times for personnel and equipment needed for ISB operations.	Be able to confirm transit times, deployment and recovery times and effective workday length for ISB operations. Provide incident command with timely updates of progress and anticipated deviations from the approved timeline.
Protective Actions	
Understand safe practices for addressing hazards associated with the work environment, use and movement of response vehicles, vessels and equipment as well ask tasks unique to ISB (i.e. fire boom deployment, ignition, etc.)	Be capable of assessing hazards and developing a Site Safety Plan for ISB operations.

Figure 2—ISB SOFR PQS Competency Area #2

Competency Area #2: Planning the ISB Response (con.)

Requisite Knowledge	Requisite Skill
Spill Control Agent Usage	
Understand how to identify environmental conditions where use of spill control agents (demulsifiers, herders) may be successful in enhancing the effectiveness of an ISB, the legal requirements for using spill control agents and the hazards and application techniques for spill control agents.	Be capable of assessing worker safety issues related to the use of spill control agent in various operating environments and recommending safety precautions for their use. Be capable of providing information and planning details to incident command to facilitate decisions about whether to contact authorities to request use of spill control agents.
Personal Protective Equipment (PPE) during ISB	
Understand the appropriate use and limitations of general PPE, PPE for fire, oil and chemical hazards and safety equipment including personal flotation devices (PFDs) which may be used during ISB operations. Understand factors specific different ISB work tasks which guide the selection of appropriate PPE. Understand methods for preventing cross-contamination of PPE during ISB operations.	Be capable of training workers to correctly don, wear and doff PPE and safety equipment. Be capable of guiding decisions regarding selection of appropriate PPE and safety equipment for different work tasks. Be capable of ensuring that workers are trained in self- and co-worker decontamination methods and methods for removal of PPE which minimize secondary contamination.
Ignition of ISB of Spilled Oil	
Understand the construction, characteristics, anticipated effectiveness, safety and hazards of ISB ignition systems as well as optimization of ISB ignition sequencing and safe placement of ignition personnel during and after ISB ignition. This applies to on-land, on-water and aerial ignition procedures. Understand how the physical characteristics of the spilled oil and conditions in the operational environment would affect the ease of ISB ignition.	Be capable of ensuring that ISB ignition systems are deployed and used safely and that ignition specialists prepared thoroughly for ignition operations. Be capable of aiding in the development of plans for ISB ignition locations and sequencing that allow for safe placement and egress route for personnel as well as minimizing the potential to fire to spread outside of the burn area. Be capable of understanding aerial ignition safety plans, effective communications and safe use of aerial assess to conduct ISB ignition.

Figure 2 (continued)—ISB SOFR PQS Competency Area #2

Competency Area #3: Implementing an ISB Response

	Requisite Knowledge	Requisite Skill
Operational Period Briefing	Understand the components of an operational period briefing covering an Incident Command System (ICS) incident action plan.	Be capable of assisting in preparation of a concise pre-operational briefing that imparts information needed for safe and effective performance during the operational period.
Fire Suppression During ISB	Understand how to support effective fire control and smoke management procedures, use of fire breaks, safe positioning of fire suppression equipment and crews and develop of safe egress routes for on-land ISB. Understand the performance of tactical operations which result in exstinguishment of burning oil on water and how to perform fire-fighting on boom towing vessels, small boats and support vessels. Understand the capability and capacity of firefighting equipment or personnel which may be used during an ISB.	Be capable of reviewing options to ensure the availability of sufficient fire fighting resources, construction of firebreaks, egress routes and the safety of workers when fighting fires that escape the burn area for on-land ISB. Be capable of recommending options for tactical maneuvers which would exstinguish on-water burns and ensuring the availability of fire-fighting equipment and safe fire-fighting procedures for fires on vessels / small boats for on-water ISB.
Medical Emergency / First Aid during ISB	Have training or experience meeting or exceeding OSHA's Best Practices for Workplace First Aid Training Programs. Understand the location and capabilities of medical personnel stationed on-site and the nearest medical care facilities to the ISB site. Understand planning considerations for routes and means of transport to health care facilities	Be capable of identifying and designating workers available for providing first aid at a site in the event of an accident. Be capable of communicating with on-site medical personnel to discuss operational and safety objectives of an ISB. Be capable of recommending primary and secondary medical centers and the most efficient routes and means of transport to those centers.
Airborne Hazards Monitoring	Understand the components of unburned crude oil emission and emissions of combustion by-products following ignition of an ISB. Understand how to select appropriate action levels to protect workers from overexposure to airborne constituents. Know about public health standards for the general public and how to develop air monitoring protocols for areas downwind of the ISB site. Understand how to develop a Quality Assurance Project Plan (QAPP) for air monitoring.	Be capable of recommending to incident command what airborne constituents should be monitored before, during and after an ISB, where to station air monitoring personnel to protect workers and downwind receptors. Be capable of selecting appropriate air monitoring equipment and demonstrating how read-out from the equipment relates to health-protective action levels. Familiarity with Special Monitoring of Applied Resource Technology (SMART) protocols developed by various government agencies (USCG, USEPA, NOAA, CDC, BSEE). Be capable of reviewing, critiquing and approving a QAPP for monitoring of airborne hazards.

Figure 3—ISB SOFR PQS Competency Area #3

Competency Area #4: Terminating the ISB Response

Requisite Knowledge	Requisite Skill
Worker Exposure Briefing and Record Keeping	
Understand the purpose and content of worker exposure briefings and medical surveillance such as that required by HAZWOPER regulations. Understand the purpose and components of a Site Safety Plan (SSP).	Be capable of performing safety briefings which address the hazards, exposure routes and health risks resulting from oil or chemical exposure and procedures for minimizing exposures. Be capable of describing the signs and symptoms of overexposure to oil constituents, combustion byproducts or chemicals which may be present during an ISB response. Be capable of assisting incident command in assembling an ISB SSP which meets HAZWOPER regulation requirements.
Response Effectiveness, Analysis and Critique	
Understand the purposes and components of a post-incident analysis and the activity sectors that should be analyzed. Understand the purpose of a critique: that is, communicating the lessons learned from personnel assigned to each type of task, including safety.	Be capable of assisting in an after-action review of ISB activities from a safety standpoint and assist in preparation of a report for use in the incident critique.

Figure 4—ISB SOFR PQS Competency Area #4

2.1 Critical Role of Communications

The key to a successful and safe ISB is good communications. The safety of response and associated, non-response personnel will depend on adherence to a HASP and the availability and proper use of reliable communications equipment prior to and throughout an ISB operation. Such communications will be needed to warn all participants and observers about the intent to burn oil and to provide information regarding potential health and safety hazards. Proper notifications can help prevent the unexpected movement of people, aircraft and vessels into pre-designated restriction zones. In addition, routine status reports to the public and stakeholders through a Liaison Officer and Public Information Officer can help reduce the kinds of over-reaction and misinterpretation which can occur during a highly visible activity such as ISB. To assist in public communications, **Appendix C** contains FAQs and answers intended to serve as draft material for explaining the process of ISB and potential hazards associated with the smoke plume or lack thereof, to responders and/or the public.

2.2 Simultaneous Operations (SIMOPS)

During a response it is expected that different operations will be performed at the same time. In order to ensure that responders working outside of the burn operations do not interfere or accidently enter the burn area, coordination of the different operations needs to be handled. Often, this is performed in cooperation with a separate response organization branch able to track locations of response personnel and resources and ensure that safety zone boundaries and use of pre-established ingress and egress routes are enforced.

3 ISB Hazard Anticipation, Recognition, Evaluation and Control

3.1 Overview

This section covers hazard Anticipation, Recognition, Evaluation and Control (AREC) for ISB operations. In general, hazards from ISB operations will be related to:

— the spilled oil;

— response activities;

— the impacted/surrounding environment; and

— exclusion zone control.

In the sections below, each of these hazards is addressed in turn, through discussions of how each of these hazards can be evaluated and controlled. New hazards should be evaluated and controlled as they become known.

Despite the perceived hazards of ISB ignition, fire, and the resulting smoke plume, these have not been found to present the highest risks to responders. For example, lessons learned and injury logs from the Deepwater Horizon response, where ISB was used as a countermeasure, show that the highest hazards were due to vessel to vessel transfers, thermal stress (i.e., heat stress not from ISB), fatigue, slips, trips and falls (e.g., on small boats or crew vessels) and ergonomics (e.g., hand, arm, back and muscle strain). Cold stress may also be a general hazard to response workers in cold climates. As the Guide is designed to assist SOFRs and safety and health professionals in the context of an ISB, these generic hazards will not be discussed except when relevant to unique aspects of performing an ISB.

In order to anticipate ISB hazards, safety personnel can take actions in advance, such as becoming familiar with ISB operations, knowing the hazards associated with spilled oils and controlled burns, reviewing past burn plans and HASPs, and discussing operations and lessons learned with experienced

ISB responders. By anticipating hazards, a SOFR or an associated safety and health professional can better prepare for the pre-tactics and tactics meetings conducted during specific incidents.

Recognition of hazards typically initially occurs during the pre-tactics meeting when the JSA is started. Hazard recognition continues to occur as the operations are prepared and executed. Field evaluations of potential hazards is critical for proper development of HASPs and JSAs. Because new information will become available as the operations progress, the anticipation and recognition phases, as part of the continuous improvement process, need to be repeated in order to address the hazards. Once hazards are recognized, then they need to be evaluated to assess their risks and to determine what control or mitigation measures should and could be implemented. Evaluation can be performed using different risk assessment tools; no matter how it is done, results need to be clearly documented. Furthermore, as new information changes initial evaluation inputs, a new risk assessment should be performed, documented and communicated. An after action review process may also be performed to determine if controls measures were effective in promoting safe work practices and serve as tool for continued improvement of safety in the future.

The control measures selected for ISB operations, such as wearing fire resistant clothing and using skimmers to recover the residue, should reduce the overall risk, not increase it or transfer it. The hierarchy of controls should always be considered with risk elimination and risk substitution being preferred. Risk elimination or substitution is to be followed by, in order of preference, engineering controls, work practice and administrative controls, and PPE. Safety personnel can consult API Recommended Practice 98, *Personal Protective Equipment Selection for Oil Spill Responders* (API 2015b) to aid in PPE selection. Once control measures have been chosen, then responders need to be trained before they are implemented. Control measures found ineffective or that increase risks should be quickly re-evaluated.

3.2 Spilled Substance

3.2.1 Petroleum Hydrocarbon Oils

The ability to ignite and sustain an ISB is related to the volatile petroleum hydrocarbon content of the spilled petroleum hydrocarbon liquid or product (referred to as “oils”). The volatile hydrocarbon vapors are the fuel source which facilitates ISB ignition and acts to maintain the burn. There is a wide range of petroleum hydrocarbon liquids or products (referred to as “oils”), but not all are candidates for ISB. For instance, gasoline, a refined petroleum product is typically not considered for a controlled ISB as its properties (highly flammable) make burning it more difficult to control. Moreover, gasoline, which is predominately composed of lighter ends, generally evaporates too quickly to facilitate a controlled burn. Conversely, very viscous oils, such as bitumen, are typically composed of few volatile compounds and are very difficult to ignite and maintain combustion.

The principle hazards associated with oils, generally, are[2]:

— flammability;

— explosive vapors;

— toxicity;

— acute inhalation hazards [Hydrogen sulfide (H_2S)];

— the slippery nature of oil.

[2] Adapted from IPIECA, 2012, p. 6

3.2.2 Properties of Petroleum Hydrocarbon Oils

The Occupational Safety and Health Administration (OSHA) notes that an " 'average' crude oil contains 84% carbon, 14% hydrogen, 1–3% sulfur, and approximately 1.0% nitrogen, 1.0% oxygen, and 0.1% minerals and salts" (OSHA, 1999). The properties of the spilled oil will, of course, depend on the actual material as each will possess different characteristics (**Table 1**). Oils have been classified into five groups based on their chemical and physical characteristics which influence their behavior once spilled. In general:

— **Group 1** oils (e.g. gasoline, jet fuel) are very volatile, have a low flashpoint and high vapor pressure, and are not recommended for an ISB due to the high volatility and the risk of flashback (USCG, 2003).

— **Group 2** oils (e.g. no. 2 fuel oil, diesel fuel) are moderately volatile and the lower explosive limit tends to be low. These oils are good candidates for ISB. On water, Group 2 refined oils do not emulsify and the crude oils are slow to emulsify (>24 hours) (USCG, 2003).

— **Group 3** oils consist of medium weight oils (e.g. medium crudes and no. 4 fuel oil). Although they are good candidates for ISB, on water they emulsify rapidly, typically reducing the window of opportunity to successfully initiate ISB to less than 24 hours.

— **Group 4** oils (e.g. diluted bitumen (dilbit), bunker C fuel, no. 6 fuel oil) are some of the heaviest that will burn. On water, the window of opportunity is limited for Group 4 oils as they emulsify quickly and, once emulsified, are difficult to ignite (USCG, 2003).

— **Group 5** oils have low volatile content, require intensive ignition efforts, and are not good candidates for ISB. They tend to sink in water.

Table 1 illustrates the vast differences between the groups' behaviors which influences their amenability to ISB. Depending on the composition of an oil, these properties will vary even within the Groups.

Table 1—Oil Groups and General Behaviors[3]

Group	Behaviors
Group 1: Gasoline products—Not a Candidate for ISB for Safety Reasons	Specific gravity is < 0.80; API gravity >45. Very volatile and highly flammable. Evaporate and dissolve rapidly (in a matter of hours). Narrow cut fraction with no residues. Low viscosity; spreads rapidly into thin sheens. Will penetrate substrates but are not sticky. High acute toxicity to animals and plants.
Group 2: Diesel-like Products and Light Crude Oils—Candidate for ISB	Specific gravity range of 0.80-0.85; API gravity range of 35-45. Moderately volatile and soluble. Crude oils can leave residue after evaporation is complete. Low to moderate viscosity; spreads rapidly into thin slicks. Are more bioavailable than lighter oils (in part because they persist longer), so are more likely to affect animals in water and sediments.

[3] Modified from API (2001): Table 1

Group	Behaviors
Group 3: Medium Crude Oils and Intermediate Products—Candidate for ISB	Specific gravity range of 0.85–0.95; API gravity range of 17.5–35. Moderately volatile. For crude oils, up to one-third will evaporate in the first 24 hours. Moderate to high viscosity; will spread into thick slicks. Are more bioavailable than lighter oils (because they persist longer), so are more likely to affect animals in water and sediments.
Group 4: Heavy Crude Oils and Residual Products—Might be a Candidate for ISB	Specific gravity range of 0.95–1.00; API gravity range of 10–17.5. Very little product loss by evaporation or dissolution. Very viscous to semi-solid; might require heating during transport. Can form stable emulsions and become even more viscous. Tend to break into tar balls quickly. Low acute toxicity to water-column biota. Penetration into substrates will be limited at first, but can increase over time. Can cause long-term effects via smothering or coating, or as residues in the water column and sediments.
Group 5: Sinking Oils—Not a Good Candidate for ISB on Water or Ice	Specific gravity >1.00; API gravity < 10. Very little product loss by evaporation or dissolution. Very viscous to semi-solid; might require heating during transport or blended with a diluent which can evaporate if spilled into the environment. Low acute toxicity to water-column biota. Penetration into substrates will be limited at first, but can increase over time. Can cause long-term effects via smothering or coating, and as residues in sediments.

3.2.3 Hazard Recognition, Evaluation, and Control for Burning Petroleum Hydrocarbon Oils

To perform an ISB, hydrocarbon vapors which evaporate from spilled oil during the early stages of a response are ignited to promote beneficial oil removal through combustion. However, the same vapor emissions which are key to igniting and sustaining an ISB can also pose a significant physical hazard to spill response workers if vapors drift away from a slick at a concentration which can unintentionally or unexpectedly ignite. Air monitoring of hydrocarbon vapors around the incident is an important step in determining where an exclusion zone and/or safety zone boundary should be established. Hydrocarbon vapor air monitoring results, as well as wind speed and direction data, can also inform those overseeing the ISB as to preferred ignition options and direction of approach. This air monitoring can be performed with combustible gas detectors which are available from a variety of commercial vendors. The SOFR should consult with members of the UC/IC to agree on action levels for flammable atmospheres (i.e., above which it is not safe to remain in the area), which in most settings is 10% of the lower explosive limit (LEL). Of note, atmospheres containing hydrocarbon vapors at levels considered hazardous to human health, but below a point of concern for flammability, are possible during oil spill responses. Therefore, both flammability hazards and chemical hazards (discussed below) should be evaluated in parallel for establishment of exclusion zones and safe working conditions.

A summary of key physical hazards relating to ISB fire hazards and control measures are presented in **Table 2** below:

Table 2—Flammability/Fire Hazards and Control Measures for ISB

Hazard/Cause	Risk/Effect	Control Measures
Intense fires [a]	Responder might not be able to move quickly enough or far away enough from heat	A, B, C, E, F, G, H, I, J, K, M, N, O
	Severe burns, thermal stress	A, B, C, D, G, H, I, J, K, M, N, O
	Damage to equipment	A, B, D
	Responder injury or equipment, vehicle, or vessel damage due to sudden site evacuation	A, B, D, E, F, G, J
Secondary fires or Unintentional fires [b]	Unexpected and uncontrolled burns	A, B, D, I, J, K, L, M, N
	Burns outside of set boundaries	A, B, D, I, J, K, L, M, N
	Injury to responders and/or public	A, B, C, D, E, G
Flashback [c]	Burns to responders and damage to equipment	A, B, C, G, H, I, J, K, M, N, O
Incidental fires [d]	Burns to responders and damage to equipment	A, B, C, G, H, I, J, K, M, N, O
	Equipment loss or failure	A, B, D, E, G, I, K, M, N
	Loss of transportation (vessel, vehicle)	A, B, D, E, G, I, K, M, N
	Damage to environment	A, B, D, K, N

Control Measures Key:

A. Develop a communications plan and burn plan.
B. Monitor weather, winds, and currents and designate ISB safety zones.
C. Keep responders more than 4 fire diameters away from burn except for short amounts of time (then no closer than 2 fire diameters). Does not apply to firefighters in turnout gear.
D. Ensure there is no vessel or vehicle movement in areas where concentrations of VOCs pose an ignition threat
E. Develop a traffic/vessel control plan.
F. Assign positions, outline responsibilities, and ensure personnel are trained for their position.
G. Brief personnel before each shift regarding safety plans.
H. Use Hazardous Waste Operations and Emergency Response (HAZWOPER) and ISB trained personnel.
I. Keep all possible ignition sources at safe distances from spilled oil.
J. Develop a site-specific health and safety plan (HASP), air monitoring plan, and emergency action plan.
K. Prepare emergency burn termination procedures and pre-ignition checklists.
L. Control oil slick movement with boom or barriers.
M. Keep other sources of fuel from site.
N. Onsite firefighting equipment staged in "*fire-free*" zone surrounding the burn.
O. Level D PPE plus fire resistant clothing

Notes: [a] Ability to burn with intense heat due to volatility. [b] Unintentional fires may occur due to migration of low flashpoint, flammable hydrocarbon vapors away from the spill location and unplanned introduction of an ignition source.[c] Vapors could allow the flames to spread at rates up to 91 meters/second creating a significant hazard to the responders working near the site. [d] Due to equipment malfunction or localized fuel spill.

3.2.4 Chemical Hazards and Controls for Spilled Oil

The term "oils" includes a wide range of chemical mixtures that originate from crude oil. Oils are composed of hydrocarbons which are individual chemicals that are composed of carbon and hydrogen. Oils contain aliphatic and aromatic[4] hydrocarbons. A small percentage of the overall chemical composition of oil are chemicals which contain nitrogen, oxygen or sulfur in addition to carbon and hydrogen. Some "sour" oils contains hydrogen sulfide (H_2S), a toxic and flammable gas, which can lead to severe acute toxicity at high concentrations (i.e. > 20 ppm). The chemical composition of oils are not uniform in nature, varying even within the same oilfield (OSHA, 1999).

[4] Aliphatic refers to petroleum hydrocarbons with straight or branched chains or non-aromatic, cyclic rings of carbon and hydrogen atoms all joined with single bonds. Aromatic refers to single or conjugated planar rings with alternating single or double bonds.

Volatile petroleum hydrocarbons (e.g. benzene, toluene, ethyl benzene and xylene [BTEX] and short-chain hydrocarbons < C_{12}) are the most likely to be inhaled by response workers and also have the greatest potential to be an inhalation hazard prior to ISB ignition. **Table 3** is a summary of acute and chronic health effects associated with constituents of oil. Air monitoring of hydrocarbon vapors and comparison to occupational exposure limits (OELs) can aid in determining where an exclusion zone and/or safety zone boundary should be established. **Table 4** is a summary of control measures for chemical hazards associated with constituents of oil and chemicals used during ISB operations.

Table 3—Health Effects of Selected Volatile Components of Oil [5]

		Benzene	Cyclohexane	Ethyl benzene	n-Hexane	Toluene	Xylenes	Naphthalene	Butane	Hydrogen Sulfide
Acute Health Effects	Eye, nose, and/or upper respiratory tract irritation	x	x	x	x	x	x	x		x
	Central nervous system effects (dizziness, headaches, narcosis)	x	x	x	x	x	x	x	x	x
	Dyspnea, shortness of breath	x						x		
	Nausea	x	x	x	x	x	x	x	x	x
	Dermatitis		x	x	x	x	x			x
	Numbness, muscle weakness				x					
	Respiratory sensitization							x		
	Dilated pupils and lacrimation									x
	Eye injury		x			x	x			
Chronic Health Effects	Known human carcinogen (IARC-1)	x								
	Possible carcinogen (IARC-2B)		x	x				x		
	Dermatitis, defatting, or drying/cracking of skin	x	x		x	x	x			
	Peripheral nervous system effects				x					
	Central nervous system (CNS) effects	x				x	x		x	x
	Weight loss									x
	Liver injury					x	x			
	Kidney injury					x	x			
	Cataracts							x		
	Anemia (aplastic/hemolytic)	x						x		

Source: OSHA, 2015; NIOSH, 2015.

[5] It is important to note that the acute and chronic health effects listed below would not automatically be expected to occur upon exposure to crude oil vapors. The potential to experience health effects is determined by the intensity, duration, frequency and route of exposure as well as interindividual sensitivity. Different acute and chronic health effects would occur at different dose thresholds. In a controlled work environment, most people's exposure to crude oil vapors occur at levels and durations which would not be associated with an adverse health effect.

Table 4—Chemical Hazards of Spilled Oil and Control Measures.

Hazard/Cause	Risk/Effect	Control Measures
VOC inhalation [a,e]	Acute effects (general)-irritant to skin, eyes and respiratory tract, CNS depressant, drowsiness, fatigue	A, B, C, D, E, F, G, H, I
	Acute and chronic health effects due to specific constituents (see Table 3)	
Hydrogen Sulfide inhalation [b,e]	Sudden loss of sense of smell	A, B, C, D, E, F, H
	Acute effects (see Table 3)	
Dermal contact with oil constituents [c,e]	VOCs-Absorption into blood stream and systemic toxic effects	A, B, D, E, I, J, K, L, M
	VOCs-Irritation of skin	
	VOCs-Dermatitis	
	Heavier Compounds-Irritation d	
	Heavier Compounds-Dermatitis	
	Heavier Compounds-Sensitization of skin	

Control Measures Key:

A. Develop site specific safety plan & air monitoring plan.
B. Develop with Operations Section safe work practices focused on keeping personnel free of contamination and away from fresh oil.
C. Keep personnel, vessels, vehicles upwind of spilled oil.
D. Use HAZWOPER trained personnel.
E. Train personnel on hazards of contact and inhalation of oil and to report symptoms of overexposure.
F. Continuously perform real-time area monitoring with multi-gas meter for VOCs and hydrogen sulfide.
G. Monitor personnel for VOCs (full shift samples) to characterize exposures.
H. Select, provide and train responders on use of PPE as determined by Job Safety Analysis (JSA).
I. Keep public away from fresh oil.
J. Substitute, if possible, solvent based degreasers with safer products.
K. Prevent secondary contamination and accidental ingestion of oil - provide hygiene facilities or materials for hand, arm and face washing.
L. Establish decontamination station.
M. Train personnel on proper use of PPE and ensure appropriate PPE is available for use.

[a] Inhalation of VOCs which have high vapor pressure (i.e. likely to evaporate).

[b] Inhalation of hydrogen sulfide from sour crude oil or the decomposition of biological materials in oil.

[c] Handling oil coated equipment, ropes and boom, operations where there is the potential for oil contaminated water to splash (e.g., boat operations, boom retrieval), and performing post-burn maintenance on the boom.

[d] Polycyclic Aromatic Hydrocarbons (PAHs), creosote, coal tar.

[e] The SOFR may consult with technical specialists, such as Industrial Hygienists or Toxicologist, regarding acceptable exposure limits and potential toxicities which may result from inhalation exposures or dermal contact with petroleum products.

Continuous or frequent monitoring with real-time instrumentation should be employed to measure concentrations of different constituents in the air during the response. Common examples of real-time instruments which can be used to monitor hydrocarbon vapors and gases include multi-gas meters equipped with photo-ionization detectors (PIDs) and chemical-specific colorimetric detection tubes. PID equipped multi-gas meters are not chemical-specific and provide a readout for total volatile organic compounds (VOCs) which is appropriate for monitoring the complex mixtures of hydrocarbon vapors which are emitted from crude oil. Colorimetric detector tubes are chemical-specific and can be used to detect individual hydrocarbon constituents of crude oil which may be present as vapors. There are also some chemical-specific real-time monitoring instruments, such as benzene and H_2S monitors, which are commercially available. In addition, in order to characterize personal exposures, consideration should be given to full shift, personal sampling (analytical) for constituents of concern associated with the spilled oil using passive diffuser badge (preferred) or industrial hygiene sampling pumps. The SOFR may consult with Technical Experts with expertise in air monitoring or industrial hygiene in order to select appropriate air monitoring equipment and methodology, to understand the strengths and limitations of air monitoring equipment which may be available during an oil spill response, to establish air monitoring protocols and to interpret the resulting data.

In order to evaluate potential inhalation hazards for responders, airborne concentrations of volatile chemicals and gases need to be compared to occupational exposure standards selected for use as action levels during a response. Many organizations, such as the US Coast Guard (USCG), default to using the American Conference of Industrial Hygienists (ACGIH) Threshold Limit Values (TLVs) as an occupational exposure standard for response activities. TLVs are typically based on the most current science and more conservative than Occupational Safety and Health Administration (OSHA) Permissible Exposure Limits (PELs). Occupational exposure standards for select volatile petroleum hydrocarbons and H_2S which can be found in oil are listed in **Table 5**. There is no occupational exposure standard for crude oil hydrocarbon vapor mixtures. However, total VOC readouts may be compared to occupational exposure standards for hydrocarbon vapor mixtures which have a similar constituency as what would be expected from crude oil (i.e. gasoline vapors). The SOFR should consult with Technical Specialists, the public health lead, other members of the UC/IC and other available resources (i.e. toxicologists, public health professionals) in order determine the scope and breadth of an air monitoring protocol for volatile hydrocarbon vapors and which occupational exposure standards may be appropriate for use in evaluating potential exposures to response workers. For additional reference, the reader is referred to the *Emergency Response to Oil Spill Initial Sampling Strategy* developed by OSHA for air monitoring crude oil spills (OSHA, 2010).

Table 5—Occupational Exposure Standards and Guidelines

Analyte	CAS Number	ACGIH		OSHA		NIOSH		Units
		TLV-TWA [a]	TLV-STEL [b]	PEL-TWA [c]	PEL-Ceiling [d]	REL-TWA [e]	REL-STEL [f]	
Benzene	71-43-2	0.5	2.5	1	5	0.1	1	ppm
Cyclohexane	110-82-7	100	NE	300	NE	300	NE	ppm
Ethyl benzene	100-41-4	20	NE	100	NE	100	125	ppm
n-Hexane	110-54-3	50	NE	500	NE	50	NE	ppm
Toluene	108-88-3	20	NE	200	300, 500**	100	150	ppm
Xylenes	varies	100	150	100	NE	100	150	ppm
Naphthalene	91-20-3	10	NE	10	NE	10	15	ppm
Hydrogen Sulfide	7783-06-4	1	5	NE	20, 50**	NE	Ceiling 10**	ppm
Gasoline Vapors	8006-61-19	300	500	500	NE	NE	NE	ppm

NE = Not Established. **10-min peak per 8-hour shift.

[a] ACGIH The Threshold Limit Value-Time Weighted Average (TLV-TWA) is the concentration for a normal 8-hour workday and a 40-hour workweek, to which nearly all workers could be repeatedly exposed, day after day, without adverse effect (ACGIH, 2015).

[b] ACGIH Threshold Limit Value-Short-Term Exposure Limit (TLV-STEL) is the concentration that shall at no time be exceeded (ACGIH, 2015).

[c] OSHA Permissible Exposure Limit-Time Weighted Average (PEL-TWA) is the permissible concentration in air of a substance that shall not be exceeded in an 8-hour work shift or a 40-hour work week (OSHA 29 CFR 1910.1000).

[d] OSHA Permissible Exposure Limit-Ceiling (PEL-Ceiling) is the concentration to which workers cannot be exposed to for any period of time. If instantaneous monitoring is not feasible, then the ceiling shall be assessed as a 15-minute time-weighted average (TWA) exposure, which shall not be exceeded at any time during the working day. (OSHA 29 CFR 1910.1000).

[e] NIOSH Recommended Exposure Limit-Time Weighted Average (REL-TWA) is a concentration believed to be protective of worker safety and health over a working lifetime (NIOSH, 2015)

[f] NIOSH Recommended Exposure Limit-Short-Term Exposure Limit (REL-STEL) is a 15-minute TWA exposure that should not be exceeded at any time during a workday (NIOSH, 2015).

3.3 Response Activities

3.3.1 Burn Operations Plan

In order to maintain organization within the response effort, a site-specific burn operations plan and an ISB application will be drafted prior to ignition. Approval of the burn operations plans and the ISB application must be obtained from UC/IC prior to ignition. The ISB Worker Health and Safety Plan, a supplement to the overarching HASP, will also need to be developed prior to approval. The ISB Worker Health and Safety Plan should specifically address operational details included in the Burn Operations Plan (Burn Plan) as the risks associated with any particular burn will need to be addressed on a case-by-case basis. The Burn Plan includes:

— **Resources:** Details the equipment and personnel needed to execute an ISB.

— **Burn feasibility:** Verification that topographic circumstances, current weather conditions, proximity to population centers and access for ignition are suitable for initiation of an ISB.

— **Operational checklists:** A chronological checklist of all operations critical for completion before, during, and after ignition.

— **Action plan:** To supplement the operational checklists, a plan that details vehicle and vessel deployment, method of ignition, weather forecasts, types and amount of vegetation (for on-land ISB) and water conditions (for near-shore and off-shore ISB) for the specific geographic area.

— **Communications:** Means of communication between operations and various stakeholders.

— **Burn termination criteria:** Pre-established criteria that indicates the environment, community or worker health or safety is threatened and ISB operations must be terminated.

3.3.2 Response Vehicles and Use of Fire Breaks (on-land ISB).

For land-based ISB, a variety of different response vehicles and equipment can be used to help facilitate burn operations and potentially provide means for containment of an ISB to a defined geographic area. Types of vehicles and equipment potentially used during a land-based ISB include passenger vehicles or work trucks, fire engines, portable fire foam tanks, emergency medical service (EMS) vehicles and mobile trailers. Each of these vehicle types represents a hazard to workers in the area of an ISB. Construction equipment, such as bulldozers and backhoes can also be used to construct fire breaks prior to initiating a land-based ISB. The ISB Worker Health and Safety Plan should include information on the location of fire breaks and safe-distances from fire breaks during ISB activities. The ISB Worker Health and Safety Plan should also include general information of vehicle and traffic safety in addition to information regarding hazards associated with specialized vehicles or construction equipment.

3.3.3 Boom Handling

Fire boom is larger and heavier than conventional boom which can create additional stressors to the responders handling it (USCG, 2003). Boom retrieval is particularly difficult as the fabric might become waterlogged and damaged due to the fire which increases the ergonomic and crushing/pinch point hazards. Likewise, fire boom can become slippery and could be a dermal contact hazard when it is contaminated with oil or burn residue (USCG, 2003). Workers handling boom should be equipped with proper PPE that limits dermal contact with spilled oil or burn residue.

Figure 5—Fire Boom Being Deployed from Vessel During Training
(USCG, 2010a)

For on-water ISB, booms are often retrieved using cranes and winches on a vessel's deck. When booms are being moved using equipment, responders should keep clear of cables and lines under tension and out of their bight (a loop where, if tightened, could entrap a person and cause serious injury). Crane operations on vessels can be particularly hazardous as the roll of a vessel can swing a load uncontrollably or cause it to fall. Cranes safety precautions, such as using a lead line to control the load, should be developed.

Figure 6—Deck Operations for Boom Deployment
(USCG, 2010b)

3.3.4 Vessel-to-Vessel Transfers (On-water ISB)

Although not entirely unique to ISB operations, vessel to vessel transfers were determined to be one of the most hazardous tasks during Deepwater Horizon ISB operations (Mabile 2013). Vessel to vessel transfer hazards include man overboard, pinch points, crushing (between the two vessels), and crane line failure which may result in severe injury/death and drowning. Controls to prevent injury include developing JSAs for the task, ensuring personnel are trained on performing transfers, and maintaining and testing crane function prior to use (Mabile, 2013). Additional controls include:

— ensuring the sea state is below 3 on the Beaufort scale[6];

— requiring personnel to wear a Type 1 Personal Flotation Device (PFD);

— requiring two people to assist the person being transferred;

— clear communications between the vessels performing transfer;

— explicit approval from receiving vessel for transfer to commence;

— having a life ring with a retrieving line at the rail;

— readying a portable rescue ladder;

— performing a safety brief prior to transfer that includes man overboard procedures.

3.3.5 Use of Additives

In some situations, additives are used to promote ignition of the spilled oil. Prior to selection for use, the additive Safety Data Sheet (SDS) should be reviewed to ensure that the hazards can be controlled to reduce risk to an acceptable level. Ignition promotion additives usually have the desired characteristic of being very flammable. For example, fresh light crude oil, gasoline, diesel and kerosene have been used as ignition promoters. Emulsion breaker additives, such as aluminum chloride, may also be used to reduce the oil's water content to facilitate ignition and sustained burning. These chemicals are highly acidic skin and eye irritants. Risks, therefore, include fire, skin and/or eye irritation, and dermatitis in addition to the risks discussed earlier associated with oils. Other additives to oil slicks (e.g. oil herders) can be used to alter surface tension, constrict a slick's surface area, and thicken to oil to make it more amenable to ISB.

3.3.6 Igniter Operations

Ignition devices each have their own set of hazards and should only be assembled and used by trained personnel following manufacturer's or developer's directions. Key hazards of ignition devices are generally associated with the materials used such as gelled fuel, gasoline, crude oil, diesel, or a mixture thereof, which can result in fire or explosion if not properly handled. Another, although lesser, hazard is dermal exposure to the chemicals used which can result in skin irritation or chemical absorption. Studies have not found that commercial ignition devices are susceptible to accidental activation, temperature extremes, or vibration (Buist et al., 2013).

When soaking rags or sorbent materials for use as an ignition device, it is recommended that diesel be used as it has a more powerful flame and is slower burning (Buist et al., 2013). Flares, used alone with a float or attached to gelled fuel in a plastic bottle, can be used to ignite floating oil. Inland and in marshes, propane and butane torches and weed burners (see Figure 7) have been used to ignite oil (Buist et al., 2013). Additional information on ignition systems can be found in the *Interagency Aerial Ignition Guide* (NWCG, 2015) and *Interagency Ground Ignition Guide* (NWCG, 2011) from the National Wildfire Coordinating Group.

Controls to mitigate igniter hazards include working with the manufacturer to develop the best ignition system, training personnel involved in ignition procedures, measuring for VOCs prior to deploying igniter, and ensuring, for aerial deployment, that aircraft fly perpendicular to the position of vehicles, vessels or boom to reduce possibility of flying over personnel (NOAA, 1996).

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[6] The Beaufort Sea scale is a measure that relates wind speed to the observed conditions at sea or on land. For more information see http://www.rmets.org/weather-and-climate/observing/beaufort-scale

Figure 7—Igniting Oil with a Propane Burner
(Photo source: API, 2002)

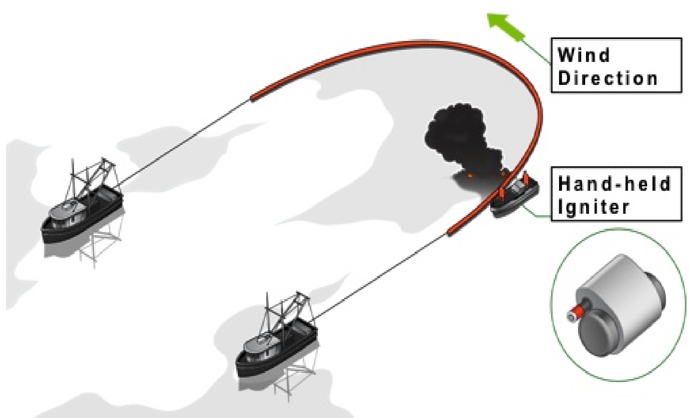

Figure 8—Fire Boom Deployed Using Two Vessels with Hand-held Ignition
(Drawing courtesy of BP)

3.3.7 Fire Control

Similar to ignition control, fire control has the added issues of distance and size (Mabile, 2013). Burning should not be used when there is the potential for the fire to spread uncontrollably or back to the source (well, tank, truck, pipeline, railcar, vessel, etc.) (ARPEL, 2006). Regional Response Team (RRT) IV (1995) directs that a risk assessment, at a minimum, needs to include:

— the expected size and duration of burn based on estimated oil volumes, burn rates and burn-area control measures, etc.;

— the location of the burn and any possible change in location due to spreading of oil on land or water, equipment failure, construction of fire break or use of containment boom, etc. (this should include the possible movements of personnel, response vehicles and vessels and animals to areas where potential exposures to excessive heat and/or combustion products is reduced or eliminated);

— the movement and duration of burn for any oil that might be released (accidentally or in response to an emergency) from within an area of controlled burning;

— the location and type of fixed equipment/facilities that could conceivably be exposed to burning oil or heavy concentrations or combustion products.

On land, the fuel loading of vegetation[7] which could be accidentally ignited should be considered (API, 2015a). Responders may consider the removal or reduction of excess vegetative fuel or construction of a fire break which separates the spilled oil from vegetative fuel sources as a fire control measure.

Red flag conditions indicate that a burn should be postponed, and include:

— wind gusts greater than 40 mph (35 knots);

— relative humidity less than 20 %;

— air temperature greater than 80 ºF; or

— a cold front is expected to pass within the next 12 hours (air inversion) (API, 2015a).

The best way to control a burn is to manage containment or barriers effectively. On land, different types of fire breaks apply depending on terrain and circumstance. These include a wetted perimeter, a line of mowed vegetation, felled trees or tilled ground, ditches, roads or even snow and ice. On water, fire boom is commonly used as an oil collection and containment method. Fire booms also provide containment barriers for some inland burns, such as those performed in a wetland or to supplement burns performed on ice or snow. For oil spilled amongst ice on water, breaks in the ice can naturally contain the slick if ice is thick enough. However, low concentrations of ice will not function well as containment and fire boom could be needed.

There are techniques to help prevent secondary fires. Personnel should be aware that during inland burns, even well-planned firebreaks and berms might not provide a sufficient barrier to prevent secondary fires. Responders and safety personnel should be vigilant during the burn, constantly monitoring the potential of the fire to escape containment. Having on-the-ready firefighting resources present during a burn is a control measure to address secondary fires that may start outside the main containment barrier. Even though extinguishing a burn can be difficult after ignition, on-the-ready firefighting resources can help terminate a burn if circumstances warrant. On water, if boom is used in a tow, in order to prevent the fire from reaching the towing vessels, the direction of movement should be into the wind and at a speed matching the flame's propagation rate (approximately 0.4 knots) (ARPEL, 2006).

3.3.8 Terminating the Burn

As a burn is terminated, either naturally or intentionally, risks from burn operations are greatly reduced. On land or on water burns, fire monitors or water cannons can be stationed nearby in strategic locations to help control a burn (USCG, 2003). Aircraft with water-bombing capabilities can also be used for on-land burns if available (ARPEL, 2006). API (2015a) notes that, for pool fires, firefighting foam could help suffocate a fire but there needs to be enough foam supply or this control measure might not succeed. Should foam be selected as a control, calculations will need to be performed and vetted with the firefighters prior to the burn.

[7] Vegetative fuel loading refers to the weight per unit area of fuel, typically expressed in terms of tons per acre or tonnes per hectare.

During Deepwater Horizon, several methods were tested and found to work to terminate on-water burns. Fires can be extinguished over water by having the towing vessels speed up, entraining oil into the water as it escapes under the fire boom, allowing the fire to self-extinguish when the fuel loading becomes minimal. An alternative method is to have one vessel release its boom and allow the oil/fire slick to dissipate, thereby reducing slick thickness to a point below that needed to sustain a burn. Caution should be used with this option as it will allow the fire to expand initially in size as it increases the spread of the oil slick thereby increasing the radiant heat and smoke production (USCG, 2003).

3.3.9 Residue Clean Up

After termination of an ISB, the burn area may contain burn residue with higher viscosity and differing chemical composition (i.e., relatively higher content of high molecular weight hydrocarbons) as compared to the parent oil. The burn area could also contain some amount of unburned oil that can potentially be reignited if it has sufficient volatile components and is of sufficient thickness for ignition. Unlike unburned oil, burn residue is depleted of volatiles and would be difficult to ignite. On land unburned oil or burn residue can be recovered using a variety of manual or mechanical methods. On water, unburned oil or burn residues often continue to float, which would facilitate recovery efforts. However, residues may also sink, hindering recovery.

Recovery methods on land and water include using containment boom, sorbent boom and pads, manual recovery (e.g. shovels), or mechanical equipment once the residue or unburned oil has cooled. On water, for residue or unburned oil that has sunken, options include using fishing trawlers and divers. Manual recovery in open water is usually performed from a low-freeboard vessel. Mechanical recovery can be accomplished with larger vessels. Recovered residue will need to be stored for transportation. On land, residue is typically loaded directly into a tank truck. On a vessel, a tank or floating bladder can be used.

Chemical hazards of unburned oil may be similar to those listed in **Table 4** for freshly spilled oil. Chemicals hazards of burn residue are predominantly dermal as the volatile components have been removed. Control measures for dermal contact with spilled oil listed in **Table 4** may also be appropriate when addressing burn residue. Steps for reducing risk associated with recovery of unburned oil or burn residue include development of a task-specific JSA, reigniting unburned oil to reduce amount, allowing unburned oil or residue to remain in environment, using mechanical equipment for recovery whenever feasible, and training responders on how to recover these materials safely with emphasis on ergonomics and back safety.

3.3.10 Decontamination

Decontamination of personnel and equipment prevents cross contamination to other areas. On shore, the OSR decontamination plan can be used for ISB operations. On vessels, decontamination can be a difficult task due to limitations in the space, the amount of support personnel and equipment available, including storage for contaminated rinse water, and the ability to safely remove PPE on a moving platform. Each vessel that handles contaminated equipment and boom should establish a decontamination zone on the deck of the vessel when feasible in order to remove gross contamination prior to reaching shore where a more thorough decontamination can be performed. Likewise, personnel should be decontaminated to prevent exposure and cross contamination to the interior of the vessel.

Hazards of decontamination include exposure to aerosolized petroleum hydrocarbons and dermal contact, thermal stress, slips, trips and falls, and ergonomic issues. The risks include injury, illness and muscle-skeletal strain. Controls include developing a JSA for the decontamination station prior to operations and ensuring an appropriate amount of supplies and personnel are on-site.

3.4 The Working Environment During an ISB

The hazards encountered in the working environment during response could include severe weather, insects and wildlife, poisonous plants, slips, trips and falls, thermal stress, ultra-violet radiation, fatigue, stress, noise, work over-water, ice or land, and night operations. These hazards are not unique to ISB operations and, as such, are not addressed in this Guide. References to learn more about how to assess the risk and control hazards associated with the working environment include: *NIEHS Oil Spill Cleanup Training Tool* (NIEHS 2010) and *IPIECA Oil Spill Responder Health and Safety* (IPIECA, 2012) both of which are in the bibliography[8].

3.4.1 Most Common ISB Hazards

The hazards most commonly identified during ISB as having the potential to impact the working environmental is heat from the fire as well as the thick, black smoke plumes produced by burning the oil. The sections below discuss heat as a hazard of the working environment near an ISB as well as various components of an ISB smoke plume and controls to help limit potential exposures to these components.

3.4.2 Heat

Burning of oil produces intense heat. Reported flame temperatures for burning crude oil have been reported in excess of 2100 °C. The heat from an ISB will move away from the source, through the atmosphere either as conductive (i.e. transferred through the air) or radiative (i.e. transferred through the heating of nearby objects), and decrease in intensity with distance from the source. Production of heat by an ISB creates a potential hazard for response workers. The heat from ISB can contribute to heat exhaustion in response workers and could burn unprotected skin given a sufficient exposure period and heat intensity.

3.4.3 Combustion By-Products

Once ignited, the oil removal rate is a function of the type of oil, its thickness, and environmental conditions with most burns lasting less than an hour (Buist et al., 1999). The volume of oil during a burn is rapidly reduced. Oil will burn at a rate of approximately 1.0 - 4.5 millimeters (mm) of thickness per minute depending on the type of oil, percent water content (emulsification), and its initial thickness. Thicker oil slicks typically burn faster and then slow down as oil is removed. For example, Group 2 oils greater than 10 mm thick can burn at a rate of 4.0 mm/min initially and will slow down to approximately 2.0 mm/min as the thickness decreases to 5 mm. Once a burn is complete, the production of combustion by-products stops.

The combustion by-products produced during a burn are illustrated in **Figure 9**. On a percentage mass basis, carbon dioxide (CO_2) and water are the predominant combustion by-products produced by burning of oil. However, burning of oil also produces smoke, which is a visible suspension of particulate matter in air. This particulate matter (PM) is primarily composed of carbon and commonly referred to as soot. Burning of oil can produce smaller amount of combustion gases (carbon monoxide (CO), nitrogen oxides (NO_x), sulfur oxides (SO_x)). In an outdoor environment, the concentrations of these combustion gases will rapidly dissipate in the atmosphere. Burning of oil can also result in emission of volatile organic compounds (VOCs) and polycyclic aromatic hydrocarbons (PAHs). PAHs will be predominantly adhered to carbon particulates in smoke.

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[8] During the Deepwater Horizon event, the National Institute of Occupational Health and Safety (NIOSH) developed guidance for oil spill responder health monitoring and surveillance which may also be of use to ISB Safety Officers (King and Gibbins, 2011).

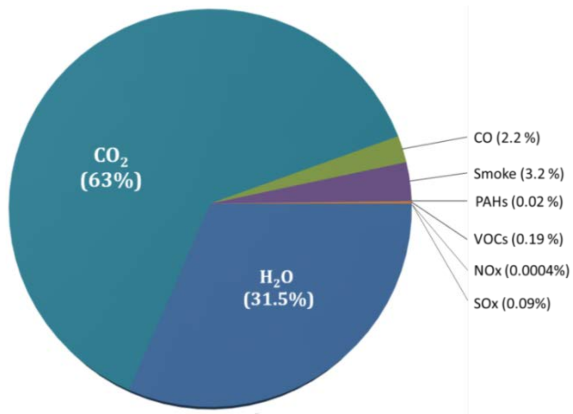

Figure 9—Graphical Depiction of Emissions from ISB
(adapted from Booher and Janke, 1997)

The thick, black smoke in the burn plume can be of concern to nearby human populations or ecologically sensitive areas and resources but is often not a human health concern more than a few kilometers downwind if there is good atmospheric mixing. Since most PM precipitation occurs near the fire, this is the main area of concern.

3.4.3.1 Smoke Particulates

The visible black particulate matter which emanates from burning of oil is 80% to 90% inert elemental carbon with only trace amounts of organic compounds (Booher and Janke, 1997). It is important to note that the quantity of PM produced by a burning pool of oil will be influenced by the type of petroleum that is burning. This PM yield ranges from 1 to 15% of the original oil volume (Fingas, 2011; Ferek et al., 1997). For example, approximately 5-8% of the volume of burning diesel fuel is emitted as PM, compared to 1 to 2% for burning crude oil (Fingas, 2010).

The individual particles in particulate matter are not uniform in size. Some components of particulate matter are large enough to be seen as smoke. Others are so small that they can only be detected with electron microscopy. All particulate matter produced by ISB is transported into the air by turbulence and updrafts. Larger particles usually remain in the air for a few minutes to hours and settle to the ground near the source; while smaller particles (aerodynamic diameter of ten micrometers and smaller, PM_{10}) can remain in the air from several days to weeks and be spread by winds over wide areas or long distances from the original source (Middlebrook et al., 2011). These particles are generally removed from the atmosphere by wet precipitation or when they come in contact with other surfaces. Only the smallest particles (aerodynamic diameter of 2.5 micrometers and smaller, $PM_{2.5}$) tend to remain in the air for long periods; however, as distance from the burn increases, the dilution of particulate matter in the atmosphere increases.

3.4.3.2 Combustion Gases

The combustion gases emitted during an ISB generally do not provide a serious threat to human-health and safety except in the direct vicinity of a burn. The concentrations of gases in a smoke plume can exceed concentration levels of concern at a burn origin point, yet are quickly diluted below such thresholds within very short distances from the fire. There are many oxygenated gaseous combustion by-products generated during an ISB, including carbon dioxide, water vapor, carbon monoxide, sulfur oxides, sulfuric acid, nitrogen oxides, and VOCs. Research has shown that these by-products are common components of any petroleum oil combustion and are found to have little concern to downwind populations under most weather conditions.

3.4.4 Less Common Hazards: Atmospheric Temperature Inversion

A temperature inversion occurs when the air temperature close to the earth cools down creating apocket overlaying thin layer of warmer air that acts like a lid that prevents normal convective overturning of the atmosphere from penetrating through the inversion (**Figure 10**). This typically occurs at night as the sun sets and the air temperature cools. This phenomenon could prevent airborne PM (such as smoke from an ISB) from rising vertically and dispersing but does not prevent lateral transport and dispersion of PM horizontally. The height of where the inversion occurs negatively influences the height of the mixing layer.

Because of the potential for atmospheric inversions, ISB operations are not typically performed during early morning hours or at night as this can increase the risk of the smoke plume remaining close to the ground thereby potentially decreasing visibility and increasing the potential for exposure of responders. However, in some cases, especially in remote areas on land or ice, night operations can be performed due to the time sensitivity of ISB. API (2015a) states that atmospheric stability classes A, B, and C[9] (unstable) are best for ISB operations when there is strong solar radiation and low wind speed creating increased atmospheric turbulence. A stable atmosphere, on the other hand, could possibly keep the smoke close to the ground. The timing of initiating an ISB can be adjusted to occur before or after atmospheric temperature inversions or during stable conditions to help facilitate vertical transport and dispersion of PM and other combustion by-products.

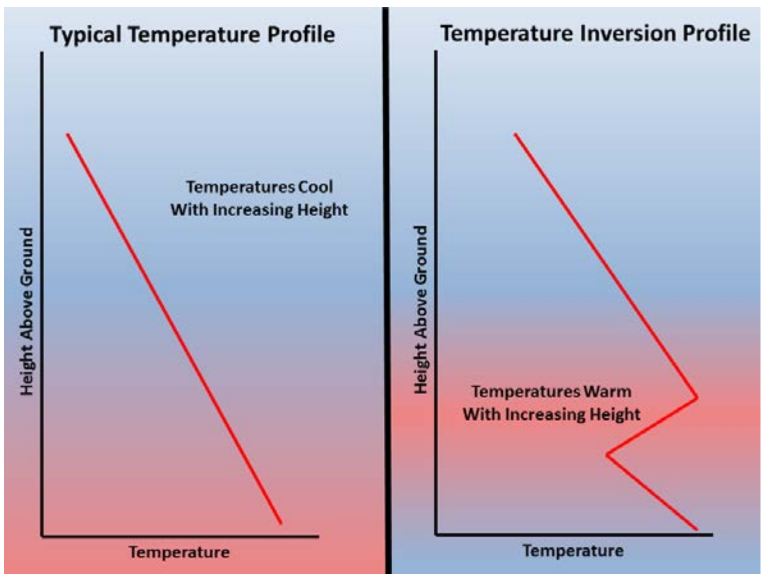

Figure 10—Temperature and Inversion Profiles

3.4.5 Hazards and Controls for Smoke Plumes

Because of its visibility and size, the smoke plume associated with the controlled burning of oil is often the factor of largest concern for the public and responders. The public may perceive visible smoke plumes as harmful even though actual health impacts may be minimal or absent. In order to ensure that the smoke plume does not become an actual concern for the responders or public, an understanding of where and in what concentration the plume will likely travel should be achieved prior to burn operations. Projecting the movement and dilution of a smoke plume and monitoring the concentration of particulates (based on size)

[9] See API (2015a) Appendix C for information regarding atmospheric stability classes.

are the primary means to evaluate the risks associated with the plume. Monitoring for selected sizes of particulate matter (e.g., $PM_{2.5}$ and PM_{10}) will better characterize the plume's true hazards.

Fine carbon particulate matter ($PM_{2.5}$) represents the greatest hazard to the general public and responders. The $PM_{2.5}$ (fine) particulates are small enough in size that they can be inhaled deeply into the lungs; PM_{10} (coarse) particulates can also be inhaled, but are typically caught in the thoracic region of the respiratory system and, therefore, do not penetrate deep into the lungs. Fine PM can be transported from the combustion source, due to wind and environmental stability, resulting in potential inhalation exposures for a wider area of the public. Of note, airborne particulate matter is often present as a component of background in many locations. The SOFR may coordinate with technical experts (such as Environmental Scientists or Incident Meteorologist) to determine site-specific background concentrations of ambient particulate matter. For near shore or on-land burns, ISB air monitoring should be coordinated with an overall incident air monitoring plan which may include monitoring of both responders and the community surrounding a spill.

Volatile organic compounds, PAHs, and combustion gases are additional combustion by-products of burning oils that, while also having the potential to impact human health, will pose less of a concern for the public given their relatively lower emissions and rapid dilution into ambient air which will act to minimize exposures.

When evaluating the risk of exposure to particulate matter in the smoke plume for responders, the National Response Team (NRT) recommends using the United States Environmental Protection Agency's (USEPA) National Ambient Air Quality Standards (NAAQS) for $PM_{2.5}$ and PM_{10} and averaging the concentration levels over one hour (not 24 hours) to ensure that overall PM NAAQS are not exceeded at any time. In addition, the USEPA has established an air quality index (AQI) based on $PM_{2.5}$. The AQI is a nationally uniform index used for reporting and forecasting daily air quality. The AQI informs the public how clean or polluted the air is using a standardized vocabulary (i.e. Good, Moderate, Unhealthy, etc.,) and an easy-to-understand normalized numerical scale of 0 to 500 which corresponds to a range of airborne $PM_{2.5}$ concentrations (USEPA, 2012). The SOFR, in cooperation with local public health officials, regulators and Incident Command, should determine which health standards are applicable for ensuring that response personnel and the public are not overexposed to respirable particulates and other combustion by-products and determine appropriate response actions relating to transient decreases in air quality associated with ISB.

Table 6 summarizes estimates of airborne emissions from burning crude oil at the burn site and one kilometer downwind and compares them health standards available in the literature[10]. As shown in **Table 6**, particulate concentrations are highest at the burn site but decrease quickly with distance as particulates become diluted with the ambient air, disperse, and fall out (Buist et al., 2013). Although the levels of $PM_{2.5}$ and PM_{10} are expected to exceed their NAAQS at the site of the burn, the levels will rapidly dissipate as distance increases from the smoke source. For example, following controlled burns of oil released in the Deepwater Horizon spill, fine particulate matter concentrations were reduced to 0.007-0.02 mg/m^3 at a distance of ~39 kilometers downwind of the spill (Middlebrook et al., 2012). In other monitored oil burns, total suspended particulate concentrations within the smoke plume were between 100-180 mg/m^3 and dropped to <0.20 mg/m^3 when measured approximately 30 meters downwind of the plume (Booher and Janke, 1997). Particulate concentration would need to be monitored at ground level during a burn in order to understand the potential hazard for response personnel and the public.

[10] OELs, such as ACGIH TLVs and OSHA PELs, can be applied to responder exposures; however, for community or public health exposures, preferential consideration should be given to use of the EPA National Ambient Air Quality Standards (NAAQS) and any applicable state standards.

Table 6—Estimated Airborne Emissions from Burning of Oil and Comparison to Occupational and Public Health Standards

Component of Concern		Occupational Standards [a]	Public Health Standards [a]	Range at the Burn Site	Range One Kilometer Downwind
Smoke Particulates	$PM_{2.5}$	Not Established	35 μg/m^3 (24 hr EPA NAAQS) 0–12 μg/m^3 (AQI: 0–50, Good) 12.1–35.4 μg/m^3 (AQI: 50–100, Moderate) 35.5–55.4 μg/m^3 (AQI: 101–150, Unhealthy for Sensitive Subgroups) 55.5–150.4 μg/m^3 (AQI: 151–200, Unhealthy) 150.5–250.4 μg/m^3 (AQI: 201–300, Very Unhealthy) > 250.5 (AQI: 301–400, Hazardous)	0.0–2.4 mg/m^3 [b] (from diesel)	No data identified for ISB
	PM_{10}	Not Established	150 μg/m^3 (24 hr EPA NAAQS)	850 μg/m^3 [c]	86 μg/m^3 [d]
PAHs		200 μg/m^3 (OSHA PEL) [e]	Not Established	0.0–13.1 μg/m^3 [b]	No data identified for ISB
Gases and Vapors	CO_2	5,000 ppm (OSHA PEL)	Not Established	26 - 543 ppm [f]	<32 ppm [g]
	SO_2	0.25 ppm (ACGIH STEL) 5 ppm (OSHA PEL)	0.075 ppm (1 hr EPA NAAQS) 0.5 ppm (3 hr EPA NAAQS)	2 ppm [h,i]	< 0.0012 ppm [i]
	NO_2	5 ppm (OSHA Ceiling)	0.1 ppm (1 hr EPA NAAQS)	0.0001–0.0006 average ppm [j]	0.0001 ppm [j]
	CO	50 ppm (OSHA PEL)	35 ppm (1 hr EPA NAAQS) 9 ppm (8 hr EPA NAAQS)	0.14–0.15 average ppb [j]	0.14 ppb [j]
	Total VOCs [k]	300 ppm (ACGIH TLV) 500 ppm (OSHA PEL)	Not Established	0.0026–0.0083 average ppm [j]	0.0013–0.0016 ppb [j]

Notes: Units of ppm are most appropriate for gases and vapors, and μg/m^3 is more appropriate for particulates and fumes. [a] USEPA (2015) [b] Fingas & Punt (2000). [c] Buist et al. (1999). [d] Fingas et al. (1994). [e] While the Occupational Safety and Health Administration (OSHA) has not established an occupational exposure standard for PAHs, there is an exposure limit for volatiles from coal tar pitch that covers the PAHs anthracene, benzo(a)pyrene, phenanthrene, acridine, chrysene, and pyrene. The current air standard for coal tar pitch volatiles in the workplace is 0.2 milligram/cubic meter (mg/m^3) based on an 8–hour time-weighted average (TWA) permissible exposure limit (PEL) for the benzene-soluble fraction of coal tar pitch volatiles. [f] Fingas (2010) [g] Fingas et al. (1995) [h] Booher & Janke (1997) [i] Note that the level of SO_2 is dependent on the amount of sulfur in the oil. SO_2 levels are typically very low. Detection tubes can be used to perform real time sampling. Buist et al. (1999). [j] Middlebrook et al. (2012). [k] The ACGIH Threshold Limit Value (TLV) provided is for gasoline vapors. There are no established limits in U.S. for VOCs, crude oil or total hydrocarbons. Fingas et al. (1994) notes that the VOCs emitted from crude oil exceed those emitted from burned oil

Airborne particulate concentrations can be evaluated using real-time instrumentation such as aerosol monitors. These types of instruments can be equipped with size-selective impactors which measure particulate matter concentrations within a particular size distribution. Collection of real-time readings will allow safety personnel to monitor air quality related to the ISB and advise response workers or members of UC/IC of actions which may be taken to minimize potential exposures. The SOFR may consult with technical experts in the fields of air monitoring and/or industrial hygiene to ensure proper selection, use and calibration of aerosol monitors based on site-specific conditions.

The concentration of PM downwind of a burn can be difficult to predict as they are dependent on “soot yield, fire size, burn efficiency, distance downwind from the burn, terrain features, and atmospheric conditions” (Buist et al., 2013). Therefore, to support safety personnel and responders in determining if the conditions support a burn, computer models have been developed to estimate the distances over which smoke plumes will impact over flat and complex terrain (Buist et al., 2013). Models include, but are not limited to: NOAA’s HYSPLIT[11] and NIST’s ALOFT[12].

Modeling software can be used by the NOAA Scientific Support Coordinator (SSC) or a technical specialist to assist the SOFR and Burn Boss in determining if the burn plume trajectory would be favorable or unfavorable based off of available atmospheric data. Modeling results are dependent on the mixing layer depth relative to the elevation of the burn site, terrain, and wind speed. Mixing layer depths are related to the atmospheric stability with very stable atmospheres, such as those that occur at night, coinciding with low mixing layer depths (Buist et al., 2013).

This type of modeling has been performed previously to predict the distance required for PM generated as part of an ISB smoke plume to reach concentrations that fall below levels of concern for human health based off of the PM_{10} and $PM_{2.5}$ NAAQS. As an example, Buist et al. (2013) used ALOFT to predict the time it would take for PM_{10} and $PM_{2.5}$ to fall below the NAAQS of 150 µg/m^3 and 35 µg/m^3, respectively, as a function of terrain height and mixing layer depth. Results from this modeling could be useful when either air monitoring data is not available, when performance of air monitoring during a burn is not feasible, or when developing the HASP for the initial burn. The tables below (**Table 7** and **Table 8**) summarize the ALOFT modeling results from Buist et al. (2013), whereas**Table 9** summarizes physical and chemical hazards posed by smoke from an ISB and lists possible control measures to mitigate subsequent risks.

Table 7—Estimated PM_{10} Concentrations Downwind of Burn Below 150 µg/m^3

Kilometers Downwind For One-hour Average PM_{10} from a Crude Oil Burn to Fall Below NAAQS of 150 µg/m^3						
Fire Size	**Terrain Height (m)**	**Mixing Layer Height (m)**				
		0 to 100	**100 to 250**	**250 to 500**	**500 to 1000**	**> 1000**
1000 oil barrels (bbl)/hour (160 m^3/hour	0 to 25 (flat terrain)	5	4	3	2	1
	25 to 250	10	8	6	4	3
	250 to 500	15	12	10	8	5
	> 500	20	17	15	12	10
2000 bbl/hour (320 m^3/hour)	0 to 25 (flat terrain)	7	6	5	4	3
	25 to 250	12	10	8	6	5
	250 to 500	17	14	12	10	7
	> 500	22	19	17	14	12
(Buist et al., 2013, page 239)						

11 The HYSPLIT (Hybrid Single Particle Lagrangian Integrated Trajectory) modeling software was developed by the National Oceanic and Atmospheric Administration (NOAA) to perform simple air parcel trajectories and complex dispersion and deposition simulations (http://www.arl.noaa.gov/documents/Summaries/hysplit_trifold.pdf).

12 The ALOFT (A Large Outdoor Fire Plume Trajectory) modeling software was developed by the National Institute of Standards and Technology (NIST) to predict the downwind distribution of smoke particulates and combustion products for large outdoor fires.

Table 8—Estimated $PM_{2.5}$ Concentrations Downwind of Burn Below 35 µg/m3

Kilometers Downwind for One-hour Average PM2.5 from a Crude Burn to Fall Below NAAQS of 35 mg/m3						
Fire Size	**Terrain Height (m)**	**Mixing Layer Height (m)**				
		0 to 100	**100 to 250**	**250 to 500**	**500 to 1000**	**> 1000**
1000 bbl/hour (160 m^3/hour)	0 to 25 (flat terrain)	12	11	10	9	8
	25 to 250	17	15	13	11	10
	250 to 500	22	19	17	15	12
	> 500	27	24	22	19	17
2000 bbl/hour (320 m^3/hour)	0 to 25 (flat terrain)	14	13	12	11	10
	25 to 250	19	17	15	13	12
	250 to 500	24	21	19	17	14
	> 500	29	26	24	21	19
(Buist et al., 2013, page 239)						

Table 9—Hazards and Control Measures for Smoke Plumes

Hazard	Risk/Effect	Controls
Black smoke [a]	Loss of ability to see other responders or operations	A, B, C, D, E, F, G, H, I, J, K, L, M, N, O, Q
	Disorientation	
	Concern of public and responders as to their health and health of environment	
	Create shorting or grounding in high voltage power lines	
Airborne smoke particulates (soot) [b]	Fine PM is small enough to access the gas exchange regions of the lung when inhaled	A, B, C, D, E, F, G, H, I, J, K, L, M, N, O
	At moderate to high concentrations it is an eye, nose and respiratory irritant	
	High concentrations can cause persistent cough, phlegm, wheezing, and difficulty breathing.	
	Individuals with pre-existing respiratory or heart disease may have increased sensitivity to smoke compared to the general population.	
	Can be transported considerable distances from the combustion source, resulting in potential inhalation exposures for a wider area of the public	
	EPA NAAQS PM levels may be exceeded	
Additional combustion by-products [c]	Levels of CO could be high in plume. Past monitoring has not found CO to be an issue if there is no entry into the plume	A, B, C, D, E, F, G, H, I, J, K, L, M, O
	Overexposure to CO can result in headache, nausea, dizziness, confusion and at high concentration levels, can lead to asphyxia and death	
VOCs [d]	This will pose less of a concern than PM given that their relatively lower emissions and rapid dilution into ambient air will act to minimize exposures to these constituents	A, B, C, D, E, H, J, O
	VOCs can be detectable within smoke plume above burning oil yet concentrations are usually below OELs and decrease quickly as plume moves from burn site	
PAHs [e]	This will pose less of a concern than PM given that their relatively lower emissions and rapid dilution into ambient air will act to minimize exposures to these constituents	A, B, C, D, E, H, J, O
	PAHs concentrations are higher in oil than in smoke as they are burned in combustion process. Levels decline quickly as smoke plume moves away from burn site	
	There are no symptoms of overexposure	

Table 9 —Hazards and Control Measures for Smoke Plumes (continued)

Combustion gases (CO_2, NO_x, and SO_x) [f]	Their rapid dilution into ambient air will act to minimize exposures to these constituents	A, B, C, D, E, F, G, H, I, J, K, L, N, O
	CO_2 (an asphyxiant) is predominant combustion gas and concentrations can be elevated at burn site. Concentrations decline to background immediately as smoke moves away from burn.	
	Overexposure to CO_2 can result in headache, dizziness, shortness of breath, increased heart rate. At very high concentration levels, exposure can lead to convulsions, asphyxia, coma and death	
	Studies have shown only very low concentration levels of NO_x or SO_x in smoke plumes; well below NAAQS and OELs	
Surface contamination [g]	Primarily an aesthetic concern, can be difficult to remove soot once it penetrates material	A, D, E, J, K, O, P

Control Measures Key:

A. Account for hazards of smoke plume in burn plan and health and safety plan
B. Brief personnel prior to burn on safety plan and emergency action plan; debrief post burn to gather lessons learned
C. Train personnel to never position themselves or their teams immediately downwind of smoke plume
D. Plan for location and movement of all personnel and vessels/vehicles during burn
E. Move auxiliary vessels/vehicles upwind and up current from burn site
F. Designate ISB safety or control zones & publish in Federal Aviation Administration (FAA) Notice for Aviators & USCG Notice to Mariners
G. Use traffic controllers to enforce zones
H. Ensure communications plan is in place and meets needs of responders & support teams
I. Predict ISB plume safety zone distances using modeling or tables; use NAAQS as exposure limit when determining zone size
J. Obtain weather prediction (wind, air inversions, and temperatures)
K. Ensure no population centers are immediately downwind and account for potential wind shifts
L. Pre-stage air monitoring stations
M. Perform real-time monitoring of CO, $PM_{2.5}$ and PM_{10} for responders and nearby receptors (if applicable); deploy SMART[1] monitoring if conditions or location warrants it
N. Use NRT guidance and set action level at NAAQS for $PM_{2.5}$ and PM_{10} for 1 hour, TWA
O. Prepare risk communication plan for responders, stakeholders and public
P. Clean structures and vehicles contaminated with soot
Q. Remain clear of high voltage power lines; notify utility if power lines or transformers are nearby.

Notes:

[a] Can impede visibility to personnel, vessels, aircraft.

[b] Is predominantly made of fine particulate matter (PM) with average of less than 1 micrometer (µm) in diameter.

[c] Produced during incomplete combustion and carried in smoke plume.

[d] Are additional decomposition products which can be carried from burn in smoke and reach responders or public.

[e] Decomposition products are carried from burn in smoke and reach responders or public.

[f] These gases are created during burn and carried from burn in smoke plume; can reach responders or public.

[g] Contamination of surfaces with soot and other particulate matter produced by incomplete combustion.

For inland or near-shore burns, the timing of an ISB can be adjusted to in an effort to manage the smoke that will be produced. Delaying a burn could be useful if current meteorological conditions might produce an undesired impact on nearby receptors (i.e., communities or ecological receptors) or if more favorable wind conditions are anticipated that would be more advantageous in helping loft and disperse the smoke plume. The *Smoke Management Guide for Prescribed and Wildland Fire* published by the National Wildfire Coordinating Group (NWCG, 2001) provides useful information regarding smoke management practices which could be applicable to ISB. Those involved in planning for an ISB could consider consulting with an incident meteorologist[13], an expert weather forecaster with specialized training regarding fire behavior and fire operations, to determine an optimal time window for initiation of an ISB.

3.5 Site Control

3.5.1 Safety Zones Control

Site control and monitoring of the burn area is necessary to ensure responders and non-responders do not enter the burn area without permission. Typically, responders are required to report to the Burn Boss before entering or departing the burn area. Risks of not having well-planned site control include injury or illness to bystanders or responders, spread of fire, and exposure to the oil or smoke plume.

Prior to ISB operations, safety zones will need to be established around the burn site for the responders. A safety zone defines where it is safe for responders during a controlled burn and takes into consideration possible flashback during ignition, risk of secondary or unintentional fires, proximity to the heat from the fire, and exposure to smoke emissions.

The potential for causing injury to response workers is a function of both the level of heat and the duration of exposure. Protective distances from large fires can be determined using the fire diameter as a rule-of-thumb. A fire diameter is defined as the distance from one side of the fire to the opposite side. If the area of a fire is not circular, a fire diameter can be conservatively determined as the distance between the two furthest points on the edge of the fire boundary. The safe approach distance to an *in-situ* oil fire is from two to four times the distance of the fire diameter away from the closest edge of the fire, depending on duration of exposure, as shown in **Table 10**. Prior to initiating an ISB a safe approach distance can be estimated based on the expected area of the fire and the duration of work activities to be conducted. After initiating the ISB, if the area of the fire deviates from that estimated prior to ignition, safe approach distances might have to be reconsidered.

Table 10—Safe Approach Distances for In-situ Oil Fires

Duration of Work Activity	Safe Approach Distance (in fire diameters)
Unknown	4
30 min	3
5 min	2
Source: Buist et al., 2003	

[13] To learn more about incident meteorologists (IMETs) and their role in wildland fire response, visit: http://www.noaa.gov/features/02_monitoring/imets.htm

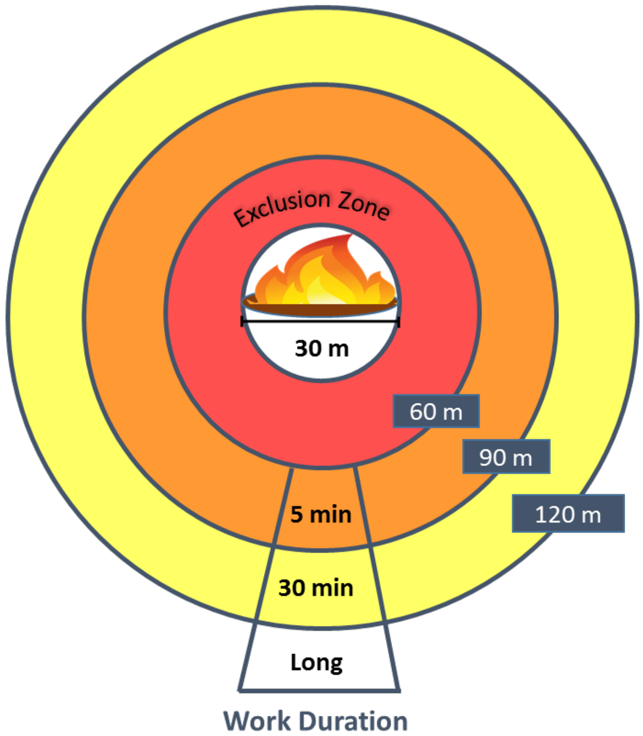

Figure 11—Example Exclusion Zones Based on Fire Diameter

For on-water burns, it is important to recognize that the oil contained in a towed boom is relatively thick in the early stages of a burn and that this thickness is maintained by towing or holding vessel position relative on oncoming current. If the towing was to stop or slow or the boom was to break, then this thick layer would spread quickly to cover an area several times that of the previously boomed oil. This will increase the fire diameter, the heat flux from a fire, and the need for responders to move further away to avoid injury or discomfort.

In addition, for inland and near shore burns, API (2015a) notes that very heavy smoke can lead to shorting or grounding of high voltage transmission lines by conducting electricity. One control to consider is to keep responders at least 30 meters from the furthest extent of the power line (API, 2015a). Likewise, if insulators are coated with a dense layer of soot, over time they could short to ground (API, 2015a). In order to prevent this from occurring, ISB should be avoided near high voltage lines and the line operators should be notified (API, 2015a).

3.5.2 Traffic Control

Traffic control supports site control in preventing non-response assets and personnel from entering a burn area where they could be exposed to hazards. Traffic control entails developing, as needed, land, sea and air traffic routes and detours to ensure non-responders do not inadvertently enter the burn area or are exposed to the smoke plume. Traffic routes, support areas and no-entry zones should be documented using appropriate maps. Prior to and during burn operations, the Operations Section needs to coordinate with the local airports, marinas, state and local highway agencies, and local law enforcement to ensure that notifications are made to the public. Official notifications include, but are not limited to, the FAA for Notice to Aviators and the USCG for Notice to Mariners. Notifications should be coordinated with the Public Information Officer (a position in the NIMS / ICS Command Staff) and should be documented in communications section of the burn operations plan.

4 Summary and Conclusions

An ISB SOFR should be able to display a number of competencies whose requisite knowledge and skills center upon anticipating, recognizing, evaluating and controlling (AREC) hazards that are both common to OSR activities and unique to ISB operations. General categories of hazards identified for ISB operations include those from the spilled substance, response activities, the working environment and inadequate site control:

— hazards from the spilled oil include flammability (fire and explosion), vapor inhalation and direct contact;

— hazards associated with response activities include the operation of response vehicles and vessels, unique tasks performed during an ISB (i.e. use of additives, igniter operations, fire control) as well as residue cleanup and decontamination;

— hazards most commonly associated with the work environment are heat from the ISB fire and combustion by-products produced during the ISB, particularly smoke particulates;

— lastly, inadequate site controls, such as improper delineation of the burn area and failure to establish "fire-free" zones and traffic control measures may have negative impacts on the safety of response workers.

The information contained in the Guide will aid SOFRs and safety professionals in understanding and preparing for the types of hazards that can be encountered in a situation where ISB is considered as a response option. Most of the risks are related to flammability, fire hazards and exposure to heat (responders, equipment, and burning non-target areas): see **Table 2**. However, some hazards which can be encountered during a response can be associated with exposure to volatile oil components or use of chemicals (e.g., promoters or accelerants) during ISB: see **Table 3 and Table 4**. For easy reference, pertinent OELs from ACGIH, OSHA, and NIOSH are presented in **Table 5**. Possible hazards associated with ISB emissions (gas and particulate) are presented in **Tables 6–8**. **Table 9** provides a summary of hazards, their potential effects, and AREC-based control options. Safe approach distances for control of exposure to heat are presented in **Table 10**.

This Guide identifies PQS information and competencies for SOFRs, ISB hazard types, their potential risks or effects, and a variety of control measures for each hazard type. To support ISB Safety Officers prior to and during an ISB, the following information is also provided:

— U.S. Federal Agency Sources and Websites

— Bibliography of Recommended Readings

— List of Acronyms and Abbreviations

— References

— Appendices

The appendices include: A) A general example for a responder Health and Safety Plan (HASP) which includes its own set of six appendices including air monitoring; B) an example Job Safety Analyses (JSA) for inland, near shore, and on-water ISB; and C) risk communication tools in a Q&A format to aid a SOFR in preparing site-specific plans in advance of an ISB operation.

5 U.S. Government Agency Sources and Websites

Source: United States Coast Guard (USCG)

Link: https://homeport.uscg.mil/ under Library tab is link to Incident Command System

Summary of information provided:

— Incident Management Handbook (IMH)

— ICS forms

— ICS job aids

— USCG Safety Officer PQS for Type 3 incidents

Source: Federal Emergency Management Agency (FEMA)

Link: http://training.fema.gov/EMIWeb/is/ICSResource/index.htm

Summary of information provided:

— ICS review documents

— ICS training courses

— ICS job aids

— ICS forms

— ICS position checklists

— NIMS reference documents

Source: Environmental Protections Agency (EPA) On-Scene Coordinator

Link: http://epaosc.org/default.aspx under Health & Safety tab

Summary of information provided:

— Safety Officer Toolbox

— EPA's Emergency Responder Health and Safety Manual

Source: National Oceanic and Atmospheric Administration (NOAA)

Link: http://response.restoration.noaa.gov/oil-and-chemical-spills/oil-spills/response-tools/response-tools-oil-spills.html under the Office of Response and Restoration

Summary of information provided:

— Modeling tools

— Environmental Sensitivity Index Maps and data

— Publications specific to ISB under the "Publications" link

Source: Centers for Disease Control and Prevention (CDC)/National Institute for Occupational Safety and Health (NIOSH)

Links: http://www.cdc.gov/niosh/ & http://www.cdc.gov/niosh/topics/oilspillresponse/

Summary of information provided:

— NIOSH Pocket Guide (free to download)

— NIOSH Manual of Analytical Methods

— Human Health Evaluations for Deepwater Horizon Response Workers

— Exposure data for ISB operations from Deepwater Horizon

— Lessons learned from Deepwater Horizon Response

— Information on hazards typically encountered at oil spill

Source: National Institute of Environmental Health Sciences

Safety and Training of Oil Spill Response Workers

Link: http://tools.niehs.nih.gov/wetp/index.cfm?id=2495

Summary of information provided:

— Booklet of safety awareness training material for clean-up workers

— Training material

— Information also provided in Spanish and Vietnamese

Source: U.S. Army Corps of Engineers

Safety and Occupational Health

Link: http://www.usace.army.mil/SafetyandOccupationalHealth.aspx

Summary of information provided:

— EM 385-1-1 Safety and Health Requirements Manual

    — vehicle and machinery safety,

    — load handling equipment,

    — electrical safety, and

    — material handling, storage and disposal

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7 Acronyms and Abbreviations

ACGIH	American Conference of Governmental Industrial Hygienist
AEGL	Acute Exposure Guideline Levels
AIHA	American Industrial Hygiene Association
API	American Petroleum Institute
AQI	Air Quality Index
AREC	Anticipate, Recognize, Evaluate, and Control
BBL	Barrels
BTEX	Benzene, Toluene, Ethyl Benzene, and Xylene
Burn Boss	ISB Burn Group Supervisor
CDC	Center for Disease Control and Prevention
CNS	Central Nervous System
CO	Carbon Monoxide
CO_2	Carbon Dioxide
DOE	Department of Energy
DWH	Deepwater Horizon
EMS	Emergency Management Services
ERPG	Emergency Response Planning Guidelines
FAA	Federal Aviation Administration
FEMA	Federal Emergency Management Admin.
H_2S	Hydrogen Sulfide
HASP	Health and Safety Plan
HAZWOPER	Hazardous Waste Operations and Emergency Response
IARC	International Agency for Research on Cancer
IC/UC	Incident Commander/Unified Commander
ICP	Incident Command Post
ICS	Incident Command System
IHM	Incident Management Handbook

ISB	*In-situ* Burning
JSA	Job Safety Analysis
LEL	Lower Explosive Limit
mg/m^3	Milligrams per cubic meter
$\mu g/m^3$	Microgram per cubic meter
NAAQS	National Ambient Air Quality Standards
NIMS/ICS	National Incident Management System/Incident Command System
NIOSH	National Institute for Occupational Safety and Health
NOAA	National Oceanic and Atmospheric Administration
NOx	Nitrogen Oxides
NRT	National Response Team
O_2	Oxygen
OEL	Occupational Exposure Limit
OSHA	Occupational Safety and Health Administration
OSR	Oil Spill Response
PAH	Polycyclic Aromatic Hydrocarbons
PEL	Permissible Exposure Limit
PFD	Personal Flotation Device
PID	Photo-ionization Detector
PM	Particulate Matter
PPB	Parts Per Billion
PPE	Personal Protective Equipment
$PM_{2.5}$	Particulate Matter of 2.5 Microns in Diameter or Smaller
PM_{10}	Particulate Matter of 10 Microns in Diameter or Smaller
PPM	Parts Per Million
PQS	Performance Qualification Standard
REL	Recommended Exposure Limit
RRT	Regional Response Team

QAPP Quality Assurance Project Plan

SDS Safety Data Sheet

SIMOPS Simultaneous Operations

SMART Special Monitoring of Applied Response Technologies

SOFR Safety Officer

SO_2 Sulfur Dioxide

SOx Sulfur Oxides

SSC Scientific Support Coordinator

STEL Short-term Exposure Limit

TEEL Temporary Emergency Exposure Limits

TLV Threshold Limit Value

TWA Time Weighted Average

UEL Upper Explosive Limit

USCG United States Coast Guard

USEPA United States Environmental Protection Agency

VOC Volatile Organic Compounds

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(This link goes to a secure server that requires a login; please contact EPA for further information)

Appendices

Appendix A: General Example of an ISB Worker Health and Safety and Plan

Appendix B: Examples of JSAs for Inland, Near Shore, and On-Water ISB

Appendix C: Frequently Asked Questions (FAQs) Regarding Conduct of ISB

Appendix A

General Example of an ISB Worker Health and Safety Plan

GENERAL EXAMPLE[14]

In-Situ Burn (ISB) Worker Health and Safety Plan[15]

Prepared for:

Prepared by:

Date:

Worker Health and Safety Plan Approval:

Signature	Agency / Organization	Date
Signature	Agency / Organization	Date
Signature	Agency / Organization	Date

[14] This document is an example of what type of information may be included in an ISB Health and Safety Plan and must be tailored to the Burn Operations Plan, spill and burn location, response personnel and working conditions. It is not comprehensive and may need to be expanded to address the hazards assessed in the ISB Job Safety Analysis. Adapted from Sample Site Safety Plan for Marine In-Situ Burn Operations, NOAA, 1996.

[15] The ISB Worker Health and Safety Plan is intended to complement the comprehensive Site Safety Plan (SSP) developed for all spill response operations. Information pertaining to all operations, such as the hazards of oil, thermal stress, and fatigue, does not need to be repeated in the ISB Health and Safety Plan; rather, it is presumed that all operations follow the safety requirements of the SSP while additional requirements are included in the ISB Health and Safety Plan.

1.0 *In-Situ* Burn (ISB) Overview

1.1 Site Location [16]

The spill source is located ____.

At _______ (time) the location / leading edge was:

Lat ________________N, Long __________________W.

1.2 Predicted Weather Conditions

Insert current conditions and future forecasts including temperature, humidity, winds and precipitation. For off-shore or near-shore locations include information on sea state, water temperature and tides/currents where applicable.

2.0 Objectives

All work shall be conducted in accordance with procedures established during pre-burn briefings and work plans. A site specific safe work plan will be provided by the *In-Situ* Burn Group supervising the burn and support services. Detailed objectives will be developed daily in accordance with the Burn Operations Plan. Daily objectives will be communicated to personnel during the pre-departure operations and safety briefing.

3.0 Response Organization

3.1 Overview

The organizational chart outlining each critical task will be established during development of the Burn Operations Plan. The ISB Worker Health and Safety Briefing Sheet will be reviewed and signed off on by each worker prior to operations. Likewise, the Pre-Ignition Safety Checklist (attached) will be completed.

3.2 Required Assets [17]

The following assets, depending on the location of the proposed burn, may be required:

— Incident Command Post (on-land) or Primary Control Ship (on-water) to provide central command operations at the burn scene;

— Deflection Task Force to deflect oil to retrievable position;

— Burn Task Force to collect and ignite oil;

— Reserve/Supply provide logistic support to task force;

— Helicopter for ignition of oil (if employed); and

— Helicopter or fixed-wing aircraft for aerial surveillance.

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[16] *Terms and techniques need to be confirmed with Operations Section as this Plan needs to be tailored to the Burn Operations Plan.)*

[17] *Refer to the Burn Operations Plan for detailed operational techniques and tailor the safety plan to support the Operations Plan.*

3.3 Personnel Responsibilities

Burn Group Supervisor (Burn Boss): provides the coordination link between all burn operations and the Unified Command. The Supervisor will ensure Deflection, Burn, and Reserve/Supply Assets task forces are coordinated during operation. A Deputy Supervisor may be established and will have all responsibilities of the Burn Group Supervisor.

ISB Safety Officer: The responsibilities of the ISB Safety Officer operations include (but are not limited to):

— Ensuring worker health and safety during burn operations;

— Conducting pre-burn safety briefing on operational procedures and goals;

— Identifying potential emergencies;

— Explaining emergency communication protocols and emergency burn-termination criteria;

— Coordinating and executing the ISB Worker Health and Safety Plan;

— Assigning and monitoring activities of Safety Observers deployed in the field or on vessels;

— Maintaining this plan and providing daily updates (as needed);

— Acting as liaison with Safety Observers from organizations participating in the response effort and ensuring all briefing are being conducted; and

— Reporting to the Safety Officer.

Safety Assistants: The ISB Safety Officer operations designates an assistant (also qualified as an air monitor) at each burn location (on-land) and/or onboard each vessel (on-water) to conduct air monitoring and provide safety oversight for a particular portion of operation. Responsibilities include:

— Informing personnel about safety measures specific to the particular locations or vessels;

— Ensuring that personnel understand emergency communications and procedures;

— Monitoring all safety aspects of the ISB response as it pertains to that location or vessel;

— Coordinating with Task Force Leader for concerns and potential hazards; and

— Monitoring atmospheric conditions for potentially hazardous airborne constituents as identified in the ISB Air Monitoring Plan.

Task Force Leader: Will manage personnel associated with task force and report to Burn Group Supervisor.

Technical Specialist: Technical Specialists may include an Industrial Hygiene Specialist, Air Monitoring Specialist, Incident Meteorologist, an individual who coordinates field operations and provides spotting and aerial surveillance or any number of other technical specialties which may be consulted regarding site specific scenarios

Air Operations: No aircraft will be allowed in the immediate airspace while ISB operations are active. Pilots of helicopters or fixed-wing aircraft used for aerial surveillance support for the burn will brief the

Burn Group Supervisor on intended operations and receive permission from Burn Group Supervisor before entering the airspace.

Primary Control Ship (*on-water ISB only*): The ISB Safety Officer will be on the Primary Control Ship and will report to the Offshore Branch Director, via the Burn Group Supervisor. The Primary Control Ship controls all aspects of the burn, including:

— Ensuring overall safety, including adequacy of designated ISB location; absence of other sources of secondary ignition nearby; and safety of projected path of the sweep (while burning) for operators;

— Communicating with all personnel involved in the burn to ensure awareness of events taking place before, during, and after the burn;

— Delivering or delegating final command for ignition of the burn;

— Maintaining communication with the Offshore Branch Director;

— Preparing firefighting equipment onboard for accessibility and use;

— Cross-checking to verify that all safety requirements of the burn are addressed;

— Monitoring and maintaining pre-designated “fire-free” zones.

Deflection Task Force (*on-water ISB only*) is responsible for:

— Maintaining consistent tow speeds, boom configurations, and oil collection rates;

— Performing emergency termination procedures.

Burn Task Force is responsible for:

— Reporting all hazards to Unified Command and/or Primary Control Ship;

— Assisting Unified Command and/or Primary Control Ship with burn observations and effectiveness monitoring;

— For on-water ISB: Towing boom, collecting and igniting captured oil, maintaining consistent tow speeds, boom configurations and oil collection rates;

— Performing emergency termination procedures.

Reserve/Supply Task Force is responsible for:

— Maintaining readiness for support to burn operations.

4.0 Burn Area Control

4.1 Burn Operations Plan (Burn Plan)

In order to maintain organization within the response effort, a site specific burn plan and an *in-situ* burn application will be drawn up prior to ignition of the burn. The Plan includes:

— Burn feasibility: verification that window of opportunity exists for loft of smoke plume;

— Operational checklists: a chronological checklist of all operations critical for completion before, during, and after ignition;

— Action plan: to supplement the operational checklists, a plan that details vehicle and vessel deployment, method of ignition, weather forecasts, and water conditions (if applicable) for the specific geographic area;

— Burn termination criteria: if it is determined if worker health or safety is threatened.

4.2 Traffic Control

Movement of non-response vehicles, vessels and aircraft in the vicinity of the burn may be affected by ISB response activity and smoke production. Prior to and during burn operations, the response activity shall be coordinated with local airports, the FAA for Notice to Aviators, and the USCG for Notice to Mariners. ISB zones and traffic control parameter shall be identified prior to ignition and documented verbally and with maps.

4.3 Responder Location

An important consideration in maintaining the safety of response personnel is the location and placement of response personnel in relation to the burning oil. Location and movement of all personnel throughout the response effort will be planned prior to ignition of the burn. All personnel will remain out of the downwind zone. Auxiliary vehicles, vessels and aircraft nonessential to the burn must remain in pre-designated safe zones, traveling upwind and up current from the burn location.

4.4 Vehicle and/or Vessel Location

An important consideration in maintaining the safety of response personnel is the location and placement of response vehicles and vessels in relation to the burning oil. Location and movement of all vehicles and vessels throughout the response effort will be planned prior to ignition of the burn. All personnel will remain out of the downwind zone. Auxiliary vehicles, vessels and aircraft nonessential to the burn must remain in pre-designated safe zones, upwind and up current from the burning slick. To avoid exposure to excessive heat and to emissions, all personnel will remain at least three to five fire diameters away. During on-water burns, towing vessels should be positioned, so that there is an absolute minimal chance of being surrounded by or coming into contact with concentrations of oil that could pose a threat due to deliberate or accidental ignition.

4.5 Site Control

Before entering or departing a burn area, or associated ISB zones, all personnel, vehicles and vessels must report via radio to the Burn Boss or designated check-in person. All persons entering the burn area must subscribe to this portion of the approved Health and Safety Plan. ISB Zones are established in the Burn Plan. All personnel will have adequate training on ISB operations and hazardous waste operations safety and health in accordance with the overarching Site Safety Plan.

4.6 Boom Handling

Fire-resistance boom is a key tool when performing on-water ISB and may also be employed for near-shore and on-shore burns in certain situations. Experience has shown that booms can be deployed quickly and safely if the following considerations are recognized and planned for in advance:

— The storage of boom in protected containers as close as possible to the potential area of use. This will minimize personnel exposure and response time for last-minute maintenance and transport of the boom.

— Preparation of the boom so that the most effective length is stored with all connectors secured, tow bridles in place, and proper lengths of towline already connected or immediately available. This will reduce the need for personnel to work on the boom or its support systems while it is under tension and/or in the water.

— Stacking of the boom in its container so that it can be pulled out quickly without snagging or twisting. A single twist of the boom can render it nearly useless for oil containment at or near the twist, and it can be dangerous attempting to untwist the boom by hand once the boom is in the water.

— If the boom must be held in place (i.e., partially deployed) in order to add sections of boom or make adjustments, personnel need to anticipate the drag forces on the deployed boom (e.g., vessel-induced or natural currents). Personnel should avoid standing on or holding the boom during such adjustments and use proper tie-downs and anchor points to eliminate tension in the portion of boom being worked on.

— Select tie-downs, towlines, tow posts, etc. with due consideration of the average and peak drag forces that may be experienced during deployment and use of any fire containment boom.

— Provide for adequate communications between personnel on the boom-towing vessels and those tending the movement of boom out of its container. Personnel should agree in advance on an alternate communications plan involving a few basic hand signals to be used if radio contact is lost.

— Supply an adequate amount of tow line to provide a safe distance and reaction time for the full range of potential burn situations that could develop.

4.7 Igniters

Ignition Safety: Ignition of the oil should receive careful consideration. Weather and water conditions should be kept in mind, and proper safety distances adhered to at all times. Given the range of igniter types and ignition methods, manufacturer specifications for proper deployment shall be followed.

Igniter Systems: The person deploying the igniter will be trained in the use of the igniter. Safety recommendations of manufacturer shall be followed.

Helitorch or Other Air-Deployable Igniter Systems:

IMPORTANT NOTE: The helicopter or fixed-winged aircraft deploying a Helitorch ignition or other air-deployable igniter will maintain flight paths perpendicular to the boats and boom to eliminate flying over any response vehicles or vessels.

Type of Igniter:____

Additives:____

Manufacturer:____

Point of Contact:____

Attach an SDS for additives and igniter contents.

Hand-held Igniter Systems: The person deploying the hand-held igniter will be trained in the use of the igniter. Follow safety recommendations of manufacturer.

Type of Igniter:____

Additives:____

Manufacturer:____

Point of Contact:____

Attach an SDS for additives and igniter contents.

4.8 Premature and Secondary Ignition Sources

As with conventional oil containment measures, premature or accidental ignition of the oil must be avoided at all costs. During the early phases of a spill response, when oil may be relatively fresh and volatile, the concern for unwanted ignition would be no different than that for conventional oil containment efforts.

Proper consideration must be given to the proximity of potential ignition sources to any combustible oil up until the time of deliberate ignition. Before deliberate ignition, site-specific atmospheric conditions will be considered to ensure that no one is within or near any potential large concentrations of vapors which might flash upon ignition. If atmospheric conditions are very still, considerable concentrations of ignitable vapors may collect in the atmosphere above the oil so the ignition should commence from an appropriately safe distance. Monitoring should be considered to rule out unintentional ignition.

Because of the difficulty of igniting weathered oil, the concerns for unwanted ignition and secondary fires are normally minimal. If, on the other hand, a deliberate burn were planned near shore, along a shoreline or river bank, in a marsh, or onshore, the potential for secondary fires would have to be considered carefully. The proximity of ignitable vegetation, trees, docks, and other facilities would need to be examined with respect to the initial movement of vapors (prior to ignition) and the potential movement of burning oil. Fire breaks may be needed to prevent the fire's spread.

4.9 Pre-Ignition Checks

Prior to commencing the burn, the following checks should be made:

— Radio checks ensure that personnel, vehicle and vessel involved is aware of how much time is left before the ignition to burn. They also verify that personnel, vehicles or vessels are aware of the designated burn trajectory.

— The ISB Safety Officer communicates with the Safety Officer and Burn Group Supervisor to obtain final approval to burn.

— The ISB Safety Officer communicates with spotter plane and obtains verification of a clear burn path ahead.

— Spotter Plane reiterates the locations of oil-free safe areas where personnel, vehicle and vessels can retreat and regroup, should an emergency arise.

Refer to the Pre-ignition checklist (attached) for additional information.

4.10 "Go/No Go" Policy

The organization must ensure delegation of authority of veto power prior to ignition. Each safety observer can veto the commencement of the burn based upon safety concerns within each area of responsibility and coordinate with Burn Group Supervisor. Each Task Force Leader must ensure that all personnel are in the correct and safe place and that all equipment is in proper working order before ignition of the burn.

4.11 Burn Watch

Once the contained oil is ignited, the supervisor of each work group or operator of each boom-towing vessel will maintain a burn watch. Proper attention to the status of the burn, the proximity of the burn operations to vehicles, vessels or other pooled oil or oils slicks and the speed and positions of each of the towing vessels for on-water burns should be monitored to allow personnel to respond quickly to unexpected events. For on-water burns the vessel operator will have a pre-approved and agreed-upon plan of action it becomes necessary to modify the size, and therefore the rate, of the burn; to provide assistance to other personnel or vessels; or to terminate the burn. All personnel will be aware of those potential actions in order to minimize reaction time, confusion, and risk of exposure to unsafe conditions.

4.12 Termination of Burn

In most circumstances, the Burn Group Supervisor should plan to allow the oil to burn to completion once it has ignited. However, premature termination of a burn may be necessary if worker health is threatened due to a wind or weather shift, or a secondary ignition of another pool of oil or slick is a possibility. For on-land burns, fire-fighting resources may be employed to help terminate a burn, however extinguishing the fire may be difficult. For on-water burns, the fire may be extinguished prematurely by both towing vessels accelerating ahead at several knots (2-3 knots), forcing the oil beneath the boom, and removing it from the combustion zone. A secondary option is to release the tow line from one of the towing vessels while the other moves ahead at 2-3 knots; this allows the oil to spread out quickly to a thinness that cannot support combustion. Refer to the appendices for more detail on terminating a burn.

4.13 Additional Safety Considerations

Standard safety considerations as outlined in the Site Safety Plan will also be used during ISB operations no matter the location. From a safety standpoint, however, the following factors will be emphasized for the planning and implementation of any burn.

- Prior to ignition, all personnel will be positioned upwind or crosswind from the burn location or target slick (on-water burns) so that they are well outside the anticipated path of the smoke plume. Personnel near the burn site or target slick will be prepared to move indoors and/or don protective respirators should they unexpectedly be caught in a portion of the smoke plume. Such exposures should be minimal or nonexistent with proper attention to wind conditions and personnel location.

- Should a particular spill situation involve the potential use of fire containment boom in an attached mode very close to the spill source, personnel and equipment will be kept at a safe operating distance from any unexpected explosion or premature ignition of oil at or within the source.

- Any contained oil is ignited only after all “predetermined” burn requirements are met and confirmed via radio link with all key participants. As with any spill response operation, the safety of personnel on location depends on both a clear and concise plan of operations and on reliable communications.

- For off-shore burns, aerial support involving fixed-wing aircraft and/or helicopters will be available so that communications can be maintained regarding the location of the boom-towing vessels relative to the oil to be collected and burned, other oil slicks in the same general area, other vessels in the area, and the anticipated region of influence from combustion products once the oil is ignited.

- For off-shore burns, vessel to vessel transfers have been found to be one of the most hazardous tasks during ISB. Personnel required to transfer from one vessel to another need to do so only after being trained and equipped with PPE such as Type 1 or better PFD. Other controls include:

    - Ensuring the sea state is below 3 on the Beaufort Sea scale

    - Requiring two people to assist the person being transferred

— Clear communications between the vessels performing transfer

— Explicit approval from receiving vessel for transfer to commence

— Having a life ring with a retrieving line at the rail

— Readying a portable rescue ladder

— Performing a safety brief prior to transfer that includes man overboard procedures

5.0 Hazard Evaluation

5.1 Airborne Particulate Matter

Particulate matter are small pieces of solid carbon or liquid hydrocarbon suspended in the air, and are considered by most experts to be the primary airborne health hazard associated with *in-situ* burn emissions. Particulate matter is a by-product of incomplete combustion and is also called "soot." Other combustion products that may be of concern to responders include SO_x, NO_x, CO and CO_2. Research has found that levels of these compounds fall off dramatically outside of the plume due to dilution.

Hazard Description: Particulates less than 10 micrometers in diameter can be inhaled in and reach the upper (i.e. thoracic) region of the respiratory system. Particles less than 2.5 micrometers can reach the deeper portion of the lungs. Studies show that the ground level concentrations of respirable particulate matter near to ISB events usually remain below safety levels (except for the area directly in the smoke plume). For most people, exposure to inert particulates becomes a problem only at high concentrations. However, sensitive individuals may develop problems at levels much lower than that.

Permissible Exposure Limits (PEL) for Particulate Matter: National Response Team recommends using the USEPA's National Ambient Air Quality Standards (NAAQS) for $PM_{2.5}$ and PM_{10} and averaging the levels over one hour to ensure no one is exposed above the 24 hour NAAQS. The 24 hour NAAQS for $PM_{2.5}$ and PM_{10} are 35 $\mu g/m^3$ and 150 $\mu g/m^3$, respectively.

Symptoms of Exposure: Exposure to particulate matter may cause irritation of the mucous membranes (nose, eyes, and throat), persistent coughing and wheezing. It may also cause respiratory tract distress such as difficulty breathing.

Basic Precautions: Using respirators and eye protection (i.e., full-face air purifying respirator with P100 and organic vapor (OV) cartridge) suitable for protection from particulate matter will reduce exposure[18]. Note, the use of full-face respirators may reduce visibility of wearer, thereby creating an additional hazard. The best precaution, is to avoid overexposure altogether. Keep vehicles, vessels and personnel out of the smoke plume and monitor atmospheric conditions to ensure that the winds do not shift and place the responders downwind of the burn.

5.2 Environmental Monitoring for Chemical Hazards

To ensure the health and safety of responders, all personnel, response vehicles and vessels are restricted from entering the smoke plume or from approaching the fire perimeter closer than 3 fire diameters away. Data analyzed from the Newfoundland Offshore Burn Experiment (NOBE) and

[18] Wearing full-face respirators while performing vessel operations may create hazards so the risk of exposure must be weighed against the safety risks of using the respiratory protection. Emergency escape breathing apparatuses may be considered for use to allow personnel to move out of the plume should that become necessary.

Deepwater Horizon demonstrated that PM_{10} and $PM_{2.5}$ levels were low upwind and outside of the smoke plume. Until further experience is gained, however, it is strongly recommended that levels of particulate matter be monitored for workers' health and safety. Additionally, if for some reason a responder must move close-in to the burn, proper personal protective equipment and monitoring must be performed.

Direct reading hand-held instrumentation which provide continuous readings of air quality may be used to monitor near response personnel on near downwind receptors during the course of an ISB.[19] The air monitoring procedures, instrumentation and action levels are detailed in the Air Monitoring Plan for In Situ Burn Operations (attached). Instruments may include hand-held particulate monitors as wells multi-gas meters equipped a photo-ionization detector (PID) for volatile organic compounds, a sensor for monitoring flammable atmospheres (i.e. lower explosive limit (LEL) sensor) and/or chemical-specific sensors for combustion gases (CO, SO_x, NO_x), volatile constituents of potential concern (i.e. benzene) and oxygen (O_2). Colormetric detector tubes may also be used to detect specific combustion gases or volatile compounds. Monitoring equipment should be calibrated and maintained in accordance with the manufacturer's instructions. Air monitoring personnel should also have an understanding of potential interferences which may affect instrument readings (i.e. high humidity, extreme temperatures, cross-reacting constituents).

Zones of potentially hazardous substances, based on either human inhalation hazard potential or flammability, may be encountered based upon wind and weather patterns. Of note, hydrocarbon vapor concentrations typically exceed occupational exposure limits (OEL) prior to presenting either a flammability hazard or a immediate danger to life and health (IDLH). The projected extent and direction of vapor migration prior to burn and smoke plume migration during the burn (along with any other applicable hazards found during the site survey) may be marked on site maps to help guide air monitoring activities.

5.3 Burn Hazards

Although safe practices should eliminate the possibility of a responder getting burned during an ISB, contingencies for such a scenario must be identified. Depending on the severity of the burn, damage inflicted will vary from superficial reddening of the skin to extensive surface blistering and death of underlying tissues. The correct first aid treatment for all burns is to cover the burnt surface with loose, dry, sterile dressings to reduce the dangers of infection. Handling the burnt area must be reduced to a minimum and any temptation to clean its surface resisted. All burns of more than a trivial nature should be referred to the hospital.

5.4 Heat Proximity

Exposure of personnel to uncomfortable or dangerous levels of heat can be minimized or eliminated with proper considerations for personnel placement during a burn. Personnel should not approach the burn fewer than five fire diameters for any extended length of time. For brief amounts of time (<30 minutes), approaches up to three fire diameters may be made. This does not apply to firefighters in turnout gear.

5.5 Other Hazards (Not ISB-specific)

For other hazards refer to the Site Safety Plan for the incident.

6.0 Selection of Controls

Controls are selected based off of the hazards identified and assessed in the Job Safety Analysis (ICS 215A). Preference should always be to select controls that eliminate or engineer out the hazards. Work practice and administrative controls such as training should be implemented when engineering controls

[19] Refer to the Air Monitoring Plan for ISB for more details.

are not sufficient to eliminate the hazards. Examples include creating safe work practices that ensure that all personnel and equipment are protected from any harmful exposure to heat and/or combustion products. Lastly, personal protective equipment should be considered when unmitigated hazards still remain. PPE is always the last resort but during responses will need to be used. An assessment of hazards (such as a Job Safety Analysis) will be used for the selection of proper personal protective equipment.

The JSA for this operation is located _____________(fill in the blank)________.

PPE requirement can is located in Attachment ______(fill in the blank)_________.

7.0 Decontamination Procedures

Contaminated personnel and personnel entering contaminated areas will be decontaminated in accordance with the current Decontamination Plan. Decontaminating boom and equipment while on a vessel underway poses unique hazards. An underway decontamination plan should be developed as a contingency should this task be necessary.

8.0 Public Safety

To ensure health and safety, Special Monitoring of Applied Response Technologies (S.M.A.R.T.) protocols (NOAA, 2006) or similar principles will be instituted in accordance with Regional Response Team _(*fill in the blank*)__ In-Situ Burn Plan as required based on trajectory of burn plume.

9.0 Emergency Procedures

9.1 Emergency Medical Procedures

Refer to applicable section of the Medical Plan for details. If an injury occurs during ISB, the following actions need to be taken:

— Immediately report injury to Burn Group Supervisor and relay information through the chain of command.

— Immediately inform ISB Safety Officer of the injury.

— Contact the appropriate hospital or first aid station identified in Medical Plan, as appropriate, to notify them of incoming victim.

— Dispatch onsite medical aid, as required. Paramedic will be available at _____________________.

— The Burn Group Supervisor will enlist support of personnel capable of rendering additional assistance if needed.

— Transport victim to designated hospital. Medical evacuation by helicopter to the pre-identified hospital will be decided by the Burn Group Supervisor in conjunction with the Safety Officer or ISB Assistant Safety Officer.

9.2 Emergency Termination of Burn

Refer to Emergency Burn Termination Procedures in Attachment____(*fill in the blank*)___.

9.3 Emergency Fire Procedures

DO NOT attempt to fight fires other than small fires. A small fire is generally considered to be a fire in the early stages of development, which can readily be extinguished with personnel and equipment in the immediate area in a few minutes time.

— DO NOT take extraordinary measures to fight fires.

— You MUST sound the appropriate fire signal (*add signal description here*) if fire cannot be put out quickly.

— Alert nearby personnel to call for assistance.

— Notify supervisor.

— The Burn Safety Officer will ensure that the fire is extinguished before restarting work.

10.0 Communications

A Communications Plan containing a contact list and the details of the radio frequencies to be used will be completed and included in or attached to the ISB Health and Safety Plan prior to operations.

It is essential that all personnel directly involved with the control of the burn and safety have a dedicated radio link for their own communications. A separate communications link will be established for information flow between the operators of response equipment, towing vessels and other non-control participants (e.g., aerial spotters, monitoring and sampling personnel, etc.).

Radio Communication: Dedicated radio links with specific frequencies will be established for vehicle-to-vehicle, vessel-to-vessel, vehicle/vessel-to-command, vessel-to-air, and air-to-air communications. Repeater stations will be arranged for as appropriate for distant or blocked communication paths.

Assignment of Frequencies:

Primary Command Channel (for general command communications):

Freq:__________ Channel:_____________ (VHF__ UHF__ CB__ Other_____)

Boom-Towing Vessel Channel (dedicated for boom-towing vessels):

Freq:__________ Channel:_____________ (VHF__ UHF__ CB__ Other_____)

Safety Vessel Channel (dedicated for routine communication):

Freq:__________ Channel:_____________ (VHF__ UHF__ CB__ Other_____)

Aircraft Channel (dedicated for aircraft):

Freq:__________ Channel:_____________ (VHF__ UHF__ CB__ Other_____)

Emergency Channel (dedicated for emergency communications):

Freq:__________ Channel:_____________ (VHF__ UHF__ CB__ Other_____)

Other: ______________________________________

Freq:__________ Channel:_____________ (VHF__ UHF__ CB__ Other_____)

Emergency Communications: An emergency can be communicated or declared using any of the above frequencies. All working frequencies will be monitored throughout the ISB effort by Unified Command and/or the Command Vessel and Safety Vessel. Once an emergency situation has been declared and identified, all response vessels will monitor the dedicated emergency radio channel for emergency instructions. The Burn Boss will request any further changes in radio channel selection as appropriate.

As part of the "Go/No-Go" policy, each ISB Assistant Safety Officer/Observer may stop the response effort by declaring an emergency. In declaring an emergency, the party must identify its operating unit or vessel and must provide a description of the problem. In the event of radio equipment failure, instructions to switch to other frequencies will be given by the communications officer.

During development of a Communications plan the SOFR, in conjunction with other NIMS / ICS Command positions, should determine an appropriate means of alerting hospitals and medical centers if patients with burn-related injuries are in route.

Emergency Phone Numbers

Burn Boss:

(_____) ______________________

ISB Safety Officer:

(_____) ______________________

Position / Name:

____

(_____) ______________________

Position / Name:

____

(_____) ______________________

Hospital:

Name: ___________________

(_____) ______________________

11.0 Site Safety Briefings

Prior to the commencement of the ISB response effort, a safety orientation for all personnel should be conducted. Burn safety meetings will then be held at the beginning of each work shift prior to the ignition of the burn. At a minimum, these meetings will describe the work to be accomplished, emergency response and safety procedures and recent changes, communications plan and site-specific safety considerations.

12.0 Training

Each individual involved with the controlled burning of oil will complete classroom and/or hands-on training. Training will be appropriate for the type and level of responsibility assigned to the individual. Training topics will include: (Note: Add specific topics here. Examples include: 40 hour HAZWOPER, basic ISB instruction, how to perform surveillance and wildlife spotting, air monitoring, PPE, and how to protect sensitive resources, boom handling techniques, safe boat handling).

13.0 Recommended Appendices

— PPE Requirements

— ISB Worker Health & Safety Briefing Sheet

— Emergency Burn Termination Procedures

— Pre-ignition Safety Checklist

— ISB Air Monitoring Plan

Attachment A: PPE Requirements

General Policy: Level of PPE should be evaluated based upon the hazards identified in the site characterization. All governmental regulations must be followed. According to safe *in-situ* burn practices, workers should be kept out of the smoke plume and at a safe distance from the fire, thus a high level of PPE may be unnecessary. The recommended PPE ensemble is Level D for the entire burn response operation. During pre-ignition and the burn phase, personnel should have access to respirators and goggles. As a precautionary measure, fire resistant clothing may be necessary for personnel on the safety vessel. (Refer below to specific ensemble configurations.)

Other issues to keep in mind include:

— People handling burn residues need protective clothing to prevent skin contact.

— People handling igniters should use flame-resistant coveralls and gloves.

— Boom-towing vessel personnel must be properly fitted and trained prior to commencing operation.

— Firefighters should be in full turnout gear.

Coverall Specification: Coveralls will be fire resistant and in hot weather, lightweight to prevent overheating. The permeability the coveralls to oil and burn residue should also be considered. Coveralls will be worn at all times by response personnel potentially at risk to exposure. During pre-burn, burn, and post-burn operations, fire-resistant coveralls should not be worn when directly handling spilled oil, because any oil that gets on the suit becomes potentially flammable.

Respirator Specification: All respirator selection and use will be in accordance with 29 CFR 1910.134 or other applicable regulations (cite other governing regulations).

PPE Ensembles

Level D Ensemble: minimum required for all workers involved with ISB Operations

— Fire-resistant coveralls

— NFPA rated fire-resistant gloves

— Fire-resistant hood

— Face shield, as required

— Goggles, as required

— Hardhat (Class C or better) for boom and crane operations

— Personal Flotation Device (PFD) type I or better (for off-shore or near-shore burns)

— Rubber steel toe/shank safety boots with textured bottoms

— Accessible: NIOSH-certified, full-face air purifying respirator with P100/Organic Vapor dual cartridge and/or, on person, ready to use, Emergency Escape Breathing Apparatus

Attachment B: ISB Worker Health & Safety Briefing Sheet

Objectives

All work shall be conducted in accordance with procedures established in the Burn Operations Plan (Burn Plan). A site specific safe work plan will be provided by _____*(fill in the blank)*______who is providing the burn and support services. Detailed objectives have been developed and are part of the overall Burn Plan. Daily objectives will be communicated to personnel during the pre-departure safety briefing.

Background

The spill source is located _______*(fill in the blank)*__________. *In-situ* burning of oil may offer a logistically simple, rapid, and relatively safe means for reducing the net environmental impact of oil spill. In-situ burning emits a plume of black smoke, composed primarily (90%) of carbon dioxide and water vapor; the remainder of the plume is gases and particulates, mostly unburned carbon particulates, known as soot. Downwind of the fire, the gases dissipate to acceptable levels relatively quickly.

Primary Control Ship provides a platform for coordination of tasks forces and contingency firefighting in the event of an emergency.

Burn Boss provides the coordination link between all burn operations and the Incident Commander and the Unified Command. The Supervisor will ensure Deflection, Burn and Reserve Assets task forces are coordinated during operation.

Task Force Leader will manage personnel associated with task force and report to Burn Group Supervisor.

Technical Specialist provides spotting and aerial surveillance.

ISB Safety Officer ensures worker health and safety during burn operations; conducts pre-burn safety briefings on operational procedures and goals; identifies potential emergencies; explains emergency communication protocols and emergency burn-termination criteria; and reports to the Incident Commander/Unified Command via the Burn Group Supervisor.

(Fill in company or personnel name(s) below)

_______________________________ will conduct area air monitoring near workers, vehicles or on towing vessels and will enforce action levels below to ensure the safety and health of the workers.

The SMART (Special Monitoring of Applied Response Technologies) Team will be deployed and will conduct environmental and community air monitoring ensuring the safety and health of neighboring and downwind areas.

Air Operations: No aircraft will be allowed in the immediate airspace while ISB operations are active. Pilots of helicopters or fixed-wing aircraft used for aerial surveillance support for the burn will brief the ISB Safety Officer on intended operations and receive his/her permission before entering the airspace.

Site Control: Anyone entering or departing a burn area, or associated control zones, reports to the ISB Safety Officer.

Contact List

Function and Name	Phone Number	Radio Contact
Burn Group Supervisor:	________________	__________________
ISB Assistant Safety Officer:	________________	__________________
Primary Control Ship:	________________	__________________
Deflection Task Force:	________________	__________________
Burn Task Force:	________________	__________________
Reserve/Supply Task Force:	________________	__________________
Air Operations:	________________	__________________

Hazards Evaluation

During ISB operations the risks to workers is predominantly due to safety issues, dermal contact with oil when retrieving contaminated boom, heat stress, pinch points and crushing hazards, being struck by an object, falling overboard and drowning during on-water operations or ergonomic strain due to the manual labor involved. Secondary to the safety hazards is the potential to be exposed to atmospheric hazards, such as particulate matter (such as soot), vapors from the oil, and gases. Of this group, the airborne particulates are considered to be the main airborne health hazard associated with in-situ burn emissions. Particulates are formed during incomplete combustion and contain microscopic pieces of solid carbon or liquid hydrocarbon (soot). Because they are so small, they can become suspended in the air. Extremely small particles may be breathed into lungs. Keeping out of the smoke plume and monitoring for particulate matter will ensure that personnel are not exposed. PPE should be donned if exposure is unavoidable (i.e., note PPE here such as a full-face air purifying respirator with P100/OV cartridge).

Operations of vessels and burning of oil may create carbon monoxide (CO) and carbon dioxide (CO2) gases. No previous air monitoring of burn operations has found CO or CO2 to be issues; however, CO produced by engines has been found to accumulate particularly when boats are at idle with no winds.

Other Hazards:

For heat-related hazards and other non-ISB specific hazards, refer to the Site Safety Plan.

On-site work

All workers to follow direction of the Burn Boss.

Communications

Emergency Communications will be via radio channel ____(*fill in the blank*)______.

Standard communications are established in the Burn Plan.

Personnel Protective Equipment

NOTE PPE selected will be determined by the JSA. Information here is for example purposes only.

PPE required for all workers involved with igniting operations:

— Fire-resistant coveralls and gloves

— Rubber steel toe/shank safety boots

— Personal Flotation Device (PFD)

— Safety Glasses

— Full-face air purifying respirator with P100/OV Cartridges (accessible) or

— Emergency escape breathing apparatus (on person)

Required for all workers involved in boom retrieval

— Oil resistant coveralls

— Rubber steel toe/shank safety boots with textured bottoms

— Leather gloves

— Hardhat

— Personal Flotation Device (PFD)

— Safety Glasses

Attachment C: Emergency Burn Termination Procedures

Go/No-Go Policy: The ISB Group Supervisor shall delegate authority of veto power prior to ignition, such that if an emergency situation arises after ignition, anyone can request termination of the burn by following emergency communications procedures specified in the communications plan.

Termination can occur by either:

— On land: For pool fires, firefighting foam may be used to suffocate the fire. It is critical that there be enough foam available for the size of the fire before being used as this is an “all or nothing” tactic. Firefighters should be involved in determining if there is sufficient foam for the operations.

— On-water: one-line drop burn termination—The contained oil can be dumped to terminate the burn by releasing one end of the containment boom (this will typically be done by the lead boom-towing vessel, i.e., the starboard tow vessel). The second tow vessel should then increase speed to straighten the boom and allow the oil to spread to a thickness that will not support combustion.

— On-water: two-line drop termination—In an extreme emergency, both tow vessels may drop their towlines and accelerate away from the burn to the designated safe zone.

In the Event of a Towing Vessel Emergency: If a towing vessel develops a problem, which could affect the vessel’s ability to maneuver, the personnel on that vessel should immediately notify the other towing vessel and the Safety Observer or ISB Safety Officer on board the Primary Control Ship. In this event, the following procedures should be followed, unless circumstances dictate otherwise:

1) The disabled towing vessel should drop its towline immediately.

2) The other towing vessel should veer away from the disabled vessel towing the boom with it, so as to remove the boom from the disabled vessel.

3) The next closest vessel (command or safety) should immediately retrieve the crew and passengers from the disabled vessel or assist the disabled vessel to a safe area.

4) The other vessel (whichever one is not retrieving the crew and passengers) should have any firefighting equipment charged and ready to assist in the rescue, as required.

5) All vessels except the disabled one should regroup to the safety zone as required until the burn is extinguished and deemed safe by the ISB Assistant Safety Officer. Once the area is deemed safe, the crew may return to the disabled vessel to investigate repairs and evaluate options.

Attachment D: Pre-ignition Safety Checks

The ISB Assistant Safety Officer aboard the Primary Control Ship should perform, or confirm that others have performed, the following pre-ignition checks:

1) All radio frequencies and radio protocols should be verified during transit to the spill site and before collection of oil. Vessel Masters should agree upon:

a) Health and safety considerations

b) Delegation of Primary Control Vessel

c) Emergency Burn Termination procedures (separate Attachment)

d) Target tow speed and direction (wind dependent)

e) Other items, as warranted by tactical response requirements.

2) LEL should be monitored and evaluated to ensure ignition will not trigger back flash.

3) Perform a radio check and make sure that each vessel involved is aware of how much time is left before the ignition to burn. Also, verify that each vessel is aware of the designated burn trajectory.

4) Verify that personnel handling igniters are wearing flame-retardant clothing and other appropriate PPE as described in the PPE Requirements Attachment.

5) Obtain final approval to burn from Unified Command.

6) Verify the burn path ahead is clear before ignition.

7) Ensure boom-towing vessels and boom are pointed upwind.

8) Designate a safe area where there is no spilled oil that all vessels can retreat to and regroup in, should accidental ignition or some other emergency arise. The designated safe area should be marked on the site map and the map distributed to all the vessels involved in the ISB operation.

9) Special precautions are required if ignition is to be attempted from the air. In general, any heli-torch apparatus should approach the area to be burned on a course parallel with the tow vessels and perpendicular to the fire boom. Specific detailed procedures should be established before using an aerial platform for ignition.

Attachment E: Decontamination Plan

1.0 Hazard Communication

All personnel involved in the response must have received the appropriate level of OSHA HAZWOPER training and annual refresher training.

2.0 Suiting Out (Support/Cold Zone)

Personnel will be suited out in proper personnel protective equipment (PPE) at the following location:

____

Equipment required at the dress out station (*task dependent*):

- ❑ ________________________________
- ❑ ________________________________
- ❑ ________________________________
- ❑ ________________________________
- ❑ ________________________________
- ❑ ________________________________

A supervisor shall be appointed to ensure all personnel are properly suited and equipped according to the Site Safety Plan. Access to the "hot zone" will be limited to the individuals necessary to the operation. Everyone entering the hot zone must wear the prescribed PPE and have received the required training.

3.0 Entry Into Work Area (Exclusion/Hot Zone)

All personnel shall enter the work area through a single entry corridor. All personnel shall be officially logged in. Unless otherwise posted, the entry and exit point to the hot zone shall be at:

____

4.0 Personnel Decon Station

A personnel decontamination line will be established and maintained prior to deployment of equipment which may come in contact with spilled oil or oil slicks (on-water scenarios).

The DECON LINE shall be at the following location:

____

In order to minimize the generation of waste stream, dry decon will be used to the maximum extent possible. Tools and other non-disposable items will be cleaned with a non-hazardous solution (citrus, simple green, etc), wiped, and returned to service.

— **Decon Station Supplies:** Examples are: eye wash station, first aid kit, hand wipes, waterless hand cleaner, large plastic bags etc.

— Additional items:

— _____________________________________

— ____

— ____

— ____

— ____

— ____

— ____

— **Personnel:** Two personnel to assist the "dirty" crew with the DECON process shall man the line. Decon line personnel shall be suited out in boot covers, splash suit, gloves, eye protection and hard hat.

— **DECON LINE STEPS**: Line the floor with sorbent roll, and cover all walls leading to showers with polyethylene sheeting. Prepare drop buckets and trash cans lined with double bags. Have scissors, chairs or benches available to assist with suit removal.

1) **Tool drop:** Deposit reusable tools, hard hats, eye protection into tub. Items will be cleaned, rinsed and reused by on-coming shift workers.

2) **Gross decon:** First Decon Line support person wipes off excess contamination with rags or sorbent material. All contaminated rags and sorbents will be stored in double lined plastic bags.

3) **PPE suit removal:** Second decon line support person will assist in the removal of the splash suit. Remove duct tape. Suits will not be re-used. Remove jacket, outer gloves, pants and boot covers. Keep inner gloves on at this point. Peel suit away so that clean interior is exposed. Discard contaminated suit into double lined plastic bag.

4) **Inspection:** Remove inner gloves. Use hand cleaner and paper towels to remove any excess oil from the skin. Inspect for oiled inner garments. Before departing decon line, decon leader will inspect for any missed contamination, log person out, and direct to shower and clothing change. Recommend using only one shower so that only one has to be decontaminated after operations are complete. If possible, use a shower that drains to the sewage tank instead of the gray water holding tank.

5) **Medical oversight:** Under certain situations, workers will need to be inspected for signs of heat or cold exposure, dehydration, or other special needs.

— **Equipment DECON**:

— As response equipment is brought back to the DECON station, it may be covered with oil. To limit the potential spread of contamination, gross excess contamination shall be removed with rags or sorbent material. Where possible, equipment will be placed on sorbent material, and covered to prevent rain from washing off remaining oil. Equipment will be cleaned with a non-hazardous cleaner (simple green, citrus orange, etc.) to the extent possible upon recovery.

— To limit the spread of contamination, all dirty gear shall be stored in a designated location, leaving sufficient room for a proper decontamination reduction line to operate.

Attachment F: Air Monitoring Plan for In-Situ Burn Operations

Prepared for:

Prepared by:

Date:

1.0 Purpose and Overview

This Air Monitoring Plan is intended to protect the health and safety of workers and others who may be affected by the in-situ burn operations. Likewise, it is intended to monitor the air to protect downwind receptors.

The plan covers:

— The characterization and monitoring of air before, during, and after operations;

— Sampling protocols and documentation;

— The protection of workers during sampling operations;

— Required actions for specific levels of contaminants found.

Air monitoring will be conducted prior to the ISB operation to determine background levels at the burn location. Air monitoring activities will continue until the ISB operation is complete, at which time post-operation air monitoring readings will be taken. Air monitoring data will be summarized and reported to the Safety Officer or his/her designee daily. Levels found over the action level (as defined below) shall be reported immediately to the Safety Officer by the quickest means possible. See attached forms for calibration and sampling logs.

2.0 Air Sampling

Air monitoring will only be conducted by qualified personnel, as determined by their employer.[20] For on-land and near-shore burns, air monitoring personnel will be assigned to specific task groups and/or stationed in strategic locations in relation to the burn location. For off-shore burns air monitoring personnel will be stationed on vessels conducting ISB operations throughout the spill area.

The air monitoring personnel may be equipped with instruments capable of detecting the constituents listed below. The suite of constituents being monitored may vary based on what is known about the chemical composition of the spilled oil or site-specific conditions.

— Particulate Matter (PM) [21]: PM_{10} and $PM_{2.5}$

— Volatile Organic Compounds (VOCs),

— Lower Explosive Limit (LEL),

— Oxygen Levels (O_2),

— Carbon Monoxide (CO),

— Benzene, and

— Hydrogen Sulfide (H_2S).

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20 Personnel who serve as air monitoring personnel for this response shall be qualified in accordance with their respective organizations' policies to perform initial site surveys and site monitoring using appropriate atmospheric monitoring equipment for oil spill response, recovery and remediation activities.

21 Particulates less than 10 microns in diameter can be inhaled and some may reach the lungs. Studies show that the ground level concentrations of PM-10 nearby ISB events usually remain below safety levels (except for the area directly in the smoke plume). For most people, exposure to inert particulates may produce symptoms only at high concentrations. However, sensitive individuals may develop symptoms at relatively lower levels.

Real-time air monitoring may be performed using multi-gas meters with photo-ionization detectors (PIDs), flammability and chemical-specific sensors. The PIDs will be used to detect volatile components of the spilled oil. Chemical specific sensors (or colormetric detector tubes as a secondary instrument) may be used for chemical specific analysis in the event that elevated VOCs are detected using a PID. The air monitoring equipment being used is listed in Table 1. The ISB Assistant Safety Officer may consult with industrial hygiene or toxicology experts to aid in refining the suite of constituents being monitored and setting of site-specific action levels.

Air monitoring may also be conducted at selected locations that will address potential off-site receptors, accounting for possible changes in wind-direction. In addition, air monitoring may be conducted as needed in response to potential concerns or complaints raised on or off-site. Locations will be determined prior to the commencement of the operation as they are dependent on the type, size, and location of the operation. At a minimum, samples should be taken at several locations around the operations and at different distances from the operations in order to characterize the site and its perimeter. Sampling should be done at continuous intervals downwind until there are a sufficient non-detect readings for the contaminant of concern. The Safety Officer or industrial hygienist overseeing the air monitoring should make this determination based off of the operations and atmospheric conditions.

Table F.1—Real-Time Air Monitoring Equipment

Instrument/Sensor		Constituent
Particulate monitor	Size-Selective Impactor	PM_{10} $PM_{2.5}$
Multi-gas meter	Photoionization Detector (PID)	VOCs
	Photoionization Detector with Chemical Separator Tube	Benzene
	Flammable Atmosphere Sensor	LEL
	Chemical-specific Sensors	SO_x, NO_x, CO, CO_2, H_2S
Gas Sampling Pumps	Colormetric Detector Tubes	SO_x, NO_x, CO, CO_2, H_2S, Benzene

3.0 Survey Guidelines and Results

3.1 Initial Site Survey:

A site survey should occur prior to entry into the oil impacted area. A diagram indicating where sampling was conducted and the results should be developed and documented in the sampling report.

3.2 Site Monitoring:

Monitoring locations should be chosen based on the potential for smoke plume and vapors to reach responders or the community and environmentally sensitive areas. Monitoring locations need to remain flexible as conditions or events change, but should take into account:

— Prevailing winds

— Atmospheric conditions

— Location and magnitude of the burn

— Modeling output (if available)

— Location of population centers and sensitive environments/habitats

— Input from state and local health officials

Air monitoring personnel should be deployed upwind of the sensitive locations and responders (or with the responders) so that appropriate actions can be taken in the event that air quality action levels are exceeded.

Pre-burn monitoring should be performed to characterize the site prior to operations. After the initial characterization has been completed, air monitoring should be continued at regular intervals in the vicinity of operations being conducted and upwind of selected sensitive areas. All results will be reviewed regularly by the ISB Assistant Safety Officer. Daily, the results should be sent to the Safety Officer for review and documentation. At no time shall air monitoring activities impede operations or endanger personnel.

Decisions regarding location(s), time, and duration of air monitoring activities will be guided by the ISB Assistant Safety Officer. Readings should be documented regularly or if there is a change in an airborne constituent concentration. If site conditions change (such as the amount of oil in the work area, an increase in a reading of VOCs, or a shift in the winds towards the workers, for example), air monitoring should be done immediately following the change, and the need to monitor more frequently should be considered.

Spill recovery sites and source control sites personnel and supervisors shall be updated regularly of the air monitoring results.

3.3 Results of Air Monitoring

1) **Initial:** Immediately following the initial site survey, the results shall be explained to the lead supervisor for the work area or work group and/or the captain of the vessel.

2) If results are at or above the action level, a determination of whether to proceed with the operations shall be made by the lead supervisor/captain in consultation with the assigned Assistant Safety Officer.

— An action level is a concentration of an airborne constituent which, when detected, triggers an action such as notification of supervisors and safety officers, donning of respiratory protection or stop work an egress from an area.

— The action level is typically set at or below an American Conference of Governmental Industrial Hygienists (ACGIH) Threshold Limit Value (TLV) or other industrial hygiene standard (National Institute of Occupational Safety and Health (NIOSH) Recommended Exposure Limit (REL); Occupational Safety and Health Administration (OSHA) Permissible Exposure Limit; American Industrial Hygiene Association (AIHA) Workplace Environmental Exposure Level (WEEL)). One exception is particulate matter, where action levels may be based upon the EPA NAAQS or AQI values.

— If work is to continue when the action level is reached, air monitoring should be done continuously until the level drops below the action level.

3) If results are at or above an excursion limit, entry should not be made unless so authorized by the Unified Command via the chain of command.

— An excursion limit typically refers to a range of concentrations that are above a PEL or TLV but below a ceiling limit (i.e. concentration which workers must not be exposed to at any time) which workers may be exposed to for short periods of time (i.e. 15 or 30 minutes) only a limited number of times during a work shift. Note that excursion limits and ceiling limits may not be established by regulatory or scientific organizations for all constituents of potential concern.

— When reached, both personnel and equipment should immediately depart the area.

— If at any time the levels reach the excursion limit, Ceiling or IDLH, vessels/personnel shall depart area to a safe area upwind until it is determined that the site is again safe for personnel. Operations may need to be suspended.

4) If other personnel are working nearby, for example, on an adjacent beach, production asset or vessel, all results at or above the action level shall be shared with their site safety officer or lead supervisor/captain.

5) All documentation at the end of the shift (or at minimum of every 24 hours) shall be turned in to (hard copy or electronically) the Unified Command Safety Officer (contact info is below).

6) Site personnel shall be updated regularly of the air monitoring results.

7) Adequate and proper PPE shall be available to personnel exposed to contaminants at or above the Action Level. If results are at or above the excursion level but below the Ceiling or IDLH level, entry should not be made unless so authorized by the Unified Command via the chain of command. If workers remain this area, adequate and proper PPE must be issued and worn by all personnel in that area.

4.0 Calibration and Maintenance of Field Instruments

Air monitoring equipment must be successfully tested at the beginning of each shift and calibrated in accordance with the manufacturers' instructions. The Limits of Detection/ Measurement Range for each instrument must be noted on the air sampling logs. All equipment calibration shall be noted in the calibration log. Post-calibration of instruments should also be performed and documented in order to assess whether air monitoring equipment was functioning properly during the work shift. Maintenance records on the individual instrument may be required. Copies of the instrument factory calibration should be maintained for each instrument.

Any instrument unable to be calibrated successfully shall be tagged as “inoperable” and taken out of use. Notifications will be made to the ISB Assistant Safety Officer especially if the instrument’s operations and previous results are in question.

Calibration equipment shall be kept by the air monitor; requests for more equipment or calibration gas shall be made well in advance of the need.

5.0 Data Quality and Documentation Management

Real-time readings will be documented on appropriate logs and forms (see attached). Data will be sent daily to the ISB Assistant Safety Officer or, more frequently, as directed. As directed, the ISB Assistant Safety Officer will forward all data and field notes to the Safety Officer. Data will be reviewed for accuracy by an Industrial Hygienist working for the Safety Officer prior to being released.

Additionally, maps or diagrams of sampling locations and data summaries will be provided daily to Unified Command.

Questions or concerns shall be directed to the Safety Office at: ______________________

ISB Monitoring Recorder Sheet

Date: __________ Time: ____________ **General Location:__________________________**	
General Information	**Weather information**
Recorder name	Temperature
Operator name	Wind direction
Vehicle/vessel # or Task Group ID:	Wind speed
Monitoring Instrument Manufacturer and Model #	Relative humidity
Monitoring Instrument #	Cloud cover
Burn #	
Calibration factors:	

Excerpt from SMART Guide, 2006

Comments should include: location of the smoke plume relative to the instrument, interfering particulate sources, any malfunction of the instrument

Time	GPS reading	Particulates concentration	Comments & observations
	lat:________________ long:	Inst: ________ TWA:	
	lat:________________ long:	Inst: ________ TWA:	
	lat:________________ long:	Inst: ________ TWA:	
	lat:________________ long:	Inst: ________ TWA:	
	lat:________________ long:	Inst: ________ TWA:	
	lat:________________ long:	Inst: ________ TWA:	
	lat:________________ long:	Inst: ________ TWA:	
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	lat:________________ long:	Inst: ________ TWA:	
	lat:________________ long:	Inst: ________ TWA:	
	lat:________________ long:	Inst: ________ TWA:	
	lat:________________ long:	Inst: ________ TWA:	

Excerpt from SMART Guide, 2006.

Appendix B

Examples of JSAs for Inland, Near-shore, and On-water ISB

DEVELOP FIRE CONTAINMENT

TASK	**Develop fire containment**	**PREPARED BY**	Signature	Date
LOCATION		**REVIEWED BY**	Signature	Date
			Signature	Date
			Signature	Date
			Signature	Date
DATE PREPARED	X/X/XX New [X] Revised [ ]	**PPE REQUIREMENTS**	Leather Gloves Safety glasses or goggles Hard Hat, Hearing Protection Safety boots	

Issue of Concern/Activity	Potential Hazards/Risks	Control Measures
Ensure area to be burned is contained.	Spread of fire or secondary fires.	Collect spilled oil in natural depressions or low lying areas. Natural or man-made barriers may be used.
		Physically contain spilled oil with berms, ditches, or dikes.
		Create fire breaks to prevent spread in deserts, fields, prairies and savanna.
		For inland waters or on broken ice, fire boom may be used.
		Evaluate fuel load (of vegetation and oil) to predict burn size.
		Stage fire suppression equipment around burn perimeter. Obtain suitable source(s) for water supply. If foam is to be used, ensure there is sufficient supply.
		Consider batch burning of slick segments for better control of fire propagation.

IGNITION

TASK	**Ignition of oil slick**	**PREPARED BY**	Signature	Date
LOCATION		**REVIEWED BY**	Signature	Date
			Signature	Date
			Signature	Date
			Signature	Date
DATE PREPARED	X/X/XX New ☐ Revised ☐	**PPE REQUIREMENTS**	Hearing Protection Fire resistant clothing and gloves Safety glasses or goggles Boots	

Issue of Concern/Activity	Potential Hazards	Control Measures
Igniting oil using hand held device.	Secondary fire, premature ignition, explosion, or flashback during ignition.	Follow user's manual for device or develop safe work practices when igniter is improvised.
		Delineate and enforce safety zone prior to ignition.
		Perform pre-ignition safety checks including checking LEL. Verify all pre-burn conditions of approval have been met.
	Burns to person conducting ignition.	Inform all onsite personnel of intent to ignite.
	Flames and burns to nearby personnel and vessels.	Verifying that igniter and work plan is suitable for material being burned.
		Verify burn path ahead is clear before ignition.
		Designate a safe area where there is no spilled oil that all personnel can retreat and regroup in.

		Ignite upwind or sequence ignition to give better control of burn.
	Excessive heat and/or blast.	Prior to ignition ensure all personnel are upwind or crosswind from the target slick.
		Work with meteorologist to confirm weather conditions (winds, currents).
	Contamination with gelled fuel or starter causing skin irritation, chemical absorption, and dermatitis.	Use only trained personnel.
		Chemical resistant PPE and safety goggles and face shield when potential exposure to ignition chemicals exists.
Using aerial ignition device (e.g., helitorch)		Work with meteorologist to confirm weather conditions (winds, currents).
		Develop aerial ignition plan.
		Have aircraft delivering igniter fly perpendicular to the operations to reduce chance of flying over personnel.

MONITOR BURN OPERATIONS

TASK	**Monitoring burn operations**	**PREPARED BY**	Signature	Date
LOCATION		**REVIEWED BY**	Signature	Date
			Signature	Date
			Signature	Date
			Signature	Date
DATE PREPARED	X/X/XX New [X] Revised [ ]	**PPE REQUIREMENTS**	Hard Hat (if needed) or sun protective head gear Respiratory protection (emergency use) Safety Glasses or goggles Leather Gloves Safety Boots	

Issue of Concern/Activity	Potential Hazards	Control Measures
Exposure to heat of burn.	Burns, thermal stress.	Keep all personnel 4-5 fire diameters away from burn at all times; enter no closer than 3 fire diameters for periods less than 30 minutes.
		Maintain communications between all onsite personnel.
		Have firefighting and EMS capabilities at site.
Secondary fires.	Burns and entrapment of personnel in burn area.	Keep potential ignition sources out of new oil slick areas.
Spread of fire.	Burns and entrapment of personnel in burn area.	Develop emergency termination plan. Have firefighters prepared to respond. Verify sufficient supply of water and foam (if used).
Exposure to smoke plume.	Inhalation of combustion gases or particulate matter greater than the exposure limit.	Remain upwind of the smoke plume or of a sufficient distance to not allow personnel to be exposed to emissions.

	Acute health effects from exposure to combustion by-products including coughing, wheezing, phlegm, irritation of eyes, nose and throat.	Provide personnel with full-face APR P100/OV to have accessible and/or emergency escape breathing device to have on person.
	Acute effects of CO or CO2 include difficulty breathing, headache, dizziness or nausea.	Use air monitors to perform real-time monitoring of particulate matter, CO, O2 and LEL. Develop action level criteria.
	Decreased visibility.	Use SIMOPS when other response activities are taking place or other burns are being perform simultaneously.
	Grounding or shorting of high voltage transmission lines.	Where there may be smoke impacts to roads, ensure roads are closed and detours are made.
		Ensure public safety notifications have been made through emergency management agency, law enforcement, FAA and utilities.
		Maintain emergency communications, especially when there is reduced visibility, for safety and evacuations.
		Use modeling to predict plume trajectory. Work with meteorologist to confirm weather conditions are favorable for a burn (e.g., so that plume rises and dissipates quickly).
Exposure to oil vapors.	Acute health effects from unburned oil (e.g., VOCs) including headache, dizziness, irritation of nose, eyes, throat, and CNS depression.	Use air monitors to perform real-time monitoring of VOCs and benzene. Develop action level criteria.
	Chronic health effects from constituents (e.g., benzene).	Perform, on representative responders, full-shift BTEX monitoring using organic vapor monitoring badges.
Monitoring operations (land, water).	Fatigue from long hours.	Ensure sufficient crew size to maintain watch.
		Enforce work limits (e.g., no more than 14 hours / day including commute to/from site)
	Noise from equipment and engines.	Provide and enforce use of hearing protection devices.
	Slips, trips and falls.	Have sufficient lighting to illuminate work areas. Keep walking and working surfaces free of trip hazards and clean.

	Thermal stress.	Monitor personnel for thermal stress. Develop and enforce work/break schedule to ensure responders have sufficient rest and recovery times. Ensure workers are properly hydrated.
		Provide cooling or heating stations or shelters for personnel.
	UV radiation.	Sun block and shelter.
		Wide rimmed hats (when hard hat is not needed) and long sleeves.
	Drowning.	Use PFD when working on near water.

RECOVER RESIDUE USING HAND TOOLS

TASK	**Recover residue using hand tools**	**PREPARED BY**	Signature	Date
LOCATION		**REVIEWED BY**	Signature	Date
			Signature	Date
			Signature	Date
			Signature	Date
DATE PREPARED	X/X/XX New [X] Revised [ ]	**PPE REQUIREMENTS**	Safety Glasses/Goggles Chemical resistant gloves, PPE Rubber safety boots	

Issue of Concern/Activity	Potential Hazards	Control Measures
Manual recovery of residue.	Muscle-skeletal injuries such as back strain.	Use proper lifting techniques for every lift (bend at the knees, not at the waist).
		When working from small boat, ensure all rails, safety chains, etc. are in place to reduce the likelihood of falling overboard. Don PFD.
		Use additional people to help with heavy items and/or those that have an odd shape or are awkward to handle.
		On open or flowing water, collections using rakes, nets, skimmers and/or sorbents are suitable for heavier oily burn residues.
	Chemical contamination (residue on skin may cause irritation, dermatitis and/or sensitization).	Use chemical resistant PPE protecting skin where contamination is likely.
		Safety glasses or goggles to prevent eye injury or splash of contaminated material into eyes.
		Safety boots must be worn; rubber, slip resistant safety boots are preferred.

		Provide hygiene facilities and decon station.
	Thermal stress.	Monitor personnel for thermal stress. Develop and enforce work/break schedule to ensure responders have sufficient rest and recovery times.
		Provide cooling or heating stations or shelters for personnel.
	UV Radiation.	Sun block and shelter.

FIRE BOOM DEPLOYMENT, TOW, AND RETRIEVAL

TASK	**Fire boom deployment, tow, and retrieval**	**PREPARED BY**	Signature	Date
LOCATION	Vessel deck	**REVIEWED BY**	Signature	Date
			Signature	Date
			Signature	Date
			Signature	Date
DATE PREPARED	X/X/XX New [X] Revised [ ]	**PPE REQUIREMENTS**	Leather Gloves Personal Flotation Device Hard Hat, Hearing Protection Safety boots	

Issue of Concern/Activity	Potential Hazards	Control Measures
Extension and retraction of boom.	Pinch hazards from lines and moving equipment.	Keep fingers clear of lines that are tightening (or can tighten).
Tending lines attached to various components of system. Carrying and moving materials.	Becoming entrapped in lines and being pulled into water during deployment.	Keep all body parts clear of connection areas that move (such as extend and retract)
		Ensure boom is properly stored so it does not snag or twist.
	Muscle strain or injury. Hand or limb injury.	Use proper lifting techniques for every lift (bend at the knees, not at the waist).
		Use additional people to help with heavy items and/or those that have an odd shape or are awkward to handle.
	Line snapback or breaking.	Inspect equipment before deployment. Ensure tie downs, tow lines, tow posts are strong enough to withstand average and peak forces.
		Allow only personnel performing operations to be on deck during boom tending.
	Load swings or drops during crane operations.	Use lead line to control load; keep personnel at safe distance when moving load.

	Drowning. Fall overboard (injury, hypothermia).	When in a position where a fall-overboard is possible, a Personal Flotation Device must be worn.
		Ensure all rails, safety chains, etc. are in place to reduce the likelihood of falling overboard.
	Crushing, pinching or abrasion hazards from boom, chain, line.	Safety boots must be worn for protection from potential items that may drop down unexpectedly.
		Provide adequate communications for responders involved in boom-towing vessels and personnel tending boom.
		Use leather gloves to protect the hand from scratches/cuts.
		Keep hands clear of loads as they are being lowered to the deck.
		Anticipate drag forces by vessel movement and currents; use proper techniques to eliminate tension where work is being performed.
Operating Prime Mover.	Elevated noise level.	Double hearing protection required within 3-meter of prime mover when it is operating.
	Carbon monoxide exposure.	Try to position prime mover so exhaust vents away from vessel. Stay up-wind of exhaust.
	Diesel spill while fueling.	Dispense fuel at a controlled rate so that an overflow does not occur. Position a sorbent pad where it will catch any material should it spill.
	Inability to operate emergency shut-down.	Operator must know where the emergency shut-down controls are located and how to use them.
	Eye injury from pressurized hydraulic lines.	Safety glasses must be worn when connecting/disconnecting hydraulic lines.
	Hydraulic fluid spill.	Use chemical resistant PPE when cleaning up hydraulic fluid spills.
	Fall overboard.	When in a position where a fall-overboard is possible, a Personal Flotation Device must be worn.
	Foot and hand injury.	Use leather gloves to protect the hand from scratches/cut. Wear appropriate footwear to prevent crush or cut injuries.

Exposure to oil slick - vapors or dermal contact.	Secondary fire or unintentional fire.	Ensure all possible ignition sources such as boat engines remain safe distance from slick
	Contamination of vessels or equipment.	Use air monitor to test for VOCs and LEL.
	Interference with oil containment operations.	Ensure all involved vessels maintain communications with one another. Use SIMOPS if needed.
	Acute health effects from oil (e.g., VOCs)	Train personnel on hazards of oil exposure.
	Acute effects of VOC exposure include headache, dizziness, irritation of nose, eyes, throat, and CNS depression.	Keep personnel safe distance from oil, especially if it is fresh and emitting VOCs.
		Use spotter aircraft if needed to maintain operational picture.

EXAMPLE JSA – IN-SITU BURNING – NEAR SHORE AND ON-WATER

IGNITION OF OIL SLICK

TASK	**Ignition of oil slick**	**PERFORMED BY**	Signature	Date
LOCATION		**REVIEWED BY**	Signature	Date
			Signature	Date
			Signature	Date
			Signature	Date
DATE PREPARED	X/X/XX New [X] Revised [ ]	**PPE REQUIREMENTS**	Hearing Protection Personal Floatation Device Fire resistant clothing and gloves Safety glasses or goggles and boots	

Issue of Concern/Activity	Potential Hazards	Control Measures
Igniting oil.	Secondary fire, premature ignition, explosion, or flashback during ignition.	Follow user's manual for device or develop safe work practices when igniter is improvised.
		Delineate and enforce safety zone prior to ignition.
		Perform pre-ignition safety checks including checking LEL and pre-burn conditions have been met.
	Burns to person conducting ignition.	Inform all onsite personnel of intent to ignite.
	Flames and burns to nearby personnel and vessels.	Verifying that igniter and work plan is suitable for material being burned.
		Verify burn path ahead is clear before ignition.
		Designate a safe area where there is no spilled oil that all personnel can retreat and regroup in.
		Ensure boom-towing vessels and boom are pointed upwind.
	Excessive heat and/or blast.	Prior to ignition ensure all personnel are upwind or crosswind from the target slick.

	Contamination with gelled fuel or starter causing skin irritation, chemical absorption, and dermatitis.	Work with meteorologist to confirm weather conditions (winds, currents).
		Use only trained personnel.
		Chemical resistant PPE and safety goggles and face shield when potential exposure to ignition chemicals exists.
Using aerial ignition device (e.g., helitorch)		Work with meteorologist to confirm weather conditions (winds, currents).
		Develop aerial ignition plan.
		Have aircraft delivering igniter fly perpendicular to the operations to reduce chance of flying over personnel.

MONITORING BURN OPERATIONS

TASK	**Monitoring burn operations**	**PREPARED BY**	Signature	Date
LOCATION	All Vessels	**REVIEWED BY**	Signature	Date
			Signature	Date
			Signature	Date
			Signature	Date
DATE PREPARED	X/X/XX New [X] Revised [ ]	**PPE REQUIREMENTS**	Personal Flotation Device (PFD) Respiratory protection on hand, hearing protection Safety Glasses or goggles Leather Gloves Safety Boots	

Issue of Concern/Activity	Potential Hazards	Control Measures
Exposure to heat of burn.	Burns, thermal stress.	Keep all personnel 4-5 fire diameters away from burn at all times; enter no closer than 3 fire diameters for periods less than 30 minutes.
		Maintain communications between fire monitor personnel and boom-towing vessel.
		Use tow lines of sufficient length to keep tow vessels at least 5 fire diameters from burn.
		Have firefighting and EMS capabilities at site.
		Ensure burning oil remains in lower third of boom.
Secondary fires.	Burns and entrapment of personnel in burn area.	Keep vessels out of new oil slick areas by monitoring their trajectories.
Spread of fire.	Burns and entrapment of personnel in burn area.	Develop emergency termination plan. Have fire boats prepared to respond.

		Have towing vessels move into wind with speed matching flame's propagation rate.
Exposure to smoke plume.	Inhalation of combustion gases or particulate matter greater than the exposure limit.	Remain upwind of the smoke plume or of a sufficient distance to not allow personnel to be exposed to emissions.
	Acute health effects from exposure to combustion by-products.	Provide personnel with full-face APR P100/OV to have accessible and/or emergency escape breathing device to have on person.
	Acute effects from smoke include coughing, wheezing, phlegm, irritation of eyes, nose and throat.	Maintain communications between fire monitor personnel and boom-towing vessel and other vessels that may be affected by lowered visibility.
	Acute effects of CO or CO_2 include difficulty breathing, headache, dizziness or nausea.	Use SIMOPS when other response activities are taking place or other burns are being perform simultaneously.
	Decreased visibility.	Use air monitors to perform real-time monitoring of particulate matter, CO, O2 and LEL. Develop action level criteria.
		Use modeling to predict plume trajectory. Work with meteorologist to confirm weather conditions are favorable for a burn (e.g., so that plume rises and dissipates quickly).
Exposure to oil vapors.	Acute health effects from unburned oil (e.g., VOCs) including headache, dizziness, irritation of nose, eyes, throat, and CNS depression.	Use air monitors to perform real-time monitoring of VOCs and benzene. Develop action level criteria.
	Chronic health effects from constituents (e.g., benzene).	Perform, on representative responders, full-shift BTEX monitoring using organic vapor monitoring badges.
Underway operations.	Fatigue from long hours and/or motion sickness.	Ensure sufficient crew size to maintain watch.
		Enforce work limits (e.g., no more than 14 hours / day including commute to/from site).
	Noise from deck equipment and engines.	Provide and enforce use of hearing protection devices.
	Slips, trips and falls.	Maintain well lit deck; ensure materials are stowed for sea; ensure railings and safety lines are in place.

	Thermal Stress.	Monitor personnel for thermal stress. Develop and enforce work/break schedule to ensure responders have sufficient rest and recovery times. Ensure workers are properly hydrated.
		Provide cooling or heating stations or shelters for personnel.
	UV radiation.	Sun block and shelter.
		Wide rimmed hats (when hard hat is not needed) and long sleeves.
	Drowning. Fall overboard.	Use PFD when working on deck.

EXAMPLE JSA – IN-SITU BURNING – NEAR SHORE AND ON-WATER

RECOVER RESIDUE

TASK	**Recover residue using hand tools**	**PREPARED BY**	Signature	Date
LOCATION	Onboard Vessel	**REVIEWED BY**	Signature	Date
			Signature	Date
			Signature	Date
			Signature	Date
DATE PREPARED	X/X/XX New [X] Revised [ ]	**PPE REQUIREMENTS**	Personal Flotation Device (PFD) Safety Glasses Chemical resistant gloves, PPE Rubber safety boots	

Issue of Concern/Activity	Potential Hazards	Control Measures
Manual recovery of residue from water.	Fall overboard.	Use proper lifting techniques for every lift (bend at the knees, not at the waist).
		Ensure all rails, safety chains, etc. are in place to reduce the likelihood of falling overboard.
	Muscle-skeletal injuries such as back strain.	Use additional people to help with heavy items and/or those that have an odd shape or are awkward to handle.
		Work together as a team when lifting items to ensure simultaneous movement of parts.
		Use chemical resistant PPE protecting skin where contamination is likely.
		When in a position where a fall-overboard is possible, a Personal Flotation Device must be worn.

	Chemical contamination (residue on skin may cause irritation, dermatitis and/or sensitization).	Safety glasses or goggles to prevent eye injury or splash of contaminated material into eyes.
		Safety boots must be worn; rubber, slip resistant safety boots are preferred.
		Provide hygiene facilities and decon station.
	Thermal stress.	Monitor personnel for thermal stress. Develop and enforce work/break schedule to ensure responders have sufficient rest and recovery times. Ensure workers are properly hydrated.
		Provide cooling or heating stations or shelters for personnel.
	UV Radiation.	Sun block and shelter.

Template for JSA

TASK		**PREPARED BY**	Signature	Date
LOCATION		**REVIEWED BY**	Signature	Date
			Signature	Date
			Signature	Date
			Signature	Date
DATE PREPARED	X/X/XX New ☐ Revised ☐	**PPE REQUIREMENTS**		

Issue of Concern/Activity	Potential Hazards	Control Measures

Appendix C

Frequently Asked Questions (FAQ) Regarding Conduct of ISB

What is in-situ burning?

In-situ burning is an oil spill response technology that removes spilled oil from a land, snow, ice, or water surface by combustion of hydrocarbon vapors, and which yields predominantly carbon dioxide (CO_2) and water (H_2O) to the atmosphere. *In-situ* burns are short-term events, typically lasting only a few hours.

How is in-situ burning performed?

In-situ burning is the combustion of spilled oil at or very near a spill site. Two types of equipment are used for *in-situ* burning: some means of containment to keep slicks thick enough to generate sufficient vapors for burning, and a means of ignition. Containment can be achieved naturally by local topography, man-made changes in topography (e.g., berms or dams), or using specially-constructed fire boom. Igniters vary in complexity from matches to flares, torches, and the use of gelled fuel. Response personnel augment their response equipment to address fire control (e.g., creating fire breaks, firefighting, etc.).

For spills on land, *in-situ* burning can be conducted in most habitats whether dry land, wetlands, or shorelines. Spilled oil can be contained or collected in natural ditches or behind constructed dikes. If a spill is on snow, then oiled snow can be collected into cones and burned.

For spills on water, boats tow a fire-resistant boom arranged in a U shape to collect and contain spilled oil. Towboats advance slowly to ensure a reasonable thickness of oil (approximately 1/10 of an inch) at the apex of the boom.[1]

Once a burn is ignited, responders monitor its progress and trajectory of the smoke plume, assess fire control, and maintain safe distances for heat protection. Once a burn has extinguished, responders asses the amount and location of any burn residue or unburned oil and determine if further steps are needed to remove it or whether it can be left to degrade naturally.

Why burn spilled oil?

In-situ burning can remove large volumes of spilled oil from the surface of land and water more rapidly and efficiently than physical containment and recovery.[1,2] For example, a pool of oil 300 ft. in diameter can burn at a rate of over 40,000 gallons per hour. Studies have shown up to 90% - 99% of spilled oil volume can be removed by *in-situ* burning.[1]

As most of spilled oil will be converted to gaseous combustion products when burned, the need for equipment and responders to assist in collection, storage, treatment, transport, and disposal of recovered oil and oily wastes is greatly reduced.[1,2] *In-situ* burning also reduces the number of equipment and responders needed to clean oiled habitats, the potential for effects to habitats from clean-up operations themselves, and the exposure potential to wildlife using a habitat.

In-situ burning can effectively limit responder exposures to oil-related compounds and the potential for any associated adverse health effects.

— Light-weight components of oil, namely volatile organic compounds such as benzene and alkylbenzenes, evaporate rapidly from freshly spilled oil and can be readily inhaled. Emissions of these volatile compounds from unburned crude oil can be more than three times higher than when burning oil.[3-5]

— Reducing emissions of these light-weight compounds is a benefit to responder safety because they are potentially flammable.

What compounds are in smoke from burning spilled oil?

Smoke plumes rise vertically into the atmosphere and are composed of a heated combination of particulate matter, mainly black carbon particles (soot), and combustion gases.[6] Most oil in an *in-situ* burn is converted to water vapor, carbon dioxide, and black carbon soot, with much smaller amounts of carbon monoxide and other gases.[7,8] Amounts and concentrations of these materials fluctuate with local weather conditions, composition of the spilled oil, and temperature of the burn.

Burning generates smoke, which can be a concern for response personnel and the general public. [9]

— Carbon monoxide and other respiratory-tract irritant gases in a smoke plume are a concern for responders working very close to a burn. However, these gases rapidly dilute with distance from the smoke plume.

— Medium- and heavy-weight components of oil evaporate more slowly and can act as dermal irritants if they directly contact the skin of responders or wildlife.

— Particulate matter from an *in-situ* burn smoke plume is the primary public health concern from. Because of their small size, some smoke particles can be inhaled deep into the lungs.[8,10]

Typically, *in-situ* burns are completed in a few hours, so smoke plumes would be present for only a short time and their components rapidly dissipate[2]. Response personnel can limit their exposure to smoke by wearing appropriate respiratory protection and by positioning themselves upwind from a smoke plume. Compared to wildfires, *in-situ* burns are much shorter in duration and much smaller in scale.[1,11] Both factors limit the area of potentially affected individuals to those closer to a burn site.

Is smoke from in-situ burning similar to other types of smoke, such as wood smoke?

Smoke generated from *in-situ* burning of spilled oil is similar to smoke from other fuel sources, including wood.[9,12]

— Smoke from *in-situ* burns will typically have a thicker/blacker appearance than smoke from burning wood, as most of the burning oil is transformed to black, elemental carbon particulate matter. Decreased moisture content in oil, compared to wood, further contributes to the darker appearance of smoke from burning oil.

— Wood is a combination of cellulose, lignin, tannins, oils, fats, resins, waxes, and starches that produces an ashen grey colored smoke when burned.[11]

Where does smoke go?

The intense heat from an *in-situ* burn will loft smoke particles high into the air above a burn. Smoke particles will remain aloft until they cool and fall back to the ground.[13] Wind conditions affect the movement of these lofted smoke particles, diluting and spreading them downwind until they eventually reach ground level.

What are the health effects of smoke exposure?

Any health effects from inhalation of smoke from burning oil generally occur very soon after exposure.

— Exposure to visible levels of particulate matter can lead to irritation of the eyes, nose, and respiratory tract.[6] These effects are typically short-lived and symptoms resolve soon after a person leaves the smoky area.

— Not everyone who is exposed to smoke from burning oil (not just from *in-situ* burning) will experience adverse health effects.

Factors such as the level and duration of exposure, age, individual susceptibility, and the presence of pre-existing respiratory and cardiovascular diseases influence an individual's sensitivity.[9] Persons exposed to smoke from burning oil may be concerned that they have an increased risk of developing cancer. Sixty years of data from studies of firefighters indicate it is unlikely that limited, short-term exposure to smoke from burning oil would increase the risk of developing cancer.[14-19]

How can you tell if smoke exposure is affecting you?

Momentary exposures to visible levels of smoke from burning oil can cause eye and airway irritation, similar to the effects experienced when passing through campfire smoke.[9] Smoke exposure could be affecting you if you are experiencing:

— Coughing

— Sore/scratchy throat

— Difficulty breathing

— Chest pains

— Headache

— Teary/stinging eyes

— Runny nose

— Worsening of asthma or other respiratory condition

For brief exposures to visible levels of smoke, the above symptoms are generally short-lived and will resolve over time with rest and fresh air.

Individuals with heart disease may experience chest pain, elevated heart rate, shortness of breath, and increased fatigue upon inhaling smoke particulate matter regardless of source.[9] Smoke exposure could also worsen the symptoms of chronic lung diseases.[11]

Can smoke affect public drinking water or groundwater supplies?

Public drinking water systems utilizing potable surface water bodies (e.g., streams, rivers, lakes) use various methods of treatment to provide safe drinking water for communities. Treatment typically involves coagulation and flocculation, sedimentation, filtration, and disinfection to remove various constituents and particulate impurities that may be present. Thus, it is unlikely that oil-related fire smoke would affect public drinking supplies originating from surface waters.[20] It is very unlikely that smoke from an *in-situ* burn would affect well water or groundwater quality because there is either minuscule or no route of exposure.[21,22]

State regulators can conduct an inspection of public water systems to evaluate water quality in areas affected by fire smoke. If inspection finds that a water distribution system has been physically damaged by a fire, then state regulators can issue a "boil water advisory" indicating water should be boiled or disinfected prior to consumption and/or that alternative sources of potable water (e.g., bottled water) should be used.[23]

What may I be asked to do if there is an in-situ burn near my home?

In the event of a nearby *in-situ* burn, follow the instructions of your local officials. Generally, leaving smoky areas is the best way to limit inhalation of smoke particles. If advised to remain indoors, keep all windows and outside doors closed. Use any air conditioning with the fresh-air intake closed and a clean filter.[24] If unable to remain indoors, seek shelter at designated locations away from smoke.

What are the potential impacts of smoke to gardens, food, and crops?

Fruits and vegetables that have been covered in soot can still be eaten, though care should be taken to clean the surface of every food item. This may prove difficult for gardeners cultivating leafy vegetables and/or small fruits such as grapes. If you ultimately choose not to eat the produce in your garden, the affected vegetation can be washed and composted.[25,26] Farmers have historically relied on the spreading of ash from agricultural slash and burn practices to return essential nutrients to their soils.

Can smoke affect the health of my pets?

Pet health effects from smoke inhalation will be similar to those in humans.[27] Smoke exposure from any type of fire can lead to some eye redness and squinting, and sufficient exposure to smoke can cause pets to sneeze, wheeze, and cough. These effects are typically short-lived and symptoms should resolve soon after a pet is removed from a smoky area. In the event of high levels of outdoor smoke from any type of fire, protect your pets from smoke exposure by keeping them inside as much as possible with the windows closed, and consider boarding your pets in an area unaffected by smoke.

What impact will smoke have on homes and property?

As with any fire, homes, vehicles, and other properties downwind can have soot deposits on their exterior surfaces.

— Ash on external surfaces is unlikely to cause any short or long term health effects and is predominantly an aesthetic concern. It is easier to remove soot soon after it deposits since soot becomes more difficult to remove over time. When removing soot from a surface, take care to limit the pressure on and movement of the layer of soot since this could push soot deeper into the surface being cleaned.

— Most homes' and businesses' interiors affected by smoke should only require a light dusting to remove any soot and ash. Air conditioner filters may need to be replaced. HEPA-certified vacuum cleaners are effective in removing dry soot particles deposited on carpet.

— Buildings closer to a smoke source can be more affected by soot and have a smoky odor in attics, ventilation systems, and/or some interior spaces. In these situations, more intensive or repeated cleanings may be needed.

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