# FIELD EXPERIENCE WITH CONTROLLED BURNING OF INLAND OIL SPILLS

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**ABSTRACT:** *Marathon Pipe Line Company (MPL) uses controlled burning as a means to clean up small oil spills and their residues in its gathering systems in oil-producing areas of southern Illinois. Controlled burning can be a quick, effective, and environmentally sound method of remediating small inland oil spills in rural areas. This paper focuses on actual field decision making and experience with controlled burning. MPL's evaluation process in deciding to conduct burning of a spill is discussed in detail. Such factors as the volume of oil released, the surrounding terrain, current and predicted weather, the accessibility of the oil, public health and safety, and proper permission to burn are considered. The decision to burn must be made within a few days of the spill because the light components of the crude oil rapidly volatilize, making the oil much less flammable and less likely to burn completely. When the decision is made to burn, additional control factors must be considered during the conduct of the burn, such as safe burn initiation, use of firebreaks and other fire control methods, burn direction versus wind direction, generation of airborne embers, and site security. Finally, postburn evaluation is discussed. Case studies of actual MPL-conducted burns and postburn analytical data of the burned areas are presented and compared to current Illinois cleanup criteria. The data indicate that controlled burning followed by surface bioremediation can quickly and successfully remediate small crude oil spill sites to Illinois cleanup standards.*

## Background

Marathon Pipe Line Company (MPL) operates crude oil–gathering pipelines in southern Illinois. Gathering pipelines are used to collect produced crude from production tank batteries and direct it to larger storage facilities and trunk lines for shipment to refineries. Gathering lines are typically small-diameter (2″- to 6″-diameter), low-volume, low-pressure lines; some are even operated under a vacuum. Small oil spills of 1 to 40 barrels (bbl) (1 barrel = 42 gallons) from gathering lines are typically caused by either internal or external corrosion or third-party damage to the pipelines. These oil spills are usually in rural areas and may impact cultivated fields, isolated roadside and farm ditches, and small sloughs, streams, and marshy areas.

Typically, the cleanup of these small spills is initiated by recovering all free product with vacuum trucks and sorbent materials. The affected soil is then limed, fertilized, and tilled periodically to allow for natural bioremediation of the remaining traces of oil. Recovery of free product and bioremediation of affected soil constitute MPL's preferred method of cleanup of small oil spills. In inaccessible, wet, or stubble/brushy areas, recovery and bioremediation may be impractical. In these cases, the unrecoverable oil may be burned if conditions are favorable. Six factors will influence the decision to burn.

## Factors influencing the decision to conduct burning

The *volume of oil released* is an important factor in the decision to burn. Small volumes of oil (between 1 and 5 bbl) are easier to control. Larger volumes of oil may burn more completely but usually are harder to control.

The type and moisture content of the *surrounding terrain* are very important and will have a bearing on all the other factors to a greater or lesser degree. The location of the oil relative to the surrounding vegetation must be evaluated to determine if the burn can be conducted safely in a controlled manner. An oil spill under very dry conditions in a flat area surrounded by grassy fields, for example, would be a less likely burn candidate than a spill contained in a slough surrounded by wet vegetation after a heavy rain.

Predicted *weather conditions* are critical. The wind speed should not be greater than 1 to 3 mph if the surrounding area is dry, or the fire will be difficult to control. If the surrounding area is wet, then a somewhat greater wind speed can be tolerated. It is important to remember that the stronger the wind, the farther the smoke will be carried along the ground. Wind speed and direction must not carry the smoke to nearby residences or obscure visibility on roads. Burning should not be initiated if storms are predicted during the anticipated burn time, not only because there will be rain but also because of unpredictable wind speed and direction and the lightning that may occur. However, if storms are predicted for the evening or next morning after an oil spill, a burn may be highly advantageous in removing oil quickly in advance of the storm and preventing possible runoff.

*Accessibility* of the released oil is another important element. If the released oil and contaminated soil are accessible to conventional oil removal equipment, such as vacuum trucks or all-terrain equipment, then it is preferable to recover the oil by conventional means. If the oil is in an inaccessible location such as a marsh, heavily overgrown creek bed, or wet corn stubble field, all oil possible may be removed by vacuum truck, and then the inaccessible remainder may be burned. Oil trapped under ice

in small streams is a good candidate for burning if holes can be knocked in the ice and the oil ignited; the burning oil will melt the remainder of the ice and free trapped oil that would otherwise be inaccessible.

*Public health and safety* is a major factor in the decision to burn. Oil located in a remote location is the best candidate for a burn because there is minimal disruption to the public. Oil spills in populated or industrial areas should not be burned without careful evaluation, because the chance of accidental damage to property or concern by local residents is greatly increased. Although offshore studies have indicated that emissions from in-situ crude oil burns are below health criteria levels at relatively close distances (Fingas *et al*., 1995), a potential burn should be evaluated carefully if people could be exposed to the smoke at very close range. A release site should usually not be burned near a home or town where the smoke could cause a health concern, or where the smoke could obstruct visibility on a nearby roadway. Burns should not be conducted in the immediate vicinity of any aboveground piping, tanks, or any other equipment that could be damaged. Additional public health and safety considerations are discussed in the following section.

*Permission* to burn must be obtained from the property owner and the appropriate state environmental agency. This may be oral or written depending on the state, and a follow-up report may be required. In Illinois the Illinois Environmental Protection Agency may orally grant permission to burn after an initial report of a release is made. A follow-up report is also required. Local ordinances may also regulate burning, and various local governmental bodies may need to be consulted prior to a controlled burn.

## Public health and safety

As stated previously, protection of public health and safety is of paramount importance during a controlled burn. Both the handling of the burn and the public's perception of the handling of the burn are important. In addition to the protection of the public from smoke or uncontrolled fire, two other factors should be considered.

First, local fire departments and law enforcement officials should always be notified prior to the burn. They should be given the exact location and expected time and duration of the burn. The reason for this is twofold: first, the responders may respond to a planned burn as a potential emergency if they are unaware that it is a controlled burn; second, if any problems would develop with the burn, the responders may be able to respond more effectively if they are aware of the burn in advance. Local emergency responders can be requested to provide standby fire control at a burn site, but this should only be requested if absolutely necessary. Many rural volunteer fire departments have scarce resources to provide extensive standby fire control.

Second, the entity conducting the burn must be able to provide appropriate site security and prevent public access to the burn site. Large fires may bring out several "gawkers," some of which may be traveling across fields in all-terrain vehicles. Sufficient personnel must be on hand to patrol the site on all accessible sides. The blockage of any public roads must be coordinated with local law enforcement officials in advance.

## Environmental damage concerns and evaluation

Prior to conducting a controlled burn, the area should be evaluated for possible sensitive habitats or other potential environmental concerns. Cleanup alternatives should always be reviewed to use the least damaging alternative. Although it has been demonstrated that burning can be a very effective method of cleanup and that damaged vegetation can recover quickly (Mendelssohn *et al,* 1995) burning is not suitable in all cases.

Most gathering field oil spills are in oil production or agricultural areas without significant sensitive or wildlife habitat. Streams and waterways typically have been previously affected by agricultural runoff (sediment load and agricultural chemicals).

A controlled burn will effectively remove residual and trace amounts of oil that are very difficult to remove by other means. In contrast, more long-term vegetation damage has been observed from mechanical recovery methods due to vehicles, heavy equipment, people, dragging of hoses, and so on. Mechanical equipment moving through an oil spill area may incorporate the oil into mud, vegetation, and debris, making it very difficult to remove, whereas burning will quickly remove the oil from the ground surface without causing any incorporation.

It has been noted that trees may be killed by sustained burning. This may be unavoidable. If oil is to be burned in a tree-lined creek, it is advisable to try to move any accumulations downstream to an open area prior to burning or to wet the surrounding area with water first.

## Timing of the burn

As spilled crude oil is exposed to the atmosphere, the lighter fractions will begin to evaporate. The warmer the ambient temperature, the faster evaporation occurs. As the light ends evaporate, the oil will be more difficult to ignite and the burn will be more difficult to sustain and less likely to be complete. Thus the decision to burn typically must be made quickly, within 24 hours of the release if possible. The type of crude spilled (light versus heavy) will be a factor because the lighter crudes ignite much more readily but evaporate faster. In subzero temperatures, the oil will evaporate much more slowly and may be readily ignited even after 2 or 3 days have passed, especially if it is a light crude.

Forecasted weather is important to the timing of the burn. A burn should be completed before any predicted weather change. Fronts and storms are usually accompanied by strong and shifting winds, and controlled burns should normally not be conducted in weather of this type.

Most states require that burning be conducted during daylight hours only. At night, winds decrease, the air becomes more humid, and dense smoke can accumulate in the burn area. Personnel safety is obviously a concern as well. Thus a controlled burn should normally be initiated early in the day so it will extinguish itself before nightfall.

## Conduct and control of the burn

Once all the required factors have been considered and permission secured, the burn can be initiated. Prior to ignition, the entire affected area should be surveyed. Any areas identified where the burn may spread beyond the oil should be wetted down, or a firebreak dug or tilled. Personnel may attempt to move floating oil on water into open areas where trees and brush are less likely to ignite from the burning oil.

The characteristics of crude oil vary greatly. Spilled light crude may ignite readily from any ignition source, but if it is a heavy or weathered crude, ignition may not occur easily. If the crude cannot be lit, a small amount of a more flammable substance such as kerosene may be very carefully poured onto the edge of the crude oil and lighted. Prior to ignition, the container of ignitable material should be removed to a safe distance. The oil may be then be ignited with a long-handled propane torch or a flare. An area of the oil where it is relatively thin and isolated, such as a finger of oil going up a ditch, should be ignited first and allowed to spread. Attempting to directly ignite a large pool of oil is very dangerous and should not be attempted without careful evaluation.

The oil should be ignited on the downwind side and allowed to burn upwind. The burn will be much slower, more complete, and more easily controllable. In streams with very little current the wind can actually blow the oil upstream to the fire. This holds the burn to a smaller area. A burn should not be initiated on the upwind side of the oil and allowed to burn downwind on land or water, because it may spread very quickly and cover a larger area than is readily controllable.

Enough personnel must be available to patrol the burn area on all sides. They should wear flame-retardant clothing, hard hats, safety glasses, and sturdy leather footwear. They should be equipped with hand implements and possibly water spray jugs to extinguish any burning vegetation, embers, and other material that may spread beyond the desired burn area. Hand-held radios should be used if at all possible for communication among personnel.

## Postburn cleanup and evaluation

When the burn is complete, the entire area must again be patrolled very carefully for signs of any hot spots that might flare up or ignite vegetation. These areas must systematically be sprayed with water, covered with soil, or otherwise completely extinguished. The entire area must also be checked for any residual unburned oil or other burn residues.

Any unburned crude oil must be removed or reignited. Any partially burned oil or oily debris, such as leaves along stream banks, must be removed. Heavier crude oils may leave behind a cohesive tarry residue after burning, which should be removed and disposed of properly.

Burned soil will frequently form a crust that retards revegetation. Accessible burned areas of soil should be fertilized and tilled within a few weeks of the burn. This will break up the crust, aerate the soil, and promote rapid revegetation. Erosion problems may also develop after a burn. Vegetation mats or other standard erosion control measures should be employed.

The burned area must be checked periodically during the recovery process to ensure that revegetation is occurring properly. Additional erosion control, debris removal, fertilization, or tilling may be necessary.

## Case studies

Sampling has been conducted by MPL at some controlled burn sites in Illinois to verify soil and water cleanup to state standards (Illinois Environmental Protection Agency, 1996). The Illinois Tier I Soil Cleanup Objectives for Residential Properties Migration to Class I Groundwater Route Values (the most restrictive Illinois standards) are as follows: benzene 0.02 mg/kg, ethylbenzene 5.0 mg/kg, toluene 5.0 mg/kg, and total xylene 74 mg/kg.

Following is a brief synopsis of data obtained from some representative controlled burn sites in southern Illinois that have been sampled and that meet Illinois Tier I Cleanup Objectives. Data were obtained primarily to verify that representative soil at the site had met state cleanup standards; thus the sampling and analysis protocols are not of the same magnitude and rigor as that of a formal research study. Total petroleum hydrocarbon-diesel range organics (TPH-DRO) have no standard cleanup level in Illinois; TPH-DRO data are presented as a general indicator of petroleum hydrocarbon level. In all cases the oil released was Illinois basin crude.

**Release site #1 (Figure 1).** This was a release of 10 bbl of crude oil in a production lease road in a corn stubble field on April 6, 1995. A 2000-square-foot area of ground surface was affected. Approximately 9.5 bbl of the oil were recovered by vacuum truck. The remaining 0.5 bbl coated the ground surface and was trapped in ruts, weeds, and corn stubble. This area was burned the same day, then later fertilized and tilled. Soil sampling was performed on May 26, 1995. Sample results of two areas of the cornfield and the center of the lease road met Illinois Tier I Soil Cleanup Objectives for benzene, toluene, ethylbenzene, and xylene (commonly known as BTEX). Total petroleum hydrocarbon-diesel range organics (TPH-DRO) ranged from less than 20 ppm to 342 ppm.

**Release site #2 (Figure 2).** On April 4, 1995, a release of 5 bbl of crude oil occurred in a slough area containing standing water. An area of the slough of approximately 3300 square feet was affected. Approximately 2 bbl of the oil were recovered by vacuum truck and absorbents; 3 bbl were inaccessible. Two controlled burns were conducted on April 5 and April 7, 1995, to remove the remaining 3 bbl of oil. After the burn, water was pumped out of the slough and small traces of crude oil that continued to seep into the slough were picked up with absorbents and peat moss. The slough area was fertilized, limed, and tilled. The site was sampled on August 23, 1996. Six samples were obtained from various areas of the slough and slough bank. All six samples met Illinois Tier I Soil Cleanup Objectives for BTEX. TPH-DRO ranged from 742 ppm to 7178 ppm.

**Release site #3 (Figure 3).** One-half bbl of crude oil was released in a field of corn stubble and stalks on March 25, 1994, covering an area of approximately 300 square feet. The site was burned the same day. After the burn, the area was tilled and normal farming activity resumed. The site was sampled on August 23, 1996. Five soil samples were obtained from the affected area. All five samples met Illinois Tier I Soil Cleanup Objectives for BTEX. TPH-DRO ranged from less than 20 ppm to 2083 ppm.

**Release site #4 (Figure 4).** A release of 3 bbl of crude oil occurred on January 14, 1995 in a wet and muddy bean stubble field. The oil affected an area of 3750 square feet in the bean field and an additional 10,560 square feet in small adjacent drainage ditches. The oil in the ditches was recovered with a vacuum truck and sorbents. The oil in the bean field, approximately 2 bbl, was burned on the same day. Normal cultivation was resumed in the spring. The site was sampled on August 23, 1996. Three soil samples were obtained in the bean field and one soil sample in the adjacent ditch. All four samples met Illinois Tier I Soil Cleanup Objectives for BTEX. TPH-DRO ranged from 28 ppm to 1011 ppm.

**Release site #5 (Figure 5).** A 1-bbl release of crude oil occurred January 4, 1993 in a partially flooded corn stubble field during heavy

Figure 1. Revegetated release site #1, 16 months after burning (08/13/96)

Figure 2. Revegetated release site #2, 16 months after burning (08/12/96)

Figure 3. Revegetated release site #3, 28 months after burning (08/13/96)

rain. The oil was partially floating on standing water in the field, and partially mixed with mud and corn stalks. An area of approximately 33,000 square feet was affected by a thin film of oil. The oil was burned the same day. In the spring, the area was limed and tilled. Normal cultivation was resumed. Five soil samples were obtained from the affected area on August 23, 1996. All five samples met Illinois Tier I Soil Cleanup Objectives for BTEX. TPH-DRO ranged from 21 ppm to 275 ppm.

**Release site #6 (Figure 6).** A release of 5 bbl of crude oil occurred in a wet, muddy bean stubble field January 12, 1995. The oil affected an area of 750 square feet in the bean field and 1500 square feet in a small field ditch. Approximately 2 bbl of oil were recovered by vac-

Figure 4. Revegetated release site #4, 19 months after burning (08/13/96)

Figure 5. Revegetated release site #5, 43 months after burning (08/13/96)

uum truck. The remainder of the oil was trapped in bean stubble and dense grass in the ditch. Heavy rains were forecasted for the area. The remainder of the oil was burned the same day. The area was then tilled. Three composite soil samples were obtained on July 21, 1995. All three samples met Illinois Tier I Soil Cleanup Objectives for BTEX. TPH-DRO ranged from 157 ppm to 740 ppm.

## Conclusion

Controlled burning of small inland oil spills in rural areas can be a safe, environmentally sound, and effective cleanup method. Each oil spill site must be evaluated on an individual basis. Six basic factors influence the decision to conduct a controlled burn; the factors are vol-

Figure 6. Revegetated release site #6, 19 months after burning (08/12/96)

ume of oil released, surrounding terrain, weather conditions, accessibility of the oil, public health and safety, and proper permission. If all factors have been evaluated and appear favorable, in most cases the oil can be burned safely and effectively if proper procedures are followed. After burning and proper remedial treatment of the burned area, revegetation normally will occur. The burned area should meet Illinois Tier I cleanup standards after sufficient time is allowed for biodegradation of traces of hydrocarbon constituents.

## Biography

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