

FINAL

Site Inspection Work Plan

for

Per-and Polyfluoroalkyl Substances (PFAS)

at

**National Aeronautics and Space Administration (NASA)
Jet Propulsion Laboratory (JPL)
Pasadena, California**

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APPENDICES

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APPENDIX B:	Accident Prevention Plan/Site Safety and Health Plan (APP/SSHP)
APPENDIX C:	QC Checklists and Forms
APPENDIX D:	NASA Memo – PFAS Investigation Derived Waste Disposal

ABBREVIATIONS

%	percent
°F	degrees Fahrenheit
µg/L	micrograms per liter
AFFF	aqueous film-forming foam
AHA	Activity Hazard Analysis
amsl	above mean sea level
AOPC	Areas of Potential Concern
APP/SSHP	Accident Prevention Plan/Site Safety and Health Plan
bgs	below ground surface
Caltech	California Institute of Technology
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
COPC	Contaminant of Potential Concern
CSM	Conceptual Site Model
DI	deionized
DQCR	Daily Quality Control Report
DQO	Data quality objective
DTSC	Department of Toxic Substances Control
CDWR	California Department of Water Resources
Ebasco	Ebasco Services, Inc.
ELAP	Environmental Laboratory Accreditation Program
Feet per day	ft/day
FFA	Federal Facilities Agreement
FFRDC	federally funded research and development center
FID	flame ionization detector
ft	feet/foot
FWEC	Foster Wheeler Environmental Corporation
G2S	G2S LLC
GALCIT	Graduate Aerospace Laboratories of the California Institute of Technology
gpm	gallons per minute
GPS	Global Positioning System
HA	Health Advisory
IDW	investigation derived waste
IX	ion exchange
JPL	Jet Propulsion Laboratory
LACoFD	Los Angeles County Fire Department
LARWQCB	Los Angeles Regional Water Quality Control Board
LAWC	Lincoln Avenue Water Company
LC/MS/MS	liquid chromatography-tandem mass spectrometry

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LGAC	Liquid-Phase Granular Activated Carbon
Ma	million years old
MHTS	Monk Hill Treatment System
NASA	National Aeronautics and Space Administration
NPL	National Priorities List
NTC	National Training Center
NTU	nephelometric turbidity unit
OU	operable unit
PA	Preliminary Assessment
PAR	Preliminary Assessment Report
PFAS	Per- and Polyfluoroalkyl Substances
PFBS	perfluorobutanesulfonic acid
PFHpA	perfluoroheptanoic acid
PFHxS	perfluorohexane sulfonate
PFNA	perfluorononanoic acid
PFOA	perfluorooctanoic acid
PFOS	perfluorooctane sulfonate
PID	photoionization detector
POC	point of contact
PPE	Personal protection equipment
ppm	parts per million
ppt	parts per trillion
psi	pounds per square inch
PWP	Pasadena Water and Power
PWS	Performance Work Statement
QA/QC	Quality Assurance/Quality Control
QSM	Quality Systems Manual
RCRA	Resource Conservation and Recovery Act
ROD	Record of Decision
RSL	Regional Screening Level
RTC	response to comment
RWQCB	Regional Water Quality Control Board
SI	Site Inspection
SSHO	Site Safety and Health Officer
SWRCB	State Water Resources Control Board
UFP-QAPP	Uniform Federal Policy for Quality Assurance Project Plans
USACE	United States Army Corps of Engineers
USC	United States Code
USCS	Unified Soil Classification System
USEPA	United States Environmental Protection Agency
VOA	volatile organic analysis
VOC	Volatile Organic Compound

1.1 Purpose of Report

This work plan for the Per- and Polyfluoroalkyl Substances (PFAS) Site Inspection (SI) at the National Aeronautics and Space Administration's (NASA's) Jet Propulsion Laboratory (JPL) in Pasadena, California was prepared by G2S LLC (G2S), under Contract No. W912PL21D0021 as part of Delivery Order No. W912PL21F0046. The work plan outlines the purpose of the investigation, sets objectives, and details the planned procedures and processes that will be implemented to conduct the PFAS SI.

1.2 Project Objectives

The objective for the PFAS SI at NASA JPL is to implement the environmental investigations specified in the Per-and Polyfluoroalkyl Substances Preliminary Assessment (PA) Report (PAR) for the Jet Propulsion Laboratory (Tetra Tech, 2021) Appendix F SI Work Plan and prepare a final SI Report. The SI environmental investigations are to be completed in compliance with the Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA), 42 United States Code (USC) § 9601 et seq. and State of California environmental regulations dated July 2019.

The objectives of the PFAS SI environmental investigations at NASA JPL are as follows:

1. Investigate the presence or absence of PFAS at or associated with four Areas of Potential Concern (AOPCs) recommended in the PAR for further assessment.
 - AOPC 1: Emergency Landing Facility
 - AOPC 2 and 3: Waste Disposal Areas (Seepage pits [40] and waste pits [4] comprising AOPC 2 and AOPC 3 respectively are considered as a single potential source)
 - AOPC 4: Building 170 Fabrication Shop
 - AOPC 5: Former Building 218 and Building 291 Photography Labs
2. Collect groundwater samples from multiple existing monitoring wells within and downgradient of JPL to assess presence or absence of PFAS in groundwater at or associated with AOPC 1, 2, 3, 4, and 5.
3. Collect soil samples at two intervals (0 to 0.5 feet [ft] and 0.5 ft to 2 ft below ground surface (bgs)) to assess presence or absence of PFAS in soil at or associated with AOPC 1.

1.3 Regulatory Framework

In October 1992, the JPL site was placed on the National Priorities List (NPL) and, therefore, is subject to the provisions of CERCLA to regulate investigation and cleanup. The parties to the Federal Facilities Agreement (FFA) include NASA, the United States Environmental Protection Agency (USEPA), the California Department of Toxic Substances Control (DTSC), and the Regional Water Quality Control Board (RWQCB). NASA is the lead federal agency, and USEPA, DTSC, and RWQCB provide guidance and oversight to the JPL CERCLA Program. The PFAS PA was conducted voluntarily by NASA following the CERCLA process.

NASA Headquarters conducted PFAS PAs at 10 NASA Centers/Facilities (JPL being one of the ten facilities) to identify whether past or present activities may have resulted in a release of PFAS into the environment and to qualitatively evaluate potential exposure to PFAS in environmental media for receptors at and within a 1-mile radius of each NASA Center/Facility. The PFAS PA for JPL was finalized in February 2021 and the PFAS SI that is the subject of this work plan is the next step in the CERCLA process based on the findings of the PA.

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1.4 Report Organization

This PFAS SI Work Plan is organized as follows:

- Section 1, Introduction – Describes the project objectives, regulatory framework, and content of the PFAS SI Work Plan.
- Section 2, Site Background – Provides background information including site location and description, site history, summary of previous investigations, and regulatory history.
- Section 3, Environmental Setting – Summarizes physical characteristics of the Site including climate, topography, geology, hydrogeology, surface water features, and land use.
- Section 4, Work Plan Approach – Provides an overview of the Conceptual Site Model (CSM), the PFAS SI objectives, and the project approach.
- Section 5, Field Activities – Describes procedures for the implementation of investigation activities including groundwater sampling, soil sampling, and investigation-derived waste (IDW) management.
- Section 6, Quality Assurance/Quality Control (QA/QC) - Details QC responsibilities, submittals, control, verification, acceptance and testing procedures, QC methods, and completion inspections.

The following are appended to this document:

- Appendix A: Uniform Federal Policy-Quality Assurance Project Plan (UFP-QAPP)
- Appendix B: Accident Prevention Plan/Site Safety and Health Plan (APP/SSHP)
- Appendix C: QC Checklists and Forms
- Appendix D: NASA Memo – PFAS Investigation Derived Waste Disposal

2.1 Site Location and Description

JPL is a federally funded research and development center (FFRDC) in Pasadena, California, currently operated under contract with the California Institute of Technology (Caltech) for NASA. JPL's primary activities include the exploration of the earth and solar system by automated spacecraft and the design and operation of the Global Deep Space Tracking Network.

Located in Los Angeles County, the JPL site is situated between the incorporated cities of La Cañada-Flintridge and Pasadena and is bordered on the east by the unincorporated community of Altadena. JPL encompasses approximately 176 acres of land and more than 150 buildings and other structures. Of the JPL facility's 176 acres, approximately 156 acres are federally owned. The remaining land is leased for parking from the City of Pasadena and the Flintridge Riding Club. Development at JPL is primarily located in two regions, an early-developed northeastern area and a later-developed southwestern area. Figure 1 is a location map showing the JPL facility and surrounding areas.

Under the CERCLA program, JPL has been divided into three operable units (OUs). OU1 addresses on-facility groundwater at JPL; OU2 addresses on-facility vadose zone soil at JPL; and OU3 addresses off-facility groundwater adjacent to the JPL property. Cleanup of OU2 is complete, as documented in the Remedial Action Report for Operable Unit 2 (NASA, 2007). A Final Record of Decision (ROD) is currently in place for both OU1 and OU3 (NASA, 2018).

The remedies for OU1 and OU3 include three treatment systems: the Source Area Treatment System (OU1) and two systems in OU3, the Monk Hill Treatment System (MHTS) and the Lincoln Avenue Water Company (LAWC) Treatment System. These systems utilize liquid-phase granular activated carbon (LGAC) to remove volatile organic compounds (VOCs) and ion exchange (IX) to remove perchlorate. For the source area treatment system, the treated water is reinjected into the aquifer utilizing three injection wells located approximately 350 feet up gradient from the extraction wells. Treated water from the MHTS and LAWC Treatment System is used as drinking water.

The PAR recommended four AOPCs (the Site) for further assessment and one AOPC was added during the SI. The description of each AOPC location is provided below. Figure 2 presents a Site map showing the locations of the AOPCs.

2.1.1 AOPC 1: Emergency Landing Facility

The Emergency Landing Facility is an approximately 1.25-acre area located in the northern portion of JPL off Mesa Road near Building 243. The facility is located on the mesa north of and at a higher elevation than the main campus of JPL (north of the JPL Thrust Fault) and has a heliport that is used to support Los Angeles County Fire Department (LACoFD) helicopters in the event of a forest fire (Tetra Tech, 2021).

2.1.2 AOPC 2 and 3: Waste Disposal Areas (Seepage Pits and Waste Pits)

40 seepage pits (collectively AOPC 2) and four waste pits (collectively AOPC 3) are being considered as a single potential source. The seepage pits were used from approximately 1945 to 1960 to dispose of a variety of liquid wastes associated with laboratory operations, including sanitary wastes, solvents, paints, wastewater from parts cleaning, and other chemicals. The seepage pits were constructed as open boreholes, often lined with brick, that were designed to have liquids seep directly into the soils. Seepage pits are located primarily in the eastern/northeastern portion the JPL facility.

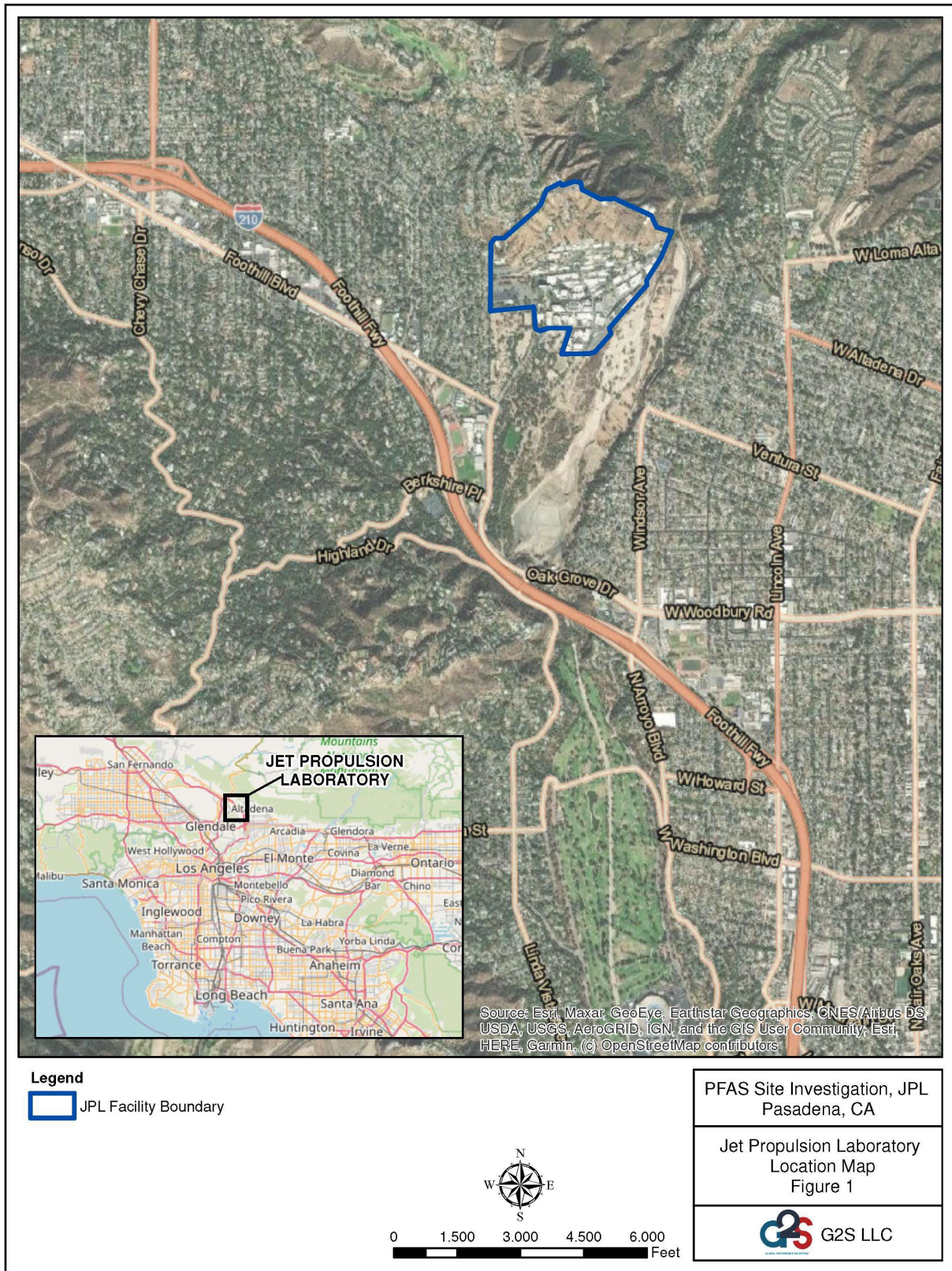


Figure 1. Site Location Map

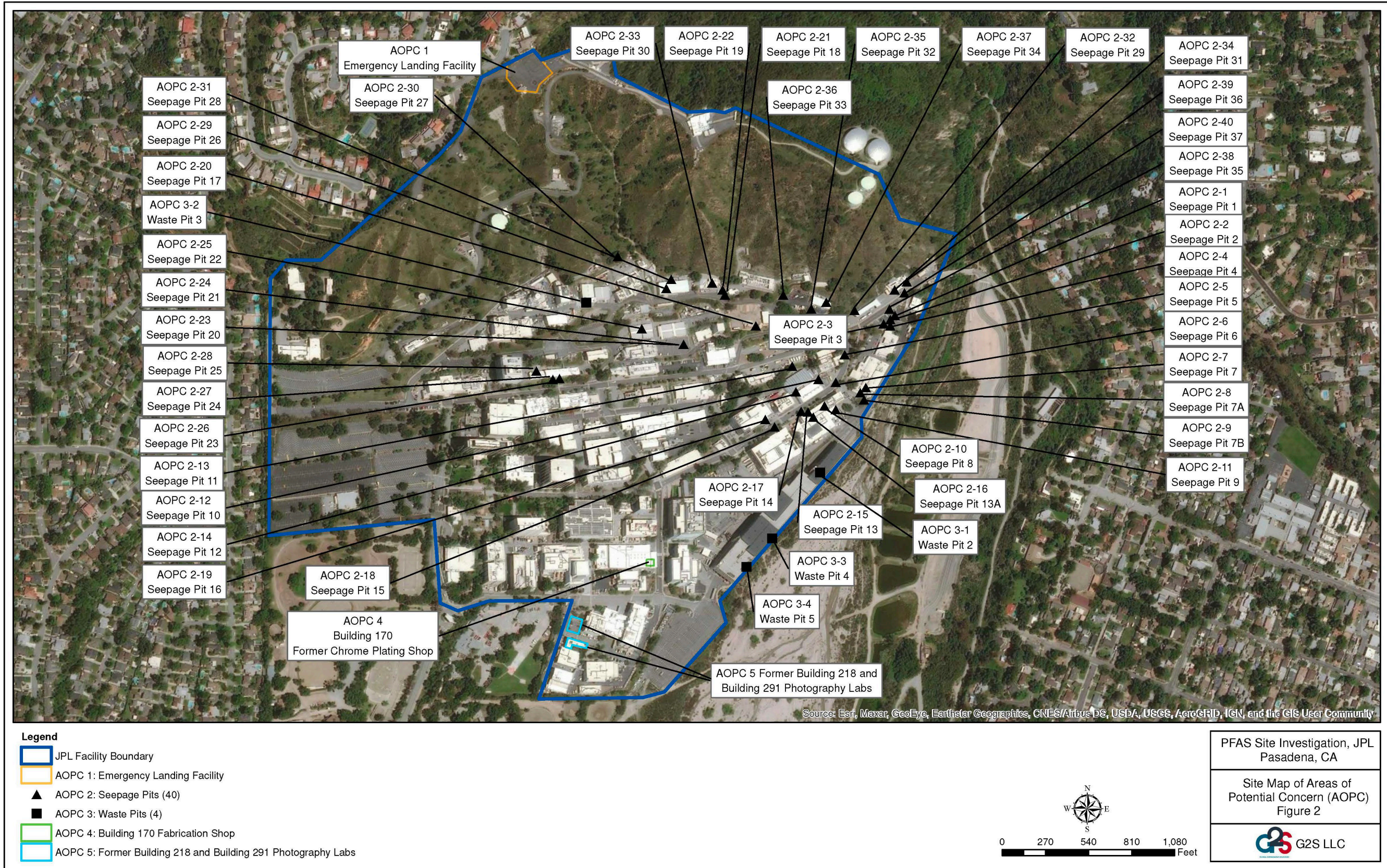


Figure 2. Site Map of AOPCs

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The waste pit disposal areas were located along what was the boundary between JPL and the Arroyo Seco at the time, but they currently fall within the JPL boundary. One additional waste disposal area was documented to the south of Former Building 45. Waste pits were used from 1945 to 1960 to dispose of materials such as wood, glass, metal parts and shavings, drums of chemical wastes, and other hazardous and municipal wastes and were designed as open, bermed areas that were later backfilled.

2.1.3 AOPC 4: Building 170 Fabrication Shop

Building 170 houses the Fabrication Shop and is in the southern portion of JPL between Mariner Road and Forestry Camp Road.

2.1.4 AOPC 5: Former Building 218 and Building 291 Photography Labs

Former Building 218 was located in the southern portion of JPL directly west of current Building 202. Building 291 is located in the southern portion of JPL.

2.2 Site History

JPL is a NASA facility for research and development of space exploration, including rocket propellant design and testing, spacecraft material and equipment design, assembly and testing, and research related to alternative energy sources and pollution control (Ebasco Services, Inc. [Ebasco], 1988). JPL was originally founded in 1944 in partnership with the Guggenheim Aeronautical Laboratory at the California Institute of Technology (GALCIT) and the U.S. Army to develop rocket-based weapons, guided missiles, and solid rocket propellant. Activities at JPL supported the launch of the U.S.'s first satellite in 1958. In recent decades, JPL has functioned as NASA's primary center for unmanned interplanetary exploration and assists with aeronautical research and development (Ebasco, 1988). (Tetra Tech, 2021).

The history of each AOPC being investigated as part of the PFAS SI is provided below.

2.2.1 AOPC 1: Emergency Landing Facility

According to the 2021 PAR, the current heliport area was paved and housed antennae by 1964. In addition, aerial photographs reviewed during the PA indicate that the heliport may have been present as early as 1972 but didn't appear on a site map until 1986. Aqueous film-forming foam (AFFF) was stored in Building 242A (covered shed adjacent to the helipad and Building 243) to support emergency response for a potential helicopter fire. The PAR found limited information regarding the type of AFFF stored or the period during which the AFFF was stored in Building 243A. They learned of a one-time training exercise was conducted by JPL and the LACoFD during which AFFF was applied on the helipad. The PA was unable to determine the timing of the exercise through records review, but interviews indicated it was before 2010. Once the training exercise was completed, the AFFF was washed from the helipad and directed to the southern edge of the helipad toward the sloped edge of the mesa. The AFFF-containing wash water may have been diverted through a storm drain at the southwestern corner of the helipad, which empties downslope in a catchment drain at the bottom of the hill and/or it may have washed down the side of the mesa south of the Emergency Landing Facility. AFFF containing wash water from the uphill mesa could have potentially entered storm drain inlets located on the slope of the mesa below the southern edge of the helipad. These inlets appear to ultimately discharge to the off-Site Arroyo Seco (Tetra Tech, 2021).

2.2.2 AOPC 2 and 3: Waste Disposal Areas (Seepage Pits and Waste Pits)

When JPL was operated by GALCIT and the U.S. Army, 40 seepage pits (collectively AOPC 2) and 4 waste pits (collectively AOPC 3) were used for liquid and solid waste disposal. The seepage pits were used from approximately 1945 to 1960 to dispose of a variety of liquid wastes associated with laboratory operations, including sanitary wastes, solvents, paints, wastewater from parts cleaning, and other chemicals. The waste pits were used within the same period to dispose of materials such as wood, glass,

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metal parts and shavings, drums of chemical wastes, and other hazardous and municipal wastes and were designed as open, bermed areas that were later backfilled. The seepage pits were constructed as open boreholes, often lined with brick, that were designed to have liquids seep directly into the soils. Plumbing from sinks and drains in the buildings at JPL were piped directly to the seepage pits. Many seepage pits also had cleanouts outside the building where liquids could be dumped directly into the pits. Historical operations in buildings connected to various seepage pits include propellant preparation and testing, and laboratories for hydraulics and solid fuels. The exact materials that were disposed into seepage pits were not well documented but based on historical operations at JPL and the period of seepage and waste pit use, it is possible that PFAS-containing materials were also disposed in AOPCs 2 and 3 (Tetra Tech, 2021).

2.2.3 AOPC 4: Building 170 Fabrication Shop

Building 170 was constructed in the early 1960s and expanded in the late 1960s or early 1970s. A small metal plating shop was formerly located within the southeast portion of the building that was used for electroplating and chrome plating as recently as the early 1990s. Liquids used in the plating process were reportedly discharged to a floor drain in the plating room and passed through a below-ground clarifier on the southern side of Building 170 prior to discharge to the sanitary sewer. The room housing the plating shop was renovated in 2016 and the floor was raised, covering the floor drain with wooden floorboards. The room is currently used to wash and clean parts made in the fabrication shop (Tetra Tech, 2021).

According to the USEPA, PFAS were used as a surfactant, wetting agent, and mist suppressing agent for chrome plating, and PFAS were used to improve the quality of electroless plating of copper and stabilize coating baths for depositing nickel-boron layers. Further, the USEPA identified PFAS use to treat metal surfaces to prevent corrosion, reduce mechanical wear, and enhance aesthetic appearance. Lastly, machine parts were at times cleaned after nickel plating with a solution containing PFOS. Therefore, Building 170 was identified as an AOPC based on potential use of PFAS in the fabrication shop.

2.2.4 AOPC 5: Former Building 218 and Building 291 Photography Labs

Former Building 218 and current Building 291 formerly housed photography labs. Former Building 218 was constructed in the late 1960s or early 1970s and demolished sometime between 2015 and 2018. Building 291 was constructed in the late 1960s or early 1970s. Building 291 was also titled Procurement Services (1970s and 1980s) and Compensation (1990s and possibly early 2000s). No information regarding the operational period of or details about the activities in the photography labs was found during the PA (Tetra Tech, 2021). These buildings were identified as an AOPC due to their potential to house photolithology processes and the use of PFAS in photographic solutions.

2.3 Past Site Investigations

Numerous environmental investigations pertaining to OU1, OU2 and OU3 have been carried out under the CERCLA program and are available on the NASA JPL electronic repository of related documents available at <http://jplwater.nasa.gov>.

A groundwater monitoring program has been in place at JPL since August 1996 and has been expanded as the number of monitoring wells was also expanded. Currently the monitoring program is made up of 25 monitoring wells and 82 different sampling points. JPL monitoring wells are sampled on a quarterly basis to maintain a comprehensive understanding of the subsurface conditions within OU1 and OU3 groundwater (Tetra Tech, 2021). PFAS analyses have not been conducted on any of the JPL groundwater monitoring wells. PFAS analyses have not been conducted on samples collected from the OU1 system.

LAWC sampled LAW Well No. 6 in 2018 for six PFAS: perfluorooctanoic acid (PFOA), perfluorooctane sulfonate (PFOS), perfluorobutanesulfonic acid (PFBS), perfluorohexane sulfonate (PFHxS), perfluoroheptanoic acid (PFHpA), and perfluorononanoic acid (PFNA). No PFAS were

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detected above laboratory reporting limits, which were 0.020 micrograms per liter ($\mu\text{g/L}$) for PFOA, 0.040 $\mu\text{g/L}$ for PFOS, 0.090 $\mu\text{g/L}$ for PFBS, 0.030 $\mu\text{g/L}$ for PFHxS, 0.010 $\mu\text{g/L}$ for PFHpA, and 0.020 $\mu\text{g/L}$ for PFNA.

Pasadena Water and Power (PWP) sampled untreated groundwater from Arroyo Well and Well 52 in April and May 2020 for the same six PFAS. PFBS was detected in Arroyo Well at 0.0032 $\mu\text{g/L}$ (April) and 0.0031 $\mu\text{g/L}$ (May). In April, PFBS and PFHxS were detected in Well 52 at 0.0031 $\mu\text{g/L}$ and 0.0020 $\mu\text{g/L}$, respectively. No other PFAS were detected in Arroyo Well and Well 52 above the laboratory reporting limits, which were 0.0020 $\mu\text{g/L}$ for all six PFAS. The April and May 2020 detections of PFBS and PFHxS are below the May 2022 tap water USEPA Regional Screening Levels (RSLs) of 0.6 $\mu\text{g/L}$ and 0.039 $\mu\text{g/L}$, respectively.

In June 2022, the USEPA issued revised interim health advisories for PFOA and PFOS that replace those EPA issued in 2016. The interim health advisory levels are 0.000004 $\mu\text{g/L}$ for PFOA and 0.00002 $\mu\text{g/L}$ for PFOS. In addition, the USEPA issued final health advisories for PFBS and hexafluoropropylene oxide dimer acid (HFPO-DA; referred to as GenX). The final health advisory levels are 2.0 $\mu\text{g/L}$ for PFBS and 0.010 $\mu\text{g/L}$ for GenX.

A PA for PFAS was carried out for JPL and was completed in 2021. The PA involved extensive records review, interview of key JPL personnel, a Site visit, development of an initial CSM and recommendations of AOPCs for further assessment.

3 ENVIRONMENTAL SETTING

The following sections provide information regarding the environmental setting for JPL including the climate, topography and surface features, geology, hydrogeology, surface water features, and land-use. The information in this section is drawn from Section 3 of the JPL PFAS PAR and provides a baseline of information to support the development of the PFAS SI Work Plan, the execution of the PFAS SI field activities, and the context to interpret future results and findings.

3.1 Climate

JPL is located in an area with a Mediterranean climate at an elevation of 1,100 ft above sea level. The average temperature over the course of a year in Pasadena is 64 degrees Fahrenheit (°F). The average summer high is 88°F with a winter low of 46°F. Summers are hot, arid, and clear, whereas winters are cool, wet, and partly cloudy. JPL receives approximately 21 inches of rain a year, with most of the precipitation received between November and April. The majority of rainfall occurs in February, with an average of 3.2 inches of rain over the course of the month. (Tetra Tech, 2021)

3.2 Topography and Surface Features

JPL is located in Los Angeles County, California, encompassing approximately 176 acres in the San Gabriel Mountains east of the City of Los Angeles (Figure 3). JPL consists of office buildings, laboratories, and other facilities related to propulsion research and development. The JPL property is divided into two main areas: a relatively undeveloped northern area and the main campus, which encompasses the remainder of the property. Elevations of JPL range from approximately 1,080 to 1,280 ft above mean sea level (amsl) within the main campus to 1,560 ft amsl near the northern boundary. Steep hills and slopes generally separate the northern portion from the main JPL campus. Hills continue from the base of the high elevation northern portion of JPL down into and throughout the main campus, ultimately leveling off to the south/southeast. A mesa is present in the northern area of JPL, and a helipad for emergency use and radio and antenna testing facilities are located on the mesa. (Tetra Tech, 2021)

3.3 Geology

JPL is located in the far northwestern region of the San Gabriel Valley along the southern flank of the San Gabriel Mountains (Figure 4). The San Gabriel Mountains are part of the Transverse Ranges geomorphic province, which is comprised of east-west trending mountain ranges resulting from north-south compression and deformation (Foster Wheeler Environmental Corporation [FWEC], 1999a; FWEC, 1999b). The San Gabriel Valley, like other valleys in the region, is filled with Quaternary alluvial deposits of Pleistocene to Holocene age (approximately 2.5 million years old [Ma] to present). In the vicinity of JPL, these deposits extend from the ground surface to a depth of approximately 600 to 2,000 feet, depending on proximity to the San Gabriel Mountains and relationship to underlying faults (FWEC, 1999a). These alluvial deposits are typically poorly sorted sands and gravels with some discontinuous lenses of finer (fine sand and silt) and coarser (cobbles and boulders) material. The alluvial deposits overlie the regional basement rock, a leucocratic granodiorite of Cretaceous age (approximately 65 to 122 Ma), which is light gray to buff colored and has a fine- to medium-grained crystalline texture (Dibblee, 1989; FWEC, 1999a). This basement rock also constitutes the San Gabriel Mountains and outcrops in some areas near JPL on steeper slopes on the north end of the Site and along the Arroyo Seco (Dibblee, 1989)

Lithology at JPL is characterized as medium to coarse grained sand and gravel interbedded with fine sands and silts consistent with the regional alluvial deposits (FWEC, 1999a). Relatively thin intervals of cobbles and boulders are present throughout the alluvial sequence and represent higher energy depositional environments (e.g., stream channels). Detailed characterization of the JPL lithology was

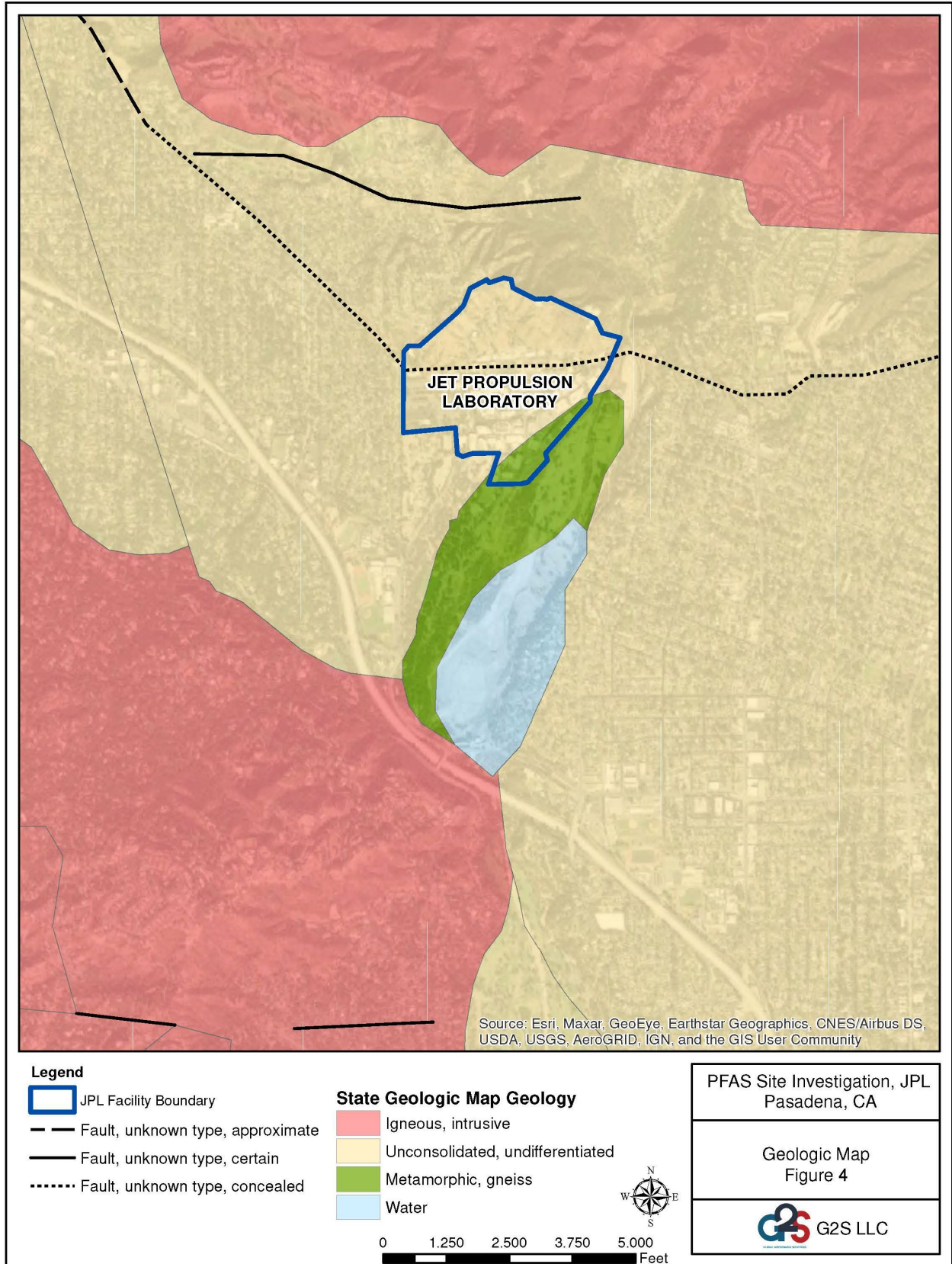


Figure 4. Geologic Map

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conducted during the installation of the on- and off-site monitoring well network at JPL (FWEC, 1999a), and the discontinuous layers of finer grained (silty) material at depth are used to define the aquifer layer boundaries, which are described in section 3.4 below.

Multiple mapped faults are located at JPL and in the nearby area (Dibblee, 1989; FWEC, 1999a; FWEC, 1999b; Morton and Yerkes, 1987). The Tujunga Fault (also referred to as the JPL Thrust Fault) cuts east-west across the main JPL property and other unnamed fault traces run outside the JPL boundary to the north in a similar orientation. These faults are broadly referred to as the Sierra Madre Fault Zone. The JPL Thrust Fault represents a north-south boundary between shallow bedrock and deeper alluvium (NASA, 2018). North of the fault, bedrock occurs within 2 to 100 feet of ground surface, with groundwater primarily present in joints and fractures within the shallow bedrock. Due to its low porosity, this shallow bedrock is considered non-water bearing and separate from the JPL groundwater system (NASA, 2018). Therefore, the bedrock north of the JPL Thrust Fault is not therefore a possible migration pathway for contaminants into the JPL groundwater system (NASA 2018). South of the JPL Thrust Fault, groundwater occurs in the deeper aquifer layers described in Section 3.4 (NASA, 2018). Further to the north in the San Gabriel Mountains, the south branch of the San Gabriel Fault trends northwest-southeast (Tetra Tech, 2021).

3.4 Hydrogeology

JPL is located within a groundwater basin known as the Raymond Basin, which is adjacent to the San Fernando Valley and San Gabriel Valley Basins (State of California Department of Water Resources [DWR], 2004a; DWR, 2004b; DWR, 2004c). Groundwater drawn from the Raymond and San Fernando Valley groundwater basins is used for drinking water in communities surrounding JPL. Drinking water supply wells (also referred to as production wells) in both the Raymond and San Fernando Valley Basins are located within a 4-mile radius of JPL (Appendix B; NASA, 2019b). Based on prior hydrogeologic investigations of the Raymond Basin, there are four distinct aquifer layers in the area surrounding JPL (FWEC, 1999a; FWEC, 1999b; NASA, 2019b): the upper Older Fanglomerate Series; the lower Older Fanglomerate Series; the Pacoima Formation; and the Saugus Formation.

In most areas, only the first three aquifer layers are present; however, in areas where the crystalline basement is deeper, the fourth and deepest alluvial aquifer layer (the Saugus Formation) is present. These aquifers, while similar in their alluvial composition, are defined by observed differences in hydraulic head during pumping of production wells in the vicinity of JPL. The differing responses to pumping at different screen depths, along with subtle differences in geologic composition, have been used to define the aquifer boundaries (FWEC, 1999a; FWEC, 1999b).

The shallowest two aquifers are the upper and lower Older Fanglomerate Series, which are sometimes simply referred to collectively as the Older Fanglomerate Series. These aquifers are present in the Cenozoic basin-filling alluvial deposits described above and underlie the current surface alluvium (FWEC, 1999a). These deposits range in thickness from 300 to 800 feet in the vicinity of JPL. The composition of the alluvial deposits that comprise the Older Fanglomerate Series is similar to that of recent alluvial and stream channel deposits in the area. The Older Fanglomerate Series is subdivided into upper and lower parts based on inferred age and spatial relationship to present-day stream channels. The composition of the upper and lower parts of the series is generally the same, with lithology dominated by fluvial arkosic sands (i.e., sands composed of less than 25 percent [%] feldspar grains) with abundant gravel and boulders. The upper and lower sections of the Older Fanglomerate Series are inferred to be separated, at least locally, by fine-grained (silt-rich) layers of relatively low permeability. As mentioned above, the boundary between the upper and lower Older Fanglomerate has been distinguished based on the hydraulic response to pumping of nearby production wells screened at different depths (FWEC, 1999a; FWEC, 1999b).

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The third aquifer layer is the Pacoima Formation, which lies, in most areas around JPL, unconformably upon the granodiorite basement. In some areas where the regional basement is deeper, the Pacoima Formation lies unconformably atop a fourth alluvial aquifer layer, described below. This formation is characterized by fluvial sands with gravel and boulders and is differentiated from the overlying Older Fanglomerate Series by characteristic dark reddish-orange weathering. This formation is 200 – 300 feet thick in the vicinity of JPL.

The fourth aquifer layer, the Saugus Formation, is present in some areas of the Raymond Basin between the Pacoima Formation and crystalline basement rock. The Saugus Formation is up to 200 feet thick and is composed of arkosic sand with some pebbles and areas that are more conglomeratic. The differentiation of the Saugus and overlying formations is not clearly defined. The formations are generally defined based on the degree of sorting and the composition of lithic clasts in the sediments. Broadly, the Saugus Formation represents a lower-energy depositional environment (e.g., floodplain) relative to the overlying fanglomerate deposits.

Observation and monitoring wells are screened in all four aquifer layers, and groundwater present in the first (shallowest) aquifer layer is considered to be under unconfined conditions. Drinking water supply wells within 4 miles of JPL are also screened within all four aquifer layers. Recharge in the vicinity of JPL occurs naturally through precipitation and through flooding of the Arroyo Seco spreading grounds with water during the rainy season (FWEC, 1999a). In the vicinity of JPL, depth to groundwater in the shallowest aquifer is approximately 200 feet (NASA, 2018), although it ranges between approximately 20 feet and 270 feet due to the steep topography present at JPL and the effects of seasonal groundwater recharge in the Arroyo Seco spreading grounds to the southeast of JPL (Figure 3) and groundwater pumping from the nearby municipal production wells (FWEC, 1999a). Depth to groundwater in monitoring wells located at the northern extent of the Arroyo Seco are typically 80 to 120 feet shallower than the surrounding water table (NASA, 2018). At this location, groundwater mounding attributed to recharge and faulting results in depths to water between approximately 80 and 120 feet (NASA 2018).

Deeper groundwater in the second to fourth aquifer layers may be under semi-confined conditions due to local lenses of fine-grained material separating some layers. These lenses are discontinuous and occur at a range of depths throughout the stratigraphic sequence. The influence of these fine-grained layers on local hydrogeologic conditions is observed in hydraulic head differences in deeper, multi-port monitoring wells (FWEC, 1999a). During periods when production wells are extracting groundwater in the area, hydrographs from multi-port monitoring wells indicate that downward migration of groundwater would be expected. However, in winter months when groundwater extraction is typically paused, the hydraulic head in deeper aquifer layers can temporarily be equal to or above that of shallower aquifer layers in some monitoring wells (FWEC, 1999a). The hydraulic response recorded at the monitoring wells during these pumping events suggests a semi-confined nature for these deeper aquifers; however, vertical hydraulic communication between the aquifers appears to occur given the presence of perchlorate and various VOCs in deeper aquifer layers and the spatially discontinuous nature of the confining layers (FWEC, 1999a; NASA, 2019a). Hydraulic conductivity values were estimated during large-scale pump testing completed in 2001. Horizontal conductivity values were estimated to be 14.4 feet per day (ft/day), 28.2 ft/day, 27.9 ft/day, and 3.9 ft/day in the upper Older Fanglomerate Series, lower Older Fanglomerate Series, Pacoima Formation, and Saugus Formation, respectively. Vertical conductivity between the upper and lower Older Fanglomerate Series was estimated at 0.0092 ft/day, between the lower Older Fanglomerate Series and Pacoima Formation at 0.0060 ft/day, and between the Pacoima and Saugus formations at 0.011 ft/day.

The direction of groundwater flow in the vicinity of JPL is dynamic due to the influences of natural seasonal groundwater recharge, groundwater recharge in the Arroyo Seco spreading grounds, and groundwater pumping from municipal production wells in the immediate JPL vicinity, with groundwater

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pumping having the most pronounced influence (FWEC, 1999a). Throughout most of the year, groundwater flow in the aquifers is predominantly to the southeast (NASA, 2019a) towards the pumping City of Pasadena municipal supply wells. The groundwater production wells are typically shut down for a relatively short period of time during the wet, winter season (Section 3.4), during which time the groundwater flow direction has been observed to reverse flow towards the west across JPL. Although the duration of these flow reversal can span multiple weeks, they generally last for only a period of days (FWEC, 1999a). Further, based on measurements of contaminants in JPL monitoring wells there does not appear to be significant contaminant migration to the west (FWEC, 1999a).

Beneficial uses for groundwater in the aquifers of the Raymond and San Fernando Valley Basins have been designated by the Los Angeles Regional Water Quality Control Board (LARWQCB) in their Basin Plan (LARWQCB, 2014). In both the Raymond and San Fernando Valley Basins, beneficial uses exist, and are protected under the Basin Plan, for municipal, industrial service supply, industrial process supply, and agricultural purposes. (Tetra Tech, 2021)

3.5 Surface Water Features

JPL is located in an urban setting, and rainfall in the area is generally captured by engineered storm drain systems. Runoff from the San Gabriel Mountains above JPL is transferred via a network of underground storm drains to the Arroyo Seco. Runoff collected on JPL is directed via a network of underground storm drains that lead to 13 discharge points along the east/southeastern JPL property boundary that outfall to the Arroyo Seco. Some storm drains on JPL are directed to the sanitary sewer, but most are directed to the Arroyo Seco. The largest stormwater discharge outfall from JPL is located at the southeastern corner of Building 349.

The Devils Gate Dam is located south of JPL along the Arroyo Seco and north of Interstate 210. The area upstream from the dam along the Arroyo Seco is referred to as Devils Gate Reservoir. Water levels in the reservoir fluctuate throughout the year as rainfall is received and allowed to flow through the dam. Significant portions of the reservoir bed are not inundated with water throughout the year. During wet periods, surface water is periodically diverted to the Arroyo Seco spreading grounds along the eastern banks of the reservoir. These areas serve to provide groundwater recharge to the Raymond Basin. The Arroyo Seco is channelized downstream from the Devils Gate Dam and drains into the Los Angeles River. The main pathways for surface water in the area are downstream or down-system flow in natural or engineered waterways, percolation into alluvial aquifers, and evaporation.

Beneficial uses for Arroyo Seco surface water have been identified in the LARWQCB Basin Plan (LARWQCB, 2014). The designations include existing, intermittent, and potential beneficial uses for different parts of the Arroyo Seco water course; these three categories are to be protected under the Basin Plan. In the immediate vicinity of JPL, beneficial uses are designated for the upper and lower portions of Devils Gate Reservoir along the Arroyo Seco; these include potential (municipal), intermittent (groundwater recharge and municipal), and existing (wildlife habitat) uses. Recreational activities such as swimming and boating are not among the beneficial uses identified for the Arroyo Seco waterway in the vicinity of JPL. (Tetra Tech, 2021)

3.6 Land Use

JPL is a NASA facility for research and development of space exploration, including rocket propellant design and testing, spacecraft material and equipment design, assembly and testing, and research related to alternative energy sources and pollution control (Ebasco Services, Inc. [Ebasco], 1988). In recent decades, JPL has functioned as NASA's primary center for unmanned interplanetary exploration and assists with aeronautical research and development (Ebasco, 1988). The area of JPL is zoned as Public/Semi-Public (City of La Cañada Flintridge, 2016). There is no residential use of the property.

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The land use within a 1-mile radius of JPL is residential, recreational, and commercial. The Los Angeles County Fire Camp #2 (a Los Angeles County-operated station established to respond to fires, floods, and other natural or manmade disasters) and the Hahamongna Watershed Park are located adjacent to and south of JPL. Potentially sensitive receptors located within a 1-mile radius of JPL include 42 daycare centers, 4 schools (public and private), 6 schools/day care centers, 1 community center, and the Angeles National Forest (Tetra Tech, 2021).

4.1 Conceptual Site Model

A CSM is an essential engineering management tool that helps the project team successfully manage a site through the investigation and remediation process. A comprehensive and dynamic CSM includes background information, geologic and hydrogeologic data, contaminant source, distribution, and fate and transport data, and risk assessment information (United States Army Corps of Engineers [USACE], 2012) and should be updated as more information is collected about a site. The information that serves as the basis of the CSM is included in Sections 2 and 3. Data collected as part of this SI will be used to update and refine the CSM.

4.1.1 Potential Contaminant Sources

Available data indicate that the potential contaminant sources for PFAS at JPL are associated with four AOPCs identified as AOPC 1 through AOPC 4. AOPC 1 consists of an Emergency Landing Facility with a heliport where an AFFF release potentially occurred during a one-time training exercise. AOPC 2 and AOPC 3 consist of 40 seepage pits and four waste pits, respectively, and are considered as a single potential source. The seepage pits, constructed as open boreholes, were historically used to dispose of liquid wastes associated with laboratory operations. The waste pits, historically operated by the City of Pasadena, were constructed as open, bermed areas and used to dispose of various types of solid waste as well as hazardous and municipal wastes. AOPC 4 consists of the Fabrication Shop, identified as Building 170, where chrome plating operations were formerly performed. See Sections 2.2 and 2.3 for further detail on each of the AOPC's and previous PFAS investigations.

4.1.2 Affected Media

Potentially affected media at the Site include surface soil and groundwater associated with AOPC 1 and groundwater associated with AOPCs 2 through 4 related to the potential PFAS contaminant sources identified in Section 4.1.1 above. Low levels of PFBS and PFHxS were detected offsite in untreated groundwater from the PWP extraction wells located downgradient of the Site, as documented in the 2021 PFAS PAR for JPL (Tetra Tech, 2021). It should be noted that the detected PFBS and PFHxS concentrations were below the May 2022 tap water RSLs of 0.6 µg/L for PFBS and 0.039 µg/L PFHxS. The objective of the PFAS SI environmental investigation at JPL is to determine whether groundwater and surface soils in the respective AOPCs are affected media.

Soil gas is not included as an affected media since PFAS are not considered to be volatile nor are airborne particulates from potentially impacted soil considered to be a significant source of PFAS (Tetra Tech, 2021).

4.1.3 Potential Human Receptors and Exposure Pathways

Potential exposure pathways related to groundwater associated with potential PFAS releases from JPL sources would likely be limited to the drinking water wells located downgradient to the southeast of the facility. Hydrogeologic investigations have identified four distinct aquifer layers in the basin, which has been impacted by other contaminants of concern released at JPL. Any infiltration occurring from the seepage or waste pits through the highly permeable vadose zone would have most likely impacted the shallow aquifer at locations on or near the Site.

The lower three aquifer units have been observed to be semi-confined based on previous testing and observations; however, other contaminants of concern released at JPL have been found at the highest concentrations in the intermediate aquifers. For this reason, these layers could also experience impact by a PFAS release at JPL. The document review performed for the PA indicated the presence of drinking water wells screened in each of the four aquifer layers; however only one well is screened in the deepest

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aquifer. The most likely migration pathway would be towards the drinking water supply wells operated by the City of Pasadena and LAWC. Any further downgradient migration would likely be limited due to the extraction already occurring from these wells. Furthermore, as distance from the facility increases, the likelihood of a complete exposure pathway would decrease.

With regard to potential soil exposure pathways, four AOPCs have been identified where PFAS are known to or could have potentially been released to soil. Most of these locations are either currently covered with pavement or buildings, or residual PFAS in soil would be greater than 2 feet bgs. Where exposed surface soils exist (AOPC1), surface soils will be sampled to evaluate the presence or absence of any potentially remaining PFAS, which if present could result in a complete exposure pathway for on-Site worker receptors. Subsurface soils at AOPC1 do not have a complete exposure pathway and therefore were not included in the SI activities. Should PFAS be found in surface soil above project screening levels, additional sampling may be proposed to determine presence in subsurface soils. In the remaining AOPCs 2 through 4 associated with the waste and seepage pits and chrome plating facility, screening is recommended through the sampling of groundwater at existing monitoring wells to evaluate the potential for the presence of PFAS in both groundwater and soil (Tetra Tech, 2021). The historical waste and seepage pits extended below grade, therefore any potential release would have been directly to subsurface soils and not surface soils. Groundwater is the primary potential exposure pathway of concern at JPL. Rather than sample subsurface soil directly, the SI proposes to sample groundwater because of the demonstrated fate and transport at the site of non-PFAS contaminants, including perchlorate and volatile organic compounds, that have migrated from the waste and seepage pit source areas into groundwater. Given the potential PFAS release would have occurred at the same time and via the same release mechanism, if a release had occurred, detection of PFAS in groundwater would be expected. Should PFAS be found above project screening levels in groundwater, additional sampling may be proposed to determine presence in subsurface soils.

The SI that is the subject of this report will seek to determine the presence or absence of PFAS associated with soil and groundwater at the four AOPCs to provide additional information for the CSM and any likely human exposure pathways and potential impacts.

4.1.4 Potential Ecological Receptors and Exposure Pathways

Potential ecological receptors and exposure pathways were evaluated and documented in the PAR for JPL. There are no surface water bodies within the Site boundaries. The Arroyo Seco, located within a 1-mile radius of the Site, is situated along the eastern and southern sides of JPL and would be the most likely pathway for any potential PFAS releases to reach surface water. Mechanisms for entry into surface water would be through surface water runoff or stormwater discharge.

Potential ecological receptors in the area of the Arroyo Seco and the surrounding habitat were identified in the PAR. The habitat areas identified within a 1-mile radius of the facility are known to be inhabited by sensitive species including several endangered species such as the southwestern willow flycatcher, the Sierra Madre yellow-legged frog, and Nevin's barberry (Tetra Tech, 2021).

The SI that is the subject of this report will seek to determine the presence or absence of PFAS associated with the four AOPCs to provide additional information for the CSM and any likely ecological exposure pathways and potential impacts.

4.1.5 Contaminants of Potential Concern

Contaminants of potential concern (COPCs) are contaminants that based on the potential contaminant sources may be present at the Site or based on existing data for the Site are known to be present at the Site that may contribute to risk or adverse effects to potential receptors. For the purposes of this CSM and SI Work Plan, COPCs are limited to the PFAS compounds which are the subject of this inspection.

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The 2021 PAR provides existing data for PFAS compounds that have been obtained from the sampling of existing monitoring wells in 2018 and 2020. Analyses in 2018 and 2020 were limited to the following PFAS compounds:

- Perfluorooctanoic acid (PFOA)
- Perfluorooctane sulfonate (PFOS)
- Perfluorobutanesulfonic acid (PFBS)
- Perfluorohexane sulfonate (PFHxS)
- Perfluoroheptanoic acid (PFHpA)
- Perfluorononanoic acid (PFNA)

The only detections at or above the laboratory detection limit of 0.0020 ug/L were for PFBS and PFHxS. The highest concentration of PFBS (0.0032 µg/L) detected in Arroyo Well in April of 2020 was below the USEPA RSL of 0.6 µg/L. The highest concentration of PFHxS (0.0020 µg/L) detected in Well 52 in April 2020 was below the USEPA RSL of 0.039 µg/L.

The regulatory status and analytical methods associated with PFAS compounds continue to evolve rapidly. For the purpose of this PFAS SI, analysis of 32 PFAS compounds will be included as presented in Table 1. This list encompasses PFAS compounds from the California State Water Resources Control Board's (SWRCB's) Order for the Determination of the Presence of Per- and Polyfluoroalkyl Substances at Publicly Owned Treatment Works (SWRCB, 2020), the SWRCB's Order for the Determination of the Presence of Per- and Polyfluoroalkyl Substances at Chrome Plating Facilities (SWRCB, 2019), and compounds listed in Department of Defense (DoD) Quality Systems Manual (QSM) 5.3 Table B-15 (DoD, 2019). Where applicable, analytical results will be compared to USEPA RSLs from May 2022 (USEPA, 2022) and California Water Boards Notification Levels as detailed in Worksheet #15 of the UFP-QAPP included as Appendix A.

Table 1. SI List of PFAS Compounds

Analyte	CAS Number	CA POTW Order	CA Chrome Plating Order	DoD QSM 5.3 Table B-15
		31 compounds	25 compounds	24 compounds
FTS 4:2	757124-72-4	X	X	X
FTS 6:2	27619-97-2	X	X	X
FTS 8:2	39108-34-4	X	X	X
N-ETFOSAA	2991-50-6	X	X	X
N-MEFOSAA	2355-31-9	X	X	X
PFBA	375-22-4	X	X	X
PFBS	375-73-5	X	X	X
PFDA	335-76-2	X	X	X
PFDOA	307-55-1	X	X	X
PFDS	335-77-3	X	X	X
PFHPA	375-85-9	X	X	X
PFHPS	375-92-8	X	X	X
PFHXA	307-24-4	X	X	X
PFHXS	355-46-4	X	X	X
PFNA	375-95-1	X	X	X
PFNS	98789-57-2			X
PFOA	335-67-1	X	X	X
PFOS	1763-23-1	X	X	X
PFOSA	754-91-6	X	X	X
PFPEA	2706-90-3	X	X	X
PFPEs	630402-22-1	X	X	X
PFTEDA	376-06-7	X	X	X
PFTRDA	72629-94-8	X	X	X
PFUDA	2058-94-8	X	X	X
HFPO-DA (GenX)	13252-13-6	X		
11-CI-PF3OUdS	763051-92-9	X	X	

Analyte	CAS Number	CA POTW Order	CA Chrome Plating Order	DoD QSM 5.3 Table B-15
		31 compounds	25 compounds	24 compounds
9-CI-PF3ONS	756426-58-1	X	X	
ADONA	919005-14-4	X		
N-ETFOSA	4151-50-2	X		
N-ETFOSE	1691-99-2	X		
N-MEFOSA	31506-32-8	X		
N-MEFOSE	24448-09-7	X		

4.2 SI Objectives

The PFAS SI at JPL is part of NASA Headquarters efforts to identify whether past or present activities at 10 NASA Centers/Facilities have resulted in the release of PFAS into the environment. The Site-specific objectives for JPL are driven by the recommendations from the PAR for the facility and are as follows:

- Investigate the presence or absence of PFAS at or associated with four AOPCs recommended in the PAR for further assessment.
 - AOPC 1: Emergency Landing Facility
 - AOPC 2 and 3: Waste Disposal Areas (Seepage pits (40) and waste pits (4) comprising AOPC 2 and AOPC 3 respectively are considered as a single potential source)
 - AOPC 4: Building 170 Fabrication Shop
 - AOPC 5: Former Building 218 and Building 291 Photography Labs
- Collect groundwater samples from multiple existing monitoring wells within and downgradient of JPL to assess presence or absence of PFAS in groundwater at or associated with AOPC 1, 2, 3, 4, and 5.
- Collect soil samples at two intervals (0 to 0.5 ft and 0.5 to 2 ft bgs) to assess presence or absence of PFAS in soil at or associated with AOPC 1.

4.3 SI Approach

The PFAS SI objectives for the Site will be met through field inspection activities involving the collection of groundwater samples from existing monitoring wells and the collection of soil samples.

- The approach to sampling groundwater in association with AOPC 1 will be to sample two wells (MW-4 and MW-16) at various depth intervals and analyze samples for the full suite of COPCs as identified in Section 4.1.5. Locations coincide with the stormwater conveyance from the potential release (MW-4) and downgradient of the downstream stormwater outfall (MW-16) as detailed in Table 2 and Figure 6.
- The approach to soil sampling is to sample surface soils from six locations at two depths (0-0.5 and 0.5-2.0 ft bgs) adjacent to the helipad and, if accessible (see Section 5.2 for further discussion), in the depression below the helipad in AOPC 1 as shown in Figure 5 for the full suite of COPCs as identified in Section 4.1.5.
- The approach to groundwater sampling in association with AOPCs 2 and 3 is to sample six existing monitoring wells (MW-4, MW-16, MW-12, MW-15, MW-17, and MW-24) at various depth intervals and analyze samples for the full suite of COPCs as identified in Section 4.1.5. Locations as shown in Figure 6 include areas downgradient of waste and seepage pits, downgradient of the Site, as well as a historical source area associated with the JPL Superfund Site as described in Table 2.
- The approach to groundwater sampling associated with AOPC 4 will be to sample one well (MW-4) at various depth intervals and analyze samples for the full suite of COPCs as identified in Section 4.1.5. The selected location as shown in Figure 6 is downgradient of the building associated with former chrome plating operations.

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- The approach to groundwater sampling associated with AOPC 5 will be to sample one well (MW-5) and analyze samples for the full suite of COPCs as identified in Section 4.1.5. The selected location as shown in Figure 6 is downgradient of Former Building 218 and Building 291.

Table 2 summarizes the SI Approach and sampling rationale to address data needs at the Site. The proposed soil sampling locations for AOPC 1 are shown in Figure 5, and the proposed groundwater sampling locations for AOPC 1 through AOPC 4 are shown in Figure 6. It should be noted that the sample collected from MW-16 and the samples collected from the four discrete depths of MW-4 will be used in the evaluation of multiple AOPCs as indicated in Table 2. Field activities are described in further detail in Section 5.0. Sampling design and rationale is provided in Worksheet #17 of the Uniform Federal Policy-Quality Assurance Project Plan (UFP-QAPP) (Appendix A).

Once laboratory analysis is complete and data have been validated, any PFAS detections will be compared with the project screening levels established in the UFP-QAPP Worksheet #15. For groundwater, project screening levels are based on the California Water Boards Notification Levels. For soils, the project screening levels are based on the USEPA RSLs. Should groundwater detections exceed the project screening levels, additional monitoring or investigation of PFAS may be completed. Should any groundwater and/or soil detections exceed the USEPA RSLs, consideration of the magnitude and frequency of detections will serve as the basis for a decision as to if the site moves forward from the SI phase to the remedial investigation phase.



Figure 5. AOPC 1: Proposed Soil Sampling Locations.

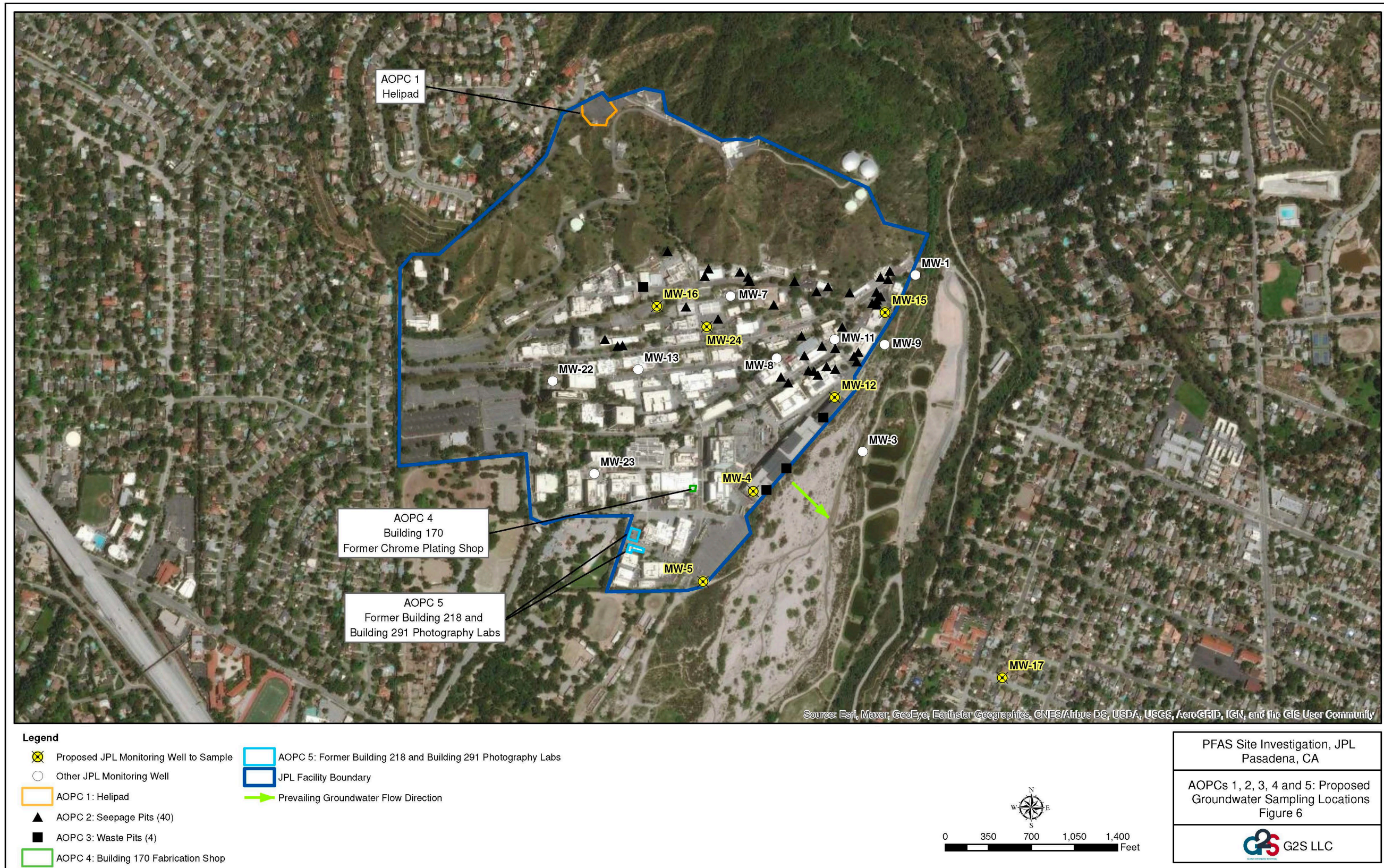


Figure 6. AOPCs 1, 2 and 3, 4, and 5: Proposed Groundwater Sampling Locations

Table 2. SI Approach Summary for the Jet Propulsion Laboratory

Area of Potential Concern	Location	Number of Samples	Rationale
AOPC 1: Emergency Landing Facility Soil	3 locations adjacent to and 3 locations downgradient of heliport	12 samples (0-0.5 and 0.5-2.0 ft bgs at each of 6 locations)	Determine presence or absence of PFAS in surface soils adjacent to the helipad where an AFFF release occurred during a one-time AFFF training exercise (may have washed off the helipad at the end of training).
AOPC 1: Emergency Landing Facility Groundwater	MW-4	4 depths/screens	Determine presence or absence of PFAS in Site groundwater adjacent to stormwater conveyance from the AFFF release area to the largest stormwater outfall.
	MW-16	1 depth	Determine presence or absence of PFAS in groundwater downgradient of the AFFF release near the downstream stormwater outfall.
AOPCs 2 and 3: Waste Disposal Areas Groundwater	MW-4	4 depths/screens	Determine presence or absence of PFAS in groundwater downgradient of the area associated with multiple waste pits.
	MW-16	1 depth	Determine presence or absence of PFAS in groundwater downgradient of Waste Pit 3.
	MW-12	5 depths/screens	Determine presence or absence of PFAS in groundwater downgradient of the area associated with multiple seepage and waste pits.
	MW-15	1 depth	Determine presence or absence of PFAS in groundwater within the perched aquifer adjacent to the area of former seepage pits.
	MW-17	5 depths/screens	Determine presence or absence of PFAS in groundwater downgradient of JPL in the vicinity of City of Pasadena wells Arroyo Well and Well 52.
AOPC 4: Building 170 Fabrication Shop Groundwater	MW-4	4 depths/screens	Determine presence or absence of PFAS in groundwater downgradient of former chrome plating operations at Building 170.
AOPC 5: Former Building 218 and Building 291 Photography Labs Groundwater	MW-5	1 depth	Determine presence or absence of PFAS in groundwater downgradient of photography labs for Former Building 218 and Building 291.

Field activities described in this Work Plan include the areas both within and beyond the Site boundary as required to determine the presence or absence of PFAS associated with the identified AOPCs. These field activities include mobilization, soil sampling, groundwater sampling and associated health and safety monitoring, QA/QC activities, and disposal of IDW.

G2S will establish Site controls to ensure that any site inspection activities do not temporarily or permanently impact or contaminate the project Site or surrounding area. G2S will be responsible for decontaminating all equipment and/or tools, removing any temporary facilities, and restoring all areas impacted by Site activities. The anticipated PFAS SI field program is summarized in the sections below. All field activities will be executed in accordance with the UFP-QAPP and the APP/SSHP included as Appendix A and Appendix B of this document.

5.1 Mobilization

Following coordination with JPL regarding Site access and schedule, G2S will mobilize a team, including support vehicles, equipment, and materials, to complete the investigation. Proposed soil sampling locations will be marked and coordinated with any relevant entities prior to commencement of ground-intrusive activities. Given the limited number and shallow depth of soil samples associated with the inspection, the presence of underground utilities is not expected to impact sampling activities.

Notifications will be provided to the appropriate entities prior to sampling any offsite groundwater monitoring wells. Once field activities are complete, G2S will demobilize from the Site removing all equipment and materials brought onto the site.

5.2 Soil Sampling

Soil sampling will be conducted in accordance with the UFP-QAPP presented in Appendix A and the procedures described in this section. Sampling includes the collection of six soil samples from the southern edge of the helipad at AOPC 1 and six samples from the depression below the helipad (contingent upon accessibility). The exact sample locations will be as close as possible to the proposed locations; however, final locations will be based on an on-site evaluation of the physical features and the ability to access the proposed locations. If a sample cannot be collected where planned, the decision process for changing the location of a soil sample will involve the site supervisor coordinating with the project manager to ensure the alternative proposed location meets the sampling objectives of the initial location. Samples will be collected from three locations at each of the respective areas from depths of 0 to 0.5 ft bgs and 0.5 to 2.0 ft bgs at each location. Proposed sampling locations are shown in Figure 5. Each of the samples will be analyzed for the PFAS compounds identified in Section 4.1.5 by liquid chromatography-mass spectrometry (LC/MS/MS) and according to the quality control procedures included in Section 5.4.

Due to the shallow nature of soil samples being collected, sample collection will take place via hand-auger at the designated locations. An experienced G2S field geologist will log soils encountered during sampling activities. The field geologist will visually inspect, classify, and log the soil samples retrieved from the boreholes according to the Unified Soil Classification System (USCS). Photoionization detector (PID) readings will be taken and recorded in the boring log. The PID will be calibrated daily or when conditions warrant recalibration. Lithologic descriptions of the soils will be recorded and will include, as applicable, the following information: physical characterization and grain-size distribution of the sample, stratigraphic boundaries, color changes, thickness of individual units, samples or cuttings collected, odor, and any other conditions encountered. The Global Positioning System (GPS) coordinates of each soil

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sampling location will be recorded using a Trimble GeoXH 6000 handheld unit (or equivalent), with accuracy of less than 1 meter (real time).

All sampling equipment will be decontaminated between sample locations. Expendable materials will be used to the maximum extent possible to reduce decontamination requirements and to minimize the potential for cross-contamination between sampling locations. Because of the low detection limits and the relatively high potential for cross-contamination of PFAS compounds, additional precautions need to be taken during sampling as described in detail in SOP No. 5 Soil Sampling for Chemical Analysis (PFAS Specific), Attachment B of the UFP-QAPP (Appendix A). These procedures should be reviewed carefully by all individuals involved in sample collection prior to initiating field activities. Once collected, each sample will be labeled with a unique sample identification, chilled, and shipped under chain-of-custody to an Environmental Laboratory Accreditation Program (ELAP)-certified laboratory.

5.3 Monitoring Well Sampling

Groundwater samples will be collected from existing NASA groundwater monitoring wells located both onsite and downgradient of the JPL site as part of the SI. NASA's monitoring well network consists of a total of twenty-five (25) wells, fifteen (15) of which contain multiple screened intervals (e.g., Westbay® multiport wells) and the remaining ten (10) are shallow standpipe wells with single screened intervals and dedicated submersible pumps. The sampling will be conducted in accordance with the UFP-QAPP presented in Appendix A and the procedures described in this section. Sampling includes the collection of groundwater samples from varying depths at six locations (Table 2). These wells include shallow standpipe wells MW-15 and MW-16, and Westbay® multiport wells MW-4, MW-12, MW-17, and MW-24. Each of the samples will be analyzed for the PFAS compounds identified in Section 4.1.5 by LC/MS/MS and according to the quality control procedures included in Section 5.4.

As the well cover for each monitoring well is removed, the air in the breathing zone will be monitored with a PID or equivalent to ensure that escaping VOCs do not pose an adverse health effect to the field sampling team. The instrument will be calibrated in accordance with the manufacturer's requirements. Calibration data will be recorded in the instrument use log.

Since two different well types will be sampled for PFAS compounds groundwater level measurements and sampling procedures are described separately below. Section 5.3.1 covers sampling of shallow standpipe wells and section 5.3.2 covers sampling of the Westbay® wells.

5.3.1 Shallow Monitoring Wells

Two shallow groundwater monitoring wells will be sampled as part of NASA's SI. These two wells are traditional monitoring wells constructed of a single blank casing and screen installed within a single borehole. MW-15 is constructed with a 4-inch diameter stainless steel blank casing to a depth of 19.00 ft bgs and stainless-steel screen interval from 19.00 to 69.00 ft bgs. The screen length is 50.00 feet, and the screen slot size is 0.010-inch. MW-16 constructed with a 4.5-inch diameter schedule 80 PVC blank casing to a depth of 230.00 ft bgs and stainless-steel screen interval from 230.00 to 280.00 ft bgs. The screen is 50.00 feet in length and the screen slot size is 0.010-inch. Both wells were designed to intersect the groundwater table with screen lengths to account from seasonal groundwater level fluctuations.

5.3.1.1 Dedicate Submersible Pump Removal

The shallow groundwater monitoring wells are equipped with dedicated Grundfos® Redi-Flo submersible pumps. Since these pumps may contain Teflon® components, they will be removed from the wells a minimum of one month prior to PFAS sampling.

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5.3.1.2 Groundwater Level Measurement

Groundwater-level measurements will be taken from each shallow monitoring well before purging is initiated. The groundwater will be allowed to equilibrate with atmospheric conditions for approximately 5 minutes before taking water level measurements. A permanent reference mark is scribed onto the top of the casing to provide a consistent reference point from which all levels are measured. Depth to water (DTW) measurements will be taken to an accuracy of 0.01 ft using a water level probe and will be decontaminated prior to measuring at other monitoring wells. The measurements will be checked by slowly raising and lowering the tape and watching the instrument response. The measurement will be recorded in the field logbook. The G2S SOP No. 1 Water Level Measurement (PFAS Specific) is provided in Attachment B of the UFP-QAPP (Appendix A).

5.3.1.3 Low Flow Groundwater Sampling

Prior to sampling, the shallow monitoring wells will be purged using the low flow/minimal drawdown method. In this method the well will be purged with a PFAS-free non-dedicated bladder pump (i.e., QED Well Wizard Zero) set at the middle of the water column (i.e., midpoint between the static water level and total well depth). The well will be purged at a rate between 0.2 to 0.5 liter per minute that minimizes drawdown to less than 0.33 feet. Water quality parameters will be measured at the start of purging and then every three to five minutes thereafter. The well will be purged until water quality parameters have stabilized. Stabilization is achieved after three consecutive readings within:

- ± 0.1 units for pH
- ± 10 millivolts for oxidation-reduction potential (ORP)
- ± 0.2 mg/L for dissolved oxygen (DO)
- $\pm 3\%$ of reading ($\pm 0.2^\circ\text{C}$) for temperature
- $\pm 10\%$ of reading for turbidity
- $\pm 3\text{-}5\%$ of reading for conductivity.

5.3.1.4 Groundwater Sample Collection

Upon parameter stabilization, sampling will be initiated. The sample flowrate will be adjusted to minimize aeration, bubble formation, turbulent filling of sample bottles, or loss of volatiles due to extended residence time in tubing. G2S will collect groundwater samples for laboratory chemical analysis of PFAS compounds. Each sample will be labeled with a unique sample identification, chilled, and shipped under chain-of-custody to an ELAP-certified laboratory

All sampling equipment will be decontaminated between sample locations. Expendable materials will be used to the maximum extent possible to reduce decontamination requirements and to minimize the potential for cross contamination between sampling locations. Because of the low detection limits and the relatively high potential for cross-contamination of PFAS compounds, additional precautions need to be taken during sampling as described in detail in SOP No. 2 Groundwater Sampling (PFAS Specific), Attachment B of the UFP-QAPP (Appendix A). These procedures should be reviewed carefully by all individuals involved in sample collection prior to initiating field activities.

5.3.2 Westbay™ Multiport Wells

Four Westbay™ multiport groundwater monitoring wells will be sampled as part of NASA's SI. These wells allow for the monitoring and sampling of five separate screened intervals within the aquifer from each well. Westbay™ manufactured the multi-port casing systems installed in each of the deep wells and the equipment required to sample each well. Based on information provided by Westbay™, the multi-port systems have been used successfully in California to collect samples for PFAS analysis and no issues with cross-contamination or false positive results have been reported.

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To briefly summarize the deep well sampling procedure, the sampling probe consists of four 250-mL stainless steel tube-shaped containers, linked together with flexible hose, attached beneath an electrically activated valve opening assembly. The entire apparatus is lowered to a sampling port of the desired screen. The sampling port valve is opened by actuating the sampling probe, allowing groundwater from the port to fill the sample collection tubes. The sampling port is then closed, and the sample brought to ground level to be placed in the appropriate sample containers. Throughout sampling of the deep wells, no purging is required before sampling (Foster Wheeler, 1999).

For the purposes of NASA's PFAS SI, four multiport wells with a total of 19 ports (see Table 3) will be sampled (i.e., MW-4 [Screens 1, 2, 4, and 5], MW-12 [Screens 1 – 5], MW-17 [Screens 1 – 5], and MW-24 [Screens 1 – 5]) by Westbay™ trained and certified technicians.

Table 3. Multiport Well Identification, Screened Interval, and Sampling Port Depth

Well ID	Screened Interval (ft bgs)	Sampling Port (ft bgs)
MW-4 (Screen 1)	147 – 157	150.00
MW-4 (Screen 2)	237 – 247	240.00
MW-4 (Screen 4)	389 – 399	392.00
MW-4 (Screen 5)	509 – 519	513.00
MW-12 (Screen 1)	135 – 145	140.00
MW-12 (Screen 2)	240 – 250	243.00
MW-12 (Screen 3)	315 – 325	323.00
MW-12 (Screen 4)	430 – 440	436.00
MW-12 (Screen 5)	546 – 556	548.00
MW-17 (Screen 1)	246 – 256	250.00
MW-17 (Screen 2)	336 – 376	370.00
MW-17 (Screen 3)	466 – 476	468.00
MW-17 (Screen 4)	578 – 588	582.00
MW-17 (Screen 5)	723 – 733	726.00
MW-24 (Screen 1)	275 – 285	279.00
MW-24 (Screen 2)	370 – 380	373.00
MW-24 (Screen 3)	430 – 440	435.00
MW-24 (Screen 4)	550 – 560	554.00
MW-24 (Screen 5)	675 – 685	678.00

5.3.2.1 Westbay™ Pressure Profiling

The multiport wells are constructed with hydraulically isolated ports. Fluid pressure and temperature measurements are made using a portable sampling probe which is a wireline-operated probe that is lowered into the multiport well casing from the land surface and positioned at a selected measurement port coupling. The positioned probe is then coupled with the measurement port inlet valve to allow monitoring of groundwater outside the multiport casing and within the monitoring zone; where groundwater in this zone is vertically isolated between upper and lower packers. Coupling the probe with the measurement port inlet valve is done by extending the backing shoe on the probe to create a hydraulic seal between the probe and the port and to open the port. Fluid pressure and temperature measurements are then transmitted to the land surface through the wireline communication cable, processed using a data acquisition system, and recorded (Fisher and Twining, 2010).

Pressure measurements are used to calculate the depth to water in the multiport wells:

$$H = -D + (P_2 - P_{\text{atm}}) \times 2.307 \text{ ft/pounds per square inch (psi)}$$

Where:

H = depth to water

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D = depth to measurement port

P_{atm} = atmospheric pressure

P2 = pressure measured in the measurement port

The groundwater elevation at each port is calculated from the depth to water and the elevation of the measurement datum:

$$GW_{\text{elev}} = G_s - H$$

Where:

GW_{elev} = ground water elevation

G_s = ground surface elevation (measurement datum)

H = depth to water calculated (first calculation above)

5.3.2.2 Westbay™ Multiport Sample Collection

Fluid samples are obtained by lowering a sampling probe and sample container(s) to the desired measurement port coupling. The sampling probe operates in similar fashion to the pressure probe except that a groundwater sample is drawn through the measurement port coupling. Whenever the sampling probe is operated with the sampling valve closed, it is identical to a pressure probe and supplies the same data. The procedure for collecting a groundwater sample is as follows:

A clean, empty sample container is attached to the sampling probe. The probe and container are prepared (e.g., cleaned and often evacuated) in a manner suited to the specific project and the sampling valve is closed to prevent the fluid inside the Westbay™ casing from entering the sample container. The probe and container are lowered to below the selected measurement port coupling. If a magnetic collar is present, the probe detects the magnetic field, confirming the location of the probe. The location arm is released, the probe is positioned in the measurement port coupling and the fluid pressure inside the Westbay™ casing is recorded.

The probe shoe is activated and pushes the probe against the wall of the coupling so that the face seal on the probe seals around the measurement port valve at the same time as the face of the probe pushes the valve open. The interior passage of the probe is now hydraulically connected to the fluid outside the coupling, but no fluid movement takes place. During this operation the change in fluid pressure is observed at the surface and may be recorded.

The sampling valve in the probe is opened, allowing fluid from outside the measurement port to flow through the probe and enter the sample container. The pressure displayed at ground surface drops and then recovers as the fluid in the container builds to formation pressure. Once the container is full, the sampling valve is closed. The shoe is retracted and the fluid pressure inside the Westbay™ casing is once again recorded. The sampling probe and sample container are then pulled to the surface. The sample is typically transferred to alternate containers for transport and analysis, then the sampling probe and container(s) can be cleaned, and the procedure repeated (Westbay, 2020).

5.4 Sampling Quality Control

The field QC samples will be assigned unique sample numbers and will be submitted to the analytical laboratory. If abnormalities are detected in field QC samples, the data associated with the QC samples will be flagged and appropriate actions will be taken to rectify issues. Table 4 summarizes the QA/QC sampling that will be performed as part of the SI.

Table 4. SI QA/QC Samples

QA/QC Sample ¹	Matrix	Sample ID	Number of Samples	Analysis	Rationale
Field Duplicate Samples	Groundwater	DUP-#MMDDYY	3	PFAS by LC/MS/MS	Assess field and analytical precision and sample heterogeneity
	Soil	DUP-#MMDDYY	2	PFAS by LC/MS/MS	Assess field and analytical precision and sample heterogeneity
Equipment Blanks	Water	EQP-1	1	PFAS by LC/MS/MS	Assess potential sources of cross-contamination from soil sampling
	Water	EQP-2	1	PFAS by LC/MS/MS	Assess potential sources of cross-contamination from monitoring well sampling
Field Blanks	Water	FB-#MMDDYY	TBD (1 per day of sampling)	PFAS by LC/MS/MS	Assess potential ambient contamination in the field or potential cross-contamination as a result of sample handling
MS/MSD	Groundwater	MW-#MS/MSD	2	PFAS by LC/MS/MS	Assess interferences in analytical precision caused by sample matrix
	Soil	MW-#MS/MSD	1	PFAS by LC/MS/MS	Assess interferences in analytical precision caused by sample matrix
Source Blank ¹	Water	SB-#MMDDYY	TBD	PFAS by LC/MS/MS	Confirm the lack of detectable PFAS compounds in source water

Notes:

¹ If water for equipment blanks, field blanks, and sampling equipment is provided by an on-site source rather than the laboratory, the source will be sampled for PFAS by LC/MS/MS compliant with QSM Table B-15 prior to use to confirm lack of detectable PFAS compounds.

Field Duplicate Samples - Field duplicate samples will be collected at a rate of 10% of the total number of groundwater samples during each groundwater sampling event and 10% of the total number of soil samples during each soil sampling event. For all water samples, duplicate samples will be collected by retaining consecutive samples from the sampling device. Duplicate soil samples will be collected by dividing the sample in half and placing each half into separate sample containers for analysis.

Equipment Rinsate Blanks - Equipment rinsate blanks will be collected during soil and groundwater sampling to ensure that nondedicated sampling devices have been decontaminated effectively. Equipment rinsate blanks will consist of the rinse water used in the final step of the sampling equipment decontamination procedure. One rinsate sample will be collected to assess potential sources of cross-contamination from soil sampling, and one rinsate sample will be collected to assess potential sources of cross-contamination from monitoring well sampling.

Field Blanks - Field blank samples will accompany each cooler that contains groundwater samples. There will be one field blank per day of sampling. Field blanks will be prepared at the analytical laboratory by filling volatile organic analysis (VOA) vials with deionized (DI) water. Field blanks are not to be opened in the field. Field blanks indicate whether the field samples have been contaminated during storage and shipping. The results of the field blank analysis will be used to evaluate the field sample data in a manner consistent with the project Data Quality Objectives (DQOs).

MS/MSD – MS/MSD will be analyzed at a rate of 5% of the total number of groundwater samples during each groundwater sampling event and 5% of the total number of soil samples during each soil sampling event.

Source Blanks – If water for equipment blanks, field blanks, and decontamination of sampling equipment is provided by an on-site source rather than the laboratory, source blanks will be collected to ensure that this water is not a source of contamination. Source blank samples will be collected at a frequency of one for each source of water used. If the water source changes, additional source blank

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samples will be collected. To prepare source blanks, the appropriate containers will be filled with source water at the same time that it is used for its intended purpose.

Temperature Blanks - Temperature blank samples will accompany each cooler that contains samples with a temperature preservative requirement. The temperature blank will be prepared either by the analytical laboratory or the field sampling crew by filling VOA vials with DI water. The temperature of the samples will be verified upon arrival at the analytical laboratory using the temperature blank.

5.5 Investigation-Derived Waste (IDW) Management

This section describes the waste-disposal procedures that will be followed during field activities. IDW will be handled in accordance with the NASA Memo entitled PFAS Investigation Derived Waste Disposal dated April 29, 2021 (NASA, 2021) included as Appendix D.

Solid Waste

The limited soils disturbed during the collection of soil samples at six locations to a depth of two feet will be containerized, labeled, and stored onsite pending receipt of analytical results from soil samples. Per the NASA Memo, if PFAS are detected above 0.126 parts per million (ppm), the soils from the respective boring will be disposed of using incineration or by solidification and landfill via U.S. Ecology, unless an alternative option is approved based on site-specific conditions. If there are no exceedances, the soils will be managed according to normal protocols described in detail in SOP No. 6 IDW Management (PFAS Specific), Attachment B of the UFP-QAPP (Appendix A).

Used personal protective equipment (PPE) generated during inspection and sampling activities will be placed in plastic bags and/or drums if visible evidence of contamination is observed. If sampling results indicate that Resource Conservation and Recovery Act (RCRA)-characteristic hazardous wastes exist, the PPE will be disposed of according to RCRA standards. Otherwise, the PPE will be disposed of as ordinary solid waste.

Liquid Waste

Wastewater will be generated from groundwater sampling activities and equipment decontamination processes. Wastewater will be collected in drums and/or tanks. The drums/tanks will be labeled with the well number(s) and date(s) of collection, generator name, point of contact (POC) name, and the POC's phone number. Containers will be stored in a suitable temporary storage area near the OU-1 Source Area Treatment Facility. Wastewater will not be sampled and will be treated at the OU-1 Source Area Treatment Facility located in the north-central portion of the JPL facility.

6 QUALITY ASSURANCE / QUALITY CONTROL

All work performed under this task order will adhere to the site-specific UFP-QAPP (Appendix A) that has been prepared to define a project-specific set of procedures and performance criteria to assure delivery of data that meet the client's expectations, acceptable scientific and engineering standards, and project quality objectives. The G2S QC Manager has responsibility for implementing and overseeing the quality system and ensuring project personnel adhere to corporate and contract-specific QA/QC requirements.

This section presents requirements for field QC documentation and was developed in accordance with applicable federal standards. The objective is to establish the project QC systems by defining the processes and organization that will ensure project activities conform to project objectives. G2S is responsible for QC of work related to the performance of this task order. G2S will implement an effective QC system, consisting of the procedures outlined herein, operations procedures, training, and a defined QC organization.

6.1 Quality Control Responsibilities

The project will use a three-phase control system for all aspects of the work; procedures for scheduling, reviewing, certifying, and managing submittals; control, verification, and acceptance testing procedures; reporting procedures; a list of the definable features of the work; and procedures for tracking deficiencies from identification through acceptable corrective action. The three phases of control include Preparatory, Initial, and Follow-Up phases, which are described in detail in Section 6.4.

It is G2S's policy to allocate personnel with the appropriate training and authority to develop, refine, and implement our quality systems. A QC Manager and sufficient number of additional qualified personnel have been assigned to the project to ensure contract compliance. A qualified member of the QC organization will be at the site at all times during progress of the work and will have complete authority to take any action necessary to ensure compliance with the contract.

6.1.1 Personnel and Respective Authorities

See UFP-QAPP Worksheets #3& 5 and #4, 7, and 8 for responsibilities and authorities of the project.

6.1.2 Subcontractor Management

G2S will maximize project control by retaining program, task order, and site management (safety and QC) functions. Subcontracts will be formulated to reflect the detailed scope, performance objectives, and specifications of the project. Provisions of the basic contract, health and safety requirements, and QA/QC requirements will be 'flowed-down' as appropriate. Other provisions will include strict procedures for implementing subcontractor change orders, expediting dispute resolutions, and implementing corrective actions. Subcontractors may perform work utilizing their own QC procedures provided they are approved by G2S, and consistent with the quality management program outlined in this section.

The performance baseline will be developed jointly with key team subcontractors. Discrete tasks and milestones will be formally entered into the management control system. Performance against the fiscal and project schedule baseline will be monitored informally by the Project Manager on a weekly basis, and formally each month as part of the total project status review and routine progress reporting. The field performance of all subcontractors will be monitored at all times by the Site Supervisor and Site Safety and Health Officer (SSHO), who will record observations of progress in a formal daily log and discuss project status daily with the Project Manager. Deviations from the baseline will be closely monitored. Negative subcontractor performance trends will instigate an interim performance review and discussions with G2S's contract management personnel. As required, a corrective action plan will be developed to bring schedule/cost performance back in line with the baseline.

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6.2 Reporting and Deliverables

G2S will comply with the reporting and deliverable procedures specified in the Performance Work Statement (PWS) for the JPL SI. These include meetings, presentations, informal and formal correspondence, teleconferences, project status reports, and final reports. The Project Manager will be responsible for reviewing and certifying that all submittals are in compliance with the contract requirements. Documents will be submitted according to the timeframes specified in the PWS in order to allow sufficient time for review and comment prior to initiation of work activities.

The Project Manager will ensure that all deliverables are submitted to the recipients in the quantity and format specified in the PWS. G2S will maintain a complete, up-to-date file of all submittals. Documents will be produced with client draft, draft, and final versions unless otherwise approved or indicated. G2S will respond to comments and promptly furnish a corrected submittal in the format and number of copies specified in the PWS. All documents will be identified as draft until completion of the required response to comments (RTC) and approval from the NASA Project Manager, at which time they will become final.

6.3 Control Verification, Acceptance and Testing Procedures

This section includes the control, verification, and acceptance testing procedures for each specific analytical test to be performed.

G2S will collect representative soil and groundwater samples for laboratory analysis. Upon request, G2S will furnish to the Government duplicate samples for possible testing by the Government, if required. All sample analytical results will be provided on industry standard forms. Sample collection, analysis, and reporting are included in the UFP-QAPP.

G2S or an approved subcontractor will perform the following activities, and will record and provide the following data:

- Verify that testing procedures comply with performance objectives;
- Verify that facilities and testing equipment are available, and comply with testing standards;
- Check test instrument calibration data against certified standards;
- Verify that recording forms and test identification control number system, including all of the test documentation requirements, have been prepared;
- Record results of all tests taken, both passing and failing, on the report for the date taken. Actual test reports will be submitted later with a reference to the test and date taken.

6.4 Quality Control Methods

Contractor quality control is the means by which the Contractor ensures that the work, to include that of subcontractors and suppliers, complies with the requirements of the task order for each definable feature of the work, as specified in the APP/SSHP (Appendix B).

G2S will perform three phases of control for each definable feature of work. The three phases of control include Preparatory, Initial, and Follow-Up. Preparatory Phase control will be used to establish quality prior to mobilization and commencement of site activities, and delivery of materials. Initial Phase control will verify that all necessary procedures have been instituted to ensure conformance with the project plans. Follow-Up Phase control will include daily checks and documentation of project requirements to ensure that quality work will be produced throughout the duration of the project. Contractor Production Reports will be prepared during SI activities.

Example forms that will be used to document each of the three phases of control are provided in Appendix C, and include:

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- Preparatory Phase Inspection Checklist;
- Initial Phase Inspection Checklist;
- DQCR.

6.4.1 Preparatory Phase

This phase will be performed prior to beginning work on each definable feature of the work, and after all the required work plans are approved. The preparatory phase inspection includes a review of all work requirements, a physical examination of all required materials and equipment, an examination of the work areas, and a demonstration of field activity preparation. Work cannot begin on a definable feature of work until the preparatory phase is complete. The Preparatory Inspection Checklist is included in Appendix C.

The following activities will also be performed during the Preparatory Phase:

- Review of regulations and contract requirements;
- Review of plans, maps, and drawings;
- Identification of project team;
- Identification and completion of training;
- Verification that all materials and/or equipment are on hand or have been scheduled for acquisition at the proper time, and have been tested, submitted, and approved;
- Review of provisions made to provide required control inspections and testing;
- Physical check of instruments, logbooks, forms, reference documents, sample packaging and shipping supplies, materials, and equipment to confirm they are on-site, and conform to project requirements;
- Examination of the work areas to assure that all preliminary and preparatory work has been completed, and the work areas are ready for the start of activities;
- Review of the appropriate activity hazard analyses (AHA) to assure safety requirements are met;
- Discussion of procedures for controlling the quality of the work, including repetitive deficiencies;
- Documentation of workmanship standards for each feature of work; and
- Review of sampling procedures, materials, equipment calibration, decontamination, labeling, IDW procedures, and shipping requirements.

Included in this phase is a meeting conducted by the Project Manager and/or Site Superintendent and attended by G2S staff and the subcontractor(s) for the definable feature of work (if applicable). The results of the preparatory phase action will be documented in the Contractor Production Reports, and in the Preparatory Phase Checklist.

6.4.2 Initial Phase

The Initial Phase is defined as the beginning of a definable feature of work. The Initial Phase checklist is included in Appendix C. The following will be accomplished during the Initial Phase:

- Check preliminary work including the review of the preparatory meeting minutes;
- Check new work to ensure that it is in full compliance with performance objectives;
- Verify the adequacy of controls to ensure full compliance, and verify the required control inspection and testing;
- Establish the level of workmanship and verify that it meets minimum acceptable workmanship standards. Field notes will be inspected, equipment calibration observed and verified, labels and shipping will be inspected, and an inspection of QA/QC requirements and compliance will be completed;
- Check for omissions and resolve all differences of interpretation with NASA Project Manager;

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- Check safety activities to include compliance with and upgrading of the APP/SSHP and AHAs, as necessary;
- Complete general check of dimensional requirements (e.g., proposed sample locations);
- Review the APP/SSHP, including the AHAs, with each worker and document the review on the daily report. Have each worker sign the appropriate form in the APP/SSHP stating that they have reviewed and understand the APP/SSHP; and
- Repeat the Initial Phase for each new crew member on-site, or any time acceptable specified quality standards are not being met. Document all new crew member orientations.

NASA Project Manager will be notified in advance of the beginning of the Initial Phase. G2S's Project Manager and/or Site Superintendent will lead the Initial Phase Meeting, and the meeting will be attended by the Subcontractor Field Lead responsible for that definable feature of work.

6.4.3 Follow-Up Phase

Daily checks will be performed until completion of the particular feature of work to assure continued compliance with performance standards established at the initial phase in conjunction with project requirements. The daily check will accomplish the following tasks:

- Check that the work is in compliance with project requirements;
- Check that the quality of performance is maintained, as required;
- Check that the testing is performed by the approved laboratory;
- Check that the rework items are being corrected; and
- Perform daily tailgate safety briefings and site safety inspections.

The checks will be recorded on the Contractor Production Reports. Final follow-up checks will be conducted, and all deficiencies corrected prior to the start of additional features of work that may be affected by the deficient work. The G2S Team will not build upon nor conceal non-conforming work.

6.4.4 Documentation

G2S will maintain current records of all control activities, inspections, and sampling documentation. These will include factual evidence that the required control phases and tests have been performed, including the number and results, nature of defects, causes for rejection, proposed remedial action, corrective actions taken, conforming and defective features, and a statement that all supplies and materials incorporated in the work are in full compliance with the terms of the contract. These records will include the work of subcontractors and suppliers. G2S will ensure that the records are available for review by the Government, and all documentation will be submitted to the NASA Project Manager upon request. Otherwise, the documentation will be included in an appendix of the final report for the project. Project documentation will be maintained for a minimum of 10 years, or for the length of time specified by the client or regulatory agencies. Items to be documented when appropriate include, but are not limited to, the following:

- Instrument calibration and maintenance records;
- Field notebooks and daily activity logs;
- Sample collection logs;
- Field monitoring/screening results and associated data sheets;
- Equipment inspection checklists;
- Sample labels and chain-of-custody records;
- Training records;
- Pre-entry health and safety briefings and daily tailgate safety meetings;
- Weight tickets;

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- Manifests;
- Submittal Status Log;
- Testing Plan and Log;
- Rework Items List; and
- Contractor Production Reports.

The Contractor Production Report will include the following information:

- Date;
- Weather conditions;
- Contractor/subcontractor personnel on site;
- General description of field activities performed (investigations, boring installations, well construction, aquifer tests, sampling, operational checks, etc.);
- Significant accomplishments/observations;
- Quality control activities performed (including field calibrations and inspections);
- Problems or deficiencies encountered/corrective actions taken;
- Future field activities; and
- Additional documentation (test results, checklists, health and safety, etc.).

These records will cover both conforming and deficient conditions. All calendar days during the site-specific fieldwork will be accounted for. At a minimum, one report will be prepared and submitted to account for each time period when no fieldwork is being performed. Reports will be signed and dated. The Contractor Production Report form is included in Appendix C.

An approved copy of the applicable Work Plan and associated UFP-QAPP, as well as copies of all completed daily reports, will be maintained by G2S at the job site. All quality control documents will be available for review by the Government QA representatives and/or Contracting Officer. At the completion of the project, quality control documents will be included as an appendix to the project's Final Report.

6.4.5 Additional Quality Control

Additional quality control measures for the sampling and analysis to be performed at the Site are discussed in the UFP-QAPP.

6.5 Completion Inspections

This section describes the completion inspections and procedures for tracking investigation/construction deficiencies from identification through acceptable corrective action. It also defines the verification procedures to ensure that the identified deficiencies have been corrected.

6.5.1 Punch-Out Inspection

The Site Superintendent will conduct an inspection of work near completion for major definable work features specified in the AHA (Appendix B). The Site Superintendent will develop a punch list of items that do not conform to the approved work plan. The punch list of deficiencies will be included in the QC documentation and will include the estimated date by which the deficiencies will be corrected.

The Project Manager and/or Site Superintendent will make a second inspection to ascertain that all deficiencies have been corrected. Once this is accomplished, G2S will notify the NASA Project Manager that the site is ready for the Pre-Final Inspection.

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6.5.2 Pre-Final Inspection

NASA may choose to perform this inspection to verify that the work is complete, and a Pre-Final Punch List may be developed as a result of this inspection. The Project Manager and/or Site Superintendent will ensure that all items on this list have been corrected before notifying NASA that a Final Inspection can be scheduled. Any items noted on the Pre-Final Inspection will be corrected in a timely manner. These inspections and any deficiency corrections required will be accomplished within the time slated for completion of the entire work, or any particular increment thereof, if the project is divided into increments by separate completion dates.

6.5.3 Final Acceptance Inspection

The Project Manager and/or Site Superintendent, and NASA personnel, may be in attendance at this inspection. The Final Acceptance Inspection, if desired, will be formally scheduled by NASA based upon results and resolution of any issues from the Pre-Final Inspection.

6.5.4 Notification of Noncompliance

NASA will notify G2S of any detected noncompliance with the foregoing requirements. G2S will take immediate corrective action after receipt of such notice. When such a notice is delivered to G2S at the work site, it will be deemed sufficient for the purpose of notification.

6.5.5 Quality Assurance Comments

During the course of the project, G2S may receive various QA comments from NASA that will reflect Site activity corrections or reflect outstanding or future items needing attention. G2S will acknowledge receipt of these comments on the Contractor Production Report, and the Contractor Production Report will also reflect when these items are specifically completed or corrected to permit NASA verification.

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Appendix A – Uniform Federal Policy-Quality Assurance Project Plan (UFP-QAPP)

Appendix B – Site Safety and Health Plan/Accident Prevention Plan (APP/SSHP)

Appendix C – QC Checklists and Forms

Appendix D – NASA Memo – PFAS Investigation Derived Waste Disposal