Mitigation of Petroleum Vapor Intrusion Using Low-Flow Air Injection

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Background/Objectives. Migration of volatile constituents from contaminated soil and groundwater into overlying structures, referred to as vapor intrusion, has proven to be a human health risk driver. In some cases, remediation of contaminated soil and groundwater can take years or decades to complete, making it necessary to install mitigation measures to prevent vapor migration and protect human health within overlying structures. One of the most common mitigation techniques is sub-slab depressurization, which involves extracting soil vapor from beneath a structure and venting it to the atmosphere, creating a negative pressure differential across the slab and preventing vapor intrusion into a structure. However, in some instances, operation of a sub-slab depressurization system can draw contaminated vapors from deeper portions of the subsurface directly beneath a building slab. If the sub-slab depressurization system is shutdown, or if there is an upward advective gradient, these vapors can then enter the structure, creating a greater risk to human health than was present prior to installation of the mitigation system. In addition, at sites impacted by petroleum hydrocarbons, it is well understood that aerobic biodegradation has the potential to reduce volatile petroleum hydrocarbon concentrations by several orders of magnitude, as long as the supply of oxygen is not rate limited (DeVaull et al., 1997; Roggemans et al., 2001; Abreu et al., 2009; Michalski et al., 2012). Therefore, to enhance aerobic biodegradation and prevent vapor migration (as observed during operation of sub-slab depressurization systems), a unique low-flow air injection technique was designed and tested within a residential structure where an acute inhalation risk was present due to vapor intrusion of volatile petroleum hydrocarbons.

Approach/Activities. Injection of ambient air had been previously tested beneath a large commercial building on a former refinery resulting in an increase in oxygen concentrations and enhanced aerobic biodegradation directly beneath the building slab (Luo et al. 2013). Ambient air was introduced beneath the commercial building through a large diameter horizontal well. During the current study, ambient air was injected directly beneath the residential structure at flow rates less than 0.5 liter per minute through 0.5-inch diameter by 6-inch long stainless steel sub-slab probes. The probes were installed on 12-foot centers and connected to a pump via a simple manifold and ¼-inch thick walled flexible tubing. Separate sub-slab probes installed on 12-foot centers were used to monitor oxygen and volatile petroleum hydrocarbon concentrations during injection of ambient air. Indoor air concentrations were also screened routinely to confirm the effectiveness of the mitigation technique.

Results/Lessons Learned. Injection of ambient air at low-flow rates resulted in an increase in oxygen and decrease in petroleum hydrocarbon concentrations across the residential building slab. The concentration of total volatile petroleum hydrocarbons in indoor air also decreased resulting in mitigation of the vapor intrusion pathway. Within one day of startup of the low-flow injection system, the average oxygen concentration increased from 4.6% to 12.1%. The corresponding average total volatile petroleum hydrocarbon concentration decreased from more than 120,000 parts per million by volume (ppmv) to less than 7,100 ppmv. Within one week the average oxygen concentration increased to 19.2% and the average total volatile petroleum hydrocarbon concentration decreased below 100 ppmv. The concentration of total volatile petroleum hydrocarbons in indoor air were reduced below the acute screening level within three days of startup of the low-flow air injection system.