

SPECIAL MONITORING of APPLIED RESPONSE TECHNOLOGIES for ISB Burn Operations

Developed by:
National Response Team Workgroup 2023



Top: Test burn conducted on Little Sand Island at USCG Joint Maritime Test Facility in Mobile, Alabama November, 2017. NOAA. Bottom right and left: ISB in marsh Delta National Wildlife Refuge, Louisiana 2014. NOAA.

SMART is a living document

Special Monitoring of Applied Response Technologies (SMART) is a living document. In accordance with the intent of the original workgroup who developed the SMART protocols, the following represents an **update** to existing SMART protocol **specifically as it addresses in situ burns (ISB)**. A separate effort is being conducted by a National Response Team (NRT) workgroup focused on SMART protocols for dispersant use. The NRT ISB workgroup has attempted to incorporate changes in technologies, accumulated experience, and operational improvements in our effort to update the SMART protocol and this document, specifically as it addresses ISB operations. It is our desire to continue to encourage future updates to the SMART manual for ISB protocol through multi-agency participation and recommend those activities are coordinated through the NRT Science and Technology (S&T) subcommittee. Comments and suggestions to improve the SMART protocol are welcome and should be provided to the NRT S&T.

SMART approval status

In October 2022, the workgroup submitted the updated document to the NRT for review and approval.

Acknowledgments

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SMART is a Guidance Document Only

Purpose and Use of this Guidance:

This manual and any internal procedures adopted for its implementation are intended solely as guidance. They do not constitute rulemaking by any agency and may not be relied upon to create right or benefit, substantive or procedural, enforceable by law or in equity, by any person. Any agency or person may take action at variance with this manual or its internal implementing procedures. Mention of trade names or commercial products does not constitute endorsement or recommendation for their use by the USCG, BSEE, NOAA, EPA, CDC, or the Government of the United States of America.

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List of Acronyms

AQG	Air Quality Guideline
AQI	Air Quality Index
ATSDR	Agency for Toxic Substances and Disease Registry
BSEE	Bureau of Safety and Environmental Enforcement
CDC	Centers for Disease Control and Prevention
EPA	Environmental Protection Agency
ERT	Emergency Response Team
FOSC	Federal On-scene Coordinator
GPS	global positioning system
ICS	Incident Command System
ISB	in situ burn
LOC	Levels of Concern
$\mu\text{g}/\text{m}^3$	micrograms per cubic meter
NAAQS	National Ambient Air Quality Standard
NOAA	National Oceanic and Atmospheric Administration
NRT	National Response Team
PM _{2.5}	particulates equal to or smaller than 2.5 $\mu\text{g}/\text{m}^3$
QA/QC	Quality Assurance/Quality Control
RRT	Regional Response Team
SMART	Special Monitoring of Applied Response Technologies
SSC	Scientific Support Coordinator
TTPs	Tactics, Techniques, and Protocols
TWA	time-weighted average
UC	Unified Command
USCG	United States Coast Guard

INTRODUCTION

The Special Monitoring of Applied Response Technologies (SMART) protocol for in situ burn (ISB) and dispersant operations was developed and approved by the National Response Team (NRT) in 1997 and was updated in 2006. In accordance with the intent of the original workgroup who developed the SMART protocol, the NRT Science and Technology subcommittee formed a workgroup in 2021 to provide an update to the existing SMART protocol specifically as it addresses ISB and dispersant operations. While the original SMART protocol addressed **both dispersant and ISB** operations in one document, the 2021 workgroup recommended creating updated guidance on SMART protocols in **two separate documents**, one focused on monitoring for use of dispersants, the other focused solely on ISB operations. This document is intended to provide an update for the SMART protocol associated with **ISB operations ONLY**.

National protocols designed to standardize monitoring are an important aid to the Federal On-Scene Coordinator (FOSC) in fulfilling their responsibilities as defined in the National Oil and Hazardous Substances Pollution Contingency Plan (40 CFR Part 300). Protocols are also needed to provide guidance to, and oversight of, industries' monitoring of response efforts during spills. Accordingly, all of the nation's Regional Response Teams (RRTs) have developed pre-approval and operational conditions and requirements for ISB operations, including the widespread adoption of the SMART protocol. Many regions have also designated specific pre-approval and exclusion zones for ISB operations. In addition to the federal, regional, and state regulations and guidelines, a number of standards have been developed for ISB operations. While these regulations, standards, and guidelines are designed to address operational requirements, methods, organizational elements, planning, and policy, none are designed specifically to address burn monitoring for the purpose of informing decision making with real-time, scientifically based data. This is the essential objective of SMART for ISB operations.

Since its inception in the 1990s, the SMART protocol has been used extensively throughout the nation during ISB operations both on water and on land. SMART was used during the initial ISB operations for the Mississippi Canyon 252 (*Deepwater Horizon*) incident in 2010. Approximately 411 offshore ISBs were conducted during the *Deepwater Horizon* incident resulting in an estimated 250,000 barrels of oil removed from the water (On Scene Coordinator Report *Deepwater Horizon*, 2011). From 2010 to 2022, at least sixteen significant ISBs of oil on water have been conducted in the U. S. with all but one taking place in the coastal marshes of Louisiana (Michel and Zengel, 2021), SMART operations have been routinely conducted in all of these ISB operations and, in many instances, have been a conditional requirement of the approving RRT.

The original intent of the SMART protocol was to establish a monitoring system for **rapid collection and reporting of real-time, scientifically based information**, in order to assist the FOSC or Unified Command (UC)¹ with **decision-making** during an ISB. This continues to be the guiding principle of SMART for ISB operations.

SMART provides guidance on monitoring methods, equipment, personnel training, and command and control procedures that are designed to strike a balance between the operational demands for rapid

¹ There may be some instances where the FOSC has authority and preauthorization to proceed with, continue, or discontinue ISB operations. For the purposes of this document, there is no intentional distinction as to whether the SMART protocols are specifically designed for the FOSC or the UC. Rather, the protocols are intended to serve command decision making wherever it occurs under applicable authorities, jurisdiction, etc.

response and the FOSC or UC's need for feedback from the field in order to make informed decisions based upon operational data. While the technology, tools, or methods used for SMART operations may change based upon advances in scientific knowledge and technology, the overall **design and objectives** established in the original protocol remain the same. Special emphasis or explanation is provided wherever new procedures, techniques, or technology are incorporated into this current SMART protocol. As stated in the original SMART protocol, the SMART protocol for ISB should be considered a living document and future updates should be made in accordance with significant advances in applicable science.

The specific guidelines, procedures, and methods developed for the SMART ISB monitoring as outlined in this document may be adopted for other hazardous substance responses, particularly where particulate air emissions should be monitored. In addition, SMART-type monitoring that emphasizes providing timely and scientifically based information to the FOSC or UC may be developed for additional alternative oil spill response techniques or could be adapted to other chemical spills into fresh or marine water.

General Information on ISB SMART Protocols

A. General Considerations and Assumptions

There are several considerations that guided the initial and current workgroup in developing and updating the SMART guidelines:

1. SMART is designed for use at oil spills both inland and in coastal zones, as described in the National Oil and Hazardous Substances Pollution Contingency Plan.
2. SMART does not directly address the health and safety of spill responders or monitoring personnel, because this is covered by the general site safety plan for the incident (as required by 29 CFR 1910.120).
3. SMART does not provide complete training on monitoring for a specific technology. Rather, the protocol assumes that monitoring personnel are fully trained and qualified to use the equipment and techniques mentioned and to follow the SMART guidelines.
4. SMART attempts to balance feasible and operationally efficient monitoring with solid scientific principles.
5. In general, SMART guidelines are based on the roles and capabilities of available federal, state, and local teams, and Scientific Support Coordinators (SSC) provided by the National Oceanic and Atmospheric Administration (NOAA; primarily in the coastal zone), the U.S. Environmental Protection Agency (EPA; primarily in the inland zone), or State agencies. The SSC most often fills the role of Technical Specialist mentioned throughout the document. Users may adopt and modify the ISB protocols to address specific needs and availability of resources.
6. SMART uses the best available technology that is operationally practical. SMART represents a living document and should be revised and improved based on lessons learned from the field, advances in technology, and developments in techniques.
7. SMART **should not** be construed as a regulatory requirement, but has been well-established as a best practice available for the FOSC or UC to assist in decision-making. While every effort should be made to implement SMART or parts of it in a timely manner, **ISB operations should**

not be delayed solely to allow the deployment of the SMART teams, particularly in instances where these operations are authorized or approved by the FOSC in accordance with applicable regulations specified in the National Contingency Plan; or area or regional contingency plans; or, where other incident or location-specific monitoring protocols have been established for ISB operations.

8. SMART is not intended to supplant private efforts in monitoring response technologies, but is written for adoption and adaptation by any private or public agency. Furthermore, users may choose to tailor the ISB protocols to specific regional needs. While currently addressing monitoring for ISB operations, SMART protocols may be developed for other response methods, or for spills other than oil.
9. It is important that the FOSC or UC agree on the monitoring objectives and goals for any response countermeasures early on in an incident. This decision, like all others, should consider tradeoffs associated with the implementation of the strategy and should be documented.

B. Document Organization

This document is intended to outline SMART protocols associated with ISB operations only and is divided into three sections:

Section 1: Background Information provides a brief overview of the response technology being used, defines the primary purpose for monitoring, and discusses monitoring assumptions.

Section 2: Monitoring Procedures provide general guidelines on what, where, when, and how to monitor; information on organization; information flow; team members; and reporting of data.

Section 3: Provides detailed information to support and expand Sections 1 and 2.

MONITORING ISB OPERATIONS

1. BACKGROUND

1.1 Mission Statement

The **primary objective** of SMART for ISB operations is **to provide timely, scientifically based information on emissions from ISB operations to the FOSC and, where appropriate, the UC for the purpose of decision making related to ISB operations**. Specifically, SMART for ISB is designed to provide the FOSC/UC with relevant and timely emissions data to assess and evaluate potential impacts to public health or sensitive resources from ISB operations. While it is assumed that the decision to **initiate** an ISB is made prior to the collection of SMART data, the SMART protocol outlines essential elements that should be considered when planning for an ISB. The intent of this revision to the SMART protocol is to enhance and update the process, and provide a resource for readily available tools and procedures that can be used by the FOSC and, where appropriate, the UC to gather useful information for the purpose of decision making related solely to ISB operations and planning. They are not intended to replace any established protocols or procedures outlined in area or regional plans or applicable regulations, nor replace any protocols or procedures to address health and safety of the spill responders or monitoring personnel.

1.2 Overview of ISB

ISB of oil may offer a logistically simple, rapid, efficient, and relatively safe means for reducing the net environmental impact of an oil spill. An effective ISB can substantially reduce the need for and impacts from the collection, storage, transport, and disposal of recovered material by rapidly removing large portions of the oil from the water or land surface and converting to gaseous combustion products and particulates. In comparison to other removal techniques it may require less equipment, generate greater removal rates and may be the only viable removal option in certain circumstances. As with any response technique, ISB has several considerations: the oil needs to be thick and fresh enough to sustain a burn, wind and sea conditions must not be prohibitive, and appropriate fire containment equipment, protocols, or methods must be available. Specific checklists for operational considerations and decision-making associated with initiating an ISB have been developed by a number of RRTs. A list of these guidance documents along with their hyperlinks is included in Appendix A. Users should refer to these and/or other regional or area specific documents for additional guidance and requirements.

In addition, ISB operations typically emit a plume of black smoke, composed primarily (80-85%) of carbon dioxide and water; the remainder of the plume is composed of gases and particulates, mostly black carbon particulates, commonly referred to as soot. These soot particulates give the smoke its dark color. Downwind of the fire, the gases and particulate emissions dissipate relatively quickly. The main public health concern associated with burning oil is the particulates in the smoke plume. Further details on emissions is included in Section 2.

ISB has been demonstrated as an effective spill response option under a range of conditions. However, as with all response options, potential impacts from these operations should be weighed against their overall benefit in reducing or mitigating impacts from the oil. Most notably, concerns have been raised regarding the possible health effects from exposure to particulates in the smoke plume to the general public. SMART for ISB is designed as a practical means for assessing these impacts to better aid the FOSC or UC in command decisions related to continuing, or terminating ISB as a response method.

2. MONITORING PROCEDURES

2.1 General Considerations

SMART for ISB consists of two components: continual visual monitoring of the smoke plume and, when necessary, the use of air monitoring equipment capable of detecting emissions of concern from the ISB operations. Air monitoring is recommended when there is a need for the FOSC or UC to assess or monitor emissions and when the predicted trajectory of the smoke plume indicates that the smoke may impact public health or other sensitive resources. Results from extensive air monitoring conducted during experimental ISBs and actual incidents demonstrate that the primary contaminant of concern with the greatest potential for public health impacts are particulates that are in the 2.5 μm ($\text{PM}_{2.5}$) range.

The concentration of particulate emissions from ISBs as related to the distance from the burn are influenced by a number of factors. The primary factors include:

- Surface area of burning oil,
- Duration of the burn, and
- Atmospheric conditions during the burn.

Other factors such as the type of oil and combustion efficiency as influenced by environmental conditions may also have a significant impact on burn emissions.

Information on **estimating** particulate emission concentrations for ISB operations is included in Appendix B. **It is important to note that emissions from ISBs are a result of a number of complex, inter-related, and often variable conditions. If ISB conditions are well understood and do not deviate significantly during the course of the burn, certain trends or qualitative estimations may be possible.** For example, ISBs conducted for long durations under very stable atmospheric conditions (e.g., inversion and low to variable winds) would be expected to have higher concentrations of emissions at ground level a greater distance from the burn than ones conducted with the same oil under more unstable atmospheric conditions and moderate wind speeds (e.g., good mixing). Thus, while emissions estimates may be useful in determining the optimum locations for monitoring, they should not be used as a substitute for actual monitoring.

Emissions from air monitoring may serve as the best means for determining the appropriateness for any subsequent burns **where public exposure is in question, or in determining how far from a burn specified levels of concern (LOC) are exceeded under actual environmental conditions present during the initial or test burn.**

Again, it is important to note that particulate monitoring may not be needed when burn conditions and smoke trajectory are well understood and worker and public health impacts are not in question (e.g., when the burn is conducted many miles offshore or in a very remote area many miles from populated areas).

Guidelines and references designed to aid in determining the extent of potential impacts from an ISB are included in both Appendices A and B. Again, it is important to note that these SMART protocols are **not** designed to replace or contradict any existing regulations, but rather serve as a tool for acquiring timely, scientifically based data to aid in decision making. Additionally, the SMART protocol is not designed to address worker exposure monitoring.

Execution of an ISB typically has a very narrow window of opportunity. This is particularly true when there is a noncontinuous oil release in open water, or the discharge is not readily contained and protected from weathering. Even in some instances when this window of opportunity is extended

(e.g., when there is a continuous source of fresh oil), conditions may abruptly change and the window of opportunity may be significantly reduced or lost altogether. It is thus imperative that the monitoring teams are alerted of possible ISB that require SMART operations **even if implementation is not certain**. This increases the likelihood of timely and orderly SMART operations.

2.2 Sampling and Reporting

Monitoring operations may need deployment of one or more monitoring teams. SMART recommends three monitoring teams for **large-scale** burning operations where public exposure to emissions is in question. In some instances, such as small, isolated, and short duration burns, a single team may be able to satisfy the data quality objectives. Each team uses a real-time particulate monitor instrument capable of detecting the small particulates emitted by the burn (2.5 micrometers in diameter or smaller), a global positioning system (GPS) device, and any other equipment required for deploying, collecting, documenting, and communicating the data.

Each monitoring instrument provides an instantaneous particulate concentration as well as the time-weighted average over the duration of the data collection. The readings are displayed on the instrument's screen and stored in its data logger. In addition, particulate concentrations are logged manually every few minutes by the monitoring team in the recorder data log. During the course of the sampling, it is expected that the instantaneous readings may vary widely. However, the calculated time-weighted average (TWA) readings are less variable, since they represent the average of the readings collected over the sampling duration, and hence are a better indicator of particulate concentration trends. When the time-weighted average readings approach or exceed the specified LOC, the team leader conveys this information to the ISB Monitoring Group Supervisor who passes it on to the Technical Specialist in the Planning Section (Scientific Support Coordinator, or other technical specialist where applicable), who reviews and interprets the data and passes them, with appropriate recommendations, to the FOSC or UC.

2.3 Monitoring Locations

Monitoring locations should be based upon the predicted trajectory and potential for emissions from the burn operations to reach the public or impact environmentally sensitive areas. Taking into account the prevailing and forecasted winds and atmospheric conditions, the location and magnitude of the burn, modeling output (if available)², the location of and proximity to human health receptors, and input from state and local health officials (when available), the monitoring teams are deployed in locations where monitoring is needed to assess whether emissions exceed any LOC established for the incident. Precise monitoring locations should be flexible and determined on a **case-by-case basis** with input from technical specialists and/or public health officials when available.

For burn operations where exposure to smoke (particulate emissions) by the public or other sensitive resources is probable, monitoring teams should be deployed as close as practical to the receptor being monitored. All team monitoring locations should be coordinated by the Group Supervisor who should consult with the Technical Specialist on the data quality objectives as appropriate.

When practical, at least one team should be deployed either upwind of the burn location, or at the location where potential exposure is being monitored to determine background concentrations. This should be done prior to the onset of actual burn operations. The second and/or subsequent teams should be deployed downwind of the burn location and just upwind or near to the population or other sensitive area that is being monitored for impacts. Teams should remain at their designated locations throughout

² A number of models have been used to estimate emissions from oil fires and ISB operations. To date, it is unclear as to whether any current particulate emissions model is readily available and well-suited to support ISB burn operations. Research in this area is ongoing and future products may be available. Please refer to Appendix B for a discussion of emissions modeling.

the burn unless moving is necessary to improve sampling capabilities or adapt to changes in burn and wind conditions. Additional teams that are more mobile in nature may be useful in certain circumstances, particularly if there is a high likelihood of changing conditions or there is a need to better define areas of impact from emissions. Team locations should be accurately recorded using GPS. The number and locations of all teams should be well communicated prior to and during ISB operations up through the Group Supervisor to the Technical Specialist (where appropriate) and the FOSC or UC.

An idealized depiction of monitoring team locations for a typical ISB operation and further discussion on monitoring locations is provided in Section 3.7. Again, actual locations should be optimized based on the needs of the response.

It should be emphasized that, while visual observation is conducted continuously as long as the burn takes place, air sampling using particulate monitors **may not be required if there is no potential for public exposure to the smoke.**

2.4 Levels of Concern (LOC) for Particulate Emissions

It is important to keep in mind that real-time particulate monitoring of emissions from ISB operations is one factor among several, including smoke modeling and trajectory analysis, visual observations, and behavior of the smoke plume. The FOSC or UC must determine early on in the response what conditions, in addition to any LOC, justify termination of a burn or other action to protect public health or other sensitive resources. The FOSC or UC should work closely with appropriate State, local, and Federal Public Health organizations in determining burn termination thresholds in addition to any LOC for emissions or other parameters.

NRT guidelines have been established utilizing the current EPA primary and secondary standards for PM_{2.5} (annual average standards with levels of 12.0 µg/m³ and 15.0 µg/m³, respectively; 24-hour standards with 98th percentile forms and levels of 35 µg/m³) and PM₁₀ (24-hour standards with one-expected exceedance forms and levels of 150 µg/m³). Again, this was determined to be a **guideline** for use and is consistent with updates to the EPA's National Ambient Air Quality Standard (NAAQS). This reflected a greater concern for PM_{2.5} particulates in terms of potential impacts from ISB operations.

The following presents other LOC for particulates that have been developed by national health agencies and **could be** considered by the FOSC or UC when determining an action level or LOC for emissions from ISB operations.

The Centers for Disease Control and Prevention (CDC) Agency for Toxic Substances and Disease Registry (ATSDR) has recommended thresholds for particulate monitoring during emergencies based on the World Health Organization Air Quality Guideline (AQG). ATSDR recommends 25 ug/m³ for PM_{2.5} and 50 ug/m³ for PM₁₀ based on one-hour time weighted averages. Exceedances above the AQG would require human exposure near that location be evaluated and protective measures implemented by local authorities in the UC as appropriate. If no exceedance of the AQG in the area, then no actions were recommended as necessary.

Another means for the FOSC or UC to consider LOC for particulates is to use a scalable approach such as the one provided in the AirNOW Air Quality Index in Table 1 (next page).

Table 1. AirNOW Community Action Levels and Actions [derived from EPA 454/B-18-007 Technical Assistance Document for the Reporting of Daily Air Quality – the Air Quality Index (AQI)].

PM _{2.5} Threshold Levels (µg/m ³)		Level of Health Concern	Meaning	Action
1 Hr. Avg.	24 Hr. Avg.			
COMMUNITY ACTION LEVELS				
0.0 – 40.0	0.0 – 12.0	Good	Air quality is considered satisfactory, and air pollution poses little or no risk.	Implement communication plan.
40.1 – 80.0	12.1 – 35.4	Moderate	Air quality is acceptable; however, for some pollutants there may be a moderate health concern for a very small number of people who are unusually sensitive to air pollution.	Issue public announcement about health effects. Stay out of areas with visible smoke.
80.1 – 175.0	35.5 – 55.4	Unhealthy for Sensitive Groups	Members of sensitive groups may experience health effects. The general public is not likely to be affected.	Recommend evacuation or shelter-in-place for Sensitive populations.
175.1 – 300.0	55.5 - 150.4	Unhealthy	Everyone may begin to experience health effects; members of sensitive groups may experience more serious health effects.	Consider closing schools and cancelling outdoor events. Recommend shelter-in-place for affected neighborhoods.
300.1 - 500.0	150.5 - 250.4	Very Unhealthy	Health warnings of emergency conditions. The entire population is more likely to be affected.	Consider closing schools and cancel all outdoor events. Recommend shelter-in-place and/ or evacuation for affected neighborhoods.
> 500.0	> 250.5	Hazardous	Health alert: everyone may experience more serious health effects.	Recommend closing schools & cancel outdoor events. Recommend closing workplaces and <u>neighborhood</u> .

This table is commonly referred to for guidance on impacts to public health from particulate emissions from wildfires. Rather than establishing set thresholds, this guidance allows users to understand the potential severity of human health impacts and corresponding recommended actions over a range of particulate concentrations and may be well suited to similar use for ISB operations.

In addressing particulate monitoring for ISB, the NRT has previously emphasized that concentration trends, rather than individual readings, should be used to decide whether to continue or terminate the ISB. For SMART operations, the **time-weighted average (TWA)** generated by the particulate monitors is recommended as the method used to ascertain the trend. In instances where the air quality in the region where the ISB is being conducted already exceeds the NAAQS, **and** if burning the oil will add to the particulate exposure concentration in that region **beyond a 24-hour period**, the NRT recommends that burning not take place. SMART can be used to take background readings to indicate whether the region is within the NAAQS before the ISB operation takes place. The monitoring teams should report ambient readings to the FOSC or UC, especially if these readings approach or exceed the NAAQS. It is important to note that ISB operations are typically very short in duration (minutes for most, singular hours for very extensive burns) and that the NAAQS is a guideline developed to assess risk for long term exposure. Thus, using NAAQS as a guideline is a very conservative approach for evaluating potential impacts from exposure to particulates.

2.5 SMART as Part of the ICS Organization

SMART activities are directed by the Operations Section Chief in the Incident Command System (ICS). It is recommended that a "group" be formed in the Operations Section that directs the monitoring effort under a Monitoring Group Supervisor. Under each group there are monitoring teams. At a minimum, each monitoring team consists of two trained members: a monitor and assistant monitor. An additional team member could be used to assist with sampling and recording. The monitor serves as the team leader. The teams report to the Monitoring Group Supervisor who directs and coordinates team operations, under the control of the Operations Section Chief.

2.6 Information Flow and Data Handling

Communication of monitoring results should flow from the field (Team lead or Monitoring Group Supervisor as appropriate) to those persons in the UC who can interpret the results and use the data. Typically, this falls under the responsibility of the Technical Specialist on ISB in the Planning Section of the command structure. This role is typically filled by the NOAA SSC for incidents under the jurisdiction and authority of the United States Coast Guard (USCG), or the EPA Environmental Response Team (ERT) for incidents under the jurisdiction and authority of the EPA.

In a fully staffed ISB operation, the observation and monitoring data will flow from the Monitoring Teams to the Monitoring Group Supervisor. The Group Supervisor then forwards the data to the Technical Specialist. The Technical Specialist or his/her representative reviews the data and, **most importantly, formulates recommendations based on the data** and the Technical Specialist **communicates these recommendations to the FOSC or UC**. When all these positions are not capable of being occupied, the intent and overall objective of conveying accurate and timely data from field monitoring to the Technical Specialist and then the FOSC or UC should be followed as closely as possible to ensure informed decision making.

Quality assurance and control should be applied to the data at all levels. The Technical Specialist is the custodian of the data during the operation, but ultimately the data belongs to the FOSC or UC. The FOSC or UC should ensure **that the data are properly archived, presentable, and accessible for the benefit of future ISB operations**.

3. ATTACHMENTS

The following attachments are designed to assist response personnel in implementing the SMART protocol. A short description of each attachment is provided below.

Number	Title	Description
3.1	Roles and Responsibilities	Provides detailed roles and responsibilities for responders filling monitoring positions
3.2	Command, Control, and Data Flow	A suggested ICS structure for controlling monitoring units and transferring monitoring results
3.3	ISB Monitoring Training Outline	General training guidelines for ISB monitoring
3.4	ISB Monitoring Job Aid Checklist	A checklist to assist in assembling and deploying SMART ISB monitoring teams
3.5	ISB Monitoring Equipment List	A list of equipment needed to perform SMART operations
3.6	ISB Particulate Monitor Performance Requirements	Abbreviated performance requirements for particulate monitors
3.7	ISB Monitoring Locations	An example of monitoring locations
3.8	ISB Monitoring Recorder Sheet	A template for manual recording of ISB data
3.9	ISB Monitoring Data Sample: Graph	An example of ISB data

3.1 Roles and Responsibilities

3.1.1 Monitoring Team Leader

The Monitoring Team Leader:

- Selects specific team locations
- Conducts monitoring
- Ensures health and safety of team
- Ensures monitoring QA/QC
- Establishes communication with the group supervisor
- Conveys to him/her monitoring data as needed

3.1.2 Monitoring Group Supervisor

The Monitoring Group Supervisor:

- Oversees the deployment of the teams in the group
- Ensures safe operation of the teams
- Ensures QA/QC of monitoring and data
- Establishes communication with the field teams and the command post
- Conveys to the command post particulate level trends as needed
- Addresses monitoring technical and operational problems, if encountered

3.1.3 ISB Technical Specialist

The ISB Technical Specialist or his/her representative:

- Establishes communication with the Monitoring Group Supervisor
- Receives the data from the Group Supervisor
- Ensures QA/QC of the data
- Analyzes the data in the context of other available information and incident-specific conditions, formulates recommendations to the UC
- Forwards the recommendations to the UC
- Makes the recommendations and data available to other entities in the ICS, as needed
- Archives the data for later use

Role and Function	Training	Number (typical)
<u>Monitoring Team Leader</u> Leads the monitoring team	SMART Monitor Training	1 or more
<u>Monitor Assistant</u> Assists with data collection	SMART Monitor Training	same as above
<u>Monitoring Group Supervisor</u> Coordinates and directs teams; field QA/QC of data; links with UC	SMART Monitor training. Group Supervisor training	1 per group
<u>ISB Technical Specialist</u> Overall QA/QC of data; reads and interprets data; provides recommendations to the UC	SMART Monitor training. Scientific aspects of ISB	1 per response

3.2 Command, Control, and Data Flow

In general, ISB monitoring operations take place as an integral part of the Incident Command System (Figures 1 and 2).

ISB monitoring operations are directed by the Operations Section Chief or deputy. The Operations Section Chief provides the Monitoring Group Supervisor with tactical directions and support regarding deployment, resources, communications, and general mission as adapted to the specific incident. The Operations Section consults with the ISB monitoring Technical Specialist about the specifics of the monitoring operations, especially if they affect the data collected. The Monitoring Group Supervisor provides specific direction to the monitoring teams during field deployment and operations.

The observation and monitoring data flow from the Monitoring Teams to the Monitoring Group Supervisor. After initial QA/QC, the Monitoring Group Supervisor passes the data to the Technical Specialist. The Technical Specialist or his/her representative reviews the data, applies QA/QC if needed, and, most importantly, formulates recommendations based on the data. The Technical Specialist forwards these recommendations to the UC.

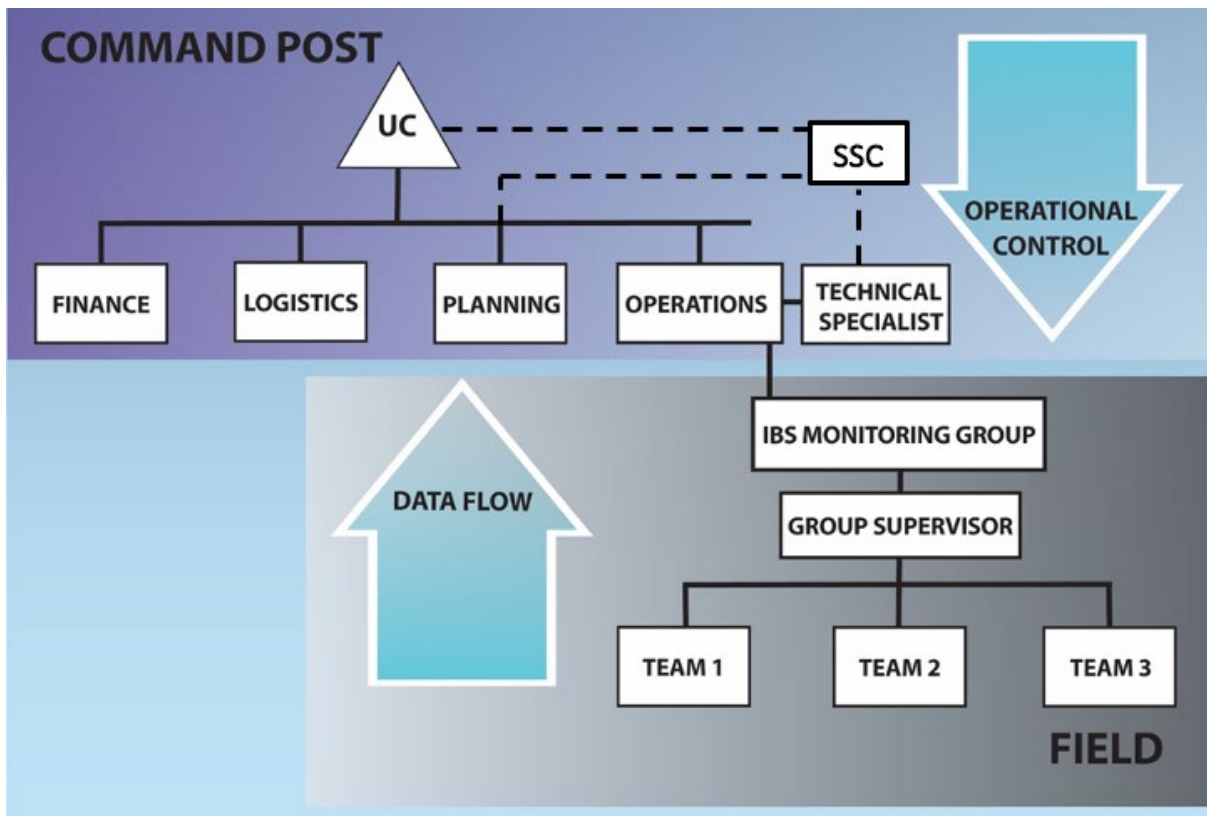


Figure 1. Command, control, and data flow during ISB monitoring operations.

3.3 ISB Monitoring Training Outline

3.3.1 General

Training for ISB monitoring operations consists of an initial Monitor Level Training for all, Group Supervisor Training for supervisors, and refresher training sessions every six months for all.

3.3.2 Monitor Level Training

The Monitor Level Training includes monitoring concepts, instrument operation, work procedures, and a field exercise.

Topic	Duration
<ul style="list-style-type: none"> Brief review of ISB Review of SMART: What is it, why do it, what is it good for 	1 hour
<ul style="list-style-type: none"> Monitoring strategy: Who, where, when Open water, inland Reporting: What and to whom LOC: What is the LOC, how to report it Instantaneous reading vs. TWA, use of recorder data sheet 	1 hour
<ul style="list-style-type: none"> Basic instrument operation (hands-on): How the particulate monitoring instrument works, and how to operate it: brief description of mechanism, setup, and calibration, reading the data, what do the data mean; trouble shooting Using GPS Downloading data 	2 hours
Field exercise: Set up the instruments outdoors and measure background readings. Using a smoke source monitor for particulate levels; practice recording the data and reporting it. When done, practice downloading the data	4 hours

3.3.3 Group Supervisor Training

Supervisor training may include two options:

- Independent training at each unit; or
- An additional structured day of training as suggested below

Topic	Duration
<ul style="list-style-type: none"> Review of ICS and the role of the Monitoring Group in it Roles of Monitoring Group Supervisor What the data mean QA/QC of data Command and control of teams Communication with the Technical Specialist 	1 hour
Field exercise: Practice deploying instruments in the field with emphasis on reporting, QA/QC of data, communication between teams and the group supervisor, and group supervisor to the Technical Specialist	3-6 hours
Back to the base, practice downloading the data	30 min.
Lessons learned	30 min.

3.3.4 Refresher Training

Topic	Duration
Review of SMART: What is it, why do it, what is it good for?	15 minutes
<ul style="list-style-type: none"> • Monitoring and reporting: Who, where, and when • Level of concern • What do the data mean • Reporting the data • Work with the Technical Specialist 	30-45 minutes
<ul style="list-style-type: none"> • Basic instrument operation (hands-on): How the monitoring instrument works, how to operate it; brief description of mechanism, setup, and calibration • Reading the data, trouble-shooting • Using GPS 	2 hours
Downloading data	30 minutes
<ul style="list-style-type: none"> • Field exercise: Outside the classroom, set up the instrument and measure background readings. Using a smoke source, monitor particulate level • Practice recording the data and reporting it • Back to the base, download data 	1-2 hours

3.4 ISB Monitoring Job Aid Checklist

This checklist is designed to assist SMART ISB monitoring by listing some of the tasks to accomplish before, during, and after the monitoring operations.

√	Item	Do
	Preparations	
	Activate personnel	Notify monitoring personnel and the Technical Specialist
	Conduct equipment check	<ul style="list-style-type: none"> • Check equipment using equipment checkup list. • Verify that the monitoring instruments are operational and fully charged • Include safety equipment
	Coordinate logistics	Coordinate logistics (e.g., deployment platform) with ICS Operations
	Amend Site Safety Plan	Amend site safety plan to include monitoring operations
	Monitoring Operations	
	Monitoring Group setup	<ul style="list-style-type: none"> • Coordinate with Operations Section Chief • Coordinate with Technical Specialist
	Conduct briefing	<ul style="list-style-type: none"> • Monitoring: what, where, who, how • Safety and emergency procedures
	Deploy to location	Coordinate with Operations Section Chief
	Select site	<ul style="list-style-type: none"> • Safe • Consistent with monitoring plan • As little interference as possible • Communication with Group Supervisor and UC possible
	Set up instrumentation	Unpack monitoring instruments and set up, verify calibration, if applicable
	Mark position	<ul style="list-style-type: none"> • Use GPS to mark position in recorder sheet • Re-enter position if changing location
	Collect background data	Start monitoring. If possible, record background data before the ISB begins
	Collect ISB data	<ul style="list-style-type: none"> • Continue monitoring as long as ISB is ongoing • Monitor for background readings for 15-30 minutes after the ISB is completed and smoke clears
	Record data	Enter: <ul style="list-style-type: none"> • Instantaneous and TWA readings every 3-5 minutes, or other fixed intervals • Initial position from GPS, new position if moving • Initial wind speed and direction, air temperature, relative humidity, re-enter if conditions change
	Conduct quality assurance and quality control	<ul style="list-style-type: none"> • Verify that instrument is logging the data • Record data, location, relative humidity, temp, wind, interferences in the recorder data sheet • Note and record interference from other sources of particulates such as industry, vehicles, vessels

Report by team	Report to Group Supervisor: <ul style="list-style-type: none"> • Initial background readings • TWA readings (every 15 minutes) • TWA readings when exceeding LOC, (every 5 minutes) • Interferences • Safety problems • QA/QC and monitoring problems
Report by Group Supervisor	Report to the Technical Specialist: <ul style="list-style-type: none"> • Initial background readings • TWA, when exceeding LOC • Data QA/QC and monitoring problems
Report by Technical Specialist	Report to the UC: <ul style="list-style-type: none"> • TWA consistently exceeding LOC • Recommend go/no-go
Post Monitoring	
Debrief and lessons learned	<ul style="list-style-type: none"> • What went right, what went wrong • Problems and possible solutions • Capture comments and suggestions
Preserve data	<ul style="list-style-type: none"> • Download logged data from monitoring instrument to a computer • Collect and review Recorder data logs • Generate report
Prepare for next ISB	Clean, recharge, restock equipment

3.5 ISB Monitoring Equipment List

(For each team, unless otherwise noted)

√	Item	Qty	Remarks
	Particulate monitoring instruments, accessories (data loggers) and manuals	1 or more	
	Computer and cables	1/group	Should include downloading software
	Recorder data sheets	10	
	Write-in-the-rain notebooks, pens	3	
	Job aid check list	1	
	GPS	1	
	Extra batteries for GPS	1	
	Radio	1	
	Cell phone	1	
	Satellite phone	1	When cellular service or radio signal are insufficient to provide real time communications from the field to the Monitoring Group Supervisor and Technical Specialist
	Binoculars	1	
	Stop watch	1	
	Digital camera	1	Camcorder optional
	Thermometer	1	
	Humidity meter	1	
	Anemometer	1	

3.6 Particulate Monitor Performance Requirements

SMART does not require nor endorse a specific brand of particulate monitoring instrument. SMART specifies performance criteria, and instruments meeting them may be used for ISB monitoring.

Recommended monitoring equipment criteria

- Rugged and portable: monitors should be suitable for field work, withstand shock, and be easily transportable in a vehicle, small boat, or helicopter. Maximum size and weight of the packaged instrument should not exceed 50 pounds.
- Power & Operating duration: monitors should be battery powered and capable of operating for the duration of the ISB or at least eight hours.
- Operating temperature: 0-120 °F.
- Suitability: monitors should be suitable for the media measured, i.e., smoke particulates. Monitors should be able to measure concentrations corresponding to total particulate, 0 to 10 micrometers particulate fractions (PM₁₀), and the 0 to 2.5 micrometers particulate fractions (PM_{2.5}).
- Readout/display: monitors should provide real-time, continuous readings, as well as time-weighted average readings in µg/m³.
- Data logging: monitors should provide data logging for 8 hours or more.
- Reliability: monitors should be based on established technology and operate as specified by the manufacturer.
- Sensitivity: A minimum sensitivity of 1 µg/m³.
- Concentration range: At least 1-40,000 µg/m³.
- Calibration: monitors should be calibrated in accordance with manufacturer's recommendations.
- Accuracy: monitor accuracy should be understood and should meet data quality objectives sufficient to determine with acceptable level of confidence whether specified level(s) of concern has been exceeded. A correction factor should be applied to readings from monitors when appropriate³.
- Data download: monitors should be compatible with readily available computer technology, and provide software for downloading data.

Additional monitoring equipment considerations

- Data transmission: monitors capable of transmitting data through cellular or other networked connectivity from a remote location to a centralized location may offer advantages over those without this capability.
- Lightweight, remote- platform capability: monitors that can be mounted on mobile, remotely operated platforms such as small-unmanned aircraft systems (sUAS) may offer greater flexibility for adjusting to changes in wind and smoke direction and allow monitoring teams to optimize proximity of monitoring to the ISB without increasing safety concerns such as risk of personnel exposure.
- Reasonable cost and readily accessible: optimal monitoring equipment should be readily accessible and obtainable at reasonable cost and should be supported by the manufacturer. Equipment that is difficult to obtain or maintain may be used to supplement, but should not replace operationally tested equipment that meet the established performance criteria.

³ Commonly used optical instruments may have a correction factor of 2 to 3 when compared to other Federal Reference or Federal Equivalency Methods (FRM and FEM, respectively) designated equipment (McNamara et. al., 2011).

3.7 ISB Monitoring Locations

Air monitoring locations are primarily determined by the potential for smoke exposure to the public. Monitoring teams should attempt to deploy where the potential for public (not response personnel) exposure to smoke is most probable (e.g., downwind of the burn and nearest the first encountered populated area). Precise monitoring locations should be flexible and determined on a case-by-case basis considering such factors as population density, population sensitivity, and accessibility.

Air monitoring conducted prior to a ISB should be performed to determine background concentrations for comparison to NAAQS, or, as a basis for developing incident specific LOC. If air monitoring is conducted pre-burn, the location of monitoring should be near to the locations where monitoring will be conducted during burning. An **idealized** deployment of air monitoring locations during a ISB is depicted in **Figure 2**. One team is deployed at the upwind edge of a sensitive location (e.g., a populated area). A second team deploys at the downwind end of this location. Once deployed, teams stay at their designated monitoring locations, moving only to improve sampling capabilities. For example, a team may move locations if burn conditions change and the smoke from the ISB changes trajectory towards an unmonitored populated area. A third team may be more mobile, and may deploy to cover any areas where potential gaps in coverage become evident during the burning operation. All movement and placement of air monitoring teams should be coordinated by the Monitoring Group Supervisor and communicated to the Technical Specialist. Coordinates for all fixed monitoring locations should be recorded. Any mobile monitoring teams should record their positions at sufficient intervals to satisfy the monitoring objectives.

It should be emphasized that, while visual observation is conducted continuously as long as the ISB takes place, air sampling for particulates using the SMART protocol is not required if there is no potential for public exposure to the smoke.

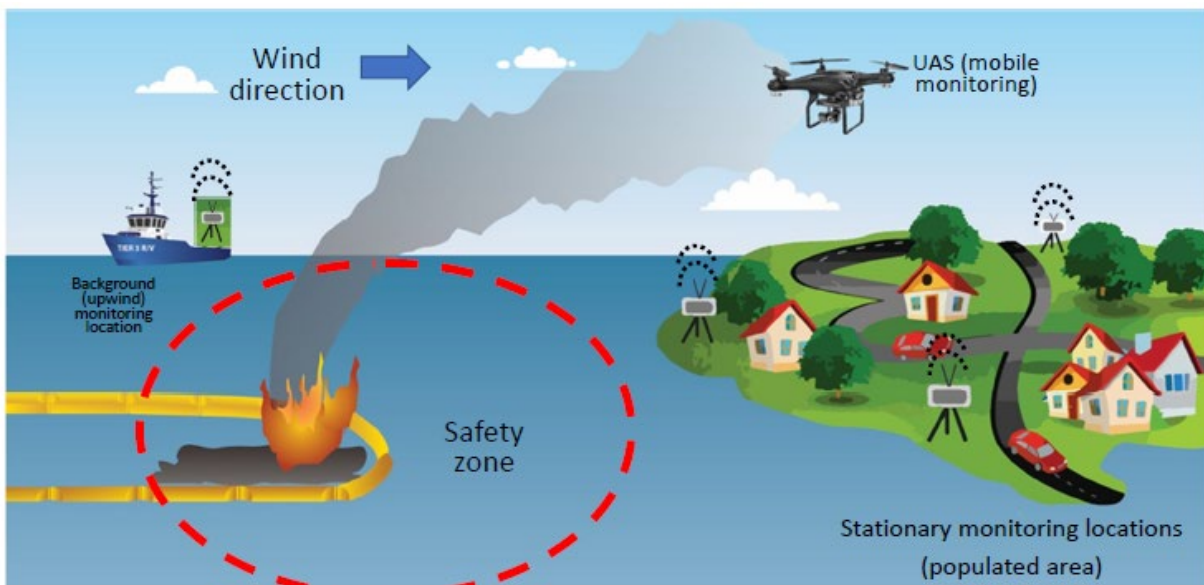


Figure 2. Idealized⁴ depiction of ISB operations with **potential** air monitoring locations (for reference only, not to scale).

⁴ Actual locations and type of equipment utilized for ISB burn operations may vary according to availability of equipment and the objectives of monitoring activity.

3.9 ISB Monitoring Data Sample: Graph

The graph below represents field monitoring data from a test burn smoke plume near Mobile, Alabama, on September 25, 1997, after the data were downloaded from the instrument. The graph (Figure 3) portrays the differences between the transient instantaneous readings (Concentration) and the time weighted average readings (TWA). Note that while instantaneous readings varied widely, the TWA remained relatively constant throughout the burn. **The TWA provides an indication of the concentration trends, which is a more stable and reliable indicator of exposure to particulates.**

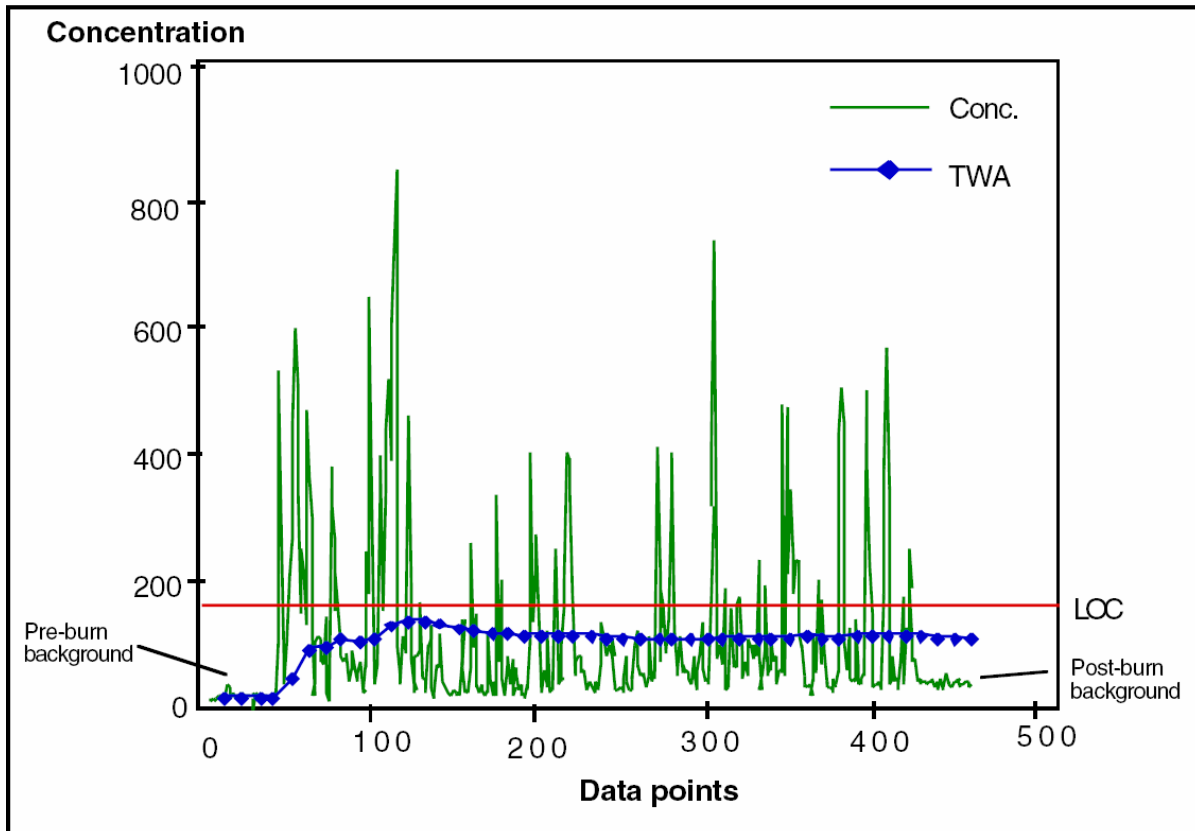


Figure 3. Graph of instantaneous and TWA particulate concentrations.

APPENDIX A: REFERENCES CITED AND SMART RESOURCES

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APPENDIX B: ESTIMATING AND MODELING PARTICULATE EMISSIONS

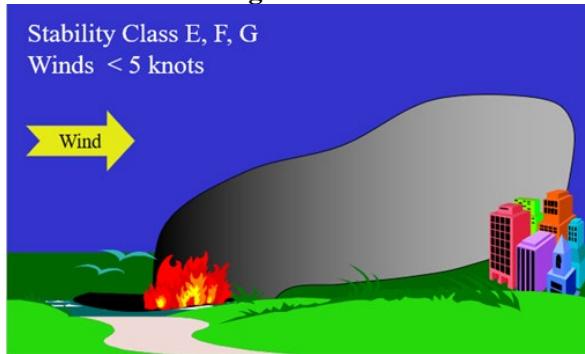
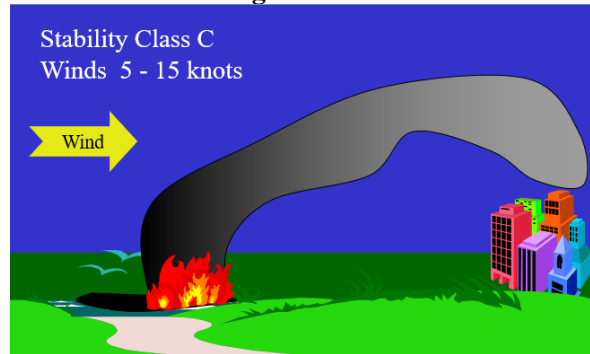
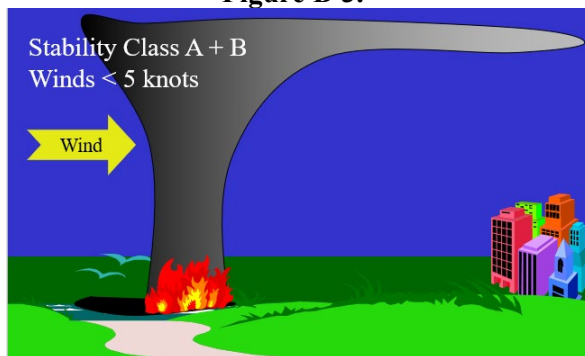
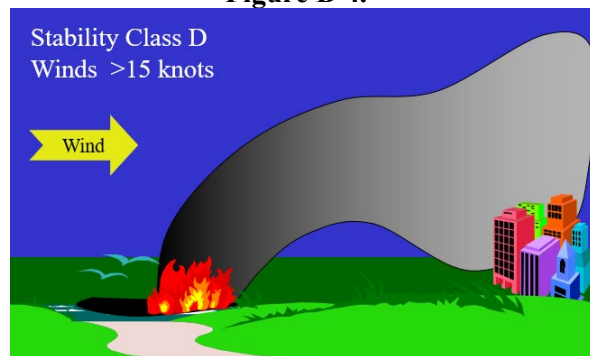
Emissions Estimations

Estimating the distance downwind from an ISB burn that particulate emission concentrations (e.g., PM_{2.5} or PM₁₀ concentrations) may exceed specified LOC is subject to a relatively high degree of uncertainty due to both the variability of atmospheric conditions (particularly at the scale which most ISBs are conducted) and the broad range of interactions between the atmospheric transport mechanisms. The primary atmospheric conditions that influence the transport of particulate emissions downwind from a ISB include **atmospheric stability, wind speed, and mixing height**. These conditions may vary during the course of a single burn or from one burn to another. Other parameters that affect particulate concentrations (eg., the duration, amount, condition, and properties of the oil being burned) may range from relatively small, open-water ISBs of short duration to longer duration ISBs covering greater areas (e.g. several acres of marsh or land ISBs including vegetation). As such, effectively estimating emissions for a particular ISB based on previous ISBs (including experimental burns) requires that all of the influencing variables and ISB parameters are closely comparable and do not deviate significantly for the duration of the ISB.

Despite the high degree of uncertainty in estimating burn emission concentrations, there are some generalizations that can be made which relate the principle atmospheric conditions affecting transport of particulate emissions to their relative concentrations as distance from the burn increases. For example:

- **Increases in atmospheric stability** generally result in higher concentrations of particulates at ground level and a gradual decrease in concentrations as distance from the burn increases. As atmospheric stability **increases**, more of the smoke plume is forced towards the ground resulting in increases in total concentrations of particulates at ground level. **Burns conducted in moderate to highly stable atmospheres with low winds (Figure B-1) will result in higher concentrations of particulates at ground level greater distances from the burn when compared to those conducted in more unstable atmospheres and similar wind conditions (Figure B-2).**
- Conversely, **decreases in atmospheric stability** generally result in lower concentrations of particulates at ground level and rapid decreases in concentrations as distance from the burn increases. As atmospheric stability **decreases**, more of the smoke plume is lifted from the ground resulting in decreases in total concentrations of particulates at ground level. **Smoke plumes from burns conducted in moderate to highly unstable atmospheric conditions with relatively low wind speeds will tend to rise quickly and result in rapidly decreasing concentrations of particulates at ground level as distance from the burn increases (Figure B-3).** These conditions are generally recognized as optimum for ISB operations as they are not likely to result in exceedances in LOC for particulates beyond the immediate location of the burn.
- **Increases in wind speed** will result in increases in the speed that the smoke plume travels and tend to increase the distance downwind that particulate concentrations may exceed LOC. In high wind conditions, the wind may overwhelm the tendency of the smoke to rise and could result in increases in particulate concentrations at ground level greater distances downwind from the burn location. Thus, emissions may exceed LOC greater distances from the burn location under higher winds than would result from lower wind conditions under the same atmospheric conditions, particularly when atmospheric conditions are more stable (Figure B-4).

It is important to note that changes in concentrations of particulates are a function of the **combined effects of both wind speed and atmospheric stability as well as the distance from the burn.** Accordingly, these factors and how they impact the smoke plume as well as the primary burn parameters (duration, amount, and type, of oil) should **all** be considered when estimating emissions impacts and determining optimum monitoring locations.

Figure B-1.**Figure B-2.****Figure B-3.****Figure B-4.**

Emissions Modeling

A number of models have been used to estimate emissions from oil fires and ISB operations (see references below). To date, it is unclear as to whether any current particulate emissions model is readily available and well-suited to support ISB operations. While the NOAA Hysplit Trajectory model is operational, it is primarily used for modeling smoke from large-scale forest fires, and may not be well-suited for modeling emissions from ISB operations that are typically much smaller in scale and shorter in duration. Another operational model is available from the Interagency Modeling and Atmospheric Assessment Center (IMAAC). IMAAC coordinates and disseminates federal atmospheric dispersion modeling and hazard prediction products and is supported (24/7), but it is unclear as to the limitations of this model for estimating particulate emissions from oil fires. Information on IMAAC support is included below.

IMAAC Support

The IMAAC provides plume models for real-world emergencies involving significant hazardous atmospheric releases and atmospheric modeling support for National Level Exercises and local exercises. State, local, and federal officials can request IMAAC support by contacting the IMAAC Technical Operations Hub, managed by the Defense Threat Reduction Agency, at (703) 767-2003 or

emailing IMAAC@fema.dhs.gov.

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