

Landfill Fires Guidance Document

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Although no U.S. agency tracks the number of surface and subsurface landfill fires, they are more common than expected.

The disposal of lithium-containing electronics has accelerated the number of fires at transfer stations, trash trucks, and the working face of landfills. Most incidents are minor and typically handled by the operating facility or local emergency responders. Subsurface fires seldom become large-scale environmental responses.

Types of Landfill Fires

The most common types of fires occur at the surface, where fuel and oxygen are abundant. These fires can burn between the surface and two feet below ground. The other type of fires are subsurface fires, extending to 40 feet and beyond.

Surface Landfill Fires

A surface fire can start if the facility accepts waste with potential ignition sources. For example:

- Hot ashes
- Electronics with lithium batteries or
- A discarded cigarette

Arson and wildfires have also started surface fires at landfills.

To keep surface fires small, the operator should take immediate action to suppress the flames. Actions may include:

- Using heavy equipment to move the burning material to a safe area,
- Applying soil to suffocate the fire, or
- Using water with firefighting Class A foam.

If no action is taken, burning trash can generate significant odors and toxic smoke. The toxicity of this smoke depends on the composition of the waste stream—the more plastic, the higher the potential toxicity.

Subsurface Landfill Fires

Subsurface Elevated temperature (SET) events have been documented in:

- Municipal solid waste landfills (MSWLFs),
- Construction demolition debris landfills,
- Industrial waste fills,
- Compost facilities,
- Shredded tire fills,
- Sawdust piles, and
- Sanitary dumps.

SET events need to be quickly evaluated by the operator to prevent a smolder from occurring. Subsurface fires can sometimes go undetected until a sinkhole or smoke appears. Typically, a smolder has no observable flame or smoke unless the waste is excavated and exposed to the atmosphere.

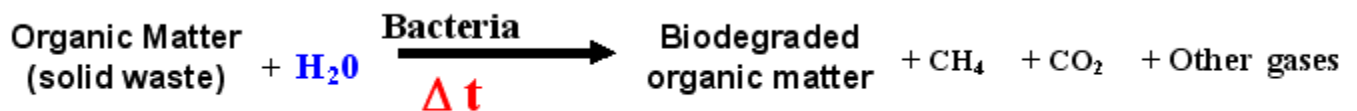
Subsurface fires typically:

- Are detected by elevated or increasing gas temperatures at the wellheads, changes in landfill gas composition, settlement, smoke, or other observable physical expressions.
- Start from overdrawing oxygen through the landfill gas collection system or allowing oxygen to enter the waste cell through erosion and/or settlement fissures in the cover or abandoned piping.

Subsurface fires are more likely to smolder without visible flame or smoke. Smolders are characterized by a unique odor, rising gas temperatures, lower methane (CH₄) concentrations, increased hydrogen (H₂), carbon monoxide (CO), and volatile organic compounds (VOCs) in gas extraction wells. The waste mass tends to oxidize within the influence zone of the extraction well or near a surface feature that allows oxygen to enter the waste mass.

How Spontaneous Combustion Occurs

In waste or compost, spontaneous combustion can occur when the waste is heated by biological decomposition and chemical oxidation. The resulting heat causes waste to reach the autoignition point. This type of rapid oxidation in a municipal, construction/wood waste facility, or compost facility is related to the amount of water in the material. Aerobic and anaerobic bacteria in organic matter require water to break down organic matter biologically. As shown in the equation below, organic material (solid waste) with sufficient moisture content is biodegraded by bacteria, producing heat (Δt) along with CH_4 gas, carbon dioxide (CO_2) gas, as well as other gases, and degraded organic material.



Equation Text Description: In the presence of bacteria, organic matter (solid waste) and water react to produce increased heat (Δt), methane (CH_4) gas and carbon dioxide (CO_2) gas as well as other gases and degraded organic material.

Under these conditions, spontaneous combustion can occur in waste or other materials such as compost, sawdust, or hay. Combustion in solid waste will produce significant amounts of H_2 , carbon monoxide (CO), and other VOCs. The VOCs from smoldering incidents typically include measurable quantities of acetonitrile, acetone, benzene, 2-butanone (MEK), carbon disulfide, and tetrahydrofuran. Other VOCs detected in smoldering incidents include ethyl acetate, toluene, vinyl acetate, and xylene.

Detecting Subsurface Fires

Physical evidence of a smolder includes a sinkhole or depression, smoke, burned/melted infrastructure, or soot in the gas collection system. As temperatures increase within the waste mass, landfill gas quickly changes from predominantly equal parts CH_4 (50-60% v/v) and CO_2 (40-55% v/v) to a mainly CO_2 (60-80% v/v), H_2 (10-30% v/v), and CO (> 1,500 ppmv). The landfill operator experiencing a possible SET event should collect and analyze gas samples for CO , H_2 , and VOCs.

Generally, a subsurface fire can be confirmed by the operator using a combination of factors below:

- Substantial settlement over days or weeks;
- Smoke or smoldering odor emanating from the gas extraction system or the landfill;
- Levels of CO over 1,500 parts per million (ppm);
- CH₄ levels below 15 percent in gas extraction wells;
- H₂ concentrations over 5 percent in gas extraction wells;
- Combustion residue in gas extraction wells of flame arrestors;
- High levels of VOCs in gas extraction wells;
- Increased gas temperatures above 145 Fahrenheit (°F) or 10 to 15 °F increases within two weeks.
- Gas extraction wellhead temperatures over 190 °F; or
- In-situ waste temperatures over 230 °F.

If a subsurface fire expands, one can expect elevated waste and gas temperatures, changes in landfill gas composition, elevated gas and leachate pressures, severe increases in odors and emissions, damage to the landfill gas collection system due to temperatures, increased leachate volume and migration, changes in the chemical makeup of the leachate and gas, slope movement, and rapid and unusual settlement.

Subsurface Fire Investigative Sampling

The operator must acquire analytical results through quantitative laboratory analysis to assess a subsurface fire using landfill gasses, CO, H₂, and VOCs. Most field portable equipment only has qualitative abilities. Portable equipment is susceptible to cross-sensitivity with high temperatures, humidity, and other constituents of landfill gas (for example, volatile organic compounds, hydrogen sulfide, etc.). As a result, landfill gas sampling using portable equipment under these conditions may produce artificially high CO readings or false positive readings.

As specified above, CalRecycle staff considers levels of CO above 1,500 ppm to be a positive indication of an active smolder. Levels of CO between 1,000 and 1,500

ppm are considered suspicious and require further air and temperature monitoring. Levels between 500 and 1,000 ppm may indicate pre- or post-fire conditions, but active combustion is typically absent. CO levels below 500 ppm confirm that the smolder is not present.

The operator should perform additional waste characterization on leachate and condensate from a SET event in areas where temperatures exceed 160°F. Past sampling results of leachate in SET event areas have exceeded the federal hazardous waste criteria for benzene.

Employee Health and Safety Risks

Subsurface landfill fires can create many types of worker health and safety hazards. Landfill operators should communicate these conditions to all site personnel. Site hazards may include slips, trips, falls, confined space issues, CO, hydrogen sulfide (H₂S) and toxic gas exposures, cave-ins due to the void spaces, and burn issues from the elevated temperatures. The operator should implement safety protocols related to subsurface landfill fires for all personnel.

Past CalRecycle SET event investigations have revealed CO levels from 2,500 to 28,000 parts per million (ppm) at the ground surface and benzene levels up to 64 ppm at fissures or 570 ppm directly in landfill gas. Depending on chemical levels and exposure routes, certain gasses may be immediately dangerous to life or health. Site air quality monitoring for toxic and landfill gasses may be necessary.

CalRecycle staff has also recorded temperatures over 450 degrees Fahrenheit within 1 to 3 feet below the ground surface. Although not typical, sinkholes over 20 feet in diameter and 5 feet in depth have occurred during subsurface fires.

Suppression Methods

As with any fire, the reaction stops once one side of the tetrahedron (i.e., heat, fuel, oxygen, and chemical chain reaction) collapses. Landfill fires can be extinguished by smothering with soil, using heavy equipment and a suppressant agent, and/or simply temporarily shutting down the gas extraction system.

Depending on site conditions, a barrier may be necessary to contain the reaction. No one method will work for all conditions, and each suppression plan will be

unique due to site-specific conditions, odor concerns, and impacts on local communities. At times, constructing an additional soil cap or soil/air barrier will prevent the expansion of the reaction. In contrast, at other times, using heavy equipment to excavate the waste and suppress it with water and foam may be necessary.

Interim Cap Recommendations

Based on past experiences with other landfill fires and the thermal properties of plastics (e.g., geosynthetic material), it is not recommended that a geosynthetic material be used over the incident until the subsurface fire is extinguished or a soil buffer layer of at least 24 inches is placed over the waste. It is recommended that the soil layer be constructed of a soil with the following properties:

- A clean, low permeability soil capable of obtaining a permeability of 1×10^{-5} cm/sec with a maximum particle size of three inches or less;
- The soil should be classified as SC, ML, CL, or CH according to the Unified Soil Classification System;
- The soil should be compacted to a minimum of 90 percent of the maximum dry density as determined by ASTM D-1557;
- The cover should extend 100 feet beyond the identified smolder area;
- The cover should be a minimum of 24 inches in depth;
- Soil lifts should not exceed 9 inches before compaction.

Suppression Agents

Although there are many foam and wetting agents, it is best to use a Class A foam or wetting agent. These chemicals include a surfactant that reduces surface tension and improves water penetration depth. Class A Foam and wetting agents work on three-dimensional fires like solid waste. Class B foams are ineffective for waste fires because they are two-dimensional products that create a foam blanket to prevent the release of flammable vapor and separate the fuel from the oxygen it needs to burn.

Water

Applying large amounts of water or “drowning” the smolder is not recommended. Excess water may accelerate the fire potential by increasing the amount of biological activity and heat or increased leachate levels. Past fire responses that have used excessive water flows have caused slope stability issues and contaminated runoff.

Recommendation Actions Summary

If the operator suspects a subsurface fire, the operator should:

- Close landfill gas extraction wells in the impacted area and adjust or tune the surrounding gas wells to prevent oxygen intrusion from exceeding two percent;
- Do not rely on the daily or interim soil cover. Place at least 24 inches of compacted low-hydraulic conductivity soil over the area affected by the SET event or well exhibiting elevated temperatures plus an additional 100 feet beyond the impacted area.
- Be aggressive in initiating and conducting a root cause analysis. The root cause analysis should rule out unknown industrial or reactive wastes, such as aluminum dross or fly ash, as the root cause. The operator should install at least three downhole thermocouple assessment arrays in the SET event area and observe drill tailings for unknown industrial wastes.
- If a wellhead temperature exceeds 160°F, collect downhole well temperatures every ten vertical feet and in any adjacent well with a wellhead temperature above 145°F. Downhole gas well temperatures are more reliable than temperatures measured at the wellhead. Past temperatures at the wellhead versus downhole temperatures have shown a difference of up to 100°F.
- Collect analytical samples for landfill gas extraction wells within the SET event, even below 145°F.
- Plan on increased odors and surface emissions from pressure increases due to temperature increases. As the SET event expands, additional landfill gas extraction wells will be necessary to mitigate pressure and odors. Beware of

encountering leachate geysers while drilling gas wells in areas with a rapidly expanding SET event.

- Do not overdraw the landfill gas collection system and keep O₂ below two percent.
- Expect the polyvinyl chloride (PVC) wells to fail due to high temperatures. Based on the measured high temperatures, different landfill gas well materials (e.g., chlorinated polyvinyl chloride (CPVC) or steel) should be selected for new well casings.
- Expect slope instability and changes in waste shear strength and unit weight as the SET event expands.
- Consider designing and constructing isolation or barrier walls between large waste disposal units or new operational units at critical interfaces.
- Expect accelerated settlement rates in SET event areas.

Who Needs to Be Notified?

If the landfill fire is localized and contained in a small area, the Local Enforcement Agency, appropriate CalRecycle staff, and the local fire department should be notified. Site-specific factors, permit conditions, or other mandates may require the landfill operator or site owner to notify other entities, including the local air quality management district, the United States Environmental Protection Agency, the California Office of Emergency Services, the local hazardous materials program, and neighbors.

Related Links

- [Fires at Solid Waste Facilities](#)
- [Landfill Fires Guidance Document](#)

For more information, contact EngineeringSupport@calrecycle.ca.gov