

EXECUTIVE SUMMARY

This report documents the results of the Hill Air Force Base Operable Unit 12 (OU 12) Source Zone Delineation Demonstration. The demonstration was conducted to investigate volatile organic compound contamination in the vadose zone of the suspected OU 12 source area using rapid decision-making based on real-time data collected in the field via direct sampling ion trap mass spectrometry (DSITMS) for rapid identification of contaminant concentrations. The investigation consisted of two technology demonstrations – (1) wireline cone penetrometer system for multiple tool usage and (2) soil vapor extraction (SVE) for vadose zone characterization.

The Wireline CPT demonstration was conducted within the vadose zone and capillary fringe underlying the general area defined as the suspected source zone at OU 12. During the first four days of soil sampling using the Wireline CPT sampler, approximately 205 soil samples were collected from vertical traces at 5 discrete locations (approximately 50 samples per day). An increase in sample collection frequency occurred during the last five days of field operations, where approximately 395 soil samples were collected from vertical traces at 11 discrete locations (approximately 80 samples per day). In total, 599 soil samples were collected from vertical traces at 16 discrete locations during the nine working days of the Wireline CPT demonstration. Samples were generally collected along 1-foot sampling intervals from approximately 20 to 65 feet bgs.

Inference of the magnitude and spatial extent of TCE contamination in the vadose zone at OU 12 was accomplished using three-dimensional modeling of TCE concentration measured in the soil samples retrieved with the Wireline CPT sampler. An isometric view of the 100 µg/kg iso-concentration surface from the final three-dimensional model of TCE contamination in soil is shown in Figure ES-1. The view is from the southwest corner of the model domain, looking to the northeast. The spheres on each of the borings represent soil sample locations, color-coded according to the measured concentration of TCE. The highest concentrations of TCE were observed in samples collected from U2-1804 at a depth of 27 feet (154,000 µg/kg) and 29 feet (73,000 µg/kg) below ground surface (bgs); from U2-1807 at 33 feet bgs (144,000 µg/kg); and from U2-1817 at 29 feet bgs (131,900 µg/kg). In contrast, surrounding borings yielded no soil samples with a measured TCE concentration greater than 10,000 µg/kg. During the analysis of samples collected from U12-1807, four samples (30 to 33 feet bgs) were observed to contain a light nonaqueous phase liquid (LNAPL). In addition, two samples (27 to 29 feet bgs) from U12-1804 were observed to contain a LNAPL.

Based on the results of the TCE soil model, contamination in the vadose zone at OU 12 has a distinctly layered character. Individual layers are elliptical in plan-view, approximately 5 to 10 feet thick, several hundreds of square feet in areal extent, and are present over most of the entire thickness of the vadose zone within the modeled region. The layers of TCE contamination tend to reside in silty-sand soils, joined vertically by narrow and tortuous throat-like connections evocative of migration pathways. This spatial pattern of TCE contamination in soil suggests that water, percolating downward under the force of gravity and carrying with it dissolved TCE, spreads laterally when it encounters capillary barriers. Pathways through the barriers are ultimately found, providing the contaminated water with a new avenue for downward percolation.

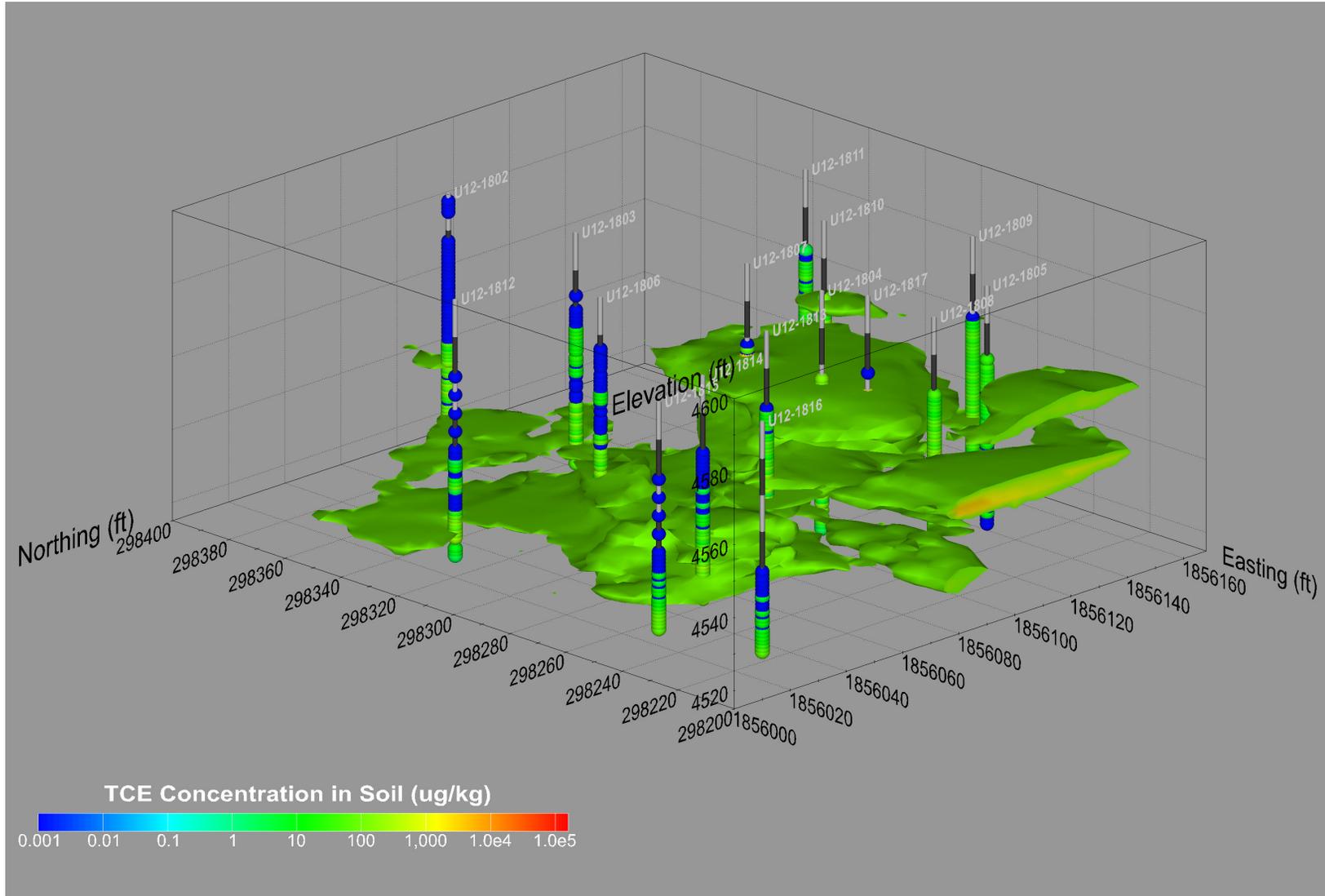


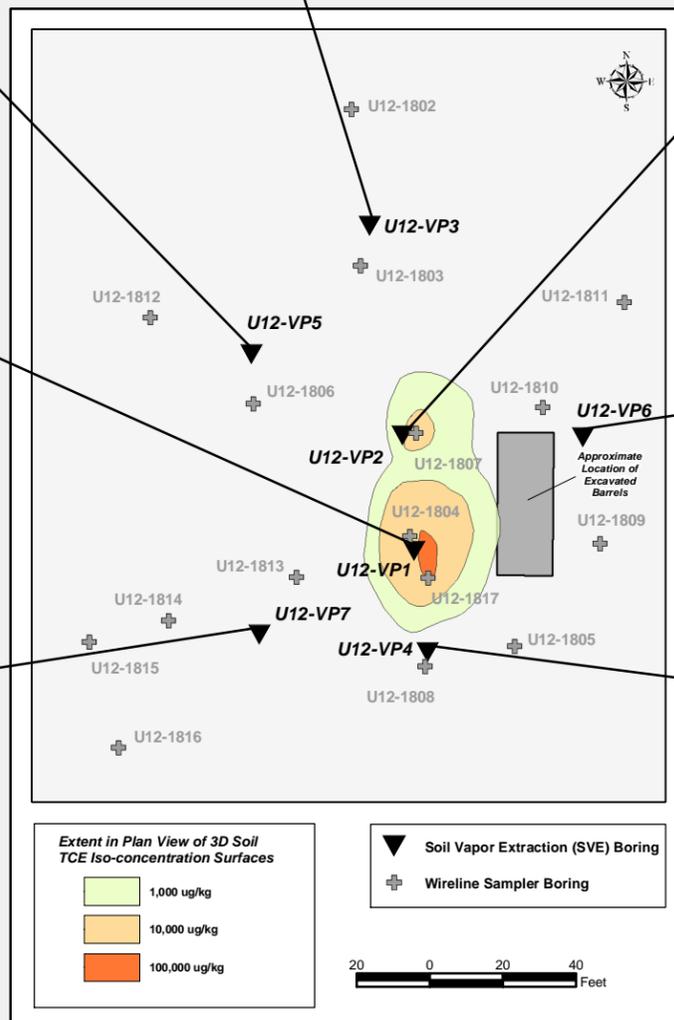
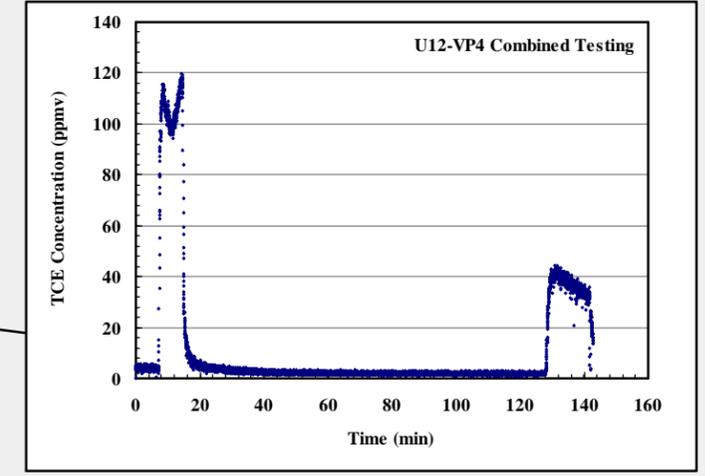
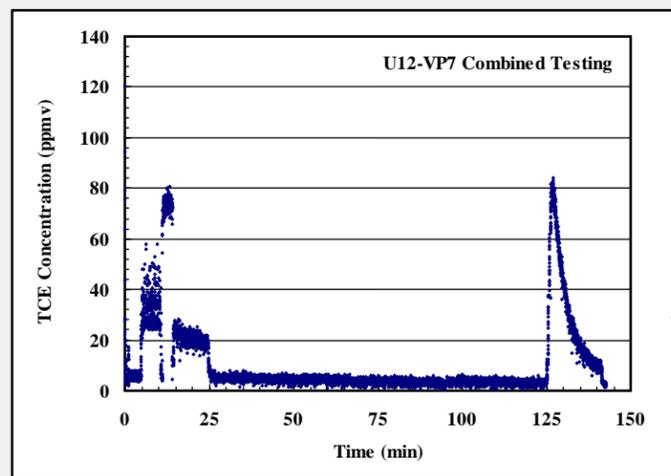
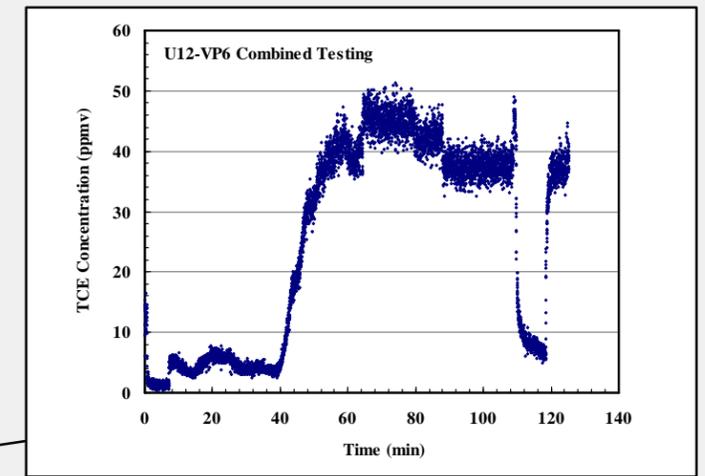
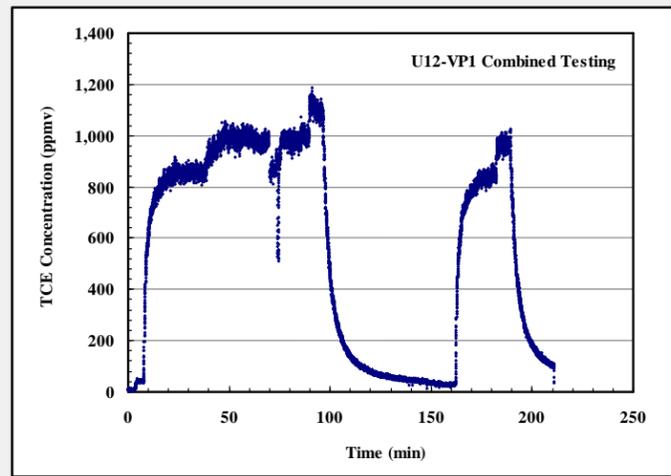
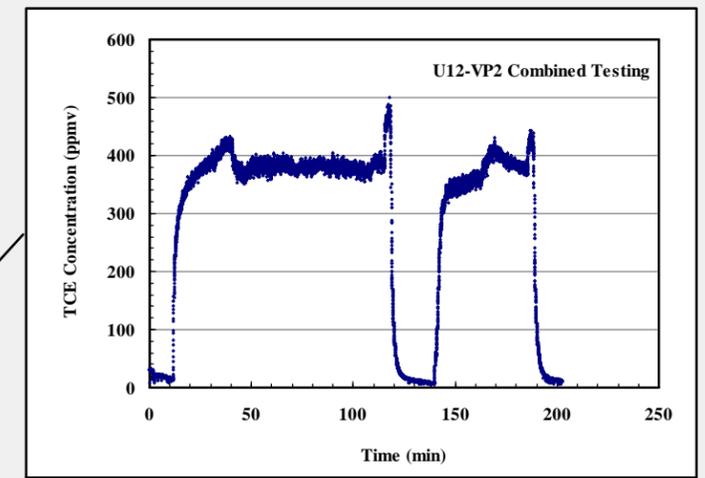
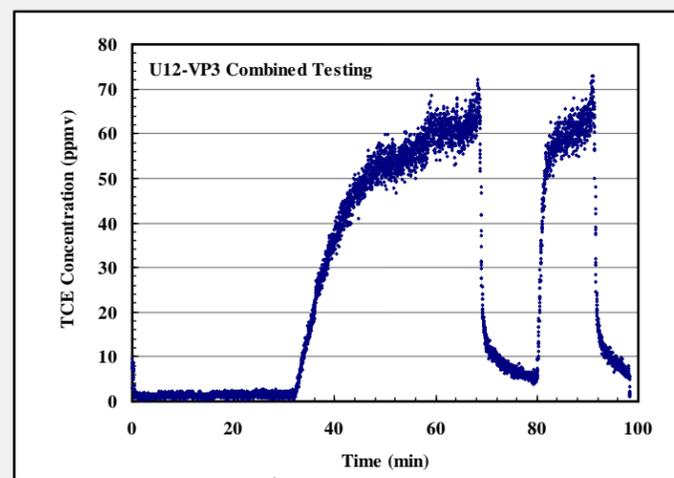
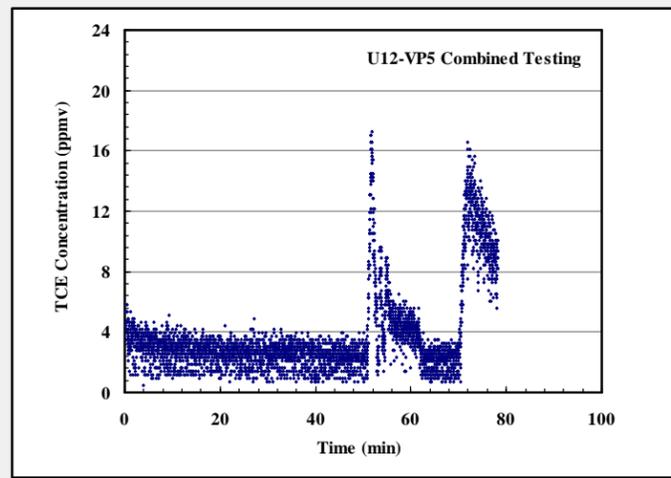
Figure ES-1. Iso-concentration surface of the 100 mg/kg TCE contamination in soil constructed using 599 wireline soil samples from 16 borings.

The SVE demonstration conducted in the suspected source zone at OU 12 focused on step tests for estimating TCE distribution within the vadose zone of the investigative area using a multiphase, multicomponent numerical model. The concentration of TCE in time was monitored on one-second intervals via the on-site laboratory using DSITMS, resulting in over 66,000 data. The TCE time-series data collected during the demonstration were compared with simulated time-series data using a theoretical distribution of TCE mass in the zone of influence and a sequential forward numerical modeling scheme in an attempt to help delineate source-zone contamination in the vadose zone of the investigative area. Although the step tests were optimized to assess contaminant distribution within the vadose zone of the investigative area, the data also provide an indication of the pneumatic response of the subsurface at OU 12 during vapor extraction operations. Based on a maximum radial extent of induced subsurface vacuum of 0.01 inch of water, the zone of pneumatic influence observed during the OU 12 SVE demonstration ranged from approximately 50 to 80 feet in the southern section of the investigative area to over 100 feet in the northern section. The average zone of pneumatic influence within the investigative area was approximately 85 feet. The average *in situ* air permeabilities observed during vapor extraction operations is typical of the fine-grained material in the vadose zone at OU 12 and ranged from 5 to 20 Darcy with a geometric mean of approximately 10 Darcy.

Over 160 theoretical source configurations were simulated numerically during the demonstration. The best correlation between the predicted and measured TCE vapor-phase concentration profile was obtained using a theoretical TCE source located approximately 8 feet northwest of U12-VP1 and 19 feet southeast of U12-VP2. This source was assumed to be 5 feet by 5 feet in areal extent, 10 feet thick, and containing 400 mg/kg TCE. For this source configuration, the predicted vapor-phase concentrations and the general concentration profiles were in relatively good agreement for five of the seven extraction wells but significant differences were observed for two wells distant from the assumed source location. In addition, the predicted TCE concentration profiles for U12-VP1 and U12-VP2 did not exhibit the characteristic exponential decline that was observed in the measured concentrations during periods of blower shutdown.

The vapor-phase concentration of TCE observed during SVE operations at OU 12 closely correlate with the spatial distribution of the TCE soil contamination as shown in Figure ES-2. The highest TCE vapor concentration was observed at U12-VP1 located approximately 20 feet west of the southern end of the drum excavation area. The maximum concentration of TCE in the extracted vapor from this location was approximately 1,150 ppmv. The next highest concentration of TCE was observed at U12-VP2, located approximately 35 feet north of U12-VP1 and 20 feet west of the north end of the drum excavation area. The maximum concentration of TCE in the extracted vapor at U12-VP2 during testing was approximately 500 ppmv. The concentration of TCE in the extracted vapor from the other five wells was less than approximately 100 ppmv during vapor extraction operations.

Although a final source configuration was not obtained with the sequential forward modeling scheme, the SVE modeling did suggest that the highest levels of soil contamination are located near the top of the screened intervals of U12-VP1 and U12-VP2. Based on the results of the model, it is inferred that the major source of TCE contamination is located in the upper portion of the vadose zone (20 to 35 feet bgs) offset slightly to the east of U12-VP1 and moderately more distant from U12-VP2. Based on the results of the SVE modeling, soil concentrations may be closely approaching the saturation limit where a dense



OPERABLE UNIT 12 SOURCE INVESTIGATION AREA

TCE Vapor Phase and Soil Concentrations

Operable Unit 12 (OU 12)
Hill Air Force Base, Utah

URS

FIGURE ES-2

nonaqueous phase liquid (DNAPL) is expected to exist; however, TCE concentrations observed during the Wireline CPT soil investigation do not support the presence of a separate DNAPL phase. The modeling of TCE contamination in the soil illustrated that the highest levels of soil contamination are in the range of 100 mg/kg to 200 mg/kg and are located near the top of the screened intervals of U12-VP1 and U12-VP2. Thus, it is likely that the major TCE contamination in the investigative area is associated with a sorbed fraction and probably a separate LNAPL phase that was identified in the vicinity of vapor extraction wells U12-VP1 and U12-VP2 during the Wireline CPT soil investigation (soil samples that exhibited LNAPL also were shown to contain elevated concentrations of TCE).