

Biological treatment involves the use of micro organisms or vegetation (phytoremediation). This measurement is not required, but it is available to resolve regulatory concerns. In addition to fuels, aerobic bioventing has treated a variety of other contaminants, including nonhalogenated solvents, such as benzene, acetone, toluene, and phenol; lightly halogenated solvents, such as 1,2-dichloroethane, dichloromethane, and chloro benzene; and SVOCs, such as some PAHs (Figure 4). The manual contains information on bioventing principles; site characterization; field treatability testing; system design, operation, and installation; site closure; and techniques to demonstrate the extent and mechanism for contaminant removal. Low oxygen levels (less than five percent) are a good indicator that existing bacteria are capable of degrading the contaminants of concern, because soil gas in uncontaminated soil generally exhibits oxygen concentrations similar to ambient air. For sites where non-fuel contaminants are to be treated by bioventing, other factors may be considered in establishing biological a bioventing system has been soil gas monitoring to ensure that the site is well oxygenated, in situ respiration testing to monitor the progress of remediation, and operation and maintenance of the bioventing system. Bioventing involves supplying oxygen to contaminated unsaturated soils with low oxygen concentrations to facilitate aerobic microbial biodegradation. For example, laboratory and pilot-scale studies may be needed to evaluate effectiveness, design the bioventing system, estimate treatment times, and demonstrate that biodegradation is the primary mechanism of removal. The injection system should be designed considering soil gas permeability, contaminant diffusion and distribution, and environmental factors, such as moisture content, pH, temperature, and electron acceptor conditions. Performance monitoring, after and amount of contaminant removed, oxygen supply, and carbon dioxide generation, as well as mass balances relating the three amounts, may be useful in establishing bioremediation as the primary mechanism of removal. Many naturally occurring microorganisms (typically, bacteria and fungi) can transform hazardous chemicals to substances that may be less hazardous than the original compounds. When building foundations or similar structures are close to the site, vacuum extraction wells, which draw air through the subsurface, may be used to avoid the buildup of contaminated, and possibly explosive, vapors in the building basements. Microbial bioremediation occurs under both aerobic and anaerobic conditions and at contaminated sites as either intrinsic and/or enhanced biodegradation. Typically, the environment is manipulated by supplying amendments, such as air, organic substrates, nutrients, and other compounds, whose absence limit 15 treatment. A soil gas survey can provide useful information, especially at sites with relatively shallow contamination (depths typically less than 20 ft). In addition, the soil gas survey can be useful in delineating the extent of contamination and identifying locations for vent wells and monitoring points. Microorganisms also have been used to alter the valence of some hazardous metals (e.g., Cr(VI)), thereby making them less hazardous and less mobile. Several plant species have the ability to bioaccumulate heavy metals found in the soil, and some tree species can sequester, destroy, and/or evapotranspire various organic compounds. The U.S. Air Force Bioventing Initiative and the U.S. EPA Bioremediation Field Initiative evaluated bioventing at 125 sites contaminated by petroleum hydrocarbons. At sites using extractive bioventing, the degree of volatilization versus biodegradation may be determined by measuring offgas concentrations. Finally, measurement of stable isotope ratios may be

useful in qualitatively validating biodegradation as the mechanism of contaminant removal. Monitored natural attenuation (MNA) often relies on intrinsic bioremediation as an important removal mechanism. Bioventing is typically operated in air injection mode to alleviate low oxygen levels in the subsurface.