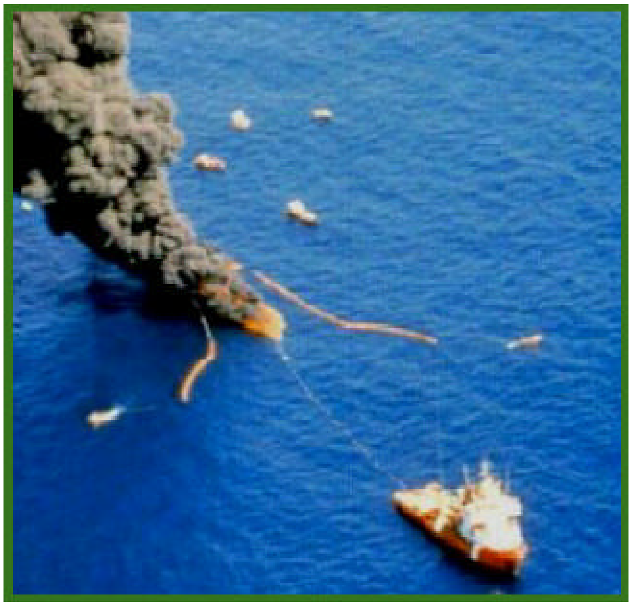
British Columbia/Canada



British Columbia/Canada In-situ Oil Burning Policy and Decision Guidelines

May, 2001

British Columbia/Canada

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Statement of Authority

The *British Columbia/Canada In-situ Oil Burning Policy and Decision Guidelines* apply to the Pacific region of Canada. This document has been developed under the authority of the federal *Fisheries Act, Canada Shipping Act, Canada Environmental Protection Act,* and the provincial *Environment Management Act*, by Fisheries and Oceans Canada, Environment Canada, and the British Columbia Ministry of Environment, Lands and Parks, respectively.

The document addresses marine oil spill incidents in which the federal and/or provincial lead government agency would consider the in-situ burning of contained oil. This action would be under special circumstances and where considered as a safe, viable means to mitigate the impact of fresh oil on people and the environment. The policy and operational guidelines provide the direction and procedures to expedite in-situ burn decisions and to ensure public safety and maximum environmental protection.

Donna Petrachenko, Regional Director General Fisheries and Oceans, Pacific Region	Date
Don Fast, Director General Environment Canada, Pacific & Yukon Region	Date
Derek Thompson, Deputy Minister Ministry of Environment, Lands and Parks Province of British Columbia	Date

Acknowledgments

Acknowledgement is provided to Environment Canada's Environmental Technology Centre (Ottawa) for their technical review and support. In-situ oil burning is internationally recognized as a safe and viable alternative to oil spill mitigation due to the extensive field research undertaken by the centre. Special acknowledgment is also given to the Northwest Area Committee of the State of Washington that provided the template for this document. The committee members include the US Coast Guard, US Environmental Protection Agency, Washington Department of Ecology, Oregon Department of Environmental Quality, and the State of Idaho. Their contribution, and that of Working Groups, have assisted in promoting cooperation in spill response preparedness for the shared US and Canadian marine waters.

All photographs are of the Newfoundland Offshore Burn Experiment (NOBE) undertaken in eastern Canada in 1993 by Foss Environmental Ltd. for Environment Canada and the Canadian Coast Guard. Photographs are the courtesy of Environment Canada.

Preface

The burning of oil on water (in-situ) during a major marine oil spill is a viable means to mitigate the impact of spilled oil on people and the environment. This action will be under special circumstances, such as a major offshore spill of petroleum from an oil tanker, and undertaken in conjunction with other spill recovery efforts such as booming and skimming. The *British Columbia/Canada In-situ Oil Burning Policy and Decision Guidelines* provides the regional direction and procedures to expedite in-situ burn decisions and to ensure public safety and maximize environmental protection.

The interest in burning oil as a response technique is largely driven by the environmental and ecology agencies along the Pacific west coast as there is a high likelihood of a net environmental benefit from its application if correctly timed and appropriately implemented. There is a need to move from the research phase to the policy and procedural stages. In-situ burning capitalization and application by the oil industry and its response organizations will only occur if government environmental agencies take a lead in the in-situ burn decision-making process.

The development of this document is the result of years of work, millions of dollars in research, and practical experience. The document is dynamic and will be periodically reviewed by the BC Marine Spill Coordination Committee to incorporate any new information that becomes available.

Acronyms

ALOFT - A Large Outdoor Fire Plume Trajectory Model - Flat Terrain
ICS - Incident Command System (International)
ISB - In Situ Oil Burn (International)
NOAA - National Oceanic and Atmospheric Administration (United States)
NOBE - Newfoundland Offshore Burn Experiment (Canadian)
PM - Particulate Matter (International)
REET - Regional Environmental Emergency Response Team (Canadian)
RO - Response Organization (Canadian)
RP - Responsible Party (Canadian/United States)
SMART - Special Monitoring of Applied Response Technologies (United States)

Table of Contents

Chapter One: Background

Definition of In-situ Oil Burning

"In-situ" is the Latin term for *in place*. In-situ burning, as it relates to oil spills, is the controlled burning of oil on water at or near the spill site.

Purpose and Scope

The purpose of this document is to define the conditions under which oil burning may occur on a pre-approved or case-by-case basis, as well as to define the conditions under which burning will not be allowed in British Columbia. The focus of the policy and decision guidelines for in-situ oil burning is: for the marine environment, for an accidental oil release, during an emergency situation, and for a controlled or contained burn. This policy describes:

- authority framework;
- decision procedures, and;
- environmental impacts and public health issues.

It is beyond the scope of this document to provide a comprehensive scientific analysis of in-situ burning of oil. As the document focuses on decision-making, it does not provide instructions on how to conduct an in-situ oil burn, nor address operational requirements for the safety and health protection of the trained responders tasked with conducting a burn. Operational instructions, including worker safety, are available in reports dealing with burning methods. Detailed technical information is provided in Environment Canada's report: *In-situ Burning: A Cleanup Technique for Oil Spills on Water (2000)*.

Authority

(Canadian)
Authority for the development of the *British Columbia/Canada In-situ Oil Burning Policy and Decision Guidelines* and its implementation is under the federal *Fisheries Act*, *Canada Shipping Act*, *Canada Environmental Protection Act*, and the provincial *Environment Management Act*. The respective agencies are Fisheries and Oceans Canada, Environment Canada, and BC Ministry of Environment, Lands and Parks.

(United States)
The federal *Oil Pollution Act of 1990* requires that a rapid decision-making process be established for oil spill response actions, such as in-situ burning of oil. The Act requires the US Coast Guard and Environmental Protection Agency to form Area Committees and develop Area Contingency Plans for each of their zones of responsibility, such as for the Northwest states and Alaska. Area planning committees are comprised of federal, state, and local agency members, and representation from the spill response community. These Area Contingency Plans identify the authorities that make an in-situ burn decision and the decision process itself. The 1999 *Special Monitoring of Applied Response Technologies* (SMART) guidelines prepared by the US Coast Guard, National Oceanic and Atmospheric Administration, US Environmental Protection Agency, and Centres for Disease Control and Prevention provides protocols for monitoring and decision-making (referred to as: SMART Guidelines).

Development of Policy and Decision Guidelines

The *British Columbia/Canada In-situ Burning Policy and Decision Guidelines* document is based on the efforts taken by the states of Washington, Oregon, and Alaska to prepare Area Contingency Plans, as well as work by the States/BC Oil Spill Task Force on alternative response technology. The extensive in-situ oil burning research by Environment Canada provided significant technical foundation to assess both efficacy and health/environmental issues. The United States' SMART guidelines on monitoring and decision-making also provide a foundation for these guidelines. These international and national efforts took several years, and involved diverse interests including industry, environmental groups, federal, state, provincial, and local government agencies.

Guidance and review of the *British Columbia/Canada In-situ Oil Burning Policy and Decision Guidelines* was undertaken by members of the BC Marine Spill Coordination Committee (MSCC) as well as selected industry representatives, environmental non-government organizations, and scientific authorities. Environment Canada and Ministry of Environment, Lands and Parks, as members of the MSCC, took the lead in preparing this document.

Chapter Two:
Role of Burning During Oil Spill Response

Overview

Spill prevention is the first line of defense. However, it is prudent to assume that a major oil spill can occur as vast quantities of oil are shipped through the shared West Coast waters of the United States and Canada. Each year, there are over 400 tanker shipments of crude oil through Juan de Fuca strait. A similar number of tankers travel down British Columbia's West Coast to California. The risk of spill increases as these single-hulled tankers age and marine traffic increases. Numerous bulk cargo and container vessels transit coastal waters *en route* to and from the ports of Vancouver and Prince Rupert - about 10,000 transits *per* year. These deep-sea vessels can carry over 5,000 barrels[1] of bunker fuel to operate their engines. Barges carrying heavy fuel oils and refined petroleum routinely travel the inside passages of British Columbia. There are over 200 coastal marine oil-handling facilities in British Columbia that load and off-load petroleum products, and store such products near environmentally sensitive shores. Should a spill occur, it is necessary to have a range of response options to protect people, property and the environment.

In-situ burning has been recognized for many years as an effective way to eliminate large quantities of spilled oil. Prior to 1980, most attempts to burn spilled oil were undertaken without the aid of fire-resistant booms. The effectiveness of such burns depended on the availability of docks, shorelines, or winds to keep the spilled oil thick enough to support combustion. Fire-resistance booms capable of containing spilled oil and holding it in place (in-situ) for burning are now available. The use of fire boom enables the control of the burn, such as rate of combustion, and to quickly extinguish the fire.

Effective and sustained combustion of oil on water requires that the oil be at least 2 to 3 millimeters (about 0.1 inch) thick. Without a fire boom to maintain an adequate thickness for combustion, unconfined oil will quickly extinguish when it thins. Most accidental and deliberate burns of spilled oil at sea without containment will not have sustained combustion. Burning is usually limited to the region immediately adjacent to the source of spillage. With the development of fire containment booms, controlled in-situ burning of spilled oil can now be carried out safely and efficiently.

Significant advancements have been made on our scientific understanding of large-scale oil burning. In 1993, a large-scale test burn conducted off the coast of Newfoundland, Canada yielded significant information about the efficacy of in-situ oil burning. More than 200 samplers were employed to gather data on more than 2,000 parameters. The extensive analysis not only addressed oil ignition and control issues, but resolved many environmental and health impact concerns. As a result of several large-scale controlled burns in North

[1] In the oil industry, a common volume measure is "barrel" which is 159 liters or 42 gallons (US)

America and internationally, many environmental agencies and oil companies recognize and include in-situ burning in their spill response plans. However, it is important to emphasize that the combustion of spilled oil is not seen as a substitute for the containment and physical removal of spilled oil. Conventional booming and skimming operations will always be conducted wherever they can be implemented safely and with a reasonable degree of effectiveness. In-situ burning provides an expanded response capability.

The potential for in-situ burning must be determined based on the specific conditions present at the time of the spill, such as calm waters and favourable winds. A determination will need to be made whether burning should be used in conjunction with, or as a temporary alternative for, conventional cleanup techniques. The objective is to find the right mix of equipment, personnel and techniques that will achieve the greatest net benefit to the environment and maximum human safety and health protection.

Response to an accidental release of large quantities of oil often results in environmental trade-off. In-situ oil burning is no exception. The trade-off for choosing to burn is to allow short-term, managed air pollution compared to long-term, difficult to manage on-water oiling and on-shore contamination. Controlled offshore burning of contained oil may have no measurable impact to marine and coastal ecology, whereas oil on water and shores can have devastating and long-term effects. Environmental and ecology agencies recognize this fact and concur that in-situ burning is a viable tool in spill management. As such, the assessment of the trade off of air pollution *versus* oiled waters and shores is not a major decision factor in determining whether to burn. What is not, however, a trade-off is causing human health impacts. Protection of human health, particularly the general public, is the major issue and the focus of the *British Columbia/Canada In-situ Burning Policy and Decision Guidelines.* Extensive, multi-million dollar studies on in-situ oil burning have helped define when, where and how to achieve the primary response priority of protecting people, yet obtain the environmental protection advantage of in-situ burning.

Historical Perspective on In-situ Burning

For over 30 years, intentional burning of spilled oil has been an emergency response option. This deliberate ignition of spilled oil is not, however a routine practice. It is more widely used on land and on small water bodies in petroleum-producing regions. Burning of crude oil spills in muskeg environments within the Northeast petroleum fields of British Columbia is a standard, but not common occurrence. There is, however, only limited public acceptance towards prescribed burning of oil - either to experimental burns or as a response option. The public skepticism is twofold. First, there is a general misunderstanding of the management opportunities to mitigate potential health impacts from emissions, and second there is a perception that lower response cost is the motivation for burning oil rather than environmental protection. These concerns will be addressed more fully when explaining health concerns, efficacy, and trade off associated with in-situ oil burning.

Countries are beginning to incorporate in-situ oil burning as a response option as a result of several extensive experimental and operational burns over the last decade in Canada, United States, Finland, and Sweden. A test burn during the 1989 *Exxon Valdez* tanker spill in Alaska provided favourable results on the efficacy and safety of in-situ oil burning. The 1993 Newfoundland Offshore Burn Experiment (NOBE) addressed many of the operational, air quality and marine impact concerns – with favourable results. NOBE put Canada at the international forefront on the scientific understanding of this technology.

The States/British Columbia Oil Spill Task Force, with member representation from the environment and ecology agencies from the states of Alaska, Washington, Oregon, and California and the Province of British Columbia, felt that the health impacts could be managed. The Task Force considered there was also good potential for a net environmental protection benefit from in-situ oil burning. A 1998 Task Force report on Alternative Response Technologies recommended that member agencies develop, in co-operation with federal agencies, policies and decision guidelines on how to make the decision to undertake an in-situ burn on the Pacific west coast. To date, all US states along the Pacific west coast have developed or are drafting in-situ oil burning policies and guidelines. The *BC Citizen's Advisory Committee on Oil Spill Prevention and Response* recognized in their 1995 annual report acknowledged this work and stated "In situ burning has the potential to achieve remarkable results in certain definable spill cases.." and recommended that British Columbia examine the appropriateness of the alternative technology to mechanical oil removal. The *British Columbia/Canada In-situ Burn Policy and Decision Guidelines* fulfills this intent from British Columbia's perspective.

Potential Effectiveness of In-situ Burning

For oil burning to be effective, it must be employed early on in the spill in a timely manner before the spilled oil weathers and loses its flammable constituents. The window of opportunity is generally less than 72 hours. Optimally, the decision to burn should be made within 6 to 8 hours after the spill. Most oil types will burn on water, as long as the oil is thick enough. Oils that pose a risk to British Columbia's waters and are conducive to in-situ oil burning include crude, bunker and blended oils, jet fuels, and diesel.

The efficiency of in-situ burning is highly dependent on a number of physical factors such as sea states, winds, water temperatures, oil types, and volumes. Test burns and applications in actual spill situations demonstrate it can be very effective in removing large quantities of contained oil from the water. Oil burns with a thickness reduction rate of approximately 3.75 millimeters (0.15 inch) *per* minute. This rate equates to a nominal combustion rate of about 5,000 liters/square meter◆day (100 US gallons/square foot◆day). Depending on the thickness of contained oil within a fire boom, the efficiency can be between 95 to 99 percent. Burn efficiency is a function of the amount of oil before burning, less the volume remaining as residue (expressed as a percentage).

A burn efficiency of 98 percent was obtained during a test burn of Alaska North Slope crude oil conducted on the second day of the *Exxon Valdez* spill (March, 1989). The oil was collected by fire-resistant boom towed in a U-configuration behind two fishing boats. Within 1 hour and 15 minutes after ignition, approximately 57,000 to 114,000 liters (357 to 714 barrels) was burned with about 1,136 liters (7 barrels) of burn residue remaining. The Newfoundland Offshore Burn Experiment (NOBE) conducted in August 1993 had similar efficiencies. During sea trials, a 213 meter (770 ft.) fire boom held about 48 cubic meters (302 barrels) of oil which was almost completely burned (99 per cent) in an hour and half.

In-situ Burning in Relation to Other Response Methods

To minimize environmental damage caused by oil spills, responders work to keep spilled oil from impacting sensitive areas and resources. During an offshore spill, oil must be quickly removed from the surface to minimize impacts to birds and mammals, and kept from reaching natural and cultural resources on or near shores. Three general categories of oil spill response options include:

- mechanical containment and recovery of oil;
- application of chemical dispersants; and
- in-situ burning.

The use of each of these techniques involves trade off in relation to environmental impacts and efficacy, as follows:

Mechanical skimming of oil is the least harmful to the marine environment. However, skimming generates a large quantity of oil-and-water mixture that must be stored, transferred onshore to be landfilled, recycled, incinerated or disposed of in an environmentally acceptable manner. Mechanical oil recovery can also take a long time. Often oil encounter rates are so low that meaningful recovery rates are nearly impossible to achieve. The additional constraints imposed by wind (less than 2 meters [7 ft]) and currents (less than 0.4 meters/second [0.7 knots]) commonly reduce actual recovery rates to a few 10s to 100s of liters *per* minute. In situations where the skimming can be used close to an ongoing spill, the potential oil encounter rates and recovery rates can be higher. High recover rates can rarely be sustained because of on-site oil storage limitations. During open-water spills, it is not uncommon to experience a mechanical recovery of as little as 10% to 15% of the volume spilled. Skimming operations require a large investment of personnel, vessels, skimmers, pumping systems and storage containers. The costs associated with physical removal and disposal often run about $100 to $1000 *per* barrel.

Chemical dispersants cause oil to break into small droplets that mix into and disperse within the water column. Efficiency rates are highly variable depending on the application method and oil type/thickness, as well as environmental factors such as sea conditions. Dispersants do not remove the oil from the water *per se*, but disperse it through surface waters to promote natural biodegradation. Dispersants can be applied to very large areas, but water depths need to exceed 10 meters (approx. 30 feet). The potential effects on fish, plankton and other marine organisms within the water column have to be weighed against the consequences of untreated oil left on the water surface or allowed to contaminate shores. The ecological impacts of dispersed oil are not as well understood as impacts of surface oil on birds, mammals, and inter-tidal organisms. Certain seasons and areas are not suitable for dispersant use such as during shellfish and crab larval stages and within shallow estuaries. Operational policy and guidelines have not been established for British Columbia due the ecological complexity associated with dispersant use. Dispersants cost about $50 to $100 *per* barrel of oil dispersed.

In-situ burning can eliminate anywhere from 95 percent to 99 percent of the original volume of oil contained in a fire resistant boom by the rapid combustion of hydrocarbons. In-situ burning can potentially remove as much oil in one day as mechanical methods could in one month. A typical fire-boom towed in a U-configuration can handle from 500 to a thousand barrels of oil, eliminating greater than 95% of the oil in an hour or two. Residues from burning represent a small percentage (<1 per cent) of the initial oil volume burned. The residue is easy to retrieve. The volatile fractions of fresh oil are quickly and completely consumed by the inferno. The smoke plume near the fire is massive, though the soot generated typically represents 10 per cent or less of the original volume of oil burned. The emissions are less toxic to marine life and people than the liquid and volatile gases of fresh oil containing alkanes and aromatic hydrocarbons. Burning oil in-situ is extremely fast. It eliminates the difficulty of oil storage and land-based disposal, alleviates the harmful effects of surface oil on birds and mammals, decreases shore contamination, and reduces exposure of harmful volatile hydrocarbon constituents on cleanup workers or to people residing next to a heavily oiled shore. The cost of in-situ burning is about $20 to $50 *per* barrel of oil burned.

The removal of oil on water by mechanical methods (booms and skimmers) is three to ten times less costly than removal of equivalent amounts of oil from shoreline cleanup. Non-mechanical methods, such as dispersant and in-situ burning, can be ten to a thousand times less costly. However, the driving factor for using non-mechanical methods - particularly in-situ burning - is not cost savings, but the positive net environmental benefit and reduced health risk to people from exposure to fresh oil.

The proper use of in-situ burning at the right time, the right place, and under the right conditions, provides a supplemental response method to existing conventional cleanup techniques. In-situ burning allows response personnel some additional control over the type and location of an oil spill's impact on human health, wildlife and the environment.

Chapter Three:
Using In-Situ Burning in British Columbia

In-situ Oil Burning Policy

Under the circumstances specified in this document, it is the regional policy of the Government of Canada (represented by Fisheries and Oceans Canada, Environment Canada) and the Government of British Columbia (represented by BC Ministry of Environment, Lands and Parks) to either use or encourage the spiller to burn an accidental spill of oil. The oil spill response priorities on whether to allow in-situ oil burning are the protection of:

1. people
2. property, and
3. environment.

An over-riding consideration in deciding to burn oil in-situ is the protection of human health.

The authority to approve an in-situ burn rests with those lead government agencies responsible for directing the response or for approving the response strategy of the Responsible Party (polluter or spiller). The decision to burn must be made expeditiously - within a few hours - and conform to this policy and these decision guidelines. The capitalization (*e.g.* purchase of fire boom) and response preparedness for in-situ burning rest with those that ship or handle oil. This enhanced preparedness can be established through their Canadian Coast Guard certified Response Organization.

The decision to burn will be based on either **pre-approved areas**, a **case-by-case basis** or **not allowed**. Pre-approved areas are defined as those burn areas that are of sufficient distance offshore as not to pose a health concern to the general populace. The buffer distances for pre-approved areas are based on the amount and type of oil being burned, safe distances calculated from empirical research data, and an additional safe distance to provide enhanced margin of public safety. Pre-approved areas assume that no real-time air sampling of particulates (smoke) is needed as modeled/empirical data already reveal safe-levels or no exposure to the public would result - even with an on-shore wind. All proposed burn areas nearer to shore will be considered on a case-by-case basis. For case-by-case basis, smoke plume modeling and sampling will be conducted where there is the potential for people to be exposed to the smoke of duration and concentration to potentially pose a health risk.

Generally, people should not be exposed to small particulate matter of less than 2.5 microns (referred to as: $PM_{2.5}$) in concentrations that exceed 65 micrograms *per* cubic meter (μ/m^3) of air averaged over a 24 hour period. This is a health standard to protect public welfare from continued exposures to common or industrial emissions, such as wood-stoves, automobiles, and industry stack emissions.

Canada's national exposure standard for in-situ oil burning is 150 μ/m^3 of 10 microns (PM_{10}) averaged over a 24 hour period.[2] The United States national standard 150 μ/m^3 of PM_{10} is averaged over a shorter period of 1 hour.[3] The standard of in situ oil burning along British Columbia's coast is the more stringent of these two standards of - **150 m/$\mathbf{m^3}$ of $\mathbf{PM_{10}}$ averaged over a 1 hour period**. This air quality standard reflects the typical short-duration and transitory nature of smoke from a control oil burn, compared to continued, long-term public exposures to a region's industrial pollution sources. It is also generally understood this particulate level from burning oil is conservative, and that other pollutants - such as burned gases - reach safe background levels well before the above $PM_{2.5}$ or PM_{10} conditions are reached.

The closest allowable distance for an in-situ oil burn to any permanent residence, industrial facility, agricultural land, active bird or mammal colony is one kilometer (0.54 nautical miles).

No in-situ oil burn will be conducted within 5 kilometers (2.7 nautical miles) of the US/Canada border without approval by the US Unified Command.[4]

In all cases, it will also be recognized in the decision process whether to conduct a burn, that the general public should not be exposed to excessive fumes from fresh oil. Fresh oil, such as crude oil, often contains toxic volatile organic compounds that can drift several kilometers inland. The impact to human health for air quality degradation from fumes can have significantly more acute and chronic impacts than from smoke particulates.

The maximum allowable burn area of one or more fire-boom arrangements is 750 m^3 (8100 ft^2) for Class B and C: Medium and High Viscosity Oils (Crude, Bunker, Lube, Blends) and 500 m^3 (5400 ft^2) and for Class A: Low Viscosity Oils (Diesel, Kerosene, Jet Fuels) within any strait, passage or other inland waterway such as the Strait of Georgia, Haro Strait, and Johnston Strait. This restriction does not apply to open ocean conditions such as within the Pacific Ocean, Juan de Fuca, Hecate and Dixon straits.

Open ocean in-situ oil burning will comply with the *1996 Protocol to the Convention on the Prevention of Marine Pollution by Dumping of Wastes and Other Matter* (the Protocol*)*, and will be conducted under Article 8, Section 1 of the Protocol whereby the prohibition on incineration is lifted "…so as to minimize the likelihood of damage to human or marine life..." and under permit pursuant to Article 8.2 of the Protocol "...in emergencies posing an unacceptable threat to human health, safety or the marine environment and admitting of no other feasible solution."

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[2] Environment Canada, February 2000, I*n-situ Burning: A Cleanup Technique for Oil Spills on Water*.

[3] In 1995, the US National Response Team for oil spills adopted a public health protection standard of 150 μ/m^3 of PM_{10} averaged over a one hour period based on analysis by the Occupational Safety and Health Administration, Centres for Disease Control and Prevention, and Environmental Protection Agency.

[4] In the Incident Command System (ICS), Unified Command is a unified team effort that allows all agencies with jurisdictional (lead/key) responsibility for the incident to manage an incident by establishing a common set of incident objectives and strategies. This is accomplished without losing or abdicating agency authority, responsibility, or accountability. The Responsible Party (company) is also part of unified command.

Authorization Procedures

These guidelines provide a decision-making process to evaluate the appropriateness of using in-situ burning during a spill response. The process is based on the premise that a rapid decision is essential if oil burning is to be used, since oil quickly evaporates and emulsifies (mixes with water) and becomes more difficult to ignite and to support combustion.

(Canada)

Under the *British Columbia/Canada In-situ Oil Burning Policy and Decision Guidelines*, authorization to undertake an oil burn rests with the federal and provincial lead agencies whether in a monitoring or responding capacity, and based on analysis and advice provided by environmental specialists and scientific authorities. Refer to Appendix A for the decision flowchart. Depending on the situation, the proposal to use in-situ burning can be provided by the Responsible Party, suggested by a lead agency, or implemented directly by a lead agency if in command of the response.

The lead federal agency is the Canadian Coast Guard of Fisheries and Oceans Canada, as defined by the *Canada Shipping Act* and *Oceans Act*. The lead provincial agency is the BC Ministry of Environment, Lands and Parks as defined under the *Emergency Program Act* and it Emergency Program Management Regulation (Schedule 1).

Environmental specialists and scientific experts within a unified Incident Management Team will provide the technical input and/or review of an application to undertake an in-situ oil burn. Refer to Appendix B for the Oil Burn Application. These people can include, but are not limited to, personnel from Fisheries and Oceans Canada, Environment Canada, BC Ministry of Environment, Lands and Parks, Ministry of Health, Regional and Municipal health agencies and First Nations. These personnel may participate in the Regional Environmental Emergency Response Team (REET). REET is an environmental/technical advisory body to Command, and is co-chaired by Environment Canada and BC Ministry of Environment, Lands and Parks.[5]

For open ocean incineration which must comply with the *1996 Protocol to the Convention on the Prevention of Marine Pollution by Dumping of Wastes and Other Matter,* a permit will be issue pursuant to Article 8.2 of the Protocol by Environment Canada.

(United States)

As *per* the Area Contingency Plans for the Northwest (Washington and Oregon) and for Alaska, authorization to burn in-situ rests with the Unified Command. Unified Command consists of Federal, State and Responsible Party on-scene coordinators as well as local and tribal on-scene coordinators, as appropriate. The Unified Command - as part of the Incident Command System - is responsible for overseeing the entire response effort, which includes the decision to use in-situ oil burning. Refer to respective Area Contingency Plans for more information. In addition to Area Contingency Plans, the 2001 *Special Monitoring of Applied Response Technologies* (SMART) guidelines prepared by the US Coast Guard, National Oceanic and Atmospheric Administration, US Environmental Protection Agency, and Centres for Disease Control and Prevention provides protocols for monitoring and decision-making.

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[5] The "Environmental Unit' within the Planning Section of the *BC Marine Oil Spill Response Plan* serves the provincial involvement in the federal REET.

Approvals to In-situ Burn

There are three categories of decision-making: *pre-approved*, *case-by-case*, and *not allowed*, as follows:

Pre-approved - refers to off shore distances where burning will adequately meet the in-situ policy health criteria regardless of wind direction. These specified distances offshore are based on the type of oil being burned, the amounts of contained oil and calculated safe distances (from actual burn data) to protect public health. Table 1 provides the distances offshore that are pre-approved for in-situ burning of oil. The main stipulation for a pre-approved area burn is submittal of a burn application and supporting information as shown in Appendix B. Application information includes amounts and type of oil, and data on meteorological conditions. Situation-specific stipulations from authorizing agencies may still be required before a burn is allowed.

TABLE 1 - PRE-APPROVED DISTANCES OFFSHORE FOR IN-SITU BURNING (Distances Offshore)

Oil Type & Containment Boom Area in Square Meters (Square Feet)	Calculated Safe Distances Offshore for Public Protection in Kilometers (Nautical Miles)	Pre-approved Areas as Distance Offshore in Kilometers (Nautical Miles)
	[1 kilometer = 0.62 miles = 0.54 nautical mile] NOTE: Calculated safe distances at ground-level are based on empirical data from test burns and on the health protection criteria of PM_{10} of 150µg/m^3 averaged over 24 hours.	NOTE: Pre-approved safe distances the application of the public health criteria of as well as an additional margin of safety.
Class B and C: Medium and High Viscosity Oils (Crude, Bunker, Lube, Blends)		
250 m^2 (2,690 ft^2)	0.08 km (0.04)	**5.5 km (3 nautical miles)**
500 m^2 (5,400 ft^2)	0.5 km (0.27)	**5.5 km (3 nautical miles)**
750 m^2 (8,100 ft^2)	3.2 km (1.7)	**5.5 km (3 nautical miles)**
Class A: Low Viscosity Oils (Diesel, Kerosene, Jet Fuels)		
250 m^2 (2,690 ft^2)	0.35 km (0.19)	**9.3 km (5 nautical miles)**
500 m^2 (5,400 ft^2)	6.9 km (3.7)	**9.3 km (5 nautical miles)**

As a burn in a pre-approved area is distant from shore, undertaking smoke plume modeling and/or having air monitoring capability in place is not a pre-requisite to approving a burn unless there are site-specific conditions identified by the scientific authorities. These conditions could be a combination of unfavourable on-shore winds and/or heights of land that may cause the smoke plume to reach a populated area. Public notification by general media (radio, newspapers, television) is, however, required.

Case-by-Case - is required when the lead government agencies determines that the application conforms with the policy health criteria and decision guidelines, but the burn will occur closer to shore than a pre-approved distance as set in Table 1. Approval to burn is then considered on a case-by-case basis by government in co-operation with the Responsible Party (spiller) and its response organization. Command will consult with environmental specialists and scientific experts to obtain weather data and information on the potential concentrations of pollutants that may reach shore from both burn by-products and fresh oil. The driving decision factor will be whether the wind is offshore or parallel to shore so as to avoid inland smoke pollution that can potentially put people's health at risk. Data from a predictive smoke plume model and air monitoring becomes important should there be the potential for onshore pollution that affects people, due to wind conditions, inversions, and/or heights-of-land, then. The predictive model to be used is ALOFT (*A Large Outdoor Fire Plume Trajectory Model - Flat Terrain* - See Appendix D). If the plume potentially affects a community, then air quality monitoring for particulates is required. If the decision is to burn, then the same procedures apply as those for pre-approved areas - including submitting an in-situ burn application and public notification. If the decision is not to burn, the application will be re-evaluated if conditions change.

Other burning strategies (scenarios) that are case-by-case include:

1. In-situ ignition of bulk and/or bunker fuel contained within a disabled or stranded vessel to mitigate catastrophic release;
2. Burning of oil in estuary or wetland conditions where responder access and mechanical removal would be more damaging to the environment;
3. Burning oil pooled in inter-tidal coves and bays either naturally or by deflection booming; and/or
4. Unconfined burning from a catastrophic oil spill.

Not Allowed - if the application to burn does not conform with the policy and these decision guidelines, burning will not be allowed. The decision can be re-assessed in the event of favourable weather changes. In-situ burns within 1 kilometer (0.5 nautical mile) to permanent residences or industrial facilities where evacuation or work stoppage is not practical, productive agricultural land, active bird or mammal colony will not be allowed.

No in-situ oil burn will be conducted within 5 kilometers (2.7 nautical miles) of the US/Canada border without approval by the US Unified Command.

Exposure Limits for Emissions

Though burning provides a high degree of environmental protection, a key issue is to ensure that pollutants from in-situ burning emissions do not have an adverse impact to human health. The primary pollutant of health concern is the very small particulate matter contained in the smoke plume - generally referred to as "soot". These particulates are generally less than 10 and 2.5 microns (μ) in size (referred to as: "PM_{10}" or "$PM_{2.5}$"). Research on real and experimental oil burns show that other pollutants, such as volatile hydrocarbons, quickly dissipate. Burn by-products reach background levels well before particulates reach concentrations that pose as a health concern. This means that the tail end of a plume has one potentially harmful constituent - very small particulates. These small particulates of soot quickly reach very low concentrations downwind and at ground levels due to aerial dispersal and lofting of the smoke by the fire's heat. From actual field measurements of many large-scale burns in open ocean, the ground-level emission and pollution levels at 150 meters (490 ft) from the fire are typically below occupational exposures, and at 500 meters (1,640 ft) the levels are difficult to detect. Table 2 shows the distances from crude and diesel oil burns where safe health levels are reached for a variety of substances. The calculations are based on empirical data collected from 30 test burns and over 150 individual compounds measured. Crude and diesel oils are addressed separately because burning diesel produces more soot (approx. 8%) compared to crude oil (approx. 1%).

TABLE 2 - CALCULATED SAFE HEALTH DISTANCES
(From a 500 m^2 continuous contained oil burn and air quality measured at ground level)

SUBSTANCE	CRUDE OIL Distance to the Safe Health Level[1] in Meters (Feet)	DIESEL OIL Distance to the Safe Health Level in Meters (Feet)
Total Particulates	510 m (1,673 ft)	3340 m (10,988 ft)
PM_{10}	520 m (1,705 ft)	6930 m (22,799 ft)
$PM_{2.5}$	530 m (1,739 ft)	7340 m (24,081 ft)
Total Volatile Organics- VOCs	< 500 m (1,640 ft)	< 500 m (1,640 ft)
Polycyclic Aromatic Hydrocarbons -PAHs	< 500 m (1,640 ft)	< 500 m (1,640 ft)
Fixed Gases	< 500 m (1,640 ft)	< 500 m (1,640 ft)
Carbonyls	< 500 m (1,640 ft)	< 500 m (1,640 ft)

[1] Health Criteria is PM_{10} not exceeding 150 μ/m^3 averaged over a 24 hour period.

Potential ground impacts can occur if there is stable atmosphere conditions that traps the smoke, heights of land that may be impinged by the plume, and/or fumigation. Generally, these conditions are detectable during the evaluation stage of the pre-approval checklist. Nevertheless, the pre-approved distances (Table 1) are greater than the calculated safe distances to account for these conditions and during an onshore wind.

An area equal to the "calculated safe distances" shown in Table 1will be considered a minimum "control zone" where boats and aircraft will not be allowed access, unless approval is provided. This is to ensure that people are not exposed to the heavy smoke plume in the immediate vicinity of the plume, or interfere with responders.

The smoke plume usually stays well above ground level and disperses quickly. On occasion the plume can reach the ground - for reasons described above. An exposure criteria for particulates has been established for these guidelines, whereby people should not be exposed to concentrations of PM_{10} greater than 150 μ/m^3 averaged over one hour. At this concentration, the smoke would be seen as a light haze in the sky.

The short, one hour averaged exposure limit is used as the health criteria, compared to the typical practice of averaging exposure over 24 hours, because the shorter time period is a safer, more conservative criteria and reflects the fact that in-situ burning generally does not last more than several hours.

In-situ burning will not be approved, or a burn ceased, if there were likelihood that the PM_{10} criteria would be exceeded where people reside. The decision must also weigh the risk to people of the volatiles that evaporate from unburned oil. In some cases, it may be less harmful to people to burn the oil rather than let it evaporate in the presence of people - particularly shoreline cleanup crews or residents living a few kilometers from heavily oiled shores. These factors and background particulate levels will be taken into consideration when determining health risk. Specialists responsible for evaluating weather data and air quality in the area proposed for an in-situ burn will incorporate these concerns when assessing exposures.

It is the responsibility of lead government agencies, in either monitoring or responding roles, to ensure that an approved burn will be within the emission criteria set by this policy and decision guidelines. On approving in-situ burning as a tactical response method, government will need to instill public and political confidence on the safety and efficacy of in-situ burning, in a manner similar to that required for communicating other environmental trade-offs or impact issues such as related to wildlife rescue, shoreline cleanup protection and cleanup strategies, and oily waste removal.

Modeling and Monitoring

Pre-burn modeling of the smoke plume by computers to predict smoke direction, plume configuration, and burn by-product concentrations is a useful tool for determining if emission criteria for public protection will be met. However, plume dispersion modeling is not an exact science. As such, the off-shore distances for pre-approved areas of 5.5 km (3 nautical miles) for Class B & C oils and 9.3 km (5 nautical miles) for Class A oils are based on empirical research data from test burns rather than computer plume-modeling. In pre-approved areas, plume modeling is not necessary to make the decision to burn, but may be used in conjunction with the burn operations when available in a timely manner. Measurements of local meteorological conditions alone can adequately provide sufficient information on whether a burn should occur - paying particular attention to wind direction and speeds, atmospheric stability, and heights-of-land. Computer-based plume modeling essentially becomes more important when a burn is proposed inshore of the distances set for pre-approved areas (*e.g.* case-by-case situation). Modeling will have a much higher weight in a case-by-case situation and where there are complex meteorological conditions.

Though there are several air-quality modeling programs available, ALOFT (A Large Outdoor Fire Plume Trajectory) developed by the National Institute of Standards and Technology is the recommended model for in-situ oil burning in the marine environment. Canada has experience with this model. ALOFT is also used by Alaska to determine safe distances. Information on the ALOFT model can be obtained from the US National Institute of Standards and Technology at their internet site: http://fire.nist.gov/aloft

The US National Oceans and Atmospheric Administration (NOAA) provides a useful computer aid (MAC and DOS) for in-situ burning that calculates the burn rate and soot production based on amounts and types of oil being burned. It can be obtained from:
http://response.restoration.noaa.gov/oilaids/ISB/ISB.html

The applicant, whether industry or government, for in-situ burning will be required to have the ALOFT model and a trained person (or arrangements) as part of their in-situ oil burning capability within any case-by-case situation. Portable meteorological stations will also be required to provide local, real-time meteorological data at the in-situ site, and if of concern, on shore as well.

Monitoring is the process of sampling the air for specific contaminants. Like modeling, air monitoring can be difficult to undertake in the field. Nevertheless, land-based monitoring will be incorporated as part of in-situ burning operations during a case-by-case situation. Purchase and/or arrangements will be required by the applicant for air monitoring equipment for particulates (PM_{10}) for a case-by-case burn, unless special dispensation is given by Command. Information from monitoring will be continuously evaluated to ensure the burn is conducted safely. Weather and sea conditions will also be continuously monitored, and, if conditions become unfavorable, the burn will be extinguished. Extinguishing a burn takes only five to ten minutes, either by releasing the boom to allow the burning oil to thin, or speeding the pull of the boom to smother the fire.

An operational guideline for in-situ burn air monitoring is provided by Environment Canada's February 2000, *In-situ Burning: A Cleanup Technique for Oil Spills on Water* (see this report's Appendix F). This guideline is available from Environment Canada's Environmental Technology Centre (Emergencies Science Division), Ottawa, Ontario (http://www.etcentre.org/divisions/esd/english/esd.html)

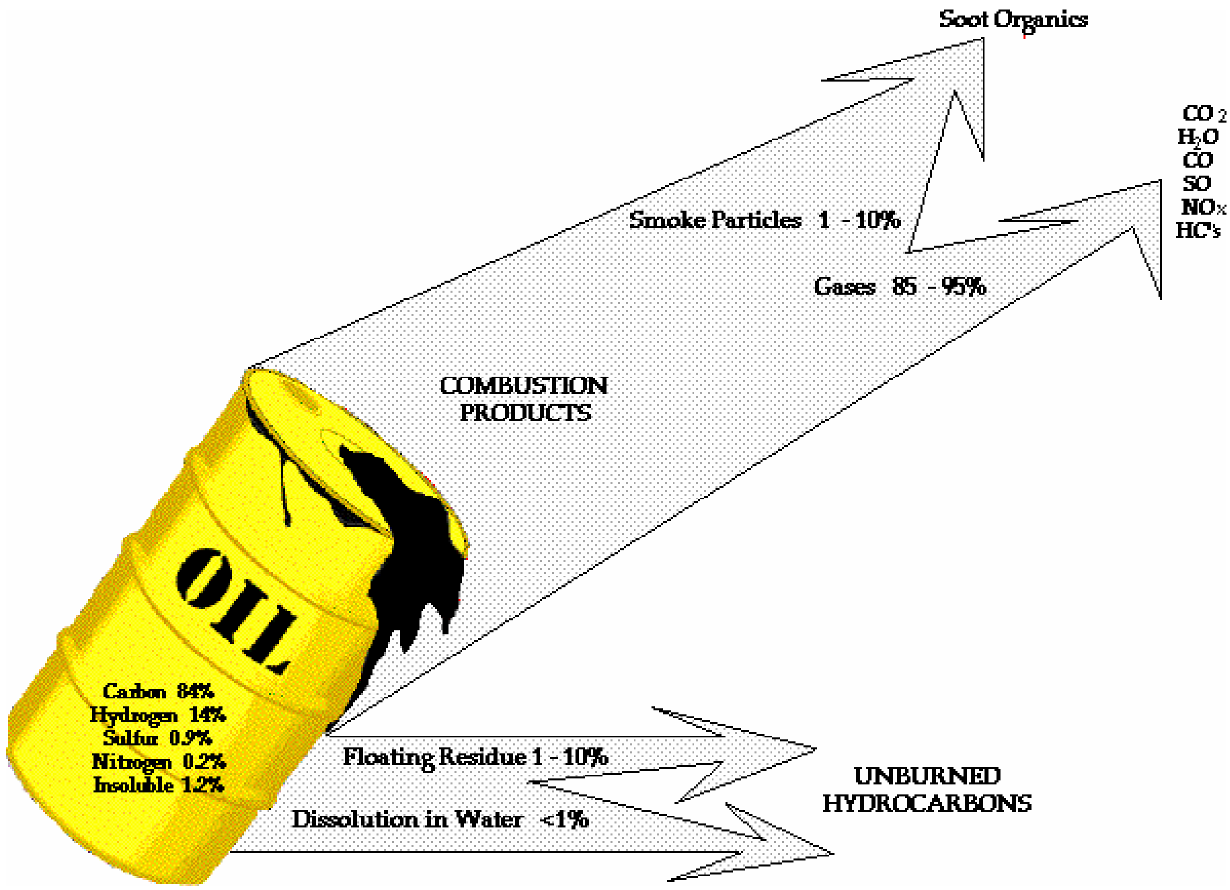
Further guidance on air monitoring is provided by the January 2001, *Special Monitoring of Applied Response Technologies* guideline document (SMART Guideline) of the US Coast Guard, National and Atmospheric Administration, US Environment Protection Agency, and Centers for Disease Control and Prevention. The SMART Guide establishes a monitoring system for rapid collection and reporting of real-time, scientifically based information, in order to assist the Command with decision-making during in situ burning. Available at: http://response.restoration.noaa.gov/oilaids/ISB/ISB.html

Chapter Four:
Human Health & Safety

By-products of In-situ Burning and Health Concerns

It is the vapours of oil that burn. However, there are some by-products from in-situ burning since no combustion process is completely efficient in oxidizing a source material such as oil. If efficiency were complete, the final result would be carbon dioxide (CO_2), water (H_2O) and an assortment of sulfur and nitrogen residues. However, in-situ burning of oil does not achieve complete efficiency and leaves combustion by-products. Although the exact mix of these by-products varies, some general observations can be made. There are three general categories of combustion by-products:

- airborne components;
- unburned oil; and
- floating residues.



Airborne Components — Many of the concerns associated with in-situ burning stem from the generation of a massive, dramatic smoke plume. The plume is particularly intimidating if seen near the fire. Based on this concern, the components of airborne by-products have been the focus of oil burn experiments. The following compounds have been extensively measured during in-situ burns:

- Smoke Particles
- Volatile Organic Compounds (VOCs)
- Carbon Dioxide (CO_2);
- Carbon Monoxide (CO);
- Carybonyls
- Sulphur Dioxide (SO_2)
- Polynuclear Aromatic Hydrocarbons (PAHs);
- Nitrogen Oxides (NO_x); and
- Dioxins and dibenzofurans

Smoke Particles (Soot): Despite the highly visible character of smoke generated, typically less than 14 percent of the original amount of a crude oil is converted into smoke during combustion. The particulate portion of the smoke is largely comprised of elemental carbon (90 percent). The main health concern is the small particulate material of less than 10 and 2.5 micron (µm) in size.

The following lists public safety criteria for particulates used for in-situ burning on the Pacific West Coast:

- State of Washington and the US National Strike Team - PM10 concentration of 150 µg/m3 averaged over one hour at ground-levels in populated areas (Northwest Area Contingency Plan: In Situ Burning Policy and Operational Guidelines 1995 /National Response Team, Science & Technology Committee's: Guidance on Burning Spilled Oil In Situ, 1995, respectively)
- State of Alaska - PM2.5 concentration of 65 µg/m3 averaged over one hour at ground-levels in populated areas (Annex F, Unified Plan: In Situ Burning Guidelines for Alaska, 1995)[6]
- State of California - PM10 concentration of 50 µg/m3 averaged over 24 hours (1998, California Policy for the Use of In-Situ Burning in Waters Off the State, Department of Fish and Game, Office of Spill Prevention and Response)

The particulate criteria for *British Columbia/Canada In-situ Oil Burning Policy and Decision Guidelines is* air quality exposure to general populace not to exceed PM_{10} concentration of 150 $\mu g/m^3$ averaged over one hour.

Volatile Organic Compounds (VOCs): When oil is burned, volatile organic compounds are released and fuel the fire. As the fire rapidly consumes VOCs, their levels fall below health concerns, even near the fire. Concentrations of VOCs are actually about three times higher around fresh, evaporating oil than from burning oil. VOCs are the main irritant for on-water and onshore workers removing fresh oil.

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[6] Based on plume modeling by the State of Alaska, the downwind safe separation distance from human populations - using the $PM_{2.5}$ concentration of 65 $\mu g/m^3$ averaged over one hour criteria- from in situ oil burning is estimated to be 4.8 kilometers (2.6 nautical miles).

Carbon Dioxide (CO_2): The primary gaseous product is Carbon Dioxide (CO_2). Carbon Dioxide is a product of complete combustion, and poses no health risk in an open-air environment. The normal atmospheric levels are about 350 parts *per* million (ppm). Levels very near a burn may reach 500 ppm.

Carbon Monoxide (CO): This gas is a by-product of incomplete combustion, and is present in a concentration about 25 times lower than CO_2. Field measurements of Carbon Monoxide close to the fire are typically near or below detection levels.

Carbonyls: This class of substances consists of partially oxidized materials whose main constituents are aldehydes (*e.g.* acetaldehyde, formaldehyde) and ketones (*e.g.* acetone). Carbonyls from oil fires are at very low concentrations and well below health concerns, even close to the fire.

*Sulfur dioxide (SO_2)***:** This gas is formed when Sulfur in the oil oxidizes during the combustion process. The concentration of SO_2 depends on the sulfur content of the oil. Concentrations measured in oil fires and controlled laboratory experiments range from a few parts *per* billion (ppb) to 0.8 parts *per* million (ppm). Most readings were at safe levels below 0.1 ppm.

Polycyclic Aromatic Hydrocarbons (PAHs): Polycyclic Aromatic Hydrocarbons (PAHs) are a group of hydrocarbons characterized by several benzene rings. Some members of this group are known or suspected carcinogens if one is exposed over a long period (*e.g.* years). The suite of PAHs occurring in the smoke plume is nearly the same as that in the burning oil, but at much lower concentrations. Concentrations within soot and burn residue are at low concentrations, and often just above detection levels. Ground-level concentrations of PAHs found in the Kuwait oil fires were in the sub-parts *per* billion.

Nitrogen Oxides (NO_x), (Nitrogen Dioxide (NO_2) and Nitrogen Monoxide (NO)): These are gaseous by-products of oil combustion. Nitrogen oxides at very high concentrations are strong irritants to the eyes and respiratory tract. The maximum concentration of NO_2 is 0.02 ppm which is much lower than the US Occupational Safety and Health Administration eight hour Permissible Exposure Limit PEL (short-term exposure only) of 1 ppm.

Dioxins and Dibenzofurans: There has been no indication that these compounds are produced by the burning of oil at sea.

The particulates and gases at the levels described above are of primary concern to spill responders tasked with conducting the in-situ burn operations due to their close proximity to the fire and smoke. A few kilometers downwind from a burn these gases generally reach background levels or are undetectable, and pose little or no public health concern (see: Table 2).

The volatile gases of fresh oil - either on water or on shore - are significantly more toxic to people and animals. Nevertheless, addressing and answering health considerations are a high priority for decision-makers when undertaking experimental burns and during actual spill burns.

For purposes of risk communication, it can be useful to relate risks anticipated to be incurred from in-situ burning to a more familiar situation - such as a forest slash burn. Slash burns are a common activity in British Columbia to reduce the risk of forest fires or manage a fire - both a preventative and response tool. Based on the analysis of the Newfoundland Offshore Burn Experiment where oil was burning at a rate of 200 barrels *per* hour for about 1.5 hours, revealed that:

- smoke particles smaller that 2.5 µm are comparable to a nine acre slash burn;
- the amount of CO is comparable to a 0.1 acre slash burn;
- the amount of CO_2 is comparable to a two acre slash burn; and
- PAHs emissions would be equivalent to a seven acre slash burn.

The extent to which particles and gases would present a health risk during a planned oil burn to the general populace would be minimal. The safe distances and/or acceptable atmospheric conditions to conduct a burn are designed to keep exposure to zero or to very low and short duration. Responders themselves would be provided the appropriate training and personal safety equipment to protect them from smoke and fumes. The establishment of a "controlled" zone around the fire protects public from exposure to the intensive smoke plume.

Residue Components - The main constituent remaining after a burn is residue**.** In the controlled test burn during the *Exxon Valdez* spill, an estimated 57,000 to 144,000 liters (15,000 to 30,000 gallons) of crude oil was burned with only about 1,136 liters (300 gallons) of stiff, taffy-like burn residue remaining. The composition of the residue is similar to the original oil, but the residue is depleted in volatile hydrocarbons. Consequently, the resultant "tar patty" had no detectable acutely toxic compounds common in fresh oil such as; benzene, toluene, xylene, and alkanes. The operational implication is that some provision is needed to pick up and disposal of the residue.

Chapter Five: Potential Ecological Effects of Burning Oil

Response to an accidental release of large quantities of oil often results in trade-off - the burning of oil is no exception. The trade-off for choosing to burn is to allow short-term, managed air pollution compared to long-term, difficult to manage surface water oiling and shore contamination. Burning has very little impact on marine and coastal ecology, whereas oil on water and shores can be devastating. However, there are some public concerns about the effects to global and regional air quality from emissions, and ecological impacts from heating water and remaining residue.

Global and Regional Air Quality Impacts

The concern that an in-situ burn produces greenhouse gases (*e.g.* Carbon Dioxide) and contributes to global air pollution is a moot issue for several reasons. Firstly, most of the oil would be combusted by automobiles and industry and converted to greenhouse gases over the long-term anyway. Even mechanically collected oil is recycled and turned into green house gases as it's returned for industrial use.

The contribution to long-term regional air pollution is nominal. An in-situ burn of a marine oil spill is not a routine practice, but an emergency activity that would normally not extend over a 72 hour period. An in-situ burn itself may only last a few hours because a fire boom has a limited period of use before it degrades.

Surface-water Impacts

Though only a small portion of heat from burning oil is radiated back to the oil and underlying water, it can be sufficient to actually boil water. This action occurs only immediately under the burning oil, and under static burns. Since it is necessary to corral and keep forward motion of the fire boom, the accumulation of heated water is very low. Operationally, the residence time of the burning layer over a given water surface is generally too brief to induce boiling. Observations during large-scale burns using towed containment-boom did not give any indication of water boiling because cool seawater is continually supplied below the oil layer. Nevertheless, there is some effect on the microlayer of surface water.

The water surface represents a unique and important ecological niche called the "surface microlayer". The microlayer is considered to be the upper millimeter or less of the water surface. This layer is a habitat for many sensitive life stages of many organisms, including eggs and larval stages of fish and crustaceans as well as reproductive stages of other plants and animals. It is known that cod, sole, flounder, hake, anchovy, crab and lobster have egg or larval stages that develop in this layer. Although most studies of the microlayer have been conducted near shore, some results suggest that even far off the east and west coasts of North America, eggs and larval stages of fish concentrate at the surface at certain times of the year.

Despite the overall ecological importance of the surface microlayer, the long-term net loss of biomass is small or non-existent. This marginal impact is due to the intermittent nature of an oil burn, the small size of the affected area, and the high renewal rate of the surface microlayer resulting from new growth and replenishment from adjacent areas. Floating surface oil has a greater impact on the microlayer organisms than in-situ burning, due to its extensive coverage. As a result, in-situ burning can have a net environmental benefit from rapidly removing large areas of surface oil.

Deep water impacts are nominal. Analysis of water samples collected from the upper 20 centimeters of the water column immediately following a burn of crude oil yielded relatively low concentrations of total petroleum hydrocarbons (1.5 ppm) or less than 1 per cent of the total volume of the oil burned. Compounds that have low water solubility tend to concentrate at the surface. These compounds accumulate in the surface microlayer until absorption and sedimentation remove them, or dilution significantly reduces known toxicity to marine organisms.

As mentioned, there is always some residue (typically less than 1 per cent) of unburned oil. Fish, birds, mammals and other organisms could ingest burn residues. However, these impacts would be much less severe than those manifested through exposure to a large, non-contained oil spill. Furthermore, residues can be retrieved.

Soot residues of large size particulates fall out of the smoke plume within a kilometer of the fire. The remaining particulates drift and disperse within the air column. The soot that falls on water is generally undetectable as it is thinly deposited, disperses, and mixes with the water or floating oil.

In summary, the ecological consequence to the marine ecosystem of in-situ burning is very low. The comparison to the ecological impacts of surface oil and shore contamination is outlined next.

Chapter Six:
Potential Effects of Oil on Marine Ecology

Resources at Risk and Impacts

Spilled oil can be dispersed widely over the ocean surface. Dispersed oil can weather on the open ocean, linger in nearshore environments, or accumulate onshore. Long-lasting environmental damage can often be avoided if spilled oil is removed from surface waters quickly and prevented from reaching shore.

Biological resources tend to concentrate in critical habitats such as beaches, estuaries, and wetlands. Coastal habitats - particularly nearshore areas - provide food and shelter for most organisms at one or more stages of their life histories. For instance, most marine bird species are very reliant on nearshore habitats for staging and wintering. Oil deposited on coastlines may smother coastal plants and animals, and leave a tar-like coating that can persist for years. Intertidal organisms with slimy surfaces resist coating (e.g. starfish, algae), but others, especially vascular plants and barnacles, can be smothered. In addition, once oil is trapped in sediments it can be recirculated into the water and remain in the food chain for many years.

The long-term impacts to birds and mammals include lower reproduction rates and physical mutations in offspring. Wildlife officials are concerned that oil spills have had a measurable impact on seabird populations and their ability to recover. Oil from the 1988 *Nestucca* spill off the Washington coast killed estimated 56,000 seabirds of various species. A significant percentage of local nesting populations of Common Murres and Marbled Murrelets were killed by the 1991*Tenyo Maru* spill.

Heavy crude oil in contact with mammals and birds can destroy the insulating ability of fur and feathers, reduce buoyancy, and are ingested as the animal attempts to clean itself. These animals can die from exposure, drowning, ingestion of oil, or suffocation.

When higher forms of marine life eat oil-tainted organisms, oil residues may be retained in tissues. Sub-lethal effects include reduced resistance to disease, lower reproductive potential and changes in schooling and migration behavior.

Chapter Seven:
Potential Trade-Off

Consideration of Risk

Because of impacts of oil spills to people, wildlife and the environment, significant oil spills are - and must be - recognized as emergency situations. The response must be appropriate to the magnitude of the spill and the potential impacts that will result. Because of the acute toxicity of oil, there will always be impacts. However, choices must often be made in combating a spill that will require trade off among those impacts. The impacts of oil in the water and on shorelines must be weighed against the impacts of pollutants in the atmosphere when considering in-situ burning. All impacts to the environment, wildlife, the economy, and human health must be considered and trade off must be examined in terms of risk.

As is the case with all response methods, the environmental trade-off associated with in-situ burning is situation dependent. In-situ burning can offer important advantages over other response methods in specific cases and may not be advisable in others, depending on the overall mix of circumstances. Information contained in this document has gone into detail about many of the “pros” and “cons” regarding the use of in-situ oil burning. These are summarized below.

Pros

In-situ oil burning:

- is efficient by removing up to 99 percent of contained oil from the water's surface at very high elimination rates.
- offers a realistic means of oil removal if storage facilities for oily wastes are overwhelmed or not available.
- reduces the amount of shoreline contamination and the exposure of birds and mammals to floating oil.
- lessens the need for shoreline cleanup and oily waste disposal which are orders of magnitude more expensive.
- reduces the amount of exposure of toxic fresh oil to shoreline workers or residents living near a heavily oiled beach.
- removes the volatile emission components from fresh, evaporating oil.
- has minimal logistics for on water containment and removal (no skimmers or floating oil storage requirements).
- has the capability for 24 hour operations for oil removal.
- has no water depth constraints.
- can be quickly extinguished if required.
- has minimal environmental impacts to marine waters and ecosystems.

Cons

In-situ oil burning:

- produces thick clouds of black smoke near the source of the burn, and small particulates can be carried to areas where they could impact human populations.
- creates a visual impact from the smoke plume which could cause people to become alarmed.
- requires careful and measured communication of the environmental trade-off.
- requires careful evaluation to ensure public health risk is fully considered in the decision to burn and during the burn operation.
- requires a common understanding by environment and health agencies that it is a safe undertaking.
- feasibility is limited by physical constraints such as the degree of emulsification and wind and wave height.
- requires containment of the oil in a fire boom in order to obtain a thickness that will sustain combustion.
- has a narrow window of opportunity in which to conduct in-situ burning that limits public and agency debate.
- requires a controlled zone around the fire to exclude public boaters and aircraft from the heavy smoke plume and from interfering with response operations.
- the significant cost-saving to the polluter may incorrectly be viewed as the primary motive for its use.

Chapter Eight:
Operational Considerations

Minimal Considerations for Effective In-Situ Oil Burning

The minimal considerations and limitations for effective in-situ burning are summarized as follows:

Weathering — Weathering (*i.e*. natural evaporation of volatile vapours) decreases ignitability and combustibility of spilled oil as weathering results in the loss of volatile compounds. Up to about 20 percent evaporation appears to not affect the burn efficiency of crude oil. Between 20 and 35 percent weathering can actually increase burn efficiency. Beyond 35 percent, efficiency declines. In-situ combustion of weathered oil is still possible despite the loss of most volatile hydrocarbons in crude oil during the first two or three days of aging.

Emulsification — Emulsification (*i.e*. mixing of oil and water) decreases ignitability and combustibility. Oil at sea tends to emulsify quickly. After one day, the water content of emulsified oil can be as high as 70 percent. The controlling factor in the combustion of emulsions is the removal of water, which is accomplished either through the boiling of the water out of the emulsion, or by breaking the emulsion chemically.

Thickness — Thicker layers of oil are easier to ignite and sustain. Combustion of an oil slick is sustained as long as the contained oil remains above a minimum thickness. This threshold thickness ranges from 0.8 to 3 millimeters (mm). The thickness necessary for successful ignition increases with the state of weathering and the viscosity of oils.
Burn efficiency varies significantly with slick thickness. With a slick of 10 mm thickness, approximately 80 to 90 percent of the oil may burn. With a slick of 100 mm thickness, approximately 98 to 99 percent maybe burned. This requires that spilled oil must be concentrated by containment to prevent spreading and the resultant thinning of surface layers - usually by fire-resistant boom. Fire booms resemble standard oil containment booms, but are constructed with high temperature materials such as ceramics and steel. Significant improvements in boom design, performance, and reusability have been achieved with booms that are internally water-cooled. In-situ burning has been most often considered and tested with crude oil spills. However, its feasibility with other kinds of products (*e.g.*, marine diesel fuel and Bunker C fuel) has been demonstrated. There are some difficulties with establishing and maintaining necessary slick thickness for lighter oils and some difficulty in igniting heavier oils. Crude (unrefined) oil often works the best.

Ignition — Spilled oil must be ignited if in-situ burning is to be used as a response method. Several methods have been used to experimentally and operationally ignite oil slicks, such as heli-torches and floating gel-packs.

In summary, oil thickness and emulsification are the most limiting factors. A minimum oil thickness is required to light the slick. In addition, the efficiency of a burn is largely a function of the oil thickness and increases with slick thickness. Large oil pools burn more efficiently than small pools. Water content is probably the second most influential variable affecting the ignition and efficiency of the burn. For a given thickness of oil, ignition times increase only slightly with weathering, but increase dramatically with emulsification. If water content of emulsified oil reaches the 30-50 percent level, successful ignition will require a large ignition source such as a heli-torch. Oil type and water content have only a marginal effect on efficiency provided the oil can be ignited. If ignited, large amounts of contained oil can be eliminated rapidly and safely.

Readings and Appendices

Suggested Readings

Appendix A - ISB Decision Flowchart

Appendix B - ISB Application &Checklist

Appendix C - Monitoring Guidelines

Appendix D - Smoke Plume Dispersion Modeling

Appendix E - Public Communication

Suggested Readings

There is a plethora of scientific articles on in-situ oil burning. The follow are suggested readings from which the *British Columbia/Canada In-situ Oil Burning Policy and Decision Guideline*s have been developed.

Allen, A.A., 1998. Offshore Oil Spill Response*: An Overview of Mechanical Recovery and Dispersant Application Techniques, with an Emphasis on Controlled "In situ Burning"*. Prepared for Burrard Clean Operations Ltd., North Vancouver, B.C. by Spiltec, Woodinville, Washington.

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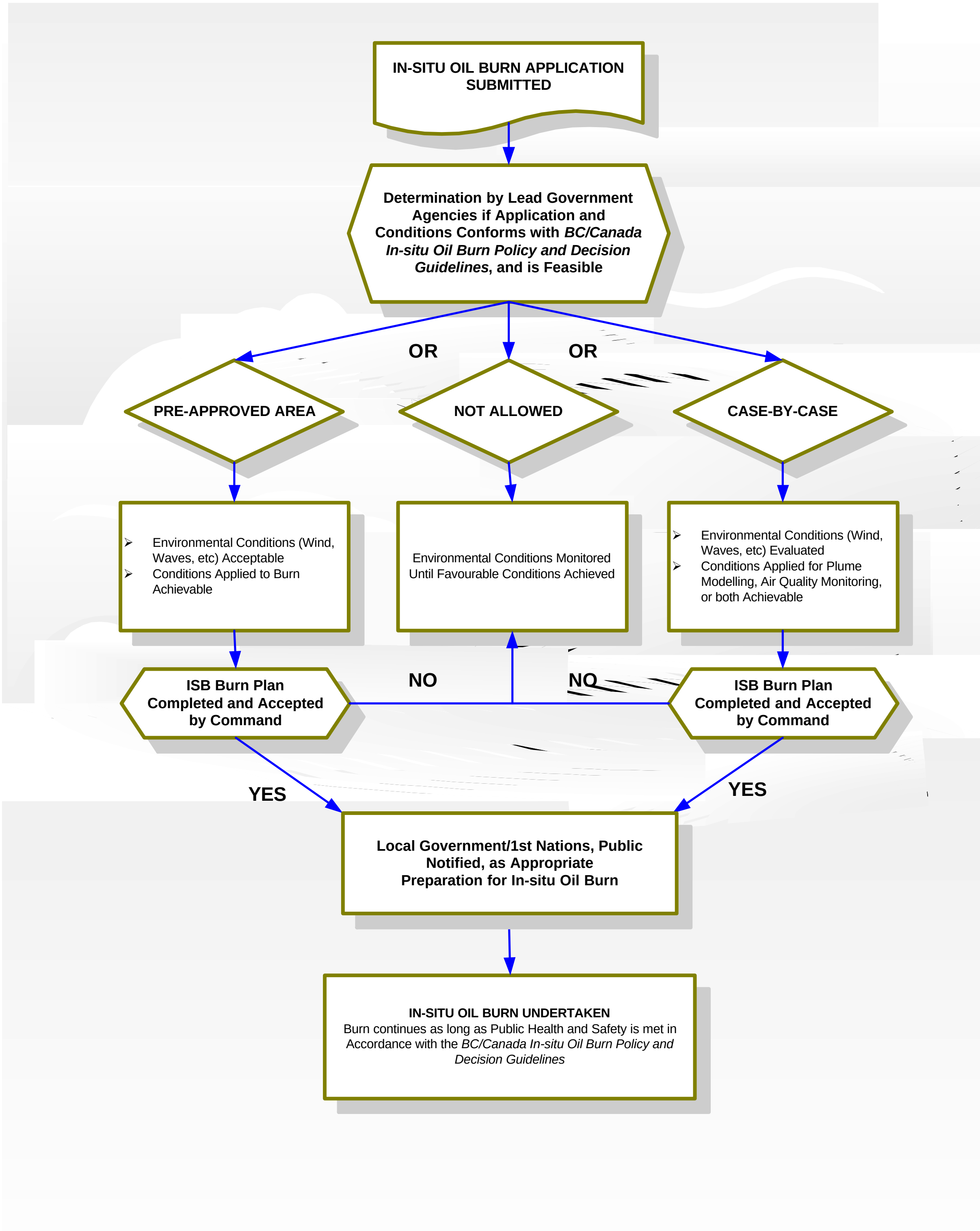
Appendix A
ISB Decision Flowchart



Appendix B
ISB Application & Checklist

The following application and checklist provide the required information to assess any request to conduct an in-situ oil burn in Canadian marine waters. The flowchart in Appendix A summarizes the process for making a decision. The decision to burn involves two basic factors:

1. the benefits of removing fresh oil to reduce overall ecological impacts; and
2. whether it is practical, feasible, and safe to burn given the existing field conditions.

The application process begins with identifying the applicant (Part 1), which can be a Responsible Party (spiller), or a government agency, followed by a feasibility analysis (Part 2). If feasible, the checklist (Part 3) and burn plan (Part 4) are to be completed. Approval is provided by the federal and provincial agencies with lead authorities for response monitoring (Part 5). If the checklist and worksheet fail to show that in-situ burning is not feasible or appropriate, changes in environmental or other factors may make in-situ burning an option later on.

Aids for In-situ Oil Burning

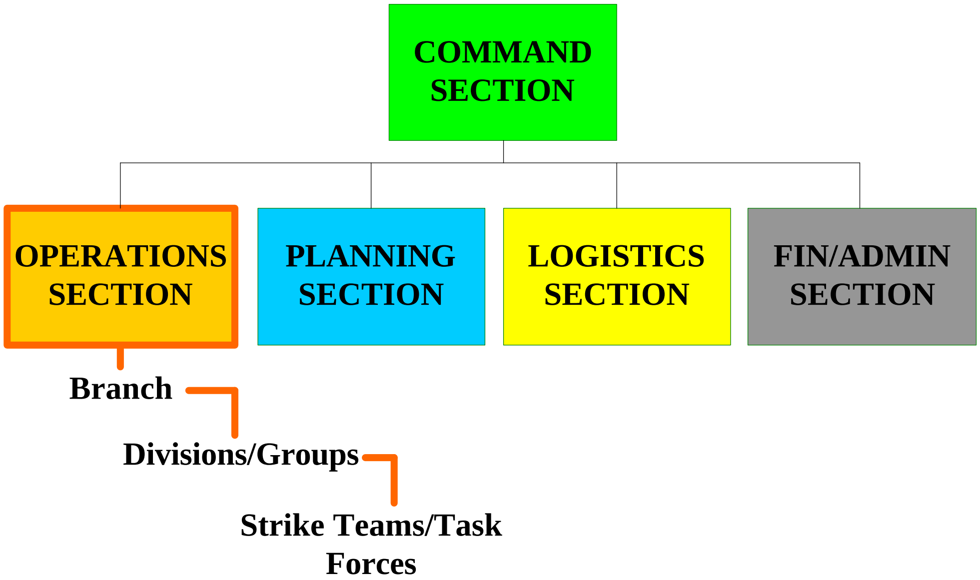
The US National Oceans and Atmospheric Administration (NOAA) provides a useful computer-based "Spill Tools" (MAC and DOS) for in-situ burning that calculates the burn rate and soot production based on amounts and types of oil being burned. The determination of oil evaporation levels, and the efficacy of undertaking an in-situ oil burn, can be evaluated by the NOAA's Spill Tool ADIOS 2 *(Automated Data Inquiry for Oil Spills*). ADIOS2 is an oil weathering model. These programs can be obtained from: http://response.restoration.noaa.gov/oilaids/spiltool/intro.html

The US National Institute of Standards and Technology provides information on the ALOFT model at: http://fire.nist.gov/aloft

2001 SMART guideline (Special Monitoring of Applied Response Technologies) developed by US Coast Guard, National Oceanic and Atmospheric Administration, US Environmental Protection Agency, Centers for Disease Control and Prevention, Seattle, Washington, and supporting information can be found at: http://response.restoration.noaa.gov/oilaids/ISB/ISB.html

Command, Control, and Information Flow for In-situ Oil Burning

In-situ burn operations take place as an integral part of the Incident Command System (ICS). The ICS is an organizational structure employed by many companies and government agencies in order to manage major emergencies, such as a major oil spill.[7] The ICS organization of an Incident Management (Response) Team is comprised of five functional sections: **Command**, **Operations**, **Planning, Logistics** and **Finance/Administration**: The "basic" structure is as follows:



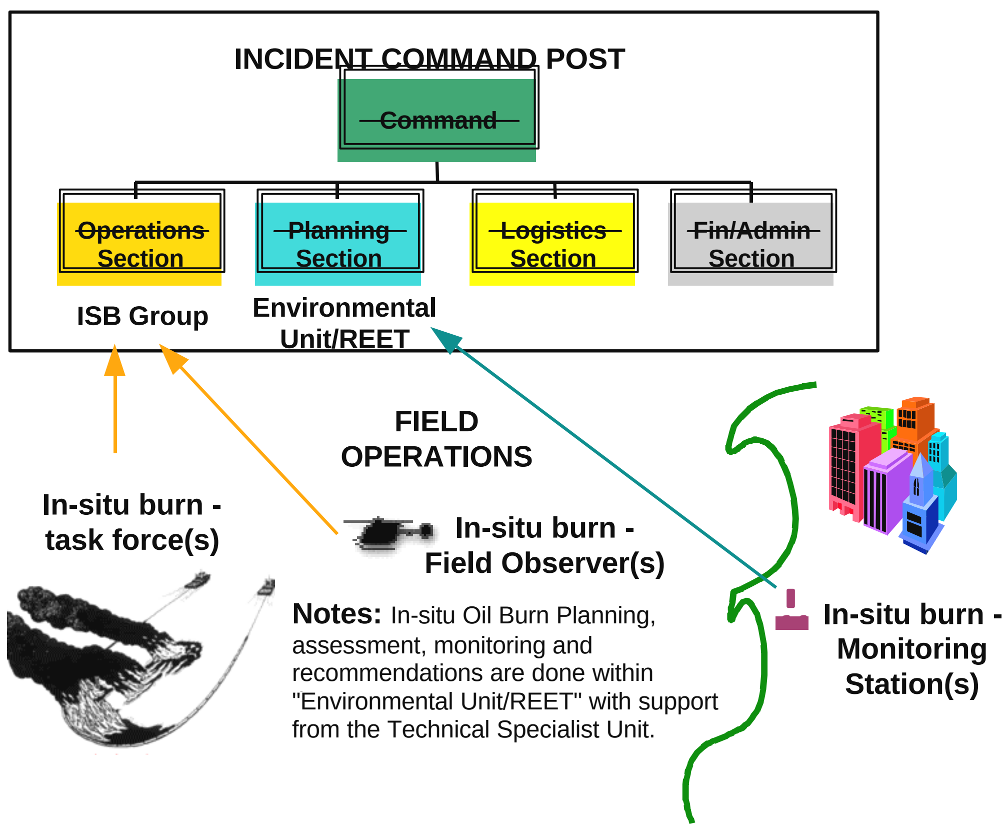
Authorization to undertake an oil burn rests with the federal and provincial lead agencies whether in a monitoring or responding capacity, and based on analysis and advice provided by environmental specialists and scientific authorities (referred to as: Technical Specialists). The lead federal agency is the Canadian Coast Guard of Fisheries and Oceans Canada, as defined by the *Canada Shipping Act* and *Oceans Act*. The lead provincial agency is the BC Ministry of Environment, Lands and Parks as defined under the *Emergency Program Act* and it Emergency Program Management Regulation (Schedule 1).

[7] The Incident Command System stems back to 1970 during the California "wildfires" and the need to have an organizational system to manage complex, multi-agency incidents. The ICS is now widely adopted by both industry and government. The Government of British Columbia has adopted ICS as a standard for site management of a large incident, and the Federal Government employs ICS for large marine oil spills.

In-situ oil burning operations are directed by the Operations Section Chief or designate. An In-situ Burn Group should be established with the Operations Section to conduct air quality monitoring for public health and safety, and the burn itself. Field observers (single resource) or teams (task forces) should be deployed for visual monitoring of the smoke plume and air sampling. These field personnel report to the In-situ Burn Group. Deployment will be in accordance with the In-situ Burn Application, conditions applied to the Burn Plan, and the Incident Action Plan.

Environmental specialists and scientific experts (referred to as "Technical Specialists) provide the technical input and/or review of an application to undertake an in-situ oil burn. These tasks can include plume modeling. These people can include, but are not limited to, personnel from Fisheries and Oceans Canada, Environment Canada, BC Ministry of Environment, Lands and Parks, Ministry of Health, Regional and Municipal health agencies and First Nations. They participate in the federal Regional Environmental Emergency Response Team (REET). REET is an environmental/technical advisory body to Command. The "Environmental Unit' within the Planning Section of the *BC Marine Oil Spill Response Plan* serves the provincial involvement in the federal REET. The REET is co-chaired by Environment Canada and BC Ministry of Environment, Lands and Parks. The co-chairs have sign-off authority to the review of the In-situ Oil Burn Application with recommendations and suggested conditions to Command. Command has final approval.

The REET (Environmental Unit) are the recipients of any air monitoring data and make recommendations on whether the *British Columbia/Canada In-situ Oil Burn Policy and Decision Guidelines* are being complied with. The co-chairs can advise Command on matter pertaining to further in-situ oil burn operation.



IN-SITU BURN APPLICATION AND APPROVAL
British Columbia/Canada In-situ Oil Burning Policy and Decision Guidelines

PART 1 - Applicant

Applicant: ____

Applicant is: Responsible Party ____ or Lead Agency: _____

Incident Commander: ________________ Contact Phone Number: ____________

In-situ Checklist and Burn Plan prepared by: _____________________ Contact Phone Number: __________

Application Submitted to (Name and Agency with Lead Authorities):
(Name) (Position)
Federal: ____
Provincial: ____________________________________

Application Submitted on: (Date) ________________ at (Time) ______________.

PART 2 - Feasibility Analysis

The applicant must be able to demonstrate and to validate the following answers to the approving agencies with lead monitoring or command responsibilities:

⇒ Is the spilled oil already burning? Yes __ No ___
(If yes, skip feasibility questions and proceed with the rest of application).

⇒ Is the oil concentration, weathered condition, and type suitable for containment and burning?. Yes ___ No ___

⇒ Are sea stages and meteorological conditions conducive to in-situ burning of released oil?
Yes ___ No ___

⇒ Are burn location, oil type and quantity, prevailing and forecasted winds and atmospheric conditions likely to cause particulate exposures to onshore populace to exceed the 150 $\mu m/m^3$ averaged over a one hour period as stipulated in the *BC/Canada In-situ Oil Burning Policy and Decision Guideline*? Yes ___ No ___

⇒ Is in-situ burning the only practical option due to location, environmental conditions and/or availability of other response options (*e.g.* mechanical recovery, dispersant use, no action)?
⇒ Yes ___ No ___

⇒ Will in-situ burning be undertaken in conjunction with other oil recovery operations?
Yes ____ No ____

⇒ Will in-situ burning provide a net over-all environmental protection benefit compared to available mechanical recovery? Yes ___ No ___

⇒ Are equipment and trained personnel available to conduct an in-situ burning operation?
Yes___ No ___

PART 3 - Application Checklist

Incident and Spill Information

⇒ Date of incident (month/date/year): ________________ Time of incident (24 hr): ___________

⇒ Name of Incident: ____

⇒ Source of spill: Tanker/Barge ___
Bulk Cargo/Container/Passenger Vessel ___
Fuel Handling Facility ___

⇒ Cause of spill: (Vessel) grounding ___ collision ___ explosion ____
(Facility) loading ___ storage failure ___ pipeline rupture ____
Other (Specify): ____________________________________

⇒ Name of responsible party: ________________________________

⇒ Location of incident: _________________ Latitude: _____ N Longitude ______ W

⇒ Type(s) of oil spilled: ____

⇒ Estimated volume of oil spilled into water at time of burn application: (barrels) ______ or (cubic meters) _________

⇒ Estimated volume of oil at risk of spilling: (barrels) _________ or (cubic meters):______________

⇒ Release status: Stopped __ Intermittent __ Continuous __

⇒ Oil Slick condition near source: Continuous ___ Large patches ___ Ribbons ____

⇒ Anticipated oil trajectory (over next 24 hours): out to sea ___ towards land ___ or parallel to shore.

⇒ Oil distance to nearest land: (kilometers) ____ or (nautical miles) ___

⇒ Expected areas and times of shoreline oil impact:
1. area: _____________________ date: ___________ time: ________ (24 hr)
2. area: _____________________ date: ___________ time: ________ (24 hr)
3. area: _____________________ date: ___________ time: ________ (24 hr)
4. area: _____________________ date: ___________ time: ________ (24 hr)

⇒ Distance and direction to nearest population center(s) (including occupied First Nations Reservations/Lands):

1. Name: ____________ Distance_____________ (km) Direction (NWES)_________
2. Name: ____________ Distance_____________ (km) Direction (NWES)_________
3. Name: ____________ Distance_____________ (km) Direction (NWES)_________
4. Name: ____________ Distance_____________ (km) Direction (NWES)_________

PROVIDE MAP OF INCIDENT LOCATION, OIL TRAJECTORY, POTENTIAL SHORE OILING, AND PROPOSED AREA OF IN-SITU OIL BURN(S)

Information on Oil Condition for In-situ Burning at Target Time of Burn Operation.

⇒ Estimated percentage of natural dispersion and evaporation during:
first 24 hours ____________% second 24 hours ______________%

⇒ Current oil emulsification: Unknown ___ None ___ Light (0-20%) ___
Moderate (21-50%)___ Heavy (over 50%) ___

⇒ Estimated thickness of uncontained oil at proposed burn location: (millimeters) ______

Information on Weather and Environmental Conditions for In-situ Burning at Target Time of Burn Operation

⇒ Weather factors:

1. Temperature: Air = _______ °C Water = ________ °C
2. Weather: Clear __ Partly cloudy __ Overcast __ Rain __ Fog __ Snow __ Freezing __
3. Surface visibility ________ (kilometers) Ceiling level ___________ (metres)

⇒ Weather forecast precipitation free: ___ yes ___ no

⇒ Visibility sufficient for burn operations/observations (greater than 150 meters vertical/1 kilometer (0.5 nautical miles): ___ yes ____ no

⇒ Surface current: Speed _______(knots) Direction (from)_________

⇒ Winds: Speed _______ (knots) Direction (from) ___________

⇒ Winds are: ___ on-shore, ____ parallel to shore, or _____ off-shore

⇒ Forecasted winds: Forecast Period (hours) _____ Speed _______ (knots)
Direction (from) ___________

⇒ Forecasted winds will be: ___ on-shore, ____ parallel to shore, or _____ off-shore

⇒ Tide stage at targeted burn time: Flood ____ Ebb ____ Slack Water ____

⇒ Sea State is: Calm ___ Choppy ____ Swell (meters) ____

⇒ Waves: Less than <1/3 meter __ < 1 meter __ More than 1 meter __

⇒ Wave Direction (from) ____

⇒ Other weather/sea condition information:

____
____
____
____
____

PART 4 – In-situ Burn Plan

⇒ Target date and time of in-situ burn: (date) _______ (time) ________

⇒ Number of in-situ burn task forces: _______

⇒ Information on each in-situ burn task force:

Task Force#1: Latitude: _____ N Longitude ______ W
Time of Fire Boom On-scene (24 hr) _______ deployed (24 hr) ______
Distance from Shore: _____ (kilometers) or ______ (nautical miles)
Distance from Spill Site: _____ (kilometers) or ______ (nautical miles)
Fire Boom Type: ___________________ Length (meters) _______
Oil Containment Area within Boom (m^2) ______
Time of Ignition (24 hr) _______ Completion of Ignition (24 hr) _____ Total (hours) ____
Estimated Rate of Burn: ____________________ (liters/m^2/hour)
Estimated Volume to be Burned __________ (liters).

Task Force#2: Latitude: _____ N Longitude ______ W
Time of Fire Boom On-scene (24 hr) _______ deployed (24 hr) ______
Distance from Shore: _____ (kilometers) or ______ (nautical miles)
Distance from Spill Site: _____ (kilometers) or ______ (nautical miles)
Fire Boom Type: ___________________ Length (meters) _______
Oil Containment Area within Boom (m^2) ______
Time of Ignition (24 hr) _______ Completion of Ignition (24 hr) _____ Total (hours) ____
Estimated Rate of Burn: ____________________ (liters/m^2/hour)
Estimated Volume to be Burned __________ (liters).

Task Force#3: Latitude: _____ N Longitude ______ W
Time of Fire Boom On-scene (24 hr) _______ deployed (24 hr) ______
Distance from Shore: _____ (kilometers) or ______ (nautical miles)
Distance from Spill Site: _____ (kilometers) or ______ (nautical miles)
Fire Boom Type: ___________________ Length (meters) _______
Oil Containment Area within Boom (m^2) ______
Time of Ignition (24 hr) _______ Completion of Ignition (24 hr) _____ Total (hours) ____
Estimated Rate of Burn: ____________________ (liters/m^2/hour)
Estimated Volume to be Burned __________ (liters).

⇒ Total combined in-situ oil burn ___________ (m^2)

⇒ Buffer or procedures established to avoid ignition of main oil slick? Yes ___ No ____

⇒ The designated in-situ burn division(s) and vessel and air-craft control zone (Provide Map)

⇒ Time of Notice to Mariners and Aircraft: (24 hr) __________.

⇒ Method(s) used to notify residents living within the potential smoke plume trajectory:
1. radio announcement ________________
2. press release ______________________
3. public meeting ____________________
4. individual notification ______________
5. other (specify) ____________________

⇒ Type of ignition system: _______________________________

⇒ If a heli-torch ignition system is to be used, is the helicopter qualified for offshore flight and does it meet federal aircraft certification requirements? Yes ___ No ____

⇒ Are sufficient numbers of trained personnel available on-scene to conduct safe and effective burn?
Yes ___ No ___

⇒ Is nighttime burning being planned. Yes ___ No___

⇒ Method of collecting burned oil residue: ______________________________

⇒ Proposed interim storage and disposal of burned oil residue: ______________________________

⇒ Is smoke dispersal modeling support available? Yes ___ No ___
If yes, what model is to be used. ________________________ Contact: (name & phone number) ____________________

⇒ Is "real time" air quality monitoring support available? Yes ___ No ____
If yes, provide number and location of stations:

1. ____________________________________
2. ____________________________________
3. ____________________________________

Assisting or co-operating consultants or agencies to provide air quality services (name and phone no.):

1. _____________________________ ________________________
2. _____________________________ ________________________
3. _____________________________ ________________________
4. _____________________________ ________________________

The information contained in Parts 1 to 4 has been reviewed and approved by the Incident Commander of the applying company or agency, and is based on the best available weather and marine information and is in accordance with the *British Columbia/Canada In-situ Oil Burning Policy and Decision Guidelines:*

___________________________	________________	_____________
Incident Commander	Date	Time

APPLICATION (PARTS 1 TO 4) TO BE PROVIDED TO THE REGIONAL ENVIRONMENTAL EMERGENCY RESPONSE TEAM (ENVIRONMENTAL UNIT) CO-CHAIRS FOR EVALUATION

PART 5 – Approval

Information and recommendation from the Regional Environmental Emergency Response Team (Environmental Unit)

⇒ The in-situ burn location is:

___ within a pre-approved area in accordance with Table 1 of the *British Columbia/Canada In- situ Oil Burning Policy and Decision Guidelines*.
___ is a case-by-case decision.

⇒ Is there a net environmental protection benefit to in-situ burning? Yes ___ No ___

⇒ The in-situ burn plan and the existing and forecasted meteorological conditions for the duration of the burn are favourable, indicating the in-situ burn is feasible, and provides reasonable assurance that the PM_{10} exposure criteria prescribed by the *British Columbia/Canada In-situ Burning Policy and Decision Guidelines* will not be exceeded. Yes ____ No ____

⇒ Recommendation is:
____ Approve without conditions
____ Approve with conditions as follows:
1. ____
2. ____
3. ____
4. ____

___ Not approve for the following reason(s):
____
____
____
____
____
____

REET co-chair (Environmental Unit) with recommendation authority for in-situ burning;

Environment Canada: ________________________ ___________ ________
(Name) (Date) (Time)

BC Environment, Lands and Parks: ____________________ ___________ _______
(Name) (Date) (Time)

Comments for consideration by Command:

____
____
____
____
____
____

Decision by lead Federal Monitoring Officer and Provincial Incident Commander

☐ Approved without conditions
☐ Approved with conditions as stipulated above:
☐ Not Approved for the reason(s) provided above

Federal Monitoring Officer: ______________________ ____________ ________
(Name) (Date) (Time)

Provincial Incident Commander ______________________ ____________ ________
(Name) (Date) (Time)

Instructions from Command:

____
____
____
____
____
____

Appendix C
Air Monitoring Guidelines

Introduction

Air quality monitoring is considered an integral part of the in-situ burn implementation whenever there is a likelihood of people being exposed to burn by-products. In-situ burning may affect two groups of people: responders conducting the burn and the general public. The following monitoring guidelines are directed only towards public health protection, as occupational health safety monitoring for responders would be required with the detailed operational plan for in-situ burning (*i.e.* pursuant to Workers Compensation Board's Occupational Health Safety regulation). The following monitoring guidelines do not address sampling to enhance the scientific understanding of in-situ burning. In an emergency situation, research must take a secondary role to ensuring timely and effective application of in-situ burning for the protection of the environment.

Air quality monitoring is not a pre-requisite for an in-situ oil burn within a pre-approved area, unless stipulated by Command. The latter stipulation for air monitoring is when the meteorological information in the burn application indicates a potentially affected populace. For a case-by-case decision, air quality monitoring is relevant for onshore winds and a potentially affected populace. Air monitoring of a plume heading out-to-sea is not required.

Air monitoring equipment and expertise can be provided by the Responsible Party, its Response Organization, consultants, environmental agencies, or combinations thereof. Field air monitoring should be undertaken by the Operations Section of the Incident Management Team (see Appendix ?). Within the Planning section, the Technical Specialist Unit should identify a meteorologist, air quality specialist, and in-situ burn specialist – and supporting staff if needed. These specialists are tasked with designing, gathering, and interpreting all aspects of air quality monitoring. Through the "chain-of-command", they must be prepared to support the strategic direction of Command whether to undertake an in-situ oil burn and its continued operation. The following provides some general guidance. The specialist's expertise in weather, in-situ burning methodology, and air quality science provides the comprehensive basis for assessing and guiding an in-situ oil burn.

Exposure limits - In order to make decisions regarding the continuation of an in-situ burn, it is advisable to collect information concerning concentrations of particulates. Particulates is the targeted parameter, as other constituents such as volatile organic compounds (VOCs) and polycyclic aromatic hydrocarbons (PAHs) reach background levels before the particulate criteria of this guideline are reached. The Province of British Columbia's in-situ oil burn criteria is PM_{10} is 150 $\mu g/m^3$ averaged over one hour. This calculated time-weighted average reading, *versus* instantaneous readings, is the relevant air quality measurement for determining if an in-situ oil burn should be approved or continued.

Sampling - Sampling may be conducted for several reasons:

1. to determine background ambient levels of particulates within a community prior to a burn;
2. to assess exposure levels at different points, to provide immediate feedback to Command, and to verify visual observations of plume behavior;

3. to validate smoke dispersion models; and/or
4. to satisfy other scientific or historical data collection needs.

Item 2 is the over-riding priority. Based on large-scale test burns, the concentration of gases in the plume drops below the exposure limit within several hundred meters of the burn. Particulate concentrations in the center of the plume may remain above the level of concern for several kilometers downwind. Sampling of particulates of PM_{10} micron size and at ground-level is the focus of the monitoring program.

Monitoring - Real-time monitoring should be established when anticipated weather conditions and/or the location of the burn produces a situation in which the general public could be affected by the smoke plume. Depending on circumstances, the burn may be monitored by qualitative assessment (*i.e.* visual observation) and/or by quantitative methods that employ air quality sampling.

Visual observations - Visual observations should be conducted to track plume direction and height, and to verify that the smoke plume behaves as predicted by weather data and/or computer modeling. Ignition of industrial smoke flare rockets (in a safe location away from volatile fumes) to the expected height of smoke prior to a burn provides a visual indication of potential plume trajectory.

When to Sample - Sampling is an option that may be exercised at any time during the burn. It is desirable to sample when there is a potential for public exposure, even if it is expected to be below the limits of exposure.

Sampling Equipment - Sampling equipment should:

- be portable, easily deployable, and available when needed;
- be sensitive, accurate and precise enough to provide meaningful data at the $PM_{2.5}$ level; and
- provide real-time readings and have the capability to log readings over several hours in order to get the average concentrations over an extended period of time.

Recommended sampler is the MIE RAM-1 Portable Real-time Aerosol Monitor or MIE DataRam Real-time Aerosol Monitor. Operational guidelines for In-situ Burn Air Monitoring Equipment is provided in Appendix F of Environment Canada's report (February 2000) *In-situ Burning: A Cleanup Technique for Oil Spills on Water*.

In addition, sampling pumps using filter media may be deployed at various locations. This data, though not real time, may be used for exposure assessment, model validation, and to provide information for future in-situ burns. The Applicant may either obtain this equipment as part of its in-situ burn capability (*e.g.* booms, ignitors, modeling program, and portable meteorological stations), or make arrangements with agencies/consultants that have this equipment.

Sampling Location - The monitoring strategy for in-situ burning is based on the need to measure the possible effect of in-situ burning on the public. It will be conducted if there is reason to believe that in-situ burning may affect populated areas. Whenever a smoke plume potentially affects a community, there should be at least three monitoring stations capable of sampling for particulates.

Real-time particulate samplers should be positioned where the smoke exposure to the public may be most substantial. Locations to consider include:

- the shoreline, at the expected centerline of the plume;
- at the population center of concern; and/or
- in several locations in the vicinity of the populations downwind of the burn.

These particulate samplers, which can operate for more than eight hours, will collect particulate readings before the burn begins (to gather background data), during the actual burn, and if possible, after the burn is over to collect post-burn readings. Sampling results will be followed closely, and relayed to the Planning Section during the burn. The Specialist Unit within the Planning Section should be advised if it is established that the readings exceed the level of concern. Sampling location should be based on priority concerns, with the first priority given to population areas downwind of the burn. For model validation, samplers should be placed at different distances from the burn to collect particulate concentration data at ground level.

Sampling Limitations - In general, air sampling is not a requirement for conducting an in-situ burn within a pre-approved area, but its importance increases with the proximity of population to the burn site where the wind is blowing towards the populated area. Sampling is valuable as feedback to Planning, and can increase the comfort level of both those conducting the burn and those potentially exposed to it.

Trends should be determined since single numbers can be misleading. The readings of a real time particulate monitor may fluctuate widely, depending on nearby activity such as passing cars or smoke from woodstoves from nearby houses. Averaging the readings over a period of time *(e.g.* 6 to15 minutes*)* should provide an indication of the trend, and will show whether particulate concentrations go up or remain steady. Visual observations coupled with sampling that could provide the general trend of particulate concentrations should be useful in determining the potential effect of the burn on nearby populations.

The limitations and shortcomings of sampling data should be clearly stated. These data should be interpreted correctly, and the numbers should be presented with the associated uncertainty and possible inferences and inaccuracies.

Appendix D
Plume Dispersion Modeling: Available Tools

Background

Smoke dispersion modeling has been used over the past decade to assist in the permitting process of large industrial sources that release pollutants into the air from smokestacks. The original models were small statistically based simulations of pollution impacts on the surrounding area. Though models were never used to replace monitors, these tools proved to be important because of the excessive costs and time associated with properly operating a large number of air quality monitors. Mathematical models were able to predict maximum levels of concentration of pollutants, and in some situations, help determine the proper location of a limited number of air quality monitors. This enabled industry to lower costs associated with monitoring and prevented facilities from operating prior to evaluating the impact of their airborne pollution on the surrounding population.

Smoke dispersion models offer similar advantages to in-situ burning as they do to industry. Mathematical models are able to give insight on maximum downstream concentrations of open burning smoke plumes. In addition, models can be used to prevent the starting of in-situ fires that could result in impacts to human health due to adverse smoke dispersal conditions.

One problem with using dispersion models for determining airborne impacts from in-situ oil burns is that their use is relatively untested compared to terrain models. Commonly available air quality models have been specifically designed for industrial stacks and fugitive emission situations. Large ponds of burning fuel oil display characteristics uncommon to industrial style sources. As a result, modification and testing of mathematical models for large oil fires continues to be developed.

The goal is to incorporate new and changing methods of analysis including air quality modeling, monitoring, and professional judgment to provide well-rounded meteorological support during an oil spill event.

Modeling Tools

The following is a brief summary of a few mathematical modeling tools that may be utilized during the evaluation of an in-situ burn.

ALOFT

ALOFT (A Large Outdoor Fire plume Trajectory model - Flat Terrain) is a computer based model to predict the downwind distribution of smoke particulate and combustion products from large outdoor fires. ALOFT was developed by the US National Institute of Standards and Technology. Measurements and observations at experimental fires have shown that the downwind distribution of smoke is a complex function of the fire parameters, meteorological conditions and topographic features. To incorporate these features, ALOFT solves the fundamental fluid dynamic equations for the smoke plume and its surroundings. ALOFT is the public domain version of the model for flat terrain using windows based personal computers. Information is available on the internet at: http://fire.nist.gov/aloft. The program contains a graphical user interface for input and output and a user modifiable database of fuel and smoke emission parameters. The output can be displayed as downwind, crosswinds and vertical smoke concentration contours. Information on using the program is available with on-line help commands in the program. ALOFT was used in the Newfoundland Offshore Fire Experiment performed in August of 1993.

NOAA - SPILL TOOL: In Situ Oil Burn Calculator

The US National Oceans and Atmospheric Administration (NOAA) provides a useful computer aid (MAC and DOS) Spill Tool called "In Situ Oil Burn Calculator". This Spill Tool calculates the burn rate and soot production based on amounts and types of oil being burned, and graphically plots plume heights, configuration, and direction. It also estimates how much fire boom is needed to burn a specified amount of spilled oil or section of an oil slick, and how many burns would be required. Responders can make predictions either for oil already spilled on the water ("batch mode"), or for oil that is continuing to spill ("continuous mode"). The In Situ Oil Burn Calculator can be obtained from: http://response.restoration.noaa.gov/oilaids/spiltool/spiltool.html

Appendix E
Public Communications

BURNING AN OIL SPILL

Overview

The people responsible for cleaning up oil spills in British Columbia are investigating a practice called *in-situ oil burning*. *In-situ* is Latin for "in place". Burning parts of an oil spill under a controlled situation can rapidly eliminate oil that injures and kills wildlife, fouls coastal shores and exposes people to harmful petroleum vapours.

The best way to deal with an oil spill is to prevent it in the first place. But if oil is on the water, responders must choose cleanup methods that most effectively minimize damage to the environment. In-situ oil burning provides an expanded choice. An objective is to find the right mix of methods that achieve the greatest net benefit to the environment, and maximum human safety and health protection.

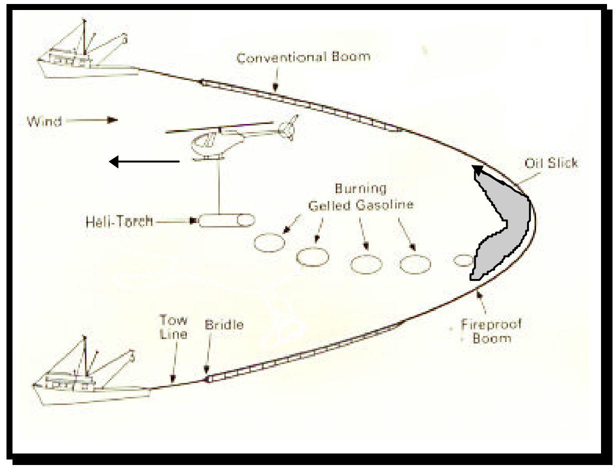
Response to an accidental release of large quantities of oil often results in environmental trade off - in-situ burning is no exception. The trade off for choosing to burn is to allow short-term, managed air pollution compared to long-term, difficult to manage on-water oiling and on-shore contamination. Burning has little impact on marine and coastal ecology, whereas oil on water and shores can be devastating. Environmental and ecology agencies recognize and concur with this finding. What is not, however, a trade-off is causing human health impacts from the smoke plume. Though constituting a small percentage of the original amount of spilled oil, smoke is the largest, most visible outcome of burning oil on water.

Health protection is the main focus of the *British Columbia/Canada In-situ Oil Burning Policy and Decision Guidelines.* This document has been prepared to guide the decision of when and where to undertake an in-situ oil burn. Many test burns and years of research have provided a high degree of confidence that human health can be protected, while achieving the environmental protection of an in-situ oil burn. To mitigate public health impacts, the main factors in considering a burn is to either conduct in an in-situ oil burn a safe distance off-shore, or if close to shore, only when the wind conditions are offshore and/or in a remote location.

What Happens During an In-situ Burn?

A Controlled Burn

Oil on water does not burn unless it is at least a few millimeters thick and fresh. Before a burn, oil is concentrated in a fire resistant floating barrier called a "fire boom". A boat tows each end. The oil trapped inside the fire boom is ignited as the boom collects more of the spilled oil. An in-situ oil burn generally lasts only a few hours and can be quickly extinguished in a few minutes by curtailing oil capture.



Public Will Be Notified

The smoke from an in-situ burn is dramatic if viewed close-up. From a public perspective from the shore, the plume will look small in comparison to the wide, ocean expanse. This is because a burn will only be conducted a safe distance off-shore - *i.e.* several kilometers, and/or in a remote location. Nevertheless, the main reason for public notification is to avoid any alarm stemming from an unusual, but intentional, occurrence. Public notification is not for mitigating health concerns *per se*, as the burn location, meteorological conditions, and other factors designed to protect human health, as stipulated in *British Columbia/Canada In-situ Oil Burning Policy and Decision Guidelines*, must be met. Furthermore, the smoke consists largely of carbon soot. The more harmful, volatile chemicals in fresh oil are destroyed in the fire. Depending on the location or the fire in relation to coastal communities, mass media contact or direct notification will be done to make sure the word gets out as quickly as possible.

The Decision to Burn

Decision Must Be Made Quickly

The old saying that "oil and water don't mix" is true, but does not apply to a marine oil spill situation. The combustible gasses in spilled oil quickly evaporate when stirred up by wind and waves. The oil then becomes a froth that is difficult to ignite, as well as to mechanically recover. Managers of a spill response must immediately decide whether to conduct a burn, usually within a few hours after a spill. By 72 hours, it maybe too late to burn. A primary purpose of the *British Columbia/Canada In-situ Oil Burning Policy and Decision Guidelines* is to expedite the decision-making process, without compromising public health and safety.

Incident Commanders make the Call

The response to a major oil spill is overseen jointly by incident commanders from federal and provincial governments and the party responsible for the spill. These people, in consultation with their scientific advisors, decide whether to conduct an in-situ burn. The decision-making process and the factors to consider are provided in the *British Columbia/Canada In-situ Oil Burn Policy and Decision Guidelines.* This document is based on extensive scientific research from many large-scale test burns of oil within ocean environments. The researchers studied both the removal efficacy and health impact of burning oil.

Conditions for In-situ Burning

Only oil corralled and contained behind fire boom is burned, ensuring the rate of burn can be controlled - including rapid extinguishing. Oil spread thinly over the water will not burn, as such, there is little possibility for sustained combustion of an uncontained oil slick. The following conditions must be met before a burn is approved:

- an application must be submitted with appropriate information on environmental conditions to assess its efficacy and public safety.
- people will not be exposed to smoke that exceeds health standards;
- sea and weather conditions must allow for an effective burn.
- methods and processes must be in place to cease burning.

Why Burn Oil Instead of Collecting It?

Oil needs to be removed from surface water quickly if one wishes to avoid expensive and damaging shoreline contamination, or to alleviate surface oil contact with birds and mammals. Typically, spilled oil is corralled by booms and scooped up by boats with devices that skim the oil off the water. The problem is that mechanical cleanup usually recovers only 15 to 20 percent of the original amount of spilled oil, and is a very slow process. The amount of oil removed by in-situ burning in a few hours can exceed the amounts collected mechanically in a month.

Experience with in-situ burning indicates that up to 99 percent of the oil burned maybe removed from the water while having relatively little impact on marine ecosystem. Smoke generated by burning an oil spill, however, contains organic particulates that could be a human health concern if high concentrations of smoke drifted into a populated area for a sustained period. Therefore, in-situ burning is allowed only under very specific conditions as stipulated in *British Columbia/Canada In-situ Oil Burning Policy and Decision Guidelines.*

The Challenge of Communications

One of the greatest challenges when deciding to burn spilled oil as a response technique is communicating its nature, scope, and risk. The following provides some frequently asked questions about why to burn, how decisions are made, and what the consequences are.

BURNING OF OIL IN THE MARINE ENVIRONMENT
Frequently Asked Questions

Q 1. *What is the basis behind the decision to burn spilled oil?*

It is prudent to assume that a major oil spill can occur as vast quantities of petroleum are shipped through the shared west coast waters of the United States and Canada. Each year, there are over 400 shipments of crude oil through Juan de Fuca Strait. Larger tankers also travel offshore of British Columbia *en route* to California. The burning of contained oil in place (in-situ) allows response personnel an additional capability to manage an oil spill's impact on the environment, as long as human health is not in jeopardy.

In-situ burning has been recognized for many years as an effective way to eliminate large quantities of spilled oil. Fire-resistance booms capable of containing spilled oil and holding it in place for burning are now available. The use of a boom also enables the control of the burn, such as rate of combustion and to quickly extinguish the fire.

Significant advancements have been made in our scientific understanding of large-scale oil burning. A large-scale test burn conducted off the coast of Newfoundland in 1993 not only solved oil ignition and control issues, but resolved many environmental and health impact concerns. The advantages of in-situ burning as an oil-spill response technique include:

- removal of large volumes of oil can be rapid and effective - typically 90 to 99% removal at a rate of many barrels each hour;.
- oil can be safely and effectively eliminated without the need to find environmentally safe land storage and disposal opportunities;
- in-situ burning can be conducted quickly due to minimal logistic and personnel support required compared to mechanical recovery methods; and
- burning may only be the only practical response technique available.

Q 2. ***Why not just clean it up*?**

In-situ burning is one of several options available to combat a spill. It should complement other options, not exclude them. When possible, spill responders start mechanical recovery immediately, using booms, skimmers, and other equipment. When feasible to carry out, in-situ burning is fast and efficient. It can remove up to 99 percent of the oil contained in the boom, and reduce the need for storage and disposal. When it is safe and environmentally wise to use in-situ burning, the environment benefits because more oil will be removed from the water.

Q 3. *Who is promoting the use of in-situ burning.*

The interest in burning of oil is largely driven by the environmental and ecology agencies along the Pacific west coast as there is a high likelihood of a net environmental benefit from its application, if appropriately timed, located, and implemented.

The oil industry has taken a "wait and see" approach to in-situ burning. Purchasing of specialized equipment and training in its use will only occur in the oil industry if there some certainty that government is prepared to make a decision to use in-situ oil burning methods.

Industry or government does not see the combustion of spilled oil as a substitute for the containment and physical removal of spilled oil. Conventional booming and skimming operations will always be conducted wherever they can be implemented safely and with a reasonable degree of effectiveness.

Q 4. *On what type of spill event could in-situ burning be done.*

The burning of contained oil on water during a marine oil spill is a proven and viable means to mitigate the impact of fresh oil on people and the environment. Burning would be under special circumstances, such as an offshore spill of crude oil from an oil tanker, release of large volumes of oil from a bulk carrier's fuel tanks, a petroleum barge grounding, or pipeline break. The burning of oil would not be viewed as a "routine" approach to spill response, nor as a substitute to traditional mechanical recovery. To deploy a fire boom is a significant commitment in resources and effort. A fire boom is expensive and can only handle five or six burns before it is no longer useable. It then must be disposed of.

Q 5. *What guides the decision to burn oil in the marine environment?*

The *British Columbia/Canada In-situ Oil Burning Policy and Decision Guidelines* provides the direction and procedures to expedite in-situ burn decisions, to ensure public safety, and to maximize environmental protection. The document's purpose is to define the conditions under which burning may occur on a pre-approved or case-by-case basis, as well as define the areas and conditions under which burning will not be allowed.

The scientific foundation for the policy and decision guidelines are derived from the results of millions of dollars of research and development work in the United States and Canada, such as the 1993 Newfoundland Offshore Burn Experiment (NOBE).

Q 6. *Who makes the decision to undertake in-situ burn?*

The decision to undertake in-situ burn is a significant tactical decision. The proposal to burn can be put forward by the Responsible Party (spiller) or by government. The decision to burn must be made expeditiously to be effective - within a few hours. The authority to approve an in-situ burn rests with the lead government agencies responsible for directing the response or for approving the response strategy of the Responsible Party. Federally, this is the Federal Monitoring Officer of the Canadian Coast Guard (Fisheries and Oceans Canada). Provincially, the Provincial Incident Commander of the Ministry of Environment, Lands and Parks makes the decision.

The decision will be undertaken in accordance with the *British Columbia/Canada In-situ Oil Burning Policy and Decision Guidelines*. The primary consideration is protecting human life and health, followed by a net benefit in the protection of marine birds, mammals and fish, and of coastal shore ecosystems.

Q 7. *What will the public see during an in-situ burn?*

A smoke plume is the most obvious outcome of an in-situ oil burn. From a few kilometers, the smoke plume looks like a smudge-pot fire within an ocean expanse, but up close, the plume is very dramatic and intimidating. Despite the highly visible character of the plume, less than 10 percent of the original amount of the oil is converted into smoke. The particulate portion of the smoke is largely comprised of elemental carbon (soot), while the primary gaseous products are Carbon Dioxide, Nitrogen Oxides, and water vapour. Toxic volatile components of fresh oil are burned off in the fire. Though not seen by the general public, there is some tarry residue created after the burn. This residue can be readily picked up.

Q 8. *How long will the smoke stay in the air?*

The duration of the smoke plume will vary depending on the conditions at the time of the burn. The plume may stay in the general burn area for several hours while the burn continues. The thickest part of the plume will, however, dissipate within a few hours after a burn ceases. It only takes a few minutes to put out the fire. The incident commander(s) may choose not to conduct the burn if the weather conditions indicate the air is stagnant and smoke may linger over a populated area. The *British Columbia/Canada In-situ Oil Burning Policy and Decision Guidelines* sets air quality criteria for public exposure to the smoke plume that must not be exceeded should the plume ever drift towards land and people.

Q 9. *What happens to the smoke when the fire occurs?*

Because of the intense heat, the smoke plume usually goes up into the atmosphere several hundreds to several thousands of meters. It then levels off and is blown by the wind in a narrow, and often meandering band. After that, it moves about according to high elevation wind conditions. Some parts of the plume may occasionally and temporarily dip back down toward the surface. The latter becomes a health problem only if human populace is exposed over a sustained period.

Q 10. *Have pre-approved areas been established for in-situ burning?*

Pre-approved areas have been established whereby a burn may be undertaken at minimum, specified distances offshore. The distances vary depending on the type and amount of oil being proposed for burning. Pre-approved areas are necessary to expedite the decision-making process. The offshore distances range from 3 nautical miles (5.5 km) for heavy crude-like oils to 5 nautical miles (9.3 km) for light diesel-type oils. All distances exceed the calculated safe distances needed to protect public health. The calculated safe distances are derived from real field data obtained during numerous test burns and scientific studies. Approval to burn is not automatic, there are steps required, such as: submission of an in-situ burn application, a feasibility analysis, supporting meteorological and sea conditions, and a burn plan. The type of information and how it is used are described in the *British Columbia/Canada In-situ Oil Burning Policy and Decision Guidelines.*

Q 11. *Would a burn be allowed close to shore?*

Any proposal to burn oil nearer to shore than the pre-approved distances will be assessed on a case-by-case basis. The direction of wind, remoteness of the area, and other factors would be major considerations before a burn would be approved. There must be reasonable assurances that people will not be exposed to excessive concentrations of pollutants regardless of the distances offshore. The burn will be monitored to ensure it can continue to be conducted safely, and it will be stopped if it can not.

Q 12. *What areas are ruled out for burning categorically?*

Some areas in British Columbia are unlikely to be approved for a burn because of the proximity of populated areas, weather patterns, terrain or conditions that result in a health risk. Each proposal to burn oil under an emergency situation will be assessed on a pre-approved area or case-by-case basis and in accordance with the policy and decision guidelines for British Columbia.

Q 13. *Where else is oil burning allowed?*

The first recorded in-situ burn in Canada was in 1958 on the Mackenzie River (NWT - Canada). Since then, there have been over 40 recorded incident and experimental oil burns. Burning oil spilled in muskeg environments in British Columbia's Northeast petroleum fields is a standard, but not routine practice. Several West Coast US states have policies that allow burning under specific circumstances. The State of Washington allows in-situ burning on a pre-approval and case-by-case basis. Alaska allows it, and in some cases prefers it, in light of the *Exxon Valdez* experience. Hawaii also has policy allowing burning in some circumstances, as do Texas and Louisiana. Several other states are considering burning, including California, Florida and Georgia. In-situ burning is also used internationally in Norway and Finland.

Q 14. *What is the trade-off between air quality effects of burning and the impacts of spilled oil on the environment?*

Oil is persistent and toxic to the environment. As long as oil floats on the water or remains on the beach, it can oil birds and mammals, contaminate shellfish beds, damage archeological sites, coat recreational beaches, and destroy coastal habitat. Oil from the 1988 *Nestucca* barge spill off the State of Washington coast killed an estimated 56,000 seabirds of various species. A significant percentage of nesting populations of common murres and marbeled murrelets were killed by the *Tenyo Maru* fish packer spill which occurred at the entrance to Juan de Fuca strait in 1991.

Wildlife vulnerable to oil spills include shorebirds, bald eagles, sea otters, sea lions, harbour seals and terrestrial mammals that may feed on oiled carcasses. Oil that comes into contact with mammals and birds can destroy the insulating ability of fur and feathers, reduce buoyancy, and be ingested as the animal cleans itself. These animals can quickly die of exposure, drowning, internal bleeding and suffocation. Long-term impacts to birds and mammals include lower reproduction rates and physical mutations in offspring. In addition, once oil is trapped in sediments it can be re-circulated into the water and remain in the food chain for many years.

Fresh oil, particularly crude, can have significant health impact on responders who breathe the vapours or get the oil on their skin. Ingested or aspirated (inhaled) fresh oil can even cause death to a responder, such as during an accidental fall into oily water. The less oil to deal with, the less health consequences to workers. Vapours from fresh oil on beaches can also migrate several kilometers inland and affect the general public.

The above impacts are weighed against the burning of oil offshore where air quality impacts are of short duration, measurable and controllable, and the marine ecological impact is minimized. Every barrel of oil burned is a pollutant not available to wildlife contact, not requiring manual removal, not needing transportation and disposal, and not exposing volatile chemicals to workers or the general public.

Q 15. *Will I be notified of a burn in my area?*

Any time oil is spilled, effort is made to inform the public about the effects of the spill and the actions being taken to combat the spill. If burning were determined to be an appropriate response tool, officials involved in the response will make an effort to inform people about the burn.

Q 16. *What health criteria will be used?*

To protect public health, spill responders will use a conservative outdoor air-quality criteria to guide their burning decisions. This criteria and how it is applied is explained in the *British Columbia/Canada In-situ Oil Burning Policy and Decision Guidelines*. Fine particle pollution is the major concern in evaluating health effects from smoke. The toxic compounds commonly associated with fresh oil are rapidly burned and/or dispersed within a few hundred meters of the fire. Particles of carbon soot drift and disperse over several kilometers. Of these particulates, the most problematic are those of very small size - less than 10 or 2.5 microns (thousandths of a millimeter) in diameter. Two hundred 2.5-micron particles would stretch across the period at the end of this sentence. Depending on the oil type and amount being burned, these fine particulates are widely dispersed and of low concentrations within a few kilometers downwind. At ground-level, the health criteria is a maximum public exposure to Particulate Matter of 10 micron size of a concentration of 150 micrograms *per* cubic meter of air averaged over an hour period. At this level, the smoke would appear as a light haze high in the sky.

Q 17. *How does the emission criteria for oil burning compare to other types of common air emissions?*

Based on the analysis of the Newfoundland Offshore Burn Experiment, emission rates were calculated at 200 barrels of oil burned *per* hour, revealing that:

- smoke particles produced are comparable to those of a 9 acre slash burn;
- the amount of CO is comparable to a 0.1 acre slash burn;
- the amount of CO_2 is comparable to a 2 acre slash burn;
- PAH emissions would be equivalent to a 7 acre slash burn.

Q 18 *Why burn oil when people are sometimes not allowed to use their woodstoves and forest companies are not allowed to slash burn?.*

Woodstoves and slash burns represent a more continuous, persistent source of airborne pollutants that can have a detrimental effect on human health. In-situ burning of accidentally spilled oil will occur very infrequently, and will last for a short period of time - typically a few hours each day and limited to a three day period. For the most part, any approval for a burn would be far out to sea, or when the smoke plume would be blown offshore. Moreover, an oil spill is an emergency situation that may require extraordinary measures. Those responsible for responding to a spill may conclude that a temporary source of airborne pollutants is necessary to achieve the overall goal of reducing the serious pollution caused by spilled oil.

Q 19. *How are air quality criteria applied?*

Air quality usually returns to normal background levels a few kilometers downwind of an oil spill burn. Meteorologists will mainly use information on current and forecasted weather conditions to assess the path and the rate of dispersion of the fire's smoke plume. If necessary, such as in a case-by-case decision, plume dispersion modeling may be undertaken and air sampling conducted. This information will enable spill responders to know whether it is likely that smoke will exceed the emission criteria for a populated area.

Q 20. *Will I have to leave my home or stay indoors if a burn is conducted near where I live?*

Those in charge of responding to a spill would not approve in-situ burning, or continued burning, if it is necessary for people to leave their homes or stay indoors. If meteorological conditions and/or monitoring shows air quality impacts above those set by the policy and guidelines, then the burn will be extinguished.

Q 21. *Should we be more worried about preventing the spill instead of burning it?*

Preventing spills is absolutely our number one priority. The oil industry and government agencies are working hard to find ways to prevent spills from happening. It is far less costly to prevent spills than to clean them up. There are laws and regulations that address prevention. Despite everyone's efforts, spills do sometimes happen, and the response community must be prepared to use all appropriate tools to respond effectively.

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