HEALTH CONSULTATION

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Florida State Fire College

Per – and Polyfluoroalkyl Substances (PFAS)

Report 1

On-site investigation of per- and polyfluoroalkyl substances (PFAS) in groundwater and surface soil

11655 NW Gainesville Road,
Ocala, Florida 34482

Prepared by:
Florida Department of Health
Division of Disease Control and Health Protection
Bureau of Environmental Health

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Prepared by:
Florida Department of Health
Bureau of Environmental Health
Public Health Toxicology
Hazardous Waste Site Health Risk Assessment

FOREWORD

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Cooperative Agreement with
U. S. DEPARTMENT OF HEALTH AND HUMAN SERVICES
Agency for Toxic Substances and Disease Registry

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EXECUTIVE SUMMARY

The purpose of this report is to evaluate and communicate the possibility of public health threat from exposure (contact) to per- and polyfluoroalkyl substances (PFAS) in drinking water and soil at the Florida State Fire College (FSFC) in Marion County, Florida.

Perfluorooctane sulfonate (PFOS; also known as perfluorooctane sulfonic acid) and perfluorooctanoic acid (PFOA) are part of a large group of chemicals collectively referred to as PFAS. Historically, PFAS have been used in a variety of industries and consumer products, primarily due to their resistance to degradation and their ability to repel oil and water. PFAS are common in textiles, manufacturing, and metal plating. Most notably, PFOA and PFOS have been prevalent components of aqueous film forming foam (AFFF) used by firefighting professionals in communities, refineries, military installations, airports, and chemical plants.

Since 2018, the Florida Department of Environmental Protection (FDEP) Site Investigation Section has conducted several PFAS studies and it has been demonstrated that AFFF has been a source of groundwater contamination. When contaminated groundwater is used to supply drinking and irrigation water systems, people can be exposed to the contamination. For these reasons, firefighter training facilities, including the FSFC, warrant closer investigation.

The FSFC is located on 11655 Northwest Gainesville Road, Ocala, Florida. The facility trains as many as 200 people per session, which lasts up to 22 weeks. Trainees reside in dorms at the facility and are served meals through an on-site cafeteria.

In early August 2018, FDEP contacted the FSFC and confirmed that AFFF has been used for training on-site. FDEP also learned that the facility has an on-site water supply well, which is used for drinking and other household purposes. In early September, FDEP collected a water sample from this well for PFAS analysis. The combined concentration of PFOA and PFOS was 250 nanograms per liter (ng/L) exceeding the United States Environmental Protection Agency (EPA) lifetime health advisory level of 70 ng/L.

Additional water samples were collected from the well and from an indoor tap and tested for PFAS. These water samples also contained PFOA and PFOS concentrations higher than the EPA lifetime health advisory level. Furthermore, soil samples were collected from the site and tested for PFAS. Some soil samples at the site contained PFOA and PFOS above national screening levels used to identify possible concerns. Thus, the Florida Department of Health (FDOH) conducted an assessment to evaluate the possible health risks associated with exposure to PFOA and PFOS via drinking water and soil at the FSFC. Two additional members of the PFAS family were evaluated; perfluorononanoic acid (PFNA) and perfluorohexane sulfonate (PFHxS, also known as perfluorohexane sulfonic acid). FDOH used provisional health guidelines provided by the Agency for Toxic Substances and Disease Registry (ATSDR) in the assessment.

Based on review of the available environmental data and federal health guidelines for PFOA, PFOS, PFNA and PFHxS, FDOH reached the following conclusions for human exposure to PFAS at the Florida State Fire College:

Human exposure to PFAS at the FSFC via drinking water

Conclusion # 1:

Workers and students, who drank water daily at the FSFC for two weeks or longer with 2018/2019 a ***PFOS*** level of 250 ng/L may be at risk of harmful non-cancer health effects; specifically, immune effects.

Basis for Conclusion #1

Levels of PFOS found in 2018/2019 in drinking water at the FSFC could increase the risk of harmful non-cancer health effects in workers and students, who drank the water daily for two weeks or longer *(intermediate and chronic exposure durations)*. The estimated exposures for PFOS exceed ATSDR's provisional health guidelines for intermediate exposure. This assessment considered all workers and students, including those who plan to become pregnant, as well as pregnant and lactating women. Based on predictions made from animal studies, the estimated exposures are well below levels predicted to cause developmental effects in humans, but similar to levels predicted to cause immune effects. PFOS exposure has also been associated with other health effects, including effects to liver, serum cholesterol, thyroid, reproduction, and preeclampsia (pregnancy-induced hypertension). However, based on the drinking water levels found at the FSFC, immune effects are of most concern.

People with underlying health conditions such as a compromised immune system may be at increased risk of immune and other health effects.

Conclusion # 2:

2018/2019 levels of ***PFOA, PFNA*** and ***PFHxS*** in the drinking water at the FSFC are not expected to cause harmful non-cancer health effects to ***workers*** and ***students,*** who drank the water daily for two weeks or longer. ***However***, PFOA, PFNA and PFHxS could have contributed to the overall PFAS exposure.

Basis for Conclusion #2

2018/2019 levels of PFOA and PFNA are below their respective ATSDR comparison values. Comparison values (also called screening values) are health-based estimates of chemical concentrations in the environment (chemical amounts in water, soil, air, etc.) expected to be safe for people. While maximum levels of PFHxS exceeded the respective ATSDR comparison value, an in-depth evaluation did not find an increased risk of developing non-cancer health effects likely. The estimated doses were below ATSDR's health guideline for PFHxS, the provisional minimal risk level (MRL). MRLs are estimates of the daily chemical doses that a person can be exposed to without risk of developing non-cancer health effects.

Current information on the combined effects of PFAS mixtures is very limited and poorly understood. Though, for some other chemical classes, it is known that compounds with similar toxic action can contribute to a combined increased effect. Meaning, the mixture of compounds could increase the potential risk of developing

non-cancer health effects compared to the effect of each individual compound. If PFOA, PFAS, PFNA, and PFHxS have similar toxic actions, it is possible, but uncertain, that the combined risk of all PFAS found at the FSFC could potentially be higher than the risk found for each individual compound. However, it should be considered that at the FSFC site, PFOS is the predominant contaminant causing toxicity. The individual toxicity contributions of PFOA, PFNA, PFHxS and other PFAS are low compared to PFOS.

Conclusion # 3:

Some health risk evaluations for drinking water at the FSFC are limited.

a. Exposure before 2018/2019 cannot be evaluated.
b. Exposure after 2018/2019 is unlikely to occur.
c. Cancer risk for ***workers*** who drank water at the FSFC daily for one year or longer with 2018/2019 PFAS levels is uncertain.
d. Cancer risk is not evaluated for ***students***.

Basis for Conclusion #3a

Exposure before 2018/2019 cannot be evaluated because no data exist for PFAS in drinking water at the FSFC before this time. Without data, FDOH is not able to evaluate the likelihood of harmful health effects to former workers and students, who may have been exposed to PFAS in FSFC drinking water before 2018/2019.

Basis for Conclusion #3b

Future exposure (after 2018/2019) to PFAS by drinking the water at the FSFC is unlikely. FSFC has installed and maintained a granulated activated carbon (GAC) multi-canister (16 canisters) filter system for the cafeteria and dorms. FDOH and FDEP remain in active communication with the FSFC to ensure that workers and students remain informed.

Basis for Conclusion #3c+d

2018/2019 levels of ***PFOA*** in drinking water at the FSFC are below levels expected to increase risk of cancer in ***workers,*** who drank the water for one year or longer. Cancer risk is not evaluated for ***students*** because they are exposed for less than one year.

The estimated increased cancer risk for workers exposed to PFOA via drinking water is less than one in a million, which in general, is considered extremely low. However, current limitations of scientific knowledge prevent comprehensive evaluation of the cancer risk, which must therefore be considered uncertain.

Note: Current information on the ability of PFAS to cause cancer in humans is very limited***.*** Epidemiological studies have associated ***PFOA*** exposure with kidney, prostate and testicular cancers. The current cancer estimation for PFOA is based on testicular cancer from an animal study.

PFOS, PFNA and PFHxS are currently not classified as human carcinogens. Present knowledge limits the ability to estimate increased cancer risk for PFAS in general.

Next Steps:

A GAC multi-canister (16 canisters) filter system for the cafeteria and dorms has been installed on the well that supplies water at the FSFC for drinking, showering, and other activities.

FDOH also recommends periodic monitoring of the GAC filter (via well water and indoor tap water samples) to ensure continued functionality of the GAC filter and to prevent exposure to PFAS-contaminated water on-site. FDOH and FDEP remain in active communication with the FSFC to ensure that workers and students remain informed.

FDOH further recommends that visiting children are kept under supervision and prevented from consuming PFOS-contaminated water at the FSFC until the long-term solution has been approved. PFOS exposure has been associated with developmental effects such as reduced birth weight, childhood obesity and small developmental delays.

Human exposure to PFAS at the FSFC via showering

Conclusion # 4:

Workers and ***students*** who showered at the FSFC with water containing 2018/2019 levels of ***PFAS*** daily for two weeks or longer are not likely to experience health effects due to PFAS exposure via showering. While showering exposure alone is not expected to cause non-cancer health effects, it could have contributed to the overall PFAS exposure at the site.

Basis for Conclusion #4

2018/2019 levels of ***PFOA and PFOS*** in water at the FSFC are below levels expected to increase risk of harmful non-cancer health effects in ***workers and students,*** who showered in the water daily for two weeks or longer.

Due to limited scientific information, risk via showering exposure cannot be evaluated for ***PFNA and PFHxS***. Showering is generally considered a minor pathway for PFAS; however, it could contribute to a combined exposure of all exposure routes.

Current information on the combined effects of PFAS mixtures is very limited and poorly understood. For some other chemical classes, it is known that compounds with similar toxic action can contribute to a combined increased effect. Meaning, the mixture of compounds could increase the potential risk of developing health effects compared to the effect of each individual compound. If PFOA, PFAS, PFNA, and PFHxS have similar toxic actions, it is possible, but uncertain, that the

combined risk of all PFAS found at the FSFC could potentially be higher than the risk found for each individual compound. However, it should be considered that at the FSFC site, PFOS is the predominant contaminant causing toxicity. The individual toxicity contributions of PFOA, PFNA, PFHxS and other PFAS are low compared to PFOS.

Conclusion # 5:

Some health risk evaluations for showering at the FSFC are limited.

a. Exposure before 2018/2019 cannot be evaluated.
b. Exposure after 2018/2019 is unlikely to occur.
c. Cancer risk for ***workers*** who showered at the FSFC daily for one year and longer with PFAS levels found in water in 2018/2019 is uncertain.
d. Cancer risk is not evaluated for ***students***.

Basis for Conclusion #5a

Exposure before 2018/2019 cannot be evaluated because no data exist for PFAS in water at the FSFC before this time. Without data, FDOH is not able to evaluate the likelihood of harmful health effects to former workers, who may have been exposed to PFAS via showering at the FSFC before 2018/2019.

Basis for Conclusion #5b

Future exposure (after 2018/2019) to PFAS via showering is unlikely. FSFC has installed and maintained a GAC multi-canister (16 canisters) filter system for the cafeteria and dorms. FDOH and FDEP remain in active communication with the FSFC to ensure that workers and students remain informed.

Basis for Conclusion #5c+d

2018/2019 levels of ***PFOA*** in water at the FSFC are below levels expected to increase risk of cancer in ***workers*** who showered in the water for one year or longer. Cancer risk is not evaluated for ***students*** because they are exposed for less than one year.

The estimated increased cancer risk for workers exposed to ***PFOA*** via showering is less than one in a million, which in general, is considered extremely low. However, current limitations of scientific knowledge prevent comprehensive evaluation of cancer, which must therefore be considered uncertain.

Note: Current information on the ability of PFAS to cause cancers in humans is very limited**.** Epidemiological studies have associated ***PFOA*** exposure with kidney, prostate and testicular cancers. The current cancer estimation for PFOA is based on testicular cancer from an animal study.

PFOS, PFNA and PFHxS are currently not classified as human carcinogens. Present knowledge limits the ability to estimate increased cancer risk for PFAS in general.

Next Steps

FDOH recommends periodic monitoring of the GAC filter (via well water and indoor tap water samples) to ensure continued functionality of the GAC filter and to prevent exposure to PFAS-contaminated water on-site. FDOH and FDEP remain in active communication with the FSFC to ensure that workers and students remain informed. While showering exposure alone is not expected to cause non-cancer health effects, it could contribute to the overall PFAS exposure at the site and should be considered in the overall PFAS evaluation at the site.

Human exposure to PFAS in surface soil

Conclusion #6:

2018/2019 PFOS concentrations in soil from the former drum and tote storage area (***AOC1***) are of elevated concern. ***Workers, students and potential trespassers*** exposed to surface soil from AOC1 via skin and incidental ingestion of soil particles in air and on their hands could be at increased risk of non-cancer health effects; specifically, developmental and immune effects.

Basis for Conclusion #6

2018/2019 levels of ***PFOS*** in surface soil at ***AOC1*** could increase the risk of harmful non-cancer health effects in ***workers, students, and potential trespassers***, who get exposed to the soil for two weeks or longer *(intermediate and chronic exposure durations)*. The estimated exposures for PFOS exceed ATSDR's provisional health guideline for intermediate exposure. This assessment considered all workers, students, and trespassers, including those who plan to become pregnant, as well as pregnant and lactating women. Based on predictions made from animal studies, the estimated exposures are close to levels predicted to cause developmental effects in humans, and very close to levels predicted to cause immune effects. PFOS exposure has also been associated with other health effects, including effects to liver, serum cholesterol, thyroid, reproduction and preeclampsia.

Developmental effects observed in humans include small decreases in birth weight. The fetus can be exposed to PFAS in-utero and lactating mothers can pass PFAS onto to their child via the breastmilk. Therefore, avoiding exposure to PFAS is important for lactating women and ***women of childbearing age***. Pregnant women could also be at increased risk of preeclampsia.

People with underlying health conditions such as a compromised immune system may be at increased risk of immune and other health effects.

Conclusion #7:

The above evaluation of potential risk for ***workers*** and ***students*** to develop non-cancer health-effects from exposure to ***PFOS-***contaminated surface soil at ***AOC1 (Conclusion #6)*** may be overestimated.

Basis for Conclusion #7

AOC1 is located at one corner of the property very distant from the indoor buildings. Many samples were collected from AOC1 and PFOS levels varied greatly from lower than current methods can detect to the maximum level used for this risk evaluation. AOC1 is fenced, routinely locked and only irregularly accessed by some workers and not by students. Access has generally been limited to maintenance workers, who mow the area, and to contract instructors, who accessed storage drums three to four times a year. FDOH considered that mowing could disturb surface soil. Furthermore, soil and dust can be transported with wind and on people's skin, clothes and shoes from one area to another, including indoor buildings. This assessment was designed to be protective of the worst-case scenario. FDOH acknowledges that the health risk may be overestimated.

Conclusion #8:

Workers, students and trespassers exposed to ***PFOA, PFNA and PFHxS*** in surface soil at AOC1 to AOC5, as well as ***PFOS*** in surface soil at AOC2 to AOC5 at the FSFC are not likely to experience harmful non-cancer health effects due to exposure via incidental ingestion and/or dermal contact of PFAS-contaminated surface soil (based on 2018/2019 levels). However, the added PFAS exposure could possibly increase risk of developing non-cancer health effects.

Basis for Conclusion #8

2018/2019 levels of PFOA, PFNA and PFHxS in surface soil at AOC1 to AOC5, as well as PFOS levels in surface soil at AOC2 to AOC5 at the FSFC are below levels expected to cause harmful non-cancer health effects in workers, students, and trespassers exposed over a two-week period or longer. However, while no non-cancer health effects are expected, the PFAS concentrations at the specific locations could contribute to the overall PFAS exposure at the site.

Current information on the combined effects of PFAS mixtures is very limited and poorly understood. For some other chemical classes, it is known that compounds with similar toxic action can contribute to a combined increased effect. Meaning, the mixture of compounds could increase the potential risk of developing non-cancer health effects compared to the effect of each individual compound. If PFOA, PFAS, PFNA and PFHxS have similar toxic actions, it is possible, but uncertain, that the combined risk of all PFAS found at the FSFC could potentially be higher than the risk found for each individual compound. However, it should be considered that at the FSFC site, PFOS is the predominant contaminant causing toxicity. The individual toxicity contributions of PFOA, PFNA, PFHxS and other PFAS are low compared to PFOS.

Conclusion # 9:

Some health risk evaluations for exposure to surface soil at the FSFC are limited.

a. Exposure before 2018/2019 cannot be evaluated.

b. Exposure after 2018/2019 is possible, until the soil has been remediated (cleaned up).
c. Cancer risk for ***workers and potential trespassers*** who were exposed to 2018/2019 surface soils via incidental ingestion and/or dermal contact daily for one year and longer is uncertain.
d. Cancer risk is not evaluated for ***students***.

Basis for Conclusion #9a

Exposure before 2018/2019 cannot be evaluated because no data exist for surface soil before this time. Without data, FDOH is not able to evaluate the likelihood of harmful health effects to former workers, students, and potential trespassers who may have been exposed to PFAS in FSFC surface soil before 2018.

Basis for Conclusion #9b

Future exposure (after 2018/2019) to PFAS via surface soil is possible unless the soil is remediated (cleaned up). It is not possible to predict how much the PFAS levels in surface soils will change over time. Therefore, it is not possible to complete a meaningful evaluation.

Basis for Conclusion #9c+d

2018/2019 levels of ***PFOA, PFNA and PFHxS*** in surface soil at ***AOC1 to AOC5*** are below levels expected to increase risk of cancer in ***workers and potential trespassers,*** who have been exposed to the soil for one year or longer. Cancer risk is not evaluated for students because they are exposed for less than one year.

The estimated increased cancer risk for workers exposed to PFOA, PFNA and PFHxS via surface soil is less than one in a million, which in general, is considered extremely low. However, current limitations of scientific knowledge prevent comprehensive evaluation of cancer, which must therefore be considered uncertain.

Note: Current information on the ability of PFAS to cause cancers in humans is very limited***.*** Epidemiological studies have associated ***PFOA*** exposure with kidney, prostate, and testicular cancers. The current cancer estimation for PFOA is based on testicular cancer from an animal study.

PFOS, PFNA and PFHxS are currently not classified as human carcinogens. Present knowledge limits the ability to estimate increased cancer risk for PFAS in general.

Next Steps

Until FDEP has completed soil cleanup at AOC1, FDOH recommends that workers, students and trespassers, including those who plan to become pregnant, as well as lactating and pregnant women, avoid exposure to contaminated soil at AOC1 by avoiding the area or by wearing protective gear.

Additionally, FDOH recommends that pregnant and lactating women avoid spending time on the outdoor grounds as they may be exposed to contaminated soil by incidental ingestion and dermal contact with dust.

It is further recommended that children are kept under supervision and prevented from coming into contact with soil at the FSFC. It is recommended that children do not spend time on the outdoor grounds, where they would be at increased risk of exposure to PFOS in soil.

Outdoor soil can become a hazard for indoor workers, students and visitors when the soil is carried inside. Increased hygiene practices are recommended. Thorough hand washing can prevent incidental ingestion of contaminated soil and dust. To avoid transferring soil contamination from the outside to the indoor facilities, it is recommended that outdoor shoes and clothes are kept outside, and outdoor clothes are washed after each use.

FDOH recommends mitigation (removal or cleanup) of all contaminated soil once FDEP has finalized its investigation into the extent of soil contamination. FDEP continues the PFAS assessment at the FSFC. A primary objective is to delineate the extent of soil contamination to conduct cleanup activities. Soil cleanup typically includes excavation of contaminated soil that is either an exposure risk or a significant source to groundwater contamination via leaching. The excavated soil is replaced with “clean fill,” thereby greatly minimizing the risk of exposure to workers, students and the environment. AOC1 is the highest priority for a likely source removal to occur [FDEP, personal communication, 2021]. FDOH recommends that workers wear protective gear during remediation work. Further, FDOH recommends continued soil testing until mitigation has been completed. If mitigation is delayed, FDOH recommends continued assessments of future health risks including data monitoring.

Additional Conclusions

Conclusion # 10:
The risk of health effects to ***visitors*** of the FSFC cannot be evaluated.

Basis for Conclusion #10

For this health assessment, there is too much uncertainty in the frequency and duration of possible visits to perform a correct assessment that would not under- or overestimate potential risk.

Next Steps

A GAC multi-canister (16 canisters) filter system for the cafeteria and dorms has been installed on the well that supplies water at the FSFC for drinking, showering, and other activities. The filter eliminates possible exposure to PFAS contaminated drinking water.

Though, it is recommended that visiting children are kept under supervision and prevented from coming into contact with soil at the FSFC. It is recommended that children and pregnant and lactating women do not spend time on the outdoor grounds, where they would be at increased risk of contact with PFOS in soil.

Conclusion # 11:
The risk of ***breastfeeding*** cannot be assessed. Possible health effects associated with PFAS exposure via breastfeeding cannot be evaluated.

Basis for Conclusion #11
Possible health effects associated with PFAS exposure via breastfeeding cannot be evaluated due to current data limitations. PFAS can be transferred to infants via breastfeeding. Based on current knowledge, ATSDR recommends that the health and nutritional benefits of breastfeeding outweigh the risks associated with PFAS in breast milk.

Next Steps
A woman's decision to breastfeed is individual and involves many considerations in addition to chemical contamination. Women with concerns about findings at the FSFC may find it helpful to discuss breastfeeding with their health care provider. ATSDR has produced a PFAS-guidance document for health care professionals:
https://www.atsdr.cdc.gov/pfas/docs/ATSDR_PFAS_ClinicalGuidance_12202019.pdf

Conclusion # 12:
The possible risk of health effects due to ***acute, short term exposure*** of less than two weeks to ***PFOA, PFOS, PFNA and PFHxS*** in drinking/showering water and surface soil at the FSFC cannot be evaluated.

Basis for Conclusion #12
No health guidelines are available to evaluate acute exposure to PFAS.

Next Steps
FDOH recommends that workers, students, visitors and trespassers, who were, are or/will be present at the FSFC for less than two weeks follow the recommendations made for longer exposure. It is unknown when health guidelines for short-term exposure may become available.

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Limitations of Findings
All health assessments, to varying degree, require the use of assumptions, judgments and incomplete data, which introduce some uncertainties to final risk estimates. Some specific sources of uncertainty in this health consultation include exposure parameter estimates, use of modeled exposure doses and current toxicological knowledge.

FDOH health assessors do not know exactly when soil contamination occurred, when the contamination reached 2018/2019 groundwater concentrations, or how contaminant concentrations in groundwater and soil varied over time. FDOH health assessors also do not know exactly how much water each individual drinks or how much soil each person is exposed to on a daily basis. Furthermore, toxicological knowledge for PFAS is limited. The tools used to predict increased non-cancer and cancer risk for this health consultation report are based on data from epidemiological and animal studies, which lead to uncertainty in risk estimates. Suggestive (uncertain) evidence has linked PFOA to three types of cancers: kidney, prostate and testicular cancer. Due to data limitations, however, the value used to estimate increased cancer risk associated with PFOA is based only on data for one type of cancer (testicular).

People at the FSFC are exposed to a PFAS mixture as well as several different exposure routes including those from consumer products. The current tools available to perform risk estimation for PFAS do not allow assessment of risk caused by multiple PFAS compounds and routes of exposure. Therefore, risk is estimated separately for each PFAS compound (*i.e.*, PFOA, PFOS, PFNA or PFHxS) and route (e.g., drinking water). Because of these and other uncertainties, health assessors may have overestimated or underestimated health risk. This health consultation does not represent an absolute estimate of risk to persons exposed to chemicals at the FSFC.

The FDOH health assessment process is conducted to protect human health. Therefore, assumptions and judgments in the assessment of the site's impact on public health erred on the side of caution and may have overestimated public health risk.

This health consultation used screening levels and health guidelines developed by the ATSDR. These levels are lower than EPA's HAL, and therefore offer a more protective assessment, which result in estimated risk at drinking water levels below the HAL. All guidelines made to assess public health are precautionary. It is important to note that findings of risk do not mean that health effects are certain to happen.

This health consultation provides specific public health recommendations based on toxicological literature, site-specific levels of environmental contaminants, evaluation of possible exposure pathways, duration of exposure and characteristics of the exposed population.

Contaminant exposure does not always lead to harmful effects. The risk of harmful effects to a human depends on the type and amount of contaminant the human is exposed to, how exposure occurs, how well the contaminant is absorbed, how frequent and for how long exposure occurs, as well as on individual genetics and lifestyles.

For More Information

If you have concerns about your health or the health of your children, contact your health care provider. For further health evaluation information about the FSFC, contact FDOH at phtoxicology@flhealth.gov or toll free at 877-798-2772.

ACRONYMS AND ABBREVIATIONS

ATSDR	Agency for Toxic Substances and Disease Registry
AFFF	Aqueous Film-Forming Foam
CSF	Cancer Slope Factor
EPA	U.S. Environmental Protection Agency
EPC	Exposure Point Concentration
FDEP	Florida Department of Environmental Protection
FDOH	Florida Department of Health
FSFC	Florida State Fire College
HAL	Health Advisory Level
HED	Human Equivalent Dose
mg/kg	Milligrams per kilogram
mg/kg/day	Milligrams per kilogram per day
MRL	Minimal Risk Level
ng/L	Nanograms per liter
PFAS	Per- and polyfluoroalkyl substances
PFHxS	Perfluorohexane sulfonate/perfluorohexane sulfonic acid
PFNA	Perfluorononanoic acid
PFOA	Perfluorooctanoic acid
PFOS	Perfluorooctane sulfonate/perfluorooctane sulfonic acid
ppt	Parts per trillion

1. STATEMENT OF ISSUES

Since 2018, the Site Investigation Section of the Florida Department of Environmental Protection (FDEP) has become involved in several studies concerning per- and polyfluoroalkyl substances, collectively referred to as PFAS.

PFAS are a large group of manufactured chemicals, which have been used in a wide range of industrial and consumer products since the 1940s [ITRC 2020a]. PFAS are utilized in consumer products for their ability to make the products resistant to heat, water, oil and grease. Examples of consumer products that contain PFAS include but are not limited to some nonstick cookware, electrical wire insulation, stain-resistant carpets and fabrics, waterproof clothing, food packaging, cosmetics and other personal care products. Further, PFAS have been prevalent components of aqueous film forming foams (AFFF, also known as firefighting foam) used in firefighting activities [ATSDR 2018a; EPA 2017].

PFAS do not break down easily after use and disposal but can persist for a long time in the environment, where they can enter waterways and human food chains [EPA 2017]. Today, PFAS are global contaminants found in air, soil, water, plants, animals, food and indoor dust [Ahrens 2011; Scher et al. 2018; Scheringer et al. 2014; Sunderland et al. 2019]. Most of the U.S. population have measurable levels of PFAS in their bodies [ATSDR 2019a]. The main source of PFAS exposure in humans is through ingestion of PFAS-contaminated water and food [ATSDR 2019a].

The most widely studied PFAS are perfluorooctanoic acid (PFOA) and perfluorooctane sulfonate (PFOS, also known as perfluorooctane sulfonic acid). Increasing, although more limited, scientific information is becoming available for other PFAS including perfluorononanoic acid (PFNA) and perfluorohexane sulfonate (PFHxS).

Various studies discovered PFAS in groundwater at and near areas that used, stored and disposed of AFFF [Backe et al. 2013; Hatton et al. 2018; Moody and Field 1999]. These findings have prompted a Florida-wide investigation of firefighter training facilities to delineate the extent of a possible PFAS contamination in Florida and to ensure public safety.

In August 2018, FDEP and the Florida Department of Health (FDOH) initiated their Florida-wide collaborative investigation starting at the Florida State Fire College (FSFC). The facility has used AFFF during their training activities. Further, the facility uses a potable water well (located on-site) for drinking and other household purposes.

Initial water samples collected from the well that supplies the FSFC with water used for drinking, showering and other activities contained 250 nanograms per liter (ng/L) of combined PFOA and PFOS. This concentration exceeds the United States Environmental Protection Agency (EPA) lifetime health advisory level (HAL)[1] for combined PFOA and PFOS in drinking water of 70 ng/L [EPA 2016]. The lifetime HAL for PFOA and PFOS was issued as a guidance to protect Americans over a lifetime consumption

[1] The EPA HAL is reported in parts per trillion (ppt), which is the same as nanograms per liter (ng/L). One ng equals 0.000000001 gram, and there are 454 grams to a pound. To visualize one ppt, think of roughly one grain of sand in an Olympic size swimming pool.

(approximately 78 years) of PFOA and PFOS in drinking water [EPA 2016]. EPA considers its lifetime HAL protective for all populations, even the most sensitive populations, including fetuses and nursing infants. Exceedance of the lifetime HAL prompts further investigation and assessment of possible health threats. However, it is important to note that a person's consumption of water above the lifetime HAL for any period of time does not imply that the person will experience health effects.

After the initial investigation at the FSFC, additional water samples were collected from the well supplying the FSFC with water used for drinking, showering and other activities. A sample was also taken directly from an indoor water tap at the FSFC. Soil samples were collected from five different locations at the FSFC. These locations were identified as Areas of Concern (AOC) 1 through 5.

In this report, FDOH health assessors evaluated possible health implications of FSFC on-site PFAS contamination for students, workers and trespassers. The following items were reviewed:

- available environmental data for PFAS,
- possible PFAS exposure pathways[2] and
- the possibility of increased cancer and non-cancer health risks associated with PFAS.

Data collected at the FSFC site led to the assumption of possible off-site contamination. Further sampling was conducted at neighboring businesses and residential drinking water wells within a 1-mile radius of the FSFC. The results of these off-site investigations are reported in the FSFC Health Consultation Reports 2 and 3 and are available at:

floridahealth.gov/environmental-health/hazardous-waste-sites/Reports/hw-public-comments.html

Note: Data limitations and gaps in current knowledge of PFAS toxicology contributed to uncertainty in evaluating possible health threats. Precautionary assumptions and judgment were used to derive conclusions that may overestimate risk but are protective of public health.

2. BACKGROUND

2.1 Site Description

The FSFC is located in Ocala, Marion County, Florida (Figure 1). The college staffs 28 full-time employees and 55 part-time workers, as well as guest instructors. As many as 200 students are enrolled for each class term of up to 22 weeks. The students reside in dorms at the facility and are served meals through an on-site cafeteria. The FSFC is surrounded by the Florida Department of Correction facilities to the west and south, Lhoist

[2] An exposure pathway (or route) describes the way by which people can come in contact with a chemical (e.g., ingestion of water). This includes the path a chemical moves from where it was released to the point of human contact (e.g., disposal → groundwater → indoor water tap). FDOH considered the possible pathways at the FSFC for three timeframes: before 2018/2019, during 2018/2019 and after 2018/2019.

North America, Inc. to the northeast, east and southeast, as well as private residences to the north/northwest.

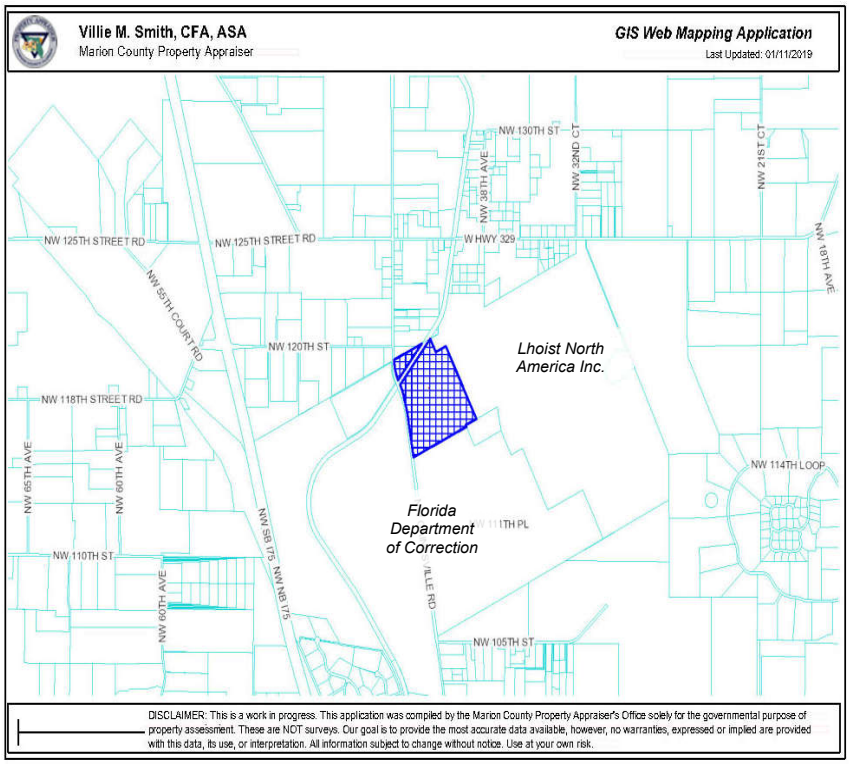

Figure 1: Florida State Fire College site location (Blue). [Marion County Property Appraiser 2019].

The site includes an administrative building, auditorium, dormitories, a cafeteria, an office building housing the Bureau of Fire & Arson Investigation, a maintenance building, a fire station (Apparatus Bays), firefighting training areas, storage areas, as well as, a HazMat training area, retention ponds and vegetation (Figure 2).

2.2 Site History

In 1989, the FSFC moved to its current location at 11655 NW Gainesville Rd, Ocala, Florida, seven miles north of Ocala.

In early August 2018, FDEP confirmed storage and previous use of PFAS-based firefighting foam at the FSFC. It was also confirmed that the facility obtains its drinking water from an on-site well. The analysis of the well water showed that the PFOA+PFOS level in FSFC well water exceeded EPA's lifetime HAL of 70 ng/L.

In September 2018, FSFC employees and students were notified about the water sampling results. Per FDOH recommendation, a short-term alternative water source for drinking, cooking and brushing teeth was supplied by FDEP and the Department of Financial Services. A long-term solution to provide clean water to workers and students is currently being developed. In September 2019, a granular activated carbon (GAC) filter

was installed at the facility. The initial filter was later replaced by a GAC multi-canister (16 canister) filter system and the filtered water is monitored to assess filter efficiency.

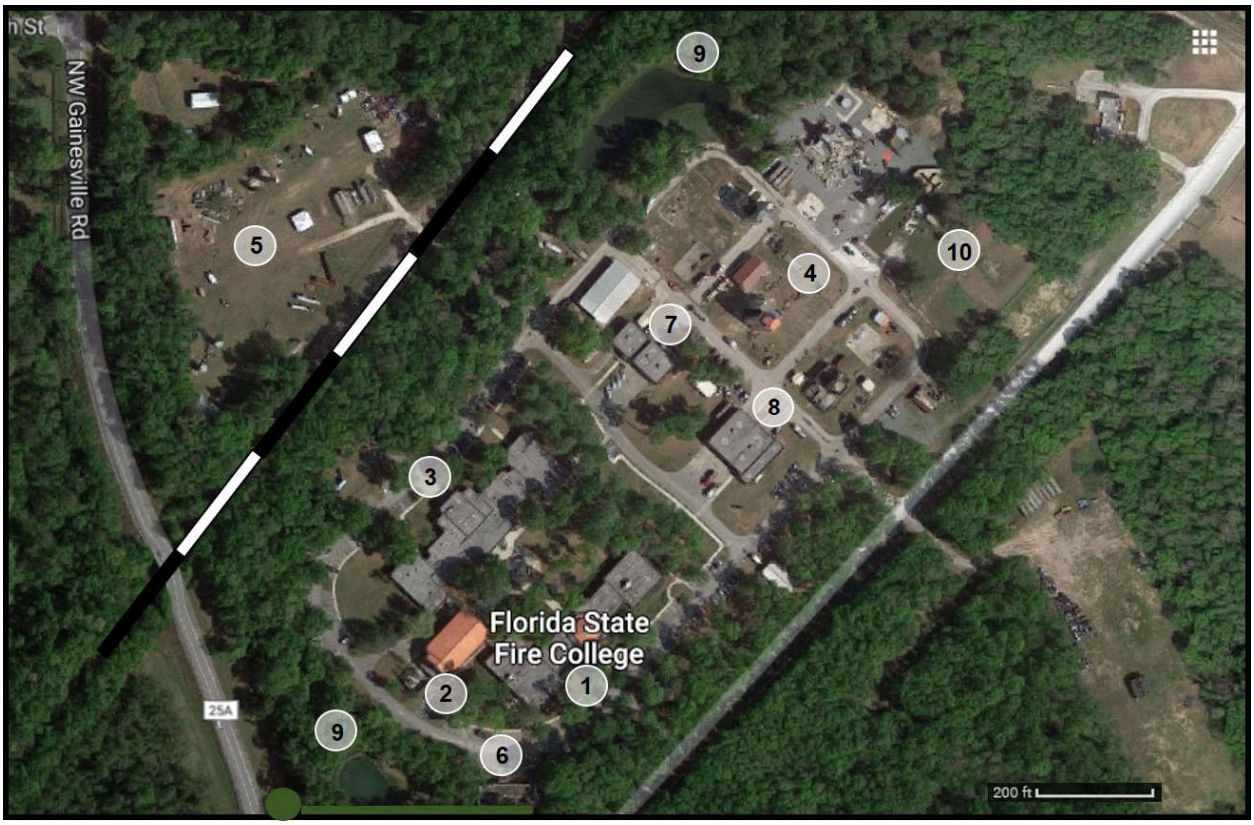

Figure 2 Florida State Fire College, Marion County [Adapted from Google Maps 2019]. 1) Administrative building; 2) auditorium; 3) dormitories and cafeteria; 4) firefighting training area [AOC2 and AOC3]; 5) HazMat training area [AOC5]; 6) Bureau of Fire and Arson Investigation; 7) maintenance building; 8) fire station; 9) storm water retention ponds [AOC4]; 10) former tote and drum storage area [AOC1]. AOC = area of concern.

In November 2018, water was sampled from an indoor water tap and 37 soil samples were collected from five areas of concern (AOC 1-5) (Figure 3).

From March to September, additional soil samples were collected from AOC1 and AOC3. AOC1 was also sampled in September and November 2019. Sampling is on-going to delineate the extent of the soil contamination for cleanup activities. Soil cleanup typically includes excavation of contaminated soil that is either an exposure risk or a significant source to groundwater contamination via leaching. The excavated soil is replaced with “clean fill”, thereby greatly minimizing the risk of exposure. AOC1 is the highest priority for a likely source removal to occur [FDEP, personal communication, 2021].

Since 2018, FDEP and FDOH have been working to assess the extent of PFAS groundwater contamination within a 1-mile radius of the FSFC. The off-site investigation includes potable well testing at private residences and businesses, including the adjacent Lhoist Mine. The off-site well water health evaluations are conducted separately. Results of these evaluations are published in FSFC Health Consultation Reports 2 and 3.

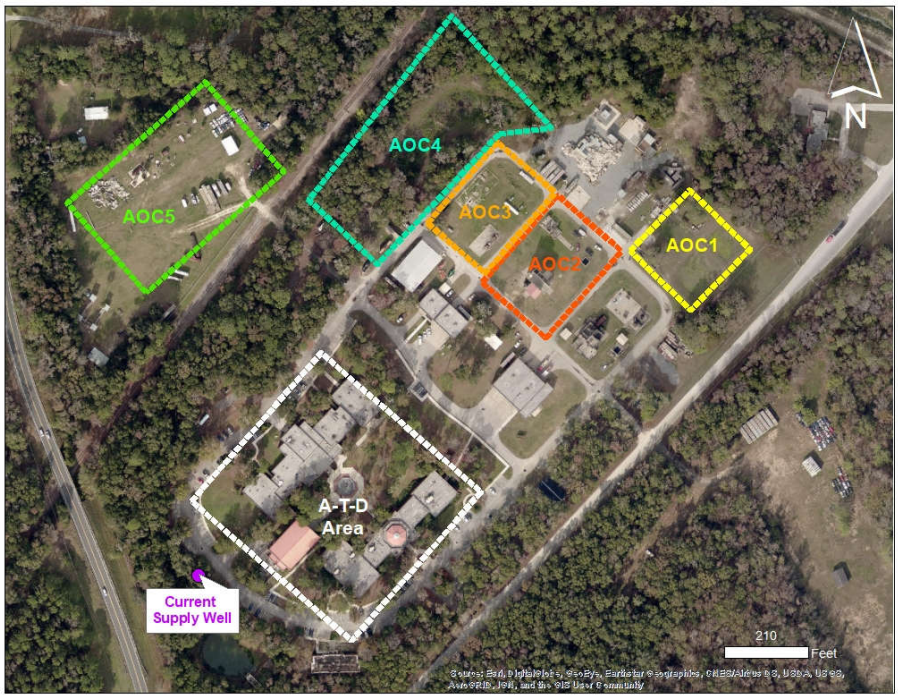

Figure 3: PFAS soil sampling areas designated by usage type at the Florida State Fire College, Marion County (November 2018 to September 2019). AOC – Area of Concern [AOC1 – Former Drum and Tote Storage; AOC2 – Training Tower Block; AOC3 – New Burn Building Block; AOC4 – Storm Water Pond; AOC5 – HazMat Training Area]; and A-T-D Area – Administrative – Classroom Training– Dorm Area.

Future sampling results will determine the most appropriate course of action regarding additional assessment and outreach activities.

2.3 Site Demographics

According to the 2010 census data (Appendix A), 4,631 people live within a 1.0-mile radius of the FSFC site [EPA 2010]. Of the total population, 61% were white, 36% were black, 2% reported as other and 1% of the population was reported as two or more races. A geographical analysis by ATSDR found no child day care centers and one place of worship within the 1-mile radius (Appendix A).

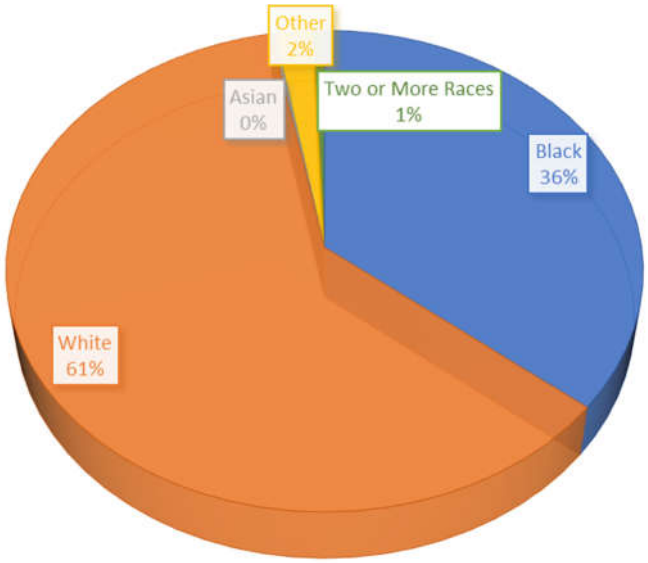

Figure 4: 2010 census-based, demographic overview within a 1-mile radius of the Florida State Fire College, Marion County.

3. DISCUSSION

3.1. Evaluation Process

A human health risk assessment conducted for a contaminated site evaluates and characterizes the risk posed to human health by the contaminant(s) detected at the site. The assessment is conducted through the following main steps:

- a planning step and hazard identification (usually done by the investigating agency such as FDEP),
- an exposure assessment,
    - evaluation of available environmental data
    - evaluation of exposure pathway (investigating how can people be exposed/come in contact with the chemical(s))
- a health effects assessment and
- a risk characterization and communication step.

The investigating agency (in this case FDEP) is generally responsible for the hazard identification (A). FDOH completes the exposure assessment (B), the health effects assessment (C) and the risk characterization (D) briefly described in the following sections (further detailed in Appendix B):

A. Planning and Hazard Identification

This step includes collection and initial evaluations of environmental data (chemical concentrations in water, soil and air) and is conducted by the investigating agency.

B. Exposure Assessment

- Exposure Pathway Analysis (Section 3.2)
- Environmental Data and Screening (Section 3.3)

The exposure assessment identifies and characterizes if, where and how the population can come in contact with the contaminant. During this process, the environmental data (chemical concentrations in exposure medium such as water, soil and air) are evaluated by comparing the levels to federal **screening levels**[3] referred to as **comparison values (CV)**. If a chemical concentration for a site exceeds the screening level, the chemical is of potential concern and possible health risk is assessed during the next step.

C. Health Effects Assessment

- Cancer and Non-Cancer Health Risk Evaluation (Section 3.4)

[3] **Screening levels** are estimates of chemical concentrations in the environment (water, soil, air, etc.) that a person can be exposed to without considerable health risk. Screening levels are health-based and set far below levels known to cause harmful effects. The value of a screening level is called a comparison value (CV), because it is used to compare with. If a chemical concentration at a site is higher than its CV, the chemical is of concern and needs further evaluation.

The likelihood of health effects caused by the chemical of concern depends on how exposure occurs (intended and incidental ingestion, breathing and/or skin contact), the amount of chemical present, how often (frequency) exposure takes place and how long (duration) a person is in contact with the chemical. Many of these factors are determined by human behavior and current health condition, which vary with genetics and population type (e.g., child or adult, worker or resident). Therefore, the health assessor identifies site-specific population scenarios, for which relevant daily exposure doses can be estimated. An **exposure dose** is the amount of chemical taken up by a person per body weight per day (milligram chemical/kilogram body/day). The estimated daily doses are compared with federal **health guidelines**[4] to determine if site-related doses are of concern. This health consultation used ATSDR's **provisional minimal risk level (MRL) for PFOA, PFOS, PFNA and PFHxS**. If an estimated dose is higher than the health guideline, the possible health implications are evaluated and communicated for each possible pathway.

D. Risk Characterization and Communication

- Conclusions (Section 4)
- Recommendations (Section 5)
- Public Health Action Plan (Section 6)

Based on the findings from Step A and B, conclusions and recommendations are established and communicated. A public health action plan is developed and communicated to the community of concern. FDOH can make recommendations but has no regulatory jurisdiction.

3.2. Exposure Pathway Analysis

Chemical contamination is mainly a concern for human health, if humans can get exposed to (come in contact with) the chemical. Without human contact, the chemical cannot enter the body and cause harmful effects. If exposure is possible, several criteria determine the actual risk of harm. These aspects are evaluated in the health risk evaluation (Section 3.4).

The "Exposure Pathway Analysis" evaluates if, what, where, how and for whom exposure is possible and considers the following five main elements:

- a **source** of chemical contamination,
- an **exposed environmental element**,
- an **exposure point** where chemical contact can happen,
- an **exposure route** by which the chemical can enter the body and

[4] A **health guideline** is an estimate of the daily chemical exposure dose that a person can be exposed to without considerable health risk. Health guidelines are set far below levels known to cause harmful effects. If an estimated dose for a site is higher than the guideline, health risk is possible and must be further evaluated.

- an **exposed population**.

Once all possible pathways have been identified, the health assessor evaluates the likelihood for each pathway to occur. The pathways are classified as completed, potential or eliminated. A **completed pathway** is a pathway, where all five elements can be verified and for which all data exist to conduct a health risk assessment. A **potential pathway** is a likely pathway for which one or more elements are uncertain. Completed and potential pathways are further evaluated in the health risk evaluation (Section 3.4). An **eliminated pathway** is a pathway for which one or more elements are missing and is usually not further evaluated.

Health assessors considered three timeframes of exposure:

- Pre 2018/2019 (before PFAS testing)
- 2018/2019 (start of PFAS testing)
- Post 2018/2019 (PFAS mitigation has been initiated)

3.2.1 Pathway Identification

The FDOH health assessors identified all pathways by which people at the FSFC could have been, could be or could become exposed to on-site PFAS contamination:

ELEMENT	***FSFC***
✓ the ***source*** of chemical contamination	historical use and storage of AFFF
✓ the ***environmental element*** to hold or transport the chemical(s)	groundwater, soil, surface water (ponds)
✓ the ***exposure point*** where people can come in contact with the chemical(s)	on-site indoor drinking water and showering taps, on-site surface water (ponds), on-site surface and sub-surface soil
✓ the ***exposure route*** by which the chemical(s) can enter the body	Ingestion (intended and incidental), dermal (skin) contact, inhalation
✓ the ***exposed population/community***	workers, students, visitors, trespassers

Completed Pathways

The past use and storage of PFAS-containing AFFF [***source***] at the FSFC (on-site) have contaminated the surrounding groundwater and soil **[*environmental elements*]**. Periods of rain could have contributed to moving PFAS from the surface soil into deeper soil and groundwater. Once dissolved, PFAS can stay in water for long periods of time.

Workers and students **[*exposed population*]** on the site could be exposed to PFAS-contaminated groundwater and soil. PFAS exposure via indoor water taps **[*exposure***

point groundwater] includes ingestion via drinking, cooking and brushing teeth, as well as, inhalation and dermal contact via showering [***exposure routes water***]. PFAS exposure via soil includes dermal contact and incidental ingesting of soil particles in air and on hands [***exposure routes soil***]. FDOH considered exposure via surface soil (0 – 2 feet deep) a completed pathway. (Exposure to deeper sub-surface soil is not considered possible for the FSFC; see below for further explanation).

PFAS are not easily absorbed over the skin and do not vaporize easily [ATSDR 2018b; EPA 2016]. Thus, dermal and air contact are generally not considered major pathway elements for PFAS. However, some dermal contact and inhalation (from evaporation of PFAS-contaminated water) could occur while showering and were therefore considered completed exposure routes for workers and students.

Potential Pathways

If one or more elements were uncertain, a pathway was identified as a ***potential pathway*** at the FSFC:

- ✓ pre 2018/2019 exposure to contaminated drinking and showering water – workers and students
  - ➔ Exposure to PFAS-contaminated indoor tap water via drinking, cooking, brushing teeth and/or showering may have occurred before 2018/2019, but this time frame lacks environmental data (Figure 5.a).

- ✓ exposure to contaminated indoor tap water via drinking – visitors
  - ➔ FDOH considered that visitors of workers and students at the FSFC could have been exposed to PFAS if they drank water from the indoor FSFC taps during visits. Exposure data are however limited for this pathway to evaluate if visitors drink the water, and, how often and for how long visitors visit (Figure 5.a).

- ✓ pre and post 2018/2019 exposure to contaminated surface soil – workers and students
  - ➔ Pre 2018/2019 exposure to PFAS-contaminated surface soil might have occurred, but environmental data lack for this time frame (Figure 5.a).
  - ➔ Post 2018/2019 exposure to PFAS-contaminated surface soil is possible until cleanup of PFAS-contaminated surface soil has been completed. Environmental data for this time frame lack and cannot be predicted (Figure 5.a).

- ✓ exposure to contaminated surface soil - AOC4, workers and students
  - ➔ Area of Concern 4 (AOC4) is a designated retention pond area. The retention ponds are not used by workers and students [FSFC, personal communication, 2011]. However, FDOH considered access during dry periods potential (Figure 5.a).
- ✓ exposure to contaminated surface soil - trespassers

➔ Trespassing is unknown at the FSFC. FDOH considered trespassing a possibility, because trespassers could potentially be exposed to PFAS in surface soil at the site (Figure 5.a).

Eliminated Pathways

If one or more elements were missing, a pathway was identified as an ***eliminated pathway***:

- ✓ post 2018/2019 exposure to contaminated drinking and showering water at the FSFC
  - ➔ Mitigation efforts prevent future exposure to PFAS-contaminated on-site water via drinking, cooking, brushing teeth and showering (Figure 5.a). Mitigation efforts at the FSFC include supply of bottled water and the installation of a GAC multi-canister (16-canister) filter system.

- ✓ exposure to surface water
  - ➔ Exposure to surface water before, during and after 2018/2019 is very unlikely, because the retention ponds have not been, are not and will not be used for drinking and/or recreational purposes [FSFC, personal communication, 2011] (Figure 5.b).

- ✓ exposure to sub-surface soil
  - ➔ Exposure to PFAS in sub-surface soil (two feet and deeper) before, during and after 2018/2019 is very unlikely. Two (2) feet and below is deep enough to prevent human contact unless construction work or other soil moving work occurs. No such work is known to have taken place or to be planned on-site. FDEP's contractors wear necessary personal protective equipment when conducting site-assessment activities (Figure 5.b).

See Figures 5.a and 5.b for a detailed representation of all pathways at the FSFC Site.

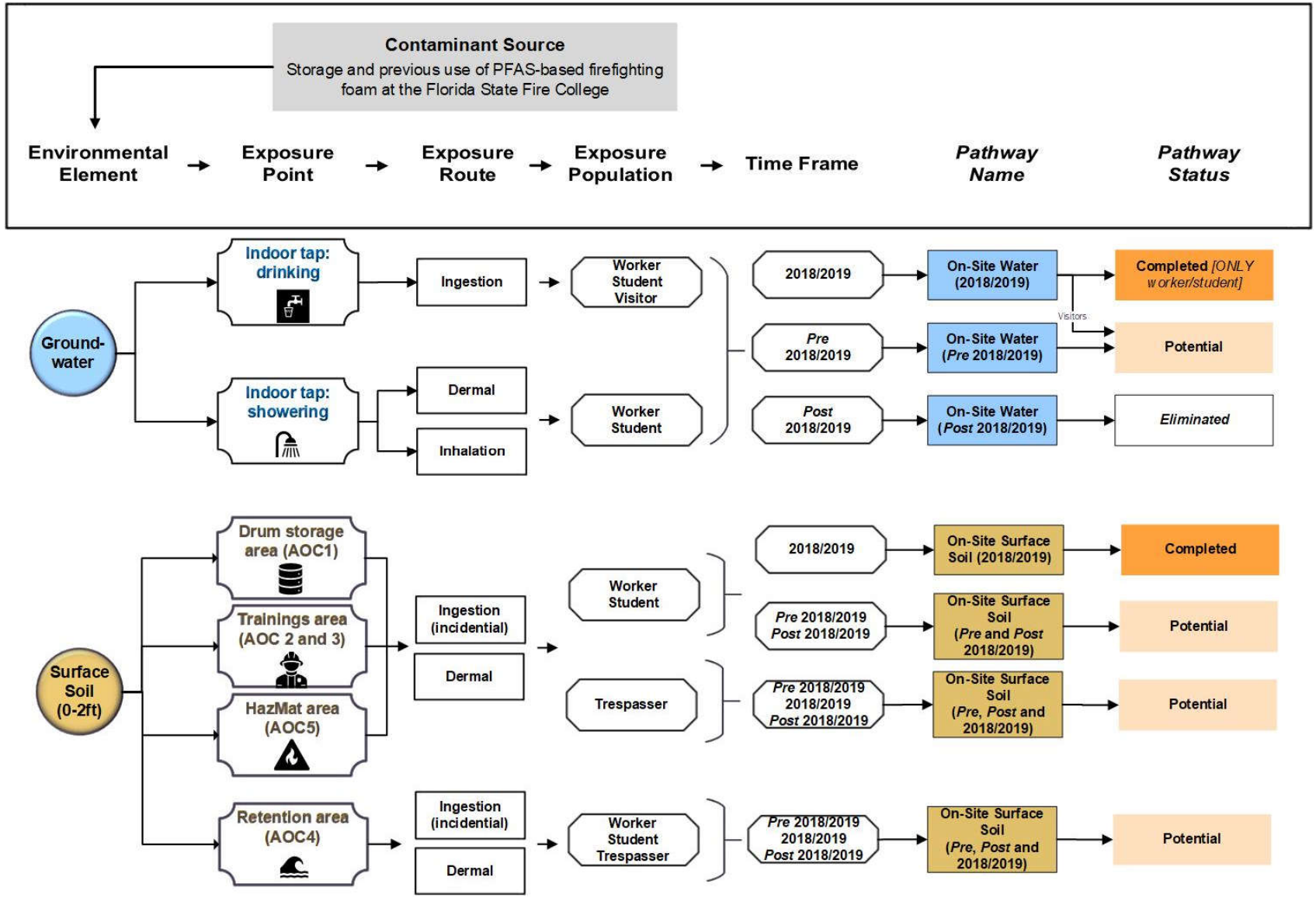

Figure 5.a: Overview of exposure pathways investigated for groundwater and surface soil for the Florida State Fire College, Marion County.

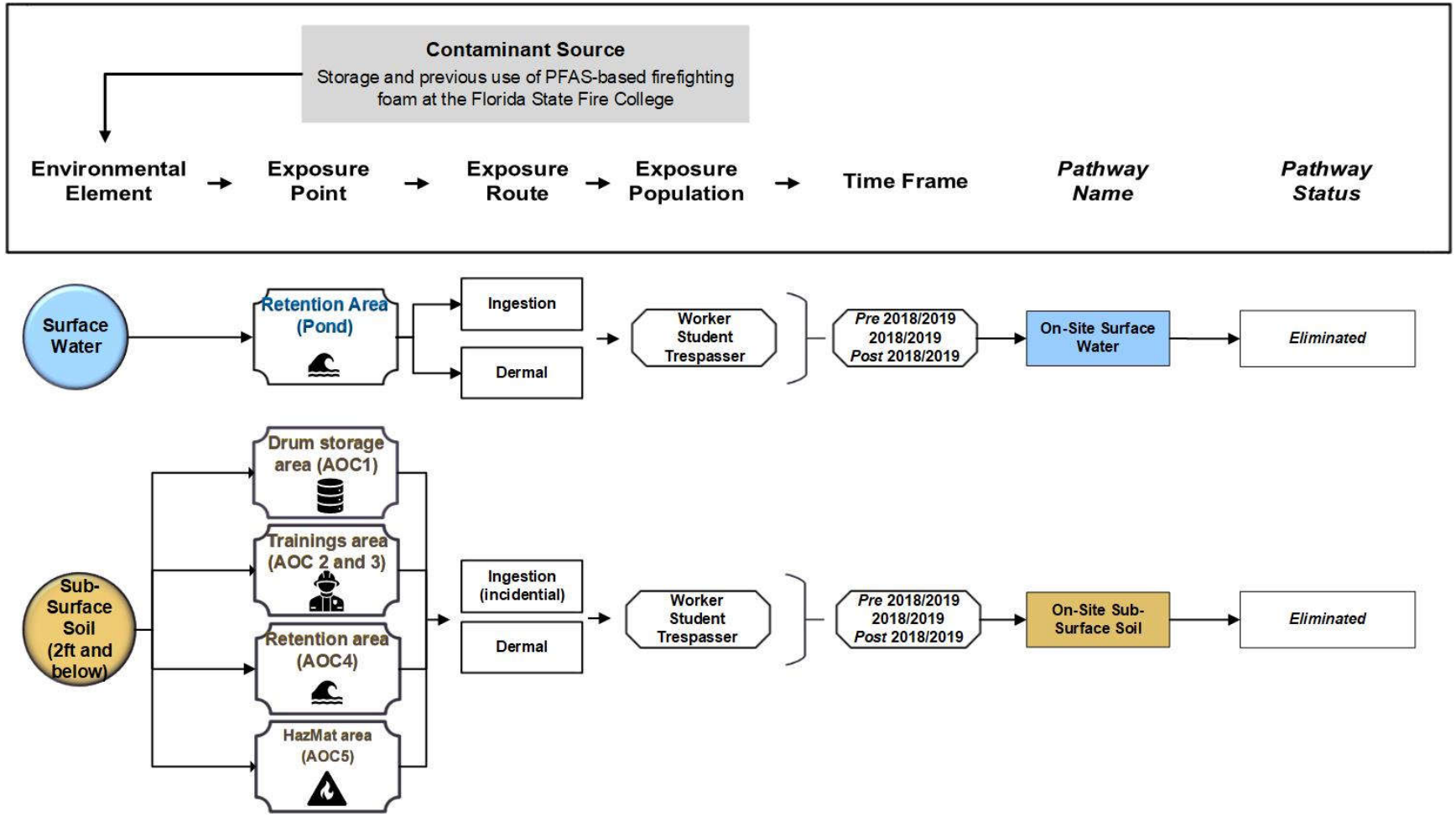

Figure 5.b: Overview of exposure pathways investigated for surface water and sub-surface soil for the Florida State Fire College, Marion County.

3.3. Environmental Data Assessment

3.3.1. Environmental Data Screening

Environmental data (chemical concentrations in groundwater and soil) were evaluated to determine the need for further evaluation of possible health risks to the on-site FSFC community. PFAS concentration data for the site were screened with ATSDR's health-based comparison values (CVs)[3]. Chemicals with concentrations greater than their CVs are identified as chemicals of potential concern (see Section 3.3.2). A concentration above the CV is not necessarily a health threat, but it indicates the need for further health effects assessment (Section 3.4).

Note: PFAS are a large group of many compounds. Many PFAS were detected in the samples. This assessment evaluates four PFAS: PFOA, PFOS, PFNA and PFHxS. At the time of assessment, ATSDR has concluded that toxicological information is only sufficient to develop health guidelines[4] and associated CVs for these four PFAS [ATSDR 2018b]. FDOH adheres to ATSDR's recommendation that all four PFAS must be evaluated in depth (Section 3.4), whenever one or more of these exceed their CV. FDOH acknowledges that the combined risk of all PFAS may be higher than what might be expected from any one of these four PFAS individually.

Water

In August and September 2018, FDEP collected water samples from the on-site well (used as the main water supply for all on-site activities) and from an indoor tap (Tables 1 and 2, Appendix C, Table C-1):

Table 1: Maximum concentration (ng/L) of PFOA, PFOS, PFNA and PFHxS collected from the on-site supply well and their respective ATSDR comparison values[5].

	Maximum Concentration (ng/L)	***ATSDR Comparison Value (ng/L)[5]***	***Above ATSDR Comparison Value?***
PFOA	10	21	No
PFOS	240	14	**Yes**
PFNA	1.7	21	No
PFHxS	190	140	**Yes**

Table 2: Maximum concentration (ng/L) of PFOA, PFOS, PFNA and PFHxS collected from an indoor tap and their respective ATSDR comparison values[5].

	Maximum Concentration (ng/L)	***ATSDR Comparison Value (ng/L)[5]***	***Above ATSDR Screening Value?***
PFOA	7	21	No
PFOS	250	14	**Yes**
PFNA	1.4	21	No
PFHxS	130	140	No

[5] ATSDR's environmental media evaluation guides for childhood intermediate exposure were used as they are the most protective values. These concentrations are not expected to cause harmful non-cancer health effects in humans, including sensitive populations (i.e., children).

The maximum water concentrations of PFOS and PFHxS exceed their ATSDR CVs (Tables 1 and 2). In accordance with ATSDR recommendation, all PFAS, including PFOA and PFNA, were further evaluated in the health risk assessment (Section 3.4).

Soil

Soil sampling activities are ongoing to investigate the extent of soil contamination and determine the best approach for cleanup at the FSFC site (see Section 2.2). This assessment considered soil data collected from November 2018 through November 2019. These soil data are presented in Appendix C, Tables C-2 and C-3.

FSFC soil sampling includes on-site collection of surface soil (0 – 2 feet) and sub-surface soil (from 2 feet and down to the groundwater table). In November 2018, soil samples were collected from different locations within five on-site Areas of Concern (AOC) 1 to 5 (Figure 3). From March to May 2019, additional soil samples were collected from AOC1 and AOC3. From September to November 2019, soil sampling was continued at AOC1.

Table 3: Overview of soil sampling areas of concern (AOC 1-5).

AREA OF CONCERN (AOC)	USAGE
AOC1	Former drum and tote storage
AOC2	Training tower block
AOC3	New burn building block
AOC4	Stormwater pond
AOC5	HazMat training area

Table 4: Overview of ATSDR soil comparison values[5] for PFOA, PFOS, PFNA and PFHxS.

	ATSDR Comparison Value (mg/kg)[5]
PFOA	0.16
PFOS	0.10
PFNA	0.16
PFHxS	1.00

➔ ***Surface Soil:***

Detailed surface soil data are presented in Appendix C, Table C-2. The following summarizes the findings:

AOC1: The maximum PFOA, PFOS and PFHxS concentrations in surface soil at AOC1 exceed their respective ATSDR comparison values (Table 4). The maximum PFNA level was below its ATSDR comparison value.
In accordance with ATSDR recommendation, all four PFAS were further evaluated in the health risk assessment (Section 3.4).

AOC2: The maximum PFOA, PFOS, PFNA and PFHxS concentrations in surface soil at AOC2 did not exceed their respective ATSDR comparison values (Table 4). Therefore, AOC2 was not further considered in the health risk assessment (Section 3.4).

AOC3 + AOC4: + AOC5 The maximum PFOS concentrations in surface soil at AOC3, AOC4 and AOC5 exceed its respective ATSDR comparison value (Table 4). The maximum PFOA, PFNA, and PFHxS levels were below their ATSDR comparison values. ***In accordance with ATSDR recommendation, all four PFAS were further evaluated in the health risk assessment (Section 3.4).***

➔ ***Sub-Surface Soil:***

Sub-surface soil at 2 feet and below is deep enough to prevent human contact, unless construction work or other soil moving work occurs. Except for work conducted by the FDEP contractors, who wear appropriate personal protective equipment, no such work is scheduled or known to have taken place at the FSFC. Thus, sub-surface soil was not evaluated for this health assessment. It is recommended that future excavation workers follow the general recommendations made to prevent exposure via surface soil. (See Appendix C, Table C-3).

3.3.2. Identification of Chemicals of Potential Concern

If screened chemical concentrations are above ATSDR's health-based CVs (see Section 3.3.1), the FDOH health assessor classifies these as chemicals of potential concern to be evaluated further. The in-depth evaluation (Section 3.4) assesses if the chemicals of potential concern pose risk to the public health. ** ***During this public health assessment process (see Section 3.4), site-specific exposure variables (such as duration and frequency) and the toxicology of the contaminant are evaluated in depth to determine likelihood of possible health effects. The health assessor estimates site-specific exposure doses for each contaminant and compares these with their respective health guideline.***

Table 5: Summary of screening results for maximum PFOA, PFOS, PFNA and PFHxS concentrations in water and surface soil.

	Exceedance of ATSDR Comparison Value[5]	
	Water	***Surface Soil***
PFOA	No	**Yes**
PFOS	**Yes**	**Yes**
PFNA	No	No
PFHxS	**Yes**	**Yes**

Based on the comparison results (Table 5), PFOS and PFHxS are of potential concern in water at the FSFC. PFOA, PFOS and PFHxS are of potential concern in surface soil. PFNA is not of concern in indoor tap water or surface soil at the FSFC.

In accordance with ATSDR's recommendation, all four PFAS were further evaluated for exposure via both drinking/showering water and surface soil, because a minimum of one of these PFAS exceeded its CV for water and/or soil.

3.4. Non-Cancer & Cancer Health Risk Evaluation

When exposure pathways and chemicals of potential concern have been selected for further evaluation, daily ***exposure doses*** are estimated to assess risk of non-cancer and cancer health effects (See Appendix B for detailed description of dose estimation). A daily ***exposure dose*** is the amount of a chemical a person is exposed to in their ambient environment in a day. The ***exposure dose*** calculation uses site-specific input parameters (*e.g.*, chemical concentrations) and population-specific input parameters (*e.g.*, age, intake rates, age-specific body weight) (Appendix C, Tables C-4 to C-7).

When evaluating a possible, harmful non-cancer health risk, the estimated daily exposure doses are compared with ATSDR's minimal risk levels (MRLs)[6]. An MRL is an estimated safe dose, which is considered unlikely to cause adverse effect in humans for a given exposure scenario. Thus, if an estimated exposure dose is lower than the MRL, harmful non-cancer health effects are considered unlikely. If an estimated exposure dose is equal to or exceeds the MRL, harmful non-cancer health effects could be possible. When estimated doses exceed the MRL, the potential non-cancer health risks are more carefully evaluated and communicated to the relevant community. Further information on the possible non-cancer illnesses caused by PFOA, PFOS, PFNA and PFHxS exposure is presented in Section 3.4.1 and Appendix E.

Cancer risk is evaluated as the potential of ***increased cancer risk*** (see Appendix B). In general, one of every three Americans is expected to be diagnosed with cancer at least once in their lifetime. FDOH considers an ***increased cancer risk*** of one-in-a-million extremely low (one in a million = 10^{-6}, 1E-06 in the results tables, Appendix D). It means that in a population of one million 'exposed' people, one additional occurrence of cancer is expected compared to an 'unexposed' population. The risk of ***increased cancer*** is generally communicated as follows:

1 in 10 (10^{-1})	"very high" increased cancer risk
1 in 100 (10^{-2})	"high" increased cancer risk
1 in 1,000 (10^{-3})	"moderate" increased cancer risk
1 in 10,000 (10^{-4})	"low" increased cancer risk
1 in 100,000 (10^{-5})	"very low" increased cancer risk
1 in 1,000,000 (10^{-6})	"extremely low" increased cancer risk

[6]A **minimal risk level (MRL)** is developed to protect the most sensitive populations. An MRL is an estimate of the daily human exposure to a hazardous substance that is likely to be without considerable risk of adverse non-cancer health effects over a specified route and duration of exposure. To derive an MRL, the lowest chemical daily dose observed to cause the most sensitive health effect (for example a developmental effect) is identified. Then this chemical dose is lowered by applying one or more numbers called uncertainty factors. This way the MRL is set far below any daily dose known to cause the most sensitive effect known.

Increased cancer risk is evaluated for populations exposed to PFOA for one year or longer. Increased cancer risk is not evaluated for exposure less than one year. PFOS, PFNA and PFHxS are currently not classified as potential carcinogens and are therefore not evaluated for increased cancer risk. Cancer risk estimation for PFAS is generally very uncertain due to lack and/or limitation of toxicological information.

The health risk assessment for the FSFC is site-specific and considered three populations:

- workers,
- students and
- trespassers (Appendix C, Tables C-4 to C-7).

Although visitors are possibly exposed to PFAS in drinking water and soil during short visits at the FSFC, there are too many uncertainties regarding exposure duration and frequency for this population to conduct a meaningful exposure assessment. For members of the community, who are concerned about the possible health risks posed to their visitors, it is recommended to follow the general recommendations made for workers, students and trespassers.

3.4.1. PFAS-Related Health Effects – A General Overview

PFAS is a family with more than 4,000 identified compounds [ITRC 2020a]. However, sufficient information needed to evaluate possible health threats is only available for relatively few PFAS [ITRC 2020b]. The lack and/or limitation of toxicological information and the extensive level of effort needed to develop other parameter values needed for health risk evaluation prevent the establishment of compound-specific health guidelines for most PFAS [ATSDR 2018b].

Most of the current human health effects information for PFAS is derived from epidemiological studies, which have linked PFAS exposure with increased frequency of some health outcomes. Epidemiological studies are important to help indicate possible effects of chemical exposure. Though, dose-effect relationships necessary to produce health guidelines cannot be established without controlled studies. Therefore, current PFAS health guidelines rely on controlled animal studies, which have shown similar effects in animals dosed with known (often high) PFAS concentrations. However, it is not certain that humans will respond to the same concentrations with the same type and degree of effect.

As of today, human epidemiological and animal studies have not found consistent links for PFAS causing cancer. Epidemiological studies have suggested links between PFOA exposure and elevated rates of kidney, prostate and testicular cancers, whereas animal studies have observed increased rates in liver, pancreatic and testicular cancers. Results of animal studies provide suggestive evidence of a link between PFOS exposure and increased incidences of liver, thyroid and mammary tumors [ATSDR 2018b]. A causal link between PFOS exposure and human cancers is lacking. Other PFAS than PFOA may have the potential to cause cancers but further research and toxicological information is needed.

Scientists are still learning about the health effects of PFAS. Possible non-cancer health effects include effects to the liver, thyroid, serum cholesterol, immune and reproductive systems. Pregnant and lactating women, and, women and men who plan to become parents, could be at risk of health effects in their unborn or infants drinking breastmilk. Effects could include reduced birth weight, developmental effects such as small delays in puberty, as well as, childhood obesity [Braun 2017]. Pregnant women exposed to PFAS could be more susceptible to preeclampsia (hypertension during pregnancy), though findings are inconsistent [Borghese et al. 2020; Savitz et al. 2012; Stein et al. 2009; Wikström et al. 2019]. People with pre-existing conditions such as compromised liver or immune system, or elevated serum cholesterol may be more sensitive to PFAS exposure. Table 6 below provides a summary of possible health effects of PFAS exposure in humans based on epidemiological data. This general overview does not necessarily reflect possible health risk at the FSFC.

Table 6: General overview of possible health effects from PFAS exposure in humans based on epidemiological data.

Organ/system	*Associated health effect*	*PFOA*	*PFOS*	*PFNA*	*PFHxS*
Cardiovascular	Preeclampsia	**X**	**X**	**X†**	**X‡**
Liver	Liver damage (increase in serum enzymes, decrease in bilirubin)	**X**	**X**		**X**
Blood	Increased serum lipids (mainly total cholesterol and low-density lipoprotein (LDL) cholesterol)	**X**	**X**	**X**	
Thyroid	Increased risk of thyroid disease	**X**	**X**		
Immune	Decreased antibody response to vaccines	**X**	**X**		**X**
Respiratory	Increased risk of asthma diagnosis	**X**			
Reproductive	Increased risk of reduced fertility	**X**	**X**		
Developmental	Small decreases in birth weight	**X**	**X**		
Carcinogenicity	Kidney, prostate, testicular cancer	**X**			

Adapted from ATSDR's draft toxicological profile for PFAS [ATSDR 2018b].
†[Wikström et al. 2019], ‡[Borghese et al. 2020]

More detailed information about PFAS in general and about the possible health effects of exposure to PFOA, PFOS, PFNA and PFHxS can be found in Appendix E.

3.4.2. Florida State Fire College – On-Site PFAS Health Risk Evaluation

Workers and Students

Health assessors estimated daily doses for workers and students aged 16 and older (including pregnant and lactating women) exposed to PFAS via drinking/showering water and surface soil. The exposure estimation in this report used maximum PFAS levels found in well and indoor tap water in August and September 2018, and in surface soil sampled

from November 2018 through November 2019 (Section 3.3.1, Appendix C, Tables C-1 and C-2).

Workers were assumed to be exposed to water and soil for five days per week, 50 weeks per year and for up to 30 years (Appendix C, Tables C-4 to C-6). Students were assumed to be exposed to contaminated water and soil for five days per week, every week for 22 weeks.

A higher than average ***drinking water*** intake rate of 3.588 liters/day was used (Appendix C, Table C-4). This intake rate is equivalent to the reasonable maximum average for lactating women [ATSDR 2016]. Students and teachers at the college perform strenuous outdoor activities during their fire training. Due to the elevated temperatures and humidity during most of the year in Florida and the physical nature of the training, it is likely that students and teachers have higher drinking water intake rates than the average population (for more information see Appendix F).

Showering exposure (inhalation and dermal exposure) was evaluated for PFOA and PFOS using a software model (Shower Model) developed by ATSDR. Showering input parameters are presented in Appendix C, Table C-5. PFNA and PFHxS are not currently included in the Shower Model. However, showering is in general considered as a minor pathway for PFAS due to their poor absorption over the skin and minimal vaporization into the air (inhalation).

Exposure via surface soil (incidental ingestion and dermal exposure) was assessed for AOC1, AOC3, AOC4 and AOC5. Exposure via soil was not assessed for AOC2, where soil levels were below ATSDR's health-based CVs.

Exposure to soil was evaluated separately for indoor workers, outdoor workers and students. Indoor workers spend all day inside. Outdoor workers include outdoor maintenance workers with generally low intensity soil contact, as well as teachers, who are part time indoors and part time outdoors with possibly higher intensity soil contact while outside (overall low intensity soil contact). Students have similar mixed indoor and outdoor work as teachers (overall low intensity soil contact). All soil input parameters are presented in Appendix C, Table C-6.

Detailed information regarding the calculation process are provided in Appendix B. Detailed results of exposure doses and risk estimates for workers and students can be found in Appendix D, Tables D-1 to D-10 and Tables D-11 to D-16, respectively.

Note: Cancer risk (chronic risk) is only evaluated for exposure of one year or longer. Therefore, increased cancer risk was not evaluated for students who reside at the FSFC for 22 weeks.

Acute effects from less than two weeks of exposure could not be assessed because no health guidelines exist for short term exposure.

Exposure to PFAS via on-site drinking water

Pre 2018/2019: Data for FSFC drinking water do not exist before 2018. Therefore, FDOH is not able to evaluate the likelihood of harmful health effects to former workers and students, who may have been exposed to PFAS in FSFC drinking water before 2018.

2018/2019: Estimated daily doses, minimal risk levels (MRLs)[6], non-cancer risk and increased cancer risk for exposure of two weeks or longer to ***PFOA, PFOS, PFNA and PFHxS*** are presented in Appendix D, Tables D-1 and D-11.

Non-cancer health risk: Estimated doses for ***PFOA, PFNA and PFHxS*** are less than their respective provisional MRLs. Estimated doses for ***PFOS*** are greater than the respective MRL. When estimated doses are greater than the MRL, health risk is further evaluated.

Workers and students, including pregnant and lactating women, who drank indoor tap water at the FSFC with 2018/2019 ***PFOS*** levels could be at increased risk of non-cancer health effects. ***PFOA, PFNA and PFHxS*** levels in drinking water at the FSFC during 2018/2019 likely do not pose risk of non-cancer health effects via drinking but contribute to overall PFAS exposure at the FSFC.

FDOH health assessors evaluated the estimated ***PFOS*** doses for FSFC drinking water in more detail by comparing them with exposure doses for humans predicted from animal studies (see Appendix B, Section 2 for more detail). Estimated PFOS doses are only a little higher than the respective MRL, which is based on the most sensitive effect known. Therefore, it is possible that people exposed to PFOS via drinking of indoor tap water at the FSFC are mostly at risk of very sensitive effects (that occur at low doses).

Animal studies on rodents have identified developmental and immune effects as the most sensitive targets of PFOS exposure [ATSDR 2018b]. The doses estimated for workers and students at the FSFC are well below doses predicted to cause developmental effects (Appendix B, Section 2). Therefore, developmental effects are not expected to be likely for infants and children of FSFC workers and students from exposure to PFOS in drinking water alone.

The estimated doses are, however, close to doses predicted to cause immune effects based on animal studies (Appendix B, Section 2). Therefore, workers and students who drank indoor tap water at the FSFC with 2018/2019 levels of PFAS may be at risk of immune effects. Human epidemiological studies have found associations between PFOS exposure and decreased antibody response to some vaccines. These studies did not find an association with increased rates of vaccine-preventable diseases. Therefore, it is uncertain if the studied immune responses would lead to adverse health effects.

In addition to developmental and immune effects, PFOS has been associated with various health effects including effects to liver, serum cholesterol, as well as thyroid, reproduction and preeclampsia.

Sensitive populations including pregnant and lactating women, men and women planning to have a baby, and people with pre-existing health conditions such as a compromised liver or immune function, or, elevated cholesterol levels may be at increased risk of health effects.

FDOH health assessors acknowledges that workers and students, including pregnant and lactating women, may be exposed to low levels of other PFAS compounds as well as PFOS from other sources (such as on-site surface soil, furniture and consumer products). Additional exposure may increase the possibility of risk of harmful non-cancer health effects. Though, the actual combined risk from multiple PFAS and from multiple sources cannot be evaluated. Furthermore, at the FSFC, PFOS is the predominant contaminant and the individual contributions of PFOA, PFNA, PFHxS and other PFAS are low in comparison. Other PFOS sources and exposure routes such as surface soil at AOC1 could elevate the risk of developing non-cancer health effects (in-depth discussion, see ***Exposure to PFAS in on-site surface soil***).

Increased cancer health risk: Increased cancer risk is estimated to be less than one in a million for workers exposed to ***PFOA*** for one year or longer. Increased cancer risk of one in a million is generally considered extremely low. However, current limitations of scientific knowledge prevent comprehensive evaluation of cancer, which must therefore be considered uncertain. Epidemiological studies have associated ***PFOA*** exposure with kidney, prostate and testicular cancers. The above cancer estimation is based on testicular cancer from an animal study. ***PFOS, PFNA and PFHxS*** are currently not classified as human carcinogens[7].

Cancer is not considered for students, as they are residing at the FSFC for less than one year. Cancer risk is not evaluated for exposure periods less than one year.

Exposure to PFAS in on-site showering water

Pre 2018/2019: Data for PFAS in water at the FSFC do not exist before 2018. Therefore, FDOH was not able to evaluate the likelihood of harmful health effects to former workers and students, who may have been exposed to PFAS via showering at the FSFC before 2018.

2018/2019: Estimated daily doses (for inhalation and dermal contact), minimal risk levels (MRLs)[6], non-cancer risk and increased cancer risk for exposure of two weeks or longer to ***PFOA and PFOS*** are presented in Appendix D, Tables D-2 and D-12.

[7] Carcinogen - A chemical that can cause cancer.

Non-cancer health risk: Estimated daily exposure doses for ***PFOA*** and ***PFOS*** via showering were less than their respective MRLs. When doses are less than MRL, non-cancer health risk is unlikely. PFNA and PFHxS currently cannot be evaluated using the Shower Model. However, showering is generally considered as a minor pathway for PFAS due to their poor absorption over the skin and minimal vaporization into the air (inhalation).

Workers and students, including pregnant and lactating women, who showered at the FSFC with 2018/2019 levels of ***PFOA*** and ***PFOS*** are not likely to experience non-cancer illnesses from PFOA and PFOS exposure via showering alone.

FDOH health assessors acknowledges that workers and students, including pregnant and lactating women, may be exposed to low levels of other PFAS compounds as well as PFOS from other sources (such as on-site surface soil, furniture and consumer products). Additional exposure may increase the possibility of risk of harmful non-cancer health effects. Though, the actual combined risk from multiple PFAS and from multiple sources cannot be evaluated. Furthermore, at the FSFC, PFOS is the predominant contaminant and the individual contributions of PFOA, PFNA, PFHxS and other PFAS are low in comparison. Other PFOS sources and exposure routes such as surface soil at AOC1 could elevate the risk of developing non-cancer health effects (in-depth discussion, see ***Exposure to PFAS in on-site surface soil***).

Increased cancer health risk: Increased cancer risk is estimated to be less than one in a million for workers exposed to ***PFOA*** for one year or longer. Increased cancer risk of one in a million, is generally considered extremely low. However, current limitations of scientific knowledge prevent comprehensive evaluation of cancer, which must therefore be considered uncertain. Epidemiological studies have associated ***PFOA*** exposure with kidney, prostate and testicular cancers. The above cancer estimation is based on testicular cancer from an animal study. ***PFOS, PFNA and PFHxS*** are currently not classified as human carcinogens.

Cancer is not considered for students as they are residing at the FSFC for less than one year. Cancer risk is not evaluated for exposure periods less than one year.

By contributing to total PFAS exposure, showering exposure may increase the total risk of health effects for FSFC workers. Due to the limited understanding of PFAS mixture effects, the actual combined risk cannot be evaluated at this time. Drinking water exposure is likely the dominant pathway for PFAS exposure at the FSFC, with PFOS being the main contaminant of concern.

Exposure to PFAS in on-site surface soil

Pre 2018/2019: Soil data do not exist from before 2018. FDOH was not able to evaluate the likelihood of harmful health effects to former workers and students, who may have been exposed to PFAS in surface soil at the FSFC before 2018.

2018/2019: Estimated daily doses, minimal risk levels (MRLs)[6], non-cancer risk and increased cancer risk for exposure of two weeks or longer to ***PFOA, PFOS, PFNA*** and ***PFHxS*** in surface soil at ***AOC1 and AOC3 to AOC5*** are presented in Appendix D, Tables D-3 to D-10 and D-13 to D-16. ***AOC2*** was not considered a health risk, because PFAS levels were below CVs (Section 3.3.2).

Non-cancer health risk: Estimated daily doses for exposure of two weeks or longer to ***PFOA, PFNA*** and ***PFHxS*** in contaminated surface soil from areas ***AOC1 and AOC3 to AOC5*** are less than their respective provisional MRLs. Estimated daily doses for exposure to ***PFOS***-contaminated surface soil from ***AOC3 to AOC5*** are also less than the respective provisional MRL. However, estimated daily doses for exposure of two weeks or longer to ***PFOS***-contaminated surface soil from ***AOC1*** exceed the respective provisional MRL.

Estimated doses lower than the respective MRL are not likely to cause non-cancer health effects in the exposed population. Therefore, harmful non-cancer health effects are not expected for FSFC students, and, indoor and outdoor workers exposed to 2018/2019 levels of PFOA, PFNA and PFHxS at AOC1 to AOC5, and PFOS in surface soil at AOC3 to AOC4. Based on this evaluation of individual PFAS levels, surface soil at ***AOC3 to AOC5*** are not of concern.

Because estimated ***PFOS*** doses for ***AOC1*** exceed the respective MRL, non-cancer health risk was further evaluated for indoor and outdoor workers, including students and teachers, who incidentally ingest soil particles and/or come in skin contact with PFOS-contaminated surface soil from AOC1 for two weeks or longer.

The estimated PFOS doses for exposure to surface soil at AOC1 are much greater than the provisional MRL. FDOH health assessors evaluated the possible risk of these exposure doses by comparing them with estimated exposure doses for humans predicted from animal studies (see Appendix B, Section 2 for more detail). Animal studies with rodents have identified developmental and immune effects as the most sensitive targets of PFOS exposure [ATSDR 2018b]. The estimated PFOS doses for AOC1 are close to doses predicted to affect development and particularly close to doses predicted to cause immune effects (Appendix B, Section 2).

Developmental effects associated with PFAS exposure in human epidemiological studies include small decreases in birth weight, which have also been observed in animal studies together with small delays in development. The fetus can be exposed to PFAS in-utero and lactating mothers can pass PFAS on to their child via the breastmilk [ATSDR 2018a]. Therefore, risk of developmental effects could be of concern for pregnant and lactating women, as well as, for women who plan to become pregnant. Pregnant women could also be at increased risk of preeclampsia.

Reduced immune responses have been observed in animals exposed to PFOS. Human epidemiological studies have found associations between PFOS exposure and decreased antibody response to vaccines. These vaccine studies did not find an association with increased rates of vaccine-preventable diseases. Therefore, it is uncertain if the studied immune responses would lead to adverse health effects. In addition to developmental and immune effects, PFOS has been associated with various health effects including effects to liver, serum cholesterol, as well as thyroid, reproduction and preeclampsia.

Sensitive populations including pregnant and lactating women, men and women planning to have a baby, and people with pre-existing health conditions such as compromised liver or immune function, or, elevated cholesterol levels may be at increased risk of health effects.

FDOH health assessors acknowledges that workers and students, including pregnant and lactating women, may be exposed to low levels of other PFAS compounds as well as PFOS from other sources including drinking water, showering, furniture and consumer products. Additional exposure may increase the possibility of risk developing harmful non-cancer health effects. Though, the actual combined risk from multiple PFAS and from multiple sources cannot be evaluated. Furthermore, at the FSFC, PFOS is the predominant contaminant and the individual contributions of PFOA, PFNA, PFHxS and other PFAS are low in comparison Other PFOS sources and exposure routes such as surface soil at AOC1 could elevate the risk of developing non-cancer health effects

It is important to acknowledge that PFOS levels of concern have only been found in surface soil at AOC1. Many soil cores were collected from AOC1 and PFOS levels varied greatly across these cores (Appendix C, Tables C-2). The PFOS level used for this evaluation is the highest level found at AOC1. Approximately 50 percent of the samples tested from AOC1 had PFOS levels above CV, but this does not imply that PFAS concentrations found in these 50 percent of samples would result in doses above MRL. This evaluation is representative of a very localized area within AOC1. In addition, AOC1 is at the far corner of the property. It is an area that is irregularly accessed (approximately 3-4 times per year) by a few maintenance workers and instructors, but not by students [FDEP, personal communication, 2021]. While access has been infrequent, it should be considered that mowing could disturb surface soil. Soil and dust could be transported with wind and on people's skin, clothes and shoes from one area to another, including indoor buildings. This assessment was designed to be protective of the worst-case scenario and the health risk evaluation may be overestimated.

Increased cancer health risk: Increased cancer risk is estimated to be less than one in a million for workers exposed to ***PFOA*** for one year or longer. Increased cancer risk of one in a million is generally considered extremely low. However, current limitations of scientific knowledge prevent comprehensive evaluation of cancer, which must therefore be considered uncertain. Epidemiological studies have associated ***PFOA*** exposure with kidney, prostate and testicular cancers. The

above cancer estimation is based on testicular cancer from an animal study. ***PFOS, PFNA and PFHxS*** are currently not classified as human carcinogens.

Cancer is not considered for students, as they are residing at the FSFC for less than one year. Cancer risk is not evaluated for exposure periods less than one year.

Post 2018/2019: Exposure to PFAS in surface soil after 2018/2019 and possible threat to human health are possible if the soil is not remediated (cleaned up), particularly at AOC1. It is not possible to predict how much the PFAS levels in surface soils will change over time. Therefore, it is not possible to complete a meaningful evaluation. The site assessment activities by FDEP are ongoing. A primary objective is to delineate the extent of soil contamination to conduct cleanup activities. Soil cleanup typically includes excavation of contaminated soil that is either an exposure risk or a significant source to groundwater contamination via leaching. The excavated soil is replaced with "clean fill," thereby greatly minimizing the risk of exposure to workers, students and the environment. AOC1 is the highest priority for a likely source removal to occur [FDEP, personal communication, 2021]. FDOH recommends that workers wear protective gear during remediation work. Further, FDOH recommends continued soil testing until mitigation has been completed. If mitigation is delayed, FDOH recommends continued assessments of future health risks including data monitoring

Trespassers

Health assessors estimated daily exposure doses for trespassers aged 16 and older, who were potentially exposed to 2018/2019 levels of PFOA, PFOS, PFNA and PFHxS in surface soil at the FSFC (Appendix C, Table C-2). The estimation assumed that trespassers intrude three days per week, 52 weeks per year and for up to 10 years (Appendix C. Table C-7). Health assessors used the maximum concentrations measured for PFOA, PFOS, PFNA and PFHxS in surface soil at AOC1 and AOC3 to AOC5 (Appendix C, Table C-2). Exposure was not assessed for AOC2, where soil levels were below ATSDR health-based CVs (Section 3.3). Detailed results of the exposure dose calculations for trespassers can be found in Appendix D, Tables D-17 to D-20.

Note: Health assessors did not evaluate trespassers' exposure to indoor tap water as they are not expected to have access to indoor water taps while unlawfully entering the FSFC.

Exposure to PFAS in on-site surface soil

Pre 2018/2019: Soil data from before 2018 do not exist. Therefore, FDOH was not able to evaluate the likelihood of harmful health effects to former trespassers, who may have been exposed to PFAS in surface soil at the FSFC before 2018.

2018/2019: Estimated daily doses, minimal risk levels (MRLs)[6], non-cancer risk and increased cancer risk for exposure of two weeks or longer to ***PFOA, PFOS, PFNA*** and ***PFHxS*** in surface soil at ***AOC1 and AOC3 to AOC5*** are presented in Appendix D, Tables D-3 to D-10 and D-13 to D-16. ***AOC2*** was not considered a health risk because PFAS levels were below CVs (Section 3.3.2).

Non-cancer health risk: Estimated daily doses for exposure of two weeks or longer to ***PFOA, PFNA*** and ***PFHxS*** in contaminated surface soil from areas ***AOC1 and AOC3 to AOC5*** are less than their respective provisional MRLs. Estimated daily doses for exposure to ***PFOS***-contaminated surface soil from ***AOC3 to AOC5*** are also less than the respective provisional MRL. However, estimated daily doses for exposure of two weeks or longer to ***PFOS***-contaminated surface soil from ***AOC1*** exceed the respective provisional MRL

Estimated doses lower than the respective MRL are not likely to cause non-cancer health effects in the exposed population. Therefore, harmful non-cancer health effects are not expected for potential trespassers exposed to 2018/2019 levels of PFOA, PFNA and PFHxS at AOC1 to AOC5, and PFOS in surface soil at AOC3 to AOC4. Based on this evaluation of individual PFAS levels, surface soil at ***AOC3 to AOC5*** is not of concern.

Because estimated ***PFOS*** doses for ***AOC1*** exceed the respective MRL, non-cancer health risk was further evaluated for potential trespassers, who incidentally ingest soil particles and/or come in skin contact with PFOS-contaminated surface soil from AOC1 for two weeks or longer.

The estimated PFOS doses for exposure to surface soil at AOC1 are much greater than the provisional MRL. FDOH health assessors evaluated the possible risk of these exposure doses by comparing them with estimated exposure doses for humans predicted from animal studies (see Appendix B, Section 2 for more detail). Animal studies with rodents have identified developmental and immune effects as the most sensitive targets of PFOS exposure [ATSDR 2018b]. The estimated PFOS doses for AOC1 are close to doses predicted to affect development and particularly close to doses predicted to cause immune effects (Appendix B, Section 2).

Developmental effects associated with PFAS exposure in human epidemiological studies include small decreases in birth weight, which have also been observed in animal studies together with small delays in development. The fetus can be exposed to PFAS in-utero and lactating mothers can pass PFAS on to their child via the breastmilk [ATSDR 2018a]. Therefore, risk of developmental effects could be of concern for pregnant and lactating women, as well as, for women who plan to become pregnant. Pregnant women could also be at increased risk of preeclampsia.

Reduced immune responses have been observed in animals exposed to PFOS. Human epidemiological studies have found associations between PFOS exposure and decreased antibody response to vaccines. These vaccine studies did not find

an association with increased rates of vaccine-preventable diseases. Therefore, it is uncertain if the studied immune responses would lead to adverse health effects.

In addition to developmental and immune effects, PFOS has been associated with various health effects including effects to liver, serum cholesterol, as well as thyroid, reproduction and preeclampsia.

Sensitive populations including pregnant and lactating women, men and women planning to have a baby, and people with pre-existing health conditions such as compromised liver or immune function, or, elevated cholesterol levels may be at increased risk of health effects.

FDOH health assessors acknowledges that potential trespassers, may be exposed to low levels of other PFAS compounds as well as PFOS from other sources including drinking water, showering, furniture and consumer products. Additional PFAS exposure could increase the risk of developing harmful, non-cancer health effects. Though, the actual combined risk from multiple PFAS and from multiple sources cannot be evaluated.

Increased cancer health risk: Increased cancer risk is estimated to be less than one in a million for trespassers exposed to ***PFOA*** for one year or longer. Increased cancer risk of one in a million is generally considered extremely low. However, current limitations of scientific knowledge prevent comprehensive evaluation of cancer, which must therefore be considered uncertain. Epidemiological studies have associated ***PFOA*** exposure with kidney, prostate and testicular cancers. The above cancer estimation is based on testicular cancer from an animal study. ***PFOS, PFNA and PFHxS*** are currently not classified as human carcinogens.

Post 2018/2019: Future exposure to PFAS in surface soil after 2018/2019 and possible threat to human health are possible if the soil is not remediated (cleaned up), particularly at AOC1. It is not possible to predict how much the PFAS levels in surface soils will change over time. Therefore, it is not possible to complete a meaningful evaluation. The site assessment activities by FDEP are ongoing. A primary objective is to delineate the extent of soil contamination to conduct cleanup activities. Soil cleanup typically includes excavation of contaminated soil that is either an exposure risk or a significant source to groundwater contamination via leaching. The excavated soil is replaced with “clean fill,” thereby greatly minimizing the risk of exposure to workers, students and the environment. AOC1 is the highest priority for a likely source removal to occur [FDEP, personal communication, 2021.

Visitors

Exposure to PFAS via on-site drinking water

Pre 2018/2019: FSFC drinking water data do not exist before 2018. Therefore, FDOH was not able to evaluate the likelihood of harmful health effects to former visitors, who may have been exposed to PFAS in drinking water at the FSFC before 2018.

2018/2019: Health assessors were unable to evaluate the possibility of health risk for visitors exposed to PFAS-contaminated drinking water, because receptor-specific input parameter data (such as frequency and duration) are limited. Due to many uncertainties, the potential to either greatly under or overestimate risk is too high to conduct a valid health evaluation.

Exposure to PFAS in on-site surface soil

Pre 2018/2019: Soil data do not exist before 2018. Therefore, FDOH was not able to evaluate the likelihood of harmful health effects to former visitors, who may have been exposed to PFAS in surface soil at the FSFC before 2018.

2018/2019: Health assessors were unable to evaluate the possibility of health risk for visitors exposed to PFAS-contaminated surface soil, because receptor-specific input parameter data (such as frequency and duration) are limited. Due to many uncertainties, the potential to either greatly under or overestimate risk is too high to conduct a valid health evaluation.

Further, the maximum soil PFAS concentrations were found in a restricted area prohibited to visitors (AOC1). Therefore, it is not expected for visitors to be exposed to PFAS concentration via incidental ingestion of and dermal contact with surface soil at this area. It shall be considered that soil and dust can be transported with wind and on people's skin, clothes and shoes from AOC1 to other areas such as the indoor buildings. In general, it seems that visitors tend to stay for short periods of time only and remain mainly indoors. It is recommended, however, that all occupants of the FSFC follow the recommendations made for workers and students.

Breastfeeding Women

Previous health consultations for PFAS-contaminated sites have attracted questions about the risk of breastfeeding [ATSDR 2020].

Possible health effects associated with PFAS exposure via breastfeeding cannot be evaluated due to current limitations in toxicological data. It is known that PFAS can be transferred to infants via breastfeeding [ATSDR 2018a]. Based on current knowledge,

ATSDR recommends that the health and nutritional benefits of breastfeeding outweigh the risks associated with PFAS in breast milk.

The decision to breastfeed is an individual choice and involves many considerations other than just the chemical contamination. Women with concerns about findings at the FSFC may find it helpful to discuss breastfeeding with their health care provider. Guidance for health care professionals regarding PFAS can be found here [ATSDR 2019b]: https://www.atsdr.cdc.gov/pfas/docs/ATSDR_PFAS_ClinicalGuidance_12202019.pdf

4. CONCLUSIONS

Based on the available environmental data and federal guidelines for PFOA, PFOS, PFNA and PFHxS, FDOH health assessors made the following conclusions for the Florida State Fire College:

Exposure to PFAS in drinking and showering water

- ✓ Workers and students, including those who plan to become pregnant, as well as pregnant and lactating women, who drank water at the FSFC daily for two weeks or longer with 2018/2019 PFOS levels of 250 ng/L may be at risk of harmful non-cancer health effects; specifically, immune effects.

- ✓ 2018/2019 levels of PFOA, PFNA and PFHxS in drinking water at the FSFC are not expected to cause harmful non-cancer health effects to workers and students, who drank the water daily for two weeks or longer.

- ✓ Workers and students, who showered at the FSFC daily for two weeks or longer with 2018/2019 levels of PFAS are not likely to experience health effects due to PFAS exposure via showering.

- ✓ Evaluation of increased cancer risk due to exposure to 2018/2019 PFAS levels in water at the FSFC via drinking and/or showering is uncertain.

- ✓ Evaluation of probable health outcomes due to PFAS exposure via drinking water and showering at the FSFC before 2018/2019 cannot be assessed due to lack of data.

- ✓ PFAS exposure via drinking water and showering at the FSFC after 2018/2019 is unlikely because alternative clean water is being provided, and a filter has been installed on the supply well.

Exposure to PFAS in surface soil

- ✓ Based on 2018/2019 levels, PFOS concentrations in soil from the former drum and tote storage area (AOC1) are of elevated concern.

- ✓ The evaluation of potential risk for workers and students to develop non-cancer health-effects from exposure to 2018/2019 PFOS levels in surface soil at AOC1 may be overestimated.

- ✓ Workers, students and potential trespassers, exposed to 2018/2019 PFOS levels in surface soil from AOC1 via skin contact and incidental ingestion of soil particles, for a two-week period or longer could be at increased risk of non-cancer health effects; specifically, developmental and immune effects.

- ✓ Workers, students and trespassers exposed to PFOA, PFNA and PFHxS in surface soil at AOC1 to AOC5, as well as PFOS in surface soil at AOC2 to AOC5 at the FSFC are not likely to experience harmful non-cancer health effects due to exposure via incidental ingestion and/or dermal contact of PFAS-contaminated surface soil at these AOCs (based on 2018/2019 levels).

- ✓ Evaluation of increased cancer risk due to exposure to 2018/2019 PFAS levels in surface soil via incidental ingestion and dermal contact is uncertain.

- ✓ Evaluation of probable health outcomes due to exposure to PFAS levels in surface soil at the FSFC before and after 2018/2019 cannot be assessed due to the lack of data.

Additional Conclusions

- ✓ The risk of health effects to ***visitors*** of the FSFC cannot be evaluated.

- ✓ The risk of ***breastfeeding*** cannot be assessed. Possible health effects associated with PFAS exposure via breastfeeding cannot be evaluated.

- ✓ The possible risk of health effects due to acute, short-term exposure of less than two weeks to PFOA, PFOS, PFNA and PFHxS in drinking/showering water supplied by the on-site well and surface soil at the FSFC cannot be evaluated.

- ✓ While some PFAS levels and exposure routes alone are not expected to cause non-cancer health effects, they could contribute to the overall PFAS exposure at the site.

5. RECOMMENDATIONS

1. Workers, students, visitors and trespassers, who were/are/will be present at the FSFC for less than two weeks, should follow the recommendations made for longer term exposure over two weeks. It is unknown when health guidelines for short-term exposure may become available.

2. Until FDEP has approved a long-term solution for clean water at the FSFC, workers, students and visitors should continue to use the bottled water supplied at the FSFC. Based on ATSDR's recommendations for PFAS, FDOH suggests that bottled water is used for cooking, brushing teeth and drinking.

3. Periodic monitoring of the filtered indoor tap water is recommended to ensure the continued functionality of the GAC filter and to prevent exposure to PFAS-contaminated water on-site via drinking, cooking, brushing teeth and showering.

4. Until FDEP has completed mitigation of the soil contamination at AOC1, workers, students and trespassers should avoid exposure to PFOS-contaminated soil at AOC1 (Former Drum and Tote Area) by avoiding the area or by wearing protective gear.

5. Pregnant and lactating women should avoid spending time on the outdoor grounds, because they may be exposed to PFOS-contaminated soil by incidental ingestion and dermal contact with dust.

6. Until FDEP has approved long-term solutions for clean water at the FSFC and finished mitigation of contaminated surface soil at the FSFC, visiting children should be kept under supervision and prevented from consuming PFOS-contaminated water and coming into contact with surface soil at the FSFC. It is recommended that children do not spend extensive play time on the outdoor grounds, where they could be at increased risk of exposure to PFOS-contaminated surface soil.

7. Outdoor soil could become a health threat for indoor workers, students and visitors, when the soil is carried inside. Increased hygiene practices are recommended. Thorough hand washing can prevent incidental ingestion of contaminated soil and dust. To avoid transferring soil contamination from the outside to the indoor facilities, it is recommended that outdoor shoes and clothes are kept outside, and that outdoor clothes are washed after each use.

8. Mitigation (removal or cleanup) of all contaminated soil is recommended, when FDEP has finalized its investigation of the extent of soil contamination. FDOH further recommends that on-site workers wear protective gear during remediation work.

9. Further, FDOH recommends continued soil testing until mitigation has been completed. If mitigation is delayed, FDOH recommends regular assessment of future health risks including continued data collection.

10. A decision to breastfeed is an individual choice, which involves many considerations other than the chemical contamination. Women with concerns regarding findings at the FSFC may find it helpful to discuss breastfeeding with their health care provider.

6. PUBLIC HEALTH ACTION PLAN

Actions Completed	
August 2018	- FDEP confirmed that the FSFC had used AFFF during training and had a supply well. - FDEP sampled water from the FSFC supply well for analysis.
September 2018	- FDEP received the well water sample analysis results. The combined PFOS and PFOA levels were above EPA's drinking water health advisory level. - FDEP held teleconferences to inform FSFC, the Florida Department of Financial Services and FDOH of the results. - FDOH recommended a short-term alternative water source. - FDEP started supply of bottled water to the FSFC. - A confirmatory well water sample was collected. - A draft action plan was developed and included identification and sampling of potable wells within a 1-mile radius of the FSFC. - First notification letter to FSFC employees and students.
October 2018	- FDOH commenced private well sampling. - Second notification letter to FSFC employees and students.
November 2018	- Notification of private well water results. - FDEP collected indoor tap water, surface water, sediment and soil samples at the FSFC for analysis. - FDEP installed a water filter at one private residence.
December 2018	- Open house held at the FSFC. - Visit to Lhoist Mine. Water fountains had been placarded to prevent use and bottled water supplied.
January 2019	- FDEP had 16 containers (drums and totes) of AFFF removed.
February 2019	- FDEP installed further water filters at private residences.
March 2019	- FDEP collected additional soil samples for analysis.
April-May 2019	- FDEP collected additional soil samples to delineate soil contamination.
June 2019	- FDEP installed monitoring wells at nine locations. - FDEP sent notification letters to 49 properties in the potential groundwater plume area.

	- FDOH held an open house at the FSFC for community members including private property owners and residents.
August 2019	- FDEP installed a water filter at the Lhoist Mine supply well. - Groundwater monitoring wells were sampled.
September 2019	- FDEP originally installed a GAC water filter at the supply well which was later replaced by the FSFC with a GAC multi-canister system. - FDEP collected additional soil samples to delineate soil contamination.
November 2019	- FDEP installed further monitoring wells and completed additional sampling of groundwater and soil.
December 2019	- FDEP contractor shares soil and groundwater assessment reports with FDEP, FDOH and the FSFC.
February 2021	- FDOH released three Health Consultation reports for public comment. The reports evaluate possible health impacts to the public at the FSFC, the Lhoist Mine Site and Residential Wells within a 1-mile radius of the FSFC.

Ongoing Actions

- FDEP continues to provide an alternative drinking water supply.
- FDOH is testing filtered water to determine a long-term clean drinking water solution for the FSFC.
- FDEP continues to delineate the groundwater plume and soil contamination at the FSFC.
- FDOH and FDEP remain in constant communication with the FSFC to ensure faculty and students remain informed and continue to have access to bottled water until water quality is restored through the modification of the existing well and installation of a filtration system.
- FDOH continues to perform private well sampling and conduct outreach to homeowners encouraging their participation.
- FDOH is collecting public comments regarding the Health Consultation reports.

Actions Planned

TBA	Analytical results will determine the most appropriate course of action regarding possible future assessment and outreach.

*****FDOH staff will ask for public comments on this draft report and address them in the final version.*****

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Report Preparation

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APPENDIX A. FLORIDA STATE FIRE COLLEGE DEMOGRAPHICS

Table A1: EJSCREEN Census 2010 Summary Report

Location: User-specified polygonal location
Ring (buffer): 1-miles radius
Description: Florida State Fire College

Summary	Census 2010
Population	4,631
Population Density (per sq. mile)	1,084
Minority Population	2,042
% Minority	44%
Households	104
Housing Units	121
Land Area (sq. miles)	4.27
% Land Area	100%
Water Area (sq. miles)	0.00
% Water Area	0%

Population by Race	Number	Percent
Total	4,631	-------
Population Reporting One Race	4,601	99%
White	2,819	61%
Black	1,661	36%
American Indian	7	0%
Asian	10	0%
Pacific Islander	1	0%
Some Other Race	103	2%
Population Reporting Two or More Races	30	1%
Total Hispanic Population	366	8%
Total Non-Hispanic Population	4,265	92%
White Alone	2,589	56%
Black Alone	1,636	35%
American Indian Alone	6	0%
Non-Hispanic Asian Alone	9	0%
Pacific Islander Alone	1	0%
Other Race Alone	2	0%
Two or More Races Alone	22	0%

Population by Sex	Number	Percent
Male	1,837	40%
Female	2,794	60%

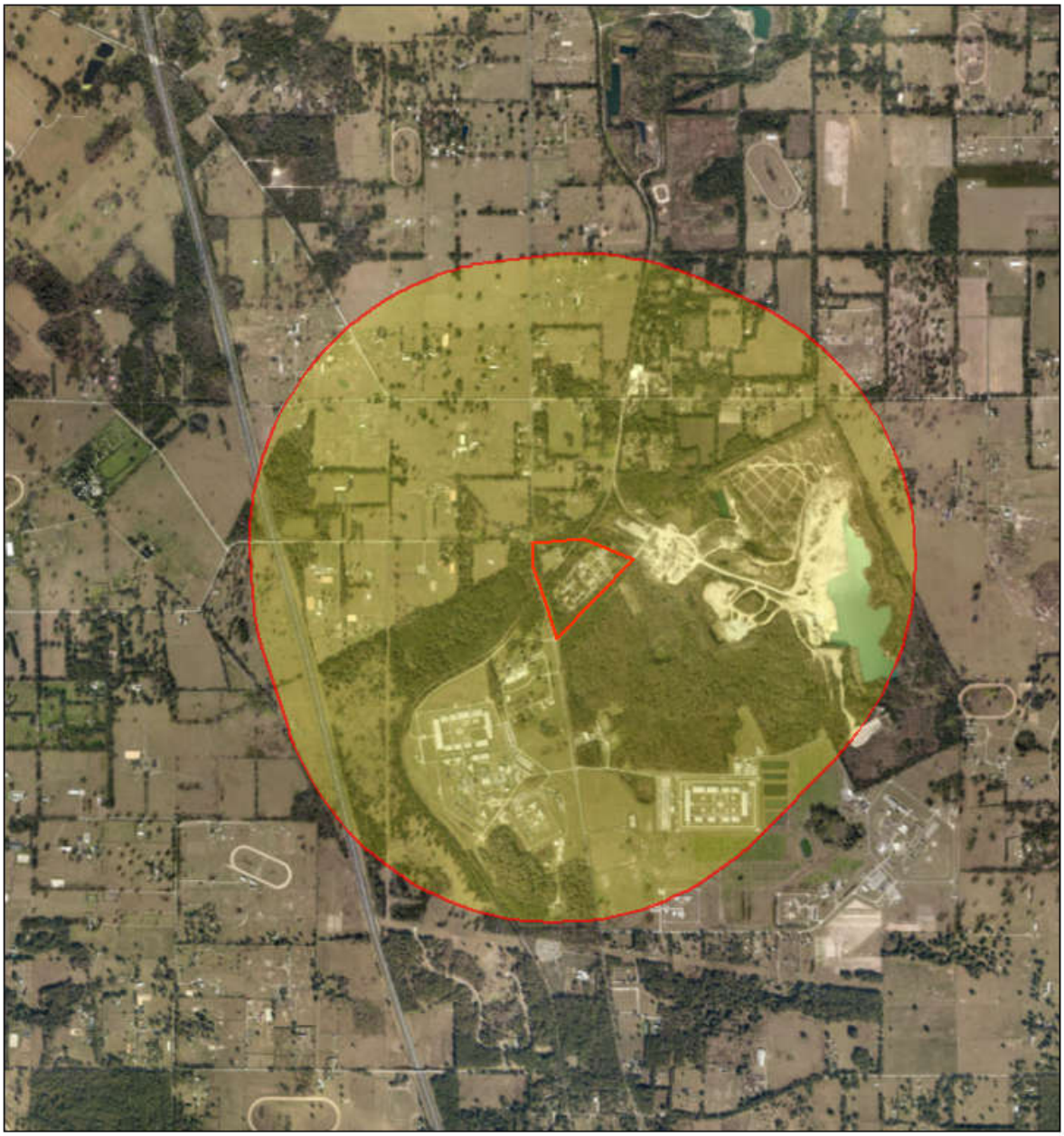
Population by Age	Number	Percent
Age 0-4	22	0%
Age 0-17	173	4%
Age 18+	4,458	96%
Age 65+	172	4%

Households by Tenure	Number	Percent
Total	104	
Owner Occupied	80	77%
Renter Occupied	24	23%

Data Note: Detail may not sum to totals due to rounding. Hispanic population can be of any race.
Source: U.S. Census Bureau, Census 2010 Summary File 1.

Figure A1: EJSCREEN Census 2010 Map

Florida State Fire College



July 17, 2019

Buffer Area

Digitized Line

1:36,112

0 0.3 0.6 1.2 mi

0 0.5 1 2 km

Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

EJSCREEN 2018

Figure A2: Florida State Fire College Point of Interest Map provided by ATSDR's Geospatial Research, Analysis, and Services Program, 2019

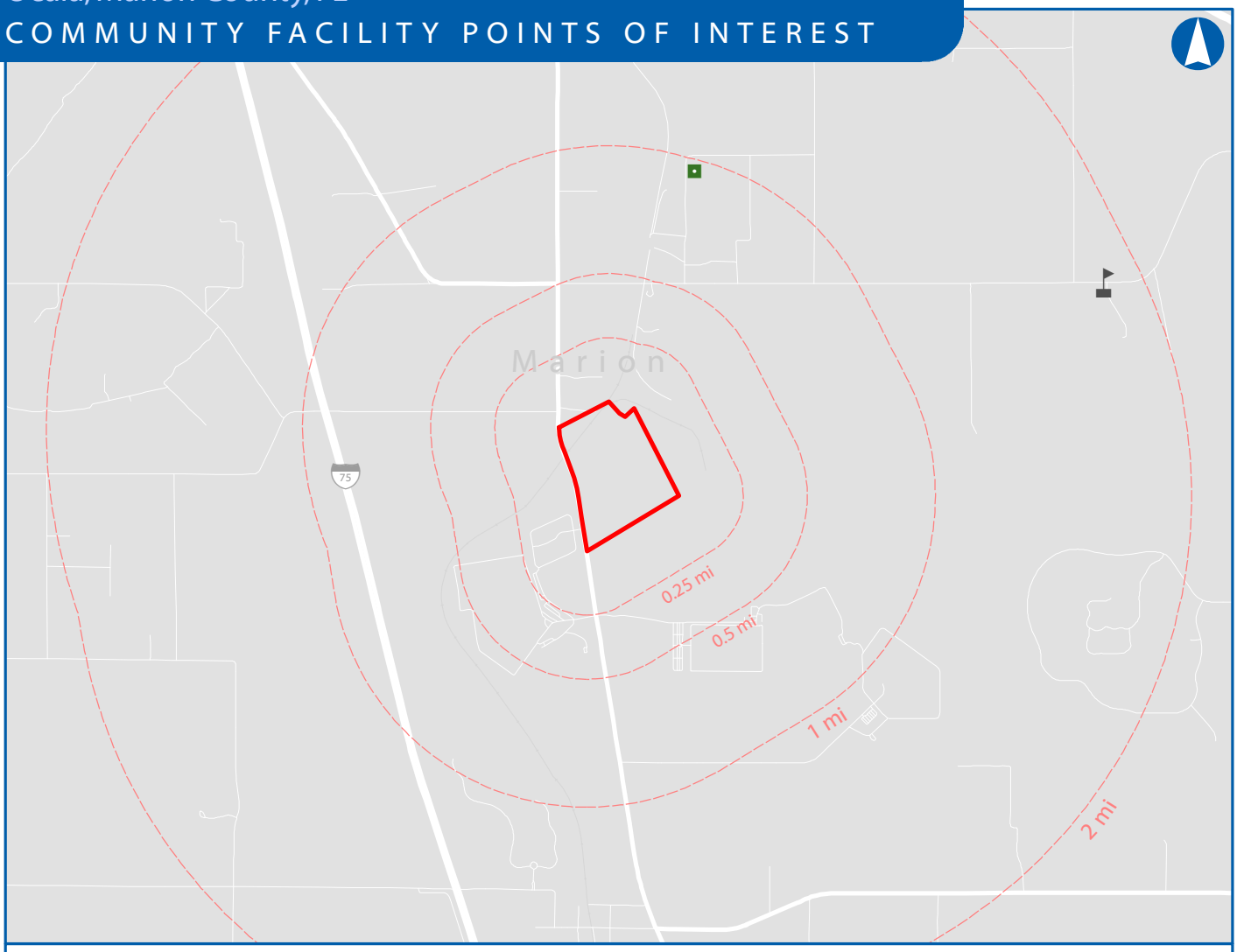
FL State Fire College

Ocala, Marion County, FL

COMMUNITY FACILITY POINTS OF INTEREST

EPA FACILITY ID UNAVAILABLE

INTRODUCTORY MAP SERIES



The Community Facility Points of Interest Map depicts the site of interest and community gathering centers in the local area. Information on number, type, and distribution of these facilities is important to efforts to communicate findings to the local population.

Within a 5-mile buffer of this site are located 38 community gathering centers of which 84% are designated as places of worship.

Community Facility Points of Interest

Within specified distance of site boundary. Not all buffers may be shown on map

Facility	0.25 mile	0.5 mile	1 mile	3 miles	5 miles
Libraries[3]	0	0	0	0	0
Schools[3]	0	0	0	1	3
Colleges/Universities[4]	0	0	0	0	0
City Halls[3]	0	0	0	0	0
Civic Centers[3]	0	0	0	0	0
Court Houses[4]	0	0	0	0	0
Places of Worship[4]	0	0	1	5	32
Day Care Centers[5]	0	0	0	0	3
Parks[4]	0	0	0	0	0

Data Sources: [1]ATSDR GRASP Hazardous Waste Site Boundary Database. [2]ATSDR GRASP. [3]HERE NorthAmerica 2018R2. [4]TomTom 2019Q1. [5]ORNL 2018
Projection: NAD 1983 StatePlane Florida West FIPS 0902 Feet.

PRJ 05611 INM7 9/12/19

GRASP

Agency for Toxic Substances and Disease Registry
Division of Toxicology and Human Health Sciences

ATSDR

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APPENDIX B. EXPLANATION OF HUMAN HEALTH EVALUATION AND CALCULATION PROCESS

1. Screening Process

To evaluate environmental data (e.g., PFAS levels in groundwater and soil), FDOH uses comparison values/**screening levels**[1] to determine which chemicals need further health evaluation. In accordance with ATSDR recommendations, FDOH always uses the lowest available CV for screening because this results in the most protective assessment. ATSDR's CVs are derived from health-based daily exposure doses set far below those known to cause health effects (further detailed in Section 2 of this appendix). The health-based doses are converted to environmental concentrations (*e.g.,* PFAS in water or soil), which then represent estimated safe levels that a person can be exposed in their environment without risk of health effects. ATSDR develops CVs for both non-cancer health effects and cancer. For PFAS, the lowest CVs available are ATSDR's CVs for non-cancer health effects. We used the following CVs for PFAS in this report:

Environmental Media Evaluation Guides (EMEGs) — ATSDR estimates EMEGs for specific media (*e.g.*, water and soil), as well as for specific durations of exposure. Acute exposure is defined as 14 days or less and intermediate exposure is defined as 15 to 364 days. When exposure is longer than 1 year it is considered chronic. FDOH used the EMEGs developed for childhood intermediate exposure (Appendix C, Tables C-1 to C-3), because these CVs are the most protective of all age groups.

If a chemical concentration for a site is higher than the CV, the chemical is of potential concern and health risk must be evaluated. For example, if it is found that a chemical level in the indoor tap water is higher than its CV, and if people drink or may drink that water, a health effects assessment is warranted.

2. Estimation of Exposure Dose and Exposure Factor

The presence of chemical contamination alone does not necessarily cause harm. The contamination must be able to enter the body to cause harm. The likelihood of adverse health effect depends on factors such as the amount of chemical that humans come in contact with, how well it is taken up by the human body, how often (frequency) and for how long the contact with the chemical occurs (duration). Many of these factors are determined by body weight, sex, behavior, occupation, indoor and/or outdoor exposure, residential exposure and so on. Because human health risk cannot be assessed only from chemical concentrations, exposure doses are estimated for **site- and population/receptor-specific scenarios**.

[1] **Screening levels** are estimates of chemical concentrations in the environment (water, soil, air, etc.) that a person can be exposed to without considerable health risk. Screening levels are health-based and set far below levels known to cause harmful effects. The value of a screening level is called a comparison value (CV), because it is used to compare with. If a chemical concentration at a site is higher than its CV, the chemical is of concern and needs further evaluation.

An **exposure dose** is the amount of chemical taken up by a person per body weight per day (milligram chemical/kilogram body/day). The contaminant can be taken up from water, soil or air, and it can be taken up via ingestion, absorption over the skin or via inhalation (breathing it in). Doses are calculated per body weight, because the same amount of chemical is not likely to cause the same magnitude of health effect in a large adult as it would in a small child.

To estimate doses, health assessors used ATSDR's Public Health Assessment Site Tool program (PHAST), which uses the following equations (Eq. B-1 and B-2):

$$\textbf{Dose} = (C \times IR \times EF \times CF) / BW$$

C = *Chemical Concentration in the environmental element (e.g., milligram chemical per liter of water (mg/L))*
IR = *Ingestion Rate (e.g., liter of water consumed per day (L/day))*
EF = *Exposure Factor (no unit)*
CF = *Conversion Factor (chemical-specific) (no unit)*
BW = *Body Weight (kg)*

Equation B-1: Dose calculation

$$EF = (EFr \times ED) / AT$$

EFr = *Exposure Frequency (days per week, or, days per year)*
ED = *Exposure Duration (days or years)*
AT = *Averaging Time (days or years)*

Equation B-2: Exposure Factor calculation

For example:

*For an adult person of **80 kg** body weight working at a facility for **5 days per week, 50 weeks per year** (assuming 2 weeks of annual leave) for **10 years**, and **ingesting 3 liters of water** a day that contains an average **contaminant concentration of 1 mg/L**, the exposure dose is estimated as follows:*

Dose = (1 mg/L x 3 L/day x EF x 1) / 80 kg = 0.026 mg/kg/day

$EF_{chronic}$ = (5 days/week x 50 weeks/year) x 10 years / 3,650 days = 0.68

The above example represents a simple scenario for exposure via drinking water. Other types of exposure involve more receptor-specific considerations. When dermal exposure doses are estimated, the assessor must also account for the skin surface area available for exposure and this varies with age. The FSFC and population/receptor-specific human health cancer and non-cancer risk evaluation input parameters and results for the dose calculations are listed in Appendix C and D, respectively.

The estimated daily doses are compared with national **health guidelines**[2]. This health consultation used ATSDR's **provisional minimal risk level (MRL) for PFOA, PFOS, PFNA and PFHxS**. To be protective of the most sensitive populations, MRLs are based on the highest dose, where no effect was observed for the most sensitive endpoint (health effect), or, by the lowest dose observed to cause that endpoint. Then several uncertainty factors are applied to lower the dose to make it as protective as possible and to account for uncertainty. An example of an uncertainty factor is a number to account for human variability because some people are more sensitive to certain effects than others.

- **Estimation of non-cancer risk:**

Non-cancer health effects refer to all health effects, such as immune and developmental effects, except cancer. The risk of non-cancer health effect is assessed by screening (comparison) of the estimated dose with the respective health guideline[2], in this case the provisional MRL. This comparison is done by dividing the estimated dose by the MRL resulting in an **'Hazard Quotient'** (HQ):

$$\mathbf{HQ = D / MRL}$$

HQ = Hazard Quotient
D = Exposure Dose (mg/kg/day)
MRL = Minimal Risk Level (mg/kg/day)

Equation B-3: Hazard Quotient calculation

An estimated exposure dose lower than the MRL derives a hazard quotient (HQ) of less than 1, which indicates non-cancer health risk is unlikely. An estimated exposure dose equal to or higher than the MRL derives an HQ equal to or higher than 1, which indicates non-cancer health risk is possible. The higher the HQ, the higher the possibility of non-cancer health risk.

If an estimated dose is higher than the health guideline, the possible health implications are evaluated in more detail for the population of concern.

When toxicological information is available, the health assessor may compare estimated doses directly with doses known to cause effect. This comparison helps evaluate what types of effects are likely to be of most concern. The health assessor also uses professional judgement in the evaluation. When estimated doses are close to the guideline value, the health assessor may use extra precaution if the population in question could be considered more sensitive than the average population (*e.g.*, an elderly population may be particularly susceptible to immune effects).

The evaluation for the FSFC included in-depth assessment of some estimated doses for PFOS, because they exceeded the provisional MRL. Health assessors compared the

[2] A h**ealth guideline** is an estimate of the daily chemical exposure dose that a person can be exposed to without considerable health risk. Health guidelines are set far below levels known to cause harmful effects. If an estimated dose for a site is higher than the guideline, health risk is possible and must be further evaluated.

estimated PFOS doses with 'human equivalent doses' (HED) predicted from animal studies. This evaluation used HED derived for PFOS for developmental and immune effects by ATSDR [ATSDR 2018[3], 2020[4]]. Developmental and immune effects were selected for the evaluation as these are the most sensitive endpoints found for PFOS to date.

Predicted human equivalent doses (HED) for PFOS
Based on lowest observed adverse effect levels (LOAEL) found in animal studies

Effect type	LOAEL, HED	Study Reference
Developmental effect	0.0021 mg/kg/day	Luebker et al. 2005
Immune effect	0.00041 mg/kg/day	Dong et al. 2011
Immune effect	0.000031 mg/kg/day	Guruge et al. 2009

HEDs were derived from the study references by ATSDR [ATSDR 2018[3], 2020[4]].

- **Estimation of increased cancer risk:**

Cancer risk is referred to as 'increased' cancer risk because there is always some risk of cancer. One in every three Americans is expected to be diagnosed with cancer in their lifetime. Increased cancer risk is calculated using a chemical-specific standard called a 'cancer slope factor' (CSF). CSFs only exist for chemicals known to cause cancer. The International Agency for Research on Cancer (IARC) has classified PFOA as possibly carcinogenic to humans [IARC 2017[5]]. PFOS is not classified as a human carcinogen [ATSDR 2018[3]; EPA 2017[6]]. For chemicals for which cancer-association data lack, the derivation of a CSF is impossible. A CSF is available for PFOA, but not for PFOS, PFNA and PFHxS. To assess the possibility of increased cancer-risk, the estimated dose is multiplied by the chemical-specific CSF:

$$\textbf{Increased cancer risk} = D \times CSF$$

D = Exposure Dose (mg/kg/day)
CSF = Cancer Slope Factor $(mg/kg/day)^{-1}$

Equation B-4: Cancer risk calculation

Because of uncertainties involved with estimating cancer risk, ATSDR employs a weight-of-evidence approach in evaluating relevant data [ATSDR 2018]. Therefore, the

[3][ATSDR] Agency for Toxic Substances and Disease Registry. 2018. Toxicological profile for Perfluoroalkyls. (Draft for Public Comment). Atlanta, GA [updated 2019 September 26, accessed 2019. Available from: http://www.atsdr.cdc.gov/toxprofiles/tp.asp?id=1117&tid=237

[4][[ATSDR] Agency for Toxic Substances and Disease Registry. 2020. Health Consultation. Per-and Polyfluoroalkyl Substances (PFAS) in the Pease Tradeport Public Water System. Final Release. Atlanta, GA [updated 2020 March 20; accesses 2020 April]. Available from: https://www.atsdr.cdc.gov/HAC/pha/pease/Pease_Air_Force_Base_HC-508.pdf

[5][IARC] International Agency for Research on Cancer 2017. IARC Monographs on the identification of carcinogenic hazards to humans. Volume 110. Lyon France [updated 2020 March; accessed 2020 May]. Available from: https://monographs.iarc.fr/list-of-classifications/

[6] [EPA] United States Environmental Protection Agency. 2017. Technical Fact Sheet - Perfluorooctane Sulfonate (PFOS and Perfluorooctanoic acid (PFOA). (EPA 505-F-17-001). Washington DC [updated 2017 November; accessed 2020 May]. Available from: https://www.epa.gov/sites/production/files/2017-12/documents/ffrrofactsheet_contaminants_pfos_pfoa_11-20-17_508_0.pdf

increased risk for cancer is described in words (qualitatively) rather than giving a numerical risk estimate only. Numerical risk estimates must be considered in the context of the variables and assumptions involved in calculating those estimates and in the broader context of biomedical opinion, host factors and actual exposure conditions.

The risk of increased cancer is generally communicated as follows:

1 in 10 (10^{-1})	“very high” increased cancer risk
1 in 100 (10^{-2})	“high” increased cancer risk
1 in 1,000 (10^{-3})	“moderate” increased cancer risk
1 in 10,000 (10^{-4})	“low” increased cancer risk
1 in 100,000 (10^{-5})	“very low” increased cancer risk
1 in 1,000,000 (10^{-6})	“extremely low” increased cancer risk

FDOH considers increased cancer risk of one-in-a-million extremely low (10^{-6}, 1E-06 in the results tables, Appendix D), because it indicates that in a population of one million ‘exposed’ people, only one additional occurrence of cancer is expected compared to an ‘unexposed’ (normal) population.

Note: Current information on the ability of PFAS to cause cancers in humans is very limited. Epidemiological studies have associated PFOA exposure with kidney, prostate and testicular cancers. The current cancer estimation for PFOA is based on testicular cancer from an animal study.

PFOS, PFNA and PFHxS are currently not classified as human carcinogens. Present knowledge limits the ability to estimate increased cancer risk for PFAS in general.

APPENDIX C. HUMAN HEALTH CANCER AND NON-CANCER RISK EVALUATION INPUT PARAMETERS

WATER CONCENTRATIONS

Table C-1. Contaminants of concern in water collected from the drinking water supply well and from an indoor tap at the Florida State Fire College (on-site).

Contaminant	*Source of Screening Guideline*	*Comparison Value* (ng/L)*	*Concentration Range (ng/L)*	*# Above Comparison Value/Total #*
PFOA	***ATSDR Int. EMEG Child****	**21**	7 – 10	0 / 3
PFOS		**14**	220 - 250	3 / 3
PFNA		**21**	1.4 – 1.7	0 / 3
PFHxS		**140**	130 – 190	2 / 3

ATSDR - Agency for Toxic Substances and Disease Registry
EMEG - Environmental Media Evaluation Guide
Int. - Intermediate (15-364 days of exposure)
ng/L - Nanograms per liter
Non-remediated - Not cleaned up by, e.g., a filter
PFHxS - Perfluorohexane sulfonate
PFNA - Perfluorononanoic acid
PFOA - Perfluorooctanoic acid
PFOS - Perfluorooctane sulfonate

**Int. EMEG Child - ATSDR's screening values for child exposure were derived from known toxicological information for PFOA, PFOS, PFNA and PFHxS. Based on ATSDR's evaluation, these concentrations are not expected to cause harmful non-cancer health effects in humans, including sensitive populations (i.e., children).*

SOIL CONCENTRATIONS

Table C-2. Contaminants of concern in non-remediated surface soil (0 to 2 feet) at Florida State Fire College (on-site).

Contaminant	Source/ Screening Guideline	Comparison Value* (mg/kg)	AOC1		AOC2		AOC3	
			Concentration Range (mg/kg)	# Above Comparison Value//Total #	Concentration Range (mg/kg)	# Above Comparison Value//Total #	Concentration Range (mg/kg)	# Above Comparison Value//Total #
PFOA	***ATSDR/ Int. EMEG Child****	***0.160***	0.00011† - 0.44	3 / 112	0.00011†- 0.0077	0 / 8	0.00031 – 0.0018	0 / 14
PFOS		***0.100***	0.0002 – 150+‖	49 / 112	0.0033 - 0.041	0 / 8	0.0067 – 0.160	4 / 14
PFNA		***0.160***	ND – 0.015	0 / 112	0.00008†– 0.0055	0 / 8	0.00027 – 0.0028	0 / 14
PFHxS		***1.000***	0.00021†– 1.4	1 / 112	0.0007 – 0.0083	0 / 8	0.0016 – 0.019	0 / 14

Contaminant	Source/ Screening Guideline	Comparison Value* (mg/kg)	AOC4		AOC5	
			Concentration Range (mg/kg)	# Above Comparison Value//Total #	Concentration Range (mg/kg)	# Above Comparison Value//Total #
PFOA	***ATSDR/ Int. EMEG Child****	***0.160***	0.00055 – 0.0092	0 / 10	0.00029 – 0.021	0 / 11
PFOS		***0.100***	0.0077 – 0.260	3 / 10	0.00075 – 0.300	1 / 11
PFNA		***0.160***	0.00024 – 0.0013	0 / 10	0.00053 – 0.01	0 / 11
PFHxS		***1.000***	0.0011 – 0.017	0 / 10	ND – 0.0086	0 / 11

† < RL - Below method reporting limit
+L - Off-scale high; true value is higher
‖J3 - Estimated value; may not be accurate

AOC - Area of concern
ATSDR - Agency for Toxic Substances and Disease Registry
EMEG - Environmental Media Evaluation Guide
EPA - United States Environmental Protection Agency
Int. - Intermediate
mg/kg - Milligram per kilogram
ND - Not detected
Non-remediated - Not cleaned up
PFHxS - Perfluorohexane sulfonate
PFNA - Perfluorononanoic acid
PFOA - Perfluorooctanoic acid
PFOS - Perfluorooctane sulfonate

**Int. EMEG Child - ATSDR's screening values for child exposure were derived from known toxicological information for PFOA, PFOS, PFNA and PFHxS. Based on ATSDR's evaluation, these concentrations are not expected to cause harmful non-cancer health effects in humans, including sensitive populations (i.e., children).*

Table C-3. Contaminants of concern in non-remediated sub-surface soil (2 feet and below) at Florida State Fire College (on-site).

Contaminant	Source/ Screening Guideline	Comparison Value* (mg/kg)	AOC1		AOC3	
			Concentration Range (mg/kg)	# Above Comparison Value//Total #	Concentration Range (mg/kg)	# Above Comparison Value//Total #
PFOA	***ATSDR/ Int. EMEG Child****	***0.160***	ND – 1.2	5 / 132	0.00056 – 0.34	1 / 4
PFOS		***0.100***	ND – 0.110[+‖]	102 / 132	0.083 – 2.4	3 / 4
PFNA		***0160***	ND – 0.019	0 / 132	ND – 0.0021	0 / 4
PFHxS		***1.000***	0.00015[†] – 4.5[+]	9 / 132	0.0059 - 3.3[+]	1 / 4

[†] < RL - Below method reporting limit
[+]L - Off-scale high; true value is higher
[‖]J3 - Estimated value; may not be accurate

AOC - Area of concern
ATSDR - Agency for Toxic Substances and Disease Registry
EMEG - Environmental Media Evaluation Guide
EPA - United States Environmental Protection Agency
Int. - Intermediate
mg/kg - Milligram per kilogram
Non-remediated - Not cleaned up
ND - Not detected
PFHxS - Perfluorohexane sulfonate
PFNA - Perfluorononanoic acid
PFOA - Perfluorooctanoic acid
PFOS - Perfluorooctane sulfonate

**Int. EMEG Child - ATSDR's screening values for child exposure were derived from known toxicological information for PFOA, PFOS, PFNA and PFHxS. Based on ATSDR's evaluation, these concentrations are not expected to cause harmful non-cancer health effects in humans, including sensitive populations (i.e., children).*

RECEPTOR-SPECIFIC PARAMETERS

Table C-4. Worker and Student Input Parameters for Drinking Water Exposure Evaluation

Exposure Group		Body Weight (kg)	Age-Specific Exposure Duration *Intermediate / Chronic*	Intake Rate* (L/day)
Worker	**16 to < 21 years**	71.6	50 weeks / 5 years	3.59
	Adult	80	50 weeks / 30 years	3.59
Student	**16 to < 21 years**	71.6	22 weeks / NA	3.59
	Adult	80	22 weeks / NA	3.59
Worker/Student	**Pregnant Women**	73	NA	3.59
	Lactating Women	73	NA	3.59

Exposure Group	Duration	Days	Weeks	Years	Non-Cancer Exposure Factor	**EF cancer:** EF non-cancer x Age-Specific Exposure Duration (years)/78 years
Worker, adult	**Chronic**	5	50	30	0.68	
Student	**Intermediate**	5	22	NA	0.71	

Chronic - Exposure duration of one year or more
EF - Exposure factor
Intermediate - Exposure duration of 15 to 364 days
kg - Kilogram
L/day - Liters per day
NA - Not applicable
< - Less than

**Intake rate - A high intake rate of 3.59 L/d was selected a) to ensure protection of the most sensitive population, the pregnant/lactating woman, and b) to represent a realistic intake rate for workers and students performing strenuous labor under high temperature conditions.*

Table C-5. Worker and Student Input Parameters for Showering Exposure Evaluation

Exposure Group		Body Weight (kg)	Skin Area (cm^2)		Breathing Rate (L/min)		Average Daily Exposure (min/day)	
			Hand Surface Area	Total Skin Surface Area	Shower	Main House	Shower	Main House
Worker/Student	**16 to < 21 years**	71.6	830	18,400	12.00	11.32	26	814
	Adult	80	980	19,650	12.34	10.53	26	814
	Pregnant Woman	73	890	18,160	15.47	15.47	26	814
	Lactating Woman	73	890	18,160	15.47	15.47	26	814

cm^2 - Square centimeter
kg - Kilogram
L - Liter
L/min - Liters per minute
Min - Minutes
min/day - Minutes per day
< - Less than

Table C-6. Worker and Student Input Parameters for Exposure via Incidental Ingestion and Dermal Contact with Soil

Exposure Group / Age		Body Weight (kg)	Age-Specific Exposure Duration	Intake Rate (mg/day)	Adherence Factor to Skin (mg/cm^2-event)	Combined Skin Surface Area* (cm^2)
Indoor Worker	**16 to < 21 years**	71.6	5 years	60**	0.2	2,791
	Adult	80	30 years	60**	0.07	3,470
Outdoor Worker (low intensity soil contact)	**16 to < 21 years**	71.6	5 years	100	0.2	2,791
	Adult	80	30 years	100	0.07	3,470
Student	**16 to < 21 years**	71.6	22 weeks	100	0.2	2,791
	Adult	80	22 weeks	100	0.07	3,470

Exposure Group	Duration	Days	Weeks	Years	Non-Cancer Exposure Factor	EF cancer: EF non-cancer x Age-Specific Exposure Duration (years)/78 years
Worker, adult	**Chronic**	5	50	30	0.68	
Student	**Intermediate**	5	22	NA	0.71	

Chronic - Exposure duration of one year or more
cm^2 - Square centimeter
EF - Exposure factor
Intermediate - Exposure duration of 15 to 364 days
kg - Kilogram
mg/day - Milligrams per day
mg/cm^2-event - Milligrams per square centimeter and event
NA - Not applicable
< - Less than

**Combined skin surface area for workers and students includes head, hands and forearms. It is expected that workers and students wear trousers and shoes.*
***The intake rate used for indoor workers was selected to be protective of potential upper end (higher than median) incidental soil intake.*

Table C-7. Trespasser Input Parameters for Exposure via Incidental Ingestion and Dermal Contact with Soil

Exposure Group / Age		Body Weight (kg)	Age-Specific Exposure Duration	Intake Rate (mg/day)	Adherence Factor to Skin (mg/cm^2-event)	Combined Skin Surface Area* (cm^2)
				Default		
Trespasser	**16 to < 21 years**	71.6	5 years	100	0.2	6,083
	Adult	80	10 years	100	0.07	6,030

Exposure Group	Duration	Days	Weeks	Years	Non-Cancer Exposure Factor	EF cancer:
Trespasser, adult	**Chronic**	3	52.14	10	0.43	EF non-cancer x Age-Specific Exposure Duration (years)/78 years
Trespasser, 16 to < 21	**Chronic**	3	52.14	5	0.43	
Trespasser	**Intermediate**	3	52	NA	0.43	

Chronic - Exposure duration of one year or more
cm^2 - Square centimeter
EF - Exposure factor
Intermediate - Exposure duration of 15 to 364 days
kg - Kilogram
mg/day - Milligrams per day
mg/cm^2-event - Milligrams per square centimeter and event
NA - Not applicable
< - Less than

**Combined skin surface area for trespassers includes head, hands, forearms, lower legs and feet. It is expected that trespassers may wear shorts and bare feet/sandals.*

APPENDIX D. HUMAN HEALTH NON-CANCER AND CANCER RISK EVALUATION OUTPUT RESULTS

WORKERS INDOOR TAP WATER EXPOSURE

*Table D-1. Estimated doses, non-cancer risk (hazard quotients) and increased cancer risk for **workers** exposed to **2018/2019** levels of PFOA, PFOS, PFNA and PFHxS in non-remediated indoor tap water at the Florida State Fire College (on-site) via **ingestion (drinking)**.*

Contaminant	Exposure Group	EPC (mg/L)	Chronic Dose (mg/kg/day)	ATSDR MRL* (mg/kg/day)	Chronic Hazard Quotient	Increased Cancer Risk
PFOA	16 to < 21 years	0.000010	3.4E-07	3E-06	0.11	<1E-06**
	Adult		3.1E-07		0.10	
	Pregnant Women		3.4E-07		0.11	
	Lactating Women		3.4E-07		0.11	
PFOS	16 to < 21 years	0.00025	8.6E-06	2E-06	4.3	Not classified as carcinogens
	Adult		7.7E-06		3.8	
	Pregnant Women		8.4E-06		4.2	
	Lactating Women		8.4E-06		4.2	
PFNA	16 to < 21 years	0.0000017	5.8E-08	3E-06	0.019	
	Adult		5.2E-08		0.017	
	Pregnant Women		5.7E-08		0.019	
	Lactating Women		5.7E-08		0.019	
PFHxS	16 to < 21 years	0.00019	6.5E-06	2E-05	0.33	
	Adult		5.8E-06		0.29	
	Pregnant Women		6.4E-06		0.32	
	Lactating Women		6.4E-06		0.32	

<- Less than

1E-06 - one in a million

ATSDR - Agency for Toxic Substances and Disease Registry
Chronic - Exposure duration of one year or more
EPC - Exposure point concentration (concentration in non-remediated indoor tap water)
mg/L - Milligram contaminant per liter of water
mg/kg/day - Milligram contaminant per kilogram body weight per day
MRL - Minimal risk level (ATSDR's health guideline below which minimal risk is expected)
* - Current PFAS MRLs are provisional
** - PFOA cancer slope factor = 0.07 $(mg/kg/day)^{-1}$
- Potential risk (*i.e.*, hazard quotient above 1)

PFHxS - Perfluorohexane sulfonate
PFNA - Perfluorononanoic acid
PFOA - Perfluorooctanoic acid
PFOS - Perfluorooctane sulfonate

*Table D-2. Estimated doses, non-cancer risk (hazard quotients) and increased cancer risk for **workers** exposed to **2018/2019** levels of PFOA, PFOS, PFNA and PFHxS in non-remediated indoor tap water at the Florida State Fire College (on-site) via **showering**. [Model based maximum input: 4-person household, two showers a day, fan on, gone during the day].*

Contaminant	Exposure Group	EPC	ATSDR MRL* (mg/kg/ day)	Inhalation Dose (mg/kg/day)	Dermal Dose (mg/kg/day)	Combined Dose (mg/kg/day)	Chronic Hazard Quotient (combined)	Increased Cancer Risk (combined)
PFOA	16 to < 21 years	10 ng/L [1] 3.4E-10 mg/m^3 [2] 1.6E-12 mg/m^3 [3]	3E-06	1.2E-12	1.6E-09	1.6E-09	5.3E-04	<1E-06**
	Adult			1.1E-12	1.5E-09	1.5E-09	5.0E-04	
	Pregnant Women			1.5E-12	1.5E-09	1.5E-09	5.0E-04	
	Lactating Women			1.5E-12	1.5E-09	1.5E-09	5.0E-04	
PFOS	16 to < 21 years	250 ng/L [1] 7.4E-10 mg/m^3 [2] 3.4E-12 mg/m^3 [3]	2E-06	2.5E-12	6.7E-08	6.7E-08	3.4E-02	PFOS is not classified as a carcinogen
	Adult			2.3E-12	6.4E-08	6.4E-08	3.2E-02	
	Pregnant Women			3.2E-12	6.6E-08	6.6E-08	3.3E-02	
	Lactating Women			3.2E-12	6.6E-08	6.6E-08	3.3E-02	
PFNA	*Model does not currently calculate shower scenarios for PFNA and PFHxS*							
PFHxS								

[1] – EPC Water [2]– EPC Air, Shower [3] – EPC Air, Main House

ATSDR - Agency for Toxic Substances and Disease Registry
Chronic - Exposure duration of one year or more
EPC - Exposure point concentration (in non-remediated indoor tap water/air (estimated))
mg/kg/day - Milligram contaminant per kilogram body weight per day
MRL - Minimal risk level (ATSDR's health guideline below which minimal risk is expected)
ng/L - Nanograms per liter
PFHxS - Perfluorohexane sulfonate
PFNA - Perfluorononanoic acid
PFOA - Perfluorooctanoic acid
PFOS - Perfluorooctane sulfonate

< - Less than
1E-06 - One in a million
mg/m^3 - Milligrams per cubic meter
* - PFAS MRLs are provisional
** - Cancer slope factor = 0.07(mg/kg/day)$^{-1}$

WORKERS SOIL EXPOSURE

*Table D-3. Estimated doses, non-cancer risk (hazard quotients) and increased cancer risk for **indoor workers** exposed to **2018/2019** levels of PFOA, PFOS, PFNA and PFHxS in non-remediated surface soil (0 – 2 feet) at **AOC1** at the Florida State Fire College (on-site) via **incidental ingestion and dermal contact**.*

Contaminant	Exposure Group	EPC (mg/kg)	Chronic Dose (mg/kg/day)	ATSDR MRL* (mg/kg/day)	Chronic Hazard Quotient	Increased Cancer Risk
PFOA	16 to < 21 years	0.44	4.9E-07	3E-06	0.16	<1E-06**
	Adult		3.2E-07		0.11	
PFOS	16 to < 21 years	150	0.00017	2E-06	83	Not classified as carcinogens
	Adult		0.00011		54	
PFNA	16 to < 21 years	0.015	1.7E-08	3E-06	0.0055	
	Adult		1.1E-08		0.0036	
PFHxS	16 to < 21 years	1.4	1.6E-06	2E-05	0.078	
	Adult		1.0E-06		0.051	

ATSDR - Agency for Toxic Substances and Disease Registry
Chronic - Exposure duration of one year or more
EPC - Exposure point concentration (concentration in non-remediated soil)
mg/kg - Milligram contaminant per kilogram of soil
mg/kg/day - Milligram contaminant per kilogram body weight per day
MRL - Minimal risk level (ATSDR's health guideline below which minimal risk is expected)
PFHxS - Perfluorohexane sulfonate
PFNA - Perfluorononanoic acid
PFOA - Perfluorooctanoic acid
PFOS - Perfluorooctane sulfonate
* - Current PFAS MRLs are provisional
** - PFOA cancer slope factor = 0.07 $(mg/kg/day)^{-1}$
- Risk (*i.e.*, hazard quotient above 1)

< - Less than
1E-06 - One in a million

*Table D-4. Estimated doses, non-cancer risk (hazard quotients) and increased cancer risk for **indoor workers** exposed to **2018/2019** levels of PFOA, PFOS, PFNA and PFHxS in non-remediated surface soil (0 – 2 feet) at **AOC3** at the Florida State Fire College (on-site) via **incidental ingestion and dermal contact**.*

Contaminant	Exposure Group	EPC (mg/kg)	Chronic Dose (mg/kg/day)	ATSDR MRL* (mg/kg/day)	Chronic Hazard Quotient	Increased Cancer Risk
PFOA	16 to < 21 years	0.0018	2.0E-09	3E-06	0.00066	<1E-06**
	Adult		1.3E-09		0.00043	
PFOS	16 to < 21 years	0.16	1.8E-07	2E-06	0.089	Not classified as carcinogens
	Adult		1.2E-07		0.058	
PFNA	16 to < 21 years	0.0028	3.1E-09	3E-06	0.0010	
	Adult		2.0E-09		0.00067	
PFHxS	16 to < 21 years	0.019	2.1E-08	2E-05	0.0011	
	Adult		1.4E-08		0.00069	

ATSDR - Agency for Toxic Substances and Disease Registry
Chronic - Exposure duration of one year or more
EPC - Exposure point concentration (concentration in non-remediated soil)
mg/kg - Milligram contaminant per kilogram
mg/kg/day - Milligram contaminant per kilogram body weight per day
MRL - Minimal risk level (ATSDR's health guideline below which minimal risk is expected)
PFHxS - Perfluorohexane sulfonate
PFNA - Perfluorononanoic acid
PFOA - Perfluorooctanoic acid
PFOS - Perfluorooctane sulfonate
< - Less than
1E-06 - One in a million
* - Current PFAS MRLs are provisional
** - PFOA cancer slope factor = 0.07 $(mg/kg/day)^{-1}$

*Table D-5. Estimated doses, non-cancer risk (hazard quotients) and increased cancer risk for **indoor workers** exposed to **2018/2019** levels of PFOA, PFOS, PFNA and PFHxS in non-remediated surface soil (0 – 2 feet) at **AOC4** at the Florida State Fire College (on-site) via **incidental ingestion and dermal contact**.*

Contaminant	Exposure Group	EPC (mg/kg)	Chronic Dose (mg/kg/day)	ATSDR MRL* (mg/kg/day)	Chronic Hazard Quotient	Increased Cancer Risk
PFOA	16 to < 21 years	0.0092	1.0E-08	3E-06	0.0034	<1E-06**
	Adult		6.6E-09		0.0022	
PFOS	16 to < 21 years	0.26	2.9E-07	2E-06	0.14	Not classified as carcinogens
	Adult		1.9E-07		0.094	
PFNA	16 to < 21 years	0.0013	1.4E-09	3E-06	0.00048	
	Adult		9.4E-10		0.00031	
PFHxS	16 to < 21 years	0.017	1.9E-08	2E-05	0.00094	
	Adult		1.2E-08		0.00061	

ATSDR - Agency for Toxic Substances and Disease Registry
Chronic - Exposure duration of one year or more
EPC - Exposure point concentration (concentration in non-remediated soil)
mg/kg - Milligram contaminant per kilogram
mg/kg/day - Milligram contaminant per kilogram body weight per day
MRL - Minimal risk level (ATSDR's health guideline below which minimal risk is expected)
PFHxS - Perfluorohexane sulfonate
PFNA - Perfluorononanoic acid
PFOA - Perfluorooctanoic acid
PFOS - Perfluorooctane sulfonate
< - Less than
1E-06 - One in a million
* - Current PFAS MRLs are provisional
** - PFOA cancer slope factor = 0.07 $(mg/kg/day)^{-1}$

*Table D-6. Estimated doses, non-cancer risk (hazard quotients) and increased cancer risk for **indoor workers** exposed to **2018/2019** levels of PFOA, PFOS, PFNA and PFHxS in non-remediated surface soil (0 – 2 feet) at **AOC5** at the Florida State Fire College (on-site) via **incidental ingestion and dermal contact**.*

Contaminant	Exposure Group	EPC (mg/kg)	Chronic Dose (mg/kg/day)	ATSDR MRL* (mg/kg/day)	Chronic Hazard Quotient	Increased Cancer Risk
PFOA	16 to < 21 years	0.021	2.3E-08	3E-06	0.0078	<1E-06**
	Adult		1.5E-08		0.0051	
PFOS	16 to < 21 years	0.30	3.3E-07	2E-06	0.17	Not classified as carcinogens
	Adult		2.2E-07		0.11	
PFNA	16 to < 21 years	0.01	1.1E-08	3E-06	0.0037	
	Adult		7.2E-09		0.0024	
PFHxS	16 to < 21 years	0.0086	9.5E-09	2E-05	0.00048	
	Adult		6.2E-09		0.00031	

ATSDR - Agency for Toxic Substances and Disease Registry
Chronic - Exposure duration of one year or more
EPC - Exposure point concentration (concentration in non-remediated soil)
mg/kg - Milligram contaminant per kilogram
mg/kg/day - Milligram contaminant per kilogram body weight per day
MRL - Minimal risk level (ATSDR's health guideline below which minimal risk is expected)
PFHxS - Perfluorohexane sulfonate
PFNA - Perfluorononanoic acid
PFOA - Perfluorooctanoic acid
PFOS - Perfluorooctane sulfonate
< - Less than
1E-06 - One in a million
* - Current PFAS MRLs are provisional
** - PFOA cancer slope factor = 0.07 $(mg/kg/day)^{-1}$

*Table D-7. Estimated doses, non-cancer risk (hazard quotients) and increased cancer risk for **outdoor workers** (including maintenance workers and teachers) exposed to **2018/2019** levels of PFOA, PFOS, PFNA and PFHxS in non-remediated surface soil (0 – 2 feet) at **AOC1** at the Florida State Fire College (on-site) via **incidental ingestion and dermal contact**.*

Contaminant	Exposure Group	EPC (mg/kg)	Chronic Dose (mg/kg/day)	ATSDR MRL* (mg/kg/day)	Chronic Hazard Quotient	Increased Cancer Risk
PFOA	16 to < 21 years	0.44	6.6E-07	3E-06	0.22	<1E-06**
	Adult		4.7E-07		0.16	
PFOS	16 to < 21 years	150	0.00022	2E-06	110	Not classified as carcinogens
	Adult		0.00016		80	
PFNA	16 to < 21 years	0.015	2.2E-08	3E-06	0.0075	
	Adult		1.6E-08		0.0053	
PFHxS	16 to < 21 years	1.4	2.1E-06	2E-05	0.10	
	Adult		1.5E-06		0.074	

ATSDR - Agency for Toxic Substances and Disease Registry
Chronic - Exposure duration of one year or more
EPC - Exposure point concentration (concentration in non-remediated soil)
mg/kg - Milligram contaminant per kilogram
mg/kg/day - Milligram contaminant per kilogram body weight per day
MRL - Minimal risk level (ATSDR's health guideline below which minimal risk is expected)
PFHxS - Perfluorohexane sulfonate
PFNA - Perfluorononanoic acid
PFOA - Perfluorooctanoic acid
PFOS - Perfluorooctane sulfonate
< - Less than
1E-06 - One in a million
* - Current PFAS MRLs are provisional
** - PFOA cancer slope factor = 0.07 $(mg/kg/day)^{-1}$
- Risk (*i.e.*, hazard quotient above 1)

*Table D-8. Estimated doses, non-cancer risk (hazard quotients) and increased cancer risk for **outdoor workers** (including maintenance workers and teachers) exposed to **2018/2019** levels of PFOA, PFOS, PFNA and PFHxS in non-remediated surface soil (0 – 2 feet) at **AOC3** at the Florida State Fire College (on-site) via **incidental ingestion and dermal contact**.*

Contaminant	Exposure Group	EPC (mg/kg)	Chronic Dose (mg/kg/day)	ATSDR MRL* (mg/kg/day)	Chronic Hazard Quotient	Increased Cancer Risk
PFOA	16 to < 21 years	0.0018	2.7E-09	3E-06	0.00089	<1E-06**
	Adult		1.9E-09		0.00064	
PFOS	16 to < 21 years	0.16	2.4E-07	2E-06	0.12	Not classified as carcinogens
	Adult		1.7E-07		0.085	
PFNA	16 to < 21 years	0.0028	4.2E-09	3E-06	0.0014	
	Adult		3.0E-09		0.00099	
PFHxS	16 to < 21 years	0.019	2.8E-08	2E-05	0.0014	
	Adult		2.0E-08		0.0010	

ATSDR - Agency for Toxic Substances and Disease Registry
Chronic - Exposure duration of one year or more
EPC - Exposure point concentration (concentration in non-remediated soil)
mg/kg - Milligram contaminant per kilogram
mg/kg/day - Milligram contaminant per kilogram body weight per day
MRL - Minimal risk level (ATSDR's health guideline below which minimal risk is expected)
PFHxS - Perfluorohexane sulfonate
PFNA - Perfluorononanoic acid
PFOA - Perfluorooctanoic acid
PFOS - Perfluorooctane sulfonate
< - Less than
1E-06 - One in a million
* - Current PFAS MRLs are provisional
** - PFOA cancer slope factor = 0.07 $(mg/kg/day)^{-1}$

*Table D-9. Estimated doses, non-cancer risk (hazard quotients) and increased cancer risk for **outdoor workers** (including maintenance workers and teachers) exposed to **2018/2019** levels of PFOA, PFOS, PFNA and PFHxS in non-remediated surface soil (0 – 2 feet) at **AOC4** at the Florida State Fire College (on-site) via **incidental ingestion and dermal contact**.*

Contaminant	Exposure Group	EPC (mg/kg)	Chronic Dose (mg/kg/day)	ATSDR MRL* (mg/kg/day)	Chronic Hazard Quotient	Increased Cancer Risk
PFOA	16 to < 21 years	0.0092	1.4E-08	3E-06	0.0046	<1E-06**
	Adult		9.8E-09		0.0033	
PFOS	16 to < 21 years	0.26	3.9E-07	2E-06	0.19	Not classified as carcinogens
	Adult		2.8E-07		0.14	
PFNA	16 to < 21 years	0.0013	1.9E-09	3E-06	0.00065	
	Adult		1.4E-09		0.00046	
PFHxS	16 to < 21 years	0.017	2.5E-08	2E-05	0.0013	
	Adult		1.8E-08		0.00090	

ATSDR - Agency for Toxic Substances and Disease Registry
Chronic - Exposure duration of one year or more
EPC - Exposure point concentration (concentration in non-remediated soil)
mg/kg - Milligram contaminant per kilogram
mg/kg/day - Milligram contaminant per kilogram body weight per day
MRL - Minimal risk level (ATSDR's health guideline below which minimal risk is expected)
PFHxS - Perfluorohexane sulfonate
PFNA - Perfluorononanoic acid
PFOA - Perfluorooctanoic acid
PFOS - Perfluorooctane sulfonate
< - Less than
1E-06 - One in a million
* - Current PFAS MRLs are provisional
** - PFOA cancer slope factor = 0.07 $(mg/kg/day)^{-1}$

*Table D-10. Estimated doses, non-cancer risk (hazard quotients) and increased cancer risk for **outdoor workers** (including maintenance workers and teachers) exposed to **2018/2019** levels of PFOA, PFOS, PFNA and PFHxS in non-remediated surface soil (0 – 2 feet) at **AOC5** at the Florida State Fire College (on-site) via **incidental ingestion and dermal contact**.*

Contaminant	Exposure Group	EPC (mg/kg)	Chronic Dose (mg/kg/day)	ATSDR MRL* (mg/kg/day)	Chronic Hazard Quotient	Increased Cancer Risk
PFOA	16 to < 21 years	0.021	3.1E-08	3E-06	0.010	<1E-06**
	Adult		2.2E-08		0.0074	
PFOS	16 to < 21 years	0.30	4.5E-07	2E-06	0.22	Not classified as carcinogens
	Adult		3.2E-07		0.16	
PFNA	16 to < 21 years	0.01	1.5E-08	3E-06	0.0050	
	Adult		1.1E-08		0.0035	
PFHxS	16 to < 21 years	0.0086	1.3E-08	2E-05	0.00064	
	Adult		9.2E-09		0.00046	

ATSDR - Agency for Toxic Substances and Disease Registry
Chronic - Exposure duration of one year or more
EPC - Exposure point concentration (concentration in non-remediated soil)
mg/kg - Milligram contaminant per kilogram
mg/kg/day - Milligram contaminant per kilogram body weight per day
MRL - Minimal risk level (ATSDR's health guideline below which minimal risk is expected)
PFHxS - Perfluorohexane sulfonate
PFNA - Perfluorononanoic acid
PFOA - Perfluorooctanoic acid
PFOS - Perfluorooctane sulfonate
< - Less than
1E-06 - One in a million
* - Current PFAS MRLs are provisional
** - PFOA cancer slope factor = 0.07 $(mg/kg/day)^{-1}$

STUDENT INDOOR TAP WATER EXPOSURE

*Table D-11. Estimated doses and non-cancer risk (hazard quotients) for **students** exposed to **2018/2019** levels of PFOA, PFOS, PFNA and PFHxS in non-remediated indoor tap water at the Florida State Fire College (on-site) via **ingestion (drinking)**.*

Contaminant	Exposure Group	EPC (mg/L)	Int. Dose (mg/kg/day)	ATSDR MRL* (mg/kg/day)	Int. Hazard Quotient
PFOA	16 to < 21 years	0.000010	3.6E-07	3E-06	0.12
	Adult		3.2E-07		0.11
	Pregnant Women		3.5E-07		0.12
	Lactating Women		3.5E-07		0.12
PFOS	16 to < 21 years	0.00025	8.9E-06	2E-06	4.5
	Adult		8.0E-06		4.0
	Pregnant Women		8.8E-06		4.4
	Lactating Women		8.8E-06		4.4
PFNA	16 to < 21 years	0.0000017	6.1E-08	3E-06	0.34
	Adult		5.4E-08		0.30
	Pregnant Women		6.0E-08		0.33
	Lactating Women		6.0E-08		0.33
PFHxS	16 to < 21 years	0.00019	6.8E-06	2E-05	0.020
	Adult		6.1E-06		0.018
	Pregnant Women		6.7E-06		0.020
	Lactating Women		6.7E-06		0.020

ATSDR - Agency for Toxic Substances and Disease Registry
EPC - Exposure point concentration (concentration in non-remediated indoor tap water)
Int. - Intermediate exposure of 15 to 364 days
mg/L - Milligram contaminant per liter of water
mg/kg/day - Milligram contaminant per kilogram body weight per day
MRL - Minimal risk level (ATSDR's health guideline below which minimal risk is expected)
* - Current PFAS MRLs are provisional
- Risk (*i.e.*, hazard quotient above 1)

< - less than

PFHxS - Perfluorohexane sulfonate
PFNA - Perfluorononanoic acid
PFOA - Perfluorooctanoic acid
PFOS - Perfluorooctane sulfonate

*Table D-12. Estimated doses and non-cancer risk (hazard quotients) for **students** exposed to **2018/2019** levels of PFOA, PFOS, PFNA and PFHxS in non-remediated indoor tap water at the Florida State Fire College (on-site) via **showering**. [Model based maximum input: 4-person household, two showers a day, fan on, gone during the day].*

Contaminant	Exposure Group	EPC	Inhalation Dose (mg/kg/day)	Dermal Dose (mg/kg/day)	Combined Dose (mg/kg/day)	ATSDR MRL* (mg/kg/day)	Int. Hazard Quotient(combined)
PFOA	16 to < 21 years	10 ng/L [1] 3.4E-10 mg/m^3 [2] 1.6E-12 mg/m^3 [3]	1.2E-12	1.6E-09	1.6E-09	**3E-06**	5.5E-04
	Adult		1.1E-12	1.6E-09	1.6E-09		5.2E-04
	Pregnant Women		1.6E-12	1.6E-09	1.6E-09		5.2E-04
	Lactating Women		1.6E-12	1.6E-09	1.6E-09		5.2E-04
PFOS	16 to < 21 years	250 ng/L [1] 7.4E-09 mg/m^3 [2] 3.4E-12 mg/m^3 [3]	2.6E-12	7.0E-08	7.0E-08	**2E-06**	3.5E-02
	Adult		2.4E-12	6.7E-08	6.7E-08		3.4E-02
	Pregnant Women		3.4E-12	6.9E-08	6.9E-08		3.4E-02
	Lactating Women		3.4E-12	6.9E-08	6.9E-08		3.4E-02
PFNA	*Model does not currently calculate shower scenarios for PFNA and PFHxS*						
PFHxS							

[1] – EPC Water [2]– EPC Air, Shower [3] – EPC Air, Main House

ATSDR - Agency for Toxic Substances and Disease Registry
EPC - Exposure point concentration (in non-remediated indoor tap water/air (estimated))
Int. - Intermediate exposure of 15 to 364 days
mg/kg/day - Milligram contaminant per kilogram body weight per day
MRL - Minimal risk level (ATSDR's health guideline below which minimal risk is expected)
ng/L - Nanograms per liter
PFHxS - Perfluorohexane sulfonate
PFNA - Perfluorononanoic acid
PFOA - Perfluorooctanoic acid
PFOS - Perfluorooctane sulfonate

* - PFAS MRLs are provisional
mg/m^3 - Milligrams per cubic meter
< - Less than
1E-06 - One in a million

STUDENT SOIL EXPOSURE

*Table D-13. Estimated doses and non-cancer risk (hazard quotients) for **students** exposed to **2018/2019** levels of PFOA, PFOS, PFNA and PFHxS in non-remediated surface soil (0 – 2 feet) at **AOC1** at the Florida State Fire College (on-site) via **incidental ingestion and dermal contact**.*

Contaminant	Exposure Group	EPC (mg/kg)	Int. Dose (mg/kg/day)	ATSDR MRL* (mg/kg/day)	Int. Hazard Quotient
PFOA	16 to < 21 years	0.44	6.8E-07	3E-06	0.23
	Adult		4.9E-07		0.16
PFOS	16 to < 21 years	150	0.00023	2E-06	120
	Adult		0.00017		83
PFNA	16 to < 21 years	0.015	2.3E-08	3E-06	0.0078
	Adult		1.7E-08		0.0055
PFHxS	16 to < 21 years	1.4	2.2E-06	2E-05	0.11
	Adult		1.6E-06		0.078

ATSDR - Agency for Toxic Substances and Disease Registry
EPC - Exposure point concentration (concentration in non-remediated soil)
Int. - Intermediate exposure of 15 to 364 days
mg/kg - Milligram contaminant per kilogram
mg/kg/day - Milligram contaminant per kilogram body weight per day
MRL - Minimal risk level (ATSDR's health guideline below which minimal risk is expected)
PFHxS - Perfluorohexane sulfonate
PFNA - Perfluorononanoic acid
PFOA - Perfluorooctanoic acid
PFOS - Perfluorooctane sulfonate
< - Less than
1E-06 - One in a million
* - Current PFAS MRLs are provisional
- Risk (*i.e.,* hazard quotient above 1)

*Table D-14. Estimated doses and non-cancer risk (hazard quotients) for **students** exposed to **2018/2019** levels of PFOA, PFOS, PFNA and PFHxS in non-remediated surface soil (0 – 2 feet) at **AOC3** at the Florida State Fire College (on-site) via **incidental ingestion and dermal contact**.*

Contaminant	Exposure Group	EPC (mg/kg)	Int. Dose (mg/kg/day)	ATSDR MRL* (mg/kg/day)	Int. Hazard Quotient
PFOA	16 to < 21 years	0.0018	2.8E-09	3E-06	0.00093
	Adult		2.0E-09		0.00067
PFOS	16 to < 21 years	0.16	2.5E-07	2E-06	0.12
	Adult		1.8E-07		0.089
PFNA	16 to < 21 years	0.0028	4.4E-09	3E-06	0.0015
	Adult		3.1E-09		0.0010
PFHxS	16 to < 21 years	0.019	3.0E-08	2E-05	0.0015
	Adult		2.1E-08		0.0011

ATSDR - Agency for Toxic Substances and Disease Registry
EPC - Exposure point concentration (concentration in non-remediated soil)
Int. - Intermediate exposure of 15 to364 days
mg/kg - Milligram contaminant per kilogram
mg/kg/day - Milligram contaminant per kilogram body weight per day
MRL - Minimal risk level (ATSDR's health guideline below which minimal risk is expected)
PFHxS - Perfluorohexane sulfonate
PFNA - Perfluorononanoic acid
PFOA - Perfluorooctanoic acid
PFOS - Perfluorooctane sulfonate
< - Less than
1E-06 - One in a million
* - Current PFAS MRLs are provisional

*Table D-15. Estimated doses and non-cancer risk (hazard quotients) for **students** exposed to **2018/2019** levels of PFOA, PFOS, PFNA and PFHxS in non-remediated surface soil (0 – 2 feet) at **AOC4** at the Florida State Fire College (on-site) via **incidental ingestion and dermal contact**.*

Contaminant	Exposure Group	EPC (mg/kg)	Int. Dose (mg/kg/day)	ATSDR MRL* (mg/kg/day)	Int. Hazard Quotient
PFOA	16 to < 21 years	0.0092	1.4E-08	3E-06	0.0048
	Adult		1.0E-08		0.0034
PFOS	16 to < 21 years	0.26	4.0E-07	2E-06	0.20
	Adult		2.9E-07		0.14
PFNA	16 to < 21 years	0.0013	2.0E-09	3E-06	0.00067
	Adult		1.4E-09		0.00048
PFHxS	16 to < 21 years	0.017	2.0E-09	2E-05	0.0013
	Adult		1.4E-09		0.00094

ATSDR - Agency for Toxic Substances and Disease Registry
EPC - Exposure point concentration (concentration in non-remediated soil)
Int. - Intermediate exposure of 15 to364 days
mg/kg - Milligram contaminant per kilogram
mg/kg/day - Milligram contaminant per kilogram body weight per day
MRL - Minimal risk level (ATSDR's health guideline below which minimal risk is expected)
PFHxS - Perfluorohexane sulfonate
PFNA - Perfluorononanoic acid
PFOA - Perfluorooctanoic acid
PFOS - Perfluorooctane sulfonate
< - Less than
1E-06 - Less than one in a million
* - Current PFAS MRLs are provisional

*Table D-16. Estimated doses and non-cancer risk (hazard quotients) for **students** exposed to **2018/2019** levels of PFOA, PFOS, PFNA and PFHxS in non-remediated surface soil (0 – 2 feet) at **AOC5** at the Florida State Fire College (on-site) via **incidental ingestion and dermal contact**.*

Contaminant	Exposure Group	EPC (mg/kg)	Int. Dose (mg/kg/day)	ATSDR MRL* (mg/kg/day)	Int. Hazard Quotient
PFOA	16 to < 21 years	0.021	3.3E-08	3E-06	0.011
	Adult		2.3E-08		0.0078
PFOS	16 to < 21 years	0.30	4.7E-07	2E-06	0.23
	Adult		3.3E-07		0.17
PFNA	16 to < 21 years	0.01	1.6E-08	3E-06	0.0052
	Adult		1.1E-08		0.0037
PFHxS	16 to < 21 years	0.0086	1.3E-08	2E-05	0.00067
	Adult		9.5E-09		0.00048

ATSDR - Agency for Toxic Substances and Disease Registry
EPC - Exposure point concentration (concentration in non-remediated soil)
Int. - Intermediate exposure of 15 to364 days
mg/kg - Milligram contaminant per kilogram
mg/kg/day - Milligram contaminant per kilogram body weight per day
MRL - Minimal risk level (ATSDR's health guideline below which minimal risk is expected)
PFHxS - Perfluorohexane sulfonate
PFNA - Perfluorononanoic acid
PFOA - Perfluorooctanoic acid
PFOS - Perfluorooctane sulfonate
< - Less than
<1E-06 - One in a million
* - Current PFAS MRLs are provisional

TRESPASSER SOIL EXPOSURE

*Table D-17. Estimated doses, non-cancer risk (hazard quotients) and increased cancer risk for **trespassers** exposed to **2018/2019** levels of PFOA, PFOS, PFNA and PFHxS in non-remediated surface soil (0 – 2 feet) at **AOC1** at the Florida State Fire College (on-site) via **incidental ingestion and dermal contact**.*

Contaminant	Exposure Group	EPC (mg/kg)	Chronic Dose (mg/kg/day)	ATSDR MRL* (mg/kg/day)	Chronic Hazard Quotient	Increased Cancer Risk
PFOA	16 to < 21 years	0.44	5.8E-07	3E-06	0.19	<1E-06**
	Adult		3.6E-07		0.12	
PFOS	16 to < 21 years	150	0.00020	2E-06	100	Not classified as carcinogens
	Adult		0.00012		61	
PFNA	16 to < 21 years	0.015	2.0E-08	3E-06	0.0066	
	Adult		1.2E-08		0.0041	
PFHxS	16 to < 21 years	1.4	1.9E-06	2E-05	0.093	
	Adult		1.1E-06		0.057	

ATSDR - Agency for Toxic Substances and Disease Registry
Chronic - Exposure duration of one year or more
EPC - Exposure point concentration (concentration in non-remediated soil)
mg/kg - Milligram contaminant per kilogram
mg/kg/day - Milligram contaminant per kilogram body weight per day
MRL - Minimal risk level (ATSDR's health guideline below which minimal risk is expected)
PFHxS - Perfluorohexane sulfonate
PFNA - Perfluorononanoic acid
PFOA - Perfluorooctanoic acid
PFOS - Perfluorooctane sulfonate
< - Less than
1E-06 - One in a million
* - Current PFAS MRLs are provisional
** - PFOA cancer slope factor = 0.07 $(mg/kg/day)^{-1}$
- Risk (*i.e.*, hazard quotient above 1)

*Table D-18. Estimated doses, non-cancer risk (hazard quotients) and increased cancer risk for **trespassers** exposed to **2018/2019** levels of PFOA, PFOS, PFNA and PFHxS in non-remediated surface soil (0 – 2 feet) at **AOC3** at the Florida State Fire College (on-site) via incidental ingestion and dermal contact.*

Contaminant	Exposure Group	EPC (mg/kg)	Chronic Dose (mg/kg/day)	ATSDR MRL* (mg/kg/day)	Chronic Hazard Quotient	Increased Cancer Risk
PFOA	16 to < 21 years	0.0018	2.4E-09	3E-06	0.00080	<1E-06**
	Adult		1.5E-09		0.00049	
PFOS	16 to < 21 years	0.16	2.1E-07	2E-06	0.11	Not classified as carcinogens
	Adult		1.3E-07		0.065	
PFNA	16 to < 21 years	0.0028	3.7E-09	3E-06	0.0012	
	Adult		2.3E-09		0.00076	
PFHxS	16 to < 21 years	0.019	2.5E-08	2E-05	0.0013	
	Adult		1.5E-08		0.00077	

ATSDR - Agency for Toxic Substances and Disease Registry
Chronic - Exposure duration of one year or more
EPC - Exposure point concentration (concentration in non-remediated soil)
mg/kg - Milligram contaminant per kilogram
mg/kg/day - Milligram contaminant per kilogram body weight per day
MRL - Minimal risk level (ATSDR's health guideline below which minimal risk is expected)
PFHxS - Perfluorohexane sulfonate
PFNA - Perfluorononanoic acid
PFOA - Perfluorooctanoic acid
PFOS - Perfluorooctane sulfonate
< - Less than
1E-06 - One in a million
* - Current PFAS MRLs are provisional
** - PFOA cancer slope factor = 0.07 $(mg/kg/day)^{-1}$

*Table D-19 Estimated doses, non-cancer risk (hazard quotients) and increased cancer risk for **trespassers** exposed to **2018/2019** levels of PFOA, PFOS, PFNA and PFHxS in non-remediated surface soil (0 – 2 feet) at **AOC4** at the Florida State Fire College (on-site) via incidental ingestion and dermal contact.*

Contaminant	Exposure Group	EPC (mg/kg)	Chronic Dose (mg/kg/day)	ATSDR MRL* (mg/kg/day)	Chronic Hazard Quotient	Increased Cancer Risk
PFOA	16 to < 21 years	0.0092	1.2E-08	3E-06	0.0041	<1E-06**
	Adult		7.5E-09		0.0025	
PFOS	16 to < 21 years	0.26	3.4E-07	2E-06	0.17	Not classified as carcinogens
	Adult		2.1E-07		0.11	
PFNA	16 to < 21 years	0.0013	1.7E-09	3E-06	0.00057	
	Adult		1.1E-09		0.00035	
PFHxS	16 to < 21 years	0.017	2.3E-08	2E-05	0.0011	
	Adult		1.4E-08		0.00069	

ATSDR - Agency for Toxic Substances and Disease Registry
Chronic - Exposure duration of one year or more
EPC - Exposure point concentration (concentration in non-remediated soil)
mg/kg - Milligram contaminant per kilogram
mg/kg/day - Milligram contaminant per kilogram body weight per day
MRL - Minimal risk level (ATSDR's health guideline below which minimal risk is expected)
PFHxS - Perfluorohexane sulfonate
PFNA - Perfluorononanoic acid
PFOA - Perfluorooctanoic acid
PFOS - Perfluorooctane sulfonate
< - Less than
1E-06 - One in a million
* - Current PFAS MRLs are provisional
** - PFOA cancer slope factor = 0.07 $(mg/kg/day)^{-1}$

*Table D-20. Estimated doses, non-cancer risk (hazard quotients) and increased cancer risk for **trespassers** exposed to **2018/2019** levels of PFOA, PFOS, PFNA and PFHxS in non-remediated surface soil (0 – 2 feet) at **AOC5** at Florida State Fire College (on-site) via incidental ingestion and dermal contact.*

Contaminant	Exposure Group	EPC (mg/kg)	Chronic Dose (mg/kg/day)	ATSDR MRL* (mg/kg/day)	Chronic Hazard Quotient	Increased Cancer Risk
PFOA	16 to < 21 years	0.021	2.8E-08	3E-06	0.0093	<1E-06**
	Adult		1.7E-08		0.0057	
PFOS	16 to < 21 years	0.30	4.0E-07	2E-06	0.20	Not classified as carcinogens
	Adult		2.4E-07		0.12	
PFNA	16 to < 21 years	0.01	1.3E-08	3E-06	0.0044	
	Adult		8.1E-09		0.0027	
PFHxS	16 to < 21 years	0.0086	1.1E-08	2E-05	0.00057	
	Adult		7.0E-09		0.00035	

ATSDR - Agency for Toxic Substances and Disease Registry
Chronic - Exposure duration of one year or more
EPC - Exposure point concentration (concentration in non-remediated soil)
mg/kg - Milligram contaminant per kilogram
mg/kg/day - Milligram contaminant per kilogram body weight per day
MRL - Minimal risk level (ATSDR's health guideline below which minimal risk is expected)
PFHxS - Perfluorohexane sulfonate
PFNA - Perfluorononanoic acid
PFOA - Perfluorooctanoic acid
PFOS - Perfluorooctane sulfonate
< - Less than
1E-06 - One in a million
* - Current PFAS MRLs are provisional
** - PFOA cancer slope factor = 0.07 $(mg/kg/day)^{-1}$

APPENDIX E. CHEMICAL-SPECIFIC TOXICITY INFORMATION

The toxicology of PFAS is not fully understood. Available toxicological information is based on epidemiological and animal studies. ***Epidemiological studies*** have investigated populations across three levels of exposure from background to high. Most Americans are exposed to very low levels of PFAS and this is called background. Mid-level exposure is exposure to residents near facilities that use or produce PFAS and high-level exposure refers to occupational exposure for workers at such facilities.

Epidemiological studies look at disease trends (differences) in observations across such different exposure populations but are not 'controlled' experiments. This means that many important, sometimes unknown variables cannot be accounted for, such as pre-existing conditions and other factors that may affect a person's susceptibility to disease. These types of studies produce data with high uncertainty (data that are not certain to be accurate).

The results of epidemiological studies for PFAS to date have been inconclusive, and most studies have focused on PFOA and PFOS with less data available for PFNA, PFHxS and other PFAS. However, data suggest a number of possible ***non-cancer health effects*** associated with PFOA, PFOS, PFNA and/or PFHxS exposure [ATSDR 2018[1]]. Possible effects include changes to the liver, thyroid, serum cholesterol, immune and reproductive systems. Pregnant and lactating women, and, women and men who plan to become parents, could be at risk of health effects in their unborn or nursing children, including reduced birth weight and developmental effects such as small delays in puberty [ATSDR 2018], as well as childhood obesity [Braun 2017][2]. Pregnant women exposed to PFAS could be more susceptible to preeclampsia (hypertension during pregnancy), though findings are inconsistent [Borghese et al. 2020[3]; Savitz et al. 2012[4]; Stein et al. 2009[5]; Wikström et al. 2019[6]]. The following table outlines the possible effects of PFAS exposure as indicated by epidemiological studies to date.

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[1] [ATSDR] Agency for Toxic Substances and Disease Registry. 2018. Toxicological profile for Perfluoroalkyls. (Draft for Public Comment). Atlanta, GA [updated 2019 September 26, accessed 2019. Available from: http://www.atsdr.cdc.gov/toxprofiles/tp.asp?id=1117&tid=237

[2] Braun JM. 2017. Early-Life Exposure to EDCs: Role in Childhood Obesity and Neurodevelopment. Nat Rev Endocrinol 13(3): 161-173.

[3] Borghese MM, Walker M, Helewa ME, Fraser WD and Arbuckle TE. 2020. Association of Perfluoroalkyl Substances with Gestational Hypertension and Preeclampsia in the MIREC Study. Environ Int 141: 105789.

[4] Savitz DA, Stein CR, Bartell SM, Elston B, Gong J, Shin H-M and Wellenius GA. 2012. Perfluorooctanoic Acid Exposure and Pregnancy Outcome in a Highly Exposed Community. Epidemiology 23(3): 386-392.

[5] Stein CR, Savitz DA and Dougan M. 2009. Serum Levels of Perfluorooctanoic Acid and Perfluorooctane Sulfonate and Pregnancy Outcome. Am J Epidemiol 170(7): 837-846.

[6] Wikström S, Lindh CH, Shu H and Bornehag C-G. 2019. Early Pregnancy Serum Levels of Perfluoroalkyl Substances and Risk of Preeclampsia in Swedish Women. Sci Rep 9(1): 9179.

Possible health effects of PFAS exposure in humans based on epidemiological data.					
Organ/system	**Associated health effect**	**PFOA**	**PFOS**	**PFNA**	**PFHxS**
Cardiovascular	Pregnancy-induced hypertension/preeclampsia	**X**	**X**	**X†**	**X‡**
Liver	Liver damage (increase in serum enzymes, decrease in bilirubin)	**X**	**X**		**X**
Blood	Increased serum lipids (mainly total cholesterol and low-density-lipid (LDL) cholesterol)	**X**	**X**	**X**	
Thyroid	Increased risk of thyroid disease	**X**	**X**		
Immune	Decreased antibody response to vaccines	**X**	**X**		**X**
Respiratory	Increased risk of asthma diagnosis	**X**			
Reproductive	Increased risk of reduced fertility	**X**	**X**		
Developmental	Small decreases in birth weight	**X**	**X**		
Carcinogenicity	*Kidney, prostate, testicular cancer*	**X**			

Adapted from ATSDR's draft toxicological profile for PFAS. †[Wikström et al. 2019][6], ‡[Borghese et al. 2020][3].

Controlled animal studies can better demonstrate cause and effect than uncontrolled epidemiological studies. Animal studies generally use high exposure doses and cannot replace human studies. However, by studying the same endpoints (effects) observed in epidemiological studies under controlled conditions (known chemical doses, duration, etc.), animal studies can be used to support epidemiological findings.

To date, animal studies investigating PFAS have been conducted mostly with rodents but also with non-human primates (monkeys). Overall, these studies have identified liver, immune and reproductive systems, as well as development as the primary targets of toxicity for PFOA. For PFOS, animal studies have identified liver, nervous and immune systems, as well as development as sensitive targets of toxicity. Animal studies have also observed developmental effects for PFNA exposure, and, liver and immune effects for PFHxS.

ATSDR used these animal studies to develop ***provisional minimal risk levels (MRLs)*** for PFOA, PFOS, PFNA and PFHxS [ATSDR 2018]. These MRLs were used as health guidelines for this health assessment. MRLs are developed to protect the most sensitive populations. An MRL is an estimate of the daily human exposure to a hazardous substance that is likely to be without considerable risk of adverse non-cancer health effects over a specified route and duration of exposure. To derive an MRL, the lowest chemical daily dose observed to cause the most sensitive health effect (for example a developmental effect) is identified. Then this chemical dose is lowered by applying one or more numbers called uncertainty factors. This way the MRL accounts for uncertainty and is set far below any daily dose known to cause the most sensitive effect known.

ATSDR found developmental effects data to be the most sensitive and robust for PFOA, PFOS and PFNA, while immune effects were found to be the most sensitive endpoint for PFHxS. Animal data also indicate that immune effects may be a more sensitive endpoint for PFOS. However, developmental effects data were used to estimate minimal risk levels for three of the four PFAS (PFOA, PFOS and PFNA). It is important to consider that the fetus and baby can be exposed to PFAS in the womb and through lactation. Furthermore, PFAS exposure to adults can cause effects in their offspring.

Developmental effects observed in animals exposed to ***PFOA*** include prenatal loss, decreased pup survival and birth weight, delayed development (e.g., eye opening, mammary gland development, skeletal changes) and increased motor activity [ATSDR 2018]. (Effects to mammary gland development did not cause effects in the offspring). The MRL for PFOA is based on the lowest dose observed to cause developmental effects in mice. The observed endpoints were altered motor activity and skeletal changes in offspring of exposed mice [Koskela et al. 2016[7]; Onishchenko et al. 2011[8]].

PFOS-associated developmental effects observed in rodent studies include lowered pup survival, lowered birth and body weight, lowered motor activity and developmental delays [ATSDR 2018]. The most sensitive endpoints observed were decreased body weight and delayed eye opening in offspring of rats, which were exposed from before mating through gestation and lactation [Luebker et al. 2005[9]]. The MRL for PFOS is based on the highest dose tested without observing these effects. As noted, animal data indicate that PFOS may cause immune effects (lowered immune response) at doses ten times lower than those causing developmental effects. Thus, the immune system may be a very sensitive target for PFOS exposure. This endpoint was not used for the MRL, because the studies, which tested potential for immune effects used a species for which it is difficult to translate animal doses to representative human doses [ATSDR 2018[1]]. Instead, a modification factor was added as an additional precaution to the typical uncertainty factors.

More limited data are available for PFNA and PFHxS. The MRL for ***PFNA*** is based on developmental endpoints in mice (decreased body weight and delayed development) [Das et al. 2015[10]]. The dose used to estimate MRL is the highest dose tested without observable effects. Developmental toxicity has not been investigated for ***PFHxS***, which appears to target the immune system. The endpoint used for MRL estimation is thyroid

[7]Koskela et al. 2016. Effects of developmental exposure to perfluorooctanoic acid (PFOA) on long bone morphology and bone cell differentiation. Toxicol Appl Pharmacol 301:14-21.

[8]Onishchenko et al. 2011. Prenatal exposure to PFOS or PFOA alters motor function in mice in a sex-related manner. Neurotox Res 19:452-461.

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follicular cell damage in a rat species [Butenhoff et al. 2009[11]]. The dose used to estimate MRL is the highest dose tested without observable effects.

The findings in animal studies support data from human epidemiological studies, which have also found associations between PFOA and PFOS exposure, and, small decreases in birth weight (ATSDR, 2018). Further, PFOA, PFOS, PFNA and PFHxS exposure have also been linked to reduced antibody response to vaccines in human epidemiological studies [ATSDR 2018[1]]. Though these studies did not find an association with increased rates of vaccine-preventable diseases.

Cancer potential: The International Agency for Research on Cancer has classified ***PFOA*** as possibly carcinogenic to humans [IARC 2017[12]]. PFOA has been associated with testicular, prostate and kidney cancer; however, epidemiological data are inconclusive. The guideline (cancer slope factor) used to evaluate increased cancer risk for PFOA was developed based on animal data for one cancer type only (testicular). There is suggestive evidence that PFOS may be able to cause liver, thyroid and mammary cancers [ATSDR 2018[1]]. At this time, ***PFOS, PFNA and PFHxS*** are not classified as human carcinogens. Information for these PFAS is very limited.

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PER- AND POLYFLUOROALKYL SUBSTANCES (PFAS)

PFAS (per- and poly-fluoroalkyl substances) are a group of man-made chemicals found in air, soil, ground and surface water, and in people around the world. Studies about health effects of PFAS exposure in humans and animals have not reached clear conclusions. However, results do suggest that certain PFAS may be related to specific health problems, so researchers continue to study them.

The purpose of this factsheet is to provide an overview of frequently asked questions regarding PFAS in the environment and their possible health effects, as well as regulatory guidance and biomonitoring information. ***Note:** Questions discussed in this factsheet mainly focus on perfluorooctanoic acid (PFOA) and perfluorooctane sulfonate (PFOS) as these are the most common and well-studied PFAS.*

General Facts

What are PFAS?

PFAS do not occur naturally in the environment. They are manufactured chemicals and have been used in:

- Surface protection of non-stick cookware.
- Stain resistant carpets and fabrics.
- Waterproof mattresses and clothing.
- Grease-resistant food packaging.
- Some firefighting materials.
- Photo imaging, metal plating, printers, and copy machines.

The most common and well-studied PFAS are perfluorooctanoic acid (PFOA) and perfluorooctane sulfonate (PFOS). Information needed for investigating PFAS such as toxicity values, screening levels and lifetime health advisory levels (HAL) as provided by the U.S. Environmental Protection Agency (EPA) are only available for these two compounds.

Why are PFAS a concern?

PFAS are widespread and global. Once released, they are very persistent in the environment and the human body. They can be found in:

- Air
- Soil
- Water (ground and surface water)
- Blood
- Urine
- Breast milk
- Umbilical cord blood

How can I be exposed to PFAS?

The main way you can be exposed to PFAS is by swallowing them when you:

- Drink contaminated water.
- Eat fish caught from waters contaminated with PFAS.
- Eat food packed in PFAS-containing material (e.g., popcorn bags).
- Transfer them hand to mouth from surfaces treated with PFAS, such as carpets.

If you work with PFAS you can also be exposed to them by breathing them in or through skin contact. The uptake of PFAS through skin contact is slow and not considered significant.

For infants and toddlers, hand-to-mouth is considered the most significant source of exposure.

How long do PFAS remain in the body?

On average, PFAS can remain in the body between two and nine years.

How can PFAS potentially affect health?

- Effects on health from exposure to low levels of PFAS are not well known. Studies in humans and animals are inconclusive but suggest that certain PFAS may cause health effects.

- Non-cancer effects appear more common and include:
  - Increased cholesterol levels
  - Impacts on human hormones
  - Impacts on human immune system
  - Fetal and infant developmental effects

Can PFAS cause cancer?

- The U.S. Environmental Protection Agency (EPA) has determined there is **some** evidence that PFAS can cause cancer.

- The International Agency for Research on Cancer has classified PFOA as **possibly** cancer causing, although, there is currently no consistent scientific evidence that PFOS and PFOA cause cancer in humans.

- Some animal studies have suggested a higher risk of certain cancers, such as prostate, kidney, or testicular cancer. Humans and animals often react differently to chemicals (including PFAS) and not all the effects seen in animal tests may occur in humans.

- Some increases in kidney, prostate, and testicular cancers have been seen in individuals exposed to higher PFAS levels, mostly in occupational exposures. Most of these exposures were in people who worked in, or lived near, PFAS manufacturing facilities.

How certain are the studies that showed health risks?

- Correlations between exposure to PFAS and health effects have been inconsistent.

- More research is needed to fully understand any health effects in humans.

- Animals (mostly rats and mice) exposed to much higher levels than most people showed several health problems, such as liver damage, developmental and reproductive effects, and changes in hormone levels.

- Some human studies have found increases in prostate, kidney, and testicular cancers in workers exposed to PFAS and people living near facilities producing PFAS. However, other studies did not report a link between cancer and PFAS.

- Studies should be interpreted carefully, since the effects were not consistent across studies, there were contradictory findings among studies, and exposure levels were much higher than seen in the general population.

PFAS Regulation and Advisories

What levels of PFAS in water are considered harmful?

- The EPA has developed a lifetime drinking water health advisory level (HAL) for PFOA and/ or PFOS of 70 ng/L. The level is equal to the amount of a shot glass (1.5 oz) in approximately 150 million gallons of water. Drinking water at or below this standard for a lifetime is not expected to harm your health.

- If testing shows that your drinking water contains PFOA and/ or PFOS above the EPA HAL, use other water sources for drinking, preparing food, cooking, brushing teeth, and other uses when you might swallow water. Because the HAL is based upon long-term exposure, a short-term increase above the HAL should not increase risk significantly.

Biomonitoring and Blood Testing

Can a test determine whether I have been exposed to PFAS?

PFAS can be measured in blood, serum, and urine. However, doctors do not conduct this test to make a diagnosis or decide on treatment.

When is testing of PFAS useful and what can the results tell me?

- Testing for PFAS can be useful when they are part of a scientific investigation or a health study to determine how often and at what levels the chemical is found in the population. One such study is the National Health and Nutrition Examination Survey.

- Blood tests can be helpful when researching health effects from PFAS among persons who have been exposed to very high concentrations of the chemical, such as workers in industries where PFAS was used.

- Results of biomonitoring can compare the PFAS results from individuals tested with national averages established through these types of studies.

What can the results from blood testing for PFAS NOT tell me?

Most people in the United States (U.S.) will have measurable amounts of PFAS in their blood. We do not know how this impacts our health. These blood tests ***will not***:

- Provide information to pinpoint whether PFAS caused a particular health problem or to decide on treatment.

- Predict or rule-out the development of future health problems related to a PFAS exposure.

- Identify how or where the PFAS exposure occurred.

What is currently known about PFAS blood levels in U.S. population?

- The National Report on Human Exposure to Environmental Chemicals Report has reported that serum levels of PFAS appear to be higher in the U.S. than in some other countries.

- For the average American the PFAS level is 2,100 and 6,300 ng/L per liter of blood, respectively. The level is equal to the amount of 30 to 90 shot glasses (1.5 oz), respectively, in approximately 150 million gallons of water. These levels have been shown to be higher if a person's drinking

water source is contaminated with PFAS or if a person is exposed at a workplace that produces the PFAS product. More information can be found at: https://www.atsdr.cdc.gov/pfas/docs/ATSDR_PFAS_ClinicalGuidance_12202019.pdf or at: https://www.pehsu.net/.

Individual Concerns

If my drinking water is above the PFAS HAL, should my pets drink it?

No. Pets should be given the same drinking water you drink. As with humans, if the drinking water contains PFAS contaminant levels above the EPA HAL, use alternative water sources.

I drank water that exceeded the HAL for PFAS while I was pregnant and lactating. What impact could it have on my child?

- We do not have data to assess past risks to you and your family.
- Exposure to PFAS from drinking water with concentrations above the HAL may affect children's developmental health, including impaired growth, learning, and behavior.
- Studies in humans and animals are inconclusive and further, intense research is needed to know for sure about possible health effects related to duration and frequency of exposure.

We have tried to get pregnant for a long time without success. Could it be due to drinking water levels above the HAL for PFAS?

Infertility can be caused by many factors, both natural and chemical. At this time, we don't know if exposure to PFAS in drinking water above the HAL can affect infertility.

If PFAS have been found in my soil and water, should I be concerned?

While garden fruits and vegetables should be considered when evaluating the risk to exposure of PFAS, no data are currently available for Florida to evaluate possible risks. However, the Florida Department of Health would consider evaluation when data become available.

Can I water my lawn with water containing PFAS?

- Watering a lawn with non-edible plants and grass poses little risk.
- PFAS (PFOA and PFOS) are not absorbed effectively through the skin, nor is inhalation of vapors from water with PFAS likely to cause health problems.
- Remember that some well water specifically used for lawn maintenance only is usually not to be used for drinking purposes. For this chemical, drinking is a main route of exposure.

Can I use reuse water for watering my home produce?

No. Reuse water should never be used for home-grown produce due to the concern for human microbial pathogens. Reuse water should also not be used for drinking.

Can I swim in my pool if it is contaminated with PFAS?

Skin contact with and breathing PFAS (PFOA and PFOS) are minor concerns because these exposures are either uncommon or very low. You can drain and replace pool water with clean water from a different source. However, if you are careful to avoid swallowing pool water which is always a good practice, the risk of exposure to PFAS from swimming should be very low.

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If you have questions or comments about this factsheet, we encourage you to contact us.

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APPENDIX F. MEETING MINUTES CONFERENCE CALL WITH UNIVERSITY OF FLORIDA - NOVEMBER 14, 2019.

Minutes for the November 14, 2019 teleconference regarding exposure pathways and receptor input parameters for the Marion County Florida State Fire College

The teleconference was attended by the Florida Department of Health (FDOH) and the University of Florida (UF). It focused on the exposure parameters used in the health effects assessment for the Marion County Florida State Fire College. The fire college has previously used per- and polyfluoroalkyl substance (PFAS)-based firefighting foams. Because the facility obtains its drinking water from an on-site supply well, a water sample was analyzed in August 2018 for PFAS. The combined concentration of perfluorooctanesulfonic acid (PFOS) and perfluorooctanoic acid (PFOA) in this sample was 250 ng/L, which exceeds the U.S. EPA health advisory level of 70 ng/L. Additionally, some soil samples at the site exceeded ATSDR's guidelines used for screening PFOS and PFOA in soil. Based on the presence of PFAS above screening levels, the FDOH is performing a health effects assessment for the Florida State Fire College based on five different site-specific exposure populations: workers, students, visitors of workers, visitors of students, and trespassers.

1. The proposed drinking water intake rate for workers and students is 3.588 L/day. This is equivalent to the recommended drinking water intake rate for lactating women. This drinking water ingestion rate was chosen for the following reasons:

    a. The toxicity values for PFOA and PFOS utilized by the ATSDR at this time were derived by the United States Environmental Protection Agency (USEPA) in their health assessments of these chemicals. The critical effect for both of these toxicity values are developmental endpoints. Therefore, the most sensitive lifestage for exposure to this chemical is the pregnant and lactating mother. Use of the pregnant and lactating mother drinking water ingestion rate ensures that the most sensitive lifestage is protected. By extension, any other lifestage or receptor with less exposure will be protected as well (e.g., non-pregnant or lactating workers, students, and visitors).

    b. Students and teachers at the college perform strenuous outdoor activities during their fire training. Due to the elevated temperatures and humidity during most of the year in Florida and the physical nature of the training, it is likely that students and teachers have higher drinking water intake rates than the average population. The current default drinking water intake rate of 2.5 L/d represents the 90^{th} percentile drinking water rates for adults over age 21 based on National Health and Nutrition Examination Survey (NHANES) data from 2003-2006. A higher percentile may be more representative of increased drinking water intake rates among teachers and students at the fire college. The 95^{th} percentile drinking water rate based on NHANES data from 2003-2006 is 3.1 L/d. Recently, the drinking water intake rates were updated using the NHANES 2005-2010 data. The 95^{th} percentile updated drinking water rate for adults aged 21 to 50 years is 3.4 L/d. Both of these values are less than the proposed drinking water intake rate of 3.588 L/d, suggesting the proposed value is also protective of students and teachers at the fire college.

2. The proposed indoor worker incidental soil ingestion rate is 30 mg/day. This is the median dust ingestion rate for adults listed in the 2011 Exposure Factors Handbook. The proposed incidental soil ingestion rate for outdoor workers (maintenance workers) is 100 mg/day, which represents the 95th percentile soil ingestion rate for adults. The scenario appears to use an upper end soil ingestion rate for outdoor workers and a median dust ingestion rate for indoor workers. While we acknowledge that indoor workers likely ingest less soil than outdoor workers, using a lower percentile is not appropriate. The percentiles represent variability in the population so they encompass not only lower exposures, but individual behaviors that would increase or decrease the incidental ingestion of soil (e.g., hand-to-mouth behavior, hand washing, etc.). Therefore, we recommend using an upper-end estimate of the dust ingestion rate of 60 mg/d to represent indoor workers. Indoor workers are unlikely to ingest soil, per se, but may ingest soil as a component of indoor dust. Using the upper-end dust ingestion rate is protective of indoor workers with higher than median incidental ingestion.