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Standard Guide for In-Situ Burning of Oil Spills in Marshes[1]

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1. Scope

1.1 This guide addresses in-situ burning as a response tool for oil spills that occur in marshes.

1.2 In-situ burning, mechanical recovery, treating agent application, and natural recovery are the usual options available to an on-scene coordinator for the control and cleanup of spilled oil.

1.3 The purpose of this guide is to provide the user with general information on in-situ burning in marshes as a means of controlling and removing spilled oil.

1.4 This guide outlines considerations that can be used to conduct an in-situ burn in marshes.

1.5 In making in-situ burn decisions, appropriate government authorities should be consulted.

1.6 The values stated in SI units are to be regarded as standard. No other units of measurement are included in this standard.

1.7 *This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.*

2. Referenced Documents

2.1 *ASTM Standards:*[2]

F1788 Guide for In-Situ Burning of Oil Spills on Water: Environmental and Operational Considerations

F1990/F1990M Guide for In-Situ Burning of Spilled Oil: Ignition Devices

3. Terminology

3.1 *airborne emissions*—compounds or substances that are emitted into the air as a result of a fire.

3.2 *fresh oil*—oil recently spilled that is un-weathered and un-emulsified.

3.3 *in-situ burning*—burning of oil directly on the water or marsh surface.

3.4 *marsh*—a wetland characterized by grassy surface mats that are frequently interspersed with open water or by a closed canopy of grasses, sedges, or other herbaceous plants.

3.5 *residue*—the material, excluding airborne emissions, remaining after the oil stops burning.

3.6 *wetland*—land that has the water table at, near, or above the land surface, or that is saturated for long enough periods to promote hydrophilic vegetation and various kinds of biological activity which are adapted to the wet environment.

4. Significance and Use

4.1 This guide is meant to aid spill response teams during planning, training, exercising, spill response, and remediation.

4.2 In the marsh environment, removal of the oil by in-situ burning may be the only method available to responders. The soft, soggy soil and presence of water and the potential for ecological damage may inhibit the deployment of conventional oil recovery equipment and personnel, while the shallow water may not allow the deployment and operation of skimmers, booms, and storage devices.

5. Background

5.1 In-situ burning of oil has been conducted successfully in a number of marshes. Within several years, recovery was nearly complete in areas where water level was sufficient (exceeded 2 cm) to provide protection to plant roots. Where this was not the case, recovery was slower.

5.2 Ignition equipment for in-situ burning in marshes may be minimal. Ignition devices may be the only specific equipment required. Ignition equipment may include a variety of devices (Guide F1990/F1990M).

6. General Considerations for Making In Situ Burn Decisions for Marshes

6.1 The decision of whether or not to use in-situ burning in a given spill situation is always one involving trade-offs. General considerations such as smoke plume generated and the potential for secondary fires, and specific factors such as marsh

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[2] For referenced ASTM standards, visit the ASTM website, www.astm.org, or contact ASTM Customer Service at service@astm.org. For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.

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type, water level, season, wildlife present, and vegetation recovery should be considered. The human population, potentially affected by the smoke plume, should be considered as noted in Guide F1788. In certain cases, burning of oiled vegetation can also be considered.

6.2 Oil floating on water should be at least 2 to 3 mm thick to be burned efficiently. Natural containment of spilled oil can occur in marshes, providing such layer thickness. Wind may also concentrate the oil to the desired thickness (Guide F1788).

6.3 Oil spilled in marshes is less prone to emulsification than in higher energy, open water environments. The slower emulsification process provides responders with a wider window of opportunity in which to plan and execute in-situ burning operations.

6.4 In some areas, intentional and controlled burning of marshes is a common method of controlling vegetation and reducing organic debris, with beneficial results for the marshes (**1**).[3]

6.5 Water level has been shown to be a major factor affecting plant recovery following in-situ burning in marshes (**2**, **3**, **4**). When the water depth is at least 2 cm, it provides an insulating layer to plant root and rhizomes, keeping their temperature below 60°C and allowing faster recovery.

6.6 Fire spreading needs to be considered. Flattened vegetation and green, un-oiled vegetation may not provide adequate firebreaks, especially in the presence of strong winds. Wetting the perimeter may be beneficial.

6.7 In-situ burning in a timely manner will simplify ignition, reduce the area affected, and minimize the duration of vegetation exposure to the toxic effects of the oil.

6.8 Burning in the winter months may require special considerations because of ice and snow. Cold results in increased oil viscosity and reduced spreading potential. Several burns in ice and snow-covered marshes also proved to be effective and provided for good long-term recovery of the marshes.

6.9 In-situ burning of oil may generate a substantial smoke plume. If human exposure is possible, smoke plume monitoring near population centers should be considered as noted in Guide F1788.

6.10 Utility lines, buildings, and other structures need to be protected from fire.

6.11 Smoke may impair visibility and impact air traffic in the burn area.

6.12 The spilled oil will not be consumed completely by the fire. Residue will be left after the burning has ended. The effects of the residue should be considered. A thick and dense layer of residue will impede revegetation. The effect of the residue should be weighed against impacts of removing the residue, and particularly the effects of movement over the marsh by people and equipment used to remove the residue.

[3] The boldface numbers in parentheses refer to a list of references at the end of this standard.

6.13 The presence of endangered or threatened species must be considered before making the decision to burn.

7. Operational Considerations

7.1 Appropriate regulatory agencies and fire departments should be consulted prior to conducting a burn.

7.2 A burn plan should be developed with the help of a marsh and fire ecologist. Air, burn, and plume models should be run to predict the effect of the burn on the area. The burn plan and a fire safety plan should include: weather, fire calculations, plume modeling, and air and fire modeling protocols, sensitive ecological areas, marsh conditions, seasonal implications, and oil properties. The area should be surveyed for utility lines, pipelines, buildings, and other man-made structures. The risk posed by the burn to these structures should be assessed.

7.3 When a marsh is impacted by an oil spill, all methods of response and cleanup should be considered and assessed for tradeoffs, feasibility, and net benefit to the environment.

7.4 Environmental risk considerations should include the effects of the plume, soot, heat flux, fire spread and remaining burn residue (Guide F1788).

7.5 Risks to human health and safety should be considered, both to personnel conducting the burn, and to the general public. Monitoring protocols should be implemented in accordance with local regulations, and the monitoring teams should be alerted (Guide F1788). Plume, air, and fire modeling results should be considered.

7.6 Prevention or control of secondary fires should be planned for. Provision should be made for changes in wind direction or speed.

7.7 Local aviation, navigation, and highway authorities should be notified before the burn is initiated.

7.8 The burn should be monitored and recorded, including direction, altitude, and behavior of the smoke plume. Still and video photography should be used for documentation.

7.9 After the burn has been extinguished, the area should be surveyed, and the effectiveness of the burn should be assessed and documented. A fire watch should be established to ensure that the fire is completely extinguished.

7.10 Residual oil contamination may be ignited, if possible.

7.11 If possible, burn residues should be collected and disposed of in accordance with local regulations. Oil residue collection may not always be advisable, and should be weighed against the potential damage from people and equipment used for residue collection.

7.12 Monitoring of marsh recovery and potential restoration should be conducted.

8. Summary

8.1 Oil spills in marshes may present unique challenges for response personnel. Access may be difficult, and the presence of water and soft substrate may preclude the use of conventional oil cleanup equipment and personnel. Shallow water may not allow the use of vessels and successful deployment of booms and skimmers. In-situ burning may provide the most suitable, and sometimes the only option for removing the spilled oil from the environment. Use of machinery and human foot traffic can result in mixing of oil with sediments, which can have an adverse effect on marshes.

8.2 The decision to conduct in-situ burning should consider a variety of factors including marsh type, vegetation recovery, water level, presence of wildlife, and secondary fires. Consultation with biologists, fire ecologists, and other experts is essential. For a successful burn to occur, the oil thickness should be greater than 2 to 3 mm. A water depth of at least 2 cm will encourage rapid vegetation recovery.

8.3 Before conducting the burn, an in-situ burning plan and fire safety plan should be completed. Appropriate regulatory agencies and fire departments should be notified, and burn permit(s) sought. Risk to human heath shall be considered. Monitoring of the burns and smoke plume should be conducted if necessary. When the fire has been extinguished, burn residues may be collected and disposed of, if advisable. Monitoring of the marsh should be conducted to follow recovery.

9. Keywords

9.1 in situ burning; marsh; oil spills; tradeoffs

APPENDIX

(Nonmandatory Information)

X1. CASE STUDIES

X1.1 Seven case studies are presented to exemplify the use of in-situ burning in marshes (Refs (**5-16**)).

X1.1.1 *Copano Bay:* (Ref (**5**))—On January 7, 1992, an underground pipeline ruptured by Chiltipin Creek near Copano Bay, Texas, spilling 460 m^3 (2900 barrels) of South Texas light crude oil into a salt marsh. Vacuum trucks, skimmer, pumps, and sorbents were brought to the scene but proved to be only marginally effective. After considering various options, a decision was made to burn the oil. The oil was ignited four days after it spilled, and burned for 20 h in various areas. The area was surveyed, and pockets of remaining oil were ignited later. At the time of the burn the marsh was covered with water from recent heavy rainfall, providing protection to plant roots and rhyzomes. A study to monitor marsh plant recovery over a period of five years suggested that plant diversity in the impacted area was reduced, but that total plant biomass was similar to the control area after two growth seasons.

X1.1.2 *Rockefeller Refuge:* (Ref (**6-8**))—On March 13, 1995, approximately 6 m^3 (40 barrels) of condensate oil (API Gravity 40 to 42) spilled from a pipeline in the Rockefeller Refuge, Louisiana, affecting 20 ha. (50 acres) of brackish marsh. Mechanical cleanup equipment was brought on scene, but was both ineffective at collecting the oil and damaging to the marsh. In-situ burning of marshes is commonly used in that area to reduce organic debris, reduce unwanted fires, and enhance marsh growth. At the time of the spill the water layer over the marsh soil was 5 to 10 cm thick. In-situ burning of the oiled marsh was approved and conducted four days after the burn, removing the oil from 8 ha. (20 acres) of the impacted marsh. Studies conducted three years later concluded that the areas impacted and burned recovered better than the areas impacted but not burned. Three years after the burn, the burned areas attained the same plant density as the reference area.

X1.1.3 *Ruffy Brook:* (Ref (**9, 10**))—On July 22, 2000 a transfer pipeline near Ruffy Brook, Minnesota, failed and released over 8 m^3 (50 barrels) of medium Bow River crude oil into a marsh fed by Ruffy Brook. The spill affected approximately 3 acres of fresh water marsh, that was covered by water 30 to 100 cm above the marsh soil surface. Mechanical recovery was deemed difficult to deploy and potentially damaging to the marsh, so in-situ burning was conducted the same day of the spill. The burn lasted for three hours, and remaining pockets of oil were ignited over a period of three days. No secondary burning occurred during this operation. It is estimated that 80 % of the oil was consumed during the burn. A significant amount of burn residue (in some places 1 cm thick) was left after the fire went out. The residue was picked up by hand three days later. There is no evidence that any residue sank. The marsh was visited a year later, and found to have recovered well, with the exception of willows, a fire sensitive species. The quick response prevented spreading of the oil and thereby minimizing damage to the marsh.

X1.1.4 *Bayou Tank Battery:* (Ref (**11**))—On August 17, 2002, a spill occurred at a tank battery in the Sabine National Wildlife Refuge in Southwestern Louisiana. The spill of 24 to 50 m^3 (150 to 300 barrels) crude oil ran into the adjacent marsh. Salt water spilled together with the oil, spread the oil over about 1.5 Ha (3.5 acres) of dense marsh. A burn was started on the first day. A survey indicated that most of the oil had been successfully removed from the marsh. The removal of the residue, however, proved to be difficult and took several days to accomplish using sorbents and nets. Soil samples were taken in unaffected and burn areas to assess them for metal content. Analysis of the soil samples for cadmium, chromium, copper, lead, manganese, nickel, vanadium, and zinc showed that the metal contents were relatively the same in the area under the burn and nearby. This indicated that burning, at least in this particular case, did not increase the soil metal content for those metals noted. The burn did show, however, that removal of residue is difficult and requires significant time.

X1.1.5 *Use of In Situ Burning at a Diesel Spill in Wetlands and Salt Flats, Northern Utah, U.S.A: Remediation Operations and 1.5 Years of Post-Burn Monitoring:*
(Ref (**12**))—On 21 January 2000, a release of an estimated

16 m^3 (100 barrels) of diesel occurred from a product transportation pipeline north of Great Salt Lake in Utah. Because of weather (freeze/thaw periods and wind), the product spread over 15 Ha of salt flat and wetlands during the next few days. Initial oil containment efforts were successful in reducing the risk of oil impacts in a nearby national migratory bird refuge. However, the risk remained to migratory waterfowl that were expected to arrive at the impacted wetland within approximately 6 weeks. As a result, in situ burning was proposed to remove the free-phase diesel and destroy the oiled vegetation. Upon approval of a site remediation plan and fire management plan, a Heli-Torch was used on 10 March, 2000 to initiate a burn of the most-highly impacted 5 Ha. The following month (late-April), 1.3 Ha of remaining lightly oiled vegetation were burned using drip torches and propane wands for ignition. It was estimated that 75 to 80 % of the spilled diesel was burned in these operations. Because burning of the oil and impacted vegetation would not remove Diesel that had penetrated into the soils, bioremediation techniques were subsequently implemented to further reduce hydrocarbon levels in the soil and attain the regulatory cleanup target of 20 mg/kg total polycyclic aromatic hydrocarbons.

X1.1.6 *Mosquito Bay:* (Ref (**10, 13**))—On April 5, 2001, 160 m^3 (1000 bbl) condensate spilled in Mosquito Bay, Louisiana in a remote coastal marsh. The oil spill resulted from the failure of a 20-in. pipeline. The spill oiled a total of 15 Ha with heavy oil covering approximately 5 ha. The brackish tidal marsh included *Distichlis spicata* (salt grass), *Spartina alternaflora* (cord grass), and *Spartina pattens* (wire grass). The oil penetrated burrows and root cavities during the low tide. Pre-burn surveys and photo documentation were conducted. The oil was burned on April 12 and 13, approximately 7 to 8 days after the spill occurred. Varying daily wind speeds and tidal changes contributed to the challenge of this response. After the burn, >40 ha. were burned which was nearly 3 times the oiled area. Burning was effective in removing surface oil, but not subsurface oil. Vegetation died in areas of heavy oiling, but recovery occurred in light and unoiled areas.

X1.1.7 *Tank Spill Resulting from a Hurricane:* (Ref (**14, 15, 16**))—On August 29, 2005. Hurricane Katrina made landfall near Buras, Louisiana and caused an oil storage tank to rupture, spilling about 600 m^3 (95 barrels) of Louisiana Sweet Crude. Most of the oil migrated to the retention pond at the facility. During Hurricane Rita (September 24), approximately 16 to 40 m^3 of oil were released into the adjacent marsh environment. A portion of the marsh was heavily oiled or moderately oiled (ca. 2 Ha and 6 Ha., respectively). A total of 15.5 Ha of marsh were covered by the oil. On October 12 to 13, a burn was initiated and covered 7.9 Ha of the marsh. Test plots were sampled 9 months and one year after the burn. Re-growth from heavily and moderately-oiled plots (28 plots) were compared to two non-oiled and non-burned or reference plots. The plots were monitored for aboveground biomass, plant height, and stem density. Total aboveground biomass, live biomass, and dead biomass in the oil and burned zones were not significantly different than those in the reference areas after one year. Stem heights also showed recovery within one year and the number of stems of the dominant plant, *Scirpus*, in the oil and burned areas was equal to, or greater than, that in the reference areas. Complete recovery of the aboveground vegetation occurred within one year after the burn.

REFERENCES

(1) Michel, J., Nixon, Z., and Hinkeldey, H., Use of In Situ Burning as an Oil Spill Response Tool: Follow-up of Four Case Studies, *2003 International Oil Spill Conference Proceedings*, American Petroleum Institute, Washington, D.C., 2003.

(2) Bryner, N. P., Walton, W. D., Twiley, W.H., and Roadarmel, G., In-situ Burning in the Marshland Environment – Soil Temperatures Resulting from Crude Oil and Diesel Fuel Burns, *Proceedings of the 24th AMOP Technical Seminar*, Environment Canada, Ottawa, Ontario, 2001, pp. 729–753.

(3) Bryner, N. P., Walton, W. D., DeLauter L.A. and Twiley, W.H., In-situ Burning in the Marshland Environment – Soil Temperatures, *Proceedings of the 23th AMOP Technical Seminar*, June 14-16, Vancouver, BC, Environment Canada, Ottawa, Ontario, 2000, pp. 823–846.

(4) Michel, J., Scholz, D., Warren, S. R. and Walker, A.H., In-Situ Burning– A Decision Maker's Guide to In-Situ Burning, *American Petroleum Institute, Regulatory Analysis and Scientific Affairs, Publication Number 4750*, 2005.

(5) Hyde, L. J., Withers, K., and Tunnell, Jr., J.W., Coastal High Marsh Oil Spill Clean-up by Burning: Five-Year Evaluation, *Proceedings of the 1999 International Oil Spill Conference*, American Petroleum Institute, Washington, D.C., 1999, pp. 1257–12607.

(6) Hess, T. J., Byron, I., Finley, H.W., and Henry, C.H., The Rockefeller Refuge Oil Spill: A Team Approach to Incident Response, *Proceedings of the 1997 International Oil Spill Conference*, American Petroleum Institute, Washington, D.C., 1997, pp. 817–821.

(7) Pahl, J.W., and Mendelson, I.A., The Application of In-situ Burning to a Louisiana Coastal Marsh Following a Hydrocarbon Product Spill: Preliminary Assessment of Site Recovery, *Proceedings of the 1997 International Oil Spill Conference*, American Petroleum Institute, Washington, D.C., 1997, pp. 823–828.

(8) Pahl, J.W., and Mendelson, I.A., Recovery of a Louisiana Coastal Marsh Three Years After In-situ Burning of a Hydrocarbon Product Spill, *Proceedings of the 1999 International Oil Spill Conference*, American Petroleum Institute, Washington, D.C., 1999, pp. 1279–1282.

(9) Dahlin, J., Zengel, S., Headley, C. and Michel, J., Compilation and Review of Data on the Environmental Effect of In Situ Burning of Inland and Upland Oil Spills, *American Petroleum Institute, Health and Environmental Sciences Department, Publication Number 4684*, 1999.

(10) Michel, J., Inland In-Situ Burning Case Histories: Upland and Wetlands, *EPA Freshwater Spills Symposium Proceedings*, 2002.

(11) Sneddon, J., Hardaway, C., Bobbadi, K.K., Beck, J.N., "A Study of Crude Oil Site for Selected Metal Contamination Remediated by a Controlled Burning in Southwest Louisiana", *Microchemical Journal*, Vol82, No. 1, 2006, pp. 8-16 .

(12) Allen, A. et al., Use of In Situ Burning at a Diesel Spill in Wetlands and Salt Flats, Northern Utah, U.S.A: Remediation Operations and 1.5 Years of Post-Burn Monitoring, *2005 International Oil Spill Conference Proceedings*, American Petroleum Institute, Washington, D.C., 2003.

(13) Henry, C., Thumm, S., Cuty, P., Brolin, J. and Michel, J., Application of In Situ Burning During the Mosquito Bay Spill: Observations and Trade-Off Discussions, *2005 International Oil Spill Conference Proceedings*, American Petroleum Institute, Washington, D.C., 2003.

(14) Baustian, J.J., Mendelssohn, I.A., Lin, Q., Rapp, J., and Myers, J., "Year-one Recovery of an Intermediate Marsh in South Louisiana after an In-situ Burn for Oil Spill Remediation," in *Proceedings of the Thirtieth Arctic and Marine Oil Spill Program Technical Seminar*, Environment Canada, Ottawa, Ontario, 2007, pp. 851–876.

(15) Merten, A., Cooperative Efforts to Use In Situ Burning in Empire, LA, in an Intermediate Marsh Following Hurricane Katrina and Rita, *EPA Freshwater Spills Symposium Proceedings*, 2006 .

(16) Baustian, J., Mendelssohn, I., Lin, Q., Rapp, J. "In situ burning restores the ecological function and structure of an oil-impacted coastal marsh" *Environmental Management*, 46 (5), 2010, pp. 781-789.

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