Addressing PFAS Contamination at Moffett Federal Airfield

by Peter Strauss and Lenny Siegel
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For several years, federal agencies have been investigating releases of per- and polyfluoroalkyl substances (PFAS) at current and former military airfields across the country, and Moffett Federal Airfield, in Mountain View and Sunnyvale, California, is finally subject to such an investigation. Perhaps the study was delayed by the fact that the Navy transferred most of the former Moffett Naval Air Station to NASA Ames Research Center, also located at Moffett Field, in 1994. Perhaps there was less urgency because no one currently drinks the groundwater at Moffett and no one swims in its surface waters. However, the releases from the 2,000-acre facility pose a continuing risk to the San Francisco Bay.

The 1991 Base Realignment and Closure Commission, backed by Congress, recommended the closure of the Moffett Naval Air Station. Most of the Navy property was transferred to NASA's Ames Research Center, which has controlled 500 acres there since 1939. The military housing areas were transferred to the Air Force and then the Army. Today, NASA leases 1,000 acres of the former Naval Air Station, as well as another 42 acres of historic Ames property, to Google's Planetary Ventures subsidiary. The California Air National Guard operates a 23-acre enclave within the former Navy property.

Immediately south of the U.S. 101 freeway is the MEW Superfund Study Area. A sizable plume—known now as the Regional Plume—of contaminated groundwater from MEW flows under the highway, mixing with contamination released by both the Navy and NASA. The Superfund National Priorities List contains four named sites for this area: Moffett Field, former Fairchild Semiconductor (for which Schlumberger is responsible), Intel, and Raytheon Semiconductor. None of these corporations is operating, other than their continuing environmental activities, within the Study Area.

Moffett Field in 2017

In 2020, under direction from NASA headquarters, Ames conducted a Preliminary Assessment (PA) "to evaluate potential releases of PFAS into the environment."[1] It issued the PA report in January 2021. In August 2022 it published a bulky draft Site Inspection (SI) Report, listing 26 areas of potential concern (AOPCs), locations at Moffett Field where PFAS have been detected or are suspected. Most of the AOPCs had elevated levels of perfluorooctane sulfonate (PFOS) and perfluorooctanoic acid (PFOA) released by the Navy while it was operating the Naval Air Station. These PFAS compounds were major ingredients of fire-fighting foam, or AFFF (aqueous film-forming foam), which was used to put out liquid-fuel fires. Nearly every military base that had or has aircraft used and stored AFFF.

The NASA SI indicates that there are several non-AFFF sources as well. These include: four AOPCs (3, 4, 21, and 22) resulting from hydraulic fluid disposal or related use, brine from industrial wastewater pretreatment (AOPC 20), fuel/water disposal, fuel spills, and leaking underground storage tanks (AOPC 26), and two additional off-site AOPCs that were identified as potential contributing sources of PFAS from upgradient industrial activities (24 and 25). In addition, groundwater extraction and treatment systems (GWETS)—designed to remove volatile organic compounds such as trichloroethylene (TCE)—may also handle PFAS from both AFFF and non-AFFF sources.

U.S. EPA and the San Francisco Bay Regional Water Quality Control Board—environmental regulators for this activity—as well as the Navy and private companies responsible for some of the pollution at Moffett Field—submitted comments, and Ames completed the final SI in May 2023. Its next step is to conduct additional sampling as part of an Expanded Site Inspection (ESI), which it hopes to publish around November 2024. Following the ESI it plans a Remedial Investigation, with a preliminary target publication date of July 2026.

The Center for Public Environmental Oversight (CPEO) has reviewed both versions of the SI.[2] We are impressed by the depth and breadth of the Ames investigation, and we are pleased that all 26 sites will carry forward into the Expanded SI. Before we get into the details, here are our principal high-level findings.

- There are currently no drinking water exposures to the PFAS contamination at Moffett Field, but continuing releases to the San Francisco Bay and its associated wetlands pose a long-term threat to public health and the environment.
- In some instances, soil sampling results are high, which could lead to PFAS-contaminated soil and dust exposures to workers and residents.
- We support Ames' intent to apply interim remedies to prevent PFAS from spreading off the facility.
- The U.S. Navy has an agreement with NASA headquarters that NASA Ames is responsible for funding and conducting the environmental response for Navy-caused PFAS releases.

[1] Ames staff explained its progress at a May 11, 2023 virtual meeting of the Moffett Federal Airfield Community Advisory Board. See https://archive.org/details/MoffettCAB20230511. NASA'S presention begins 31 minutes into the recording.

[2] Because many of the AOPCs listed by NASA are within Operable Unit 2 of the Middlefield-Ellis-Whisman (MEW) Superfund Study Area, a substantial portion of the research—particularly Peter Strauss's work—for this review came from CPEO's U.S. EPA Technical Assistance Grant for the MEW sites.

- Ames' ability to conduct its investigations and potential remediation is limited by the uncertainty of Federal funds for that purpose.
- The Remedial Investigation should be designed to evaluate Natural Resource Damages.
- There needs to be a robust sampling and analysis plan for the designated AOPCs and the entire area under the stewardship of NASA Ames.
- The electronics manufacturers that operated across U.S. 101 used a variety of PFAS compounds. NASA and the MEW companies should sample for those substances.

Background on PFAS

PFAS, colloquially known as "forever chemicals," constitute a large family of fluorinated compounds, exceeding several thousand. They vary widely in their chemical and physical properties. The persistence and mobility of some PFAS, combined with decades of widespread use, have resulted in their global presence in environmental media and human bloodstreams. PFAS have been used in industry and consumer products since the 1940s, but because they have recently come to the attention of investigators and the public, they are considered emerging contaminants. It was not until the early 2010s that methods to detect a limited number of PFAS became widely available and had detection limits in water low enough to be commensurate with levels of potential human health effects. The physical and chemical properties that make some PFAS persistent and mobile in the environment also make them particularly challenging to remediate. As with any new and evolving area of science, our knowledge is far from complete.

Toxicological studies have raised potential health concerns regarding the persistence and bioaccumulative nature of many PFAS. Even at extremely low concentrations—often measured in parts per trillion in drinking water—EPA has written that PFAS exposure can unacceptably increase the risk of the following:[3]

- Reproductive effects, such as decreased fertility or increased high blood pressure in pregnant women.
- Developmental effects in children, including low birth weight, accelerated puberty, bone variations, and behavioral changes.
- Increased risk of some cancers, including prostate, kidney, and testicular cancers.
- Reduced ability of the body's immune system to fight infections, including reduced vaccine response.
- Interference with the body's natural hormones.
- Increased cholesterol levels and/or risk of obesity.

PFOA and PFOS are two of the most widely used and studied chemicals in the PFAS group, largely because they were used in aqueous film-forming foam (AFFF). They are prevalent at Moffett and are present in nearly all our recommended priority areas.

The armed services used AFFF to fight aircraft fires, and more important by quantity, to train repeatedly to fight aircraft fires. PFOS and PFOA were the first two PFAS family members to receive a lifetime health advisory from EPA. PFOA and PFOS were also used or used to produce

[3] "Our Current Understanding of the Human Health and Environmental Risks of PFAS," U.S. EPA, https://www.epa.gov/pfas/our-current-understanding-human-health-and-environmental-risks-pfas

non-stick and waterproof consumer products such as Teflon, Scotchgard, and Gore-Tex. These PFAS analytes are both classified as "likely to be carcinogenic" to humans. In drinking water, harmful levels of these compounds are measured in nanogram per liter (ng/L—that is, parts per trillion, or ppt). In soil, they are measured in µg/kg or parts per billion (ppb). There is a new U.S. EPA Regional Screening Level (RSL) for surface water, based on human recreational risk for a child under age six. The state of California has also provided Environmental Screening levels (ESLs) for groundwater for PFOS and PFOA. The state has also established soil ESLs for human health more stringent than the EPA RSLs, for soil that supports vegetation for ecologically significant habitat, and for surface water that protects aquatic habitat. The screening levels for the five PFAS compounds most likely to be found at Moffett Field are provided in Table 1.[4]

Table 1: Federal and State Screening Levels

Chemical	EPA Regional Screening Level			California Environmental Screening Level			
	Groundwater	Soil	Surface Water	Groundwater	Soil *Human Health*	Soil *Vegetation*	Surface Water *Aquatic*
	ng/L	µg/kg	ng/L	ng/L	µg/kg	µg/kg	ng/L
PFBS[5]	600	1900	8760				
PFHxS[6]	39	130	530				
PFNA[7]	5.9	19	79				
PFOA	6	19	87.7	5.1	3.8	84	75
PFOS	4	13	59	6.5	12	13	4400

In a separate 2022 study by the San Francisco Estuary Institute (SFEI), PFAS were detected across San Francisco Bay in harbor seals, cormorants, fish, bivalves, sediment, ambient water, wastewater, and stormwater.[8] Concentrations of PFOS in Bay harbor seals and bird eggs were some of the highest detected globally, and they remain a risk to hatching success in cormorants in the South Bay. Also in the South Bay, some fish have concentrations of PFAS exceeding thresholds for human consumption advisories that have been established by other states. The study concluded:

> Overall, PFAS in San Francisco Bay waters appear to be a potential human health concern in terms of seafood ingestion, rather than a concern for aquatic biota. These findings

[4] A recent United States Department of Defense (DoD) memorandum directs use of soil and tap water RSLs for six PFAS. However, only one groundwater sample for HFPO-DA exceeded RSLs, by 0.1 ppt. Therefore, we listed the only the five PFAS.

[5] PFBS = Perfluorobutane sulfonic acid

[6] PFHxS = Perfluorohexanesulfonic acid

[7] PFNA = Perfluorononanoic acid

[8] Miguel Mendez, M; Trinh, M; Miller, E; Sutton, R.; "PFAS in San Francisco Bay Water," San Francisco Estuary Institute, November, 2022, https://www.sfei.org/sites/default/files/news/PFASinBayWater2022_Final.pdf.

> support the current classification of PFAS as emerging contaminants of Moderate Concern in the Bay.[9]

That is, people who eat seafood from the Bay may be at risk of unacceptable exposure, depending upon how much fish they eat.

The Challenges of PFAS

Seven key characteristics of PFAS make them challenging to investigate and to remediate.

Persistence.

PFAS compounds do not readily break down in the environment. Therefore, continuing releases add to the environmental load. This also means that they are not candidates for monitored natural attenuation, the process through which some contaminants break down in the subsurface, for example. For other hazardous substances, this approach is sometimes acceptable when active treatment reaches a point of significantly diminishing returns.

Bioaccumulation

Not only are PFAS persistent in the environment, but they build up in fish, other wildlife, and vegetation, and accumulate through the food chain. That means that even the gradual migration of PFAS from source area into habitat such as the San Francisco Bay will increase the toxic load on the environment. Thus, it's essential to prevent contamination from spreading.

Toxicity

The toxicity of the PFAS that have been subject to studies is not just that they unacceptably increase the risk of cancers and other diseases and conditions. Most of them pose unacceptable risks at extremely low concentrations, with screening and regulatory thresholds orders of magnitude below those for other common contaminants, such as trichloroethylene. That's one reason why it's difficult to develop analytical techniques to measure the presence of PFAS. Those low thresholds also make it more challenging to remove PFAS from water. For example, filtration systems such as granular activated charcoal must be designed to remove lower chemical concentrations. Systems that remove other contaminants down to regulatory levels may actually spread PFAS through the effluent.

In 2017, the military switched its AFFF to shorter-chain PFAS, on the assumption that they are not as toxic as the longer chain analytes. Shorter chain PFAS are sometimes referred to as C6, representing 6 carbon atoms, as opposed to longer-chain PFAS, which are sometimes referred to as C8. The ITRC Technical and Regulatory Guidance notes:

> Although some short-chain PFAS appear to be less bioaccumulative, the publicly available data are limited. Some short-chain PFAS can be persistent and tend to be more water–soluble and more mobile than long-chain PFAS. Because of their greater water solubility, studies indicate short-chain substitutes are more readily taken up by plants than longer chain PFAS, including food crops. In their Interim Chemical Action Plan for PFAS,

[9] *ibid*., p. 20.

> the Washington State Department of Ecology and Washington State Department of Health … states that short-chain PFAS are difficult to remove from water, noting further, "Without additional health and safety data, it is impossible for us to evaluate whether short-chain replacements are safe substitutes. If environmental exposures to short-chain PFAS are found to pose health risks to people or the environment, mitigation will be difficult and expensive."[10]

Diversity

Researchers and regulators have focused their efforts on well-known PFAS, such as PFOS and PFOA, but there only a few studies of the toxicity and other characteristics of the vast number of other members of the PFAS family. Our understanding of the effects of PFAS on other organisms is still in its infancy.

Ubiquity

Now that we can measure many PFAS at extremely low levels, we know that it is found over much of the planet, within the bloodstreams of people on every continent. It is impossible to return everyone to pristine conditions, and our governments and scientists have not yet developed a framework to maximize the use of limited resources to protect people and the natural environment.

Comingling

PFAS is frequently found in groundwater and soil in mixtures with other contaminants. Some of the most hazardous sites are the result of military fire-fighter training. No one doubts the needs of the armed forces and other aircraft operators to prepare for potentially devastating aircraft fires, but their historical training method was to pour fuel and/or hazardous wastes into pits or onto the ground, torch the material, and use AFFF to douse the fires. Therefore, at many military bases, hazardous substances such as TCE are found in groundwater and soil along with PFOS and PFOA. There is some anecdotal evidence that PFAS migrates more quickly if it is a mixture with chlorinated solvents.[11] Groundwater extraction and treatment (pump and treat) systems designed to reduce the risk of exposure to TCE and other chlorinated volatile organic compounds were in most cases not designed to capture (and definitely not destroy) PFAS. If they nevertheless remove PFAS from groundwater, they create wastes that at this point can only be landfilled. If they fail to extract PFAS from liquid waste streams, they spread them to surface waters.

Difficult to Destroy

Though there are now numerous methods for removing PFAS from water and soil, technologies for destroying PFAS are largely experimental and energy intensive. AFFF is designed

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[10] "Per- and Polyfluoroalkyl Substances Technical and Regulatory Guidance," Interstate Technology and Regulatory Council (ITRC), June 2022, section 13.1.6, https://pfas-1.itrcweb.org/wp-content/uploads/2022/09/PFAS-Guidance-Document-9-2022.pdf. ITRC is a national organization led by the states that prepares documents meant to guide state regulators on technical options for remediation.

[11] While writing a part of the ITRC technical and regulatory guidance, Strauss heard this argument but was not able to confirm it. It is still being investigated by regulators.

to resist heat and is not destroyed unless temperatures reach extremely high levels. In a controversial July 2023 Interim Guidance, the Defense Department PFAS Task Force endorsed incineration as long as it is carried out in permitted hazardous waste incinerators with control devices that can remove hydrogen fluoride.[12] However, incineration may generate dangerous products of incomplete combustion (PICs) that potentially contain dioxins and/or furans, and it is not always regulated with PFAS-specific emission conditions and limits. In 2020 ITRC reported:

> at the time of publication, this [incineration] is an active area of research to evaluate effective destruction temperatures and treatment time, the potential to generate products of incomplete combustion, stack gas analyses, deposition onto land, and other risk factors. When considering waste disposal options, transportation costs, energy costs, regulatory approvals, and final disposition of process waste residues should be evaluated, as these differ among incineration facilities.[13]

Areas of Potential Concern

Below is a brief description of Areas of Potential Concern identified in the Site Inspection report. Detections of PFOS, PFOA, and PFHxS in each AOPC are shown in Table 2A, 2B, and 2C, respectively. It should be noted that NASA has recommended additional investigation for all areas.

AOPC 1—Former Firefighting Training Area

Historically, fire-fighting training was conducted in burn pits, in which hazardous chemicals and waste were ignited and put out with water or AFFF. The burn pits were removed during the mid-1990s. However, AFFF was used for firefighting training until 2018. During annual training exercises, AFFF was discharged onto the runway or the adjacent grassy area. PFAS samples on the western edge of the runways detected PFOS and PFOA significantly above state and federal soil and groundwater (GW) screening levels. Several other PFAS chemicals were also detected at this site.

AOPC 2—Sunnyvale Golf Course Crash Site

In April, 1973 a NASA research jet and a Navy P-3C prop-jet submarine chaser collided 300 feet above the Sunnyvale Municipal Golf Course as they approached Moffett Field, killing 16 crew and erupting in fire. Recent sampling at the crash site found PFOS well above screening levels in both soil and groundwater and PFOA above the groundwater screening levels.

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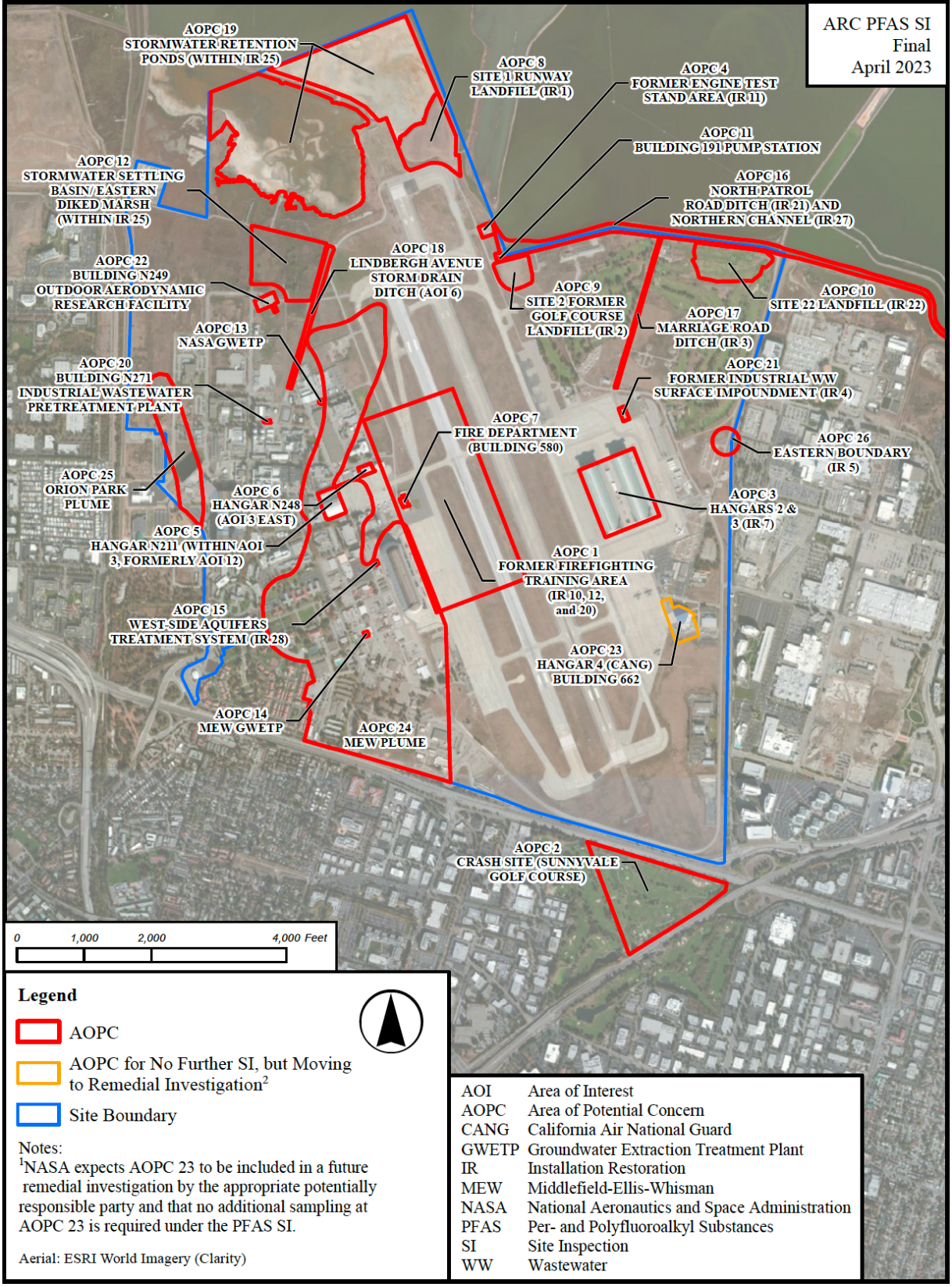
[12] Assistant Secretary of Defense (Energy, Installations, and Environment), "Interim Guidance on Destruction or Disposal of Materials Containing Per- and Polyfluoroalkyl Substances in the United States," July 11, 2023, https://www.acq.osd.mil/eie/eer/ecc/pfas/docs/news/Memorandum_for_Interim_Guidance_on_Destruction_or_Disposal_of_Materials_Containing_PFAS_in_the_U.S.pdf . See also "Per- and Polyfluoroalkyl Substances (PFAS): Incineration to Manage PFAS Waste Streams." U.S. EPA, July, 2019, https://www.epa.gov/sites/default/files/2019-09/documents/technical_brief_pfas_incineration_ioaa_approved_final_july_2019.pdf

[13] "Treatment Technologies and Method for Per- and Polyfluoroalkyl Substances (PFAS)," ITRC, August, 2020, p. 4, https://pfas-1.itrcweb.org/wp-content/uploads/2020/10/treatment_tech_508_Aug-2020-Final.pdf

FIGURE 1-2 OVERVIEW OF AREAS OF POTENTIAL CONCERN
PFAS SITE INSPECTION FOR AMES RESEARCH CENTER



AOPC 3—Hangars 2 and 3

This area encompasses Moffett Field's two enormous wooden hangars, as well as surrounding facilities and paved areas. Hangar 2 is being used for lighter-than-air aircraft development. Structurally unsound Hangar 3 is slated for demolition. Though NASA reports, "No AFFF Fire Suppression Systems (FSSs) were installed in Hangars 2 and 3," PFOA, PFOS, and other PFAS analytes have been found in groundwater above regulatory guidelines. Formerly unpaved areas were used for hazardous waste disposal before 1978, and those areas were addressed in a removal action (that did not include any monitoring of PFAS in soil or groundwater).

AOPC 4—Former Engine Test Stand Area

Isolated near the northeastern edge of the runways, this fenced, 200 foot-square paved area was used for testing turbine engines. PFOA above regulatory guidelines has been found in groundwater there. "The primary source of contamination is runoff from precipitation and pressure washing of the slab."

AOPC 5—Aircraft Servicing Facility Building N211 (Hangar N211)

Hangar N211 has had an active Fire Suppression System (FSS) from the 1940s to the present. AFFF was first introduced by the Naval firefighting services in 1964. In 2017, the military switched to shorter chain (C6) AFFF firefighting foams that do not contain PFOS or PFOA, but still contain PFAS. However, it's not clear how the old AFFF was disposed of. Currently, this AOPC has 2,500 gallons of AFFF. Several historic releases of AFFF from this building entered the storm drain system, and the area has very high levels of AFFF-related analytes in groundwater, including the highest concentration of PFOS (40,000 ng/L) measured at Moffett.

In addition, a metal-finishing operation was located in Building N211. (PFAS were commonly used as surfactants to control hexavalent chrome air emissions in metal finishing.) Although this operation was shut down in 2004, a spill report indicated that a release of an unknown quantity occurred in April 2005.

AOPC 6—Aircraft Servicing Facility Building N248 (Hangar N248)

Hangar N248 has had an active AFFF storage facility from the 1970s to present. The AFFF storage tanks have 1,600 gallons of capacity. They lie outside the southwest corner of the building. The hangar also has two small interior 100-gallon AFFF tanks without secondary containment. Historic releases of AFFF have occurred, releasing AFFF to the surrounding paved areas and the storm drain system. The solid matter that was sorbed onto soil was disposed in a landfill and contaminated water was discharged to vegetated areas. High levels of PFOS have been found in groundwater and soil at this site.

AOPC 7—Fire Department (Building 580)

Building 580 serves as the Fire, Air Crash, and Rescue Station for the airfield. The Navy operated this department until 1995. For the next ten years, the 129th California Air National Guard (CANG) Rescue Wing ran this facility. Since then, NASA's Fire Department has operated

the building. In 2000, 300 gallons of AFFF were released into storm drains. Until 2017, AFFF was discharged onto the runway and grassy areas as a part of annual testing. For the purposes of further investigation, AOPC 7 will be subsumed into AOPC 1. PFOA and PFOS were detected above soil RSLs/ESLs, and PFOS, PFOA, PFHxS, and PFNA were detected above RSLs.

AOPC 8—Runway Landfill

This 14-acre former landfill, located at the north end of the runways, accepted a variety of wastes from 1965 through the late 1970s, and in the late 1990s additional waste from the Golf Course Landfill was added, as part of remediation of that site. The landfill is capped, and groundwater and landfill gases are regularly monitored. "The groundwater gradient in the landfill area is to the south away from the San Francisco Bay." PFOA has been detected in groundwater just above screening levels.

AOPC 9—Former Golf Course Landfill

The 7-acre landfill, just east of the runways, accepted industrial wastes from the 1940s through the 1960s, but it was excavated and consolidated with the Runway Landfill in the late 1990s. Though it's considered a "clean closure," PFOA, PFOS, and PFHxS have been detected in site groundwater in the hundreds of ng/L. Depending on the hydraulic gradient, this groundwater could drain into AOPC 16 (North Patrol Road Ditch and Northern Channel) and travel unimpeded to the S.F. Bay.

AOPC 10—Site 22 Landfill

This 9.4-acre landfill at the northeastern corner of Moffett Field, beneath the current golf course, accepted domestic wastes, plus some industrial wastes, from 1950 to 1967. It is currently capped, subject to groundwater and landfill gas monitoring. PFOA, PFOS, and PFHxS have been found above groundwater screening levels. As with the Golf Course Landfill, this AOPC could drain into AOPC 16.

AOPC 11—Building 191 Pump Station

The Navy named this "Building 191," but it's nothing more than a pumphouse, located at the western end of both the North Patrol Road Ditch and the parallel Northern Channel. But it's an important pumphouse, lifting stormwater from Moffett Field's eastern drainage system toward the San Francisco Bay via the Northern Channel, Moffett Channel, and Guadalupe Slough. That drainage system may also be subject to groundwater infiltration. Building 191 is a significant concern because the water it pumps is not subject to any treatment. Three PFAS compounds are above their respective surface water screening levels: PFOS at 1,400 ng/L; PFHxS and PFOA were found in the hundreds of ng/L.

AOPC 12—Stormwater Settling Basin (SWSB)/Eastern Diked Marsh (EDM)

Most stormwater drainage from the western portion of Moffett Field, including the areas west of the runways such as Hangar N211 (AOPC 5), flows into the SWSB. Prior to 1992, it drained directly into the EDM. It is a concrete basin approximately 100 feet long and 75 feet wide.

Stormwater enters the SWSB from the south, and settled stormwater exits through the outfall into the EDM. During periods of heavy rainfall, stormwater may also flow through the SWSB overflow spillway directly into the EDM. Accumulated sediments within the SWSB are removed annually for off-site disposal. Sediments from the surface of the EDM at the two SWSB outfall locations are sampled annually. Surface water samples detected small quantities of PFAS. Further sampling is recommended by NASA.

At Building 191 surface and drainage water from the east side of Moffett Field is pumped, untreated, toward the Bay

AOPC 13—NASA Groundwater Extraction Treatment System (GWETS)

NASA entered into an agreement with the MEW companies to address the Regional Plume in the northernmost area of Ames Research Center. The NASA groundwater extraction well network captures areas downgradient of documented AFFF releases from the firefighting training area, Hangar N211, and Hangar N248. The NASA GWETS began operations in 2001. Extracted groundwater is passed through two 5,000-pound granulated activated carbon (GAC) vessels. One effluent sample exceeded the RSL for PFOS. GWETS effluent—which barely exceeded the PFOS groundwater screening level in one sample—is discharged to either Stevens Creek, which flows into the Bay, or the reuse pipeline into the Building N271 Industrial Wastewater Pretreatment Plant (IWPP), discussed as part of AOPC 20.

AOPC 14—Middlefield-Ellis-Whisman Groundwater Extraction Treatment System

In prior years, the MEW GWETS treated groundwater with two low-profile air strippers. Because air stripping is not an effective method of treatment for PFAS, PFAS passed through the MEW GWETS until 2021. One of the air strippers was replaced in 2021 with two GAC tanks. Coincidently, GAC is one of the treatment technologies for PFAS, although GAC that contains bituminous coal rather than coconut shells is more effective. Influent/effluent samples were taken. Effluent samples exceeded RSLs (groundwater) for PHFxS, PFOA and PFOS. The effluent is combined with the NASA GWETS effluent for either reuse on site (see AOPC 20) or discharged into Stevens Creek. The SI states, "The MEW GWETS should be updated to reduce concentrations of PFAS to below appropriate discharge concentrations in Stevens Creek."

AOPC 15—West-Side Aquifers Treatment System (WATS)

Originally installed by the Navy in 1998, WATS is now operated by NASA Ames. WATS remediates groundwater contaminants originating from Navy sources and the commingled MEW Regional Plume. Extracted groundwater passes through one of two series of two 2,000-pound GAC vessels operating in parallel before discharge to the storm drain. It ultimately flows through the SWSB/EDM and discharges into the Stormwater Retention Pond (SWRP). Twelve of the 28 PFAS compounds were detected in the influent sample but only one was detected in the effluent sample, below screening levels. Still, NASA recommends routine quarterly monitoring.

AOPC 16—North Patrol Road Ditch and Northern Channel

The North Patrol Road Ditch feeds surface water to the Building 191 pumphouse, and the Northern Channel receives the pumped water. In the past, waste industrial fluids were poured into the Ditch. As part of the Navy's cleanup, soil and sediment containing PCBs, pesticides, and heavy metals were excavated from the Channel and Ditch, followed by physical and ecological restoration. PFOS and PFOA were found in groundwater in the hundreds of ng/L, well above screening levels, and PFHxS was detected just above its groundwater screening level.

AOPC 17—Marriage Road Ditch

The Marriage Road Ditch flows northward along Marriage Road, which divides the Moffett Golf Course in half. According to a Navy study, hundreds of thousands of gallons of volatile organic wastes were released into the ditch, and it was excavated/dredged along with AOPC 16. PFHxS, PFOA, and PFOA were found in groundwater significantly above the applicable screening levels.

AOPC 18—Lindbergh Avenue Storm Drain Ditch

This former 2,000-foot-long ditch flows northward through the northern part of the historic NASA Ames campus. Though it principally carried stormwater, it also received liquid industrial wastes. After it was closed in 1993, NASA excavated the ditch and replaced it with a buried concrete pipe. PFOS and PFHxS were found in the hundreds of ng/L in groundwater samples, and PFOA also exceeded its groundwater screening level.

AOPC 19—Stormwater Retention Pond

The Stormwater Retention Pond does exactly what its name implies. It collects freshwater run-off from the western half of Moffett Field, removing it through evaporation. Removal of PCBs, pesticides, and heavy metals from the soil and sediment, followed by ecological restoration, has been one of the largest and lengthiest cleanup projects conducted by the Navy at Moffett Field. Many in the local community hope that eventually a tidal connection to the Bay can be restored. The only PFAS surface water sample at the Pond was unusable, so more sampling is planned. No soil or sediment samples have been taken.

Stormwater Retention Pond with Hangar One, the OARF (see AOPC 22), Wind Tunnel, and Google's Bayview campus in the distance

AOPC 20—Building N271 Industrial Wastewater Pretreatment Plant (IWPP)

Building N271 houses two reverse osmosis (RO) units for on-site water reuse. They have operated since 2013. Some of the treated groundwater from the combined NASA/MEW GWETS is polished at the IWPP with an RO system before it is reused as cooling water for the Arc Jet Complex, which simulates atmospheric reentry. The reused water is discharged to the Palo Alto sanitary sewer. All other industrial wastewater west of the runway, along with the unused treated water from the combined GWETs, is discharged without pretreatment to the Palo Alto system.

Reverse osmosis is often used to treat PFAS-contaminated water. RO removes compounds from the water solutions by passing pressurized water across a semipermeable membrane. Treated water (permeate) passes through the membrane and the rejected water (concentrate) is collected for disposal or discharge, depending on the nature of the compounds present. The concentrate is discharged to the Palo Alto Sewer.

One problem with RO is fouling of the membrane. Chemical methods are widely used by RO for membrane cleaning and regeneration. In turn, spent cleaning solution may contain PFAS and needs to be managed properly.

One effluent sample from this site was taken and it exceeded RSLs for PFHxS, PFOA, and PFOS by a factor of ten. Furthermore, we do not know where and how the GAC and RO membranes are regenerated or disposed. Filtered PFAS compounds are not broken down unless the GAC is sent to a specialized regeneration facility that breaks down some PFAS during heating. Furthermore, the SI states that "However, GAC and RO are not currently optimized for PFAS removal." What may mean is that the GAC canisters probably are composed of coconut shells rather than bituminous coal, and the membrane for RO may not be suitable for removal of PFAS.

AOPC 21—Former Industrial Wastewater Surface Impoundment

NASA reports that from 1968 to 1979 15 million gallons of wastewater, including petroleum hydrocarbons and other volatile organic compounds, were deposited in these unlined ponds, just north of Hangar 3, before discharge to the Sunnyvale Treatment Plant. The soil has been cleaned up, but groundwater cleanup continues. PFOA, PFHxS, and PFOS have been measured in groundwater in excess of their respective screening levels.

AOPC 22—Building N249 Outdoor Aerodynamic Research Facility

Built in 1969 and upgraded in 1994, the "mothballed" OARF is a gantry structure located at the northern end of the historic Ames Campus. PFHxS and PFOS have been detected above groundwater screening levels there.

AOPC 23—Hangar 4 (California Air National Guard) Building 662

This is an open-bay hangar located east of the runways. The Air National Guard has conducted its own investigation, reporting AFFF releases to the storm drains, sanitary sewer, and a grassy area that occurred in 2005, 2006, 2007, and 2012. PFOA was measured in groundwater at levels approaching 600 ng/L, and PFOS also exceeded its screening level.

AOPC 24—Middlefield-Ellis-Whisman Plume

The MEW regional groundwater plume of volatile organic compounds (VOCs), primarily TCE, is approximately 1 ½-miles long and a half-mile wide, at multiple depths. Much of the plume was released from semiconductor wafer fabrication, metal plating, and other manufacturing operations by companies in the MEW Superfund Study Area, generally bounded by three streets—Middlefield Road, Ellis Street, and Whisman Road—south of Highway 101, across from Moffett Field. Under EPA regulatory authority, they are responsible for treating portions of the plume north of 101. In that area, PFOA, PFOS, and PFHxS have been measured above groundwater screening levels. The SI states, "Because use of PFAS is also associated with semiconductor manufacturing and metal finishing operations, AOPC 24 is likely to be an off-site source of PFAS and is upgradient of NASA property." Not only does the semiconductor industry argue that PFAS use is essential to chipmaking today, but there is evidence that the MEW companies used PFAS at least as early as the 1970s.

AOPC 25 – Orion Park

No party has accepted responsibility for VOC contamination in the groundwater at this AOPC, formerly a military housing area. From 2008 to 2019, NASA treated the northern end of this plume for VOCs, as it encroached on NASA's property, by an air sparge and soil-vapor extraction (AS/SVE) system. It continues to monitor the VOC plume. Since PFAS are not readily volatile, this system did not remediate any PFAS. PFOS was measured slightly above screening levels at this AOPC.

AOPC 26 – Eastern Boundary

This area refers to two potential sources: 1) A petroleum fuel farm that hosted fifteen underground storage tanks, six above-ground storage tanks, and an oil-water separator; and 2) Lockheed Martin (formerly Lockheed Missiles & Space Company), which since the late 1950s has been conducting metal-finishing operations immediately east of Moffett Field. PFOS, PFOA, and PFHxS were all measured in the hundreds of ng/L in groundwater, and PFNA also exceeded its screening level.

Analysis

Wetlands and the Bay

At this time, the principal pathways for PFAS from Moffett Field to enter the environment are direct and indirect releases to the San Francisco Bay. Exposure standards for PFAS in surface water—or from seafood ingestion—are in their infancy. That is, more research needs to be done.[14] It is clear, however, that once PFAS enters the Bay it will remain or even spread in the environment.

At the May 2023 Community Advisory Board (CAB) meeting, NASA officials explained that it was their priority to prevent additional releases of PFAS into the Bay and its wetlands. It's clear that water contaminated with PFAS is passing through the Building 191 pump-station to the Bay, without any form of treatment. However, the levels discharged from the western half of Moffett are not yet known. For example, there has only been one sample taken from the Stormwater Retention Pond

Moffett Field is located on the San Francisco Bay, with nearly two miles of wetlands frontage. In fact, with some portions of the concrete runways below sea level, much of the facility might be considered to be part of the Bay. These wetlands are home to several federal Endangered Species, Threatened Species, and California Species of Special Concern. In response to community activism that began more than two decades ago, the Navy has completed sediment excavation and ecological restoration at the Stormwater Retention Pond, along with the adjacent Eastern Diked Marsh, and the east side surface channels near Building 191.

[14] The federal screening level for surface water exposures is based on a child who is recreationally swimming. This is an unlikely occurrence at Moffett Field. The state screening level for aquatic toxicity takes both ecotoxicity and human health toxicity into account, the latter based on general toxicity from consumption of fish.

Surface run-off and water collected in drains from the eastern half of Moffett Field are released, via the Building 191 pump, into the channels that connect to the Bay. So PFAS from many of the AOPCs has already entered the open Bay.

The Stormwater Retention Pond, at the northern end of the facility, is considered a seasonal, freshwater surface water body. However, the Navy's removal of contaminated sediment was based upon the conclusion that it could at some point be restored as a tidal marsh. A portion of it—the Stevens Creek Nature Study Area—is owned by the Midpeninsula Regional Open Space District (MROSD), which has indicated an interest in opening the dikes to connect it directly to the Bay, as part of regional wetlands restoration activities. Unless NASA builds new dikes, this would connect NASA portion of the Pond to the Bay. Treated water from the WATS (AOPC 15), as well as surface water run-off, enters the Stormwater Settling Basin (AOPC 12) where it flows into the Eastern Diked Marsh and then the Stormwater Retention Pond (SWRP) (AOPC 19). Thus, tidal restoration, while ecologically desirable, would open up new pathways for PFAS releases to the Bay.

Finally, Stevens Creek runs along the western edge of the Federal property and the Stevens Creek Nature Study Area. Stevens Creek, which is a rich feeding ground for birdlife, eventually makes it way to the Bay. NASA's Groundwater Extraction Treatment System (AOPC 13) and the MEW Groundwater Extraction Treatment System (AOPC 14) release much of their treated water into Stevens Creek. Unless the treatment systems are designed to remove low levels of PFAS, they may actually be discharging PFAS into the Creek—and thus the Bay. The remainder of the treated water is treated via reverse osmosis at the Building N271 IWPP (AOPC 20), then used for cooling before discharge into the Palo Alto Sanitary Sewer. However, because all waste water does not go through RO, the membrane cleaning fluids and pretreatment wastes may contain high levels of PFAS. More sampling is needed to determine how much PFAS is being discharged by one of the treatment systems and the Building N271 Industrial Wastewater Pretreatment Plant.

Soil Exposure

The most likely direct exposures to PFAS at Moffett Field are from contaminated soil. Screening levels for soil are based on the inhalation of fugitive dust, dermal contact, and incidental ingestion. Since Moffett Field is an active facility, with thousands of people working, studying, and recreating there on a daily basis, those are all potential pathways. NASA identified several areas that workers may access on a daily basis. These include:

- AOPC 2 – Crash Site (Sunnyvale Golf Course)
- AOPC 3 – Hangars 2 & 3
- AOPC 5 – Hangar N211
- AOPC 6 – Hangar N248
- AOPC 7 – Fire Department (Building 580)
- AOPC 10 – Site 22 Landfill
- AOPC 23 – Hangar 4 (CANG) Building 662.

Additionally, the SI acknowledges that maintenance workers may enter any of the AOPCs periodically, and future construction workers could be exposed at any of the AOPCs if construction

activities include land disturbance. However, the SI analyzed soil samples from only four AOPCs (AOPC 1, 2, 6, and 7). Furthermore, significant residential development is planned, with a likelihood of additional playgrounds and childcare facilities. Thus ground-disturbing activity in areas with elevated PFAS in soil could spread PFAS in dust, exposing future residents, as well as children who attend the existing daycare facility at Ames.

Natural Resource Damages.

A little-known provision of the Superfund Law (Comprehensive Environmental Response, Compensation, and Liability Act, or CERCLA) is the assessment of Natural Resource Damages. If the release of hazardous substances damages habitat or species, agencies serving as Natural Resource Trustees may require action to restore the habitat or species and/or seek monetary compensation for the loss of natural resources. Normally an Ecological Risk Assessment (ERA) is conducted during the Remedial Investigation/Feasibility Study phase of the response. That's the next step after the ESI.

The SI does not mention anything about Natural Resource Damage Assessment, but given the likely long-term effects of PFAS releases on the Bay ecosystem, plans should be made to conduct one. In the absence of established surface water and wildlife exposure standards for PFAS, it's important that the ESI collect some of the data necessary to begin the ERA, including an estimate of how much PFAS has been discharged into the Bay and Stevens Creek. Sediment samples should be taken from all present and past surface water features at Moffett Field as well as Stevens Creek.

Anti-Degradation.

California's Porter-Cologne Act forms the basis of the state's Anti-Degradation Policy. Water resources are protected, whether or not they are currently serving beneficial purposes. Thus, the Regional Water Board, with EPA support, required the cleanup of TCE from the Eastside Aquifer at Moffett Field, even though no one is currently drinking the water. This is because it is a "potential" drinking water source. However, after the Navy installed a pump-and- treat system, it shut it down after four years because contamination was relatively low and they regarded this as a non-drinking water source. With community support, EPA and the Regional Board allowed the system to be shut down as long as the highest levels of contaminants were treated using biotic and chemical remediation. The regulators "exempted" a portion of the aquifer with high total dissolved solids, some of which is due to subsurface saltwater intrusion from the Bay, because regardless of TCE contamination it would require substantial treatment before any use.

Cleaning up the groundwater isn't just a legal requirement. As long as high levels of PFAS remain in the groundwater, there is a risk that they might contaminate surface water or soil. In the long run, NASA and the regulators should consider cleanup of PFAS from Moffett Field's groundwater.

Sampling

Of the 26 AOPCs, only 4 had soil samples, 19 had groundwater samples, 5 had surface water samples, and 4 had influent/effluent samples. We support the ESI because substantially more sampling is necessary to more carefully delineate the contamination, initiate interim remedial actions, and eventually develop a remedial action plan.

In addition, potential sources of PFAS were identified at 24 AOPCs that were known or suspected locations of AFFF release, landfills, effluent from water treatment systems or other non-AFFF sources at Moffett Field. That's a good start, but given the changing land use patterns at military bases and NASA centers, there may be other release sites. Yet there were no random samples of areas outside of these AOPCs, which still make up most of the property.

Funding

NASA Ames' stated intent is clear, but qualified. It can only conduct activities funded by Congress and for which money is allocated by NASA Headquarters. Ames competes with several other NASA centers with similar or greater environmental requirements. While Congress now routinely adds money to the Defense Department budget requests to expand PFAS cleanup, NASA's admittedly smaller PFAS problem receives little attention. The Navy, in its comments, on the Draft Site Inspection, eschewed any responsibility for cleanup. And an Ames official told the May 2023 CAB that NASA headquarters had agreed to cover all costs associated with Moffett contamination caused by the Navy. This is significant, because the Navy caused most of the documented PFAS releases associated with Moffett Field.

Thus, NASA's studies, planning, and eventually cleanup are encumbered by the uncertainty of receiving adequate funding. Congress could either ensure funding through the NASA budget or make a policy decision that the Navy is responsible for funding the cleanup of the PFAS it released into most of the AOPCs. Other parties, such as the MEW companies, Lockheed, and the Air National Guard may also be responsible for funding portions of cleanup.

Recommendations

We recommend the following to NASA, U.S. EPA, and the Water Board.

Establish Remediation Priorities

Because of the long-term bioavailability of PFAS compounds and the slow remediation process, NASA should prioritize the remediation of source areas with the highest concentrations of PFAS. Based on our review of the various AOPCs, **Table 3** identifies our recommended priority for each AOPCs.

Priority 1 is prevention of PFAS from entering the San Francisco Bay, either as discharge into the sewer system or direct discharge (to Stevens Creek or Building 191, or areas where groundwater may be flowing to the Bay.

Priority 2 is prevention of health consequences from direct exposure (e.g., soil dust exposure) or future exposure from relatively high levels of PFAS in groundwater. In most cases, Priority 2 sites have soil or groundwater samples that exceed RSLs or ESLs by over 10 times.

Priority 3 are all other AOPCs that exceed any RSL or ESL. However, as more sampling is done during the Expanded Site Investigation (ESI) and the Remedial Investigation (RI), some of the AOPCs may end up with either a higher or lower priority.

Prevent PFAS from Entering Wetlands and the San Francisco Bay

We wish to reinforce NASA's promise to prevent the spread of PFAS into our waterways. There are no enforceable federal surface water standards for any PFAS, nor are there PFAS health advisories for the consumption of fish from San Francisco Bay. California has an ESL for protection of the aquatic ecosystem for only PFOA and PFOS. It is incumbent upon all parties to slow the spread of PFAS to the Bay by cutting off pathways and implementing interim remedies in those areas most likely to release PFAS to the Bay. That is, action should be taken before the lengthy CERCLA remedy selection process is completed and before enforceable surface-water standards are established for all relevant PFAS compounds.

Establish Institutional Controls

Areas with elevated levels of PFAS in soil should be evaluated for the application of land use controls to prevent direct exposure to contamination as well as the aerial dispersion of contaminated dust. These may include restrictions on ground-disturbing activities and the limitation of sensitive uses.

Expedite Additional Investigation

NASA began the PFAS Site Inspection at Moffett Field in 2019. This SI will be followed by an Expanded Site Investigation (ESI) and Remedial Investigation (RI) to evaluate the vertical and horizontal extent of PFAS at Moffett. All investigations should be funded and conducted as quickly as possible. None of the identified AOPCs should be screened out until evaluated in the RI. Particularly important are the Eastern Diked Marsh and the Stormwater Retention Pond, which may contain PFAS-contaminated sediment but have barely been sampled.

Furthermore, NASA, the regulatory agencies, and the MEW companies should compile a list of PFAS compounds that were used in semiconductor and other electronics production in the MEW Study Area. To the degree practical, those should be analyzed in groundwater and soil samples, including samples collected south of Highway 101

Optimize Treatment Systems

Absent a Feasibility Study to evaluate treatment options that include innovative destruction technologies, GAC canisters that are used by the NASA, WATS, and MEW treatment systems should be replaced with GAC containing bituminous coal, rather than coconut shells. Additionally, pilot studies should be considered for the Eastern Diked Marsh and the Stormwater Retention Pond

to entrain PFAS in the sediment. For example, it may be possible to mix GAC with soil and sediment to slow or halt migration.

Questions for the Agencies

CPEO is submitting the following questions to U.S. EPA, the Bay Area Regional Water Quality Control Board, and NASA Ames Research Center:

1. Will additional analysis be required if EPA or the state establishes more protective screening levels or establish screening levels for additional PFAS?

2. Are all of the Areas of Potential Concern (AOPCs) covered by NASA's Federal Facilities Agreement? How will the responsibility of other parties, such as the Navy, California Air National Guard (CANG), the MEW Companies, and Lockheed Martin be determined?

3. The Site Inspection identified PFAS exceedances that may be present under the runways. Will sampling be conducted to determine if the runway subsurface is contaminated?

4. Do any of the agencies believe that shorter chain PFAS (C6) are safer than long-chain. PFAS (C8)? There is substantial evidence that C6 migrates more quickly and is almost as toxic as C8.

5. Are there any plans to dispose of PFAS-containing Aqueous Film-Forming Foam (AFFF) that is currently stored at Moffett Field.

6. Are any steps being taken to ensure that PFAS above today's stringent screening levels are not discharged from existing groundwater treatment systems?

7. How are pretreatment and treatment wastes, such as the GAC from filtration systems and RO membranes, being disposed of? Additionally, how are wastes from cleaning RO membranes disposed of?

8. Are the MEW Companies being required to sample for PFAS south of Highway 101? This may require a separate investigation.

9. Pesticides were widely used in the Moffett wetlands as well as agricultural and residential areas of the base. Did any contain PFAS compounds? If so, this may become an issue of controversy surrounding financial responsibility among the various parties.

10. Is the regional wastewater treatment system in Palo Alto aware of potential PFAS contamination of its influent? Is it sampling for it? Do these contaminants end up in the discharge from the plant and/or the biosolids that are used for fertilizer?

11. Recreational and subsistence fishing take place in the South Bay. Will EPA or California be establishing screening levels for surface water based upon seafood consumption or for PFAS in seafood?

Table 2A: PFOS Maximum Detections by AOPC

		PFOS			
AOPC	Location	Groundwater	Soil	Surface Water	Effluent
	Screening Level	4 ng/L	12 µg/kg	4400 ng/L	none
1	Former Firefighting Training Area	**7700**	**920**		
2	Sunnyvale Golf Course Crash Site	**35**	**41**		
3	Hangars 2 and 3	**160**			
4	Former Engine Test Stand Area				
5	Hangar N211	**40000**			
6	Hangar N248	**15000**	**1900**		
7	Fire Department (Building 580)				
8	Runway Landfill				
9	Former Golf Course Landfill	**500**			
10	Site 22 Landfill	**53**			
11	Building 191 Pump Station			1400	
12	Stormwater Basin/Diked Marsh			5.5	
13*	NASA Pump & Treat			7.4	4.1
14*	MEW Pump & Treat			7.4	94
15	West-Side Aquifers Treatment				
16	N. Patrol Rd Ditch/Northern Channel	**500**			
17	Marriage Road Ditch	**150**			
18	Lindbergh Avenue Ditch	**470**			
19**	Stormwater Retention Pond				
20	Industrial Wastewater Pretreatment				210
21	Industrial Wastewater Impoundment	**99**			
22	Outdoor Aerodynamic Facility	**15**			
23	CANG Hangar 4	**35**			
24	Middlefield-Ellis-Whisman Plume	**57**			
25	Orion Park Former Housing	**9**			
26	Eastern Boundary	**490**			

Exceedances are in bold.

*Same sample was used for AOPC 13 and 14.

** No valid samples were collected in AOPC 19.

Table 2B: PFOA Detections by AOPC

		PFOA			
AOPC	Location	Groundwater	Soil	Surface Water	Effluent
	Screening Level	5.1 ng/L	3.8 µg/kg	75 ng/L	none
1	Former Firefighting Training Area	**350**	**120**		
2	Sunnyvale Golf Course Crash Site		**7.7**		
3	Hangars 2 and 3	**62**			
4	Former Engine Test Stand Area	**110**			
5	Hangar N211	**380**			
6	Hangar N248	**610**	**5.1**		
7	Fire Department (Building 580)		**4.2**		
8	Runway Landfill	**110**			
9	Former Golf Course Landfill	**230**			
10	Site 22 Landfill	**41**			
11	Building 191 Pump Station			**340**	
12	Stormwater Basin/Diked Marsh			1.1	
13	NASA Pump & Treat*			1.1	
14	MEW Pump & Treat*			1.1	13
15	West-Side Aquifers Treatment				
16	N. Patrol Rd Ditch/Northern Channel	**230**			
17	Marriage Road Ditch	**160**			
18	Lindbergh Avenue Ditch	**34**			
19	Stormwater Retention Pond**				
20	Industrial Wastewater Pretreatment				36
21	Industrial Wastewater Impoundment	**60**			
22	Outdoor Aerodynamic Facility				
23	CANG Hangar 4				
24	Middlefield-Ellis-Whisman Plume	**11**			
25	Orion Park Former Housing				
26	Eastern Boundary	**350**			

Exceedances are in bold.

*Same sample was used for AOPC 13 and 14.

** No valid samples were collected in AOPC 19.

Table 2C: PFHxS Detections by AOPC

		PFHxS			
AOPC	Location	Groundwater	Soil	Surface Water	Effluent
	Screening Level	39 ng/L	130 µg/kg	N/A***	none
1	Former Firefighting Training Area	**3300**			
2	Sunnyvale Golf Course Crash Site				
3	Hangars 2 and 3	**180**			
4	Former Engine Test Stand Area				
5	Hangar N211	**4400**			
6	Hangar N248	**5200**			
7	Fire Department (Building 580)				
8	Runway Landfill				
9	Former Golf Course Landfill	**500**			
10	Site 22 Landfill	**120**			
11	Building 191 Pump Station			930	
12	Stormwater Basin/Diked Marsh			6	
13	NASA Pump & Treat*			5.4	
14	MEW Pump & Treat*			5.4	100
15	West-Side Aquifers Treatment				
16	N. Patrol Rd Ditch/Northern Channel	**39**			
17	Marriage Road Ditch	**190**			
18	Lindbergh Avenue Ditch	**220**			
19	Stormwater Retention Pond**				
20	Industrial Wastewater Pretreatment				230
21	Industrial Wastewater Impoundment	**83**			
22	Outdoor Aerodynamic Facility	**56**			
23	CANG Hangar 4				
24	Middlefield-Ellis-Whisman Plume	**130**			
25	Orion Park Former Housing				
26	Eastern Boundary	**350**			

Exceedances are in bold.

*Same sample was used for AOPC 13 and 14.

**No valid samples were collected in AOPC 19.

***There are no Surface Water ESLs for PFHxS. The RSL is for recreational swimming, which is unlikely to occur on waterways on or near Moffett Field.

Table 3: CPEO's Priority Levels for AOPCs

AOPC	Location	Priority Level
1	Former Firefighting Training Area	2
2	Sunnyvale Golf Course Crash Site	2
3	Hangars 2 and 3	3
4	Former Engine Test Stand Area	3
5	Hangar N211	2
6	Hangar N248	2
7	Fire Department (Building 580)	3
8	Runway Landfill	3
9	Former Golf Course Landfill	1
10	Site 22 Landfill	1
11	Building 191 Pump Station	1
12	Stormwater Basin/Diked Marsh	1
13	NASA Pump & Treat	1
14	MEW Pump & Treat	1
15	West-Side Aquifers Treatment	*
16	N. Patrol Rd Ditch/Northern Channel	1
17	Marriage Road Ditch	1
18	Lindbergh Avenue Ditch	2
19	Stormwater Retention Pond	**
20	Industrial Wastewater Pretreatment	1
21	Industrial Wastewater Impoundment	2
22	Outdoor Aerodynamic Facility	3
23	CANG Hangar 4	3
24	Middlefield-Ellis-Whisman Plume	2
25	Orion Park Former Housing	3
26	Eastern Boundary	2

Priority 1 is prevention of PFAS from entering the San Francisco Bay.
Priority 2 is prevention of direct exposure.
Priority 3 are all other AOPCs that exceed any RSL or ESL.
*No exceedances. PFBA measured at 3.9 ng/L in effluent.
**Thus far there are no valid PFAS samples.