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:

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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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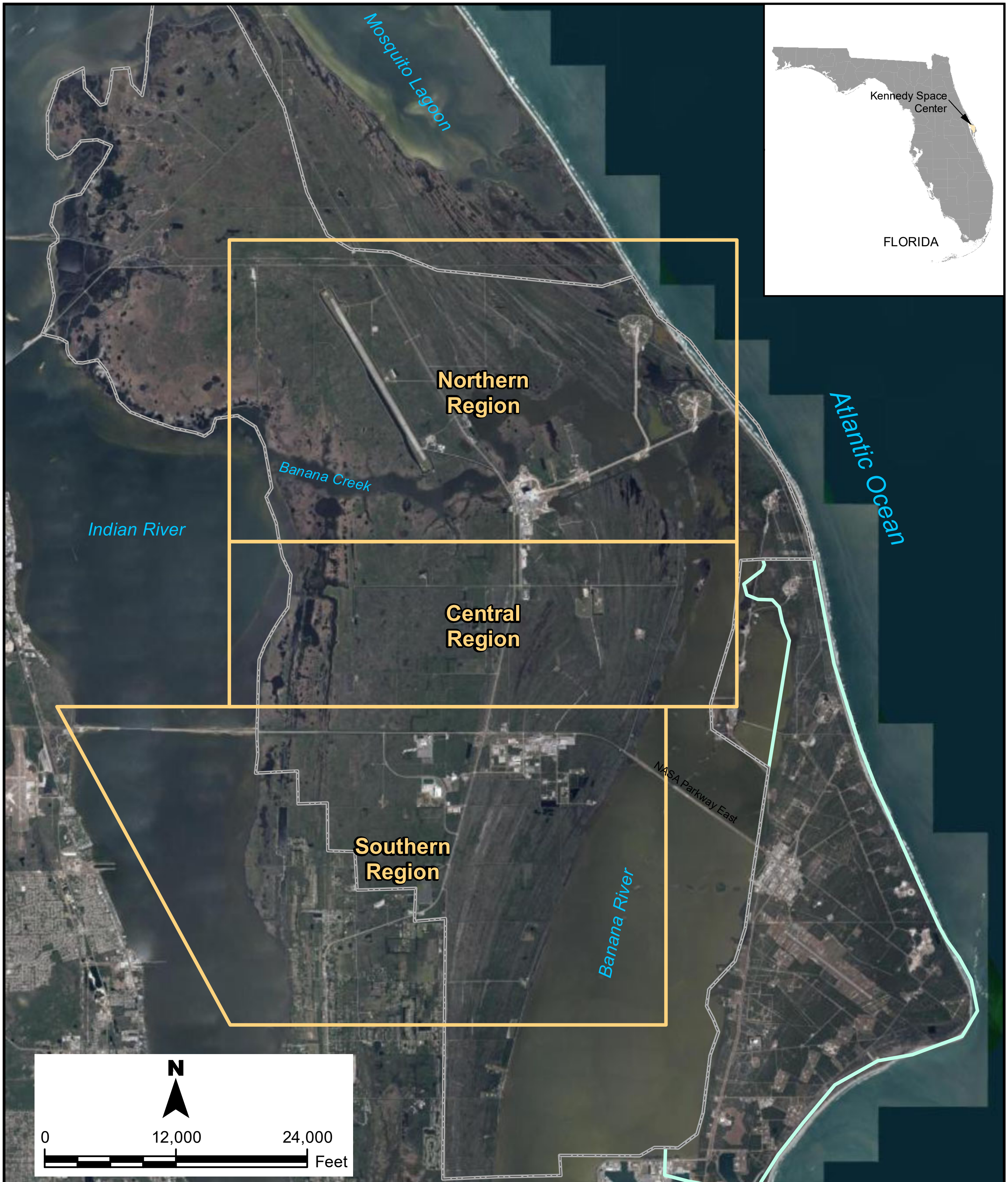

Legend

- 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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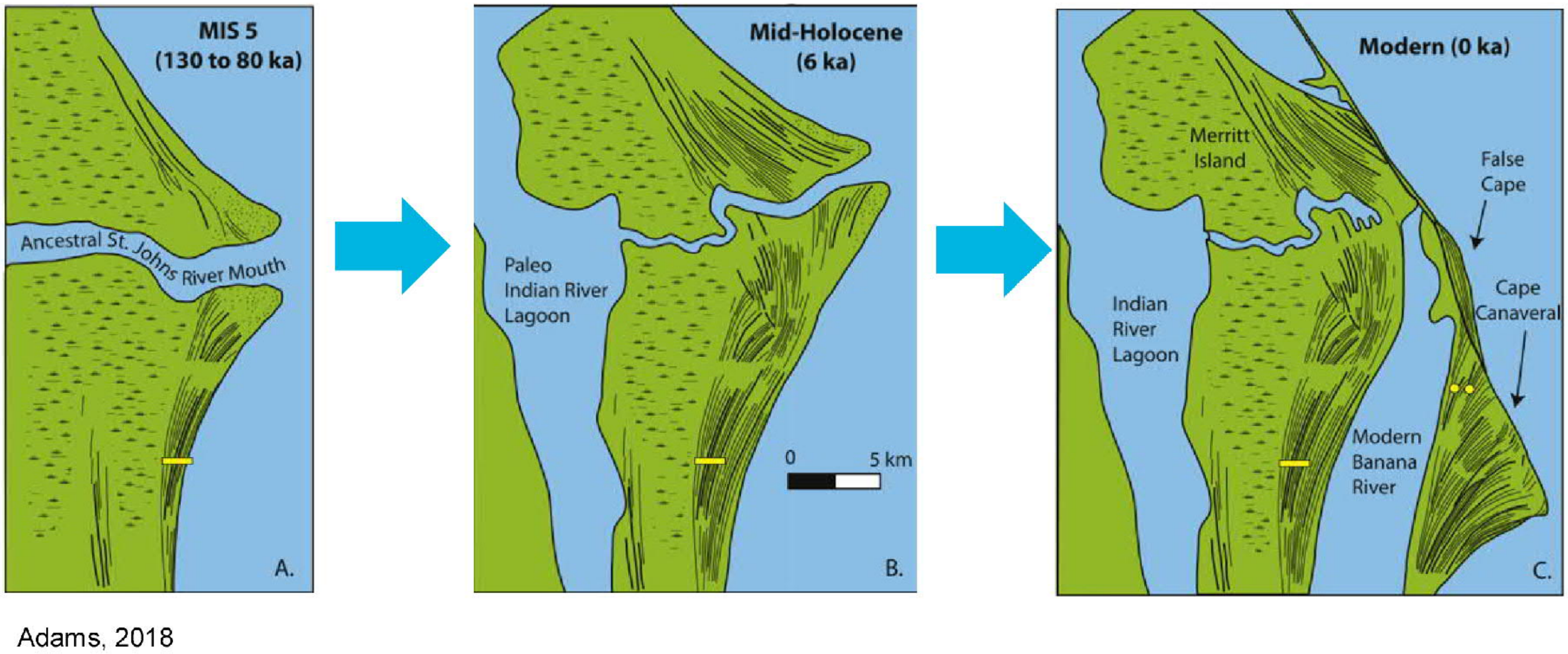

Evolution of the Merritt Island-Cape Canaveral Sedimentary Complex (MICCSC) since 130 ka.

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

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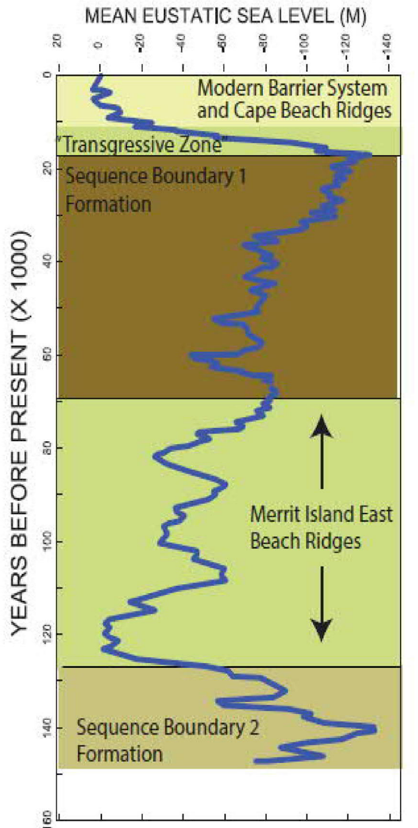
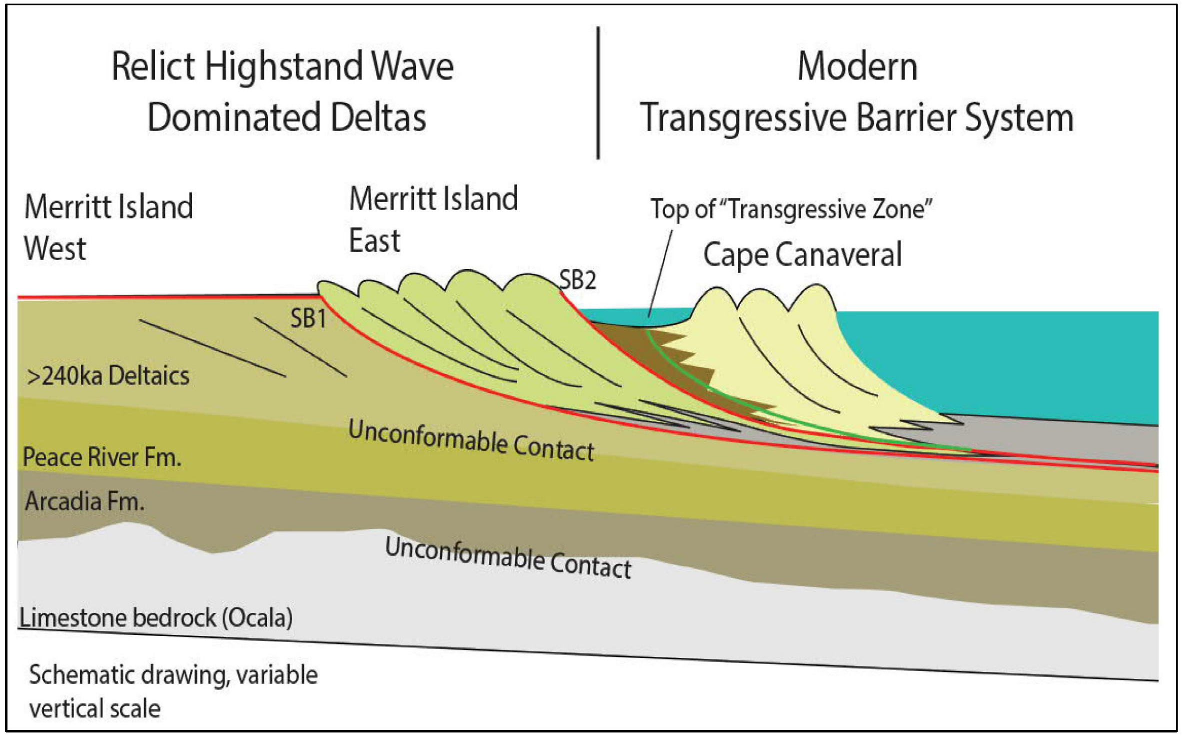


(Sea Level Curve From Shackleton, 1987)

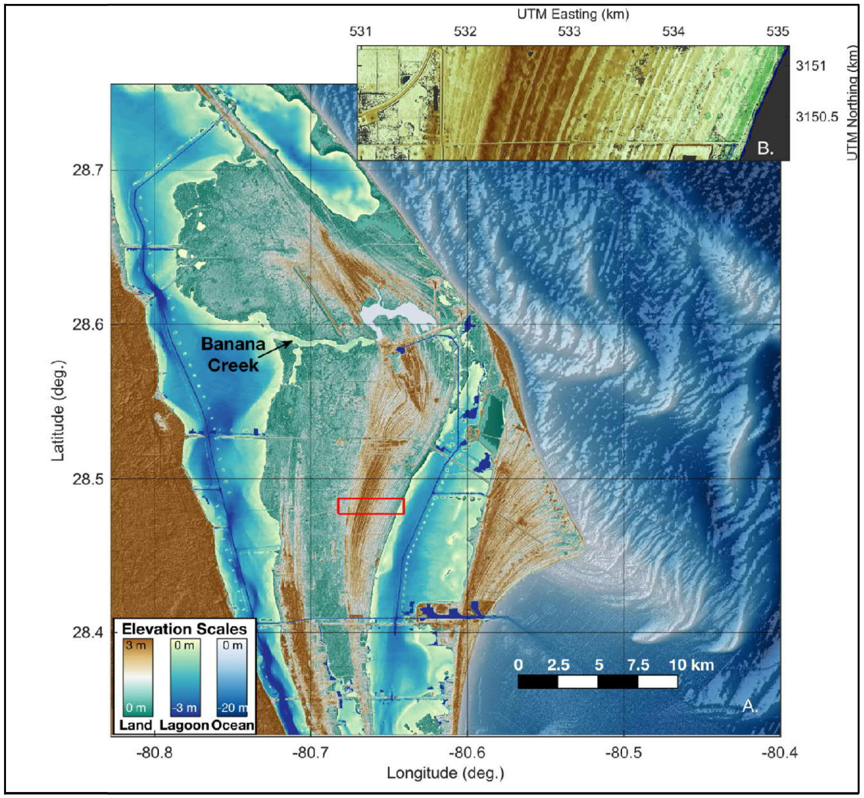


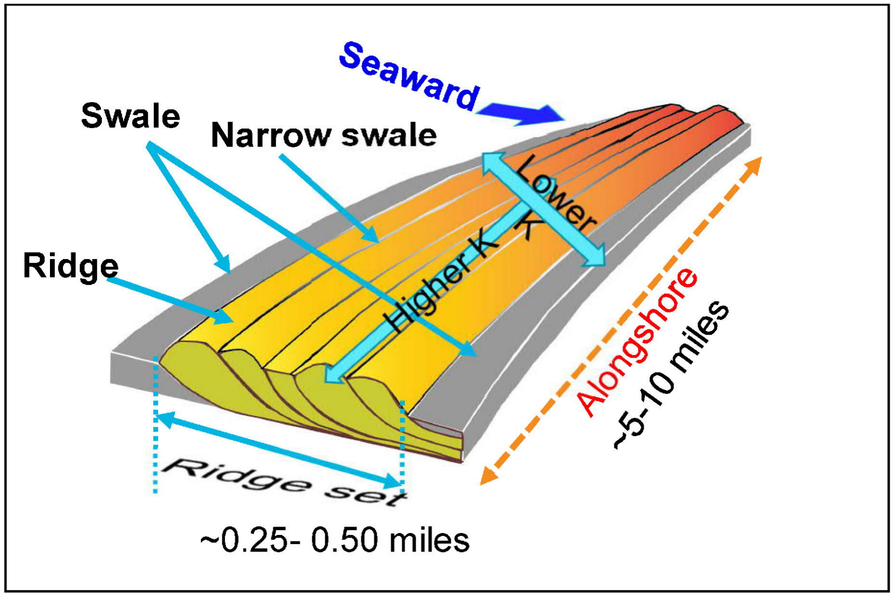
Adams, 2018

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



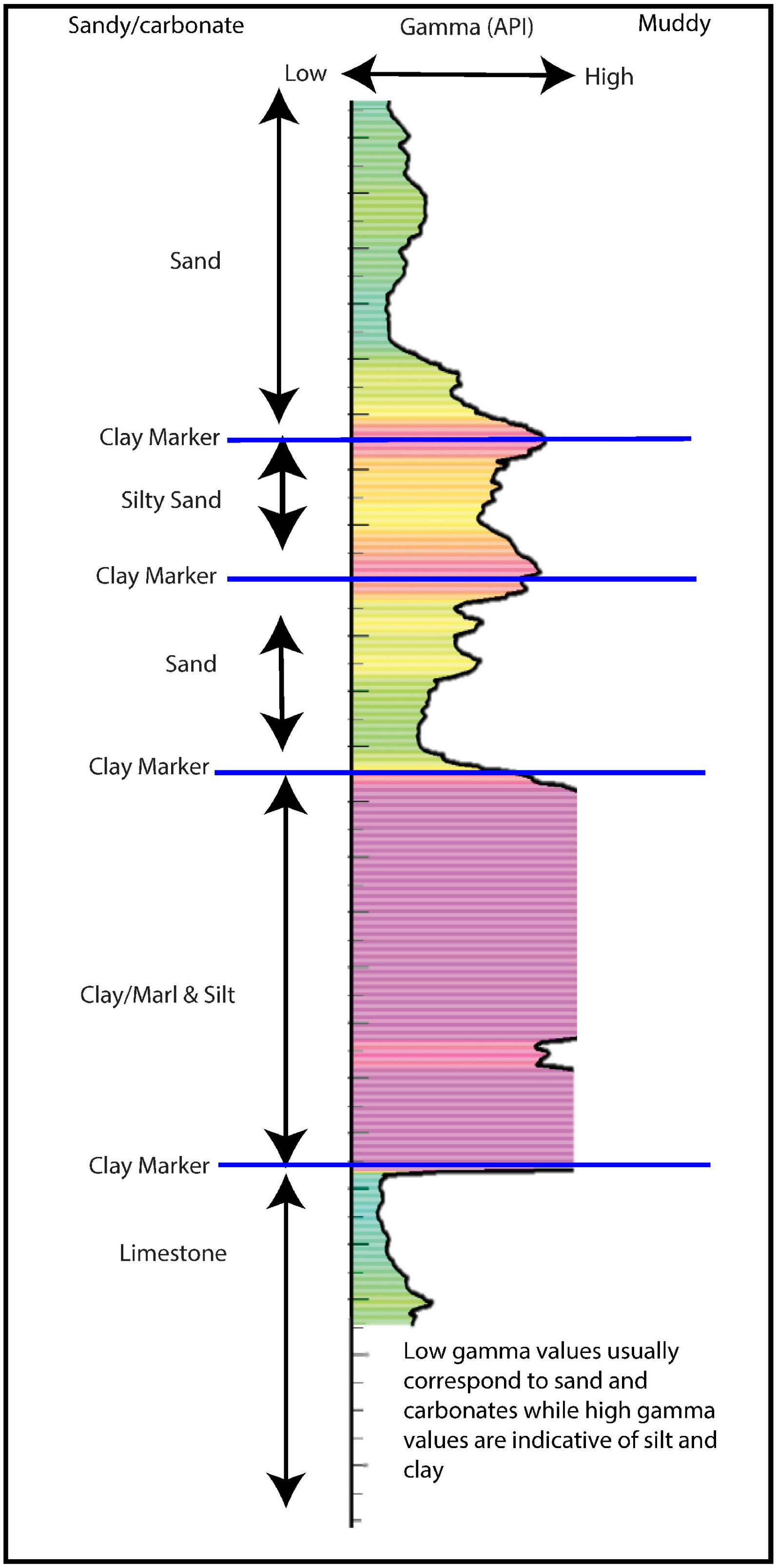


NOAA DigitalCoast website: https://coast.noaa.gov/dataregistry/search/collection

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

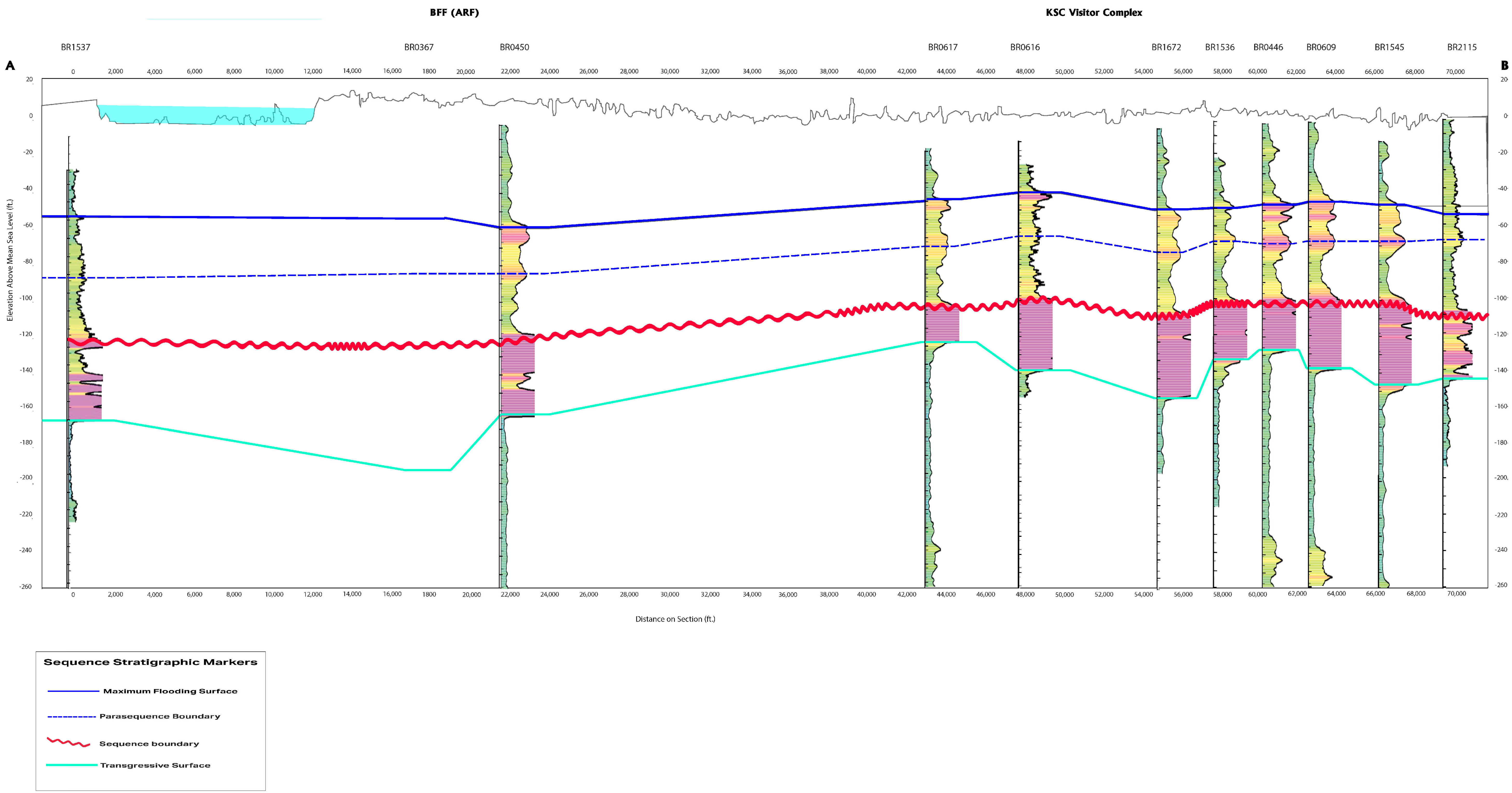
NASA Kennedy Space Center, Florida



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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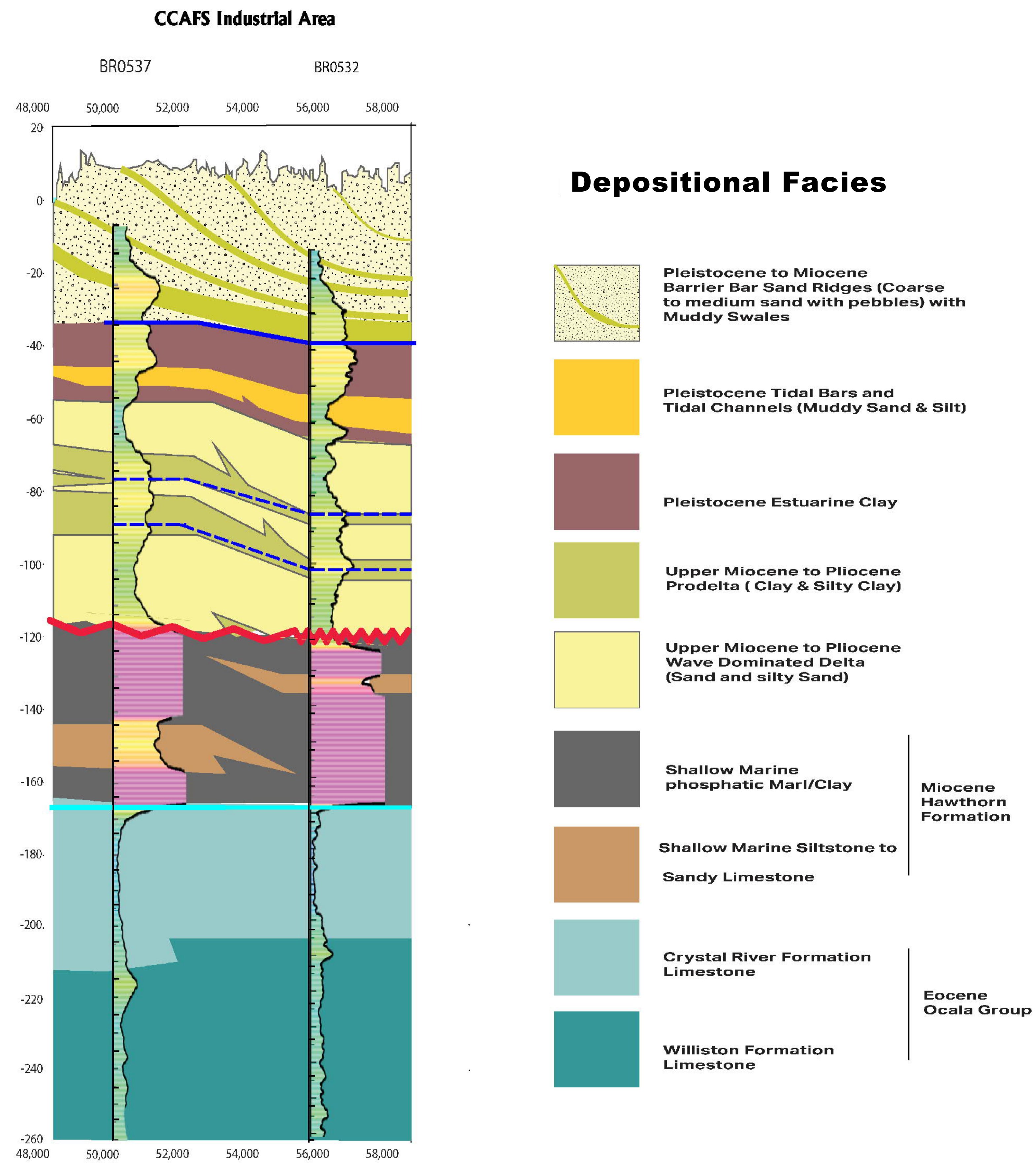

Notes:
1. NASA indicates National Aeronautics and Space Administration.
2. Gamma logs derived from Cape Canaveral Air Force Station Industrial Area.
3. ft amsl - feet above mean sea level
4. BR0537 - gamma log identifier

FIGURE 2-6
Example of Identified Depositional Facies

NASA Kennedy Space Center, Florida

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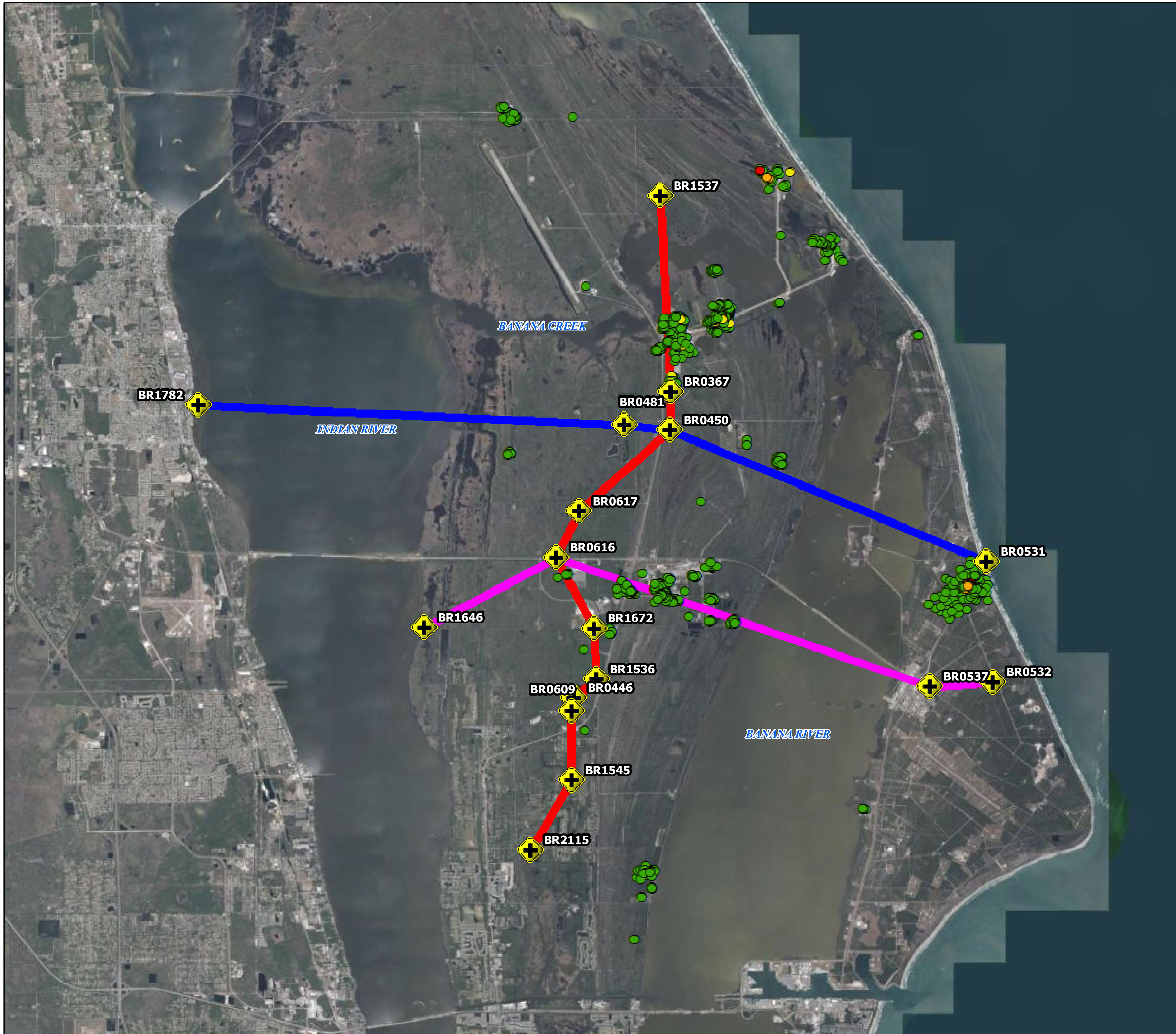

Legend

Existing Gamma Log Well Location

Existing Well Location and Depth (bls)

- 0-50
- 50-70
- 70-100
- 100-125
- Section A-A'
- Section B-B'
- Section C-C'

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

N

0 5,000 10,000 20,000 Feet

FIGURE 2-7
Regional Subsurface Geology Cross Section Transects

NASA Kennedy Space Center, Florida

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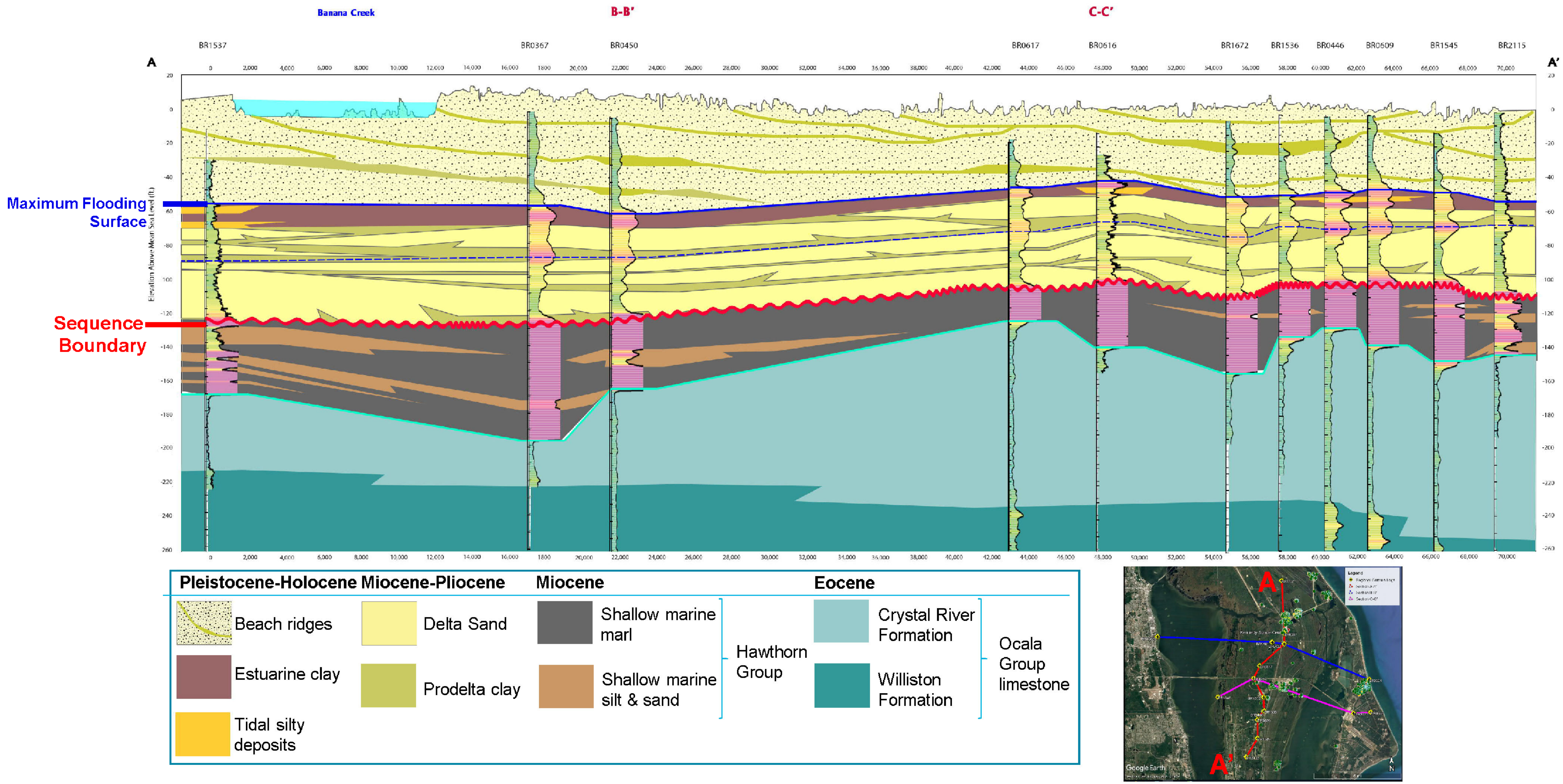

Notes:
1. NASA indicates National Aeronautics and Space Administration.
2. BR1537 - gamma log identifier
3. ft. - feet

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

NASA Kennedy Space Center, Florida

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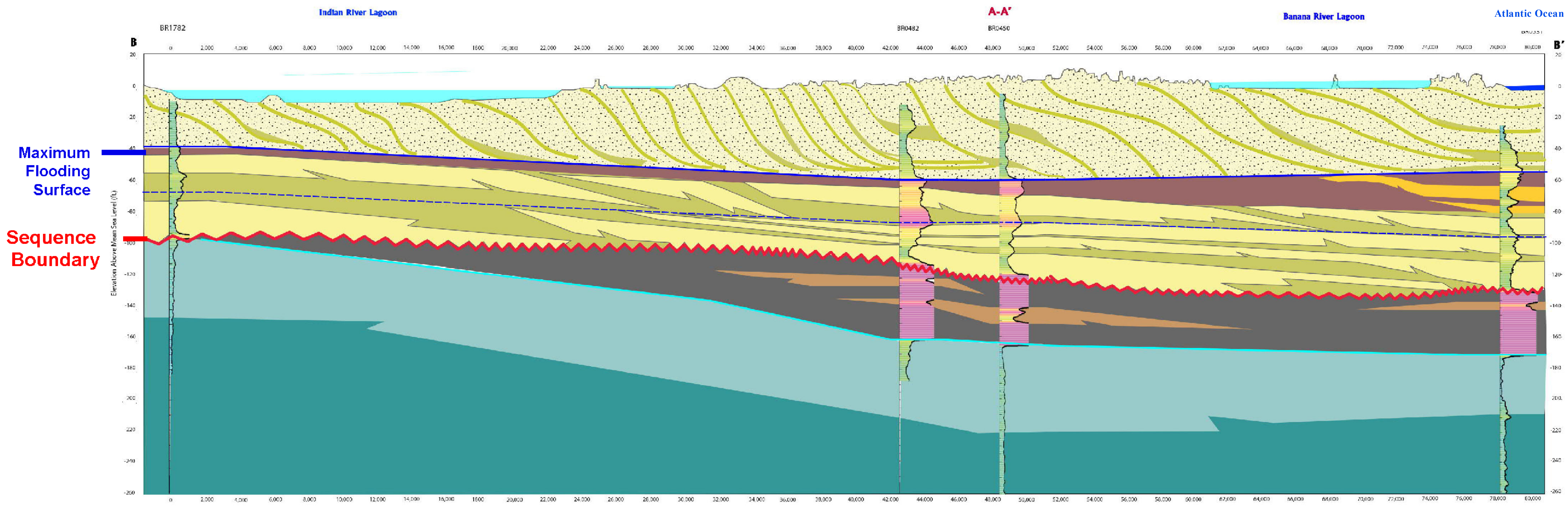

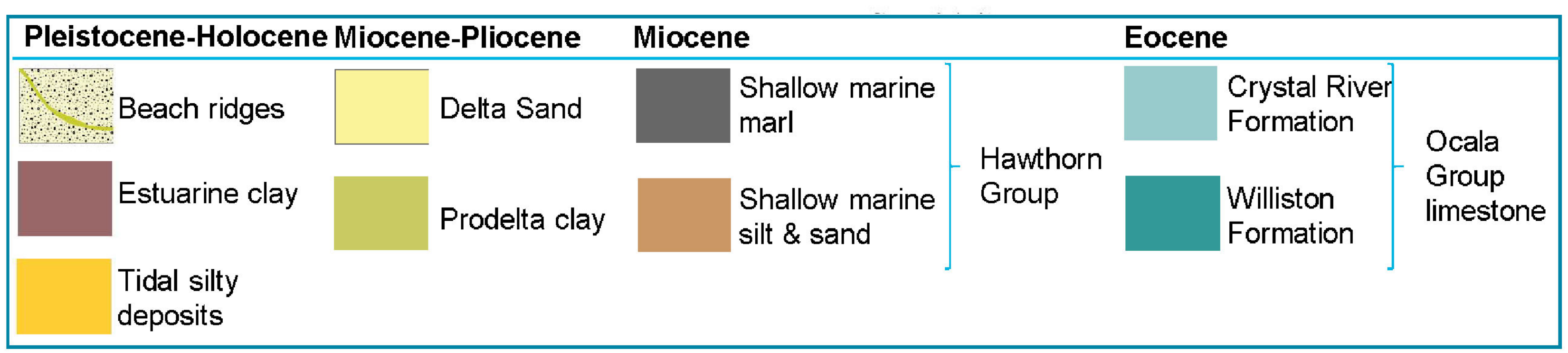

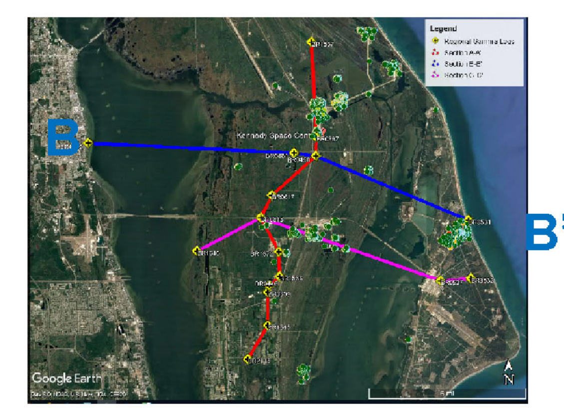

Notes:
1. NASA indicates National Aeronautics and Space Administration.
2. BR1537 - gamma log identifier
3. ft. - feet

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

NASA Kennedy Space Center, Florida

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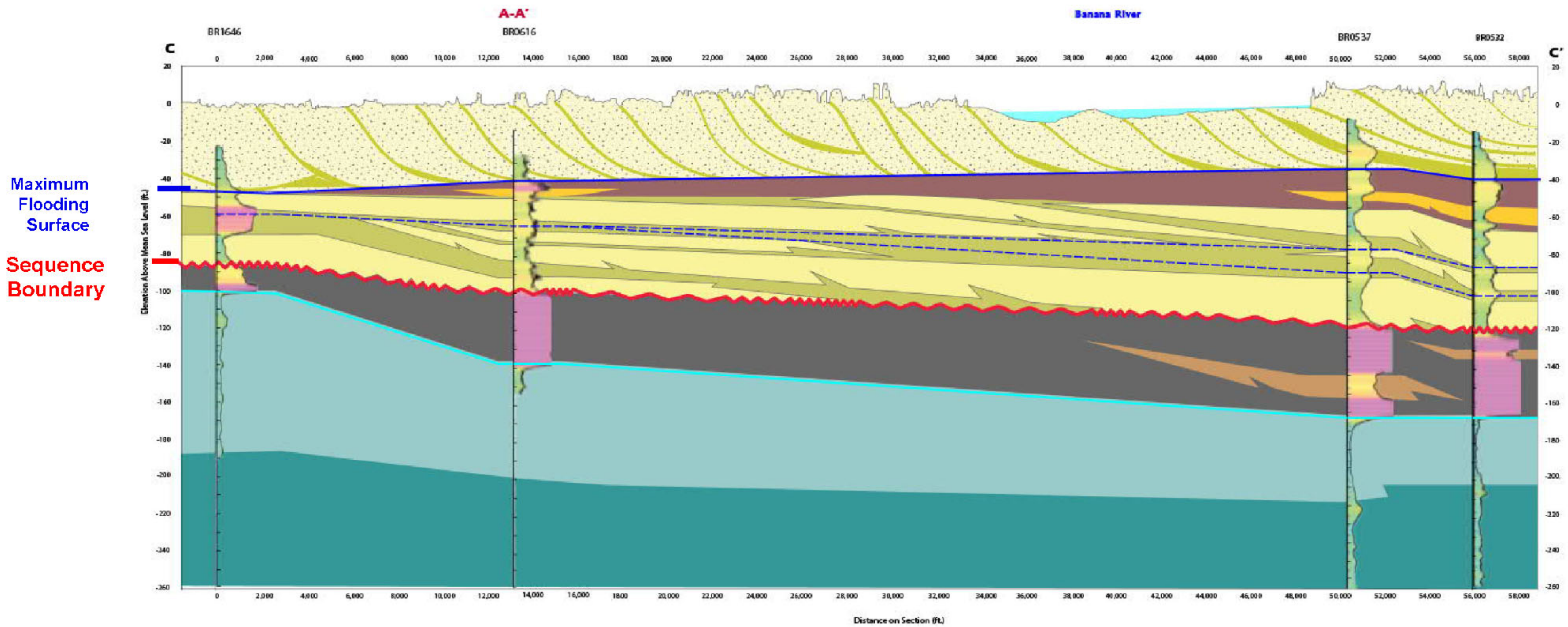
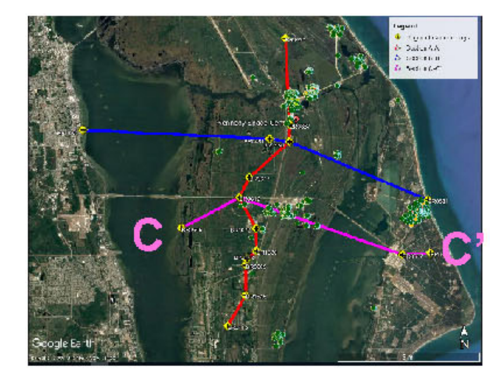


Pleistocene-Holocene	Miocene-Pliocene	Miocene		Eocene	
Beach ridges	Delta Sand	Shallow marine marl	Hawthorn Group	Crystal River Formation	Ocala Group limestone
Estuarine clay	Prodelta clay	Shallow marine silt & sand		Williston Formation	
Tidal silty deposits					



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

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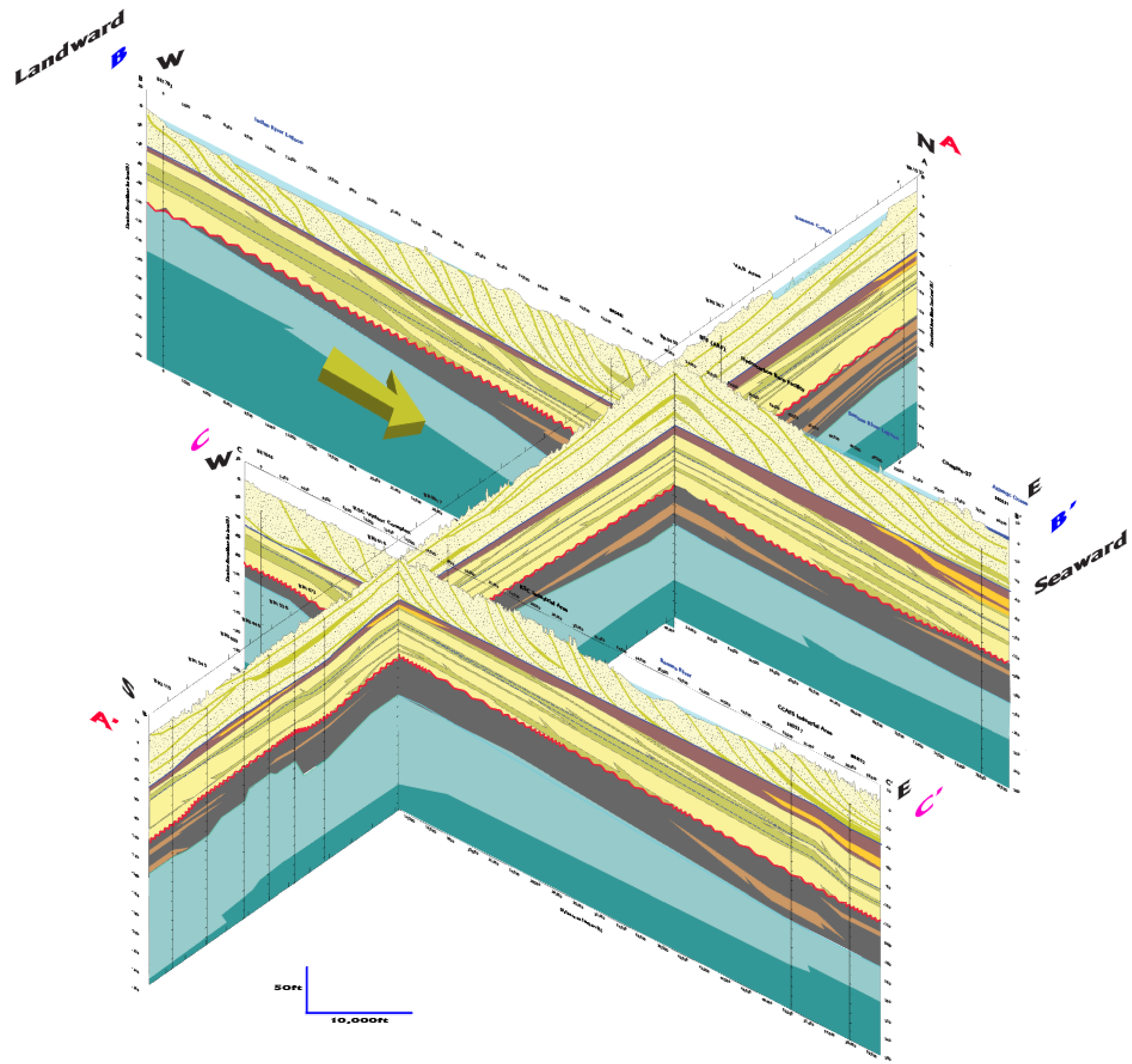
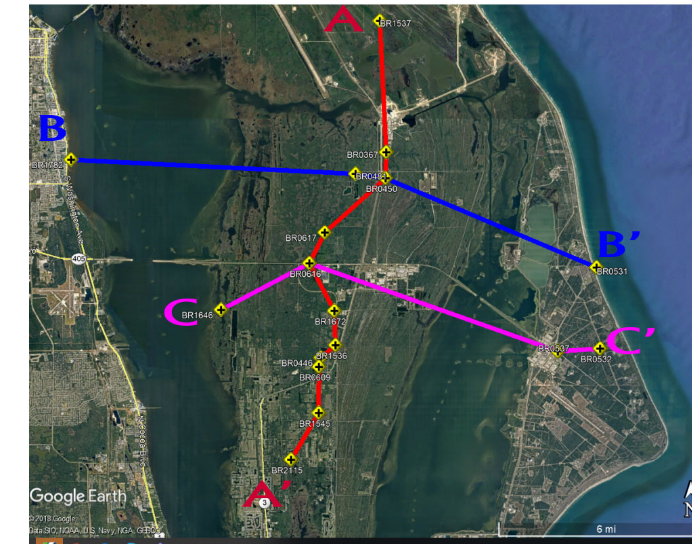




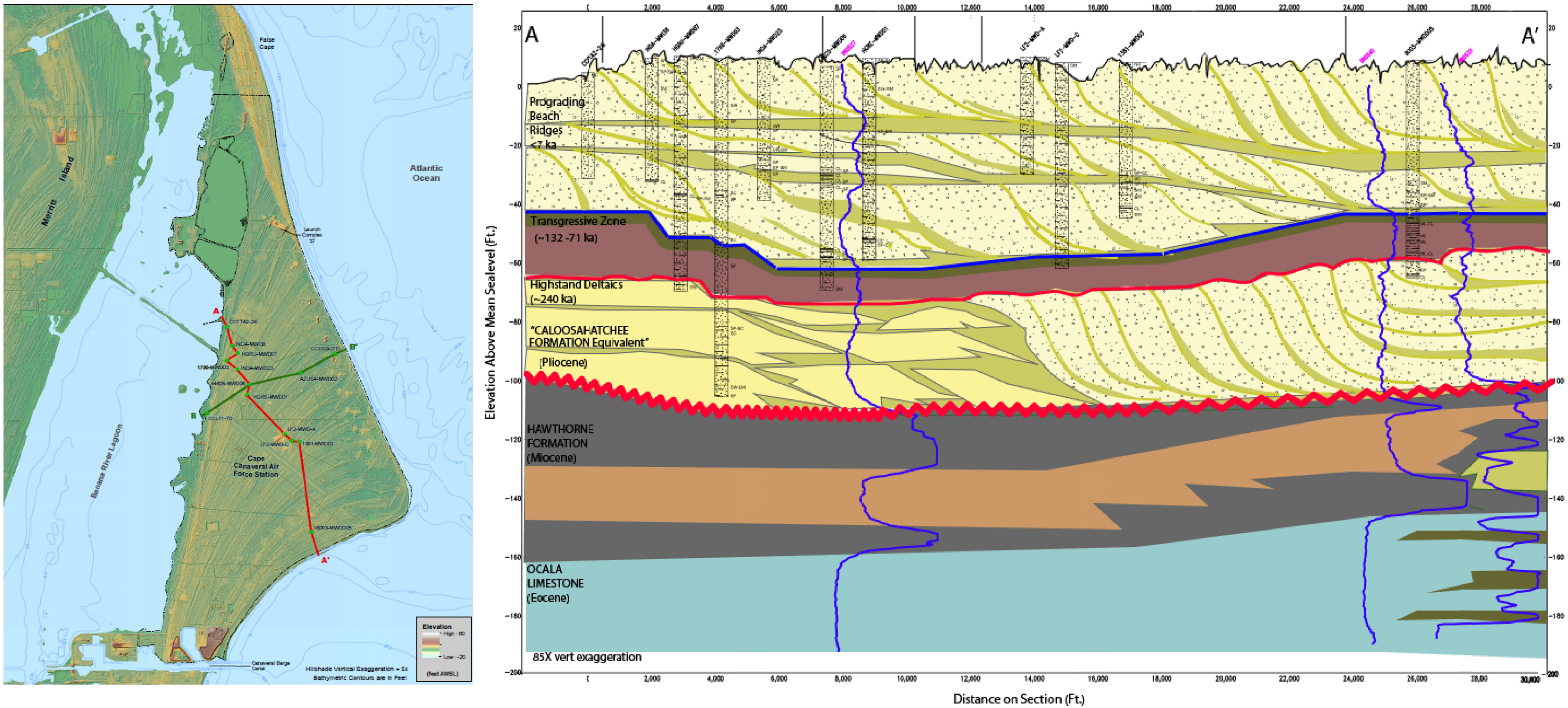
Legend

- 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



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

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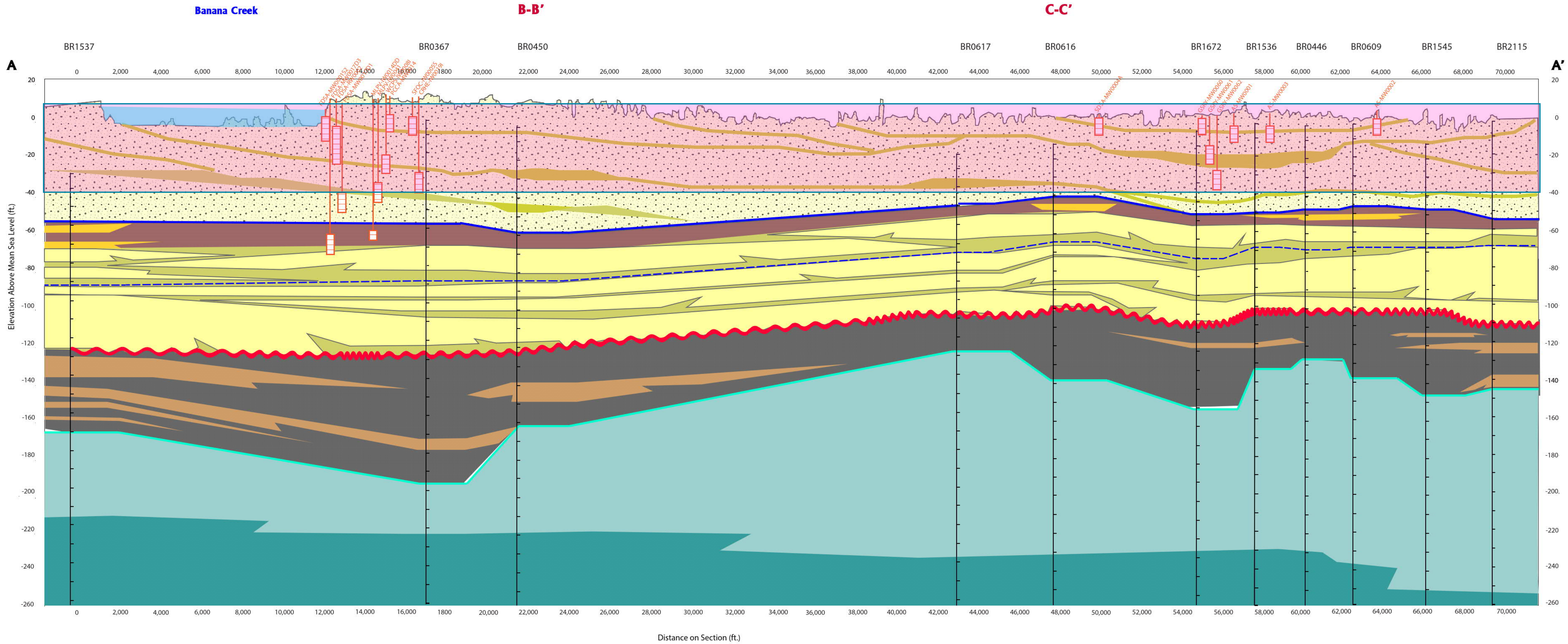


Existing Monitoring Well PFAS

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			

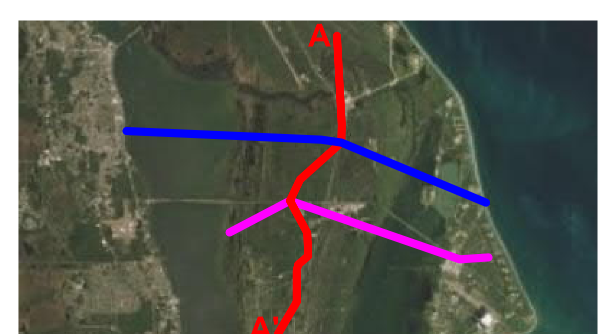
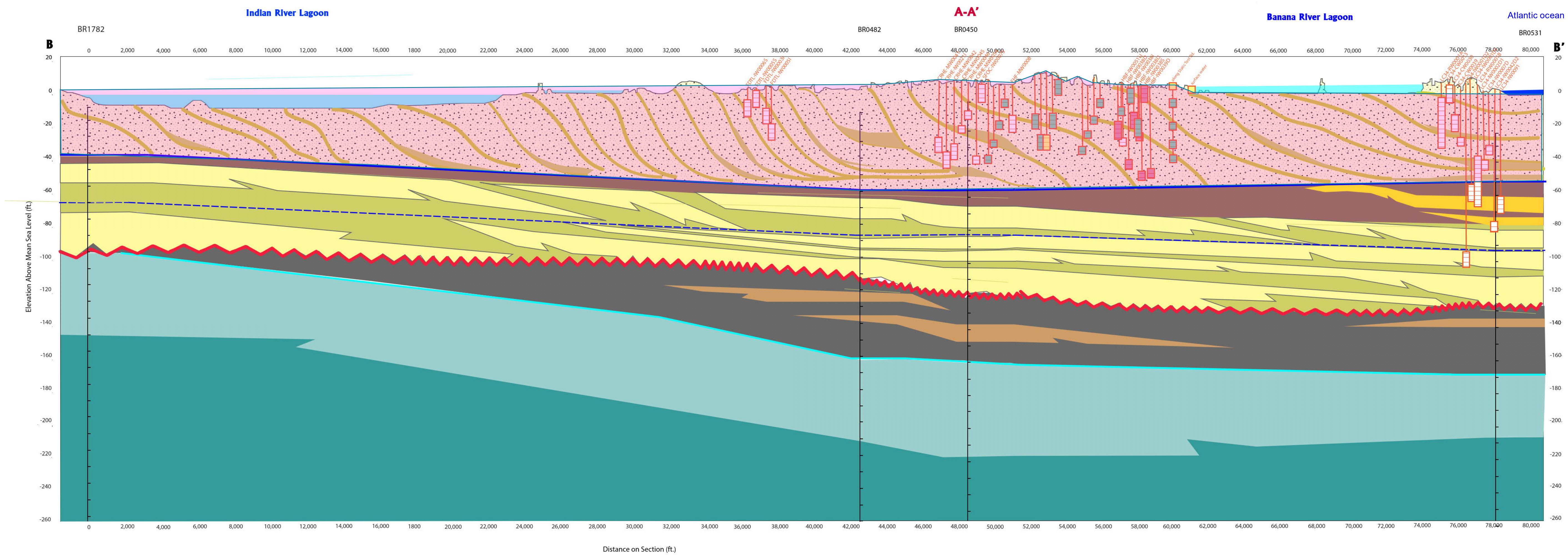


FIGURE 2-13
Regional Subsurface Geology Cross Section A-A' with Monitoring Wells

NASA Kennedy Space Center, Florida



Existing Monitoring Well PFAS

Total PFAS ng/L

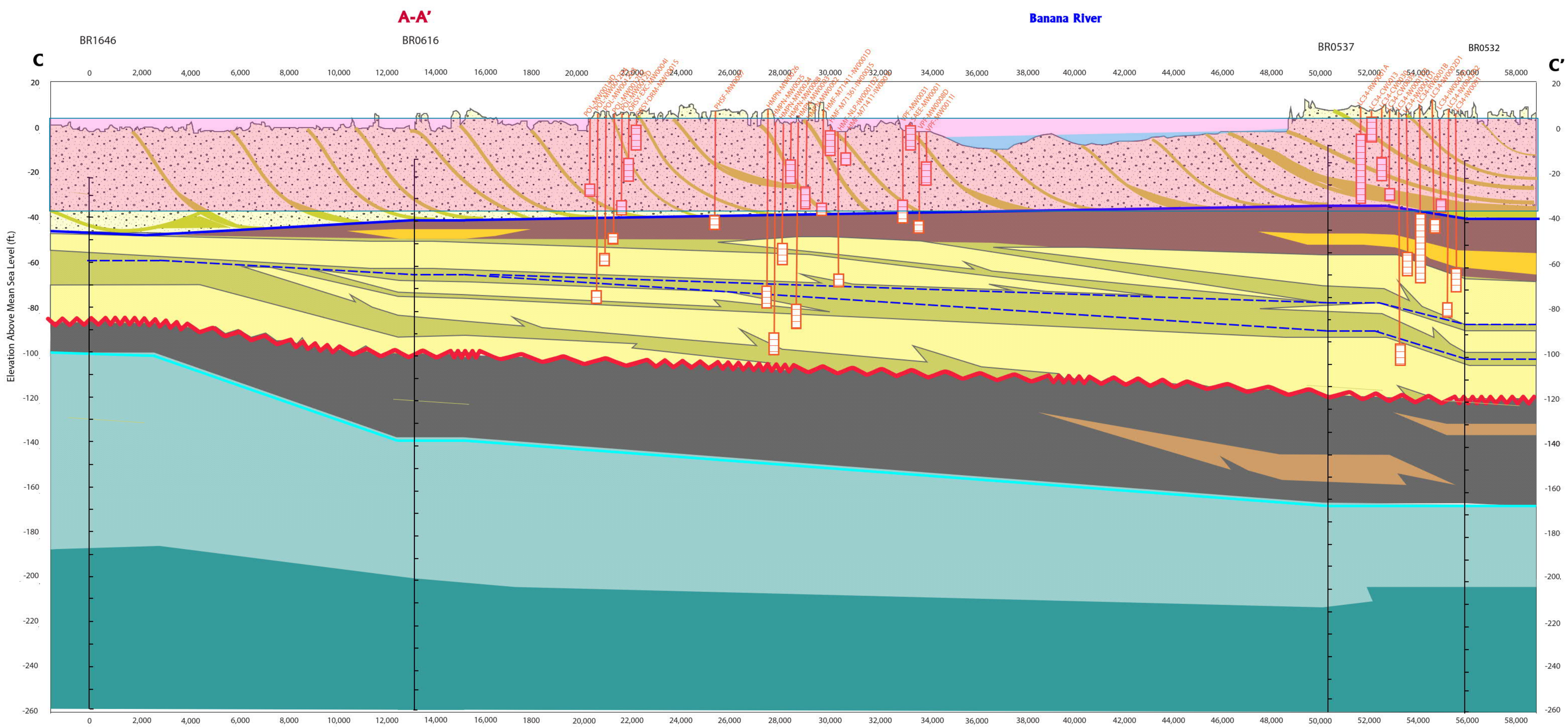
- < 100
- 100 - 1000
- > 1000

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 2-14
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			

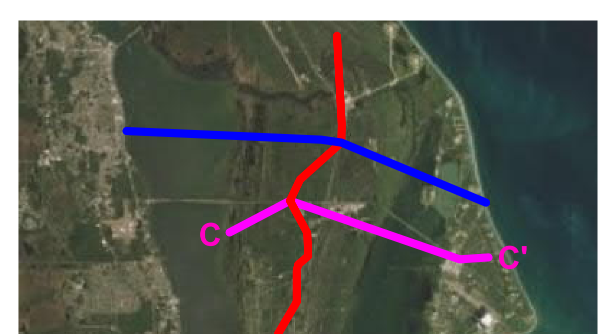


FIGURE 2-15
Regional Subsurface Geology Cross Section C-C' with Monitoring Wells

NASA Kennedy Space Center, Florida

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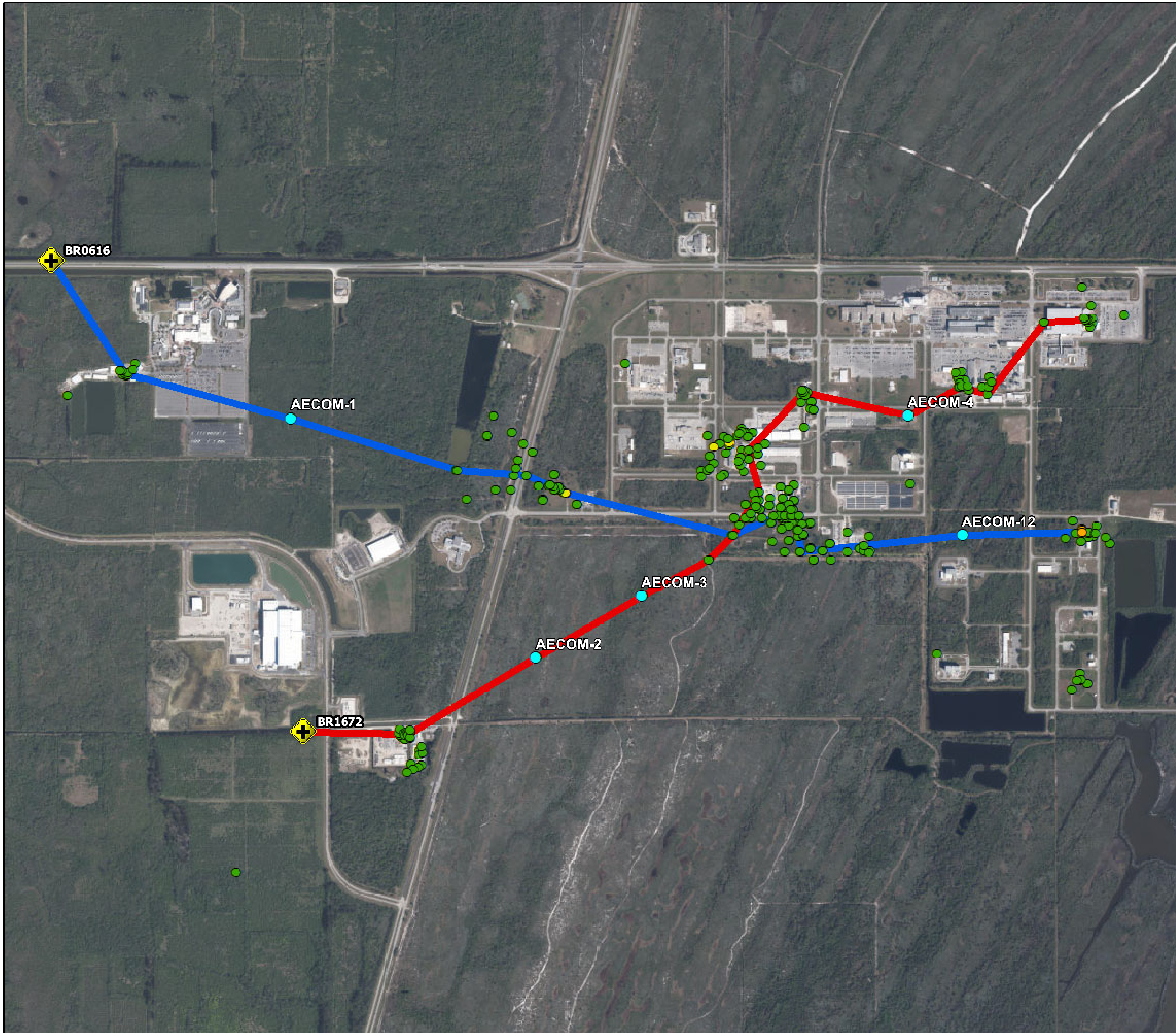


Legend

- 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'

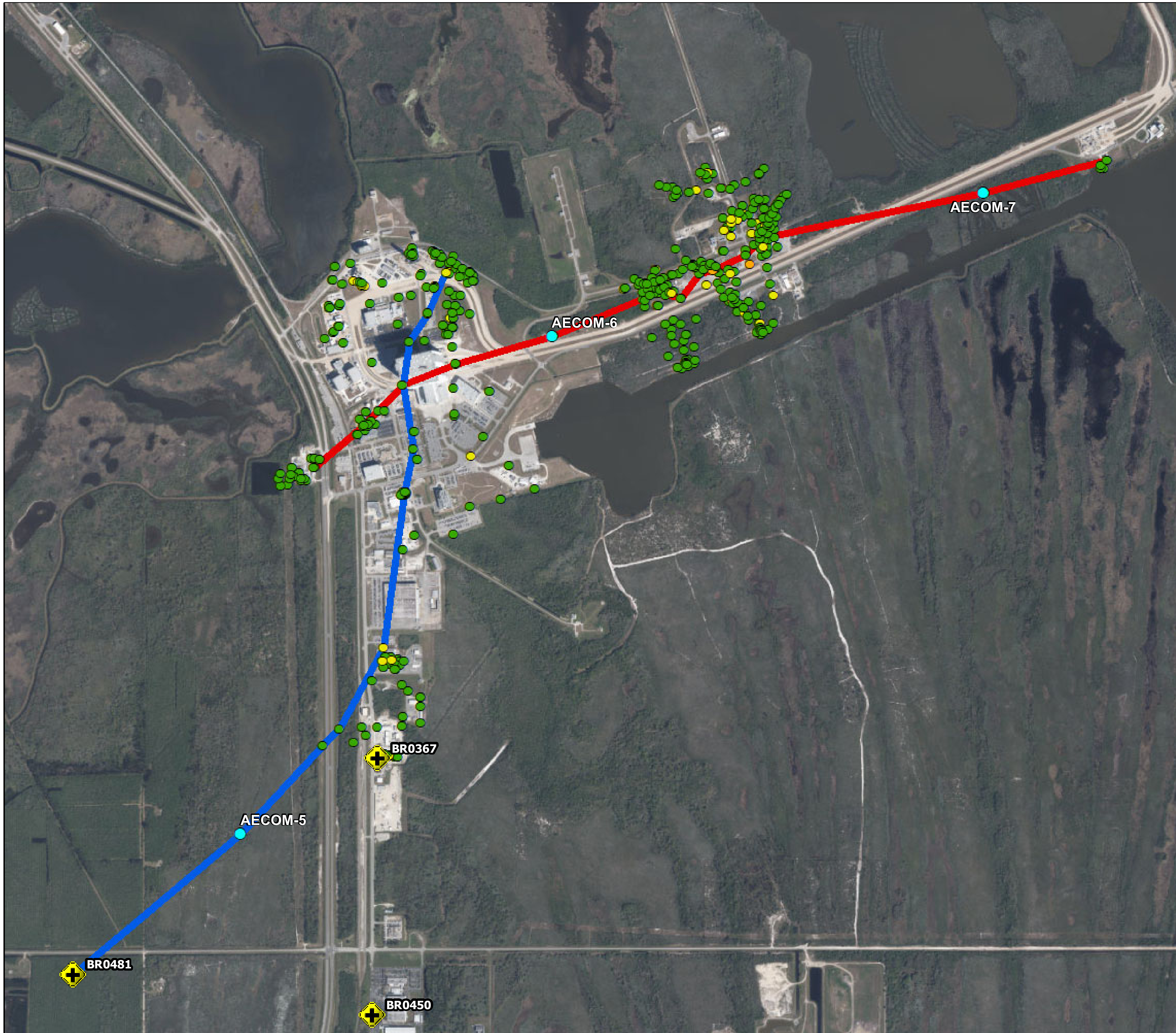
Notes:
1. Location of proposed wells may shift based on accessibility.
2. Existing gamma log data were obtained from St. Johns River Water Management District on-line database. (http://webapub.sjrwmd.com/webdataexplorer/)
3. NASA indicates National Aeronautics and Space Administration.
4. bls = below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



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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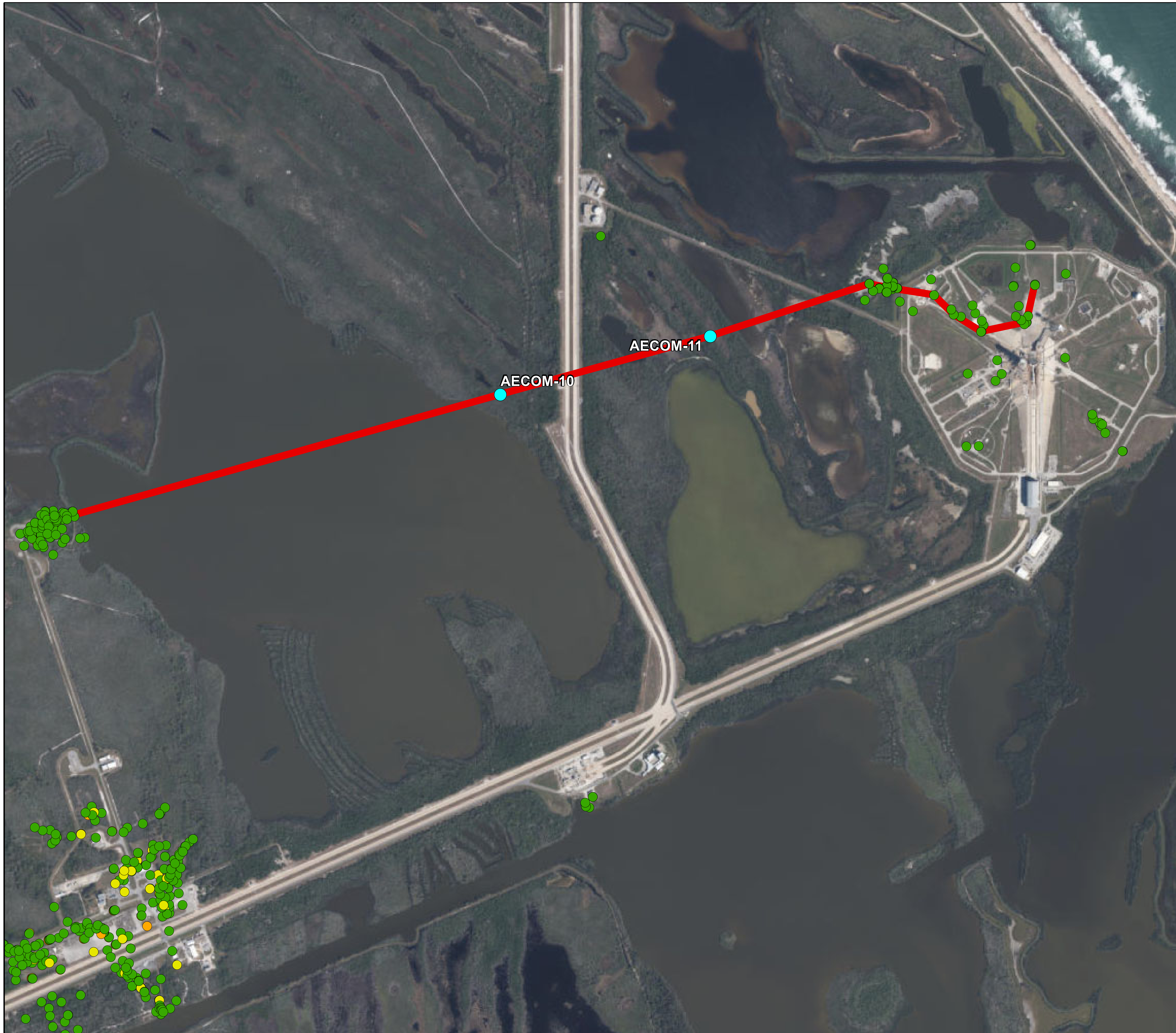


Legend

- Proposed Well

Existing Monitoring Well and Depth (bls)

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

AECOM Proposed Plume-Scale Section

- Section F-F'

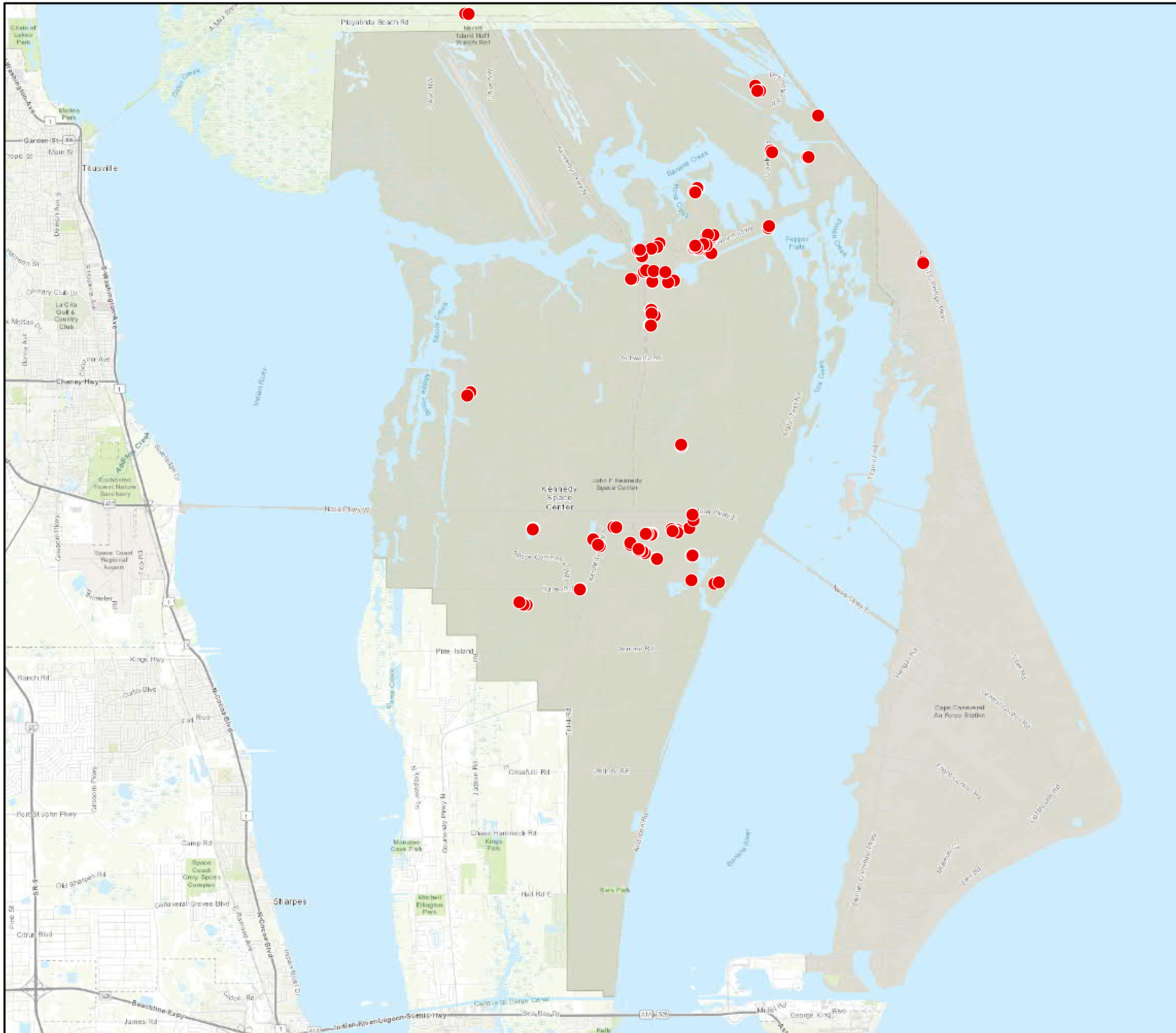
Notes:
1. Location of proposed wells may shift based on accessibility.
2. Existing gamma log data were obtained from St. Johns River Water Management District on-line database. (http://webapub.sjrwmd.com/webdataexplorer/)
3. NASA indicates National Aeronautics and Space Administration.
4. bls = below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

N

0 600 1,200 2,400 Feet

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

NASA Kennedy Space Center, Florida



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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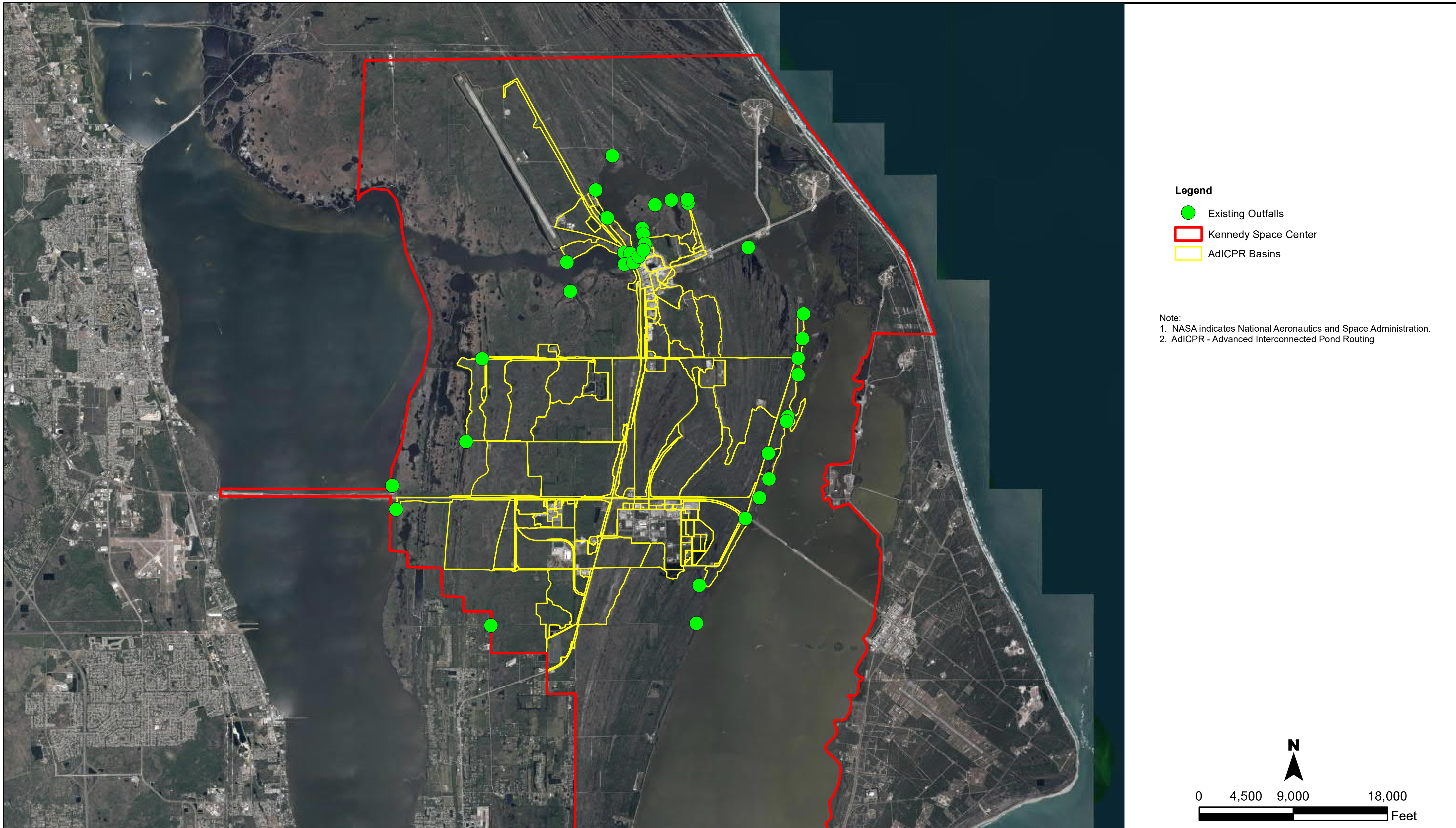

FIGURE 4-1
Stormwater Drainage Basins and Outfalls

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;

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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.

- 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);
- 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 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.

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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;

[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).

<u>Shipment</u>: 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 <u>Sampling QA/QC</u>

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

Dip Samplers: 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 (1st rinse);
3. Rinse thoroughly with PFAS-free water (2nd rinse); and
4. For field instruments, rinse again with PFAS-free water (3rd 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 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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Fuji, Y., K.H. Harada, and A. Koizumi, 2013. "Occurrence of perfluorinated carboxylic acids (PFCAs) in personal care products and compounding agents." *Chemosphere* Sep; 93 (3): 538-44.

Government of Western Australia, Department of Environmental Regulation, 2016. Interim Guideline on the Assessment and Management of Perfluoroalkyl and Polyfluoroalkyl Substances (PFAS). Contaminated Sites Guidelines.

Interstate Technology Regulatory Council (ITRC), 2018. Site Characterization Considerations, Sampling Precautions, and Laboratory Analytical Methods for Per- and Polyfluoroalkyl Substances (PFAS), Fact Sheet.

Michigan Department of Environmental Quality, 2018. General PFAS Sampling Guidance.

New Hampshire Department of Environmental Services (NHDES), 2017. Frequently Asked Questions (FAQs) for Sampling and Analysis of PFAS at Waste Management Division (WMD) Sites.

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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 **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 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

Water Level Meter: 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

Depth to Groundwater Measurements: 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.

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.

Clean nitrile gloves should be worn when handling monitoring equipment.

2.3 Decontamination

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.

3. REFERENCES

Amec Foster Wheeler Environment & Infrastructure, Inc., 2016. Quality Program Plan: Site Investigation of Potential Perfluorinated Compound (PFAS) Release Areas at Multiple United States Air Force (USAF) Base Realignment and Closure (BRAC) Installations.

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Fuji, Y., K.H. Harada, and A. Koizumi, 2013. "Occurrence of perfluorinated carboxylic acids (PFCAs) in personal care products and compounding agents." *Chemosphere* Sep; 93 (3): 538-44.

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USAF, FA8903-18-F-0066. Quality Assurance Project Plan, Perfluorinated Compound Supplemental Site Inspection, 2018. Draft.

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United States Environmental Protection Agency (USEPA), Office of Emergency and Remedial Response, 1996. Sampler's Guide to the Contract Laboratory Program.

USEPA, Region III, 2009. Quality Control Tools: Blanks, Fact Sheet.

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;

[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 **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 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).

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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 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 **<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 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 **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).

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 2.2.3 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.

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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;

[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 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 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.

<u>Solid Sampling</u>: 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 (1st rinse);
5. Rinse equipment thoroughly with PFAS-free water (2nd rinse);
6. For field instruments, rinse again with PFAS-free water (3rd 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 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. DOCUMENTATION

3.1 Chain of Custody

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;

[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 **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;
- 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 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);
- 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.

<u>Soil Retrieval Equipment</u>: 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.

<u>Preservatives</u>: Sample preservatives are not used for soil samples prior to PFAS analysis.

2.2.3 Sample Collection and Labeling

<u>Container Rinsing</u>: Sample containers should not be rinsed prior to sampling.

<u>Manual Soil Sampling</u>: 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.

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 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 Decontamination

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.

Drill Rods and DPT Samplers: 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.

Samplers: 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 (1st 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 (2nd 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 (3rd 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 (4th 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 (1st rinse);
5. Rinse equipment thoroughly with PFAS-free water (2nd rinse);
6. For field instruments, rinse again with PFAS-free water (3rd 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.

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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: ____________________________