EXECUTIVE SUMMARY

This report presents the results of a remediation by natural attenuation treatability study (RNA TS) performed by Parsons Engineering Science, Inc. (Parsons ES) at Operable Unit 1 (OU 1), Hill Air Force Base, Utah. The TS evaluates the use of natural attenuation with long-term monitoring (LTM) as a remedial option for dissolved chlorinated aliphatic hydrocarbon (CAH) contamination in the surficial water-bearing zone. The presence of groundwater and soil contamination at the site has been documented during previous investigations. This TS focuses on the impact of dissolved CAHs, primarily *cis*-1,2-dichloroethene (*cis*-1,2-DCE), on the shallow groundwater system at and downgradient from the site. Site history and the results of soil, soil gas, groundwater, and surface water investigations conducted previously are summarized in this report.

Several lines of chemical and geochemical evidence indicate that dissolved CAHs are undergoing biologically facilitated reductive dehalogenation within and immediately downgradient from the contaminant source area. Microbial consumption of both native and anthropogenic organic carbon compounds have created reducing conditions that are favorable for reductive dehalogenation. The presence of these favorable conditions is supported by the following evidence:

- Concentrations of reductive dehalogenation daughter products are elevated beneath the upland terrace within and immediately downgradient from the source area, and parent solvent concentrations are relatively low;
- Historical concentration data for total 1,2-DCE suggest that concentrations of this compound in many portions of the site are gradually decreasing over time due to the combined effects of RNA and engineered remedial activities;
- Plots of electron donors, electron acceptors, and metabolic byproducts of microbially mediated reduction/oxidation (redox) reactions provide strong qualitative evidence of microbial consumption of organic carbon compounds, creating conditions favorable for reductive dehalogenation; and
- Additional indicators, such as oxidation/reduction potential (ORP), alkalinity, ammonia, and volatile fatty acids further confirm that biodegradation reactions are ongoing and have created reducing conditions that foster reductive dehalogenation.

Conditions that are conducive to the occurrence of reductive dehalogenation appear to be limited to the on-Base portion of the OU. Reductive dehalogenation appears to be relatively insignificant in the Weber River Valley alluvial aquifer; therefore, further reductive dehalogenation of CAHs that migrate off-Base appears to be minimal to non-existent. However, aerobic degradation of the less-chlorinated CAHs (DCE and vinyl chloride [VC]) is probably more prevalent. The abrupt truncation of the VC plume near the Base boundary is a direct indication that VC is being degraded in aerobic, microbially mediated redox reactions.

An important component of this study was an assessment of the potential for contamination in groundwater to impact potential receptor exposure points at concentrations above regulatory levels intended to be protective of human health and the environment. To accomplish this objective, the numerical model codes MODFLOW and MT3D were used to estimate the impacts of potential future engineered remedial actions on the future migration and persistence of dissolved *cis*-1,2-DCE within the surficial water-bearing zone under the influence of advection, dispersion, sorption, and biodegradation. In addition, the fate and transport of the *cis*-1,2-DCE plume under the influence of RNA combined with existing remedial actions was simulated to provide a baseline against which the effectiveness of potential future remedial actions can be compared. Input parameters for the numerical model were obtained from existing site characterization data, supplemented with data collected during the RNA TS. Model parameters that were not measured at the site were estimated using reasonable literature values.

The results of this study suggest that the dissolved *cis*-1,2-DCE plume will not migrate further north than is currently observed, and will gradually decrease in magnitude and extent due to the effects of natural attenuation processes operating in the groundwater, the effects of the currently operating remedial systems, and weathering of the contamination source. If additional engineered remedial actions are not implemented, then model results suggest that dissolved DCE concentrations throughout the area north of the Bambrough Canal will decrease below the Utah groundwater standard of 70 µg/L by year 2040 to 2045. In addition, dissolved DCE concentrations throughout nearly all of the off-Base area are predicted to decrease below 70 µg/L by 2097. However, the model indicates that dissolved DCE concentrations will substantially exceed 70 µg/L in the source area for more than 100 years unless natural source attenuation rates are significantly more rapid than simulated by the model.

If the preferred remedial alternative is implemented, then the model predicts that dissolved DCE concentrations north of the Bambrough Canal will decrease below 70 µg/L by approximately year 2017. Although simulated DCE concentrations in the source area decrease more rapidly than if the preferred alternative is not implemented, maximum DCE concentrations are predicted to remain above 70 µg/L for more than 100 years due to persistence of the contamination source.

Model results suggest that implementation of Source Area Alternative 3 and Non-Source Area Alternative 6 would not hasten the diminishment of the dissolved DCE plume substantially relative to the preferred alternative. Therefore, if the off-Base plume does not represent a significant threat to potential receptors, then implementation of Non-Source Area Alternative 6 may not be advisable. The effectiveness of Non-Source Area Alternative 6 could potentially be increased by increasing the pumping rates of the Non-Source Area extraction wells; however, this was not assessed using the numerical model.

The groundwater flow and contaminant transport system that is modeled is very complex, and the relevant properties and parameters are not well defined in some portions of the modeled area. As a result, the numerical model necessarily is a very simplified representation of the groundwater and contaminant transport system. However, the sensitivity analysis indicates that the selected model input parameters are reasonable, and the model predictions are believed to be useful approximations that can facilitate selection of an appropriate remedial approach.

To further calibrate the numerical model for use as a management tool at OU 1, regular sampling of LTM wells in the non-source area is recommended to monitor the degradation of the dissolved CAH plumes. Regular sampling and analysis of groundwater from selected wells will allow the effectiveness of RNA and engineered remedial actions to be monitored, and should allow assessment of whether additional engineering controls should be implemented. Likewise, the model can be adjusted to reflect future conditions measured in the aquifer.

Contaminant fate and transport model results indicate that sampling in the non-source area should continue on a biennial (every other year) basis until *cis*-1,2-DCE concentrations decrease below 70 µg/L. Assuming that the preferred remedial alternative is implemented, LTM may be required for approximately 20 years in the area north of the Bambrough Canal, and for less than 10 years in the on-Base portion of the non-source area west of the source area. Monitoring of the source area may be required for more than 100 years unless the contaminant source diminishes significantly more rapidly than simulated in the numerical model. If Source Area Remedial Alternative 3 is implemented, then annual monitoring of selected source area wells may be desirable for approximately 5 years, followed by progressively less frequent monitoring in subsequent years. The LTM plan should be reevaluated periodically and modified as necessary on the basis of newly obtained data and further calibration of the numerical model. Along with other analyses used to assess the effectiveness of RNA, the groundwater samples should be analyzed for volatile organic compounds by US Environmental Protection Agency Method SW8260A.