Appendix A

Phase II SWMU Assessment Work Plan

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June 4, 2020

Mr. John Winters, P.G.
Florida Dept. Environmental Protection
Federal Facilities Section
M.S. 4535
Bureau of Waste Cleanup
2600 Blair Stone Road
Tallahassee, Florida 32399-2400

Re: Phase II Solid Waste Management Unit (SWMU) Assessment Work Plan, Center Wide Per- and Polyfluoroalkyl Substances (PFAS), Potential Release Location (PRL) 237, Kennedy Space Center (KSC), Florida

Dear Mr. Winters:

Please find enclosed the Phase II SWMU Assessment Work Plan for the above-referenced site. The Work Plan activities were presented in an advanced data package (ADP) at the February 2020 KSC Remediation Team (KSCRT) meeting (Meeting Minute 2002-M07 and Team Decisions 2002-D30 through D33).

If you have any questions regarding this submittal, please contact me at 407.865.0649.

Sincerely,

AECOM Technical Services, Inc.

Krista Sommerfeldt, P.E.
Program Manager

Enclosure

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PHASE II SOLID WASTE MANAGEMENT UNIT (SWMU)
ASSESSMENT WORK PLAN
CENTER WIDE PER- AND POLYFLUOROALKYL SUBSTANCES (PFAS)
POTENTIAL RELEASE LOCATION (PRL) 237
KENNEDY SPACE CENTER, FLORIDA

Prepared for:

Environmental Assurance Branch
National Aeronautics and Space Administration
Kennedy Space Center, Florida 32899

A-E Contract 80KSC019D0010
Task Order 80KSC019F0289

March 2020
Revision 0

Prepared by:

AECOM
150 N Orange Ave, Suite 200
Orlando, Florida 32801
407-843-6552

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PHASE II SWMU
ASSESSMENT WORK PLAN
CENTER WIDE PFAS
PRL 237
KENNEDY SPACE CENTER, FLORIDA

March 2020

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407-843-6552

In accordance with the provisions of Florida Statutes, Chapter 471, this Phase II Assessment Work Plan has been prepared under the direct supervision of a Professional Engineer registered in the State of Florida. This work was performed in accordance with generally accepted professional engineering practices pursuant to Chapter 471 of the Florida Statutes. The data, findings, recommendations, specifications, or professional opinions were prepared solely for the use of National Aeronautics and Space Administration and the Florida Department of Environmental Protection. AECOM Technical Services, Inc., makes no other warranty, either expressed or implied, and is not responsible for the interpretation by others of these data.

Review Signature: ______________________

Krista Sommerfeldt, P.E.
Florida Registration No. 64080
Engineering Business Authorization No. 8115

Date 4/30/20

KRISTA D. SOMMERFELDT LICENSE No 64080 STATE OF FLORIDA PROFESSIONAL ENGINEER

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ABBREVIATIONS, ACRONYMS, AND SYMBOLS

ADP	Advance Data Package
AECOM	AECOM Technical Services, Inc.
AFFF	aqueous film-forming foam
AST	aboveground storage tank
BLS	below land surface
CERCLA	Comprehensive Environmental Response, Compensation and Liability Act
CS	Confirmatory Sampling
CSM	conceptual site model
DPT	direct push technology
ECHO	Enforcement and Compliance History Online
FDEP	Florida Department of Environmental Protection
FDOT	Florida Department of Transportation
FGDL	Florida Geographic Data Library
FRS	Facility Registry Service
ft	feet
GCTL	Groundwater Cleanup Target Level
GIS	geographic information system
KSC	Kennedy Space Center
KSCRT	KSC Remediation Team
LOC	Location of Concern
NAICS	North American Industry Classification System
NASA	National Aeronautics and Space Administration
ng/L	nanograms per liter
OSWER	Office of Solid Waste and Emergency Response
PA	Preliminary Assessment
PFAS	per- and polyfluoroalkyl substances
PFOA	perfluorooctanoic acid

ABBREVIATIONS, ACRONYMS, AND SYMBOLS (CONTINUED)

PFOS	perfluorooctanesulfonic acid
ppt	parts per trillion
PRISM	PRedictive Integrative Stratigraphic Modeling
PRL	Potential Release Location
RIS	Remediation Information System
RPM	Remediation Project Manager
SA	SWMU Assessment
SEMS	Superfund Environmental Management System
SSP	Space Shuttle Program
STP	sewage treatment plant
SWAPP	Source Water Assessment and Protection
SWMU	Solid Waste Management Unit
TEERM	Technology Evaluation for Environmental Risk Mitigation
Tetra Tech	Tetra Tech, Inc.
UCMR 3	Third Unregulated Contaminant Monitoring Rule
USEPA	United States Environmental Protection Agency
VAB	Vehicle Assembly Building
VSI	visual site inspection
WP	Work Plan

EXECUTIVE SUMMARY

This document presents a description of solid waste management unit (SWMU) assessment activities that will be used to identify additional locations where per- and polyfluoroalkyl substances (PFAS) may have been used at the Kennedy Space Center (KSC). The activities described herein will also be used to identify potential off-Center sources of PFAS and potential background locations for PFAS within KSC.

The SWMU assessment (SA) activities will include a desktop review of resources that include:

- KSC data repositories, including the Remediation Information System (RIS), MSDSonline, and documents from the Technology Evaluation for Environmental Risk Mitigation (TEERM).
- Publicly available data sources, including:
  - Florida Department of Environmental Protection (FDEP) Map Direct, OCULUS, Contamination Locator Map, and PFAS Databases
  - Federal databases, including the Superfund Environmental Management System (SEMS), Enforcement and Compliance History Online (ECHO), and Facility Registry Service (FRS).
  - Aerial photography from collections managed by the Florida Department of Transportation (FDOT) and University of Florida.
  - Land use maps from the Florida Geographic Data Library (FGDL).

Staff interviews will be performed on current and former personnel with direct, reliable, credible knowledge of the use of PFAS-containing chemicals at KSC. Visual Site Inspections (VSIs) will be completed at the facility and at potential areas of interest to document physical evidence that supports data collected during the desktop review and staff interviews.

A brief summary of the results of the Phase I Solid Waste Management Unit Assessment and Confirmatory Sampling Report, Center-Wide Per- and Polyfluoroalkyl Substances (PFAS) Potential Release Location 237 is also included in this Work Plan.

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1.0 INTRODUCTION

1.1 Overview

This document is the Phase II Solid Waste Management Unit (SWMU) Assessment Work Plan (WP; Phase II SA WP), which describes Preliminary Assessment (PA) activities to be completed at National Aeronautics and Space Administration (NASA) Kennedy Space Center (KSC), Potential Release Location (PRL) 237 in Merritt Island, Brevard County, Florida (Figure 1-1). The PA activities will identify locations where per- and polyfluoroalkyl substances (PFAS) (e.g., metal plating, firefighting foams, sewage treatment, and water proofing) may have been used at KSC. In addition, other sites within a 4-mile radius of KSC (not under the control of KSC) that are potential sources of a PFAS release will also be identified. This WP focuses on the PA activities, and a companion WP, the PRedictive Integrative Stratigraphic Modeling (PRISM®) WP (PRISM WP), describes methods to be used to update the existing conceptual site model (CSM).

The Phase I SWMU Assessment and Confirmatory Sampling (CS) Report Center Wide PFAS PRL 237 (Phase I Report) (Geosyntec Consultants, 2019) presented PFAS sampling results for groundwater and surface water and included recommendations for further sampling. A forthcoming WP, the Phase II CS WP (Phase II CS WP) will be submitted later in 2020. The Phase II CS WP will describe sampling activities including locations/media identified in the Phase I Report, as well as additional locations/media selected based on information derived from this Phase II SA WP and the PRISM WP.

This document was prepared by AECOM Technical Services, Inc. (AECOM) on behalf of NASA under Prime Contract Number 80KSC019D0010, Task Order 80KSC019F0289.

1.2 Work Plan Objectives and Strategies

The primary objective of this Phase II SA WP is to describe methods to be used to identify additional locations, beyond those assessed in the Phase I Report, where PFAS-containing materials/chemicals may be present at KSC. Supplemental objectives will be to identify other adjacent/surrounding businesses or operations, not under the control of KSC, that are potential sources of a PFAS release and to identify a potential background sampling location within KSC property. The primary strategies to be used during implementation of this Phase II SA WP are as follows:

- Perform a desktop review of existing information sources to identify potential PFAS use areas. The information sources will include data repositories specific to NASA, as well as online, publicly available information.
- Conduct personnel interviews with key NASA staff to identify known PFAS use areas. Visual site inspections (VSIs) will be performed to document physical evidence to supplement interview data.

1.3 Work Plan Organization

This WP is organized as follows:

Section 1.0 Introduction - describes the purpose of the project, establishes the WP objectives and strategies, and presents this outline.

Section 2.0 Phase I SWMU Assessment Overview - summarizes the assessment efforts, results, and recommendations from the Phase I Report.

Section 3.0 Methods/Approach - describes the methods and resources to be used for data resource reviews, personnel interviews, and VSIs.

Section 4.0 Reporting - describes the general content of the Phase II SWMU Assessment Report to be prepared for KSC.

References Provides a list of the references used to develop this document.

Appendix A Assessment Interview Questionnaires

Appendix B VSI Checklist

Appendix C Photographic Log

2.0 PHASE I REPORT OVERVIEW

The objective of the sampling activities described in the Phase I Report was to identify locations of concern (LOCs) associated with the storage, use, or release of materials containing PFAS at selected areas and to sample and analyze possible affected media. Potential source areas considered included aqueous film-forming foam (AFFF) storage and release areas such as fire training facilities and fire stations. Additional source areas evaluated included landfills, sewage treatment plants (STPs), sewage sludge disposal areas, and metal plating facilities.

Assessment activities described in the Phase I Report include: review of readily available information and reports related to the use, storage, and/or release of AFFF; identification of additional potential sources of PFAS; direct push technology (DPT) groundwater sampling; surface water sampling; and monitoring well sampling.

Between October 2018 and March 2019, 464 DPT groundwater samples were collected from 117 locations at depth intervals of 10, 25, 35, and 45 feet below land surface (ft BLS); 3 monitoring wells were sampled; and 37 surface water samples were collected at 36 locations. Samples collected were submitted for laboratory analysis of 14 PFAS constituents by United States Environmental Protection Agency (USEPA) Method 3535/537 Modified. The concentrations of perfluorooctanesulfonic acid (PFOS), perfluorooctanoic acid (PFOA), and the summation of PFOA and PFOS (PFOA+PFOS) were evaluated against the provisional Groundwater Cleanup Target Level (GCTL) of 70 nanograms per liter (ng/L), equivalent to parts per trillion (ppt), as calculated by the University of Florida (Stuchal and Roberts, 2018) for FDEP. Overall, 33 LOCs were identified based on source area criteria. LOCs were grouped by geographical region (Northern, Central, and Southern), as shown on **Figure 2-1**.

- Northern Region - LOCs in and around the Vehicle Assembly Building (VAB) area and northern KSC (**Figure 2-2**);
- Central Region - LOCs south of the VAB area and north of the Industrial Area of KSC (**Figure 2-3**); and
- Southern Region - LOCs in and around the Industrial Area and southern KSC (**Figure 2-4**).

2.1 Phase I Report Results Summary

Northern Region Results

A total of 301 DPT groundwater samples from 37 locations, 27 surface water samples, and 3 monitoring well samples were collected. Provisional GCTL exceedances were observed in approximately 32 percent of samples collected. The groundwater and surface water samples with the highest PFOA+PFOS concentrations were collected at LOC 2 (Fire Station #2). The highest number of exceedances were observed in the 25 ft BLS samples, but the maximum detected concentration of PFOA+PFOS (73,910 ng/L) in the northern area was collected from 10 ft BLS. Generally, concentrations decreased with depth. Surface water results ranged from 12 to 2,180 ng/L PFOA+PFOS, with the highest concentration at LOC 2 (Fire Station #2).

Central Region Results

Approximately 231 DPT groundwater samples, 34 surface water samples, and 66 monitoring well samples were collected in the Central Region by Tetra Tech, Inc. (Tetra Tech) as of April 2019. Preliminary results and recommendations were presented at the April 2019 KSC Remediation Team (KSCRT) meeting and are summarized in the July 2019 Hydrocarbon Burn Facility, SWMU 007 PFAS CS Report (Tetra Tech, 2019). The highest concentration of PFOA+PFOS in groundwater samples (286,900 ng/L) was collected from 25-35 ft BLS downgradient of former large/small burn pans and former aboveground storage tanks (ASTs). One on-site surface water sample, three culvert samples, and two Banana River samples exceeded 70 ng/L; the highest surface water sample (28,895 ng/L) was collected along the southern portion of the Hydrocarbon Burn Facility.

Southern Region Results

A total of 163 DPT groundwater samples were collected from 41 locations, and 10 surface water samples were collected from 9 locations in the Southern Region. Provisional GCTL exceedances were observed in approximately 34 percent of samples collected. The groundwater sample with the highest PFOA+PFOS concentration (245,100 ng/L) was collected from LOC 19 (Fire Station #1). Approximately 37 percent of the GCTL exceedances occurred in the 10 ft and 25 ft BLS samples, with a general decrease in concentration with depth. The highest surface water sample (979 ng/L) was collected in the Region I Stormwater Pond located in the eastern Industrial Area.

Center-Wide Results

The results of the Phase I Report indicate PFAS impacts of groundwater and surface water at KSC, with 33 percent of groundwater samples collected in the combined Northern and Southern Regions exceeding provisional GCTLs for PFOA+PFOS. Generally, concentrations of PFOS and PFOA decreased with depth, with the fewest number of provisional GCTL exceedances observed in the 45 ft BLS interval. The highest concentrations in groundwater were associated with fire stations and known or likely releases of AFFF. Some STPs and sludge disposal area samples had concentrations that exceeded 10 times the provisional GCTL. PFOS was greater than PFOA in approximately 90 percent of samples collected, with PFOS up to 80 times the PFOA concentration. PFOS and PFOA were detected in every surface water sample.

2.2 Phase I Report Recommendations

Continued SA and CS activities were recommended to further evaluate impacts at LOCs and to provide larger-scale delineation for PFAS. Recommended additional SA activities included the following:

- Investigating additional facilities that were not included under the Phase I Report or where limited information was reviewed;
- Conducting an on- and off-KSC well survey of potable, non-potable, and monitoring wells;
- Investigating the identified data gaps from the Phase I SA;

- Identifying existing monitoring wells within the initial LOCs to sample for PFAS;
- Identifying a monitoring well network and installing staff gauges to assess regional and/or Center-wide groundwater flow and the interaction between groundwater and surface water;
- Resampling previous surface water sample locations to assess potential seasonal changes in concentrations; and
- Tracking drainage patterns to determine where surface water is coming from in different stormwater ponds, basins, and other water bodies.

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3.0 METHODS/APPROACH

The methods used to fulfill the objectives specified in Section 2.2 will include a desktop review of NASA-specific and publicly available data sources, and personnel interviews supplemented with VSIs.

3.1 Desktop Review

The data review for KSC will include a comprehensive desktop review to obtain historical information relevant to past and current use and layout relevant to PFAS releases and archival search and data collection. The data review will focus on whether PFAS was stored, used, or spilled at the facility. The locations where PFAS entered the environment will be noted or the technical team will attempt to locate the most logical location on historical maps or photographs based on interviews or reports. In addition, historical information will be gathered that is related to other processes at the facility and businesses and/or operations adjacent to the KSC facility (not under the control of KSC) that use PFAS (i.e., metal plating and water proofing) and could potentially be the source of a PFAS release.

The desktop review will use data sources existing within NASA KSC, state, and federal resources to obtain historical information relevant to past and current use and relevant to PFAS releases. These sources include, but are not limited to, facility ownership and use, past assessments, water well inventory, tank storage records, landfills, biosolids, wastewater treatment plants, historical building uses, environmental investigations, records of firefighting events or training since 1960, historical record reviews, newspaper reports of firefighting, and historical photographs from 1960 to present relevant to AFFF or PFAS chemical use.

3.1.1 NASA Data Sources

The following NASA data sources will be researched:

- **Remediation Information System** (RIS). The RIS database contains records related to the KSC Remediation Program, including reports, environmental media data, and meeting records. The RIS database will be searched for a variety of keywords (e.g., PFAS, AFFF, crash) to identify potential PFAS release locations. Additional keywords identified in other phases of this assessment (e.g., MSDS search) may also be included. The RIS database also contains a GIS element that contains an analytical query tool for current and historical sites. Common facility names for buildings (beyond those identified in the Phase I Report) that may have used PFAS compounds (e.g., hangars, refueling areas, emergency response site) will also be searched.

- **MSDSonline**. The NASA MSDSonline database will be searched to identify PFAS-containing chemicals that are used at KSC. The list of PFAS compounds will be derived from the USEPA PFAS Master List of PFAS Substances (USEPA, 2020). Identified materials will be incorporated into the interview questionnaires and a keyword search in RIS.

- **Technology Evaluation for Environmental Risk Mitigation** (TEERM). The TEERM program was a part of NASA's Environmental Management Division, which sought to improve NASA's ability to adopt new environmental technologies. The TEERM team previously identified various components of the Space Shuttle Program (SSP) that used PFAS-containing materials (Meinhold, 2013). Although the TEERM program is now defunct, previous members will be interviewed to attempt to identify the specific components of the SSP that contained PFAS. This information will then be incorporated into the interview questionnaires and RIS keyword searches to identify locations at KSC in which these components were stored/handled.

3.1.2 Publicly Available Data Sources

The following publicly available data sources will be researched:

- **FDEP Map Direct Gallery**. The FDEP Map Direct Gallery will be used to identify potential sources of PFAS, not attributable to NASA, and possible receptors located within 4 miles of KSC. Information that will be obtained from the FDEP Map Direct Gallery includes:
    - **Contamination Locator Map** – contaminated sites that are currently under FDEP's cleanup oversight.
    - **Brownfields Map** – contaminated sites that have a current Brownfields Site Rehabilitation Agreement.
    - **Drycleaning Solvent Cleanup Program** – contaminated sites that are enrolled in the Drycleaning Solvent Cleanup Program. Drycleaning solvent sites have been identified as potential sources of PFAS in groundwater in Florida (Henry, Seguiti, and Watson [HSW] Engineering, Inc., 2019).
    - **Hazardous Waste Program Map** – contaminated sites that are currently enrolled in the Hazardous Waste Program.
    - **Institutional Controls Registry Map –** sites that have institutional control restrictions as defined by Florida Statutes 376.301 and 376.79. These sites can be petroleum cleanup, drycleaning solvent, Superfund, Resource Conservation and Recovery Act, Hazardous and Solid Waste Act, non-program sites (e.g., state enforcement or voluntary) and Brownfield areas.
    - **Solid Waste Disaster Debris Management Map** – sites that have been used to store debris created from natural disasters.
    - **Solid Waste Map –** sites that are solid waste management facilities or solid waste management test facilities.
    - **Storage Tank Regulation Map** – sites that are regulated under Storage Tank Compliance of the FDEP Permitting and Compliance Assistance Program. These sites have underground and above ground storage tanks.

  - **Waste Cleanup Map –** sites that are currently enrolled in the FDEP Waste Cleanup Program.
  - **2017 Map of Surface Water Plants and Drinking Water Map –** sites that provide treated water for public consumption.
  - **Biosolids Sites –** sites in which residuals from wastewater treatment processes (i.e., biosolids) are applied.
  - **Domestic Wastewater Facility Regulation and Wastewater Septic Systems –** sites that perform treatment of municipal wastewater.
  - **Source Water Assessment and Protection (SWAPP) Map –** various sites, including drinking water supply wells and underground injection control wells.
  - **Geologic Well and Borehole Data Map –** locations of groundwater wells.
  - **Fire Training Facilities Assessment for PFOA and PFOS in the Environment** – locations of fire training facilities with known releases of PFOA and PFOS into the environment.

- **FDEP Databases**. The FDEP Contamination Locator Map and Electronic Document Management System (OCULUS) databases will be researched to identify potential non-KSC sources of PFAS. The Contamination Locator Map includes sites that are enrolled in various FDEP cleanup programs (e.g., Brownfield, Petroleum, Superfund). The OCULUS database is a repository of data and reports for each FDEP division. Sites identified with the Contamination Locator Map will be researched in OCULUS to determine which sites may be candidates for PFAS releases (e.g., fire training, electroplating, landfills).

- **FDEP PFAS Database**. The FDEP maintains a spreadsheet database of both confirmed and suspected sites with PFAS contamination (FDEP, 2019).

- **FGDL Metadata Explorer**. This database (FGDL, 2020) contains GIS information related to multiple data sources (e.g., Transportation Networks, Agriculture & Farming) that can be used to identify potential sources, or receptors, of PFAS.

- **Historical Aerial Photographs**. Online repositories of aerial photographs of KSC will be analyzed to provide additional information regarding the locations of PFAS releases. For example, the locations of historical polishing ponds (identified as data gaps in the Phase I Report) will be researched using historical images. Aerial photography sources will include the FDOT Aerial Photography Archive and the University of Florida Aerial Photography: Florida Collection.

- **Superfund Environmental Management System (SEMS)**. The SEMS database contains information related to activities at hazardous waste sites managed under the USEPA's Comprehensive Environmental Response, Compensation and Liability Act (CERCLA).

- **Enforcement and Compliance History Online (ECHO)**. The ECHO database is used to search for information related to environmental compliance.

- **Facility Registry Service (FRS)**. The FRS is a USEPA database that can be queried by geographic location and North American Industry Classification System (NAICS) codes. Codes for potential PFAS source locations (e.g., airports, metal plating, sewage treatment) will be selected using methods described by Zhang and others (2016).

3.2 Interviews

The interview process will begin with a coordination interview, held via telephone with the KSC Remediation Project Manager (RPM), and will include practical questions regarding data resources, various types of document repositories, and logistics, such as facility work schedule, restrictions on when interviews may occur, and access requirements. During this interview, the KSC RPM will assist in developing a list of employees with direct, reliable, credible knowledge of past or present conditions of the facility. Interviews of current and former personnel who were involved in operations at each facility will then be conducted.

A standard set of interview questions focused on AFFF use will be used and relevant information about each interviewee, their responses, and supplemental information provided by the interviewee will be recorded. Interview questions will also be focused on NASA KSC specific items derived from the desktop review phase. This will enable interview data to be combined for review and assessment. Correlation of the interview information may identify data gaps or conflicting data that require additional data gathering. The preliminary Interview Questionnaires are included in **Appendix A**. Specific questions will be altered based on results of the desktop review. Interview Questionnaires, including significant findings and opinions on the reliability of specific accounts, will be provided in the report.

3.3 Visual Site Inspections

Visual Site Inspections (VSIs) will be completed at the facility and at potential areas of interest to document physical evidence that supports data collected during the historical records review and personnel interviews. The VSIs will include inspection from automobiles (windshield surveys) or walking surveys to help identify AFFF or other similar chemical storage, use, release, or disposal points. Personnel will use the VSI checklist in **Appendix B** to provide consistency and thoroughness at the KSC facilities and non-KSC facilities. Data to be collected include photographs of PFAS activities such as fire training, active fire, metal plating, and laundry facilities, as well as narrative descriptions. The AECOM team leader will also identify limitations, such as the restriction of photography, for security purposes and access issues. Photographs will be compiled into the photographic log in **Appendix C**.

3.4 Documentation of Nearby Off-Site PFAS Sources

If the records research or interviews indicate that PFAS contamination may be emanating from a source off-site and/or adjacent to KSC, reconnaissance will be conducted in coordination with the current property owner of the potential off-site PFAS source, when possible. Decisions regarding off-site reconnaissance will be coordinated with the NASA RPM. Potential off-site PFAS contamination sources will be evaluated using, but not limited to, the desktop review methods listed in Section 3.1.

3.5 Background Locations

Background locations are defined as "…locations that are not influenced by the releases from a site…" (USEPA, 2002). It is noted that a background location on KSC may still potentially contain detectable PFAS, as these compounds are widespread in various environmental media (Vedagiri and others, 2018; USEPA, 2017). Potential background locations for PFAS derived from KSC sources will be identified using the desktop review methodology described in Section 3.1. In general, areas that have no evidence of previous industrial activity, no previous residences, no previous commercial activity, and are not hydraulically downgradient of these previous/current activities will be considered as potential background locations. Historical aerial photographs and database information from RIS will primarily be used to identify these areas. Results derived from the PRISM WP related to groundwater and surface water flow patterns will also be used to select potential background locations.

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4.0 REPORTING

A Phase II SWMU Assessment Report will be prepared to summarize the WP process and findings, and provide a conclusion on whether evidence suggests a release of PFAS at a determined LOC. The Phase II SWMU Assessment Report will include documentation from the data resource review, including findings from interviews and the VSI, identification of adjoining or adjacent assets likely to have PFAS releases, and analysis of compiled data. If a PFAS release source is identified during the process, the LOC will be included in the Phase II SWMU Assessment and Confirmatory Sampling Report.

Should evidence of a release be found that suggests off-site exposure to potential receptors, the AECOM Project Manager will immediately notify the KSC RPM.

Confirmatory sampling will be considered when written documentation that PFAS was stored, used, or accidentally released is discovered; information from employees or former employees with first-hand knowledge of a release or usage is obtained during interviews; and/or a weight-of-evidence case may be used that AFFF or other similar chemical materials were released to the environment.

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FIGURES

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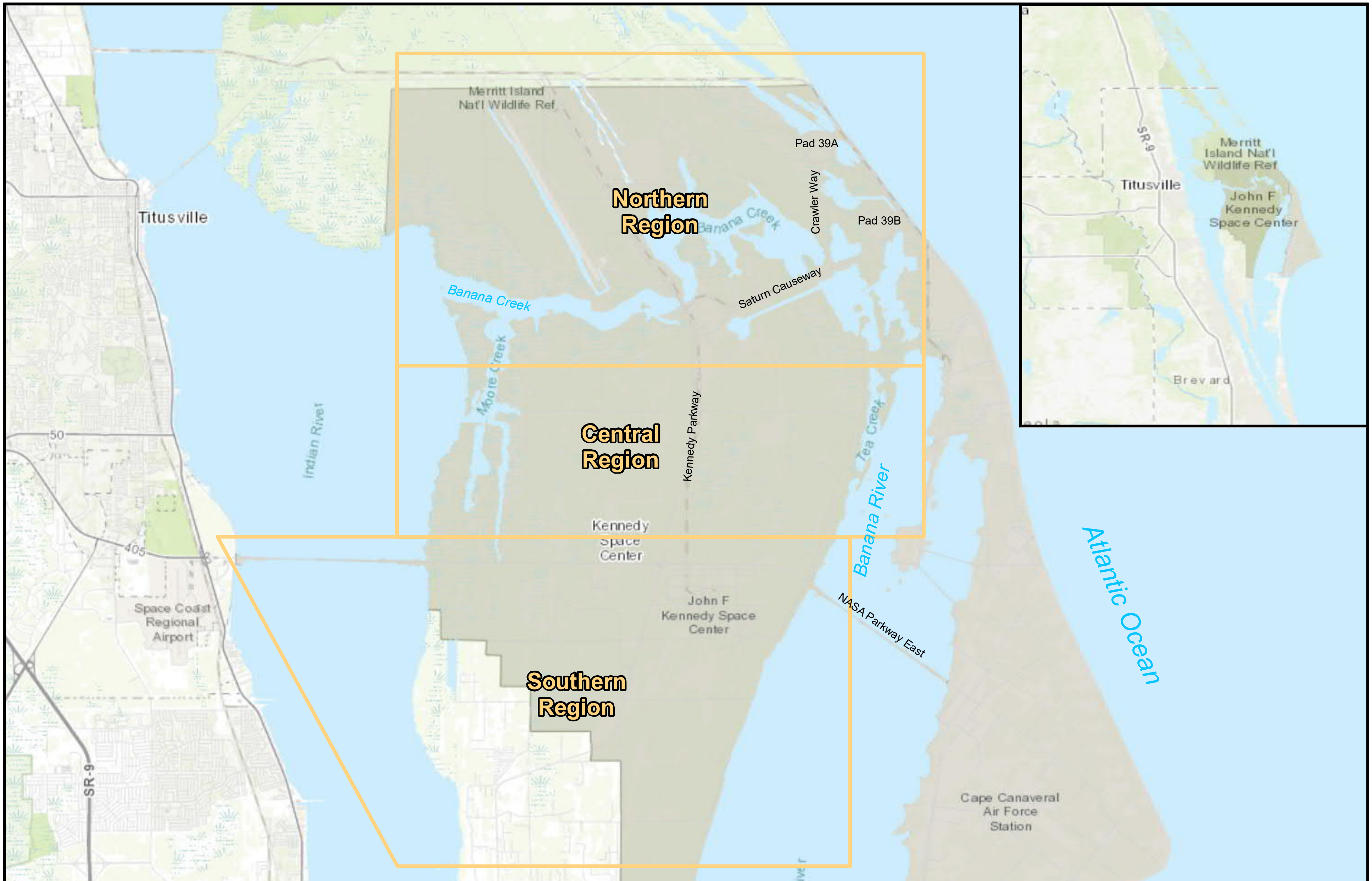
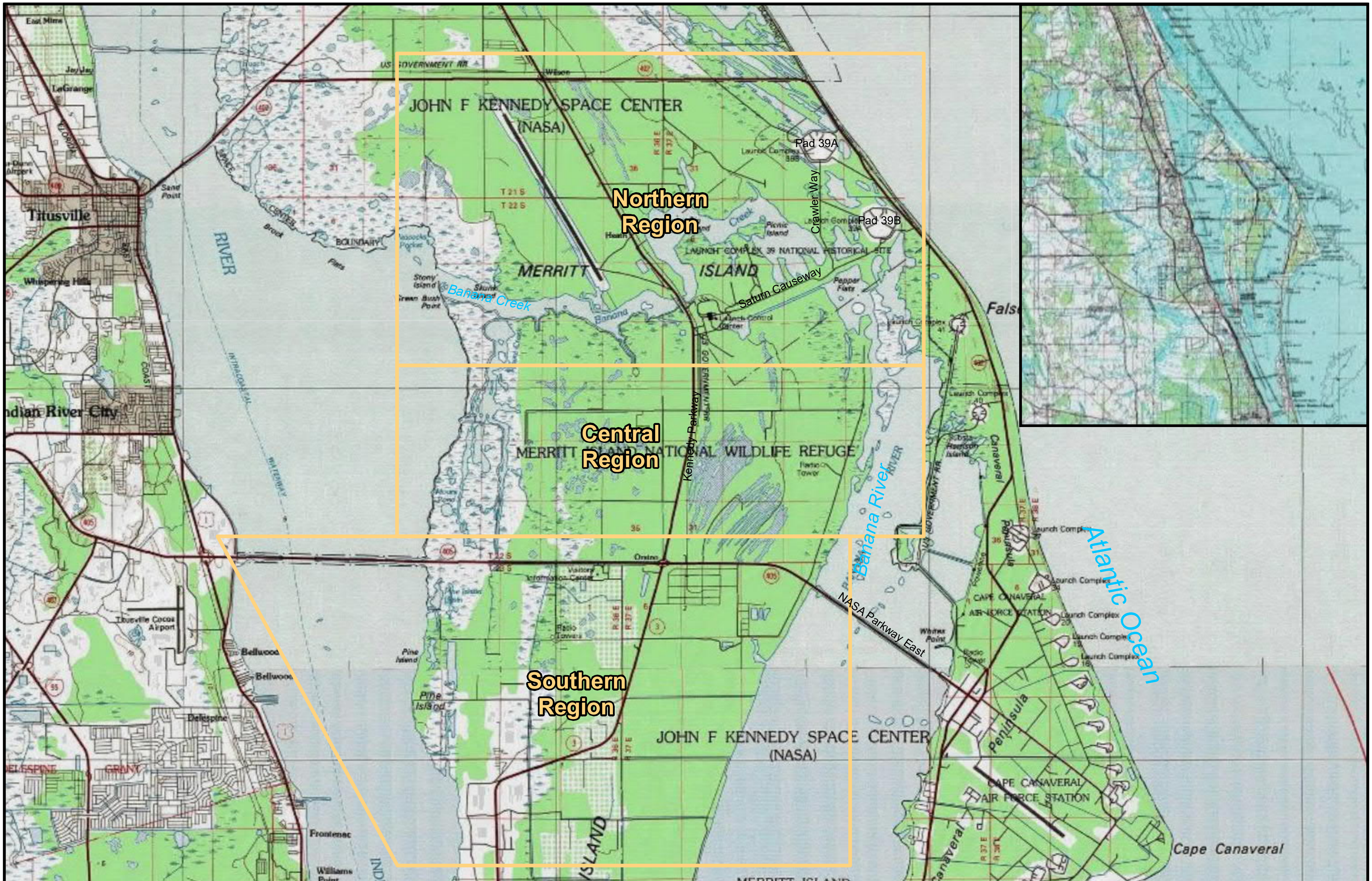


Notes:
- LOC = Location of Concern
- Region Delineation Derived From:

PHASE I SOLID WASTE MANAGEMENT UNIT ASSESSMENT AND CONFIRMATORY SAMPLING REPORT CENTER-WIDE PER- AND POLYFLUOROALKYL SUBSTANCES (PFAS), Geosyntec Consultants dated September 2019

FIGURE 1-1
Kennedy Space Center Location Map

NASA Kennedy Space Center, Florida



Notes:
- LOC = Location of Concern
- Region Delineation Derived From:

PHASE I SOLID WASTE MANAGEMENT UNIT ASSESSMENT AND CONFIRMATORY SAMPLING REPORT CENTER-WIDE PER- AND POLYFLUOROALKYL SUBSTANCES (PFAS), Geosyntec Consultants dated September 2019

N

0 12,000 24,000 Feet

FIGURE 2-1
Kennedy Space Center Quadrangle Map

NASA Kennedy Space Center, Florida

Legend

Regional Area

Historical PFAS Sampling Area

Proposed PFAS Sampling Area

Notes:
- LOC = Location of Concern
- Historical and Proposed PFAS Sampling Areas derived from: *PHASE I SOLID WASTE MANAGEMENT UNIT ASSESSMENT AND CONFIRMATORY SAMPLING REPORT CENTER-WIDE PER- AND POLYFLUOROALKYL SUBSTANCES (PFAS)*, Geosyntec Consultants dated September 2019

N

0 1,750 3,500 7,000 Feet

FIGURE 2-2
Northern Region Locations of Concern

NASA Kennedy Space Center, Florida

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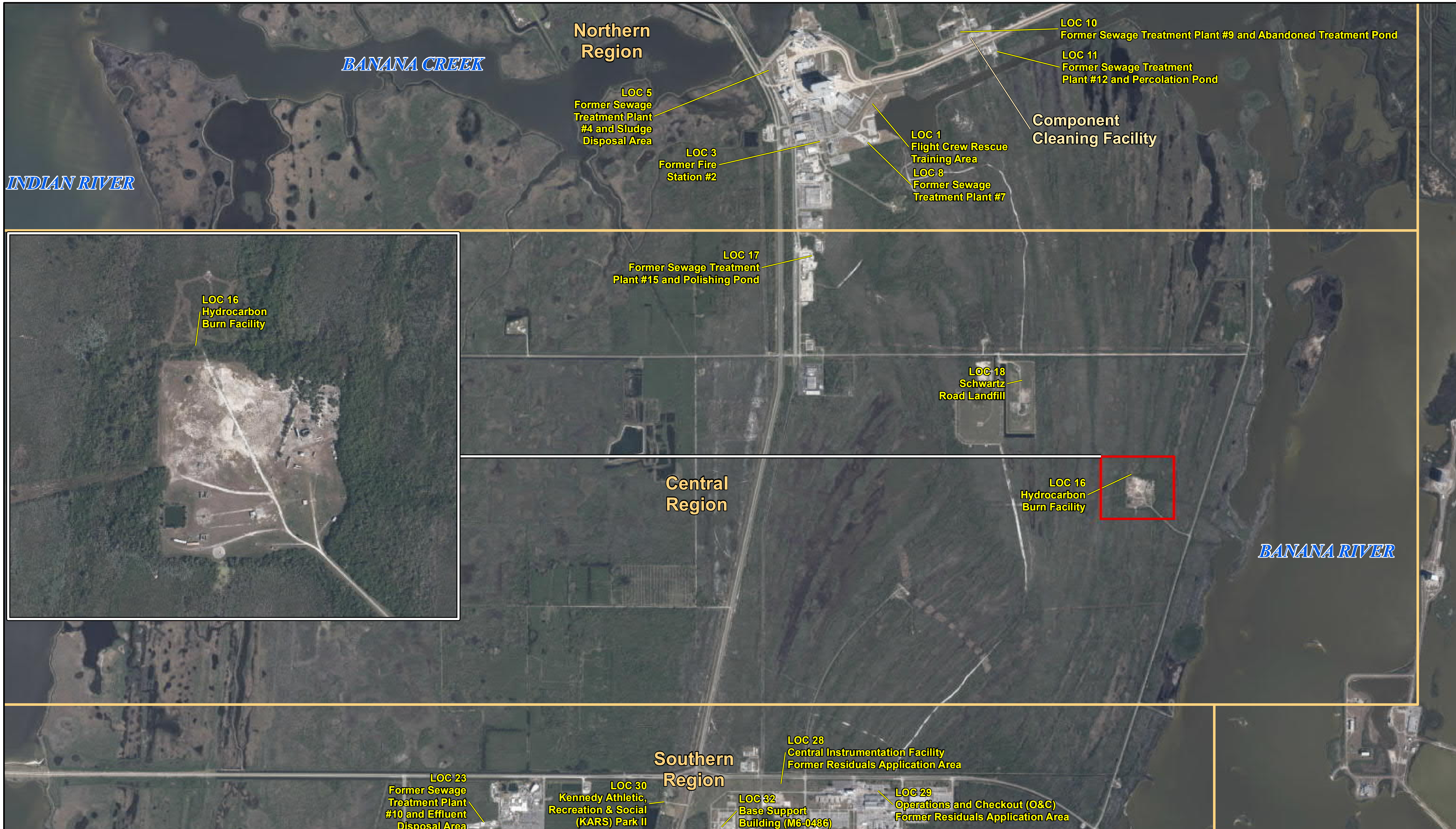

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Regional Area

Historical PFAS Sampling Area

Proposed PFAS Sampling Area

Notes:
- LOC = Location of Concern
- Historical and Proposed PFAS Sampling Areas derived from: *PHASE I SOLID WASTE MANAGEMENT UNIT ASSESSMENT AND CONFIRMATORY SAMPLING REPORT CENTER-WIDE PER- AND POLYFLUOROALKYL SUBSTANCES (PFAS)*, Geosyntec Consultants dated September 2019

N

0 1,500 3,000 6,000
Feet

FIGURE 2-3
Central Region Locations of Concern

NASA Kennedy Space Center, Florida

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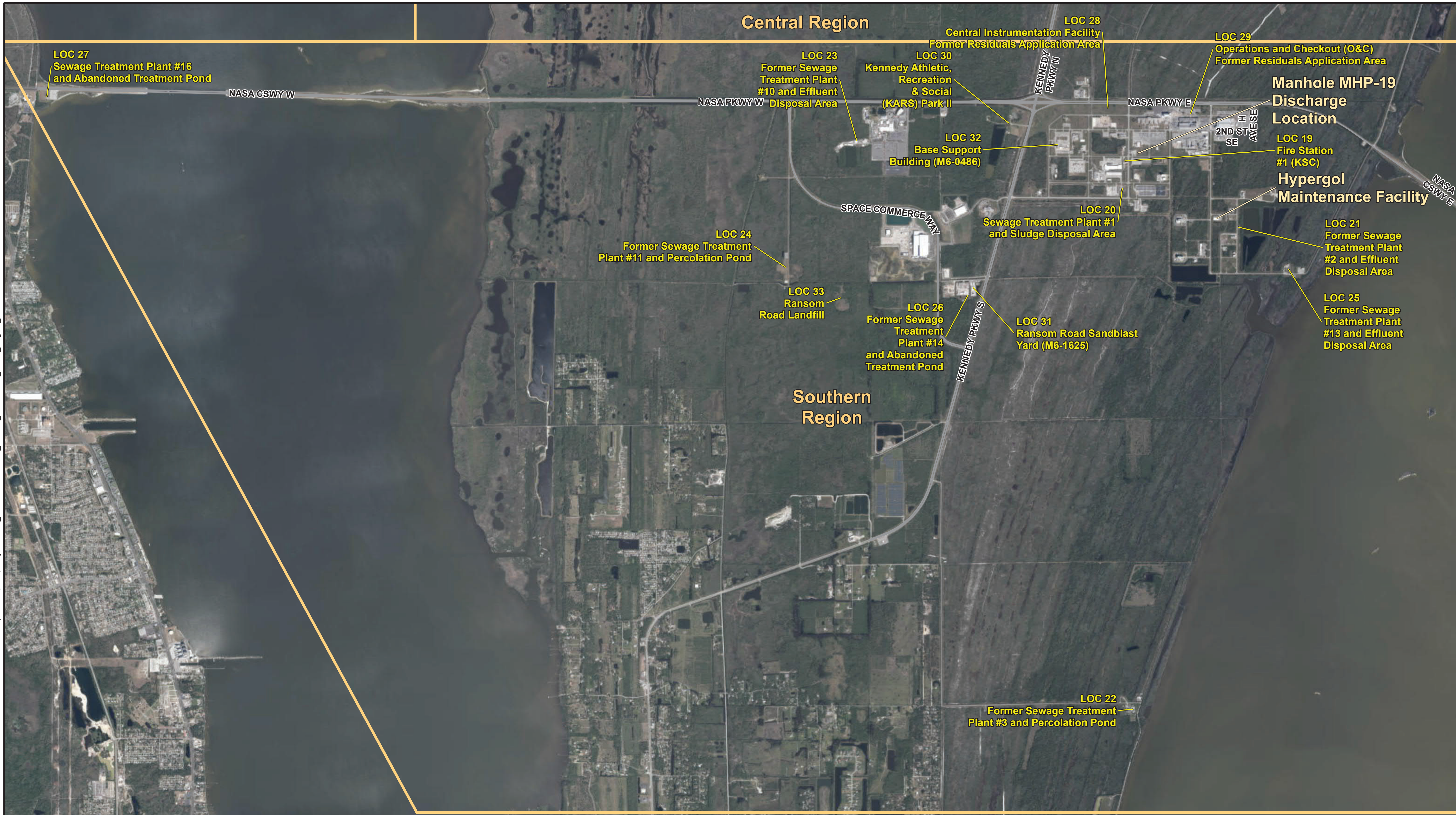

Legend

Regional Area

Historical PFAS Sampling Area

Proposed PFAS Sampling Area

Notes:
- LOC = Location of Concern
- Region Delineation Derived From: *PHASE I SOLID WASTE MANAGEMENT UNIT ASSESSMENT AND CONFIRMATORY SAMPLING REPORT CENTER-WIDE PER- AND POLYFLUOROALKYL SUBSTANCES (PFAS)*, Geosyntec Consultants dated September 2019

N

0 1,750 3,500 7,000 Feet

FIGURE 2-4
Southern Region Locations of Concern

NASA Kennedy Space Center, Florida

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APPENDIX A
ASSESSMENT INTERVIEW QUESTIONNAIRE

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Interviewee Name:____

Interviewee Title:____

Interviewee Email:____

Interviewee Phone Number:________________________________

Date/Time of Interview:___________________________________

Interviewer:____

➢ Aerospace Industry

1. Does the facility assemble, manufacture, use, repair, or store high-powered equipment associated with the aerospace industry such as aircraft, rockets, or space shuttle currently or in the past?

    a. If so, what types of hydraulic fluids are/were used (i.e., fire resistant, water or oil-based) at this facility? Include manufacturer and brand names.

    b. Where were they used/stored and how were they disposed of at the facility?

2. Were any space shuttle components manufactured, assembled, cleaned, or disposed of at the facility (e.g., external tank, rocket motors, orbiter, main engines, or solid rocket boosters)?

    a. If so, please explain process and identify where these activities were completed.

    b. Please indicate how long these activities were conducted (i.e., years).

3. Are/were flight crew equipment or space suits manufactured, assembled, cleaned, or disposed of at the facility? Are/were these materials treated with any materials to become fire-resistant or to repel stains/oil/water?

    a. What type of fire/oil/stain/water-resistant materials were used? Please provide manufacturer/brand name.

b. When (years) and where were these activities completed and materials stored?

c. How were used/waste materials disposed of at the facility.

4. Were/are specialty paints or coatings used at the facility? Specialty paints known to contain PFAS include antifouling, anti-graffiti, or anti-staining paints, and some latex paints. Were any flame-resistant paints used on equipment?

    a. Please list types of specialty paints used at the facility and manufacturer brand names.

5. Please indicate when (timeframe) and where these paints were used and identify disposal processes for waste materials.

6. Are you aware of the use of any of the below mentioned products used at the facility:
    a. Teflon aqueous fluoropolymer dispersion coating on Saint Gobain beta cloth (used in orbiter payload bay)
    b. Echelon
    c. Viton elastomers
    d. Telomer products, such as Krytox or Braycote perfluoropolyether greases

7. Are you aware of the use of any other fluorinated compounds at the facility (look for "fluoro" in the SDS/MSDS chemical listing or product name, e.g., "fluorinated surfactant(s)" or "organic fluorosulfonate")

    a. If so, what are the names of the chemicals and amounts and concentrations used? Please provide the SDS/MSDS sheets for these chemicals and a description of where they are used in your process.

➢ AFFF Use

1. A. Was/is AFFF used at this facility?
(If answer to this question is "yes," then please answer questions 1B through 25 in this section. If answer is "no," then please proceed to Other Non-AFFF PFAS Sources section.)

    B. What type of AFFF was used at this facility (i.e. 3%, 6%, High Expansion Foam)?

2. What manufacturer's AFFF products have been used on this facility (i.e. 3M, Ansul, Chemguard)?

3. Where has AFFF solution been handled (mixed, contained, stored, transferred, etc.)?

4. Has AFFF been stockpiled as a reserve supply for the facility? If so, where at the facility and provide manufacture name and date on drum/containers.

5. Please list any buildings that have automated fire suppression systems that either currently or previously used AFFF. Please specify which are current and if known, the approximate year in which any systems were taken off line or retrofitted.

6. Please list any automated fire suppression systems that have been retrofitted for use of high expansion foam.

7. Are there records showing the amount of AFFF stored in your area, at the facility, or present in automated fire suppression systems? If so, where are they kept?

8. Please describe the procedure for how the suppression systems are recharged with AFFF.

9. Please describe the processes to contain and manage AFFF in the activation of fire suppressions systems? What is location of the discharge from the AFFF containment or hanger (building) floor drains? (storm water/surface water, WWTP or AFFF lagoon/pond)

10. Have there been accidental releases of AFFF from fire suppression systems? If so, the extent possible please describe:

    a. Building number/location.

    b. Was the release contained (either in the building, by a secondary containment system, etc.)?

    c. Year the accidental release occurred.

    d. Approximate quantity of AFFF released.

    e. How was it cleaned up?

11. How are AFFF releases handled (when the suppression system goes off)?

12. Who maintained the AFFF system? Are there maintenance records?

13. Provide a list of trucks and trailers, such as Aircraft Rescue Fire Fighting (ARFF) trucks, currently carrying AFFF. To the extent possible, please describe:

    a. Where are they parked/stored?

    b. How much AFFF (gallons) is carried or stored in the specified trucks and trailers?

14. For both current and historical timeframes, please describe the process for testing/calibrating any mobile AFFF systems, including:

    a. How often are spray tests / calibration checks conducted?

    b. Where are the tests conducted?

    c. Given the location, are tests/calibration checks at the area released to the environment or contained in some way?

15. Please describe the procedure for how trucks and trailers are supplied with AFFF.

    a. Where does this resupply occur?

    b. Is there secondary containment in this area?

    c. What do you do with the empty concentrate containers?

16. Please describe the procedures for how these vehicles are cleaned/decontaminated.

    a. Where is the current vehicle cleaning/maintenance area?

    b. Are there previous areas where cleaning/maintenance was performed?

c. Was AFFF contained during cleaning/maintenance or was it released to the environment?

17. Please describe current and previous AFFF equipment storage areas.

    a. Please describe procedures for how AFFF equipment is cleaned/decontaminated. Where has the equipment currently or formerly been maintained?

18. When AFFF was used during a fire training exercise, how was the AFFF cleaned up and disposed of?

19. Please provide location of any AFFF-related records, spill logs, or historical information.

20. Please describe, or provide records for, AFFF being used in response to:

    a. Fuel releases to prevent fires?

    b. Historical emergency response sites (i.e. crash sites and fires)?

    c. Emergency runway landings where foam might have been used as a precaution?

    d. How were the releases cleaned up?

    e. Were soils removed? If so, what happened to the soil?

21. If written records are unavailable or incomplete, please provide anecdotal or verbal information and location of spills or other emergency response incidents where AFFF was used.

22. What are the locations (other than Firefighting Training Areas) where:

    a. AFFF fire suppression systems are installed?

    b. Where are these locations that currently contain or have contained AFFF (Building numbers)?

    c. If converted from AFFF, when did they convert the system to high expansion foam?

23. Are there any other locations where AFFF has been stored, released, or used (i.e. hangars, buildings, bulk fuel tank farms, fire stations, firefighting equipment testing and maintenance areas, emergency response sites, storm water/surface water, waste water treatment plants, and AFFF ponds/lagoons)?

24. Where are current and previous Firefighting Training Areas (FTA)? Please show their locations on a map.

    a. What are the years of operation for each FTA?

    b. What types of fuels/flammable were used at the FTAs?

    c. For inactive FTAs, when was the last time that fire training using AFFF was conducted at each one?

25. Are there any tenants that use AFFF?

➢ Other Non-AFFF PFAS Sources

Major non-AFFF PFAS sources include manufacturing facilities that utilized PFAS as a component of their products or operations. Potential secondary sources of PFAS from such operations include landfills and waste water treatment facilities. Manufacturing facilities known to have used PFAS-containing materials include textile and leather process facilities, paper mills, metal plating and etching facilities, wire manufactures as well as facilities that utilized surfactants, resins, molds, plastics, photography, and semiconductors. The Space Shuttle Orbiter and other shuttle components such as the external tank, rocket motors, main engines, solid rocket boosters, and flight crew equipment/space suits utilized PFAS-containing materials. Several spray coatings and greases associated with the aerospace industry are PFAS containing materials.

1. Is there anyone else or other facility organization personnel who might have information on non-AFFF PFAS sources? Please provide name, organization, position, phone number, email, etc.

2. Does the facility currently or previously operate a chrome-plating shop?

    a. Identify location and timeframe of operation.

    b. Were foams or wetting solutions ever used to suppress vapors in the process?

    c. Were wastes from the plating shop disposed of onsite? If so, please list the landfill, if known.

3. Where does the facility water supply come from?

4. Are there irrigation, non-potable or potable water wells on-site? If yes, please explain water use practices (e.g., drinking, grass irrigation). Have wells been tested for PFAS compounds?

5. Please provide information regarding any spills or releases (either reported or unreported) of aircraft fuel, cleaners, or additives, and the names of these chemicals.

6. Are there on-facility waste water treatment plants (WWTPs)? What is the fate of the effluent, waste water treatment sludge, and biosolids from (e.g., land application, discharge to municipal water supply, irrigation, etc.)?

7. Are you aware of any diversionary flow valves for any pathways to the WWTP(s) that could prevent the WWTP treatment of wastewater or stormwater?

8. What is the fate of the effluent and sludge from facility oil/water separator (OWS)? Please specify the location of the OWS.

9. Are you aware of any current/former pesticide cleanout, storage, disposal, or maintenance areas?

➢ LOCATIONS

10. Please provide information on releases of any of the following list of substances in addition to AFFF and at which locations

    a. **List of Materials**
        i. Flame retardants
        ii. Aviation hydraulic fluids
        iii. Additional aircraft fluids (i.e., fuels, cleaners/detergents, regulated or unregulated additives)

iv. Automotive fluids (i.e., fuels, cleaners/detergents, additives -regulated or unregulated)

v. Foaming agents

vi. Cleaning supplies

vii. Fire-proof coatings (paints, enamels, varnishes, etc.)

viii. Fire-proof materials (clothing, furniture, blankets, etc.)

ix. Pesticides

b. **If releases of above-listed materials have occurred,** please include known information regarding the fate of the release [i.e. did releases occur near drainage swales; were they washed to a pervious surface; did they occur on poorly maintained pervious surfaces (cracked concrete, porous asphalt, etc.); were they directed to a storm drain, trench drain, OWS, WWTP, etc.].

11. Please provide any other information regarding perfluorochemicals or substances of note not in above list. Products will have fluoro" in the SDS/MSDS chemical listing or product name. Please provide SDS/MSDS and how the chemical is used at the facility.

PFAS Preliminary Assessment Questionnaire
Emergency Response Personnel (Non-firefighter)
{*Facility, Location*}

Interviewee Name:____

Interviewee Title:____

Interviewee Email:____

Interviewee Phone Number:_____________________________________

Date/Time of Interview:_______________________________________

Interviewer:____

➢ Facility Fire Department

1. Does the facility have its own Fire Department? If not, is there a mutual aid agreement with the fire department that services the facility (e.g., local fire department or a DoD facility). Can you provide point of contact name and phone number for the fire department that services the facility?

➢ AFFF Use, Storage, Handling, Spills

1. Do you have recollection or records of AFFF being used at emergency response sites (such as plane, helicopter, or vehicle crash sites and fires), fuel releases to prevent fire, or emergency runway landings where foam might have been used as a precaution at the facility or at a location near the facility?

   If so, please identify date and location(s).

2. Are there any current or historical data/documents/records associated with AFFF that we may review/copy (such as reports/work plans, historical or operational records, incident reports, crash data, inspection reports, AFFF spill logs, documentation of AFFF releases, photo interpretation)?

3. What are the current and historical storage location(s) of the wreckage from emergency response incidents (if wreckage is stored outside)?

4. Where is AFFF and AFFF equipment stored at the facility (currently and historically), and in what approximate quantities? (Please show locations on map provided.)

   a. Please provide type of foam (i.e. 3%, 6%, High Expansion Foam) and manufacturer (i.e. 3M, Ansul, Chemguard)

   b. Please describe procedures for how AFFF equipment is cleaned/decontaminated.

   c. To the best of your knowledge, where has the equipment currently or formerly been maintained?

➢ General Information

1. Is there anyone else or other facility organization personnel that you would recommend we interview? Name, organization, position, phone number, e-mail.

2. Are there other tenants at the facility that you service? If so, please provide name of tenant and point of contact (if available).

3. Are there any other tenants/tenant organizations that currently (or historically) use AFFF?

PFAS Preliminary Assessment Questionnaire

Fire Chief or Designee(s)

{*Facility, Location*}

Interviewee Name:______________________________________

Interviewee Title:______________________________________

Interviewee Email:______________________________________

Interviewee Phone Number:______________________________

Date/Time of Interview:_________________________________

Interviewer:____

➢ Facility Fire Department

1. Does the facility have its own Fire Department? If not, is there a mutual aid agreement with the fire department that services the facility (e.g., local fire department or a DoD facility). Can you provide point of contact name and phone number for any other fire department(s) that services the facility?

➢ AFFF Purchasing, Handling, and Storage

1. Was perfluorinated AFFF historically or currently used on the facility? If so, provide any information regarding where and when.

2. Please provide type of foam (i.e. 3%, 6%, High Expansion Foam) and manufacturer (i.e. 3M, Ansul, Chemguard).

3. Where has the AFFF solution been handled (currently and historically) (such as mixed, contained, released for calibration, transferred)?

4. Where is AFFF and AFFF equipment stored at the facility (currently and historically), and in what approximate quantities? (Please show locations on map provided or describe locations).

a. Please describe procedures for how AFFF equipment is cleaned/decontaminated.

b. Where has the equipment currently or formerly been maintained?

➢ Firefighting Training Areas

1. Are any current or historical Firefighting Training Areas (FTAs) present on the facility? If yes, please show the location/s of the FTAs on the map provided.

2. To the best of your knowledge, what are/were the years of operation for each FTA you identified in your answer to Question #1 above?

3. How many FTAs are currently active? Inactive (historical in nature)? To the extent possible, please specify which are active versus historical.

4. Were fuels/flammables other than "typical" (such as JP-5, #2 Fuel Oil) used at the FTAs? If yes, what was used?

5. For inactive FTAs, to the best of your knowledge, when was the last time that fire training using AFFF was conducted at each one?

6. When AFFF was used during a fire training exercise, was the AFFF used contained and disposed, and if so, how was the AFFF cleaned up and disposed?

7. Are current and historical FTAs lined? If so, with anything other than concrete?

➢ Hangars and Buildings

1. To the best of your knowledge, which areas (such as hangars, buildings, fuel or hazardous waste storage areas) historically had or currently have automated and/or manually-activated AFFF fire suppression systems?

2. Please describe how the suppression systems are supplied with AFFF (that is, is system contained within the building, or are there separate buildings that serve to mix AFFF to supply one or more hangers with suppression systems).

3. Please describe the fire suppression system layout/activation process and if available, provide system plans or drawings.

4. When the fire suppression system engages/or engaged, what is the current, and if different, historical response process for cleaning up and removing released AFFF?

5. Have there been inadvertent releases of AFFF from hangar fire suppression systems (such as equipment failure)? If so, please provide additional details (such as when, in which hangars/buildings, could the release be quantified, was the release removed or cleaned up)?

6. Who was responsible for current or historical routine maintenance of the AFFF system/s? Were maintenance records kept, and if so where are they located?

7. For any historical activation (accidental, testing, or in response to an emergency) of AFFF systems within hangars and/or buildings, provide any information regarding the fate of the release (that is, did releases occur near drainage swales; were they washed to a pervious surface; did they occur on poorly maintained pervious surfaces [cracked concrete, porous asphalt]; were they directed to a storm drain, trench drain, oil/water separator [OWS], wastewater treatment plant).

➢ Trucks and Trailers

1. Provide a list of current and historical parking/storage areas for AFFF equipment.

2. Were the trucks currently and historically tested for spray patterns to make sure equipment is working properly? If so, how often and where are/were these spray tests performed?

3. What is the procedure on how trucks and trailers are/were supplied with AFFF?

   a. Where does/did this resupply occur?

   b. Is/was there secondary containment in this area?

   c. What happens to the empty AFFF containers?

4. What is the procedure for how these vehicles are/were cleaned, and where is/was vehicle cleaning performed (currently as well as historically)?

➢ Records, Spill logs, and Historical Information

1. To the best of your knowledge, are there any current or historical data/documents/records associated with AFFF that we may review/copy (such as reports/work plans, historical or operational records, incident reports, crash data, inspection reports, AFFF spill logs, documentation of AFFF releases, photo interpretation)?

2. Do you have recollection or records of AFFF being used in response to the following:

    a. Fuel releases to prevent fires

    b. Emergency response sites (such as plane, helicopter, or vehicle crash sites and fires)

    c. Emergency runway landings where foam might have been used as a precaution

    d. Other

3. If yes to #2, please provide any information you have regarding how and if the releases were addressed and how any released material (including foam and contaminated soil) was disposed?

4. In the potential absence of written records or incomplete written records, can you provide

anecdotal/verbal information and locations of spills or other emergency response incidents where AFFF was used that haven't already been previously discussed?

5. What are the current and historical storage location(s) of the wreckage from emergency response incidents?

➢ General Information

1. Is there anyone else or other facility organization personnel that you would recommend we interview? Name, organization, position, phone number, e-mail.

2. Are there other tenants at the facility that you service? If so, please provide name of tenant and point of contact (if available).

3. Are there any other tenants/tenant organizations that currently (or historically) use/used AFFF?

PFAS Preliminary Assessment Questionnaire

GIS Personnel and Facility Historian/Librarian

{*Facility, Location*}

Interviewee Name:____

Interviewee Title:____

Interviewee Email:____

Interviewee Phone Number:___________________________________

Date/Time of Interview:_______________________________________

Interviewer:____

➢ Infrastructure Maps, Records, Spill logs, Historical Information

1. Does the facility maintain current and historical GIS data/mapping (e.g., subsurface infrastructure).

2. Are there historical aerial photographs and other facility historical information (e.g., maps, photographs) in archive?

3. Are the following types of documents/records associated with AFFF available (such as reports/work plans, historical or operational records, incident reports, crash data, inspection reports, AFFF spill logs or database, documentation of AFFF releases, photo interpretation)?

4. Can you provide anecdotal/verbal information and locations of fuel-related spills or emergency response incidents where AFFF was used ?

➢ General Information

1. Is there anyone else or other facility organization personnel that you would recommend we interview? Name, organization, position, phone number, e-mail.

PFAS Preliminary Assessment Questionnaire

Hangar Managers, Fire Suppression System Managers, and Fire Protection Engineers
{*Facility, Location*}

Interviewee Name:____

Interviewee Title:____

Interviewee Email/phone number:_____________________________

Interviewee Phone Number:__________________________________

Date/Time of Interview:_____________________________________

Interviewer:____

➢ Hangars and Buildings

1. Which areas (such as hangars, buildings, fuel or hazardous waste storage areas) historically had or currently have AFFF fire suppression systems?

2. To the best of your knowledge, please describe the procedure on how the suppression systems are supplied with AFFF (that is, is the system contained within the building, or are there separate buildings that serve to mix AFFF to supply one or more hangers with suppression systems).

3. Please describe the fire suppression system layout/activation process and if available, provide system plans or drawings.

4. When the fire suppression system engages/or was engaged, what is the current, and if different, historical response process for cleaning up or removing AFFF?

5. To the best of your knowledge, have there been inadvertent releases of AFFF from hangar fire suppression systems (such as equipment failure)? If so, please provide additional details (such as when, in which hangars/buildings, quantification of release, and how the release was removed or cleaned up).

6. Who was responsible for current or historical routine maintenance of the AFFF system/s? Were maintenance records kept, and if so where are they located?

7. To the best of your knowledge, for any historical activation (accidental, testing, or in response to an emergency) of AFFF systems within hangars and/or buildings, provide any information regarding the fate of the release (that is, did releases occur near drainage swales; were they washed to a pervious surface; did they occur on poorly maintained pervious surfaces [such as cracked concrete, porous asphalt]; were they directed to a storm drain, trench drain, oil/water separator [OWS], or wastewater treatment plant)?

➢ AFFF Purchasing, Handling, and Storage

1. Was perfluorinated AFFF historically or currently used at the facility? If so, provide information regarding where and when.

2. Please provide type of foam (i.e. 3%, 6%, High Expansion Foam) and manufacturer (i.e. 3M, Ansul, Chemguard).

3. Where has the AFFF solution been handled (currently and historically) (such as mixed, contained, released for calibration, transferred)?

4. Where is AFFF and AFFF equipment stored at the facility (currently and historically), and in what approximate quantities? (Please show locations on map provided or describe locations).

    a. Please describe procedures for how AFFF equipment is cleaned/decontaminated.

b. To the best of your knowledge, where has the equipment currently or formerly been maintained?

➢ Hydraulic Fluids and Specialty Paints

1. Does the facility assemble, manufacture, use, repair, or store high-powered equipment associated with the aerospace industry such as aircraft, rockets, or space shuttle currently or in the past?

    a. If so, please describe activities and timeframes these activities were conducted.

    b. What types of hydraulic fluids are/were used (i.e., fire resistant, water or oil-based) at this facility? Include manufacturer and brand names.

    c. Where were they used/stored and how were they disposed of at the facility?

    d. Please provide any other information regarding perfluorochemicals or substances of note. Products will have fluoro" in the SDS/MSDS chemical listing or product name. Please provide SDS/MSDS.

2. Were/are specialty paints or coatings used or stored at the facility? Specialty paints known to contain PFAS include antifouling, anti-graffiti, or anti-staining paints, and some latex paints. Were any flame-resistant paints used on aircraft/equipment or stored at the facility?

    a. Please list types of specialty paints used/stored at the facility and manufacturer brand names.

➢ Location Information

1. If not already covered in previous questions, please provide any information on releases of AFFF that may have been diverted to or could have impacted the following items/areas:

    a. Stormwater conveyances/outfalls that drain runways, taxiways, and aprons

b. Stormwater management system (such as drainage swales, outfalls, retention/detention basins)

c. Industrial or sanitary wastewater treatment system (such as storm drain, sanitary sewer, OWS, building and plumbing drains)

d. Water supply wells (such as potable, agricultural, industrial)

e. Large-scale disposal (such as landfilling, land application of WWTP sludge, washing, dumping)

f. Other

➢ General Information

1. Is there anyone else or other facility organization personnel that you would recommend we interview? Name, organization, position, phone number, e-mail.

2. Are there any other tenants/tenant organizations that currently (or historically) use AFFF?

3. Please provide any other information regarding perfluorochemicals or substances of note not in above list. Products will have fluoro" in the SDS/MSDS chemical listing or product name.

PFAS Preliminary Assessment Questionnaire
Public Works and Facility's O&M Personnel
{*Facility, Location*}

Interviewee Name:____

Interviewee Title:____

Interviewee Email:____

Interviewee Phone Number:___________________________________

Date/Time of Interview:_______________________________________

Interviewer:____

➢ Facility Information

1. Is there a Teflon-coating shop at the facility? Historically? Provide location and timeframe of operation.

2. Is there a chrome-plating shop at the facility? Historically? Timeframe of operation?

    a. Please describe process including the types of surfactants, wetting agents, fume suppressants used in the plating process. Was foam used to suppress vapors in the process?

    b. Were any of the following demisters/defoamers/surfactant products used at the plating facility?
        - ANKOR Wetting Agent F (manufactured by Enthone)
        - Clepo Chrome Mist Control (manufactured by MacDermid Inc.)
        - Fumetrol 140 Mist Suppressant
        - Benchmark Benchbrite STX or Benchmark CFS
        - MacDermid Proquel B or Macuplex STR
        - Brite Guard AF-1 fume control

3. Where are the current or former locations of auto hobby shops and car/truck washes?

4. Are there supply wells of any kind at the facility (such as, potable, irrigation, industrial) If yes, please explain water use practices. Have wells been tested for PFAS compounds?

5. Where are the current and historical landfills/disposal sites at the facility? What are the estimated years of use for each location? Confirm known landfills/disposal sites on map.

➢ Aerospace Industrial Processes

1. Does the facility assemble, manufacture, use, repair, or store high-powered equipment associated with the aerospace industry such as aircraft, rockets, or space shuttle currently or in the past?

    a. If so, please describe activities and timeframes these activities were conducted.

    b. What types of hydraulic fluids are/were used (i.e., fire resistant, water or oil-based) at this facility? Include manufacturer and brand names.

    c. Where were they used/stored and how were they disposed of at the facility?

    d. Please provide any other information regarding perfluorochemicals or substances of note. Products will have fluoro" in the SDS/MSDS chemical listing or product name. Please provide SDS/MSDS.

2. Were/are specialty paints or coatings used or stored at the facility? Specialty paints known to contain PFAS include antifouling, anti-graffiti, or anti-staining paints, and some latex paints. Were any flame-resistant paints used on aircraft/equipment or stored at the facility?

    a. Please list types of specialty paints used/stored at the facility and manufacturer brand names.

➢ Industrial Wastewater Treatment Plant (IWTP) or Sanitary Wastewater Treatment Plant (WWTP)

1. Does the facility currently have (or has the facility historically had) an IWTP or WWTP? If yes, what are/were the timeframe of use and where is effluent from the IWTP and WWTP discharged to?

2. Which buildings and drainage features, including OWSs, discharge to the IWTP and/or WWTP?

3. Does the facility utilize oil water separators (OWSs) for the collection and separation of petroleum where AFFF might have been used for operations (such as, Fire Training Areas, Hangers, Maintenance Operations)? If so, to where did the OWSs discharge (such as WWTP, outfalls), and are there drawings available for the construction of these systems?

4. How are/have sludges, waste concentrates, and biosolids from the IWTP, WWTP, and OWS been disposed of?

    a. If known, where are any current or historical drying beds/spray fields/sludge lagoons? Please identify the approximate location/s of such features on the facility map provided.

    b. If known, has any sludge been land-applied at the facility for fertilizer or for use as landfill cover? If so, please identify the approximate location/s of such features on the facility map attached?

5. Are there any current or historical diversionary flow valves that would allow for waste to bypass the facility's treatment plant(s)?

➢ Paints and Pesticide Use/Storage/Release

1. Do you know if specialty paints containing PFAS were used in large quantities at the facility? These paints include antifouling, anti-staining, or some latex formulations. If so, please provide paint storage warehouse and disposal locations.

2. How are unused or waste paints managed?

3. Do you know if pesticides were stored, mixed or used in large quantities at the facility? If so, please provide pesticide storage warehouse and disposal locations.

4. How are unused or waste pesticides managed?

➢ Records, Spill logs, Historical Information

1. To the best of your knowledge, are there any current or historical data/documents/records associated with AFFF that we may review/copy (such as reports/work plans, historical or operational records, incident reports, crash data, inspection reports, AFFF spill logs, documentation of AFFF releases, photo interpretation)?

2. Do you have recollection or records of AFFF being used in response to the following:

    a. Fuel releases to prevent fires

   b. Emergency response sites (such as, plane, helicopter, or vehicle crash sites and fires)

   c. Other

3. If yes to Question #2, please provide any information you have regarding how and if the releases were addressed and how any released material (including foam and contaminated soil) was disposed.

4. In the potential absence of written records or incomplete written records, can you provide anecdotal/verbal information and locations of spills or other emergency response incidents where AFFF was used that have not already been previously discussed?

5. What are the current and historical storage location(s) of the wreckage from emergency response incidents (if wreckage is stored outside)?

➢ Location Information

1. If not already covered in previous questions, please provide any information on releases of AFFF that may have been diverted to or could have impacted the following items/areas:

   a. Stormwater conveyances/outfalls that drain AFFF release areas

   b. Stormwater management system (such as drainage swales, outfalls, retention/detention basins)

c. Industrial or sanitary wastewater treatment system (such as storm drain, sanitary sewer, OWS, building and plumbing drains)

d. Water supply wells (such as potable, agricultural, industrial)

e. Large-scale disposal (such as landfilling, land application of WWTP sludge, washing, dumping)

f. Other

➢ General Information

1. Is there anyone else or other facility organization personnel that you would recommend we interview? Name, organization, position, phone number, e-mail.

2. Are there any other tenants/tenant organizations that currently (or historically) use/used AFFF?

3. Are you aware of the use of any other fluorinated compounds at the facility (look for "fluoro" in the SDS/MSDS chemical listing or product name, e.g., "fluorinated surfactant(s)" or "organic fluorosulfonate")

    b. If so, what are the names of the chemicals and amounts and concentrations used? Please provide the SDS/MSDS sheets for these chemicals and a description of where they are used in your process.

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APPENDIX B

VSI CHECKLIST

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Visual Site Inspection Checklist

Names(s) of people performing VSI: ______________________

Recorded by: ______________________

Contact: ______________________

Date and Time: ______________________

Method of visit (walking, driving, adjacent): ______________________

Source/Release Information

Site Name / Area Name / Unique ID: ______________________

Site / Area Acreage: ______________________

Historic Site Use (Brief Description): ______________________

____

Current Site Use (Brief Description): ______________________

____

Physical barriers or access restrictions: ______________________

____

1. Was PFAS used (or spilled) at the site/area? **Y / N**

1a. If yes, document how PFAS was used and usage time (e.g., fire fighting training 2001 to 2014):

____

2. Has usage been documented? **Y / N**

2a. If yes, keep a record (place electronic files on a disk):

____

3. What types of activities are located near the site? **Industrial / Commercial / Plating / Waterproofing / Residential**

3a. Indicate what activities are located near the site

____

4. Is this site located at an airport/flightline? **Y / N**

4a. If yes, provide a description of the airport/flightline tenants:

____

Visual Survey Inspection Log

Other Significant Site Features:

1. Does the facility have a fire suppression system? **Y / N**

1a. If yes, indicate which type of AFFF has been used:

1b. If yes, describe maintenance schedule/leaks:

1c. If yes, how often is the AFFF replaced:

1d. If yes, does the facility have floor drains and where do they lead? Can we obtain an as built drawing?

Transport / Pathway Information

Migration Potential:

1. Does site/area drainage flow off installation? **Y / N**

1a. If so, note observation and location:

2. Is there channelized flow within the site/area? **Y / N**

2a. If so, please note observation and location:

3. Are monitoring or drinking water wells located near the site? **Y / N**

3a. If so, please note the location:

4. Are surface water intakes located near the site? **Y / N**

4a. If so, please note the location:

5. Does an adjacent non-KSC PFAS source exist? **Y / N**

5a. If so, please note the source and location.

5b. Will off-site reconnaissance be conducted? **Y / N**

Visual Survey Inspection Log

Significant Topographical Features:

1. Has the infrastructure changed at the site/area? **Y / N**

1a. If so, please describe change (ex. Structures no longer exist):

2. Is the site/area vegetated? **Y / N**

2a. If not vegetated, briefly describe the site/area composition:

3. Does the site or area exhibit evidence of erosion? **Y / N**

3a. If yes, describe the location and extent of the erosion:

Unknown

4. Does the site/area exhibit any areas of ponding or standing water? **Y / N**

4a. If yes, describe the location and extent of the ponding:

Receptor Information

1. Is access to the site restricted? **Y / N**

1a. If so, please note to what extent:

2. Who can access the site? **Site Workers / Construction Workers / Trespassers / Residential / Recreational Users / Ecological**

2a. Circle all that apply, note any not covered above:

3. Are residential areas located near the site? **Y / N**

3a. If so, please note the location/distance:

4. Are any schools/day care centers/sensitive receptors located near the site? **Y / N**

4a. If so, please note the location/distance/type:

5. Are any wetlands located near the site? **Y / N**

5a. If so, please note the location/distance/type:

Visual Survey Inspection Log

Additional Notes

APPENDIX C

PHOTOGRAPHIC LOG

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APPENDIX – Photographic Log

Kennedy Space Center, Florida	Location Name	City, State

Photograph No. 1	
Description:	
Photo Date: **Direction:**	
Photograph No. 2	
Description:	
Photo Date: **Direction:**	

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National Aeronautics and
Space Administration

John F. Kennedy Space Center
Kennedy Space Center, FL 32899

June 9, 2020

Reply to Attn of: SI-E2

TO: Mr. John Winters, P.G.
Florida Dept. Environmental Protection
Federal Facilities Section
M.S. 4535
Bureau of Waste Cleanup
2600 Blair Stone Road
Tallahassee, Florida 32399-2400

SUBJECT: Predictive Integrated Stratigraphic Modeling (PRISM®) Work Plan, Center Wide Per- and Polyfluoroalkyl Substances (PFAS), Potential Release Location (PRL) 237, Kennedy Space Center (KSC), Florida

Dear Mr. Winters,

Please find enclosed the PRISM® Work Plan for the above-referenced site. The Work Plan activities were presented in an advanced data package (ADP) at the February 2020 KSC Remediation Team (KSCRT) meeting (Meeting Minute 2002-M08 and Team Decisions 2002-D34 through D36).

If you have any questions regarding this submittal, please contact me at 321-258-8314.

Sincerely,

Michael J. Deliz, P.G.
Remediation Program Manager

Enclosure

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PREDICTIVE INTEGRATED STRATIGRAPHIC MODELING (PRISM®) WORK PLAN
CENTER WIDE PER- AND POLYFLUOROALKYL SUBSTANCES (PFAS) POTENTIAL RELEASE LOCATION (PRL) 237
KENNEDY SPACE CENTER, FLORIDA

Prepared for:

Environmental Assurance Branch
National Aeronautics and Space Administration
Kennedy Space Center, Florida 32899

A-E Contract 80KSC019D0010
Task Order 80KSC019F0289

April 2020
Revision 0

Prepared by:

AECOM
150 N Orange Ave, Suite 200
Orlando, Florida 32801
407-843-6552

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PRISM® WORK PLAN
CENTER WIDE PFAS
PRL 237
KENNEDY SPACE CENTER, FLORIDA

April 2020
Revision 0

Prepared for:
Environmental Assurance Branch
National Aeronautics and Space Administration
Kennedy Space Center, Florida 32899

A-E Contract 80KSC019D0010
Task Order 80KSC019F0289

Prepared by:
AECOM
150 N Orange Ave, Suite 200
Orlando, Florida 32801
407-843-6552

In accordance with the provisions of Florida Statutes, Chapter 471, this PRISM® Work Plan has been prepared under the direct supervision of a Professional Engineer registered in the State of Florida. This work was performed in accordance with generally accepted professional engineering practices pursuant to Chapter 471 of the Florida Statutes. The data, findings, recommendations, specifications, or professional opinions were prepared solely for the use of National Aeronautics and Space Administration and the Florida Department of Environmental Protection. AECOM Technical Services, Inc. makes no other warranty, either expressed or implied, and is not responsible for the interpretation by others of these data.

Review Signature: ______________________________

Krista Sommerfeldt, P.E.
Florida Registration No. 64080
Engineering Business Authorization No. 8115

Date: 4/30/2020

KRISTA D. SOMMERFELDT
LICENSE
No 64080
STATE OF
FLORIDA
PROFESSIONAL ENGINEER

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APPENDICES

ABBREVIATIONS, ACRONYMS, AND SYMBOLS

AdICPR	Advanced Interconnected Pond Routing
ADP	Advance Data Package
AECOM	AECOM Technical Services, Inc.
bls	below land surface
BMAP	Basin Management Action Plan
CSM	conceptual site model
DOT	Department of Transportation
DPD	decision process document
EMC	event mean concentration
FDEP	Florida Department of Environmental Protection
FS	flooding surface
GIS	geographic information system
GSL	grain-size log
IDW	investigation-derived waste
KSC	Kennedy Space Center
LIDAR	light detection and ranging
LOC	Location of Concern
MICCSC	Merritt Island-Cape Canaveral Sedimentary Complex
NASA	National Aeronautics and Space Administration
NEXRAD	Next Generation Weather Radar
PFAS	per- and polyfluoroalkyl substances
PPE	personal protective equipment
PRISM®	PRedictive Integrated Stratigraphic Modeling
RCRA	Resource Conservation and Recovery Act
RIS	Remediation Information System
RPM	Remediation Project Manager

ABBREVIATIONS, ACRONYMS, AND SYMBOLS (CONTINUED)

SAP	Sampling and Analysis Plan
SB	sequence boundary
SJRWMD	St. Johns River Water Management District
SOP	standard operating procedure
SWMM	Storm Water Management Model
SWMU	Solid Waste Management Unit
TMDL	total maximum daily load
TS	transgressive surface
USEPA	United States Environmental Protection Agency
VAB	Vehicle Assembly Building
VOC	volatile organic compound
WP	Work Plan

EXECUTIVE SUMMARY

This document presents a description of various site investigation activities that will be used to improve the conceptual site model (CSM) at the Kennedy Space Center (KSC) to develop a better understanding of the fate and transport of per- and polyfluoroalkyl substances (PFAS) in groundwater and surface water. The activities proposed herein include three primary tasks: a sequence stratigraphic analysis, groundwater and surface water gauging and sampling, and a stormwater pollutant modeling analysis.

The sequence stratigraphy work includes the following:

- Development of three regional geologic cross sections using publicly available geophysical data combined with sequence stratigraphic techniques and an analysis of regional geology. These cross sections (presented herein) span from ground to approximately 250 feet below land surface (bls).
- The proposed development of six additional cross sections that are focused on known PFAS release locations. These cross sections include: two in the Industrial Area, two near the Vehicle Assembly Building (VAB), one near the Shuttle Landing Facility, and one near Launch Complex 39A.
- To support development of the new cross sections, 12 new monitoring wells will be installed (total depth 50 feet). Gamma logging will be performed on these newly installed wells and 60 existing wells.

The groundwater and surface water gauging work includes the following:

- Manual gauging of 105 existing groundwater monitoring wells during two synoptic events; one performed in the dry season and one performed in the wet season.
- Installation of 15 datalogging multiparameter transducers within 12 groundwater monitoring wells and 3 surface water locations. Each transducer will measure/log water level, salinity/conductivity, and temperature on 15-minute intervals for three months. The transducers will be deployed during a transition period between the wet/dry seasons.
- These data will be utilized to develop a high-resolution groundwater potentiometric surface map of KSC.

The stormwater pollutant modeling analysis includes the following:

- Collection of existing site-specific and regional stormwater information related to KSC.
- Development and calibration of a stormwater pollutant model using publicly available and site-specific data. Following completion, this model will be capable of identifying the locations with highest PFAS surface water discharge.

Sampling of up to 18 existing stormwater outfalls in wet/dry conditions for PFAS and compounds indicative of municipal wastewater.

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1.0 INTRODUCTION

1.1 Overview

This document is the PRedictive Integrated Stratigraphic Modeling (PRISM®) Work Plan (WP), which describes activities to be completed at National Aeronautics and Space Administration (NASA) KSC facilities in Merritt Island, Florida (Figure 1-1). PRISM® uses best practices from the fields of geology, hydrology, and chemistry to acquire a holistic understanding of the subsurface and more accurately predict contaminant migration pathways. These activities will further develop the existing conceptual site model (CSM) to provide a better understanding of the fate and transport of per- and polyfluoroalkyl substances (PFAS) at KSC. This document was prepared as part of the Resource Conservation and Recovery Act (RCRA) Corrective Action Program being implemented at KSC and in accordance with the Decision Process Document for the RCRA Corrective Action Program (DPD) (NASA, February 2019).

AECOM Technical Services, Inc. (AECOM) prepared this document on behalf of NASA under Prime Contract Number 80KSC019D0010, Task Order 80KSC019F0289.

1.2 Work Plan Objectives and Strategies

The primary objective of this PRISM® WP is to improve the existing CSM at KSC to develop a comprehensive understanding of PFAS fate and transport in groundwater and surface water. This WP includes three main scopes of work, which are briefly described below:

- A sequence stratigraphic analysis to include development of both regional and plume-scale cross sections. These cross sections will be based on high-resolution geophysical data interpreted using knowledge of the historical geologic processes involved in forming the lithostratigraphy beneath KSC.
- A Center-wide groundwater potentiometric surface analysis supplemented with surface water gauging. These data will be used to develop a high-resolution potentiometric surface map of KSC that will provide information regarding groundwater movement and interaction with surface water.
- Preparation of a stormwater model that will be developed using existing models and upgraded with recent topography and rainfall data. Surface water sampling data will be incorporated into this model to yield predictions of PFAS mass flux in stormwater.

1.3 Work Plan Organization

This work plan is organized as follows:

Section 1.0 Introduction – describes the purpose of the project, establishes the work plan objectives and strategies, and presents this outline of WP organization.

Section 2.0 Sequence Stratigraphic Analysis – describes the sequence stratigraphy analysis, including a presentation of regional-scale stratigraphic cross sections and methods to be used to develop plume-scale stratigraphic cross sections.

Section 3.0 Groundwater and Surface Water Gauging – provides information regarding methodology employed to generate data that will be used to better understand groundwater movement and interaction with surface water.

Section 4.0 Stormwater Analysis – describes data collection and modeling analysis that will be used to estimate PFAS mass flux in stormwater at KSC.

Section 5.0 Reporting – describes how the data, analyses, and figures developed during this scope of work will be presented.

Section 6.0 Investigation-Derived Waste Management – describes methods that will be used to manage, store, sample, and dispose of investigation-derived waste (IDW).

References Provides a list of the references used to develop this document.

Appendix A Contains standard operating procedures (SOPs) for PFAS sampling.

2.0 SEQUENCE STRATIGRAPHIC ANALYSIS

2.1 Goals

The sequence stratigraphic analysis will develop a higher-resolution geologic framework for better evaluating groundwater flow paths. The following is a list of specific potential outcomes that can be achieved by performing this analysis:

- Identification of PFAS mass flux zones and estimates of their spatial continuity
- Identification of groundwater confining layers and PFAS mass storage zones and estimates of their spatial continuity
- Development of subsurface hydrogeology characteristics to estimate site-specific input parameters for stormwater and/or groundwater fate and transport models
- Identification of surface water bodies hydraulically connected to groundwater impacted with PFAS.

2.2 Geological Background

The surface of peninsular Florida is dominated by landforms of marine origin and coastal features that have been sculpted by geomorphic processes during their intermittent subaerial exposure during the late Cenozoic (Schmidt, 1997). The geologic evolution of the KSC region was affected by several processes, including global sea level changes (eustasy), sediment supply (both from landward uplands and alongshore sources), and subsidence/karstification (Adams, 2018; Burdette and others, 2010; Rink and Forrest, 2005). The present-day Merritt Island-Cape Canaveral Sedimentary Complex (MICCSC), which includes KSC, evolved during the Pleistocene to Holocene (recent) time, as a result of delta progradation towards the Atlantic Ocean via the ancestral St. Johns River, which was later subjected to intense wave reworking (Figures 2-1 through 2-3). Studies indicate that between 130,000 to 80,000 years ago, the ancestral St. Johns River emptied its sedimentary load along the central Florida coast, building a prominent fluvial delta that eventually became Merritt Island (Adams, 2018). Sometime prior to the mid-Holocene, karst-driven isostatic uplift within the central Florida peninsula created a drainage reversal, halting sediment delivery to the delta. This allowed ocean waves to erode the outer delta and transport sediment southward (via longshore drift), thus building the Cape Canaveral promontory and the eventual modern configuration of the MICCSC (Figure 2-3).

2.3 Regional Cross Section Development

The sequence stratigraphic analysis began with the development of preliminary stratigraphic models presenting regional (several miles) geologic cross sections. These cross sections are part of the CSM that will be enhanced with data collected as part of this WP. The objective of these cross sections is to develop a broad understanding of the geologic layers beneath KSC and surrounding areas. In addition to addressing the goals listed in Section 2.1, the cross sections will:

- Place monitoring well screen intervals in relation to stratigraphy, which will assist in correlation with PFAS occurrence and water elevations
- Identify data gaps for minimizing stratigraphic uncertainty
- Identify locations for vertical sampling intervals for future groundwater sampling

The methods used to develop these cross sections, and key observations, are presented in this section. These cross sections were presented as part of the PRISM® Advance Data Package (ADP)

2.3.1 Data Sources

Data from a variety of existing hydrogeological, geological, and geophysical sources were obtained through coordination with the NASA Remediation Project Manager (RPM), and searches of KSC databases and public data repositories, as described below. A previous sequence stratigraphic analysis of Cape Canaveral provides the general geomorphological, stratigraphic, and hydrogeological framework for the MICCSC (AECOM, December 2015). Several documents such as *Geology, Geohydrology and Soils of KSC: A Review* (NASA, August 1990), the *Environmental Setting Reference Manual* (NASA, May 2003), and *Environmental Resources Document* (NASA, March 2010) were also reviewed to develop an understanding of the geology specific to KSC. Focused, site-specific data from historical investigations such as boring logs, grain size data, water levels, plume maps of dissolved organic compounds, aerial photographs, and high-resolution data (e.g., Hydraulic Profiling Tool) from various areas within KSC were obtained from the Remediation Information System (RIS) database and reviewed. Extensive gamma log data for KSC were obtained from the Hydrogeologic Information System database provided by the St. Johns River Water Management District (SJRWMD, 2020).

2.3.2 Development of Stratigraphic Framework

After establishing the regional context from the literature study and data review, a geological analog was established, which allows for the determination of appropriate width-thickness ratios of lithofacies. Preparation of the geological analog is illustrated in Figures 2-4 and 2-5. Gamma logs were primarily used for lithofacies construction, as these data provide a continuous vertical measurement of clay and sand content in siliciclastic and carbonate depositional environments (Figure 2-4). Grain size logs from existing boring logs at KSC were also used to calibrate the gamma response.

Figure 2-5 illustrates how the sequence stratigraphic framework of the KSC was developed. First, the top of a regional limestone strata (Ocala Limestone) was identified as a distinct increase (positive kick) of the gamma value, shown in light blue and interpreted as a transgressive surface (TS). This regional marker differentiates the low-gamma limestone units below from high-gamma shallow marine mud above.

Secondly, a major regional erosive surface below the low-gamma sandstone units, following the shallow marine strata, was identified as a sequence boundary (SB) and is denoted by a red sinusoid. A significant flooding surface (FS), demarcated by a sharp positive kick in gamma, was interpreted to subdivide the overlying sandy units into two parasequences (building blocks of sequences). This marker parasequence boundary is shown by a dotted blue line on Figure 2-5.

Finally, the solid dark blue line (significant positive kick) was interpreted to represent the maximum landward movement of the sea, known as the maximum flooding surface (MSF), below which lies another sandy package that extends to land surface. These lithofacies can be used for correlation and prediction of the internal heterogeneity of high and low permeability zones that can affect the migration of PFAS.

2.3.3 Facies Identification

Once the stratigraphic framework was established, depositional facies within the framework were assigned by identifying vertical depositional trends (e.g., fining-upward and coarsening-upward motifs) in the gamma log responses (Figure 2-6). The vertical trends of the logs were also calibrated against core descriptions from existing boring logs. Distinction of facies also depended on lateral continuity of gamma log signatures, as well as their thickness and relationship of adjacent facies.

2.3.4 Incorporation of Monitoring Well, Water Table, and Chemistry Data

Following the establishment of the stratigraphic framework and depositional facies, screened intervals of existing monitoring wells were studied and depicted in the cross sections to analyze their relationship with the soil stratigraphy. PFAS analytical data were included to provide a preliminary evaluation of the existing monitoring well network, and PFAS concentration in relation with stratigraphy.

2.3.5 Preliminary Regional Cross Sections

Three regional stratigraphic cross sections were developed for the KSC (Figure 2-7). Cross section A-A' represents a section parallel to the paleo-shoreline (strike), whereas, cross sections B-B' and C-C' are perpendicular to the paleo-shoreline (dip). The three cross sections (Figures 2-8 through 2-10) and their fence diagram (Figure 2-11) reveal the regional subsurface stratigraphy from the Eocene to the Holocene in the MICCSC region. Eocene and Oligocene carbonates (Ocala Limestone) comprise a Paleogene erosional surface that has undergone significant dissolution (Scott, 1997).

The unconformably overlying Hawthorn group is a siliciclastic cover in north and central Florida that was deposited as sediments shed from the southern Appalachians encroached onto the carbonate platform from the north during the Miocene (Scott, 1988). Lithologically, the Hawthorn Group is primarily composed of shallow marine phosphatic clay and marl, with local siltstones and very fine sandstone. The Hawthorn group is overlain by wave-dominated, siliciclastic deltaic deposits and their associated muddy prodelta developed during the Miocene to the Pliocene.

A conspicuous sea level rise during the Pleistocene (Figure 2-2) resulted in the drowning of the deltaic system and the development of a muddy estuarine environment with sporadic tidal channel sediments of very fine sand. Finally, with the reversal of the sea level in the Holocene (Figure 2-2), a depositional highstand ensued, resulting in progradation of wave-reworked beach ridges composed of coarse sand and gravelly sand deposits. The development of these sand ridges is illustrated on Figure 2-3. Note that although these ridges are predominantly sandy, there are local muddy interlaminations due to ponding in the swales or depressions between individual beach ridges, as well as between beach ridge sets.

2.3.6 Key Observations

The shallow aquifer at KSC and Cape Canaveral resides in a sand ridge/barrier bar setting. This unit:

- Is approximately 40 feet thick
- Is largely composed of highly permeable amalgamated sand and gravelly sand
- Has local confining/low-permeability intervals that are represented by clay-filled ridge swales

A predominantly Center-wide confining layer is encountered at approximately 40 feet bls, represented by the Pleistocene estuarine clayey deposits. This confining unit:

- Is approximately 5 to 20 feet thick, thickening in the seaward direction (east)
- Appears to pinch out to the west, south of NASA Parkway West (Figure 2-10)

At KSC, deltaic deposits of the Miocene underlie the upper confining layer. This unit:

- Is approximately 40 to 60 feet thick
- May represent multiple deeper aquifers (high permeability delta parasequences)
- Has local confining units that are represented by prodelta mud and silt

In the Cape Canaveral area, the eastward portion of the Miocene deltaic deposits are modified by waves into beach ridges like the Pleistocene to present day beach ridges (Figure 2-12).

A deeper confining clay layer at approximately 120 feet bls is represented by the shallow marine, phosphatic marl/clay deposits of the Pliocene Hawthorn Group. This unit:

- Is approximately 20 to 60 feet thick, thickening in the seaward direction (east)
- Shows local units of shallow marine sand/silt
- Is eroded out to the west (north of NASA Parkway West) around the western shore of the Banana Creek River (Figure 2-9)

The monitoring wells at KSC largely show screening intervals within 40 feet bls representing the Holocene beach ridges (Figures 2-13 through 2-15). A few wells are screened in the estuarine zone below the beach ridges, as well as in the Miocene-Pliocene deltaic deposits (Figures 2-14 and 2-15).

The PFAS data have been collected from within the range of surface to 50 feet bls (i.e., predominantly the layer of beach ridges; Figures 2-13 through 2-15). The presence of high and low PFAS contamination in proximity to the beach ridges suggests local heterogeneity and/or tidal effects (Figure 2-14). Therefore, higher-resolution cross sections at key facility locations with known PFAS impacts are recommended to better evaluate stratigraphic heterogeneity at the plume-scale.

2.4 Proposed Plume-Scale Cross Sections

Plume-scale cross sections will be developed to better evaluate subsurface lithostratigraphy in areas with known PFAS impacts. The main objectives of developing these new cross sections will be:

- Improving understanding of plume-scale heterogeneity
- Assessing effect of stratigraphy on subsurface PFAS occurrence and migration

The plume-scale cross sections will be developed based on the understanding developed from the regional cross sections and additional geophysical data. Further gamma logging will be performed on existing and newly installed monitoring wells. Up to 60 existing monitoring wells will be gamma logged and 12 new monitoring wells will be installed and gamma logged (Table 2-1 and Figures 2-16 through 2-19). The purpose of the new monitoring wells is to provide stratigraphic information in areas without existing monitoring wells. New monitoring wells will be installed to a depth of approximately 50 feet bls, which will penetrate the Pleistocene estuarine clay layer. Well locations (Figures 2-16 through 2-19) are tentative and subject to modifications based on accessibility, subsurface conditions, or other logistical constraints.

2.5 Monitoring Well Construction and Sampling

Installation and development of new monitoring wells will be performed in accordance with applicable portions of the Sampling and Analysis Plan (SAP) (NASA, August 2017) and Florida Department of Environmental Protection (FDEP) SOPs (FDEP, July 2018). General well specifications are listed in Table 2-1; proposed well locations are illustrated on Figures 2-16 through 2-19. Subsurface disturbance locations will be cleared of potential underground utilities by KSC utility locators prior to commencement of fieldwork. During installation, each monitoring well will be logged by a geologist for soil type in accordance with the SAP (NASA, August 2017). In addition, borehole information will be converted into vertical grain-size logs (GSLs), which visualize both grain size and texture of soil on boring logs by utilizing a scheme of color-coded boxes of corresponding width. Following installation, new monitoring wells will be subjected to downhole geophysical logging (gamma logging) in accordance with the SAP (NASA, August 2017).

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3.0 GROUNDWATER AND SURFACE WATER GAUGING

3.1 Objective

The objective of the groundwater and surface water gauging activities will be to:

- Create a comprehensive, site-wide groundwater potentiometric surface map to identify groundwater drainage basins/flow patterns within the Upper Aquifer (0 to 40 feet bls) and Lower Aquifer (greater than 60 feet bls).
- Evaluate the extent of groundwater-surface water interaction at key stormwater discharge locations throughout KSC.

3.2 Methodology

A selection of 105 existing groundwater monitoring wells will be included in the groundwater gauging event (Table 3-1). A total of 80 wells are screened within the shallow Upper Aquifer (less than 40 feet bls), 15 wells are screened within the deep Upper Aquifer (between 40 to 60 feet bls), and 10 wells are screened in the Lower Aquifer (below 60 feet bls). Monitoring wells were selected based on the following parameters:

- Wells were selected to yield the best spatial distribution of groundwater level data throughout KSC. No more than two wells from the same Solid Waste Management Unit (SWMU) were selected to limit bias towards SWMUs with many wells.
- Wells with the greatest screen differential were selected to better evaluate vertical hydraulic gradients.
- Wells with narrower screens (5 feet) were selected preferentially, as these are more likely to be screened within one stratigraphic unit.
- Wells with recent monitoring results were selected to allow for a higher probability of locating.

The groundwater gauging scope will involve the collection of two synoptic rounds of gauging. Each round will be collected within a 12-hour period, to the extent possible. One event will be collected during the rainy season (May to October), and one event will be collected during the dry season (November to April). Wells that cannot be located will be substituted with the nearest well with similar construction parameters (e.g., total depth, screened interval). Transducers will also be placed within 12 groundwater monitoring wells and at 3 surface water locations to monitor diurnal changes in groundwater and surface water levels. The surface water transducers will be deployed within the three most significant stormwater outfalls, as described in Section 4.0. Transducers will be deployed for three months, during a transition between the rainy and dry seasons. Each transducer will monitor water level, salinity/conductivity, and temperature and log data every 15 minutes. The selected well locations are illustrated on Figure 3-1; specific transducer locations will be selected based on spatial distribution and well accessibility. Groundwater and surface water level measurements, including transducer measurements, will be performed in accordance with applicable sections of the SAP (NASA, August 2017) and FDEP SOPs (FDEP, July 2018).

4.0 STORMWATER ANALYSYS

4.1 Objective

The objective of the stormwater analysis will be to identify key point and non-point discharge locations of PFAS-containing water into surface water bodies by correlating storm/surface water drainage basins to PFAS monitoring data.

4.2 Methodology

AECOM will meet with KSC staff in charge of stormwater to discuss information concerning the Center's stormwater master system. A preliminary investigation of the existing data on the KSC stormwater management system will be conducted to determine the point source outfalls for possible PFAS loadings into the Banana and Indian Rivers. The following is a list of the anticipated documents and data that will be needed for review to determine point source locations as well as gain information regarding stormwater flow and pollutant loading:

- KSC Multi-Sector Generic Permit – This document contains outfalls that the Center maintains and monitors to ensure illicit discharges do not enter adjacent waterways. According to FDEP records (FDEP, 2020), this permit expired on April 28, 2018. It is assumed that KSC is requiring individual entities to obtain their own Multi-Sector permits dependent on their industry classification. AECOM will request these documents from KSC staff.

- KSC Stormwater Improvements (Jones Edmunds & Associates, Inc., 2011) – This report contains the most recent stormwater water quantity and water quality models and stormwater basin delineations. AECOM has obtained the report, modeling input files, and/or maps from Jones Edmunds & Associates, Inc.

- Geographic Information System (GIS) Data – These data contain various information regarding stormwater infrastructure. AECOM will request this information from KSC staff.

- St. Johns River Water Management District Permits – This includes approximately 40 different stormwater permits related to facilities with offsite surface water discharges in the boundary of KSC. These include several natural areas; permits from these areas are not required for this evaluation. AECOM will obtain the relevant permits directly from SJRWMD through their website.

- Nutrient and Dissolved Oxygen Total Maximum Daily Loads (TMDLs) for the Indian River Lagoon and Banana River Lagoon (Gao, March 2009) – This report contains information regarding stormwater flow to the Indian River Lagoon and Banana River Lagoon. AECOM has obtained this report from the FDEP.

- Basin Management Action Plan (BMAP) (Banana River Lagoon Stakeholders, January 2013) – This document contains information related to pollutant loading of the Banana River Lagoon. AECOM has obtained this report from FDEP but does not have the associated modeling files. AECOM will request the BMAP modeling for review if the BMAP report does not provide sufficient information to determine outfall locations.

- BMAP (North Indian River Lagoon Stakeholders, January 2013) – This document contains information related to pollutant loading of the North Indian River Lagoon. AECOM has obtained this report from the FDEP, but does not have the associated modeling files. AECOM will request the BMAP modeling for review if the BMAP report does not provide sufficient information to determine outfall locations.

After reviewing and compiling the above information, AECOM will generate a map of the existing stormwater permits from SJRWMD and a KSC stormwater basin map with the potential point source outfalls entering the Banana and Indian Rivers. This information will be used to develop and finalize the stormwater sampling program for PFAS (Section 4.3).

AECOM will schedule a meeting with KSC to verify the findings and to confirm that the outfalls shown on the maps are point source outfalls. No site visit is anticipated for this phase of the project by AECOM.

4.3 Outfall Sampling

Based on the review of existing data and modeling activities described in Section 4.2, up to 18 stormwater outfalls will be selected for water sampling. Existing outfall locations are illustrated on Figure 4-1. The outfalls will be selected based on their flow (higher flows will be preferentially selected) and proximity to known or suspected PFAS Locations of Concern (LOCs). Each outfall will be sampled for PFAS using USEPA Method 537.1 Modified and sucralose (specialized analysis). Sucralose will be analyzed as it can serve as an indicator compound for municipal wastewater loading to surface waters (Oppenheimer and others, 2011). As wastewater facilities at KSC contain PFAS compounds (Geosyntec Consultants, September 2019), the co-analysis of sucralose may allow for source attribution. Each outfall will be sampled twice, once during the rainy season and once during the dry season. The PFAS samples will be submitted to SGS North America (Orlando, Florida) for analysis and the sucralose samples will be submitted to ALS Environmental (Kelso, Washington). Surface water samples will be collected in accordance with the SAP (NASA, August 2017) and FDEP SOPs (FDEP, July 2018). Sampling protocols specific to sampling for PFAS in surface water will also be used (Appendix A).

4.4 Modeling

In order to estimate the quantity of stormwater discharging offsite, the existing model (Jones Edmunds & Associates, Inc., 2011) will be converted from the current format (Advanced Interconnected Pond Routing, AdICPR) into the United States Environmental Protection Agency's (USEPA's) Storm Water Management Model (SWMM). This conversion will allow for the eventual modeling of PFAS mass flux in surface water. The existing model will be converted into a custom third-party interface (either XPSWMM or PCSWMM) and project areas that were not included in the original AdICPR model will be added to the SWMM model. It is assumed that at least three new areas will need to be added:

- Shuttle Landing Facility
- Space X LC 39A Area
- Deployable Launch System Site

Additional point discharge areas (added since 2011) discovered during the permit research task will also be added to the model. As part of the conversion process, the assumptions of the original model will be verified through recent aerials for land use and light detection and ranging (LIDAR) data for stage storage. No survey will be performed during this scope of work. The point discharges (i.e., outfalls) within the 2011 model are assumed to be accurate since they were previously verified (Jones Edmunds & Associates, Inc., 2011).

Once converted, the SWMM model will be executed for peak flow discharges for 10-year and 25-year storm events, which are the most common flood intensities used for design purposes. Since this model will be used for estimating PFAS mass flux, AECOM will download publicly available Next Generation Weather Radar (NEXRAD) rainfall data for correlation with the surface water gauging data described in Section 3.2. The model will be calibrated by changing the tailwater elevations in order to produce an optimal fit between actual data and model predictions.

The pollutant mass flux component of the SWMM model will be developed based on the sampling results described in Section 4.3. This sampling data will be used as event mean concentration (EMC) data to simulate the PFAS loads. The model will simulate wet and dry weather conditions using continuous rainfall data for the sampling period.

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5.0 REPORTING

The results derived from the scope of work described herein will be used to interpret PFAS occurrence patterns and guide future investigation activities. Components of the final deliverable associated with each primary task are:

5.1 Sequence Stratigraphy

The analysis performed for this task will be reported in six (6) plume-scale cross sections illustrating sequence stratigraphy overlain with PFAS sampling data.

5.2 Groundwater and Surface Water Gauging

The main deliverable for this task will be a center-wide potentiometric surface map illustrating groundwater flow patterns. Additional figures describing groundwater to surface water relationships will also be prepared.

5.3 Stormwater Analysis

The deliverable for this task will be maps and tables summarizing the stormwater modeling methodology adopted, assumptions, input parameters, and results of the hydrologic and water quality simulations. The final report will also identify drainage basins with the highest off-site PFAS loadings.

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6.0 INVESTIGATION DERIVED WASTE MANAGEMENT

Investigation-derived waste (IDW) generated will include soil cuttings, well development, purge, and decontamination waters. Soil and water will be transferred into Department of Transportation (DOT)-approved 55-gallon drums. Each drum will be sampled for PFAS and volatile organic compounds (VOCs), and analytical results will be submitted to the NASA RPM for determination of disposal. Miscellaneous trash, construction debris, and personal protective equipment (PPE) generated during field activities will be disposed of in an appropriate trash container. Investigation-derived waste will be managed in accordance with the procedures outlined in the SAP (NASA, August 2017) and DPD (NASA, February 2019). Sampling for PFAS in IDW will be performed in accordance with the procedures included in the SAP (NASA, August 2017) and as indicated in Appendix A.

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TABLES

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Table 2-1
Proposed New Monitoring Wells and Gamma Logs
Center Wide PFAS PRL 237
Kennedy Space Center, Florida

Location	Cross Section	New Well Number	Depth (ft bls)	Existing Wells for Gamma Logging
Industrial Area	IA-1	3	50	20
Industrial Area	IA-2	2	50	
Vehicle Assembly Building	VAB-1	2	50	20
Vehicle Assembly Building	VAB-2	1	50	
Shuttle Landing Facility	SLF-1	2	50	10
Launch Complex 39A	LC39A-1	2	50	10

Notes:

ft bls - feet below land surface

Table 3-1
Proposed Monitoring Wells for Groundwater Gauging
Center Wide PFAS PRL 237
Kennedy Space Center, Florida

Upper Aquifer (0 to 40 ft bls)			**Upper Aquifer (40 to 60 ft bls)**	**Lower Aquifer (below 60 ft bls)**
39A-MW0011	FS6-MW0003	SATV-IW0009I	516S-MW0012	CCB-MW0010D
39A-MW0043	GSRY-MW0045	SFOC-IW0001S	516S-MW0022	CCB-MW0096
C5ES-MW0012I	GSRY-MW0051	SFOC-IW0006S	CCB-MW0098	HMPN-MW0003
C5ES-MW0017S	GSSP-MW0019	SSPF-MW0006	CCB-MW0064	HMPN-MW0026
CCF-IW0044	GSSP-MW0034	SSPF-MW0017	CCB-MW0109	516S-MW0021
CCF-IW0062	GSSP-MW0053	SW3-MW0001	FDSA-MW0037	CCF-IW0002D
CGO-MW0006	HMF-NLP-IW0003I	SW3-MW0009	FDSA-MW0036	CCF-IW0012D
CGO-MW0023	HMF-NLP-IW0004I	TPF-MW0001	CCF-IW0039	CCF-IW0034
CM_S-MW0005I	HMPN-MW0004	UNOA-MW0001	CCF-IW0046	FDSA-MW0017D3
CM_S-MW0044	HMPN-MW0009	VABU-IW0006D	39B-MW0011	CRHE-IW0014D
CM_S-SDJ-MW0001II	LC39OGA-MW0002	VCMA-MW0002	39B-ECS-IW0008I	
CRCA-MW0002	LC39OGA-MW0005	VPF-MW0001S	39B-MW0020	
CRCA-MW0005A	LES-IW0002S	VPF-MW0007I	CHP-MW0014	
CRHE-MW0047	LES-IW0011S	WCPS-IW0005S	CHP-MW0015	
CRHE-MW0051	LETF-MW0002	WCPS-IW0006S	CCF-IW0008ID	
DAST-MW0002	LETF-MW0005	WILC-MW0087		
DAST-MW0003	M505-MW0013	WILC-MW0089		
EDL-MW0004	M505-MW0022	M_O-MW0004		
EHF-MW0001	MLPV-IW0001D	M_O-MW0006		
EHF-MW0005	MLPV-IW0009I	OPF3-IW0006S		
FCDC-MW0001	PCCA-MW0007	ORSY-EXC-MW0001I		
FCDC-MW0002	PCCA-MW0017	ORSY-EXC-MW0003I		
FDSA-MW0014S2	POL-MW0009S	RRLF-MW0038I		
FDSA-MW0015S2	POL-MW0033I	RRLF-MW0040I		
FDTL-IW0004I	PRES-IW0002D	RRLF-MW0042I		
FDTL-IW0011I	PRES-IW0007I	SDSA-MW0007		
FS6-MW0001	PSB-MW0003I			

Notes:

ft bls - feet below land surface

FIGURES

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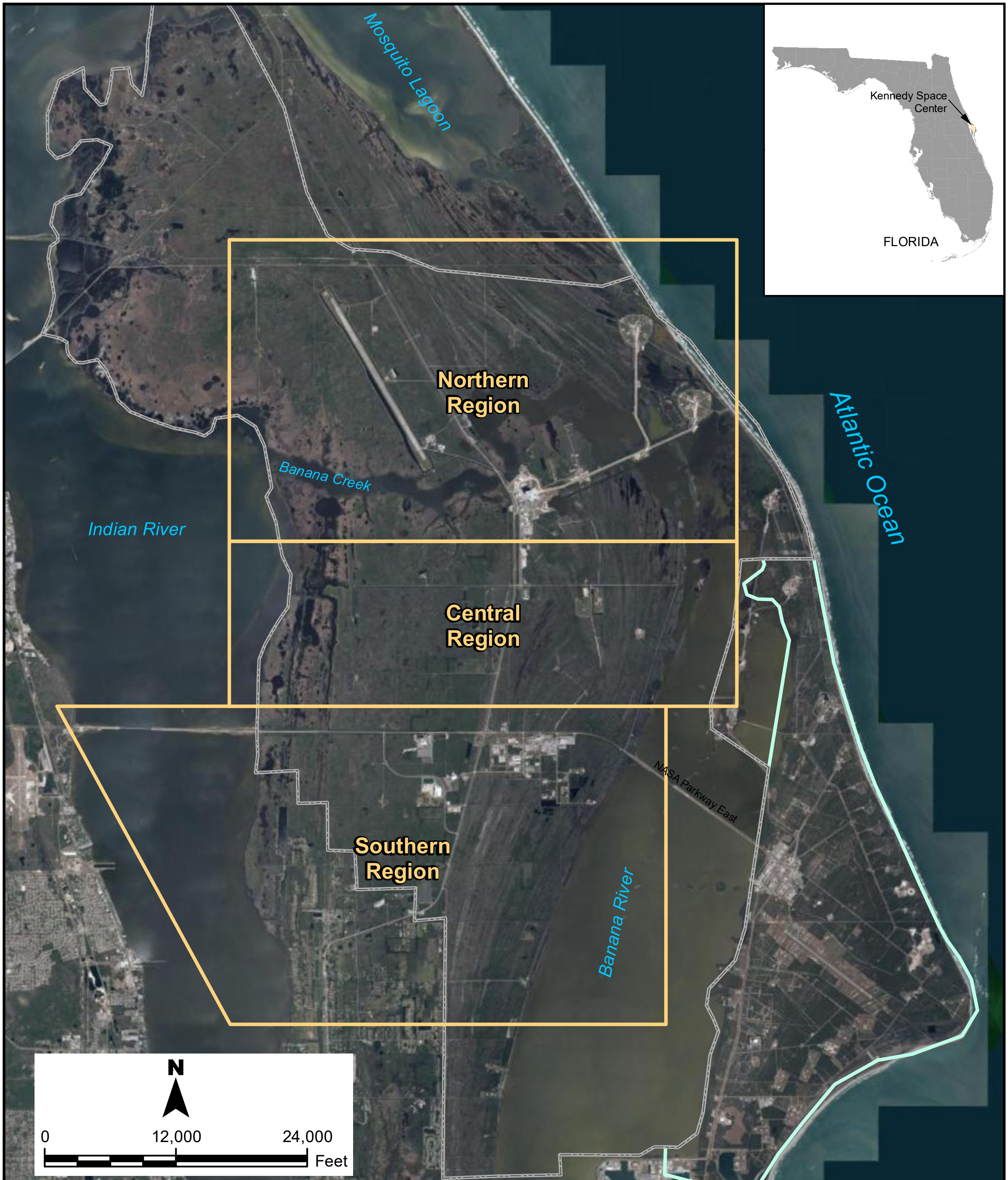

Legend

- Regional Area
- Kennedy Space Center Boundary
- Cape Canaveral Air Force Station

Notes:
1. NASA indicates National Aeronautics and Space Administration.
2. Service Layer Credits: ESRI, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS.

FIGURE 1-1
Kennedy Space Center Location Map

NASA Kennedy Space Center, Florida

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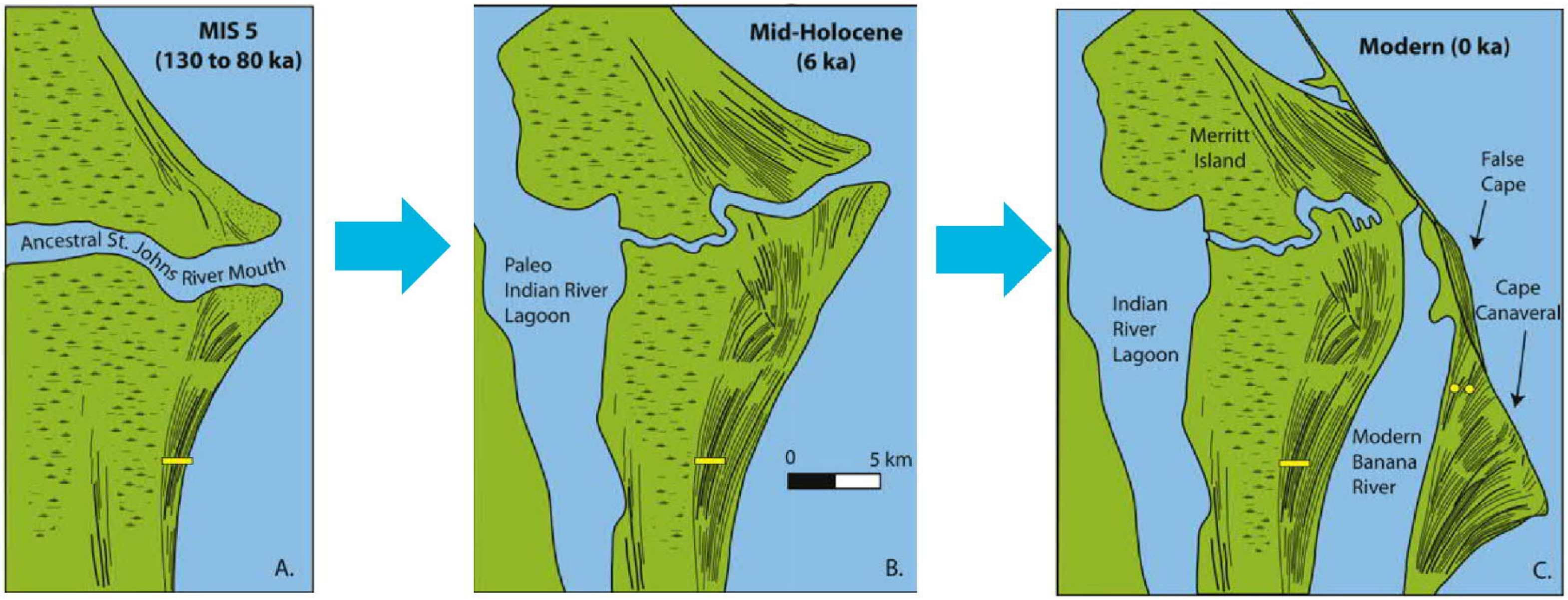


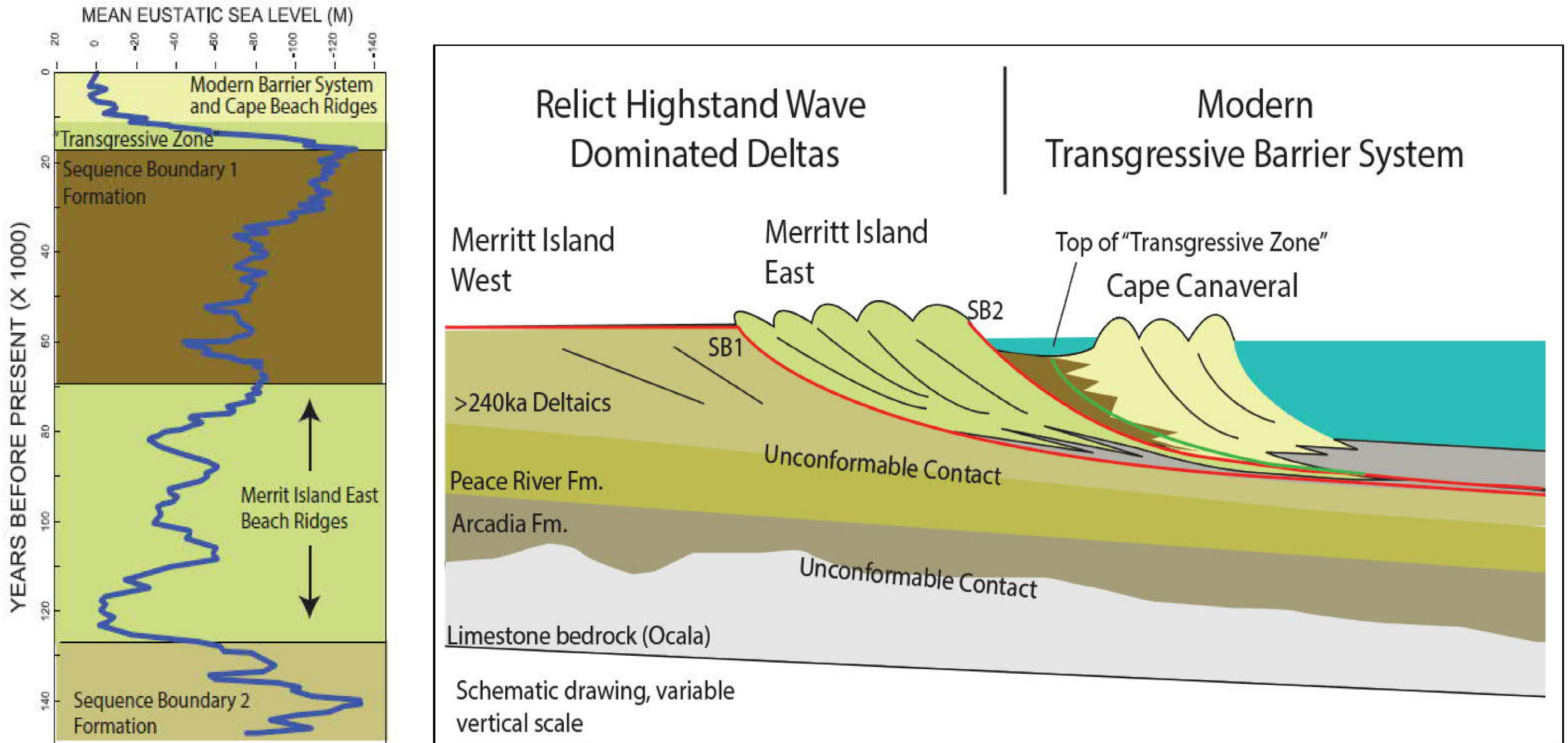
Adams, 2018

Evolution of the Merritt Island-Cape Canaveral Sedimentary Complex (MICCSC) since 130 ka.

Notes:
1. NASA indicates National Aeronautics and Space Administration.
2. ka - kilo-annum, one thousand years
3. km - kilometer

FIGURE 2-1
Evolution of the Merritt Island-Cape Canaveral Sedimentary Complex

NASA Kennedy Space Center, Florida



(Sea Level Curve From Shackleton, 1987)

Adams, 2018

Notes:
1. NASA indicates National Aeronautics and Space Administration.
2. ka - kilo-annum, one thousand years
3. SB - sequence boundary
4. Fm. - formation
5. M - meters

FIGURE 2-2
Role of Sea-Level Changes in the Evolution of the KSC Region

NASA Kennedy Space Center, Florida

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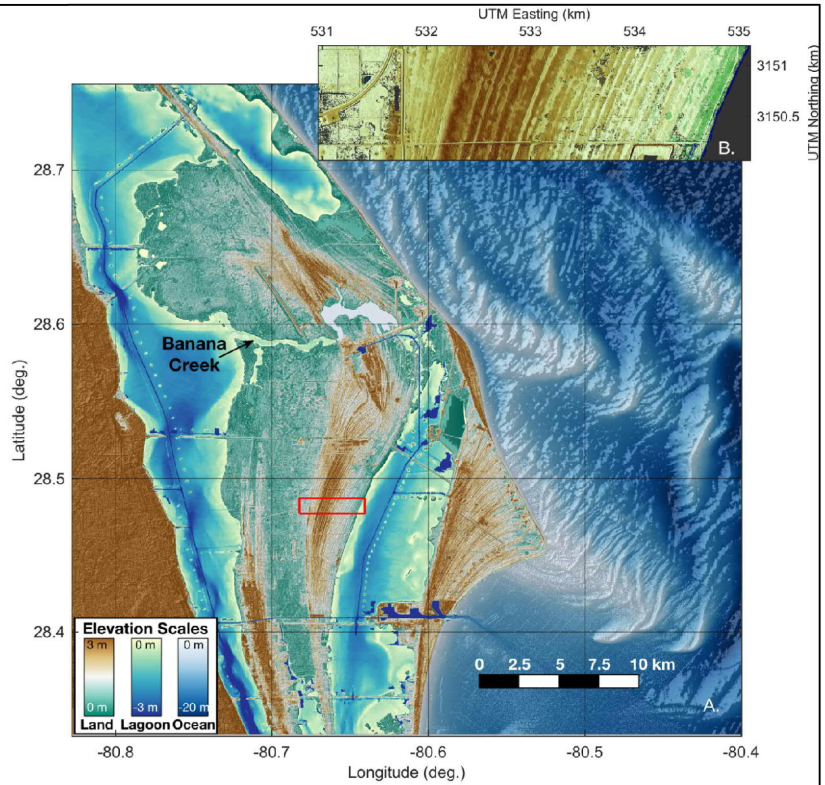
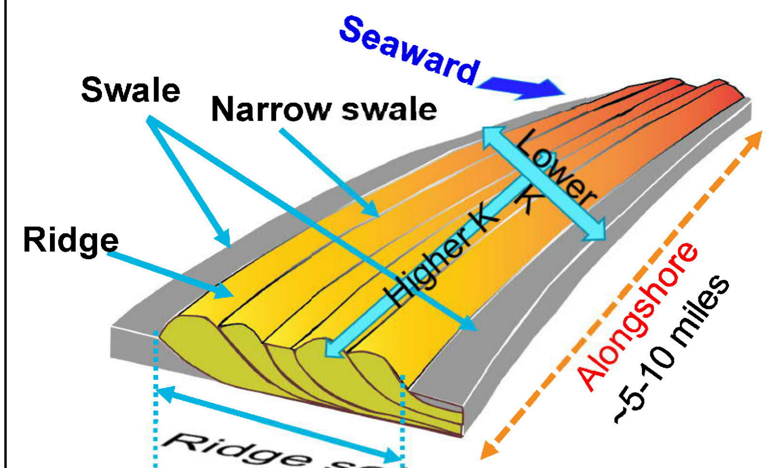


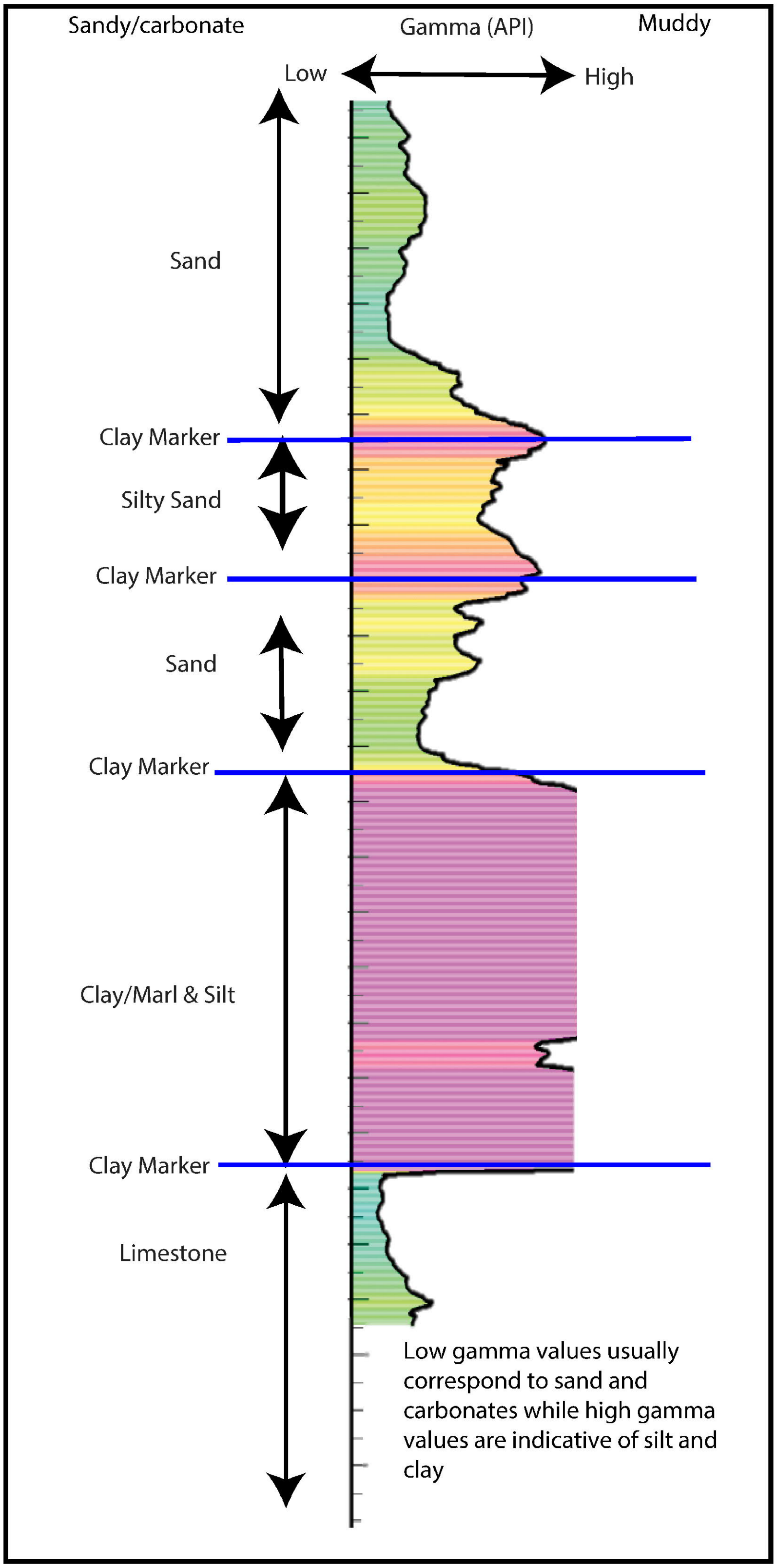


NOAA DigitalCoast website: https://coast.noaa.gov/dataregistry/search/collection

Notes:
1. NASA indicates National Aeronautics and Space Administration.
2. UTM - universal transverse Mercator
3. km - kilometer
4. m - meter
5. deg. - degrees
6. K - hydraulic permeability
7. NOAA - National Oceanic and Atmospheric Administration

FIGURE 2-3
Composition of Barrier Bar/Beach Ridges in the KSC Region

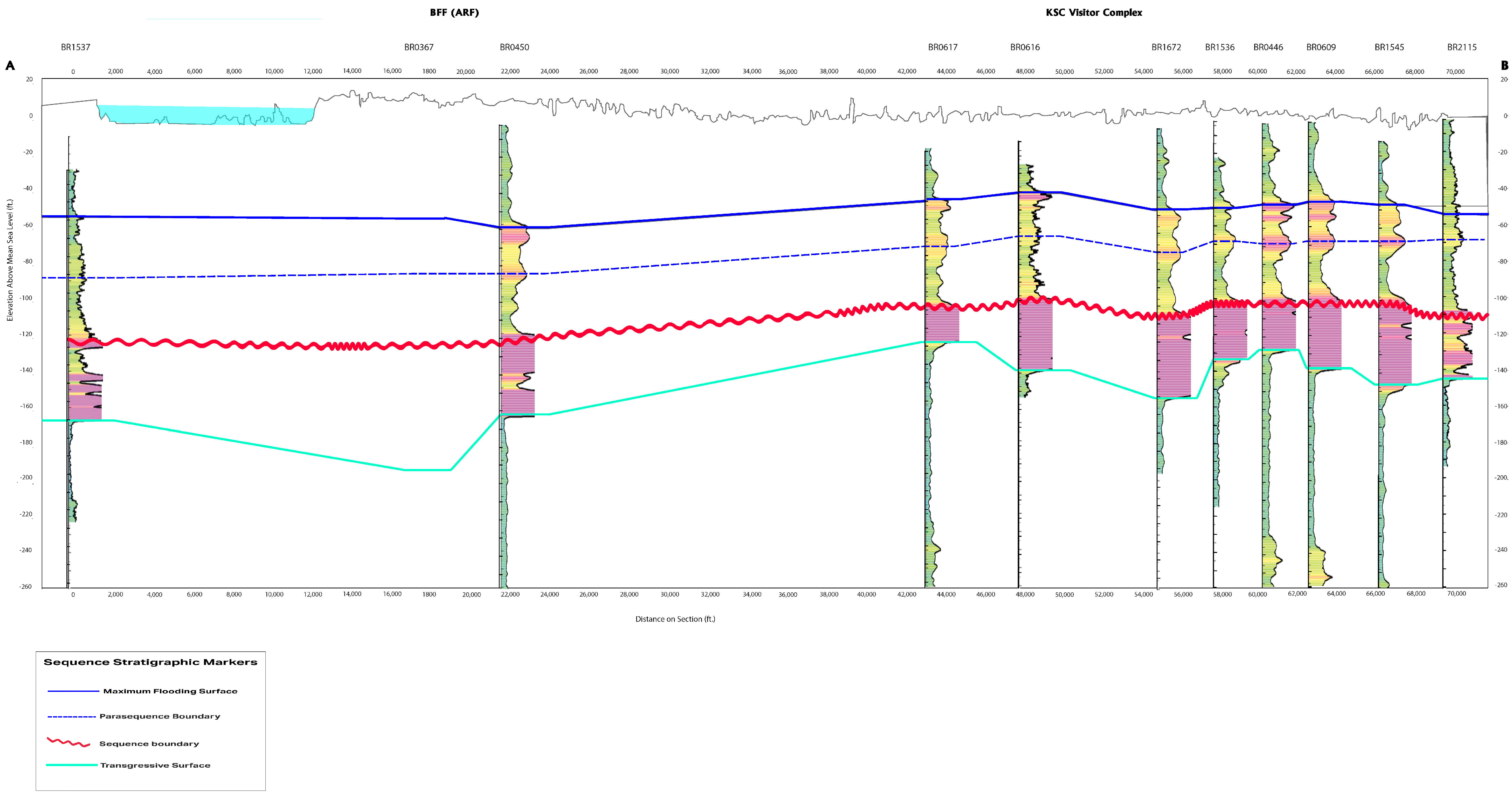
NASA Kennedy Space Center, Florida



Notes:
1. NASA indicates National Aeronautics and Space Administration.
2. Example gamma log from Merritt Island.

FIGURE 2-4
Distribution of Lithology Based on Gamma Response

NASA Kennedy Space Center, Florida



Notes:
1. NASA indicates National Aeronautics and Space Administration.
2. KSC - Kennedy Space Center
3. ft. - feet
4. BFF - Booster Fabrication Facility
5. ARF - Assembly and Refurbishment Facility
6. BR1537 - gamma log identifier

FIGURE 2-5
Placement of Sequence Stratigraphic Markers

NASA Kennedy Space Center, Florida

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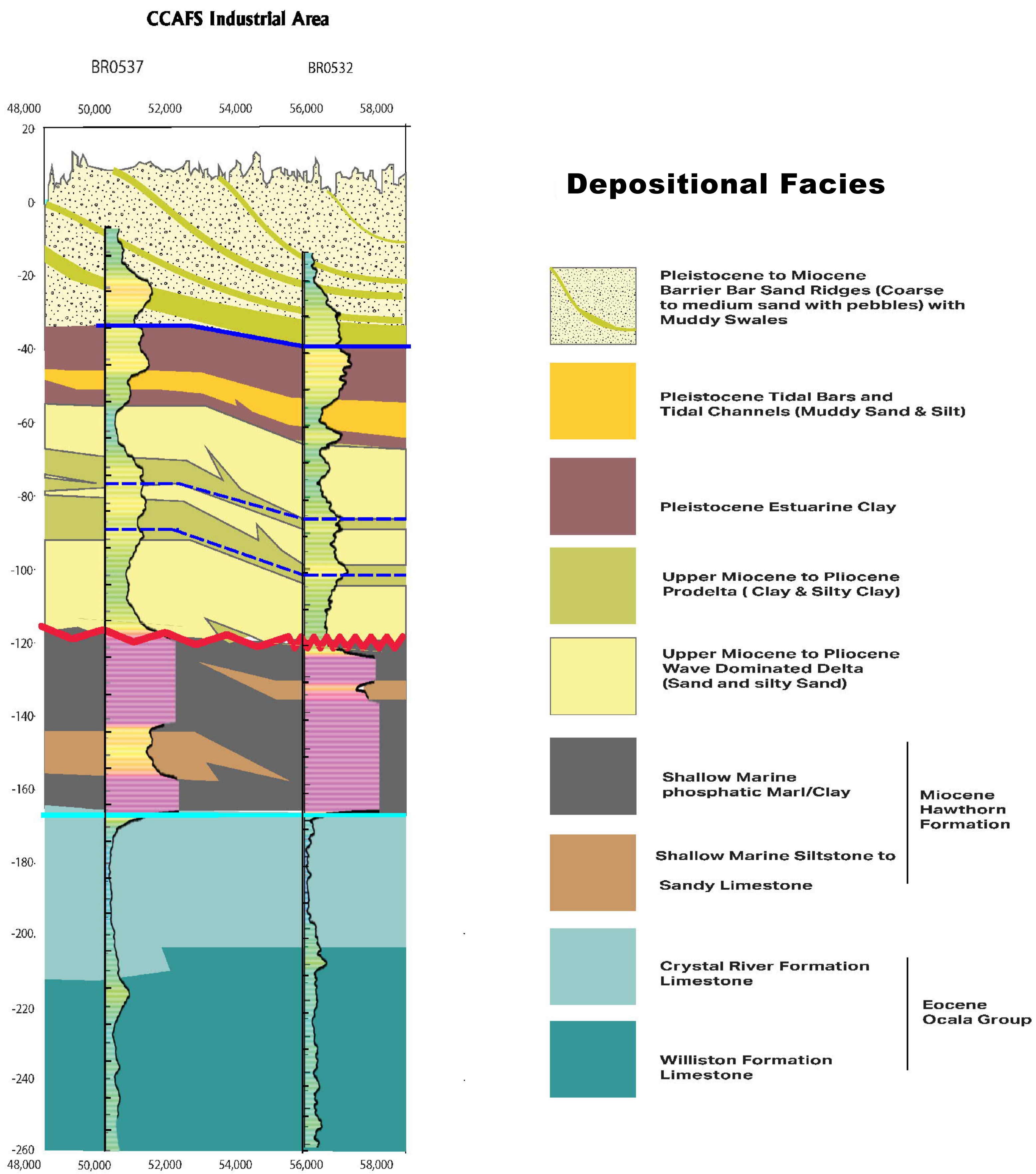

Notes:
1. NASA indicates National Aeronautics and Space Administration.
2. Gamma logs derived from Cape Canaveral Air Force Station Industrial Area.
3. ft amsl - feet above mean sea level
4. BR0537 - gamma log identifier

FIGURE 2-6
Example of Identified Depositional Facies

NASA Kennedy Space Center, Florida

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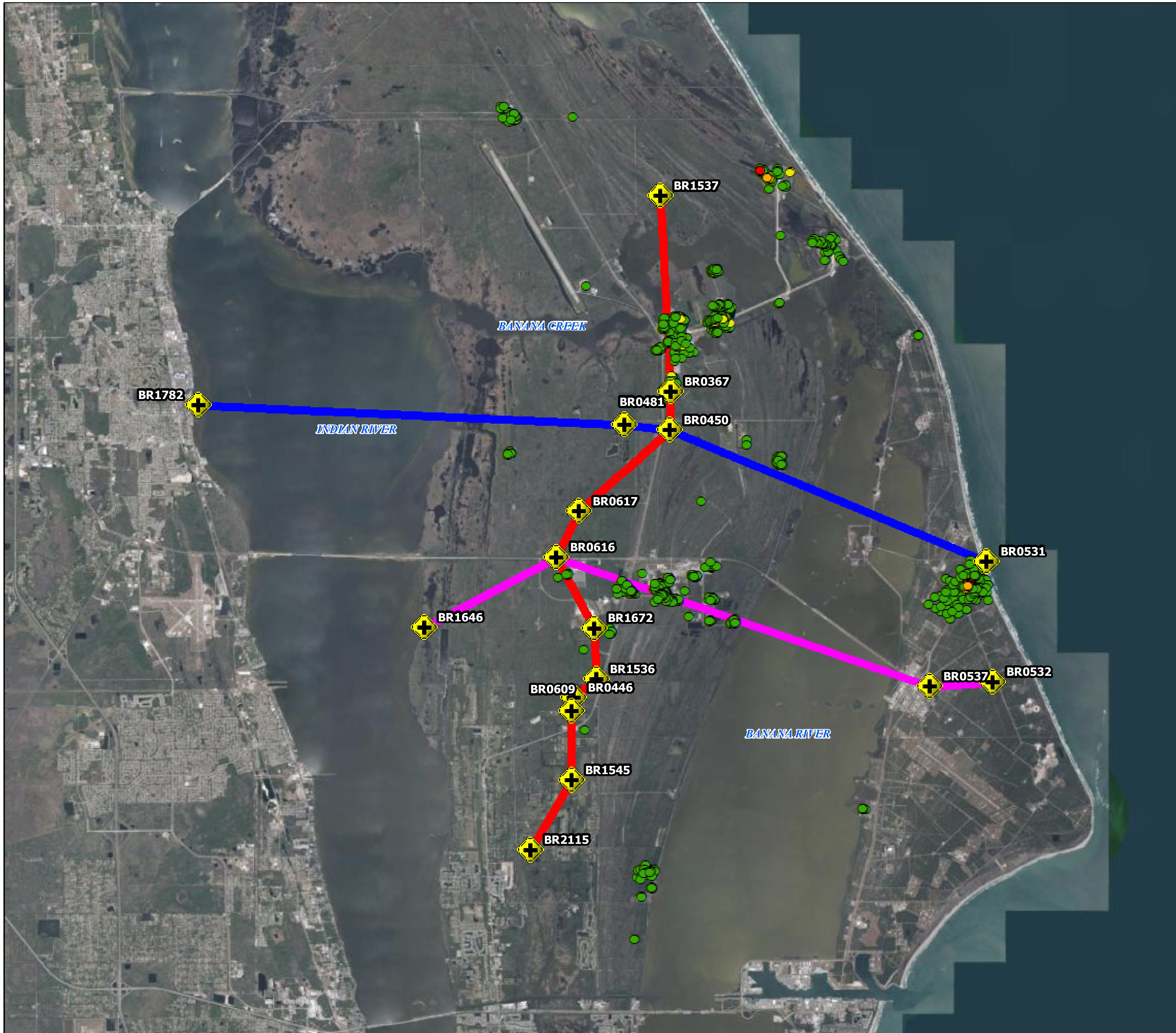

Notes:
1. Existing gamma log data were obtained from St. Johns River Water Management District on-line database. (http://webapub.sjrwmd.com/webdataexplorer/)
2. NASA indicates National Aeronautics and Space Administration.
3. bls = below land surface

FIGURE 2-7
Regional Subsurface Geology Cross Section Transects

NASA Kennedy Space Center, Florida

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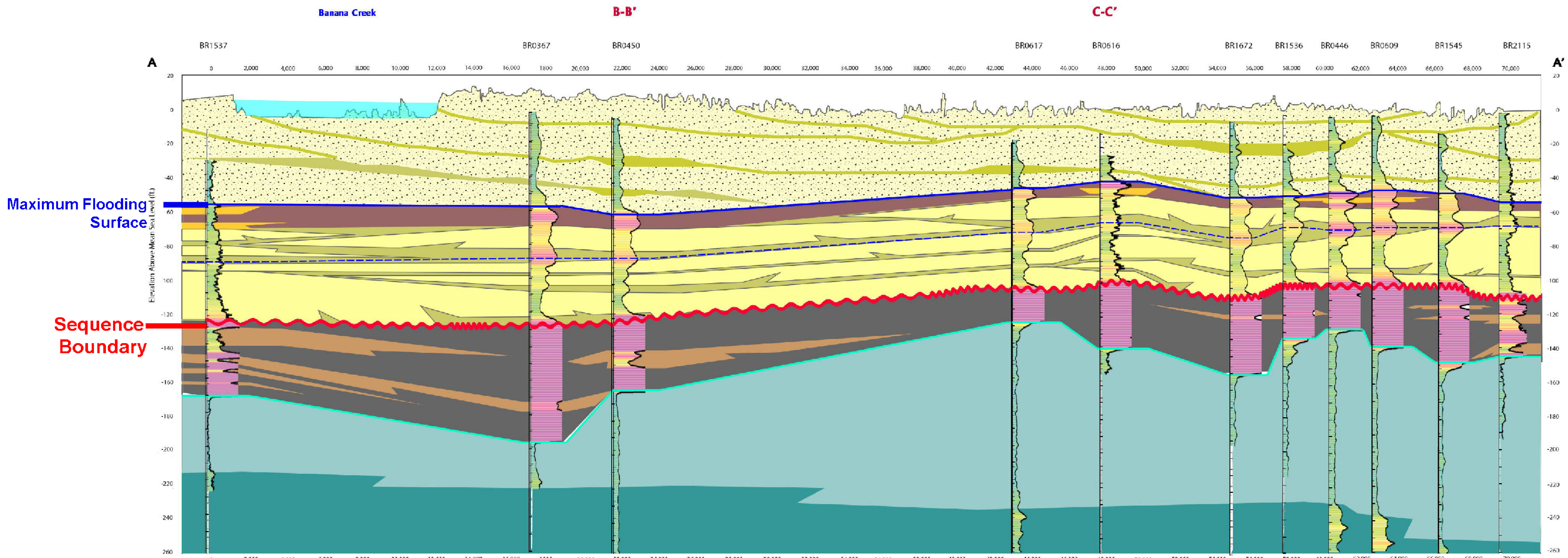

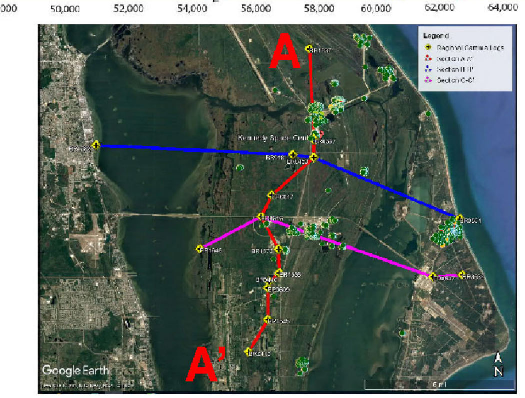

Notes:
1. NASA indicates National Aeronautics and Space Administration.
2. BR1537 - gamma log identifier
3. ft. - feet

FIGURE 2-8
Regional Subsurface Geology
Cross Section A-A'

NASA Kennedy Space Center, Florida

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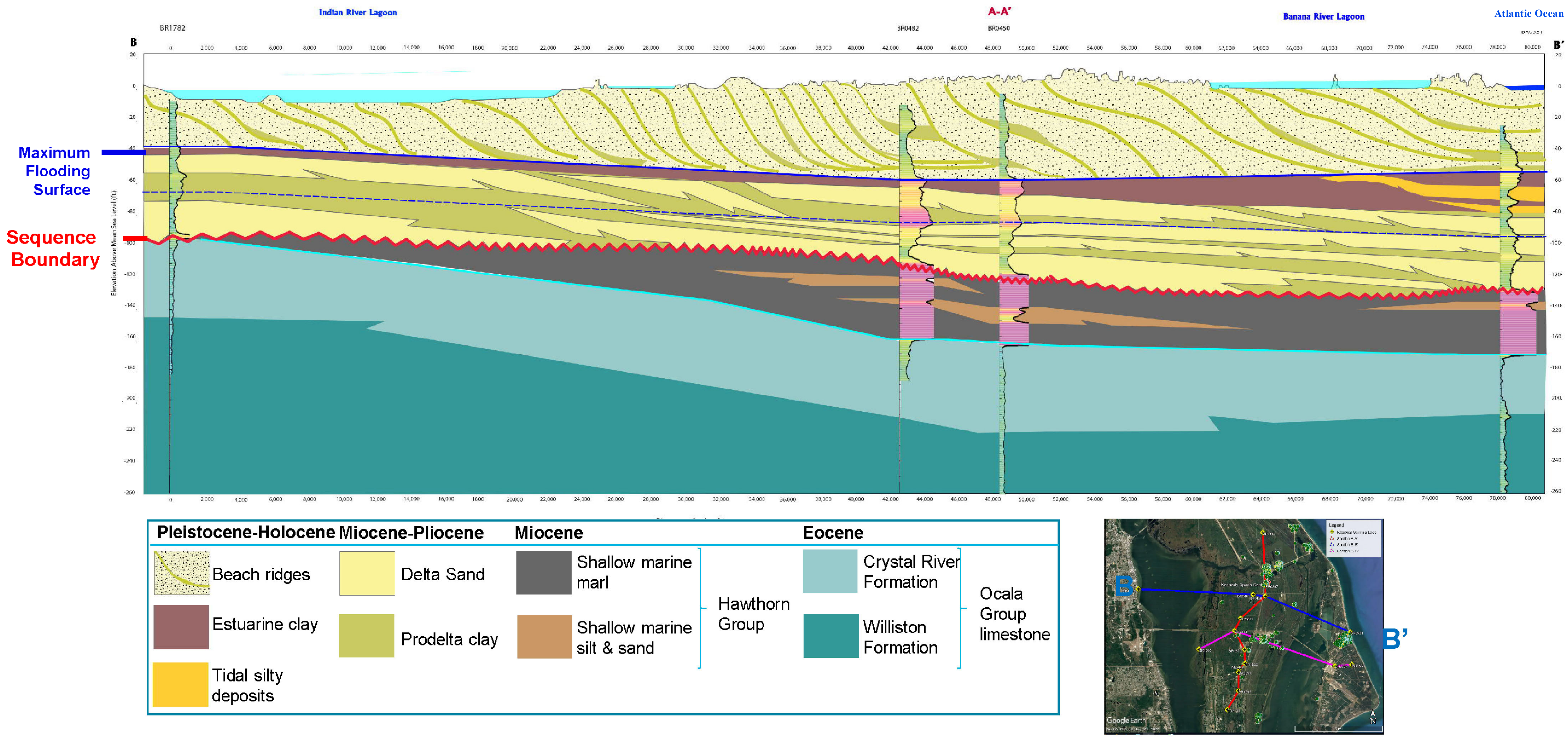

Notes:
1. NASA indicates National Aeronautics and Space Administration.
2. BR1537 - gamma log identifier
3. ft. - feet

FIGURE 2-9
Regional Subsurface Geology
Cross Section B-B'

NASA Kennedy Space Center, Florida

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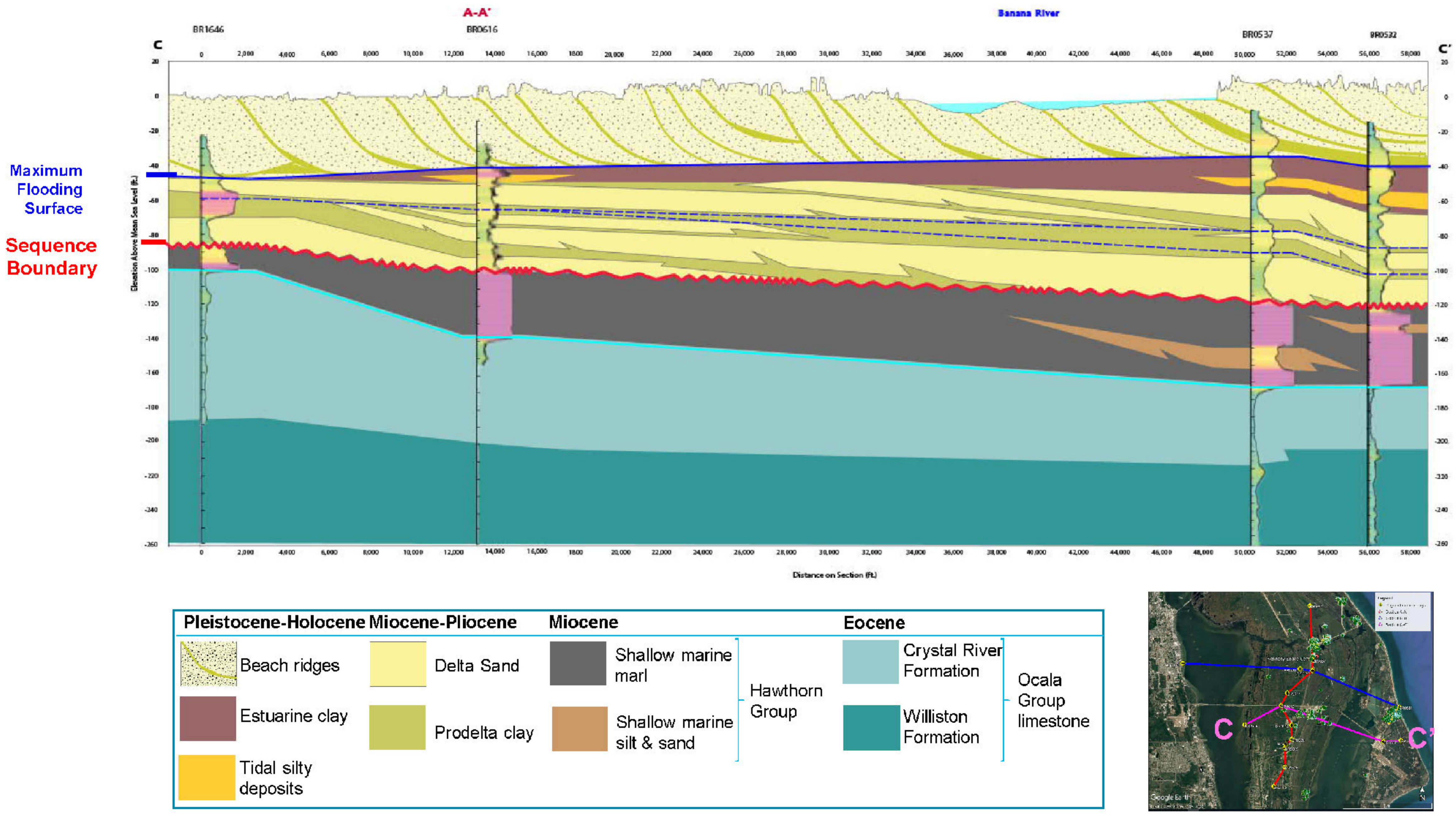
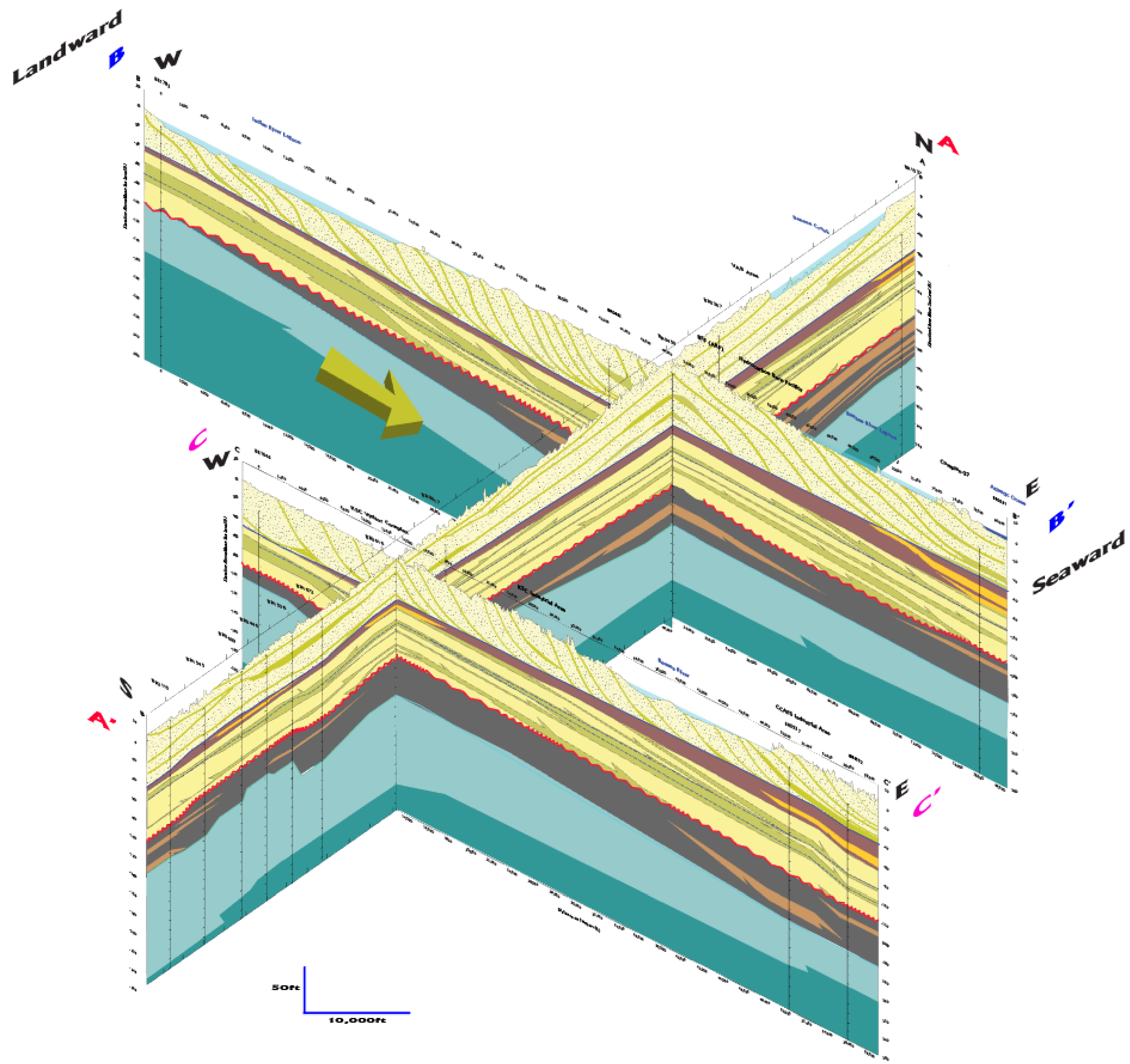
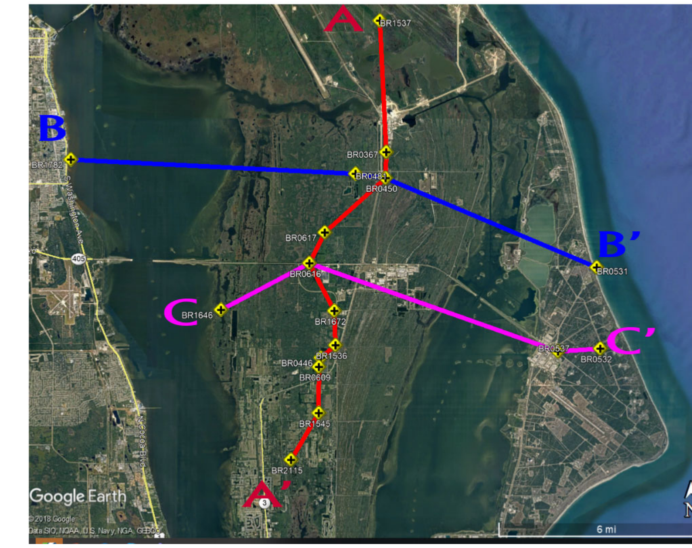


Notes:
1. NASA indicates National Aeronautics and Space Administration.
2. BR1537 - gamma log identifier
3. ft. - feet

FIGURE 2-10
Regional Subsurface Geology Cross Section C-C'

NASA Kennedy Space Center, Florida





Legend

- Pleistocene to Miocene Barrier Bar Sand Ridges (Coarse to medium sand with pebbles) with Muddy Swales
- Pleistocene Tidal Bars and Tidal Channels (Muddy Sand & Silt)
- Pleistocene Estuarine Clay
- Upper Miocene to Pliocene Prodelta (Clay & Silty Clay)
- Upper Miocne to Pliocene Wave Dominated Delta (Sand and silty Sand)
- Miocene Hawthorn Formation:
  - Shallow Marine phosphatic Marl/Clay
  - Shallow Marine Siltstone to Sandy Limestone
- Eocene Ocala Group:
  - Crystal River Formation Limestone
  - Williston Formation Limestone

Notes:
1. NASA indicates National Aeronautics and Space Administration.

FIGURE 2-11
Fence Diagram of Sections A-A', B-B' and C-C'

NASA Kennedy Space Center, Florida

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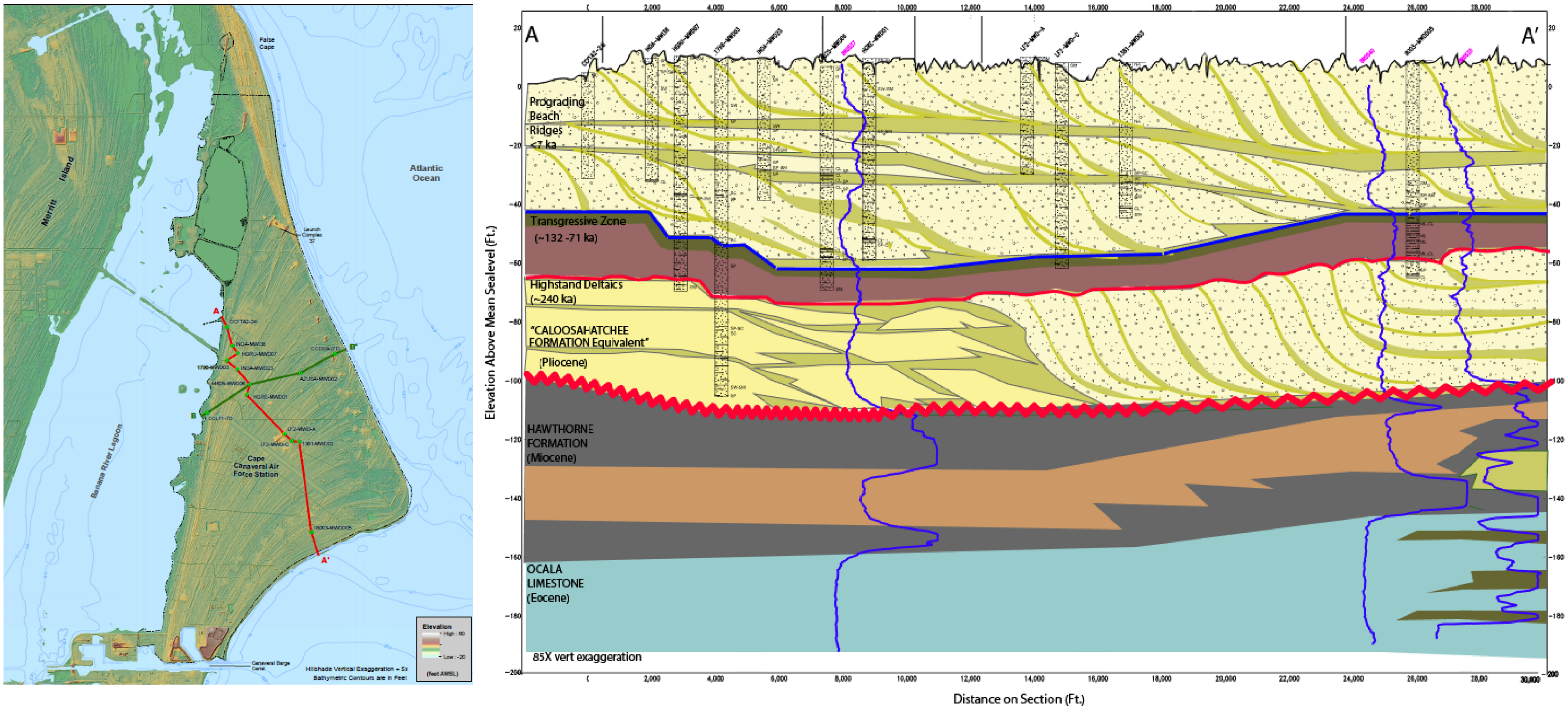
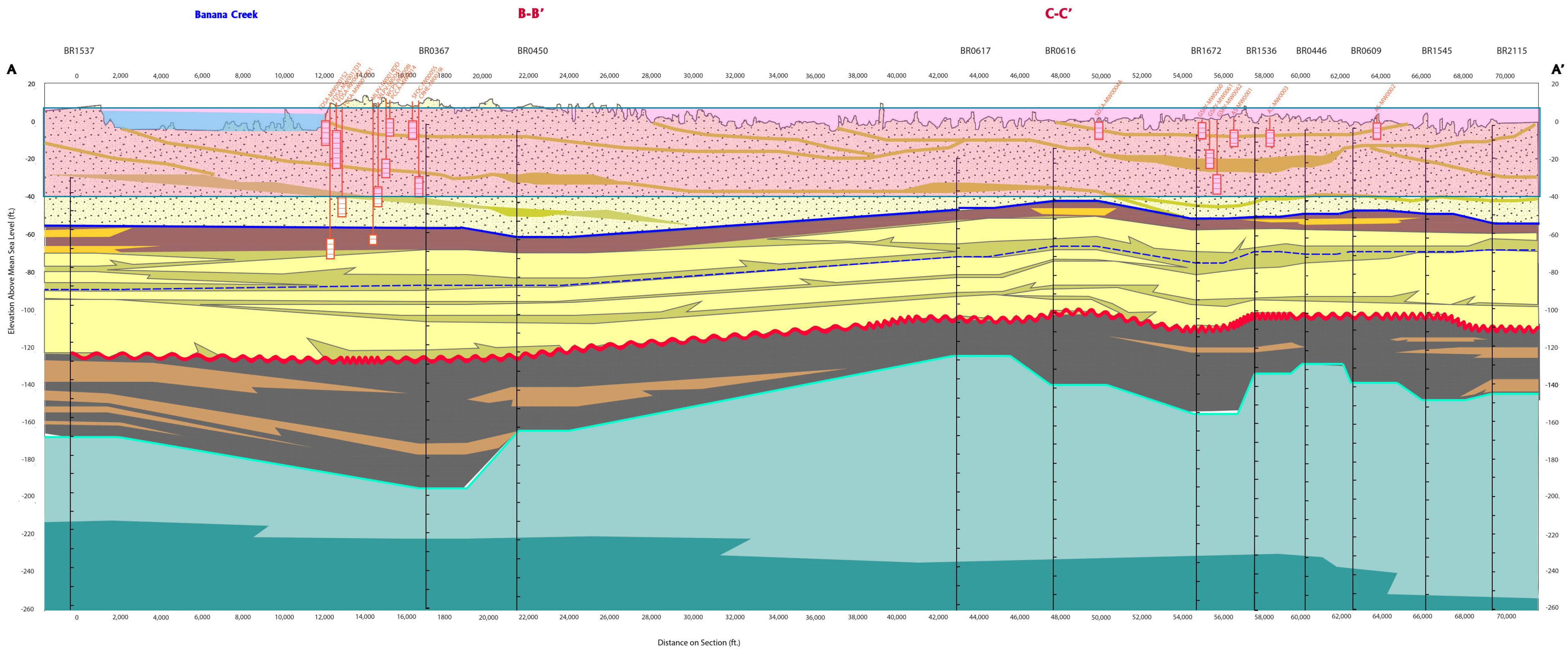


Notes:
1. NASA indicates National Aeronautics and Space Administration.
2. ka - kilo-annum, one thousand years
3. ft. - feet

FIGURE 2-12
Regional Cross Section
at Cape Canaveral

NASA Kennedy Space Center, Florida



Existing Monitoring Well PFAS

Total PFAS ng/L

- < 100
- 100 - 1000
- > 1000

Notes:
1. NASA indicates National Aeronautics and Space Administration.
2. ft. - feet
3. BR1537 - gamma log identifier
4. PFAS - per- and polyfluoroalkyl substances
5. ng/L - nanograms per liter
6. White or pink background indicates PFAS data has not been collected.

Pleistocene-Holocene	Miocene-Pliocene	Miocene		Eocene	
Beach ridges	Delta Sand	Shallow marine marl	Hawthorn Group	Crystal River Formation	Ocala Group limestone
Estuarine clay	Prodelta clay	Shallow marine silt & sand		Williston Formation	
Tidal silty deposits		Depth Interval of Phase I PFAS sampling			

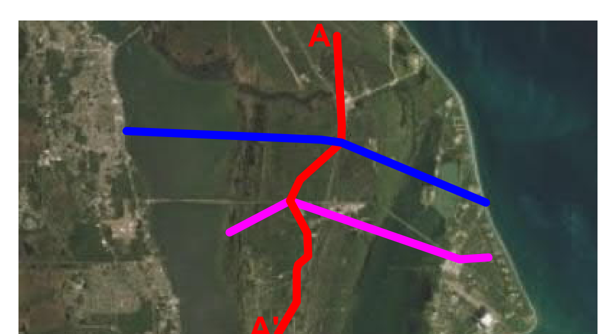


FIGURE 2-13
Regional Subsurface Geology Cross Section A-A' with Monitoring Wells

NASA Kennedy Space Center, Florida

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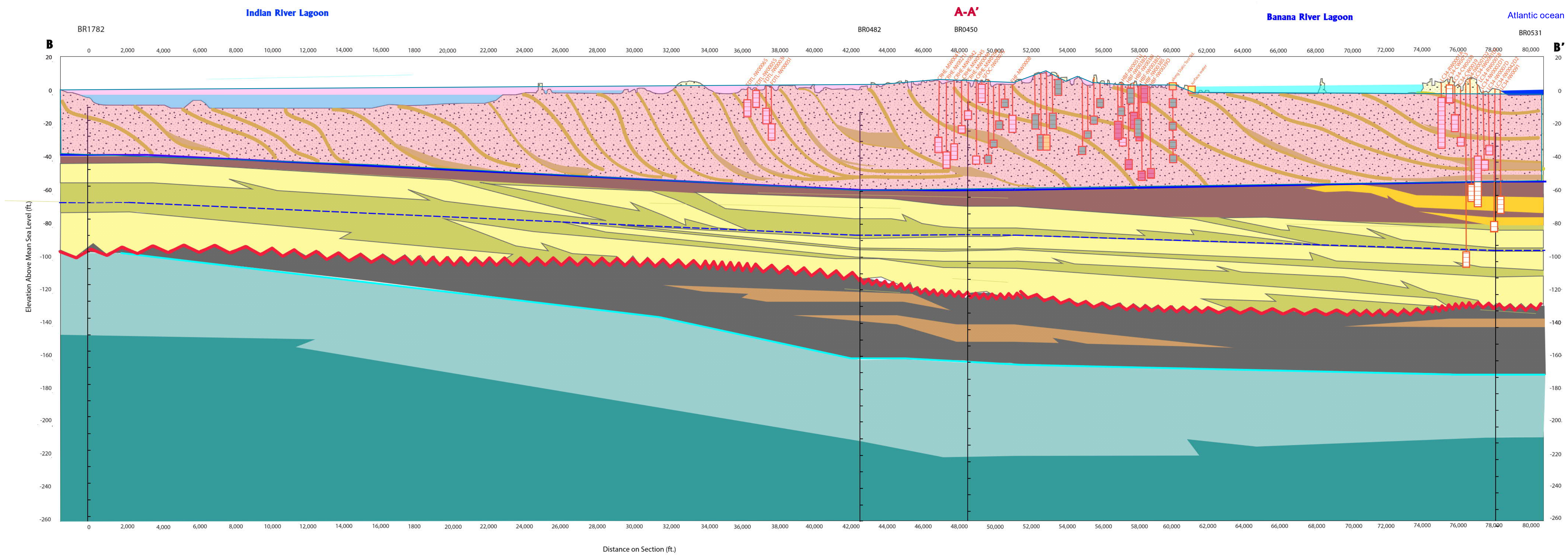


Existing Monitoring Well PFAS

Total PFAS ng/L

- < 100
- 100 - 1000
- > 1000

Notes:
1. NASA indicates National Aeronautics and Space Administration.
2. ft. - feet
3. BR1537 - gamma log identifier
4. PFAS - per- and polyfluoroalkyl substances
5. ng/L - nanograms per liter
6. White or pink background indicates PFAS data has not been collected.

Pleistocene-Holocene	Miocene-Pliocene	Miocene		Eocene	
Beach ridges	Delta Sand	Shallow marine marl	Hawthorn Group	Crystal River Formation	Ocala Group limestone
Estuarine clay	Prodelta clay	Shallow marine silt & sand		Williston Formation	
Tidal silty deposits		Depth Interval of Phase I PFAS sampling			

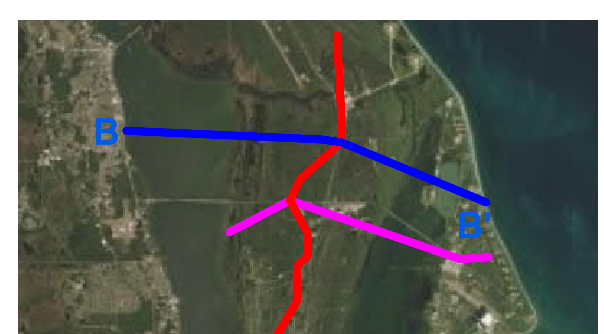
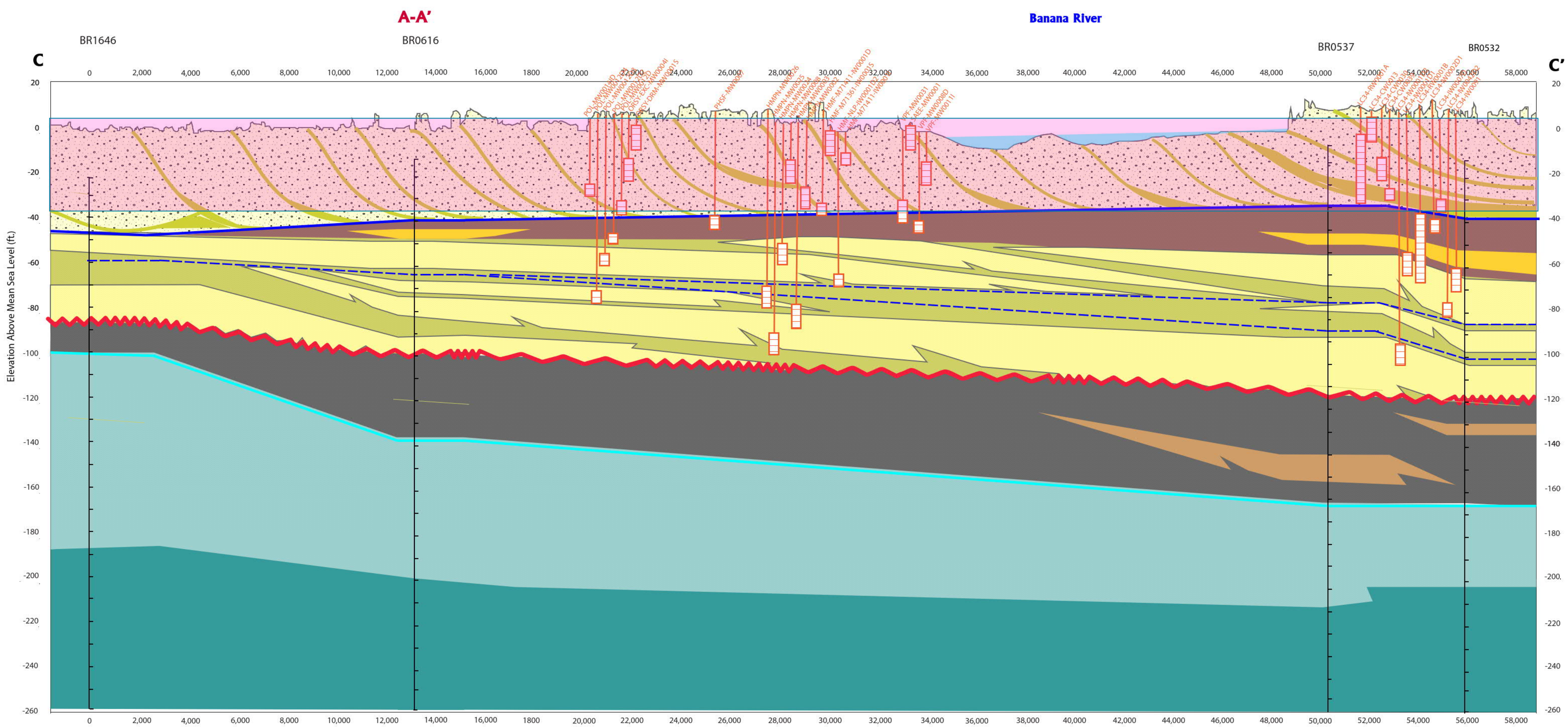


FIGURE 2-14
Regional Subsurface Geology Cross Section B-B' with Monitoring Wells

NASA Kennedy Space Center, Florida



Existing Monitoring Well PFAS

Total PFAS ng/L
- < 100
- 100 - 1000
- > 1000

Notes:
1. NASA indicates National Aeronautics and Space Administration.
2. ft. - feet
3. BR1537 - gamma log identifier
4. PFAS - per- and polyfluoroalkyl substances
5. ng/L - nanograms per liter
6. White or pink background indicates PFAS data has not been collected.

Pleistocene-Holocene	Miocene-Pliocene	Miocene		Eocene	
Beach ridges	Delta Sand	Shallow marine marl	Hawthorn Group	Crystal River Formation	Ocala Group limestone
Estuarine clay	Prodelta clay	Shallow marine silt & sand		Williston Formation	
Tidal silty deposits		Depth Interval of Phase I PFAS sampling			

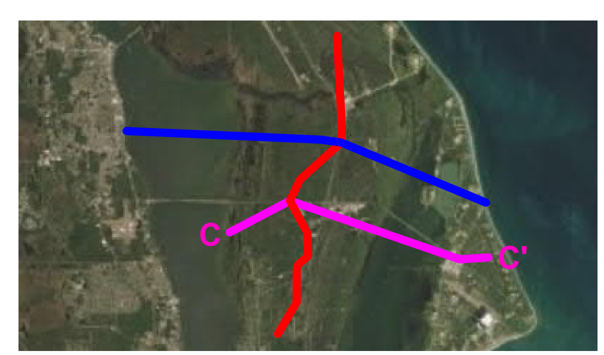


FIGURE 2-15
Regional Subsurface Geology Cross Section C-C' with Monitoring Wells

NASA Kennedy Space Center, Florida

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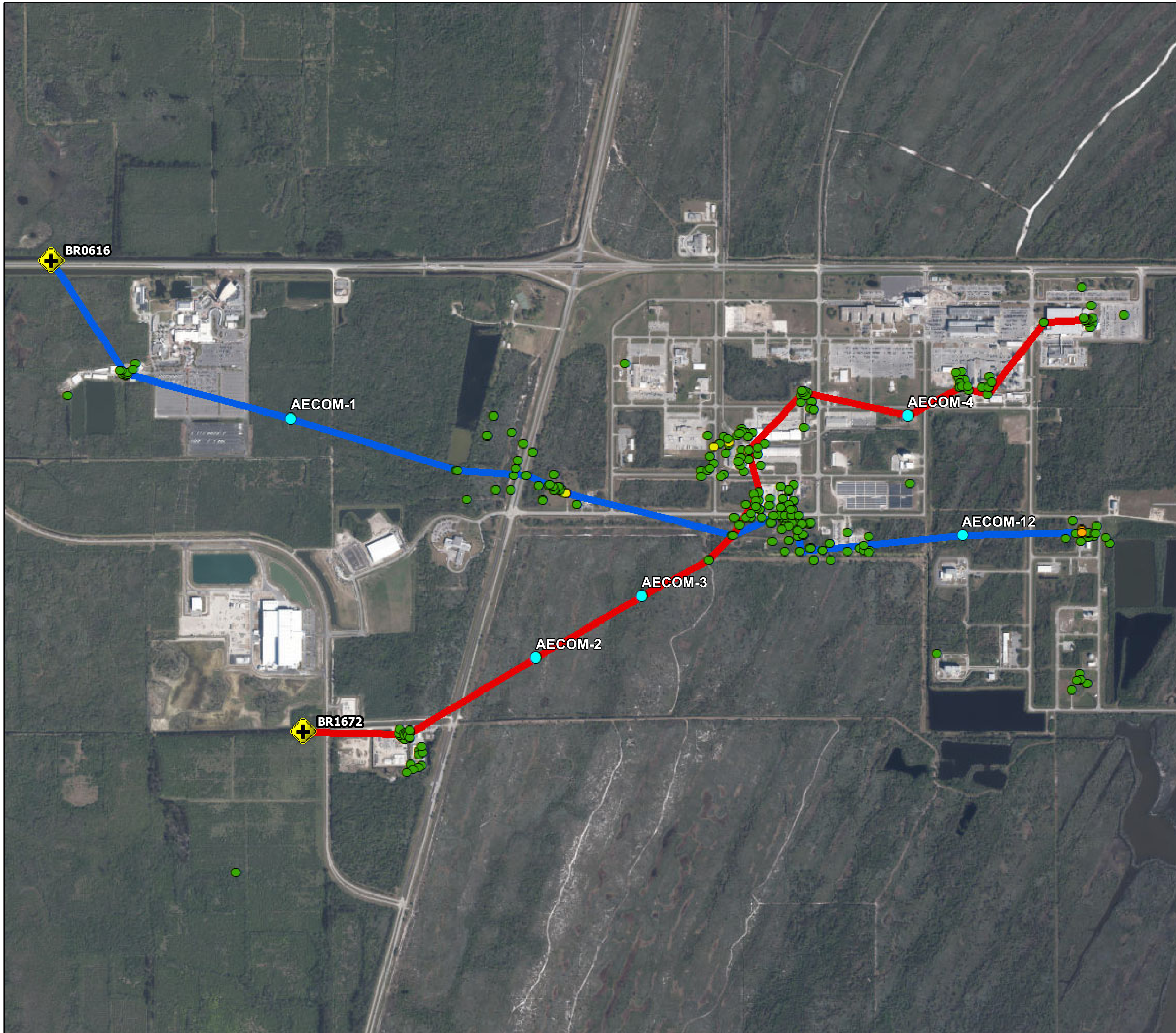

Legend

- Proposed Well
- Existing Gamma Log Well Location

Existing Monitoring Well and Depth (bls)

- 0-50
- 50-70
- 70-100
- 100-125

AECOM Proposed Plume-Scale Sections

- Section A-A'
- Section B-B'

Notes:
1. Location of proposed wells may shift based on accessibility.
2. Existing gamma log data were obtained from St. Johns River Water Management District on-line database. (http://webapub.sjrwmd.com/webdataexplorer/)
3. NASA indicates National Aeronautics and Space Administration.
4. bls = below land surface

N

0 750 1,500 3,000 Feet

FIGURE 2-16
Proposed Stratigraphic Cross Sections at Industrial Area

NASA Kennedy Space Center, Florida

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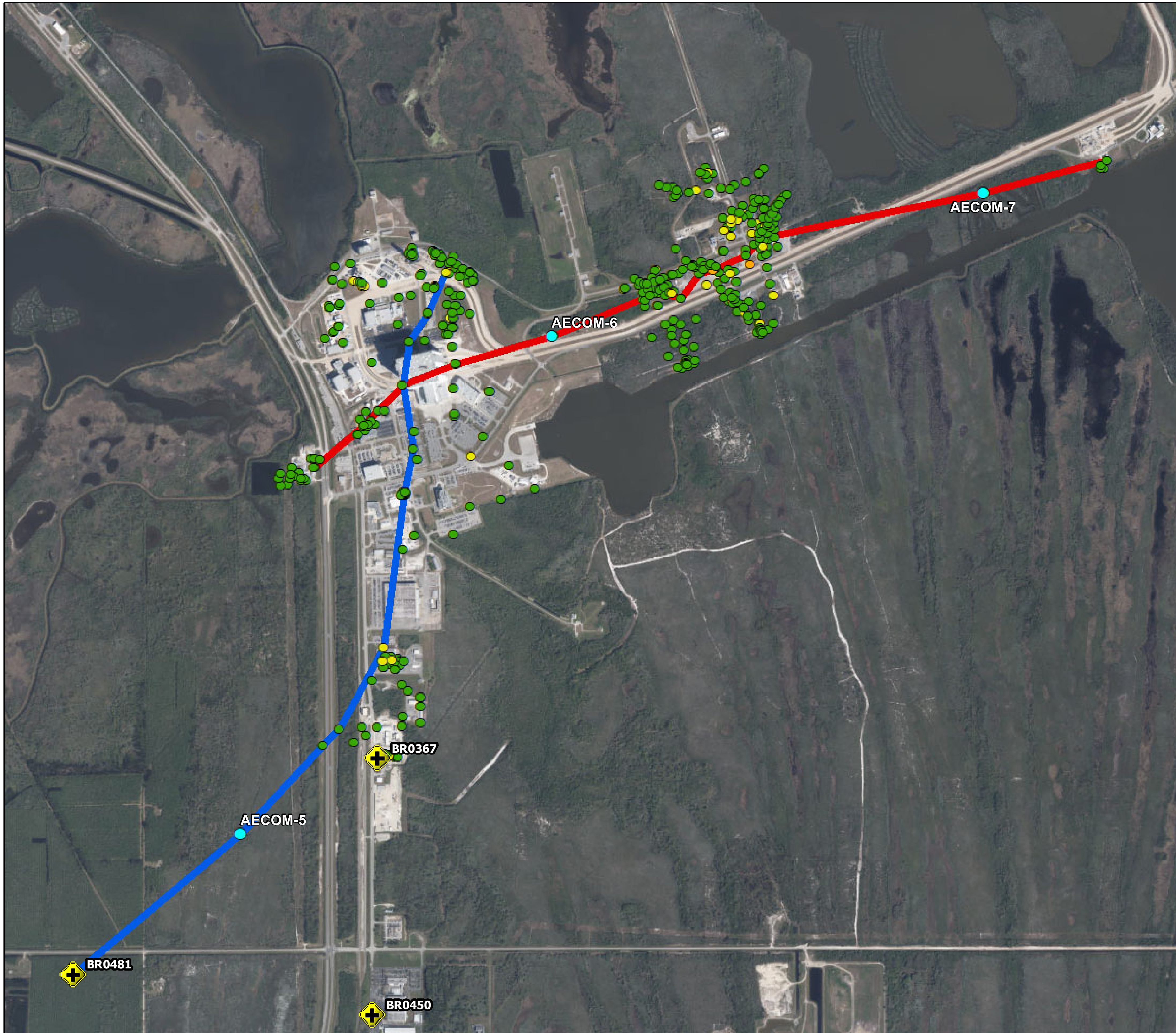

Legend

- Proposed Well
- Existing Gamma Log Well Location

Existing Monitoring Well and Depth (bls)

- 0-50
- 50-70
- 70-100
- 100-125

AECOM Proposed Plume-Scale Sections

- Section C-C'
- Section D-D'

Notes:
1. Location of proposed wells may shift based on accessibility.
2. Existing gamma log data were obtained from St. Johns River Water Management District on-line database. (http://webapub.sjrwmd.com/webdataexplorer/)
3. NASA indicates National Aeronautics and Space Administration.
4. bls = below land surface

N

0 750 1,500 3,000 Feet

FIGURE 2-17
Proposed Stratigraphic Cross Sections at Vehicle Assembly Building

NASA Kennedy Space Center, Florida

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Legend

- Proposed Well
- Existing Gamma Log Well Location

Existing Monitoring Well and Depth (bls)

- 0-50
- 50-70
- 70-100
- 100-125

AECOM Proposed Plume-Scale Section

- Section E-E'

Notes:
1. Location of proposed wells may shift based on accessibility.
2. Existing gamma log data were obtained from St. Johns River Water Management District on-line database. (http://webapub.sjrwmd.com/webdataexplorer/)
3. NASA indicates National Aeronautics and Space Administration.
4. bls = below land surface

N

0 1,000 2,000 4,000 Feet

FIGURE 2-18
Proposed Stratigraphic Cross Sections at Space Shuttle Landing Facility

NASA Kennedy Space Center, Florida

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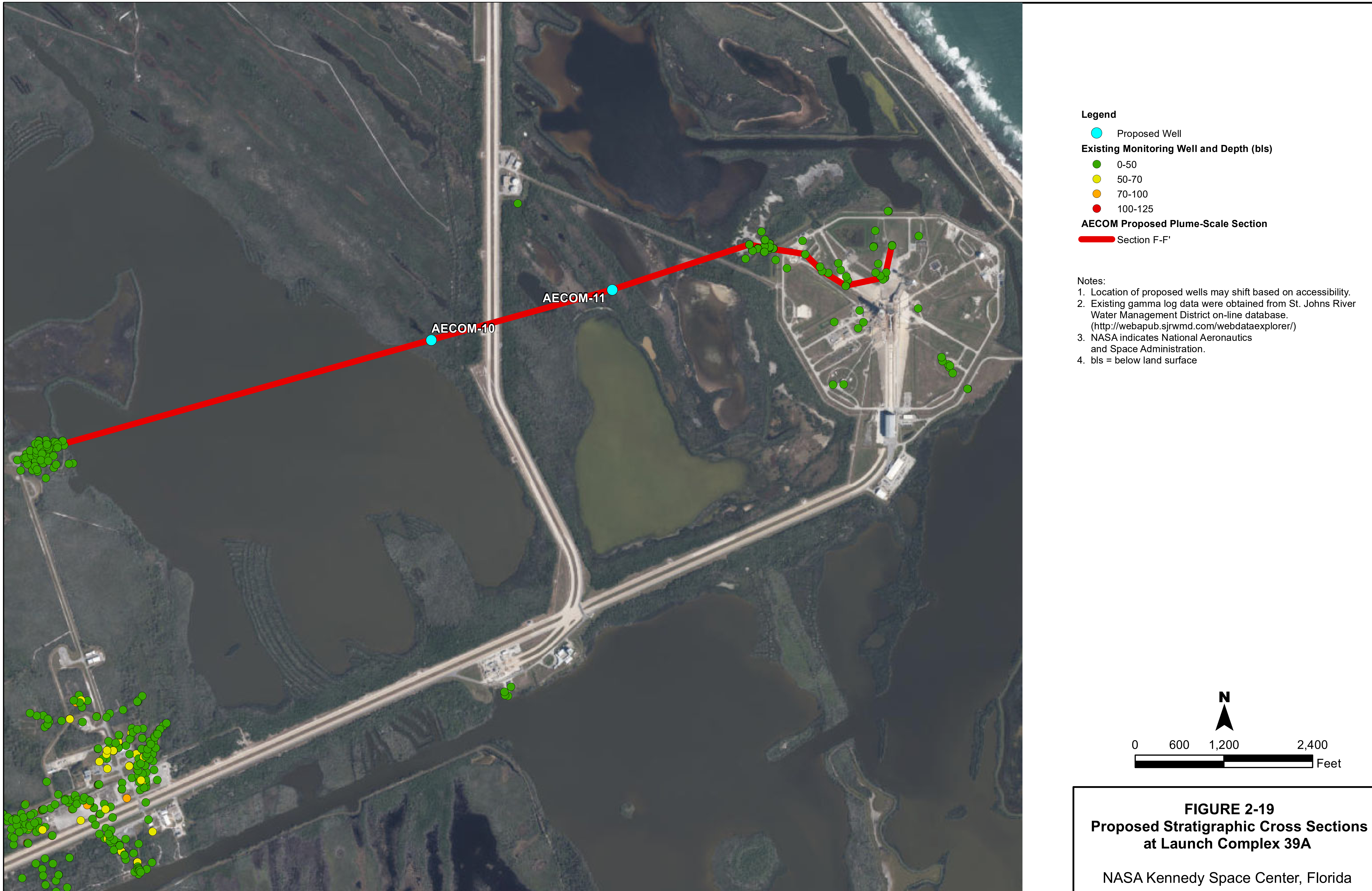

Notes:
1. Location of proposed wells may shift based on accessibility.
2. Existing gamma log data were obtained from St. Johns River Water Management District on-line database. (http://webapub.sjrwmd.com/webdataexplorer/)
3. NASA indicates National Aeronautics and Space Administration.
4. bls = below land surface

FIGURE 2-19
Proposed Stratigraphic Cross Sections at Launch Complex 39A

NASA Kennedy Space Center, Florida

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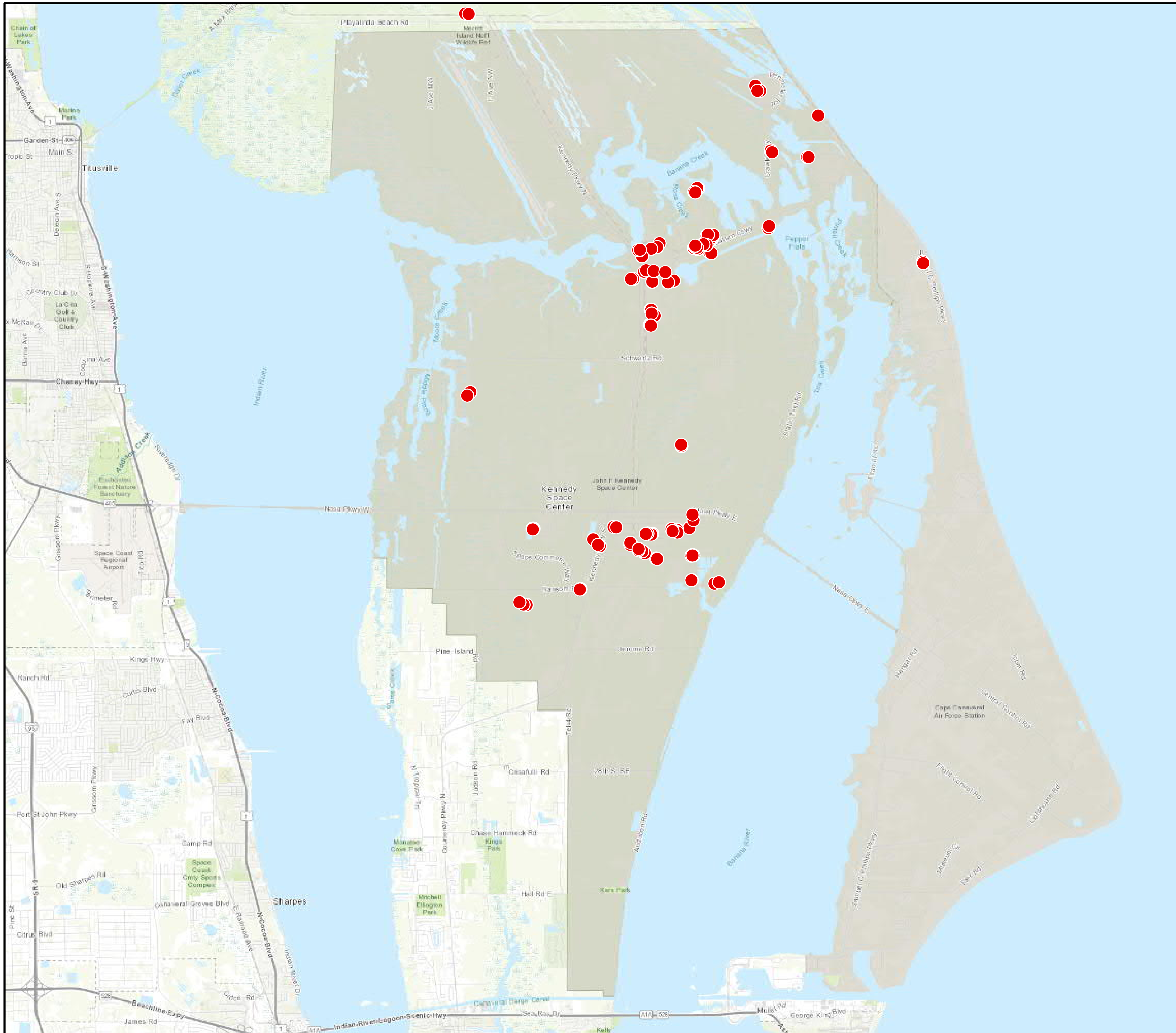

Legend

● Existing Wells

Notes:
1. Well locations are tentative and subject to modifications based on accessibility, etc.
2. Alternative well locations will be used if initial locations cannot be found.

N

0 4,500 9,000 18,000 Feet

FIGURE 3-1
Monitoring Wells Selected for Synoptic Gauging

NASA Kennedy Space Center, Florida

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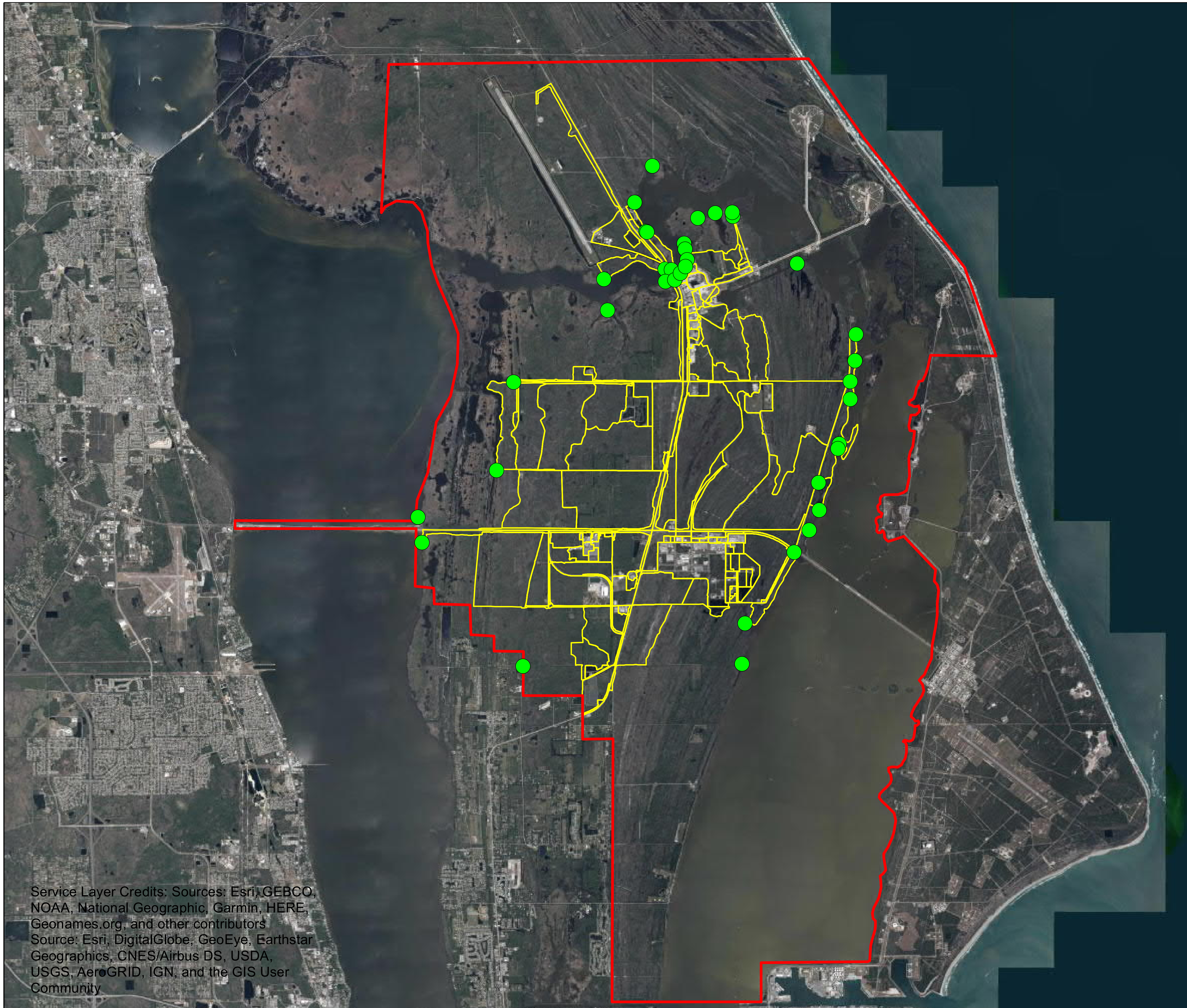

Legend

- Existing Outfalls
- Kennedy Space Center
- AdICPR Basins

Note:
1. NASA indicates National Aeronautics and Space Administration.
2. AdICPR - Advanced Interconnected Pond Routing

N

0 4,500 9,000 18,000 Feet

FIGURE 4-1
Stormwater Drainage Basins and Outfalls

NASA Kennedy Space Center, Florida

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APPENDIX A
STANDARD OPERATING PROCEDURES

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Standard Operating Procedure for Water Sampling of Outlets and Analysis of Per- and Polyfluoroalkyl Substances

1. INTRODUCTION

1.1 Purpose and Scope

Standard operating procedures (SOPs) were prepared to guide per- and polyfluoroalkyl substance (PFAS) sampling activities at National Aeronautics and Space Administration (NASA) sites. This SOP describes recommended procedures to be used by field personnel when collecting water samples from an outlet (e.g., spigot). Because PFAS are potentially present in a variety of materials that may come into contact with water samples, and because laboratory analytical method detection limits are low (low to sub nanogram per liter concentrations), conservative precautions are recommended to avoid sample cross-contamination and false positive results.

Currently, sampling guidance for PFAS is still in its infancy. Guidance from regulatory agencies often varies by state. Guidelines follow precautionary principles and may be based on anecdotal sampling experiences or on an abundance of precaution, rather than scientific studies. There is currently a need for robust, high quality guidance on PFAS sampling methods. Because there is little to no published scientific research regarding how certain materials may affect sample results, a conservative approach is recommended. The state of knowledge and practice is rapidly changing along with state and federal regulations and guidance for PFAS investigations. The procedures in this SOP are consistent with best practices at the time of authoring.

1.2 Definitions and Acronyms

1.2.1 Definitions

Outlet	An orifice for water, including, but not limited to, hoses, faucets, taps, and spigots. The water source may be surface water or groundwater. The water may be used for domestic, irrigation, or other purposes.
PFAS-free water	Water that has been analyzed by an accredited laboratory (see Section 3.1) and determined to be below the method detection limit (i.e., non-detect) for the suite of PFAS to be analyzed for in environmental samples. Method detection limits (MDLs) used during analysis of PFAS-free water should be at or below the MDLs used for environmental samples.

1.2.2 Acronyms

CoC	chain of custody
DoD	Department of Defense
DOT	Department of Transportation

ETFE	ethylene tetrafluoroethylene
FEP	fluorinated ethylene propylene
HDPE	high-density polyethylene
IATA	International Air Transport Association
ICAO	International Civil Aviation Organization
LDPE	low-density polyethylene
MDL	method detection limit
MS	matrix spike
MSD	matrix spike duplicate
NASA	National Aeronautics and Space Administration
PFAS	per- and polyfluoroalkyl substance
PFTE	polytetrafluoroethylene
PPE	personal protective equipment
PVC	polyvinyl chloride
PVDF	polyvinylidene fluoride
QA	quality assurance
QC	quality control
SOP	standard operating procedure

1.3 Equipment and Products

Sections 1.3.1 and 1.3.2 detail items that are safe to use versus not recommended for use on the job site to protect PFAS samples from potential cross-contamination. Science-based evidence is not currently available to support a determination of the realistic impact of these commonly used field items and materials on PFAS samples. In the absence of scientific-based sampling guidance, field staff, contractors, and analytical laboratories should try to avoid using items that may pose a risk for cross-contamination and false positive results and instead use acceptable alternatives identified in this section. If the field team needs to use products and equipment on site that are not recommended, additional quality assurance/quality control (QA/QC) samples may be collected to evaluate any potential impact on PFAS environmental samples. This information is also provided in an abbreviated format as a checklist for field staff to reference (Attachment A).

1.3.1 Field Equipment

Items that are **safe to use** on site when sampling for PFAS include the following:

- Sampling containers, screw caps and other equipment made from high-density polyethylene (HDPE)[1] polypropylene, silicone, acetate, or stainless steel;
- Low-density polyethylene (LDPE)[2] materials not in direct contact with the sample (e.g., Ziploc® bags);
- Sample preservatives (e.g., Trizma®);
- QA/QC samples (e.g., temperature and field blanks);
- Materials made of HDPE, silicone, acetate, or stainless steel;
- Masonite or aluminum clipboards;
- Sampling forms, loose paper or field notebooks, chain of custody (CoC) record, and sample container labels;
- Ballpoint pens;
- Alconox®, Liquinox® and Luminox® detergents;
- Paper towels;
- Trash bags;
- HDPE sheeting;
- Hard-shell coolers;
- Shipping and handling labels;
- Regular (wet) ice;
- Bubble wrap;
- Duct tape and packing tape; and
- Large (e.g., 55-gallon) containers.

Items **to be avoided (i.e., not recommended) for use** on site include the following:

- Glass sample containers, due to PFAS adherence to glass surfaces;
- Water-resistant paper, notebooks, and labels (e.g., certain Rite in the Rain® products), due to use of PFAS in water-resistant inks and coatings;

[1] HDPE plastics are commonly identified by a recycling symbol with a number 2 inside it.
[2] LDPE plastics are commonly identified by a recycling symbol with a number 4 inside it.

- Sticky notes (e.g., certain Post-It® products), due to potential use of a paper coating product Zonyl™ or similar fluorotelomer compounds;
- Plastic clipboards, binders, and spiral hardcover notebooks;
- Pens with water-resistant ink;
- Felt pens and markers (e.g., certain Sharpie® products) – some PFAS SOPs (e.g., Michigan) specifically allow Fine or Ultra-Fine Point Sharpies® and TestAmerica Laboratories, Inc. routinely uses Sharpies® in the laboratory following unpublished analytical tests that reportedly showed no impact on PFAS sample results;
- Aluminum foil, as PFAS are sometimes used as a protective layer;
- Decon 90™ liquid detergent, which reportedly contain fluorosurfactants;
- Chemical (e.g., blue) ice packs, unless it is contained in a sealed bag. Blue ice has the potential to be contaminated from previous field sampling events;
- Materials containing polytetrafluoroethylene (PFTE) including Teflon™ and Hostaflon® (e.g., tubing, tape, plumbing paste, O-rings);
- Equipment with Viton™ components (i.e., fluoroelastomers);
- Stain- or water-resistant materials, as these are typically fluoropolymer-based;
- Material containing LDPE, particularly if used in direct contact with the sample (e.g., LDPE tubing, as PFAS can sorb to the porous tubing); and
- Material containing "fluoro" in the name – this includes, but is not limited to, fluorinated ethylene propylene (FEP), ethylene tetrafluoroethylene (ETFE), and polyvinylidene fluoride (PVDF).

1.3.2 Clothing, Personal Protective Equipment (PPE), and Consumer Products

Items that are **safe to use** on site when sampling for PFAS include the following:

- Boots made of polyurethane, polyvinyl chloride (PVC), rubber, or untreated leather;
- Other field boots covered by PFAS-free (e.g., polypropylene) over-boots;
- Rain gear made of polyurethane, PVC, wax-coated, vinyl, or rubber;
- Clothing made of synthetic (e.g., polyester) or natural (e.g., cotton) fibers;
- Safety glasses;
- Reflective safety vests;
- Hardhats;
- Disposable powder-free nitrile gloves;

- Uncoated HDPE suits (e.g., certain Tyvek® products);
- Sunscreens[3] and insect repellants[4] that have been tested and found to be PFAS-free; and
- Bottled water and hydration drinks.

Items **<u>to be avoided (i.e., not recommended) for use</u>** on site include the following:

- Water- or stain-resistant boots and clothing (e.g., products containing GORE-TEX®);
- Clothing recently laundered with a fabric softener;
- Coated HDPE suits (e.g., certain Tyvek® products);
- Sunscreen and insect repellants containing fluorinated compounds as ingredients, such as polyfluoroalkyl phosphate esters;
- Latex gloves;
- Cosmetics, moisturizers, hand cream, and other related products;
- Food wrappers and packaging; and
- Food and drinks other than bottled water or hydration drinks.

Field staff should try to find acceptable alternatives to these items that still allow them to complete the field work safely and efficiently. For example, wearing long-sleeved clothing and a hard hat or sun hat may eliminate the need to use sunscreen in some climates. If an item cannot be easily avoided, additional consideration should be given to QA/QC samples to evaluate the potential impact of sample cross-contamination (e.g., field blanks).

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[3] Examples of PFAS-free sunscreens include Alba Organics Natural, Aubrey Organics, Banana Boat Sport Performance Sunscreen Lotion Broad Spectrum SPF 30, Banana Boat for Men Triple Defense Continuous Spray Sunscreen SPF 30, Banana Boat Sport Performance Coolzone Broad Spectrum SPF 30, Banana Boat Sport Performance Sunscreen Stick SPF 50, Coppertone Sunscreen Lotion Ultra Guard Broad Spectrum SPF 50, Coppertone Sport High-Performance AccuSpray Sunscreen SPF 30, Coppertone Sunscreen Stick Kids SPF 55, Jason Natural Sun Block, Kiss my Face, L'Oréal Silky Sheer Face Lotion 50+, Meijer Clear Zinc Sunscreen Lotion Broad Spectrum SPF 15, 30 and 50, Meijer Wet Skin Kids Sunscreen Continuous Spray Broad Spectrum SPF 70, Neutrogena Beach Defense Water + Sun Barrier Lotion SPF 70, Neutrogena Beach Defense Water + Sun Barrier Spray Broad Spectrum SPF 30, Neutrogena Pure & Free Baby Sunscreen Broad Spectrum SPF 60+, Neutrogena Ultra-Sheer Dry-Touch Sunscreen Broad Spectrum SPF 30, Yes to Cucumbers, and sunscreens for infants. Products with fluorinated compounds in their ingredients (e.g., polyfluoroalkyl phosphate esters) should not be worn during sampling.

[4] Examples of PFAS-free insect repellent include Jason Natural Quit Bugging Me, Repel Lemon Eucalyptus Insect repellant, Herbal Armor, California Baby Natural Bug Spray, BabyGanics, OFF! Deep Woods® spray for clothing and skin, Sawyer® do-it-yourself permethrin treatment for clothing, Insect Shield Insect® pretreated clothing, DEET products, and sunscreen/insect repellent combination product Avon Skin so Soft Bug Guard-SPF 30. Products with fluorinated compounds in their ingredients (e.g., polyfluoroalkyl phosphate esters) should not be worn during sampling.

2. FIELD PROCEDURES

2.1 Pre-Mobilization Activities

2.1.1 Health and Safety Plan

Prior to each field event, the site health and safety plan should be reviewed and updated, as necessary. Health and safety plan requirements should be reviewed for consistency with this SOP and modified as appropriate to resolve any differences.

2.1.2 Laboratory Coordination

Field personnel should communicate with the laboratory that will conduct PFAS analysis regarding the following items:

- Laboratory accreditation for PFAS analysis (see Section 3.1);
- Appropriate sample containers, labels, and preservatives (see Sections 2.2.2 and 2.2.3);
- Sample storage conditions and holding time (see Section 2.2.4); and
- The number and type of QA/QC samples (see Section 2.3).

Because there is no standard United States Environmental Protection Agency method for analyzing PFAS samples in media other than drinking water, commercial laboratories typically offer analysis for a suite of approximately 18 PFAS using a modified version of Method 537.1. Laboratories may therefore have developed their own variations to this method or another method. Project staff may consider the impact of differences in reported PFAS concentrations and the potential value of collecting and sending a split sample to a second commercial laboratory to assess variability in reported PFAS concentrations.

Laboratories conducting PFAS analysis for NASA facilities should be accredited by the United States Department of Defense Environmental Laboratory Accreditation Program (i.e. use a PFAS method that is compliant with Table B-15 of the DoD and Department of Energy consolidated Quality Systems Manual for Environmental Laboratories). States may also require that analytical laboratories are National Environmental Laboratory Accreditation Program accredited for their state and that PFAS analytical methods follow state guidelines.

2.1.3 Equipment Decontamination

Equipment should be decontaminated on site before work begins. Equipment decontamination should follow the steps outlined in Section 2.4.

2.2 Sampling

2.2.1 Sampling PPE

Gloves: Disposable powder-free nitrile gloves should be worn at all times during sample collection and handling of sampling equipment.

At a minimum, field personnel should put on a new pair of nitrile gloves after the following activities:

- Handling samples, including QA/QC samples and blanks; and
- Handling sampling equipment.

At a minimum, personnel should (1) thoroughly wash their hands with detergent (preferably Alconox®, Liquinox® or Luminox®) and PFAS-free water; (2) thoroughly dry their hands with paper towels; and (3) put on a new pair of nitrile gloves after the following activities:

- Contact with a material potentially containing PFAS;
- Change in sampling locations;
- Breaks in work;
- Washroom breaks; and
- Exit and entry into the project site exclusion zone.

2.2.2 Sampling Equipment

Sample Containers: HDPE containers with screw caps are commonly used for sample collection. Different laboratories may supply sample containers of varying sizes. Sample container caps are typically unlined.

Preservatives: Field personnel should communicate with the laboratory to determine what, if any, sample preservatives will be used. Preservatives may include Trizma® or sodium thiosulfate to remove residual chlorine from chlorinated drinking water samples.

2.2.3 Sample Collection and Labeling

This SOP is applicable only for centralized water supply outlets and does not apply to sampling of groundwater supply wells. Groundwaters supply well purging and sample collection should be conducted in accordance with applicable state regulations and sampling requirements.

Container Rinsing: Sample containers should not to be rinsed prior to sampling.

Outlet Flushing and Sample Collection: If the outlet is connected to hot and cold water sources, only the cold water should be sampled. Avoid all contact with the inside of the sample bottle and the inside of the sample cap during sampling.

1. Determine whether the outlet should be flushed prior to sample collection, based on the sampling objectives.
   a. If the objective of sampling is to assess PFAS concentrations in water used from that outlet, no flush is recommended prior to sample collection.
   b. If the objective of sampling is to assess source water quality without considering the impact of standing water in the pipe, the outlet can be opened, allowing water to flow out until the water temperature stabilizes prior to sample collection, or in accordance with state sampling requirements (e.g., a minimum of 10 minutes per New Hampshire guidelines).
2. Remove the cap from the sample container and place the container under the water outlet. Should the water pressure be too high to collect a sample without splashing, partially close the outlet as necessary;
3. Allow water to fill the sample container to the level specified by the laboratory (samples do not need to be collected headspace free);
4. Remove the sample container from the water stream and quickly close the container by screwing on the container cap; and
5. Using a paper towel, dry the outside of the sample container if necessary.

Labels: Some water-resistant inks may be potential sources of PFAS. PFAS-free container labels should be filled out using a ballpoint pen that does not have water-resistant ink, if possible. Field staff should try to avoid filling out container labels using felt pens and markers (e.g., certain Sharpie® products). Container labels should include the following information:

- A unique sample identifier;
- QA/QC sample type, if applicable;
- Sampling date and time (24-hour format);
- Sampler's name or initials; and
- Method of sample preservation.

Except for temperature blanks, all QC samples should be labeled and included on the CoC record. Duplicate samples should not be indicated as duplicates.

Wet Weather Considerations: Field sampling during wet weather (e.g., rainfall and snowfall) should be conducted wearing appropriate clothing that does not pose a risk for cross-contamination. Field personnel should try to avoid water-resistant clothing and boots. Rain gear made of polyurethane, PVC, vinyl, or rubber is an acceptable alternative. Samples and sample containers should not be opened prior to sample collection to avoid collecting precipitation. Should samples or sample containers become contaminated with precipitation, they should be discarded.

2.2.4 Sample Handling, Storage, and Shipment

Handling: Clean nitrile gloves should be worn when handling sample containers. Precautions should be taken to not drop or otherwise damage sample containers. Sample containers should **not** be placed in close proximity to a potential PFAS source.

Storage and Holding Times: Storage conditions and holding times should be determined by the laboratory. Measures should be taken to meet storage and holding time criteria (e.g., expedited shipping).

Shipment: Sample containers should be packed for shipment using the following steps:

1. Choose a cooler with structural integrity that will withstand shipment.
2. Secure and tape the drain plug with duct tape from the inside and outside.
3. Check that the caps on all sample containers are tight and will not leak.
4. Check that the sample labels are intact, filled out, legible, and that the sample identifier exactly matches the CoC record.
5. Seal each sample container in a sample bag to prevent melt water from getting into the sample or degrading the sample label.
6. Place sample containers into the cooler with their caps upright.
7. Fill any excess space within the cooler with bubble wrap (try to avoid using paper, cardboard, or polystyrene foam).
8. Fill remaining space from the top of the sample containers to the top of the cooler with wet ice that is double-bagged and sealed.
9. Seal the entire cooler with duct tape, particularly the lid, to prevent leaks.

Ship samples as non-hazardous material unless the samples meet the established Department of Transportation (DOT) criteria for a "hazardous material" or the International Air Transport Association (IATA)/International Civil Aviation Organization (ICAO) for air definition of "dangerous goods." If the samples meet criteria for hazardous materials or dangerous goods, then DOT and IATA/ICAO regulations must be followed. Prior to shipping samples, field personnel should complete the appropriate air waybill or manifest. A copy of the air waybill or manifest should be kept for recordkeeping.

2.3 Sampling QA/QC

2.3.1 Field Duplicates

Field duplicates are samples collected in the same manner and at the same time and location as a primary sample. They should be collected from locations of known or suspected contamination. Field duplicates are used to assess field and analytical precision and sample heterogeneity. Typically, at least one field duplicate is collected for every ten primary samples. Field duplicates should be labeled with a unique sample identifier and not be indicated as a duplicate (i.e., submitted as “blind”).

2.3.2 Matrix Spike and Matrix Spike Duplicate Samples

Matrix spike and matrix spike duplicate (MS/MSD) samples are aliquots of environmental samples that are spiked with a known concentration of PFAS by the laboratory. MS/MSD samples are used to assess interferences caused by the sample matrix. MS/MSD samples are not needed if the analytical laboratory is using an isotopic dilution method but are technically required to meet DoD accreditation requirements. If necessary, MS/MSD samples are to be collected in the same manner and at the same time and location as a primary sample (i.e., additional sample volume). It is preferred that this location have little to no PFAS contamination. Samples should have the same matrix to ensure a valid result; if the samples do not appear visually similar (e.g., color, suspended solids), choose another location for collection of MS/MSD samples. The number of required MS/MSD samples should be determined based on discussions with the laboratory. Typically, at least one MS/MSD sample is collected for every 20 primary samples. MS/MSD samples should be labeled with the same sample name and time as the primary sample and denoted as MS/MSD samples on the CoC and sample label.

2.3.3 Blanks

Blanks should be shipped and handled in the same manner as environmental samples. Field blanks should be labelled as such on sample bottles and on the CoC. The number and type of blanks should be determined based on discussions with the laboratory.

Field Blanks: Field blanks are used to assess ambient contamination within the field and laboratory. Field blanks should be prepared by filling a sample container with PFAS-free water in the field in the same manner as environmental samples. Field blanks are an effective way of assessing potential cross-contamination as a result of sample handling. Typically, one field blank is collected for each shipping container.

Temperature Blanks: Temperature blanks are used to assess the temperature of samples during shipping. Temperature blanks should be provided by the laboratory and prepared by filling a sample container with PFAS-free water prior to shipment of the sample containers. The blank should be kept in the cooler during sampling and shipment to the laboratory. Once the cooler

returns to the laboratory, the temperature of the blank should be measured to ensure that recommended sample storage criteria are met (typically less than 6 degrees Celsius).

2.4 Decontamination

Decontamination should occur prior to leaving the sampling area or at a central decontamination location and at the end of each work day. No field or sampling equipment is anticipated be to needed during sample collection that would require decontamination between sample locations.

Alconox®, Liquinox® and Luminox® detergents are acceptable for decontamination purposes. Use of Decon 90 should be avoided. Decontamination wastes must be properly contained and disposed of in accordance with applicable local, state and federal regulations.

2.4.1 Personnel and PPE Decontamination

A decontamination area for personnel and portable equipment may be specified in the health and safety plan. The area may include basins or tubs to capture decontamination wastes, which can be transferred to larger containers as necessary. If decontamination is needed following water outlet sampling, personnel decontamination should follow these steps:

1. Gross (e.g., soil) contamination should be scraped and wiped from boots, safety glasses, hardhats, reflective vests, and other reusable PPE. Once gross contamination has been removed, gloves should be removed by rolling off the hands in such a way to avoid exposing skin to PFAS-contaminated materials;
2. A new pair of gloves should be put on and reusable PPE should be decontaminated using PFAS-free water mixed with detergent (preferably Alconox®, Liquinox® or Luminox®) and brushes, or similar means. After debris is removed, reusable PPE should be rinsed with PFAS-free water; and
3. Hands and any exposed body parts should be washed thoroughly using detergent (preferably Alconox®, Liquinox® or Luminox®) and PFAS-free water. Hands should be dried with paper towels.

2.5 Food and Drink

Food and drink should not be brought within the exclusion zone. Food that is kept in the staging area should preferably be contained in HDPE or stainless-steel containers.

3. LABORATORY PROCEDURES

3.1 Accreditations

Laboratories conducting PFAS analysis for NASA facilities should be accredited by the United States Department of Defense Environmental Laboratory Accreditation Program, that is, use a

PFAS method that is compliant with Table B-15 of the DoD and DOE consolidated QSM 5.2 for Environmental Laboratories. States may also require that analytical laboratories are National Environmental Laboratory Accreditation Program accredited for their state and that PFAS analytical methods follow state guidelines.

4. DOCUMENTATION

4.1 Chain of Custody

4.1.1 Field Custody Procedures

A sample is considered to be in custody if the following conditions have been observed:

- It is in possession or view of the person in custody;
- It is locked in a secure area;
- It is placed in an area restricted to authorized personnel; or
- It is placed in a container and secured with an official seal, so that the sample cannot be reached without breaking the seal.

The following practices should be observed by field personnel to ensure sample custody:

- As few persons as possible will handle samples;
- The sample collector is personally responsible for the care and custody of samples collected until they are transferred to the laboratory;
- The sample collector will record sample data in the field notebook; and
- Sample labels will be completed for each sample.

4.1.2 Chain of Custody Record

All samples should be accompanied by a CoC record. The CoC record is typically provided by the laboratory. The CoC record should be fully completed in duplicate (e.g., a carbon copy). At the minimum, the following information should be included on a CoC record:

- Project name and number;
- Laboratory name and address;
- Name of person that collected the samples;
- Sample identifier;
- Sample date and time (time in 24-hour format);
- Laboratory analysis requested;

- Preservatives added to each sample;
- Sample matrix (e.g., soil, water);
- Number of containers per sample; and
- Airway bill tracking number.

As applicable, the following remarks should be added to the CoC record:

- Contractor name and address;
- MS/MSD sample volume (if necessary);
- A request for rapid turnaround time; and
- A note regarding the potential concentrations in a highly-contaminated sample.

Indication of a duplicate sample should **not** be included on a CoC record.

4.1.3 Sample Packaging

The CoC record should accompany all sample shipments. One CoC record should be prepared for each cooler and the cooler number recorded on the CoC. The samples in the cooler should be listed on the CoC record. The CoC record should be placed in a sealed plastic bag (e.g., Ziploc®) and taped to the inside lid of the cooler. If one sample is contained in two coolers (i.e., one sample has too many containers to fit in one cooler), then the original CoC should be placed in the first cooler and a copy of the CoC record should be placed in the second cooler. The duplicate copy of the CoC record should be retained by the sampler.

Custody seals should be signed and dated at the time of use. Sample shipping containers should be sealed in as many places as necessary to ensure that the container cannot be opened without breaking a custody seal. Tape should be placed over the seals to ensure that seals are not accidentally broken during shipment. If the sampler transports the samples to the laboratory without sample shipment, custody seals are not required.

4.1.4 Transfer of Custody

When transferring the possession of samples from the field sampler to a transporter or to the laboratory, the sampler should sign, date, and note the time as "relinquished by" on the CoC record. The receiver should also sign, date, and note the time as "received by" on the CoC record. The date and time of the receiver and relinquisher should be the same.

When samples are transported by a commercial carrier, the carrier will not sign the CoC record. However, the airway bill tracking number should be recorded on the CoC record. Airway bills should also be retained with the CoC record as documentation of transport. For this reason, the date and time of the receiver and relinquisher will not match when shipping with a commercial carrier.

4.1.5 Laboratory Custody Procedures

A designated sample custodian should accept custody of the shipped samples and verify that the sample identification number matches the CoC record. Pertinent information about shipment, pickup, and courier should be entered in the "Remarks" section. The temperature of the temperature blanks at the time of receiving should be noted on the CoC record.

5. REFERENCES

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Attachment A. Daily PFAS Sampling Checklist

Date: ___________________

Site Name: _____________________________________

Weather (*temperature/precipitation*): ____

Please check all boxes that apply and describe any exceptions in the notes section below along with QA/QC methods used to assess potential sample cross-contamination as a result.

Field Clothing and PPE:

- ☐ No water- or stain-resistant clothing (e.g., GORE-TEX®)
- ☐ During collection of water and sediment samples, no water- or stain-resistant boots OR water- or stain-resistant boots covered by PFAS-free over-boots
- ☐ Field boots (or overboots) are made of polyurethane, PVC, rubber, or untreated leather
- ☐ Waders or rain gear are made of neoprene, polyurethane, PVC, vinyl, wax-coated or rubber
- ☐ Clothing has not been recently laundered with a fabric softener
- ☐ No coated HDPE suits (e.g., coated Tyvek® suits)
- ☐ Field crew has not used cosmetics, moisturizers, or other related products today
- ☐ Field crew has not used sunscreen or insect repellants today, other than products approved as PFAS-free

Field Equipment:

- ☐ Sample containers and equipment in direct contact with the sample are made of HDPE, polypropylene, silicone, acetate or stainless steel, not LDPE or glass
- ☐ Sample caps are made of HDPE or polypropylene and are not lined with Teflon™
- ☐ No materials containing Teflon™, Viton™, or fluoropolymers
- ☐ No materials containing LDPE are in direct contact with the sample (e.g., LDPE tubing, Ziploc® bags)
- ☐ No plastic clipboards, binders, or spiral hard cover notebooks
- ☐ No waterproof field books
- ☐ No waterproof or felt pens or markers (e.g., certain Sharpie® products)
- ☐ No chemical (blue) ice, unless it is contained in a sealed bag
- ☐ No aluminum foil
- ☐ No sticky notes (e.g., certain Post-It® products)

Decontamination:

- ☐ Reusable field equipment decontaminated prior to reuse
- ☐ "PFAS-free" water is on-site for decontamination of field equipment
- ☐ Alconox®, Liquinox® or Luminox® used as decontamination detergent

Food and Drink:

- ☐ No food or drink on-site, except within staging area
- ☐ Food in staging area is contained in HDPE or stainless steel container

Notes:

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Field Team Leader Name (Print): ___________________________

Field Team Leader Signature: ______________________________

Date/Time: ____________________________

Standard Operating Procedure for Surface Water Sampling and Analysis of Per- and Polyfluoroalkyl Substances

1. INTRODUCTION

1.1 Purpose and Scope

Standard operating procedures (SOPs) were prepared to guide per- and polyfluoroalkyl substance (PFAS) sampling activities at National Aeronautics and Space Administration (NASA) sites. This SOP describes recommended procedures to be used by field personnel when collecting surface water samples. Because PFAS are potentially present in a variety of materials that may come into contact with water samples, and because laboratory analytical method detection limits are low (low to sub nanogram per liter concentrations), conservative precautions are recommended to avoid sample cross-contamination and false positive results.

Currently, sampling guidance for PFAS is still in its infancy. Guidance from regulatory agencies often varies by state. Guidelines follow precautionary principles and may be based on anecdotal sampling experiences or on an abundance of precaution, rather than scientific studies. There is currently a need for robust, high quality guidance on PFAS sampling methods. Because there is little to no published scientific research regarding how certain materials may affect sample results, a conservative approach is recommended. The state of knowledge and practice is rapidly changing along with state and federal regulations and guidance for PFAS investigations. The procedures in this SOP are consistent with best practices at the time of authoring.

1.2 Definitions and Acronyms

1.2.1 Definitions

PFAS-free water	Water that has been analyzed by an accredited laboratory (see Section 3.1) and determined to be below the method detection limit (i.e., non-detect) for the suite of PFAS to be analyzed for in environmental samples. Method detection limits (MDLs) used during analysis of PFAS-free water should be at or below the MDLs used for environmental samples.
Peristaltic pump	A positive displacement pump that can be used to move fluids at a fixed rate. Peristaltic pumps are typically used if the depth to water is less than approximately 25 feet.
Potable water	Water that meets state and federal drinking water requirements. Note this water may or may not have detectable PFAS concentrations.

1.2.2 Acronyms

ASTM	American Society for Testing and Materials
CoC	chain of custody

DoD	Department of Defense
DOT	Department of Transportation
ETFE	ethylene tetrafluoroethylene
FEP	fluorinated ethylene propylene
HDPE	high-density polyethylene
IATA	International Air Transport Association
ICAO	International Civil Aviation Organization
LDPE	low-density polyethylene
MDL	method detection limit
MS	matrix spike
MSD	matrix spike duplicate
NASA	National Aeronautics and Space Administration
PFAS	per- and polyfluoroalkyl substance
PTFE	polytetrafluoroethylene
PPE	personal protective equipment
PVC	polyvinyl chloride
PVDF	polyvinylidene fluoride
QA	quality assurance
QC	quality control
QSM	quality systems manual
SOP	standard operating procedure
USGS	United States Geological Survey

1.3 Equipment and Products

Sections 1.3.1 and 1.3.2 detail items that are safe to use versus not recommended for use on the job site to protect PFAS samples from potential cross-contamination. Science-based evidence is not currently available to support a determination of the realistic impact of these commonly used field items and materials on PFAS samples. In the absence of scientific-based sampling guidance, field staff, contractors, and analytical laboratories should try to avoid using items that may pose a risk for cross-contamination and false positive results and instead use acceptable alternatives identified in this section. If the field team needs to use products and equipment on site that are not recommended, additional quality assurance/quality control (QA/QC) samples may be collected to evaluate any potential impact on PFAS environmental samples. This information is also provided in an abbreviated format as a checklist for field staff to reference (Attachment A).

1.3.1 Field Equipment

Items that are **safe to use** on site when sampling for PFAS include the following:

- Dip samplers, scoops, bailers, sampling containers, screw caps and other equipment made from high-density polyethylene (HDPE)[1], polypropylene, silicone, acetate, or stainless steel;
- Low-density polyethylene (LDPE)[2] materials not in direct contact with the sample (e.g., Ziploc® bags);
- Sample preservatives (e.g., Trizma®);
- QA/QC samples (e.g., temperature and field blanks);
- Materials made of HDPE, silicone, acetate, or stainless steel;
- Peristaltic pumps that do not have Teflon components;
- Masonite or aluminum clipboards;
- Ballpoint pens;
- Sampling forms, loose paper or field notebooks, chain of custody (CoC) record, and sample container labels;
- Alconox®, Liquinox® and Luminox® detergents;
- Paper towels;
- Trash bags;
- HDPE sheeting;
- Hard-shell coolers;
- Shipping and handling labels;
- Regular (wet) ice;
- Bubble wrap;
- Duct tape and packing tape;
- Dedicated Silicon and/or HDPE tubing;

[1] HDPE plastics are commonly identified by a recycling symbol with a number 2 inside it.
[2] LDPE plastics are commonly identified by a recycling symbol with a number 4 inside it.

- Analytical field meter (e.g., temperature, pH, conductivity, oxidation-reduction potential [ORP], dissolved oxygen [DO], and turbidity);
- Water level probe(s), and
- Large (e.g., 55-gallon) containers.

Items **to be avoided (i.e. not recommended) for use** on site include the following:

- Glass sample containers, due to PFAS adherence to glass surfaces;
- Water-resistant paper, notebooks, and labels (e.g., certain Rite in the Rain® products), due to use of PFAS in water-resistant inks and coatings;
- Sticky notes (e.g., certain Post-It® products), due to potential use of a paper coating product Zonyl™ or similar fluorotelomer compounds;
- Plastic clipboards, binders, and spiral hardcover notebooks;
- Pens with water-resistant ink;
- Felt pens and markers (e.g., certain Sharpie® products) – some PFAS SOPs (e.g., Michigan) specifically allow Fine or Ultra-Fine Point Sharpies® and TestAmerica Laboratories, Inc. routinely uses Sharpies® in the laboratory following unpublished analytical tests that reportedly showed no impact on PFAS sample results;
- Aluminum foil, as PFAS are sometimes used as a protective layer;
- Decon 90™ liquid detergent, which reportedly contain fluorosurfactants;
- Chemical (e.g., blue) ice packs, unless it is contained in a sealed bag. Blue ice has the potential to be contaminated from previous field sampling events;
- Materials containing polytetrafluoroethylene (PTFE), including Teflon™ and Hostaflon® (e.g., tubing, tape, plumbing paste, O-rings);
- Equipment with Viton™ components (i.e., fluoroelastomers);
- Stain- or water-resistant materials, as these are typically fluoropolymer-based;
- Material containing LDPE, particularly if used in direct contact with the sample (e.g., LDPE tubing, as PFAS can sorb to the porous tubing); and
- Material containing "fluoro" in the name – this includes, but is not limited to, fluorinated ethylene propylene (FEP), ethylene tetrafluoroethylene (ETFE), and polyvinylidene fluoride (PVDF).

1.3.2 Clothing, Personal Protective Equipment (PPE), and Consumer Products

Items that are **safe to use** on site when sampling for PFAS include the following:

- Boots made of polyurethane, polyvinyl chloride (PVC), rubber, or untreated leather;
- Other field boots covered by PFAS-free (e.g., polypropylene) over-boots;
- Waders and rain gear made of neoprene, polyurethane, PVC, wax-coated, vinyl, or rubber;
- Clothing made of synthetic (e.g., polyester) or natural (e.g., cotton) fibers;
- Safety glasses;
- Reflective safety vests;
- Hardhats;
- Disposable powder-free nitrile gloves;
- Uncoated HDPE suits (e.g., certain Tyvek® products);
- Sunscreens[3] and insect repellants[4] that have been tested and found to be PFAS-free; and
- Bottled water and hydration drinks.

Items **to be avoided (i.e., not recommended) for use** on site include the following:

- Breathable waders made of nylon or polyester with a GORE-TEX® membrane;
- Water- or stain-resistant boots and clothing (e.g., products containing GORE-TEX®);
- Clothing recently laundered with a fabric softener;
- Coated HDPE suits (e.g., certain Tyvek® products);
- Sunscreen and insect repellants containing fluorinated compounds as ingredients, such as polyfluoroalkyl phosphate esters;

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[3] Examples of PFAS-free sunscreens include Alba Organics Natural, Aubrey Organics, Banana Boat Sport Performance Sunscreen Lotion Broad Spectrum SPF 30, Banana Boat for Men Triple Defense Continuous Spray Sunscreen SPF 30, Banana Boat Sport Performance Coolzone Broad Spectrum SPF 30, Banana Boat Sport Performance Sunscreen Stick SPF 50, Coppertone Sunscreen Lotion Ultra Guard Broad Spectrum SPF 50, Coppertone Sport High-Performance AccuSpray Sunscreen SPF 30, Coppertone Sunscreen Stick Kids SPF 55, Jason Natural Sun Block, Kiss my Face, L'Oréal Silky Sheer Face Lotion 50+, Meijer Clear Zinc Sunscreen Lotion Broad Spectrum SPF 15, 30 and 50, Meijer Wet Skin Kids Sunscreen Continuous Spray Broad Spectrum SPF 70, Neutrogena Beach Defense Water + Sun Barrier Lotion SPF 70, Neutrogena Beach Defense Water + Sun Barrier Spray Broad Spectrum SPF 30, Neutrogena Pure & Free Baby Sunscreen Broad Spectrum SPF 60+, Neutrogena Ultra-Sheer Dry-Touch Sunscreen Broad Spectrum SPF 30, Yes to Cucumbers, and sunscreens for infants. Products with fluorinated compounds in their ingredients (e.g., polyfluoroalkyl phosphate esters) should not be worn during sampling.

[4] Examples of PFAS-free insect repellent include Jason Natural Quit Bugging Me, Repel Lemon Eucalyptus Insect repellant, Herbal Armor, California Baby Natural Bug Spray, BabyGanics, OFF! Deep Woods® spray for clothing and skin, Sawyer® do-it-yourself permethrin treatment for clothing, Insect Shield Insect® pretreated clothing, DEET products, and sunscreen/insect repellent combination product Avon Skin so Soft Bug Guard-SPF 30. Products with fluorinated compounds in their ingredients (e.g., polyfluoroalkyl phosphate esters) should not be worn during sampling.

- Latex gloves;
- Cosmetics, moisturizers, hand cream, and other related products;
- Food wrappers and packaging; and
- Food and drinks other than bottled water or hydration drinks.

Field staff should try to find acceptable alternatives to these items that still allow them to complete the field work safely and efficiently. For example, wearing long-sleeved clothing and a hard hat or sun hat may eliminate the need to use sunscreen in some climates. If an item cannot be easily avoided, additional consideration should be given to QA/QC samples to evaluate the potential impact of sample cross-contamination (e.g., field blanks).

2. FIELD PROCEDURES

2.1 Pre-Mobilization Activities

2.1.1 Health and Safety Plan

Prior to each field event, the site health and safety plan should be reviewed and updated, as necessary. Health and safety plan requirements should be reviewed for consistency with this SOP and modified as appropriate to resolve any differences.

2.1.2 Laboratory Coordination

Field personnel should communicate with the laboratory that will conduct PFAS analysis regarding the following items:

- Laboratory accreditation for PFAS analysis (see Section 3.1);
- Appropriate sample containers, labels, and preservatives (see Section 2.2.2);
- Sample storage conditions and holding time (see Section 2.2.3); and
- The number and type of QA/QC samples (see Section 2.3).

Because there is no standard United States Environmental Protection Agency method for analyzing PFAS samples in media other than drinking water, commercial laboratories typically offer analysis for a suite of approximately 18 PFAS using a modified version of Method 537.1. Laboratories may therefore have developed their own variations to this method or another method. Project staff may consider the impact of differences in reported PFAS concentrations and the potential value of collecting and sending a split sample to a second commercial laboratory to assess variability in reported PFAS concentrations.

Laboratories conducting PFAS analysis for NASA facilities should be accredited by the United States Department of Defense Environmental Laboratory Accreditation Program (i.e. use a PFAS method that is compliant with Table B-15 of the DoD and Department of Energy consolidated Quality Systems Manual for Environmental Laboratories). States may also require that analytical laboratories are National Environmental Laboratory Accreditation Program accredited for their state and that PFAS analytical methods follow state guidelines.

2.1.3 Equipment Decontamination

Equipment should be decontaminated on site before work begins. Equipment decontamination should follow the steps outlined in Section 2.4.

2.2 Sampling

2.2.1 Sampling PPE

Gloves: Disposable powder-free nitrile gloves should be worn at all times during sample collection and handling of sampling equipment.

At a minimum, field personnel should put on a new pair of nitrile gloves after the following activities:

- Handling samples, including QA/QC samples and blanks; and
- Handling sampling equipment.

At a minimum, personnel should (1) thoroughly wash their hands with detergent (preferably Alconox®, Liquinox® or Luminox®) and PFAS-free water; (2) thoroughly dry their hands with paper towels; and (3) put on a new pair of nitrile gloves after the following activities:

- Contact with a material potentially containing PFAS;
- Change in sampling locations;
- Breaks in work;
- Washroom breaks; and
- Exit and entry into the project site exclusion zone.

2.2.2 Sampling Equipment

Sample Containers: HDPE containers with screw caps are commonly used for sample collection. Different laboratories may supply sample containers of varying sizes. Sample container caps are typically unlined.

Dip Sampler, Scoop or Bailer: If access to surface water is limited, the use of a dip sampler, scoop or bailer may be required. Samples from major surface water bodies can also be collected from a boat. The selection of the surface water sample collection method is beyond the scope of this SOP and should be discussed within the project team.

Peristaltic Pump: If water depth is shallow, the use of a peristaltic pump may be required. Pump components, fittings, O-rings, sampling tubing, and other sampling equipment should not include Teflon™ or other PFAS-containing materials. Dedicated HDPE or silicon tubing is recommended. The selection of the surface water sample collection method is beyond the scope of this SOP and should be discussed within the project team.

Preservatives: Field personnel should communicate with the laboratory to determine what, if any, sample preservatives will be used. Field personnel should specifically indicate to the laboratory that surface water sampling is being conducted and the sampling method(s) being used; pre-preserved bottles are not required.

2.2.3 Sample Collection and Labeling

Container Rinsing: Sample containers should not be rinsed prior to sampling.

Sequence of Sampling: When taking multiple samples from a moving body of water, samples should first be taken from downstream locations first, followed by upstream locations, to minimize sediment disturbances that may affect water quality.

Direct Sampling: Surface water samples may be collected directly (i.e., by hand) from the shoreline when access allows.

For shallow streams and pools, the following sample collection steps should be followed:

1. Remove the sample container cap above the water surface;
2. Orient the sample container horizontally, with the container opening facing upstream if the water is moving;
3. Dip the container mouth into the stream and allow for it to fill. If needed, slowly move the container in a downstream to upstream motion to help fill the sample container. Care should be taken to limit collection of debris. The container should be filled to the volume specified by the laboratory;
4. Lift the container above the water surface;
5. Use a paper towel to clean the outside of the sample container and the sample container threads. Close the sample container by screwing on the container cap; and
6. Record the sample location, sample date and time, and other applicable information in the field notebook and on sampling forms before moving on to the next sample location.

For deeper bodies of water (i.e., deeper than the container), the following sample collection steps should be followed:

1. Orient the sample container horizontally, with the container mouth facing upstream if the water is moving;
2. Dip the entire container below the water surface;
3. Remove the sample container cap with the container below the water surface. Allow for the container to fill. Care should be taken to limit collection of debris;
4. Once the container is filled to the volume specified by the laboratory, close the sample container by screwing on the container cap with the sample container still below the water surface;
5. Raise the sample container above the water surface;
6. Use a paper towel to clean the outside of the sample container;
7. Record the sample location, sample date and time, and other applicable information in the field notebook and on sampling forms before moving on to the next sample location.

Dip Sampler: Surface water samples may be collected from the bank using a dip sampler when access to the surface water is limited. The following sample collection steps should be followed when using a dip sampler:

1. Assemble the dip sampler in accordance with manufacturer instructions;
2. Insert the sample container into the dip sampler;
3. Remove the sample container cap;
4. Extend the dip sampler to the sample location;
5. Dip the sample container below the water surface. Fill the container to the volume specified by the laboratory. Care should be taken to limit collection of debris;
6. Lift the sample container above the water surface and retrieve the sample container from the dip sampler;
7. Use a paper towel to clean the outside of the sample container and the sample container threads if necessary. Close the sample container by screwing on the container cap; and
8. Record the sample location, sample date and time, and other applicable information in the field notebook and on sampling forms before moving on to the next sample location.

Peristaltic Pump: Surface water samples may be collected from the bank using a peristaltic pump. Peristaltic pumps are an effective sampling device when (1) sampling from a shallow or pool where direct sampling is difficult, and (2) a sample from a specific water depth is desired. The following sample collection steps should be followed when using a peristaltic pump:

1. Assemble the peristaltic pump in accordance with manufacturer instructions and use new, clean HDPE tubing;
2. Lower the pump intake to the desired depth;

3. Pump three sample-tubing volumes to field rinse the sample tubing. Collect this water as IDW;
4. Remove the sample container cap;
5. Fill the container to the volume specified by the laboratory;
6. Use a paper towel to clean the outside of the sample container and the sample container threads if necessary. Close the sample container by screwing on the container cap; and
7. Record the sample location, sample date and time, and other applicable information in the field notebook and on sampling forms before moving on to the next sample location.

Labels: Some water-resistant inks may be potential sources of PFAS. PFAS-free container labels should be filled out using a ballpoint pen that does not have water-resistant ink, if possible. Field staff should try to avoid filling out container labels using felt pens and markers (e.g., certain Sharpie® products). Container labels should include the following information:

- A unique sample identifier;
- QA/QC sample type, if applicable;
- Sampling date and time (24-hour format);
- Sampler's name or initials; and
- Method of sample preservation.

Except for temperature blanks, all QC samples should be labeled and included on the CoC record. Duplicate samples should not be indicated as duplicates.

Wet Weather Considerations: Field sampling during wet weather (e.g., rainfall and snowfall) should be conducted wearing appropriate clothing that does not pose a risk for cross-contamination. Field personnel should try to avoid water-resistant clothing and boots. Rain gear made of polyurethane, PVC, vinyl, or rubber is an acceptable alternative. Samples and sample containers should not be opened prior to sample collection to avoid collecting precipitation. Should samples or sample containers become contaminated with precipitation, they should be discarded.

2.2.4 Sample Handling, Storage, and Shipment

Handling: Clean nitrile gloves should be worn when handling sample containers. Precautions should be taken to not drop or otherwise damage sample containers. Sample containers should **not** be placed in close proximity to a potential PFAS source.

Storage and Holding Times: Storage conditions and holding times should be determined by the laboratory. Measures should be taken to meet storage and holding time criteria (e.g., expedited shipping).

Shipment: Sample containers should be packed for shipment using the following steps:

1. Choose a cooler with structural integrity that will withstand shipment.
2. Secure and tape the drain plug with duct tape from the inside and outside.
3. Check that the caps on all sample containers are tight and will not leak.
4. Check that the sample labels are intact, filled out, legible, and that the sample identifier exactly matches the CoC record.
5. Seal each sample container in a sample bag to prevent melt water from getting into the sample or degrading the sample label.
6. Place sample containers into the cooler with their caps upright.
7. Fill any excess space within the cooler with bubble wrap (try to avoid using paper, cardboard, or polystyrene foam).
8. Fill remaining space from the top of the sample containers to the top of the cooler with wet ice that is double-bagged and sealed.
9. Seal the entire cooler with duct tape, particularly the lid, to prevent leaks.

Ship samples as non-hazardous material unless the samples meet the established Department of Transportation (DOT) criteria for a “hazardous material” or the International Air Transport Association (IATA)/International Civil Aviation Organization (ICAO) for air definition of “dangerous goods.” If the samples meet criteria for hazardous materials or dangerous goods, then DOT and IATA/ICAO regulations must be followed. Prior to shipping samples, field personnel should complete the appropriate air waybill or manifest. A copy of the air waybill or manifest should be kept for recordkeeping.

2.3 Sampling QA/QC

2.3.1 Field Duplicates

Field duplicates are samples collected in the same manner and at the same time and location as a primary sample. They should be collected from locations of known or suspected contamination. Field duplicates are used to assess field and analytical precision and sample heterogeneity. Typically, at least one field duplicate is collected for every ten primary samples. Field duplicates should be labeled with a unique sample identifier and not be indicated as a duplicate (i.e., submitted as “blind”).

2.3.2 Matrix Spike and Matrix Spike Duplicate Samples

Matrix spike and matrix spike duplicate (MS/MSD) samples are aliquots of environmental samples that are spiked with a known concentration of PFAS by the laboratory. MS/MSD samples are used to assess interferences caused by the sample matrix. MS/MSD samples are not needed if the analytical laboratory is using an isotopic dilution method but are technically required to meet DoD accreditation requirements. If necessary, MS/MSD samples are to be collected in the same manner and at the same time and location as a primary sample (i.e., additional sample volume). It is preferred that this location have little to no PFAS contamination. Samples should have the same matrix to ensure a valid result; if the samples do not appear visually similar (e.g., color, suspended solids), choose another location for collection of MS/MSD samples. The number of required MS/MSD samples should be determined based on discussions with the laboratory. Typically, at least one MS/MSD sample is collected for every 20 primary samples. MS/MSD samples should be labeled with the same sample name and time as the primary sample and denoted as MS/MSD samples on the CoC and sample label.

2.3.3 Blanks

Blanks should be shipped and handled in the same manner as environmental samples. Field blanks should be labeled as such on sample bottles and on the CoC. The number and type of blanks should be determined based on discussions with the laboratory.

Equipment Blanks: Equipment blanks are used to assess sources of field and laboratory contamination. Equipment blanks are prepared by pouring PFAS-free water over or through decontaminated reusable field sampling equipment and collecting the rinsate in a sample container. Typically, at least one equipment blank is collected for every 10 primary samples.

Field Blanks: Field blanks are used to assess ambient contamination within the field and laboratory. Field blanks should be prepared by filling a sample container with PFAS-free water in the field in the same manner as environmental samples. Field blanks are an effective way of assessing potential cross-contamination as a result of sample handling. Typically, one field blank is collected for each shipping container.

Temperature Blanks: Temperature blanks are used to assess the temperature of samples during shipping. Temperature blanks should be provided by the laboratory or prepared by filling a sample container with PFAS-free water prior to shipment of the sample containers. The blank should be kept in the cooler during sampling and shipment to the laboratory. Once the cooler returns to the laboratory, the temperature of the blank should be measured to ensure that recommended sample storage criteria are met (typically less than 6 degrees Celsius).

2.4 Decontamination

Decontamination should occur prior to leaving the sampling area or at a central decontamination location and at the end of each work day. Additionally, sampling equipment exposed to PFAS-contaminated water should be decontaminated between sample locations.

Alconox®, Liquinox® and Luminox® detergents are acceptable for decontamination purposes. Use of Decon 90 should be avoided. Decontamination wastes must be properly contained and disposed of in accordance with applicable local, state and federal regulations.

2.4.1 Field Equipment Decontamination

<u>Dip Samplers</u>: Dip samplers and any other non-disposable sampling equipment that is in contact with surface water samples are to be fully decontaminated after each use using the following procedures:

1. Wash thoroughly using potable water and detergent (Alconox®, Liquinox® or Luminox®) to remove any remaining residual contamination;
2. Rinse thoroughly with potable water (1^{st} rinse);
3. Rinse thoroughly with PFAS-free water (2^{nd} rinse); and
4. For field instruments, rinse again with PFAS-free water (3^{rd} rinse); and
5. Dry the wet equipment with a paper towel or leave the equipment to air dry in a location away from dust or fugitive contaminants. All equipment should be dry before reuse.

2.4.2 Personnel and PPE Decontamination

A decontamination area for personnel and portable equipment may be specified in the health and safety plan. The area may include basins or tubs to capture decontamination wastes, which can be transferred to larger containers as necessary. If decontamination is needed at the end of the day following surface water sampling, personnel decontamination should follow these steps:

1. Gross (e.g., soil) contamination should be scraped and wiped from boots, safety glasses, hardhats, reflective vests, and other reusable PPE. Once gross contamination has been removed, gloves should be removed by rolling off the hands in such a way to avoid exposing skin to PFAS-contaminated materials;
2. A new pair of gloves should be put on and reusable PPE should be decontaminated using PFAS-free water mixed with detergent (preferably Alconox®, Liquinox® or Luminox®) and brushes, or similar means. After debris is removed, reusable PPE should be rinsed with PFAS-free water; and
3. Hands and any exposed body parts should be washed thoroughly using detergent (preferably Alconox®, Liquinox® or Luminox®) and PFAS-free water. Hands should be dried with paper towels.

2.5 <u>Food and Drink</u>

Food and drink should not be brought within the exclusion zone. Food that is kept in the staging area should preferably be contained in HDPE or stainless-steel containers.

3. LABORATORY PROCEDURES

3.1 Accreditations

Laboratories conducting PFAS analysis for NASA facilities should be accredited by the United States Department of Defense Environmental Laboratory Accreditation Program, that is, use a PFAS method that is compliant with Table B-15 of the DoD and DOE consolidated QSM 5.2 for Environmental Laboratories. States may also require that analytical laboratories are National Environmental Laboratory Accreditation Program accredited for their state and that PFAS analytical methods follow state guidelines.

4. DOCUMENTATION

4.1 Chain of Custody

4.1.1 Field Custody Procedures

A sample is considered to be in custody if the following conditions have been observed:

- It is in possession or view of the person in custody;
- It is locked in a secure area;
- It is placed in an area restricted to authorized personnel; or
- It is placed in a container and secured with an official seal, so that the sample cannot be reached without breaking the seal.

The following practices should be observed by field personnel to ensure sample custody:

- As few persons as possible will handle samples;
- The sample collector is personally responsible for the care and custody of samples collected until they are transferred to the laboratory;
- The sample collector will record sample data in the field notebook; and
- Sample labels will be completed for each sample.

4.1.2 Chain of Custody Record

All samples should be accompanied by a CoC record. The CoC record is typically provided by the laboratory. The CoC record should be fully completed in duplicate (e.g., a carbon copy). At the minimum, the following information should be included on a CoC record:

- Project name and number;
- Laboratory name and address;

- Name of person that collected the samples;
- Sample identifier;
- Sample date and time (time in 24-hour format);
- Laboratory analysis requested;
- Preservatives added to each sample;
- Sample matrix (e.g., soil, water);
- Number of containers per sample; and
- Airway bill tracking number.

As applicable, the following remarks should be added to the CoC record:

- Contractor name and address;
- MS/MSD sample volume (if necessary);
- A request for rapid turnaround time; and
- A note regarding the potential concentrations in a highly-contaminated sample.

Indication of a duplicate sample should **not** be included on a CoC record.

4.1.3 Sample Packaging

The CoC record should accompany all sample shipments. One CoC record should be prepared for each cooler and the cooler number recorded on the CoC. The samples in the cooler should be listed on the CoC record. The CoC record should be placed in a sealed plastic bag (e.g., Ziploc®) and taped to the inside lid of the cooler. If one sample is contained in two coolers (i.e., one sample has too many containers to fit in one cooler), then the original CoC should be placed in the first cooler and a copy of the CoC record should be placed in the second cooler. The duplicate copy of the CoC record should be retained by the sampler.

Custody seals should be signed and dated at the time of use. Sample shipping containers should be sealed in as many places as necessary to ensure that the container cannot be opened without breaking a custody seal. Tape should be placed over the seals to ensure that seals are not accidentally broken during shipment. If the sampler transports the samples to the laboratory without sample shipment, custody seals are not required.

4.1.4 Transfer of Custody

When transferring the possession of samples from the field sampler to a transporter or to the laboratory, the sampler should sign, date, and note the time as "relinquished by" on the CoC record.

The receiver should also sign, date, and note the time as "received by" on the CoC record. The date and time of the receiver and relinquisher should be the same.

When samples are transported by a commercial carrier, the carrier will not sign the CoC record. However, the airway bill tracking number should be recorded on the CoC record. Airway bills should also be retained with the CoC record as documentation of transport. For this reason, the date and time of the receiver and relinquisher will not match when shipping with a commercial carrier.

4.1.5 Laboratory Custody Procedures

A designated sample custodian should accept custody of the shipped samples and verify that the sample identification number matches the CoC record. Pertinent information about shipment, pickup, and courier should be entered in the "Remarks" section. The temperature of the temperature blanks at the time of receiving should be noted on the CoC record.

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Attachment A. Daily PFAS Sampling Checklist

Date: ___________________

Site Name: _____________________________________

Weather (*temperature/precipitation*): ____

Please check all boxes that apply and describe any exceptions in the notes section below along with QA/QC methods used to assess potential sample cross-contamination as a result.

Field Clothing and PPE:

- ☐ No water- or stain-resistant waders or clothing (e.g., GORE-TEX®)
- ☐ During collection of water and sediment samples, no water- or stain-resistant boots OR water- or stain-resistant boots covered by PFAS-free over-boots
- ☐ Field boots (or over-boots) are made of polyurethane, PVC, rubber, or untreated leather
- ☐ Waders or rain gear are made of neoprene, polyurethane, PVC, vinyl, wax-coated or rubber
- ☐ Clothing has not been recently laundered with a fabric softener
- ☐ No coated HDPE suits (e.g., coated Tyvek® suits)
- ☐ Field crew has not used cosmetics, moisturizers, or other related products today
- ☐ Field crew has not used sunscreen or insect repellants today, other than products approved as PFAS-free

Field Equipment:

- ☐ Sample containers and equipment in direct contact with the sample are made of HDPE, polypropylene, silicone, acetate or stainless steel, not LDPE or glass
- ☐ Sample caps are made of HDPE or polypropylene and are not lined with Teflon™
- ☐ No materials containing Teflon™, Viton™, or fluoropolymers
- ☐ No materials containing LDPE are in direct contact with the sample (e.g., LDPE tubing, Ziploc® bags)
- ☐ No plastic clipboards, binders, or spiral hard cover notebooks
- ☐ No waterproof field books
- ☐ No waterproof or felt pens or markers (e.g., certain Sharpie® products)
- ☐ No chemical (blue) ice, unless it is contained in a sealed bag
- ☐ No aluminum foil
- ☐ No sticky notes (e.g., certain Post-It® products)

Decontamination:

- ☐ Reusable field equipment (e.g., dip sampler) decontaminated prior to reuse
- ☐ "PFAS-free" water is on-site for decontamination of field equipment
- ☐ Alconox®, Liquinox® or Luminox® used as decontamination detergent

Food and Drink:

- ☐ No food or drink on-site, except within staging area
- ☐ Food in staging area is contained in HDPE or stainless steel container

Notes: ____

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Field Team Leader Name (Print): ___________________________

Field Team Leader Signature: ______________________________

Date/Time: ____________________________

Standard Operating Procedure for Groundwater Elevation Measurements at Monitoring Wells Containing Per- and Polyfluoroalkyl Substances

1. INTRODUCTION

1.1 Purpose and Scope

Standard operating procedures (SOPs) were prepared to guide per- and polyfluoroalkyl substance (PFAS) monitoring activities at National Aeronautics and Space Administration (NASA) sites. This SOP describes recommended procedures to be used by field personnel when measuring water level elevations in monitoring wells that contain or potentially contain PFAS. Because PFAS are potentially present in a variety of materials that may come into contact with water samples, and because laboratory analytical method detection limits are low (low to sub nanogram per liter concentrations), conservative precautions are recommended to avoid sample cross-contamination and false positive results.

Currently, site investigation guidance for PFAS is still in its infancy. Guidance from regulatory agencies often varies by state. Guidelines follow precautionary principles and may be based on anecdotal sampling experiences or on an abundance of precaution, rather than scientific studies. There is currently a need for robust, high quality guidance on PFAS sampling methods. Because there is little to no published scientific research regarding how certain materials may affect sample results, a conservative approach is recommended. The state of knowledge and practice is rapidly changing along with state and federal regulations and guidance for PFAS investigations. The procedures in this SOP are consistent with best practices at the time of authoring.

1.2 Definitions and Acronyms

1.2.1 Definitions

Dedicated equipment	Equipment that is installed in or used in just one monitoring well for purging and sampling, and that remains in that well for the duration of the monitoring program. Dedicated equipment does not need to be decontaminated between sampling events.
PFAS-free water	Water that has been analyzed by an accredited laboratory and determined to be below the method detection limit (i.e., non-detect) for the suite of PFAS to be analyzed for in environmental samples. Method detection limits (MDLs) used during analysis of PFAS-free water should be at or below the MDLs used for environmental samples.
Potable water	Water that meets state and federal drinking water requirements. Note this water may or may not have detectable PFAS concentrations.

1.2.2 Acronyms

ETFE	ethylene tetrafluoroethylene
FEP	fluorinated ethylene propylene
HDPE	high-density polyethylene
LDPE	low-density polyethylene
MDL	method detection limit
NASA	National Aeronautics and Space Administration
PFAS	per- and polyfluoroalkyl substance
PFTE	polytetrafluoroethylene
PPE	personal protective equipment
PVC	polyvinyl chloride
PVDF	polyvinylidene fluoride
QA	quality assurance
QC	quality control
SOP	standard operating procedure

1.3 Equipment and Products

Sections 1.3.1 and 1.3.2 detail items that are safe to use versus not recommended for use on the job site to protect PFAS samples from potential cross-contamination. Science-based evidence is not currently available to support a determination of the realistic impact of these commonly used field items and materials on PFAS samples. In the absence of scientific-based sampling guidance, field staff, contractors, and analytical laboratories should try to avoid using items that may pose a risk for cross-contamination and false positive results and instead use acceptable alternatives identified in this section. If the field team needs to use products and equipment on site that are not recommended, additional quality assurance/quality control (QA/QC) samples may be collected to evaluate any potential impact on PFAS environmental samples. This information is also provided in an abbreviated format as a checklist for field staff to reference (Attachment A).

1.3.1 Field Equipment

Items that are **safe to use** on site when measuring groundwater elevations in monitoring wells that may contain PFAS include the following:

- Materials made of high-density polyethylene (HDPE)[1], silicone, acetate, or stainless steel
- Low-density polyethylene (LDPE)[2] materials not in direct contact with the sample (e.g., Ziploc® bags);
- Masonite or aluminum clipboards;
- Sampling forms, and loose paper or field notebooks;
- Ballpoint pens;
- Alconox®, Liquinox® and Luminox® detergents;
- Paper towels;
- Trash bags;
- Dedicated Silicon and/or HDPE tubing;
- Water level probe(s).

Items **to be avoided (i.e., not recommended) for use** on site include the following:

- Water-resistant paper, notebooks, and labels (e.g., certain Rite in the Rain® products), due to use of PFAS in water-resistant inks and coatings;
- Sticky notes (e.g., certain Post-It® products), due to potential use of a paper coating product Zonyl™ or similar fluorotelomer compounds;
- Plastic clipboards, binders, and spiral hardcover notebooks;
- Pens with water-resistant ink;
- Felt pens and markers (e.g., certain Sharpie® products) – some PFAS SOPs (e.g., Michigan) specifically allow Fine or Ultra-Fine Point Sharpies® and TestAmerica Laboratories, Inc. routinely uses Sharpies® in the laboratory following unpublished analytical tests that reportedly showed no impact on PFAS sample results;
- Aluminum foil, as PFAS are sometimes used as a protective layer;
- Decon 90™ liquid detergent, which reportedly contain fluorosurfactants;

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[1] HDPE plastics are commonly identified by a recycling symbol with a number 2 inside it.
[2] LDPE plastics are commonly identified by a recycling symbol with a number 4 inside it.

- Materials containing polytetrafluoroethylene (PFTE) including Teflon™ and Hostaflon® (e.g., tubing, tape, plumbing paste, O-rings);
- Equipment with Viton™ components (i.e., fluoroelastomers);
- Stain- or water-resistant materials, as these are typically fluoropolymer-based;
- Material containing LDPE, particularly if used in direct contact with the sample (e.g., LDPE tubing, as PFAS can sorb to the porous tubing); and
- Material containing "fluoro" in the name – this includes, but is not limited to, fluorinated ethylene propylene (FEP), ethylene tetrafluoroethylene (ETFE), and polyvinylidene fluoride (PVDF).

1.3.2 Clothing, Personal Protective Equipment (PPE), and Consumer Products

Items that are **safe to use** on site when sampling for PFAS include the following:

- Boots made of polyurethane, polyvinyl chloride (PVC), rubber, or untreated leather;
- Other field boots covered by PFAS-free (e.g., polypropylene) over-boots;
- Rain gear made of polyurethane, PVC, wax-coated, vinyl, or rubber;
- Clothing made of synthetic (e.g., polyester) or natural (e.g., cotton) fibers;
- Safety glasses;
- Reflective safety vests;
- Hardhats;
- Disposable powder-free nitrile gloves;
- Uncoated HDPE suits (e.g., certain Tyvek® products);

- Sunscreens[3] and insect repellants[4] that have been tested and found to be PFAS-free; and
- Bottled water and hydration drinks.

Items **<u>to be avoided (i.e., not recommended) for use</u>** on site include the following:

- Water- or stain-resistant boots and clothing (e.g., products containing GORE-TEX®);
- Clothing recently laundered with a fabric softener;
- Coated HDPE suits (e.g., certain Tyvek® products);
- Sunscreen and insect repellants containing fluorinated compounds as ingredients, such as polyfluoroalkyl phosphate esters;
- Latex gloves;
- Cosmetics, moisturizers, hand cream, and other related products;
- Food wrappers and packaging; and
- Food and drinks other than bottled water or hydration drinks.

Field staff should try to find acceptable alternatives to these items that still allow them to complete the field work safely and efficiently. For example, wearing long-sleeved clothing and a hard hat or sun hat may eliminate the need to use sunscreen in some climates. If an item cannot be easily avoided, additional consideration should be given to QA/QC samples to evaluate the potential impact of sample cross-contamination (e.g., field blanks).

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[3] Examples of PFAS-free sunscreens include Alba Organics Natural, Aubrey Organics, Banana Boat Sport Performance Sunscreen Lotion Broad Spectrum SPF 30, Banana Boat for Men Triple Defense Continuous Spray Sunscreen SPF 30, Banana Boat Sport Performance Coolzone Broad Spectrum SPF 30, Banana Boat Sport Performance Sunscreen Stick SPF 50, Coppertone Sunscreen Lotion Ultra Guard Broad Spectrum SPF 50, Coppertone Sport High-Performance AccuSpray Sunscreen SPF 30, Coppertone Sunscreen Stick Kids SPF 55, Jason Natural Sun Block, Kiss my Face, L'Oréal Silky Sheer Face Lotion 50+, Meijer Clear Zinc Sunscreen Lotion Broad Spectrum SPF 15, 30 and 50, Meijer Wet Skin Kids Sunscreen Continuous Spray Broad Spectrum SPF 70, Neutrogena Beach Defense Water + Sun Barrier Lotion SPF 70, Neutrogena Beach Defense Water + Sun Barrier Spray Broad Spectrum SPF 30, Neutrogena Pure & Free Baby Sunscreen Broad Spectrum SPF 60+, Neutrogena Ultra-Sheer Dry-Touch Sunscreen Broad Spectrum SPF 30, Yes to Cucumbers, and sunscreens for infants. Products with fluorinated compounds in their ingredients (e.g., polyfluoroalkyl phosphate esters) should not be worn during sampling.

[4] Examples of PFAS-free insect repellent include Jason Natural Quit Bugging Me, Repel Lemon Eucalyptus Insect repellant, Herbal Armor, California Baby Natural Bug Spray, BabyGanics, OFF! Deep Woods® spray for clothing and skin, Sawyer® do-it-yourself permethrin treatment for clothing, Insect Shield Insect® pretreated clothing, DEET products, and sunscreen/insect repellent combination product Avon Skin so Soft Bug Guard-SPF 30. Products with fluorinated compounds in their ingredients (e.g., polyfluoroalkyl phosphate esters) should not be worn during sampling.

2. FIELD PROCEDURES

2.1 Pre-Mobilization Activities

2.1.1 Health and Safety Plan

Prior to each field event, the site health and safety plan should be reviewed and updated, as necessary. Health and safety plan requirements should be reviewed for consistency with this SOP and modified as appropriate to resolve any differences.

2.1.2 Equipment Decontamination

Equipment should be decontaminated on site before work begins. Equipment decontamination should follow the steps outlined in Section 2.3.

2.2 Groundwater Elevation Monitoring

2.2.1 Pre-Sampling Activities

Prior to the sampling event, field staff can review information from previous groundwater monitoring events to inform their knowledge of well locations, field equipment, and field conditions. Field staff should also identify upgradient wells and downgradient wells relative to potential source area wells. Wells with the lowest anticipated PFAS concentrations should be monitored first. At the beginning of each sampling day, field staff should inspect field equipment to ensure that it is in good working order.

2.2.2 Sampling PPE

Gloves: Disposable powder-free nitrile gloves should be worn at all times during sample collection and handling of sampling equipment.

At a minimum, field personnel should put on a new pair of nitrile gloves after the following activities:

- Handling samples, including QA/QC samples and blanks; and
- Handling sampling equipment.

At a minimum, personnel should (1) thoroughly wash their hands with detergent (preferably Alconox®, Liquinox® or Luminox®) and PFAS-free water; (2) thoroughly dry their hands with paper towels; and (3) put on a new pair of nitrile gloves after the following activities:

- Contact with a material potentially containing PFAS;
- Change in sampling locations;

- Breaks in work;
- Washroom breaks; and
- Exit and entry into the project site exclusion zone.

2.2.3 Monitoring Equipment

<u>Water Level Meter</u>: A water level meter is typically used to measure the depth to groundwater and/or monitor drawdown during groundwater purging prior to sampling. Water level meters should be decontaminated prior to and after each sampling location using PFAS-free water, as described in Section 2.3.

2.2.4 Groundwater Elevation Monitoring

<u>Depth to Groundwater Measurements</u>: If known, wells with the lowest PFAS concentrations should be monitored first and wells with the highest PFAS concentrations monitored last. The following sampling method should be used:

1. Measure and record the static groundwater level using a groundwater elevation probe;
2. Record parameter in field notes; and
3. Decontaminate equipment prior to proceeding to the next groundwater monitoring well location, as described in Section 2.3.

<u>Wet Weather Considerations</u>: Field sampling during wet weather (e.g., rainfall and snowfall) should be conducted wearing appropriate clothing that does not pose a risk for cross-contamination. Field personnel should try to avoid water-resistant clothing and boots. Rain gear made of polyurethane, PVC, vinyl, or rubber is an acceptable alternative.

Clean nitrile gloves should be worn when handling monitoring equipment.

2.3 <u>Decontamination</u>

Decontamination of monitoring equipment must occur prior to and between uses at each groundwater monitoring location. Decontamination should also occur prior to leaving the sampling area or at a central decontamination location and at the end of each work day.

Alconox®, Liquinox® and Luminox ® detergents are acceptable for decontamination purposes. Use of Decon 90 should be avoided. Decontamination wastes must be properly contained and disposed of in accordance with applicable local, state and federal regulations.

2.3.1 Monitoring Equipment Decontamination

All non-disposable monitoring equipment that is in contact with groundwater (e.g., field probes) must be cleaned prior to and between uses at each groundwater sampling location according to the following procedures:

1. Remove any gross (e.g., soil) contamination from monitoring equipment;
2. If heavy petroleum residuals are encountered during monitoring, use methanol or another appropriate solvent to remove any residues from monitoring equipment;
3. Wash water-resistant equipment thoroughly and vigorously with potable water containing detergent (Alconox®, Liquinox® or Luminox®) using a bristle brush or similar utensil to remove any remaining residual contamination;
4. Rinse equipment thoroughly with potable water (1^{st} rinse);
5. Rinse equipment thoroughly with PFAS-free water (2^{nd} rinse);
6. For field instruments, rinse again with PFAS-free water (3^{rd} rinse);
7. Dry the wet equipment with a paper towel or leave the equipment to air dry in a location away from dust or fugitive contaminants. All equipment should be dry before reuse.

Cleaning and decontamination of the equipment should be accomplished in stages and in such a way that the contamination does not discharge into the environment. Dedicated or disposable monitoring equipment should be considered to minimize the need for decontamination.

2.3.2 Personnel and PPE Decontamination

A decontamination area for personnel and portable equipment may be specified in the health and safety plan. The area may include basins or tubs to capture decontamination wastes, which can be transferred to larger containers as necessary. If needed following monitoring groundwater elevations, personnel decontamination should follow these steps:

1. Gross (e.g., soil) contamination should be scraped and wiped from boots, safety glasses, hardhats, reflective vests, and other reusable PPE. Once gross contamination has been removed, gloves should be removed by rolling off the hands in such a way to avoid exposing skin to PFAS-contaminated materials;
2. A new pair of gloves should be put on and reusable PPE should be decontaminated using PFAS-free water mixed with detergent (preferably Alconox®, Liquinox® or Luminox®) and brushes, or similar means. After debris is removed, reusable PPE should be rinsed with PFAS-free water; and
3. Hands and any exposed body parts should be washed thoroughly using detergent (preferably Alconox®, Liquinox® or Luminox®) and PFAS-free water. Hands should be dried with paper towels.

2.4 Food and Drink

Food and drink should not be brought within the exclusion zone. Food that is kept in the staging area should preferably be contained in HDPE or stainless-steel containers.

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Attachment A. Daily PFAS Sampling Checklist

Date: ___________________

Site Name: _____________________________________

Weather (*temperature/precipitation*): ____

Please check all boxes that apply and describe any exceptions in the notes section below along with QA/QC methods used to assess potential sample cross-contamination as a result.

Field Clothing and PPE:

- ☐ No water- or stain-resistant clothing (e.g., GORE-TEX®)
- ☐ During collection of water and sediment samples, no water- or stain-resistant boots OR water- or stain-resistant boots covered by PFAS-free over-boots
- ☐ Field boots (or over-boots) are made of polyurethane, PVC, rubber, or untreated leather
- ☐ Waders or rain gear are made of polyurethane, PVC, vinyl, wax-coated or rubber
- ☐ Clothing has not been recently laundered with a fabric softener
- ☐ No coated HDPE suits (e.g., coated Tyvek® suits)
- ☐ Field crew has not used cosmetics, moisturizers, or other related products today
- ☐ Field crew has not used sunscreen or insect repellants today, other than products approved as PFAS-free

Field Equipment:

- ☐ Sample containers and equipment in direct contact with the sample are made of HDPE, polypropylene, silicone, acetate or stainless steel, not LDPE or glass
- ☐ Sample caps are made of HDPE or polypropylene and are not lined with Teflon™
- ☐ No materials containing Teflon™, Viton™, or fluoropolymers
- ☐ No materials containing LDPE in direct contact with the sample (e.g., LDPE tubing, Ziploc® bags)
- ☐ No plastic clipboards, binders, or spiral hard cover notebooks
- ☐ No waterproof field books
- ☐ No waterproof or felt pens or markers (e.g., certain Sharpie® products)
- ☐ No chemical (blue) ice, unless it is contained in a sealed bag
- ☐ No aluminum foil
- ☐ No sticky notes (e.g., certain Post-It® products)

Decontamination:

- ☐ Reusable sampling equipment decontaminated before and after each sample location
- ☐ "PFAS-free" water is on-site for decontamination of sample equipment
- ☐ Alconox®, Liquinox® or Luminox® used as decontamination detergent

Food and Drink:

- ☐ No food or drink on-site, except within staging area
- ☐ Food in staging area is contained in HDPE or stainless steel containers

Notes: ____

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Field Team Leader Name (Print): ___________________________

Field Team Leader Signature: ______________________________

Date/Time: ____________________________

Standard Operating Procedure for Groundwater Sampling of Monitoring Wells and Analysis of Per- and Polyfluoroalkyl Substances

1. INTRODUCTION

1.1 Purpose and Scope

Standard operating procedures (SOPs) were prepared to guide per- and polyfluoroalkyl substance (PFAS) sampling activities at National Aeronautics and Space Administration (NASA) sites. This SOP describes recommended procedures to be used by field personnel when collecting groundwater samples from monitoring wells. Because PFAS are potentially present in a variety of materials that may come into contact with water samples, and because laboratory analytical method detection limits are low (low to sub nanogram per liter concentrations), conservative precautions are recommended to avoid sample cross-contamination and false positive results.

Currently, sampling guidance for PFAS is still in its infancy. Guidance from regulatory agencies often varies by state. Guidelines follow precautionary principles and may be based on anecdotal sampling experiences or on an abundance of precaution, rather than scientific studies. There is currently a need for robust, high quality guidance on PFAS sampling methods. Because there is little to no published scientific research regarding how certain materials may affect sample results, a conservative approach is recommended. The state of knowledge and practice is rapidly changing along with state and federal regulations and guidance for PFAS investigations. The procedures in this SOP are consistent with best practices at the time of authoring.

1.2 Definitions and Acronyms

1.2.1 Definitions

Bladder pump	A positive displacement pump that is acceptable for collection of all analytes and depths. Can be small enough to sample from wells as small as 3/4-inch in diameter.
Dedicated equipment	Equipment that is installed in or used in just one monitoring well for purging and sampling, and that remains in that well for the duration of the monitoring program. Dedicated equipment does not need to be decontaminated between sampling events.
Inertia pump	A riser tube fitted with a one-way foot valve. Best used on small diameter wells (2 inches or less). Can be used if the depth to water is less than approximately 25 feet.
Peristaltic pump	A positive displacement pump that can be used to move fluids at a fixed rate. Peristaltic pumps are typically used if the depth to water is less than approximately 25 feet.

PFAS-free water	Water that has been analyzed by an accredited laboratory (see Section 3.1) and determined to be below the method detection limit (i.e., non-detect) for the suite of PFAS to be analyzed for in environmental samples. Method detection limits (MDLs) used during analysis of PFAS-free water should be at or below the MDLs used for environmental samples.
Potable water	Water that meets state and federal drinking water requirements. Note this water may or may not have detectable PFAS concentrations.
Submersible pump	A positive-pressure pump that is acceptable for collection of all analytes. Achievable depths are limited by the power of the pump and length of wiring. Well must be at least 2 inches in diameter.

1.2.2 Acronyms

ASTM	American Society for Testing and Materials
CoC	chain of custody
DO	dissolved oxygen
DoD	Department of Defense
DOT	Department of Transportation
ETFE	ethylene tetrafluoroethylene
FEP	fluorinated ethylene propylene
HDPE	high-density polyethylene
IATA	International Air Transport Association
ICAO	International Civil Aviation Organization
LDPE	low-density polyethylene
MDL	method detection limit
MS	matrix spike
MSD	matrix spike duplicate
NASA	National Aeronautics and Space Administration
ORP	oxidation-reduction potential
PFAS	per- and polyfluoroalkyl substances
PFTE	polytetrafluoroethylene
PPE	personal protective equipment
PVC	polyvinyl chloride
PVDF	polyvinylidene fluoride

QA	quality assurance
QC	quality control
QSM	quality systems manual
SOP	standard operating procedure
USGS	United States Geological Survey

1.3 Equipment and Products

Sections 1.3.1 and 1.3.2 detail items that are safe to use versus not recommended for use on the job site to protect PFAS samples from potential cross-contamination. Science-based evidence is not currently available to support a determination of the realistic impact of these commonly used field items and materials on PFAS samples. In the absence of scientific-based sampling guidance, field staff, contractors, and analytical laboratories should try to avoid using items that may pose a risk for cross-contamination and false positive results and instead use acceptable alternatives identified in this section. If the field team needs to use products and equipment on site that are not recommended, additional quality assurance/quality control (QA/QC) samples may be collected to evaluate any potential impact on PFAS environmental samples. This information is also provided in an abbreviated format as a checklist for field staff to reference (Attachment A).

1.3.1 Field Equipment

Items that are **safe to use** on site when sampling for PFAS include the following:

- Sampling containers, screw caps and other equipment made from high-density polyethylene (HDPE)[1], polypropylene, silicone, acetate, or stainless steel;
- Sample preservatives (e.g., Trizma®);
- QA/QC samples (e.g., temperature and field blanks);
- Low-density polyethylene (LDPE)[2] materials not in direct contact with the sample (e.g., Ziploc® bags);
- Materials made of HDPE, silicone, acetate, or stainless steel;
- Masonite or aluminum clipboards;
- Ballpoint pens;
- Sampling forms, loose paper or field notebooks, chain of custody (CoC) record, and sample container labels;

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[1] HDPE plastics are commonly identified by a recycling symbol with a number 2 inside it.
[2] LDPE plastics are commonly identified by a recycling symbol with a number 4 inside it.

- Alconox®, Liquinox® and Luminox® detergents;
- Paper towels;
- Trash bags;
- HDPE sheeting;
- Hard-shell coolers;
- Shipping and handling labels;
- Regular (wet) ice;
- Bubble wrap;
- Duct tape and packing tape;
- Large (e.g., 55-gallon) containers;
- Submersible pumps, bladder pumps, peristaltic pumps, and inertia pumps that do not have Teflon components;
- Dedicated Silicon and/or HDPE tubing;
- Analytical field meter (e.g., temperature, pH, conductivity, oxidation-reduction potential [ORP], dissolved oxygen [DO], and turbidity); and
- Water level probe(s).

Items **to be avoided (i.e. not recommended) for use** on site include the following:

- Glass sample containers, due to PFAS adherence to glass surfaces;
- Water-resistant paper, notebooks, and labels (e.g., certain Rite in the Rain® products), due to use of PFAS in water-resistant inks and coatings;
- Sticky notes (e.g., certain Post-It® products), due to potential use of a paper coating product Zonyl™ or similar fluorotelomer compounds;
- Plastic clipboards, binders, and spiral hardcover notebooks;
- Pens with water-resistant ink;
- Felt pens and markers (e.g., certain Sharpie® products) – some PFAS SOPs (e.g., Michigan) specifically allow Fine or Ultra-Fine Point Sharpies® and TestAmerica Laboratories, Inc. routinely uses Sharpies® in the laboratory following unpublished analytical tests that reportedly showed no impact on PFAS sample results;
- Aluminum foil, as PFAS are sometimes used as a protective layer;
- Decon 90™ liquid detergent, which reportedly contain fluorosurfactants;

- Chemical (e.g., blue) ice packs, unless it is contained in a sealed bag. Blue ice has the potential to be contaminated from previous field sampling events;
- Materials containing polytetrafluoroethylene (PFTE) including Teflon™ and Hostaflon® (e.g., tubing, tape, plumbing paste, O-rings);
- Equipment with Viton™ components (i.e., fluoroelastomers);
- Stain- or water-resistant materials, as these are typically fluoropolymer-based;
- Material containing LDPE, particularly if used in direct contact with the sample (e.g., LDPE tubing, as PFAS can sorb to the porous tubing); and
- Material containing "fluoro" in the name – this includes, but is not limited to, fluorinated ethylene propylene (FEP), ethylene tetrafluoroethylene (ETFE), and polyvinylidene fluoride (PVDF).

1.3.2 Clothing, Personal Protective Equipment (PPE), and Consumer Products

Items that are **<u>safe to use</u>** on site when sampling for PFAS include the following:

- Boots made of polyurethane, polyvinyl chloride (PVC), rubber, or untreated leather;
- Other field boots covered by PFAS-free (e.g., polypropylene) over-boots;
- Rain gear made of neoprene, polyurethane, PVC, wax-coated, vinyl, or rubber;
- Clothing made of synthetic (e.g., polyester) or natural (e.g., cotton) fibers;
- Safety glasses;
- Reflective safety vests;
- Hardhats;
- Disposable powder-free nitrile gloves;
- Uncoated HDPE suits (e.g., certain Tyvek® products);
- Bottled water and hydration drinks; and

- Sunscreens[3] and insect repellants[4] that have been tested and found to be PFAS-free.

Items **to be avoided (i.e., not recommended) for use** on site include the following:

- Water- or stain-resistant boots and clothing (e.g., products containing GORE-TEX®);
- Clothing recently laundered with a fabric softener;
- Coated HDPE suits (e.g., certain Tyvek® products);
- Sunscreen and insect repellants containing fluorinated compounds as ingredients, such as polyfluoroalkyl phosphate esters;
- Latex gloves;
- Cosmetics, moisturizers, hand cream, and other related products;
- Food wrappers and packaging; and
- Food and drinks other than bottled water or hydration drinks.

Field staff should try to find acceptable alternatives to these items that still allow them to complete the field work safely and efficiently. For example, wearing long-sleeved clothing and a hard hat or sun hat may eliminate the need to use sunscreen in some climates. If an item cannot be easily avoided, additional consideration should be given to QA/QC samples to evaluate the potential impact of sample cross-contamination (e.g., field blanks).

[3] Examples of PFAS-free sunscreens include Alba Organics Natural, Aubrey Organics, Banana Boat Sport Performance Sunscreen Lotion Broad Spectrum SPF 30, Banana Boat for Men Triple Defense Continuous Spray Sunscreen SPF 30, Banana Boat Sport Performance Coolzone Broad Spectrum SPF 30, Banana Boat Sport Performance Sunscreen Stick SPF 50, Coppertone Sunscreen Lotion Ultra Guard Broad Spectrum SPF 50, Coppertone Sport High-Performance AccuSpray Sunscreen SPF 30, Coppertone Sunscreen Stick Kids SPF 55, Jason Natural Sun Block, Kiss my Face, L'Oréal Silky Sheer Face Lotion 50+, Meijer Clear Zinc Sunscreen Lotion Broad Spectrum SPF 15, 30 and 50, Meijer Wet Skin Kids Sunscreen Continuous Spray Broad Spectrum SPF 70, Neutrogena Beach Defense Water + Sun Barrier Lotion SPF 70, Neutrogena Beach Defense Water + Sun Barrier Spray Broad Spectrum SPF 30, Neutrogena Pure & Free Baby Sunscreen Broad Spectrum SPF 60+, Neutrogena Ultra-Sheer Dry-Touch Sunscreen Broad Spectrum SPF 30, Yes to Cucumbers, and sunscreens for infants. Products with fluorinated compounds as ingredients (e.g., polyfluoroalkyl phosphate esters) should not be worn during sampling.

[4] Examples of PFAS-free insect repellent include Jason Natural Quit Bugging Me, Repel Lemon Eucalyptus Insect repellant, Herbal Armor, California Baby Natural Bug Spray, BabyGanics, OFF! Deep Woods® spray for clothing and skin, Sawyer® do-it-yourself permethrin treatment for clothing, Insect Shield Insect® pretreated clothing, DEET products, and sunscreen/insect repellent combination product Avon Skin so Soft Bug Guard-SPF 30. Products with fluorinated compounds in their ingredients (e.g., polyfluoroalkyl phosphate esters) should not be worn during sampling.

2. FIELD PROCEDURES

2.1 Pre-Mobilization Activities

2.1.1 Health and Safety Plan

Prior to each field event, the site health and safety plan should be reviewed and updated, as necessary. Health and safety plan requirements should be reviewed for consistency with this SOP and modified as appropriate to resolve any differences.

2.1.2 Laboratory Coordination

Field personnel should communicate with the laboratory that will conduct PFAS analysis regarding the following items:

- Laboratory accreditation for PFAS analysis (see Section 3.1);
- Appropriate sample containers, labels, and preservatives (see Sections 2.2.3 and 2.2.4);
- Sample storage conditions and holding time (see Section 2.2.5); and
- The number and type of QA/QC samples (see Section 2.3).

Because there is no standard United States Environmental Protection Agency method for analyzing PFAS samples in media other than drinking water, commercial laboratories typically offer analysis for a suite of approximately 18 PFAS using a modified version of Method 537.1. Laboratories may have developed their own variations. Project staff may consider the impact of differences in reported PFAS concentrations and the potential value of collecting and sending a split sample to a second commercial laboratory to assess variability in reported PFAS concentrations.

Laboratories conducting PFAS analysis for NASA facilities should be accredited by the United States Department of Defense Environmental Laboratory Accreditation Program (i.e. use a PFAS method that is compliant with Table B-15 of the DoD and Department of Energy consolidated Quality Systems Manual for Environmental Laboratories). States may also require that analytical laboratories are National Environmental Laboratory Accreditation Program accredited for their state and that PFAS analytical methods follow state guidelines.

2.1.3 Equipment Decontamination

Equipment should be decontaminated on site before work begins. Equipment decontamination should follow the steps outlined in Section 2.4.

2.2 Sampling

2.2.1 Pre-Sampling Activities

Prior to the sampling event, field staff can review information from previous groundwater monitoring events to inform their knowledge of well locations, field equipment, and field conditions. Field staff should also identify upgradient wells and downgradient wells relative to potential source area wells. Wells with the lowest anticipated PFAS concentrations should be sampled first.

At the beginning of each sampling day, field staff should prepare for sampling as follows:

1. Inspect field equipment to ensure that it is in good working order; and
2. Calibrate analytical field meter(s) according to the instrument manufacturers' specifications. Record calibration results on the appropriate form(s). Instruments that cannot be calibrated should not be used.

2.2.2 Sampling PPE

Gloves: Disposable powder-free nitrile gloves should be worn at all times during sample collection and handling of sampling equipment.

At a minimum, field personnel should put on a new pair of nitrile gloves after the following activities:

- Handling samples, including QA/QC samples and blanks; and
- Handling sampling equipment.

At a minimum, personnel should (1) thoroughly wash their hands with detergent (preferably Alconox®, Liquinox® or Luminox®) and PFAS-free water; (2) thoroughly dry their hands with paper towels; and (3) put on a new pair of nitrile gloves after the following activities:

- Contact with a material potentially containing PFAS;
- Change in sampling locations;
- Breaks in work;
- Washroom breaks; and
- Exit and entry into the project site exclusion zone.

2.2.3 Sampling Equipment

Sample Containers: HDPE containers with screw caps are commonly used for sample collection. Different laboratories may supply sample containers of varying sizes. Sample container caps are typically unlined.

Preservatives: Field personnel should communicate with the laboratory to determine what, if any, sample preservatives will be used..

Pumps: A variety of pumps, including submersible pumps, bladder pumps, peristaltic pumps, or inertia pumps, may be used for groundwater sampling. The choice of sampling device should be based on site-specific considerations, including well diameter, depth to groundwater, and purge rates. Regardless of the type of pump, the pump components, fittings, O-rings, sampling tubing, and other sampling equipment should not include Teflon™ or other PFAS-containing materials. Dedicated HDPE or silicon tubing is recommended for sampling each groundwater monitoring well.

Analytical Field Meter(s): Water quality parameters commonly evaluated during sampling of groundwater monitoring wells include temperature, pH, conductivity, ORP, DO, and turbidity. Salinity and total dissolved solids will also be measured and recorded at NASA sites. Analytical field meters to measure these parameters should be free of Teflon™ and other PFAS materials (e.g., tubing, O-rings).

Water Level Meter: A water level meter is typically used to monitor drawdown during groundwater purging prior to sampling. Water level meters should be decontaminated prior to and after each sampling location using PFAS-free water, as described in Section 2.4.

2.2.4 Sample Collection and Labeling

Container Rinsing: Sample containers should not to be rinsed prior to sampling.

Well Purging and Sample Collection: If known, wells with the lowest PFAS concentrations should be sampled first and wells with the highest PFAS concentrations sampled last. Well purging and sample collection should be conducted in accordance with applicable state regulations and sampling requirements. The following sampling method should be used:

1. Measure and record the static groundwater level using a groundwater elevation probe;
2. Place the pump or bottom of the dedicated tubing into the well within the screened interval;
3. Secure the outlet of the tubing from the well to the influent of the analytical field meter;
4. Start the pump;
5. Adjust the purge rate to minimize and stabilize drawdown, as measured by the water level probe;

6. Once drawdown is stable, start recording water quality parameters;
7. Routinely measure and record water level, temperature, pH, conductivity, ORP, salinity, total dissolved solids, DO, and turbidity throughout well purging at approximately 2- to 3-minute intervals. Record the parameters on a Groundwater Sampling Form;
8. Continue to measure and record the groundwater parameters until the parameters stabilize in accordance with FDEP SOPs;
9. Disconnect the tubing from the analytical field meter;
10. Remove the cap from the sample container;
11. Place the sample container under the water stream. Fill the container to the level specified by the laboratory (samples do not need to be collected headspace free) and then turn off the pump;
12. Close the container by screwing on the cap; and
13. Using a paper towel, dry the outside of the sample container if necessary.
14. Decontaminate reusable equipment prior to proceeding to the next groundwater monitoring well location, as described in Section 2.4.

Labels: Some water-resistant inks may be potential sources of PFAS. PFAS-free container labels should be filled out using a ballpoint pen that does not have water-resistant ink, if possible. Field staff should try to avoid filling out container labels using felt pens and markers (e.g., certain Sharpie® products). Container labels should include the following information:

- A unique sample identifier;
- QA/QC sample type, if applicable;
- Sampling date and time (24-hour format);
- Sampler’s name or initials; and
- Method of sample preservation.

Except for temperature blanks, all QC samples should be labeled and included on the CoC record. Duplicate samples should not be indicated as duplicates.

Wet Weather Considerations: Field sampling during wet weather (e.g., rainfall and snowfall) should be conducted wearing appropriate clothing that does not pose a risk for cross-contamination. Field personnel should try to avoid water-resistant clothing and boots. Rain gear made of polyurethane, PVC, vinyl, or rubber is an acceptable alternative. Samples and sample containers should not be opened prior to sample collection to avoid collecting precipitation. Should samples or sample containers become contaminated with precipitation, they should be discarded.

2.2.5 Sample Handling, Storage, and Shipment

Handling: Clean nitrile gloves should be worn when handling sample containers. Precautions should be taken to not drop or otherwise damage sample containers. Sample containers should **not** be placed in close proximity to a potential PFAS source.

Storage and Holding Times: Storage conditions and holding times should be determined by the laboratory. Measures should be taken to meet storage and holding time criteria (e.g., expedited shipping).

Shipment: Sample containers should be packed for shipment using the following steps:

1. Choose a cooler with structural integrity that will withstand shipment.
2. Secure and tape the drain plug with duct tape from the inside and outside.
3. Check that the caps on all sample containers are tight and will not leak.
4. Check that the sample labels are intact, filled out, legible, and that the sample identifier exactly matches the CoC record.
5. Seal each sample container in a sample bag to prevent melt water from getting into the sample or degrading the sample label.
6. Place sample containers into the cooler with their caps upright.
7. Fill any excess space within the cooler with bubble wrap (try to avoid using paper, cardboard, or polystyrene foam).
8. Fill remaining space from the top of the sample containers to the top of the cooler with wet ice that is double-bagged and sealed.
9. Seal the entire cooler with duct tape, particularly the lid, to prevent leaks.

Ship samples as non-hazardous material unless the samples meet the established Department of Transportation (DOT) criteria for a “hazardous material” or the International Air Transport Association (IATA)/International Civil Aviation Organization (ICAO) for air definition of “dangerous goods.” If the samples meet criteria for hazardous materials or dangerous goods, then DOT and IATA/ICAO regulations must be followed. Prior to shipping samples, field personnel should complete the appropriate air waybill or manifest. A copy of the air waybill or manifest should be kept for recordkeeping.

2.3 Sampling QA/QC

2.3.1 Field Duplicates

Field duplicates are samples collected in the same manner and at the same time and location as a primary sample. They should be collected from locations of known or suspected contamination.

Field duplicates are used to assess field and analytical precision and sample heterogeneity. Typically, at least one field duplicate is collected for every 10 primary samples. Field duplicates should be labeled with a unique sample identifier and not be indicated as a duplicate (i.e., submitted as “blind”).

2.3.2 Matrix Spike and Matrix Spike Duplicate Samples

Matrix spike and matrix spike duplicate (MS/MSD) samples are aliquots of environmental samples that are spiked with a known concentration of PFAS by the laboratory. MS/MSD samples are used to assess interferences caused by the sample matrix. MS/MSD samples are not needed if the analytical laboratory is using an isotopic dilution method but are technically required to meet Department of Defense (DoD) accreditation requirements. If necessary, MS/MSD samples are to be collected in the same manner and at the same time and location as a primary sample (i.e., additional sample volume). It is preferred that this location have little to no PFAS contamination. Samples should have the same matrix to ensure a valid result; if the samples do not appear visually similar (e.g., discoloration, suspended solids), choose another location for collection of MS/MSD samples. The number of required MS/MSD samples should be determined based on discussions with the laboratory. Typically, at least one MS/MSD sample is collected for every 20 primary samples. MS/MSD samples should be labeled with the same sample name and time as the primary sample and denoted as MS/MSD samples on the CoC and sample label.

2.3.3 Blanks

Blanks should be shipped and handled in the same manner as environmental samples. Field blanks should be labeled as such on sample bottles and on the CoC. The number and type of blanks should be determined by discussions with the laboratory.

Equipment Blanks: Equipment blanks are used to assess sources of field and laboratory contamination. Equipment blanks are prepared by pouring PFAS-free water over or through decontaminated reusable field sampling equipment and collecting the rinsate in a sample container. Typically, at least one equipment blank is collected for every 10 primary samples.

Field Blanks: Field blanks are used to assess ambient contamination within the field and laboratory. Field blanks should be prepared by filling a sample container with PFAS-free water in the field in the same manner as environmental samples. Field blanks are an effective way of assessing potential cross-contamination as a result of sample handling. Typically, one field blank is collected for each shipping container.

Temperature Blanks: Temperature blanks are used to assess the temperature of samples during shipping. Temperature blanks should be provided by the laboratory and prepared by filling a sample container with PFAS-free water prior to shipment of the sample containers. The blank should be kept in the cooler during sampling and shipment to the laboratory. Once the cooler

returns to the laboratory, the temperature of the blank should be measured to ensure that recommended sample storage criteria are met (typically less than 6 degrees Celsius).

2.4 Decontamination

Decontamination should occur prior to leaving the sampling area or at a central decontamination location and at the end of each work day. Additionally, sampling equipment exposed to PFAS-contaminated water should be decontaminated between sample locations.

Alconox®, Liquinox® and Luminox ® detergents are acceptable for decontamination purposes. Use of Decon 90 should be avoided. Decontamination wastes must be properly contained and disposed of in accordance with applicable local, state and federal regulations.

2.4.1 Field Equipment Decontamination

All non-disposable sampling equipment that is in contact with groundwater (e.g., field probes, pumps) must be cleaned prior to and between uses at each groundwater sampling location according to the following procedures:

1. Remove any gross (e.g., soil) contamination from sampling equipment.
2. If heavy petroleum residuals are encountered during sampling, use methanol or another appropriate solvent to remove any residues from sampling equipment.
3. Wash water-resistant equipment thoroughly and vigorously with potable water containing detergent (Alconox®, Liquinox® or Luminox®) using a bristle brush or similar utensil to remove any remaining residual contamination.
4. Rinse equipment thoroughly with potable water (1^{st} rinse).
5. Rinse equipment thoroughly with PFAS-free water (2^{nd} rinse).
6. For field instruments, rinse again with PFAS-free water (3^{rd} rinse).
7. Dry the wet equipment with a paper towel or leave the equipment to air dry in a location away from dust or fugitive contaminants. All equipment should be dry before reuse.

Cleaning and decontamination of the equipment should be accomplished in stages and in such a way that the contamination does not discharge into the environment. Dedicated or disposable sampling equipment should be considered to minimize the need for decontamination.

2.4.2 Personnel and PPE Decontamination

A decontamination area for personnel and portable equipment may be specified in the health and safety plan. The area may include basins or tubs to capture decontamination wastes, which can be transferred to larger containers as necessary. Decontamination following groundwater monitoring well sampling should follow these steps:

1. Gross (e.g., soil) contamination should be scraped and wiped from boots, safety glasses, hardhats, reflective vests, and other reusable PPE. Once gross contamination has been removed, gloves should be removed by rolling off the hands in such a way to avoid exposing skin to PFAS-contaminated materials;
2. A new pair of gloves should be put on and reusable PPE should be decontaminated using PFAS-free water mixed with detergent (preferably Alconox®, Liquinox® or Luminox®) and brushes, or similar means. After debris is removed, reusable PPE should be rinsed with PFAS-free water; and
3. Hands and any exposed body parts should be washed thoroughly using detergent (preferably Alconox®, Liquinox® or Luminox®) and PFAS-free water. Hands should be dried with paper towels.

2.5 Food and Drink

Food and drink should not be brought within the exclusion zone. Food that is kept in the staging area should preferably be contained in HDPE or stainless-steel containers.

3. LABORATORY PROCEDURES

3.1 Accreditations

Laboratories conducting PFAS analysis for NASA facilities should be accredited by the United States Department of Defense Environmental Laboratory Accreditation Program, that is, use a PFAS method that is compliant with Table B-15 of the DoD and DOE consolidated QSM 5.2 for Environmental Laboratories. States may also require that analytical laboratories are National Environmental Laboratory Accreditation Program accredited for their state and that PFAS analytical methods follow state guidelines.

4. DOCUMENTATION

4.1 Chain of Custody

4.1.1 Field Custody Procedures

A sample is considered to be in custody if the following conditions have been observed:

- It is in possession or view of the person in custody;
- It is locked in a secure area;
- It is placed in an area restricted to authorized personnel; or
- It is placed in a container and secured with an official seal, so that the sample cannot be reached without breaking the seal.

The following practices should be observed by field personnel to ensure sample custody:

- As few persons as possible will handle samples;
- The sample collector is personally responsible for the care and custody of samples collected until they are transferred to the laboratory;
- The sample collector will record sample data in the field notebook; and
- Sample labels will be completed for each sample.

4.1.2 Chain of Custody Record

All samples should be accompanied by a CoC record. The CoC record is typically provided by the laboratory. The CoC record should be fully completed in duplicate (e.g., a carbon copy). At the minimum, the following information should be included on a CoC record:

- Project name and number;
- Laboratory name and address;
- Name of person that collected the samples;
- Sample identifier;
- Sample date and time (time in 24-hour format);
- Laboratory analysis requested;
- Preservatives added to each sample;
- Sample matrix (e.g., soil, water);
- Number of containers per sample; and
- Airway bill tracking number.

As applicable, the following remarks should be added to the CoC record:

- Contractor name and address;
- MS/MSD sample volume (if necessary);
- A request for rapid turnaround time; and
- A note regarding the potential concentrations in a highly-contaminated sample.

Indication of a duplicate sample should **not** be included on a CoC record.

4.1.3 Sample Packaging

The CoC record should accompany all sample shipments. One CoC record should be prepared for each cooler and the cooler number recorded on the CoC. The samples in the cooler should be listed on the CoC record. The CoC record should be placed in a sealed plastic bag (e.g., Ziploc®) and taped to the inside lid of the cooler. If one sample is contained in two coolers (i.e., one sample has too many containers to fit in one cooler), then the original CoC should be placed in the first cooler and a copy of the CoC record should be placed in the second cooler. The duplicate copy of the CoC record should be retained by the sampler.

Custody seals should be signed and dated at the time of use. Sample shipping containers should be sealed in as many places as necessary to ensure that the container cannot be opened without breaking a custody seal. Tape should be placed over the seals to ensure that seals are not accidentally broken during shipment. If the sampler transports the samples to the laboratory without sample shipment, custody seals are not required.

4.1.4 Transfer of Custody

When transferring the possession of samples from the field sampler to a transporter or to the laboratory, the sampler should sign, date, and note the time as “relinquished by” on the CoC record. The receiver should also sign, date, and note the time as “received by” on the CoC record. The date and time of the receiver and relinquisher should be the same.

When samples are transported by a commercial carrier, the carrier will not sign the CoC record. However, the airway bill tracking number should be recorded on the CoC record. Airway bills should also be retained with the CoC record as documentation of transport. For this reason, the date and time of the receiver and relinquisher will not match when shipping with a commercial carrier.

4.1.5 Laboratory Custody Procedures

A designated sample custodian should accept custody of the shipped samples and verify that the sample identification number matches the CoC record. Pertinent information about shipment, pickup, and courier should be entered in the “Remarks” section. The temperature of the temperature blanks at the time of receiving should be noted on the CoC record.

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Attachment A. Daily PFAS Sampling Checklist

Date: ___________________

Site Name: _____________________________________

Weather (*temperature/precipitation*): ____

Please check all boxes that apply and describe any exceptions in the notes section below along with QA/QC methods used to assess potential sample cross-contamination as a result.

Field Clothing and PPE:

- ☐ No water- or stain-resistant clothing (e.g., GORE-TEX®)
- ☐ During collection of water and sediment samples, no water- or stain-resistant boots OR water- or stain-resistant boots covered by PFAS-free over-boots
- ☐ Field boots (or over-boots) are made of polyurethane, PVC, rubber, or untreated leather
- ☐ Waders or rain gear are made of polyurethane, PVC, vinyl, wax-coated or rubber
- ☐ Clothing has not been recently laundered with a fabric softener
- ☐ No coated HDPE suits (e.g., coated Tyvek® suits)
- ☐ Field crew has not used cosmetics, moisturizers, or other related products today
- ☐ Field crew has not used sunscreen or insect repellants today, other than products approved as PFAS-free

Field Equipment:

- ☐ Sample containers and equipment in direct contact with the sample are made of HDPE, polypropylene, silicone, acetate or stainless steel, not LDPE or glass
- ☐ Sample caps are made of HDPE or polypropylene and are not lined with Teflon™
- ☐ No materials containing Teflon™, Viton™, or fluoropolymers
- ☐ No materials containing LDPE in direct contact with the sample (e.g., LDPE tubing, Ziploc® bags)
- ☐ No plastic clipboards, binders, or spiral hard cover notebooks
- ☐ No waterproof field books
- ☐ No waterproof or felt pens or markers (e.g., certain Sharpie® products)
- ☐ No chemical (blue) ice, unless it is contained in a sealed bag
- ☐ No aluminum foil
- ☐ No sticky notes (e.g., certain Post-It® products)

Decontamination:

- ☐ Reusable field equipment decontaminated prior to reuse
- ☐ "PFAS-free" water is on-site for decontamination of field equipment
- ☐ Alconox®, Liquinox® or Luminox® used as decontamination detergent

Food and Drink:

- ☐ No food or drink on-site, except within staging area
- ☐ Food in staging area is contained in HDPE or stainless steel container

Notes:

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Field Team Leader Name (Print): ___________________________

Field Team Leader Signature: ______________________________

Date/Time: ____________________________

Standard Operating Procedure for Groundwater Sampling with Direct Push Technology (DPT) and Analysis of Per- and Polyfluoroalkyl Substances

1. INTRODUCTION

1.1 Purpose and Scope

Standard operating procedures (SOPs) were prepared to guide per- and polyfluoroalkyl substance (PFAS) sampling activities at National Aeronautics and Space Administration (NASA) sites. This SOP describes recommended procedures to be used by field personnel when collecting groundwater samples using direct push technology (DPT). DPT can be employed to sample soil or groundwater using various techniques. This SOP describes the use of DPT to obtain grab groundwater samples. Because PFAS are potentially present in a variety of materials that may come into contact with water samples, and because laboratory analytical method detection limits are low (low to sub nanogram per liter concentrations), conservative precautions are recommended to avoid sample cross-contamination and false positive results.

Currently, sampling guidance for PFAS is still in its infancy. Guidance from regulatory agencies often varies by state. Guidelines follow precautionary principles and may be based on anecdotal sampling experiences or on an abundance of precaution, rather than scientific studies. There is currently a need for robust, high quality guidance on PFAS sampling methods. Because there is little to no published scientific research regarding how certain materials may affect sample results, a conservative approach is recommended. The state of knowledge and practice is rapidly changing along with state and federal regulations and guidance for PFAS investigations. The procedures in this SOP are consistent with best practices at the time of authoring.

1.2 Definitions and Acronyms

1.2.1 Definitions

Bailer	A bottom-filling cylindrical tube with a check valve at the bottom.
Direct push	A sampling method where the subsurface is directly penetrated with a small-diameter technology rod and tools using static weight or percussion.
Peristaltic pump	A positive displacement pump that can be used to move fluids at a fixed rate. Peristaltic pumps are typically used if the depth to water is less than approximately 25 feet.
PFAS-free water	Water that has been analyzed by an accredited laboratory (see Section 3.1) and determined to be below the method detection limit (i.e., non-detect) for the suite of PFAS to be analyzed for in environmental samples. Method detection limits (MDLs) used during analysis of PFAS-free water should be at or below the MDLs used for environmental samples.

Potable water	Water that meets state and federal drinking water requirements. Note this water may or may not have detectable PFAS concentrations.

1.2.2 Acronyms

ASTM	American Society for Testing Materials
CoC	chain of custody
DO	dissolved oxygen
DPT	direct push technology
DoD	Department of Defense
DOT	Department of Transportation
ETFE	ethylene tetrafluoroethylene
FEP	fluorinated ethylene propylene
HDPE	high-density polyethylene
IATA	International Air Transport Association
ICAO	International Civil Aviation Organization
LDPE	low-density polyethylene
MDL	method detection limit
MS	matrix spike
MSD	matrix spike duplicate
NASA	National Aeronautics and Space Adminstration
ORP	oxidation-reduction potential
PFAS	per- and polyfluoroalkyl substances
PFTE	polytetrafluoroethylene
PPE	personal protective equipment
PVC	polyvinyl chloride
PVDF	polyvinylidene fluoride
QA	quality assurance
QC	quality control
SOP	standard operating procedure

1.3 Equipment and Products

Sections 1.3.1 and 1.3.2 detail items that are safe to use versus not recommended for use on the job site to protect PFAS samples from potential cross-contamination. Science-based evidence is not currently available to support a determination of the realistic impact of these commonly used field items and materials on PFAS samples. In the absence of scientific-based sampling guidance, field staff, contractors, and analytical laboratories should try to avoid using items that may pose a risk for cross-contamination and false positive results and instead use acceptable alternatives identified in this section. If the field team needs to use products and equipment on site that are not recommended, additional quality assurance/quality control (QA/QC) samples may be collected to evaluate any potential impact on PFAS environmental samples. This information is also provided in an abbreviated format as a checklist for field staff to reference (Attachment A).

1.3.1 Field Equipment

Items that are **safe to use** on site when sampling for PFAS include the following:

- Sampling containers, screw caps and other equipment made from high-density polyethylene (HDPE)[1], polypropylene, silicone, acetate, or stainless steel;
- Sample preservatives (e.g., Trizma®);
- QA/QC samples (e.g., temperature and field blanks);
- Low-density polyethylene (LDPE)[2] materials not in direct contact with the sample (e.g., Ziploc® bags);
- Materials made of HDPE, silicone, acetate, or stainless steel;
- Masonite or aluminum clipboards;
- Sampling forms, loose paper or field notebooks, chain of custody (CoC) record, and sample container labels;
- Ballpoint pens;
- Alconox®, Liquinox® and Luminox® detergents;
- Paper towels;
- Trash bags;
- HDPE sheeting;
- Hard-shell coolers;

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[1] HDPE plastics are commonly identified by a recycling symbol with a number 2 inside it.
[2] LDPE plastics are commonly identified by a recycling symbol with a number 4 inside it.

- Shipping and handling labels;
- Regular (wet) ice;
- Bubble wrap;
- Duct tape and packing tape;
- Large (e.g., 55-gallon) containers;
- DPT rig, rods, and related tools;
- HDPE or stainless steel bailer and cable;
- Submersible pumps, bladder pumps, peristaltic pumps, and inertia pumps that do not have Teflon components;
- Dedicated Silicon and/or HDPE tubing;
- Analytical field meter (e.g., temperature, pH, conductivity, oxidation-reduction potential [ORP], dissolved oxygen [DO], and turbidity); and
- Water level probe(s).

Items **to be avoided (i.e. not recommended) for use** on site include the following:

- Glass sample containers, due to PFAS adherence to glass surfaces;
- Water-resistant paper, notebooks, and labels (e.g., certain Rite in the Rain® products), due to use of PFAS in water-resistant inks and coatings;
- Sticky notes (e.g., certain Post-It® products), due to potential use of a paper coating product Zonyl™ or similar fluorotelomer compounds;
- Plastic clipboards, binders, and spiral hardcover notebooks;
- Pens with water-resistant ink;
- Felt pens and markers (e.g., certain Sharpie® products) – some PFAS SOPs (e.g., Michigan) specifically allow Fine or Ultra-Fine Point Sharpies® and TestAmerica Laboratories, Inc. routinely uses Sharpies® in the laboratory following unpublished analytical tests that reportedly showed no impact on PFAS sample results;
- Aluminum foil, as PFAS are sometimes used as a protective layer;
- Decon 90™ liquid detergent, which reportedly contain fluorosurfactants;
- Chemical (e.g., blue) ice packs, unless it is contained in a sealed bag. Blue ice has the potential to be contaminated from previous field sampling events;
- Materials containing polytetrafluoroethylene (PFTE) including Teflon™ and Hostaflon® (e.g., tubing, tape, plumbing paste, O-rings);
- Equipment with Viton™ components (i.e., fluoroelastomers);

- Stain- or water-resistant materials, as these are typically fluoropolymer-based;
- Material containing LDPE, particularly if used in direct contact with the sample (e.g., LDPE tubing, as PFAS can sorb to the porous tubing); and
- Material containing "fluoro" in the name – this includes, but is not limited to, fluorinated ethylene propylene (FEP), ethylene tetrafluoroethylene (ETFE), and polyvinylidene fluoride (PVDF).

1.3.2 Clothing, Personal Protective Equipment (PPE), and Consumer Products

Items that are **safe to use** on site when sampling for PFAS include the following:

- Boots made of polyurethane, polyvinyl chloride (PVC), rubber, or untreated leather;
- Other field boots covered by PFAS-free (e.g., polypropylene) over-boots;
- Rain gear made of polyurethane, PVC, wax-coated, vinyl, or rubber;
- Clothing made of synthetic (e.g., polyester) or natural (e.g., cotton) fibers;
- Safety glasses;
- Reflective safety vests;
- Hardhats;
- Disposable powder-free nitrile gloves;
- Uncoated HDPE suits (e.g., certain Tyvek® products);
- Sunscreens[3] and insect repellants[4] that have been tested and found to be PFAS-free; and

[3] Examples of PFAS-free sunscreens include Alba Organics Natural, Aubrey Organics, Banana Boat Sport Performance Sunscreen Lotion Broad Spectrum SPF 30, Banana Boat for Men Triple Defense Continuous Spray Sunscreen SPF 30, Banana Boat Sport Performance Coolzone Broad Spectrum SPF 30, Banana Boat Sport Performance Sunscreen Stick SPF 50, Coppertone Sunscreen Lotion Ultra Guard Broad Spectrum SPF 50, Coppertone Sport High-Performance AccuSpray Sunscreen SPF 30, Coppertone Sunscreen Stick Kids SPF 55, Jason Natural Sun Block, Kiss my Face, L'Oréal Silky Sheer Face Lotion 50+, Meijer Clear Zinc Sunscreen Lotion Broad Spectrum SPF 15, 30 and 50, Meijer Wet Skin Kids Sunscreen Continuous Spray Broad Spectrum SPF 70, Neutrogena Beach Defense Water + Sun Barrier Lotion SPF 70, Neutrogena Beach Defense Water + Sun Barrier Spray Broad Spectrum SPF 30, Neutrogena Pure & Free Baby Sunscreen Broad Spectrum SPF 60+, Neutrogena Ultra-Sheer Dry-Touch Sunscreen Broad Spectrum SPF 30, Yes to Cucumbers, and sunscreens for infants. Products with fluorinated compounds in their ingredients (e.g., polyfluoroalkyl phosphate esters) should not be worn during sampling.

[4] Examples of PFAS-free insect repellent include Jason Natural Quit Bugging Me, Repel Lemon Eucalyptus Insect repellant, Herbal Armor, California Baby Natural Bug Spray, BabyGanics, OFF! Deep Woods® spray for clothing and skin, Sawyer® do-it-yourself permethrin treatment for clothing, Insect Shield Insect® pretreated clothing, DEET products, and sunscreen/insect repellent combination product Avon Skin so Soft Bug Guard-SPF 30. Products with fluorinated compounds in their ingredients (e.g., polyfluoroalkyl phosphate esters) should not be worn during sampling.

- Bottled water and hydration drinks.

Items **<u>to be avoided (i.e., not recommended) for use</u>** on site include the following:

- Water- or stain-resistant boots and clothing (e.g., products containing GORE-TEX®);
- Clothing recently laundered with a fabric softener;
- Coated HDPE suits (e.g., certain Tyvek® products);
- Sunscreen and insect repellants containing fluorinated compounds as ingredients, such as polyfluoroalkyl phosphate esters;
- Latex gloves;
- Cosmetics, moisturizers, hand cream, and other related products;
- Food wrappers and packaging; and
- Food and drinks other than bottled water or hydration drinks.

Field staff should try to find acceptable alternatives to these items that still allow them to complete the field work safely and efficiently. For example, wearing long-sleeved clothing and a hard hat or sun hat may eliminate the need to use sunscreen in some climates. If an item cannot be easily avoided, additional consideration should be given to QA/QC samples to evaluate the potential impact of sample cross-contamination (e.g., field blanks).

2. FIELD PROCEDURES

2.1 <u>Pre-Mobilization Activities</u>

2.1.1 Health and Safety Plan

Prior to each field event, the site health and safety plan should be reviewed and updated, as necessary. Health and safety plan requirements should be reviewed for consistency with this SOP and modified as appropriate to resolve any differences.

2.1.2 Laboratory Coordination

Field personnel should communicate with the laboratory that will conduct PFAS analysis regarding the following items:

- Laboratory accreditation for PFAS analysis (see Section 3.1);
- Appropriate sample containers, labels, and preservatives (see Section 2.2.3 and 2.2.4);
- Sample storage conditions and holding time (see Section 2.2.5); and
- The number and type of QA/QC samples (see Section 2.3).

Because there is no standard United States Environmental Protection Agency method for analyzing PFAS samples in media other than drinking water, commercial laboratories typically offer analysis for a suite of approximately 18 PFAS using a modified version of Method 537.1. Laboratories may therefore have developed their own variations to this method or another method. Project staff may consider the impact of differences in reported PFAS concentrations and the potential value of collecting and sending a split sample to a second commercial laboratory to assess variability in reported PFAS concentrations.

Laboratories conducting PFAS analysis for NASA facilities should be accredited by the United States Department of Defense Environmental Laboratory Accreditation Program (i.e. use a PFAS method that is compliant with Table B-15 of the DoD and Department of Energy consolidated Quality Systems Manual for Environmental Laboratories). States may also require that analytical laboratories are National Environmental Laboratory Accreditation Program accredited for their state and that PFAS analytical methods follow state guidelines.

2.1.3 Equipment Decontamination

Equipment should be decontaminated on site before work begins. Equipment decontamination should follow the steps outlined in Section 2.4.

2.2 Sampling

2.2.1 Pre-Sampling Activities

Prior to the sampling event, field staff can review information from previous site characterization data, if available, to inform their knowledge of site setting, field equipment, and field conditions. At the beginning of each sampling day, field staff should prepare for sampling as follows:

1. Inspect field equipment to ensure that it is in good working order; and
2. Calibrate analytical field meter(s) according to the instrument manufacturers' specifications. Record calibration results on the appropriate form(s). Instruments that cannot be calibrated should not be used.

2.2.2 Sampling PPE

Gloves: Disposable powder-free nitrile gloves should be worn at all times during sample collection and handling of sampling equipment.

At a minimum, field personnel should put on a new pair of nitrile gloves after the following activities:

- Handling samples, including QA/QC samples and blanks; and
- Handling sampling equipment.

At a minimum, personnel should (1) thoroughly wash their hands with detergent (preferably Alconox®, Liquinox® or Luminox ®) and PFAS-free water; (2) thoroughly dry their hands with paper towels; and (3) put on a new pair of nitrile gloves after the following activities:

- Contact with a material potentially containing PFAS;
- Change in sampling locations;
- Breaks in work;
- Washroom breaks; and
- Exit and entry into the project site exclusion zone.

2.2.3 Sampling Equipment

DPT Rig, Rods, and Screen: A DPT sampling rig such as Geoprobe is typically used. DPT rigs are equipped with hydraulic cylinders and a hydraulic hammer to advance steel drill rods (typically in 4-foot sections) and an inner stainless steel sampler through unconsolidated soils. DPT samplers typically contain a grout plug at the end of the screen to hold the screen in place and keep soils from entering the screen when advancing the rods. This plug is removable on some samplers but is typically unusable after removal and needs to be replaced.

Peristaltic Pump/Bailer: Typically, a peristaltic pump is used to collect each groundwater sample from the desired interval. Pump components, fittings, O-rings, sampling tubing and other sampling materials should not include Teflon™ or other PFAS-containing materials. New HDPE or silicon tubing is required for sampling at each location. A stainless steel bailer may be used for groundwater sampling if needed.

Sample Containers: HDPE containers with screw caps are commonly used for sample collection. Different laboratories may supply sample containers of varying sizes. Sample container caps are typically unlined.

Preservatives: Field personnel should communicate with the laboratory to determine what, if any, sample preservatives will be used.

Analytical Field Meter(s): Water quality parameters commonly evaluated during sampling of groundwater include temperature, pH, conductivity, ORP, DO, and turbidity. Salinity and total dissolved solids will also be measured and recorded at NASA sites. Analytical field meters to measure these parameters should be free of Teflon™ and other PFAS materials (e.g., tubing, O-rings).

Water Level Meter: A water level meter is sometimes used to verify depth to water during DPT groundwater sampling prior to purging. Water level meters should be decontaminated prior to and after each sampling location using PFAS-free water, as described in Section 2.4.

2.2.4 Sample Collection and Labeling

Container Rinsing: Sample containers should not to be rinsed prior to sampling.

Sample Collection: The following sampling method should be used:

1. Hand auger to approximately 5 feet below ground surface;
    a. If asphalt is present, use an asphalt bit to break up the asphalt prior to hand augering;
    b. If concrete is present, use a concrete corer or a concrete bit to remove the concrete prior to hand augering;
2. Drillers will position the DPT rig at the sampling location and place orange cones around the rig to create an exclusion zone;
    a. PPE must be worn within this area at all times. No eating, drinking, or smoking should occur within the exclusion zone;
3. Drillers will push or hammer a decontaminated sampler with a stainless steel screen and expendable tip and rods into the first borehole to the desired depth of the shallowest sample interval. If multiple samples are to be collected at each sample location, sampling will proceed from shallower to deeper intervals. All tooling will be removed from the hole after each sample is collected and decontaminated prior to subsequent use;
4. At the desired sample depth, drillers will advance inner rods to push away the expendable point off the end of the sampler. The outer rods will be pulled up to expose the screen. Drillers will remove the inner rods and decontaminate them prior to subsequent use, as described in Section 2.4;
    a. As drill rods are pulled up, they are wiped down with a rag rinsed in soapy water. Inner rods are placed into a 5-gallon bucket and rinsed with a rag using soapy water (Alconox®, Liquinox® or Luminox®).
    b. The decontamination water in the 5-gallon bucket and the cleaning rag should be changed when gross contamination is visible.
5. Drillers will insert HDPE tubing into the rods to the depth of the screened interval. The tubing may have a check valve, if needed. Tubing will be attached to a peristaltic pump and the pump turned on to pull water out of the formation, through a groundwater quality meter flow-through cell, and into a 5-gallon bucket to collect investigation-derived waste. The check valve, if used, should be decontaminated prior to and after each sampling interval;
6. Field staff will record groundwater quality parameters (pH, DO, conductivity, temperature, salinity, total dissolved solids, ORP), approximately 1 to 2 minutes apart;
7. If no VOC samples will be collected, PFAS sample containers can be filled from the tubing outlet during pump operation;

8. After sampling, the drillers will remove the screened sampler from the ground and decontaminate it prior to subsequent use, as described in Section 2.4;
9. To collect a deeper sample at the same location, drillers will attach a new stainless steel tip onto a decontaminated sampler with a stainless steel screen and push or hammer the rods and sampler to the depth of the next sample interval and repeat Steps 4 through 8;
10. Once the last sample has been collected at a given location, the borehole will be grouted through the tooling using pressure grouting. Drillers will place a new tip on the grouting sampler (which does not have a screen), drive it to total depth, and then force grout through the open sampler by pumping a mixture of high-solids bentonite and water or neat cement grout from the surface through the rod and tool string and out the bottom of the sampling tool as the tooling is pulled up and withdrawn from the hole;
11. Drill rods and other reusable equipment will be decontaminated prior to subsequent use following procedures described in Section 2.4. Used tubing will be placed in a trash bag for disposal as solid waste. Purge water and decontamination water that was collected in the 5-gallon bucket will be placed into a 55-gallon drum located on a spill pallet for characterization prior to disposal.

Labels: Some water-resistant inks may be potential sources of PFAS. PFAS-free container labels should be filled out using a ballpoint pen that does not have water-resistant ink, if possible. Field staff should try to avoid filling out container labels using felt pens and markers (e.g., certain Sharpie® products). Container labels should include the following information:

- A unique sample identifier;
- QA/QC sample type, if applicable;
- Sampling date and time (24-hour format);
- Sampler's name or initials; and
- Method of sample preservation.

Except for temperature blanks, all QC samples should be labeled and included on the CoC record. Duplicate samples should not be indicated as duplicates.

Wet Weather Considerations: Field sampling during wet weather (e.g., rainfall and snowfall) should be conducted wearing appropriate clothing that does not pose a risk for cross-contamination. Field personnel should try to avoid water-resistant clothing and boots. Rain gear made of polyurethane, PVC, vinyl, or rubber is an acceptable alternative. Samples and sample containers should not be opened prior to sample collection to avoid collecting precipitation. Should samples or sample containers become contaminated with precipitation, they should be discarded.

2.2.5 Sample Handling, Storage, and Shipment

Handling: Clean nitrile gloves should be worn when handling sample containers. Precautions should be taken to not drop or otherwise damage sample containers. Sample containers should **not** be placed in close proximity to a potential PFAS source.

Storage and Holding Times: Storage conditions and holding times should be determined by the laboratory. Measures should be taken to meet storage and holding time criteria (e.g., expedited shipping).

Shipment: Sample containers should be packed for shipment using the following steps:

1. Choose a cooler with structural integrity that will withstand shipment.
2. Secure and tape the drain plug with duct tape from the inside and outside.
3. Check that the caps on all sample containers are tight and will not leak.
4. Check that the sample labels are intact, filled out, legible, and that the sample identifier exactly matches the CoC record.
5. Seal each sample container in a sample bag to prevent melt water from getting into the sample or degrading the sample label.
6. Place sample containers into the cooler with their caps upright.
7. Fill any excess space within the cooler with bubble wrap (avoid using paper, cardboard, or polystyrene foam).
8. Fill remaining space from the top of the sample containers to the top of the cooler with wet ice that is double-bagged and sealed.
9. Seal the entire cooler with duct tape, particularly the lid, to prevent leaks.

Ship samples as non-hazardous material unless the samples meet the established Department of Transportation (DOT) criteria for a "hazardous material" or the International Air Transport Association (IATA)/International Civil Aviation Organization (ICAO) for air definition of "dangerous goods." If the samples meet criteria for hazardous materials or dangerous goods, then DOT and IATA/ICAO regulations must be followed. Prior to shipping samples, field personnel should complete the appropriate air waybill or manifest. A copy of the air waybill or manifest should be kept for recordkeeping.

2.3 Sampling QA/QC

2.3.1 Field Duplicates

Field duplicates are samples collected in the same manner and at the same time and location as a primary sample. They should be collected from locations of known or suspected contamination.

Field duplicates are used to assess field and analytical precision and sample heterogeneity. Typically, at least one field duplicate is collected for every 10 primary samples. Field duplicates should be labeled with a unique sample identifier and not be indicated as a duplicate (i.e., submitted as “blind”).

2.3.2 Matrix Spike and Matrix Spike Duplicate Samples

Matrix spike and matrix spike duplicate (MS/MSD) samples are aliquots of environmental samples that are spiked with a known concentration of PFAS by the laboratory. MS/MSD samples are used to assess interferences caused by the sample matrix. MS/MSD samples are not needed if the analytical laboratory is using an isotopic dilution method but are technically required to meet Department of Defense (DoD) accreditation requirements. If necessary, MS/MSD samples are to be collected in the same manner and at the same time and location as a primary sample (i.e., additional sample volume). It is preferred that this location have little to no PFAS contamination. Samples should have the same matrix to ensure a valid result; if the samples do not appear visually similar (e.g., discoloration, suspended solids), choose another location for collection of MS/MSD samples. The number of required MS/MSD samples should be determined based on discussions with the laboratory. Typically, at least one MS/MSD sample is collected for every 20 primary samples. MS/MSD samples should be labeled with the same sample name and time as the primary sample and denoted as MS/MSD samples on the CoC and sample label.

2.3.3 Blanks

Blanks should be shipped and handled in the same manner as environmental samples. Field blanks should be labeled as such on sample bottles and on the CoC. The number and type of blanks should be determined by discussions with the laboratory.

Equipment Blanks: Equipment blanks are used to assess sources of field and laboratory contamination. Equipment blanks are prepared by pouring PFAS-free water over or through decontaminated reusable field sampling equipment and collecting the rinsate in a sample container. Typically, at least one equipment blank is collected for every 10 primary samples.

Field Blanks: Field blanks are used to assess ambient contamination within the field and laboratory. Field blanks should be prepared by filling a sample container with PFAS-free water in the field in the same manner as environmental samples. Field blanks are an effective way of assessing potential cross-contamination as a result of sample handling. Typically, one field blank is collected for each shipping container.

Temperature Blanks: Temperature blanks are used to assess the temperature of samples during shipping. Temperature blanks should be provided by the laboratory and prepared by filling a sample container with PFAS-free water prior to shipment of the sample containers. The blank should be kept in the cooler during sampling and shipment to the laboratory. Once the cooler

returns to the laboratory, the temperature of the blank should be measured to ensure that recommended sample storage criteria are met (typically less than 6 degrees Celsius).

2.4 Decontamination

Decontamination should occur prior to leaving the sampling area or at a central decontamination location and at the end of each work day. Additionally, sampling equipment exposed to PFAS-contaminated water should be decontaminated between sample locations.

Alconox®, Liquinox® and Luminox ® detergents are acceptable for decontamination purposes. Use of Decon 90 should be avoided. Decontamination wastes must be properly contained and disposed of in accordance with applicable local, state and federal regulations.

2.4.1 Field Equipment Decontamination

Drillers typically have multiple rods and samplers on hand and thoroughly decontaminate them as a group once they have been used.

DPT Rods: As drill rods are pulled up, they are wiped down with a rag rinsed in soapy water. Inner rods are placed into a 5-gallon bucket and rinsed with a rag using soapy water (Alconox®, Liquinox® and Luminox ®). Rods are fully decontaminated using the following procedures:

1. If heavy petroleum residuals are encountered during sampling, use methanol or another appropriate solvent to remove any residues from sampling equipment;
2. Wash thoroughly and vigorously with potable water containing detergent (Alconox®, Liquinox® and Luminox ®) using a bristle brush or similar utensil to remove any remaining residual contamination;
3. Rinse thoroughly with potable water (1st rinse);
4. Rinse thoroughly with PFAS-free water (2nd rinse);
5. Leave the equipment to air dry in a location away from dust and fugitive contaminants.

DPT Samplers: Samplers are fully decontaminated using the following procedures:

1. In a constructed decontamination pit, rinse the exterior of the samplers with PFAS-free water using a pressure washer. Samplers should be laid horizontally and raised above the floor of the decontamination pit, typically on a wooden pallet. Rods and screens should be rotated midway through the rinse so that the entire exterior of the sampler is sprayed (1st rinse);
2. Clean (using a brush or clean rag) the exterior of the samplers with soapy, PFAS-free water;
3. If possible, remove the grout plugs from the sampler prior to the 2nd rinse;
4. In a 5-gallon bucket, hold the sampler vertically and use a water hose with a nozzle or a pressure washer to spray the interior of each sampler using PFAS-free water (2nd rinse);

5. Hold the nozzle close to the exterior of the sampler and move the nozzle up and down along the length of the sampler to flush out any residual soils within the screen;
6. Flip the sampler up-side down in the opposite orientation and repeat Steps 3 through 5 so that water is flushed through both ends of the sampler (3rd rinse);
7. Leave the equipment to air dry in a location away from dust and fugitive contaminants.

Other Field Equipment: All non-disposable sampling equipment that is in contact with groundwater (e.g., 5-gallon bucket, field meters) must be cleaned prior to and between uses at each groundwater sampling location according to the following procedures:

1. Remove any gross (e.g., soil) contamination from sampling equipment.
2. If heavy petroleum residuals are encountered during sampling, use methanol or another appropriate solvent to remove any residues from sampling equipment.
3. Wash water-resistant equipment thoroughly and vigorously with potable water containing detergent (Alconox®, Liquinox® and Luminox ®) using a bristle brush or similar utensil to remove any remaining residual contamination.
4. Rinse equipment thoroughly with potable water (1st rinse).
5. Rinse equipment thoroughly with PFAS-free water (2nd rinse).
6. For field instruments, rinse again with PFAS-free water (3rd rinse).
7. Dry the wet equipment with a paper towel or leave the equipment to air dry in a location away from dust or fugitive contaminants. All equipment should be dry before reuse.

Cleaning and decontamination of the equipment should be accomplished in stages and in such a way that the contamination does not discharge into the environment. Disposable sample tubing is required to minimize the need for decontamination.

2.4.2 Personnel and PPE Decontamination

A decontamination area for personnel and portable equipment may be specified in the health and safety plan. The area may include basins or tubs to capture decontamination wastes, which can be transferred to larger containers as necessary. Decontamination following groundwater sampling should follow these steps:

1. Gross (e.g., soil) (e.g., soil) contamination should be scraped and wiped from boots, safety glasses, hardhats, reflective vests, and other reusable PPE. Once gross contamination has been removed, gloves should be removed by rolling off the hands in such a way to avoid exposing skin to PFAS-contaminated materials;
2. A new pair of gloves should be put on and reusable PPE should be decontaminated using PFAS-free water mixed with detergent (preferably Alconox®, Liquinox® or Luminox®)

and brushes, or similar means. After debris is removed, reusable PPE should be rinsed with PFAS-free water; and

3. Hands and any exposed body parts should be washed thoroughly using detergent (preferably Alconox®, Liquinox® or Luminox®) and PFAS-free water. Hands should be dried with paper towels.

2.5 Food and Drink

Food and drink should not be brought within the exclusion zone. Food that is kept in the staging area should preferably be contained in HDPE or stainless-steel containers.

3. LABORATORY PROCEDURES

3.1 Accreditations

Laboratories conducting PFAS analysis for NASA facilities should be accredited by the United States Department of Defense Environmental Laboratory Accreditation Program, that is, use a PFAS method that is compliant with Table B-15 of the DoD and DOE consolidated QSM 5.2 for Environmental Laboratories. States may also require that analytical laboratories are National Environmental Laboratory Accreditation Program accredited for their state and that PFAS analytical methods follow state guidelines.

4. DOCUMENTATION

4.1 Chain of Custody

4.1.1 Field Custody Procedures

A sample is considered to be in custody if the following conditions have been observed:

- It is in possession or view of the person in custody;
- It is locked in a secure area;
- It is placed in an area restricted to authorized personnel; or
- It is placed in a container and secured with an official seal, so that the sample cannot be reached without breaking the seal.

The following practices should be observed by field personnel to ensure sample custody:

- As few persons as possible will handle samples;
- The sample collector is personally responsible for the care and custody of samples collected until they are transferred to the laboratory;
- The sample collector will record sample data in the field notebook; and

- Sample labels will be completed for each sample.

4.1.2 Chain of Custody Record

All samples should be accompanied by a CoC record. The CoC record is typically provided by the laboratory. The CoC record should be fully completed in duplicate (e.g., a carbon copy). At the minimum, the following information should be included on a CoC record:

- Project name and number;
- Laboratory name and address;
- Name of person that collected the samples;
- Sample identifier;
- Sample date and time (time in 24-hour format);
- Laboratory analysis requested;
- Preservatives added to each sample;
- Sample matrix (e.g., soil, water);
- Number of containers per sample; and
- Airway bill tracking number.

As applicable, the following remarks should be added to the CoC record:

- Contractor name and address;
- MS/MSD sample volume (if necessary);
- A request for rapid turnaround time; and
- A note regarding the potential concentrations in a highly-contaminated sample.

Indication of a duplicate sample should **not** be included on a CoC record.

4.1.3 Sample Packaging

The CoC record should accompany all sample shipments. One CoC record should be prepared for each cooler and the cooler number recorded on the CoC. The samples in the cooler should be listed on the CoC record. The CoC record should be placed in a sealed plastic bag (e.g., Ziploc®) and taped to the inside lid of the cooler. If one sample is contained in two coolers (i.e., one sample has too many containers to fit in one cooler), then the original CoC should be placed in the first cooler and a copy of the CoC record should be placed in the second cooler. The duplicate copy of the CoC record should be retained by the sampler.

Custody seals should be signed and dated at the time of use. Sample shipping containers should be sealed in as many places as necessary to ensure that the container cannot be opened without breaking a custody seal. Tape should be placed over the seals to ensure that seals are not accidentally broken during shipment. If the sampler transports the samples to the laboratory without sample shipment, custody seals are not required.

4.1.4 Transfer of Custody

When transferring the possession of samples from the field sampler to a transporter or to the laboratory, the sampler should sign, date, and note the time as "relinquished by" on the CoC record. The receiver should also sign, date, and note the time as "received by" on the CoC record. The date and time of the receiver and relinquisher should be the same.

When samples are transported by a commercial carrier, the carrier will not sign the CoC record. However, the airway bill tracking number should be recorded on the CoC record. Airway bills should also be retained with the CoC record as documentation of transport. For this reason, the date and time of the receiver and relinquisher will not match when shipping with a commercial carrier.

4.1.5 Laboratory Custody Procedures

A designated sample custodian should accept custody of the shipped samples and verify that the sample identification number matches the CoC record. Pertinent information about shipment, pickup, and courier should be entered in the "Remarks" section. The temperature of the temperature blanks at the time of receiving should be noted on the CoC record.

5. REFERENCES

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Attachment A. Daily PFAS Sampling Checklist

Date: ___________________

Site Name: _____________________________________

Weather (*temperature/precipitation*): ____

Please check all boxes that apply and describe any exceptions in the notes section below along with QA/QC methods used to assess potential sample cross-contamination as a result.

Field Clothing and PPE:

- ☐ No water- or stain-resistant clothing (e.g., GORE-TEX®)
- ☐ During collection of water and sediment samples, no water- or stain-resistant boots OR water- or stain-resistant boots covered by PFAS-free over-boots
- ☐ Field boots (or over-boots) are made of polyurethane, PVC, rubber, or untreated leather
- ☐ Waders or rain gear are made of polyurethane, PVC, vinyl, wax-coated or rubber
- ☐ Clothing has not been recently laundered with a fabric softener
- ☐ No coated HDPE suits (e.g., coated Tyvek® suits)
- ☐ Field crew has not used cosmetics, moisturizers, or other related products today
- ☐ Field crew has not used sunscreen or insect repellants today, other than products approved as PFAS-free

Field Equipment:

- ☐ Sample containers and equipment in direct contact with the sample are made of HDPE, polypropylene, silicone, acetate or stainless steel, not LDPE or glass
- ☐ Sample caps are made of HDPE or polypropylene and are not lined with Teflon™
- ☐ No materials containing Teflon™, Viton™, or fluoropolymers
- ☐ No materials containing LDPE in direct contact with the sample (e.g., LDPE tubing, Ziploc® bags)
- ☐ No plastic clipboards, binders, or spiral hard cover notebooks
- ☐ No waterproof field books
- ☐ No waterproof or felt pens or markers (e.g., certain Sharpie® products)
- ☐ No chemical (blue) ice, unless it is contained in a sealed bag
- ☐ No aluminum foil
- ☐ No sticky notes (e.g., certain Post-It® products)

Decontamination:

- ☐ Reusable field equipment (e.g., inner drill rods, samplers) decontaminated prior to reuse
- ☐ “PFAS-free” water is on-site for decontamination of field equipment
- ☐ Alconox® or Liquinox® used as decontamination detergent

Food and Drink:

- ☐ No food or drink on-site, except within staging area
- ☐ Food in staging area is contained in HDPE or stainless steel container

Notes:

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Field Team Leader Name (Print): ___________________________

Field Team Leader Signature: ______________________________

Date/Time: ____________________________

Standard Operating Procedure for Investigation-Derived Waste Sampling and Analysis of Per- and Polyfluoroalkyl Substances

1. INTRODUCTION

1.1 Purpose and Scope

Standard operating procedures (SOPs) were prepared to guide per- and polyfluoroalkyl substance (PFAS) sampling activities at National Aeronautics and Space Administration (NASA) sites. This SOP describes recommended procedures to be used by field personnel when collecting liquid or solid investigation-derived waste (IDW) samples. Because PFAS are potentially present in a variety of materials that may contact IDW samples, and because laboratory analytical method detection limits are low (low to sub microgram per kilogram and low to sub nanogram per liter concentrations), conservative precautions are recommended to avoid sample cross-contamination and false positive results.

Currently, sampling guidance for PFAS is still in its infancy. Guidance from regulatory agencies often varies by state. Guidelines follow precautionary principles and may be based on anecdotal sampling experiences or on an abundance of precaution, rather than scientific studies. There is currently a need for robust, high quality guidance on PFAS sampling methods. Because there is little to no published scientific research regarding how certain materials may affect sample results, a conservative approach is recommended. The state of knowledge and practice is rapidly changing along with state and federal regulations and guidance for PFAS investigations. The procedures in this SOP are consistent with best practices at the time of authoring. The same standard of care practiced during site investigation is recommended during IDW sample collection.

1.2 Definitions and Acronyms

1.2.1 Definitions

IDW	Liquid and solid waste material generated during sampling activities including, but not limited to, drill cuttings and excess soil sampling materials, purged groundwater, well development water, aquifer test water, and decontamination liquids.
Peristaltic pump	A positive displacement pump that can be used to move fluids at a fixed rate.
PFAS-free water	Water that has been analyzed by an accredited laboratory (see Section 2.1.3) and determined to be below the method detection limit (i.e., non-detect) for the suite of PFAS to be analyzed for in environmental samples. Method detection limits (MDLs) used during analysis of PFAS-free water should be at or below the MDLs used for environmental samples.

1.2.2 Acronyms

ASTM	American Society for Testing and Materials
CoC	chain of custody
DoD	Department of Defense
DOT	Department of Transportation
ETFE	ethylene tetrafluoroethylene
FEP	fluorinated ethylene propylene
HDPE	high-density polyethylene
IATA	International Air Transport Association
ICAO	International Civil Aviation Organization
IDW	investigation-derived waste
LDPE	low-density polyethylene
MDL	method detection limit
MS	matrix spike
MSD	matrix spike duplicate
NASA	National Aeronautics and Space Administration
PCB	polychlorinated biphenyl
PFAS	per- and polyfluoroalkyl substance
PFTE	polytetrafluoroethylene
PPE	personal protective equipment
PVC	polyvinyl chloride
PVDF	polyvinylidene fluoride
QA	quality assurance
QC	quality control
TPH	total petroleum hydrocarbons
SOP	standard operating procedure
SVOC	semivolatile organic compounds
USCS	Unified Soil Classification System
VOC	volatile organic compounds

1.3 Equipment and Products

Sections 1.3.1 and 1.3.2 detail items that are safe to use versus not recommended for use on the job site to protect PFAS samples from potential cross-contamination. Science-based evidence is not currently available to support a determination of the realistic impact of these commonly used field items and materials on PFAS samples. In the absence of scientific-based sampling guidance, field staff, contractors, and analytical laboratories should try to avoid using items that may pose a risk for cross-contamination and false positive results and instead use acceptable alternatives identified in this section. This information is also provided in an abbreviated format as a checklist for field staff to reference (Attachment A).

1.3.1 Field Equipment

Items that are **safe to use** on site when sampling for PFAS include the following:

- Sampling containers, screw caps and other equipment made from high-density polyethylene (HDPE)[1], polypropylene, silicone, acetate, or stainless steel;
- Low-density polyethylene (LDPE)[2] materials not in direct contact with the sample (e.g., Ziploc® bags);
- Materials made of HDPE, silicone, acetate, or stainless steel;
- Sampling forms, loose paper or field notebooks, chain of custody (CoC) record, and sample container labels;
- Masonite or aluminum clipboards;
- Ballpoint pens;
- Alconox®, Liquinox® and Luminox® detergents;
- Paper towels;
- Trash bags;
- HDPE sheeting;
- Hard-shell coolers;
- Shipping and handling labels;
- Regular (wet) ice;
- Bubble wrap;
- Duct tape and packing tape;

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[1] HDPE plastics are commonly identified by a recycling symbol with a number 2 inside it.
[2] LDPE plastics are commonly identified by a recycling symbol with a number 4 inside it.

- Large (e.g., 55-gallon) containers;
- Peristaltic pumps that do not have Teflon components; and
- Dedicated Silicon and/or HDPE tubing.

Items **to be avoided (i.e., not recommended) for use** on site include the following:

- Glass sample containers, due to PFAS adherence to glass surfaces;
- Water-resistant paper, notebooks, and labels (e.g., certain Rite in the Rain® products), due to use of PFAS in water-resistant inks and coatings;
- Sticky notes (e.g., certain Post-It® products), due to potential use of a paper coating product Zonyl™ or similar fluorotelomer compounds;
- Plastic clipboards, binders, and spiral hardcover notebooks;
- Pens with water-resistant ink;
- Felt pens and markers (e.g., certain Sharpie® products) – some PFAS SOPs (e.g., Michigan) specifically allow Fine or Ultra-Fine Point Sharpies® and TestAmerica Laboratories, Inc. routinely uses Sharpies® in the laboratory following unpublished analytical tests that reportedly showed no impact on PFAS sample results;
- Aluminum foil, as PFAS are sometimes used as a protective layer;
- Decon 90™ liquid detergent, which reportedly contain fluorosurfactants;
- Chemical (e.g., blue) ice packs, unless it is contained in a sealed bag. Blue ice has the potential to be contaminated from previous field sampling events;
- Materials containing polytetrafluoroethylene (PFTE) including Teflon™ and Hostaflon®;
- Equipment with Viton™ components (i.e., fluoroelastomers);
- Stain- or water-resistant materials, as these are typically fluoropolymer-based;
- Material containing LDPE, particularly if used in direct contact with the sample (e.g., LDPE tubing, as PFAS can sorb to the porous tubing); and
- Material containing "fluoro" in the name – this includes, but is not limited to, fluorinated ethylene propylene (FEP), ethylene tetrafluoroethylene (ETFE), and polyvinylidene fluoride (PVDF).

1.3.2 Clothing, PPE, and Consumer Products

Items that are **safe to use** on site when sampling for PFAS include the following:

- Boots made of polyurethane, polyvinyl chloride (PVC), rubber, or untreated leather;
- Other field boots covered by PFAS-free (e.g., polypropylene) over-boots;

- Rain gear made of polyurethane, PVC, wax-coated, vinyl, or rubber;
- Clothing made of synthetic (e.g., polyester) or natural (e.g., cotton) fibers;
- Safety glasses;
- Reflective safety vests;
- Hardhats;
- Disposable powder-free nitrile gloves;
- Uncoated HDPE suits (e.g., certain Tyvek® products);
- Sunscreens[3] and insect repellants[4] that have been tested and found to be PFAS-free; and
- Bottled water and hydration drinks.

Items **to be avoided (i.e., not recommended) for use** on site include the following:

- Water- or stain-resistant boots and clothing (e.g., products containing GORE-TEX®);
- Clothing recently laundered with a fabric softener;
- Coated HDPE suits (e.g., certain Tyvek® products);
- Sunscreen and insect repellants containing fluorinated compounds as ingredients, such as polyfluoroalkyl phosphate esters;
- Latex gloves;
- Cosmetics, moisturizers, hand cream, and other related products;
- Food wrappers and packaging; and

[3] Examples of PFAS-free sunscreens include Alba Organics Natural, Aubrey Organics, Banana Boat Sport Performance Sunscreen Lotion Broad Spectrum SPF 30, Banana Boat for Men Triple Defense Continuous Spray Sunscreen SPF 30, Banana Boat Sport Performance Coolzone Broad Spectrum SPF 30, Banana Boat Sport Performance Sunscreen Stick SPF 50, Coppertone Sunscreen Lotion Ultra Guard Broad Spectrum SPF 50, Coppertone Sport High-Performance AccuSpray Sunscreen SPF 30, Coppertone Sunscreen Stick Kids SPF 55, Jason Natural Sun Block, Kiss my Face, L'Oréal Silky Sheer Face Lotion 50+, Meijer Clear Zinc Sunscreen Lotion Broad Spectrum SPF 15, 30 and 50, Meijer Wet Skin Kids Sunscreen Continuous Spray Broad Spectrum SPF 70, Neutrogena Beach Defense Water + Sun Barrier Lotion SPF 70, Neutrogena Beach Defense Water + Sun Barrier Spray Broad Spectrum SPF 30, Neutrogena Pure & Free Baby Sunscreen Broad Spectrum SPF 60+, Neutrogena Ultra-Sheer Dry-Touch Sunscreen Broad Spectrum SPF 30, Yes to Cucumbers, and sunscreens for infants. Products with fluorinated compounds in their ingredients (e.g., polyfluoroalkyl phosphate esters) should not be worn during sampling.

[4] Examples of PFAS-free insect repellent include Jason Natural Quit Bugging Me, Repel Lemon Eucalyptus Insect repellant, Herbal Armor, California Baby Natural Bug Spray, BabyGanics, OFF! Deep Woods® spray for clothing and skin, Sawyer® do-it-yourself permethrin treatment for clothing, Insect Shield Insect® pretreated clothing, DEET products, and sunscreen/insect repellent combination product Avon Skin so Soft Bug Guard-SPF 30. Products with fluorinated compounds in their ingredients (e.g., polyfluoroalkyl phosphate esters) should not be worn during sampling.

- Food and drinks other than bottled water or hydration drinks.

Field staff should try to find acceptable alternatives to these items that still allow them to complete the field work safely and efficiently. For example, wearing long-sleeved clothing and a hard hat or sun hat may eliminate the need to use sunscreen in some climates. If an item cannot be easily avoided, additional consideration should be given to QA/QC samples to evaluate the potential impact of sample cross-contamination (e.g., field blanks).

2. FIELD PROCEDURES

2.1 Pre-Mobilization Activities

2.1.1 Health and Safety Plan

Prior to each field event, the site health and safety plan should be reviewed and updated, as necessary. Health and safety plan requirements should be reviewed for consistency with this SOP and modified as appropriate to resolve any differences (e.g., HDPE suits may be specified in the health and safety plan).

2.1.2 IDW Characterization Requirements and Disposal Coordination

Field personnel should communicate with a waste hauler and/or a waste disposal facility to understand requirements for IDW characterization and coordinate the appropriate disposal of IDW following characterization. Characterization of IDW prior to disposal is required in accordance with state and federal guidelines and waste disposal facility acceptance criteria, and typically includes volatile organic compounds (VOCs), semivolatile organic compounds (SVOCs), total petroleum hydrocarbons (TPH), metals, and other site-specific constituents that are known to be present, such as PFAS. Waste haulers may accept existing PFAS analytical results for site soil and groundwater in lieu of requiring separate IDW sampling. This SOP is only applicable if PFAS-specific IDW characterization is required.

2.1.3 Laboratory Coordination

For consistency, field personnel should send IDW samples to the same laboratory that analyzed site investigation samples. This will provide consistency with the following:

- Laboratory accreditation and analytical method for PFAS analysis;
- Appropriate sample containers, labels, and preservatives (see Section 2.2.2);
- Sample storage conditions and holding time (see Section 2.2.3); and
- The number and type of QA/QC samples (see Section 2.3).

Because there is no standard United States Environmental Protection Agency method for analyzing PFAS samples in media other than drinking water, commercial laboratories typically offer analysis for a suite of approximately 18 PFAS using a modified version of Method 537.1. Laboratories may therefore have developed their own variations.

Laboratories conducting PFAS analysis for NASA facilities should be accredited by the United States Department of Defense Environmental Laboratory Accreditation Program (i.e. use a PFAS method that is compliant with Table B-15 of the DoD and Department of Energy consolidated Quality Systems Manual for Environmental Laboratories). States may also require that analytical laboratories are National Environmental Laboratory Accreditation Program accredited for their state and that PFAS analytical methods follow state guidelines.

2.1.4 Equipment Decontamination

Equipment should be decontaminated on site before work begins. Equipment decontamination should follow the steps outlined in Section 2.4.

2.2 <u>Sampling</u>

2.2.1 Sampling PPE

<u>Gloves</u>: Disposable powder-free nitrile gloves should be worn at all times during sample collection and handling of sampling equipment.

At a minimum, field personnel should put on a new pair of nitrile gloves after the following activities:

- Handling samples, including QA/QC samples and blanks; and
- Handling sampling equipment.

At a minimum, personnel should (1) thoroughly wash their hands with detergent (preferably Alconox®, Liquinox® or Luminox®) and PFAS-free water; (2) thoroughly dry their hands with paper towels; and (3) put on a new pair of nitrile gloves after the following activities:

- Contact with a material potentially containing PFAS;
- Change in sampling locations;
- Breaks in work;
- Washroom breaks; and
- Exit and entry into the project site exclusion zone.

2.2.2 Sampling Equipment

Sample Containers: HDPE containers with screw caps are commonly used for sample collection for both solids and liquids. Different laboratories may supply sample containers of varying sizes. Sample container caps are typically unlined.

Liquid Sampling Equipment: The sample container and a peristaltic pump are typically the only equipment required to collect an IDW sample. Pump components, fittings, O-rings, sampling tubing, and other sampling equipment should not include Teflon™ or other PFAS-containing materials. Dedicated HDPE or silicon tubing is recommended. Other equipment that may be needed includes a bailer, scoop, or similar sample collection tool.

Solid Sampling Equipment: Equipment may include shovels or other excavating tools, as well as bowls, pans, trays, spoons, trowels and forceps.

Preservatives: Field personnel should communicate with the laboratory to determine what, if any, sample preservatives will be used for liquid samples. Preservatives may include Trizma® or sodium thiosulfate for liquid samples. Sample preservatives are not used for solid samples prior to PFAS analysis.

2.2.3 Sample Collection and Labeling

Container Rinsing: Sample containers should not be rinsed prior to sampling.

Liquid Sampling: Liquid IDW is typically stored in 55-gallon drums, tanks, or other large containers. Direct sample collection (i.e., only using the sample container) steps are as follows:

1. Orient the sample container horizontally;
2. Dip the entire container below the IDW surface;
3. Remove the sample container cap with the container below the IDW surface. Allow for the container to fill. Care should be taken to limit collection of debris;
4. Once the container is filled to the volume specified by the laboratory, close the sample container by screwing on the container cap with the sample container still below the water surface;
5. Raise the sample container above the IDW surface;
6. Use a paper towel to clean the outside of the sample container;
7. Record the sample location, IDW container ID, sample date and time, and other applicable information in the field notebook and on sampling forms before moving on to the next IDW sample.

Sample collection steps using a sample collection device (e.g., scoop, bailer) are below. A sample collection device may be preferred to facilitate access.

1. Assemble the sample collection device in accordance with manufacturer instructions;
2. Dip the sample collection device below the IDW surface;
3. Allow the sample collection device to fill to the sample volume specified by the laboratory. Care should be taken to limit collection of debris;
4. Retrieve the sample collection device;
5. Remove the sample container cap;
6. Fill the sample container by pouring IDW from the sample collection device into the sample container.
7. Use a paper towel to clean the outside of the sample container and the sample container threads if necessary. Close the sample container by screwing on the container cap;
8. Label the sample (see "Labels" section below); and
9. Record the sample location, IDW container ID, sample date and time, and other applicable information in the field notebook and on sampling forms before moving on to the next IDW sample.

Liquid IDW samples may be collected using a peristaltic pump. Peristaltic pumps are an effective sampling device when close-top 55-gallon drums or other containers are used for IDW storage. The following sample collection steps should be followed when using a peristaltic pump:

1. Assemble the peristaltic pump in accordance with manufacturer instructions and use new, clean HDPE tubing;
2. Lower the pump intake to below the IDW surface;
3. Route the sample tubing effluent back into the drum/container to mix the contents of the container prior to sampling;
4. Pump at least three sample-tubing volumes to field rinse the sample tubing. If water is not directed back into the drum, collect water to dispose of as IDW;
5. Remove the sample container cap;
6. Fill the container to the volume specified by the laboratory;
7. Use a paper towel to clean the outside of the sample container and the sample container threads if necessary. Close the sample container by screwing on the container cap; and
8. Record the sample location, sample date and time, and other applicable information in the field notebook and on sampling forms before moving on to the next sample location.

Solid Sampling: Solid IDW is typically stored in 55-gallon drums and other large containers. Sample collection steps are as follows:

1. If a composite sample is desired, use hand tools to collect equal volumes of solids from each IDW location to be composited (e.g., from each 55-gallon drum);
2. Remove visible vegetation or large gravel from the soil;
3. Homogenize the IDW sample(s) collected on a liner, pan, or tray, or in a bowl or alternative container;
4. Remove the cap from the sample container and fill the container with the solid sample. The container should be filled to the mass or volume specified by the laboratory;
5. Use a paper towel to clean the outside of the sample container and the sample container threads if necessary. Close the sample container by screwing on the container cap;
6. Label the sample (see "Labels" section below); and
7. Record the sample location, IDW container ID, sample date and time, and other applicable information in the field notebook and on sampling forms before moving on to the next IDW sample.

Labels: Some water-resistant inks may be potential sources of PFAS. PFAS-free container labels should be filled out using a ballpoint pen that does not have water-resistant ink, if possible. Field staff should try to avoid filling out container labels using felt pens and markers (e.g., certain Sharpie® products). Container labels should include the following information:

- A unique sample identifier;
- QA/QC sample type, if applicable;
- Sampling date and time (24-hour format);
- Sampler's name or initials; and
- Method of sample preservation.

Except for temperature blanks, all QC samples should be labeled and included on the CoC record. Duplicate samples should not be indicated as duplicates.

Wet Weather Considerations: Field sampling during wet weather (e.g., rainfall and snowfall) should be conducted wearing appropriate clothing that does not pose a risk for cross-contamination. Field personnel should try to avoid water-resistant clothing and boots. Rain gear made of polyurethane, PVC, vinyl, or rubber is an acceptable alternative. Samples and sample containers should not be opened prior to sample collection to avoid collecting precipitation. Should samples or sample containers become contaminated with precipitation, they should be discarded.

2.2.4 Sample Handling, Storage, and Shipment

Handling: Clean nitrile gloves should be worn when handling sample containers. Precautions should be taken to not drop or otherwise damage sample containers. Sample containers should **not** be placed in close proximity to a potential PFAS source.

Storage and Holding Times: Storage conditions and holding times should be determined by the laboratory. Measures should be taken to meet storage and holding time criteria (e.g., expedited shipping).

Shipment: Sample containers should be packed for shipment using the following steps:

1. Choose a cooler with structural integrity that will withstand shipment.
2. Secure and tape the drain plug with duct tape from the inside and outside.
3. Check that the caps on all sample containers are tight and will not leak.
4. Check that the sample labels are intact, filled out, legible, and that the sample identifier exactly matches the CoC record.
5. Seal each sample container in a sample bag to prevent melt water from getting into the sample or degrading the sample label.
6. Place sample containers into the cooler with their caps upright.
7. Fill any excess space within the cooler with bubble wrap (try to avoid using paper, cardboard, or polystyrene foam).
8. Fill remaining space from the top of the sample containers to the top of the cooler with wet ice that is double-bagged and sealed.
9. Seal the entire cooler with duct tape, particularly the lid, to prevent leaks.

Ship samples as non-hazardous material unless the samples meet the established Department of Transportation (DOT) criteria for a "hazardous material" or the International Air Transport Association (IATA)/International Civil Aviation Organization (ICAO) for air definition of "dangerous goods." If the samples meet criteria for hazardous materials or dangerous goods, then DOT and IATA/ICAO regulations must be followed. Prior to shipping samples, field personnel should complete the appropriate air waybill or manifest. A copy of the air waybill or manifest should be kept for recordkeeping.

2.3 Sampling QA/QC

IDW samples may be collected concurrently with site investigation samples and related QA/QC samples. QA/QC samples are not typically collected along with IDW samples, other than temperature blanks.

2.3.1 Blanks

Blanks should be shipped and handled in the same manner as environmental samples. Field blanks should be labeled as such on sample bottles and on the CoC. The number and type of blanks should be determined based on discussions with the laboratory.

Temperature Blanks: Temperature blanks are used to assess the temperature of samples during shipping. Temperature blanks should be provided by the laboratory or prepared by filling a sample container with water prior to shipment of the sample containers. The blank should be kept in the cooler during sampling and shipment to the laboratory. Once the cooler returns to the laboratory, the temperature of the blank should be measured to ensure that recommended sample storage criteria are met (typically less than 6 degrees Celsius).

2.4 Decontamination

Decontamination should occur prior to leaving the sampling area or at a central decontamination location and at the end of each work day. Additionally, sampling equipment exposed to PFAS-contaminated soil should be decontaminated between sample locations.

Alconox®, Liquinox® or Luminox® detergents are acceptable for decontamination purposes. Decon 90 should be avoided. Decontamination wastes must be properly contained and disposed of in accordance with applicable local, state and federal regulations.

2.4.1 Field Equipment Decontamination

All non-disposable sampling equipment that is in contact with contaminated soil, groundwater, or decontamination water (e.g., 5-gallon bucket, field meters, scoop, bailer, trowels, spoons, etc.) must be cleaned prior to and between uses at each sampling location according to the following procedures:

1. Remove any gross (e.g., soil) contamination from sampling equipment;
2. If heavy petroleum residuals are encountered during sampling, use methanol or another appropriate solvent to remove any residues from sampling equipment;
3. Wash water-resistant equipment thoroughly and vigorously with potable water containing detergent (Alconox®, Liquinox® or Luminox®) using a bristle brush or similar utensil to remove any remaining residual contamination;
4. Rinse equipment thoroughly with potable water (1^{st} rinse);
5. Rinse equipment thoroughly with PFAS-free water (2^{nd} rinse);
6. For field instruments, rinse again with PFAS-free water (3^{rd} rinse); and
7. Dry the wet equipment with a paper towel or leave the equipment to air dry in a location away from dust or fugitive contaminants. All equipment should be dry before reuse.

Cleaning and decontamination of the equipment should be accomplished in stages and in such a way that the contamination does not discharge into the environment. Disposable sample tubing is required to minimize the need for decontamination.

2.4.2 Personnel and PPE Decontamination

A decontamination area for personnel and portable equipment may be specified in the health and safety plan. The area may include basins or tubs to capture decontamination wastes, which can be transferred to larger containers as necessary. If decontamination is needed following soil sampling, personnel decontamination should follow these steps:

1. Gross (e.g., soil) contamination should be scraped and wiped from boots, safety glasses, hardhats, reflective vests, and other reusable PPE. Once gross contamination has been removed, gloves should be removed by rolling off the hands in such a way to avoid exposing skin to PFAS-contaminated materials;
2. A new pair of gloves should be put on and reusable PPE should be decontaminated using PFAS-free water mixed with detergent (preferably Alconox®, Liquinox® or Luminox®) and brushes, or similar means. After debris is removed, reusable PPE should be rinsed with PFAS-free water; and
3. Hands and any exposed body parts should be washed thoroughly using detergent (preferably Alconox®, Liquinox® or Luminox®) and PFAS-free water. Hands should be dried with paper towels.

2.5 <u>Food and Drink</u>

Food and drink should not be brought within the exclusion zone. Food that is kept in the staging area should preferably be contained in HDPE or stainless-steel containers.

3. DOCUMENTATION

3.1 <u>Chain of Custody</u>

3.1.1 Field Custody Procedures

A sample is considered to be in custody if the following conditions have been observed:

- It is in possession or view of the person in custody;
- It is locked in a secure area;
- It is placed in an area restricted to authorized personnel; or
- It is placed in a container and secured with an official seal, so that the sample cannot be reached without breaking the seal.

The following practices should be observed by field personnel to ensure sample custody:

- As few persons as possible will handle samples;
- The sample collector is personally responsible for the care and custody of samples collected until they are transferred to the laboratory;
- The sample collector will record sample data in the field notebook; and
- Sample labels will be completed for each sample.

3.1.2 Chain of Custody Record

All samples should be accompanied by a CoC record. The CoC record is typically provided by the laboratory. The CoC record should be fully completed in duplicate (e.g., a carbon copy). At the minimum, the following information should be included on a CoC record:

- Project name and number;
- Laboratory name and address;
- Name of person that collected the samples;
- Sample identifier;
- Sample date and time (time in 24-hour format);
- Laboratory analysis requested;
- Preservatives added to each sample;
- Sample matrix (e.g., soil, water);
- Number of containers per sample; and
- Airway bill tracking number.

As applicable, the following remarks should be added to the CoC record:

- Contractor name and address;
- A request for rapid turnaround time; and
- A note regarding the potential concentrations in a highly-contaminated sample.

3.1.3 Sample Packaging

The CoC record should accompany all sample shipments. One CoC record should be prepared for each cooler and the cooler number recorded on the CoC. The samples in the cooler should be listed on the CoC record. The CoC record should be placed in a sealed plastic bag (e.g., Ziploc®) and taped to the inside lid of the cooler. The duplicate copy of the CoC record should be retained by the sampler.

Custody seals should be signed and dated at the time of use. Sample shipping containers should be sealed in as many places as necessary to ensure that the container cannot be opened without breaking a custody seal. Tape should be placed over the seals to ensure that seals are not accidentally broken during shipment. If the sampler transports the samples to the laboratory without sample shipment, custody seals are not required.

3.1.4 Transfer of Custody

When transferring the possession of samples from the field sampler to a transporter or to the laboratory, the sampler should sign, date, and note the time as “relinquished by” on the CoC record. The receiver should also sign, date, and note the time as “received by” on the CoC record. The date and time of the receiver and relinquisher should be the same.

When samples are transported by a commercial carrier, the carrier will not sign the CoC record. However, the airway bill tracking number should be recorded on the CoC record. Airway bills should also be retained with the CoC record as documentation of transport. For this reason, the date and time of the receiver and relinquisher will not match when shipping with a commercial carrier.

3.1.5 Laboratory Custody Procedures

A designated sample custodian should accept custody of the shipped samples and verify that the sample identification number matches the CoC record. Pertinent information about shipment, pickup, and courier should be entered in the “Remarks” section. The temperature of the temperature blanks at the time of receiving should be noted on the CoC record.

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Attachment A. Daily PFAS Sampling Checklist

Date: ___________________

Site Name: _____________________________________

Weather (*temperature/precipitation*): ____

Please check all boxes that apply and describe any exceptions in the notes section below along with QA/QC methods used to assess potential sample cross-contamination as a result.

Field Clothing and PPE:

- ☐ No water- or stain-resistant clothing (e.g., GORE-TEX®)
- ☐ During collection of water and sediment samples, no water- or stain-resistant boots OR water- or stain-resistant boots covered by PFAS-free over-boots
- ☐ Field boots (or over-boots) made of polyurethane, PVC, rubber, or untreated leather
- ☐ Waders or rain gear are made of polyurethane, PVC, vinyl, wax-coated or rubber
- ☐ Clothing has not been recently laundered with a fabric softener
- ☐ No coated HDPE suits (e.g., coated Tyvek® suits)
- ☐ Field crew has not used cosmetics, moisturizers, or other related products today
- ☐ Field crew has not used sunscreen or insect repellants today, other than products approved as PFAS-free

Field Equipment:

- ☐ Sample containers, liners and equipment in direct contact with the sample are made of HDPE, polypropylene, silicone, acetate or stainless steel, not LDPE or glass
- ☐ Sample caps are made of HDPE or polypropylene and are not lined with Teflon™
- ☐ No materials containing Teflon™, Viton™, or fluoropolymers
- ☐ No materials containing LDPE are in direct contact with the sample (e.g., LDPE liners)
- ☐ No plastic clipboards, binders, or spiral hard cover notebooks
- ☐ No waterproof field books
- ☐ No waterproof or felt pens or markers (e.g., certain Sharpie® products)
- ☐ No chemical (blue) ice, unless it is contained in a sealed bag
- ☐ No aluminum foil
- ☐ No sticky notes (e.g., certain Post-It® products)

Decontamination:

- ☐ Reusable field equipment decontaminated prior to reuse
- ☐ "PFAS-free" water is on-site for decontamination of field equipment
- ☐ Alconox®, Liquinox® or Luminox® used as decontamination detergent

Food and Drink:

- ☐ No food or drink on-site, except within staging area
- ☐ Food in staging area is contained in HDPE or stainless steel container

Notes: ____

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Field Team Leader Name (Print): ___________________________

Field Team Leader Signature: ______________________________

Date/Time: ____________________________

Standard Operating Procedure for Sediment Sampling and Analysis of Per- and Polyfluoroalkyl Substances

1. INTRODUCTION

1.1 Purpose and Scope

Standard operating procedures (SOPs) were prepared to guide per- and polyfluoroalkyl substance (PFAS) sampling activities at National Aeronautics and Space Administration (NASA) sites. This SOP describes recommended procedures to be used by field personnel when collecting sediment samples beneath streams, creeks, lakes or other surface water bodies. Because PFAS are potentially present in a variety of materials that may come into contact with sediment samples, and because laboratory analytical method detection limits are low (low to sub micrograms per kilogram concentrations), conservative precautions are recommended to avoid sample cross-contamination and false positive results.

Currently, sampling guidance for PFAS is still in its infancy. Guidance from regulatory agencies often varies by state. Guidelines follow precautionary principles and may be based on anecdotal sampling experiences or on an abundance of precaution, rather than scientific studies. There is currently a need for robust, high quality guidance on PFAS sampling methods. Because there is little to no published scientific research regarding how certain materials may affect sample results, a conservative approach is recommended. The state of knowledge and practice is rapidly changing along with state and federal regulations and guidance for PFAS investigations. The procedures in this SOP are consistent with best practices at the time of authoring.

1.2 Definitions and Acronyms

1.2.1 Definitions

PFAS-free water	Water that has been analyzed by an accredited laboratory (see Section 3.1) and determined to be below the method detection limit (i.e., non-detect) for the suite of PFAS to be analyzed for in environmental samples. Method detection limits (MDLs) used during analysis of PFAS-free water should be at or below the MDLs used for environmental samples.
Potable water	Water that meets state and federal drinking water requirements. Note this water may or may not have detectable PFAS concentrations.

1.2.2 Acronyms

ASTM	American Society for Testing and Materials
CoC	chain of custody
DoD	Department of Defense

DOT	Department of Transportation
ETFE	ethylene tetrafluoroethylene
FEP	fluorinated ethylene propylene
HDPE	high-density polyethylene
IATA	International Air Transport Association
ICAO	International Civil Aviation Organization
LDPE	low-density polyethylene
MDL	method detection limit
MS	matrix spike
MSD	matrix spike duplicate
NASA	National Aeronautics and Space Administration
PFAS	per- and polyfluoroalkyl substance
PTFE	polytetrafluoroethylene
PPE	personal protective equipment
PVC	polyvinyl chloride
PVDF	polyvinylidene fluoride
QA	quality assurance
QC	quality control
QSM	quality systems manual
SOP	standard operating procedure
USGS	United States Geological Survey

1.3 Equipment and Products

Sections 1.3.1 and 1.3.2 detail items that are safe to use versus not recommended for use on the job site to protect PFAS samples from potential cross-contamination. Science-based evidence is not currently available to support a determination of the realistic impact of these commonly used field items and materials on PFAS samples. In the absence of scientific-based sampling guidance, field staff, contractors, and analytical laboratories should try to avoid using items that may pose a risk for cross-contamination and false positive results and instead use acceptable alternatives identified in this section. If the field team needs to use products and equipment on site that are not recommended, additional quality assurance/quality control (QA/QC) samples may be collected to evaluate any potential impact on PFAS environmental samples. This information is also provided in an abbreviated format as a checklist for field staff to reference (Attachment A).

1.3.1 Field Equipment

Items that are **safe to use** on site when sampling for PFAS include the following:

- High-density polyethylene (HDPE)[1], silicone, acetate, and stainless steel sampling equipment and materials (e.g., sampling containers and screw caps, bowls, pans, trays, spoons, trowels, forceps, hand augers);
- Low-density polyethylene (LDPE)[2] materials not in direct contact with the sample (e.g., Ziploc® bags);
- Plastic sleeves, core liners, and caps that do not contain Teflon™ or other fluoropolymers (e.g., acetate, polyvinyl chloride, polycarbonate);
- Masonite or aluminum clipboards;
- Ballpoint pens;
- Sampling forms, loose paper or field notebooks, chain of custody (CoC) record, and sample container labels;
- Alconox®, Liquinox® and Luminox® detergents;
- Paper towels;
- Trash bags;
- HDPE sheeting;
- Hard-shell coolers;
- Shipping and handling labels;
- Regular (wet) ice;
- Bubble wrap;
- Duct tape and packing tape; and
- Large (e.g., 55-gallon) containers.

Items **to be avoided (i.e., not recommended) for use** on site include the following:

- Tubes, liners and other components including caps or plugs made of Teflon™ or other fluoropolymers;
- Glass sample containers, due to PFAS adherence to glass surfaces;

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[1] HDPE plastics are commonly identified by a recycling symbol with a number 2 inside it.
[2] LDPE plastics are commonly identified by a recycling symbol with a number 4 inside it.

- Water-resistant paper, notebooks, and labels (e.g., certain Rite in the Rain® products), due to use of PFAS in water-resistant inks and coatings;
- Sticky notes (e.g., certain Post-It® products), due to potential use of a paper coating product Zonyl™ or similar fluorotelomer compounds;
- Plastic clipboards, binders, and spiral hardcover notebooks;
- Pens with water-resistant ink;
- Felt pens and markers (e.g., certain Sharpie® products) – some PFAS SOPs (e.g., Michigan) specifically allow Fine or Ultra-Fine Point Sharpies® and TestAmerica Laboratories, Inc. routinely uses Sharpies® in the laboratory following unpublished analytical tests that reportedly showed no impact on PFAS sample results;
- Aluminum foil, as PFAS are sometimes used as a protective layer;
- Decon 90™ liquid detergent, which reportedly contain fluorosurfactants;
- Chemical (e.g., blue) ice packs, unless it is contained in a sealed bag. Blue ice has the potential to be contaminated from previous field sampling events;
- Materials containing polytetrafluoroethylene (PTFE), including Teflon™ and Hostaflon® (e.g., tubing, tape, plumbing paste, O-rings);
- Equipment with Viton™ components (i.e., fluoroelastomers);
- Stain- or water-resistant materials, as these are typically fluoropolymer-based;
- Material containing LDPE, particularly if used in direct contact with the sample (e.g., LDPE tubing, as PFAS can sorb to the porous tubing); and
- Material containing "fluoro" in the name – this includes, but is not limited to, fluorinated ethylene propylene (FEP), ethylene tetrafluoroethylene (ETFE), and polyvinylidene fluoride (PVDF).

1.3.2 Clothing, Personal Protective Equipment (PPE), and Consumer Products

Items that are **<u>safe to use</u>** on site when sampling for PFAS include the following:

- Boots made of polyurethane, polyvinyl chloride (PVC), rubber, or untreated leather;
- Other field boots covered by PFAS-free (e.g., polypropylene) over-boots;
- Waders and rain gear made of neoprene, polyurethane, PVC, wax-coated, vinyl, or rubber;
- Clothing made of synthetic (e.g., polyester) or natural (e.g., cotton) fibers;
- Safety glasses;
- Reflective safety vests;

- Hardhats;
- Disposable powder-free nitrile gloves;
- Uncoated HDPE suits (e.g., certain Tyvek® products);
- Sunscreens[3] and insect repellants[4] that have been tested and found to be PFAS-free; and
- Bottled water and hydration drinks.

Items **to be avoided (i.e., not recommended) for use** on site include the following:

- Breathable waders made of nylon or polyester with a GORE-TEX® membrane;
- Water- or stain-resistant boots and clothing (e.g., products containing GORE-TEX®);
- Clothing recently laundered with a fabric softener;
- Coated HDPE suits (e.g., certain Tyvek® products);
- Sunscreen and insect repellants containing fluorinated compounds as ingredients, such as polyfluoroalkyl phosphate esters;
- Latex gloves;
- Cosmetics, moisturizers, hand cream, and other related products;
- Food wrappers and packaging; and
- Food and drinks other than bottled water or hydration drinks.

Field staff should try to find acceptable alternatives to these items that still allow them to complete the field work safely and efficiently. For example, wearing long-sleeved clothing and a hard hat or sun hat may eliminate the need to use sunscreen in some climates. If an item cannot be easily

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[3] Examples of PFAS-free sunscreens include Alba Organics Natural, Aubrey Organics, Banana Boat Sport Performance Sunscreen Lotion Broad Spectrum SPF 30, Banana Boat for Men Triple Defense Continuous Spray Sunscreen SPF 30, Banana Boat Sport Performance Coolzone Broad Spectrum SPF 30, Banana Boat Sport Performance Sunscreen Stick SPF 50, Coppertone Sunscreen Lotion Ultra Guard Broad Spectrum SPF 50, Coppertone Sport High-Performance AccuSpray Sunscreen SPF 30, Coppertone Sunscreen Stick Kids SPF 55, Jason Natural Sun Block, Kiss my Face, L'Oréal Silky Sheer Face Lotion 50+, Meijer Clear Zinc Sunscreen Lotion Broad Spectrum SPF 15, 30 and 50, Meijer Wet Skin Kids Sunscreen Continuous Spray Broad Spectrum SPF 70, Neutrogena Beach Defense Water + Sun Barrier Lotion SPF 70, Neutrogena Beach Defense Water + Sun Barrier Spray Broad Spectrum SPF 30, Neutrogena Pure & Free Baby Sunscreen Broad Spectrum SPF 60+, Neutrogena Ultra-Sheer Dry-Touch Sunscreen Broad Spectrum SPF 30, Yes to Cucumbers, and sunscreens for infants. Products with fluorinated compounds in their ingredients (e.g., polyfluoroalkyl phosphate esters) should not be worn during sampling.

[4] Examples of PFAS-free insect repellent include Jason Natural Quit Bugging Me, Repel Lemon Eucalyptus Insect repellant, Herbal Armor, California Baby Natural Bug Spray, BabyGanics, OFF! Deep Woods® spray for clothing and skin, Sawyer® do-it-yourself permethrin treatment for clothing, Insect Shield Insect® pretreated clothing, DEET products, and sunscreen/insect repellent combination product Avon Skin so Soft Bug Guard-SPF 30. Products with fluorinated compounds in their ingredients (e.g., polyfluoroalkyl phosphate esters) should not be worn during sampling.

avoided, additional consideration should be given to QA/QC samples to evaluate the potential impact of sample cross-contamination (e.g., field blanks).

2. FIELD PROCEDURES

2.1 Pre-Mobilization Activities

2.1.1 Health and Safety Plan

Prior to each field event, the site health and safety plan should be reviewed and updated, as necessary. Health and safety plan requirements should be reviewed for consistency with this SOP and modified as appropriate to resolve any differences.

2.1.2 Laboratory Coordination

Field personnel should communicate with the laboratory that will conduct PFAS analysis regarding the following items:

- Laboratory accreditation for PFAS analysis (see Section 3.1);
- Appropriate sample containers, labels, and preservatives (see Section 2.2.2);
- Sample storage conditions and holding time (see Section 2.2.3); and
- The number and type of QA/QC samples (see Section 2.3).

Because there is no standard United States Environmental Protection Agency method for analyzing PFAS samples in media other than drinking water, commercial laboratories typically offer analysis for a suite of approximately 18 PFAS using a modified version of Method 537.1. Laboratories may have developed their own variations. Project staff may consider the impact of differences in reported PFAS concentrations and the potential value of collecting and sending a split sample to a second commercial laboratory to assess variability in reported PFAS concentrations.

Laboratories conducting PFAS analysis for NASA facilities should be accredited by the United States Department of Defense Environmental Laboratory Accreditation Program (i.e. use a PFAS method that is compliant with Table B-15 of the DoD and Department of Energy consolidated Quality Systems Manual for Environmental Laboratories). States may also require that analytical laboratories are National Environmental Laboratory Accreditation Program accredited for their state and that PFAS analytical methods follow state guidelines.

2.1.3 Equipment Decontamination

Equipment should be decontaminated on site before work begins. Equipment decontamination should follow the steps outlined in Section 2.4.

2.2 Sampling

2.2.1 Sampling PPE

Gloves: Disposable powder-free nitrile gloves should be worn at all times during sample collection and handling of sampling equipment.

At a minimum, field personnel should put on a new pair of nitrile gloves after the following activities:

- Handling samples, including QA/QC samples and blanks; and
- Handling sampling equipment.

At a minimum, personnel should (1) thoroughly wash their hands with detergent (preferably Alconox®, Liquinox® or Luminox®) and PFAS-free water; (2) thoroughly dry their hands with paper towels; and (3) put on a new pair of nitrile gloves after the following activities:

- Contact with a material potentially containing PFAS;
- Change in sampling locations;
- Breaks in work;
- Washroom breaks; and
- Exit and entry into the project site exclusion zone.

2.2.2 Sampling Equipment

Sample Containers: HDPE containers with screw caps are commonly used for sample collection. Different laboratories may supply sample containers of varying sizes. Sample container caps are typically unlined.

Preservatives: Sample preservatives are not used for sediment samples prior to PFAS analysis.

Sediment Sampling Equipment: Sediment sampling methods vary depending on the depth of sediment sample required, nature of the surface water body (e.g., river vs. stream), depth of water, distance of the sediment sample location from the bank/shore and other factors. The selection of the sediment sample collection method is beyond the scope of this SOP. The project team is encouraged to review other published field sampling manuals and general sediment sampling procedures when formulating a site-specific work plan. This SOP focuses on two sediment sampling methods that are commonly used in shallow and deeper waters.

1. **Sediment scoop sampling –** If the surface water body is wadeable, a surface sediment sample can be collected manually using a stainless steel scoop. If the water is too deep to

wade, but is less than eight feet deep, an HDPE or metal conduit may be attached to the stainless steel scoop to collect samples.

2. **Hand auger sediment sampling –** If the surface water body is wadable with relatively shallow water, the sampling location is along a shoreline, or if the sampling location is within a drainage feature, a surface sediment sample can be collected manually using a stainless steel hand auger. If the water is too deep to wade or the sediment is too fine, core sampling is recommended.
3. **Sediment core sampling –** Core samples are useful to minimize the loss of fine-grained sediment material at the sediment-water interface and can be used to collect samples of sediments underlying shallow or deep water. This method can provide a profile to assess historic contamination as a result of sediment deposition. Manually deployed push tubes, gravity corer, or vibratory corer may be used to collect the sediment samples. Manually-deployed push tubes can be attached to a standard auger extension and handle to allow them to be corkscrewed into the sediment. A gravity corer inserts into the substrate through its own weight, and as a result the depth of penetration is determined by the amount of weight on the corer. A vibratory corer is typically used to collect samples without compaction or spreading of soft, loosely consolidated sediments.

Other methods for sediment sampling include dredging and diver-assisted sediment sampling. Dredging can be used to sample sediment from surface water bodies greater than 8 feet deep that have free vertical clearance. Samples can be collected using ponar dredges, mini-ponar dredges, or young grabs. In deep water, divers can directly access sediment and implement a variety of methods listed above.

Additional detail should also be provided in a site-specific work plan or stand-alone SOP to guide the process of compositing sediment samples, if desired prior to laboratory analysis. Incremental sampling can be used to generate a composite sample that is representative of a defined area of interest. Next, sample locations must be selected using an unbiased statistical method (e.g., collection of one sample randomly selected inside each square of a grid). Incremental sampling is then conducted, which involves the collection of equal-volume increments from each sample location. Sample increments are then combined and subsampled to create the target sample. This can be accomplished by placing the sediment from each collected sample into a pan or bowl and mixing to homogenize the sediment before placing it into the sample container. Multi-incremental sampling therefore lowers the total number of samples to be analyzed, saving analytical costs. It also provides a more representative average concentration present in sediments within the area of interest.

2.2.3 Sample Collection and Labeling

Container Rinsing: Sample containers should not be rinsed prior to sampling.

Sequence of Sampling: When taking multiple samples from a moving body of water, samples should first be taken from downstream locations, followed by upstream locations, to minimize sediment disturbance. If collecting co-located surface water and sediment samples, the surface water sample should be collected first to minimize the impact from sediment disturbance.

Sediment Scoop Sampling: Sediment samples may be collected with a stainless steel spoon or scoop directly from the surface water bed when access allows. Sampling in areas of aquatic vegetation should be avoided.

For shallow streams and pools, the following sample collection steps should be followed:

1. Wade into the surface water body towards the sample location from downstream until you get to the specified location;
2. Stand facing upstream (into the current);
3. Remove the sample container cap above the water surface;
4. Orient the stainless steel scoop so that the sample is collected in the upstream direction;
5. Scoop the sediment along the bottom of the surface water body in the direction of the current;
6. Care should be taken to minimize the loss of fine-grained material when lifting the scoop up through the current;
7. Excess water can be removed or drained from the scoop before placing the sediment into the sample container;
8. All foreign matter including stones, shells, roots, and detritus should be removed;
9. Fill the sample container to the volume indicated by the lab;
10. Use a paper towel to clean the outside of the sample container and the sample container threads. Close the sample container by screwing on the container cap; and
11. Record the sample location, sample date and time, and other applicable information in the field notebook and on sampling forms before moving on to the next sample location.

For deeper bodies of water (i.e., too deep to wade but less than eight feet), the following sample collection steps should be followed:

1. Approach the sample location using a boat, or, if the water body is narrow enough, from a bank;
2. Slowly lower the conduit with attached stainless steel scoop to the sample location;
3. Orient the stainless steel scoop so that the sample is collected in the upstream direction;
4. Scoop the sediment in the upstream direction;
5. Care should be taken to minimize the loss of fine-grained material when lifting the scoop up through the current;

6. Excess water can be removed or drained from the scoop before placing the sediment into the sample container;
7. All foreign matter including stones, shells, roots, and detritus should be removed;
8. Fill the sample container to the line indicated by the lab;
9. Use a paper towel to clean the outside of the sample container and the sample container threads. Close the sample container by screwing on the container cap; and
10. Record the sample location, sample date and time, and other applicable information in the field notebook and on sampling forms before moving on to the next sample location.

Hand Auger Sediment Sampling: Sediment samples may be collected using a hand auger in shallow waters or along shorelines.

The following sample collection steps should be followed for collecting samples in shallow water:

1. Wade into the surface water body towards the sample location from downstream until you get to the specified location;
2. Stand facing upstream (into the current);
3. Remove the sample container cap above the water surface;
4. Lower the hand auger into the sediment and advance to the desired depth;
5. Care should be taken to minimize the loss of fine-grained material when lifting the auger bucket up through the water;
6. Excess water can be drained from the auger before placing the sediment into the sample container;
7. All foreign matter including stones, shells, roots, and detritus should be removed;
8. Fill the sample container to the volume indicated by the lab;
9. Use a paper towel to clean the outside of the sample container and the sample container threads. Close the sample container by screwing on the container cap; and
10. Record the sample location, sample date and time, and other applicable information in the field notebook and on sampling forms before moving on to the next sample location.

For samples collected along shorelines or within drainage features, the following sample steps should be followed:

1. Approach the sample location from the bank;
2. Remove the sample container cap above the water surface or near the sediment surface;
3. Lower the hand auger into the sediment and advance to the desired depth;

4. Care should be taken to minimize the loss of fine-grained material when lifting the auger bucket up through any standing water;
5. Excess water can be drained from the auger before placing the sediment into the sample container;
6. All foreign matter including stones, shells, roots, and detritus should be removed;
7. Fill the sample container to the volume indicated by the lab;
8. Use a paper towel to clean the outside of the sample container and the sample container threads. Close the sample container by screwing on the container cap; and
9. Record the sample location, sample date and time, and other applicable information in the field notebook and on sampling forms before moving on to the next sample location.

Sediment Core Sampling: Sediment samples may be collected using a core sampler in either shallow or deep waters.

The following sample collection steps should be followed when using a manually-deployed push tube:

1. Wade into the surface water body towards the sample location from downstream or approach using a boat until you get to the specified location;
2. Face upstream (into the current);
3. Push the tube into the substrate until approximately four inches or less of the tube is present above the sediment-water interface;
4. For hard or coarse substrate, gently rotate or corkscrew the tube while pushing to allow for greater penetration and decrease core compaction;
5. Cap the top of the tube while it is still in the substrate;
6. Slowly extract the tube and cap the other end before it exits the water;
7. Use a paper towel to clean the outside of the tube;
8. Prior to sampling, place the tube horizontally and allow enough time for the water to drain out until fine sediment particles appear in the waste liquid;
9. Open the sampler to access the soil by cutting twice along the liner length using a hookblade utility knife and fill sample container;
10. Record the sample location, sample date and time, and other applicable information in the field notebook and on sampling forms; and
11. Move to the next sample location. A clean liner should be used for each new sample.

The following sample collection steps should be followed when using a gravity core sampler. For non-wadeable water, gravity cores are typically collected from a boat.

1. Assemble the gravity core in accordance with manufacturer instructions;
2. Lower the corer into the surface body water down allowing it to free fall to the substrate;
3. Allow the corer to penetrate the sediment under its own weight;
4. Depending on the type of gravity corer, either close the valve when it has reached the desired depth into the substrate or watch for the valve to automatically close;
5. Pull the gravity corer back to the surface;
6. Retrieve the sediment sample by sliding the liner out of the corer. This should be done over a PFAS-free surface (e.g., HDPE trash bag or sheeting);
7. Open the sampler to access the soil by cutting twice along the liner length using a hookblade utility knife and fill sample container;
8. Record the sample location, sample date and time, and other applicable information in the field notebook and on sampling forms; and
9. Move to the next sample location. A clean liner should be used for each new sample.

The following steps should be followed when using a vibratory core tube to collect samples from a boat. The boat must be capable of providing enough electricity to the vibratory corer and must have enough room to set up a tripod to hold the corer.

1. Assemble the vibratory corer in accordance with the manufacturer instructions;
2. Lower the corer into the surface body water guiding it down to maintain a vertical position;
3. Turn on the vibrating core to allow for penetration once it reaches the substrate;
4. After specified substrate depth is achieved, turn off the vibrations;
5. Pull the vibratory core tube towards the surface;
6. Cap the core just below the waterline;
7. Retrieve the sediment sample by sliding the liner out of the corer. This should be done over a PFAS-free surface (e.g., HDPE trash bag or sheeting);
8. Open the sampler to access the soil by cutting twice along the liner length using a hookblade utility knife and fill sample container; and
9. Record the sample location, sample date and time, and other applicable information in the field notebook and on sampling forms; and
10. Move to the next sample location. A clean liner should be used for each new sample.

Labels: Some water-resistant inks may be potential sources of PFAS. PFAS-free container labels should be filled out using a ballpoint pen that does not have water-resistant ink, if possible. Field staff should try to avoid filling out container labels using felt pens and markers (e.g., certain Sharpie® products). Container labels should include the following information:

- A unique sample identifier;
- QA/QC sample type, if applicable;
- Sampling date and time (24-hour format);
- Sampler's name or initials; and
- Method of sample preservation.

Except for temperature blanks, all QC samples should be labeled and included on the CoC record. Duplicate samples should not be indicated as duplicates.

Wet Weather Considerations: Field sampling during wet weather (e.g., rainfall and snowfall) should be conducted wearing appropriate clothing that does not pose a risk for cross-contamination. Field personnel should try to avoid water-resistant clothing and boots. Rain gear made of polyurethane, PVC, vinyl, or rubber is an acceptable alternative. Samples and sample containers should not be opened prior to sample collection to avoid collecting precipitation. Should samples or sample containers become contaminated with precipitation, they should be discarded.

2.2.4 Sample Handling, Storage, and Shipment

Handling: Clean nitrile gloves should be worn when handling sample containers. Precautions should be taken to not drop or otherwise damage sample containers. Sample containers should **not** be placed in close proximity to a potential PFAS source.

Storage and Holding Times: Storage conditions and holding times should be determined by the laboratory. Measures should be taken to meet storage and holding time criteria (e.g., expedited shipping).

Shipment: Sample containers should be packed for shipment using the following steps:

1. Choose a cooler with structural integrity that will withstand shipment.
2. Secure and tape the drain plug with duct tape from the inside and outside.
3. Check that the caps on all sample containers are tight and will not leak.
4. Check that the sample labels are intact, filled out, legible, and that the sample identifier exactly matches the CoC record.
5. Seal each sample container in a sample bag to prevent melt water from getting into the sample or degrading the sample label.
6. Place sample containers into the cooler with their caps upright.

7. Fill any excess space within the cooler with bubble wrap (try to avoid using paper, cardboard, or polystyrene foam).
8. Fill remaining space from the top of the sample containers to the top of the cooler with wet ice that is double-bagged and sealed.
9. Seal the entire cooler with duct tape, particularly the lid, to prevent leaks.

Ship samples as non-hazardous material unless the samples meet the established Department of Transportation (DOT) criteria for a "hazardous material" or the International Air Transport Association (IATA)/International Civil Aviation Organization (ICAO) for air definition of "dangerous goods." If the samples meet criteria for hazardous materials or dangerous goods, then DOT and IATA/ICAO regulations must be followed. Prior to shipping samples, field personnel should complete the appropriate air waybill or manifest. A copy of the air waybill or manifest should be kept for recordkeeping.

2.3 Sampling QA/QC

2.3.1 Background Samples

Based on project objectives, background samples may be collected onsite or nearby the site where little or no PFAS contamination is expected. Background samples are used to assess the natural composition of the sediment and determine that PFAS contamination in soils is localized rather than widespread. Typically, at least one background sample is collected during a sampling program.

2.3.2 Blanks

Blanks should be shipped and handled in the same manner as environmental samples. Field blanks should be labeled as such on sample bottles and on the CoC. The number and type of blanks should be determined based on discussions with the laboratory.

Equipment Blanks: Equipment blanks are used to assess sources of field and laboratory contamination. Equipment blanks are prepared by pouring PFAS-free water over or through decontaminated reusable field sampling equipment and collecting the rinsate in a sample container. Typically, at least one equipment blank is collected for every 10 primary samples.

Temperature Blanks: Temperature blanks are used to assess the temperature of samples during shipping. Temperature blanks should be provided by the laboratory or prepared by filling a sample container with PFAS-free water prior to shipment of the sample containers. The blank should be kept in the cooler during sampling and shipment to the laboratory. Once the cooler returns to the laboratory, the temperature of the blank should be measured to ensure that recommended sample storage criteria are met (typically less than 6 degrees Celsius).

2.4 Decontamination

Decontamination should occur prior to leaving the sampling area or at a central decontamination location and at the end of each work day. Additionally, sampling equipment exposed to PFAS-contaminated water should be decontaminated between sample locations.

Alconox®, Liquinox® and Luminox® detergents are acceptable for decontamination purposes. Use of Decon 90 should be avoided. Decontamination wastes must be properly contained and disposed of in accordance with applicable local, state and federal regulations.

2.4.1 Field Equipment Decontamination

Stainless steel scoops, hand augers, and any other non-disposable sampling equipment that is in contact with sediment samples are to be fully decontaminated after each use using the following procedures:

1. Wash thoroughly using potable water and detergent (Alconox®, Liquinox® or Luminox®) to remove any remaining residual contamination;
2. Rinse thoroughly with potable water (1st rinse);
3. Wash again using PFAS-free water and detergent to remove any additional remaining residual contamination;
4. Rinse thoroughly with PFAS-free water (2nd rinse);
5. Rinse again with PFAS-free water (3rd rinse); and
6. Dry wet equipment with a paper towel or leave the equipment to air dry in a location away from dust or fugitive contaminants. All equipment should be dry before reuse.

2.4.2 Personnel and PPE Decontamination

A decontamination area for personnel and portable equipment may be specified in the health and safety plan. The area may include basins or tubs to capture decontamination wastes, which can be transferred to larger containers as necessary. If decontamination is needed at the end of the day following sediment sampling, personnel decontamination should follow these steps:

1. Gross (e.g., soil) contamination should be scraped and wiped from boots, safety glasses, hardhats, reflective vests, and other reusable PPE. Once gross contamination has been removed, gloves should be removed by rolling off the hands in such a way to avoid exposing skin to PFAS-contaminated materials;
2. A new pair of gloves should be put on and reusable PPE should be decontaminated using PFAS-free water mixed with detergent (preferably Alconox®, Liquinox® or Luminox®) and brushes, or similar means. After debris is removed, reusable PPE should be rinsed with PFAS-free water; and

3. Hands and any exposed body parts should be washed thoroughly using detergent (preferably Alconox®, Liquinox® or Luminox®) and PFAS-free water. Hands should be dried with paper towels.

2.5 Food and Drink

Food and drink should not be brought within the exclusion zone. Food that is kept in the staging area should preferably be contained in HDPE or stainless-steel containers.

3. LABORATORY PROCEDURES

3.1 Accreditations

Laboratories conducting PFAS analysis for NASA facilities should be accredited by the United States Department of Defense Environmental Laboratory Accreditation Program, that is, use a PFAS method that is compliant with Table B-15 of the DoD and DOE consolidated QSM 5.2 for Environmental Laboratories. States may also require that analytical laboratories are National Environmental Laboratory Accreditation Program accredited for their state and that PFAS analytical methods follow state guidelines.

4. DOCUMENTATION

4.1 Chain of Custody

4.1.1 Field Custody Procedures

A sample is considered to be in custody if the following conditions have been observed:

- It is in possession or view of the person in custody;
- It is locked in a secure area;
- It is placed in an area restricted to authorized personnel; or
- It is placed in a container and secured with an official seal, so that the sample cannot be reached without breaking the seal.

The following practices should be observed by field personnel to ensure sample custody:

- As few persons as possible will handle samples;
- The sample collector is personally responsible for the care and custody of samples collected until they are transferred to the laboratory;
- The sample collector will record sample data in the field notebook; and
- Sample labels will be completed for each sample.

4.1.2 Chain of Custody Record

All samples should be accompanied by a CoC record. The CoC record is typically provided by the laboratory. The CoC record should be fully completed in duplicate (e.g., a carbon copy). At the minimum, the following information should be included on a CoC record:

- Project name and number;
- Laboratory name and address;
- Name of person that collected the samples;
- Sample identifier;
- Sample date and time (time in 24-hour format);
- Laboratory analysis requested;
- Preservatives added to each sample;
- Sample matrix (e.g., sediment, water);
- Number of containers per sample; and
- Airway bill tracking number.

As applicable, the following remarks should be added to the CoC record:

- Contractor name and address;
- MS/MSD sample volume (if necessary);
- A request for rapid turnaround time; and
- A note regarding the potential concentrations in a highly-contaminated sample.

Indication of a duplicate sample should **not** be included on a CoC record.

4.1.3 Sample Packaging

The CoC record should accompany all sample shipments. One CoC record should be prepared for each cooler and the cooler number recorded on the CoC. The samples in the cooler should be listed on the CoC record. The CoC record should be placed in a sealed plastic bag (e.g., Ziploc®) and taped to the inside lid of the cooler. If one sample is contained in two coolers (i.e., one sample has too many containers to fit in one cooler), then the original CoC should be placed in the first cooler and a copy of the CoC record should be placed in the second cooler. The duplicate copy of the CoC record should be retained by the sampler.

Custody seals should be signed and dated at the time of use. Sample shipping containers should be sealed in as many places as necessary to ensure that the container cannot be opened without breaking a custody seal. Tape should be placed over the seals to ensure that seals are not accidentally broken during shipment. If the sampler transports the samples to the laboratory without sample shipment, custody seals are not required.

4.1.4 Transfer of Custody

When transferring the possession of samples from the field sampler to a transporter or to the laboratory, the sampler should sign, date, and note the time as "relinquished by" on the CoC record. The receiver should also sign, date, and note the time as "received by" on the CoC record. The date and time of the receiver and relinquisher should be the same.

When samples are transported by a commercial carrier, the carrier will not sign the CoC record. However, the airway bill tracking number should be recorded on the CoC record. Airway bills should also be retained with the CoC record as documentation of transport. For this reason, the date and time of the receiver and relinquisher will not match when shipping with a commercial carrier.

4.1.5 Laboratory Custody Procedures

A designated sample custodian should accept custody of the shipped samples and verify that the sample identification number matches the CoC record. Pertinent information about shipment, pickup, and courier should be entered in the "Remarks" section. The temperature of the temperature blanks at the time of receiving should be noted on the CoC record.

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Attachment A. Daily Sampling Checklist

Date: ___________________

Site Name: _____________________________________

Weather (*temperature/precipitation*): ____

Please check all boxes that apply and describe any exceptions in the notes section below along with QA/QC methods used to assess potential sample cross-contamination as a result.

Field Clothing and PPE:

- ☐ No water- or stain-resistant waders or clothing (e.g., GORE-TEX®)
- ☐ During collection of water and sediment samples, no water- or stain-resistant boots OR water- or stain-resistant boots covered by PFAS-free over-boots
- ☐ Field boots (or overboots) are made of polyurethane, PVC, rubber, or untreated leather
- ☐ Waders or rain gear are made of polyurethane, PVC, vinyl, wax-coated or rubber
- ☐ Clothing has not been recently laundered with a fabric softener
- ☐ No coated HDPE suits (e.g., coated Tyvek® suits)
- ☐ Field crew has not used cosmetics, moisturizers, or other related products today
- ☐ Field crew has not used sunscreen or insect repellants today, other than products approved as PFAS-free

Field Equipment:

- ☐ Sample containers and equipment in direct contact with the sample are made of HDPE, polypropylene, silicone, acetate or stainless steel, not LDPE or glass
- ☐ Sample caps are made of HDPE or polypropylene and are not lined with Teflon™
- ☐ No materials containing Teflon™, Viton™, or fluoropolymers
- ☐ No materials containing LDPE are in direct contact with the sample (e.g., LPDE tubing, Ziploc® bags)
- ☐ No plastic clipboards, binders, or spiral hard cover notebooks
- ☐ No waterproof field books
- ☐ No waterproof or felt pens or markers (e.g., certain Sharpie® products)
- ☐ No chemical (blue) ice, unless it is contained in a sealed bag
- ☐ No aluminum foil
- ☐ No sticky notes (e.g., certain Post-It® products)

Decontamination:

- ☐ Reusable field equipment decontaminated prior to reuse
- ☐ “PFAS-free” water is on-site for decontamination of field equipment
- ☐ Alconox®, Liquinox® or Luminox® used as decontamination detergent

Food and Drink:

- ☐ No food or drink on-site, except within staging area
- ☐ Food in staging area is contained in HDPE or stainless steel container

Notes: ____

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Field Team Leader Name (Print): ___________________________

Field Team Leader Signature: ______________________________

Date/Time: ____________________________

Standard Operating Procedure for Soil Sampling and Analysis of Per- and Polyfluoroalkyl Substances

1. INTRODUCTION

1.1 Purpose and Scope

Standard operating procedures (SOPs) were prepared to guide per- and polyfluoroalkyl substance (PFAS) sampling activities National Aeronautics and Space Administration (NASA) sites. This SOP describes recommended procedures to be used by field personnel when collecting surface and subsurface soil samples. Because PFAS are potentially present in a variety of materials that may come into contact with soil samples, and because laboratory analytical method detection limits are low (low to sub microgram per kilogram concentrations for soil and low to sub nanogram per liter concentrations for liquids), conservative precautions are recommended to avoid sample cross-contamination and false positive results.

Currently, sampling guidance for PFAS is still in its infancy. Guidance from regulatory agencies often varies by state. Guidelines follow precautionary principles and may be based on anecdotal sampling experiences or on an abundance of precaution, rather than scientific studies. There is currently a need for robust, high quality guidance on PFAS sampling methods. Because there is little to no published scientific research regarding how certain materials may affect sample results, a conservative approach is recommended. The state of knowledge and practice is rapidly changing along with state and federal regulations and guidance for PFAS investigations. The procedures in this SOP are consistent with best practices at the time of authoring.

1.2 Definitions and Acronyms

1.2.1 Definitions

PFAS-free water	Water that has been analyzed by an accredited laboratory (see Section 3.1) and determined to be below the method detection limit (i.e., non-detect) for the suite of PFAS to be analyzed for in environmental samples. Method detection limits (MDLs) used during analysis of PFAS-free water should be at or below the MDLs used for environmental samples.
Potable water	Water that meets state and federal drinking water requirements. Note this water may or may not have detectable PFAS concentrations.

1.2.2 Acronyms

ASTM	American Society for Testing and Materials
CoC	chain of custody
DoD	Department of Defense

DOT	Department of Transportation
ETFE	ethylene tetrafluoroethylene
FEP	fluorinated ethylene propylene
HDPE	high-density polyethylene
IATA	International Air Transport Association
ICAO	International Civil Aviation Organization
LDPE	low-density polyethylene
MDL	method detection limit
MS	matrix spike
MSD	matrix spike duplicate
NASA	National Aeronautics and Space Administration
PFAS	per- and polyfluoroalkyl substance
PFTE	polytetrafluoroethylene
PPE	personal protective equipment
PVC	polyvinyl chloride
PVDF	polyvinylidene fluoride
QA	quality assurance
QC	quality control
SOP	standard operating procedure
USCS	Unified Soil Classification System

1.3 <u>Equipment and Products</u>

Sections 1.3.1 and 1.3.2 detail items that are safe to use versus not recommended for use on the job site to protect PFAS samples from potential cross-contamination. Science-based evidence is not currently available to support a determination of the realistic impact of these commonly used field items and materials on PFAS samples. In the absence of scientific-based sampling guidance, field staff, contractors, and analytical laboratories should try to avoid using items that may pose a risk for cross-contamination and false positive results and instead use acceptable alternatives identified in this section. If the field team needs to use products and equipment on site that are not recommended, additional quality assurance/quality control (QA/QC) samples may be collected to evaluate any potential impact on PFAS environmental samples. This information is also provided in an abbreviated format as a checklist for field staff to reference (Attachment A).

1.3.1 Field Equipment

Items that are **safe to use** on site when sampling for PFAS include the following:

- High-density polyethylene (HDPE)[1], silicone, acetate, and stainless steel sampling equipment and materials (e.g., sampling containers and screw caps, bowls, pans, trays, spoons, trowels, forceps);
- Low-density polyethylene (LDPE)[2] materials not in direct contact with the sample (e.g., Ziploc® bags);
- Survey stakes, flags, or whiskers;
- Drill rigs equipped with direct-push capabilities and push rods;
- Drill rigs equipped with hollow-stem augers, solid-stem augers, and drop hammers;
- Shovels, pick axes, pick mattocks, or other excavating tools;
- Stainless steel hand augers with extension rods;
- Stainless steel or brass split-spoon samplers;
- Plastic sleeves, liners, and caps that do not contain fluoropolymers (e.g., acetate, polyvinyl chloride, polycarbonate);
- Hook-blade utility knife to cut liners;
- Munsell soil color charts and grain size charts;
- Hand lenses;
- Stainless steel baskets or retainers for loose soils;
- Sampling forms, loose paper or field notebooks, chain of custody (CoC) record, and sample container labels;
- Masonite or aluminum clipboards;
- Ballpoint pens;
- Alconox®, Liquinox® and Luminox® detergents;
- Paper towels;
- Trash bags;
- HDPE sheeting;

[1] HDPE plastics are commonly identified by a recycling symbol with a number 2 inside it.
[2] LDPE plastics are commonly identified by a recycling symbol with a number 4 inside it.

- Hard-shell coolers;
- Shipping and handling labels;
- Regular (wet) ice;
- Bubble wrap;
- Duct tape and packing tape; and
- Large (e.g., 55-gallon) containers.

Items **to be avoided (i.e., not recommended) for use** on site include the following:

- Glass sample containers, due to PFAS adherence to glass surfaces;
- Water-resistant paper, notebooks, and labels (e.g., certain Rite in the Rain® products), due to use of PFAS in water-resistant inks and coatings;
- Sticky notes (e.g., certain Post-It® products), due to potential use of a paper coating product Zonyl™ or similar fluorotelomer compounds;
- Plastic clipboards, binders, and spiral hardcover notebooks;
- Pens with water-resistant ink;
- Felt pens and markers (e.g., certain Sharpie® products) – some PFAS SOPs (e.g., Michigan) specifically allow Fine or Ultra-Fine Point Sharpies® and TestAmerica Laboratories, Inc. routinely uses Sharpies® in the laboratory following unpublished analytical tests that reportedly showed no impact on PFAS sample results;
- Aluminum foil, as PFAS are sometimes used as a protective layer;
- Decon 90™ liquid detergent, which reportedly contain fluorosurfactants;
- Chemical (e.g., blue) ice packs, unless it is contained in a sealed bag. Blue ice has the potential to be contaminated from previous field sampling events;
- Materials containing polytetrafluoroethylene (PFTE) including Teflon™ and Hostaflon® (e.g., tubing, tape, plumbing paste, O-rings);
- Equipment with Viton™ components (i.e., fluoroelastomers);
- Stain- or water-resistant materials, as these are typically fluoropolymer-based;
- Material containing LDPE, particularly if used in direct contact with the sample (e.g., LDPE tubing, as PFAS can sorb to the porous tubing); and
- Material containing "fluoro" in the name – this includes, but is not limited to, fluorinated ethylene propylene (FEP), ethylene tetrafluoroethylene (ETFE), and polyvinylidene fluoride (PVDF).

1.3.2 Clothing, Personal Protective Equipment (PPE), and Consumer Products

Items that are **safe to use** on site when sampling for PFAS include the following:

- Boots made of polyurethane, polyvinyl chloride (PVC), rubber, or untreated leather;
- Other field boots covered by PFAS-free (e.g., polypropylene) over-boots;
- Rain gear made of polyurethane, PVC, wax-coated, vinyl, or rubber;
- Clothing made of synthetic (e.g., polyester) or natural (e.g., cotton) fibers;
- Safety glasses;
- Reflective safety vests;
- Hardhats;
- Disposable powder-free nitrile gloves;
- Uncoated HDPE suits (e.g., certain Tyvek® products);
- Sunscreens[3] and insect repellants[4] that have been tested and found to be PFAS-free; and
- Bottled water and hydration drinks.

Items **to be avoided (i.e., not recommended) for use** on site include the following:

- Water- or stain-resistant boots and clothing (e.g., products containing GORE-TEX®);
- Clothing recently laundered with a fabric softener;
- Coated HDPE suits (e.g., certain Tyvek® products);

[3] Examples of PFAS-free sunscreens include Alba Organics Natural, Aubrey Organics, Banana Boat Sport Performance Sunscreen Lotion Broad Spectrum SPF 30, Banana Boat for Men Triple Defense Continuous Spray Sunscreen SPF 30, Banana Boat Sport Performance Coolzone Broad Spectrum SPF 30, Banana Boat Sport Performance Sunscreen Stick SPF 50, Coppertone Sunscreen Lotion Ultra Guard Broad Spectrum SPF 50, Coppertone Sport High-Performance AccuSpray Sunscreen SPF 30, Coppertone Sunscreen Stick Kids SPF 55, Jason Natural Sun Block, Kiss my Face, L'Oréal Silky Sheer Face Lotion 50+, Meijer Clear Zinc Sunscreen Lotion Broad Spectrum SPF 15, 30 and 50, Meijer Wet Skin Kids Sunscreen Continuous Spray Broad Spectrum SPF 70, Neutrogena Beach Defense Water + Sun Barrier Lotion SPF 70, Neutrogena Beach Defense Water + Sun Barrier Spray Broad Spectrum SPF 30, Neutrogena Pure & Free Baby Sunscreen Broad Spectrum SPF 60+, Neutrogena Ultra-Sheer Dry-Touch Sunscreen Broad Spectrum SPF 30, Yes to Cucumbers, and sunscreens for infants. Products with fluorinated compounds in their ingredients (e.g., polyfluoroalkyl phosphate esters) should not be worn during sampling.

[4] Examples of PFAS-free insect repellent include Jason Natural Quit Bugging Me, Repel Lemon Eucalyptus Insect repellant, Herbal Armor, California Baby Natural Bug Spray, BabyGanics, OFF! Deep Woods® spray for clothing and skin, Sawyer® do-it-yourself permethrin treatment for clothing, Insect Shield Insect® pretreated clothing, DEET products, and sunscreen/insect repellent combination product Avon Skin so Soft Bug Guard-SPF 30. Products with fluorinated compounds in their ingredients (e.g., polyfluoroalkyl phosphate esters) should not be worn during sampling.

- Sunscreen and insect repellants containing fluorinated compounds as ingredients, such as polyfluoroalkyl phosphate esters;
- Latex gloves;
- Cosmetics, moisturizers, hand cream, and other related products;
- Food wrappers and packaging; and
- Food and drinks other than bottled water or hydration drinks.

Field staff should try to find acceptable alternatives to these items that still allow them to complete the field work safely and efficiently. For example, wearing long-sleeved clothing and a hard hat or sun hat may eliminate the need to use sunscreen in some climates. If an item cannot be easily avoided, additional consideration should be given to QA/QC samples to evaluate the potential impact of sample cross-contamination (e.g., field blanks).

2. FIELD PROCEDURES

2.1 Pre-Mobilization Activities

2.1.1 Health and Safety Plan

Prior to each field event, the site health and safety plan should be reviewed and updated, as necessary. Health and safety plan requirements should be reviewed for consistency with this SOP and modified as appropriate to resolve any differences.

2.1.2 Laboratory Coordination

Field personnel should communicate with the laboratory that will conduct PFAS analysis regarding the following items:

- Laboratory accreditation for PFAS analysis (see Section 3.1);
- Appropriate sample containers, labels, and preservatives (see Section 2.2.2);
- Sample storage conditions and holding time (see Section 2.2.3); and
- The number and type of QA/QC samples (see Section 2.3).

Because there is no standard United States Environmental Protection Agency method for analyzing PFAS samples in media other than drinking water, commercial laboratories typically offer analysis for a suite of approximately 18 PFAS using a modified version of Method 537.1. Laboratories may therefore have developed their own variations to this method or another method. Project staff may consider the impact of differences in reported PFAS concentrations and the potential value of collecting and sending a split sample to a second commercial laboratory to assess variability in reported PFAS concentrations.

Laboratories conducting PFAS analysis for NASA facilities should be accredited by the United States Department of Defense Environmental Laboratory Accreditation Program (i.e. use a PFAS method that is compliant with Table B-15 of the DoD and Department of Energy consolidated Quality Systems Manual for Environmental Laboratories). States may also require that analytical laboratories are National Environmental Laboratory Accreditation Program accredited for their state and that PFAS analytical methods follow state guidelines.

2.1.3 Equipment Decontamination

Equipment should be decontaminated on site before work begins. Equipment decontamination should follow the steps outlined in Section 2.4.

2.2 Sampling

2.2.1 Sampling PPE

Gloves: Disposable powder-free nitrile gloves should be worn at all times during sample collection and handling of sampling equipment.

At a minimum, field personnel should put on a new pair of nitrile gloves after the following activities:

- Handling samples, including QA/QC samples and blanks; and
- Handling sampling equipment.

At a minimum, personnel should (1) thoroughly wash their hands with detergent (preferably Alconox®, Liquinox® or Luminox®) and PFAS-free water; (2) thoroughly dry their hands with paper towels; and (3) put on a new pair of nitrile gloves after the following activities:

- Contact with a material potentially containing PFAS;
- Change in sampling locations;
- Breaks in work;
- Washroom breaks; and
- Exit and entry into the project site exclusion zone.

2.2.2 Sampling Equipment

Sample Containers: Depending on the method of soil sample collection, soils may be collected and placed into HDPE containers with unlined screw caps. Soil samples may also be collected using plastic, stainless steel or brass sleeves with caps placed at the ends.

Soil Retrieval Equipment: Soil retrieval methods vary depending on the depth of soil that will be sampled (e.g., topsoil, subsurface soil cores), geologic setting, need to consider contaminant drag-down/cross-contamination, and other analytes of interest (e.g., geotechnical characterization, volatile organic compounds). This SOP focuses on three soil retrieval methods:

1. **Manual soil sampling –** Equipment may include hand augers, shovels, pick axes, pick mattocks, or other excavating tools, as well as bowls, pans, trays, spoons, trowels and forceps.
2. **Direct-push sampling –** Soil is typically retrieved using a direct-push technology (DPT) rig, a solid barrel direct push sampler, and a liner to facilitate removal of the soil from the sampler. Liners may be brass, stainless steel, polyvinyl chloride, polycarbonate, acetate, or other plastics. Care should be taken to select a liner that does not contain fluoropolymers.
3. **Solid-stem auger –** Solid-stem augers may be attached to a DPT rig and used to create a "pilot" hole if lithified or dense materials are causing refusal and preventing the advancement of a solid barrel direct push sampler.
4. **Split-spoon sampling –** A hollow stem auger rig is used to drill to the desired depth(s), as well as advance stainless-steel split-spoon samplers.

An overview of other methods of soil sample collection is beyond the scope of this SOP; the reader is encouraged to review other published field sampling manuals and SOPs when formulating a site-specific work plan. Additional detail should also be provided in a site-specific work plan or stand-alone SOP to guide the process of compositing soil samples.

Preservatives: Sample preservatives are not used for soil samples prior to PFAS analysis.

2.2.3 Sample Collection and Labeling

Container Rinsing: Sample containers should not be rinsed prior to sampling.

Manual Soil Sampling: Surface soils may be collected using small hand tools (e.g., spoons, trowels, forceps). Subsurface soils may be retrieved using large hand tools (e.g., shovels, hand-augers) or heavy equipment (e.g., hydraulic excavators) in combination with small hand tools. Manual soil samples are typically retrieved as follows:

- Hand tools and/or heavy equipment are used to access the required sample depth
- If using small hand tools, soil is then sampled (see Steps 1 through 6 below).
- If using large hand tools or heavy equipment, retrieve the soil and place it on a flat PFAS-free surface for sample collection (e.g., stainless steel tray, HDPE sheeting).

Once the soil has been retrieved for sampling, follow these steps:

1. Remove visible vegetation or large gravel from the sample using small hand tools;

2. Homogenize the soil collected over the desired sampling interval;
3. Remove the cap from the sample container and fill the container with the soil sample with small hand tools. The container should be filled to the mass or volume specified by the laboratory;
4. Use a paper towel to clean the outside of the sample container and the sample container threads if necessary. Close the sample container by screwing on the container cap.
5. Label the sample (see "Labels" section below);
6. Record the sample location (horizontal), sample date and time, and other applicable information in the field notebook and on sampling forms before moving on to the next sample location; and
7. Complete soil boring logging per work plan requirements. Detailed records of soil conditions during sampling are helpful in creating and refining the conceptual site model, including sample location, depth, color, odor, lithology, hydrogeology, and readings derived from field monitoring equipment. Surface and shallow subsurface soil samples shall be described using the Unified Soil Classification System (USCS) and/or American Society for Testing and Materials (ASTM) guidance D2487 Standard Practices for Classification of Soils for Engineering Purposes, unless otherwise directed by a site-specific work plan.

Direct-Push Soil Sampling: When drilling with a DPT rig (or a sonic drill rig), subsurface soil may be retrieved using a dual-tube sampler or a single rod sampler. Both types of samplers typically use a plastic liner to facilitate soil removal. Care should be taken that the liner material does not contain fluoropolymers. Soil is typically sampled as follows:

1. Remove pavement or sub-base material that is obstructing rig access to subsurface soil;
2. Hand auger the first 5 feet of soil to clear for potential underground utilities and follow applicable sampling procedures if samples will be collected within the top 5 feet;
3. Drill to the first sample depth;
4. When the sample depth is reached, remove the drive tooling and deploy the sample barrel with a liner and a drive tip;
5. Advance the sample barrel through the desired sample interval and then retrieve the sample by pulling up the rods;
6. Slide the liner containing the soil sample from the sample barrel and place it on a PFAS-free surface (e.g., HDPE sheeting)
7. Wipe the outside of the liner with a paper towel and mark the depth on the outside of the liner with a marker;
8. Open the liner with a safe cutting tool and complete soil boring logging per work plan requirements.

9. Complete soil boring logging per work plan requirements. Detailed records of soil conditions during sampling are helpful in creating and refining the conceptual site model, including sample location, depth, color, odor, lithology, hydrogeology, and readings derived from field monitoring equipment (if applicable based on known or suspected site constituents of concern other than PFAS). Surface and shallow subsurface soil samples shall be described using the USCS and/or ASTM guidance D2487 Standard Practices for Classification of Soils for Engineering Purposes, unless otherwise directed by a site-specific work plan.
10. Remove the soil from the liner manually or using small hand tools from the desired sampling interval;
11. Homogenize the soil collected over the desired sampling interval;
12. Remove the cap from the sample container and fill the container with the soil sample with small hand tools. The container should be filled to the mass or volume specified by the laboratory;
13. Use a paper towel to clean the outside of the sample container and the sample container threads if necessary. Close the sample container by screwing on the container cap.
14. Label the sample (see "Labels" section below); and
15. Record the sample location (horizontal) and depth, sample date and time, and other applicable information in the field notebook and on sampling forms before moving on to the next sample location.

Split-Spoon Sampling: Split-spoon sampling is typically used with a hollow-stem auger drill rig. To conduct split-spoon soil sampling, follow these procedures:

1. Remove any pavement or sub-base material that is obstructing access to subsurface soil by the hollow-stem auger drill rig;
2. Hand clear first 5 feet of soil using a post hole digger to clear for potential underground utilities and follow applicable sampling procedures if samples will be collected within the top 5 feet;
3. Begin drilling; periodically remove and containerize soil cuttings that are brought to the surface by the auger flights during drilling;
4. When the desired sample depth is reached, remove the center rod and deploy the split-spoon sampler attached to the drill rod string. If necessary, insert a plastic liner prior to sampler deployment.
5. With the sampler shoe at the ground surface in the sample location, mark the center rod with the desired sample depth increments;

6. Drive the sampler using a hammer and record the number of blows required to drive the spoon through each 6-inch increment, the length of the tube that penetrates the material being sampled, the weight of the hammer, and the total distance dropped;
7. Cease driving upon reaching the sampler length or refusal. Refusal is when little to no progress is made for 50 hammer blows;
8. Pull up the center rod and sampler, remove the sampler from the drill rods, and place it on a PFAS-free surface (e.g., HDPE sheeting); and
9. Open the split spoon sampler to access the soil, being careful not to disturb the soil.
10. If using liners during sampling, wipe the outside of the sealed liner with a paper towel and mark the depth on the outside of the liner with a marker.
11. As applicable, open the liner with a utility knife and complete soil boring logging per work plan requirements. Detailed records of soil conditions during sampling are helpful in creating and refining the conceptual site model, including sample location, depth, color, odor, lithology, hydrogeology, and readings derived from field monitoring equipment. Surface and shallow subsurface soil samples shall be described using the USCS and/or ASTM guidance D2487 Standard Practices for Classification of Soils for Engineering Purposes, unless otherwise directed by a site-specific work plan.
12. Remove the soil from the liner or spoon manually or using small hand tools from the desired sampling interval;
13. Homogenize the soil collected over the desired sampling interval;
14. Remove the cap from the sample container and fill the container with the soil sample with small hand tools. The container should be filled to the mass or volume specified by the laboratory;
15. Use a paper towel to clean the outside of the sample container and the sample container threads if necessary. Close the sample container by screwing on the container cap.
16. Label the sample (see "Labels" section below); and
17. Record the sample location and depth, sample date and time, and other applicable information in the field notebook and on sampling forms before moving on to the next sample location.

<u>Labels</u>: Some water-resistant inks may be potential sources of PFAS. PFAS-free container labels should be filled out using a ballpoint pen that does not have water-resistant ink, if possible. Field staff should <u>try to avoid</u> filling out container labels using felt pens and markers (e.g., certain Sharpie® products). Container labels should include the following information:

- A unique sample identifier;
- QA/QC sample type, if applicable;

- Sampling date and time (24-hour format);
- Sampler's name or initials; and
- Method of sample preservation.

Except for temperature blanks, all QC samples should be labeled and included on the CoC record. Duplicate samples should not be indicated as duplicates.

Wet Weather Considerations: Field sampling during wet weather (e.g., rainfall and snowfall) should be conducted wearing appropriate clothing that does not pose a risk for cross-contamination. Field personnel should try to avoid water-resistant clothing and boots. Rain gear made of polyurethane, PVC, vinyl, or rubber is an acceptable alternative. Samples and sample containers should not be opened prior to sample collection to avoid collecting precipitation. Should samples or sample containers become contaminated with precipitation, they should be discarded.

2.2.4 Sample Handling, Storage, and Shipment

Handling: Clean nitrile gloves should be worn when handling sample containers. Precautions should be taken to not drop or otherwise damage sample containers. Sample containers should **not** be placed in close proximity to a potential PFAS source.

Storage and Holding Times: Storage conditions and holding times should be determined by the laboratory. Measures should be taken to meet storage and holding time criteria (e.g., expedited shipping).

Shipment: Sample containers should be packed for shipment using the following steps:

1. Choose a cooler with structural integrity that will withstand shipment.
2. Secure and tape the drain plug with duct tape from the inside and outside.
3. Check that the caps on all sample containers are tight and will not leak.
4. Check that the sample labels are intact, filled out, legible, and that the sample identifier exactly matches the CoC record.
5. Seal each sample container in a sample bag to prevent melt water from getting into the sample or degrading the sample label.
6. Place sample containers into the cooler with their caps upright.
7. Fill any excess space within the cooler with bubble wrap (try to avoid using paper, cardboard, or polystyrene foam).
8. Fill remaining space from the top of the sample containers to the top of the cooler with wet ice that is double-bagged and sealed.
9. Seal the entire cooler with duct tape, particularly the lid, to prevent leaks.

Ship samples as non-hazardous material unless the samples meet the established Department of Transportation (DOT) criteria for a “hazardous material” or the International Air Transport Association (IATA)/International Civil Aviation Organization (ICAO) for air definition of “dangerous goods.” If the samples meet criteria for hazardous materials or dangerous goods, then DOT and IATA/ICAO regulations must be followed. Prior to shipping samples, field personnel should complete the appropriate air waybill or manifest. A copy of the air waybill or manifest should be kept for recordkeeping.

2.3 Sampling QA/QC

2.3.1 Background Samples

Based on project objectives, background samples may be collected onsite or nearby the site where little or no PFAS contamination is expected. Background samples are used to assess the natural composition of the soil and determine that PFAS contamination in soils is localized rather than widespread. Typically, at least one background sample is collected during every sampling campaign; however, soil heterogeneity across the site (lateral or vertical) may warrant additional background samples.

2.3.2 Blanks

Blanks should be shipped and handled in the same manner as environmental samples. Field blanks should be labeled as such on sample bottles and on the CoC. The number and type of blanks should be determined based on discussions with the laboratory.

Equipment Blanks: Equipment blanks are used to assess sources of field and laboratory contamination. Equipment blanks are prepared by pouring PFAS-free water over or through decontaminated reusable field sampling equipment and collecting the rinsate in a sample container. Typically, at least one equipment blank is collected for every 10 primary samples. Note: if equipment that will come into contact with the soil sample is not being reused (i.e., if plastic liners and caps will be used for soil samples), equipment blanks can be omitted from the field sampling program.

Field Blanks: Field blanks are used to assess ambient contamination within the field and laboratory. Field blanks should be prepared by filling a sample container with PFAS-free water in the field in the same manner as environmental samples. Field blanks are an effective way of assessing potential cross-contamination as a result of sample handling. Typically, one field blank is collected for each shipping container.

Temperature Blanks: Temperature blanks are used to assess the temperature of samples during shipping. Temperature blanks should be provided by the laboratory or prepared by filling a sample container with water prior to shipment of the sample containers. The blank should be kept in the cooler during sampling and shipment to the laboratory. Once the cooler returns to the laboratory, the temperature of the blank should be measured to ensure that recommended sample storage criteria are met (typically less than 6 degrees Celsius).

2.4 <u>Decontamination</u>

Decontamination should occur prior to leaving the sampling area or at a central decontamination location. Additionally, sampling equipment exposed to PFAS-contaminated soil should be decontaminated between sample locations.

Alconox®, Liquinox® or Luminox® detergents are acceptable for decontamination purposes. Decon 90 should be avoided during decontamination activities. Decontamination wastes must be properly contained and disposed of in accordance with applicable local, state and federal regulations.

2.4.1 Field Equipment Decontamination

Drillers typically have multiple rods and samplers on hand and thoroughly decontaminate them as a group once they have been used.

<u>Drill Rods and DPT Samplers</u>: As drill rods are pulled up, they are wiped down with a rag rinsed in soapy water. Inner rods are placed into a 5-gallon bucket and rinsed with a rag using soapy water (Alquinox®, Liquinox® or Luminox®). DPT samplers are to be fully decontaminated after each use. DPT rods are to be fully decontaminated after each boring location using the following procedures:

1. If heavy petroleum residuals are encountered during sampling, use methanol or another appropriate solvent to remove any residues from sampling equipment;
2. Pressure wash thoroughly and vigorously using potable water and detergent (Alconox®, Liquinox® or Luminox®) to remove any remaining residual contamination;
3. Rinse thoroughly with potable water (1st rinse);
4. Rinse thoroughly with PFAS-free water (2nd rinse); and
5. Leave the equipment to air dry in a location away from dust and fugitive contaminants.

<u>Samplers</u>: Other sampling equipment (e.g., trowels, spoons, hand augers) should be placed into a 5-gallon bucket with soapy water (Alquinox®, Liquinox® or Luminox®) and wiped down with a rag. Samplers can then be fully decontaminated after each use using the following procedures:

1. Remove any gross (e.g., soil) contamination from sampling equipment;
2. If heavy petroleum residuals are encountered during sampling, use methanol or another appropriate solvent to remove any residues from sampling equipment;
3. In a constructed decontamination pit, pressure wash the exterior of the samplers with PFAS-free water. Samplers should be laid horizontally and raised above the floor of the

decontamination pit, typically on a wooden pallet and should be rotated midway through the rinse so that the entire exterior of the sampler is sprayed (1^{st} rinse);

4. Wash thoroughly using potable water and detergent (Alconox®, Liquinox® or Luminox®) to remove any remaining residual contamination;
5. Rinse the exterior thoroughly with potable water (2^{nd} rinse);
6. In a 5-gallon bucket, hold the sampler vertically and use a water hose with a nozzle or a pressure washer to spray the interior of each sampler using PFAS-free water (3^{rd} rinse);
7. Flip the sampler up-side down in the opposite orientation and repeat Step 6 so that water is flushed through both ends of the sampler (4^{th} rinse);
8. Leave the equipment to air dry in a location away from dust and fugitive contaminants.

Other Field Equipment: All non-disposable sampling equipment that is in contact with contaminated soil, groundwater, or decontamination water (e.g., 5-gallon bucket, field meters) must be cleaned prior to and between uses at each soil sampling location according to the following procedures:

1. Remove any gross (e.g., soil) contamination from sampling equipment;
2. If heavy petroleum residuals are encountered during sampling, use methanol or another appropriate solvent to remove any residues from sampling equipment;
3. Wash water-resistant equipment thoroughly and vigorously with potable water containing detergent (Alconox®, Liquinox® or Luminox®) using a bristle brush or similar utensil to remove any remaining residual contamination;
4. Rinse equipment thoroughly with potable water (1^{st} rinse);
5. Rinse equipment thoroughly with PFAS-free water (2^{nd} rinse);
6. For field instruments, rinse again with PFAS-free water (3^{rd} rinse); and
7. Dry wet equipment with a paper towel or leave the equipment to air dry in a location away from dust or fugitive contaminants. All equipment should be dry before reuse.

Cleaning and decontamination of the equipment should be accomplished in stages and in such a way that the contamination does not discharge into the environment.

2.4.2 Personnel and PPE Decontamination

A decontamination area for personnel and portable equipment may be specified in the health and safety plan. The area may include basins or tubs to capture decontamination wastes, which can be transferred to larger containers as necessary. If decontamination is needed following soil sampling, personnel decontamination should follow these steps:

1. Gross (e.g., soil) contamination should be scraped and wiped from boots, safety glasses, hardhats, reflective vests, and other reusable PPE. Once gross contamination has been

removed, gloves should be removed by rolling off the hands in such a way to avoid exposing skin to PFAS-contaminated materials;

2. A new pair of gloves should be put on and reusable PPE should be decontaminated using PFAS-free water mixed with detergent (preferably Alconox®, Liquinox® or Luminox®) and brushes, or similar means. After debris is removed, reusable PPE should be rinsed with PFAS-free water; and
3. Hands and any exposed body parts should be washed thoroughly using detergent (preferably Alconox®, Liquinox® or Luminox®) and PFAS-free water. Hands should be dried with paper towels.

2.5 Food and Drink

Food and drink should not be brought within the exclusion zone. Food that is kept in the staging area should preferably be contained in HDPE or stainless-steel containers.

3. LABORATORY PROCEDURES

3.1 Accreditations

Laboratories conducting PFAS analysis for NASA facilities should be accredited by the United States Department of Defense Environmental Laboratory Accreditation Program, that is, use a PFAS method that is compliant with Table B-15 of the DoD and DOE consolidated QSM 5.2 for Environmental Laboratories. States may also require that analytical laboratories are National Environmental Laboratory Accreditation Program accredited for their state and that PFAS analytical methods follow state guidelines.

4. DOCUMENTATION

4.1 Chain of Custody

4.1.1 Field Custody Procedures

A sample is considered to be in custody if the following conditions have been observed:

- It is in possession or view of the person in custody;
- It is locked in a secure area;
- It is placed in an area restricted to authorized personnel; or
- It is placed in a container and secured with an official seal, so that the sample cannot be reached without breaking the seal.

The following practices should be observed by field personnel to ensure sample custody:

- As few persons as possible will handle samples;
- The sample collector is personally responsible for the care and custody of samples collected until they are transferred to the laboratory;
- The sample collector will record sample data in the field notebook; and
- Sample labels will be completed for each sample.

4.1.2 Chain of Custody Record

All samples should be accompanied by a CoC record. The CoC record is typically provided by the laboratory. The CoC record should be fully completed in duplicate (e.g., a carbon copy). At the minimum, the following information should be included on a CoC record:

- Project name and number;
- Laboratory name and address;
- Name of person that collected the samples;
- Sample identifier;
- Sample date and time (time in 24-hour format);
- Laboratory analysis requested;
- Preservatives added to each sample;
- Sample matrix (e.g., soil, water);
- Number of containers per sample; and
- Airway bill tracking number.

As applicable, the following remarks should be added to the CoC record:

- Contractor name and address;
- A request for rapid turnaround time; and
- A note regarding the potential concentrations in a highly-contaminated sample.

4.1.3 Sample Packaging

The CoC record should accompany all sample shipments. One CoC record should be prepared for each cooler and the cooler number recorded on the CoC. The samples in the cooler should be listed on the CoC record. The CoC record should be placed in a sealed plastic bag (e.g., Ziploc®) and taped to the inside lid of the cooler. If one sample is contained in two coolers (i.e., one sample has too many containers to fit in one cooler), then the original CoC should be placed in the first cooler and a copy of the CoC record should be placed in the second cooler. The duplicate copy of the CoC record should be retained by the sampler.

Custody seals should be signed and dated at the time of use. Sample shipping containers should be sealed in as many places as necessary to ensure that the container cannot be opened without breaking a custody seal. Tape should be placed over the seals to ensure that seals are not accidentally broken during shipment. If the sampler transports the samples to the laboratory without sample shipment, custody seals are not required.

4.1.4 Transfer of Custody

When transferring the possession of samples from the field sampler to a transporter or to the laboratory, the sampler should sign, date, and note the time as "relinquished by" on the CoC record. The receiver should also sign, date, and note the time as "received by" on the CoC record. The date and time of the receiver and relinquisher should be the same.

When samples are transported by a commercial carrier, the carrier will not sign the CoC record. However, the airway bill tracking number should be recorded on the CoC record. Airway bills should also be retained with the CoC record as documentation of transport. For this reason, the date and time of the receiver and relinquisher will not match when shipping with a commercial carrier.

4.1.5 Laboratory Custody Procedures

A designated sample custodian should accept custody of the shipped samples and verify that the sample identification number matches the CoC record. Pertinent information about shipment, pickup, and courier should be entered in the "Remarks" section. The temperature of the temperature blanks at the time of receiving should be noted on the CoC record.

5. REFERENCES

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USAF, HQ USAF/A7C, 2012. Interim Air Force Guidance on Sampling and Response Actions for Perfluorinated Compounds at Active and BRAC Installations.

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Attachment A. Daily Sampling Checklist

Date: ___________________

Site Name: _____________________________________

Weather (*temperature/precipitation*): ____

Please check all boxes that apply and describe any exceptions in the notes section below along with QA/QC methods used to assess potential sample cross-contamination as a result.

Field Clothing and PPE:

- ☐ No water- or stain-resistant waders, or clothing (e.g., GORE-TEX®)
- ☐ During collection of water and sediment samples, no water- or stain-resistant boots OR water- or stain-resistant boots covered by PFAS-free over-boots
- ☐ Field boots (or overboots) are made of polyurethane, PVC, rubber, or untreated leather
- ☐ Waders or rain gear are made of neoprene, polyurethane, PVC, vinyl, wax-coated or rubber
- ☐ Clothing has not been recently laundered with a fabric softener
- ☐ No coated HDPE suits (e.g., coated Tyvek® suits)
- ☐ Field crew has not used cosmetics, moisturizers, or other related products today
- ☐ Field crew has not used sunscreen or insect repellants today, other than products approved as PFAS-free

Field Equipment:

- ☐ Sample containers, liners and equipment in direct contact with the sample are made of HDPE, polypropylene, silicone, acetate or stainless steel, not LDPE or glass
- ☐ Sample caps are made of HDPE or polypropylene and are not lined with Teflon™
- ☐ No materials containing Teflon™, Viton™, or fluoropolymers
- ☐ No materials containing LDPE are in direct contact with the sample (e.g., LDPE liners, Ziploc® bags)
- ☐ No plastic clipboards, binders, or spiral hard cover notebooks
- ☐ No waterproof field books
- ☐ No waterproof or felt pens or markers (e.g., certain Sharpie® products)
- ☐ No chemical (blue) ice, unless it is contained in a sealed bag
- ☐ No aluminum foil
- ☐ No sticky notes (e.g., certain Post-It® products)

Decontamination:

- ☐ Reusable field equipment decontaminated prior to reuse
- ☐ "PFAS-free" water is on-site for decontamination of field equipment
- ☐ Alconox®, Liquinox® or Luminox® used as decontamination detergent

Food and Drink:

- ☐ No food or drink on-site, except within staging area
- ☐ Food in staging area is contained in HDPE or stainless steel container

Notes:

____

____

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____

____

Field Team Leader Name (Print): ____________________________

Field Team Leader Signature: _______________________________

Date/Time: _____________________________

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Appendix B

Interviews with Various KSC Personnel

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AFF Use at KSC Meeting Notes 12/1/2020

Interview with Rick Anderson, Fire Chief conducted via Microsoft Teams

Also present: Mike Deliz (NASA), Anne Chrest (NASA), Matt Zenker (AECOM), Jennifer Joyal (AECOM), and Brittany Follett (AECOM)

- 5 Air Rescue Firefighting (ARF) Trucks at KSC:
  - ARF/Crash Truck 10 – 220 gallons of C6 Foam
  - ARF/Crash Truck 20 – 420 gallons of C6 Foam
  - ARF/Crash Truck 30 – 420 gallons of C6 Foam
    - Currently located at Base Support Operations Building (referred to as Heavy Equipment Shop during the interview)
    - 30 years old and scheduled to be decommissioned and excessed
  - ARF/Crash Truck 40 – 420 gallons of C6 Foam
    - was in operation in 2007
  - ARF/Crash Truck 50 – does not contain AFFF
    - Still at KSC but has been decommissioned; no longer in operation
    - Was utilized as a water tank but needs repair
    - Government has decided to excess this piece of equipment
  - In September 2020 C8 Foam was switched out with C6 Foam for all trucks
    - C8 will no longer be used on-site

- 3 Fire Engines in operation:
  - Engine 1 – 30 gallons of C6 Foam
  - Engine 2 – 30 gallons of C6 Foam
  - Engine 3 – 30 gallons of C6 Foam
  - Engine 12 – did not use AFFF; currently being decommissioned and excessed; is located at Base Support Operations Building (referred to as Heavy Equipment Shop during the interview)
  - Engine 22 – potentially 30 gallons of AFFF – no longer in use

- Pump Test:
  - Prior to learning about PFAS in the C-8 foam they would utilize the fire training area at Static Test Road by the hypergol pit (this area is referred to as the Hydrocarbon Burn Facility in the KSC Remediation Program) to perform tests
  - Process:
    - Within an open field foam was shot into a bucket
    - This process occurred from at least 1988 to 2007
  - Majority of the testing consisted of time and distance testing with water only
  - Refractometer tests were completed on the tanks in 2007 – Foam was not released on to the ground

  - Weather Site 509 area, on Schwartz Road, near the pond they would conduct water pump testing – No foam used

- Current and Former Fire Stations:
  - Three stations (1, 2 and 3) are currently in operation
  - Former Fire Station 2 (K6-1198) was located near VAB building
  - Former Fire Station located on Sharky road
    - Used for a buffer building and storage for Foam and Crash Trucks
  - Annual testing of pumps
- Spill Response:
  - One response to a fire off center – located on 528
    - This is the only time foam was used off center
  - Morpheus project response located on north side of SLF – large amount of foam used on-site
  - NASA asked Chief Anderson about any additional information he may have regarding former spills; he had no additional information to provide
    - Two reported spills at the former Fire Station 2
    - Spill at M&O
    - Spill report at KARS Park II

- Foam Storage:
  - All foam currently stored at Central Supply Facility
  - Former Storage Facility, south of J6-2327 (Clamshell #4), located on State Road 3 (Kennedy Parkway)
    - This building was only there for 1 year
      - Building has been torn down
    - This area is used for semi-truck and connex box storage
  - Hangar near SLF and Fire Station 2
    - Stores high expansion foam – does not have PFAS compounds
- Records of Foam Types:
  - Only use 3% mix has been used
  - Types used: Chemguard, Ansel, Millspec, etc.
- Foam Mixing Processes:
  - All processes are automated within trucks
  - Never premixed
  - Some premixed foam stored within 5-gallon buckets used for inductors on engines
    - Not used often
  - Process is completed within engine bays
  - Dry sumps within Engine Bays?
    - Old Fire Station 2 – drain within station flowed directly onto ground
    - Fire Station 1 – Drain within engine storage area

            - Trucks are parked on the south side of station
        - Fire Station 3 – Drain within engine storage area
            - Trucks stored on the east side of the station
- New Areas of Concern to take pictures:
    - Schwartz Road – North of the retention pond
    - Clam Shell area north of State Road 3 (Kennedy Parkway)
    - Area near Sharky Road
    - Southwest corner of the Hydrocarbon Burn Area (additional photos will be taken in this specific area)

AFFF Use at KSC 12/1/2020

Interview with Tim Moore, NASA Emergency Management and Fire Response conducted via Microsoft Teams

Also present: Mike Deliz (NASA), Anne Chrest (NASA), Matt Zenker (AECOM), Jennifer Joyal (AECOM), and Brittany Follett (AECOM)

- Pump test areas:
    - Old Fire Training Area – Hydrocarbon Burn Area
        - Focus on tree line area on northern area of the LOC
        - Dumping occurred ~1986-1989
    - Old Fire Station 2
        - 2 Trucks stored here
        - No flowing foam on-site
    - Starkey Road
        - Known as Center Hardstand Fire Station
            - Mobile home and buffer shed located here
            - Refraction tests potentially in this area
            - 55-gallon drums of AFFF stored here
    - Fire Station 2
    - Refraction Test – Used to track concentration of AFFF within tank
        - Time and distance test used
        - Just enough of AFFF used to get an accurate reading
- Storage of AFFF
    - Central Supply Facility
    - Contractors Road – Pesticide Area
    - Each fire station has 5-gallon buckets of AFFF
    - Station 3 has 55-gallon drums located on-site
- Spills:
    - ~20 gallons of AFFF was used off center after an accident located on 528 in 2010 or 2011
    - Morpheus – either the northern portion of SLF or the northeastern portion of runway
- Mixing
    - Done in fire station
    - Excess waste was sent away in trash

Interview with Terry White by Mike Deliz

5/28/21

Terry worked in the Orbiter Processing Facilities for before and after the Shuttle program for a total of 34 years. He began his thermal protection system (TPS) in 1979 and was the TPS subject matter expert (SME).

He was sent to Palmdale and worked in the machine shop for North American Rockwell as they built *Columbia*. The tiles were waterproofed in an oven and according to their origin design the waterproofing was supposed to last for 100 flights. However, it was soon realized after the first flight that the waterproofing was baked off of and out of the tiles during the heating of re-entry. The tiles were no longer waterproof and absorbed water as the orbiter sat on the runway or at the pad. The first water proofing method used on *Columbia* was the use of *Scothgard™* Brand Fabric Protector by the 3M company. *Scothgard™* in aerosol cans were purchased by the case to apply to the orbiters thermal protection system. "The cans were the same as what could be purchase off of the shelf in Lowes and sprayed on you couch", stated Terry. The *Scotchgard™* was applied by hand after the normal work shift in one (1) inch wide strips to the tile surfaces and all tile gaps. Its use was so plentiful that there was a "haze" in the OPF during the application and the product covered the technicians. They would joke that they were so waterproof they could walk across the river back to Titusville if the bridge was up and would not get wet. The aerosol haze was blown out of the OPFs with fans. Subsequent to the use of aerosol cans, a nitrogen bottle system was used to apply the *Scotchgard™* in a similar manner as it was more efficient than the cans based upon the multiple angles of spray. This waterproofing method was utilized from at least 1981 – 1986 with the first few flights of *Challenger*. Application methods were improved including the use of 4 foot by 8-foot work stands to assist in the application of the *Scotchgard™*. The method and product were changed though the first several flights of *Challenge*r. Challenger also utilized thermal blankets instead of tile on portions of the vehicle, that experienced similar problems, but they spray the blankets with the Scotchgard. Dimethyl ethyl silicate (DMES) was used to waterproof tiles through an injection hole in the tiles sometime after 1986. Terry was not clear of the when that happened, but that waterproofing method using 5 ccs of DMES per tile, remained in use for the rest of the Shuttle Program. I asked Terry about the fire suppression system in the OPFs and he stated it was originally halon and was converted to water. There were two accidental releases of water from the system that drenched the orbiters with "rusty" water as he described

We chatted about other things and I thanked him for his service to the country in his military and shuttle careers.

Supplement

6/7/21

I emailed Terry to get some clarification on the use of *Scotchgard™* and we talked this afternoon. *Scotchgard™* was delivered from the Logistics (I assume this was the Logistics Facility) by the pallet and stored in the breezeway between OPFs 1 and 2. OPF 2 was under construction and was not needed with one orbiter and OPF 3 was built at a later date. The breezeway was located in the current entrance and hallway area between OPFs 1 and 2. There were 12 cans of *Scotchgard™* in a case and cases were delivered by the pallet. Each tile was sprayed in a 1-inch wide swath in one direction and then the process was repeated perpendicular to the first application and then around the entire edge of the tile. A can of *Scotchgard™* lasted about 6 tiles and there were 32,000 tiles on *Columbia*. Terry stated that some of the tiles were 2 x 4 inches and others were 8 x 8 inches and every tile was sprayed with the *Scotchgard™*. The empty cans were disposed of in the garbage as they considered spent aerosol cans.

I asked him to further explain the nitrogen assist system and he stated that it was used to help in the application of the *Scotchgard™.* The system was utilized to maximize the flow out of a can during its use at multiple angles on the orbiter. If a can was held at an odd angle the amount of spray could become limited. It also helped the technician use most or all of the contents of the cans. The cans were pressurized, and the spray effectiveness was limited by the angle of the can during application, so the nitrogen helped push the spray were the technicians wanted it. He stated that it was designed by the lab folks in the Operations and Checkout Building.

Terry also talked about the fan system that was utilized to pull the vapors out of the OPF again and the stands the technicians used that were grated on the bottom and enclosed in film that had a hand hold cut in the top to allow spraying within 6 " of the vehicle. This helped prevent the technician from being covered with *Scotchgard™* when the sprayed the bottom of the orbiter.

Again, I thanked him for his service to the country.

AFFF Storage at the Central Supply Facility

- KSC Attendees:
  - Dustin Leinbach and Elizabeth Allen
- Began storage in 2017
  - No knowledge of where the buckets were stored prior to 2017
  - Approximately 300 - 5-gallon buckets brought into storage
  - No reported spills, damage or, releases reported in connection to these buckets
  - Fire Station Representatives Switched buckets to 55-gallon drums
  - 5 or 6 55-gallon drums and 100 5-gallon buckets are now stored on-site.
- Stored in building M6-0744
  - No drainage features located inside the building – sealed concrete floors
  - 1-story warehouse type building
  - Aviation hydraulic fluids and Teflon containing paints are stored within the same building as AFFF on pallets
- Stormwater drainage ditches are near the roads surrounding the building
- Additional building that potentially stores AFFF or other PFAS containing materials – K6-1547

PFAS Preliminary Assessment Questionnaire
Roads and Ground Facility Managers
Kennedy Space Center, Florida

Interviewee Name: Derick Fowler

Interviewee Title: Supervisor 11

Interviewee Email/phone number: Derick.c.fowler@nasa.gov

Interviewee Phone Number: 321-861 6297

Date/Time of Interview: 4/2/21

Interviewer: AECOM

➢ Buildings

1. Which areas (such as buildings, fuel, or hazardous waste storage areas) historically had stored or currently store Aqueous Film Forming Foams (AFFF)? None

2. To the best of your knowledge, have there been inadvertent releases of AFFF? If so, please provide additional details (such as when, in which hangars/buildings, quantification of release, and how the release was removed or cleaned up). NO

➢ AFFF Purchasing, Handling, and Storage

1. Was perfluorinated AFFF historically or currently used at the facility? If so, provide information regarding where and when. NO

2. Please provide type of foam (i.e. 3%, 6%, High Expansion Foam) and manufacturer (i.e. 3M, Ansul, Chemguard). N/A

3. Where has the AFFF solution been handled (currently and historically) (such as mixed, contained, transferred)? N/A

4. Where is AFFF stored at the facility (currently and historically), and in what approximate quantities? (Please show locations on map provided or describe locations). N/A

➢ Hydraulic Fluids and Specialty Paints

1. Does the facility assemble, manufacture, use, repair, or store high-powered equipment associated with the aerospace industry such as aircraft, rockets, or space shuttle currently or in the past? NO

   a. If so, please describe activities and timeframes these activities were conducted. N/A

   b. What types of hydraulic fluids are/were used (i.e., fire resistant, water or oil-based) at this facility? Include manufacturer and brand names.
   See Attached List.

   c. Where were they used/stored and how were they disposed of at the facility? N/A

   d. Please provide any other information regarding perfluorochemicals or substances of note. Products will have fluoro" in the SDS/MSDS chemical listing or product name. Please provide SDS/MSDS.

2. Were/are specialty paints or coatings used or stored at the facility? Specialty paints known to contain PFAS include antifouling, anti-graffiti, or anti-staining paints, and some latex paints. Were any flame-resistant paints used on aircraft/equipment or stored at the facility? NO

   a. Please list types of specialty paints used/stored at the facility and manufacturer brand names. N/A

➢ Location Information

1. If not already covered in previous questions, please provide any information on releases of AFFF that may have been diverted to or could have impacted the following items/areas:

   a. Stormwater conveyances/outfalls that drain roadways and aprons N/A

b. Stormwater management system (such as drainage swales, outfalls, retention/detention basins) N/A

c. Industrial or sanitary wastewater treatment system (such as storm drain, sanitary sewer, OWS, building and plumbing drains) N/A

d. Water supply wells (such as potable, agricultural, industrial) N/A

e. Large-scale disposal (such as landfilling, land application of Wastewater Treatment Plant sludge, washing, dumping) N/A

➢ General Information

1. Is there anyone else or other facility organization personnel that you would recommend we interview? Name, organization, position, phone number, e-mail. Glenn Willis
SC Jones Project Manager
christopher.g.willis@nasa.gov

2. Are there any other tenants/tenant organizations that currently (or historically) use AFFF? NO

3. Please provide any other information regarding perfluorochemicals or substances of note not in above list. Products will have fluoro" in the SDS/MSDS chemical listing or product name.

SITE SPECIFIC HAZARDOUS CHEMICAL LIST

SHP-F-1200B Rev. 1
8/20/2019

Facility:	M6-0486/K6-2096	Branch:	HEAVY EQUIPMENT
Date:	1/25/2021	POL #:	

Date Added	Product Name	MSDS #	Manufacturer
1/26/2012	REFRESH FLORAL AIR FRESHNER	43833	LHB INDUSTRIES
2/17/2012	KRYLON INDOOR/OUTDOOR WHITE PAINT	40504	SHERWIN WILLIAMS
3/12/2012	BR. WHITE INVERTED MARKING PAINT	44894	THE SHERWIN WILLIAMS CO
5/1/2012	STA A WAY INSECT REPELLANT TOWEL	46680	ZEP
7/10/2012	SPF 30+ SUN SCREEN TOWEL	40527	ZEP
10/24/2012	DELO 400 SAE 10W	36205	CHEVRON
11/20/2012	PERMA PATCH	B9965	NATIONAL PAVING CO
3/6/2013	PURELL ADVANCED INSTANT HAND SANITIZER	45093	GOJO INDUTRIES
6/26/2013	AIRSHEILD DIESEL EXHAUST FLUID	49317	ASHLAND
12/9/2013	E BOND EPOXIES 1240	38031	E BOND EPOXIES, INC
12/9/2013	E BOND EPOXIES 1241	38030	E BOND EPOXIES, INC
8/1/2014	REPEL 100 INSECT REPELLANT	48423	CHEMSICO DIV OF UNITED INDUSTRIES CORP
8/5/2014	THERMACELL MOSQUITO REPELLANT MATS	48908	ZOBELE INDUSTRIE CHIMICHE
10/22/2014	KRYLON INDUSTRIAL ENAMEL RED	41723	SHERWIN WILLIAMS
10/22/2014	ECO SURE INDUSTRIAL ENAMEL PAINT RED	50490	LHB INDUSTRIES
1/23/2015	PORTLAND CEMENT BASED CONCRETE PRODUCTS	43768	QUIKRETE
8/24/2015	oatey pvc heavy duty clear or gray cement -lo voc formula	48177	OATEY
8/24/2015	oatey canadian purple or clear primer nsf listed	52047	OATEY
6/13/2018	POULAN WEEDEATER 40:1 2 STROKE OIL	55490	HUSQVARNA
1/18/2011	WD-40 LUBE	5704	WD-40
1/18/2011	DIESEL FUEL	11619	VARIES
1/18/2011	GASOLINE	11616	VARIES

SITE SPECIFIC HAZARDOUS CHEMICAL LIST

Facility:	M6-0486/K6-2096	**Branch:**	HEAVY EQUIPMENT
Date:	1/25/2021	**POL #:**	

Date Added	Product Name	MSDS #	Manufacturer
1/18/2011	DURALITH GREASE EP NLGI 2	20493	CHEVRON USA
1/18/2011	DEEP WOODS OFF	27109	S.C JOHNSON AND SON
1/18/2011	STIHL LUBRICATING OIL	42693	SPECTRUM ACQUISTIIONS INC
1/18/2011	ECHO 2 CYCLE OIL	43092	CITGO PETROLEUM INC
1/18/2011	POWER PAINT CARTRIDGE	37092	FOX VALLEY SYSTEMS
1/18/2011	30W ENGINE OIL	11838	VARIES
1/18/2011	80W-90W GEAR OIL	2026	VARIES
1/18/2011	KROIL	1654	KANO LABORATORIES INC
1/18/2011	MEROPA 460 GEAR LUBRICANT	30532	TEXACO LUBRICANTS
1/18/2011	T-4 OPEN GEAR LUBE	47902	MOMAR
1/18/2011	CUTTER OUTDOORSMAN	41779	SPECTRUM ACQUISTIIONS INC
1/18/2011	TITAN 888	47901	MOMAR
1/18/2011	LUBRI-TEMP ANTI-SEIZE	13069	LAWSON
2/8/2011	WINDEX GLASS CLEANER	3592	JOHNSON
2/8/2011	ACE 2 CYCLE ENGINE OIL	45557	OLYMPIC OIL
2/21/2011	FLAT WHITE SPRAY PAINT	40504	KRYLON
2/21/2011	HEAVY DUTY OPEN GEAR AND WIRE ROPE	84	KRYLON
2/21/2011	HI TACK LUBEST GREASE	47902	MOMAR
5/26/2011	3M ULTRATHON INSECT REPELLANT 8	46588	3M
8/16/2011	BLUE DEP	48318	OLD WORLD INDUSTRIES INC
12/7/2011	WHITE AEROSAL SPRAY PAINT	132040	SHERWIN WILLIAMS
11/17/2011	SPRAY NINE	48287	SPRAY NINE

SITE SPECIFIC HAZARDOUS CHEMICAL LIST

Facility:	M6-0486/K6-2096	**Branch:**	HEAVY EQUIPMENT
Date:	1/25/2021	**POL #:**	

Date Added	Product Name	MSDS #	Manufacturer
118796	SUN X SPF 30 SUNSCREEN	118796	CORETEX PRODUCTS
	Apex hand sanitizer		Apex offense
	Triple Quick disinfectant		State indutrial prdcts/State Chemical /State ind Armor research
	isopropyl alcohol di water 70/30 wipes		JNJ Inductries inc
	hyrdra pearl hand sanitizer		hand sanitizing Products

Pesticide Use at KSC 12/1/2020

Interview with Glenn Willis, KGPC conducted via Microsoft Teams

Also present: Mike Deliz (NASA), Anne Chrest (NASA), Matt Zenker (AECOM), Jennifer Joyal (AECOM), and Brittany Follett (AECOM)

- All pesticide / herbicide storage on Contractors Road
  - 3 tractors stored on Contractors Road
    - 500-gallon tanks
  - Buildings have impervious floors with a mixing area in the back
- Brevard County will come on Center when needed to apply pesticides / Herbicides
- Where are the application areas?
  - 100 feet away from water areas
  - Fogging in areas where people are working
  - Applied in areas that are rocky / by fence lines
  - Not applied around buildings
  - All applications are based on ounces per acre
- Indicated that Fluoro compounds were not used as the main ingredient in pesticides / herbicides
  - Majority of the compounds will be food grade
  - Switched to water based chemistry in 2005
- Application schedule – 4 times a year
  - After the use of Esplanade, the application area is less than 2 times a year
- Treatment for Bees/Wasps – Soap compounds
- Sulfluromid – Not used
- LPOS – Not sure of usage
- Round up

AECOM Imagine it. Delivered.

Minutes

Meeting name Pesticide Application at Kennedy Space Center and Vicinity	**Meeting date** March 17, 2021	**Attendees** Joseph Faella; Director; Brevard County Mosquito Control (BCMC) Julie Black; Administrative Assistant BCMC Steve Whitt; North Area Supervisor BCMC Mike Buono; Ground Operationss Superintendent BCMC Jennifer Joyal; AECOM Brittany Follett; AECOM Matthew Zenker; AECOM
Time 10:30 AM	**Location** Phone Call	
Project name PFAS Investigation at Kennedy Space Center, Florida	**Project number** TQN-19F0072	
AECOM project number 60615673	**Prepared by** M. Zenker	

Pesticide Application on Merritt Island/KSC

On the east side of the Max Brewer Bridge, BCMC only applies the following larvicides within the mosquito impoundments under its control; no adulticides are utilized in these areas:

- VectoBac® - 12 lbs/acre up to 20 lbs/acre applied via helicopter as solid granules (*AECOM note: this is a bacterial product*)
- Altosid® (methoprene active ingredient) XRG (extended release) or SBG2 single brewed formulation applied via helicopter as solid briquets

JF mentioned that BCMC helicopter went to launch pads and distributed briquets (once); date not mentioned.

Mosquito Impoundment Management

BCMC manages the water levels in many mosquito impoundments. Many impoundments have pumps and/or have culverts with flashboard risers to control water levels. Impoundments are typically closed (flooded) from Spring to Fall to limit larvae hatching. Valves are typically opened in Winter to allow for fish migration. Mosquito impoundments are also periodically stocked with mosquitofish that consume larvae.

Other impoundments are managed by either the US Fish and Wildlife Service or the St. Johns Water Management District. The US Fish and Wildlife Service is mainly interested in controlling water levels based on waterfowl (not mosquito control); the St. Johns Water Management District is more interested in water quality and wildlife habitat (not mosquito control).

Adulticide Application Methods and Areas

Adulticides are applied on mainland and southern portion of Merritt Island (off Center). The application requires justification based on mosquito traps and sentinel chickens. Mosquito traps are counted for number and species of mosquito, chickens are tested for viral diseases. The application zones and recent application dates are tracked on Brevard County GIS portal. https://brevardbocc.maps.arcgis.com/apps/PublicInformation/index.html?appid=985ed67f3e6042f9a2095954e7887adc

Adulticides are applied either by a truck or a helicopter using an ultra low volume (ULV) applicator. The ULV applicator distributes adulticide as a mist to minimize ground deposition and adherence to mosquitoes. These products are applied at a rate of approximately 1 ounce per acre. The products used include:

- Kontrol™4-4 (permethrin active ingredient)
- DIBROM® (naled active ingredient); distributed at approximately 0.6 ounces per acre

PFAS in Pesticide Products

BCMC is aware of recent USEPA announcement concerning the potential presence of PFAS in fluorinated HDPE liners typically used to store insecticides. BCMC has received a letter from manufacturer of DIBROM® stating that the 30 gallon plastic containers used for shipping are not fluorinated. (*AECOM note – received via email on 3/17/21*). BCMC has received verbal statement from manufacturer of Kontrol™4-4 on this issue, but no written response.

BCMC does have some stock of Anvil® 10+10, which is named by USEPA as containing PFAS due to fluorinated HDPE liners. BCMC has one stainless steel tote of Anvil® 10+10 but have not used it. This tote does not have a plastic liner.

One HDPE drum of Anvil® 10+10 is in the BCMC southern office in Valkaria. BCMC is not actively using it, but there are records of its use in southern portion of Brevard County in 2012. There is no record of using it in the vicinity of Titusville.

BCMC has four, 30-gallon drums of AquaAnvil™, made by the same manufacturer (Clarke). These are plastic drums but have never been used. They are under discussions with manufacturer about returning these products.

Use of Sulfluramid

BCMC is not aware of ever using sulfluramid.

Ref	Action	Responsible
01	BCMC to provide maps of mosquito impoundments under their jurisdiction and dates when culverts opened/closed in last year.	BCMC
02	BCMC to forward letter stating that fluorinated liners are not used for Kontrol™4-4.	BCMC
03	BCMC to provide record of communications with Clarke regarding return of Anvil products.	BCMC

VESERIS™

March 17, 2021

To Whom It May Concern,

Re: PFAS

In light of the EPA action plans regarding the PFAS issue, Veseris has conducted a review of our MasterLine® products that are manufactured in the USA:

- Aqua-Kontrol 30-30
- Kontrol 4-4
- Kontrol 30-30
- Kontrol 31-67
- Kontrol Larvicide Oil

It has been conclusively determined that these products are sold in containers that are not fluorinated, including the 275 gallon totes, 55 gallon drums, 30 gallon drums, 2.5 gallon jugs, 1 gallon jugs or 1 quart bottles. The steel drums and steel totes do utilize a polymer coating to prevent corrosion, but this coating does not utilize fluorination in the compound.

Veseris remains committed to following the issues relating to PFAS contaminations to ensure our valued customers have the products they need to continue protecting the communities they serve from vector-borne diseases.

More extensive information can be found on the Environmental Protection Agency page dedicated to PFAS issue at **https://www.epa.gov/pfas**

Please contact me via email or phone if you have any additional questions.

Regards,

TJ Shelby
Specialty Business Manager
VESERIS
P: (801) 386-0843
tj.shelby@veseris.com

January 29, 2021

To Whom It May Concern

Ref : EPA Actions to Investigate PFA's

AMVAC Environmental Products , along with our Industry peers and multiple trade associations are engaged in many discussions pertaining to the recent EPA guidance documents and actions on a specific public health product.

The communication suggests that this is a supply chain issue with a focus on the fluorination of containers. We also understand that the EPA is conducting further studies and developing methodologies.

As we continue to learn more about the direction the EPA is taking and position of the Industry on necessary actions, we will share those updates. It should also be noted that communication is also occurring between the Federal EPA and State agencies to ensure transparency exists.

All companies are following the product stewardship directive to better understand their products and packaging specifications.

However, in response to a direct enquiry, AMVAC is confirming that the 30-gallon plastic containers currently used to ship both DIBROM® concentrate and TRUMPET® EC are NOT fluorinated.

Sincerely,

John G. Smith

Vice President, Commercial Operations
AMVAC Environmental Products

January 29, 2021

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Please contact me via email or phone if you have any additional questions.

Regards,

TJ Shelby
Specialty Business Manager
VESERIS
P: (801) 386-0843
tj.shelby@veseris.com

Pollution Incident Report

Date Of Incident:	11/2/2006 2:00:00 PM
Reported By:	E. L. Coyle
Contact Phone:	1-5319
E-Mail Contact:	
Organization:	SGS WasteOpns
Substance Material:	Fire Fighting Foam
Amount Released:	20 gal.
Incident Location:	M6-486, South Tarmac
Description:	A mixture of water and fire foam agent discharged from fire engine plumbing when Heavy Equipment mechanic opened the system to repair it. An internal failureoccurred which allowed liquid to seep into an area of plumbing that should have otherwise been dry.

Environmental Impact

Stormwater Ditch:	**Paved Area:** ✓	**Air Emission:**	**Stormwater Sewer:**
Grass/Soil:	**Direct Discharge to SurfaceWater body:**	**Domestic Sewer:**	**Secondary Containment:**
Abandoned Waste/Materials:	**Other (Explain below):**		

Impact Explanation:

Cause of Incident

Equipment Failure:	**Operator Error:**	**Transportation Accident:**	**Unknown:**	**Found on Station:**
Other:				

Cause Details:

Equipment Failure

Notifications Made

911: ✓	**NASA Environmental Spill Line (867-9005):** ✓	**Other (Explain below):** ✓

Notification Details:

Called: Support Operations (853-5211), Environmental Health (867-7138)

Spill Category

Petroleum Based:	**Fuel:**	**Industrial Wastewater:**	**Gas:**	**Other:**

Action Taken

Action Taken:	Mechanic contained the liquid on the pavement with spill socks and boom.
Cleaned up within 24 hours:	Yes
Clean-Up By:	JBOSC PESCT Kim Lucks Team Lead
Date Created:	11/3/2015 5:06:39 PM
Created By:	DataMigration
Date Modified:	
Modified By:	

Attachments

No attachments are included with this incident report.

Incident Review

Responsible Org.:	n/a
Distribution List:	
Substance Material:	Fire Fighting Foam
Identifyable:	No
Clean-Up Required:	Yes
Clean-Up By:	JBOSC PESCT
Follow-Up Required:	No
Follow-Up Assigned:	

Additional Notifications Made

FDEP:	**Brevard County:**	**SJRWMD:**	**NRC:**
SWP:	**NASA HQ:**	**RQ:**	

Comments:	[FileNet V1 Index: 381]
Date Closed:	11/8/2006 12:00:00 AM
Reviewed By:	P. Lynn/TA-C3
Date Created:	11/3/2015 5:06:39 PM
Created By:	DataMigration
Date Modified:	
Modified By:	

Progress Status History

Date of Status Change	Activity	Initiated By
11/3/2015 5:06:39 PM	Report Submitted	DataMigration
11/3/2015 5:06:40 PM	Report Accepted for Review	DataMigration
11/3/2015 5:06:41 PM	Review Completed	DataMigration

A service of the NASA/Kennedy Space Center Occupational Heath and Environmental Services Team (version 3.7.7674)

hsg HERNDON SOLUTIONS GROUP™

Waste Management

Post Emergency Spill Cleanup Action Report

Spill Tracking#: *200500269*
Spill Date: *Thursday, November 2, 2006*
Spill Time: *14:00*

Spill Location: *M6-0486 Base Support*
Responsible Party: *SGS*

Emergency ☐
Non-Emergency ☑

Cleanup Organization/Phone: *SGS Waste Management* *853-6983*

Type Of Spill:
Industrial Wastewater

GPS Coordinates

Latitude(Northing): DMS N
Longitude(Easting): DMS W

Datum of Coordinates: WGS84

Incident Description:
Mixture of water and fire foam agent discharged from plumbing when heavy equipment mechanic opened system to repair control valves.

11/06/06 CH
Incident Number: 200611A005
Incident Description & Contact Information
Contact Information
Submitted By: Edward Czarniak
Phone: 867-4030 Perf. OBS: B.2.7.2.40 Mail Code: CMT-077
Incident Details
Case Manager: GARY CORFITZSON
Submitted On: 11/02/2006 02:12 PM
Date/Time of Incident: 11/02/2006 01:30 PM
Location: Kennedy Space Center Exact Location: M6-486
Incident Description: Release of Foam From Fire Truck
Direct Cause: Defective valve in Firetruck
Contributing Cause: Removal of pressure valve on truck

Commodity Spilled/Amount: *Industrial Wastewater* *20 Gallons*

Notified By/Time: *SGS Duty Office* *14:30*

SurfaceType: *Pavement*

CleanupBrief:
Mechanic isolated water based spill on pavement with spill socks. FSA1 techs xferd fire foam concentrate from fire engine into drums for reuse after system repairs have been completed.

Waste Generated: *10 gallons contaminated socks*

Waste Disposition:
Bulked with like material

Response Time: *30 min*

Spill Team Leader: *Kim Lucks*

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