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New Tools for Evaluating Sub-Slab Depressurization Systems and Identification of Alternative Vapor Intrusion Pathway

Darius Mali (dmali@geosyntec.com), Todd McAlary (tmcalary@geosyntec.com) and Paul Nicholson (Geosyntec Consultants, Guelph, ON, Canada)
William Wertz (Geosyntec Consultants, Albany, NY, USA)

Background/Objectives. Preferential pathways have been shown to play a dominant role in trichloroethene (TCE) vapor transport into the “Sun Devil Manor” residential vapor intrusion research building (Guo 2015). The residence is owned by Arizona State University (ASU), located near Hill Air Force Base in Layton, Utah. The pathway has been identified as a land drain connecting the drainage area around the house to the sewer. The objective of this study was to demonstrate and validate newly developed tools for that could help identify the presence of a significant preferential pathway and provide an optimal sub-slab depressurization (SSD) system design for scenarios with or without a preferential pathway.

Approach/Activities. ASU installed a valve that allows the land drain to be opened or closed, so all tests were performed under both conditions to provide data that can be compared and contrasted. Transient pneumatic (flow and vacuum) tests were performed by connecting pressure transducers to several sub-slab and deeper soil gas probes and cycling the existing radon-style mitigation system on and off. This is comparable to a groundwater pumping test, and the data were analyzed using the Hantush-Jacob Leaky Aquifer Model to calculate the transmissivity of the subsurface materials and the leakance of the floor slab. Step-tests were performed by adjusting the flow to several different rates and after allowing sufficient time for the removal of several pore-volumes of the granular fill below the floor, samples of extracted gas were collected for analysis of TCE and radon concentrations. The mass removal rate was compared to previous testing performed by ASU where the house was depressurized and the mass discharge through the house was characterized for both TCE and radon with the land drain open and closed. Two types of helium tracer tests (an inter-well test and a helium flood) were performed to measure the travel time between several of the sub-slab probes and the vent pipe. Sulfur hexafluoride was released to the indoor air and monitored in both indoor air and the vent pipe to characterize the percentage of indoor air captured by the venting system.

Results/Lessons Learned. Transient vacuum measurements and helium tracer test data showed minor differences with the land drain open versus closed. However, the mass removal rates in the step tests show a difference of 2 orders of magnitude between the land drain open and closed conditions. With the land drain closed, a flow rate of about 10 standard cubic feet per minute (scfm) was sufficient to capture the TCE mass flux. The observed concentration of indoor air during the building depressurization test with the land drain was closed was <0.001 g/day. With the land drain open, a flow rate of about 100 scfm was needed to capture the TCE mass flux. The observed concentration of indoor air during the building depressurization test with the land drain was open about 0.1 to 0.3 g/day. The mass removal rate kept increasing with increasing flow rate and did not plateau as was expected, even at flow rates up to about 125 scfm. Travel times below the floor slab were very rapid and the helium tests indicated that most of the flow occurs in the granular fill below the floor slab. About 80% of the flow in the vent pipe was originating from indoor air, regardless of the flow rate in the vent pipe. This research indicates that in buildings with a preferential pathway, traditional SSD systems installed in conformance with ASTM E-2121-13 may not provide effective or efficient mitigation of the vapor intrusion pathway.