This document references Chapters and Sections from the ITRC Vapor Intrusion Technical and Regulatory Guidance, and Fact Sheets and Technology Information Sheets from the ITRC Vapor Intrusion Toolkit, published January 2026. These resources can be accessed at: **https://itrcweb.org/vapor-intrusion-toolkit**.

HIGH-VOLUME SAMPLING FACT SHEET

High-Volume Soil Vapor Sampling

High-volume soil vapor sampling (HVS) consists of extracting and monitoring a large volume of soil vapor from beneath the floor slab of a building to provide a spatially averaged sub-slab vapor concentration. HVS is typically applied at large buildings (greater than 8,000 square feet). HVS can also be completed on existing soil vapor extraction wells (similar to a soil vapor extraction pilot test) or a groundwater monitoring well with sufficient screened interval above the water table to yield an appreciable air flow. During HVS, slipstream grab samples are collected from the HVS apparatus and screened with field instruments (a photoionization detector [PID] and/or an oxygen [O_2], carbon dioxide [CO_2], and methane [CH_4] meter) to quantify a spatially averaged soil vapor concentration and/or evaluate a mass removal rate. Grab samples may also be collected for laboratory analysis.

HVS testing minimizes the risk of failing to identify areas of elevated vapor-forming chemical (VFC) concentrations that may exist between or beyond discrete sample locations. In large buildings, fewer HVS locations can provide higher confidence assessments compared to traditional sub-slab probe sampling methods. Other advantages of the HVS approach include lower investigation costs and reduced disruption to building operations as fewer sample locations are required than traditional soil-vapor sample investigations with an increase in the characterization of the subsurface concentrations. HVS can be used to demonstrate the absence of VFC sources under areas of large buildings and has the potential ability to estimate source distance from extraction point to identify hot spots.

Combining HVS with pressure field extension testing, tracer testing, and mathematical analysis (McAlary et al. 2010) can be used to quantify the radius from which vapor was extracted during the test, estimate the amount of dilution from downward leakage, and provide detailed design parameters to support an optimal design for a sub-slab mitigation system, if needed. Providing characterization and mitigation system design data in a single mobilization can further reduce costs and disruption to building occupants.

Disadvantages of HVS include understanding the leakage rate across a building floor slab and the uncertainties based on model radial flow path assumptions. HVS can support understanding the potential for inducing flow from preferential flow paths that differ from nominal vapor intrusion (VI) vapor flow path and entry locations by evaluating the pressure field extension testing data. HVS is not appropriate for residential or small commercial buildings.

High-Volume Sampling Setup

Utility Locates and Drilling

Locate and avoid underground utilities in areas for drilling the extraction pipe and communication test points (CTP).

Core a hole for the extraction pipe 2 to 6 inches in diameter (larger diameter holes are preferred when materials below the slab are less permeable.)

Prepare an extraction pipe with length sufficient to extend 1 foot above the slab, with the base of the pipe located at the bottom of the slab (i.e., not pushed into the subsurface soil).

Place a nonvolatile organic compound–emitting gasket (Teflon tape, backer rod) onto the extraction tube 1 inch from the pipe bottom. The intent of the gasket is to seal the extraction pipe to the slab so that the entire sample comes from under the slab.

Slide the extraction pipe carefully into the hole, aligning with the floor slab.

Apparatus Assembly

The apparatus assembly process is described below and depicted in Figure 1.

- Attach a manifold to the extraction pipe. The manifold includes a vacuum gauge, sampling ports (laboratory and slipstream), and a lung box.
- Add an additional sample port if using a passive sampler.
- Connect a straight pipe downstream of the manifold for smooth, laminar flow.
- Use a dilution valve for air control (to minimize fan overheating).
- Plumb piping to extraction fan or shop vac and exhaust outside (filtered if needed).

Figure 1. High-volume sampling apparatus assemblies.

Source: Geosyntec Consultants, 2023, used with permission.

Extraction Fan and Communication Test Points

Extraction fan size varies based on material permeability (up to 3 cubic meters per minute or 100 standard cubic feet per minute).

- A wet/dry vacuum (5–6.5 horsepower) or a high-vacuum radon-style fan is typically used.
- A fan capable of venting flammable gases must be used when concentrations might be near the lower explosive limit.
- Install three or more CTPs (standard soil vapor probes or equivalent) at different radial distances.
- Assess response symmetry and barriers by varying CTP locations.

Sample Collection and Analysis

To begin the HVS test, turn on the fan/vacuum and then gradually adjust the dilution valve or variable-speed controller to set the applied vacuum at a level generally no higher than 40 inches of water. Data should then be collected as described below in the following order:

1. Velocity measurement—Use a thermal anemometer or equivalent to measure velocity in the straight segment of pipe.
2. Laboratory sample—Collect a sample for laboratory analysis to establish concentrations representative of near-field vapors with minimal dilution from leakage across the floor slab.
3. Slipstream screening—Collect a 1-liter air-sampling-bag sample with a vacuum chamber (aka “lung box”) for field screening with a PID (at chlorinated hydrocarbon sites) or flame ionization detector (at petroleum hydrocarbon sites) and a landfill gas meter for O_2, CO_2, and CH_4. Continue to collect and screen periodically until the end of the test, with a goal of acquiring at least five samples.
4. Static vacuum field—Measure static vacuum at least 10 minutes after the start of HVS testing from each of the CTPs using a digital micromanometer to document the profile of vacuum as a function of distance.
5. Second laboratory sample—Near the end of the HVS test, collect a second sample for laboratory analysis to assess whether concentrations of individual VFCs increase, decrease, or stay essentially the same after removal of a large volume of soil vapor.
6. Collect transient vacuum data by cycling the fan on and off, if data are to be used to model potential mitigation system design information (McAlary et al. 2010).

Additional Uses for High-Volume Sampling

Beyond providing a spatial average of sub-slab vapor concentration at large buildings, HVS can be used to assess multiple physical characteristics in support of a VI investigation. The data collected during HVS can be used to support the VI conceptual site model (CSM) and/or obtain design parameters for a potential mitigation system.

Source Delineation

Time series results of the slipstream screening samples collected during HVS testing may be used to help determine the presence, type, and distance of a subsurface source area (**Figure 2**). Stable, low PID detections (or a field gas chromatograph with an appropriate detector for chemical specificity) are consistent with a lack of source area. Stable, moderate to high PID detections are generally consistent with a diffuse groundwater source. Increasing VFC concentrations may indicate a shallow vadose zone source some distance from the extraction pipe, whereas decreasing VFC concentrations may indicate a shallow vadose zone source near the extraction pipe.

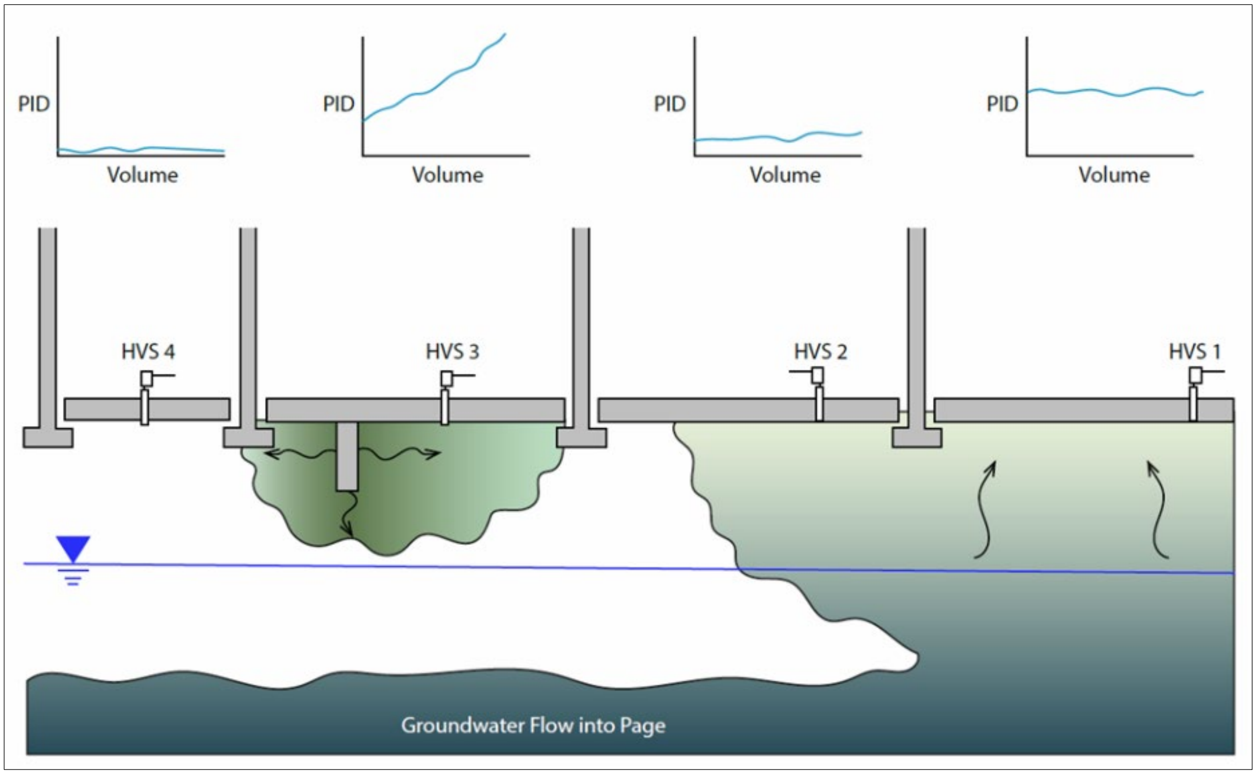

Figure 2. Diagram showing source delineation using high-volume sampling.

Source: Geosyntec, 2023, used with permission.

To support the VI CSM and source delineation, static vacuum, vapor travel time, and transient vacuum data can be modeled with the HVS data to evaluate data between and beyond the radius of influence of the HVS test.

Static Vacuum Field Testing

Gathering vacuum data is essential for understanding the VI CSM of sub-slab materials and the slab from a pneumatic perspective. This data is crucial as regulators often use it to evaluate the effectiveness of a mitigation system.

Static vacuum data becomes particularly valuable when integrated with the vapor intrusion model (VIM) model®, which was developed as part of the Environmental Security Technology Certification Program ER-201322 project and is publicly available at https://serdp-estcp.mil/projects/details/da65b962-fab4-4c3e-be46-f825896bf5d2 (McAlary et al. 2018). HVS testing can be used to determine the design of a sub-slab mitigation system if required. Pressure field extension testing (Figure 3) can be completed with CTPs, which are holes through the slab where the differential pressure between the indoor air and sub-slab can be measured to document the profile of vacuum as a function of distance from the extraction point. Static vacuum is measured from each of the CTPs using a digital micromanometer. This data is entered into the spreadsheet VIM model, along with the extraction flow rate (measured velocity multiplied by the inner cross-sectional area of the pipe). The transmissivity (T) and leakance (B) values can then be adjusted to calibrate the model to match the static vacuum data. This allows the best fit between the measured vacuum levels and the Hantush-Jacob Model to be obtained.

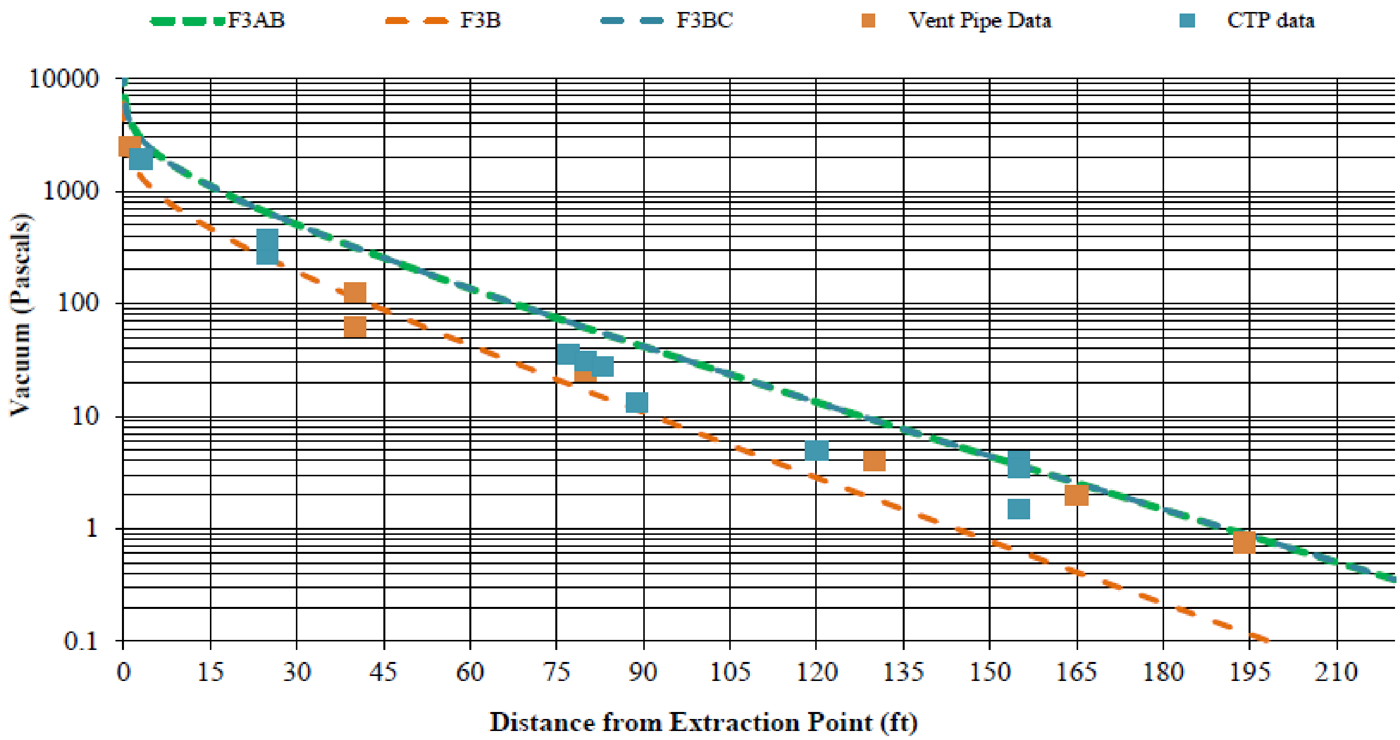

Figure 3. Example static vacuum versus distance data.

Source: McAlary et al. (2018).

This calibration not only enhances the VI CSM but also predicts vacuum levels between and beyond collected data points, offering a detailed insight into spacing requirements for a mitigation system. Additionally, fitting the model allows us to identify outliers that may indicate areas where the slab impedes vacuum propagation due to utilities, sumps, cracks, or other subsurface buildings. After T and B are modeled the VIM model provides outputs of vapor travel time vs. radius, velocity vs. radius and downward flow per 1,000 square feet vs. distance. These provide other metrics to help describe your VI CSM that go beyond static vacuum. Furthermore, fitting the static vacuum data to the model enables the calculation of a region-specific (not building-specific) pneumatic attenuation factor (McAlary et al. 2018). This attenuation factor can be useful as an additional line of evidence and can differentiate concerns with background concentrations that are often present in indoor air at active commercial/industrial buildings.

Helium Tracer Tests

The purpose of the helium injection well test is to calibrate the VIM model for the vapor travel time (i.e., the time it takes vapor to travel from some radial distance away to the extraction point). A helium interwell test is conducted by injecting a fixed volume of helium into a sub-slab probe, typically 3–18 feet away, while the HVS test is operating. The helium concentration in the extraction vent riser pipe is monitored with a helium meter. The time between the injection and the helium peak concentration measured in the vent pipe discharge represents the average travel time between the sub-slab probe and the extraction pipe (Figure 4). This data supports the understanding of how often vapor is flushed from the area of influence and the depth the system is influencing and can provide an additional line of evidence to typical pressure field extension testing.

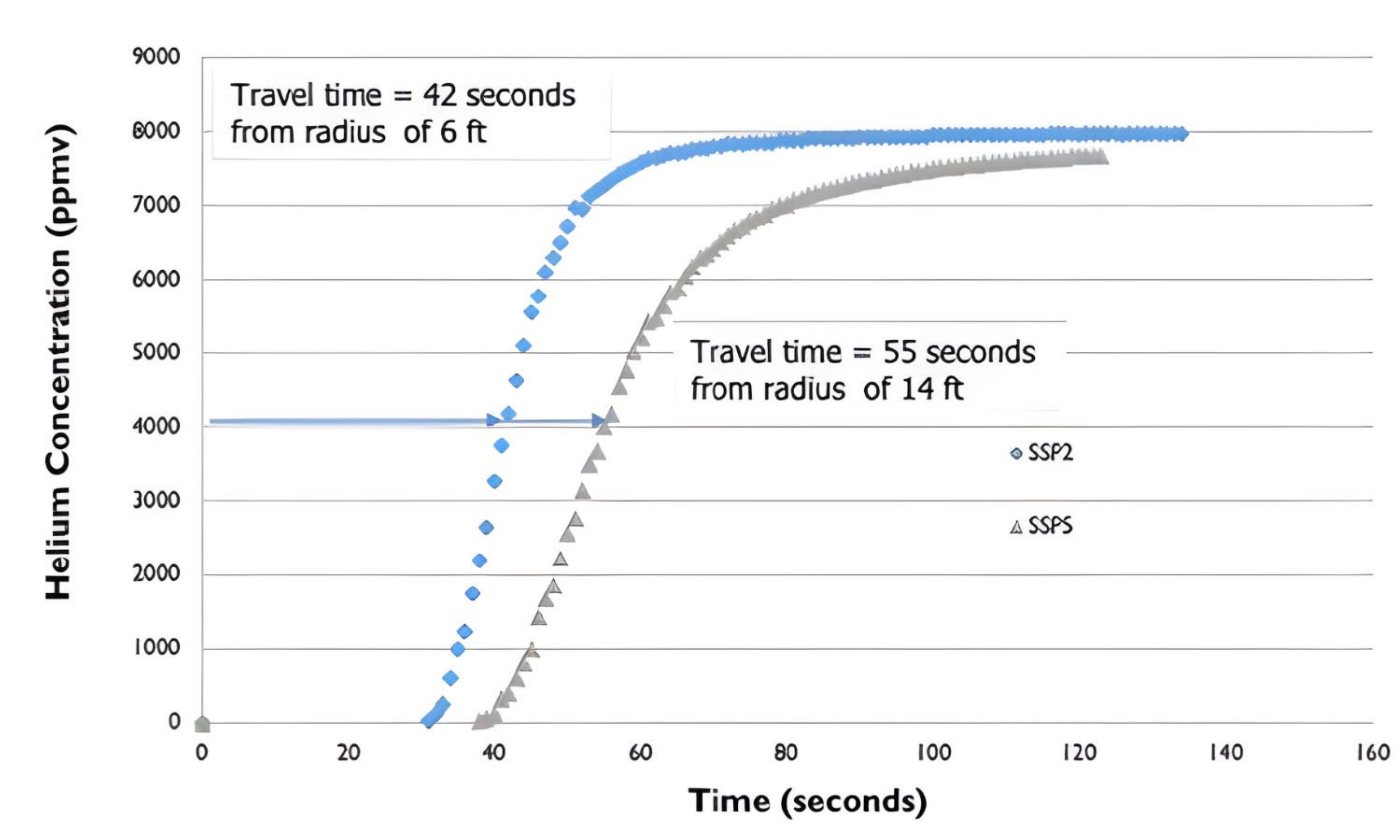

Figure 4. Example helium tracer test results.

Source: McAlary et al. (2018).

Transient Vacuum Field Testing

The transient test illustrates how differential vacuum changes over time, much like an aquifer pumping test (Massmann 1989). As with the VIM model, data points from the transient tests are matched to a model by adjusting T and B values. The Hantush-Jacob leaky aquifer model best describes the VI CSM of a building slab and subsurface materials. This model yields a nonunique solution (various T and B values can fit the model), so fitting both the AQTESOLV model and the VIM model helps achieve a unique solution and enhances confidence in each model. Many people are familiar with aquifer pumping tests, making this data more relatable to them than the VIM model.

Transient vacuum field testing may be performed at the end of a standard HVS test. It is performed by cycling the extraction fan or blower on and off while recording vacuum response and recovery at one or more CTPs using a pressure transducer with a data-logger set to record at 1-second intervals (Figure 5). Each cycle must be long enough to reach or approach steady conditions. This process usually takes only a few minutes, so it is advisable to repeat the test with at least two cycles. Analyze the data in AQTESOLV® using the Hantush-Jacob Model to calculate T and B values (enter the vacuum data after converting to units of feet of air head where 1 pascal = 0.27 feet of air column at 15°C) (Figure 6). The T and B values should be consistent with the T and B values derived by fitting the static vacuum vs. distance data to the spreadsheet model.

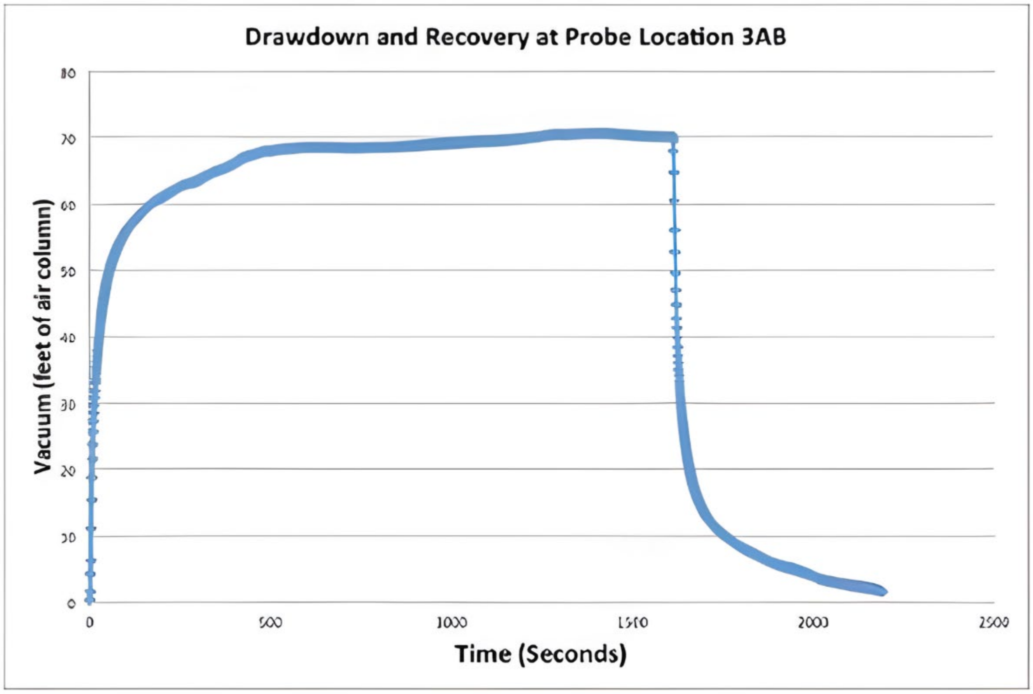

Figure 5. Example transient data.

Source: McAlary et al. (2018).

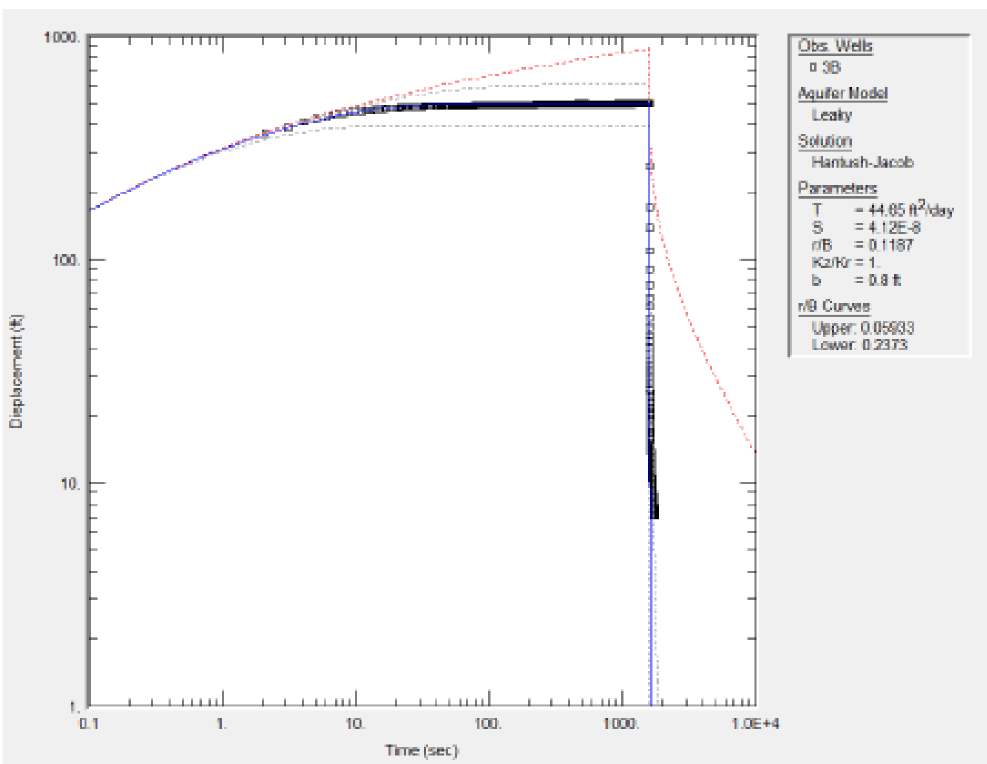

Figure 6. Example Hantush and Jacob model output from transient data.

Source: McAlary et al. (2018).

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