In Situ Air Sparging:
How to Avoid Blowing Money in the Ground

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Introduction

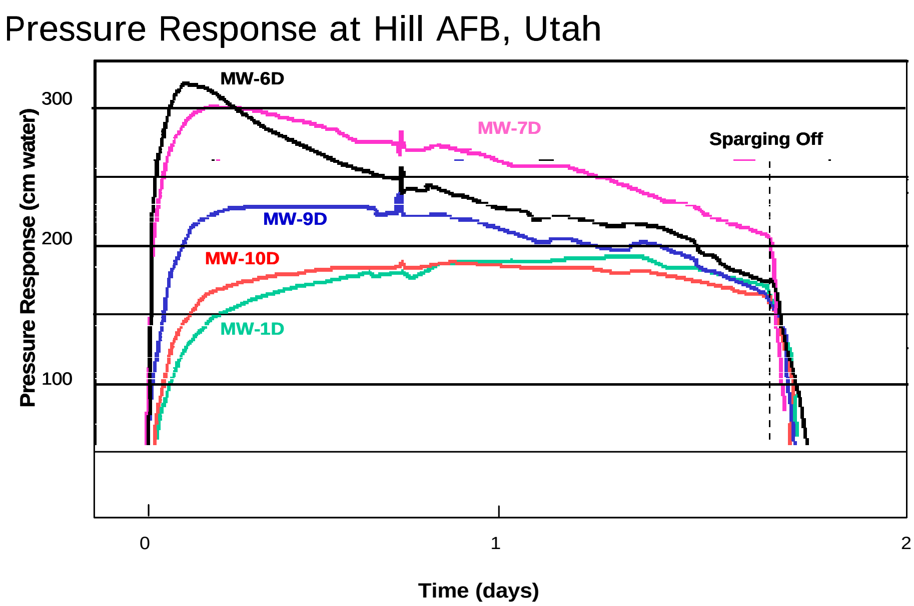
In situ air sparging (IAS) pilot test procedures have been developed that provide rapid, on-site information about IAS performance. The standard pilot test consists of a series of activities designed to look for indicators of infeasibility and to characterize the air distribution to the extent necessary to make design decisions about IAS well placement. In addition, safety hazards that need to be addressed prior to full-scale design are identified. While pilot tests are an important tool for improving our conceptual understanding of IAS behavior, predicting long-term performance based on pilot tests has proved to be difficult. Nevertheless, pilot tests have proven useful as a means of identifying “red flags” prior to installation of full-scale systems.

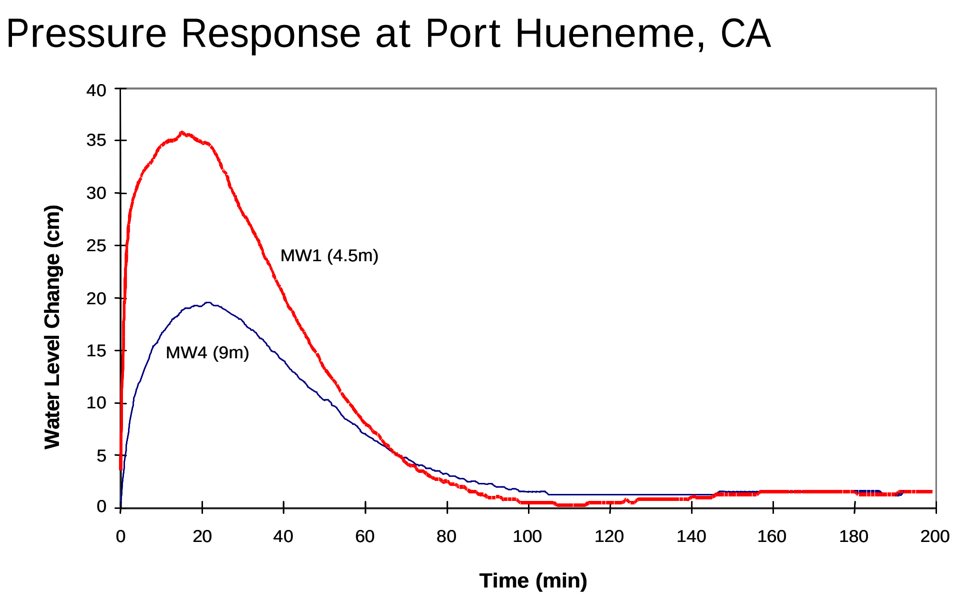
The pilot test activities, developed as parts of SERDP- and ESTCP-funded projects, include both chemical tests (tracking contaminant concentrations, dissolved oxygen and tracers) and physical tests (air flow rate and injection pressure, groundwater pressure response). The specifics of those activities are outlined in the ESTCP IAS protocol (ESTCP, 2003) and a series of manuscripts (Johnson et al., 2001a, 2001b,2001c,2001d, 2001e, Bruce et al 2001, Amerson et al., 2001). While a full discussion of the pilot test activities outlined in these publications is well beyond the scope of the current discussion, two of the pilot test activities are described briefly below. When taken together with preliminary site data, they provide a great deal of insight into IAS performance. They are discussed here because at many sites no or ineffective tests are being conducted, and the hope is that these two simple tests, which can typically be conducted in one day, will improve the diagnosis of IAS performance and prevent misapplication of the technology.

Discussion

The first activity is the measurement of hydrostatic pressure during IAS startup (and shutdown). This is best accomplished using pressure transducers in small-diameter, short-screened wells. As discussed by Johnson et al. (2001d), the duration over which hydrostatic pressure remains elevated is directly related to the tendency for the injected air to become trapped below lower-permeability strata. For highly stratified sites, pressures can remain elevated for days, while in homogeneous sites the pressure can return to near pre-IAS conditions within tens or at most a few hundred minutes. Data from two sites, Hill AFB and Port Hueneme, CA are shown in Figure 1. The Hill AFB site is stratified, with a continuous silt layer in the middle of the aquifer to be sparged. The Port Hueneme site is only mildly stratified. At Hill AFB the pressure increased upon IAS startup and remained elevated for the nearly two-day period of the test. In contrast, pressure at the Port Hueneme site returned to pre-IAS conditions within about 100 minutes of startup. Based on soil core analyses, permeability contrasts at the sand/silt interface at Hill AFB were >40X, while at the Port Hueneme site the permeability contrasts within the aquifer were on the order of 10X or less. Thus the pressure data are consistent with other site information, suggesting a potential “red flag” for Hill AFB and not for Port Hueneme.

Figure 1. Hydrostatic pressure changes during IAS startup at Hill AFB and Port Hueneme, CA





The second of the pilot test activities discussed here is designed to measure the recovery of IAS air when a soil vapor extraction system is present. The approach uses helium as a tracer injected with the IAS air and performs a mass balance on the helium removed with the SVE system. (If an SVE system is not present, air distribution can be estimated by measuring helium just above the water table, as described in Johnson et al, 2001c). Helium recovery data from the Hill AFB and Port Hueneme sites are shown in Figure 2. For the Hill AFB site, only a small fraction of the helium is recovered by the SVE system. As the figure shows, nearly all of the helium (and the corresponding IAS air) short-circuited via monitoring wells and was probably of limited value for sparging. For the Port Hueneme case, essentially all of the helium (and IAS air) was recovered by the SVE system. This is an important "red flag" issue at sites like Port Hueneme, where numerous pathways to human receptors are present in the vicinity of the contamination.

While each of the activities associated with IAS pilot tests provides information about the site, it is really the combination of that data in the context of a realistic conceptual model which provide the most robust assessment of IAS performance. Thus, the IAS protocols are designed to be used as a suite. And, while the pilot tests can not currently predict long-term IAS performance, if used as a suite they do help identify "red flags" to application of IAS at a wide range of sites.

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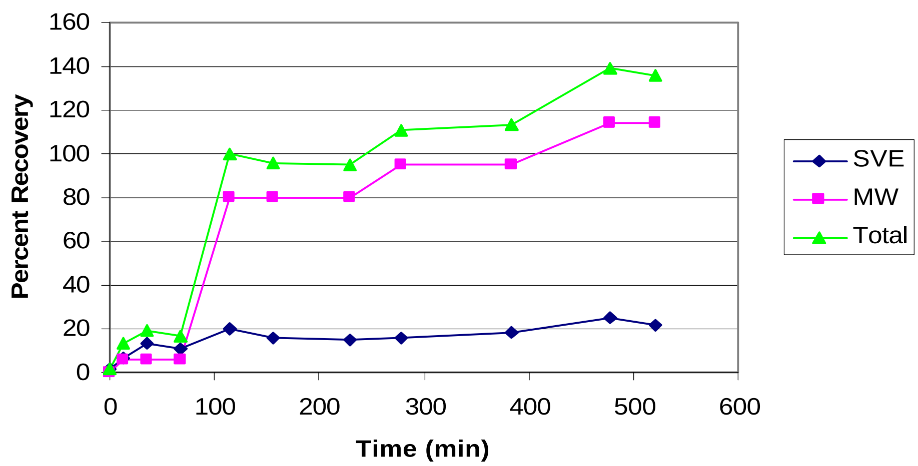
Figure 2. Air recovery using helium tracer tests at Hill AFB and Port Hueneme, CA.

Air Recovery at Hill AFB, Utah



Air Recovery at Port Hueneme, CA