SECTION 2

Decision Summary

The Decision Summary identifies the Selected Remedy, explains how the remedy fulfills statutory and regulatory requirements, and provides a substantive summary of the Administrative Record file that supports the remedy selection decisions.

2.1 Site Name, Location, and Description

Travis AFB is located midway between San Francisco and Sacramento, California, on low-lying ground within 1 mile of Suisun Marsh, an estuary of San Francisco Bay. It is located 3 miles east of downtown Fairfield and 8 miles south of downtown Vacaville in Solano County (see Figure 2.1-1). Travis AFB is an active military facility. The Base occupies more than 6,000 acres and maintains ownership of, or administrative control over, several properties at off-base locations.

As a result of past waste management and disposal practices, groundwater contamination is present at multiple locations on Travis AFB, as identified by the following site designations: Sites FT004, FT005, LF006, LF007, LF008, SS015, SS016, ST027B, SS029, SS030, SD031, SD033, SD034, SS035, SD036, SD037, DP039, SS041, and SD043. Site LF007 is a landfill and has three (3) separate contaminant plumes that are identified as Subareas LF007B, LF007C, and LF007D. These sites are organized into two (2) OUs, NEWIOU and WABOU, to facilitate the overall cleanup program.

As the lead agency for remedial activities, the AF has conducted environmental restoration at Travis AFB in accordance with CERCLA under DERP, which was established by SARA Section 211.

As the support agencies, EPA Region 9, the California DTSC, and San Francisco Bay Regional Water Board provide primary oversight of the environmental restoration actions, in accordance with CERCLA and a Federal Facilities Agreement (FFA) signed by the AF and regulatory agencies in September 1990 (Travis AFB, 1990).

Funding for remedial activities is provided by the Defense Environmental Restoration Account, a funding source approved by Congress to clean up contaminated sites on U.S. Department of Defense (DoD) installations.

Descriptions of the sites within the NEWIOU and WABOU and the historical activities that resulted in groundwater contamination are provided in the following sections. More detailed descriptions of the sites are provided in Appendix A – Conceptual Site Models of this ROD, in Section 3 of the FFS (CH2M HILL, 2011a), and in the *Groundwater Sampling and Analysis Program 2010-2011 Annual Report* (GSAP 2010-2011 Annual Report) (CH2M HILL, 2012a).

2.1.1 NEWIOU ERP Sites

The NEWIOU encompasses the following sites:

- **Site FT004 (FTA-3):** Area used for fire training exercises from approximately 1953 through 1962. During this period, waste fuels, oils, and solvents were burned on open ground. Historical practices resulted in groundwater contamination with chlorinated VOCs.
- **Site FT005 (FTA-4):** Area used for fire training exercises from approximately 1962 through 1987. During this period, waste fuels, oils, and solvents were burned on open ground. Historical practices resulted in groundwater contamination with chlorinated VOCs. The contaminant plume extends onto off-base privately owned property.
- **Site LF006 (Landfill 1):** A general refuse landfill that used trench and burn methods from approximately 1943 through 1950. Historical practices resulted in groundwater contamination with chlorinated VOCs and petroleum-fuel hydrocarbons.
- **Site LF007, including Subareas LF007B, C, and D (Landfill 2):** A general refuse landfill that used trench and cover methods from approximately 1950 through 1970. Historical practices resulted in groundwater contamination with chlorinated VOCs, dioxins, and polychlorinated biphenyls (PCBs). The Subarea LF007C contaminant plume extends onto off-base privately owned property.
- **Site SS015 (Solvent Spill Area [SSA] and Facilities 808, 1832, 552):** Facilities used between approximately 1964 and 1980 for solvent stripping of aircraft parts, aircraft maintenance and repair, OWS activities, and hazardous waste accumulation. Historical practices resulted in groundwater contamination with chlorinated VOCs.
- **Site SS016 (OSA; Facilities 11, 13/14, 18, 20, and 42/1941; and Portions of the Storm Sewer System):** Flight line support areas subject to oil spills, degreasing operations, leaking OWS, equipment maintenance and repair, aircraft and vehicle maintenance, hazardous materials storage, aircraft and vehicle washing, and stormwater runoff. Most of the areas were used from the 1940s through the present day. Historical practices resulted in groundwater contamination with chlorinated VOCs.
- **Site ST027-Area B (Facilities 1918, 1919, and 1754):** Formerly used as a test stand area for aircraft engine testing. Currently, only Facility 1918 is used. Historical activities have resulted in contamination of groundwater at the site with chlorinated VOCs, primarily TCE and petroleum-fuel constituents. The portion of the plume containing only petroleum-fuel contamination is designated as Site ST027-Area A (Site ST027A) and continues to be managed under the Travis AFB POCO program with regulatory oversight provided by the San Francisco Bay Regional Water Board. The portion of the plume with TCE contamination is designated as Site ST027-Area B (Site ST027B) and is addressed as an ERP site.
- **Site SS029 (Monitoring Well [MW]-329 Area):** Undeveloped land near the southern Base boundary. The historical uses resulting in groundwater contamination with chlorinated VOCs are unknown.

- **Site SS030 (MW-269 Area):** Mostly undeveloped land near the southern Base boundary. Historical practices associated with Building 1125, formerly located in the northernmost portion of the site near the South Base Boundary Groundwater Treatment Plant, are believed to have resulted in groundwater contamination with chlorinated VOCs. The original Building 1125 and associated infrastructure were demolished and replaced with a new building. This area currently consists of a concrete slab, a new single antenna tower, and a small shed housing electronic equipment used to support airfield operations. The contaminant plume extends onto off-base privately owned property.
- **Site SD031 (Facility 1205):** Area used for maintenance and repair of diesel generators, wash rack activities, OWS activities, and aircraft maintenance from approximately 1957 through the present day. Historical practices resulted in groundwater contamination with chlorinated VOCs.
- **Site SD033 (Storm Sewer II, South Gate Area, Facilities 810 and 1917, and West Branch of Union Creek):** Support areas used for management of stormwater runoff, fuel transport, aircraft maintenance, and aircraft washing, including the use of wash racks and OWS. Historical practices resulted in groundwater contamination with chlorinated VOCs and petroleum-fuel hydrocarbons.
- **Site SD034 (Facility 811):** An active aircraft wash rack facility with OWS and overflow pond. Leaks from the OWS resulted in free-phase Stoddard solvent floating on the groundwater table. The leaking OWS was replaced in 1994. Historical practices resulted in dissolved groundwater contamination with chlorinated VOCs and petroleum-fuel hydrocarbons. The Stoddard solvent non-aqueous medium also contains dissolved chlorinated VOCs.
- **Site SS035 (Facilities 818/819):** Active facilities used for aircraft repair, painting, and washing. A wash rack with OWS was constructed in 1970. Historical practices resulted in groundwater contamination with chlorinated VOCs.
- **Site SD036 (Facilities 872/873/876):** Facilities 872/873/876 consists of multiple-use shops, including a wash rack and OWS. Current uses include paint shops, electrical shops, landscape maintenance, paint mixing, and paint accumulation. The buildings were constructed in 1953 and are still in use. Historical practices resulted in groundwater contamination with chlorinated VOCs and petroleum-fuel hydrocarbons.
- **Site SD037 (Sanitary Sewer System; Facilities 837/838, 919, 977, 981; Ragsdale/V Street Area; and Area G Ramp):** Support areas used for management of domestic and industrial wastewater, aircraft maintenance, heavy equipment maintenance, air cargo handling, vehicle washing, fuel transport, and waste accumulation. Operations began in the 1940s and continue through the present day. Historical practices resulted in groundwater contamination with chlorinated VOCs and petroleum-fuel hydrocarbons.

2.1.2 WABOU ERP Sites

The WABOU encompasses the following sites:

- **Site LF008 (Landfill 3):** An inactive historical landfill consisting of a series of small, unlined trenches used to dispose of old pesticide containers. Historical practices resulted in groundwater contamination with organochlorine pesticides.
- **Site DP039 (Building 755, Travis AFB Battery and Electric Shop):** Prior to 1978, battery acid solutions and solvents were discharged from Building 755 into a sump. These historical practices resulted in contamination of the groundwater with chlorinated VOCs, primarily TCE.
- **Site SS041 (Building 905):** The Base Entomology Shop used Building 905 from 1983 to 1992 to prepare pesticides and herbicides for on-base use. A concrete wash rack in the back of the building was used to clean pesticide applicator vehicles, and the overspray from the washing resulted in pesticide contamination in the groundwater.
- **Site SD043 (Building 916):** An emergency electric power facility. Historical practices resulted in contamination of the groundwater with TCE.

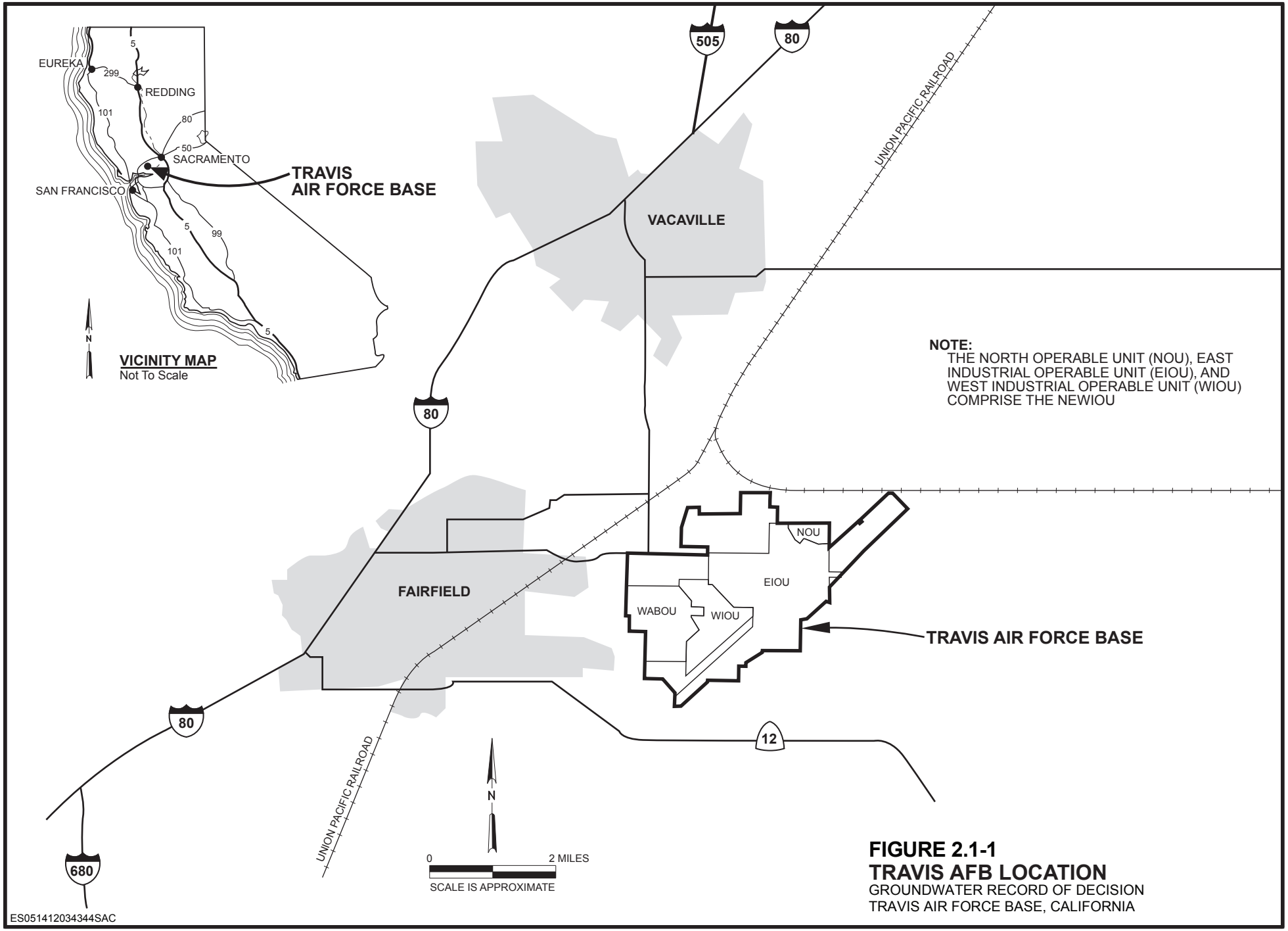

FIGURE 2.1-1
TRAVIS AFB LOCATION
GROUNDWATER RECORD OF DECISION
TRAVIS AIR FORCE BASE, CALIFORNIA

2.2 Site History and Enforcement Activities

This section provides background information, summarizes the series of previous site activities and investigations that led to this ROD, and describes the response actions undertaken for groundwater, soil, sediment, and surface water at Travis AFB. There have been no CERCLA enforcement activities with regard to these sites.

In 1983, the AF initiated the Installation Restoration Program (IRP) (now the ERP) to investigate the nature and extent of hazardous waste releases to the environment. On the basis of IRP data evaluated by EPA, Travis AFB was placed on the National Priorities List (NPL) on November 21, 1989 (54 *Federal Register* 48187). Approximately 1 year later, on September 27, 1990, the AF, EPA, the California DTSC, and San Francisco Bay Regional Water Board negotiated and signed the FFA that established the framework and schedule for environmental cleanup at Travis AFB (Travis AFB, 1990). A brief chronology of the key events related to the management of groundwater, soil, sediment, and surface water contamination at Travis AFB is summarized in Table 2.2-1.

Under the original FFA (Travis AFB, 1990), Travis AFB was treated as a single entity with one (1) associated comprehensive cleanup schedule. Then, in May 1993, the FFA was amended to divide the Base into four (4) OUs to facilitate the overall cleanup program. The four (4) OUs were as follows:

- East Industrial Operable Unit (EIOU)
- WIOU
- North Operable Unit (NOU)
- WABOU

In October 1995, the EIOU, WIOU, and NOU were combined into the composite NEWIOU. Currently, the OUs at Travis AFB are the NEWIOU and the WABOU.

This ROD addresses groundwater contamination at sites within both of these OUs. Soil, sediment, and surface water contamination within these OUs has been previously addressed in the final *Soil Record of Decision for the West/Annexes/Basewide Operable Unit* (Soil ROD for the WABOU) *(*Travis AFB, 2002b) and the final *North, East, West Industrial Operable Unit Soil, Sediment, and Surface Water Record of Decision* (NEWIOU Soil, Sediment, and Surface Water ROD) (Travis AFB, 2006a). A summary of the key events related to the management of contaminated groundwater, soil, sediment, and surface water at Travis AFB is provided in Table 2.2-1 and in the following list:

- **Preliminary Assessment (PA)/Site Inspection (SI):** Between approximately 1983 and 1994, early IRP investigations, data gathering, and work planning efforts were conducted to preliminarily assess the nature of environmental contamination at Travis AFB (Jacobs Engineering Group, Inc., 1994).
- **Remedial Investigations (RIs):** Additional RI field investigations were completed from approximately 1994 to 1997 and used to further characterize the nature and extent of contaminated groundwater at the sites within the NEWIOU and WABOU and support completion of risk assessments. The RIs concluded that groundwater contamination at Travis AFB has resulted from past waste management and disposal practices typical of

an active AF facility and identified COCs in groundwater (Radian, 1996a [WIOU]; Radian, 1995 [NOU]; Weston, 1995 [EIOU]; CH2M HILL, 1997 [WABOU]).

- **Feasibility Studies (FSs):** Two (2) FSs were completed in 1996 (NEWIOU) and 1998 (WABOU) to evaluate interim remedial alternatives for contaminated groundwater sites within the NEWIOU (Radian, 1996b) and WABOU (CH2M HILL, 1998a).
- **Decision Documents:** Two (2) RODs for soil, sediment, and surface water and two (2) IRODs for groundwater were finalized to select the final soil, sediment, and surface water remedial actions and groundwater IRAs:
  - **RODs for Soil and for Soil, Sediment, and Surface Water:** The Soil ROD for the WABOU (Travis AFB, 2002a) and the NEWIOU Soil, Sediment, and Surface Water ROD (Travis AFB, 2006a) were finalized to select the remedial alternatives for contaminated soil sites within the WABOU and contaminated soil, sediment, and surface water sites within the NEWIOU.
  - **Potrero Hills Annex Operable Unit:** As described in Part I, Table I-1 and Item C of "Assessment of the Site" of the final Soil ROD for the WABOU (Travis AFB, 2002a), the Potrero Hills Annex was transferred from the WABOU to another OU to manage its future remedial activities and will be addressed in a subsequent ROD. The Potrero Hills Annex is a 25-acre noncontiguous parcel of property under the jurisdiction of the Travis AFB installation commander that was originally part of a former NIKE missile battery. The WABOU RI detected PCB-1254 adjacent to an electrical transformer pad and metals and explosives in the vicinity of currently active explosive test facilities.

    On September 22, 1999, the California Regional Water Quality Control Board issued a Site Cleanup Requirements Order to OEA Aerospace (OEAA) and Travis AFB. The order tasks both parties with the environmental investigation of the Annex and the adjacent 525-acre OEAA property and the selection and implementation of appropriate remedial actions on both properties.

    To allow Travis AFB to comply with this order, the AF and regulatory agencies agreed in the WABOU ROD to pull the Annex out of the WABOU and postpone the application of CERCLA to the Annex while OEAA, its successors, and Travis AFB take action under the order. Investigative activities under the order at the Annex continue, primarily to determine the nature and extent of perchlorate contamination. Additionally, since removal from the WABOU, remedial activities conducted at the Annex under the order have resulted in the removal of the PCB and metals contaminated soil. Once the perchlorate-related investigative activities are complete, and any appropriate remedial action is in place, the agencies will review the results of the order and determine whether any other CERCLA-related activities are required.
  - **IRODs for Groundwater:** IRAs for groundwater were selected in the final NEWIOU Groundwater IROD (Travis AFB, 1998) and the final WABOU Groundwater IROD (Travis AFB, 1999).

- **Remedial Actions for Soil, Sediment, and Surface Water:** From 2003 through 2012, soil, sediment, and surface water remedial actions were completed at the WABOU and NEWIOU sites in accordance with the Soil ROD for the WABOU (Travis AFB, 2002a) and the NEWIOU Soil, Sediment, and Surface Water ROD (Travis AFB, 2006a). Documentation of these remedial actions is provided in multiple reports, including the final *FT005 Remedial Action Report* (ITSI Gilbane, 2012), the final *Sites SD001 and SD033 Remedial Action Report* (ITSI, 2010), the final *NEWIOU and WABOU Soil Remedial Action for Sites SD045, FT003, FT004, FT005, Union Creek SD001, and SD033, and LF007 Area E Report* (Shaw Environmental, Inc., 2008), the final *Remedial Action Report for Soil Remedial Action at Site LF008* (Shaw Environmental, Inc., 2004a), the final *Project Summary Report for the Site LF007 Phase 2 Soil Remedial Action* (Shaw Environmental, Inc., 2004b), the final *Project Summary Report for the LF007 Soil Remedial Action Phase 1, Landfill Cap, Corrective Action Management Unit Subgrade, Wetlands Mitigation* (Shaw Environmental, Inc., 2003), the final *Remedial Action Report for Soil Remedial Actions at Site LF044* (Environmental Chemical Corporation, 2003a), the final *Remedial Action Report for Soil Remedial Actions at Site RW013* (Environmental Chemical Corporation, 2003b), the final *Remedial Action Report for Soil Remedial Actions at Site SS041* (Environmental Chemical Corporation, 2003c), the final *Remedial Action Report for Soil Remedial Actions at Site LF044* (Environmental Chemical Corporation, 2003d),and the final *Reevaluation of Soil and Groundwater Contamination at Building 916 (SD043) Technical Memorandum* (CH2M HILL, 2000). Additional supporting documents are provided in the Travis AFB Administrative Record.

- **IRAs for Groundwater:** After finalization of the NEWIOU Groundwater IROD (Travis AFB, 1998) and the final WABOU Groundwater IROD (Travis AFB, 1999), groundwater IRAs were implemented to expedite remediation of groundwater contamination, reduce the levels of contamination and potential risk, and collect data necessary for the selection of final cleanup levels and technically and economically feasible long-term actions. The IRAs began in 1998 and have continued until the present. The entirety of Site ST027 was formerly managed under the POCO program and was undergoing MNA. An IRA was not specified for this site in the NEWIOU Groundwater IROD, because CERCLA contamination was not detected until after the IROD was finalized. In 1999, a portion of the plume found to be contaminated with TCE was designated Site ST027B and is now managed under the ERP.

- **Performance Monitoring, LUCs, and Five-year Reviews:** Performance monitoring of the groundwater IRAs was conducted and reported under the Travis AFB GSAP and GRIP. Descriptions of groundwater treatment plant O&M activities have been regularly reported to the regulatory agencies in monthly data sheets and in annual O&M reports. LUCs have been enforced in accordance with the NEWIOU Groundwater IROD (Travis AFB, 1998), the WABOU Groundwater IROD (Travis AFB, 1999), the Soil ROD for the WABOU (Travis AFB, 2002a), and the NEWIOU Soil, Sediment, and Surface Water ROD (Travis AFB, 2006a). The status of the LUCs is documented in annual LUC reports. The most recent LUC report is the *Annual Report on the Status of Land Use Controls on Restoration Sites in 2012* (Travis AFB, 2013). Three (3) five-year reviews for the groundwater IRAs were completed in 2003, 2008, and 2013 (CH2M HILL, 2003, 2008a, 2013b).

- **IRA Optimizations, Technology Demonstrations, and MNA Assessments and Studies:** Following the second five-year review, measures were implemented to optimize the performance of the groundwater IRAs, demonstrate the viability of alternative in situ treatment processes, and further assess the performance of natural attenuation processes (CH2M HILL, 2012d; Parsons, 2010; CH2M HILL, 2010b; CH2M HILL, 2012b).
- **FFS:** The FFS was completed in 2011 and re-evaluated remedial alternatives that could address the concentrations of COCs remaining in groundwater above levels that allow for designated beneficial uses of groundwater (domestic, municipal, agricultural, and industrial supply) as well as unlimited use and unrestricted exposure. It supports the transition from the current interim actions to final remedies, incorporation of successfully performing components of the existing interim actions into the final remedies, optimization of the interim actions, incorporation of successful treatment demonstrations, and actions based on the results of supporting studies (CH2M HILL, 2011a).
- **Vapor Intrusion Assessments:** An evaluation was completed in 2010 to assess the potential for vapor intrusion into buildings located in proximity to areas of contaminated groundwater. The assessment included field sample collection; laboratory analyses of groundwater, soil gas, and ambient air samples; and assessments of human health risks from soil vapor. An update to this evaluation was finalized in 2013, to incorporate updated toxicity values for several chemicals.
- **Technical and Economic Feasibility Analysis (TEFA):** A TEFA was completed in 2012 to evaluate the technical and economic feasibility of reducing groundwater contaminant concentrations to background levels in accordance with the intent of State Water Board Resolution 92-49 (Policies and Procedures for Investigation and Cleanup and Abatement of Discharges under Water Code Section 13304).

2.2.1 Interim Remedial Actions for Groundwater

The following subsections provide descriptions of the IRAs implemented for groundwater at the NEWIOU and WABOU sites and their performance, optimizations of interim GET systems, technology demonstrations, MNA assessments and studies, Remedial Process Optimization (RPO), vapor intrusion assessments, and the TEFA. Site-specific descriptions of the IRAs are provided in Appendix A – Conceptual Site Models.

The following IRAs for groundwater at NEWIOU Sites FT004, FT005, LF006; Subareas LF007B, LF007C, and LF007D; and Sites SS015, SS016, ST027B, SS029, SS030, SD031, SD033, SD034, SS035, SD036, and SD037 were initiated in 1998 (Travis AFB, 1998):

- **Natural Attenuation/Monitoring (i.e., MNA assessment) –** Collection of performance data and assessment of the viability of MNA as a final remedy for all, or part, of contaminated groundwater at Sites FT004 and LF006; Subareas LF007B and LF007D; and Sites SS015, SD031, SD033, SD034, SS035, SD036, and SD037.
  - Addressed the entirety of groundwater contamination at Site LF006, Subarea LF007B, Subarea LF007D, and Site SS015.
  - Taken in combination with groundwater extraction, treatment, and discharge (GET) at Sites FT004, SD031, SD033, SD034, SS035, SD036, and SD037.

  - Addressed the entirety of the plume at Site ST027. The entirety of Site ST027 was formerly managed under the POCO program with MNA as the presumptive remedy for petroleum fuel contamination in groundwater. An IRA was not specified in the NEWIOU Groundwater IROD, because CERCLA contamination was not detected until after the IROD was finalized. In 1999, a portion of the plume found to be contaminated with TCE was designated Site ST027B and is now managed under the ERP. The Site ST027A portion of the plume, with only petroleum-fuel contamination, continues to be managed under the POCO program.

- **Extraction/Treatment/Discharge (GET) –** Hydraulically capture areas of groundwater contamination and remove contaminant mass at Sites FT004 and FT005, Subarea LF007C, and Sites SS016, SS029, SS030, SD031, SD033, SD034, SS035, SD036, and SD037.

  - Addressed the entirety of groundwater contamination at Site FT005, Subarea LF007C, and Sites SS016, SS029, and SS030.

  - Taken in combination with MNA assessment at Sites FT004, SD031, SD033, SD034, SS035, SD036, and SD037.

- **Passive Skimming –** Physical removal of floating Stoddard solvent, containing dissolved COCs, at Site SD034 using passive skimmers.

The following IRAs for groundwater at WABOU Sites LF008, DP039, SS041, and SD043 were initiated in 1999 (Travis AFB, 1999):

- **Containment/Treatment/Discharge (i.e., GET) –** Prevent the migration of groundwater contamination into hydraulically downgradient areas of contaminated groundwater at Sites LF008, SS041, and SD043.

- **Source Area and Groundwater Extraction/Treatment/MNA (i.e., GET in combination with MNA) –** Vacuum-enhanced version of GET to hydraulically contain and remove relatively high concentrations of VOCs from the vadose zone and groundwater at the source of contamination and collection of performance data and assessment of the viability of MNA as a final remedy for all, or part, of the groundwater plume at Site DP039.

The IRAs have generally operated successfully from the late 1990s and early 2000s through the current date, as described in the *Second Five-year Review Report* (CH2M HILL, 2008a), FFS (CH2M HILL, 2011a), *Natural Attenuation Assessment Report* (NAAR) (CH2M HILL, 2010b), and FFS, Appendix C – Lines of Evidence for MNA (CH2M HILL, 2011a). After approximately a decade of interim remediation, concentrations of COCs in groundwater at multiple sites have been reduced. Preliminary cleanup goals (PCGs) were achieved by the interim action for Site SS041, which consisted of successful long-term operation of a GET system. However, for the other sites, concentrations of VOCs and organochlorine pesticides in groundwater remain above the lowest of either the state or federal MCLs. A summary of the performance and status of the IRAs is provided in Table 2.2-2. Further discussion of the performance and status of the IRAs is provided in Appendix A.

The locations of the sites and an overview of the current distribution of groundwater contamination are shown on Figures 2.2-1 and 2.2-2. Site-specific figures that compare the historical distribution of groundwater contamination prior to implementation of the IRAs and the current distribution of contamination after 8 to 10 years of interim remediation are shown on Figures 2.2-3 through 2.2-10. Plan view and cross section figures of each site are provided in Appendix A.

2.2.2 Optimization of Interim GET Systems

Evaluations of IRA GET system performance concluded that optimization measures were needed to improve the performance of the systems at Subarea LF007C and Sites SS016 and SS030. Summaries of these optimization measures are provided below.

2.2.2.1 Subarea LF007C GET System

The Subarea LF007C plume had migrated off-base, and the IRA GET system had not significantly reduced contaminant concentrations in the site monitoring wells. As described in the *Site LF007C Data Gaps Investigation Results Technical Memorandum* (CH2M HILL, 2012e), optimization measures were conducted in 2011-2012 to improve GET system performance. These measures included additional characterization to improve understanding of off-base contaminant distribution and groundwater flow directions. Additional optimization measures that will be conducted during 2013 include installing a higher-capacity solar-powered groundwater pump, installing larger solar panels, and rerouting the extraction well discharge pipeline. These modifications will improve the hydraulic capture of the plume, improve contaminant mass removal rates, and provide for more efficient beneficial reuse of treated groundwater in the on-base Duck Pond.

The Subarea LF007C GET system includes a provision for GSR through the use of solar-powered groundwater extraction pumps.

All Site LF007C GET optimization measures will be conducted in accordance with the U.S. Fish and Wildlife Service (USFWS) biological opinions (USFWS, 2011, 2002). Most of the contaminated groundwater at this site is located off-base and lies beneath a large vernal pool. In accordance with the USFWS biological opinions, the site will only be accessed by personnel or vehicles, and the GET system will be operated when the vernal pool is dry.

2.2.2.2 Site SS016 GET System

Although the overall IRA objectives at Site SS016 were being largely achieved, the following optimization actions described in Section 3 of the *Remedial Process Optimization Baseline Implementation Report* (BIR) (CH2M HILL, 2012f) and in Section 2.1 of the *2011 Annual Remedial Process Optimization Report for the Central Groundwater Treatment Plant, North Groundwater Treatment Plant, and South Base Boundary Groundwater Treatment Plant* (2011 Annual RPO Report) (CH2M HILL, 2012d) were taken within the OSA portion of the plume with the highest concentrations of residual contamination during September 2010 to improve the overall effectiveness of the existing GET system:

- Discontinuing operation of an inefficient and energy-intensive 2-Phase® extraction and thermal oxidation (ThOx) soil vapor treatment system within the OSA.

- Conversion of the groundwater treatment process at the Central Groundwater Treatment Plant (CGWTP) from an energy-intensive ultraviolet oxidation (UV/Ox) system to LGAC.

The cost-efficiency of the groundwater treatment process at the CGWTP was improved, resulting in lower treatment costs, less energy usage, and a reduced carbon footprint.

2.2.2.3 Site SS030 GET System

A portion of the off-base Site SS030 plume appeared to be migrating eastward and under the hydraulic influence of the adjacent Site FT005 GET system. Therefore, operation of the Site SS030 GET system was modified in 2011 to improve the hydraulic capture of the off-base plume. As described in Section 8.3 of the 2011 Annual RPO Report (CH2M HILL, 2012d), operational changes (i.e., RPO) to the existing GET system were made to maintain hydraulic capture for the entirety of the plume by increasing the rate of groundwater extraction. Groundwater monitoring data obtained under the GSAP and GRIP demonstrated that hydraulic capture of the plume was achieved and that TCE concentrations within the eastern side of the plume are declining (CH2M HILL, 2012d). Further optimization of the GET system will be conducted during 2013 by installing an additional extraction well to improve hydraulic capture of the off-base plume and reduce the wear on the existing extraction well pumps resulting from sustained high-speed operation.

2.2.3 Demonstrations of ERD Treatment Processes

Over time, the energy-intensive IRA GET systems used at several sites became less efficient and cost-effective as VOC concentrations within the portions of the plumes with the highest concentrations of residual contamination declined at an ever-decreasing rate. Therefore, beginning in 2008, in situ ERD treatment within the portions of the plumes with highest concentrations of residual contamination, consisting of in situ bioreactors and injection of EVO, was initiated to demonstrate the viability of ERD and support selection of final groundwater remedies. These demonstrations include provisions for GSR by reducing energy usage and generation of greenhouse gases (GHGs). Summaries of these bioreactors and EVO injections are provided below.

2.2.3.1 Bioreactors

Beginning in 2008, in situ bioreactors were installed within the portions of the Site SS016 and Site DP039 plumes with the highest concentrations of residual contamination as described further below:

- **Site SS016 Bioreactor –** During September 2010, operation of an existing 2-Phase® extraction and ThOx treatment system within the OSA was discontinued. Following additional plume characterizations, as described in Section 3 of the BIR (CH2M HILL, 2012f) and in Section 5.2 of the 2011 Annual RPO Report (CH2M HILL, 2012d), an in situ bioreactor was installed within the portion of the plume with the highest concentrations of residual contamination, operation of an existing OSA horizontal extraction well (EW003x16) was modified to use a solar-power pump to provide source water to the bioreactor, and the performance monitoring well network was expanded. The bioreactor at Site SS016 has been in operation since 2010.

- **Site DP039 Bioreactor –** In November 2008, as described in Section 5.1 of the 2011 Annual RPO Report (CH2M HILL, 2012d), a bioreactor was installed in the portion of the Site DP039 plume with the highest concentrations of residual contamination, operation of the existing IRA GET system was discontinued, a solar-power system was installed to provide contaminated groundwater to the bioreactor from a nearby extraction well, and the performance monitoring well network was expanded. The bioreactor at Site DP039 has been in operation since 2008.

The bioreactors installed at Sites SS016 and DP039 have successfully demonstrated the viability of in situ ERD treatment processes as a component of groundwater remediation at Travis AFB. At both sites, performance monitoring results indicate that in situ ERD processes are achieving a high rate of VOC removal efficiency, as discussed in Sections 5.1 and 5.2 of the 2011 Annual RPO Report (CH2M HILL, 2012d). Chlorinated VOCs, including TCE, cis-1,2-DCE, and vinyl chloride are being effectively degraded within each bioreactor. There is also evidence of TCE reduction in the aquifer hydraulically downgradient of each bioreactor, although the zone of treatment appears limited to the groundwater within approximately 30 feet of each bioreactor.

2.2.3.2 EVO Injections

Beginning in 2010, EVO was injected within the portions of the Site SS015, SD036, SD037, and DP039 plumes with the highest concentrations of residual contamination as described further below:

- **Site SS015 EVO Injection –** Data collected during the period of MNA assessment indicated increasing concentrations of COCs in some site monitoring wells and that the plume was likely migrating. As described in Section 2 of the BIR (CH2M HILL, 2012f) and in Section 6.4 of the 2011 Annual RPO Report (CH2M HILL, 2012d), following additional characterization conducted in 2010, supplemental injection of EVO within the portion of the plume with the highest concentrations of residual contamination was conducted, and the performance monitoring well network was expanded.
- **Site SD036 EVO Injection –** Relatively high concentrations of COCs remained in a localized portion of the plume after about 10 years of IRA GET system operation, which provided a continuing source of contamination into hydraulically downgradient portions of the plume. As described in Section 5 of the BIR (CH2M HILL, 2012f) and in Section 6.2 of the 2011 Annual RPO Report (CH2M HILL, 2012d), following additional characterization conducted in 2010, operation of the GET system was discontinued, injection of EVO within a portion of the plume with the highest concentrations of residual contamination was conducted, and the performance monitoring well network was expanded.
- **Site SD037 EVO Injection –** Similar to Site SD036, relatively high contaminant concentrations remained in a localized portion of the Site SD037 plume after years of IRA GET system operation, providing a continuing influx of contamination into hydraulically downgradient portions of the plume. As described in Section 6 of the BIR (CH2M HILL, 2012f) and in Section 6.3 of the 2011 Annual RPO Report (CH2M HILL, 2012d), following additional characterization in 2010, operation of the GET system was discontinued, injection of EVO within a portion of the plume with the highest

concentrations of residual contamination was conducted, and the performance monitoring well network was expanded.

- **Site DP039 EVO Injection –** A portion of the Site DP039 plume appeared to be migrating hydraulically downgradient of the former Site DP039 acid neutralization sump. As described in Section 7 of the BIR (CH2M HILL, 2012f) and in Section 6.1 of the 2011 Annual RPO Report (CH2M HILL, 2012d), following additional characterization in 2010, a PRB of injected EVO was installed during the summer of 2010 to intercept the plume at the 500-microgram-per-liter (µg/L) TCE isocontour, and the performance monitoring well network was expanded. The EVO PRB demonstration is located hydraulically downgradient of the Site DP039 bioreactor and an area of trees planted to study the viability of phytoremediation at the site.

The EVO injections conducted at Sites SS015, SD036, SD037, and DP039 have successfully demonstrated the viability of in situ ERD treatment processes as a component of groundwater remediation at Travis AFB. At each of the sites, performance monitoring results indicate that in situ ERD processes are achieving a high rate of VOC treatment efficiency. Chlorinated VOCs, including TCE, cis-1,2-DCE, and vinyl chloride, are being effectively degraded within the treatment zones (CH2M HILL, 2012d).

2.2.4 Demonstration of Phytoremediation

A treatability study of phytoremediation at Site DP039 was initiated in August 1998 to assess the effectiveness of planted trees to hydraulically control and remove VOC contamination from groundwater and to support selection of final groundwater remedies. A total of 2.24 acres of red ironbark eucalyptus trees were planted. In 2005, the initial evaluation concluded that, as the eucalyptus trees continue to mature, they have the potential to remediate the TCE-contaminated groundwater at the site (Parsons, 2005). At the time of the evaluation, the root systems of the trees were found to have reached the water table and contaminants were being removed through transpiration processes.

In 2010, as described in the *Phytostabilization at Travis Air Force Base, California* technical report (Parsons, 2010), another evaluation was conducted to further assess the potential of the tree stand as a remedy component at Site DP039. After approximately 14 years of study, it was successfully demonstrated that phytoremediation can be a viable component of groundwater remediation at the site. Among the key findings of the study was that phytoremediation poses a beneficial impact to the goal of reducing groundwater contaminant concentrations. Tree growth has been good, and the trees are taking up TCE in the contaminated groundwater. The overall TCE removal rate within the phytoremediation study area is currently about 2 pounds per year. In the future, maximum removal rates could rise to more than 15 pounds per year as the trees mature (Parsons, 2010).

2.2.5 MNA Assessments and Studies

With the exception of Site LF006, for which an IRA of MNA was specified, the IRODs deferred formal selection of MNA as an interim remedy, at all or portions of groundwater sites, until assessments of the viability of natural attenuation processes were conducted. Consequently, MNA assessments and studies have been conducted on an ongoing basis for approximately a decade to evaluate the viability of natural attenuation processes and to

support selection of final groundwater remedies. These assessments and studies included the following three (3) basic components or lines of evidence:

- **Interim MNA Assessments –** As described in the NAAR (CH2M HILL, 2010b) and the FFS, Appendix C – Lines of Evidence for MNA (CH2M HILL, 2011a), long-term groundwater sampling, laboratory analyses, and data evaluation were conducted at all or part of Sites FT004 and LF006, Subareas LF007B and LF007D, and Sites SS015, ST027B, SD031, SD033, SD034, SS035, SD036, SD037, and DP039 over the interim period leading up to this Groundwater ROD to assess the viability of using natural attenuation processes to remediate groundwater. Of these, only Site LF006 was specified for an IRA of MNA. MNA assessment over the interim period was specified for Site FT004, Subareas LF007B and LF007D, and Sites SS015, ST027B, SD031, SD033, SD034, SS035, SD036, SD037, and DP039. No IRA was established for NEWIOU Site ST027B, because the presence of chlorinated VOCs was unknown when the Groundwater IROD for the NEWIOU was finalized; however, MNA assessment has been ongoing at this site since 2008. Data supporting the physical attenuation process of volatilization at Travis AFB were also provided by the Site DP039 phytoremediation treatability study (Parsons, 2010).
- **Aerobic Chlorinated Cometabolism Enzyme Study –** As described in the *Technical Memorandum for Assessment of Aerobic Chlorinated Cometabolism Enzymes at Travis Air Force Base, California* (CH2M HILL, 2012b), groundwater sampling, laboratory analyses, and data evaluation were conducted at two (2) sites in 2012 to assess whether there may be a biological component to MNA at Travis AFB through aerobic chlorinated cometabolism. Data supporting a biological component of attenuation were provided by the aerobic cometabolism enzyme study. The aerobic cometabolic enzyme study indicated potential for aerobic cometabolism at similar, but non-contiguous, Sites FT004 and DP039. It is likely that cometabolic enzymes are widespread at Travis AFB sites, assuming site geochemical and contaminant histories are consistent. The study concluded that cometabolic activity may be contributing to contaminant natural attenuation at other Travis AFB sites.
- **Rebound Studies –** As described in Section 7 of the 2011 Annual RPO Report (CH2M HILL, 2012d), after approximately a decade of GET system operation, GET was discontinued, and site-specific groundwater sampling, laboratory analyses, and data evaluation were conducted at multiple sites starting in 2007 to assess whether natural attenuation processes can be used to remediate groundwater contamination. Post-GET rebound studies were conducted at the following sites: FT004, FT005, LF008, SD031, SD033, SD034, SS035, SD036, SD037, SS041, and SD043.

Based on data collected from one (1) or more of the assessments and studies listed above, the performance of natural attenuation over the interim period (referred to below as "Interim MNA Performance") at Sites FT004 and LF006, Subareas LF007B and LF007D, and Sites LF008, SS015, ST027B, SD031, SD033, SD034, SS035, SD036, SD037, DP039, and SD043 is summarized in the following subsections and in Table 2.2-3.

2.2.5.1 Interim MNA Performance at Sites FT004 and SD031

The primary groundwater COCs are TCE (Site FT004) and 1,1-DCE (Site SD031). More than a decade of groundwater monitoring data are available for these sites. The NAAR concluded that natural attenuation was occurring in the distal portion of the plume beyond the influence of the GET system (CH2M HILL, 2010b).

A rebound study began in 2007 and lasted for 1 year, when select Site FT004 and all of the Site SD031 extraction wells were shut down (CH2M HILL, 2012d). No significant rebound occurred over the 1-year period and it was determined that the rebound study would continue during the interim period and include all of the Site FT004 and Site SD031 extraction wells. As a whole, the groundwater plume has remained stable. TCE concentrations have remained stable or continued to decline in 74 percent of the wells monitored (CH2M HILL, 2012d). Similarly, 1,1-DCE concentrations have been stable or continued to decline in 100 percent of the wells monitored. In addition, continued decreasing concentrations in the portions of the Site FT004 plume with the highest concentrations of residual contamination indicate that these portions of the plume have been effectively addressed by groundwater extraction (CH2M HILL, 2012d). The rebound study at Sites FT004 and SD031 is ongoing.

Data supporting a biological component of attenuation were provided by the aerobic cometabolism enzyme study performed subsequent to the NAAR. The aerobic cometabolism enzyme study demonstrated the presence of bacteria that produce TCE cometabolic enzymes at Site FT004 and that the cometabolic enzymes are active in samples collected from the site. The study results indicated potential for intrinsic aerobic biodegradation (cometabolism) at Site FT004 (CH2M HILL, 2012d).

The absence of a continuing source and decreasing contaminant concentration trends indicate that the conditions at Sites FT004 and SD031 are suitable for an MNA remedy.

2.2.5.2 Interim MNA Performance at Site FT005

Site FT005 was not included in the NAAR because MNA assessment was not included in the IRA. However, by 2007, the concentrations of the primary contaminant (1,2-DCA) at Site FT005 had decreased, and the plume had contracted to such an extent that continued extraction had become cost-ineffective. A contaminant rebound study was initiated in 2007. Over the course of the rebound study (2007 through 2011), 1,2-DCA concentrations rebounded in only three (3) wells, indicating that GET is reaching its limit of effectiveness (CH2M HILL, 2012d).

The absence of a continuing source, generally decreasing contaminant concentration trends over the course of the rebound study, and a receding plume indicate that Site FT005 will soon be suitable for an MNA remedy. However, the rebound study data do not fully support an MNA remedy at the site. Recently observed increases in the concentrations of COCs at some wells indicate that continuation of GET system operation within those portions of the plumes is warranted.

2.2.5.3 Interim MNA Performance at Site LF006

The primary groundwater COC at Site LF006 is TCE. More than a decade of groundwater monitoring data are available for this site. The NAAR concluded that natural attenuation

was occurring at Site LF006 and that MNA is an appropriate remedy for the site (CH2M HILL, 2010b). Data from 13 years of groundwater monitoring at Site LF006 indicate that the plume is contained and has decreased in size over time (CH2M HILL, 2012a). TCE concentrations are decreasing throughout the plume. In 2011, TCE was the only contaminant to exceed interim remediation goals (IRGs). The maximum concentration of TCE detected in 2011 was 7.1 J- (estimated value) µg/L (CH2M HILL, 2012a).

The absence of a continuing source, decreasing contaminant concentration trends, and a receding plume indicate that Site LF006 is suitable for an MNA remedy.

2.2.5.4 Interim MNA Performance at Subarea LF007B

More than a decade of groundwater monitoring data are available for this site. The NAAR concluded that MNA is an appropriate remedy for the site because no groundwater COCs have been detected at Subarea LF007B for several years (CH2M HILL, 2010b). Since the NAAR was completed, the site has continued to be monitored for natural attenuation. No groundwater contaminants have been detected in the years following the NAAR (CH2M HILL, 2010b). However, in accordance with regulatory agencies requirements, at least 2 more years of monitoring will be conducted to confirm that cleanup levels have been achieved.

2.2.5.5 Interim MNA Performance at Subarea LF007D

The primary groundwater COCs at Subarea LF007D are 1,4-DCB and benzene. More than a decade of groundwater monitoring data are available for this site. The NAAR concluded that natural attenuation was occurring at Subarea LF007D and that MNA is an appropriate remedy for the site (CH2M HILL, 2010b). Groundwater contaminants (1,4-DCB and benzene) exceed MCLs at only one (1) monitoring well, MW261x07 (CH2M HILL, 2012a). The 1,4-DCB plume is contracting, as evidenced by decreasing concentration trends. The benzene plume is stable and was only detected at one (1) well at concentrations that fluctuate between 2 and 3 µg/L (compared with an MCL of 1 µg/L) (CH2M HILL, 2012a; CH2M HILL, 2012g).

The NAAR concluded that the portion of the plume where contaminants exceed MCLs is anaerobic and that anaerobic biodegradation of 1,4-DCB is occurring (CH2M HILL, 2010b). During this biodegradation process, 1,4-DCB degrades to chlorobenzene, and chlorobenzene degrades to benzene. This degradation pathway is likely contributing to the relatively constant concentrations of benzene observed in the site groundwater. In the portion of the plume where contaminant concentrations are below MCLs, geochemical data indicate aerobic conditions. After degradation of 1,4-DCB is complete (estimated to reach 5 µg/L in approximately 19 years), aquifer conditions near well MW261x07 are expected to gradually become aerobic and more conducive to the aerobic biodegradation of benzene. Oxygen reduction potential (ORP) and dissolved oxygen (DO) will continue to be monitored at this well to evaluate whether aquifer conditions are aerobic or anaerobic.

If conditions at well MW216x07 do change from anaerobic to aerobic once 1,4-DCB has been degraded, physical attenuation of benzene will occur. In the absence of biodegradation, benzene concentrations are estimated to reach 1 µg/L in approximately 4 years through physical attenuation processes only (CH2M HILL, 2012g).

The absence of a continuing source, decreasing 1,4-DCB concentration trends, receding 1,4-DCB plume, and stable benzene plume indicate that Subarea LF007D is suitable for an MNA remedy.

2.2.5.6 Interim MNA Performance at Site LF008

A contaminant rebound study was conducted at Site LF008 after the IRA GET system was shut down during the period of interim remediation. Groundwater contamination at Site LF008 consists of organochlorine pesticides, primarily alpha-chlordane. The source of the pesticides in soil was remediated in 2003 by excavation (Shaw Environmental, Inc., 2004). Site LF008 was not included in the NAAR because natural attenuation assessment was not included in the IRA. However, by 2008, after 7.5 years of groundwater extraction, no significant change in pesticide concentrations was evident at Site LF008. Therefore, a contaminant rebound study was initiated in 2008.

Over the course of the rebound study (2008 through 2011), no rebound of the pesticide plume has been evident (CH2M HILL, 2012d). The primary mechanism for attenuation at Site LF008 is likely sorption of the pesticides to the soil. The physical properties of pesticides result in a very low subsurface mobility because of strong sorption to the soil. The site sediments have a high clay content, which increases sorption and also reduces permeability (CH2M HILL, 2011a). Comparisons of filtered and non-filtered groundwater samples indicated that no detectable concentrations were in the filtered samples. This result indicates that the contamination is not dissolved in the groundwater, but rather sorbed to the fine soil particles suspended in the groundwater (CH2M HILL, 2012g).

The absence of a continuing source, stable or decreasing contaminant concentration trends over the course of the rebound study, a contracting plume, and the results of filtered versus non-filtered sample analyses indicate that Site LF008 is suitable for an MNA remedy.

2.2.5.7 Interim MNA Performance at Site SS015

The primary groundwater COCs at Site SS015 are TCE, cis-1,2-DCE, and vinyl chloride. The plume was stable for several years, but by 2009 appeared to be migrating (CH2M HILL, 2010b). In response to the plume migration, injection of EVO within the portion of the plume with the highest concentrations of residual contamination was initiated to demonstrate the viability of ERD during 2010 and 2011 (CH2M HILL, 2012d). Since the EVO injection, the combined mass of TCE, cis-1,2-DCE, and vinyl chloride declined by more than 99 percent in the treatment zone (CH2M HILL, 2012d).

The distal portion of the plume, beyond the treatment zone, is being monitored for natural attenuation. Because the extent of downgradient contamination was recently defined (2010), the monitoring history in the distal plume is insufficient to determine long-term concentration trends. However, the limited monitoring history does indicate declines in TCE, cis-1,2-DCE, and vinyl chloride concentrations in several distal monitoring wells between 2010 and 2011 (CH2M HILL, 2012d, 2012a). Between 2010 and 2011, TCE concentrations declined 70 percent and cis-1,2-DCE concentrations declined 77 percent at a monitoring well located approximately 75 feet downgradient. The decline in contaminant concentrations is likely primarily due to reduction in mass loading from the portion of the plume with the highest concentrations of residual contamination (CH2M HILL, 2012d).

Since EVO injection, only one (1) monitoring well located approximately 175 feet downgradient of the injection area, MW625x15, has continued to have increasing TCE, cis-1,2-DCE, and vinyl chloride concentrations (CH2M HILL, 2012d). COC concentrations are expected to decline in response to the reduction in mass loading to the aquifer, as they have at wells located closer to the injection area.

The decreasing contaminant concentrations in most of the distal plume wells since their installation in 2010 indicate that natural attenuation processes are a suitable component of a remedy at the site.

2.2.5.8 Interim MNA Performance at Site ST027B

The primary groundwater COC is TCE. The monitoring history for the TCE plume at Site ST027B is relatively short (4 years) when compared with the other chlorinated solvent plumes at Travis AFB. However, over the 4 years, the TCE plume has been stable. No plume or downgradient monitoring wells have increasing TCE concentration trends (CH2M HILL, 2012a). In addition, a TCE bulk attenuation rate constant of 1.1 per year has been calculated for the Site ST027B TCE plume. The positive bulk attenuation rate constant indicates that attenuation of TCE is occurring (CH2M HILL, 2011a).

The absence of a continuing source and a stable TCE plume indicate that Site ST027B is suitable for an MNA remedy.

2.2.5.9 Interim MNA Performance at Sites SD033, SD034, SS035, SD036, SD037, and SD043

The primary groundwater COC is TCE. More than a decade of groundwater monitoring data are available for the commingled groundwater plume from Sites SD033, SD034, SS035, SD036, SD037, and SD043. While the GET that addressed the groundwater plume was operational, the contaminant concentrations in the area beyond the influence of the GET system declined, and the plume was receding. The NAAR concluded that natural attenuation was occurring in the distal portion of the plume beyond the influence of the GET (CH2M HILL, 2010b).

The GET systems were shut down in April 2010 to support injection of EVO within the portions of the Site SD036 and Site SD037 plumes with the highest concentrations of residual contaminations to demonstrate the viability of ERD and to initiate a rebound study. Over a period of 1.5 years (April 2010 through December 2011), the groundwater plume has remained stable, with contaminant concentrations either stable or continuing to decline in 85 percent of the wells monitored for rebound (CH2M HILL, 2012d).

Portions of the Site SD036 and SD037 plumes with the highest concentrations of residual contamination are being addressed by the ongoing demonstrations of ERD treatment via EVO injection. Groundwater COCs at Sites SS035 and SD043 are now below MCLs (CH2M HILL, 2010c, 2012a). At Site SD034, the presence of hydrocarbons (Stoddard solvent) may enhance biodegradation; in 2011, the only volatile COCs to exceed MCLs at this site were TCE and vinyl chloride. The maximum detections of both COCs only slightly exceeded the MCLs. TCE was detected at a maximum concentration of 5.8 µg/L (the MCL is 5 µg/L), and vinyl chloride was detected at a maximum concentration of 1.6 µg/L (the MCL is 0.5 µg/L) (CH2M HILL, 2012a). Residual groundwater contamination at Site SS033 is commingled with groundwater contamination from Sites SD036 and SD037; monitoring

wells from all three (3) of these sites are used to monitor the distal portion of the plume. Stable and decreasing contaminant concentrations in most of the distal plume wells at Sites SS033, SD036, and SD037 over the rebound study period indicate that MNA is a suitable component of the remedy for the plume.

2.2.5.10 Interim MNA Performance at Site DP039

The IRA at Site DP039 is GET within the portion of the plume with the highest concentrations of residual contamination combined with natural attenuation in the distal portion of the plume. The primary groundwater COC is TCE. In addition to GET, which was performed from 2000 to 2008, several technology demonstrations and treatability studies have been performed at Site DP039, including a bioreactor, a phytoremediation treatability study/demonstration, and an EVO PRB. Operation of the IRA GET system within the portion of the plume with the highest concentrations of residual contamination was discontinued in 2008 to support the installation and operation of the in situ bioreactor. The initial planting of the trees within the phytoremediation area was performed in 1998.

The portion of the plume evaluated by the NAAR was hydraulically downgradient and outside the area of influence of the GET system, bioreactor, and area of phytoremediation. The NAAR concluded that attenuation was occurring in portions of the plume; however, increasing concentrations in some monitoring wells indicated natural attenuation alone would likely be inadequate to prevent future plume migration (CH2M HILL, 2010b). In response to this potential migration of portions of the plume, a demonstration of ERD treatment using an EVO PRB was begun in 2010. The EVO PRB intercepted the portion of the plume where TCE concentrations exceed 500 µg/L. Monitoring data indicate that the EVO PRB is successfully performing as designed (CH2M HILL, 2012d).

Data supporting the occurrence of the physical attenuation process of volatilization at Site DP039 were obtained as part of the Site DP039 phytoremediation treatability study (Parsons, 2010).

The aerobic cometabolism enzyme study demonstrated the presence of bacteria that produce TCE cometabolic enzymes at Site DP039 and that the cometabolic enzymes are active in samples collected from the site. The study results indicated potential for intrinsic aerobic biodegradation at the site (CH2M HILL, 2012b).

The portion of the Site DP039 plume where TCE concentrations exceed 500 µg/L is being addressed by a combination of an in situ bioreactor, phytoremediation, and an EVO PRB. These remedies reduce the mass loading to the aquifer and enhance the natural attenuation at the site. The stable and decreasing contaminant concentrations in several hydraulically downgradient wells in addition to data supporting the occurrence of the physical attenuation process of volatilization and the biological attenuation process of aerobic cometabolism indicate that MNA is a suitable component of the remedy for Site DP039.

2.2.6 Vapor Intrusion Assessment

During 2008-2009, Travis AFB conducted a vapor intrusion assessment to evaluate whether inhalation of VOCs migrating from groundwater into indoor air pose a risk to human health based on current and future site conditions at Sites FT004, FT005, LF006, LF007 (inclusive of Subareas LF007B, LF007C, and LF007D), LF008, SS015, SS016, ST027B, SS029, SS030, SD031,

ST032 (now a POCO site), SD033, SD034, SS035, SD036, SD037, DP039, and SD043. Investigations, including monitoring of shallow soil gas, soil vapor under building floor subslabs, building indoor air, and outdoor air, were conducted in accordance with the *Vapor Intrusion Assessment Work Plan* (CH2M HILL, 2008c), and the findings of the assessment are provided in the *Vapor Intrusion Assessment Report* (CH2M HILL, 2010a).

An update to the *Vapor Intrusion Assessment Report* (CH2M HILL, 2010a) was completed in 2013 because the toxicity values for several of the chemicals evaluated, including TCE and PCE, had changed since the vapor intrusion assessment was performed during 2008-2010. This 2013 update included all of the sites previously assessed. The results are provided in the final *Vapor Intrusion Assessment Report Update* (CH2M HILL, 2013a).

2.2.7 Technical and Economic Feasibility Analysis

In 2012, a TEFA was conducted to evaluate the technical and economic feasibility of reducing groundwater contaminant concentrations to background levels in accordance with the intent of State Water Board Resolution 92-49 (Policies and Procedures for Investigation and Cleanup and Abatement of Discharges under Water Code Section 13304. The TEFA concluded that it was not technically feasible, and thus also not economically feasible, to achieve cleanup of contaminated groundwater at Travis AFB to background concentrations (CH2M HILL, 2012h).

TABLE 2.2-1
Chronology of Key Events
Groundwater Record of Decision, Travis Air Force Base, California

Date(s)	Event
1983	Phase I PA
1983 to 1994	IRP investigations
1983 to 1989	Pre-NPL responses
November 1989	NPL listing
September 1990	FFA signed (Travis AFB, 1990)
1991	Travis AFB CRP
1993 to present	Fact sheets describing restoration program activities and milestones published
1993	FFA renegotiated to create four (4) OUs: NOU, EIOU, WIOU, and WABOU
1995	Final CRP
1995	Travis AFB RAB formed
1995	CGWTP online
1995 to present	Quarterly restoration program newsletter published and mailed
1995 to 1997	CERCLA RI for NOU, EIOU, WIOU, and WABOU (Radian, 1995; Weston, 1995; Radian, 1996a; CH2M HILL, 1997)
May 1995	Comprehensive Basewide ERA – Tier 1 (CH2M HILL, 1995)
October 1995	FFA amended to consolidate NOU, EIOU, and WIOU into the NEWIOU
May 1996	Comprehensive Basewide ERA – Tier 2 (CH2M HILL, 1996)
1996 to 1998	CERCLA FS for NEWIOU and WABOU (Radian, 1996b; CH2M HILL, 1998a)
January 1998	Final NEWIOU Groundwater IROD (Travis AFB, 1998); groundwater IRAs initiated at NEWIOU Sites FT004, FT005, LF006; Subareas LF007B, LF007C, and LF007D; and Sites LF008, SS015, SS016, ST027B, SS029, SS030, SD031, SD033, SD034, SS035, SD036, and SD037
1998	Travis AFB CRP revised
1998	SBBGWTP online; interim GET system operation initiated at Sites FT005, SS030, and SS029
1998	Site DP039 phytoremediation treatability study began (CH2M HILL, 2012a)
June 1999	Final WABOU Groundwater IROD (Travis AFB, 1999); groundwater IRAs initiated at WABOU Sites LF008, DP039, SS041, and SD043
2000	WTTP online; interim GET system initiated at Sites LF008, SD033, SD034, SS035, SD036, SD037, SS041, SD043, and DP039
2000	NGWTP online; interim GET system initiated at Sites FT004 and SD031
2000 to 2001	Site SS015 vegetable oil treatability study (CH2M HILL, 2012a)
August 2001	CIP (initial)
December 2002	Final Soil ROD for the WABOU (Travis AFB, 2002a)
December 2002 to April 2003	ThOX system offline for rebound study (CH2M HILL, 2012d)
February 2003	WTTP SVE system offline for rebound study (CH2M HILL, 2012d)

TABLE 2.2-1
Chronology of Key Events
Groundwater Record of Decision, Travis Air Force Base, California

Date(s)	Event
July 2003	CIP updated
July 2003	First Five-year Review of groundwater IRAs
January 2004	Final *Annual Report on the Status of Land Use Controls on Restoration Sites in 2003* (Travis AFB, 2004)
January 2005	Final *Annual Report on the Status of Land Use Controls on Restoration Sites in 2004* (Travis AFB, 2005b)
December 2005	Final Category IV No Further Remedial Action Planned Consensus Statement for Site SS041 (Travis AFB, 2005a)
February 2006	*Central Groundwater Treatment Plant, North Groundwater Treatment Plant, and South Base Boundary Groundwater Treatment Plant 2005 Annual Report* (CH2M HILL, 2006)
February 2006	Final *Annual Report on the Status of Land Use Controls on Restoration Sites in 2005* (Travis AFB, 2006b)
April 2006	CIP updated
May 2006	Final NEWIOU Soil, Sediment, and Surface Water ROD (Travis AFB, 2006a)
January 2007	*Central Groundwater Treatment Plant, North Groundwater Treatment Plant, and South Base Boundary Groundwater Treatment Plant 2006 Annual Report* (CH2M HILL, 2007)
January 2007	Final *Annual Report on the Status of Land Use Controls on Restoration Sites in 2006* (Travis AFB, 2007)
December 2007	Rebound studies initiated at Site FT004 (partial GET system shutdown) and Site SD031 (full GET system shutdown); rebound study initiated at Site FT005 (partial GET system shutdown) (CH2M HILL, 2012a)
January 2008	Final *Annual Report on the Status of Land Use Controls on Restoration Sites in 2007* (Travis AFB, 2008)
February 2008	*Central Groundwater Treatment Plant, North Groundwater Treatment Plant, and South Base Boundary Groundwater Treatment Plant 2007 Annual Report* (CH2M HILL, 2008c)
September 2008	Second Five-year Review of groundwater IRAs
October 2008	Site DP039 groundwater and vapor extraction offline for bioreactor sustainability study (CH2M HILL, 2012d)
December 2008	Rebound study initiated at Site LF008 (full GET system shutdown) (CH2M HILL, 2012a)
January 2009	Site SS015 natural attenuation assessment (CH2M HILL, 2012a)
January 2009	ERD treatment demonstration using a bioreactor initiated at Site DP039 (CH2M HILL, 2012d)
February 2009	Final *Annual Report on the Status of Land Use Controls on Restoration Sites in 2008* (Travis AFB, 2009)
February 2009	Remaining Site FT004 extraction wells taken offline for rebound study (CH2M HILL, 2012d)
June 2009	*2008 Annual Remedial Process Optimization Report for the Central Groundwater Treatment Plant, North Groundwater Treatment Plant, and South Base Boundary Groundwater Treatment Plant* (CH2M HILL, 2009b)
August 2009	WTTP SVE extraction system offline for rebound study (CH2M HILL, 2012d)
March 2010	Final *Vapor Intrusion Assessment Report* (CH2M HILL, 2010a)

TABLE 2.2-1
Chronology of Key Events
Groundwater Record of Decision, Travis Air Force Base, California

Date(s)	Event
April 2010	Final *Annual Report on the Status of Land Use Controls on Restoration Sites in 2009* (Travis AFB, 2010)
April 2010	Rebound studies initiated at WIOU Sites SD033, SD034, SS035, SD036, SD037, and SD043; WTTP offline and ThOx system taken offline (CH2M HILL, 2012d)
June – July 2010	ERD treatment demonstration using an injected EVO PRB initiated at Site DP039 (CH2M HILL, 2012f)
July 2010	*2009 Annual Remedial Process Optimization Report for the Central Groundwater Treatment Plant, North Groundwater Treatment Plant, and South Base Boundary Groundwater Treatment Plant* (CH2M HILL, 2010d)
July 2010	Final NAAR (CH2M HILL, 2010b)
September 2010	ERD treatment demonstration using a bioreactor initiated at Site SS016 (CH2M HILL, 2012f)
October – December 2010	ERD treatment demonstrations using EVO injection initiated at Sites SD036 and SD037 (CH2M HILL, 2012f)
December 2010 – January 2011	ERD treatment demonstration using EVO injection initiated at Site SS015 (CH2M HILL, 2012f)
February 2011	Final *Annual Report on the Status of Land Use Controls on Restoration Sites in 2010* (Travis AFB, 2011)
September 2011	*2010 Annual Remedial Process Optimization Report for the Central Groundwater Treatment Plant, North Groundwater Treatment Plant, and South Base Boundary Groundwater Treatment Plant* (CH2M HILL, 2011b)
October 2011	Final FFS (CH2M HILL, 2011a)
February 2012	Final *Annual Report on the Status of Land Use Controls on Restoration Sites in 2011* (Travis AFB, 2012a)
March 2012	Final BIR (CH2M HILL, 2012f)
May 2012	Final TEFA (CH2M HILL, 2012h)
September 2012	Final *Technical Memorandum for Assessment of Aerobic Chlorinated Cometabolism Enzymes* (CH2M HILL, 2012b)
October 2012	2011 Annual RPO Report (CH2M HILL, 2012d)
October 2012	Final *Proposed Plan for Groundwater Cleanup* (Travis AFB, 2012b)
December 2012	Final *2012 Groundwater Sampling and Analysis Program Technical Memorandum* (CH2M HILL, 2012g)
January 2013	Final *Annual Report on the Status of Land Use Controls on Restoration Sites in 2012* (Travis AFB, 2013)
February 2013	Final *Vapor Intrusion Assessment Report Update* (CH2M HILL, 2013a)
September 2013	Third Five-year Review of groundwater IRAs

Notes:

CIP = Community Involvement Plan
CRP = Community Relations Plan
ERA = Ecological Risk Assessment
NGWTP = North Groundwater Treatment Plant
RAB = Restoration Advisory Board
SBBGWTP = South Base Boundary Groundwater Treatment Plant
SVE = soil vapor extraction
WTTP = West Treatment and Transfer Plant

TABLE 2.2-2
Summary of Interim Remedial Action Performance and Status
Groundwater Record of Decision, Travis Air Force Base, California

Site	IRA	IRA Objectives	IRA Performance and Status	IRA Optimization Action, Technology Demonstration, or Study	Performance and Status of Optimization Action, Technology Demonstration, or Study
FT004 (NEWIOU)	MNA Assessment and GET	Assess viability of natural physical, chemical, and biological processes to remediate plume GET for source control	The combination of GET in the portion of the Site FT004 plume with the highest concentrations of residual contaminations and MNA in the downgradient portions of the plume has been effective. Hydraulic capture of the portion of the plume with the highest concentrations of residual contamination was achieved using GET. The effectiveness of GET is further demonstrated by declining VOC concentrations observed in the majority of site monitoring wells. Declining trends are observed in both shallow and deep monitoring wells, indicating that both the horizontal and vertical extents of the target areas are being addressed. The Site FT004 GET system has been shut down for a rebound study for the remaining period of interim remediation because the VOC concentrations in the portion of the plume with the highest concentrations of residual contamination have declined. The maximum TCE concentrations during the 2010 GSAP were observed within two (2) localized and noncontiguous portions of the plume. These included 165 µg/L in MW266x04 and 130 µg/L in MW131x04. No other concentrations above 100 µg/L were observed at the site. MNA also appears to be a viable remedy at Site FT004. Overall, contaminant concentrations are stable or declining in the downgradient MNA assessment monitoring wells. The MNA network includes both shallow and deep monitoring wells. MNA appears to be effective throughout the entire thickness of the plume.	GET optimization: Air stripping discontinued and replaced with LGAC treatment at NGWTP. Rebound study: GET system shut down for a rebound study in 2007.	The preponderance of data obtained between 4Q07and 2Q11 indicates that significant rebound of chlorinated VOC concentrations is not occurring in the absence of GET system operations.
FT005 (NEWIOU)	GET	GET for migration control[a] GET for off-base remediation	The Site FT005 GET system has been effective. The existing GET system has achieved hydraulic capture of the plume and is controlling off-base contaminant migration. A large portion of the plume has been remediated to below detectable concentrations. The extraction wells in the areas of the plume where IRA objectives have been achieved have been shut down for a rebound study for the remainder of the interim period of remediation. GET system operations are continuing in areas of the plume where contaminant concentrations are above IRGs.	GET optimization: Air stripping discontinued and replaced with LGAC treatment at SBBGWTP. Rebound study: GET system partially shut down for a rebound study in 2007.	The preponderance of data obtained between 4Q07 and 4Q11 indicates that rebound of chlorinated VOC contamination within the plume is not generally occurring in the absence of GET system operations. Extraction well operation was resumed in several wells that exhibited localized rebound of contaminant concentrations.
LF006 (NEWIOU)	MNA	Use natural physical, chemical, and biological processes to remediate plume	MNA appears to be a viable remedy at Site LF006. Data from monitoring wells indicate that groundwater contamination at Site LF006 is not migrating, and no contaminants were detected at a concentration exceeding the IRG.	None	Monitoring to evaluate natural attenuation processes is continuing.
LF007B Subarea (NEWIOU)	MNA Assessment	Assess viability of natural physical, chemical, and biological processes to remediate plume	MNA appears to be a viable remedy at Subarea LF007B. No contaminants were detected in Subarea LF007B wells sampled during the 2009-2010 GSAP events.	None	Monitoring to evaluate MNA processes is continuing.
LF007C Subarea (NEWIOU)	MNA Assessment and GET	GET for migration control[b] GET for off-base remediation[c]	The migration control and off-base remediation IRA objectives for Subarea LF007C do not appear to be fully achieved. The existing GET system is not fully effective at hydraulically capturing and remediating the TCE plume. TCE continues to migrate off-base at concentrations above the TCE IRG of 5 µg/L. Optimization of the GET IRA is required. A data gaps investigation was performed during 2011 following USFWS approval of the request to reinitiate Section 7 consultation for activities within the vernal pool at the site. Based on the results of the investigation, optimization measures for the GET system will be conducted in 2013-2014. Modeling of optimization measures was used to confirm that the entirety of the on- and off-base portions of the plume will be hydraulically captured when they are completed.	GET optimization: Air stripping discontinued and replaced with LGAC treatment at NGWTP. GET system optimization will be conducted during 2013-2014. These optimization measures include achieving greater groundwater extraction rates and expanded hydraulic capture of the off-base plume by installation of a higher capacity extraction well pump and expansion of the solar panel array that provides electrical power to the pump.	Continuing to comply with seasonal site access and GET system operational constraints imposed by the USFWS. Most of the site is located off-base and is within a large vernal pool. In accordance with USFWS requirements, the site can only be accessed by personnel or vehicles and the GET system operated when the vernal pool is dry (USFWS, 2011, 2002).
LF007D Subarea (NEWIOU)	MNA Assessment	Assess viability of natural physical, chemical, and biological processes to remediate plume	MNA appears to be a viable remedy at Subarea LF007D. The plume is stable, but concentrations have not decreased significantly during the period of interim remediation. Groundwater contamination is currently limited to a small area in the vicinity of MW261x04. Within this area, PCGs are exceeded for 1,4-DCB (12.6 µg/L vs. PCG of 5 µg/L) and benzene (3 µg/L vs. PCG of 1 µg/L). Concentrations of 1,4-DCB have decreased during the period of interim remediation. However, long-term benzene concentrations have remained relatively stable at about 3 µg/L. Contaminants do not appear to be migrating off-base to the north or east of the site.	None	Monitoring to evaluate natural attenuation processes is continuing.

TABLE 2.2-2
Summary of Interim Remedial Action Performance and Status
Groundwater Record of Decision, Travis Air Force Base, California

Site	IRA	IRA Objectives	IRA Performance and Status	IRA Optimization Action, Technology Demonstration, or Study	Performance and Status of Optimization Action, Technology Demonstration, or Study
LF008 (WABOU)	GET	GET for migration control	The migration control IRA objective at Site LF008 was achieved by the GET system. Hydraulic capture of the portion of the plume with the highest concentrations of residual contamination was achieved. The distribution of contamination in monitoring wells also indicated hydraulic containment of the plume. The GET system had limited effectiveness at removing the residual organochlorine pesticide contamination. Concentrations are stable and not migrating. The GET system is currently shut down as part of a rebound study for the remainder of the period of interim remediation. No rebound of the pesticide plume has been evident during the rebound study (CH2M HILL, 2012d).The physical properties of pesticides result in a low subsurface mobility because of strong sorption to the soil. The site sediments have a high clay content, which increases sorption and also reduces permeability (CH2M HILL, 2011a). Comparisons of filtered and non-filtered groundwater samples indicated that no detectable concentrations were in the filtered samples. This result indicates that the contamination is not dissolved in the groundwater, but rather sorbed to the fine soil particles suspended in the groundwater.	Rebound study: GET system shut down for a rebound study in 2008.	The preponderance of data obtained at Site LF008 between 4Q08 and 2Q12 indicates that significant rebound of organochlorine pesticide concentrations is not occurring in the absence of GET system operations. Concentrations are decreasing in the absence of active pumping. The data indicate that residual pesticides are almost entirely sorbed to fine soil particles and not dissolved in the groundwater.
SS015 (NEWIOU)	MNA Assessment	Assess viability of natural physical, chemical, and biological processes to remediate plume	Monitoring data indicated that MNA was not successfully addressing Site SS015 contamination. The plume appeared to be migrating, and contaminant concentrations were increasing in some wells. The limited volume of EVO injected during a 2000-2001 vegetable oil injection treatability study was probably exhausted. Optimization of the MNA IRA was required, and supplemental injection of EVO was conducted during 2010 to enhance natural attenuation processes. The performance of the EVO treatment is being evaluated.	Technology demonstration: Data gaps investigation in 2010. Installation of injection wells in 2010. EVO injection in 2010. Installation of additional monitoring wells in 2010.	The demonstration of in situ ERD treatment via injection of EVO substrate has been successful at Site SS015. Performance monitoring results provide strong indications that the reductive dechlorination process is occurring within the treatment zone. Performance monitoring and evaluations of the EVO injection are ongoing.
SS016 (NEWIOU)	GET	GET for source control[d] GET for migration control[e]	Hydraulic capture of the TARA portion of the Site SS016 plume with the highest concentrations of residual contamination has been achieved. Within the OSA portion of the plume with the highest concentrations of residual contamination, concentrations have decreased, but the extent of hydraulic capture is less certain. Declining TCE concentrations in shallow and deep monitoring wells downgradient of the OSA and TARA portions of the plume with the highest concentrations of residual contamination indicate that the horizontal and vertical extents of the plume were being addressed by the existing GET system. However, even after several years of IRA operation, the highest TCE concentrations at Travis AFB were found in OSA horizontal extraction well EW003x16 (18,000 µg/L). Therefore, IRA optimization actions were taken during 2010. These actions included a data gaps investigation to more fully define the concentrations of residual contamination within the OSA. Based on the results of the data gaps investigation, operation of a 2-Phase® extraction/ThOx treatment was discontinued, and an in situ bioreactor was installed. The performance of the bioreactor is being evaluated. The portion of the commingled Site SS016 plume (OSA/TARA that is not hydraulically captured by the OSA and TARA source control GET systems) is eventually hydraulically captured by the downgradient Site SS029 GET system.	GET optimization: 2-Phase® extraction within OSA discontinued in 2010. UV/Ox and Th/Ox treatment discontinued in 2010. Groundwater treatment replaced by LGAC at CGWTP. Bioreactor demonstration: Data gaps investigation within OSA conducted in 2010. OSA bioreactor installation in 2010.	Analytical and geochemical data collected over 1 year of operation indicate that the Site SS016 bioreactor is performing as designed and has successfully demonstrated the viability of ERD treatment using this process. Performance monitoring and evaluation of the bioreactor is ongoing. Site SS016 access is limited. The site is adjacent to, or within, an active area of military flightline operations (i.e., parking apron, taxiways, and runways).
ST027B (NEWIOU)	MNA Assessment	Assess viability of natural physical, chemical, and biological processes to remediate plume	Site ST027B is located within the NEWIOU but is not included in the NEWIOU Groundwater IROD, and an IRA of MNA Assessment was not formally selected for the site. The entirety of Site ST027 was historically managed under the POCO program at Travis AFB because petroleum hydrocarbons were believed to be the only contaminants present at this site. The presumptive remedy for POCO sites with only petroleum fuel contamination is MNA. However, an investigation conducted in 2007 discovered TCE and several other chlorinated VOCs in groundwater in the southwestern part of the site. Therefore, the site was subsequently subdivided into two (2) portions: Site ST027A (fuels contamination only) and Site ST027B (CERCLA contaminants). Groundwater contamination within Site ST027B has been routinely monitored under the GSAP and natural attenuation processes assessed in the NAAR (CH2M HILL, 2010b) even though these actions were not specified in the NEWIOU Groundwater IROD.	Study: Data gaps investigation within Site ST027B conducted during 2010.	Monitoring to evaluate natural attenuation processes is continuing. Site is bounded by military flightline operations.
SS029 (NEWIOU)	GET	GET for migration control	The migration control IRA objective at Site SS029 has been achieved. The existing GET system has achieved hydraulic capture of the on-base plume and is effectively controlling potential off-base migration of the contaminant plume.	GET optimization: Air stripping discontinued and replaced with LGAC groundwater treatment at SBBGWTP. Study: Additional site characterization was conducted during 2012 to assess alternate remediation processes.	Monitoring to evaluate GET system performance is continuing. A large portion of the site is within an area of military flightline operations.

TABLE 2.2-2
Summary of Interim Remedial Action Performance and Status
Groundwater Record of Decision, Travis Air Force Base, California

Site	IRA	IRA Objectives	IRA Performance and Status	IRA Optimization Action, Technology Demonstration, or Study	Performance and Status of Optimization Action, Technology Demonstration, or Study
SS030 (NEWIOU)	GET	GET for source control GET for migration control GET for off-base remediation	The source control, migration control, and off-base remediation IRA objectives for the Site SS030 IRA have not been fully achieved. Contaminant concentrations are declining in all of the extraction wells and all but two (2) of the monitoring wells. The off-base plume is being captured on the southern and western sides of the plume. However, increasing TCE concentrations on the eastern side of the off-base plume indicate that contamination may be escaping hydraulic capture. The groundwater elevation contours derived from the 2Q10 GSAP sampling event indicate that the hydraulic capture in this eastern area of the plume has improved after several of the adjacent Site FT005 extraction wells were taken offline for a rebound study. Optimization of the GET IRA is required. Investigations were performed during 2010-2011 to clarify groundwater flow directions and hydraulic capture. Based on the results of the investigation, optimization measures for the current GET system are being conducted as required.	GET optimization: Air stripping discontinued and replaced with LGAC groundwater treatment at SBBGWTP. Increased groundwater extraction rates from existing wells to improve hydraulic capture of the off-base plume.	Monitoring to evaluate GET system performance is continuing. Most of the site is located on off-base private property.
SD031 (NEWIOU)	MNA Assessment and GET	Assess viability of natural physical, chemical, and biological processes to remediate plume GET for source control	The combination of GET in the portion of the Site SD031 plume with the highest concentrations of residual contamination and MNA in the downgradient portions of the plume has been effective. Hydraulic capture of the portion of the plume with the highest concentrations of residual contamination was achieved using GET. The effectiveness of GET is further demonstrated by declining VOC concentrations observed in the majority of site monitoring wells. Declining trends are observed in both shallow and deep monitoring wells, indicating both the horizontal and vertical extent of the target areas are being addressed. The Site SD031 GET system has been shut down for a rebound study for the remaining period of interim remediation, because VOC concentrations have declined. The maximum 1,1-DCE concentrations during the 2010 GSAP were observed within a localized portion of the plume. These included 78.8 µg/L in EW566x31 and 7.4 µg/L in EW567x31. MNA is a viable remedy at Site SD031. Overall, contaminant concentrations are stable or declining in the downgradient MNA assessment monitoring wells. The MNA network includes both shallow and deep monitoring wells. MNA has been shown to be effective throughout the entire thickness of the plume.	GET optimization: Air stripping discontinued and replaced with LGAC groundwater treatment at NGWTP. Rebound study: GET system shut down for a rebound study.	Monitoring to evaluate natural attenuation processes is continuing. The preponderance of data obtained between 4Q07 and 2Q11 indicates that significant rebound of chlorinated VOC concentrations is not occurring in the absence of GET system operations.
SD033 (NEWIOU)	MNA Assessment and GET	Assess viability of natural physical, chemical, and biological processes to remediate plume GET for migration control[g]	The GET system for WIOU Site SD033 achieved the migration control IRA objective. Estimates of the extent of hydraulic capture indicate that VOC concentrations above 100 µg/L were captured by the existing GET system. Decreasing trends of VOC concentrations are observed throughout the commingled WIOU plume. The decreasing trend is observed in both shallow and deep monitoring wells, indicating that the horizontal and the vertical extents of the plume were addressed by the GET system. In the southern (downgradient) area of the site, MNA appears to be a viable remedy. Groundwater contamination in this area is not migrating.	GET optimization: UV/Ox groundwater treatment discontinued in 2010 and replaced by LGAC at CGWTP. Rebound study: WIOU GET system, including Site SD033, shut down for a rebound study.	Monitoring to evaluate natural attenuation processes is continuing. The preponderance of data obtained between 2Q10 and 4Q11 from the WIOU plume, including Site SD033, indicates that significant rebound is not occurring. Monitoring to evaluate contaminant rebound after discontinuing GET system operation is ongoing. The site is a component of the overall WIOU plume.
SD034 (NEWIOU)	GET	GET for source control[h] GET for migration control[i]	The GET and passive skimming systems for WIOU Site SD034 are largely achieving the source control and migration control IRA objectives. Estimates of the extent of hydraulic capture indicate that VOC concentrations above 100 µg/L are being captured by the existing GET system. Decreasing trends of VOC concentrations are observed throughout the commingled WIOU plume. The decreasing trend is observed in both shallow and deep monitoring wells, indicating that the horizontal and the vertical extents of the plume are being addressed by the existing GET system. Floating product removal of Stoddard solvent, containing dissolved COCs, is achieving the source control IRA for the site. The extent of floating product continues to be limited to the original release area and is not migrating.	GET optimization: UV/Ox groundwater treatment and VGAC vapor treatment discontinued in 2009-2010 and replaced by LGAC at CGWTP. Rebound study: WIOU GET system, including Site SD034, shut down for a rebound study.	Passive skimming operations are continuing. The preponderance of data obtained between 2Q10 and 4Q11 from the WIOU plume, including Site SD034, indicates that significant rebound is not occurring. Monitoring to evaluate contaminant rebound after discontinuing GET system operation is ongoing. The site is a component of the overall WIOU plume.
SS035 (NEWIOU)	MNA Assessment	Assess viability of natural physical, chemical, and biological processes to remediate plume	Groundwater data obtained during the period of interim remediation within the WIOU plume, including Site SS035, indicate that the plume is not migrating and COC concentrations are stable or decreasing.	Rebound study: WIOU GET system, including Site SS035, shut down for a rebound study.	Monitoring to evaluate natural attenuation processes is continuing. The site is a component of the overall WIOU plume.

TABLE 2.2-2
Summary of Interim Remedial Action Performance and Status
Groundwater Record of Decision, Travis Air Force Base, California

Site	IRA	IRA Objectives	IRA Performance and Status	IRA Optimization Action, Technology Demonstration, or Study	Performance and Status of Optimization Action, Technology Demonstration, or Study
SD036 (NEWIOU)	GET and MNA Assessment	GET for source control GET for migration control	The GET system for WIOU Site SD036 is largely achieving the source control and migration control IRA objectives. Estimates of the extent of hydraulic capture indicate that VOC concentrations above 100 µg/L were captured by the existing GET system. Decreasing trends of VOC concentrations are observed throughout the commingled WIOU plume. The decreasing trend is observed in both shallow and deep monitoring wells, indicating that the horizontal and the vertical extents of the plume are being addressed by the existing GET system. Although IRA objectives are largely being met, even after several years of IRA operation, TCE concentrations greater than 1,000 µg/L continue to be detected within the portion of the Site SD036 plume with the highest concentrations of residual contamination. Optimization of the GET IRA was required. Therefore, data gaps investigations were performed during 2010 to more fully define the extent of residual contamination. Based on the results of the data gaps investigations, optimization measures included discontinuing the GET systems and injection of EVO within the portion of the plume with the highest concentrations of residual contamination. The performance of the EVO treatment is being evaluated. In the downgradient portions of the plume, MNA appears to be a viable remedy. Groundwater contamination in this area does not appear to be migrating.	GET optimization: UV/Ox groundwater treatment and VGAC vapor treatment discontinued in 2009-2010 and replaced by LGAC treatment at CGWTP. Rebound study: WIOU GET system, including Site SD036, shut down for a rebound study in 2010. EVO demonstration: Data gaps investigation conducted during 2010. EVO injection in 2010.	The demonstration of in situ ERD treatment via injection of EVO substrate has been successful at Site SD036. Performance monitoring results provide strong indications that the reductive dechlorination process is occurring within the treatment zone. Performance monitoring and evaluations of the EVO injection are ongoing. The preponderance of data obtained between 2Q10 and 4Q11 from the WIOU plume, including Site SD036, indicates that significant rebound is not occurring. Monitoring to evaluate contaminant rebound after discontinuing GET system operation is ongoing. The site is a component of the overall WIOU plume.
SD037 (NEWIOU)	MNA Assessment and GET	GET for source control[k] GET for migration control[l]	The GET system for WIOU Site SD037 is largely achieving the source control and migration control IRA objectives. Estimates of the extent of hydraulic capture indicate that VOC concentrations above 100 µg/L were captured by the existing GET system. Decreasing trends of VOC concentrations are observed throughout the commingled WIOU plume. The decreasing trend is observed in both shallow and deep monitoring wells, indicating that the horizontal and the vertical extents of the plume are being addressed by the existing GET system. Although IRA objectives are largely being met, even after several years of IRA operation, TCE concentrations greater than 1,000 µg/L continue to be detected within the portion of the Site SD037 plume with the highest concentrations of residual contamination. Optimization of the GET IRA was required. Therefore, data gaps investigations were performed during 2010 to more fully define the extent of residual contamination. Based on the results of the data gaps investigations, optimization measures included discontinuing the GET systems and injection of EVO within the portion of the plume with the highest concentrations of residual contamination. The performance of the EVO treatment is being evaluated. In the southern (downgradient) area of the WIOU, MNA appears to be a viable remedy. Groundwater contamination in this area does not appear to be migrating.	GET optimization: UV/Ox groundwater treatment and VGAC vapor treatment discontinued in 2009-2010 and replaced by LGAC treatment at CGWTP. Rebound study: WIOU GET system, including Site SD037, shut down for a rebound study in 2010. EVO demonstration: Data gaps investigation conducted during 2010. EVO injection in 2010.	The demonstration of in situ ERD treatment via injection of EVO substrate has been successful at Site SD037. Performance monitoring results provide strong indications that the reductive dechlorination process is occurring within the treatment zone. Performance monitoring and evaluations of the EVO injection are ongoing. Monitoring to evaluate natural attenuation processes is continuing. The preponderance of data obtained between 2Q10 and 4Q11 from the WIOU plume, including Site SD037, indicates that significant rebound is not occurring. Monitoring to evaluate contaminant rebound after discontinuing GET system operation is ongoing. The site is a component of the overall WIOU plume.
DP039 (WABOU)	GET and MNA Assessment	GET for migration control GET for source control MNA to assess the viability of natural physical, chemical, and biological processes to remediate plume	The Site DP039 source control IRA objective has been partly achieved. TCE concentrations in the historical contaminant release area (i.e., a former sump) are declining, and a portion of the plume with the highest concentrations of residual contamination was hydraulically contained by a GET system. However, another portion of the plume is not hydraulically captured. This uncaptured portion of the plume, with TCE concentrations exceeding 1,000 µg/L, extends about 800 feet downgradient. This uncaptured portion of the plume with the highest concentrations of residual contamination underlies an ongoing demonstration of phytoremediation. In December 2008, an in situ bioreactor was installed in the former sump area as a technology demonstration. The performance of the bioreactor is being evaluated for the remainder of the period of interim remediation. A data gaps investigation was performed during 2010 to more fully define the extent of downgradient contamination with TCE concentrations greater than 500 µg/L. Based on the results of the data gaps investigations, an in situ PRB of EVO was installed hydraulically downgradient of an existing area of phytoremediation and upgradient of the portion of the plume undergoing MNA. The performance of the EVO PRB is being evaluated. Increasing TCE concentration trends at some monitoring wells in the distal portion of the plume indicate that MNA may not be fully effective if TCE concentrations in the untreated portion of the plume continue to exceed 1,000 µg/L and act as a continuing source of contamination into the downgradient portion of the plume.	GET optimization: UV/Ox groundwater treatment and VGAC vapor treatment discontinued in 2009-2010 and replaced by LGAC treatment at SBBGWTP. Rebound study: GET system shut down in 2008. Bioreactor demonstration: In situ bioreactor installed in 2008. Phytoremediation treatability study: Trees planted in 1998 and evaluated through 2010. EVO demonstration: Data gaps investigation conducted during 2010. EVO PRB installed in 2010.	Analytical and geochemical data collected during 3 years of operation indicate that the Site DP039 bioreactor is performing as designed and has successfully demonstrated the viability of ERD treatment processes. Performance monitoring and evaluations of the bioreactor are ongoing. A phytoremediation treatability study conducted at the site concluded that planted trees can contribute to remediation of the plume. Monitoring within the area of phytoremediation is continuing. The demonstration of in situ ERD treatment via injection of EVO substrate has been successful at Site DP039. Performance monitoring results provide strong indications that the reductive dechlorination process is occurring within the PRB treatment zone. Performance monitoring and evaluations of the EVO PRB are ongoing. Monitoring to evaluate natural attenuation processes is continuing. GET system operations have been discontinued.
SS041 (WABOU)	GET	GET for migration control	Site SS041 has been in NFRAP status. The NFRAP status is documented in a December 14, 2005, consensus statement (Travis AFB, 2005a). The IRA GET system achieved IRGs, and COCs are no longer detected in the site monitoring wells.	None	

TABLE 2.2-2
Summary of Interim Remedial Action Performance and Status
Groundwater Record of Decision, Travis Air Force Base, California

Site	IRA	IRA Objectives	IRA Performance and Status	IRA Optimization Action, Technology Demonstration, or Study	Performance and Status of Optimization Action, Technology Demonstration, or Study
SD043 (WABOU)	GET	GET for migration control	The IRA GET system has effectively reduced plume size and concentrations. No contaminants were detected above IRGs during the 2010 GSAP.	GET optimization: UV/Ox groundwater treatment and VGAC vapor treatment discontinued in 2009-2010 and replaced by LGAC treatment at CGWTP. Rebound study: WIOU GET system, including Site SD043, shut down for a rebound study in 2010.	The preponderance of data obtained between 2Q10 and 4Q11 from the WIOU plume, including Site SD043, indicate that significant rebound is not occurring. Monitoring to evaluate contaminant rebound after discontinuing GET system operation is ongoing. The site is a component of the overall WIOU plume.

[a] On-base portion of plume
[b] Plume at Base boundary
[c] Off-base portion of plume
[d] OSA portion of plume
[e] Southern portion of plume
[f] South Gate Area, Facility 1917, and Facility 810 plumes
[g] Storm sewer
[h] Bioslurp/free product removal
[i] Coordinated with Site SD037
[j] Portions of plume near Facilities 919, 977, 981, and Area G Ramp
[k] Portions of plume near Facilities 837, 838, and Ragsdale/V Area
[l] Remainder of plume

Notes:

NFRAP = No Further Remedial Action Planned
TARA = Tower Area Removal Action
USFWS = U.S. Fish and Wildlife Service
VGAC = vapor-phase granular activated carbon

TABLE 2.2-3
Lines of Evidence for Natural Attenuation
Groundwater Record of Decision, Travis Air Force Base, California

Lines of Evidence:

Line 1 = Historical data showing reductions in contaminant mass/concentration over time
Line 2 = Hydrogeologic and geochemical data that provide indirect evidence of the types of natural attenuation processes active at a site and degradation rates
Line 3 = Data from field studies to demonstrate the occurrence of a particular natural attenuation process and its ability to degrade COCs

Site (Primary COCs)	Line of Evidence					
	Line 1	**References**	**Line 2**	**References**	**Line 3**	**References**
FT004 and SD031 (TCE and 1,1-DCE)	Mann-Kendall trend analysis and chemical time-series plots for most of the downgradient monitoring wells (beyond the influence of the GET system) show decreasing concentrations.	3 (Section 2.3.1)	Geochemical data collected prior to initiation of the GET indicate reducing conditions conducive to biodegradation of chlorinated solvents.	3 (Section 2.3.2)	qPCR demonstrated the presence of bacteria that produce TCE cometabolic enzymes at Site FT004.	4
	Downgradient (beyond the influence of the GET system) monitoring and trend analysis indicate plume contraction.	3 (Section 2.3.1)	Geochemical data collected during and following GET operation indicate predominantly aerobic and oxidizing conditions, which are conducive to aerobic cometabolism but not to anaerobic degradation.	3 (Section 2.3.2), 4	Enzyme probes demonstrated that the enzymes responsible for aerobic cometabolism are active in samples collected from Site FT004.	4
	The GET system was shut down in 2007. As a whole, the groundwater plume has remained stable as evidenced by stable or continued decreasing TCE concentration trends in 74 percent of the extraction and monitoring wells and the continuing decline in TCE concentrations at downgradient well MW757x04. Similarly, 1,1-DCE concentrations were stable or decreased in 100 percent of the extraction and monitoring wells over the rebound study period.	7 (Section 7.3.1.2)	TCE point attenuation rate constants ranging from 0.058 per year to 0.58 per year were calculated (equivalent to TCE half-lives of 12 and 1 years, respectively).	3 (Section 2.3.1)	The EAP and qPCR results provide evidence of potential for intrinsic aerobic biodegradation at Site FT004. The results of the investigation are indicative of enzymatic cometabolic activity at this site.	4
	Continued decreasing concentrations in the Site FT004 extraction wells and wells within the portion of the plume with the highest concentrations of residual contamination over the course of the rebound study indicate that the portion of the plume with the highest concentrations of residual contamination has been effectively addressed by groundwater extraction and is not continuing to release mass to the groundwater plume.	7 (Section 7.3.1.2)	Numerical modeling estimated an RTF of 15 years (Site SD031) to 35 years (Site FT004) for an MNA remedy.	1 (Section 8.2.2.5)	Data collected at Site DP039 indicate that volatilization from dissolved to vapor phase occurs at Travis AFB. Most of Sites FT004 and SD031 are unpaved, and it is likely that volatilization also occurs at these sites.	1 (Section C.1.4.1), 5 (Section 4)
	In the absence of natural attenuation processes, over the 8-year MNA assessment period evaluated in the NAAR, the TCE plume would have been expected to have migrated approximately 600 feet. However, the plume receded over the assessment period.	3 (Section 2.3.1)				
FT005 (1,2-DCA)	The GET system was shut down for a rebound study in 2007. Over the course of the rebound study, 1,2-DCA concentrations rebounded in three (3) wells, indicating that GET is reaching its limit of effectiveness.	1 (Section C.1.4.2)	Numerical modeling estimated an RTF of 43 years for an MNA remedy at Site FT005.	1 (Section 8.2.2.5)	qPCR and enzyme probes at Sites FT004 and DP039 demonstrated that aerobic bacteria that produce TCE cometabolic enzymes are present at similar but geographically distant Travis AFB indicator groundwater sites and that the cometabolic enzymes are active. The primary COC at Site FT005 is 1,2-DCA, which is also readily cometabolized. Geochemical conditions and lithology at Site FT005 are similar to Sites DP039 and FT004. Aerobic cometabolism may also be contributing to natural attenuation at Site FT005.	4
	In 2010, groundwater extraction was reinitiated at three (3) extraction wells where rebound was evident. Mann-Kendall trend analysis and chemical time-series plots indicate that over the course of the rebound study, concentrations of 1,2-DCA are stable, or have declined, in 26 of 26 monitoring and extraction wells, including those where ongoing groundwater extraction is occurring.	7 (Section 7.4.1.2)				
	Monitoring and trend analysis indicate plume contraction. In 2011, 1,2-DCA was detected at concentrations exceeding the IRG at only three (3) Site FT005 wells. The maximum concentration detected was 5.8 µg/L.	7 (Section 7.4.1.1)			Data collected at Site DP039 indicate that volatilization from dissolved to vapor phase occurs at Travis AFB. Most of Site FT005 is unpaved, and it is likely that volatilization also occurs at Site FT005.	1 (Section C.1.4.2), 5 (Section 4)

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Groundwater Record of Decision, Travis Air Force Base, California

Lines of Evidence:

Line 1 = Historical data showing reductions in contaminant mass/concentration over time
Line 2 = Hydrogeologic and geochemical data that provide indirect evidence of the types of natural attenuation processes active at a site and degradation rates
Line 3 = Data from field studies to demonstrate the occurrence of a particular natural attenuation process and its ability to degrade contaminants of concern

Site (Primary COCs)	Line of Evidence					
	Line 1	References	Line 2	References	Line 3	References
LF006 (TCE)	Mann-Kendall analysis and chemical time-series plots indicate that TCE concentrations are decreasing throughout the plume. No monitoring wells have increasing TCE trends.	2 (Section 4.2.6)	TCE point attenuation rate constants ranging from 0.061 per year to 0.035 per year were calculated (equivalent to TCE attenuation half-lives of approximately 11 and 20 years).	3 (Section 3.3.1)	qPCR and enzyme probes at Sites FT004 and DP039 demonstrated that aerobic bacteria that produce TCE cometabolic enzymes are present at similar but geographically distant Travis AFB indicator groundwater sites and that the cometabolic enzymes are active. Geochemical conditions and lithology at Site LF006 are similar to neighboring Site FT004. Aerobic cometabolism may also be contributing to natural attenuation at Site LF006.	4
	Data from 13 years of groundwater monitoring at Site LF006 indicate that the plume is contained and has decreased in size over time.	2 (Section 4.2.6)	Based on a TCE attenuation half-life of 20 years, an RTF of approximately 5 years was estimated for an MNA remedy.	1 (Section 8.2.2.5)		
	TCE was the only site COC that exceeded IRGs in 2011. The maximum concentration of TCE detected in 2011 was 7.1 J- µg/L.	2 (Section 4.2.6)	A TCE bulk attenuation rate constant of 0.75 per year was calculated for Site LF006. The positive bulk attenuation rate constant indicates that attenuation of TCE is occurring.	3 (Section 3.3.1)	Data collected at Site DP039 indicate that volatilization from dissolved to vapor phase occurs at Travis AFB.	1 (Section C.1.4.3), 5 (Section 4)
	In the absence of natural attenuation processes, over the 10-year MNA assessment period evaluated in the NAAR, the TCE plume would have been expected to have migrated approximately 800 feet. However, the plume receded over the assessment period.	3 (Section 3.3.1)	Geochemical data indicate predominantly aerobic and oxidizing conditions, which are conducive to aerobic cometabolism but not to anaerobic degradation.	3 (Section 3.3.2)		
LF007B Subarea (1,4-DCB)	Groundwater contaminants have not been detected in groundwater at Site LF007B for several years. No groundwater plume currently exists at the site.	1 (Section C.1.4.4), 2 (Section 4.1.5.6)	Because no COCs exceed cleanup goals, the RTF for an MNA remedy is 0 years.	1 (Section 8.2.2.5)		
LF007D Subarea (1,4-DCB and benzene)	Contaminants 1,4-DCB and benzene exceed IRGs at only one (1) well (MW261x07). No other contaminants are detected in groundwater at Subarea LF007D at concentrations exceeding cleanup goals.	1 (Section C.1.4.4), 2 (Section 4.1.5.6)	An attenuation rate constant of 0.054 per year was calculated for 1,4-DCB (equivalent to a 1,4-DCB half-life of approximately 13 years). Based on a half-life of 13 years, the 1,4-DCB RTF for an MNA remedy is approximately 19 years.	1 (Section C.1.4.4), 3 (Section 4.3.1)	Data collected at Site DP039 indicate that volatilization from dissolved to vapor phase occurs at Travis AFB. However, volatilization is unlikely to contribute significantly to contaminant reduction at Subarea LF007D. The landfill cap likely reduces volatilization at the site. In addition, while benzene is volatile, 1,4-DCB has a relatively low volatility, and significant volatilization of 1,4-DCB is unlikely.	1 (Section C.1.4.4), 5 (Section 4)
	Mann-Kendall analysis and chemical time-series plots indicate that 1,4-DCB concentrations are declining in all three (3) monitoring wells at which it has historically been detected. In 2011, 1,4-DCB was detected only at monitoring well MW261x07.	2 (Section 4.1.5.6)	In the portion of the plume where contaminants continue to exceed IRGs, analytical and geochemical data indicate anaerobic conditions and that anaerobic biodegradation of 1,4-DCB is occurring. During the 1,4-DCB biodegradation process, 1,4-DCB degrades to chlorobenzene and chlorobenzene degrades to benzene. This degradation pathway is likely contributing to the relatively constant concentrations of benzene observed in the site groundwater. Once the 1,4-DCB source has been depleted, benzene concentrations are expected to decline through either biological or physical attenuation processes, or a combination of both.	3 (Section 4.3.2) 8		
	Plume and downgradient monitoring well data indicate that the benzene plume is stable. Benzene has only been detected in one (1) monitoring well, MW261x07. The Mann-Kendall analysis and chemical time-series plots indicate that the benzene concentrations are stable at this well (ranging between 2 and 3 µg/L).	2 (Section 4.1.5.6)				
	In the absence of natural attenuation processes, over the 10-year MNA assessment period evaluated in the NAAR, the TCE plume would have been expected to have migrated approximately 900 feet. However, the plume receded over the assessment period.	3 (Section 4.3.1)	In the portion of the plume where contaminants are below IRGs, geochemical data indicate aerobic conditions, which are conducive to biodegradation of benzene. Once the degradation of 1,4-DCB is complete, conditions near well MW261x07 are expected to gradually become aerobic and more conducive to the aerobic biodegradation of benzene. Under these conditions, the RTF for the MNA remedy is 23 years.	8		
			If conditions near well MW261x07 remain anaerobic, once the degradation of 1,4-DCB is complete, benzene is expected to attenuate through physical processes only. Under these conditions, the RTF for the MNA remedy is 49 years.	8		

TABLE 2.2-3
Lines of Evidence for Natural Attenuation
Groundwater Record of Decision, Travis Air Force Base, California

Lines of Evidence:

Line 1 = Historical data showing reductions in contaminant mass/concentration over time
Line 2 = Hydrogeologic and geochemical data that provide indirect evidence of the types of natural attenuation processes active at a site and degradation rates
Line 3 = Data from field studies to demonstrate the occurrence of a particular natural attenuation process and its ability to degrade contaminants of concern

Site (Primary COCs)	Line of Evidence					
	Line 1	**References**	**Line 2**	**References**	**Line 3**	**References**
LF008 (alpha-chlordane)	Stable pesticide concentrations over a period of 7.5 years of groundwater extraction indicate that groundwater extraction is an ineffective remedy for this site. The GET system was consequently shut down in 2008 for a rebound study.	1 (Section C.1.4.5)	The physical properties of pesticides result in very low subsurface mobility because of strong sorption of the chemical to the soil.	1 (Section C.1.4.5)		
	No significant rebound of pesticides is evident during the 3 years since the GET rebound study began. In fact, the alpha-chlordane plume has contracted since GET was taken offline in 2008.	7 (Section 7.2.1.2)	Site sediments have high clay content, which increases sorption and also reduces permeability.	1 (Section C.1.4.5)		
	Mann-Kendall analysis and chemical time-series plots indicate that alpha-chlordane concentrations are stable or have decreased at all seven (7) of the monitoring wells sampled since the initiation of the rebound study. The maximum concentration of alpha-chlordane detected in 2011 was 0.43 J- µg/L; the IRG is 0.1 µg/L.	7 (Section 7.2.1.2)	Because of the high sorption of pesticides, an RTF exceeding 100 years was estimated for both the MNA and the GET remedial alternatives.	1 (Section 8.2.2.5), 8		
SS015 (TCE, cis-1,2-DCE, and vinyl chloride)	ERD treatment of the portion of the plume with the highest concentrations of residual contamination (via EVO injection) began in 2010. Since the EVO injection, the combined mass of TCE, cis-1,2-DCE, and vinyl chloride declined by more than 99 percent in the treatment zone.	7 (Section 6.4.5)	TCE, cis-1,2-DCE, and vinyl chloride bulk attenuation rate constants of 2.3, 6.6, and 9 per year were calculated for Site SS015. The positive bulk attenuation rate constants indicate that attenuation of TCE, cis-1,2-DCE, and vinyl chloride is occurring.	1 (Section C.1.5.1)	qPCR and enzyme probes at Sites FT004 and DP039 demonstrated that aerobic bacteria that produce TCE cometabolic enzymes are present at similar but geographically distant Travis AFB indicator groundwater sites and that the cometabolic enzymes are active. Aerobic cometabolism may also be contributing to natural attenuation at Site SS015.	4
	The downgradient extent of contamination at Site SS015 was defined in 2010; consequently, the monitoring history in the downgradient portion of the plume is too short to identify long-term contaminant trends. However, concentrations of TCE, cis-1,2-DCE, and vinyl chloride have decreased in one (1) or more of the following downgradient wells since they were installed in 2010: MW2103x15, MW2105x15, MW2118x15, and MW2124x15. These wells are located downgradient of the portion of the plume with the highest concentrations of residual contamination and are outside the portion of the plume treated by ERD.	2 (Figures 4.7-8, 4.7-10, 4.7-11)	In the portion of the plume with the highest concentrations of residual contamination, anaerobic biodegradation is the primary mechanism for natural attenuation. Anaerobic biodegradation was enhanced by vegetable oil injection.	3 (Section 5.3.2)	Geochemical conditions at Site SS015 are similar to Sites FT004 and DP039, although the lithology at Site SS015 is different from these two (2) sites. Groundwater contamination at Site SS015 flows through highly weathered shallow sandstone rather than unconsolidated alluvial sediments as at Sites DP039 and FT004.	2 (Section 4.7.3)
			In the portion of the plume beyond the vegetable oil injection area, geochemical data indicate predominantly aerobic and oxidizing conditions, which are conducive to aerobic cometabolism but not to anaerobic degradation.	3 (Section 5.3.2)	Data collected at Site DP039 indicate that volatilization from dissolved to vapor phase occurs at Travis AFB. Volatilization may occur in the unpaved areas of Site SS015.	1 (Section C.1.5.1), 5 (Section 4)
	The monitoring well with the most consistent decline in TCE, cis-1,2-DCE, and vinyl chloride concentrations is MW2103x15, located approximately 75 feet downgradient of the ERD treatment area. The decline in contaminant concentrations at this well is likely primarily due to reduction in mass loading from the portion of the plume with the highest concentrations of residual contamination.	7 (Section 6.4.4.2)				
	Since EVO injection, only one (1) Site SS015 monitoring well outside of the injection area, MW625x15, has had increasing TCE, cis-1,2-DCE, and vinyl chloride concentrations. EVO injection was performed at Site SS015 as a response to increasing contaminant concentrations at this monitoring well and at wells located within the portion of the plume with the highest concentrations of residual contamination. Contaminant concentrations have not increased at monitoring wells located downgradient of MW625x15.	2 (Section 4.7.6 and Figures 4.7-8, 4.7-10, 4.7-11)				

TABLE 2.2-3
Lines of Evidence for Natural Attenuation
Groundwater Record of Decision, Travis Air Force Base, California

Lines of Evidence:

Line 1 = Historical data showing reductions in contaminant mass/concentration over time
Line 2 = Hydrogeologic and geochemical data that provide indirect evidence of the types of natural attenuation processes active at a site and degradation rates
Line 3 = Data from field studies to demonstrate the occurrence of a particular natural attenuation process and its ability to degrade contaminants of concern

Site (Primary COCs)	Line of Evidence					
	Line 1	**References**	**Line 2**	**References**	**Line 3**	**References**
Site ST027B (TCE)	The monitoring history for the TCE plume is shorter than at most of the other sites evaluated for MNA (4 years); however, available plume and downgradient monitoring data indicate that the TCE plume is stable. No plume or downgradient monitoring wells have increasing TCE concentration trends.	1 (Section C.1.4.6), 2 (Section 4.5.6.1)	A TCE bulk attenuation rate constant of 1.1 per year was calculated for Site ST027B. The positive bulk attenuation rate constant indicates that attenuation of TCE is occurring.	1 (Section C.1.4.6)	qPCR and enzyme probes at Sites FT004 and DP039 demonstrated that aerobic bacteria that produce TCE cometabolic enzymes are present at similar but geographically distant Travis AFB indicator groundwater sites and that the cometabolic enzymes are active. Geochemical conditions and lithology at Site ST027B are similar to Sites FT004 and DP039. Aerobic cometabolism may also be contributing to natural attenuation at Site ST027B.	4
	In the absence of natural attenuation processes, over the 28-month MNA assessment period evaluated during the Site ST027B characterization, the TCE plume would have been expected to have migrated approximately 290 feet. However, no appreciable migration occurred over the assessment period.	6	Numerical modeling estimated an RTF of 50 years for an MNA remedy.	1 (Section 8.2.2.5)	Data collected at Site DP039 indicate that volatilization from dissolved to vapor phase occurs at Travis AFB. Volatilization may occur in the unpaved areas of Site ST027B.	1 (Section C.1.4.6), 5 (Section 4)
			Geochemical data indicate limited evidence for anaerobic biodegradation of chlorinated VOCs. Geochemical data indicate predominantly aerobic and oxidizing conditions, which are conducive to aerobic cometabolism but not to anaerobic degradation.	6		
			Cis-1,2-DCE and vinyl chloride, TCE biodegradation daughter products, are present within the TCE plume.	6		
			Petroleum hydrocarbons, conducive to reductive dechlorination, are present within the TCE plume.	6		
Sites SD033, SD034, SS035, SD036, SD037, and SD043 (TCE)	Trend analysis in downgradient monitoring wells (beyond the influence of the GET system) show stable or decreasing concentrations.	3 (Section 6.5.1)	TCE point attenuation rate constants ranging from 0.019 to 0.058 per year were calculated (equivalent to TCE attenuation half-lives of approximately 36 and 12 years).	3 (Section 6.5.1)	qPCR and enzyme probes at Sites FT004 and DP039 demonstrated that aerobic bacteria that produce TCE cometabolic enzymes are present at similar but geographically distant Travis AFB indicator groundwater sites and that the cometabolic enzymes are active. Geochemical conditions and lithology in the WIOU are similar to neighboring Site DP039. Aerobic cometabolism may also be contributing to natural attenuation at Sites SD033, SD034, SS035, SD036, SD037, and SD043.	4
	Downgradient (beyond the influence of the GET system) monitoring and trend analysis indicate plume contraction.	3 (Section 6.5.1)	Numerical modeling estimated an RTF of 60 years for the portion of the plume beyond the 1,000-µg/L technology demonstration treatment area. This is the amount of time needed for the downgradient portion of the plume to attenuate to cleanup goals.	1 (Section 8.2.2.5)		
	The GET system was shut down in 2010 to support EVO injection within the portions of the plume with the highest concentrations of residual contamination and a rebound study in the distal portions of the plume. As a whole, the distal groundwater plume has remained stable over the rebound study period as evidenced by stable or continued decreasing TCE concentration trends in 85 percent of the extraction and monitoring wells monitored for rebound.	7 (Section 7.1.1.2)	Geochemical data indicate predominantly aerobic and oxidizing conditions, which are conducive to aerobic cometabolism but not to anaerobic degradation.	3 (Section 6.5.2)	Data collected at Site DP039 indicate that volatilization from dissolved to vapor phase occurs at Travis AFB. Volatilization may occur in the unpaved areas of Sites SD033, SD034, SS035, SD036, SD037, and SD043.	1 (Section C.1.5.3), 5 (Section 4)
	Over the rebound study period, TCE concentrations have not increased in any of the downgradient monitoring wells, which indicates that the plume is not migrating.	7 (Section 7.1.1.2)				
	In the absence of natural attenuation processes, over the 8-year MNA assessment period evaluated in the NAAR, the TCE plume would have been expected to have migrated approximately 560 feet. However, the plume receded over the assessment period.	3 (Section 6.5.1)				

TABLE 2.2-3
Lines of Evidence for Natural Attenuation
Groundwater Record of Decision, Travis Air Force Base, California

Lines of Evidence:

Line 1 = Historical data showing reductions in contaminant mass/concentration over time
Line 2 = Hydrogeologic and geochemical data that provide indirect evidence of the types of natural attenuation processes active at a site and degradation rates
Line 3 = Data from field studies to demonstrate the occurrence of a particular natural attenuation process and its ability to degrade contaminants of concern

Site (Primary COCs)	Line of Evidence					
	Line 1	References	Line 2	References	Line 3	References
DP039 (TCE)	Stable or declining TCE concentrations in five (5) of the nine (9) wells located outside of the area potentially impacted by the technology demonstrations (MW03x39, MW759x39, MW761x39, MW762x39, and MW785x39) indicate that natural attenuation is occurring at Site DP039. However, the recent increases in TCE concentrations in the other four (4) wells (MW04x39, MW758x39, MW760x39, and MW781x39) indicate that mass loading to the aquifer exceeds the aquifer attenuation capacity in portions of the plume.	4	TCE point attenuation rate constants ranging from 0.092 per year to 0.14 per year were calculated (equivalent to TCE attenuation half-lives of approximately 8 and 5 years).	3 (Section 7.3.1)	qPCR demonstrated the presence of bacteria that produce TCE cometabolic enzymes at Site DP039.	4
	The increases in TCE concentrations in portions of the plume led to the conclusion, documented in the NAAR, that natural attenuation alone may be insufficient to prevent plume migration. Consequently, to reduce mass loading on the distal portion of the plume, the EVO PRB was installed in June and July 2010.	3 (Section 7.4), 4	Numerical modeling estimated an RTF of 65 years for the portion of the plume downgradient of the EVO PRB.	1 (Section 8.6.7)	Enzyme probes at Site DP039 demonstrate that the enzymes responsible for aerobic cometabolism are active.	4
	In the absence of natural attenuation processes, over the 8-year MNA assessment period evaluated in the NAAR, the TCE plume would have been expected to have migrated approximately 240 feet. However, the southern (downgradient) edge of the plume remained stable over the assessment period.	3 (Section 7.3.1)	Geochemical data in the downgradient portion of the plume considered for MNA indicate predominantly aerobic and oxidizing conditions, which are conducive to aerobic cometabolism but not to anaerobic degradation.	3 (Section 7.3.2)	The EAP and qPCR results provide evidence of potential for intrinsic aerobic biodegradation at Site DP039. The results of the investigation are indicative of enzymatic cometabolic activity at this site.	4
					Data collected at Site DP039 indicate that volatilization from dissolved to vapor phase occurs at Travis AFB.	5 (Section 4)

References:

1 = FFS (CH2M HILL, 2011a)
2 = GSAP 2010-2011 Annual Report (CH2M HILL, 2012a)
3 = NAAR (CH2M HILL, 2010b)
4 = *Technical Memorandum for Assessment of Aerobic Chlorinated Cometabolism Enzymes at Travis Air Force Base, California* (CH2M HILL, 2012b)
5 = *Technical Report: Phytostabilization at Travis Air Force Base, California* (Parsons, 2010)
6 = *Technical Memorandum Site ST027-Area B Characterization Results* (CH2M HILL, 2010e)
7 = 2011 Annual RPO Report (CH2M HILL, 2012d)
8 = 2012 GSAP Technical Memorandum (CH2M HILL, 2012g)

Notes:

EAP = enzyme activity probe
qPCR = quantitative real-time polymerase chain reaction
RTF = remediation time frame

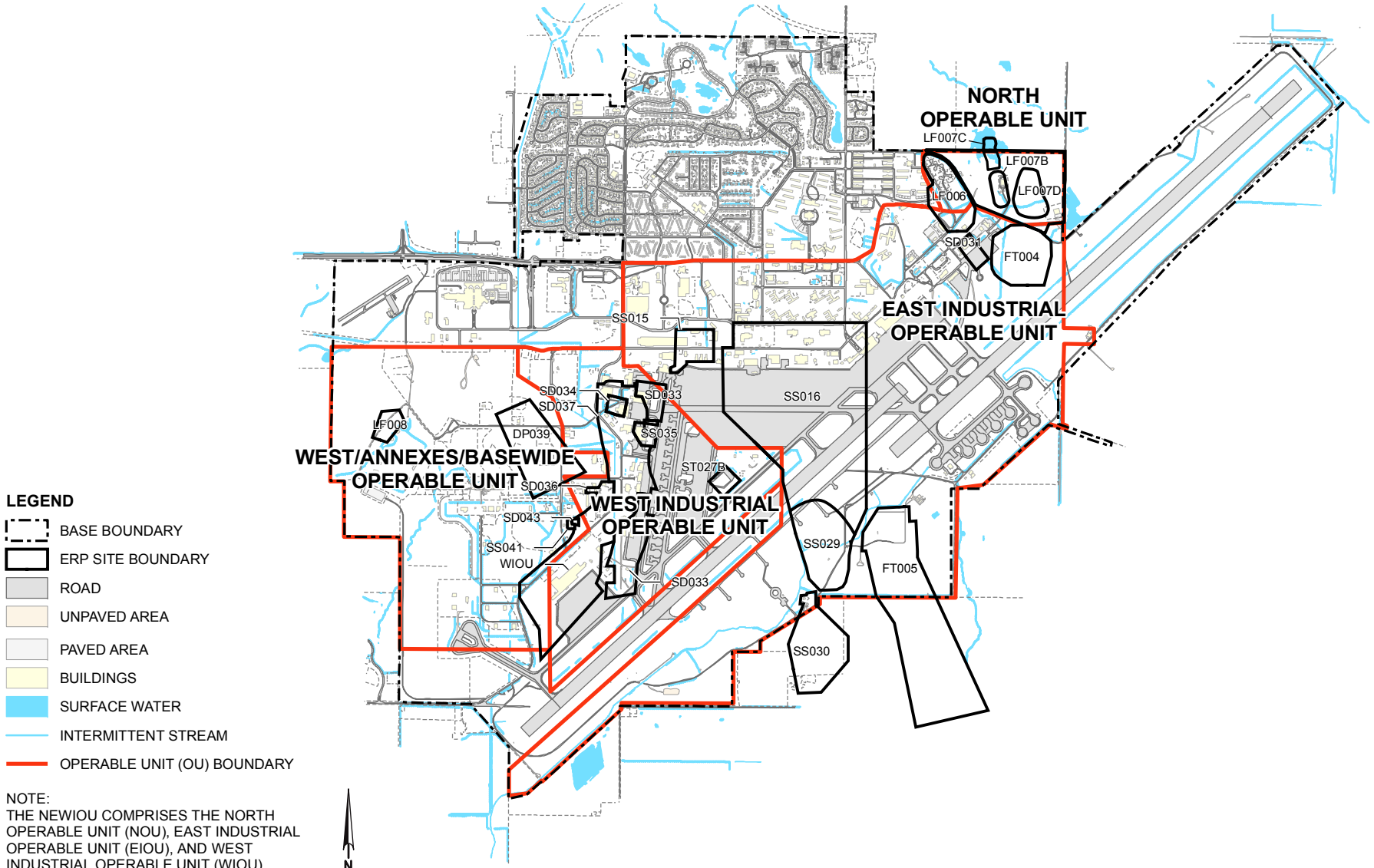


FIGURE 2.2-1
OPERABLE UNITS AND SITES
GROUNDWATER RECORD OF DECISION
TRAVIS AIR FORCE BASE, CALIFORNIA

ES051412034344SAC

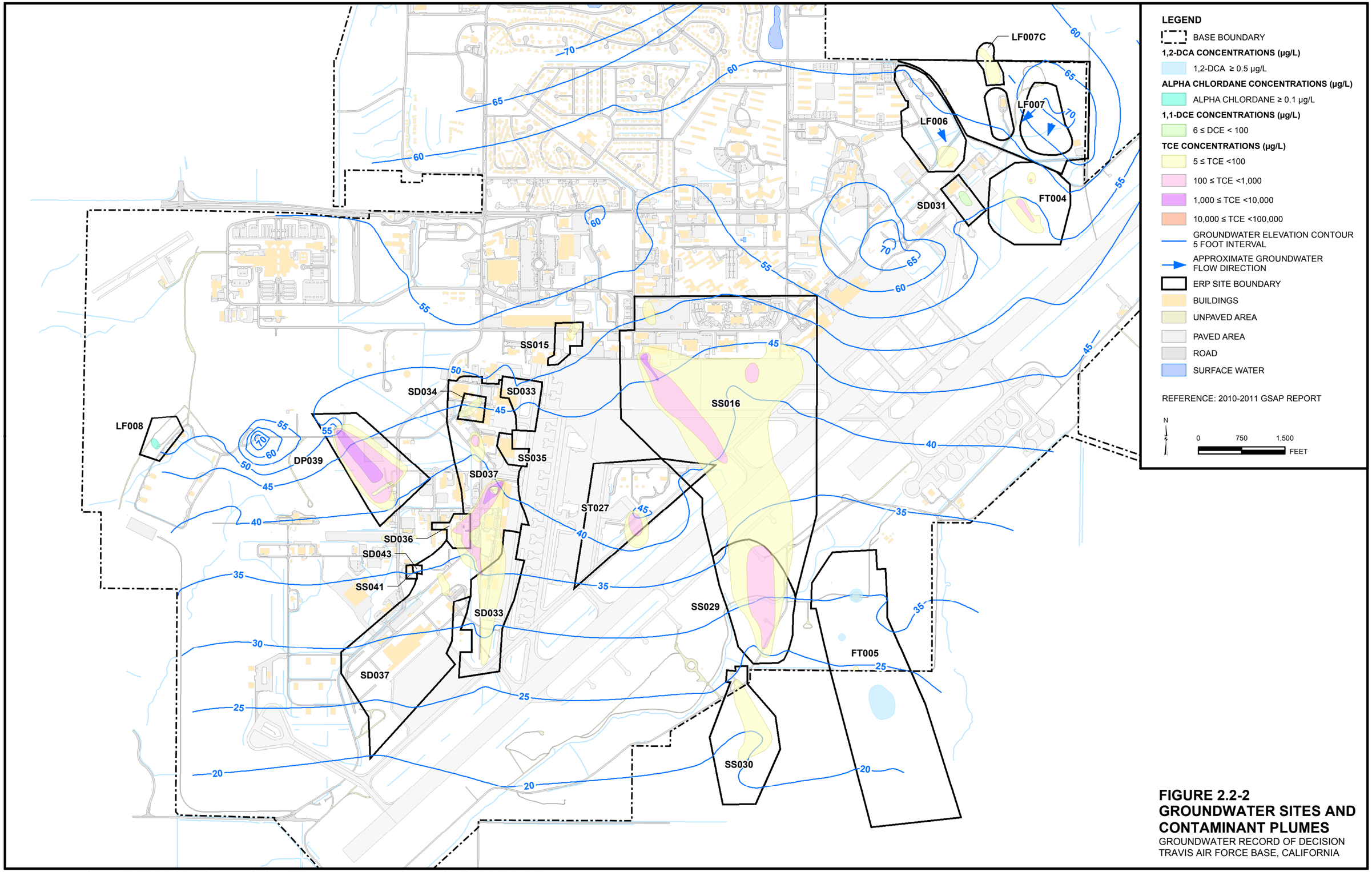
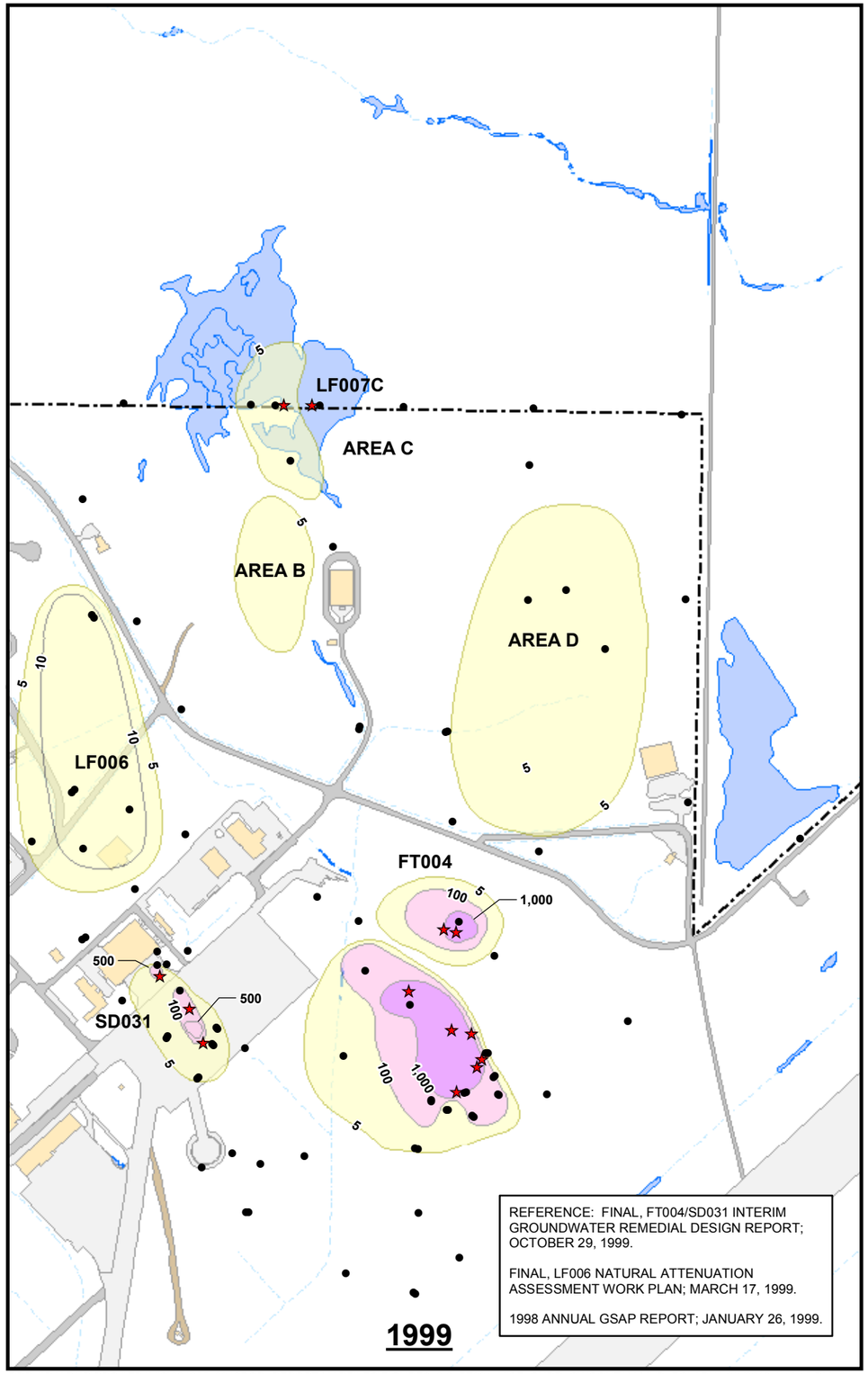
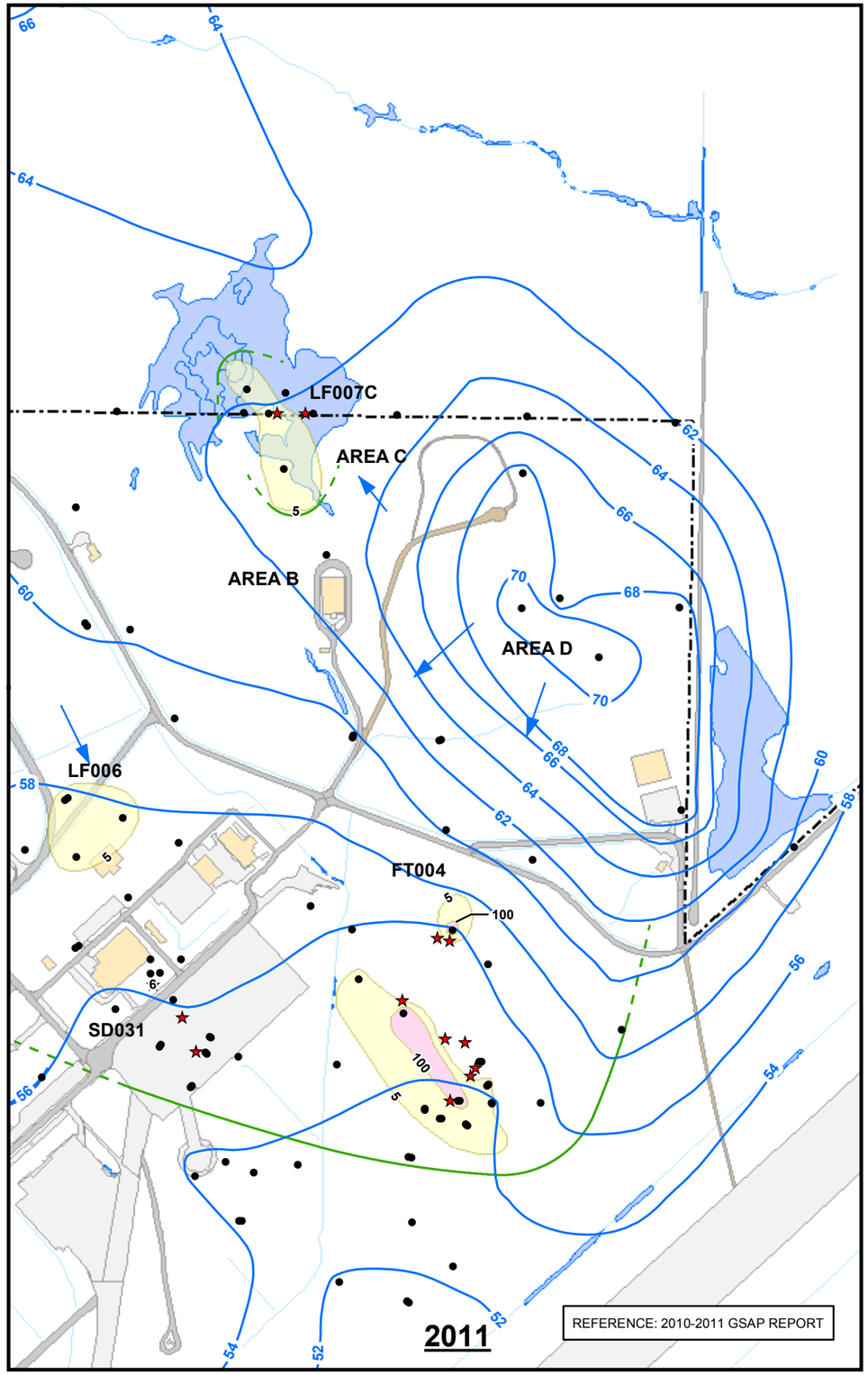
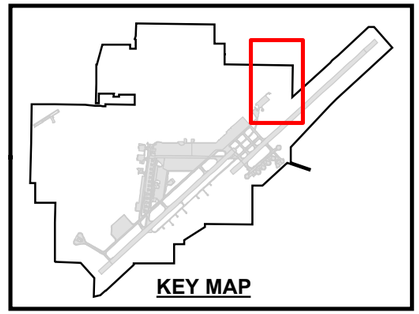


FIGURE 2.2-2
GROUNDWATER SITES AND CONTAMINANT PLUMES
GROUNDWATER RECORD OF DECISION
TRAVIS AIR FORCE BASE, CALIFORNIA

RDD \\BALDUR\PROJ\TRAVIS\381355_2012ROD_REPORT\MAPFILES\FIGURE2_2-2_BASEWIDE_PLUME_NETWORK.MXD MSCHROCK 5/29/2013 11:01:09 PM







LEGEND

- GROUNDWATER MONITORING WELL
- EXTRACTION WELL

TCE CONCENTRATIONS (µg/L)

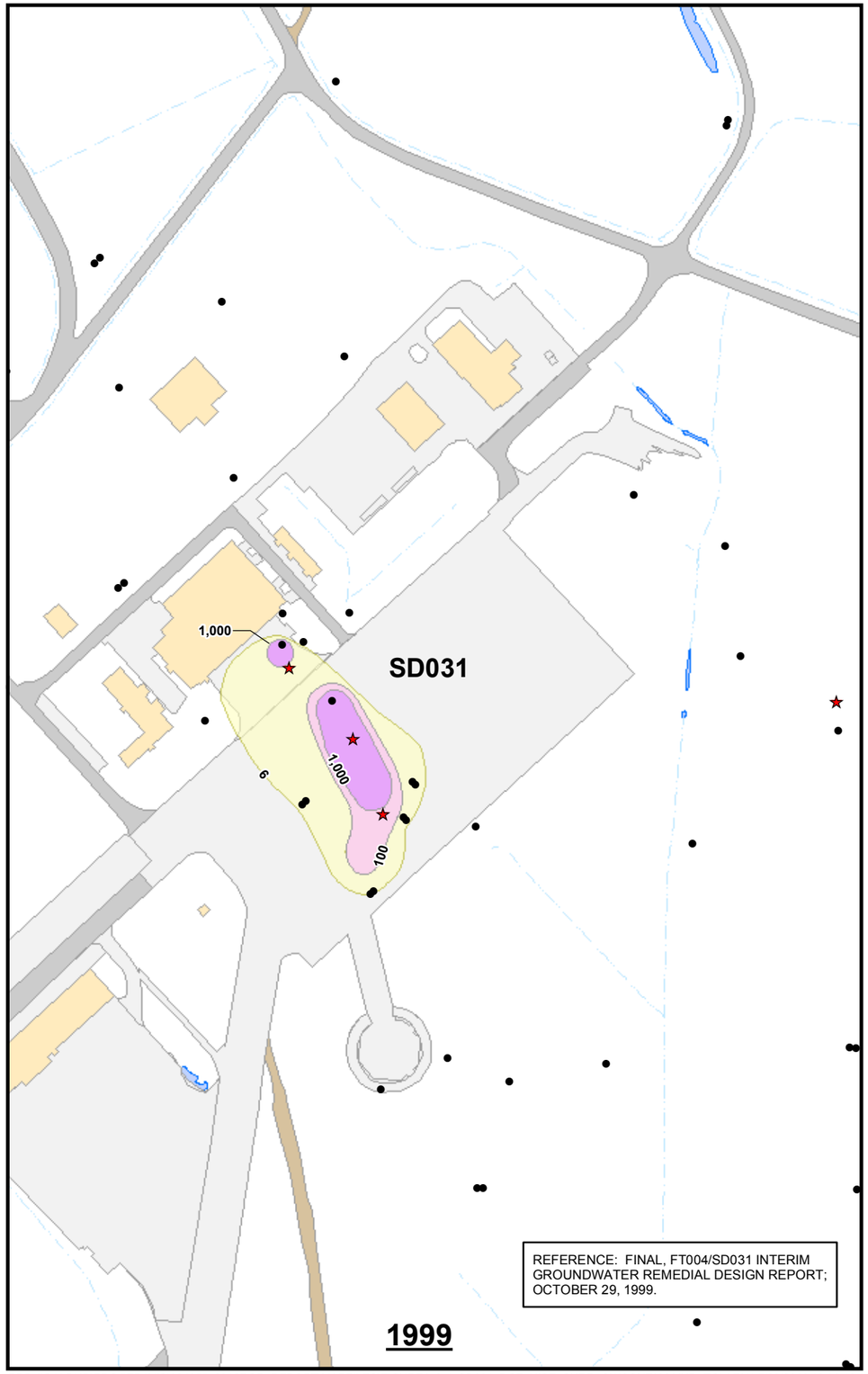
- 5 ≤ TCE <100
- 100 ≤ TCE <1,000
- 1,000 ≤ TCE <10,000
- GROUNDWATER ELEVATION (ft MSL)
- APPROXIMATE GROUNDWATER FLOW DIRECTION
- APPROXIMATE EXTENT OF HYDRAULIC CAPTURE (DASHED WHERE LESS CERTAIN)
- 5 APPROXIMATE ISOCONCENTRATION CONTOURS (µg/L)
- BASE BOUNDARY
- BUILDINGS
- UNPAVED AREA
- PAVED AREA
- ROAD
- SURFACE WATER

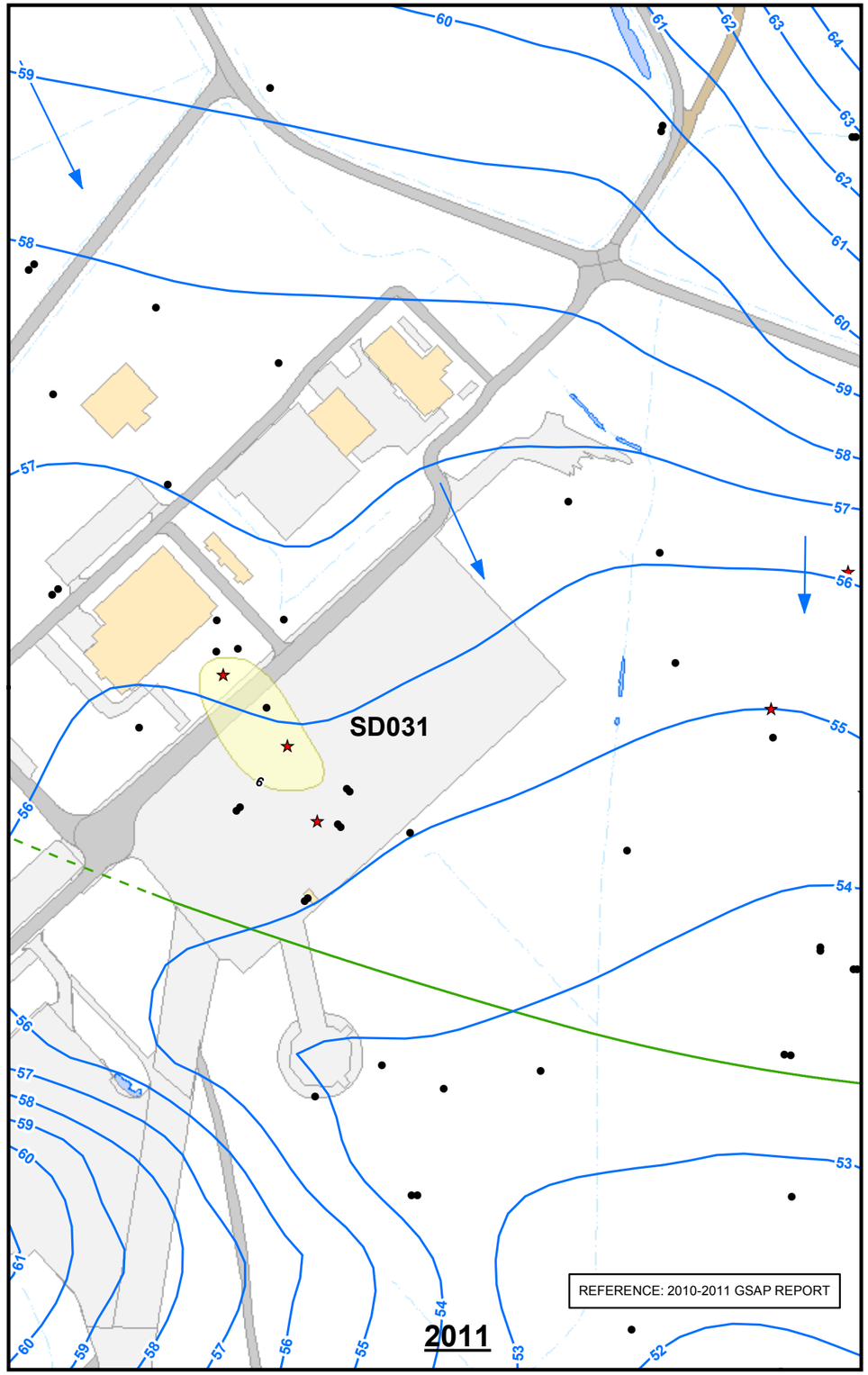
N

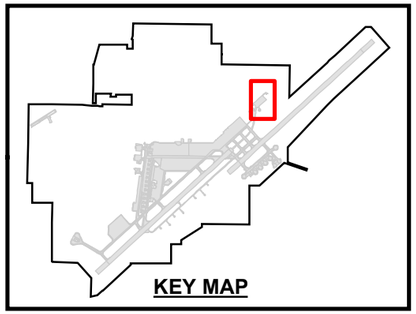
0 275 550 FEET

FIGURE 2.2-3
HISTORICAL AND CURRENT TCE GROUNDWATER CONTAMINATION - SITES FT004/SD031/LF006/LF007
GROUNDWATER RECORD OF DECISION
TRAVIS AIR FORCE BASE, CALIFORNIA

RDD \\BALDUR\PROJ\TRAVIS\381355_2012ROD_REPORT\MAPFILES\FIGURE2_2-3_FT004_HIST_CURR_GWCONTAM.MXD ECLARK1 6/4/2013 1:41:45 PM







LEGEND

- GROUNDWATER MONITORING WELL
- EXTRACTION WELL

1,1-DCE CONCENTRATIONS (µg/L)

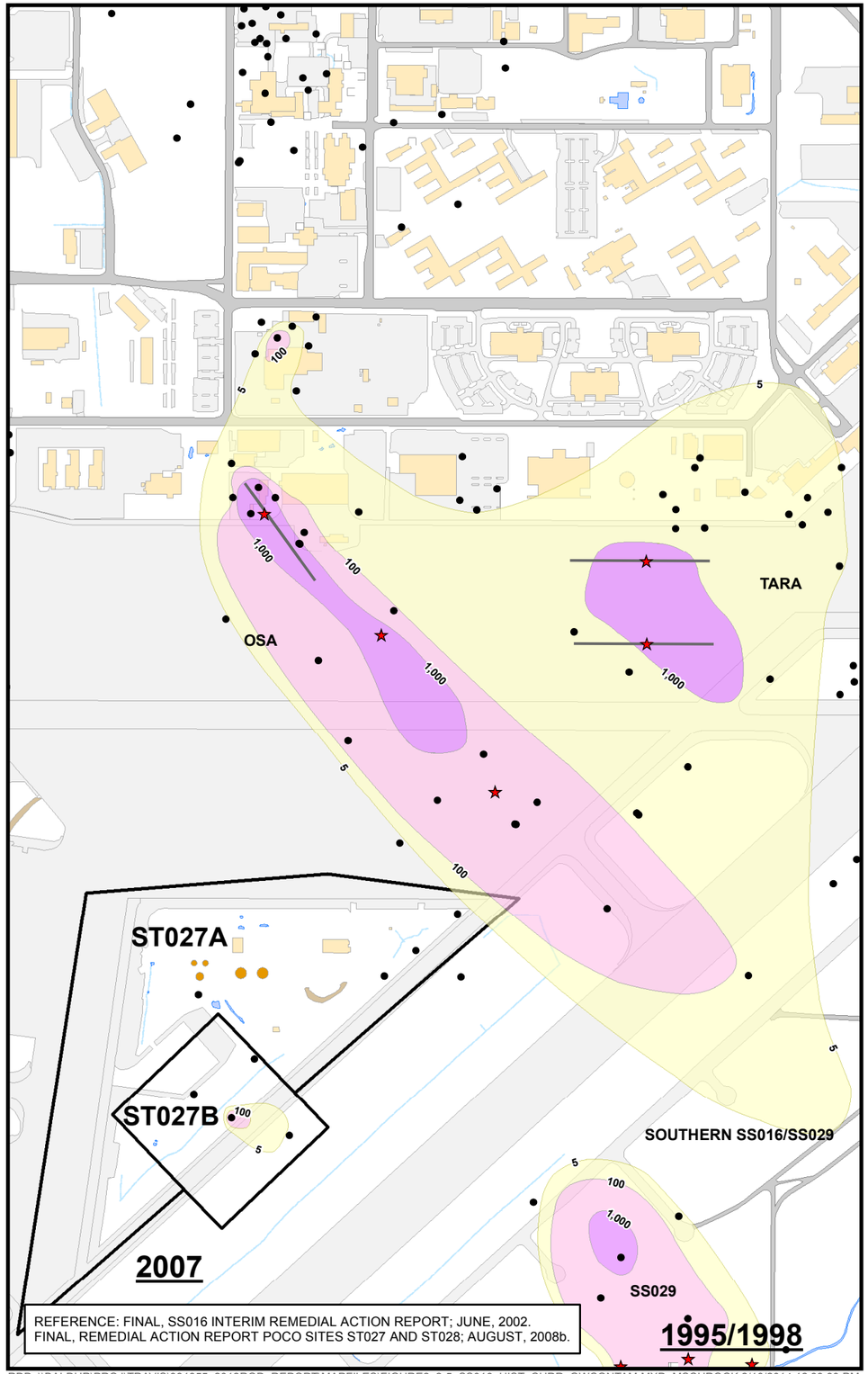
- 6 ≤ DCE < 100
- 100 ≤ DCE < 1,000
- DCE ≤ 1,000
- GROUNDWATER ELEVATION (ft MSL)
- APPROXIMATE GROUNDWATER FLOW DIRECTION
- APPROXIMATE EXTENT OF HYDRAULIC CAPTURE (DASHED WHERE LESS CERTAIN)
- 6 APPROXIMATE ISOCONCENTRATION CONTOURS (µg/L)
- BUILDINGS
- UNPAVED AREA
- PAVED AREA
- ROAD
- SURFACE WATER

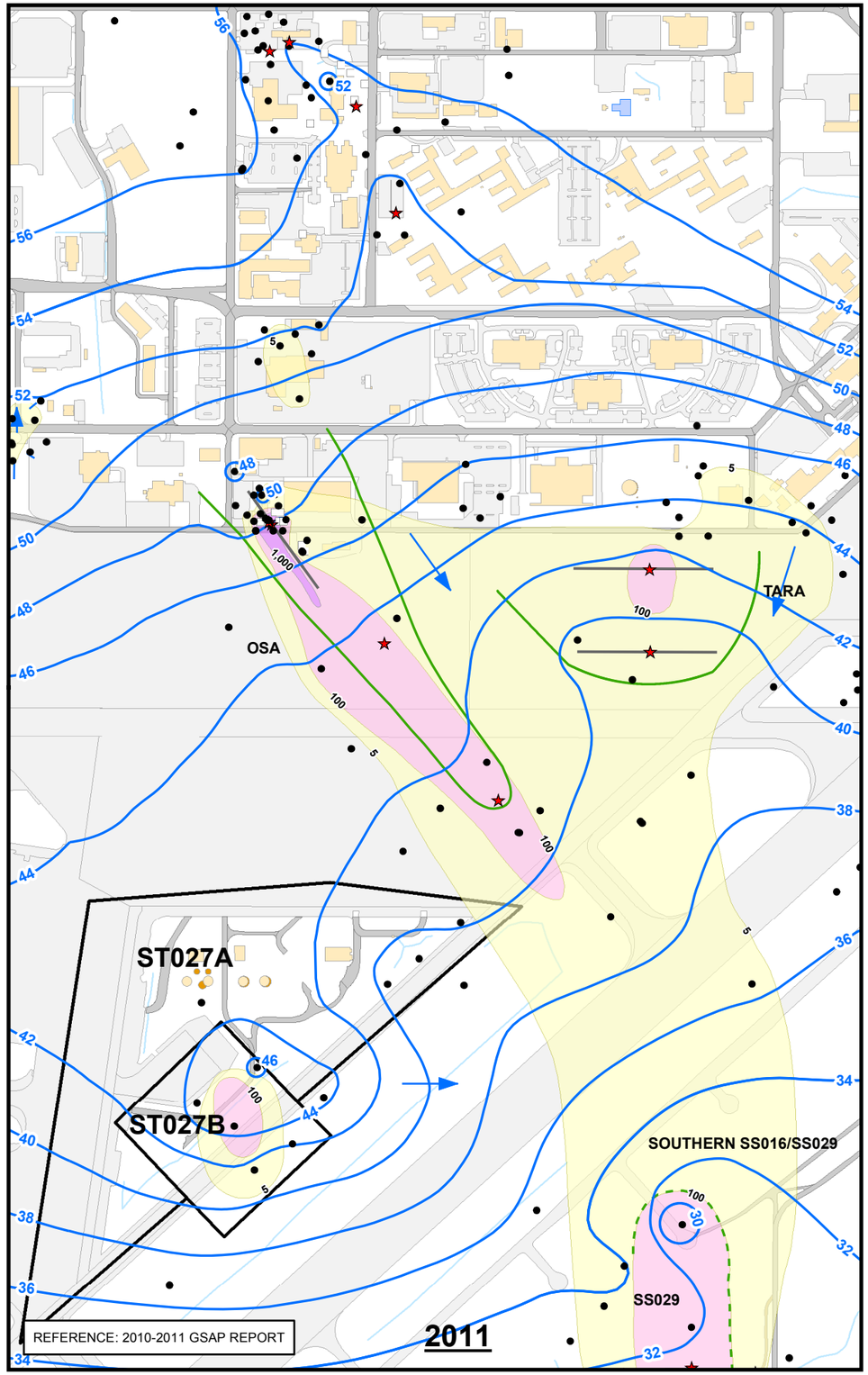
N

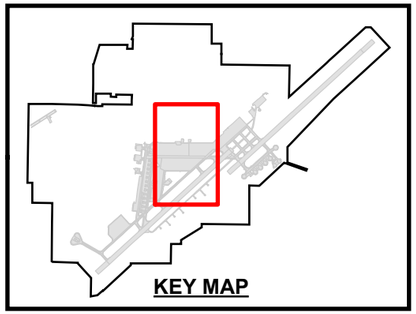
0 125 250 FEET

FIGURE 2.2-4
HISTORICAL AND CURRENT 1,1-DCE GROUNDWATER CONTAMINATION - SITE SD031
GROUNDWATER RECORD OF DECISION
TRAVIS AIR FORCE BASE, CALIFORNIA

RDD \\BALDUR\PROJ\TRAVIS\381355_2012ROD_REPORT\MAPFILES\FIGURE2_2-4_SD031_DCE_HIST_CURR_GWCONTAM.MXD ECLARK1 5/30/2013 10:30:18 AM







LEGEND

- PIEZOMETER
- GROUNDWATER MONITORING WELL
- VERTICAL EXTRACTION WELL
- HORIZONTAL EXTRACTION WELL

TCE CONCENTRATIONS (µg/L)

- 5 ≤ TCE <100
- 100 ≤ TCE <1,000
- 1,000 ≤ TCE <10,000
- GROUNDWATER ELEVATION (ft MSL)
- APPROXIMATE GROUNDWATER FLOW DIRECTION
- APPROXIMATE EXTENT OF HYDRAULIC CAPTURE
- 5 APPROXIMATE ISOCONCENTRATION CONTOURS (µg/L)
- ERP SITE BOUNDARY
- BUILDINGS
- ABOVEGROUND STORAGE TANKS
- UNPAVED AREA
- PAVED AREA
- ROAD
- SURFACE WATER

N

0 275 550 FEET

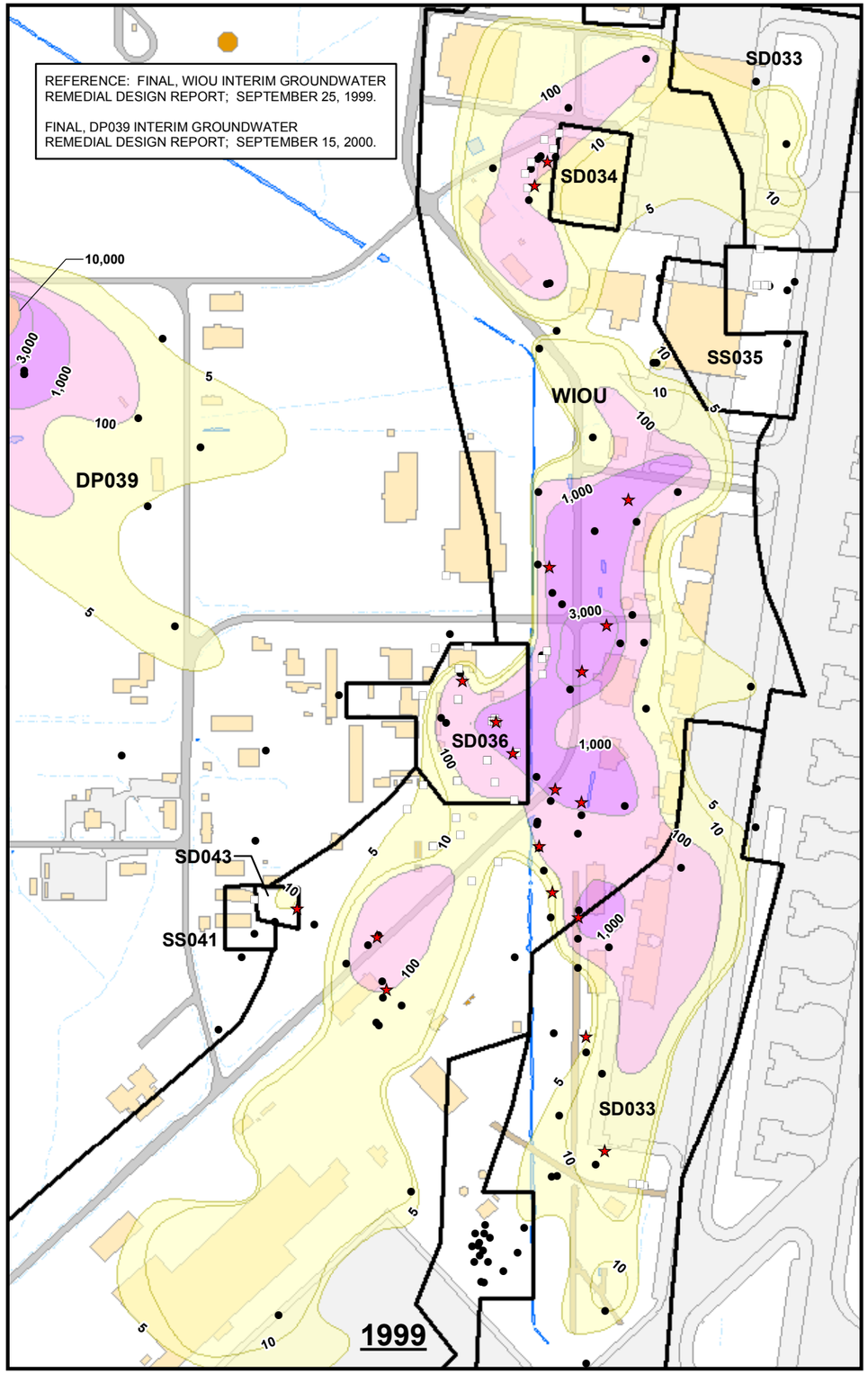
FIGURE 2.2-5
HISTORICAL AND CURRENT TCE GROUNDWATER CONTAMINATION - SITE SS016 AND SITE ST027B
GROUNDWATER RECORD OF DECISION
TRAVIS AIR FORCE BASE, CALIFORNIA

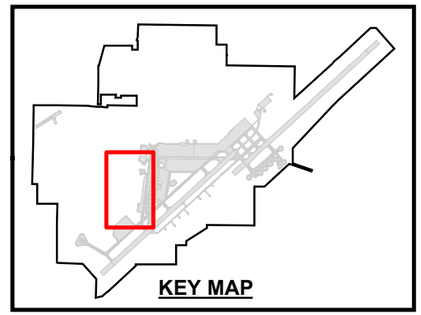
RDD \\BALDUR\PROJ\TRAVIS\381355_2012ROD_REPORT\MAPFILES\FIGURE2_2-5_SS016_HIST_CURR_GWCONTAM.MXD MSCHROCK 2/10/2014 12:38:30 PM

REFERENCE: FINAL, WIOU INTERIM GROUNDWATER REMEDIAL DESIGN REPORT; SEPTEMBER 25, 1999.

FINAL, DP039 INTERIM GROUNDWATER REMEDIAL DESIGN REPORT; SEPTEMBER 15, 2000.

REFERENCE: 2010-2011 GSAP REPORT





LEGEND

- PIEZOMETER
- GROUNDWATER MONITORING WELL
- VERTICAL EXTRACTION WELL

TCE CONCENTRATIONS (µg/L)

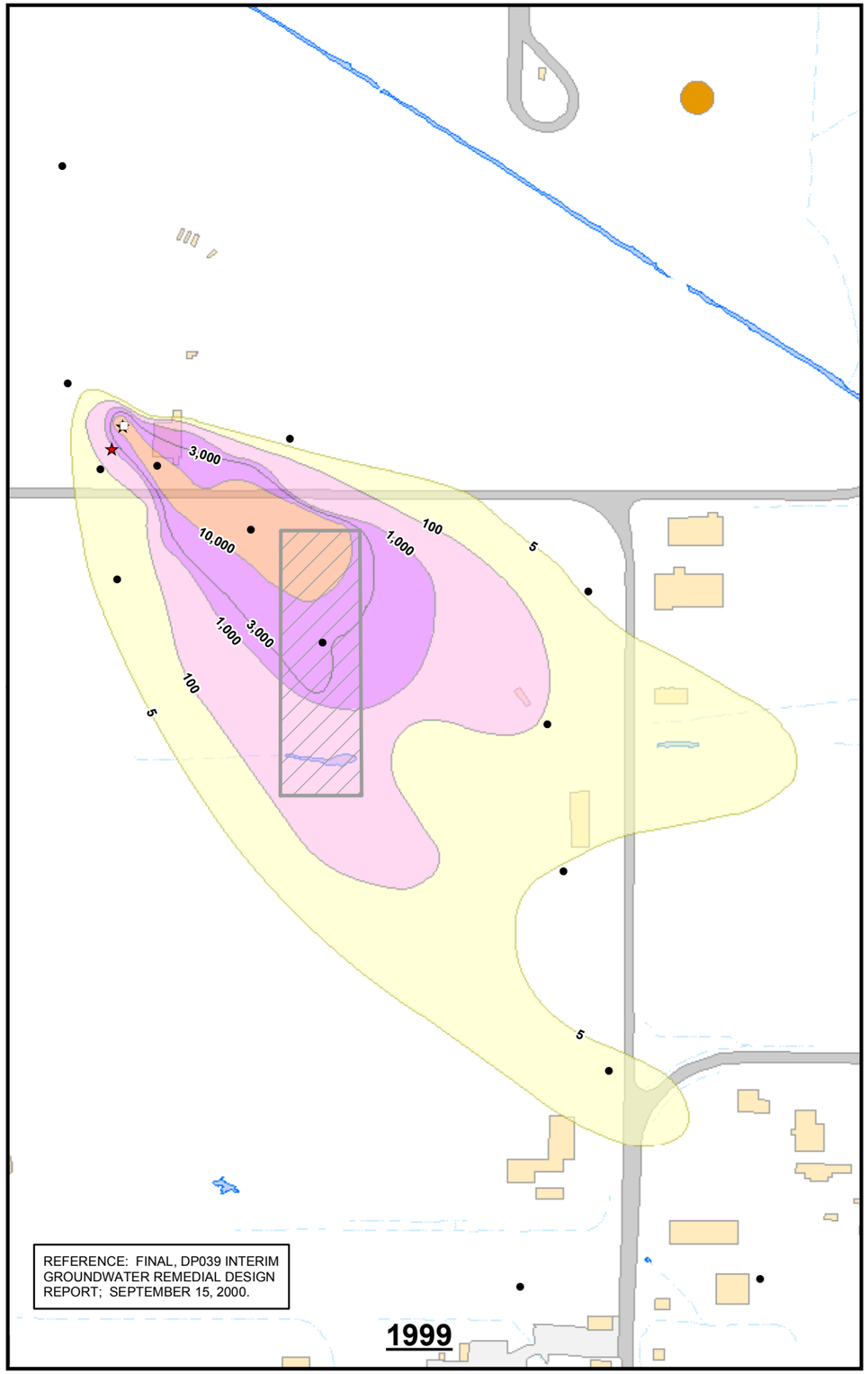
- 5 ≤ TCE <100
- 100 ≤ TCE <1,000
- 1,000 ≤ TCE <10,000
- GROUNDWATER ELEVATION (ft MSL)
- APPROXIMATE GROUNDWATER FLOW DIRECTION
- APPROXIMATE EXTENT OF HYDRAULIC CAPTURE
- 5 APPROXIMATE ISOCONCENTRATION CONTOURS (µg/L)
- ERP SITE BOUNDARY
- BUILDINGS
- ABOVEGROUND STORAGE TANKS
- UNPAVED AREA
- PAVED AREA
- ROAD
- SURFACE WATER

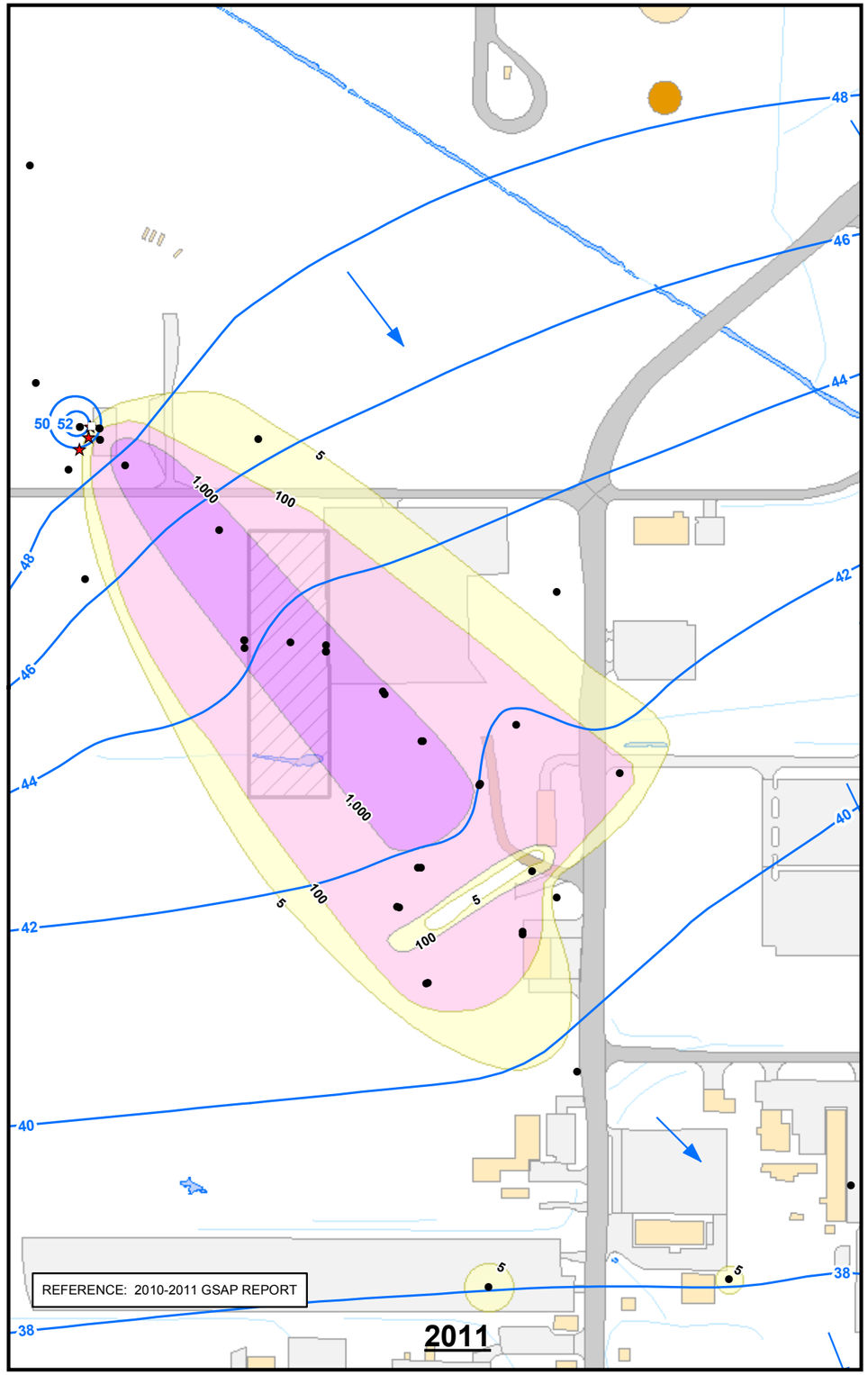
N

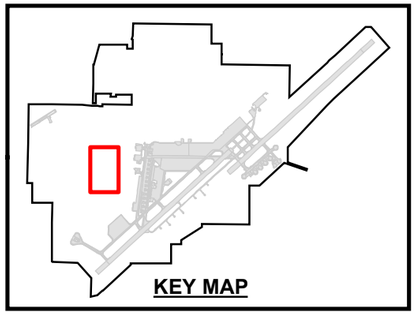
0 250 500 FEET

FIGURE 2.2-6
HISTORICAL AND CURRENT TCE GROUNDWATER CONTAMINATION - WIOU SITES
GROUNDWATER RECORD OF DECISION
TRAVIS AIR FORCE BASE, CALIFORNIA

RDD \\BALDUR\PROJ\TRAVIS\381355_2012ROD_REPORT\MAPFILES\FIGURE2_2-6_WIOU_HIST_CURR_GWCONTAM.MXD ECLARK1 6/4/2013 2:00:45 PM







LEGEND

- PIEZOMETER
- GROUNDWATER MONITORING WELL
- EXTRACTION WELL
- PHYTOREMEDIATION AREA

TCE CONCENTRATIONS (µg/L)

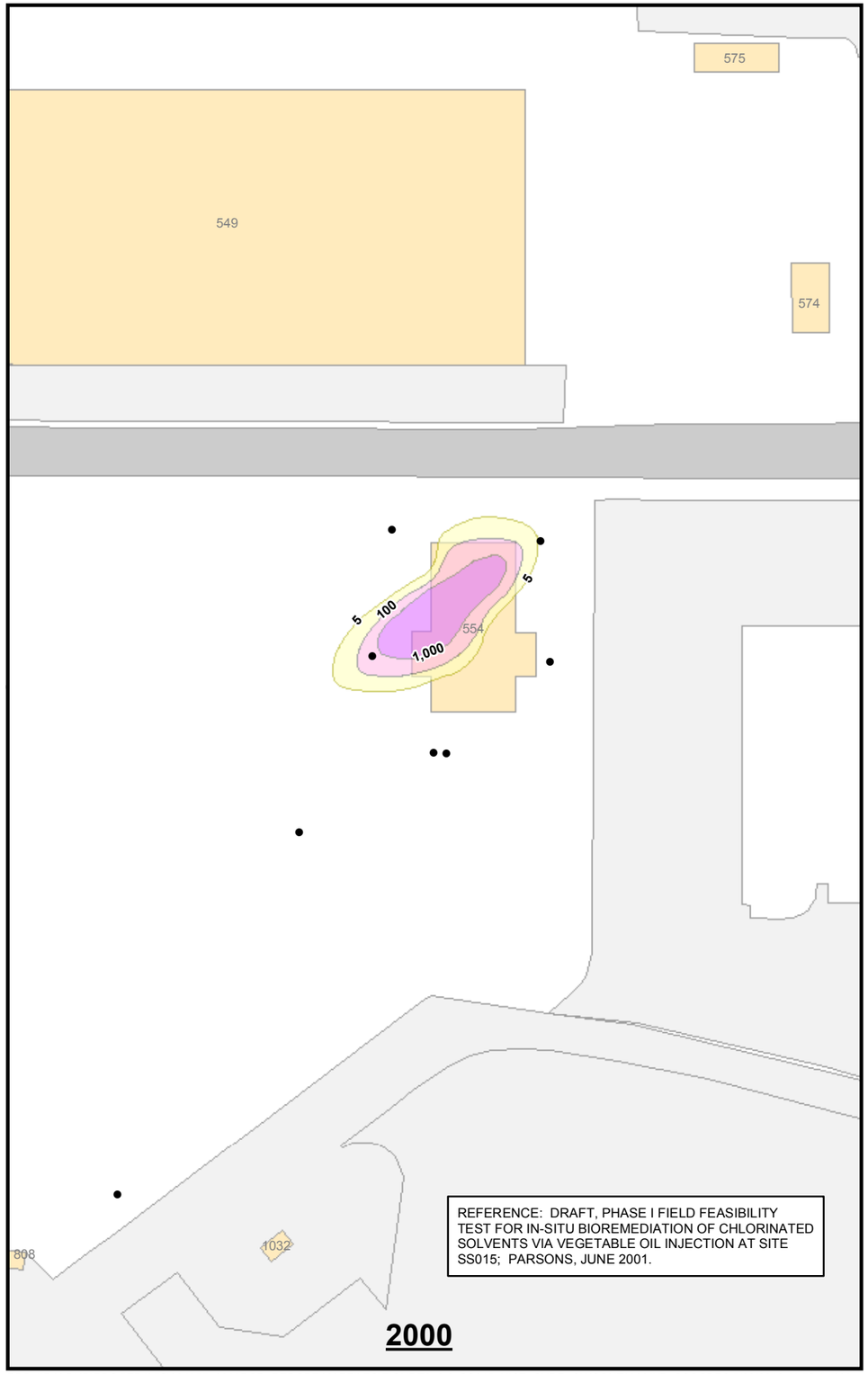
- 5 ≤ TCE <100
- 100 ≤ TCE <1,000
- 1,000 ≤ TCE <10,000
- 10,000 ≤ TCE <100,000
- GROUNDWATER ELEVATION (ft MSL)
- APPROXIMATE GROUNDWATER FLOW DIRECTION
- 5 APPROXIMATE ISOCONCENTRATION CONTOURS (µg/L)
- BUILDINGS
- ABOVEGROUND STORAGE TANKS
- UNPAVED AREA
- PAVED AREA
- ROAD
- SURFACE WATER

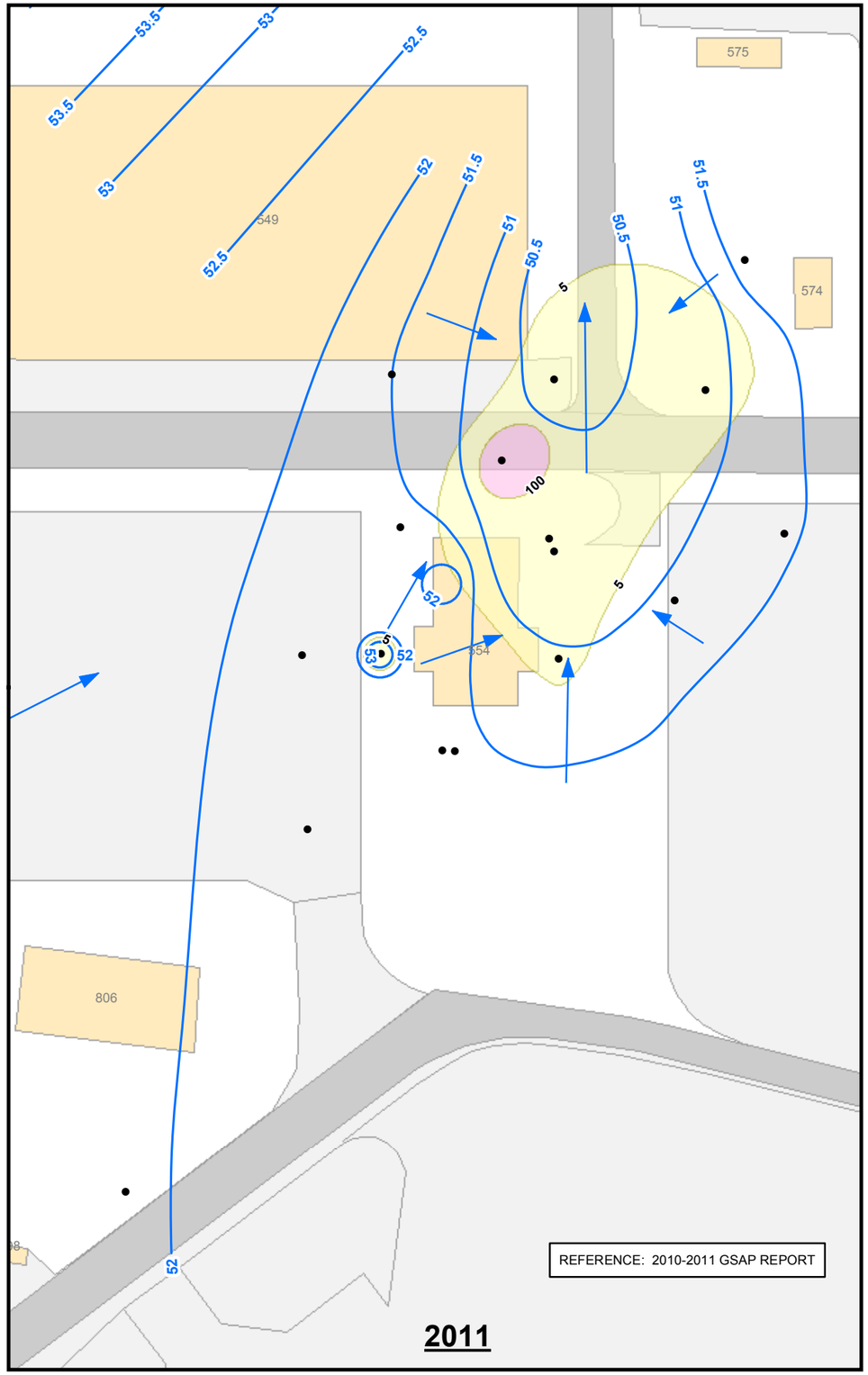
N

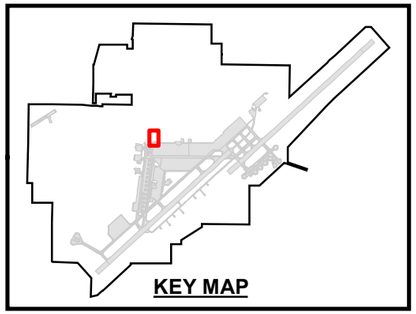
0 150 300 FEET

FIGURE 2.2-7
HISTORICAL AND CURRENT TCE GROUNDWATER CONTAMINATION - SITE DP039
GROUNDWATER RECORD OF DECISION
TRAVIS AIR FORCE BASE, CALIFORNIA

RDD \\BALDUR\PROJ\TRAVIS\381355_2012ROD_REPORT\MAPFILES\FIGURE2_2-7_DP039_HIST_CURR_GWCONTAM.MXD ECLARK1 5/30/2013 11:37:02 AM







LEGEND

- GROUNDWATER MONITORING WELLS

TCE CONCENTRATIONS (µg/L)

- 5 ≤ TCE <100
- 100 ≤ TCE <1,000
- 1,000 ≤ TCE <10,000
- 5 — APPROXIMATE ISOCONCENTRATION CONTOURS (µg/L)
- GROUNDWATER ELEVATION (ft MSL)
- APPROXIMATE GROUNDWATER FLOW DIRECTION
- 549 — BUILDINGS
- UNPAVED AREA
- PAVED AREA
- ROAD

N

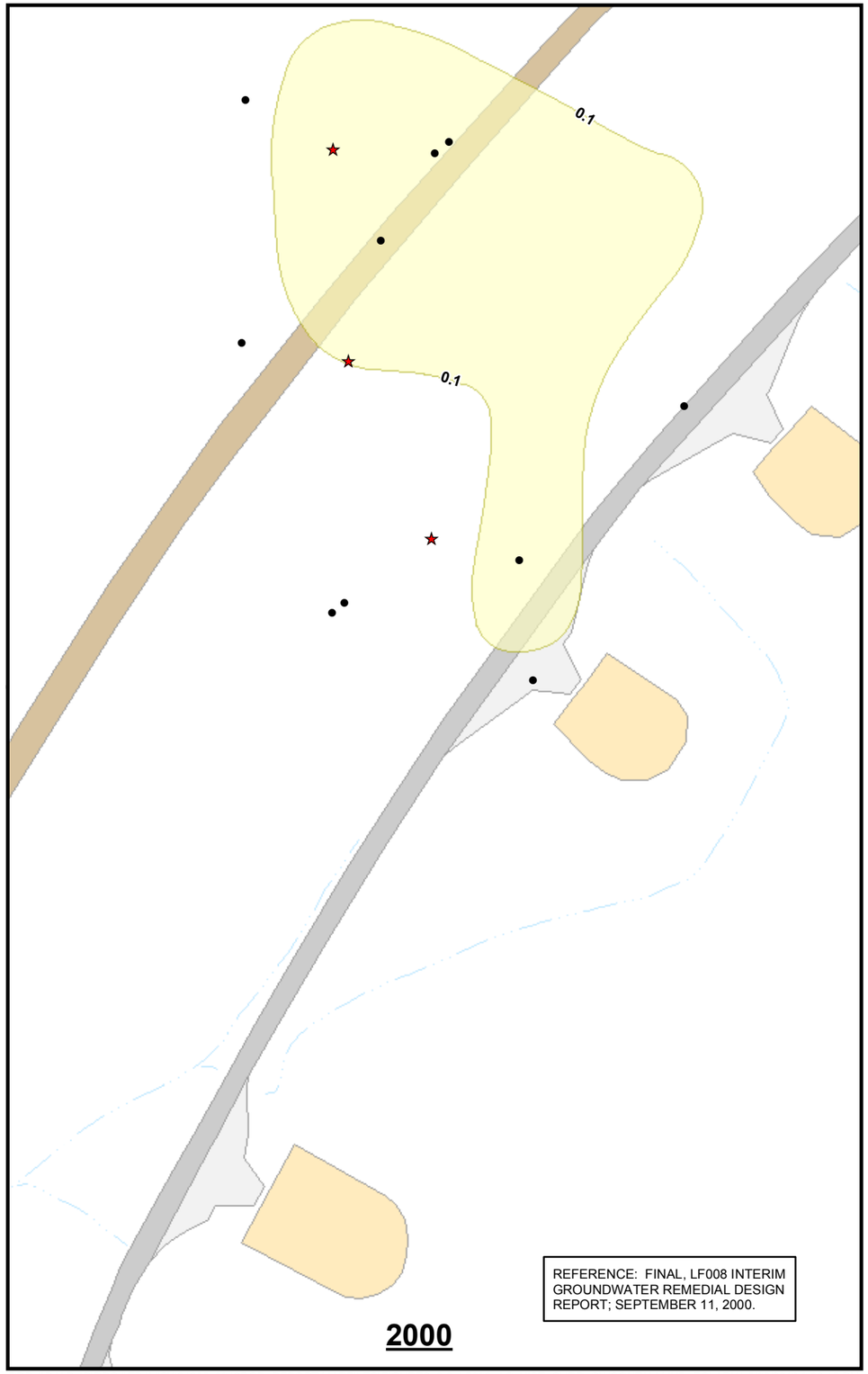
0 50 100 FEET

REFERENCE: DRAFT, PHASE I FIELD FEASIBILITY TEST FOR IN-SITU BIOREMEDIATION OF CHLORINATED SOLVENTS VIA VEGETABLE OIL INJECTION AT SITE SS015; PARSONS, JUNE 2001.

REFERENCE: 2010-2011 GSAP REPORT

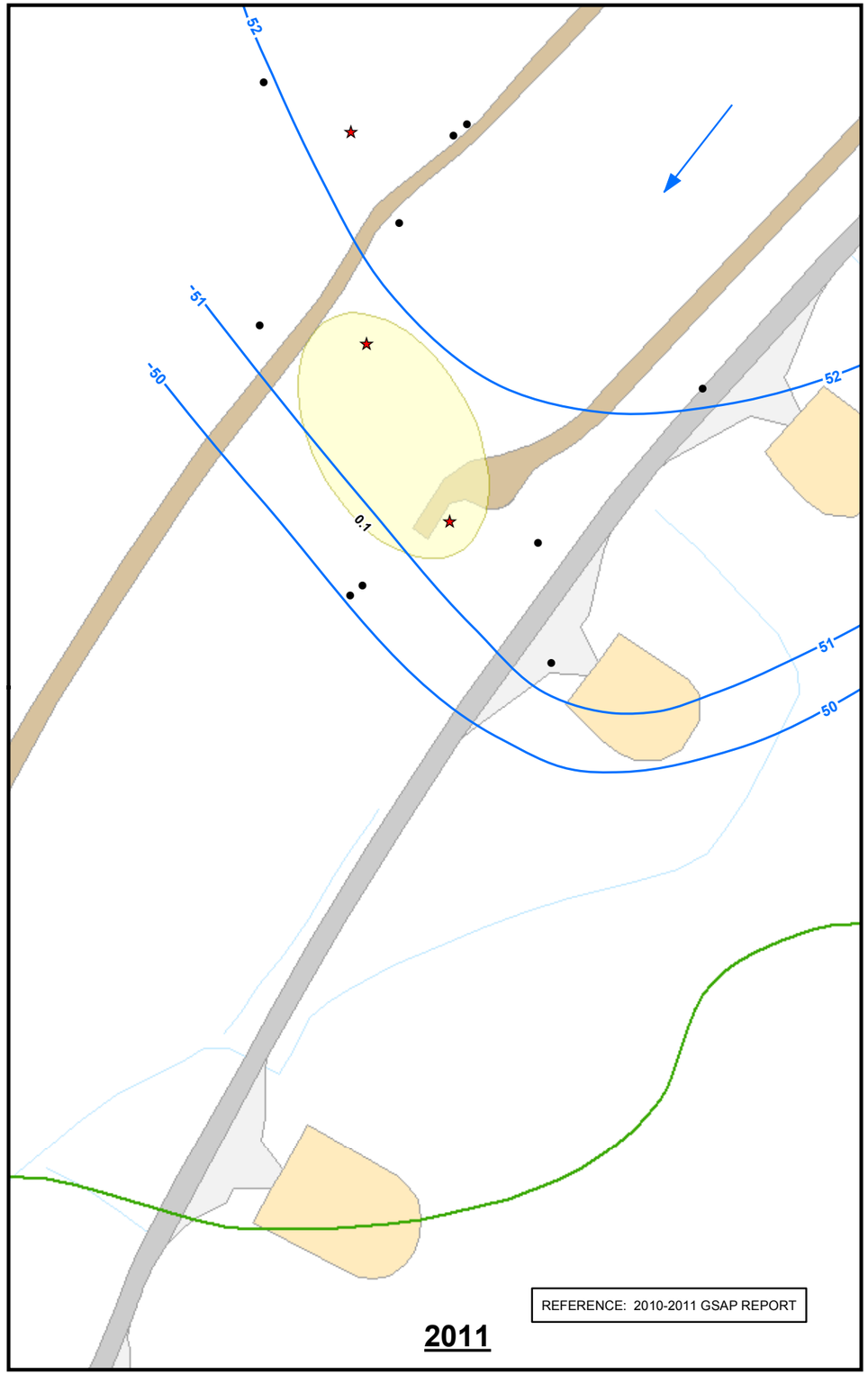
FIGURE 2.2-8
HISTORICAL AND CURRENT TCE GROUNDWATER CONTAMINATION - SITE SS015
GROUNDWATER RECORD OF DECISION
TRAVIS AIR FORCE BASE, CALIFORNIA

RDD \\BALDUR\PROJ\TRAVIS\381355_2012ROD_REPORT\MAPFILES\FIGURE2_2-8_SS015_HIST_CURR_GWCONTAM.MXD SSCOPES 5/30/2013 11:52:14 AM



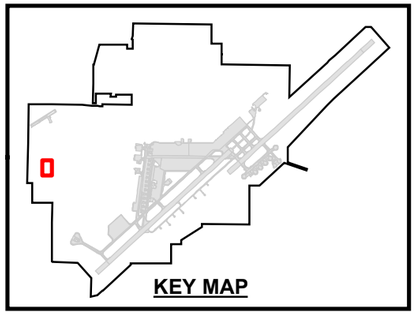
2000

REFERENCE: FINAL, LF008 INTERIM GROUNDWATER REMEDIAL DESIGN REPORT; SEPTEMBER 11, 2000.



2011

REFERENCE: 2010-2011 GSAP REPORT



LEGEND

- PIEZOMETER
- GROUNDWATER MONITORING WELL
- EXTRACTION WELL
- APPROXIMATE EXTENT OF HYDRAULIC CAPTURE (DASHED WHERE LESS CERTAIN)

ALPHA-CHLORDANE CONCENTRATIONS (µg/L)

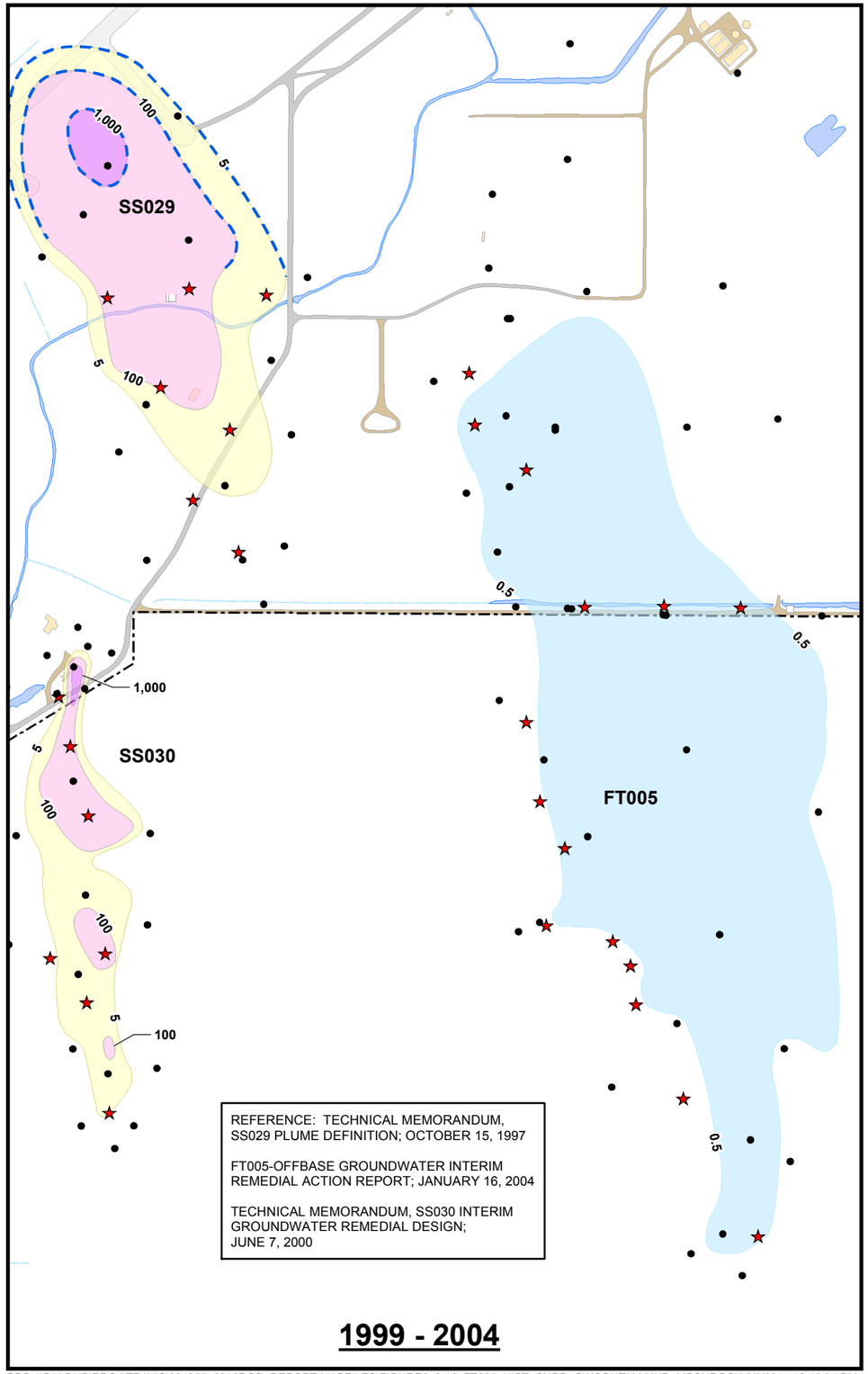
- ALPHA-CHLORDANE ≥ 0.1 µg/L
- GROUNDWATER ELEVATION (ft MSL)
- APPROXIMATE GROUNDWATER FLOW DIRECTION
- 0.1 APPROXIMATE ALPHA CHLORDANE ISOCONCENTRATION CONTOUR (µg/L)
- SURFACE WATER
- BUILDINGS
- UNPAVED AREA
- PAVED AREA
- ROAD

N

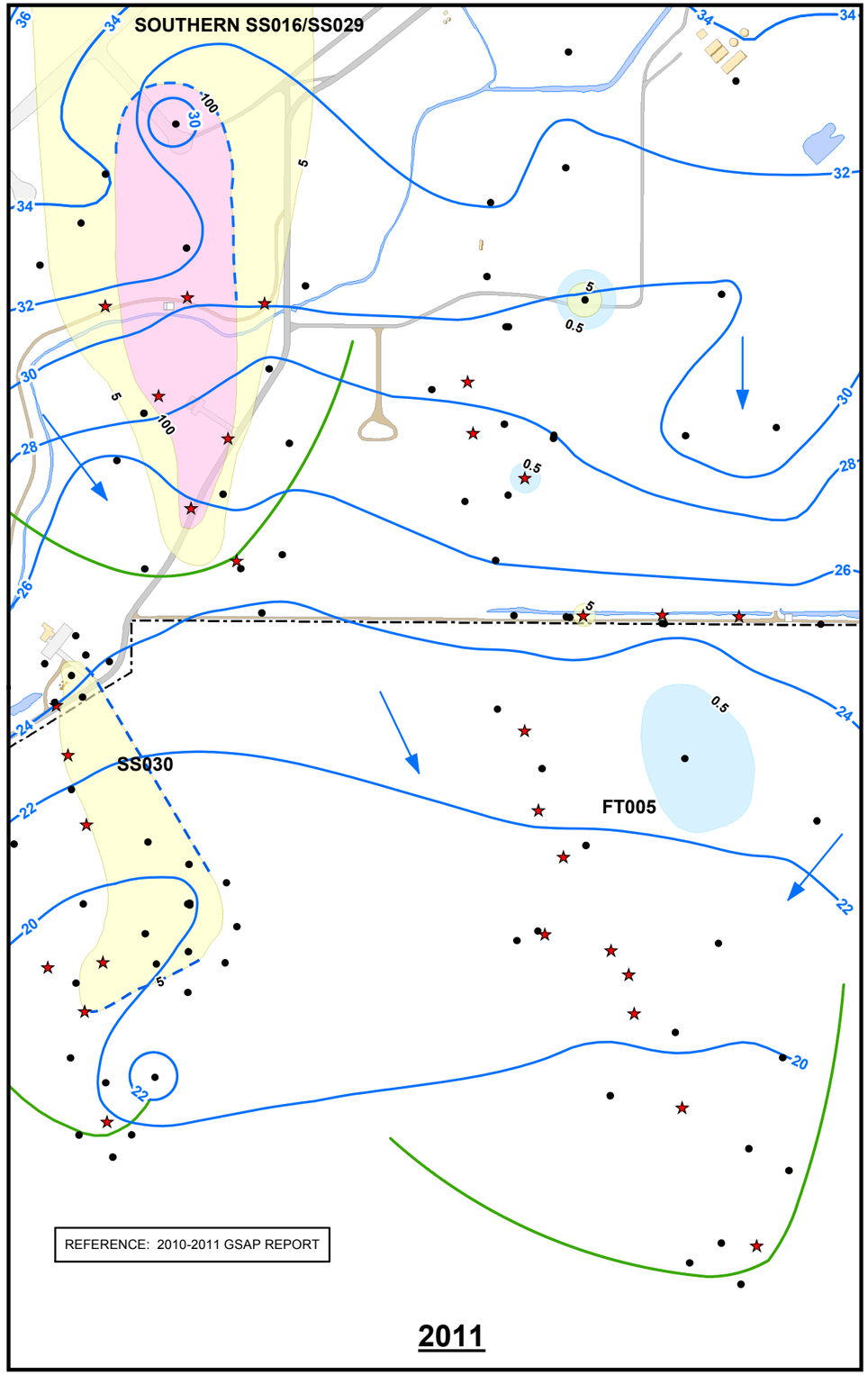
0 50 100 FEET

FIGURE 2.2-9
HISTORICAL AND CURRENT ALPHA-CHLORDANE GROUNDWATER CONTAMINATION - SITE LF008
GROUNDWATER RECORD OF DECISION
TRAVIS AIR FORCE BASE, CALIFORNIA

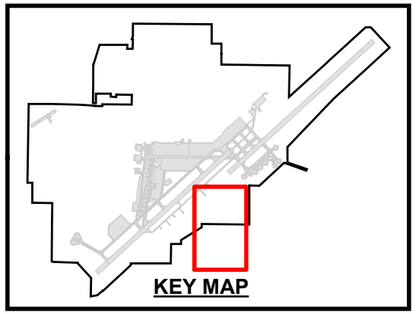
RDD \\BALDUR\PROJ\TRAVIS\381355_2012ROD_REPORT\MAPFILES\FIGURE2_2-9_LF008_AC_HIST_CURR_GWCONTAM.MXD ECLARK1 5/30/2013 3:03:47 PM



1999 - 2004



2011



LEGEND

- PIEZOMETER
- GROUNDWATER MONITORING WELL
- EXTRACTION WELL

1,2-DCA CONCENTRATIONS (µg/L)

- 1,2-DCA ≥ 0.5 µg/L

TCE CONCENTRATIONS (µg/L)

- 5 ≤ TCE <100
- 100 ≤ TCE <1,000
- 1,000 ≤ TCE <10,000
- APPROXIMATE TCE ISOCONCENTRATION CONTOUR (µg/L)
- GROUNDWATER ELEVATION (ft MSL)
- APPROXIMATE GROUNDWATER FLOW DIRECTION
- APPROXIMATE EXTENT OF HYDRAULIC CAPTURE (DASHED WHERE LESS CERTAIN)
- 5 APPROXIMATE ISOCONCENTRATION CONTOURS (µg/L)
- BASE BOUNDARY
- BUILDINGS
- UNPAVED AREA
- PAVED AREA
- ROAD
- SURFACE WATER

N

0 275 550 FEET

FIGURE 2.2-10
HISTORICAL AND CURRENT GROUNDWATER CONTAMINATION - SITES FT005/SS029/SS030
GROUNDWATER RECORD OF DECISION
TRAVIS AIR FORCE BASE, CALIFORNIA

RDD \\BALDUR\PROJ\TRAVIS\381355_2012ROD_REPORT\MAPFILES\FIGURE2_2-10_FT005_HIST_CURR_GWCONTAM.MXD MSCHROCK 2/6/2014 12:19:04 PM

2.3 Community Participation

NCP Section 300.430(f)(3) establishes a number of public participation activities that the lead agency must conduct following preparation of the Proposed Plan and review by the support agency. Components of these items and documentation of how each component was satisfied for Travis AFB are described below.

The Proposed Plan was made available to the public on October 10, 2012. The Proposed Plan and other relevant supporting documents, including RI and FS reports, can be found in the Administrative Record file and the Information Repository maintained at the Vacaville Cultural Center Library in Vacaville, California. The Administrative Record file and the Information Repository are updated regularly as documents are finalized so that they are available to the public. The notice of availability for the Proposed Plan was published in the Fairfield *Daily Republic* and Vacaville *Reporter*, newspapers of general circulation on October 12, 2012. Another notice of availability was published in the Travis AFB *Tailwind* on October 12, 2012. Appendix B contains a copy of the notice that was published in all three (3) newspapers.

In addition, the September 2012 edition of the Travis AFB environmental newsletter (the *Guardian*) summarized the purpose of the Proposed Plan, promoted public involvement in the remedy selection process, and advertised the public comment period and public meeting. The *Guardian* was distributed by electronic mail to approximately 50 government and public addresses on October 11, 2012, and by regular mail to approximately 680 government and public addresses in the Travis AFB environmental community involvement mailing list on October 12, 2012.

Finally, the Travis AFB environmental public website advertised the availability of the Proposed Plan, the opportunity to provide public comments on the proposed groundwater remedies, and the invitation to attend the public meeting.

A public comment period was held from October 10 to November 9, 2012. An extension to the public comment period was not requested. In addition, a public meeting was held on October 18, 2012, at the Northern Solano County Association of Realtors building located at 3690 Hilborn Road in Fairfield, California, to present the Proposed Plan to a broader community audience than those who had already been involved at the sites. At this meeting, representatives from the AF answered questions about the sites and the remedial alternatives. A transcript of this meeting has been added to the Administrative Record file and Information Repository.

AF responses to comments received during the public comment period are included in the Responsiveness Summary, which is provided as Section 3 of this ROD.

Other public participation requirements and outreach activities have been performed to maintain and increase public awareness and ensure that there is effective community participation in restoration decisions. Numerous community relations activities have been part of the comprehensive Travis AFB community relations program since 1990 as summarized below:

- **RAB.** In 1994, Travis AFB established a RAB comprising representatives of the community and the regulatory agencies. Through its quarterly meetings and its focus

groups, the RAB has provided valuable input about community concerns regarding the Restoration Program. The Technical Document Review focus group has reviewed and commented on the draft version of every major report. The Relative Risk focus group has provided input on the project prioritization, and the Community Relations focus group is working to reach out to all community members. The RAB replaced the Technical Review Committee, which met periodically to review program progress.

Currently, the RAB meets in April and October of each year. RAB meetings are held at various locations in Fairfield and Vacaville. All meetings are open to the public and are advertised in the Fairfield *Daily Republic,* the Vacaville *Reporter,* and the Travis AFB *Tailwind* at least 1 week in advance. The meeting date and location are also provided on the back cover of the quarterly ERP newsletter, *Guardian*, which is sent to everyone on the mailing list 2 weeks prior to the meeting, and posted on the Travis AFB Environmental Cleanup Program public web site at *http://public.travis.amc.af.mil/enviro.*

- **Administrative Record/Information Repository.** The AF established an Administrative Record to support AF decisions related to the Travis AFB ERP. In addition, the AF established a public information repository for the relevant portion of the Administrative Record at the Vacaville Cultural Center Library. Copies of previously completed RI reports, FS reports, Proposed Plans, IRODs, and RODs are available for public review.

- **CRP.** The AF implemented the first Travis AFB CRP in 1991 as a guideline for conducting community involvement activities associated with the environmental cleanup at Travis AFB. The AF revised the CRP in 1998.

- **CIP.** In August 2001, the CIP replaced the CRP. The AF revised the CIP in 2003 and 2006. The Travis AFB Restoration Program Manager (RPM) maintains the CIP.

- **Mailing List.** Travis AFB maintains a mailing list of all interested government representatives and community members for the distribution of its environmental community involvement products. The mailing list is typically updated after the publication of an environmental quarterly newsletter or on-request. The list was last updated in July 2013 and contains approximately 680 postal addresses and 50 electronic addresses.

- **Fact Sheets and Newsletters.** The AF has been publishing fact sheets describing activities and milestones in the restoration program occasionally since 1993. Since 1995, the AF has published and mailed quarterly newsletters to everyone on the mailing list. The newsletters contain information about public participation, issues of potential concern to the public, and program updates. The RPM writes a Viewpoint article for each newsletter. More information about the Travis AFB Environmental Cleanup Program is available on the public web site at http://www.travis.af.mil/enviro/index.asp.

2.4 Scope and Role of Operable Unit or Response Action

As with many large industrial facilities, the environmental problems at Travis AFB are complex. As a result, in October 1995, the AF, with concurrence from the EPA, the California DTSC, and State Water Board, organized the sites at Travis AFB into two (2) OUs, the NEWIOU and the WABOU. This ROD addresses groundwater contamination at sites within both of these OUs as described below:

- **NEWIOU –** groundwater with chlorinated VOCs, primarily TCE, 1,2-DCE, 1,1-DCE, 1,2-DCA, vinyl chloride, TPH-G, TPH-D, and related compounds originating from Sites FT004, FT005, LF006, LF007, SS015, SS016, ST027B, SS029, SS030, SD031, SD033, SD034, SS035, SD036, and SD037. Site LF007 is divided into three (3) subareas (LF007B, LF007C, and LF007D) to address different COCs.
- **WABOU –** groundwater with chlorinated VOCs (primarily TCE and related compounds) at Sites DP039 and SD043 and organochlorine pesticides (primarily alpha-chlordane) originating from Sites LF008 and SS041.

For more than a decade, Travis AFB has implemented and successfully operated IRAs for groundwater, which were selected in interim RODs (Travis AFB, 1999, 1998). Recent investigations continue to identify chlorinated VOCs and organochlorine pesticides in the groundwater at concentrations above the lowest of either the state or federal primary maximum MCLs. TPH-G and TPH-D also continue to be detected in the groundwater (EPA, 2012). As of 2012, the following contamination was detected:

- Chlorinated VOCs were detected in groundwater at the following concentrations compared with MCLs: TCE at 40,200 µg/L, compared with the MCL of 5 µg/L; 1,1-DCE at 56.7 µg/L, compared with the MCL of 6 µg/L; 1,2-DCA at 5.8 µg/L, compared with the MCL of 0.5 µg/L; cis-1,2-DCE at 8,230 µg/L, compared with the MCL of 6 µg/L; benzene at 7.6 µg/L, compared with the MCL of 1 µg/L; 1,4-DCB at 710 µg/L, compared with the MCL of 5 µg/L; PCE at 212 µg/L, compared with the MCL of 5 µg/L; and vinyl chloride at 1,100 µg/L, compared with the MCL of 0.5 µg/L.
- Organochlorine pesticides were detected in groundwater at the following concentrations compared with MCLs: alpha-chlordane at 0.43 µg/L, compared with the MCL of 0.1 µg/L and heptachlor epoxide at 0.017 J- µg/L, compared with the MCL of 0.01 µg/L.
- TPH-G and TPH-D were detected in groundwater at the following concentrations: TPH-G at 1,200 µg/L and TPH-D at 4,700 µg/L.

On the basis of this groundwater contaminant data, the AF determined that remedial action is necessary to continue to remediate groundwater at Travis AFB and to restore and protect designated beneficial uses (Travis AFB, 2002b). The AF and EPA have jointly evaluated and selected the remedies for groundwater. The California DTSC and San Francisco Bay Regional Water Board concur with the selected remedies.

To address the residual contamination in groundwater that remains after approximately a decade of interim remediation, the overall cleanup strategy for Travis AFB groundwater is to transition from the current interim actions to final remedies. This ROD presents the final response actions for groundwater. Changes, if they occur, to the remedies described in this

ROD will be documented using a technical memorandum in the Administrative Record, an Explanation of Significant Differences (ESD), or ROD amendment.

Other environmental media at Travis AFB have previously been addressed in separate decision documents. Final remedies for soil, sediment, and surface water contamination at Travis AFB have been previously selected in the final Soil ROD for the WABOU (Travis AFB, 2002b) and the final NEWIOU Soil, Sediment, and Surface Water ROD (Travis AFB, 2006a).

2.5 Site Characteristics

This section describes the general environmental setting and physical characteristics for Travis AFB, previous site characterization activities, the nature and extent of contamination, and the conceptual exposure model, which are based on information provided in Section 3 of the FFS (CH2M HILL, 2011a), the BIR (CH2M HILL, 2012f), the GSAP 2010-2011 Annual Report (CH2M HILL, 2012a), and four (4) OU-specific RI reports: the WABOU RI Report (CH2M HILL, 1997), the NOU RI Report (Radian, 1995), the EIOU RI Report (Weston, 1995), and the WIOU RI Report (Radian, 1996a).

More complete descriptions of the individual ERP site characteristics are provided in Appendix A. This appendix includes site-specific descriptions of geology, groundwater characteristics, contaminant types and distribution, the nature and status of the IRA, plan view figures, and cross sections.

2.5.1 Physiography and Climate

Travis AFB is located midway between San Francisco and Sacramento, California, on low-lying ground within 1 mile of Suisun Marsh, an estuary of San Francisco Bay. It is located 3 miles east of downtown Fairfield in Solano County. The Base occupies more than 6,000 acres and maintains ownership of, or administrative control over, several properties at off-base locations.

Topography is gently sloping to nearly flat with variations in topographic relief of up to 50 feet. Elevations at Travis AFB range from more than 100 feet above mean sea level (msl), near the northern boundary, to less than 20 feet above msl, near the South Gate. The ground surface generally slopes to the south or southeast at about 30 feet per mile.

Travis AFB has a Mediterranean climate, including wet winters and dry summers, and usually experiences mild temperatures because of its proximity to the Carquinez Straits and the coast. The mean annual temperature is 60 degrees Fahrenheit (°F). The lowest temperatures occur in January, with a mean of 46°F. The highest temperatures occur in July and August, with a mean of 72°F. Monthly mean relative humidity typically ranges from a low of 50 percent in June to a high of 77 percent in January.

Travis AFB averages 17.5 inches of rain annually. Approximately 84 percent of the annual precipitation falls during the winter season of November through March. January is the wettest month, averaging 3.7 inches of precipitation; July is the driest month averaging 0.02 inch of precipitation.

Travis AFB experiences sea breezes during the summer because of its proximity to the Carquinez Straits. The average annual wind speed is 8 knots, with a winter average of 5 to 6 knots and a summer average of 12 knots. The predominant wind directions are from the southwest and west-southwest.

2.5.2 Geology

Travis AFB is characterized by gently sloping alluvial plains and fans overlying undulating bedrock. Older Alluvium makes up most of the sediment found on the Base. Alluvium beneath Travis AFB ranges in thickness from 0 to about 110 feet. The alluvium is underlain

by bedrock consisting of semi-consolidated to consolidated sedimentary units; the alluvium and bedrock are sometimes difficult to distinguish in the field. The alluvium consists primarily of silts and clays that are low in permeability and do not transmit groundwater readily. More permeable units, such as sands and gravels, are geographically restricted and occur as lenses rather than as continuous beds that may be correlated from place to place.

Alluvium was carried in several streams (such as Union Creek) that have migrated laterally across the Base. Coarse sands and gravels are deposited in the streambed and immediately adjacent to the stream levee; finer silts and clays are deposited away from the stream during flood events. Consequently, the discontinuous sand lenses are usually elongated parallel to streams and are contained in an overall matrix of fine-grained silts and clays in the vicinity of Travis AFB. Sand lenses throughout the Base trend south-southeast. These discontinuous permeable zones are preferential pathways that create anisotropic groundwater flow in the horizontal plane.

The bedrock beneath Travis AFB is primarily sandstone and shale. The top of the bedrock unit is weathered to varying degrees and varying thickness. Consequently, bedrock generally becomes increasingly competent with depth. The composition of the most weathered portions reflects the composition of the parent material (sand and silt) and therefore may have similar permeability to the overlying alluvium. No field testing of bedrock permeability has been conducted at the Base, but unweathered bedrock is likely to have much lower permeability than the alluvium.

2.5.3 Hydrogeology

Travis AFB is located along the eastern edge of the Fairfield-Suisun Hydrologic Basin, a hydrologically distinct structural depression adjacent to the Sacramento Valley segment of the Central Valley Province. The primary water-bearing deposits at Travis AFB are the coarse-grained sediments (sand and gravel) within the extremely heterogeneous Older Alluvium and Younger Alluvium. The depth to groundwater at Travis AFB is typically 10 to 15 feet bgs. In general, groundwater elevations have remained relatively constant over time. Groundwater elevations typically fluctuate from 2 to 5 feet between fall and spring, with the maximum elevations in spring and the minimum elevations in fall.

The regional groundwater gradient is generally toward the south or southeast. Groundwater recharge occurs from the direct infiltration of rainfall on the valley surface and from the infiltration of runoff through local streambeds and creek beds. Natural groundwater discharge occurs at the marshlands near Potrero Hills, south of Travis AFB (Thomasson et al., 1960).

The groundwater flow system at Travis AFB is influenced by the configuration of alluvium and bedrock at the Base. Groundwater flow within the alluvium is typically to the south, but there are relatively small and localized variations in the flow direction because of permeability differences between the alluvium and underlying bedrock.

In accordance with the *Guidelines for Ground-Water Classification under the EPA Ground-Water Protection Strategy*), the groundwater at Travis AFB is appropriately categorized as Class IIB – groundwater that is potentially a source for drinking water (EPA, 1986). However, Travis AFB does not currently use the groundwater and has no plans to do so in the future because of the low groundwater quality and low aquifer yields.

2.5.3.1 Aquifer Stratigraphy

The aquifer system underlying Travis AFB should be viewed as a single leaky and heterogeneous aquifer system of unconsolidated alluvium, as opposed to one (1) with multiple and distinct aquifers. The depth to bedrock ranges from a few feet to tens of feet; thus, the saturated thickness of the aquifer is small compared with the length of the groundwater contaminant plumes. It is not usually possible to predict with confidence where the more permeable sand lenses may be encountered or interconnected.

The saturated alluvium thickness at Travis AFB averages approximately 28 feet. However, localized thicknesses of up to about 100 feet are found in the vicinity of Site SD036.

2.5.3.2 Groundwater Flow Velocity

Groundwater at Travis AFB is found under unconfined or semi-confined conditions and flows in a predominantly horizontal direction. Typical groundwater flow rates in the alluvium in the Base area are on the order of 100 to 200 feet per year (ft/year), assuming an effective porosity of 20 percent, which is typical for the fine-grained sediments encountered at the Base.

2.5.3.3 Horizontal and Vertical Gradients

The following subsections briefly describe the groundwater horizontal and vertical gradients at Travis AFB. More complete information is provided in annual GSAP reports and GRISRs.

Groundwater at Travis AFB flows primarily south, except where groundwater mounds or depressions exist. Local variations in flow direction are the result of the subsurface geology and groundwater pumping. Typically, the horizontal gradients in the alluvium at Travis AFB range from 0.004 to 0.008 feet per foot (ft/ft). Where groundwater mounds exist, the localized horizontal gradients are relatively steep (approximately 0.02 ft/ft) when compared with the horizontal gradients in the alluvial basins away from the mounds. The horizontal gradients typically observed in bedrock are approximately 0.01 ft/ft. In general, the magnitudes of vertical gradients in the alluvium at Travis AFB are less than 0.1 ft/ft. Few data are available regarding the vertical gradient between bedrock and alluvium. Almost all of the monitoring wells at Travis AFB are screened within the permeable zones of the alluvium. In one (1) well pair, the vertical gradient was approximately 0.00 ft/ft.

2.5.3.4 Current and Anticipated Future Groundwater Use

Travis AFB overlies the Suisun-Fairfield Valley groundwater basin. According to the Basin Plan (San Francisco Bay Regional Water Board, 2011), beneficial uses for groundwater in the Suisun-Fairfield Valley groundwater basin are municipal and domestic water supply, industrial process and industrial service water supply, and agricultural water supply.

Approximately 3,562 acre-feet per year of groundwater are pumped for agricultural use from the Suisun-Fairfield Valley groundwater basin. Although there are 15 public water supply wells within the Suisun-Fairfield Valley groundwater basin, they do not serve a municipal population. The nearest city to Travis AFB is Fairfield, California, which uses surface water rather than groundwater for their municipal water supply. Downtown Fairfield is located west of Travis AFB. Downgradient of Travis AFB is the brackish water of Suisun Marsh.

No on-base wells are currently used for potable water production at Travis AFB, and none are planned for the future. Currently, one (1) privately owned domestic water well (DWSET1x30) is located at the southern extent of Site SS030. No COCs originating from Travis AFB have been detected in this well. It has been sampled semiannually for VOCs under the Travis AFB GSAP (now GRIP). The amount and rate of groundwater production from this privately owned well is unknown, because no flow meter is installed.

Approximately 90 percent of the water used at Travis AFB is surface water originating from Lake Berryessa and Lake Oroville. This water is conveyed to a water treatment facility managed by the City of Vallejo, which provides potable water to the Base. Three (3) groundwater production wells located at the Cypress Lakes Golf Course Annex provide the remaining 10 percent of the Base water supply. These production wells are located approximately 3 miles north of Travis AFB and are hydraulically separate from the Base.

In the future, it is anticipated that the Base water will be entirely supplied by production wells located at the Cypress Lakes Golf Course Annex, and the current service from the City of Vallejo will be discontinued (Weston, 2011).

2.5.4 Surface Water

Surface water features at Travis AFB include Union Creek and a network of underground pipes, culverts, and open drainage ditches. This surface water collection system divides the Base into eight (8) independent drainage areas. The head-waters of Union Creek are located approximately 1 mile north of the Base, near the Vaca Mountains, where the creek is an intermittent stream. Union Creek splits into two (2) branches north of the Base (the Main Branch and the West Branch). As it enters Travis AFB, the Main (eastern) Branch is impounded into a recreational pond designated as the Duck Pond. At the exit from the Duck Pond, the creek is routed through an underground storm drain pipe to the southeastern area of the Base, where it empties into an open channel.

The West Branch of Union Creek flows south and enters the northwestern border of Travis AFB east of the David Grant Medical Center in an excavated channel. This channel flows south to the northeastern corner of the WABOU. The channel forms the boundary between the WIOU and the WABOU and parallels Ragsdale Street for about 4,000 feet. Flow in the channel is then directed to a culvert under the runway and discharges to the main channel of Union Creek at Outfall II. From Outfall II, Union Creek flows southwest and discharges into Hill Slough, a wetland located 1.6 miles from the Base boundary. Surface water from Hill Slough flows into Suisun Marsh.

Local drainage patterns have been substantially altered within the Base by the rerouting of Union Creek, the construction of the aircraft runway and apron, the installation of storm drain pipes and ditches, and general development (e.g., the Base Exchange, industrial shops, maintenance yards, roads, housing, and other facilities).

The eastern portion of the Base is served by one (1) of the drainage systems that collects runoff from along the runway and the inactive sewage treatment plant area and directs it to Denverton Creek and Denverton Slough. Denverton Creek is an intermittent stream near the Base. The northwestern portion of the WABOU drains to the west toward the McCoy Creek drainage area. McCoy Creek is also an intermittent stream near the Base. With the exception of these drainages, the remaining six (6) drainage areas at the Base empty into Union Creek.

2.5.5 Ecology

Travis AFB has a variety of terrestrial and aquatic/wetland habitats and wildlife that are typical of the region.

2.5.5.1 Vegetation

The terrestrial habitats at Travis AFB and adjacent areas consist of herbaceous-dominated habitats (annual grassland, pasture, and early ruderal habitat) and urban habitat (industrial areas, lawns, and ornamental plants) (Mayer and Laudenslayer, 1988).

In general, annual grassland habitat is dominated by non-native plant species. Some native plants may also be found, usually associated with undisturbed areas.

Aquatic/wetland habitats at Travis AFB include riverine (Union Creek) and riparian habitat, lacustrine (Duck Pond), and herbaceous-dominated wetlands, marshes, and vernal pools. Herbaceous wetland vegetation is found along the permanent (natural or artificial) drainages on-base and can also occur seasonally within vernal pools, swales, and ditches.

The vernal wetlands are concentrated along the western, southern, and southeastern boundaries of the Base.

Vernal pools at Travis AFB contain indicator species such as goldfields, coyote thistle, dwarf woolly-heads, water pygmy-weed, and one (1) or more species of downingia and popcornflower.

2.5.5.2 Wildlife

Terrestrial vertebrates associated with non-native annual grasslands are commonly found on Travis AFB. Typical avian species include ring-necked pheasant, American kestrel, American robin, and the western meadowlark. Reptiles observed, or potentially occurring, at the Base include the western fence lizard, gopher snake, and California red-sided garter snake. Common mammals identified include deer mouse, California ground squirrel, Botta's pocket gopher, black-tailed hare, and red fox.

Permanent wetlands and seasonally wet areas support aquatic invertebrates, fish, amphibians, reptiles, birds, and mammals. Some aquatic invertebrate species observed in herbaceous wetlands and vernal pools at Travis AFB include vernal pool fairy shrimp, damselflies, crayfish, and aquatic snails. Amphibian species identified include bullfrog, Pacific tree frog, and California tiger salamander. Aquatic birds observed on or near the Base include mallard, great egret, and great blue heron.

Many aquatic invertebrates and amphibians also use riverine and riparian habitats. These include damselflies, crayfish, aquatic snail, bullfrog, Pacific tree frog, and California tiger salamander. Fish species include mosquitofish, fathead minnow, threespine stickleback, and bluegill. Riverine/riparian habitats are also used extensively by birds and terrestrial mammals for forage, shelter, and as a source of water. These include red-winged blackbird, raccoon, muskrat, and beaver.

Habitats that support special-status species are considered sensitive habitats. Sensitive aquatic/wetland areas include vernal pools, swales, and ditches that can support special-status plants and animals. Urban environments, scattered throughout the Base, can

also support special-status species. Burrowing owls may use man-made culverts, perches, and bare earth areas that contain burrows provided by ground squirrels. Loggerhead shrikes may nest on antenna wires and forage in grasslands. Also, vernal pool fairy shrimp have been found in artificially created depressions that seasonally fill with water.

2.5.6 Previous Site Characterization Activities

Data characterizing groundwater at Travis AFB have been collected during previous site activities from 1983 to the present. These include a PA/SI, RIs completed in the mid-1990s to support development of interim remedial alternatives in two (2) FSs, IRAs initiated in 1998 and 1999, subsequent measures implemented to optimize the IRAs, technology studies and demonstrations, MNA assessments, and a vapor intrusion assessment (see Section 2.2). Groundwater sampling is also conducted under the Travis AFB GSAP and GRIP. This additional information was used to support development of remedial alternatives for groundwater in the FFS (CH2M HILL, 2011a).

A summary of these investigations is provided in Table 2.5-1, and a detailed history is included in the following reports:

- WIOU RI Report (Radian, 1996a)
- NOU RI Report (Radian, 1995)
- EIOU RI Report (Weston, 1995)
- WABOU RI Report (CH2M HILL, 1997)
- NEWIOU Groundwater IROD (Travis AFB, 1998)
- WABOU Groundwater IROD (Travis AFB, 1999)
- NAAR (CH2M HILL, 2010b)
- *Vapor Intrusion Assessment Report* (CH2M HILL, 2010a)
- *Technical Report: Phytostabilization at Travis Air Force Base, California* (Parsons, 2010)
- Section 3 of the FFS (CH2M HILL, 2011a)
- GSAP 2010-2011 Annual Report (CH2M HILL, 2012a)
- BIR (CH2M HILL, 2012f)
- 2011 Annual RPO Report (CH2M HILL, 2012d)
- *Site LF007C Data Gaps Results Technical Memorandum* (CH2M HILL, 2012e)
- *Technical Memorandum for Assessment of Aerobic Chlorinated Cometabolism Enzymes at Travis Air Force Base, California* (CH2M HILL, 2012b)
- *Vapor Intrusion Assessment Update* (CH2M HILL, 2013a)
- *2012 Groundwater Sampling and Analysis Program Technical Memorandum* (CH2M HILL, 2012g)

2.5.7 Nature and Extent of Contamination

COCs in groundwater at Travis AFB have resulted from releases of liquid solvents from past waste management and disposal practices (see Figure 2.2-2). The most significant contaminant release mechanism to groundwater is deep percolation of the liquid solvents downward, and laterally along preferential pathways, through the vadose zone and into the saturated zone. The depth to groundwater at Travis AFB is relatively shallow at approximately 10 to 15 feet bgs. Contaminants released at the ground surface have readily migrated through this shallow vadose zone and into the groundwater.

Potential secondary sources of groundwater contamination at Travis AFB include DNAPLs and a LNAPL. Relatively high dissolved-phase contaminant concentrations indicate that DNAPLs are probably present in portions of the plumes at Sites SS015, SS016, SD036, SD037, and DP039. Free-phase Stoddard solvent, an LNAPL containing dissolved COCs, is intermittently observed floating on the groundwater table at Site SD034. Additional information on the distribution of groundwater contamination at each site is provided in Appendix A – Conceptual Site Models.

It is difficult to verify the presence of DNAPLs through direct observation. Generally, their presence is indirectly estimated. One (1) approach to evaluating the possible presence of DNAPL is based on groundwater concentration data and the "1 percent of solubility" rule-of-thumb (EPA, 1992). Under this approach, DNAPL is suspected to be present when the concentration of a chemical in groundwater is greater than 1 percent of its pure-phase solubility. For example, if the concentration of TCE is greater than 14,720 µg/L in the dissolved phase (i.e., 1 percent of its pure-phase solubility of 1,472,000 µg/L), then TCE is inferred to be present as a DNAPL (EPA, 2004b). Another rule-of-thumb proposes a value of 10 percent of pure-phase solubility (Feenstra and Cherry, 1988). Taking these rules-of-thumb together, the likelihood of DNAPL contributing to the dissolved-phase plume can be summarized as follows: In cases where the maximum concentration of a COC exceeds 10 percent of its solubility, then DNAPL may be assumed to be contributing to the plume. If the maximum concentrations fall between 1 and 10 percent, then DNAPL may possibly be contributing to the plume. But, if the maximum concentration is less than 1 percent of solubility, then DNAPL can be assumed not to be present or not contributing to the plume.

However, in addition to these rules-of-thumb, it must be considered that DNAPL can remain as a residual liquid within the aquifer's soil pore spaces or it can diffuse into low permeability clays and silts. This diffused DNAPL can then act as a residual source of contamination to groundwater, even though the resultant groundwater concentrations may be lower than typically expected near the source (Cherry, 1996). These aqueous concentrations may be from 1,000 µg/L or greater. At Travis AFB, the aquifer is dominated by fine-grained silts and clays, and DNAPL has likely diffused into the finer-grained soils (Travis AFB, 1998). Therefore, a more appropriate and conservative rule-of-thumb under the conditions that exist at Travis AFB is to assume DNAPLs are contributing to a plume when the concentration of a COC is 1,000 µg/L or greater. During the period of interim remediation, these concentrations existed at Sites SS015, SS016, SD036, SD037, and DP039. Long-term operation of interim GET systems and/or the ERD treatment demonstrations implemented since 2008 using bioreactors and/or EVO injections at these sites have already reduced the highest concentrations of contaminants. Summaries of the historical and current maximum concentrations of COCs at each site are provided in Table 2.5-2 and in Appendix A.

Groundwater, soil, and soil gas sampling results from four (4) OU-specific RIs (Weston, 1995; Radian 1995, 1996a; CH2M HILL, 1997) indicate relatively low levels of VOC contamination in the soil and soil gas at the ERP sites, while the groundwater has significantly higher concentrations of contamination. No significant VOC soil contamination was found during the RI sampling, and the low levels detected are not expected to adversely impact the groundwater. Concentrations of VOCs in soil and soil gas are consistent with models of diffusion and adsorption from associated groundwater plumes, indicating that the VOC contamination in the soil and soil gas is a result of the underlying contaminated groundwater plume (Travis AFB, 2006a).

Groundwater plumes are typically characterized by chlorinated VOCs (primarily dissolved-phase TCE and related VOCs, including breakdown products) and organochlorine pesticides. The highest concentration of TCE detected in groundwater during 2010-2011 was 182,000 µg/L at Site SS016. Concentrations of TCE exceeding 10,000 µg/L were detected at Site SD036. TCE was detected at concentrations greater than ten (10) times the MCL of 5 µg/L at Sites FT004, SS015, SS016, ST027B, SS029, SS030, SD033, SD036, SD037, and DP039. Site-specific lists of COCs and summaries of the nature and extent of COCs for each of the groundwater plumes are provided in Table 2.5-2. More detailed descriptions of the nature and extent of groundwater contamination at each site are provided in the GSAP 2010-2011 Annual Report (CH2M HILL, 2012a) and in Section 3 of the FFS (CH2M HILL, 2011a).

2.5.7.1 High-concentration Portion of Plumes

DNAPL is likely present within the higher concentration portions of the Site SS015, SS016, SD036, SD037, and DP039 contaminant plumes, where relatively large-volume releases of TCE may have infiltrated through soils following the path of largest pore size or fracture aperture and affected groundwater. This typically results in sparse horizontal pools and vertical fingers of DNAPL (Kueper et al., 1989; Cohen et al., 1994). Generally, the volume of DNAPL pools and fingers near the release site is approximately 0.01 to 0.0001 of the overall source zone volume (Sale, 1998).

While DNAPL is present, groundwater moving under the hydraulic gradient will slowly erode the DNAPL pool and carry high-concentration, dissolved-phase contaminants into the hydraulically downgradient portions of the aquifer. Some DNAPLs are probably still present within the higher concentration portions of the Site SS015, SS016, SD036, SD037, and DP039 plumes even after approximately a decade of interim remediation and implementation of treatment demonstrations.

The dissolved high-concentration plume originating from a DNAPL source initially moves through the higher permeability sand seams within the overall silt and clay soil matrix. As the plume expands and eventually stabilizes, the high contaminant concentrations found within the sand seams move into the lower permeability silts and clays. After the entire DNAPL source zone has dissolved into the groundwater (typically decades), the dissolved contaminant concentrations will decline rapidly within the permeable sand seams. However, the contamination residing in the low-permeability silts and clays is then released into the sand seams. This process is driven strictly by contaminant concentration differences between the silts/clays and the sand. The process is both slow and occurs at an ever-decreasing rate. Even after apparent "remediation" of the groundwater contained within the permeable sand seams, contamination is still present within the low-permeability

silt/clay. This contamination will slowly emerge from the silt/clay and be a long-term source of contamination into the sand seams.

There are a number of challenges associated with the treatment of DNAPLs. These include the effectiveness of partial source removal, uncertainties in the location and quantity of DNAPL in the subsurface, limited availability of performance and cost data for using innovative technologies to treat DNAPLs, and uncertainties about the long-term effectiveness of DNAPL source reduction. There is an ongoing debate within the remediation community regarding the utility of partial source removal or reduction, where some but not all of the DNAPL source is removed or destroyed. Although EPA policy generally supports active attention to sources (EPA, 1993, 1999, 2002), the published results of modeling and/or laboratory-scale column studies suggest that almost all DNAPL must be removed before site risks are significantly reduced, at least in the short term (Freeze and McWhorter, 1997; Sale and McWhorter, 2001; EPA, 2004b).

LNAPL is present within the higher concentration portion of Site SD034. Stoddard solvent free product is intermittently detected floating on the groundwater table in one (1) site monitoring well. During the second quarter of 2011, Stoddard solvent was measured in only one (1) well at a thickness of 0.44 foot (CH2M HILL, 2012a).

Stoddard solvent (aka PD-680) is a petroleum distillate mixture (i.e., a mineral spirit) of 15 percent trimethylbenzene and 85 percent n-nonane with boiling point characteristics between those of common gasoline and common diesel fuels (CH2M HILL, 1999). Neither of the main constituent compounds of pure Stoddard solvent have a primary State of California or federal MCL. However, the Stoddard solvent at Site SD034 is a non-aqueous medium also containing dissolved-phase COCs at concentrations above MCLs. Previous characterization of the floating Stoddard solvent detected a cis-1,2-DCE concentration of 7,200 µg/L (CH2M HILL, 1999). The chlorinated VOCs, such as cis-1,2-DCE, and other chemicals contained in the free product matrix will dissolve into the surrounding groundwater over time and pose a continuing source of dissolved-phase groundwater contamination.

2.5.7.2 Downgradient Plumes

The dominant loss and transport mechanisms that govern downgradient, aqueous-phase dissolved plumes differ from those discussed above for the higher concentration portions of the plumes with DNAPL.

In downgradient plumes, no steep concentration gradient as described above for higher concentration portions of the plumes occurs. Instead, a combination of physical, chemical, and biological contaminant-loss mechanisms, also referred to as natural attenuation processes, begin to dominate contaminant fate and transport and lead to the eventual stabilization of the plume. The ultimate configuration of the dissolved plume downgradient of the higher concentration portions of the plume is dependent on the collective influences of the processes of adsorption, diffusion, dispersion, biodegradation, and heterogeneity of aquifer properties. These processes are described briefly in this section. For additional information, refer to the *Natural Attenuation Assessment Plan* (NAAP) (CH2M HILL, 1998b). Most of the plumes at Travis AFB are best described as downgradient, dissolved-phase plumes, including those at Sites FT004, FT005, and LF006; Subareas LF007B, LF007C, and LF007D; and Sites LF008, ST027B, SS029, SS030, SD031, SD033, SS035, SS041, and SD043.

The remaining sites have a high concentration plume component associated with a lower concentration downgradient plume component, including those at Sites SS015, SS016, SD034, SD036, SD037, and DP039.

As dissolved solvents migrate with the groundwater, a portion of the contaminants may adsorb to organic materials in the soil matrix, and thus become fixed to the soil particle surface. Adsorption is not an irreversible process; as groundwater moves through the aquifer matrix, contaminants may desorb back into groundwater.

The portion of the contaminant that is sorbed to soil and not migrating is said to be "retarded." The extent of retardation is a function of the properties of both the chemical contaminant and the soil. While this process does not actively destroy contaminant mass, if the rate of migration is retarded to a significant degree, biodegradation processes will have more time to act on the contaminant plume and degrade the contaminant of interest.

Molecular diffusion attempts to equalize solute concentrations by moving solute from high concentration zones to low concentration zones. The driving force for diffusion is differential concentrations, and the effect of diffusion is to increase the volume of contaminated groundwater, while decreasing the concentration. Diffusion is generally a slow process but may be significant in systems where the groundwater velocity is low, as is the case at many sites at Travis AFB.

Hydrodynamic dispersion tends to spread, or disperse, the solute front as it moves through the aquifer. Spreading in the direction of flow is referred to as longitudinal dispersion, which usually has a much stronger influence than spreading perpendicular to the direction of flow, or transverse dispersion (Freeze and Cherry, 1979). Dispersion also occurs because of variability in the hydraulic properties of the saturated soil present at a particular site (Gelhar et al., 1992). At Travis AFB, the complex geometry of the more permeable sand lenses occurring within the lower-permeability silt and clay alluvial matrix almost certainly results in additional spreading of migrating contaminant plumes.

Biodegradation of chlorinated compounds typically proceeds through reductive dehalogenation, but may also occur through electron donor reactions and cometabolism. Reductive dehalogenation occurs anaerobically and results in the degradation of the chlorinated compounds found in Travis AFB groundwater such as PCE, TCE, 1,2-DCE, and vinyl chloride. These processes are described in detail in the NAAP (CH2M HILL, 1998b) and NAAR (CH2M HILL, 2010b). More detailed discussions on the processes of aerobic cometabolism are provided in the *Work Plan for the Assessment of Aerobic Chlorinated Cometabolism Enzymes* (CH2M HILL, 2012c) and in the *Technical Memorandum for Assessment of Aerobic Chlorinated Cometabolism Enzymes at Travis Air Force Base, California* (CH2M HILL, 2012b).

If biodegradation is occurring at rates that are significant with respect to the movement of contamination through the aquifer, then this process can ultimately balance with the migration of the plume and lead to a plume that is stable in configuration over time. In the absence of significant degradation rates, dispersion and dilution will ultimately lead to a stable plume. However, the influence of these processes is limited, and plumes stabilized by these processes will likely have a much greater areal extent than those limited by biodegradation processes. If the aquifer downgradient of the DNAPL source has large differences in permeability, such as high-permeability sand layers acting as preferential

pathways for contaminant movement within a low permeability silt/clay matrix, then this characteristic may significantly influence the distribution of contamination in the downgradient plume.

Three (3)-dimensional, finite element computer modeling of contaminant transport was conducted using MicroFEM® software during development of the site-specific interim GET systems designs. After implementation of the IRAs, an empirical approach was taken for evaluating the long-term performance of the interim GET systems and MNA assessments. For over a decade, groundwater performance monitoring data was collected and evaluated under the GSAP in lieu of specific fate and transport modeling.

2.5.8 Conceptual Site Model

Conceptual site models were developed during the RI/FS to depict the potential relationship or exposure pathway between chemical sources and receptors. The relationships and pathways are shown on Figure 2.5-1. More complete descriptions are provided in the following reports:

- NOU RI Report (Radian, 1995) – Site LF006 and Subareas LF007B, LF007C, and LF007D
- EIOU RI Report (Weston, 1995) – Sites FT004, FT005, SS015, SS016, SS029, SS030, and SD031
- WIOU RI Report (Radian, 1996a) – Sites SD033, SD034, SS035, SD036, and SD037
- WABOU RI Report (CH2M HILL, 1997) – Sites LF008, DP039, SS041, and SD043
- *Site ST027-Area B Human Health Risk Assessment* (CH2M HILL, 2011c) – Site ST027B

An exposure pathway describes the means by which a receptor can be exposed to contaminants in environmental media. These pathways are based on current and potential future land uses and potential beneficial uses of groundwater at Travis AFB. Based on currently available information, the most plausible current or future human receptor populations that may contact COCs in groundwater consist of an on-base or hypothetical off-base industrial worker and a hypothetical on-base or off-base resident. Although future residential land use at Travis AFB is unlikely, a hypothetical future residential land use was also evaluated to support risk management decisions. Contaminated groundwater does not currently underlie any on-base residential areas. Based on current and potential future land uses at Travis AFB and in the area immediately surrounding it, the following potentially complete human exposure pathways and routes were considered for characterizing human health risks from groundwater on- and off-base:

- **Future Industrial Worker:** Inhalation of volatiles migrating from groundwater into ambient and indoor air.
- **Hypothetical Future Resident:** Ingestion of groundwater, dermal contact with groundwater, inhalation of volatiles during showering or other household activities, and inhalation of volatiles migrating from groundwater into indoor air.

No ecological receptors of concern were identified for groundwater.

No water supply wells are, nor are projected to be, threatened. Data indicate that the plumes are stable. The Site FT005, Subarea LF007C, and Site SS030 plumes extend off-base, but are not threatening water supply wells. No other plumes are migrating off-base.

TABLE 2.5-1
Previous Site Investigation and Remediation Activities
Groundwater Record of Decision, Travis Air Force Base, California

Investigation or Remediation Activity	Year, Contractor	Summary
PA/SI	1983-1986, AF	Records search and interviews with past and present Base employees who were familiar with past disposal practices. Additional interviews were conducted with local, state, and other federal agency personnel. Included field and helicopter reconnaissance.
RCRA Facilities Assessment	1991, AF	Environmental inspections at current and active facilities to identify manufacturing processes and potential avenues for contaminant releases to the environment.
PA/SI	1993-1994, Jacobs	A secondary PA/SI focused on the former Fairfield Air Station within the boundaries of Travis AFB. Also included annexes not adequately evaluated during previous investigations and more recently identified areas of concern. Sites were subsequently grouped into four (4) OUs (NOU, EIOU, WIOU, and WABOU), based on the geographic location within the Base and the source and nature of the suspected contaminants.
NOU RI	1995, Radian	Soil, sediment, soil vapor, and groundwater investigations within the NOU component of the NEWIOU. Included investigations at Sites FT004, LF006, and LF007. The main finding of the NOU RI was that groundwater was contaminated with chlorinated VOCs and petroleum-fuel constituents.
EIOU RI	1995, Weston	Soil, sediment, soil vapor, and groundwater investigations within the EIOU component of the NEWIOU. Included investigations at Sites FT004, FT005, SS015, SS016, SS029, SS030, and SD031. The main finding of the EIOU RI was that groundwater was contaminated with chlorinated VOCs and petroleum-fuel constituents.
WIOU RI	1995, Radian	Soil, sediment, soil vapor, and groundwater investigations within the WIOU component of the NEWIOU. Included investigations at Sites SD033, SD034, SS035, SD036, and SD037. The main finding of the WIOU RI was that groundwater was contaminated with chlorinated VOCs and petroleum-fuel constituents.
WABOU RI	1997, CH2M HILL	Soil, sediment, soil vapor, and groundwater investigations at WABOU Sites LF008, DP039, SS041, and SD043. The main finding of the WABOU RI was that groundwater was contaminated with chlorinated VOCs and organochlorine pesticides.
Groundwater IRAs	1998-present; CH2M HILL, GTI, OHM, URS	Groundwater IRAs at all ERP sites conducted in accordance with the NEWIOU and WABOU Groundwater IRODs. Included installation and long-term O&M of site-specific GET systems, MNA assessments, and GET systems combined with MNA assessments.
Phytostabilization Treatability Study	1998-2005, Parsons	Soil, soil vapor, and groundwater characterization conducted as part of a study of biological remediation using planted trees at Site DP039. Although the treatability study has concluded, the trees remain at the site and groundwater contamination continues to be monitored as part of an ongoing demonstration of phytoremediation processes.
Site SS015 Vegetable Oil Injection Field Treatability Study	2000-2001, Parsons	Groundwater characterization conducted as part of a limited treatability study to evaluate the feasibility of ERD facilitated by injection of soybean oil within a high concentration portion of the Site SS015 contaminant plume. The study was terminated early because of a military construction project at the site, but the findings indicated that bioremediation was taking place.

TABLE 2.5-1
Previous Site Investigation and Remediation Activities
Groundwater Record of Decision, Travis Air Force Base, California

Investigation or Remediation Activity	Year, Contractor	Summary
Vapor Intrusion Assessment	2008-2009, CH2M HILL	Characterization of soil vapor and air conducted as part of assessments of potential human health risks posed by soil vapors emanating from contaminated groundwater into building interiors. Included monitoring of shallow soil gas, soil vapor under building floor subslabs, building indoor air, and outdoor air.
Vapor Intrusion Assessment Update	2013, CH2M HILL	Provides an update to the *Vapor Intrusion Assessment Report* (CH2M HILL, 2010a). Addresses changes to the toxicity values for several chemicals, including TCE.
Site DP039 Data Gaps Investigation and ERD Treatment Demonstrations via Bioreactor EVO Injection	2008-2010, CH2M HILL	Groundwater investigation to support a demonstration of ERD treatment via an in situ bioreactor and EVO injection. Included installation of a demonstration bioreactor and modifying the existing GET system with a solar-powered groundwater circulation system to irrigate the bioreactor. Also included installation of injection wells and injection of EVO in a linear configuration to create a PRB. Performance monitoring of the bioreactor and EVO PRB is ongoing.
Site ST027B Data Gaps Investigation	2009, CH2M HILL	Groundwater and soil vapor characterization to further clarify the nature and extent of chlorinated VOC contamination and support development of human health and ecological risk assessments. Additional characterization was needed because previous investigations had identified only petroleum-fuel constituents and the entirety of the site was managed under the Travis AFB POCO program. No risk assessments were required under the POCO program. In 2007-2008, TCE was detected in a portion of plume. This portion of the plume was subsequently designated as Site ST027B and is now managed as an ERP site.
Site SD036 Data Gaps Investigation and ERD Treatment Demonstration via EVO Injection	2010, CH2M HILL	Groundwater and soil characterization to support a demonstration of ERD treatment via injection of EVO. Included installation of groundwater monitoring wells, EVO injection wells, and injection of EVO within a high concentration portion of the Site SD036 contaminant plume. Performance monitoring of the ERD treatment demonstration is ongoing.
Site SD037 Data Gaps Investigation and ERD Treatment Demonstration via EVO Injection	2010, CH2M HILL	Groundwater characterization to support a demonstration of ERD treatment via injection of EVO. Included installation of groundwater monitoring wells, EVO injection wells, and injection of EVO within a high concentration portion of the Site SD037 contaminant plume. Performance monitoring of the ERD treatment demonstration is ongoing.
Site SS015 Data Gaps Investigation and ERD Treatment Demonstration via EVO Injection	2010, CH2M HILL	Groundwater and soil characterization to support a demonstration of ERD treatment via injection of EVO. Included installation of groundwater monitoring wells, EVO injection wells, and injection of EVO within a high concentration portion of the Site SS015 contaminant plume. Performance monitoring of the ERD treatment demonstration is ongoing.
Site SS016 Data Gaps Investigation, GET System RPO, and ERD Treatment Demonstration via Bioreactor	2010, CH2M HILL	Groundwater characterization to support a demonstration of ERD treatment via an in situ bioreactor. Included installation of a demonstration bioreactor, modifying the existing GET system with a solar-powered groundwater circulation system to irrigate the bioreactor, and installation of groundwater monitoring wells. Performance monitoring of the ERD treatment demonstration is ongoing.

TABLE 2.5-1
Previous Site Investigation and Remediation Activities
Groundwater Record of Decision, Travis Air Force Base, California

Investigation or Remediation Activity	Year, Contractor	Summary
Site SS030 Data Gaps Investigation and GET System RPO	2010-2013, CH2M HILL	Groundwater characterization conducted to support improved hydraulic capture of the Site SS030 plume using the existing GET system. Included collection of in situ groundwater samples and installation of groundwater monitoring wells.
Subarea LF007C Data Gaps Investigation and GET System RPO	2011-2013 (ongoing), CH2M HILL	Groundwater characterization conducted to support optimization of the existing GET system. Included installation of groundwater monitoring wells, installation of solar-powered groundwater extraction wells, and modifications to the solar power supply.
Aerobic Chlorinated Cometabolism Enzyme Study	2012, CH2M HILL	Groundwater characterization conducted to assess the biological component of MNA contributed by aerobic chlorinated cometabolism.
Travis AFB GSAP/GRIP	Ongoing, CH2M HILL	Long-term collection of groundwater monitoring well samples and groundwater elevations. Includes off-base laboratory analyses, data validation, and reporting. Beginning in 2013, the Travis AFB GSAP transitioned to the GRIP. The findings of the groundwater monitoring program are now documented in an annual GRISR. The GRISR also documents the findings of the LTO&M program.
2012 GSAP Technical Memorandum	2012, CH2M HILL	Provides the analytical data collected during the second quarter 2012 GSAP monitoring event in the absence of a 2011-2012 Annual GSAP Report. Also, documents the results of a study of the nature of pesticide contamination at Site LF008 and provides an updated estimate of the RTF for groundwater contamination at Subarea LF007D.
LTO&M	Ongoing, CH2M HILL	LTO&M of interim remediation system infrastructure, including groundwater monitoring wells, extraction wells, injection wells, bioreactors, conveyance systems, and treatment plants. Includes collection of treatment process flow samples, off-base laboratory analyses, data validation, and reporting. Beginning in 2013, the Travis AFB LTO&M program transitioned to the GRIP. The findings of the LTO&M program are documented in an annual GRISR. The GRISR also documents the findings of the LTO&M program.

Notes:

LTO&M = long-term operations and maintenance
RCRA = Resource Conservation and Recovery Act

TABLE 2.5-2
Summary of Nature and Extent of Contamination
Groundwater Record of Decision, Travis Air Force Base, California

Site	Source of Contamination	Types and Characteristics of Contamination	COCs	Concentration (µg/L) Historical Maximum[a,b] (pre-IRA)	Concentration (µg/L) Current Maximum[c] (2010 to 2011)	Current Lateral and Vertical Extent of Contamination	Current Area and Volume of Contamination[d]	Comments
FT004	Historical practices during fire training exercises conducted between approximately 1953 and 1962. During this period, waste fuels, oils, and solvents were burned on open ground.	Chlorinated VOCs. Carcinogenic, toxic, and mobile.	TCE	**5,200**	**204 J-**	TCE plume approximate dimensions: Length: 950 feet Width: 250 feet Thickness: 30 feet	250,893 ft^2 1,455,170 ft^3	Plume is stable. Monitoring data obtained over approximately 10 years of interim remediation (combined GET and MNA assessment) did not indicate significant plume migration. A rebound study began in December 2007 and included select extraction wells. In February 2009, the remaining extraction wells were taken offline. Data obtained during the study did not indicate significant plume migration when GET system operations were discontinued.
			cis-1,2-DCE	**60.5**	**12.6 J+**			
			1,2-DCA	**5.12**	ND			
			Chloroform	15	3.8			
			Bromodichloromethane	5.7	0.73 J-			
			1,1-DCE	**42**	0.77			
			Vinyl chloride	**43.7**	**14.8**			
			1,4-DCB	3.8	ND			
		SVOCs	bis(2-Ethylhexyl)phthalate[e]	**21**	-[e]			
		Metals	Nickel[f]	**6,270**	-[f]			
					Results during shutdown of IRA GET system for rebound study.			
FT005	Historical practices during fire training exercises conducted between approximately 1962 and 1987. During this period, waste fuels, oils, and solvents were burned on open ground.	Chlorinated VOCs. Carcinogenic, toxic, and mobile.	TCE	**160**	**5.6 J-**	1,2-DCA plume approximate dimensions: Length: 600 feet Width: 400 feet Thickness: 25 to 30 feet The majority of the contaminant plume extends to off-base privately owned property.	1,258,142 ft^2 11,323,278 ft^3	Plume is stable. Plume was hydraulically captured by IRA GET system during approximately 10 years of interim remediation. A recent rebound study did not indicate significant plume migration when GET system operations were discontinued in December 2007. Recently observed increases in the concentrations of COCs at some wells indicate that continuation of GET system operation within those portions of the plumes with increasing concentrations is warranted to prevent possible future migration. Therefore, selected extraction wells continue to operate on an as-warranted basis.
			1,2-DCA	**14.2**	**5.8**			
			cis-1,2-DCE	**19**	0.48 J-			
			Chloroform	10	0.29 J-			
			Bromodichloromethane	2.0	ND			
		SVOCs	bis(2-Ethylhexyl)phthalate[e]	**50.3**	-[e]			
		Metals	Nickel[f]	**4,270**	-[f]			
					Results during shutdown of IRA GET system for rebound study.			
LF006	A historical general refuse landfill that used trench and cover methods from approximately 1943 through 1950.	Chlorinated VOCs. Primarily carcinogenic, toxic, and mobile.	TCE	**30**	**6.9**	TCE plume approximate dimensions: Length: 400 feet Width: 350 feet Thickness: 25 to 30 feet	110,447 ft^2 662,680 ft^3	Plume is stable. Monitoring data over approximately 10 years of MNA assessment did not indicate significant plume migration.
			1,1-DCE	0.64	ND			
					Results after approximately a decade of MNA assessment.			
LF007B Subarea	Portion of a historical general refuse landfill that used trench and cover methods from approximately 1950 through 1970.	Chlorinated VOCs, SVOCs, pesticides/ PCBs, and dioxins. Primarily carcinogenic, toxic, low mobility.	Benzene	**59.3**	ND	No plume dimensions. Contaminant concentrations already less than IRGs.	0 ft^2 0 ft^3	Plume is stable. Monitoring data over approximately 10 years of interim MNA assessment did not indicate significant plume migration.
			1,4-DCB	**43.8**	ND			
			Chlorobenzene	**161**	ND			
			bis(2-Ethylhexyl)phthalate[e]	**66.1**	-[f]			
			Aroclors 1242 and 1248	**14.1**	ND			
			2,3,7,8-TCDDeq	**0.55 pg/L**	ND			
					Results after approximately a decade of MNA assessment.			

TABLE 2.5-2
Summary of Nature and Extent of Contamination
Groundwater Record of Decision, Travis Air Force Base, California

Site	Source of Contamination	Types and Characteristics of Contamination	COCs	Concentration (µg/L)		Current Lateral and Vertical Extent of Contamination	Current Area and Volume of Contamination[d]	Comments
				Historical Maximum[a,b] (pre-IRA)	Current Maximum[c] (2010 to 2011)			
LF007C Subarea	Portion of a historical general refuse landfill that used trench and cover methods from approximately 1950 through 1970.	Chlorinated VOCs. Carcinogenic, toxic, low mobility.	TCE Vinyl chloride 1,1-DCE 1,2-DCA 1,2-Dichloropropane	**49.1** 0.198 0.297 0.314 3.38	**10.3** ND ND ND 0.3 J Results after approximately a decade of IRA GET system operation. Optimization pending.	TCE plume approximate dimensions: Length: 620 feet Width: 220 feet Thickness: 25 feet The majority of the contaminant plume extends to off-base privately owned property.	110,330 ft^2 485,452 ft^3	Plume is stable. Monitoring data over approximately 10 years of interim GET system operation did not indicate significant plume migration.
LF007D Subarea	Portion of a historical general refuse landfill that used trench and cover methods from approximately 1950 through 1970.	Chlorinated VOCs, SVOCs, PCBs, and dioxins. Primarily carcinogenic, toxic, low mobility.	Benzene Vinyl chloride 1,4-DCB 1,1-DCE Chlorobenzene 2,3,7,8-TCDDeq Aroclors 1242 and 1248 bis(2-Ethylhexyl)phthalate[e]	**25.8** **1.78** **43.8** 0.96 **282** **16.99 pg/L** 14.1 124	**2.2** ND **12.6** ND 30.2 ND ND -[e] Results after approximately a decade of MNA assessment.	Plume is limited to a small area in the vicinity of MW261x07.	31,000 ft^{2g} 248,000 ft^{3g}	Plume is stable. Monitoring data over approximately 10 years of interim MNA assessment did not indicate significant plume migration.
LF008	Historical disposal practices at an inactive landfill. Pesticide containers were disposed of in a series of small, unlined trenches.	Organochlorine pesticides. Carcinogenic, toxic, relatively immobile.	Alpha-chlordane Heptachlor Heptachlor epoxide	**1.7** **0.29** **0.63**	**0.43** ND **0.017 J-** Results during shutdown of IRA GET system for rebound study.	Alpha-chlordane plume approximate dimensions: Length: 195 feet Width: 112 feet Thickness: 35 feet	33,368 ft^2 233,576 ft^3	Plume is stable. Plume was hydraulically captured by IRA GET system during approximately 10 years of interim remediation. A recent rebound study did not indicate significant plume migration when GET system operations were discontinued in December 2008.
SS015	Historical practices at facilities used between approximately 1964 and 1980 for solvent stripping of aircraft parts, aircraft maintenance and repair, OWS activities, and hazardous waste accumulation.	Chlorinated VOCs. Probable DNAPL within the high concentration portion of the plume. Carcinogenic, toxic, and mobile. SVOCs Metals	TCE cis-1,2-DCE Vinyl chloride 1,2-DCA PCE bis(2-Ethylhexyl)phthalate[e] Nickel[f]	**563** **7,680** **3,220** 0.45 **105** **260** **2,210**	**226** **598** **70.6** 0.3 J **3.1** -[e] -[f] Results following demonstration of ERD treatment via injection of EVO within a high concentration portion of the plume.	cis-1,2-DCE plume approximate dimensions: Length: 360 feet Width: 160 feet Thickness:10 to 15 feet	55,994 ft^2 78,392 ft^3	Monitoring data over approximately 10 years of MNA assessment indicated some local plume migration in the direction of local groundwater flow toward the northeast. Trends indicate increasing TCE concentration at MW625x15 and decreasing TCE concentration at MW216x15 as discussed in the GSAP 2010-2011 Annual Report (CH2M HILL, 2012a). The plume has moved and increased in size primarily along the northeast-southwest axis as seen on Figure 2.2-8.

TABLE 2.5-2
Summary of Nature and Extent of Contamination
Groundwater Record of Decision, Travis Air Force Base, California

Site	Source of Contamination	Types and Characteristics of Contamination	COCs	Concentration (µg/L)		Current Lateral and Vertical Extent of Contamination	Current Area and Volume of Contamination[d]	Comments
				Historical Maximum[a,b] (pre-IRA)	Current Maximum[c] (2010 to 2011)			
SS016/ SS029	Site SS016: Historical practices within flight line support areas subject to oil spills, degreasing operations, leaking OWS, equipment maintenance and repair, aircraft and vehicle maintenance, hazardous materials storage, aircraft and vehicle washing, and stormwater runoff. Most of the areas have been used from the 1940s through the present day. Site SS029: Undeveloped land near the southern Base boundary. The historical practices resulting in groundwater contamination are unknown.	Chlorinated VOCs. Probable DNAPL within the high concentration portion of the Site SS016 OSA plume. Carcinogenic, toxic, and mobile.	TCE cis-1,2-DCE Vinyl chloride Benzene Chloroform 1,4-DCB Bromodichloromethane 1,2-DCA 1,1-DCE PCE	**210,000** **19,100** **1,530** **550** 13 **315** 1.3 **9.16** **84** **105**	**40,200** **8,230** **812** ND 0.42 J **710** ND **13.4 J** **50.2 J** **108**	Site SS016 and SS029 TCE plume approximate dimensions: Length: 5,700 feet Width: 1,400 feet Thickness: 25 to 40 feet	7,112,191 ft^2 41,250,708 ft^3	Plume is stable. Plumes were hydraulically captured by the combined site-specific IRA GET systems over approximately 10 years of interim remediation. Monitoring data indicated that some migration of the Site SS016 plume into the hydraulically downgradient Site SS029 plume was occurring. However, combined IRA GET system operations are continuing to maintain hydraulic capture of the overall plume. In October 2010, a maximum 1,4-DCB concentration of 710 µg/L was detected in MW2020Ax16. This concentration exceeded the historical maximum concentration of 1,4-DCB at the site. Monitoring well MW2020Ax16 was installed in 2010 within the higher concentration portion of the plume to support monitoring of the bioreactor. After initiation of the bioreactor, 1,4-DCB concentrations declined from 710 to 57.6 µg/L by May 2011. In October 2010, the maximum 1,2-DCA (13.4 J µg/L) concentration detected at Site SS016 slightly exceeded the historical maximum detection at source area extraction well TPE-Wx16. However, after initiation of the source area bioreactor, 1,2-DCA concentrations at this well decreased to nondetect by May 2011. In February 2011, the maximum PCE concentration detected at Site SS016 slightly exceeded the historical maximum detection at new source area well MW2112Ax16. After initiation of the source area bioreactor, PCE concentrations at this well declined to 97.8 J µg/L by May 2011 (the historical maximum concentration was 105 µg/L).
		SVOCs	bis(2-Ethylhexyl)phthalate[e]	**67.3**	-[e]			
		Metals	Nickel[f]	**6,560**	-[f]			
					Results following demonstration of ERD treatment via bioreactor within a high concentration portion of the plume. Portion of GET system shut down to support installation of bioreactor. Remainder of GET system remains in operation.			
ST027B	Historical practices at a former aircraft engine test stand area. The historical activities resulting in groundwater contamination are unknown. Historically managed under the POCO program and not included in any of the four (4) OU-specific RIs, two (2) OU-specific FSs, or two (2) groundwater IRODs. In 2007-2008, POCO investigations discovered a small, previously unknown TCE plume at concentrations greater than the IRG in the southwestern part of Site ST027. This area of TCE contamination has been designated Site ST027B.	Chlorinated VOCs. Primarily carcinogenic, toxic, and mobile.	TCE[h] Vinyl chloride[h] cis-1,2-DCE[h] Benzene Toluene	ND[h] ND[h] ND[h] 0.44 0.1	**435** **7.1** **338** 0.32 J ND	TCE plume approximate dimensions: Length: 650 feet Width: 400 feet Thickness: 30 to 35 feet Formerly managed under POCO program. Chlorinated VOCs were detected after the IROD was finalized and IRAs implemented.	183,134 ft^{2h} 1,281,938 ft^{3h}	Plume is stable. Monitoring data obtained during period of POCO and ERP program management did not indicate significant plume migration.
					Results following periods of MNA under POCO and ERP.			

TABLE 2.5-2
Summary of Nature and Extent of Contamination
Groundwater Record of Decision, Travis Air Force Base, California

Site	Source of Contamination	Types and Characteristics of Contamination	COCs	Concentration (µg/L)		Current Lateral and Vertical Extent of Contamination	Current Area and Volume of Contamination[d]	Comments
				Historical Maximum[a,b] (pre-IRA)	Current Maximum[c] (2010 to 2011)			
SS030	Undeveloped land near the southern Base boundary. Historical practices associated with Building 1125 are believed to have resulted in groundwater contamination.	Chlorinated VOCs. Carcinogenic, toxic, and mobile. Metals	TCE Chloroform Bromodichloromethane 1,2-DCA Nickel[f]	**3,860** 9.3 2 0.34 **1,850**	48.8 7.4 ND ND -[f] Results during IRA GET system operation.	TCE plume approximate dimensions: Length: 1,400 feet Width: 400 feet Thickness: 20 to 40 feet The majority of the contaminant plume extends onto off-base privately owned property.	455,647 ft^2 1,822,588 ft^3	Plume is stable. Plume was hydraulically captured by IRA GET system during approximately 10 years of interim remediation. IRA GET system operations are continuing to maintain hydraulic capture of the plume.
SD031	Historical practices in an area used for maintenance and repair of diesel generators, wash rack activities, OWS activities, and aircraft maintenance from approximately 1957 through the present day.	Chlorinated VOCs. Carcinogenic, toxic, and mobile. Metals	TCE Benzene 1,1-DCE cis-1,2-DCE Carbon tetrachloride Chloroform 1,2-DCA Vinyl chloride Nickel[f]	**8,100** **28** **7,300** **3,600** **11** 11 **5** **1.2** **6,780**	7.1 J- ND 56.7 0.78 J- ND 0.17 J ND ND -[f] Results during shutdown of IRA GET system for rebound study.	1,1-DCE plume approximate dimensions: Length: 300 feet Width: 150 feet Thickness: 25 to 30 feet	54,255 ft^2 260,424 ft^3	Plume is stable. Monitoring data obtained over approximately 10 years of interim remediation (combined GET and MNA assessment) did not indicate significant plume migration. Data obtained during a recent rebound study did not indicate significant plume migration when GET system operations were discontinued in December 2007.
SD033 (component of WIOU)	Historical practices within support areas used for management of stormwater runoff, fuel transport, aircraft maintenance, and aircraft washing, including the use of wash racks and OWS.	Primarily chlorinated VOCs. Some commingled SVOCs. Primarily carcinogenic, toxic, and mobile.	TCE 1,1-DCE 1,2-DCA cis-1,2-DCE	**200** 1.9 **1.52** **75.9**	**99.2** ND ND **50** Results during shutdown of IRA GET system for rebound study.	-[i] Site contamination is within the overall WIOU plume.	-[i]	Plume is stable. Monitoring data obtained over approximately 10 years of interim remediation (combined GET and MNA assessment) did not indicate significant plume migration. Data obtained during a recent rebound study did not indicate significant plume migration when GET system operations were discontinued in April 2010.
SD034 (component of WIOU)	Historical practices at an aircraft wash rack facility with OWS and overflow pond. Leaks from the OWS resulted in a layer of Stoddard solvent, containing dissolved COCs, floating on the groundwater table. The leaking OWS was replaced in 1994.	Primarily chlorinated VOCs. Free-phase Stoddard solvent (PD-680) LNAPL consisting of 15 percent trimethyl benzene and 85 percent n-nonane floating on groundwater table. The Stoddard solvent non-aqueous medium also contains dissolved COCs. Primarily carcinogenic, toxic, and mobile.	TCE Vinyl chloride 1,1-DCE Benzene cis-1,2-DCE PCE bis(2-Ethylhexyl)phthalate[e]	**456** **11** 3.2 **1.34** **391** **41.4** **3,350**	**5.8** **2.1** ND 0.21 J 5.7 ND -[e] Results during shutdown of IRA GET system for rebound study.	-i Free-phase Stoddard solvent, containing dissolved COCs, intermittently measured floating on groundwater table. Site contamination is within the overall WIOU plume.	-i	Plume is stable. Monitoring data obtained over approximately 10 years of interim remediation (combined GET and MNA assessment) did not indicate significant plume migration. Data obtained during a recent rebound study did not indicate significant plume migration when GET system operations were discontinued in April 2010.
SS035 (component of WIOU)	Historical practices during aircraft repair, painting, and washing. A wash rack with OWS was constructed in 1970.	Chlorinated VOCs. Carcinogenic, toxic, and mobile.	TCE	**5.3**	ND	-[i] Site contamination is within the overall WIOU plume.	-[i]	Plume is stable. Monitoring data obtained over approximately 10 years of interim remediation (combined GET and MNA assessment) did not indicate significant plume migration. Data obtained during a recent rebound study did not indicate significant plume migration when GET system operations were discontinued in April 2010.

TABLE 2.5-2
Summary of Nature and Extent of Contamination
Groundwater Record of Decision, Travis Air Force Base, California

Site	Source of Contamination	Types and Characteristics of Contamination	COCs	Concentration (µg/L)		Current Lateral and Vertical Extent of Contamination	Current Area and Volume of Contamination[d]	Comments
				Historical Maximum[a,b] (pre-IRA)	Current Maximum[c] (2010 to 2011)			
SD036 (component of WIOU)	Historical practices at Facilities 872/873/876. The facilities were constructed in 1953 and consist of multiple-use shops, including a wash rack and OWS. A leaking segment of an underground sanitary sewer may have released contamination. This segment of the sewer was repaired.	Primarily chlorinated VOCs. Probable DNAPL within a high concentration portion of the plume. Primarily carcinogenic, toxic, and mobile.	Vinyl chloride TCE 1,1-DCE cis-1,2-DCE 1,2-DCA Benzene Bromodichloromethane PCE	**360** **18,500** 3.71 **3,870** **7.9** **3.87** 2.26 **512**	**1,100** **14,400** **12.5 J-** **6,710** **1.2** 0.59 ND **13.3 J** Results following demonstration of ERD treatment via injection of EVO within a high concentration portion of the plume. IRA GET system component shut down for rebound study.	-[i] Site contamination is within the overall WIOU plume.	-[i]	Plume is stable. Monitoring data obtained over approximately 10 years of interim remediation (combined GET and MNA assessment) did not indicate significant plume migration. Data obtained during a recent rebound study did not indicate significant plume migration when GET system operations were discontinued in April 2010. In June 2011, the maximum vinyl chloride concentration detected at Site SD036 (1,100 µg/L) exceeded the historical maximum detection at ERD performance monitoring well EW594x36. The reason for this increase in vinyl chloride concentrations is that vinyl chloride is a daughter product of ERD. Elevated vinyl chloride concentrations are restricted to the EVO treatment area. The presence of ethane, ethene, and methane within the treatment area indicates ERD is going to completion and vinyl chloride is being destroyed. The maximum 1,1-DCE concentration detected at Site SD036 (12.5 J- µg/L) also exceeded the historical maximum detection at ERD performance monitoring well MW2033Ax36. The reason for this increase in 1,1-DCE concentrations within Site SD036 is that 1,1-DCE is also a daughter product of ERD. Elevated 1,1-DCE concentrations are also restricted to the EVO treatment area. The presence of ethane, ethene, and methane within the treatment area indicates ERD is going to completion and 1,1-DCE is being destroyed.
SD037 (component of WIOU)	Historical practices within support areas used for management of domestic and industrial wastewater, aircraft maintenance, heavy equipment maintenance, air cargo handling, vehicle washing, fuel transport, and waste accumulation. These operations began in the 1940s.	Primarily chlorinated VOCs. Probable DNAPL within a high concentration portion of the plume. Primarily carcinogenic, toxic, and mobile.	1,1-DCE 1,2-DCA Benzene Bromodichloromethane Carbon tetrachloride PCE TCE Vinyl chloride cis-1,2-DCE bis(2-Ethylhexyl)phthalate[e]	**8.2** **1.68** **4,240** 3 **40.4** **900** **5,800** **430** **381** **91**	4.6 ND **7.6** ND **7.6** **212** **1,720** **26.3** **749** -[e] Results following demonstration of ERD treatment via injection of EVO within a high concentration portion of the plume. IRA GET system component shut down for rebound study.	TCE plume approximate dimensions: Length: 4,650 feet Width: 750 feet Thickness: 20 to 90 feet Site SD037 plume dimensions represent the overall WIOU plume.	1,626,667 ft^2 13,664,003 ft^3	Plume is stable. Monitoring data obtained over approximately 10 years of interim remediation (combined GET and MNA assessment) did not indicate significant plume migration. Data obtained during a recent rebound study did not indicate significant plume migration when GET system operations were discontinued in April 2010.

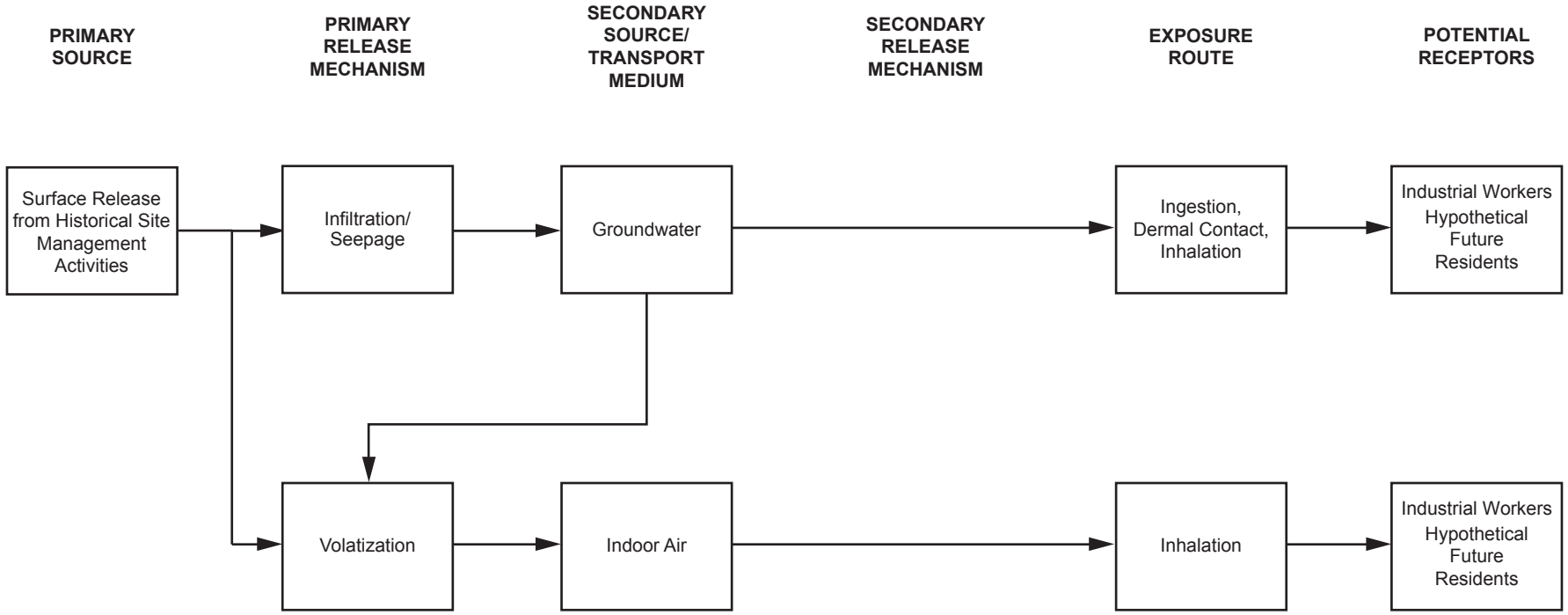
TABLE 2.5-2
Summary of Nature and Extent of Contamination
Groundwater Record of Decision, Travis Air Force Base, California

Site	Source of Contamination	Types and Characteristics of Contamination	COCs	Concentration (µg/L)		Current Lateral and Vertical Extent of Contamination	Current Area and Volume of Contamination[d]	Comments
				Historical Maximum[a,b] (pre-IRA)	Current Maximum[c] (2010 to 2011)			
DP039	Historical practice conducted prior to 1978 at Building 755. Battery acid solutions and solvents were discharged from the building into an exterior sump.	Chlorinated VOCs. Probable DNAPL within a high concentration portion of the plume. Carcinogenic, toxic, and mobile.	1,1-DCE 1,2-DCA 1,1,1-TCA 1,1,2-TCA Bromodichloromethane Methylene chloride PCE TCE	**7,900** **440** **26,000** **240** 10 **3,500** **20** **230,000**	**2,210** **5.2** ND ND ND **24** ND **1,740** Results following demonstration of ERD treatment via bioreactor and injection of EVO PRB within higher concentration portions of the plume. IRA GET system component shut down to support installation of bioreactor.	TCE plume approximate dimensions: Length: 1,720 feet Width: 820 feet Thickness: approx. 20 to 45 feet	1,144,580 ft^2 9,614,472 ft^3	Plume is stable. Monitoring data obtained over approximately 10 years of interim remediation (combined GET and MNA assessment) did not indicate significant plume migration. Data obtained during a recent rebound study did not indicate significant plume migration when GET system operations were discontinued in April 2010.
SS041	Historical activities at the Base Entomology Shop (Building 905) from 1983 to 1992 to prepare pesticides and herbicides for on-base use. A concrete wash rack in the back of the building was used to clean pesticide applicator vehicles. Overspray from the washing resulted in pesticide contamination of the groundwater.	Organochlorine pesticides. Carcinogenic, toxic, relatively immobile.	Heptachlor epoxide	**0.023 J**	ND	No plume dimensions. Contaminant concentrations already less than IRGs.	0 $ft^{2[j]}$ 0 $ft^{3[j]}$	The IRA achieved cleanup of groundwater to concentrations below detection levels. The site has been in NFRAP status since 2005.
SD043 (component of WIOU)	Historical disposal practices from maintenance activities at an emergency electric power facility.	Chlorinated VOCs. Carcinogenic, toxic, and mobile.	TCE	**38**	0.7 IRA GET system component shut down for rebound study.	-[i] Site contamination is within the overall WIOU plume.	-[i]	Plume is stable. Monitoring data obtained over approximately 10 years of interim remediation (combined GET and MNA assessment) did not indicate significant plume migration. Data obtained during a recent rebound study did not indicate significant plume migration when GET system operations were discontinued in April 2010.

[a] Maximum historical concentration prior to implementation and long-term operation of the groundwater IRA at the site. Source: GSAP 2010-2011 Annual Report (CH2M HILL, 2012a).
[b] **Bolded** concentrations are above the contaminant-specific IRG established in the NEWIOU or WABOU Groundwater IROD.
[c] Current concentration after approximately a decade of IRA operation. Source: GSAP 2010-2011 Annual Report (CH2M HILL, 2012a).
[d] Estimated based on the groundwater COC with greatest areal extent. Groundwater pore volume estimated from the plume area, saturated thickness, and a porosity of 20 percent.
[e] Bis(2-Ethylhexyl)phthalate was initially identified as a COC, but in 2002 was recognized as a field and/or laboratory artifact and not representative of groundwater contamination.
[f] Nickel was initially identified as a COC, but in 2002 it was demonstrated as leaching from the stainless steel well casings used in monitoring well construction and not representative of groundwater contamination.
[g] Contamination is limited to a small area in the vicinity of MW261x07. Plume areas and volumes are based on an approximate 100-foot plume radius around this well.
[h] Portion of Site ST027 formerly managed under the Travis AFB POCO program. Chlorinated VOCs regulated under CERCLA were not detected in the Area B portion of plume (i.e., Site ST027B) until after the NEWIOU Groundwater IROD was finalized.
[i] Included in Site SD037 estimates. The plume areas and volumes for Sites SD033, SD034, SS035, SD036, SD037, and SD043 comprise the overall WIOU plume. These site contaminant plumes are inseparably commingled and are addressed as a single WIOU plume. Site SD037 is selected as representative of the WIOU plume because the ERP site boundary has the greatest geographic extent of the component sites.

Notes:

ft^2 = square feet
ft^3 = cubic feet
ND = not detected
SVOC = semivolatile organic compound
TCDDeq = tetrachlordibenzo-p-dioxin equivalent



LEGEND

→ Potentially Complete Exposure Pathway

FIGURE 2.5-1
CONCEPTUAL EXPOSURE MODEL
GROUNDWATER RECORD OF DECISION
TRAVIS AIR FORCE BASE, CALIFORNIA

ES051412034344SAC

2.6 Current and Potential Future Land Use and Resource Uses

This section provides descriptions of the current and potential future uses of land and resources at Travis AFB.

2.6.1 Current and Potential Land Use

Travis AFB is a secured, active military facility. Access to the Base is generally limited to military members, their dependents, and civilian government employees. The Travis AFB General Plan (Travis AFB, 2002b) designates existing and planned future land use for Travis AFB into the following eight (8) functional categories:

- **Mission –** Uses are closely associated with the airfield and include facilities such as maintenance hangars and docks, avionics facilities, and other maintenance facilities. Aircraft operations facilities include control towers, Base operations, flight simulators, and other instructional facilities.
- **Administrative –** Uses include personnel, headquarters, legal, and other support functions.
- **Community –** Uses include both commercial and service activities. Examples of commercial uses include the Base Exchange, dining halls, service station, and clubs; service uses include the schools, chapel, library, and the family support center.
- **Housing –** Uses include both accompanied housing for families and unaccompanied housing for singles, temporary personnel, and visitors.
- **Base Support/Industrial –** Uses are for the storage of supplies and maintenance of Base facilities and utility systems.
- **Medical –** Uses include facilities for medical support, including the David Grant Medical Center.
- **Outdoor Recreation –** Uses include ball fields, golf course, equestrian center, swimming pools, and other recreational activities.
- **Open Space –** Used as buffers between Base facilities and to preserve environmentally sensitive areas.

Land overlying the groundwater plumes is under four (4) of these functional categories, including mission, administrative, Base support/industrial, and open space areas. Contaminated groundwater does not currently underlie any of the community, housing, medical, and outdoor recreation areas. These areas are hydraulically upgradient of the groundwater plumes.

As the lead agency, the AF has the authority to determine the future anticipated land use of Travis AFB. The AF has determined that Travis AFB is reasonably anticipated to continue as an active military facility, and current land uses are reasonably anticipated to continue indefinitely to support the mission of the facility.

The current land use of adjacent/surrounding land, including that land contiguous to the boundary of Travis AFB, is primarily livestock grazing and pasture land accompanied by low-density rural residential homes. The current use of adjacent/surrounding land is expected to remain the same over the foreseeable future. The lands surrounding Travis AFB on the northeast and east are primarily used for ranching and grazing. Areas to the south are a combination of agricultural and marshland. A few commercial/light industrial areas are present to the north of the Base. The area west of Travis AFB is predominantly residential.

2.6.2 Groundwater Beneficial Uses

Designated beneficial uses of the affected aquifer include domestic, municipal, agricultural, and industrial supply (San Francisco Bay Regional Water Board, 2011). Groundwater at Travis AFB is not currently used as a drinking water source or as a water supply for any purpose, and it is not reasonably anticipated to be used for any purpose in the future.

There is one (1) known off-base domestic water supply well located hydraulically downgradient of Travis AFB. This privately owned domestic water supply well is downgradient of the Site SS030 TCE plume. No contaminants related to the Site SS030 plume have been detected in this well.

Approximately 90 percent of the water currently used at Travis AFB is provided by the City of Vallejo and is surface water originating from Lake Berryessa and Lake Oroville. Groundwater production wells located at the Cypress Lakes Golf Course Annex provide the remaining 10 percent of the Base water supply. These production wells are located approximately 3 miles north of Travis AFB and are hydraulically separate from the Base.

Along with the industrial contaminants listed in Table 2.5-2, groundwater quality at Travis AFB is impacted by the following naturally occurring constituents at concentrations exceeding primary MCLs. Section 3.6 of the TEFA presents the groundwater quality data that is summarized in the following list (CH2M HILL, 2012h):

- Dissolved metals at concentrations exceeding the primary MCLs.
- Fluoride, sulfate, nitrate, nitrite, and turbidity at concentrations that exceed the primary MCL.
- Total dissolved solids (TDS) at concentrations that exceed 3,000 milligrams per liter (mg/L). A provision in State Water Board Resolution 88-63 – Sources of Drinking Water, Item 1a states that such concentrations are "not reasonably expected by Regional Boards to supply a public water system."

In comparison with water quality parameters measured at the City of Vacaville production wells, groundwater at Travis AFB is of lower quality. Concentrations of alkalinity, fluoride, hardness, nitrate, pH, sulfate, total organic carbon (TOC), and turbidity measured at Travis AFB are all greater than those measured in the City of Vacaville wells.

2.7 Summary of Site Risks

This section summarizes the human health risk assessments (HHRAs) for groundwater, which were performed at Travis AFB as part of the OU-specific RIs (Radian, 1995; Weston, 1995; Radian, 1996a; CH2M HILL, 1997) prior to implementation of the IRAs, and a vapor intrusion assessment for groundwater at Sites FT004, FT005, LF006, LF007, LF008, SS015, SS029, SS030, SD031, SD033, SD034, SS035, SD036, SD037, DP039, and SD043 (CH2M HILL, 2010a). The HHRAs also identified COCs associated with unacceptable risks from groundwater, as well as the potentially exposed populations and exposure pathways of primary concern. Based on the presence of unacceptable risks to a hypothetical future resident and considering that groundwater is not safe for drinking water because it remains contaminated with chlorinated VOCs and organochlorine pesticides at concentrations above MCLs, remedial action is being recommended in this ROD to further reduce risks from groundwater.

After more than a decade of interim remediation, the concentrations of COCs in groundwater and corresponding levels of potential risk have decreased or remained stable. Historical maximum concentrations of COCs at each site compared with the current maximum concentrations are provided in Table 2.5-1.

Groundwater is located below the depth at which ecological receptors are present. Therefore, there are no chemicals posing risks to environmental receptors at any of the sites.

The groundwater to surface water pathway is addressed in Section 5.1 of the final NEWIOU Soil, Sediment, and Surface Water ROD. This section of the NEWIOU Soil, Sediment, and Surface Water ROD states that extraction of groundwater has reduced levels of TCE in surface water to levels that do not pose risks to human health or the environment. Accordingly, NEWIOU Soil, Sediment, and Surface Water ROD Alternative 10 – No Action for Surface Water was the selected remedial action at all sites with surface water features (Travis AFB, 2006a).

2.7.1 Human Health Risk Assessment

The baseline HHRA estimates the potential risks a site poses to human health if no actions had been taken and identifies the COCs and exposure pathways that needed to be addressed by the remedial action. Potential human health risks from exposure to contaminated groundwater at Travis AFB calculated prior to implementation of the IRAs in the mid-1990s, and providing the basis for interim actions, and the vapor intrusion assessment are documented in the following reports:

- Appendix C of the NOU RI Report (Radian, 1995)
- Appendix K.6 of the EIOU RI Report (Weston, 1995)
- Appendix H of the WIOU RI Report (Radian, 1996a)
- Appendix G1 of the WABOU RI Report (CH2M HILL, 1997)
- *Site ST027-Area B Human Health Risk Assessment* (CH2M HILL, 2011c)
- *Vapor Intrusion Assessment Report* (CH2M HILL, 2010a)
- *Vapor Intrusion Assessment Update* (CH2M HILL, 2013a)

2.7.1.1 Approach

The HHRA consists of the following components:

- **Selection of Chemicals of Potential Concern (COPC) –** Identifies the constituents considered to be most important to the human health risk estimation process.
- **Exposure Assessment –** Identifies the pathways by which potential human exposures could occur, describes how they are evaluated, and evaluates the magnitude, frequency, and duration of these potential exposures. See Section 2.5.8 for further discussion of potential exposure scenarios.
- **Toxicity Assessment –** Summarizes the toxicity of the selected chemicals and the relationship between magnitude of exposure and the occurrence of adverse health effects.
- **Risk Characterization –** Integrates information from the exposure and toxicity assessments to characterize the risks to human health from potential exposure to chemicals in environmental media. Numerical estimates of potential carcinogenic (cancer) risks and noncarcinogenic (non-cancer) health effects are calculated.
- **Uncertainties Analysis –** Summarizes the basic assumptions used in the HHRA, as well as limitations of data and methodology.

COPCs were divided into two (2) broad groups (noncarcinogens and carcinogens) on the basis of their tendency to cause adverse non-cancer health effects, such as liver toxicity or developmental effects, or cancer. Estimates of potential non-cancer health effects and cancer risks for each COPC are calculated for each exposure scenario and media of interest. Cumulative risks, including risk from all COPCs for each exposure scenario and media of interest, are also calculated.

In the HHRA, potential cancer risk is referred to as the potential excess lifetime cancer risk (ELCR) because it would be in addition to the risk of cancer from other sources, such as exposure to too much sun. An ELCR of one-in-one-million means that there is a one-in-one-million probability that exposure to the constituent will cause cancer. For convenience, ELCR values are usually expressed using scientific notation, where one-in-one-million is expressed as 1×10^{-6} or 1.0E-06. The higher the ELCR value, the greater the probability that exposure to the contaminant will cause cancer. For a cumulative ELCR for site-related contaminants, risks are interpreted within the context of the CERCLA acceptable risk management range of 10^{-6} to 10^{-4}.

For non-cancer health effects, the body's protective mechanisms must be overcome before an adverse effect is manifested. If exposure is high enough and these protective mechanisms (or thresholds) are exceeded, adverse health effects can occur. The dose-response relationship for non-cancer effects is expressed as a reference dose (RfD). An RfD represents a level that an individual may be exposed to a constituent that is not expected to cause any harmful effects. The ratio of the chronic daily intake divided by the RfD is expressed as a hazard quotient (HQ). A hazard index (HI) is generated by adding the HQs for all COPCs and pathways that affect the same target organ (e.g., liver) or that act through the same mechanism of action within a medium to which an individual may reasonably be exposed. An HI less than or equal to 1 indicates that adverse effects are unlikely from additive exposure to constituents (i.e., exposure is less than the RfD). An HI greater than 1 indicates that adverse non-cancer health effects may occur from exposures.

2.7.1.2 Summary of Risk Estimates

See Table 2.7-1 for a summary of human health risks. These were the potential risks posed by the COCs identified during risk assessments conducted as part of the four (4) OU-specific RIs. The full list of COCs and their concentrations prior to implementation of the IRAs is provided in Table 2.5-2.

For direct contact with groundwater prior to implementation of the IRAs based on the hypothetical future residential scenario, the cumulative ELCR estimates ranged from 7.0×10^{-6} to 2.0×10^{-1}, and the cumulative HIs ranged from less than 1 to above 3,000.

For direct contact with groundwater prior to implementation of the IRAs based on the on-base industrial scenario, the cumulative ELCR estimates ranged from 2.0×10^{-6} to 3.0×10^{-2}, and the cumulative HIs ranged from less than 1 to 460.

2.7.2 Vapor Intrusion Assessments

The vapor intrusion assessments evaluated whether inhalation of volatiles migrating from groundwater into indoor air poses a risk to human health based on current and future site conditions. These assessments are documented in the *Vapor Intrusion Assessment Report* and the *Vapor Intrusion Assessment Update* (CH2M HILL, 2010a, 2013a).

2.7.2.1 Vapor Intrusion Assessment

During 2008-2009, Travis AFB conducted a vapor intrusion assessment to evaluate whether inhalation of VOCs migrating from groundwater into indoor air pose a risk to human health based on current and future site conditions at Sites FT004, FT005, LF007 (inclusive of Subareas LF007B, LF007C, and LF007D), LF008, SS015, SS016, SS029, SS030, SD031, ST032 (now a POCO site), SD033, SD034, SS035, SD036, SD037, DP039, and SD043. This assessment was conducted in accordance with the final *Vapor Intrusion Assessment Work Plan* (CH2M HILL, 2008c). Potential preferential pathways under current (commercial/industrial land use) and potential future (hypothetical residential use) conditions were evaluated. Sufficient historical data were available for Sites FT005, LF007 (inclusive of Subareas LF007B, LF007C, and LF007D), LF008, SS015, SS030, SD031, ST032 (now a POCO site), and SD043 to perform a vapor intrusion assessment. However, the need for additional data to support the assessment was identified at Sites FT004, SS016, SS029, SD033, SD034, SS035, SD036, SD037, and DP039. Therefore, additional investigation was performed at these sites in the following three (3) phases:

- **Phase 1 –** During Phase 1 of the vapor intrusion assessment, shallow soil vapor sampling, building subslab soil vapor sampling, indoor air sampling, and outdoor air sampling was conducted at Sites FT004, SS029, SD033, SD034, SS035, SD036, SD037, and DP039.
- **Phase 2 –** Phase 2 consisted of building surveys in areas where the soil gas or groundwater data indicated a potential for vapor intrusion. The building surveys were conducted at Facilities 16 (Site SS016), 18 (Site SS016), 22 (Site SS016), 755 (Site DP039), 811 (Site SD034), 836 (Site SD037), 864 (Site SD037), and 919 (Site SD037) to confirm the current building usage; identify potential soil vapor migration routes; confirm building heating, ventilation, and air conditioning operation; and identify potential sources of other chemicals within the buildings.
- **Phase 3 –** Following the completion of Phase 2, Phase 3 consisted of collecting building subslab soil vapor samples, indoor air samples, and outdoor air samples at buildings

within Sites SS016, SD033, SD034, SS035, SD036, and SD037. Data evaluations and assessment of risks were included in this phase.

2.7.2.2 Vapor Intrusion Assessment Update

During 2012-2013, an update to the *Vapor Intrusion Assessment Report* was developed because toxicity values for several of the chemicals originally evaluated had changed. This update is provided in the final *Vapor Intrusion Assessment Update* (CH2M HILL, 2013a). The results of the updated assessment were used to develop revised risk-based groundwater concentrations for residential and industrial vapor intrusion exposure scenarios and revised residential and industrial groundwater-to-indoor-air LUC boundaries.

2.7.2.3 Summary of Risk Estimates

The vapor intrusion assessments did not identify unacceptable risk from vapor intrusion into indoor air based on current site use. However, potential future vapor intrusion risks were identified at some sites if site conditions change (such as construction of new facility overlying a groundwater plume or change in facility use). See Table 2.7-2 for a summary of potential future vapor intrusion risks based on shallow soil gas data.

For an industrial exposure scenario, potential future vapor intrusion risk is posed by VOCs in groundwater at Sites FT004, SS015, SS016, SS029, and DP039. The cumulative ELCR estimates for Sites FT004, SS029, and DP039 range from 6.2×10^{-6} to 1.9×10^{-5}, and the cumulative HIs range from 2 to 7. For Sites SS015 and SS016 (where shallow soil gas samples were not collected), concentrations of COCs in groundwater are greater than risk-based concentrations (RBCs).

For a residential exposure scenario, potential future vapor intrusion risk is posed by VOCs in groundwater at Site FT004, Subarea LF007C, and Sites SS015, SS016, SS029, SS030, SD033, SS035, SD036, SD037, and DP039. Under this hypothetical future residential scenario, the cumulative ELCR estimates for Sites FT004, SS029, SD033, SS035, SD036, SD037, and DP039 range from 1.5×10^{-5} to 6.7×10^{-4}. The cumulative HIs for Sites FT004, SS029, SS035, SD036, SD037, and DP039 range from 1.4 to 140. For Sites LF007, SS015, SS016, and SS030 (where shallow soil gas samples were not collected), concentrations of COCs in groundwater are greater than RBCs.

The vapor intrusion pathway is not a potential future concern under either a residential or industrial exposure scenario at Sites FT005, LF006, LF008, ST027B, SD031, SD034, SS041, and SD043 based on the following:

- Groundwater contaminant concentrations at Sites FT005, LF006, LF008, SD031, SS041, and SD043 were below groundwater-to-indoor-air RBCs, and no additional investigation of the vapor intrusion pathway was warranted.
- Shallow soil gas concentrations detected at Site ST027B were below shallow-soil-gas-to-indoor-air RBCs.
- Shallow soil gas cumulative ELCR estimates were below (industrial exposure) or within (residential exposure) the risk management range, and cumulative HIs for Site SD034 were less than 1 for both industrial and residential exposure.

2.7.3 Basis for Action

The response actions selected in this ROD are necessary to protect the public health or welfare or the environment from actual or threatened releases of hazardous substances into the environment. The response actions are also necessary to protect the public health or welfare or the environment from actual or threatened releases of pollutants or contaminants at the sites, which may present an imminent and substantial endangerment to the public health or welfare. Groundwater at Travis AFB is not safe for use as drinking water because it is contaminated with chlorinated VOCs (primarily TCE) and organochlorine pesticides (primarily alpha-chlordane) at concentrations above MCLs. Potential risks are also posed by the slow movement of contaminated groundwater toward an off-base location where groundwater is used as drinking water. Travis AFB does not use groundwater underlying its geographic footprint and does not plan to do so in the future.

Stoddard solvent free product (LNAPL) is floating on the groundwater table at Site SD034 and potentially impacts designated beneficial uses. Stoddard solvent (aka PD-680) is a petroleum distillate mixture of 15 percent trimethylbenzene and 85 percent n-nonane. Neither of these constituent compounds have a primary State of California or federal MCL. However, the Stoddard solvent is a non-aqueous medium also containing dissolved-phase COCs (primarily cis-1,2-DCE) at concentrations above MCLs. The COCs contained in the free product will dissolve into the surrounding groundwater over time. Therefore, action is warranted to remove the free product that acts as a source of contamination to the groundwater. The free product will be removed to the maximum extent practicable, in a manner that minimizes the spread of contamination into previously uncontaminated zones by using recovery and disposal techniques appropriate to the hydrogeologic conditions at the site.

Migration of VOC vapors from groundwater to indoor air does not present an imminent and substantial endangerment to the public health or welfare based on current and anticipated site use. Potential future vapor intrusion risks are posed from exposure to VOCs (TCE, PCE, vinyl chloride, and benzene) migrating from onsite groundwater to indoor air if, in the future, buildings are constructed overlying some of the groundwater VOC plumes. Travis AFB's current indoor air vapor intrusion mitigation policy, which restricts new residential/industrial construction at portions of these sites unless vapor barriers and passive ventilation systems are installed, will be incorporated into land use restrictions as part of this response action. Residential and industrial land uses at Sites FT004, SS015, SS016, SS029, and DP039 and residential land uses at Site FT004, Subarea LF007C, and Sites SS015, SS016, SS029, SS030, SD033, SS035, SD036, SD037, and DP039 will not be allowed without prior approval from the AF and appropriate regulatory agencies until concentrations of volatile COCs in groundwater posing a potential indoor air risk are at such levels that VOCs emanating from groundwater to indoor air do not pose unacceptable risk to human health.

TABLE 2.7-1
Summary of Human Health Risks for Direct Contact with Groundwater
Groundwater Record of Decision, Travis Air Force Base, California

Site	Pre-IRA Carcinogens – ELCR Estimate		Pre-IRA Noncarcinogens – Hazard Index		Reference
	Hypothetical Future Residential	Future Industrial	Hypothetical Future Residential	Future Industrial	
FT004	NA*	5.76 E-03	NA*	3.17 E+01	Appendix K.6 of the EIOU RI Report (Weston, 1995)
FT005	1.76 E-03	5.76 E-03	1.16 E+02	3.17 E+01	Appendix K.6 of the EIOU RI Report (Weston, 1995)
LF006	3.30 E-04	5.10 E-05	5.89 E+01	1.22 E+01	Tables 6-11 and 6-12 of the NOU RI Report (Radian, 1995)
LF007B	7.80 E-04	2.70 E-04	7.00 E+01	<1 E+00	Tables 6-11 and 6-12 of the NOU RI Report (Radian, 1995)
LF007C	3.60 E-05	4.70 E-06	3.10 E+01	4.60 E+01	Tables 6-11 and 6-12 of the NOU RI Report (Radian, 1995)
LF007D	1.00 E-03	3.70 E-04	5.10 E+01	6.00 E+00	Tables 6-11 and 6-12 of the NOU RI Report (Radian, 1995)
LF008	3.00 E-05	2.00 E-05	<1 E+01	<1 E+00	Appendix G1 of the WABOU RI Report (CH2M HILL, 1997)
SS015	NA*	5.76 E-03	NA*	3.17 E+01	Appendix K.6 of the EIOU RI Report (Weston, 1995)
SS016	NA*	5.76 E-03	NA*	3.17 E+01	Appendix K.6 of the EIOU RI Report (Weston, 1995)
ST027B	2.40 E-04	1.40 E-04	2.63 E+01	1.15 E+01	Appendix H of the WIOU RI Report (Radian, 1996a)
SS029	NA*	5.76 E-03	NA*	3.17 E+01	Appendix K.6 of the EIOU RI Report (Weston, 1995)
SS030	1.76 E-03	5.76 E-03	1.16 E+02	3.17 E+01	Appendix K.6 of the EIOU RI Report (Weston, 1995)
SD031	NA*	5.76 E-03	NA*	3.17 E+01	Appendix K.6 of the EIOU RI Report (Weston, 1995)
SD033	8.90 E-05	1.10 E-04	2.32 E+01	8.20 E+00	Appendix H of the WIOU RI Report (Radian, 1996a)
SD034	2.40 E-03	1.20 E-03	2.18 E+02	6.10 E+01	Appendix H of the WIOU RI Report (Radian, 1996a)
SS035	8.60 E-05	5.00 E-05	3.5 E+00	1.50 E+00	Appendix H of the WIOU RI Report (Radian, 1996a)
SD036	6.80 E-03	2.50 E-03	1.79 E+02	2.30 E+01	Appendix H of the WIOU RI Report (Radian, 1996a)
SD037	9.60 E-04	5.70 E-04	2.44 E+02	1.02 E+02	Appendix H of the WIOU RI Report (Radian, 1996a)
DP039	2.00 E-01	3.00 E-02	>3 E+03	4.60 E+02	Appendix G1 of the WABOU RI Report (CH2M HILL, 1997)
SS041	7.00 E-06	2.00 E-06	<1 E+00	<1 E+00	Appendix G1 of the WABOU RI Report (CH2M HILL, 1997)
SD043	1.00 E-04	5.00 E-05	3.50 E+01	2.20 E+01	Appendix G1 of the WABOU RI Report (CH2M HILL, 1997)

*The EIOU RI determined that future residential land use at this site was unlikely; therefore, this exposure route was not included in the risk assessment (Weston, 1995).

TABLE 2.7-2
Summary of Human Health Risks for Indoor Air Vapor Intrusion
Groundwater Record of Decision, Travis Air Force Base, California

Site[b]	ELCR Estimate[a]		Hazard Index[a]	
	Hypothetical Future Residential	On-base Industrial	Hypothetical Future Residential	On-base Industrial
FT004	2.2 E-04	6.2 E-06	46	2
ST027B	2.0 E-06	7.0 E-08	0.1	0.005
SS029	6.7 E-04	1.9 E-05	140	7
SD033	1.5 E-05	6.1 E-07	0.51	0.024
SD034	7.4 E-06	3.0 E-07	0.18	0.01
SS035	3.5 E-05	1.3 E-06	1.4	0.066
SD036	6.4 E-05	1.7 E-06	12	0.56
SD037	8.1 E-05	3.2 E-06	3.3	0.16
DP039	3.6 E-04	7.5 E-06	54	3

[a] Reflects range of estimates for multiple exposure areas.
[b] Potential future risk from vapor intrusion if site conditions change (such as construction of new facility overlying a groundwater plume or change in facility use).

Source: *Vapor Intrusion Assessment Update* (CH2M HILL, 2013a).