

**FINAL**

**SITE INSPECTION REPORT**

**SITE INSPECTION OF AQUEOUS FILM FORMING FOAM (AFFF) RELEASE AREAS  
ENVIRONMENTAL PROGRAMS WORLDWIDE**

**VANDENBERG AIR FORCE BASE  
SANTA BARBARA COUNTY, CALIFORNIA**

**Prepared for:**

**Air Force Civil Engineer Center  
Joint Base San Antonio – Lackland, Texas**



**Prepared by:**



**Amec Foster Wheeler Programs, Inc.**



**Oneida Total Integrated Enterprises**

**Contract FA8903-16-D-0027**

**Task Order 0004**

**MARCH 2019**

This page intentionally left blank.

## TABLE OF CONTENTS

|   |           |
|---|-----------|
| <b>ACRONYMS.....</b>  | <b>v</b>  |
| <b>EXECUTIVE SUMMARY .....</b>  | <b>ix</b> |
| <b>1.0 INTRODUCTION .....</b>   | <b>1</b>  |
| 1.1 PER- AND POLY-FLUORINATED ALKYL SUBSTANCES OVERVIEW .....               | 1         |
| 1.2 PROJECT OBJECTIVES .....  | 3         |
| 1.3 PROJECT SCOPE.....  | 4         |
| <b>2.0 AFFF RELEASE AREA BACKGROUND .....</b>                               | <b>5</b>  |
| 2.1 SITE LOCATION AND SETTING .....   | 5         |
| 2.2 SITE HISTORY .....  | 5         |
| 2.3 PREVIOUS INVESTIGATIONS.....  | 5         |
| <b>3.0 FIELD ACTIVITIES AND ANALYTICAL PROTOCOL.....</b>                    | <b>7</b>  |
| 3.1 AFFF RELEASE AREA 1: FT021 (FORMER FTA) .....                           | 13        |
| 3.1.1 Sample Location and Methodologies.....                                | 13        |
| 3.1.2 Analytical Results .....  | 14        |
| 3.1.3 Conclusions .....   | 16        |
| 3.2 AFFF RELEASE AREA 2: 1992 FUEL SPILL .....                              | 16        |
| 3.2.1 Sample Location and Methodologies.....                                | 16        |
| 3.2.2 Analytical Results .....  | 17        |
| 3.2.3 Conclusions .....   | 18        |
| 3.3 AFFF RELEASE AREA 3: 2006 FUEL SPILL .....                              | 19        |
| 3.3.1 Sample Location and Methodologies.....                                | 19        |
| 3.3.2 Analytical Results .....  | 19        |
| 3.3.3 Conclusions .....   | 21        |
| 3.4 AFFF RELEASE AREA 4: 2009 AFFF RELEASE .....                            | 21        |
| 3.4.1 Sample Location and Methodologies.....                                | 21        |
| 3.4.2 Analytical Results .....  | 22        |
| 3.4.3 Conclusions .....   | 23        |
| 3.5 AFFF RELEASE AREA 5: SPRAY NOZZLE (REFRACTOMETER) TEST AREA (SNTA)..... | 23        |
| 3.5.2 Analytical Results .....  | 23        |
| 3.5.3 Conclusions .....   | 25        |
| <b>4.0 MIGRATION/EXPOSURE PATHWAYS AND TARGETS.....</b>                     | <b>27</b> |
| 4.1 SOIL (SURFACE AND SUBSURFACE) EXPOSURE PATHWAY .....                    | 27        |
| 4.1.1 Local Geologic Setting.....   | 27        |
| 4.1.2 Soil Exposure Pathways and Targets.....                               | 27        |
| 4.1.3 Soil Exposure Conclusions.....  | 28        |
| 4.2 GROUNDWATER MIGRATION PATHWAY .....                                     | 28        |

|            |  |           |
|------------|--|-----------|
| 4.2.1      | Local Hydrogeologic Setting .....              | 28        |
| 4.2.2      | Groundwater Exposure Pathways and Targets..... | 29        |
| 4.2.3      | Groundwater Migration Pathway Conclusions..... | 30        |
| 4.3        | SEDIMENT EXPOSURE PATHWAY.....                 | 31        |
| 4.3.1      | Sediment Exposure Pathways and Targets.....    | 31        |
| 4.3.2      | Sediment Exposure Conclusions .....            | 31        |
| <b>5.0</b> | <b>SUMMARY AND CONCLUSIONS .....</b>           | <b>33</b> |
| <b>6.0</b> | <b>REFERENCES .....</b>                        | <b>41</b> |

### FIGURES

|              |  |
|--------------|--|
| Figure 2.1-1 | Installation Location Map  |
| Figure 2.3-1 | AFFF Release Areas   |
| Figure 3.1-1 | Sampling Locations and Excavation Backfill Water Elevation (September 2018), FT021 (Former FTA), AFFF Release Area 1 |
| Figure 3.1-2 | PFAS in Soil, FT021 (Former FTA), AFFF Release Area 1  |
| Figure 3.1-3 | PFAS in Excavation Backfill Water, FT021 (Former FTA), AFFF Release Area 1   |
| Figure 3.1-4 | PFAS in Sediment, FT021 (Former FTA), AFFF Release Area 1  |
| Figure 3.2-1 | Sampling Locations and Groundwater Elevations (September 2018), 1992 Fuel Spill, AFFF Release Area 2                 |
| Figure 3.2-2 | PFAS in Soil, 1992 Fuel Spill, AFFF Release Area 2   |
| Figure 3.2-3 | PFAS in Groundwater, 1992 Fuel Spill, AFFF Release Area 2  |
| Figure 3.3-1 | Sampling Locations and Groundwater Elevations (September 2018), 2006 Fuel Spill, AFFF Release Area 3                 |
| Figure 3.3-2 | PFAS in Soil, 2006 Fuel Spill, AFFF Release Area 3   |
| Figure 3.3-3 | PFAS in Groundwater, 2006 Fuel Spill, AFFF Release Area 3  |
| Figure 3.3-4 | PFAS in Sediment, 2006 Fuel Spill, AFFF Release Area 3   |
| Figure 3.4.1 | Sampling Locations, 2009 AFFF Release, AFFF Release Area 4   |
| Figure 3.4-2 | PFAS in Soil, 2009 AFFF Release, AFFF Release Area 4   |
| Figure 3.5-1 | Sampling Locations, Spray Nozzle Test Area, AFFF Release Area 5  |
| Figure 3.5-2 | PFAS in Soil, Spray Nozzle Test Area, AFFF Release Area 5  |
| Figure 3.5-3 | PFAS in Sediment, Spray Nozzle Test Area, AFFF Release Area 5  |
| Figure 4.1-1 | Desktop Four-Mile Water Well Review Results  |

### TABLES

|             |                                      |                    |
|-------------|--------------------------------------|--------------------|
| Table 1.1-1 | Regulatory Screening Values          | (Page 3 in Report) |
| Table 3.0-1 | Monitoring Well Construction Details | (Tables Section)   |
| Table 3.0-2 | Groundwater Elevations               | (Tables Section)   |

|             |   |                     |
|-------------|---|---------------------|
| Table 3.1-1 | Summary of Soil Analytical Results                            | (Tables Section)    |
| Table 3.1-2 | Summary of Soil General Chemistry Analytical Testing Results  | (Tables Section)    |
| Table 3.1-3 | Summary of Groundwater Analytical Results                     | (Tables Section)    |
| Table 3.1-4 | Summary of Sediment Analytical Results                        | (Tables Section)    |
| Table 4.0-1 | Conceptual Site Model: Installation-Wide Summary              | (Tables Section)    |
| Table 5.0-1 | Summary of Analytical Results and Screening Level Exceedances | (Page 35 in Report) |

## **APPENDICES**

|            |   |
|------------|---|
| Appendix A | Photograph Logs   |
| Appendix B | Field Forms   |
|            | B-1 Field Activity Daily Logs                           |
|            | B-2 Daily PFAS Protocol Checklists                      |
|            | B-3 Tailgate Safety Meeting Reports                     |
|            | B-4 Soil Boring/Monitoring Well Construction Records    |
|            | B-5 Soil Sample Collection Logs                         |
|            | B-6 Screened Well Construction Forms                    |
|            | B-7 Well Development Logs                               |
|            | B-8 Water Quality Sampling Instrument Calibration Forms |
|            | B-9 Groundwater Sampling Logs                           |
|            | B-10 Sediment Sample Collection Logs                    |
| Appendix C | Laboratory Analytical Reports (DVD)                     |
| Appendix D | Data Validation Report                                  |
| Appendix E | Investigation-Derived Waste Information                 |

This page intentionally left blank.

## ACRONYMS

|                     |  |
|---------------------|--|
| %                   | percent  |
| AFCEC               | Air Force Civil Engineer Center                        |
| AFFF                | Aqueous Film Forming Foam                              |
| Amec Foster Wheeler | Amec Foster Wheeler Environment & Infrastructure, Inc. |
| amsl                | above mean sea level                                   |
| BRAC                | Base Realignment and Closure                           |
| btoc                | below top of casing                                    |
| CoC                 | Chain-of-Custody                                       |
| DoD                 | Department of Defense                                  |
| DWR                 | California Department of Water Resources               |
| ELLE                | Eurofins Lancaster Laboratories Environmental          |
| FTA                 | Fire Training Area                                     |
| ft bgs              | feet below ground surface                              |
| FTS                 | fluorotelomer sulfonate                                |
| HA                  | Health Advisory  |
| HDPE                | high-density polyethylene                              |
| HSA                 | Hollow Stem Auger                                      |
| IDW                 | Investigation-Derived Waste                            |
| IRP                 | Installation Restoration Program                       |
| ISWP                | Installation-Specific Work Plan                        |
| JP-8                | Jet Propellant Fuel Number 8                           |
| LC-MS/MS            | Liquid Chromatography and Tandem Mass Spectrometry     |
| LOD                 | limit of detection                                     |
| LOQ                 | limit of quantitation                                  |
| µg/L                | micrograms per liter                                   |
| mg/kg               | milligrams per kilogram                                |
| MS/MSD              | matrix spike/matrix spike duplicate                    |
| MW                  | Monitoring Well  |

### ACRONYMS cont'd

|          |  |
|----------|--|
| NEtFOSAA | n-ethyl perfluorooctanesulfonamidoacetic acid                      |
| NMeFOSAA | n-methyl perfluorooctanesulfonamidoacetic acid                     |
| OTIE     | Oneida Total Integrated Enterprises                                |
| PA       | Preliminary Assessment   |
| PFAS     | per- and polyfluorinated alkyl substances                          |
| PFBS     | perfluorobutanesulfonic acid                                       |
| PFDA     | perfluorodecanoic acid   |
| PFDoA    | perfluorododecanoic acid   |
| PFHpA    | perfluoroheptanoic acid  |
| PFHxA    | perfluorohexanoic acid   |
| PFHxS    | perfluorohexane sulfonic acid                                      |
| PFNA     | perfluorononanoic acid   |
| PFOA     | perfluorooctanoic acid   |
| PFOS     | perfluorooctanesulfonic acid                                       |
| PFTA     | perfluorotetradecanoic acid  |
| PFTTrDA  | perfluorotridecanoic acid  |
| PFUnA    | perfluoroundecanoic acid   |
| pH       | potential of hydrogen  |
| PID      | Photoionization Detector   |
| PPE      | personal protective equipment                                      |
| PVC      | polyvinyl chloride   |
| QC       | Quality Control  |
| QPP      | Quality Program Plan   |
| RI       | Remedial Investigation   |
| RPM      | Remedial Project Manager   |
| RSL      | Regional Screening Level   |
| SAF/IE   | Secretary of the Air Force, Installations, Environment, and Energy |
| SD       | Sediment   |
| SDG      | sample delivery group  |
| SI       | Site Inspection  |
| SIR      | Site Inspection Report   |
| SNTA     | Spray Nozzle (Refractometer) Test Area                             |
| SOP      | Standard Operating Procedure                                       |
| S.U.     | Standard Unit  |
| THQ      | target hazard quotient   |
| TOC      | total organic carbon   |



**ACRONYMS cont'd**

|       |   |
|-------|---|
| U.S.  | United States                                 |
| USAF  | United States Air Force                       |
| USEPA | United States Environmental Protection Agency |
| VAFB  | Vandenberg Air Force Base                     |
| WCR   | well completion report                        |

This page intentionally left blank.

## EXECUTIVE SUMMARY

This Site Inspection (SI) Report (SIR) was prepared by Oneida Total Integrated Enterprises (OTIE) under Contract No. FA8903-16-D-0027, Task Order 0004, to document the results of SI activities conducted at five aqueous film forming foam (AFFF) release areas located at Vandenberg Air Force Base (VAFB). The purpose of the SI was to determine, through environmental media sampling, if a release of per- and polyfluorinated alkyl substances (PFAS) has occurred at potential AFFF release areas identified by others during Preliminary Assessment (PA) activities at locations where AFFF was released to the environment (CH2M Hill, 2015). The data presented in this SIR were collected and evaluated in accordance with the Final Installation-Specific Work Plan (ISWP) (OTIE, 2018) and the General Quality Program Plan (QPP) (Amec Foster Wheeler, 2018).

PFAS are a class of synthetic organofluorine compounds that possess a chemical structure that gives them unique properties, including thermal stability and the ability to repel both water and oil. These chemical properties make them useful components in a wide variety of consumer and industrial products, including non-stick cookware, food packaging, waterproof clothing, fabric stain protectors, lubricants, paints, and firefighting foams such as AFFF. AFFF concentrate contains fluorocarbon surfactants to meet required performance standards for fire extinguishing agents (Department of Defense [DoD] Military Specification MIL-F-24385F [SH], Amendment 1, 5 August 1994) (DoD, 1994). The United States (U.S.) Air Force (USAF) began purchasing and using AFFF containing PFAS (specifically perfluorooctanesulfonic acid [PFOS] and/or perfluorooctanoic acid [PFOA]) for extinguishing petroleum fires and during firefighting training activities in 1970. AFFF was primarily used on USAF installations at fire training areas (FTAs), but may have also been used, stored or released from hangar fire suppression systems, at firefighting equipment testing and maintenance areas, and during emergency response actions for fuel spills and/or aircraft mishaps.

The U.S. Environmental Protection Agency (USEPA) Office of Water issued lifetime drinking water Health Advisory (HA) values for PFOS and PFOA in May 2016 that replaced the 2009 Provisional HA values. The HA values for PFOS and PFOA are 0.07 micrograms per liter ( $\mu\text{g/L}$ ) for each constituent. The USEPA also recommended that when these two chemicals co-occur in a drinking water source, a conservative and health protective approach that compares the sum of the concentrations (PFOS+PFOA) to the HA value be applied (0.07  $\mu\text{g/L}$ ) (USEPA, 2016a and 2016b). HA values are not to be construed as legally enforceable federal standards and are subject to change as new information becomes available (USEPA, 2016a and 2016b). Although the USEPA has not established HA values for PFAS in soil, the USAF calculated a residential screening level of 0.126 milligrams per kilogram ( $\text{mg/kg}$ ) for PFOS and PFOA in soil and sediment, based on a target hazard quotient (THQ) of 0.1, using the USEPA Regional Screening Level (RSL) calculator (USEPA, 2018). This screening value was presented in the Final ISWP (OTIE, 2018).

While PFOS and PFOA are the focus of the HA and provide specific targets for the USAF to address in the SI, USEPA has also derived an RSL for perfluorobutanesulfonic acid (PFBS) for which there is a Tier 2 toxicity value (Provisional Peer Review Toxicity Value) (USEPA, 2017). Based on the ISWP,

concentrations of PFBS detected in groundwater and soil/sediment were compared to the USEPA RSLs of 40 µg/L and 130 mg/kg, based on a THQ of 0.1, respectively.

The USEPA and the State of California have not issued HA values or promulgated standards for any other PFAS constituents to date.

VAFB is an active USAF installation that occupies approximately 99,604 acres on the south-central coast of California and is located approximately 50 miles north of Santa Barbara in Santa Barbara County (**Figure 2.1-1**). The Santa Ynez River runs east/west and bisects the Base into North Base and South Base. An active airfield is present in the developed area of North Base between Tangair Road and 13th Street, northwest of California Boulevard. VAFB is headquarters to the 30<sup>th</sup> Space Wing, with primary missions to launch and track polar-orbiting satellites, test and evaluate the intercontinental ballistic missile systems, and operate the Western Range.

The PA provided findings to assess if AFFF containing PFAS was stored, handled, used or released at VAFB (CH2M Hill, 2015). Seventeen potential AFFF release areas were identified during the PA research, with the following five AFFF Release Areas recommended for SI and observed during the installation scoping visit conducted by OTIE on 19 January 2017:

1. AFFF Release Area 1: FT021 (Former FTA);
2. AFFF Release Area 2: 1992 Fuel Spill;
3. AFFF Release Area 3: 2006 Fuel Spill;
4. AFFF Release Area 4: 2009 AFFF Release; and,
5. AFFF Release Area 5: Spray Nozzle (Refractometer) Test Area.

The specific objectives of the SI were as follows:

- Determine if PFAS are present in soil, groundwater, or sediment at AFFF release areas selected for SI;
- Determine if PFOS and PFOA concentrations in soil or sediment exceed the calculated RSL of 0.126 mg/kg, based on a residential exposure scenario, and PFBS concentrations in soil or sediment exceed the USEPA residential RSL of 130 mg/kg;
- Determine if concentrations of PFOS, PFOA, or the sum of PFOS and PFOA, in groundwater exceed the USEPA HA value of 0.07 µg/L, and if PFBS concentrations in groundwater exceed the USEPA Tap Water RSL of 40 µg/L; and,
- Identify potential receptor pathways with immediate impacts to human health (immediate impact to human health is considered consumption of drinking water with PFOS/PFOA above the USEPA HA value or PFBS above the USEPA Tap Water RSL).

### PFAS Analytical Results

PFAS were detected in the surface soil and/or in subsurface soil at AFFF Release Areas 1 through 5. PFOS exceeded the calculated RSL in surface soil and subsurface soil (to a depth of 4.5 feet below ground surface [ft bgs]) at AFFF Release Area 1 and surface soil at AFFF Release Areas 4 and 5. These AFFF release areas consist of unpaved areas with exposed surface soil or partially covered with vegetation.

PFAS was detected in localized excavation backfill water at AFFF Release Area 1 and in groundwater at AFFF Release Areas 2 and 3. PFOS, PFOA, and PFOS + PFOA were detected in the water at AFFF release Area 1 and in groundwater at AFFF Release Area 2 at concentrations above the USEPA HA. Exposure pathways were evaluated for these AFFF release areas.

PFAS were detected in sediment samples from AFFF Release Areas 1, 3, and 5. PFOS and PFOA exceeded the calculated RSLs at AFFF Release Area 5.

### Surface and Subsurface Soil Receptors

Surface and subsurface soil in AFFF Release Areas 1, 4, and 5 are potentially accessible by USAF personnel, site workers, site visitors, and trespassers involved in any activity that exposes them to the impacted soil, particularly site workers performing ground-disturbing activities. AFFF Release Area 1 is accessible to USAF personnel, site workers, site visitors, and/or trespassers. AFFF Release Area 4, located adjacent to the runway, is in a flightline controlled movement area, and accessible to duty-related personnel only. Accessibility to AFFF Release Area 5, located behind a fenced, locked gate, is controlled by the Vandenberg AFB Fire Department. Access to source area soil is not expected to change in the future.

Potential exposure routes for surface and subsurface soil include inhalation of impacted surface soil dust particles and ingestion of and dermal contact with impacted soil.

Based on the SI, potential complete pathways for human exposure to PFAS-impacted surface soil through inhalation, ingestion, and/or dermal contact were identified for AFFF Release Areas 1, 4, and 5.

### Groundwater/Excavation Backfill Water Receptors

Localized water associated with previous excavation backfill activities (excavation backfill water) was encountered at AFFF Release Area 1. No groundwater was encountered at AFFF Release Area 1 during the remedial investigation (USAF, 2008) or during the AFFF SI (Section 3.1.2.3). Although groundwater was encountered in each boring at AFFF Release Area 2 at depths ranging from approximately 17 to 27 ft. bgs (**Table 3.0-2**), the site-specific groundwater flow direction was not determined during the SI field effort due to limited groundwater elevation data. In general, the shallow groundwater in the vicinity of the Burton Mesa area exists in relatively thin, disconnected lenses perched on low permeability layers and directly overlying bedrock. Groundwater flow on the Burton Mesa is highly variable and dependent on localized site characteristics (MWH, 2012).

The primary potable water source for VAFB is through the State Water Project, with supplemental supply wells located upgradient in a basin not known to be hydrologically connected to identified AFFF source areas.

The pathway for human receptors' exposure to groundwater via a direct ingestion of drinking water is incomplete from Base water supply wells because the wells are not hydrologically connected to PFAS-impacted shallow groundwater. However, the potential exists for PFAS-impacted groundwater at AFFF Release Area 2 to interact with surface ponds and creeks, or for groundwater to surface as natural springs. Additionally, the potential exists for site workers to be exposed to PFAS-impacted water at AFFF Release Area 1 during potential excavation activities. Potential exposure pathways for human receptors at AFFF Release Area 1 include dermal contact or ingestion.

Based on the SI, potential complete pathways were identified for human exposure to PFAS-impacted excavation backfill water at AFFF Release Area 1, and groundwater for AFFF Release Area 2.

#### Sediment Receptors

Sediment in the AFFF Release Area 5 is potentially accessible by USAF personnel, residents, site workers, site visitors, and/or trespassers involved in any activity that exposes them to the impacted sediment. AFFF Release Area 5 is a gated facility and no one is admitted without permission of facility personnel. Access to sediment is not expected to change in the future.

Potential exposure routes for sediment include dermal contact with or ingestion of sediment, or inhalation of dust from sediment during site maintenance activities or site visits.

Based on the SI, potential complete pathways for human exposure to PFAS-impacted sediment through inhalation, ingestion, and/or dermal contact were identified for AFFF Release Area 5.

## 1.0 INTRODUCTION

This Site Inspection (SI) Report (SIR) was prepared by Oneida Total Integrated Enterprises (OTIE) under Contract No. FA8903-16-D-0027, Task Order 0004 between Amec Foster Wheeler Programs, Inc. (Amec Foster Wheeler) and the Air Force Civil Engineer Center (AFCEC), to document the results of SI activities conducted at five aqueous film forming foam (AFFF) release areas located at Vandenberg Air Force Base (VAFB). The purpose of the SI is to evaluate the potential presence of select per- and polyfluoroalkyl substances (PFAS) in environmental media samples collected from the AFFF release areas identified by others in the Preliminary Assessment (PA) (CH2M Hill, 2015). This SIR details the work performed and identifies potential human exposure pathways with risk for impacts to human health. While a screening level ecological risk assessment is not included in the scope of this SI, the findings of this SI will be used as a basis for Air Force decision-making related to prioritizing AFFF release sites for further investigation and mitigating human exposure to any impacted drinking water. Based on the findings of the SI, certain AFFF release areas are recommended for advancement to a remedial investigation (RI). An ecological risk assessment will be included as part of the RI.

The data presented in this SIR were collected and evaluated in accordance with the Final Installation-Specific Work Plan (ISWP) (OTIE, 2018) and the General Quality Program Plan (QPP) (Amec Foster Wheeler, 2018).

### 1.1 PER- AND POLY-FLUORINATED ALKYL SUBSTANCES OVERVIEW

PFAS are a class of synthetic organofluorine compounds that possess a chemical structure that gives them unique properties, including thermal stability and the ability to repel both water and oil. These chemical properties make them useful components in a wide variety of consumer and industrial products, including non-stick cookware, food packaging, waterproof clothing, fabric stain protectors, lubricants, paints, and firefighting foams such as AFFF. AFFF concentrate contains fluorocarbon surfactants to meet required performance standards for fire extinguishing agents (Department of Defense [DoD] Military Specification MIL-F-24385F [SH], Amendment 1, August 1994). The United States (U.S.) Air Force (USAF) began purchasing and using AFFF containing PFAS (perfluorooctanesulfonic acid [PFOS] and/or perfluorooctanoic acid [PFOA]) for extinguishing petroleum fires and during firefighting training activities in 1970, as confirmed by the following federal government documents:

- Military Specification for AFFF (MIL-F-24385), formally issued in 1969 (DoD, 1969);
- General Accounting Office determination on sole source award protest to provide AFFF to the Navy in December 1969; and,
- *A History of USAF Fire Protection Training at Chanute Air Force Base, 1964-1976* (Coates, 1977).

AFFF was primarily used on USAF installations at fire training areas (FTAs), but may have also been used, stored or released from hangar fire suppression systems, at firefighting equipment testing and maintenance areas, and during emergency response actions for fuel spills and/or aircraft mishaps.

The USEPA Office of Water issued lifetime drinking water Health Advisory (HA) values for PFOS and PFOA in May 2016 to protect humans from potential risk from exposure to these chemicals through drinking water. The 2016 HA values replaced the 2009 Provisional HA values. The HA values for PFOS and PFOA are 0.07 micrograms per liter ( $\mu\text{g/L}$ ) for each constituent. The USEPA also recommended that when these two chemicals co-occur in a drinking water source, a conservative and health protective approach that compares the sum of the concentrations (PFOS+PFOA) to the HA value be applied (0.07  $\mu\text{g/L}$ ) (USEPA, 2016a and 2016b). HA values identify the concentration of a contaminant in drinking water at which adverse health effects are not anticipated to occur over specific exposure durations (e.g., one day, 10 days, a lifetime). They serve as informal technical guidance to assist federal, state, and local officials, and managers of public or community water systems in protecting public health when emergency spills or other contamination situations occur. The 2016 HA guidance provides information on the environmental properties, health effects, analytical methodology, and treatment technologies for removing drinking water contaminants. HA values are not to be construed as legally enforceable federal standards and are subject to change as new information becomes available (USEPA, 2016a and 2016b).

Although the USEPA has not published Regional Screening Levels (RSLs) for PFOS or PFOA in soil or sediment, the USAF calculated a 0.126 milligrams per kilogram ( $\text{mg/kg}$ ) screening level for PFOS and PFOA in soil and sediment using the USEPA RSL calculator (USEPA, 2018) and a target hazard quotient (THQ) of 0.1. This screening value was presented in the Final ISWP (OTIE, 2018).

While PFOS and PFOA are the focus of the HA and provide specific targets for USAF to address in the SI, USEPA has also derived RSL values for perfluorobutanesulfonic acid (PFBS), for which there is a Tier 2 toxicity value (Provisional Peer Review Toxicity Value) (USEPA, 2017). Based on the Final ISWP (OTIE, 2018), concentrations of PFBS detected in groundwater and soil were compared to the USEPA Tap Water RSL of 40  $\mu\text{g/L}$  and residential RSL of 130  $\text{mg/kg}$  based on a THQ of 0.1, respectively.

**Table 1.1-1** below presents the screening values for comparing analytical results for PFOS, PFOA, and PFBS. Neither the USEPA nor the State of California have issued HA values or promulgated standards for any other PFAS to date.



**Table 1.1-1. Regulatory Screening Values.**

| Parameter | Chemical Abstract Number | USEPA Regional Screening Level Table (November 2018) <sup>a</sup> |                  | Calculated RSL for Soil and Sediment <sup>b</sup> (mg/kg) | USEPA Health Advisory for Drinking Water for Groundwater <sup>c,d</sup> (µg/L) |
|-----------|--------------------------|---|------------------|---|--|
|           |                          | Residential Soil and Sediment (mg/kg)                             | Tap Water (µg/L) |   |  |
| PFOS      | 1763-23-1                | NL  | NL               | 0.126   | 0.07   |
| PFOA      | 335-67-1                 | NL  | NL               | 0.126   |  |
| PFBS      | 375-73-5                 | 130   | 40               | NL  | NL   |

**Notes:**

- a USEPA Regional Screening Level (2018) [<https://www.epa.gov/risk/regional-screening-levels-rsls-generic-tables>] using a THQ of 0.1. Residential soil screening values were used for screening PFBS in sediment.
- b Screening levels, based on a residential exposure scenario, were calculated using the USEPA Regional Screening Level calculator ([https://epa-prgs.ornl.gov/cgi-bin/chemicals/csl\\_search](https://epa-prgs.ornl.gov/cgi-bin/chemicals/csl_search)) and a THQ of 0.1 (USEPA, 2018).
- c USEPA, May 2016a. "Drinking Water Health Advisory for Perfluorooctane Sulfonate (PFOS)" and USEPA, 2016b. "Drinking Water Health Advisory for Perfluorooctanoic Acid (PFOA)."
- d When both PFOA and PFOS are both present, the combined concentrations of PFOA and PFOS should be compared with the 0.07 µg/L health advisory level.

mg/kg – milligrams per kilogram

µg/L – micrograms per liter

NL – not listed

PFBS – perfluorobutanesulfonic acid

PFOA – perfluorooctanoic acid

PFOS – perfluorooctanesulfonic acid

THQ – target hazard quotient

USEPA – Environmental Protection Agency

## 1.2 PROJECT OBJECTIVES

In accordance with DoD Instruction 4715.18, "Emerging Contaminants (ECs)" (DoD, 2009), the *Interim USAF Guidance on Sampling and Response Actions for Perfluorinated Compounds at Active and Base Realignment and Closure (BRAC) Installations* (USAF, 2012), and the Secretary of the Air Force, Installations, Environment, and Energy (SAF/IE) *Policy on Perfluorinated Compounds of Concern* (USAF, 2016), using a step-wise strategy, the USAF will:

- 1) Identify locations where there is a reasonable expectation that there may have been a release of PFAS (defined below) associated with USAF actions;
- 2) Determine if there is unacceptable risk to human health and the environment; and,
- 3) Address releases that pose an unacceptable risk, including offsite migration.

The primary objectives of this SI were to:

- Determine if PFAS are present in soil, groundwater, or sediment at AFFF release areas selected for SI;

- Determine if PFOS and PFOA concentrations in soil or sediment exceed the calculated RSL of 0.126 mg/kg, based on a residential exposure scenario, and if PFBS concentrations in soil or sediment exceed the USEPA residential RSL of 130 mg/kg;
- Determine if concentrations of PFOS, PFOA, or the sum of PFOS and PFOA in groundwater exceed the USEPA HA value of 0.07 µg/L, and if PFBS concentrations in groundwater exceed the USEPA Tap Water RSL of 40 µg/L; and,
- Identify potential exposure pathways in soil, sediment, and groundwater;
- Identify potentially complete exposure pathways with immediate impacts to human health (immediate impact to human health is considered consumption of drinking water with PFOS/PFOA above the USEPA HA value or PFBS above the USEPA Tap Water RSL).

### 1.3 PROJECT SCOPE

AFFF release areas were selected for SI at VAFB based on research conducted by CH2M Hill (2015) during a PA and the installation scoping visit conducted by OTIE in 19 January 2017.

The following AFFF release areas were sampled under this SI:

- AFFF Release Area 1: Former Site FT-07 FT021 (Former FTA);
- AFFF Release Area 2: 1992 Fuel Spill;
- AFFF Release Area 3: 2006 Fuel Spill;
- AFFF Release Area 4: 2009 AFFF Release; and
- AFFF Release Area 5: Spray Nozzle (Refractometer) Test Area.

Environmental media evaluated included surface and subsurface (vadose zone) soil, groundwater collected from temporary monitoring wells, and sediment.

This SIR discusses and provides a comparison of SI analytical results to regulatory screening values for PFOS, PFOA, and PFBS in soil, groundwater, and sediment provided in **Table 1.1-1**. The remaining PFAS do not have screening values; therefore, only the results for PFOS, PFOA, and PFBS are discussed in detail and presented on figures. However, all data are presented in the soil, groundwater, and sediment analytical tables.

## **2.0 AFFF RELEASE AREA BACKGROUND**

### **2.1 SITE LOCATION AND SETTING**

VAFB is an active USAF installation that occupies approximately 99,604 acres on the south-central coast of California and is located approximately 50 miles north of Santa Barbara in Santa Barbara County (**Figure 2.1-1**). The Santa Ynez River runs east/west and bisects the Base into North Base and South Base. An active airfield is present in the developed area of North Base between Tangair Road and 13th Street, northwest of California Boulevard.

### **2.2 SITE HISTORY**

VAFB began as Camp Cooke Army Base in March 1941. Following transfer to the USAF, the base was re-designated VAFB in October 1958. VAFB is headquarters to the 30<sup>th</sup> Space Wing, with primary missions to launch and track polar-orbiting satellites, test and evaluate the intercontinental ballistic missile systems, and operate the Western Range.

### **2.3 PREVIOUS INVESTIGATIONS**

CH2M Hill was contracted by AFCEC to prepare a PA at VAFB to identify potential releases of PFAS to the environment from the use or storage of AFFF (CH2M Hill, 2015). Seventeen potential AFFF release areas were identified during the PA research, with the following five AFFF release areas recommended for SI (**Figure 2.3-1**):

- 1) **AFFF Release Area 1 - FT021 (Former FTA):** AFFF Release Area 1 FT021 (Former FTA) was formerly known as Installation Restoration Program [IRP] Site 21. The Former FTA was in operation from 1958 to 1989, during which an unknown amount of AFFF was used during training exercises. Fire training activities were performed on bare soil with no liners. Extinguishing agents containing PFAS and water were discharged to an unlined drainage channel which discharges approximately 600 feet northwest of the East Burn Pit. Soil excavations were conducted between 2004 and 2006 as part of IRP remedial activities at the burn pit and drainage channel. However, the eastern portion of the eastern burn pit was not excavated and PFAS may be present in the soil at the site. Remedial activities performed at FT021 did not evaluate the presence of PFAS.
- 2) **AFFF Release Area 2 - 1992 Fuel Spill:** An unknown amount of AFFF was used during emergency response actions after a tanker truck delivering gasoline overturned at the Main Gate at the intersection of Lompoc Casmalia Road and California Boulevard. AFFF was used to extinguish the fire that engulfed the tanker truck and would have infiltrated into the subsurface soil in the grassy area to the west.
- 3) **AFFF Release Area 3 - 2006 Fuel Spill:** An unknown amount of AFFF was used during emergency response actions after a truck delivering Jet Propellant Fuel Number 8 (JP-8) overturned near Highway 1 and Santa Lucia Canyon Road. AFFF was sprayed onto the truck and tanker to prevent the generation of flammable vapors at the spill location. Precipitation during the emergency response actions may have influenced the migration of AFFF to the

dry creek bed adjacent to the north. Cleanup actions initiated after the incident included excavation of contaminated soil.

- 4) **AFFF Release Area 4 - 2009 AFFF Release:** AFFF was inadvertently released from a fire engine during a fire training drill. The AFFF was released onto the apron southwest of Hangar 1735 and migrated to the grassy area adjacent to and southwest of the apron. The amount of AFFF released is estimated to be between 25 and 500 gallons.
- 5) **AFFF Release Area 5 - Spray Nozzle (Refractometer) Test Area:** Annual refractometer tests are performed in the northeast portion of the current FTA. Fewer than 10 gallons of AFFF are released each year onto a dirt/gravel area and allowed to infiltrate into the ground. Precipitation runoff from the Spray Nozzle Test Area flows to a drainage ditch located immediately northeast of the release area.

### 3.0 FIELD ACTIVITIES AND ANALYTICAL PROTOCOL

SI activities were conducted at VAFB between 10 and 28 September 2018 at the five AFFF release areas identified during PA activities at locations where AFFF was released to the environment (CH2M Hill, 2015) (**Figure 2.3-1**). Sample locations were determined following discussions among OTIE, VAFB, and AFCEC personnel, and were documented in the Final ISWP (OTIE, 2018). Environmental media sampled during the SI included surface soil, subsurface soil, groundwater, and sediment.

Photographic documentation of the SI activities is provided in **Appendix A** and field documentation is provided in **Appendix B**. Inspection activities were recorded by field personnel on field activity daily logs (**Appendix B-1**), and daily PFAS protocol checklists were completed to ensure PFAS were not introduced by OTIE employees or subcontractors (**Appendix B-2**). A tailgate safety meeting was conducted each morning prior to beginning work, with the tailgate safety meeting reports provided in **Appendix B-3**.

#### Soil Boring Advancement and Soil Sample Collection

OTIE advanced 14 soil borings for the collection of soil samples and/or temporary monitoring well installation by a California-licensed driller, S & G Drilling, Inc., of Lompoc, California in accordance with California Well Standards Bulletins 74-81 and 74-90, Chapter II, Section 23 and the ISWP (OTIE, 2018). Soil borings were initially cleared to a depth of five feet below ground surface (ft bgs) with a hand auger (unless refusal was met) and completed using hollow stem auger (HSA) drilling methods. Soil samples were continuously collected from ground surface to first-encountered groundwater using a hand auger or decontaminated five-foot split spoon sampler in accordance with Standard Operating Procedure (SOP) AFW-02 (PFAS) – *Soil Sampling* (Appendix D, General QPP), field-screened with a photoionization detector (PID) equipped with a 10.6 electron volt lamp for volatile organic vapors, and logged by a qualified geoscientist in accordance with the Unified Soil Classification System. The resulting soil boring information, PID readings, lithologic data, and soil sample depths are included on soil boring/monitoring well records provided in **Appendix B-4**. Samples for laboratory analysis were extracted from the hand auger or split spoon sampler and transferred directly into laboratory-provided, high-density polyethylene (HDPE) containers. Sample containers were sealed, labeled, packed into ice-filled coolers, and delivered under chain-of-custody (CoC) to Maxxam Laboratories in Ontario, Canada for PFAS analysis or Eurofins Lancaster Laboratories Environmental (ELLE) in Lancaster, Pennsylvania for physiochemical properties analysis. Soil Sample Collection Logs are provided in **Appendix B-5**.

#### Temporary Monitoring Well Installation and Development

Six temporary monitoring wells were installed between 10 and 24 September 2018 to assess PFAS concentrations in groundwater at the AFFF Release Area 1 (FT021 [Former FTA]), AFFF Release Area 2 (1992 Fuel Spill), and AFFF Release Area 3 (2006 Fuel Spill). The water encountered at AFFF Release Area 1 is excavation backfill water and not considered site groundwater. Groundwater was not encountered at AFFF Release Area 4 (2009 AFFF Release) or AFFF Release Area 5 (Spray Nozzle

[Refractometer] Test Area). Monitoring well construction was based on observed depth to water at the time of drilling and geologic conditions encountered.

Temporary monitoring wells were installed through 8.25-inch outside-diameter hollow stem augers and screened from approximately 3 to 13 ft bgs (AFFF Release Area 1), 16 to 35 ft bgs (AFFF Release Area 2), and 63 to 74 ft bgs (AFFF Release Area 3). Well construction was based on observed depth to water at the time of drilling and geologic conditions encountered. All new monitoring wells were constructed in accordance with the ISWP and SOP AFW 04 (PFAS) – *Monitoring Well Installation* (Appendix D, General QPP). The temporary monitoring wells were constructed of two-inch-diameter, Schedule 40 polyvinyl chloride (PVC) casing and a threaded 10-foot section of 0.010-inch, slotted two-inch-diameter Schedule 40 PVC well screen and end cap. A #2/16 fine-sand filter pack was installed from the bottom of the boring to two feet above the screened portion of the well casing. A three-foot-thick bentonite seal was installed above the filter pack and hydrated in approximate six-inch-lifts. Well construction details are provided for the five temporary wells on screened well construction forms in **Appendix B-6. Table 3.0-1** summarizes the well construction details for the temporary monitoring wells.

The temporary wells were developed to establish hydraulic connection with the formation so that groundwater samples are representative of the shallow aquifer(s) beneath the AFFF release areas. The wells were developed in general accordance with SOP AFW 05 (PFAS) – *Well Development* (Appendix D, General QPP) using PFAS-free equipment including a stainless-steel bailer and a stainless steel submersible pump outfitted with disposable HDPE tubing. Well development continued until the field water quality parameters stabilized. Well Development Logs were completed and are included in **Appendix B-7**.

### Groundwater Elevations

Depth-to-water measurements were recorded from each temporary monitoring well prior to groundwater sampling activities in September 2018, and groundwater elevations were calculated relative to top-of-casing elevations surveyed by a California-licensed surveyor, Encompass Consultant Group, Inc. of Camarillo, California. **Table 3.0-2** summarizes the measured well and water depths and top of casing elevations. Water was encountered at AFFF Release Area 1 at 3.41 feet below top-of-casing (btoc), and the calculated water elevation was 351.23 feet above mean sea level (amsl). Because other deeper borings advanced outside of the former excavation area at AFFF Release Area 1 did not encounter water, the water encountered within the former excavation area is considered to be localized water accumulating in the excavation backfill (termed “excavation backfill water” in this report), and therefore no groundwater was encountered at AFFF Release Area 1. Groundwater encountered in AFFF Release Area 2 ranged from 17.15 to 26.91 ft btoc and the calculated groundwater elevations ranged from 488.22 to 500.85 feet amsl. Groundwater was encountered in AFFF Release Area 3 at depths of 64.65 to 66.40 feet btoc and the calculated groundwater elevations were 162.89 and 163.66 feet amsl. Groundwater was not encountered in AFFF Release Areas 4 or 5.

### **Groundwater Sampling**

The groundwater sampling program included the collection of groundwater samples for laboratory chemical analysis of PFAS from each of the six new temporary groundwater monitoring wells. Samples were collected using low-flow groundwater sampling methods with a stainless steel submersible pump equipped with new, disposable HDPE tubing. The HDPE tubing was connected to a flow-through cell to monitor groundwater stability for potential of hydrogen (pH), temperature, specific conductivity, dissolved oxygen, turbidity, and oxidation/reduction potential. Groundwater sampling equipment was calibrated on a daily basis prior to use, and the calibration data recorded on water quality sampling instrument calibration forms (**Appendix B-8**). Depth-to-water measurements and field parameters were monitored until groundwater indicator parameters reached stabilization criteria or one hour, in accordance with SOP AFW-03 (PFAS) – *Groundwater Sampling* (Appendix D, General QPP). The flow-through cell was then disconnected, and groundwater samples were collected directly into laboratory-provided HDPE containers from the discharge tubing.

The sample containers were sealed, labeled, packed on ice in an insulated cooler, and delivered to Maxxam Laboratories under CoC protocol. Groundwater sampling activities were documented on Groundwater Sampling Records provided in **Appendix B-9**.

### **Soil Boring/Temporary Monitoring Well Abandonment**

The six temporary monitoring well casings and screens were removed, pressure washed, and disposed by the drillers following groundwater sampling and surveying. The six temporary monitoring well boreholes were abandoned on 27 and 28 September 2018 with a 5% bentonite-neat Portland cement mixture, placed using a tremie pipe from the bottom of the boring to the top, and the surface restored to match the existing surroundings in accordance with SOP AFW-06 (PFAS) – *Borehole Abandonment* (Appendix D, General QPP), the ISWP (OTIE, 2018), and California Well Standards (California Department of Water Resources, 1981 and 1991).

### **Sediment Sampling**

Sediment samples were collected to assess if PFAS is present at and in downstream drainage areas associated with AFFF Release Area 1 (FT021 Former FTA), AFFF Release Area 3 (2006 Fuel Spill), and AFFF Release Area 5 (Spray Nozzle Test Area) during the SI. Samples were collected with a decontaminated stainless steel hand auger, in accordance with SOP AFW-07 (PFAS) – *Sediment Sampling* (Appendix D, General QPP), and placed in laboratory-provided HDPE containers. The sample containers were sealed, labeled, packed on ice in an insulated cooler, and delivered to Maxxam Laboratories under CoC protocol. Sample collection data was documented on the Sediment Sample Collection Logs provided in **Appendix B-10**.

### Total Sample Counts

The following total sample counts for each media (including field duplicate samples) during SI activities at VAFB are listed below:

- Twenty-seven (27) soil samples (including three field duplicate samples) were collected at 14 soil boring locations during the SI;
- Eight groundwater samples (including two field duplicate samples) were collected from six temporary monitoring wells during the SI; and,
- Seven sediment samples (including one field duplicate sample) were collected at three AFFF release areas during the SI.

Samples collected during the SI were analyzed for the following 16 PFAS compounds:

- PFOS;
- PFOA;
- PFBS;
- Perfluoroheptanoic acid (PFHpA);
- Perfluorohexanesulfonic acid (PFHxS);
- Perfluorononanoic acid (PFNA);
- N-Ethyl perfluorooctanesulfonamidoacetic acid (NEtFOSAA);
- N-Methyl perfluorooctanesulfonamidoacetic acid (NMeFOSAA);
- Perfluorodecanoic acid (PFDA);
- Perfluorotetradecanoic acid (PFTA);
- Perfluorododecanoic acid (PFDoA);
- Perfluorohexanoic acid (PFHxA);
- Perfluorotridecanoic acid (PFTrDA);
- Perfluoroundecanoic acid (PFUnA);
- 6:2 fluorotelomer sulfonate (FTS); and,
- 8:2 FTS.

Soil, groundwater, and sediment samples were analyzed by Maxxam Laboratories, a DoD Environmental Laboratory Accreditation Program accredited laboratory. Samples were analyzed by Modified USEPA Method 537 using Liquid Chromatography and Tandem Mass Spectrometry (LC-MS/MS). The LC-MS/MS method provides acceptable detection limits to confirm the presence of PFAS listed above. The laboratory analytical reports for the PFAS samples collected during the SI are included in **Appendix C**.

PFOS, PFOA, and PFBS analytical results are discussed in the following sections, while the analytical results for the remaining PFAS constituents are tabulated and provided at the conclusion of this SIR.

Co-occurrence of PFOS and PFOA (PFOS + PFOA) in aqueous samples was reported using the following guidelines:



1. If PFOS and PFOA are both detected in concentrations at or above the laboratory detection level (DL) in groundwater used for drinking water, then the reported concentration for PFOA was added to the reported concentration for PFOS.
2. If only PFOS or only PFOA is detected at or above the DL in groundwater, then the concentration of the detected analyte only is reported.
3. If neither PFOA nor PFOS are detected at concentrations at or above the DL, then co-occurrence was reported as *Not Detected*.

One composite surface soil sample and one composite subsurface soil sample were also collected at each AFFF release area where soil sampling was conducted and submitted to ELLE for laboratory analysis of physiochemical properties, including pH (USEPA Method 9045B), particle size analysis (ASTM International D422), and total organic carbon (TOC) content (USEPA 9060A or Lloyd Kahn Method). A composite sampling strategy was used to reduce spatial heterogeneity, and to improve estimates of mean concentrations and particle size distribution that are representative of each AFFF Area across distinct depth horizons. The laboratory analytical reports for the physiochemical properties samples collected during the SI are included in **Appendix C**.

#### **Data Validation and Usability Assessment**

Laboratory analytical data from soil, sediment, and water samples collected between 10 and 26 September 2018 and analyzed for PFAS compounds were validated in October 2018. OTIE evaluated/validated analytical results from 10 Maxxam Laboratory sample delivery groups (SDGs); samples consisted of 24 soil, 6 groundwater, and 6 sediment normal samples, 6 duplicate samples, and 5 matrix spike/matrix spike duplicate (MS/MSD) pairs. Samples were collected in accordance with the ISWP (OTIE, 2018) and analyzed for PFASs by Modified USEPA Method 537. Maxxam Laboratory SDGs underwent a Level II data validation review, while 10% of the data underwent a Level IV data validation review. Level II and Level IV quality control (QC) forms are summarized in the Data Validation Reports A (**Appendix D**). There were no Exception Reports. OTIE evaluated 1,100 data records from field normal and field QC samples during the validation process and flagged less than 10% of the records as J or UJ qualified indicating estimated values. The U flag indicates that the analyte was not detected above the limit of detection; the J flag indicates that the result is estimated. The flagging was due to field duplicate imprecision, surrogate recoveries outside of acceptance criteria, poor MS/MSD recoveries, and/or analyte concentrations between the detection limit and the Limit of Quantification (LOQ). About 30% of the samples required re-extraction due to the presence of high concentration of detected analytes. Reanalysis and dilutions were within method specific criteria and did not require flagging. Analytical results for, PFHxS, PFHxA, PFOA, and PFOS from the sets of field duplicate pairs were qualified because of imprecision between the results. The groundwater samples from 2006 Fuel Spill (AFFF Release Area 3) arrived at the laboratory at a slightly elevated temperature of 10.8 degrees Celsius compared to the QPP-specified maximum of 10 degrees Celsius due to FedEx shipping delays (the sample holding time was not exceeded as a result of the shipping delays). However, the slightly elevated temperature is not anticipated to have impacted sample analysis quality due the stability of the

PFAS chemical structure, which require extreme heat to be degraded and/or destroyed. These sample results were flagged UJ for non-detects and J for detects.

Analytical uncertainty due to sampling or analytical imprecision is not interpreted to adversely affect overall data usability. The reviewing chemist determined that the data adequately represented the intended goals of the project. All samples were collected in accordance with the SOPs outlined in the QPP (Amec Foster Wheeler, 2018). All analytical data was deemed usable. No data were rejected for being outside of acceptance criteria. The laboratory achieved 100% completeness which was above the 95% goal as required by the project data quality objectives.

For the areas sampled in this SI, the decision to advance each of the areas for further investigation was based on all data. A description of the data validation scope, procedures, observations and actions is presented in the Data Validation Report provided in **Appendix D**.

### **Surveying**

The soil borings, newly installed temporary monitoring wells, and sediment sample locations were surveyed by a California-licensed surveyor, Encompass Consultant Group of Camarillo, California, for horizontal coordinates and/or top-of-casing elevations (**Table 3.0-1**). Horizontal coordinates were surveyed based on California State Plane Coordinate System, North Zone, United States Survey Feet, North American Datum of 1983. Ground surface and top-of-casing elevations were surveyed based on the North American Vertical Datum of 1988.

### **Investigation-Derived Waste**

Investigation-Derived Waste (IDW) consisted of soil cuttings from soil boring advancement, well abandonment soil cuttings, well development water, groundwater sampling purge water, equipment and abandoned well screen, decontamination water, disposable personal protective equipment (PPE), and other miscellaneous refuse. Used PPE and other miscellaneous refuse were placed in plastic bags and discarded into an on-base sanitary trash container for disposal at a sanitary landfill. Soil and liquid IDW were segregated by AFFF Area, and containerized in 38 Department of Transportation-approved 55-gallon steel drums. The drums were staged on wooden pallets on the southeast side of the Former FTA (AFFF Release Area 1), as designated by Mr. Jeff Holston of AFCEC. Grab samples were collected from each drum of IDW during the SI and composite samples were prepared, one per media per AFFF area, on 28 September 2018. Ten IDW samples were submitted to Maxxam Laboratories for PFAS analysis and ELLE for laboratory analysis for volatile organic compounds, California Assessment Method 17 metals, total petroleum hydrocarbons (gasoline range organics, oil range organics, and diesel range organics), flashpoint (water only), and pH (water only), and moisture (soil only) to determine the applicable disposal options (**Appendix C**). IDW transportation/disposal documentation will be provided in the Final SIR (**Appendix E**).

### **3.1 AFFF RELEASE AREA 1: FT021 (FORMER FTA)**

The Former FTA was in operation from 1958 to 1989, during which an unknown amount of AFFF was used during training exercises. Extinguishing agents containing PFAS and water were discharged to an unlined drainage channel which discharges approximately 600 feet northwest of the East Burn Pit (Figure 3.1-1).

#### **3.1.1 Sample Location and Methodologies**

Sampling locations for AFFF Release Area 1 FT021 (Former FTA) are presented on **Figure 3.1-1**. Soil, excavation backfill water, and sediment are discussed below.

##### **3.1.1.1 Soil Samples**

Soil borings 21-B-26 and 21-B-27 were advanced on 10 September 2018 where AFFF was released to the ground during training activities and within the former excavation area. Soil boring 21-B-28 was advanced on 13 September 2018 in the estimated source area, approximately 50 feet west of the western terminus of the drainage channel, where AFFF-containing runoff resulting from former firefighting activities may have flowed and accumulated (Figure 3.1-1). Soil samples were also collected at two additional surface soil sampling areas, 21-S-14 and 21-S-15, where AFFF may have been released to the ground surface during fight training activities. Surface soil sampling areas, 21-S-14 and 21-S-15, were located outside the former excavation area.

Surface soil samples were not collected at boring locations 21-B-26 and 21-B-27 inside the former excavation footprint, as it is likely that PFAS-impacted soil may have been removed and replaced with fill during prior remedial excavation activities (OTIE, 2018). In order to evaluate potential impacts to surface soil in the vicinity of the former fire training activities, OTIE collected three surface soil samples (2 normal and 1 field duplicate samples) at 21-S-14 and 21-S-15. Additionally, a surface soil sample was collected at 21-B-28.

In accordance with the ISWP (OTIE, 2018), OTIE collected a subsurface soil sample from the backfill soil in 21-B-26 immediately above the accumulated water encountered within the backfill and a subsurface soil sample from 21-B-27 immediately above the soil-bedrock interface. The subsurface soil sample in 21-B-28 was collected immediately above the soil-bedrock interface because groundwater was not encountered during drilling activities. Subsurface sample depths range from 4.2 to 19.9 ft bgs. Composite surface soil samples were collected from all borings from 0.0 to 0.5 ft bgs and 3.5 to 19.5 ft bgs for TOC, pH, and particle size analysis.

##### **3.1.1.2 Excavation Backfill Water Samples**

A temporary monitoring well was installed in soil boring 21-B-26 on 10 September 2018 to assess PFAS concentrations in the excavation backfill water encountered beneath the AFFF release source area (Figure 3.1-1). However, no groundwater was encountered at FT021 during historical remedial

investigation activities (USAF, 2008) or during this AFFF SI. The temporary monitoring well installed in boring 21-B-26 was sampled on 21 September 2018.

### **3.1.1.3 Sediment Samples**

One sediment sample (21-SD-1) was collected on 14 September 2018 at the surface in the unlined drainage channel located on the north side of the former FTA to assess potential impacts from AFFF-containing surface and storm water runoff from the AFFF Release Area 1 source area during the SI (Figure 3.1-1).

## **3.1.2 Analytical Results**

### **3.1.2.1 Soil Results**

Four surface soil samples (three normal and one field duplicate) and three subsurface soil samples were collected for PFAS analysis, with results provided in Table 3.1-1, illustrated on Figure 3.1-2, and summarized below.

#### **21-S-14:**

- PFOS was detected below the calculated RSL in surface soil at a maximum concentration of 0.017 mg/kg (0.0 to 0.5 ft bgs).
- PFOA was detected below the calculated RSL in surface soil at a maximum concentration of 0.038 mg/kg (0.0 to 0.5 ft bgs) (field duplicate).
- PFBS was detected below the USEPA RSL in surface soil at a maximum concentration of 0.0010 mg/kg (0.0 to 0.5 ft bgs).

#### **21-S-15:**

- PFOS was detected below the calculated RSL in surface soil at a concentration of 0.110 mg/kg (0.0 to 0.5 ft bgs).
- PFOA was detected below the calculated RSL in surface soil at a concentration of 0.0059 mg/kg (0.0 to 0.5 ft bgs).
- PFBS was detected below the USEPA RSL in surface soil at an estimated concentration of 0.00084 mg/kg (0.0 to 0.5 ft bgs).

#### **21-B-26:**

- PFOS was detected above the calculated RSL in subsurface soil at a concentration of 0.190 mg/kg (4.2 to 4.7 ft bgs).
- PFOA was detected below the calculated RSL in subsurface soil at a concentration of 0.0065 mg/kg (4.2 to 4.7 ft bgs).
- PFBS was detected below the USEPA RSL in subsurface soil at an estimated concentration of 0.00051 mg/kg (4.2 to 4.7 ft bgs).

**21-B-27:**

- PFOS was detected below the calculated RSL in subsurface soil at a concentration of 0.056 mg/kg (8.5 to 9.0 ft bgs).
- PFOA was detected below the calculated RSL in subsurface soil at a concentration of 0.0029 mg/kg (8.5 to 9.0 ft bgs).
- PFBS was detected below the USEPA RSL in subsurface soil at an estimated concentration of 0.00030 mg/kg (8.5 to 9.0 ft bgs).

**21-B-28:**

- PFOS was detected above the calculated RSL from the surface sampling interval at a concentration of 0.550 mg/kg (0.0 to 0.5 ft bgs) and was not detected from the subsurface sampling interval (19.4 to 19.9 ft bgs).
- PFOA was detected below the calculated RSL from the surface sampling interval at a concentration of 0.014 mg/kg (0.0 to 0.5 ft bgs) and was not detected from the subsurface sampling interval (19.4 to 19.9 ft bgs).
- PFBS was detected below the USEPA RSL in both sampling intervals at a maximum estimated concentration of 0.0028 mg/kg (0.0 to 0.5 ft bgs).

The composite TOC concentrations ranged from 256 J mg/kg (3.5 to 19.5 ft bgs) to 10,700 mg/kg (0.0 to 0.5 ft bgs), while the composite pH concentrations ranged from 5.79 Standard Unit (S.U.) (3.5 to 19.5 ft bgs) to 6.56 S.U. (0.0 to 0.5 ft bgs) (**Table 3.1-2**).

The particle size distribution for the 0.0 to 0.5 ft bgs sample was 37.4% fines (silt and clay), 60.2% sand (fine to coarse), and 2.5% gravel (fine), while the 3.5 to 19.5 ft bgs sample was 25.9% fines (silt and clay), 70.7% sand (fine to coarse), and 3.5% gravel (fine) (**Appendix C**). The material description for the 0 to 0.5 feet bgs sample was a light yellowish brown, silty fine sand with gravel, while the 3.5 to 19.5 feet bgs sample was described as a brown, silty sand with fines and gravel.

**3.1.2.2 Excavation Backfill Water Results**

Two excavation backfill water samples (one normal and one field duplicate) were collected from the temporary monitoring well installed in soil boring 21-B-26. PFAS results are provided in **Table 3.1-3**, illustrated in **Figure 3.1-3**, and summarized below.

**21-B-26:**

- PFOS was detected above the USEPA HA value at a concentration of 150 µg/L.
- PFOA was detected above the USEPA HA value at a maximum concentration of 8.2 µg/L (field duplicate).
- PFOS + PFOA was detected above the USEPA HA value at a maximum concentration of 158.2 µg/L (field duplicate).

- PFBS was detected below the USEPA Tap Water RSL at an estimated concentration of 1.1 µg/L.

### **3.1.2.3 Sediment Results**

One sediment sample was collected from the unlined drainage channel for PFAS analysis (**Figure 3.1-4**), Analytical laboratory results are provided in **Table 3.1-4** and summarized below.

#### **21-SD-1**

- PFOS was detected below the calculated RSL at a concentration of 0.012 mg/kg.
- PFOA was detected below the calculated RSL at an estimated concentration of 0.00066 mg/kg.
- PFBS was not detected.

### **3.1.3 Conclusions**

PFOS and PFOA were detected in soil samples at AFFF Release Area 1. PFOS exceeded the calculated RSL in surface soil (0.0 to 0.5 ft bgs) at 21-B-28 and subsurface soil (4.2 to 4.7 ft bgs) at 21-B-26. PFOA was detected in all soil samples except the deepest soil sample (19.4 to 19.9 ft bgs) at concentrations below the calculated RSL. PFBS was detected in all soil samples collected at concentrations below the USEPA RSL.

PFOS, PFOA and PFOS + PFOA exceeded the USEPA HA value in excavation backfill water from the temporary monitoring well in boring 21-B-26. PFBS was detected at concentrations below the USEPA Tap Water RSL in the water samples collected from the former excavation backfill.

PFOS and PFOA were detected at concentrations below the calculated RSL in the sediment sample collected in AFFF Release Area 1. PFBS was not detected in the sediment sample.

## **3.2 AFFF RELEASE AREA 2: 1992 FUEL SPILL**

An unknown amount of AFFF was used during emergency response actions when a tanker truck delivering gasoline overturned at the Main Gate at the intersection of Lompoc Casmalia Road and California Boulevard. The AFFF applied during the incident would have infiltrated into the subsurface soil in the grassy area to the west.

### **3.2.1 Sample Location and Methodologies**

#### **3.2.1.1 Soil Samples**

Soil borings 1992FS-B-1, 1992FS-B-2, and 1992FS-B-3 were advanced on 17 and 18 September 2018 at the top of the slope in the presumed area of the 1992 fuel spill and in topographically low-lying areas downslope from the crash area (**Figure 3.2-1**). Soil samples were collected for PFAS analysis from each boring at the surface (0.0 to 0.5 ft bgs) and subsurface (18.0 to 29.0 ft bgs, capillary fringe zone). Composite soil samples were also collected from each soil boring from 0.0 to 0.5 ft bgs and 17.5 to 29.0 ft bgs and submitted for TOC, pH, and particle size analysis. Groundwater was encountered at approximately 22.0 to 34.6 ft bgs during boring advancement.

### **3.2.1.2 Groundwater Samples**

Three temporary monitoring wells (1992FS-B-1, 1992FS-B-2, and 1992FS-B-3) were installed in the soil borings on 17 and 18 September 2018 to assess PFAS concentrations in the groundwater beneath the AFFF Release Area 2 source area (**Figure 3.2-1**). The wells were sampled on 21 and 25 September 2018.

## **3.2.2 Analytical Results**

### **3.2.2.1 Soil Results**

Four surface soil samples (three normal and one duplicate) and three subsurface soil samples were collected for PFAS analysis, with results provided in **Table 3.1-1**, illustrated on **Figure 3.2-2**, and summarized below.

#### **1992FS-B-1:**

- PFOS was detected below the calculated RSL at the two sampling intervals at a maximum concentration of 0.0057 mg/kg (0.0 to 0.5 ft bgs).
- PFOA was not detected from the surface sampling interval (0.0 to 0.5 ft bgs) and was detected below the calculated RSL from the subsurface sampling interval at an estimated concentration of 0.00068 mg/kg (18.0 to 18.5 ft bgs).
- PFBS was not detected from either sampling interval.

#### **1992FS-B-2:**

- PFOS was detected below the calculated RSL from the surface sampling interval at a concentration of 0.0096 mg/kg (0.0 to 0.5 ft bgs) and was not detected from the subsurface sampling interval (28.5 to 29.0 ft bgs).
- PFOA was detected below the calculated RSL from the surface sampling interval at an estimated concentration of 0.00056 mg/kg (0.0 to 0.5 ft bgs) and was not detected from the subsurface sampling interval (28.5 to 29.0 ft bgs).
- PFBS was not detected at either sampling interval.

#### **1992FS-B-3:**

- PFOS was detected below the calculated RSL from the surface sampling interval at a concentration of 0.029 mg/kg (0.0 to 0.5 ft bgs) and was not detected from the subsurface sampling interval (23.5 to 24.0 ft bgs).
- PFOA was detected below the calculated RSL from the surface sampling interval at a concentration of 0.0025 mg/kg (0.0 to 0.5 ft bgs) and was not detected from the subsurface sampling interval (23.5 to 24.0 ft bgs).
- PFBS was not detected at either sampling interval.

The composite TOC concentrations ranged from 242 J mg/kg (17.5 to 29.0 ft bgs) to 25,300 mg/kg (0.0 to 0.5 ft bgs), while the composite pH concentrations ranged from 7.07 S.U. (0.0 to 0.5 ft bgs) to 7.54 S.U. (18.0 to 29.0 ft bgs) (**Table 3.1-2**).

The particle size analytical results for the 0 to 0.5 ft bgs sample was 28.0% fines (silt and clay), 65.7% sand (fine to coarse), and 6.4% gravel (fine to coarse), while the 17.5 to 29.0 ft bgs sample was 15.1% fines (silt and clay) and 84.9% sand (fine to coarse) (**Appendix C**). The material description for the 0 to 0.5 ft bgs sample was a brown to dark yellowish brown, silty fine sand. The 17.5 to 29.0 ft bgs sample was described as a dark yellowish brown to light gray, poorly graded sand with silt.

### **3.2.2.2 Groundwater Results**

Three groundwater samples were collected for PFAS analysis, with the results provided in **Table 3.1-3**, illustrated in **Figure 3.2-3**, and summarized below.

#### **1992FS-B-1:**

- PFOS was detected above the USEPA HA value at a concentration of 0.65 µg/L.
- PFOA was detected above the USEPA HA value at a concentration of 0.071 µg/L.
- PFOS + PFOA was detected above the USEPA HA value at a concentration of 0.721 µg/L.
- PFBS was detected below the USEPA Tap Water RSL at a concentration of 0.048 µg/L.

#### **1992FS-B-2:**

- PFOS was detected above the USEPA HA value at a concentration of 0.35 µg/L.
- PFOA was detected below the USEPA HA value at a concentration of 0.063 µg/L.
- PFOS + PFOA was detected above the USEPA HA value at a concentration of 0.413 µg/L.
- PFBS was detected below the USEPA Tap Water RSL at a concentration of 1.1 µg/L.

#### **1992FS-B-3:**

- PFOS was detected below the USEPA HA value at a concentration of 0.044 µg/L.
- PFOA was detected below the USEPA HA value at a concentration of 0.029 µg/L.
- PFOS + PFOA was detected above the USEPA HA value at a concentration of 0.073 µg/L.
- PFBS was detected below the USEPA Tap Water RSL value at a concentration of 0.32 µg/L.

### **3.2.3 Conclusions**

PFOS and/or PFOA were detected at concentrations below the calculated RSLs in surface soil at the three sampling locations and in subsurface soil samples from 1992FS-B-1 only. PFBS was not detected in surface or subsurface soil from AFFF Release Area 2.

PFOS, PFOA and/or PFOS + PFOA exceeded the USEPA HA value in groundwater samples collected from each temporary monitoring well installed at AFFF Release Area 2. PFBS was detected in groundwater below the USEPA Tap Water RSL in each well.



### **3.3 AFFF RELEASE AREA 3: 2006 FUEL SPILL**

An unknown amount of AFFF was used during emergency response actions when a truck delivering JP-8 overturned near Highway 1 and Santa Lucia Canyon Road. Precipitation during the emergency response actions may have influenced potential migration of AFFF to the dry creek bed adjacent to the north.

#### **3.3.1 Sample Location and Methodologies**

##### **3.3.1.1 Soil Samples**

Two soil borings (2006FS-B-1 and 2006FS-B-2), were advanced on 14, 18, and 24 September 2018 at the head of the slope near the south-central portion of the AFFF Release Area and topographically downslope from the fuel spill where AFFF may have been released directly to soil (**Figure 3.3-1**). Soil samples were collected for PFAS analysis from each boring at the surface (0.0 to 0.5 ft bgs) and subsurface in the capillary fringe zone (63.0 to 64.8 ft bgs). Composite soil samples were collected from each soil boring from 0.0 to 0.5 ft bgs and 62.5 to 65.0 ft bgs for TOC, pH, and particle size analysis. Groundwater was encountered at approximately 69.5 and 71.0 ft bgs in 2006FS-B-1 and 2006FS-B-2, respectively, during boring advancement.

##### **3.3.1.2 Groundwater Samples**

Three groundwater samples (two normal and one field duplicate) were collected in two temporary monitoring wells installed in soil borings 2006FS-B-1 and 2006FS-B-2 to assess PFAS concentrations in the groundwater beneath the AFFF release source area (**Figure 3.3-1**). The wells were sampled on 26 September 2018.

##### **3.3.1.3 Sediment Samples**

Two sediment samples (2006FS-SD-1 and 2006FS-SD-2) were collected on 14 September 2018 during the SI to assess potential impacts from AFFF-containing surface and storm water runoff from AFFF Release Area 3 at the inlet and outlet, respectively, of a drainage culvert that conveys runoff from the area to the dry creek bed across the highway connector to the north (**Figure 3.3-1**).

#### **3.3.2 Analytical Results**

##### **3.3.2.1 Soil Results**

Two surface soil and two subsurface soil samples were collected for PFAS analysis, with the results provided in **Table 3.1-1**, illustrated in **Figure 3.3-2**, and summarized below.

##### **2006FS-B-1:**

- PFOS was detected below the calculated RSL from the surface sampling interval at a concentration of 0.078 mg/kg (0.0 to 0.5 ft bgs) and was not detected from the subsurface sampling interval (64.3 to 64.8 ft bgs).

- PFOA was detected below the calculated RSL from the surface sampling interval at an estimated concentration of 0.00049 mg/kg (0.0 to 0.5 ft bgs) and was not detected from the subsurface sampling interval (64.3 to 64.8 ft bgs).
- PFBS was detected below the USEPA RSL from the surface sampling interval at an estimated concentration of 0.00079 mg/kg (0.0 to 0.5 ft bgs) and was not detected from the subsurface sampling interval (64.3 to 64.8 ft bgs).

#### **2006FS-B-2:**

- PFOS was detected below the calculated RSL from the surface sampling interval at a concentration of 0.026 mg/kg (0.0 to 0.5 ft bgs) and was not detected from the subsurface sampling interval (63.0 to 63.5 ft bgs).
- PFOA was detected below the calculated RSL from the surface sampling interval at an estimated concentration of 0.00046 mg/kg (0.0 to 0.5 ft bgs) and was not detected from the subsurface sampling interval (63.0 to 63.5 ft bgs).
- PFBS was detected below the USEPA RSL from the surface sampling interval at an estimated concentration of 0.00047 mg/kg (0.0 to 0.5 ft bgs) and was not detected from the subsurface sampling interval (63.0 to 63.5 ft bgs).

The composite TOC concentrations ranged from 618 mg/kg (62.5 to 65.0 ft bgs) to 81,000 mg/kg (0.0 to 0.5 ft bgs), while the composite pH concentrations ranged from 7.41 S.U. (62.5 to 65.0 ft bgs) to 7.47 S.U. (0.0 to 0.5 ft bgs) (**Table 3.1-2**).

The particle size analytical results for the 0 to 0.5 ft bgs sample was 9.3% fines (silt and clay), 57.4% sand (fine to coarse), and 33.4% gravel (fine to coarse), while the 62.5 to 65.0 ft bgs sample was 42.2% fines (silt and clay), 53.8% sand (fine to coarse), and 4.0% gravel (fine) (**Appendix C**). The material description for the 0 to 0.5 ft bgs sample was a yellowish brown to brown, silty gravel with fine to coarse sand. The 62.5 to 65.0 ft bgs sample was described as a light yellowish brown to light brownish gray, silty fine sand with trace gravel.

#### **3.3.2.2 Groundwater Results**

Three groundwater samples (including two normal samples and one field duplicate sample) were collected from two temporary monitoring wells installed in soil boring 2006FS-B-1 and 2006FS-B-2. PFAS results are provided in **Table 3.1-3**, illustrated in **Figure 3.3-3**, and summarized below.

#### **2006FS-B-1:**

- PFOS was detected below the USEPA HA value at a maximum estimated concentration of 0.013 µg/L.
- PFOA was not detected in groundwater.
- PFOS + PFOA was detected below the USEPA HA value at an estimated concentration of 0.013 µg/L.

- PFBS was detected below the USEPA Tap Water RSL at an estimated concentration of 0.071 µg/L (field duplicate).

#### **2006FS-B-2:**

- PFOS was not detected in groundwater.
- PFOA was not detected in groundwater.
- PFOS + PFOA was not detected in groundwater.
- PFBS was detected below the USEPA Tap Water RSL at an estimated concentration of 0.045 µg/L.

#### **3.3.2.3 Sediment Results**

Two sediment samples (2006FS-SD-1 and 2006FS-SD-2) were collected for PFAS analysis with results provided in **Table 3.1-4**, illustrated in **Figure 3.3-4**, and summarized below.

#### **2006FS-SD-1:**

- PFOS was detected below the calculated RSL at a concentration of 0.064 mg/kg.
- PFOA was detected below the calculated RSL at an estimated concentration of 0.00059 mg/kg.
- PFBS was detected below the USEPA RSL at an estimated concentration of 0.00047 mg/kg.

#### **2006FS-SD-2:**

- PFOS was detected below the calculated RSL at a concentration of 0.037 mg/kg.
- PFOA was not detected.
- PFBS was detected below the USEPA RSL at an estimated concentration of 0.00032 mg/kg.

#### **3.3.3 Conclusions**

PFOS, PFOA, and PFBS were detected in surface soil at concentrations below the RSLs and were not detected in the subsurface soil samples from the three sampling locations in AFFF Release Area 3. PFOS, PFOS + PFOA, and PFBS were detected below the USEPA HA value and USEPA Tap Water RSL in the groundwater sample from the temporary monitoring well installed in boring 2006FS-B-1. PFOA was not detected in any of the wells. PFBS was detected below the USEPA Tap Water RSL in all three wells. PFOS, PFOA, and PFBS were detected in sediment at concentrations below the USEPA Tap Water RSLs at AFFF Release Area 3.

### **3.4 AFFF RELEASE AREA 4: 2009 AFFF RELEASE**

AFFF inadvertently released from a fire engine during a fire training drill flowed onto the apron southwest of Hangar 1735 and migrated to the grassy area adjacent to and southwest of the apron.

#### **3.4.1 Sample Location and Methodologies**

Soil borings 2009AFFF-B-1 and 2009AFFF-B-2 were advanced on 12 September 2018 in the grassy area adjacent to the concrete apron southwest of Hangar 1735, approximately equidistant laterally from the

northwest and southeast boundaries of the AFFF Release Area in the potential accumulation area (**Figure 3.4-1**). Soil samples were collected for PFAS analysis from each boring at the surface from 0.0 to 0.5 ft bgs and in the subsurface at 31.5 and 34.0 ft bgs immediately above the bedrock interface. Composite soil samples were collected from each soil boring from 0.0 to 0.5 ft bgs and 30.5 to 34.0 ft bgs for TOC, pH, and particle size analysis. Groundwater was not encountered during boring advancement at this AFFF release area.

### **3.4.2 Analytical Results**

#### **3.4.2.1 Soil Results**

Two surface soil samples and three subsurface soil samples (two normal and one duplicate) were collected for PFAs analysis, with the results provided in **Table 3.1-1**, illustrated in **Figure 3.4-2**, and summarized below.

##### **2009AFFF-B-1:**

- PFOS was detected below the calculated RSL from the surface sampling interval at a concentration of 0.091 mg/kg (0.0 to 0.5 ft bgs) and was not detected from the subsurface sampling interval (31.5 to 32.0 ft bgs).
- PFOA was detected below the calculated RSL from the surface sampling interval at a concentration of 0.0015 mg/kg (0.0 to 0.5 ft bgs) and was not detected from the subsurface sampling interval (31.5 to 32.0 ft bgs).
- PFBS was detected below the USEPA RSL at the two sampling intervals at a maximum estimated concentration of 0.00063 mg/kg (0.0 to 0.5 ft bgs).

##### **2009AFFF-B-2:**

- PFOS was detected above the calculated RSL from the surface sampling interval at a concentration of 0.180 mg/kg (0.0 to 0.5 ft bgs) and was detected below the calculated RSL from the subsurface sampling interval at an estimated concentration of 0.00055 (33.5 to 34.0 ft bgs).
- PFOA was detected below the calculated RSL from the surface sampling interval at a concentration of 0.0014 mg/kg (0.0 to 0.5 ft bgs) and was not detected from the subsurface sampling interval (33.5 to 34.0 ft bgs).
- PFBS was detected below the USEPA RSL from the surface sampling interval at a concentration of 0.0014 mg/kg (0.0 to 0.5 ft bgs) and was not detected from the subsurface sampling interval (33.5 to 34.0 ft bgs).

The composite TOC concentrations ranged from 807 mg/kg (30.5-34.0 ft bgs) to 18,400 mg/kg (0.0 to 0.5 ft bgs), while the composite pH concentrations ranged from 5.23 S.U. (30.5-34.0 ft bgs) to 5.80 S.U. (0.0 to 0.5 ft bgs) (**Table 3.1-2**).

The particle size analytical results for the 0 to 0.5 ft bgs sample was 14.6% fines (silt and clay), 75.6% sand (fine to coarse), and 9.8% gravel (fine to coarse), while the 30.5-34.0 ft bgs sample was 18.7% fines

(silt and clay), 54.0% sand (fine to coarse), and 27.3% gravel (fine) (**Appendix C**). The material description for the 0 to 0.5 ft bgs sample was a brown to light brownish gray, silty fine sand. The 30.5 to 34.0 ft bgs sample was described as a light yellowish brown to brownish yellow silty fine sand with cherty fragments.

### **3.4.3 Conclusions**

PFOS was detected above the calculated RSL in surface soil (0.0-0.5 ft bgs) and was below the calculated RSL in subsurface soil. PFOA and PFBS were detected in soil at AFFF Release Area 4 at concentrations below the RSL.

## **3.5 AFFF RELEASE AREA 5: SPRAY NOZZLE (REFRACTOMETER) TEST AREA (SNTA)**

Annual refractometer tests are performed with an AFFF/water mixture at the northeast portion of the current FTA, with AFFF released onto a dirt/gravel area and allowed to infiltrate into the ground. Surface water from the SNTA flows through culverts and surface flow into an adjacent drainage ditch, which circumnavigates the current FTA before discharging to a potential wetland west of the AFFF release area (USFWS, 2019).

### **3.5.1.1 Soil Samples**

Soil borings SNTA-B-1 and SNTA-B-2 were advanced on 11 and 13 September 2018 in the unpaved area located in the northeast portion of the current FTA, where AFFF may have been released directly to soil during routine refractometer testing (**Figure 3.5-1**). Soil samples were collected for PFAS analysis from each boring at the surface (0.0 to 0.5 ft bgs) and subsurface immediately above the bedrock interface (19.0 to 20.5 ft bgs). Composite soil samples were collected from each soil borings from 0.0 to 0.5 ft bgs and 18.5 to 20.5 ft bgs for TOC, pH, and particle size analysis.

### **3.5.1.2 Sediment Samples**

Four sediment samples (SNTA-SD-1 through SNTA-SD-3) were collected on 13 September 2018 to assess potential impacts to surface and storm water runoff in the drainage canal adjacent to the Refractometer Test Area at the perimeter of the existing fire training pit and near the outlet of the drainage canal before it discharges to a low-lying wetland area (**Figure 3.5-1**).

## **3.5.2 Analytical Results**

### **3.5.2.1 Soil Results**

Two surface soil samples and four subsurface soil samples were collected for PFAS analysis, with results provided in **Table 3.1-1**, illustrated in **Figure 3.5-2**, and summarized below.

**SNTA-B-1:**

- PFOS was detected above the calculated RSL from the surface sampling interval at a concentration of 0.150 mg/kg (0.0 to 0.5 ft bgs) and was not detected from the subsurface sampling interval (20.0 to 20.5 ft bgs).
- PFOA was detected below the calculated RSL from the surface sampling interval at a concentration of 0.0021 mg/kg (0.0 to 0.5 ft bgs) and was not detected from the subsurface sampling interval (20.0 to 20.5 ft bgs).
- PFBS was detected below the USEPA RSL from the surface sampling interval at a concentration of 0.0019 mg/kg (0.0 to 0.5 ft bgs) and was not detected from the subsurface sampling interval (20.0 to 20.5 ft bgs).

**SNTA-B-2:**

- PFOS was detected above the calculated RSL from the surface sampling interval at a concentration of 1.10 mg/kg (0.0 to 0.5 ft bgs) and was not detected from the subsurface sampling interval (19.0 to 19.5 ft bgs).
- PFOA was detected below the calculated RSL from the surface sampling interval at a concentration of 0.0029 mg/kg (0.0 to 0.5 ft bgs) and was not detected from the subsurface sampling interval (19.0 to 19.5 ft bgs).
- PFBS was detected below the USEPA RSL from the surface sampling interval at a concentration of 0.0050 mg/kg (0.0 to 0.5 ft bgs) and was not detected from the subsurface sampling interval (19.0 to 19.5 ft bgs).

The composite TOC concentrations ranged from 259 J mg/kg (18.5 to 20.5 ft bgs) to 3,790 mg/kg (0.0 to 0.5 ft bgs), while the composite pH concentrations ranged from 5.91 S.U. (18.5 to 20.5 ft bgs) to 8.27 S.U. (0.0 to 0.5 ft bgs) (**Table 3.1-2**).

The particle size analytical results for the 0 to 0.5 ft bgs sample was 7.6% fines (silt and clay), 53.1% sand (fine to coarse), and 39.3% gravel (fine to coarse), while the 18.5 to 20.5 ft bgs sample was 14.4% fines (silt and clay), 62.3% sand (fine to coarse), and 23.3% gravel (fine) (**Appendix C**). The material description for the 0 to 0.5 ft bgs sample was a yellowish brown to light yellowish brown, silty fine sand. The 18.5 to 20.5 ft bgs sample was described as olive yellow, silty fine sand with cherty fragments.

**3.5.2.2 Sediment Results**

Four sediment samples (three normal and one field duplicate) were collected for PFAS analysis, with results provided in **Table 3.1-4**, illustrated in **Figure 3.5-3**, and summarized below.

**SNTA-SD-1:**

- PFOS was detected above the calculated RSL at a maximum concentration of 0.930 mg/kg.
- PFOA was detected below the calculated RSL at a maximum concentration of 0.068 mg/kg.

- PFBS was detected below the USEPA RSL at an estimated maximum concentration of 0.072 mg/kg.

**SNTA-SD-2:**

- PFOS was detected above the calculated RSL at a concentration of 1.7 mg/kg.
- PFOA was detected above the calculated RSL at a concentration of 0.250 mg/kg.
- PFBS was detected below the USEPA RSL at a concentration of 0.180 mg/kg.

**SNTA-SD-3:**

- PFOS was detected above the calculated RSL at a concentration of 2.2 mg/kg.
- PFOA was detected below the calculated RSL at a concentration of 0.100 mg/kg.
- PFBS was detected below the USEPA RSL at a concentration of 0.044 mg/kg.

**3.5.3 Conclusions**

PFOS, PFOA, PFBS were detected in surface soil samples and sediment samples at AFFF Release Area 5. Concentrations of PFOS in the surface soil samples exceeded the calculated RSL at both sampling locations while PFOS was not detected in the subsurface samples. PFOA and PFBS were detected at concentrations below the RSL in the surface soil samples and were not detected in the subsurface samples. PFOS, PFOA, and PFBS were detected in all three sediment samples; PFOS and PFOA were detected above the calculated RSL in one or more sediment samples.

This page intentionally left blank.



## 4.0 MIGRATION/EXPOSURE PATHWAYS AND TARGETS

An updated base-wide conceptual site model table is provided as **Table 4.0-1**. The table provides an overview of the facility, physical, release, land use, exposure, and ecological profiles at VAFB and has been updated to include information collected during this SI. More detailed descriptions of source area conditions and exposure pathways are described in the following sections. Descriptions of the geologic and hydrogeologic setting at VAFB were obtained from the PA (CH2M Hill, 2015) and updated with information collected during the AFFF SI.

### 4.1 SOIL (SURFACE AND SUBSURFACE) EXPOSURE PATHWAY

#### 4.1.1 Local Geologic Setting

Geology at Vandenberg AFB is generally characterized by folded and faulted bedrock units overlain by more recent unconsolidated deposits. The developed area of Vandenberg AFB, including each of the AFFF Release Areas, is located on a broad erosional terrace known as Burton Mesa (**Figure 4.1-1**). Burton Mesa is bounded to the north by San Antonio Creek, to the south by the Santa Ynez River, to the east by the Purisima Hills, and to the west by the Pacific Ocean (MWH, 2012).

Bedrock on Burton Mesa consists of the late Miocene Sisquoc and Monterey Formations (Dibblee, 1988 and 1989). The Sisquoc Formation is composed of white, laminated diatomite; white, diatomaceous mudstone and shale; and light gray, diatomaceous claystone and shale. Monterey Formation is a white-weathering, brittle, cherty shale. No major faults are mapped within Burton Mesa (MWH, 2012).

In most areas of Burton Mesa, thin sand and gravel deposits overlie bedrock (Dibblee, 1988 and 1989). The uppermost 20 feet of sediments in the northern portion of the developed area of Vandenberg AFB are composed of silty sands, clayey sands, and poorly graded sands (MWH, 2012). A clay layer underlies the sands. Fine- to medium-grained sands, grading laterally eastward to lean clay, have been encountered beneath a 2-foot- to 4-foot-thick fat clay at about 15 feet bgs (MWH, 2012).

Soils encountered in borings drilled during the SI consisted generally of fine- to medium-grained sands, silt, and clay. The Monterey Formation was encountered at three of the AFFF Release Areas during the SI at the following depths:

- AFFF Release Area 1: FT021 (Former FTA) – 20 to 35 ft bgs;
- AFFF Release Area 4: 2009 AFFF Release – 32 and 34 ft bgs; and
- AFFF Release Area 5: Spray Nozzle (Refractometer) Test Area – 20 ft bgs.

#### 4.1.2 Soil Exposure Pathways and Targets

PFAS were detected in the surface soil and/or in subsurface soil at AFFF Release Areas 1 through 5. PFOS exceeded the calculated RSL in surface soil and subsurface soil (to a depth of 4.7 ft bgs) at AFFF Release Area 1 and in the surface soil interval at AFFF Release Areas 4 and 5. These AFFF release areas consist of unpaved areas with exposed surface soil or grass.

Surface and subsurface soil in AFFF Release Areas 1, 4, and 5 are generally potentially accessible by USAF personnel, site workers, site visitors, and trespassers involved in any activity that exposes them to the impacted soil, particularly site workers performing ground-disturbing activities. AFFF Release Area 1 is accessible to USAF personnel, site workers, site visitors, and/or trespassers. AFFF Release Area 4, located adjacent to the runway, is in a flightline controlled movement area, and accessible to duty-related personnel only. Accessibility to AFFF Release Area 5, located behind a fenced, locked gate, is controlled by the Vandenberg AFB Fire Department. Access to source area soil is not expected to change in the future.

Potential exposure routes for surface and subsurface soil include inhalation of impacted surface soil dust particles and ingestion of and dermal contact with impacted soil.

#### **4.1.3 Soil Exposure Conclusions**

Based on the SI, potential complete pathways for human exposure to PFAS-impacted surface soil through inhalation, ingestion, and/or dermal contact were identified for AFFF Release Areas 1, 4, and 5.

### **4.2 GROUNDWATER MIGRATION PATHWAY**

#### **4.2.1 Local Hydrogeologic Setting**

On the Burton Mesa plateau, where AFFF Release Areas 1, 2, 4, and 5 are located, the overburden is thin and discontinuous, and infiltrating rainwater collects in small, sand-filled bedrock depressions and forms discontinuous, isolated lenses of perched groundwater (MWH, 2012). AFFF Release Area 3 is located southeast of the Burton Mesa on the western edge of the Lompoc Uplands Basin (MWH, 2012) and southeast of the other AFFF release areas.

Groundwater flow on the Burton Mesa is dictated primarily by surface topography and depth to bedrock. Regional groundwater flow is primarily along the bedrock surface that slopes to the west and northwest toward the Pacific Ocean. In the canyons, groundwater moving through the generally permeable alluvial deposits follows the flow pattern of the surface streams (MWH, 2012). On the southern portion of the Burton Mesa, where AFFF Release Area 3 is located, bedrock dips to the south and groundwater generally flows southward into the Lompoc Plain Basin.

The shallow perched groundwater system on the Burton Mesa is recharged via infiltration of precipitation and surface water, as well as leaks from potable water pipes.

Shallow perched groundwater is in direct communication with ponds or creeks at some locations. Shallow groundwater also surfaces as natural springs in the faces of ravines or coastal cliffs. Hydraulic gradients of the shallow, perched groundwater are influenced largely by the configuration of the bedrock surface and vary widely (CH2MHill, 2015). Estimated hydraulic conductivity values from a nearby site on the Burton Mesa range from 0.011 feet per day to 11 feet per day, with a calculated geometric mean of 0.36 feet per day (Shaw, 2006).

Burton Mesa is separated from the adjacent San Antonio Creek Valley drainage basin to the north and northeast by the Purisima Hills uplands (Hutchinson, 1980) (**Figure 4.1-1**). The San Antonio Creek Valley drainage basin is a nearly closed basin with no significant groundwater movement into or out of the Basin (Hutchinson, 1980). Because the groundwater divides generally coincide with topographic divides (Hutchinson, 1980), groundwater from Burton Mesa is not in hydraulic communication with San Antonio Creek Valley basin groundwater.

#### **4.2.2 Groundwater Exposure Pathways and Targets**

Once in groundwater, PFAS are highly mobile and will migrate near the same velocity as groundwater due to their high solubility and low partition coefficient value. PFAS are chemically and biologically stable in the environment and resist typical environmental degradation processes. As a result, these chemicals are extremely persistent in the environment, with a half-life greater than 41 years for PFOS and greater than 92 years for PFOA (USEPA, 2014). PFBS is generally less toxic and less bio-accumulative in wildlife and humans (USEPA, 2017).

PFOS, PFOA, and PFOS + PFOA were detected in localized excavation backfill water at AFFF Release Area 1 and in groundwater beneath AFFF Release Area 2 at concentrations above the USEPA HA. Exposure pathways were evaluated for these AFFF release areas.

Human receptors potentially exposed to PFAS in groundwater include USAF personnel, residents, site workers, site visitors, and/or trespassers involved in any activity that exposes them to the impacted groundwater at AFFF Release Areas 1 and 2.

The excavation backfill water is not groundwater, but rather rainwater that has infiltrated former excavation backfill and is retained on-site in the backfill material. Groundwater was not encountered in AFFF Release Area 1 during the SI activities or during historical remedial investigation activities (USAF, 2008). Although groundwater was encountered in each boring at AFFF Release Area 2 at depths ranging from approximately 17 to 27 ft. bgs (**Table 3.0-2**), the site-specific shallow groundwater flow direction was not determined during the SI field effort due to limited groundwater elevation data collected during the SI and the absence of historical groundwater elevation data.

Neither the excavation backfill water encountered in AFFF Release Area 1, nor the shallow groundwater sampled at AFFF Release Area 2 are known drinking water sources. The primary source of drinking water at Vandenberg AFB comes from surface water from Northern California through the State Water Project Pipeline (CH2M Hill, 2015). Drinking water for the installation is supplemented as needed by four on-Base water supply wells (Wells 4, 5, 6 and 7) located in the outlying areas in the northeastern portions of the Base approximately four miles northeast of AFFF Release Area 2 (CH2M Hill, 2015) (**Figure 4.1-1**). These four water supply wells are screened between 162 and 390 feet bgs (CH2M Hill, 2015). During the 7 March 2017 Scoping Meeting and Site Walk with Regulatory Agencies, the Remedial Project Manager (RPM) reported that PFAS were not detected in the four on-Base water supply wells (OTIE, 2018). However, the RPM later learned that samples were not collected from these

wells, but from the Base water distribution system when it was connected to the State waters (Gerber, 2019). State waters do not include groundwater or surface water from the installation or groundwater from Base water supply wells.

#### **Four-Mile Radius Search, AFFF Area 2**

A desktop water well review of the California Department of Water Resources (DWR) identified eight water supply wells within a four-mile radius of AFFF Release Area 2. The search was performed radially from the release area as opposed to the installation boundary since the release area is located several miles from the installation boundary and in consideration that the PFAS-impacted shallow groundwater is known to be discontinuous across the Installation.

Four of the well locations were shown to be south of the Purisima Hills and San Antonio Creek Valley drainage basin boundary. OTIE reviewed well completion reports (WCRs) for two of these wells and noted that the location information is misrepresented in the database, and the wells are actually located outside the four-mile radius. WCRs were not available for the other two wells; therefore, OTIE contacted the DWR to obtain additional information regarding the wells. DWR personnel indicated that the two records were non-well records and were imported into the database in error (DWR, 2018b).

The remaining four groundwater wells within the four-mile radius of AFFF Release Area 2 are the four installation supply wells mentioned above. These wells are located northeast of the topographic divide (Purisima Hills) in the San Antonio Creek Valley Basin. As previously stated, the topographic divide generally coincides with the groundwater divide; therefore, these wells are in a hydrologically disconnected groundwater basin northeast of AFFF Release Area 2. Accordingly, the groundwater exposure pathway from use of water from these wells is incomplete for AFFF Release Area 2.

The next nearest water supply wells are more than four miles south-southwest near the mouth of the Santa Ynez River (USAF, 2010).

#### **4.2.3 Groundwater Migration Pathway Conclusions**

The primary potable water source for VAFB is through the State Water Project Pipeline, with supplemental supply wells located upgradient of AFFF Release Area 2 and in a hydrologically disconnected basin. Because the groundwater from these supply wells is not in communication with the PFAS-impacted shallow groundwater beneath AFFF Release Area 2, and because PFAS was not detected in samples from these supply wells, the pathway for human receptors' exposure to groundwater via direct ingestion of drinking water is not present from Base water supply wells. However, the potential exists for PFAS-impacted water at AFFF Release Area 2 to interact with surface ponds and creeks, and for groundwater to surface as natural springs. Additionally, the potential exists for site workers to be exposed to PFAS-impacted water at AFFF Release Area 1 during potential excavation activities. Potential exposure pathways for human receptors at AFFF Release Area 1 include dermal contact or ingestion.

Based on the SI, potential complete pathways for human exposure to PFAS-impacted excavation backfill water and groundwater were identified for AFFF Release Areas 1 and 2, respectively.

### **4.3 SEDIMENT EXPOSURE PATHWAY**

#### **4.3.1 Sediment Exposure Pathways and Targets**

PFAS were detected in sediment samples from AFFF Release Areas 1, 3, and 5. PFOS and PFOA exceeded the calculated RSLs at AFFF Release Area 5.

Sediment in the AFFF Release Area 5 is potentially accessible by USAF personnel, residents, site workers, site visitors, and/or trespassers involved in any activity that exposes them to the impacted sediment, with the highest likelihood of exposure during site maintenance activities. AFFF Release Area 5 is a gated facility and no one is admitted without permission of facility personnel. Access to sediment is not expected to change in the future.

Potential exposure routes for sediment include dermal contact with or ingestion of sediment, or inhalation of dust from sediment during site maintenance activities or site visits.

#### **4.3.2 Sediment Exposure Conclusions**

Based on the SI, potential complete pathways for human exposure to PFAS-impacted sediment through inhalation, ingestion, and/or dermal contact were identified for AFFF Release Area 5.

This page intentionally left blank.

## 5.0 SUMMARY AND CONCLUSIONS

As stated in Section 1.0 Introduction, the objectives of this study were to:

- 1) Determine if PFAS are present in soil, groundwater, and sediment at AFFF release areas selected for SI;
- 2) Determine if PFAS concentrations in sampled media exceed applicable USEPA HA values and RSLs;
- 3) Identify potential exposure pathways in soil, sediment, and groundwater; and,
- 4) Identify potentially complete exposure pathways with immediate impacts to human health (immediate impact to human health is considered consumption of drinking water with PFAS above the applicable USEPA HA value and USEPA Tapwater RSL).

**Section 3** of this SI details the analytical results for PFAS at each AFFF release area. **Table 5.0-1** (below) summarizes exceedances by area and media, fulfilling the objectives of the SI. Potential human receptors and pathways are discussed in **Section 4** and summarized below **Table 5.0-1**.

This page intentionally left blank.



**Table 5.0-1. Summary of Analytical Results and Screening Level Exceedances.**

| AFFF Release Area                      | Parameter                             | Maximum Detected Concentration | Screening Value | Units | Number of Samples*/ Number of Exceedances | Exceeds Screening Level | Potentially Complete DW Exposure Pathway | Recommendation     |
|--|---------------------------------------|--------------------------------|-----------------|-------|---|-------------------------|--|--------------------|
| AFFF Release Area 1                    | Surface Soil (0.0 to 0.5 ft bgs)      |                                |                 |       |   |                         | No                                       | Advance Area to RI |
|  | PFOS                                  | 0.550                          | 0.126           | mg/kg | 4/1                                       | Yes                     |  |                    |
|  | PFOA                                  | 0.014                          | 0.126           | mg/kg | 4/0                                       | No                      |  |                    |
|  | PFBS                                  | 0.0028 J                       | 130             | mg/kg | 4/0                                       | No                      |  |                    |
|  | Subsurface Soil (4.2 to 19.9 ft bgs)  |                                |                 |       |   |                         |  |                    |
|  | PFOS                                  | 0.190                          | 0.126           | mg/kg | 3/1                                       | Yes                     |  |                    |
|  | PFOA                                  | 0.0065                         | 0.126           | mg/kg | 3/0                                       | No                      |  |                    |
|  | PFBS                                  | 0.00051 J                      | 130             | mg/kg | 3/0                                       | No                      |  |                    |
|  | Excavation Backfill Water             |                                |                 |       |   |                         |  |                    |
|  | PFOS                                  | 150                            | 0.07            | µg/L  | 2/2                                       | Yes                     |  |                    |
|  | PFOA                                  | 8.2                            | 0.07            | µg/L  | 2/2                                       | Yes                     |  |                    |
|  | PFOS + PFOA                           | 158.2                          | 0.07            | µg/L  | 2/2                                       | Yes                     |  |                    |
|  | PFBS                                  | 1.1 J                          | 40              | µg/L  | 2/0                                       | No                      |  |                    |
|  | Sediment                              |                                |                 |       |   |                         |  |                    |
|  | PFOS                                  | 0.012                          | 0.126           | mg/kg | 1/0                                       | No                      |  |                    |
|  | PFOA                                  | 0.00066 J                      | 0.126           | mg/kg | 1/0                                       | No                      |  |                    |
| PFBS                                   | ND                                    | 130                            | mg/kg           | 1/0   | No  |                         |  |                    |
| AFFF Release Area 2<br>1992 Fuel Spill | Surface Soil (0.0 to 0.5 ft bgs)      |                                |                 |       |   |                         | No                                       | Advance Area to RI |
|  | PFOS                                  | 0.029                          | 0.126           | mg/kg | 4/0                                       | No                      |  |                    |
|  | PFOA                                  | 0.0025                         | 0.126           | mg/kg | 4/0                                       | No                      |  |                    |
|  | PFBS                                  | ND                             | 130             | mg/kg | 4/0                                       | No                      |  |                    |
|  | Subsurface Soil (18.0 to 29.0 ft bgs) |                                |                 |       |   |                         |  |                    |
|  | PFOS                                  | 0.0029                         | 0.126           | mg/kg | 3/0                                       | No                      |  |                    |
|  | PFOA                                  | 0.00068 J                      | 0.126           | mg/kg | 3/0                                       | No                      |  |                    |

| AFFF Release Area                      | Parameter                             | Maximum Detected Concentration | Screening Value | Units | Number of Samples*/ Number of Exceedances | Exceeds Screening Level | Potentially Complete DW Exposure Pathway | Recommendation              |
|--|---------------------------------------|--------------------------------|-----------------|-------|---|-------------------------|--|-----------------------------|
| AFFF Release Area 2 (continued)        | PFBS                                  | ND                             | 130             | mg/kg | 3/0                                       | No                      | No                                       | Advance Area to RI          |
|  | Groundwater                           |                                |                 |       |   |                         |  |                             |
|  | PFOS                                  | 0.65                           | 0.07            | µg/L  | 3/2                                       | Yes                     |  |                             |
|  | PFOA                                  | 0.071                          | 0.07            | µg/L  | 3/1                                       | Yes                     |  |                             |
|  | PFOS + PFOA                           | 0.721                          | 0.07            | µg/L  | 3/3                                       | Yes                     |  |                             |
|  | PFBS                                  | 1.1                            | 40              | µg/L  | 3/0                                       | No                      |  |                             |
| AFFF Release Area 3<br>2006 Fuel Spill | Surface Soil (0.0 to 0.5 ft bgs)      |                                |                 |       |   |                         | No                                       | Further Evaluation Deferred |
|  | PFOS                                  | 0.078                          | 0.126           | mg/kg | 2/0                                       | No                      |  |                             |
|  | PFOA                                  | 0.00049 J                      | 0.126           | mg/kg | 2/0                                       | No                      |  |                             |
|  | PFBS                                  | 0.00079 J                      | 130             | mg/kg | 2/0                                       | No                      |  |                             |
|  | Subsurface Soil (63.0 to 64.8 ft bgs) |                                |                 |       |   |                         |  |                             |
|  | PFOS                                  | ND                             | 0.126           | mg/kg | 2/0                                       | No                      |  |                             |
|  | PFOA                                  | ND                             | 0.126           | mg/kg | 2/0                                       | No                      |  |                             |
|  | PFBS                                  | ND                             | 130             | mg/kg | 2/0                                       | No                      |  |                             |
|  | Groundwater                           |                                |                 |       |   |                         |  |                             |
|  | PFOS                                  | 0.013 J                        | 0.07            | µg/L  | 3/0                                       | No                      |  |                             |
|  | PFOA                                  | ND                             | 0.07            | µg/L  | 3/0                                       | No                      |  |                             |
|  | PFOS + PFOA                           | 0.013 J                        | 0.07            | µg/L  | 3/0                                       | No                      |  |                             |
|  | PFBS                                  | 0.071 J                        | 40              | µg/L  | 3/0                                       | No                      |  |                             |
|  | Sediment                              |                                |                 |       |   |                         |  |                             |
|  | PFOS                                  | 0.064                          | 0.126           | mg/kg | 2/0                                       | No                      |  |                             |
|  | PFOA                                  | 0.00059 J                      | 0.126           | mg/kg | 2/0                                       | No                      |  |                             |
|  | PFBS                                  | 0.00047 J                      | 130             | mg/kg | 2/0                                       | No                      |  |                             |

| AFFF Release Area  | Parameter                             | Maximum Detected Concentration | Screening Value | Units | Number of Samples* / Number of Exceedances | Exceeds Screening Level | Potentially Complete DW Exposure Pathway | Recommendation     |
|--|---------------------------------------|--------------------------------|-----------------|-------|--|-------------------------|--|--------------------|
| AFFF Release Area 4<br>2009 AFFF Release                         | Surface Soil (0.0 to 0.5 ft bgs)      |                                |                 |       |  |                         | No                                       | Advance Area to RI |
|  | PFOS                                  | 0.180                          | 0.126           | mg/kg | 2/1  | Yes                     |  |                    |
|  | PFOA                                  | 0.0015                         | 0.126           | mg/kg | 2/0  | No                      |  |                    |
|  | PFBS                                  | 0.0014                         | 130             | mg/kg | 2/0  | No                      |  |                    |
|  | Subsurface Soil (31.5 to 34.0 ft bgs) |                                |                 |       |  |                         |  |                    |
|  | PFOS                                  | 0.00055 J                      | 0.126           | mg/kg | 3/0  | No                      |  |                    |
|  | PFOA                                  | ND                             | 0.126           | mg/kg | 3/0  | No                      |  |                    |
|  | PFBS                                  | 0.00056 J                      | 130             | mg/kg | 3/0  | No                      |  |                    |
| AFFF Release Area 5<br>Spray Nozzle<br>(Refractometer) Test Area | Surface Soil (0.0 to 0.5 ft bgs)      |                                |                 |       |  |                         | No                                       | Advance Area to RI |
|  | PFOS                                  | 1.10                           | 0.126           | mg/kg | 2/2  | Yes                     |  |                    |
|  | PFOA                                  | 0.0029                         | 0.126           | mg/kg | 2/0  | No                      |  |                    |
|  | PFBS                                  | 0.0050                         | 130             | mg/kg | 2/0  | No                      |  |                    |
|  | Subsurface Soil (19.0 to 19.5 ft bgs) |                                |                 |       |  |                         |  |                    |
|  | PFOS                                  | ND                             | 0.126           | mg/kg | 2/0  | No                      |  |                    |
|  | PFOA                                  | ND                             | 0.126           | mg/kg | 2/0  | No                      |  |                    |
|  | PFBS                                  | ND                             | 130             | mg/kg | 2/0  | No                      |  |                    |
|  | Sediment                              |                                |                 |       |  |                         |  |                    |
|  | PFOS                                  | 2.2                            | 0.126           | mg/kg | 4/4  | Yes                     |  |                    |
|  | PFOA                                  | 0.250                          | 0.126           | mg/kg | 4/1  | Yes                     |  |                    |
|  | PFBS                                  | 0.180                          | 130             | mg/kg | 4/0  | No                      |  |                    |

**Notes:**

\* includes normal and field duplicate samples (count does not include quality control samples)  
AFFF – aqueous film forming foam  
FTA – Fire Training Area  
ft bgs – feet below ground surface

DW – Drinking Water  
J - The reported result is an estimated value.  
µg/L – micrograms per liter  
mg/kg – milligrams per kilogram  
ND – not detected

PFBS – perfluorobutanesulfonic acid  
PFOS – perfluorooctanesulfonic acid  
PFOA – perfluorooctanoic acid  
RI – Remedial Investigation  
SI – Site Inspection

Potential human health pathways were identified and detailed in Section 4 of this SIR. The potential receptors and targets vary by AFFF release area. Media-specific pathways and receptors are discussed below.

#### Surface and Subsurface Soil Receptors

PFAS were detected in the surface soil and/or in subsurface soil at AFFF Release Areas 1 through 5. PFOS exceeded the calculated RSL in surface soil and subsurface soil (to a depth of 4.5 ft bgs) at AFFF Release Area 1 and in the surface soil interval at AFFF Release Areas 4 and 5. These AFFF release areas consist of unpaved areas with exposed surface soil or grass.

Surface and subsurface soil in AFFF Release Areas 1, 4, and 5 are potentially accessible by USAF personnel, site workers, site visitors, and trespassers involved in any activity that exposes them to the impacted soil, particularly site workers performing ground-disturbing activities. AFFF Release Area 1 is accessible to USAF personnel, site workers, site visitors, and/or trespassers. AFFF Release Area 4, located adjacent to the runway, is in a flightline controlled movement area, and accessible to duty-related personnel only. Accessibility to AFFF Release Area 5, located behind a fenced, locked gate, is controlled by the Vandenberg AFB Fire Department. Access to source area soil is not expected to change in the future.

Potential exposure routes for surface and subsurface soil include inhalation of impacted surface soil dust particles and ingestion of and dermal contact with impacted soil.

Based on the SI, potential complete pathways for human exposure to PFAS-impacted surface soil through inhalation, ingestion, and/or dermal contact were identified for AFFF Release Areas 1, 4, and 5.

#### Groundwater/Excavation Backfill Water Receptors

PFAS was detected in localized excavation backfill water at AFFF Release Area 1 and in groundwater at AFFF Release Areas 2 and 3. PFOS, PFOA, and PFOS + PFOA were detected in the water at AFFF release Area 1 and in groundwater at AFFF Release Area 2 at concentrations above the USEPA HA. Exposure pathways were evaluated for these AFFF release areas.

Although localized excavation backfill water was encountered at AFFF Release Area 1, no groundwater was encountered at this area during the remedial investigation (USAF, 2008) or during the AFFF SI (Section 3.1.2.3). Although groundwater was encountered in each boring at AFFF Release Area 2 at depths ranging from approximately 17 to 27 ft. bgs (**Table 3.0-2**), the site-specific groundwater flow direction was not determined during the SI field effort due to limited groundwater elevation data. In general, the shallow groundwater in the vicinity of the Burton Mesa area exists in relatively thin, disconnected lenses perched on low permeability layers and directly overlying bedrock. Groundwater flow on the Burton Mesa is highly variable and dependent on localized site characteristics (MWH, 2012).

The primary potable water source for VAFB is through the State Water Project, with supplemental supply wells located upgradient in a basin not hydrologically disconnected to identified AFFF source areas.

The pathway for human receptors' exposure to groundwater via a direct ingestion of drinking water is not present from Base water supply wells because the wells are not hydrologically connected to PFAS-impacted shallow groundwater. However, the potential exists for PFAS-impacted groundwater at AFFF Release Area 2 to interact with surface ponds and creeks, or for groundwater to surface as natural springs. Additionally, the potential exists for site workers to be exposed to PFAS-impacted water at AFFF Release Area 1 during potential excavation activities. Potential exposure pathways for human receptors at AFFF Release Area 1 include dermal contact or ingestion.

Based on the SI, potential complete pathways were identified for human exposure to PFAS-impacted excavation backfill water at AFFF Release Area 1, and groundwater for AFFF Release Area 2.

#### Sediment Receptors

PFAS were detected in sediment samples from AFFF Release Areas 1, 3, and 5. PFOS and PFOA exceeded the calculated RSLs at AFFF Release Area 5.

Sediment in the AFFF Release Area 5 is potentially accessible by USAF personnel, residents, site workers, site visitors, and/or trespassers involved in any activity that exposes them to the impacted sediment. AFFF Release Area 5 is a gated facility and no one is admitted without permission of facility personnel. Access to sediment is not expected to change in the future.

Potential exposure routes for sediment include dermal contact with or ingestion of sediment, or inhalation of dust from sediment during site maintenance activities or site visits.

Based on the SI, potential complete pathways for human exposure to PFAS-impacted sediment through inhalation, ingestion, and/or dermal contact were identified for AFFF Release Area 5.

This page intentionally left blank.

## 6.0 REFERENCES

- Amec Foster Wheeler Environment & Infrastructure, Inc. (Amec Foster Wheeler), 2018. *Final (Revision 2) Quality Program Plan, Site Inspection of Film Forming Foam (AFFF) Release Areas Environmental Programs Worldwide*. October.
- California Department of Water Resources, 1981. *Water Well Standards: State of California Bulletin 74-81*. December.
- California Department of Water Resources, 1991. *California Well Standards Bulletin 74-90 (Supplement to Bulletin 74-81)*. June.
- California Department of Water Resources (DWR), 2018a. *Well Completion Report Map Application*. Available at <https://www.arcgis.com/home/item.html?id=181078580a214c0986e2da28f8623b37>. Accessed 26 October 2018.
- DWR, 2018b. *Personal communication with Benjamin Brezing*. November 15.
- CH2M Hill, Inc. (CH2M Hill), 2015. *Final Preliminary Assessment Report for Perfluorinated Compounds at Vandenberg Air Force Base, Santa Barbara County, California*. November.
- Coates, C. Y., 1977. *A History of USAF Fire Protection Training at Chanute Air Force Base, 1964-1976. Chanute Technical Training Center, Chanute AFB, Illinois*. February.
- Department of Defense (DoD), 1969. MIL-F-24385, Military Specification: Fire Extinguishing Agent, Aqueous Film Forming (AFFF) Liquid Concentrate, Six Percent, for Fresh and Sea Water. November.
- DoD, 1994. MIL-F-24385F (SH) *Amendment 1, Fire Extinguishing Agent, Aqueous Film Forming Foam (AFFF) Liquid Concentrate, for Fresh and Seawater*. 5 August.
- DoD, 2009. *Department of Defense Instruction Number 4715.18, Emerging Contaminants (ECs). Incorporating Change 1, December 13, 2017*. 11 June.
- Dibblee, Thomas W., Jr., 1988. *Geologic Map of the Lompoc and Surf Quadrangles*. Edited by Helmut E. Ehrenspeck, Dibblee Geological Foundation, Santa Barbara, California.
- Dibblee, Thomas W., Jr., 1989. *Geologic Map of the Casmalia and Orcutt Quadrangles*. Edited by Helmut E. Ehrenspeck, Dibblee Geological Foundation, Santa Barbara, California.
- Gerber, Kathleen. 2019. Email communication clarifying PFAS samples collected by Base Bioenvironmental in 2016. 3 January.
- Hutchinson, C. B., 1980. *Appraisal of Ground-Water Resources in the San Antonio Creek Valley, Santa Barbara County, California*. U.S. Geological Survey Water Resources Investigations Open-File Report 80-750.
- MWH Americas (MWH), 2012. *Final Background and Standard Approach For Investigation of Compliance Restoration Program Sites. Revision 5*. August.
- National Oceanic and Atmospheric Administration (NOAA), 2017. Climate Data Online (<https://www.ncdc.noaa.gov/cdo-web/>).

- Oneida Total Integrated Enterprises (OTIE), 2018. *Final Installation-Specific Work Plan at Vandenberg Air Force Base, Santa Barbara, California, Site Inspection of Aqueous Film Forming (AFFF) Release Areas Environmental Programs Worldwide*. August.
- Shaw Environmental, Inc. (Shaw), 2006. *Final Supplemental Remedial Investigation Report, IRP Site 50, Operable Unit 1, Vandenberg Air Force Base, California*. July.
- United States Air Force (USAF), 2008. *Final Record of Decision/Remedial Action Plan, Site 21 – Fire Training Area, Operable Unit 4, Vandenberg Air Force Base, California*. August.
- USAF, 2010. Final Record of Decision/Remedial Action Plan, Site 33 Missile Silo 576-E, Vandenberg Air Force Base, California. Contract No. F41624-03-D-8617, Task Order 0071. Prepared by Tetra Tech, Inc. May.
- USAF, 2012. HQ USAF/A7C. *Interim Air Force Guidance on Sampling and Response Actions for Perfluorinated Compounds at Active and BRAC Installations*. August.
- USAF, 2016. *Memorandum for AF/A4, AF/SG, AFIMSC/CC, NGB/CR, SAF/IE Policy on Perfluorinated Compounds*. 11 August.
- United States Environmental Protection Agency (USEPA), 2014. *USEPA Fact Sheet. Emerging Contaminants Fact Sheet – PFOS and PFOA*. March.
- USEPA, 2016a. *Drinking Water Health Advisory for Perfluorooctane Sulfonate (PFOS)*. May.
- USEPA, 2016b. *Drinking Water Health Advisory for Perfluorooctanoic Acid (PFOA)*. May.
- USEPA, 2017. Assessing and Managing Chemicals under TSCA, Per- and Polyfluoroalkyl Substances (PFASs) under TSCA. Updated 13 March. <https://www.epa.gov/assessing-and-managing-chemicals-under-tsca/risk-management-and-polyfluoroalkyl-substances-pfass>. Accessed on 12 April 2017.
- USEPA, 2018. *Regional Screening Level (RSL) Summary Table (TR = 1E-06. HQ =0.1) November 2018*. <https://www.epa.gov/risk/regional-screening-levels-rsls-generic-tables>. Accessed November.
- United States Fish and Wildlife Service (USFWS), 2019. National Wetlands Inventory. <https://www.fws.gov/wetlands/data/mapper.html>. Accessed 4 January.



## FIGURES

This page intentionally left blank.

## FIGURE ACRONYMS

|        |                           |       |   |
|--------|---------------------------|-------|---|
| AFFF   | aqueous film forming foam | N     | normal sample                                 |
| AFB    | Air Force Base            |       |   |
| B      | Soil boring               | PFAS  | per- and polyfluorinated alkyl substances     |
| FD     | field duplicate sample    | PFBS  | perfluorobutanesulfonic acid                  |
| FTA    | fire training area        | PFOA  | perfluorooctanoic acid                        |
| ft bgs | feet below ground surface | PFOS  | perfluorooctanesulfonic acid                  |
| GW     | Groundwater               | RSL   | Regional Screening Level                      |
| HA     | Health Advisory           | SD    | sediment                                      |
|        |                           | THQ   | Target Hazard Quotient                        |
| µg/L   | micrograms per liter      | USEPA | United States Environmental Protection Agency |
| mg/kg  | milligrams per kilogram   |       |   |

## FIGURE NOTES

**Highlighted** = Detected concentration of analyte exceeds USEPA HA value or USEPA Tap Water RSL for groundwater, **or** exceeds USEPA RSL for soil or sediment.

J = The reported result is an estimated value.

U = The analyte was not detected above the reported limit of detection.

UJ = The analyte was not detected and was reported as less than the limit of detection. However, the associated numerical value is approximate.

Groundwater elevations in feet above mean sea level.

## Screening Values

| Soil / Sediment                     |   |
|-------------------------------------|---|
| Analyte                             | USEPA RSL <sup>a,b</sup>                  |
| Perfluorooctanoic acid (PFOA)       | 0.126 mg/kg                               |
| Perfluorooctanesulfonic acid (PFOS) | 0.126 mg/kg                               |
| Perfluorobutanesulfonic acid (PFBS) | 130 mg/kg                                 |
| Groundwater                         |   |
| Analyte                             | USEPA HA <sup>c,d</sup> /RSL <sup>a</sup> |
| Perfluorooctanoic acid (PFOA)       | 0.07 µg/L                                 |
| Perfluorooctanesulfonic acid (PFOS) | 0.07 µg/L                                 |
| Perfluorobutanesulfonic acid (PFBS) | 40 µg/L                                   |

Screening Value Table Notes:

a USEPA Regional Screening Levels, November 2018 (USEPA, 2018) [<https://www.epa.gov/risk/regional-screening-levels-rsls-generic-tables>] using a THQ of 0.1. Soil screening values were used for screening PFBS in sediment.

b Screening levels, based on a residential exposure scenario, were calculated using the USEPA Regional Screening Level calculator ([https://epa-prgs.ornl.gov/cgi-bin/chemicals/csl\\_search](https://epa-prgs.ornl.gov/cgi-bin/chemicals/csl_search)) and a THQ of 0.1.

c USEPA, 2016a. "Drinking Water Health Advisory for Perfluorooctane Sulfonate (PFOS)" and USEPA, 2016b. "Drinking Water Health Advisory for Perfluorooctanoic Acid (PFOA)."


d The USEPA also recommended that when these two chemicals co-occur in a drinking water source, a conservative and health protective approach that compares the sum of the concentrations (PFOS+PFOA) to the HA value (0.07 µg/L) (USEPA, 2016a and 2016b).




This page intentionally left blank.



**FIGURE 2.1-1**  
**Installation Location Map**  
**Vandenberg Air Force Base**  
**Lompoc, California**

Site Inspection of Aqueous  
 Film Forming Foam (AFFF)  
 Release Areas  
 Environmental Programs Worldwide  
 Site Inspection Report


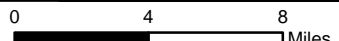
**Air Force Civil Engineer Center**  
  
 2261 Hughes Avenue  
 Building 1, Suite 155  
 JBSA Lackland, Texas 78236

- Symbol Key**
-  Vandenberg AFB Installation Boundary
  -  Approximate Zoomed Extent
  -  AFFF Release Area

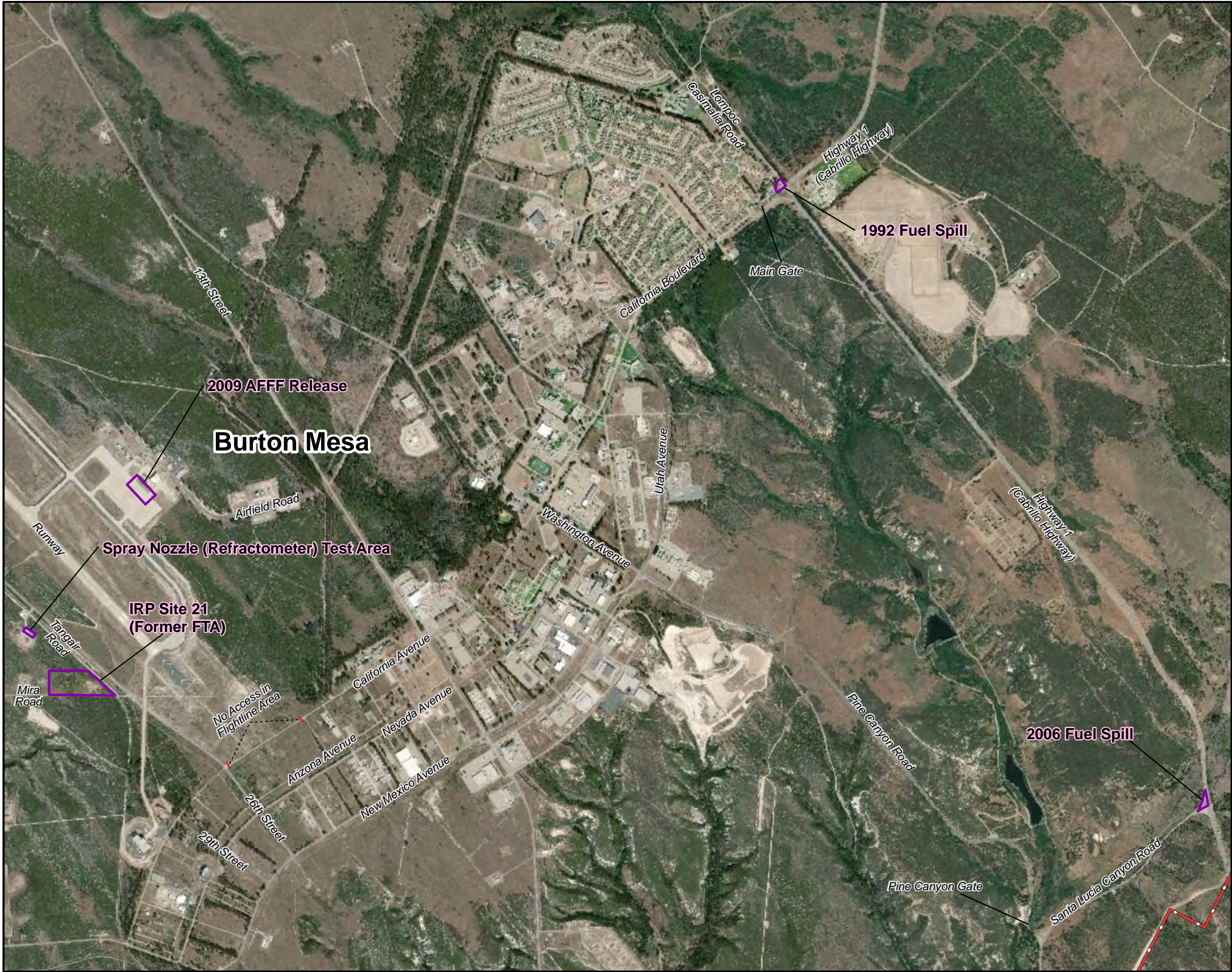
**Notes**  
 AFB = Air Force Base

Service Layer Credits: USGS The National Map:  
 National Boundaries Dataset, 3DEP Elevation Program,  
 Geographic Names Information System, National  
 Hydrography Dataset, National Land Cover Database,

Disclaimer: For general reference purposes only.  
 DO NOT USE to determine, certify, or verify  
 map features, scale and/or other information.

|   |                                   |                  |
|---|-----------------------------------|------------------|
|  | <b>Contract: FA8903-16-D-0027</b> |                  |
|   | <b>By: MLW</b>                    | <b>1/14/2019</b> |
|  |                                   |                  |





**FIGURE 2.3-1**  
**AFFF Release Areas**  
**Vandenberg Air Force Base**  
**California**

Site Inspection of Aqueous  
Film Forming Foam (AFFF)  
Release Areas  
Environmental Programs Worldwide  
Site Inspection Report

**Air Force Civil Engineer Center**



2261 Hughes Avenue  
Building 1, Suite 155  
JBSA Lackland, Texas 78236

**Symbol Key**

- Vandenberg AFB Installation Boundary
- AFFF Release Area

Service Layer Credits: Source: Esri, DigitalGlobe,  
GeoEye, Earthstar Geographics, CNES/Airbus DS,  
USDA, USGS, AeroGRID, IGN, and the GIS User  
Community (2016)

Disclaimer: For general reference purposes only.  
DO NOT USE to determine, certify, or verify  
map features, scale and/or other information.



**Contract: FA8903-16-D-0027**

**By: MLW**

**1/14/2019**

0 1,250 2,500  
Ft.





**FIGURE 3.1-1**  
**Sampling Locations and Excavation**  
**Backfill Water Elevation**  
**(September 2018)**  
**FT021 (Former FTA)**  
**AFFF Release Area 1**  
**Vandenberg Air Force Base**  
**California**

Site Inspection of Aqueous  
Film Forming Foam (AFFF)  
Release Areas  
Environmental Programs Worldwide  
Site Inspection Report

**Air Force Civil Engineer Center**



2261 Hughes Avenue  
Building 1, Suite 155  
JBSA Lackland, Texas 78236

**Symbol Key**

- Soil Boring/Temporary Monitoring Well
- Sediment Sample
- Soil Boring
- Surface Soil Sample
- Unlined Drainage Channel
- 01/2006 Excavation
- 12/2005 Excavation
- 10/2004 Excavation
- Former Burn Pit
- AFFF Release Area
- Surface Water Flow Direction
- 351.23 Water Elevation (ft amsl)

**Notes**

Water encountered is excavation backfill water.  
No groundwater is present.

Site features and excavation boundaries  
from Versar 2008

Service Layer Credits: Source: Esri, DigitalGlobe,  
GeoEye, Earthstar Geographics, CNES/Airbus DS,  
USDA, USGS, AeroGRID, IGN, and the GIS User  
Community (2016)

Disclaimer: For general reference purposes only.  
DO NOT USE to determine, certify, or verify  
map features, scale and/or other information.



**Contract: FA8903-16-D-0027**

**By: MLW** **1/14/2019**

0 50 100  
Ft.