Health Consultation

Public Comment Version

Evaluation of Environmental Radiological Sampling Data
Collected from 2016 to 2022 Near the Portsmouth Site

U.S. Department of Energy (U.S. DOE) Portsmouth Site
(Formally known as Portsmouth Gaseous Diffusion Plant)

PIKETON, PIKE COUNTY, OHIO

EPA FACILITY ID: OH7890008983

SEPTEMBER 29, 2023

PUBLIC COMMENT PERIOD ENDS: November 13, 2023

U.S. DEPARTMENT OF HEALTH AND HUMAN SERVICES
Agency for Toxic Substances and Disease Registry
Office of Community Health and Hazard Assessment
Atlanta, Georgia 30333

Health Consultation: A Note of Explanation

A health consultation is a verbal or written response from ATSDR to a specific request for information about health risks related to a specific site, a chemical release, or the presence of hazardous material. To prevent or mitigate exposures, a consultation may lead to specific actions, such as restricting use of or replacing water supplies; intensifying environmental sampling; restricting site access; or removing the contaminated material.

In addition, consultations may recommend additional public health actions, such as conducting health surveillance activities to evaluate exposure or trends in adverse health outcomes; conducting biological indicators of exposure studies to assess exposure; and providing health education for health care providers and community members. This concludes the health consultation process for this site, unless additional information is obtained by ATSDR which, in the Agency's opinion, indicates a need to revise or append the conclusions previously issued.

Please address comments regarding this report to:

Agency for Toxic Substances and Disease Registry
Attn: Records Center
4770 Buford Highway NE, MS S106-5
Chamblee, Georgia 30341

You may contact ATSDR toll free at
1-800-CDC-INFO
or
visit our home page at: https://www.atsdr.cdc.gov

HEALTH CONSULTATION

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Prepared by the
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Contents

Acronyms and Abbreviations

Am	americium
ASER	U.S. DOE Annual Site Environmental Reports
ATSDR	Agency for Toxic Substances and Disease Registry
CDC	Centers for Disease Control and Prevention
CCSE	Pike County Community Comprehensive Sampling Evaluation (Synonymous with ISP)
IAA	Interagency agreement
ISP	Independent Sampling Plan/Data Project (Synonymous with CCSE)
MARLAP	Multi-Agency Radiological Laboratory Analytical Protocols Manual
MARSAME	Multi-Agency Radiation Survey and Assessment of Materials and Equipment Manual
MARSSIM	Multi-Agency Radiation Survey and Site Investigation Manual
MCL	maximum contaminant level
MDA	minimum detectable activity
mrem/year	millirem per year
MRL	minimal risk level
MS	mass spectroscopy
NAU	Northern Arizona University
NCEH	National Center for Environmental Health
NCI	National Cancer Institute
NIOSH	National Institute Occupational Safety and Health
Np	neptunium
NPDES	National Pollution Discharge Elimination System
ODH	Ohio Department of Health
OSWDF	Onsite Waste Disposal Facility
pCi/g	picocuries per gram
pCi/L	picocuries per liter
pCi/m^3	picocuries per cubic meter
PHA	public health assessment
PHAP	public health action plan
PORTS	Portsmouth Gaseous Diffusion Plant
Pu	plutonium
RAP-3	Department of Energy Radiological Assistance Program, Region 3

SRNL	Savannah River National Laboratory
Tc	technetium
TLD	thermoluminescent dosimeter
U	uranium
U.S. DOE	U.S. Department of Energy
U.S. EPA	U.S. Environmental Protection Agency

1. Summary

Introduction

In response to health concerns brought to the attention of the Health Commissioner of the Pike County General Health Department by local community members, the U.S. Department of Energy (U.S. DOE) requested the Agency for Toxic Substances and Disease Registry (ATSDR) to conduct an independent public health evaluation of radiological contaminants near the U.S. DOE Portsmouth Site (PORTS) in Pike County, Ohio. In this health consultation report, ATSDR evaluated environmental radiological sampling data collected off-site within a six-mile study area near PORTS from 2016 to 2022. The environmental samples were analyzed for a standard set of radionuclides including transuranic radionuclides (americium-241, neptunium-237, plutonium-238, and plutonium-239/240), technetium-99, uranium, and uranium isotopes (uranium-233/234, uranium-235/236, and uranium-238).The sources of samplings datasets include:

- Pike County Community Comprehensive Sampling Evaluation (CCSE) Project, also known as the Independent Sampling Project (ISP)
- Ohio Department of Health
- Northern Arizona University
- U.S. DOE PORTS
- U.S. DOE Radiological Assistance Program (RAP-3)

Conclusion

ATSDR concludes that exposure to radionuclides in the off-site outdoor air, soil, sediment, indoor dust, and surface water within a 6-mile radius of the U.S. DOE PORTS facility from 2016 to 2022 is not expected to harm people's health. The reason for this is the environmental samples collected in this off-site area and timeframe contained radionuclides at levels not expected to cause harmful health effects.

Basis for Decision

Based on the available environmental samples collected in this off-site area and timeframe, almost all the radionuclides were detected in each of media at radiological concentrations below media-specific screening values considered safe and are much lower than concentrations observed to cause adverse health effects in human studies. For the various uranium radionuclides, the radiological concentrations were within background concentration ranges of radionuclides found in Ohio and across the globe. For the few environmental samples with transuranic radionuclides detected above screening values and above background levels, the measured concentrations resulted in estimated radiological doses that are more than 30 thousand times lower than doses that have been observed to cause adverse health effects in human studies as reported in the peer-reviewed scientific literature.

The specific basis from each study for the no public health hazard conclusion is presented below by media.

Outdoor Air

U.S. DOE air monitoring stations from 2016-2020

- The concentrations of americium-241, neptunium-237, plutonium-237, plutonium-238, plutonium 239/240, technetium-99, uranium-233/234, uranium-235/236, and uranium-238 in the outdoor air at U.S. DOE air monitoring stations are lower than the NRC 10 CFR 20 regulatory radiological air concentration limits for members of the public.

- Estimated radiation doses from breathing americium-241, neptunium-237, plutonium-237, plutonium-238, plutonium 239/240, technetium-99, and uranium isotopes (uranium-233/234, uranium-235/236, and uranium-238) in outdoor air at the U.S. DOE air monitoring stations are at least 30 thousand times lower than doses that resulted in observed bone tumors in human studies of alpha emitting radioactive substances.

- The annual and five-year average ambient external radiation doses at the U.S. DOE air monitoring stations are lower than the national natural background radiation dose and the ATSDR minimal risk level (MRL).

ODH air monitoring stations from 2020 to 2022

- Based on the initial screening of the radiation concentrations detected in the outdoor air samples, the majority of radiological concentrations were below the minimum detectable activity (MDA) and the results would be considered zero (0); that is, not present in the outdoor air.

- The radioisotope concentrations measured above the MDA are near the MDA resulting in high uncertainties in the measurements. This makes estimated radiological concentrations and any associated radiological dose estimates not meaningful. These estimated doses would be so low that ATSDR would not expect to see any observable adverse health effects.

***U**.S. DOE Radiological Assistance Program Team 3 at Zahn's Corner Middle School in May 2019*

- Based on the initial screening of the radiation concentrations detected in the outdoor air samples, all the radiological concentrations for transuranic radionuclides and uranium-235 were below the MDA.

- All the measured radioisotope concentrations measured above the MDA are near the MDA resulting in high uncertainties in the measurements. This makes estimated radiological concentrations and any associated radiological dose estimates not meaningful. These estimated doses would be so low that ATSDR would not expect to see any observable adverse health effects.

Northern Arizona University analysis of air sampling from local private air monitors from May 2019 to January 2022

- ATSDR was not able to use the NAU results to conduct a public health effects evaluation of radionuclides detected in the outdoor air samples collected by local residents.

- NAU reported activity in picocuries/gram of filter material, to quantify number of atoms and mass ratio of uranium isotopes and not air concentrations (picocuries/cubic meter of air) that ATSDR uses to compare to relevant air screening and health guideline levels.

- The NAU data objectives were to determine what transuranic radionuclides or uranium isotopes detected in off-site outdoor air were released from PORTS.

Indoor Air

U.S. DOE Radiological Assistance Program Team 3 sampling at Zahn's Corner Middle School

- Based on the initial screening for the radiation concentrations in the indoor air samples, all the radiological concentrations for transuranic radionuclides and uranium-235 were below the MDA and the results would be considered 0 (zero); that is, not detectable in the indoor air.

- All the measured radioactive concentrations are either below the MDA or close to the MDA resulting in high uncertainties in the measurement which makes the very low radiological concentrations estimates and any associated radiological dose estimates not meaningful.

- Also, any estimated doses would be so low that ATSDR would not expect to see any observable adverse health effects.

Dust Samples on Interior Surfaces

U.S. DOE Radiological Assistance Program Team 3 sampling at Zahn's Corner Middle School

- The radiological concentrations of radionuclides in RAP-3 dust swipe samples show that the amount of radioisotopes that could be removed from the interior dust were less than 0.1% of the applicable allowable limits listed in the in the Multi-Agency Radiation Survey and Assessment of Materials and Equipment Manual (MARSAME).

Independent Sampling Plan interior settled dust collected from September 2020 to February 2021.

- The radiological concentration results of ISP interior settled dust samples show that the amount of radioisotopes that could be removed from the interior dust were less than 2% of the applicable allowable limits listed in MARSAME.

Northern Arizona University dust collected from attic and living spaces of a residence in 2023.

- ATSDR is not able to compare the removable radioactive concentrations detected on the baby wipe samples to the applicable allowable limits listed in the MARSAME because the NAU results were not expressed as activity per

square centimeter or per 100 square centimeters. Therefore, ATSDR is not able to use the NAU dust wipe results to conduct a public health effects evaluation of removable radionuclides in dust samples collected by local residents.

Soil

Independent Sampling Plan soil collected in the 6-mile study area October 4, 2020, through February 17, 2022.

- The estimated internal radiological dose for the transuranic elements is less than 1 millirem per year (mrem/year) and the estimated internal dose from the technetium-99 is also less than 1 millirem. At these extremely low radiological doses, ATSDR would not expect to see any observable adverse health effects.

- Radioactive concentrations of uranium isotopes in the soil are within the expected natural background concentrations of uranium reported in Ohio soils by Myrick in 1983.

U.S. DOE Portsmouth/Paducah Project Office Environmental Geographic Analytical Spatial Information System (PEGASIS) soil samples collected within and outside PORTS boundary from 2016 to 2020.

- Estimated internal radiological dose from americium-241 and plutonium isotopes in soil is less than 1 mrem/year which is at least 30 thousand times less than doses observed to cause bone tumor in human studies of radium dial painters. The radiological dose of technetium-99 in soil is also less than 1 mrem/year. Since these doses are so low, these doses are not expected to harm people's health.

- The radioactive concentrations of uranium-234, uranium-235, and uranium-238 are not significantly different than natural background concentrations of uranium reported in Ohio soil by Myrick, et al. [1983].

Sediment

Independent Sampling Plan sediment collected in the 6-mile study area October 4, 2020, through February 17, 2022.

- The estimated radiological dose from americium-241, plutonium isotopes, and technetium-99 is less than 1 mrem/year. The dose is so low that ATSDR concludes the sediment dose is below levels expected to harm people's health.

- There does not appear to be any significant excess uranium isotopes in the sediments as the detected uranium in the sediments is essentially identical to the typical background levels of uranium in the state of Ohio as reported by Myrick, et al. [1983].

U.S. DOE PEGASIS sediment collected within and outside PORTS boundary from 2016 to 2020.

- The estimated radiological dose from americium-241, plutonium isotopes, and technetium-99 is less than 1 mrem/year. The dose is so low ATSDR concludes the sediment dose is below levels expected to harm people's health.

- There does not appear to be any significant excess uranium in the sediments as the detected uranium in the sediments is essentially identical to the typical background levels of uranium in the state of Ohio as reported by Myrick, et al. [1983].

Surface Water

Independent Sampling Plan surface water collected in the 6-mile study area October 4, 2020, through February 17, 2022.

- All detected radiological isotopes were less than the ATSDR derived radiological maximum contaminant levels (MCLs) and the estimated doses are less than 4 mrem/year.

Next Steps

Having evaluated the available radiological environmental sampling data from 2016 to 2022, ATSDR recommends:

1. U.S. DOE inform and make the data available to the public in timely manner when contaminant concentrations are detected above a regulatory limit or significantly elevated above normal.
2. Upon request, ATSDR will review sampling data, comment on public health implications, and make recommendations to protect public health.
3. U.S. DOE continue its preventative measures to reduce or prevent any future releases of contaminants to the off-site air, soil, groundwater, and surface water during the decontamination, disassembly, demolition, and transportation of the large process buildings, other structures, and infrastructures that require disposal in off-site waste facilities and the on-site OSWDF.
4. U.S. DOE continue to conduct on-site and off-site radiological and non-radiological environmental monitoring to ensure compliance with laws and regulations and to prevent unnecessary exposures of workers and the assure the public to that their exposure to contaminants is minimal.

For More Information

If you have questions about this document, call our toll-free number at 1-800-CDC-INFO and ask for information on the ATSDR health consultation on radiological contaminants near the U.S. DOE Portsmouth Site in Pike County, Ohio.

2. Background

2.1 Statement of Issue and Purpose

This ATSDR health consultation is a public health evaluation of radiological environmental sampling data collected on-site and off-site from 2016 to 2022 at the U.S. Department of Energy (U.S. DOE) Portsmouth Site, formerly known as the Portsmouth Gaseous Diffusion Plan (hereby "PORTS") in Pike County, Ohio. The U.S. DOE requested ATSDR to conduct an independent public health evaluation of radiological contaminants detected near the PORTS site in response to community health concerns about radiological contaminants detected in Piketon, Ohio near PORTS. ATSDR is not tasked with determination of the source of radiological contaminants.

In the spring of 2019, Pike County community members brought health concerns to the attention of the Health Commissioner of Pike County General Health Department (PCGHD) as a result of the release of the 2017 U.S. DOE Annual Site Environmental Reports (ASERs) in March 2019 on the detections of various radionuclides. The radionuclides detected in various off-site media near PORTS in 2017 were Neptunium-237 , plutonium-239/240 , technetium-99 , Uranium-238 , Uranium-233/234 , and Uranium-235/236 (U-235/236) [U.S. DOE 2019, Solutient 2020]. The primary community concern was a detection of Neptunium-237 at U.S. DOE's off-site air monitoring station A41A, near the local middle school, Zahn's Corner Middle School; this station is located approximately 1.5 miles northeast of PORTS property boundary [Solutient 2020]. In fall/winter 2018 through 2019, community members collected dust samples in the school and residential attics, as well as surface soil samples and sediment samples from local creeks and the Scioto River. In April 2019, the Northern Arizona University (NAU) reported that analytical results of the community-based samples indicate that "non-natural U, and non-fallout Np and Pu are systematically present in many locations" [NAU 2019]. The report also stated that enriched uranium was found inside the school and attic dusts of selected residences.

In a July 2019 ATSDR technical assistance letter to the Ohio Department of Health (ODH), ATSDR supported U.S. DOE efforts to fund an external independent third party to collect environmental samples in the community [ATSDR 2019]. In 2020, the PCGHD and Pike County community members worked with Ohio University (OU) and their contractors to plan the collection and analysis of radiological environmental samples. This effort is known as the Pike County Community Comprehensive Sampling Evaluation (CCSE) Project, also known as the Independent Sampling Project (hereby "ISP") [Solutient 2020]. These environmental samples were collected on public property within a 6-mile radius of the U.S. DOE property boundary. This study area size was selected by the CCSE to focus on residential properties or those properties for which people were most likely to be exposed from the PORTS releases [Solutient 2020].

This ATSDR health consultation evaluates environmental radiological sampling data from ISP, ODH, U.S. DOE PORTS, U.S. DOE Radiological Assistance Program (RAP-3), and the NAU.

2.2 Site Description and Timeline

In 1954, the Atomic Energy Commission (AEC) established the 3,777-acre PORTS in the Ohio Valley along the Scioto River, 4.0 miles south of downtown Piketon in Pike County, Ohio, which is approximately 70 miles south of Columbus [U.S. DOE 2015]. PORTS gaseous diffusion operations enriched uranium from 1954 to 2001 for a nuclear weapon production program, a Navy nuclear submarine propulsion program, and commercial nuclear power reactors [U.S. DOE 2015]. See Figure 1 and 2 for the location of PORTS.

The main gaseous diffusion enrichment process buildings at PORTS were X-326, X-330, and X-333. These process buildings covered about 93 acres of land with 10 million square feet of indoor floor space that housed the cascades of multiple enrichment cells having a combined length over one mile. The three process buildings, as well as most of the over 400 buildings, structures, utility systems, and infrastructure units, were situated within the approximately 1,200-acre industrialized area that lies within Perimeter Road, including a 750-acre area with security-controlled access. This industrial area is located within the 3,469.5-acre site of PORTS (originally 3,777 acres, with 300 acres being transferred to the Southern Ohio Diversification Initiative, SODI). The 2,500+ acre portion of the DOE property outside of Perimeter Road is used for a variety of purposes, including reindustrialization, a water treatment plant, sediment ponds, sanitary and inert landfills, cylinder storage yards, open fields, and forested buffer areas.

The local geography of Piketon, Scioto Township, and the surrounding area near PORTS is best described as rolling hills with both agricultural areas and wooded/forested areas, and predominantly rural countryside. Little Beaver Creek runs through the north part the DOE property, outside of the Perimeter Road and meets with Big Beaver Creek and runs to the Scioto River. The Scioto River is 0.9 miles west of the DOE property (closest point) and 2.2 miles from the industrial area. The Scioto River ultimately meets the Ohio River south of PORTS near the city of Portsmouth, which is about 20 miles south of the facility.

In the southern portion of the state of Ohio, the summers are humid and warm, with the highest temperatures in June through August, averaging about 83.4 to 86 degrees Fahrenheit. The precipitation rates are relatively constant over the year with the most rain received from March to July. The lowest temperatures are in January and December, averaging about 41.3 to 45.7 degrees Fahrenheit. The winds are calm (less than 2 miles per hour (MPH)) about 51% of the time, with monthly averages ranging from 1.9 MPH to 4.8 MPH. Winds typically blow from the south. Wind speeds, on average, are higher in the winter and spring months compared to the summer and fall months [Mesonet 2023].

Figure 1. Location of Portsmouth Site (PORTS)

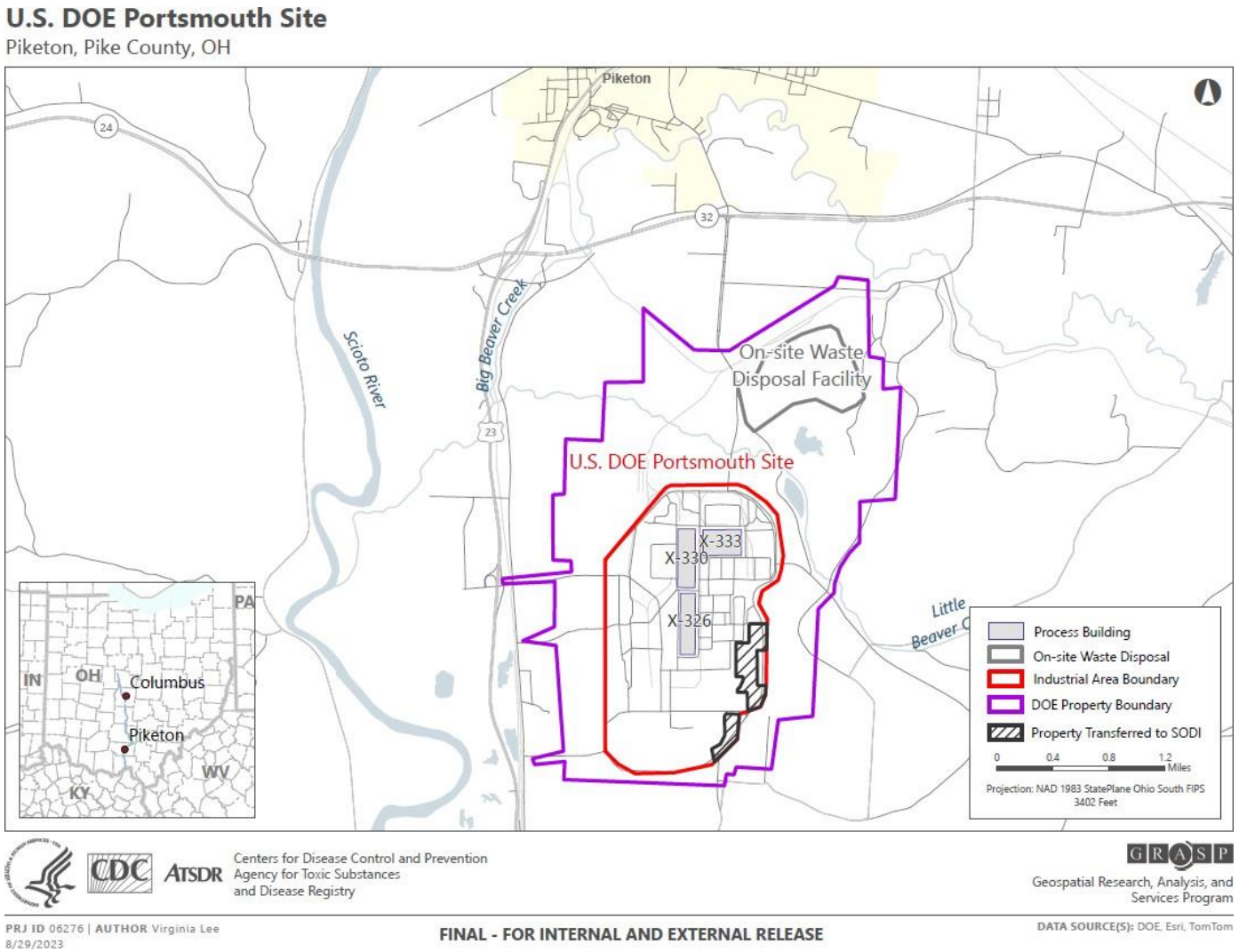
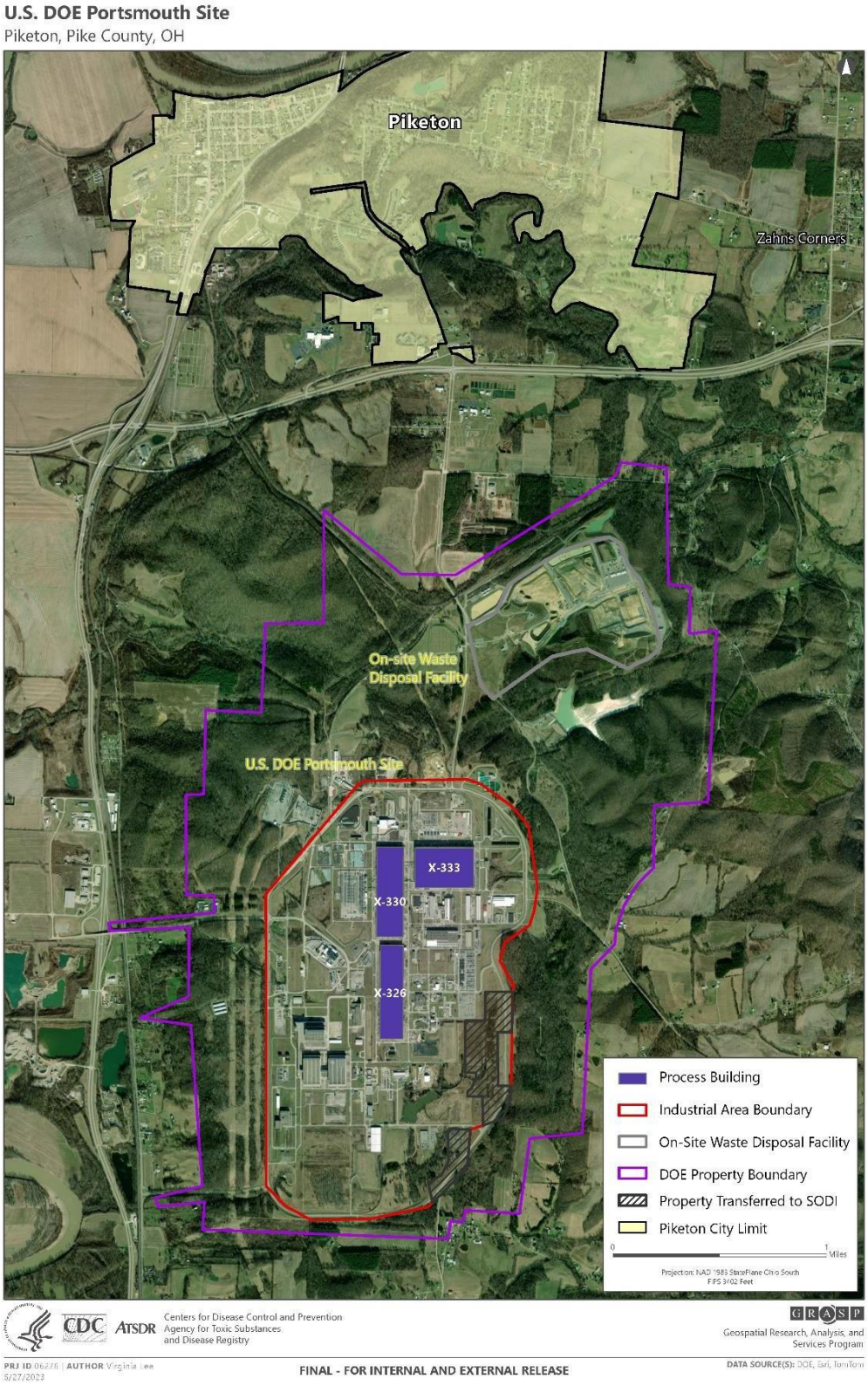


Figure 2. Location of Portsmouth Site (PORTS)



2.2.1 Site History and Operations

In the early 1950s, the AEC expanded production of enriched uranium to maintain the nation's superiority in the development and use of highly-enriched uranium (over 20 percent Uranium-235) for military purposes—nuclear weapons program and Navy nuclear submarine propulsion—and in later years, low-enriched uranium for fuel for commercial nuclear power reactors [U.S. DOE 2015]. The PORTS gaseous diffusion plant was one of three uranium enrichment facilities originally constructed in the United States; the other two were constructed in Oak Ridge, Tennessee, and Paducah, Kentucky [U.S. DOE 2003]. In 1952, the AEC began construction of PORTS with the first enrichment diffusion cells online in 1954, and the facility was fully operational in March 1956 [U.S. DOE 2003]. In 1977, the newly created U.S. DOE assumed responsibility for PORTS uranium enrichment operations [U.S. DOE 2003].

From 1954 to 2001, PORTS produced and received uranium at various enrichments from Oak Ridge or Paducah, including highly-enriched uranium. Gaseous diffusion operations occurred in the three PORTS process buildings where uranium was enriched in the Uranium-235 isotope. The diffusion process pumped gaseous uranium hexafluoride (UF_6) containing both Uranium-238 and Uranium-235 isotopes across barriers (porous membrane filter) in the gaseous diffusion cascades, causing a separation of the uranium isotopes according to the isotope atomic weight [U.S. DOE 2003]. The enriched Uranium-235 was used to fuel nuclear reactors and for nuclear weapons production at levels ranging from a few percent to over 95 percent Uranium-235.

Some of the source product at PORTS included recycled uranium received from the U.S. DOE Idaho reprocessing plants [U.S. DOE 2003]. PORTS received the first shipment of recycled uranium in 1973 and this continued until 1976. Relative to U.S. DOE's other operations, PORTS received only a small quantity (4 metric tons) of recycled uranium from the production plants [U.S. DOE 2003]. The concentration of transuranic isotopes and fission products in the recycled uranium originally entering the feed plant was very small. The recycled uranium received by Portsmouth is estimated to have contained less than a milligram of plutonium and technetium, and less than a gram of neptunium. Various chemical processes prior to recycled uranium hexafluoride being fed to the enrichment process stripped most of the transuranic isotopes from the recycled uranium. However, trace concentrations of plutonium, neptunium, and technetium remained with the uranium after the chemical processing.

In 1991, PORTS terminated the production of highly-enriched uranium [U.S. DOE 2003]. In 1993, the United States Enrichment Corporation (USEC) leased and assumed responsibility for operations of PORTS uranium enrichment plants [U.S. DOE 2003]. DOE retained ownership of PORTS and responsibility for environmental restoration and waste management activities. PORTS continued to produce only low-enriched uranium for commercial power plants until May 2001 when the three production facilities were placed into a "cold-standby" mode [U.S. DOE 2015]. In the cold-standby process, buildings were nonoperational but maintained the capability to restart production of enriched uranium. In 2005, DOE terminated the cold-standby program which stopped the maintenance of the gaseous diffusion restart capability. Since then, the production facilities have been maintained in cold shutdown until 2010, when U.S. DOE began decontamination and decommissioning [U.S. DOE 2015].

2.2.2 Remediation and Cleanup

Past PORTS operations generated hazardous chemical, radioactive, mixed (hazardous and radioactive), and nonchemical (sanitary) wastes resulting in the contamination of air, soil, groundwater, and surface water. In 1989, the U.S. DOE established the Office of Environmental Restoration and Waste Management (currently named the Office of Environmental Management (EM)) to oversee and complete the nationwide safe cleanup of the environmental legacy brought about from five decades of nuclear weapons development and government-sponsored nuclear energy research [U.S. DOE 2023]. Since 1989, the DOE EM Environmental Restoration Program at PORTS has been addressing inactive sites and contaminated soil, sediment, surface water, and groundwater associated with PORTS facilities [U.S. DOE 2023]. DOE also conducted environmental monitoring of radiological and chemical contaminants in air, water, soil, sediment, and biota (animals, vegetation, and crops) at locations on PORTS property and off-site near PORTS. This monitoring assessed potential exposure and human health impacts from contaminants released by past PORTS operations and environmental cleanup. The environmental data collected by the U.S. DOE is entered into an online searchable database called the Portsmouth and Paducah Project Office (PPPO) Environmental Geographic Analytical Spatial Information System (PEGASIS)[1] and reported on an annual basis in the Annual Site Environmental Report (ASER).

In August 1989, a Consent Decree between the Ohio Environmental Protection Agency (Ohio EPA) and the U.S. DOE required the investigation and cleanup of contaminated environmental media and waste units at PORTS in accordance with the Resource Conservation and Recovery Act (RCRA) [U.S. DOE 2015]. A 1997 Administrative Consent Order additionally required investigation and remediation of solid and hazardous waste units in accordance with RCRA and the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) of 1980, as amended by the Superfund Amendments and Reauthorization Act of 1986 [U.S. DOE 2015]. The U.S. EPA Administrative Consent Order was terminated in 2017 [U.S. DOE 2023].

In April 2010, the Ohio EPA issued, and U.S. DOE entered into, the *Director's Final Findings and Orders for Removal Action and Remedial Investigation and Feasibility Study and Remedial Design and Remedial Action (*DFF&O) which provides the framework to address the decontamination and decommissioning of PORTS and support facilities using the CERCLA process [U.S. DOE 2010]. The DFF&O defines the steps for identifying a range of technical cleanup alternatives for projects and for reaching formal decisions on how best to proceed. The USEC returned the PORTS gaseous diffusion plant facilities to U.S. DOE in 2011 for decontamination and decommissioning.

In July 2015, Ohio EPA concurred with the U.S. DOE Record of Decision on the evaluation project details to decontaminate, dismantle, and demolish the three large process buildings (each more than 30 acres under roof), other structures, and infrastructures that require disposal by U.S. DOE at PORTS [U.S. DOE 2015]. From 2011 through 2020, the inoperative X-326 building was decontaminated and decommissioned. The characterization of residual contamination in the building and process equipment was conducted with the collection of more than 1 million measurements for contaminants. Furthermore, over 7,000 components were dismantled, removed, and safely shipped offsite for disposal at licensed facilities. In May 2021, controlled structural demolition of the X-326 began with the complete demolition of this half-mile-long building by June 2022 [U.S. DOE 2023]. As of spring 2023, the second of the site's three process buildings, the X-333, is undergoing decontamination and decommissioning.

[1] US DOE PEGASIS: https://pegasis.ports.pppo.gov/Pegasis/Default.aspx.

[1] US DOE ASER: https://www.energy.gov/pppo/articles/portsmouth-annual-site-environmental-reports

In June 2015, Ohio EPA also concurred with the U.S. DOE Record of Decision on site-wide waste disposition evaluation project to dispose of waste generated under other DFF&O projects at PORTS [U.S. DOE 2015]. The selected remedy is the construction of an engineered on-site disposal cell, known as the On-Site Waste Disposal Facility (OSWDF). The OSWDF is a 100-plus acre state-of-the-art permanent disposal site specially engineered with multiple layers of construction liners and natural liners below and above with a grass-covered cap. The disposal system is designed to have divided individual cells that will consolidate demolition debris and rubble into one centralized confined space. Each of the three main process buildings will take up approximately 3 cells. The OSWDF will accommodate more than five million cubic yards of low-level waste materials from the demolished PORTS buildings that meets the Ohio EPA approved waste acceptance criteria. The more-contaminated demolition debris not meeting the waste acceptance criteria is to be shipped out of state to appropriate licensed off-site disposal facilities. In June 2016, U.S. DOE began the siting and construction of the OSWDF located in the northeast corner of the DOE reservation. The construction of OSWDF Cell 1 was completed in March 2020. The construction of OSWDF Cells 4 and 5 was completed in December 2021 [US DOE 2020; US DOE 2022]. In May 2021, the OSWDF accepted the first placement of waste from X-326. Approximately 135,000 cubic yards debris generated from X-326 was disposed of in the OSWDF [U.S. DOE 2023]. The X-326 building debris shipped out of state contained more than 99 percent of the detected radioactivity [U.S DOE 2022].

2.2.3 ATSDR Involvement

2.2.3.1 Previous ATSDR Involvement at PORTS

In 1992, ATSDR received a petition from community members to address health concerns related to PORTS [ATSDR 1996]. In November 1996, ATSDR released a public health assessment (PHA) for the U.S. DOE Portsmouth Gaseous Diffusion Plant site in Piketon, Pike County, Ohio [ATSDR 1996]. ATSDR evaluated the available on-site and off-site environmental sampling data and other available health outcome data for Pike County. ATSDR's assessment for radiological contaminants focused on hydrogen fluoride, uranium hexafluoride, and uranium oxide that were present in environmental media and evaluated further for potential public health implications [ATSDR 1996]. When the PHA was released in 1996, Neptunium-237 and plutonium were not evaluated or discussed. The ATSDR conclusions are summarized below:

1. Hydrogen fluoride releases since the early 1960s represented no apparent hazard to human health. There was no evidence of off-site exposures to hydrogen fluoride releases that could result in adverse health outcomes.
2. Uranium concentrations[1] on- and off-site were similar to those found throughout South-Central Ohio, and therefore did not indicate any history of uranium releases.
3. Off-site contamination was not at levels that could cause adverse health effects.
4. Readily available information on health outcomes did not suggest any increases in selected diseases or conditions.
5. ATSDR reviewed the numerous reported health effects and did not find levels of exposure with a plausible link to the Portsmouth Gaseous Diffusion Plant.
6. ATSDR concluded that the Portsmouth Gaseous Diffusion Plant and its operations represented no apparent hazard to off-site public health.

[1] Current sampling on-site and off-site at PORTS does show higher uranium concentrations at some on-site locations and therefore more recent information may conflict with this statement from the 1996 PHA. Additionally, it is known that contamination is higher in some building debris and environmental media (i.e., soil) versus other media (i.e., surface water).

Due to concerns in the community, ATSDR did provide the community around the Portsmouth Gaseous Diffusion Plant with a site-specific environmental health education workshop to address specific community health concerns. Specifically on June 18, 1995, ATSDR conducted the workshop at the Vern Riffe Vocational School in Piketon [ATSDR 1996].

On July 18, 2019, ATSDR responded in a letter to the ODH, Bureau of Environmental Health and Radiation Protection concerning their request for technical assistance regarding recent reports that trace amounts of uranium, neptunium, and plutonium were detected in the community near the PORTS [ATSDR 2019]. In the response, ATSDR evaluated and provided a public health perspective on the available environmental sampling data around PORTS and the applicability of radiological bioassay. During the evaluation of available information and in preparing the letter, ATSDR worked closely with the Centers for Disease Control and Prevention (CDC) National Center for Environmental Health (NCEH), Division of Environmental Health Science and Practice, Radiation Studies Section and the National Institute for Occupational Safety and Health (NIOSH). ATSDR concluded the following:

1. Recent quarterly air sampling results did not show any Neptunium-237 concentrations exceeding detection limits except for the September 2017 detection at the A41A monitoring station near Zahn's Corner Middle School. The concentration of Neptunium-237 detected was extremely low and would result in an estimated annual effective dose of 0.3 millirem per year (mrem/year) which is 0.1% of the annual dose from natural background radiation of 310 mrem/year to the U.S. population.
2. The NAU study focused mainly on ratios of radioactive atoms and only reported a small subset of the overall samples in concentrations. Based on the maximum estimated concentration of Neptunium-237 and plutonium reported in a Little Beaver Creek sediment sample, the estimated effective annual doses from Neptunium-237 and plutonium are more than one million times lower than the natural background radiation dose of 310 mrem/year to the U.S. population.
3. ATSDR supports the U.S. DOE efforts to fund an external independent third party to collect environmental samples in the community.
4. Bioassays of Neptunium-237, plutonium, and uranium for the public living near Zahn's Corner are not warranted.
5. An epidemiological study in the Piketon area is not currently warranted as the radiological doses are a very small fraction of the natural background radiation and are not at the level where adverse health effects are observable based on the available environmental data.

2.2.3.2 Current Involvement

In 2022, the U.S. DOE entered into an Interagency Agreement (IAA) with ATSDR for ATSDR to conduct an independent public health evaluation of radiological contaminants detected near the PORTS site [ATSDR 2019]. This was in response to community health concerns about the detection of Neptunium-237 at the off-site air monitoring station near Zahn's Corner Middle School and the NAU report that enriched uranium was found inside the school and attic dusts of selected residences. This health consultation report contains ATSDR's evaluation of on-site and off-site radiological sampling data collected from 2016 to 2022 near PORTS to address the concerns of community members.

3. Community Description

3.1 Community Demographics

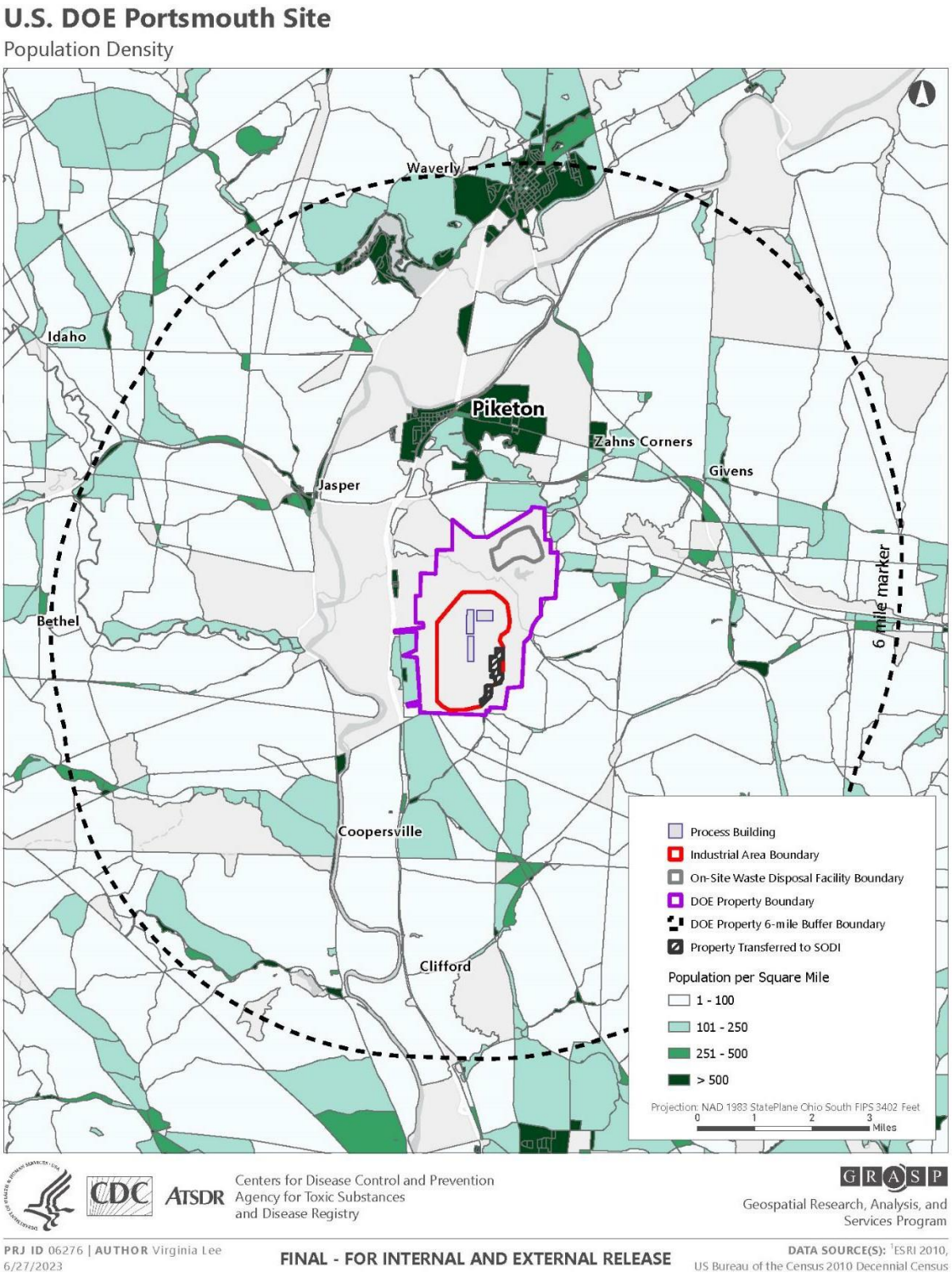
An estimated 12,658 people were living within six miles of the PORTS facility in 2010 [ESRI 2010, U.S. Census 2010]. Table 1 shows the number of people living in the study area by distance from PORTS. The table also provides the total populations, including children under 5 years old, women of childbearing age, and adults 66 years and older.

Figure 3 shows population density within the 6-mile study area radius from the PORTS boundary.

Table 1. Demographics within a six-mile radius of the PORTS facility

Distance from PORTS	One Mile	Two Miles	Three Miles	Four Miles	Five Miles	Six Miles
Total Population	907	1,788	4,889	7,441	9,213	12,658
Under 5 Years	71	175	480	701	855	1,160
66 Years and Older	98	181	642	976	1,213	1,726
Female 15 to 44 Years	172	350	942	1,440	1,761	2,419

Figure 3. Map of population density within 6-mile radius of PORTS



3.2 Community Concerns

Responding to community health concerns is an essential part of ATSDR's overall mission and commitment to public health. ATSDR actively gathered concerns and other information from the people who live or work near PORTS. Area residents also voiced concern about cancer during ATSDR's public availability sessions in Piketon, Ohio on August 9, 10, and 11, 2022. ATSDR was particularly interested in hearing from local residents of the area, civic leaders, health professionals, and community groups. The individual concerns expressed were related to uranium compounds and isotopes as well as transuranic radionuclides released from PORTS into off-site areas. Citizens expressed concerns about a perceived increase in cancer in the areas surrounding PORTS. In addition, other non-cancer illnesses were mentioned. In this health consultation, ATSDR took into consideration community comments and concerns about exposure to radiological isotopes released from PORTS when evaluating whether radioactivity concentrations detected in the air, soil, sediment, and dust samples are at levels that could result in harmful health effects.

Concerns related to non-radiological chemical contaminants in the environment and occupational exposures during years of gaseous diffusion operations at PORTS were also brought to the attention of ATSDR; however, these concerns are not within the scope of this health consultation.

4. Sampling Data

ATSDR evaluated several datasets with radiological sampling data collected from 2016 to 2022, primarily off-site of PORTS. The following datasets were included:

- ISP radiological sampling data collected in 2021,
- U.S. DOE monitoring data (PEGASIS/ASER) from 2016 to 2022,
- ODH air monitoring data collected from 2020 to 2022,
- U.S. DOE Radiological Assistance Program (RAP-3) sampling data collected in 2019, and
- Northern Arizona University (NAU) data collected in 2022.

The samples were analyzed for a standard set of radionuclides including transuranic radionuclides (americium-241, neptunium-237, plutonium-238, and plutonium-239/240), technetium-99, uranium, and uranium isotopes (uranium-233/234, uranium-235/236, and uranium-238). There are 92 elements typically found in nature with uranium being element 92 with 92 protons. Elements with more than 92 protons are called transuranic elements. Technetium (43 protons) is not naturally occurring, and all its elemental forms are radioactive. Before atomic fission was discovered in the mid-1930s, the transuranic elements were not found in nature. If one considers the presence of fallout materials as part of the "natural" or man-made environment, then they are present. For this health consultation, we are using naturally occurring background in the United States prior to atmospheric testing. That is, transuranic radionuclides and technetium are not present in natural occurring background.

4.1 Independent Sampling Plan, ISP

ATSDR received from Ohio University all the ISP radiological data collected by Solutient. This included off-site soil, sediment, interior dust, and surface water sampling data collected within 6 miles from the PORTS perimeter of the industrial area from October 4, 2020, through February 17, 2022. This study area size was selected by the CCSE to focus on residential properties or those properties for which

people were most likely to be exposed from the PORTS releases [Solutient 2020]. Figure 4 shows the locations of radiological surface soil, surface water, and sediment samples collected. The ISP samples were analyzed for a standard set of radionuclides. The number of sample analyses from the ISP is shown in Table 2. A "sample analysis" is each individual radiological isotope analysis. Therefore, each sample could have multiple sample analyses. For every sample, multiple isotopes are evaluated for (i.e., 6,156 air sample analyses could involve sampling for 10 isotopes and therefore only 600 actual samples, not including duplicate samples).

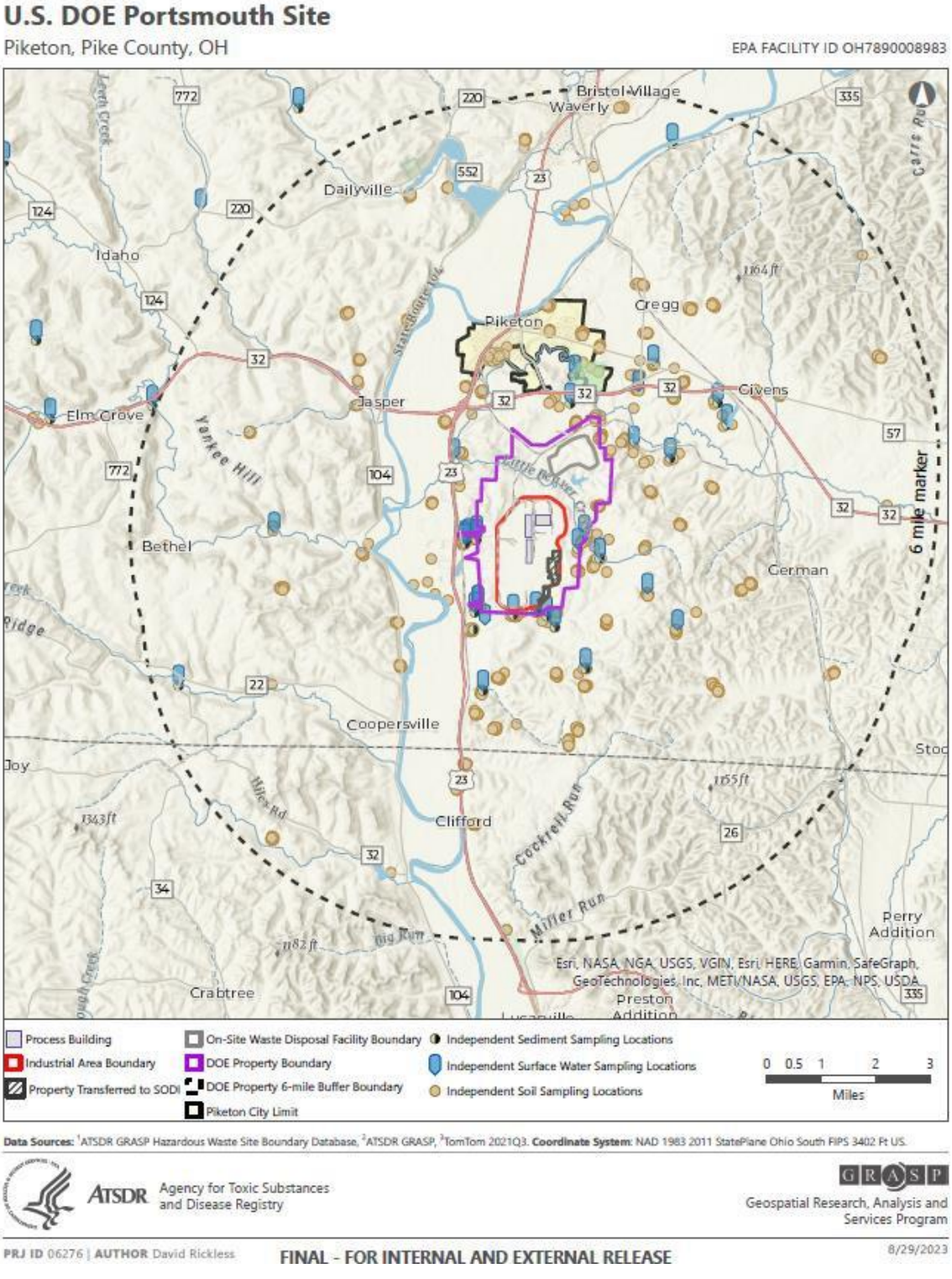
The ISP report states that the 6-mile radius from the PORTS property boundary was selected because it is known that airborne particulates deposition originating from PORTS is inversely proportional to the distance from the site boundary. According to the ISP report, populations further away from the PORTS site are less likely to receive a measurable number of radioisotopes deposited on the ground because of airborne dispersion [Solutient 2020]. The ISP collected significantly more off-site radiological samples than typically reported by U.S. DOE at PORTS. The advantage of more off-site radiological samples is that the distribution of contaminants in the environment is better characterized. Solutient used well-established protocols and methods for environmental radiological sampling and laboratory analysis, including quality control/quality assurance procedures, data verification and validation, including data qualification and rejection which are described in the ISP's Sampling Analysis Plan (SAP), Data Quality Objectives (DQOs), and Quality Assurance Project Plan (QAPP). The methods used are outlined in the laboratory reports supplied to ATSDR.

Table 2. Number of radiological sample analyses collected by media for the Independent Sampling Plan

Radionuclides Analyzed	Soil Sample Analyses	Surface Water Sample Analyses	Sediment Sample Analyses*	Total Number of Sample Analyses
All Radionuclides	8508	419	257	9184
Americium-241	983	53	32	1068
Neptunium-237	1075	53	32	1160
Technetium-99	1075	48	33	1156
Plutonium-239/240	1075	53	32	1160
Plutonium-238	1075	53	32	1160
Uranium-234	1075	53	32	1160
Uranium-235	1075	53	32	1160
Uranium-238	1075	53	32	1160

* Sample analysis is the number of analyses of each individual radiological isotope in the samples collected.

Figure 4. Locations of ISP radiological surface soil, surface water, and sediment samples collected by Solutient from October 4, 2020, to February 17, 2022



4.2 U.S. DOE PEGASIS & ASER

As part of U.S. DOE EM program, U.S. DOE conducts environmental monitoring on and off the PORTS site. ATSDR downloaded environmental radiological sampling data from U.S. DOE's PEGASIS. PEGASIS includes the data from the EM program, whereas U.S. DOE's ASER reports only includes some of the data collected.

From PEGASIS, ATSDR downloaded a total of 7,679 radiological sample analyses at PORTS collected from January 1, 2016, through September 2, 2022. The main parameter ATSDR used was the flag indicating radiological analysis of the associated sample. ATSDR only evaluated the air and soil samples in the predominant wind direction and sediment samples. See Table 3 for the number of sample analyses performed by media.

Table 3. Number of sample analyses by media from the PEGASIS database collected from January 1, 2016, through September 2, 2022

	Air	Sediment	Soil
Total Number of Sample Analyses	6,156	826	697

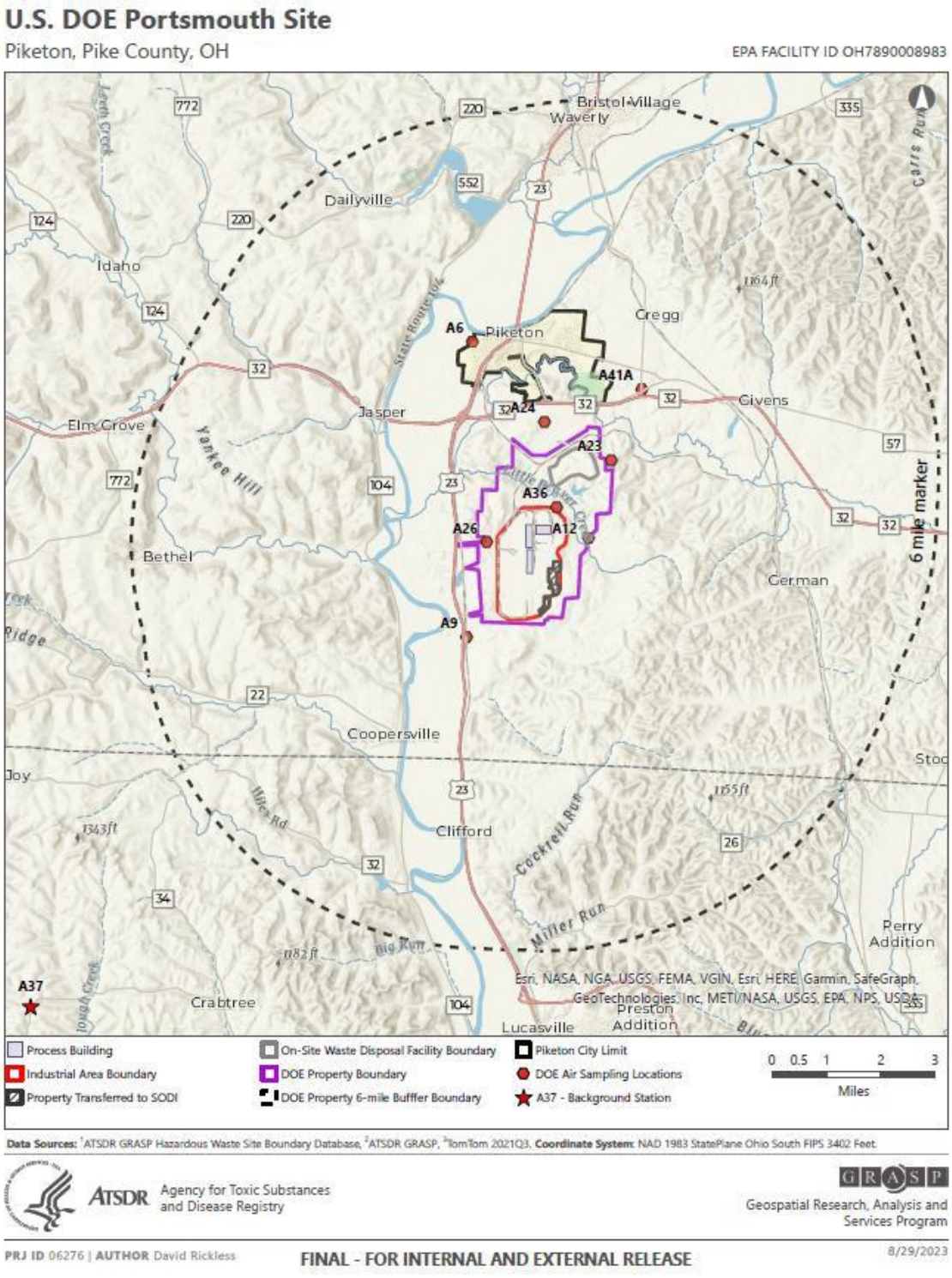
* Sample analysis is the number of analyses of each individual radiological isotope in the samples collected.

4.2.1 Air Monitoring

ATSDR evaluated U.S. DOE air sampling data from nine (9) air monitoring stations at both on-site locations and off-site locations around PORTS [See Figure 5]. The six off-site monitors included A6, A9, A23, A24, A41A, and A37. Off-site monitoring station A37 is a background station located in Otway approximately 30 miles southwest of PORTS. The off-site air monitoring stations included locations near Piketon (A6, A24) and the Zahn's Corner Middle School (A41A). Two off-site air monitoring stations are located just outside the U.S. DOE property boundary near the On-site Waste Disposal Facility (OSWDF) (A23) and southwest of the facility near U.S Highway 23 (A9). The on-site monitoring stations (A12, A26, and A36) are located inside the DOE PORTS property boundary near the industrial area boundary where the ongoing building demolition and other remediation activities are occurring.

Two types of air samples were collected: annual ambient radiation doses and concentrations of radioactive particulates in outdoor air. Annual ambient radiation doses (millirem per year; mrem/year) are continuously measured using devices called dosimeters. The annual ambient radiation dose is a non-specific measurement and is not related to any specific radioactive material. Concentrations of radioactive particulates in outdoor air are measured by outdoor air monitors and reported in picocuries per cubic meter (pCi/m^3) of air. The ambient air radiological particulate samples were analyzed for the standard set of radionuclides.

Figure 5. Locations of U.S. DOE radiological air monitoring stations at PORTS



4.2.2 Soils

ATSDR evaluated U.S. DOE soil samples collected near ambient air monitoring stations at both on-site locations and off-site locations around PORTS. The U.S. DOE also collected soil samples at several areas both within the fenceline of PORTS as well as outside the primary plant boundary. The soil samples were analyzed for the standard set of transuranic radionuclides, technetium-99, uranium, and uranium isotopes.

4.2.3 Sediments

ATSDR evaluated upstream and downstream U.S. DOE sediment data collected at both on-site locations and off-site locations from 2016 to 2022. These locations include the NPDES outfalls on the east and west sides of PORTS, and at a location on Big Beaver Creek upstream from the confluence with Little Beaver Creek. Samples were analyzed for the standard set of transuranic radionuclides, technetium-99, uranium, and uranium isotopes.

4.3 Ohio Department of Health Air Monitoring

ATSDR evaluated the ODH radiological air monitoring data collected at eight on-site and off-site locations from October 2020 to December 2022 at PORTS [ODH 2021]. On a quarterly basis, ODH collected air filters and analyzed for the standard set of radioisotopes. The analyses were performed by several different laboratories. The ODH air monitors were co-located with U.S. DOE air monitoring stations. This allows for independent comparisons and validations of each organization's results.

4.4 U.S. DOE Radiological Assistance Program (RAP-3)

ATSDR evaluated U.S. DOE Radiological Assistance Program Team 3 (RAP-3) air and swipe samples collected inside and around the Zahn's Corner Middle School area in May 2019 [NNSA RAP 2019]. Three high-volume and four low-volume air samples were collected inside and around the school. The air samples were analyzed for the standard set of transuranic radionuclides, uranium isotopes. These air samples were shipped to the Savannah River Site for radiochemical separation and analysis by alpha spectrometry. Thirty-nine 100 cm^2 swipe samples (surface or dust samples) were collected inside the school and analyzed for gross alpha and gross beta activity. The U.S. DOE presented these findings in public meetings and made their results public.

Five swipe samples were taken in triplicate. Five locations at the Zahn's Corner Middle School were identified by the concerned citizen as places where some of the original samples were taken and sent to NAU for analysis. Contamination swipe samples were taken at these locations in triplicate. One set of samples was sent to Savannah River National Laboratory (SRNL) for low-level isotopic quantification. The remaining samples were transferred to the State and County for independent analysis.

4.5 Northern Arizona University (NAU)

ATSDR reviewed the NAU letter dated March 27, 2020, on the uranium concentration and isotope compositions in 46 air filter sections collected using a high-volume air sampler from May to October 2019 from a local resident's own air monitoring network. From this network**,** 42 samples were collected along with four (4) blank samples to aid in comparison. Portions of these samples were prepared for inductively coupled plasma mass spectroscopy (ICP-MS) which measures the number of atoms present in the samples. NAU reported the results for uranium (234, 235, and 238) as well as the presence of Uranium-236 which can be present in recycled uranium. Once the number of atoms of each isotope was determined, NAU calculated the ratios. This allows for the comparison to known ratios of naturally occurring uranium with the ratio of the material collected from the residential air monitoring network.

ATSDR reviewed the NAU letter dated June 21, 2022, related to wipe samples collected in Lucasville, Ohio from a private residence. The wipe samples were described as a "baby wipe" fabric used to collect dust from the residence. The samples, collected from the attic and living spaces, were prepared for ICP-MS using an ion exchange system to separate the uranium from other materials. Portions of the samples were also prepared for the determination of both bismuth and uranium. These wipe samples were collected in the attic (five samples), the house air conditioning system (three samples), and a sample from an unspecified location. The isotopes reported in this study included Uranium-234, Uranium-235, Uranium-238 as well as Uranium-236. The bismuth was not identified as any specific isotope.

ATSDR reviewed two letters dated April 5, 2023. One letter was related to a private outdoor air monitoring location in Seal Township; the other letter discussed information from the public-owned air monitoring stations in Scioto Township.

The Seal Township samples appear to have been prepared using previously discussed procedures yielding samples for analysis by ICP-MS methods. This letter discusses several sets of air filter materials collected by the private owner of the air station. In one set of four quarterly samples covering approximately one year of data (April 18, 2020, through April 4, 2021), the results for uranium isotopes and Neptunium-237 were reported.

Another section of the letter gives the results of 23 samples collected between April 4, 2021, and January 23, 2023. These samples were collected on a bi-weekly basis and were analyzed for the ratios of uranium isotopes including Uranium-234, Uranium-235, Uranium-238, and Uranium-236 (found in recycled uranium). In the final part of the letter, the results of 13 air samples collected biweekly from January 23, 2022, to July 24, 2022, were presented. These results show the ratio of Uranium-235/Uranium-238.

The second letter of April 5, 2023 evaluated air samples collected in Scioto Township. Composite air samples collected quarterly from August 10, 2019, through April 4, 2021, were analyzed by ICP-MS as described in previous letters from NAU. These analyses included uranium ratios and the presence of Neptunium-237. Twenty-three biweekly air monitoring samples from February 20, 2022, through March 6, 2022, and April 16, 2022, through May 1, 2022, were also evaluated for uranium ratios. Lastly, NAU evaluated 13 individual samples collected between January 23, 2022, and July 24, 2022. These samples were evaluated for the ratio of Uranium-235/Uranium-238.

NAU stated these results were similar to those seen in the resident-owned air monitoring location described in the letter dated March 27, 2020.

5. Scientific Evaluations

5.1 Exposure Pathway Analysis

5.1.1 What is meant by exposure?

ATSDR's public health assessments are driven by human exposure or contact. Radiological contaminants released into the environment have the potential to cause harmful health effects. Nevertheless, a release does not always result in adverse exposure. People can only be exposed to a contaminant if they come into contact with that contaminant. If no one comes into contact with a contaminant, then no exposure occurs, and thus no health effects could occur. However, with radioactive contaminants, this direct contact does not have to occur. Often the general public does not have access to the source area of contamination or areas where contaminants are moving through the environment. This lack of access to these areas becomes important in determining whether people could come into contact with the contaminants. In the case of radiological contamination, however, exposure can occur without direct contact because of the emission of certain types of radiation.

The exposure pathway is a contaminant's route from a source to the people exposed. ATSDR identifies and evaluates exposure pathways by considering how people might come into contact with a contaminant. An exposure pathway could involve air, surface water, groundwater, soil, dust, or even plants and animals. Exposure can occur by breathing, eating, drinking, or by skin contact with a substance containing the radiological contaminants. Exposure to radiation also can occur by being near the radioactive material.

For an exposure to occur, an exposure pathway must be completed. A completed exposure pathway must include the following five elements:

1. A source of contamination,
2. An environmental medium through which the contaminant is transported,
3. A point of human exposure,
4. A route of human exposure, and
5. An exposed population.

A potential exposure pathway is present when one or more of the elements is absent, or if information is insufficient to eliminate or exclude the element. The pathway is eliminated if one or more element is absent, and it never will be (or is extremely unlikely to be) present (ATSDR 2022).

In this health consultation on PORTS, ATSDR scientists evaluated site-specific conditions at PORTS from 2016 to 2022 to determine whether people living near PORTS are being exposed to radiological contaminants off-site from the decontamination, decommissioning, demolition, and disposal of the process buildings and the construction of the OSWDF. ATSDR evaluated whether exposure to contaminated off-site media (air, indoor dust, soil, sediment, surface water) has occurred or is occurring through inhalation, ingestion, or dermal (skin) contact. ATSDR evaluated air monitoring data to

determine if radiological contaminants were released into the air from the PORTS facility and dispersed into off-site areas. ATSDR also evaluated soils and sediments because radiological contaminants present in soil and sediment samples can come from multiple sources. These sources include naturally occurring radioisotopes typically found in soil and sediment samples. Radiological contaminants can also settle in soils and sediments after being released from human activities such as PORTS facility operations (which can accumulate in soil and sediment over the facility's years of operation) and those in fallout (which were released during the historical atmospheric testing of atomic bombs prior to 1964). Table 4 is a site conceptual model of exposure pathways evaluated at PORTS in this health consultation.

ATSDR scientists then consider whether environmental radiological contamination is present at levels that might affect public health and if exposure is possible. The first step in this process of evaluating radiological contaminants is to conduct screening to determine whether detected contaminants will require further evaluation.

Table 4. Exposure pathways evaluated by ATSDR at the PORTS Facility

Potential Sources	Environmental Medium and Transport	Exposure Point	Exposure Route	Potentially Exposed Population
PORTS facility Past gaseous diffusion operations Decontamination, decommissioning, demolition, and disposal of the process buildings Construction of the On-Site Waste Disposal Facility (OSWDF)	Air Radiological contaminants released from PORTS into on-site ambient (outdoor) air which then is dispersed into off-site ambient air and deposits in soil, sediment, interior dust	Off-site residential, rural, and commercial areas within 6 miles of PORTS	Inhalation of air Incidental ingestion and dermal (skin) contact with indoor dust, soil, and sediments	General population living near the PORTS facility.
PORTS facility Past gaseous diffusion operations Decontamination, decommissioning, demolition, and disposal of the process buildings Construction of the OSWDF	Surface Water Radiological contaminants released from PORTS into on-site watershed and deposits in soil and sediment.	Off-site creeks, rivers, and ponds within 6 miles of PORTS	Incidental ingestion and dermal (skin) contact with surface water and sediments	Individuals swimming, playing, or fishing in a creek, river, or pond within 6 miles PORTS

5.2 Screening Analysis

ATSDR's screening analysis for radioisotopes is a systematic method to consistently sort through sampling datasets by media to evaluate the variability and viability of the sampling data, assess the radiological concentration values used in the evaluation, and identify contaminant concentrations that do and do not require further public health evaluation. Depending on the contaminant, a determination if the radiologic contaminant is significantly different from natural background levels is also made.

5.2.1 Initial Screening of Radiological Concentrations

ATSDR conducted an initial screening of each dataset by media using the radioanalytical laboratory data used to estimate the radiological concentrations which were used in this health consultation. ATSDR evaluated the laboratory values by reviewing three reporting values for each analysis performed by the laboratory. These are the result of the measurement, the associated uncertainty of the measurement (an estimate of the unknown factors impacting the measurement), and the minimum detectable activity (MDA). The MDA is the statistical lower limit for which the measurement would be valid. As the measured radioactive concentration becomes smaller and approaches the MDA, the uncertainty of the measured concentration increases.

For this health consultation on PORTS, the initial screening evaluation was on a case-by-case basis using a combination of the three radioanalytical laboratory values of measured radioactive concentrations for individual radioisotopes with the following approach:

1. If the reported radiological concentration is greater than the MDA, ATSDR considered the concentration as a valid result. ATSDR used the concentration as reported even if the uncertainty in the measured result is larger than the value of the concentration result.
2. If the radiological concentration is below the MDA or reported as a negative value and the radionuclide is known or expected to be present, then ATSDR inserts a value equal to one-half the MDA (one-half of the MDA is used because if zero is selected, the value is artificially lowered; if the detection limit is selected, the value is artificially raised).

This initial screening approach of the radioanalytical laboratory data at PORTS allows ATSDR to still evaluate radiological concentrations despite limitations in method detection. Therefore, all radiological analyses were included for consideration in ATSDR's evaluation after initial screening.

5.2.2 Media-specific Screening

ATSDR conducted the media-specific screening of each dataset by media using the valid radiological concentration values (or values adjusted by adding one-half of the MDA) from the initial screening. Within each sampling dataset, radiological concentration values of the same radioisotope are used to calculate the mean or average of all the analyses of the same radionuclide in the same media and compare this mean to local, regional, or national background concentrations of the naturally occurring radioisotopes in the environment, federal agency standards, or ATSDR health guidelines. Exposures to site-specific radiological concentrations less than these media-specific comparison values are not expected to cause health effects in people. Therefore, radionuclide levels below comparison values do not pose a public health hazard and are not evaluated further for a given medium.

While radiological concentrations below the respective comparison values can be considered safe, it does not automatically follow that any environmental radioisotope concentrations that are statistically greater than the ambient background levels or exceed the recommended standard or health guideline would be expected to produce adverse health effects. These radiological values are not observable health effect thresholds and are many times lower than levels at which no effects were observed in studies on experimental animals or in human epidemiologic studies. If site-specific radiological concentrations are above these comparison values, ATSDR further analyzes exposure variables to estimate site-specific doses where possible and compares these estimated doses to doses associated with harmful health effects reported in peer-reviewed human studies in the scientific literature.

Table 5 includes the radiological media-specific screening levels by media.

Local background concentrations are from the U.S. DOE background monitoring station A37 located in Otway approximately 30 miles southwest of PORTS. When peer-reviewed background concentrations are available, those concentrations are cited as well.

The NRC radiological concentrations for residents (non-worker) are based on the Nuclear Regulatory Commission 10 Code of Federal Regulations Part 20 Standard for Protection Against Radiation [NRC 10 CFR 20]. NRC 10 CFR 20 radiological concentrations are equivalent to the radionuclide concentrations which, if inhaled or ingested continuously over the course of a year, would produce a total effective dose equivalent of 50 mrem/year. The total effective dose equivalent is defined as the numeric sum of the external effective dose equivalent and the committed effective dose equivalent for internal exposures over a 50-year period.

The ATSDR minimal risk level (MRL) is a substance-specific health guideline estimate of daily human exposure to a substance that is likely to be without appreciable risk of adverse noncancer health effects over a specified duration of exposure. The ATSDR chronic exposure MRL for ionizing radiation is derived using the no-observed-adverse-effect level (NOAEL) divided by an uncertainty factor approach. ATSDR derived the chronic-duration MRL of 100 mrem/year for ionizing radiation by dividing the average annual effective dose to the U.S. population (360 mrem/year) by an uncertainty factor (safety factor) of 3 to account for human variability [ATSDR 1999b]. The average annual effective dose to the U.S. population is obtained mainly from naturally occurring terrestrial radioactive material, cosmic radiation, and radiation from consumer products [BEIR V 1990 as cited in ATSDR 1999b]. The natural background radiation dose is 310 mrem/year which does not include medical exposures; however, this type of natural exposure is highly variable. The annual effective dose of 360 mrem/year has not been associated with adverse health effects in humans or animals. The MRL of 100 mrem/year is the only ATSDR derived screening value for external exposure and external dose from ionizing radiation. Internal radiation doses are evaluated on a case-by-case basis using peer-reviewed human studies or animal studies where appropriate.

Table 5. Radiological media-specific screening levels by media

Media	Media-specific screening levels
Outdoor air concentration of radioactive particulates dose	Local and state background concentrations Radiation concentrations based on NRC 10 CFR 20 standard
Outdoor air ambient radiation	ATSDR chronic exposure minimal risk level (MRL) for ionizing radiation exposure
Soil	National background soil measurements* Ohio background soil measurements*
Sediment	National background soil measurements Ohio background soil measurements
Indoor dust	The Multi-Agency Radiation Survey and Assessment of Materials and Equipment Manual (MARSAME)
Surface water	U.S. EPA Clean Water Act maximum contaminant levels (MCL) ATSDR applied the U.S. EPA Unregulated Contaminant Monitoring Rule to derive the radionuclide concentrations for specific radioisotopes resulting in a dose of 4 mrem/year†

Source: URL: https://www.epa.gov/dwucmr/learn-about-unregulated-contaminant-monitoring-rule

* National and Ohio background soil measurements, see table 18

† The U.S. EPA Unregulated Contaminant Monitoring Rule allows the evaluation of contaminants that are not regulated by the Safe Drinking Water Act. For radioactive materials, only a few specific materials are expressly regulated. Other radioisotopes can be evaluated using a derived MCL for specific radioisotopes based on a dose of 4 millirem per year.

NRC 10 CFR 20 = Nuclear Regulatory Commission 10 Code of Federal Regulations Part 20 Standard for Protection Against Radiation; MARSAME = Multi-Agency Radiation Survey and Assessment of Materials and Equipment Manual

5.3 Outdoor Air Evaluation

ATSDR evaluated the air exposure pathway via potential inhalation of radiological contaminants in ambient (outdoor) air by the population living near the PORTS facility. ATSDR evaluated outdoor air radiological datasets collected by U.S. DOE, Ohio DOH, the U.S. DOE RAP program, and NAU from January 2016 to September 2022. See Table 6 for the number of ambient air sample analyses for each dataset. One sample can be analyzed multiple times for multiple radiologic contaminants.

Table 6. Number of ambient air radiological sample analyses

	U.S. DOE PEGASIS/ASER	ODH	DOE RAP Program	Northern Arizona University
Number of sample analyses	6,156	917	7	42

5.3.1 U.S. DOE Outdoor Air Data

ATSDR obtained 6,156 radiological outdoor air sample analyses from the U.S. DOE PEGASIS/ASER database. These samples analyses were collected from many areas inside and outside the fenceline of PORTS. ATSDR evaluated about 3,800 outdoor air samples analyses collected at nine U. S. DOE sampling locations for further evaluation. These sites were at on-site locations and off-site locations around PORTS and covered the timeframe from January 1, 2016, through September 2, 2022. The three on-site stations (inside the U. S. DOE PORTS property boundary) included A12, A26, and A36. The six off-site stations included A6, located in northwest Piketon; A41A, located near Zahn's Corner Middle School; A24, located north of the DOE property boundary midway between PORTS and Piketon; A23, located adjacent to the DOE property boundary near the On-site Waste Disposal Facility boundary; A9, located southwest near the DOE property boundary; and A37, the background station located in Otway approximately 30 miles southwest of PORTS. ATSDR selected air monitoring stations most likely to be impacted by radiological releases from PORTS activities during the time period evaluated.

At each of the air monitoring stations reported in this health consultation, the U.S. DOE used air samplers to measure the amounts of dusts and certain radioisotopes in the air. An air sampler functions by using pumps to pull air through filters that collect dust in the outdoor air. The filters are collected on a regular schedule and subjected to analysis. The concentration of radioactive particulates expressed as activity per cubic meter of air (picocuries per cubic meter, pCi/m^3) is determined by analyzing the filters. The concentration of contaminants in the air can be calculated from the analytical results and the time the air sampler operates, and the flow rate. The air monitoring samples were analyzed for the standard set of transuranic radionuclides, technetium-99, uranium, and uranium isotopes.

The U.S. DOE also continuously measured ambient radiation dose levels around air monitoring stations using dosimeters. Dosimeters are typically one of two types, a thermoluminescent dosimeter (TLD) or an optically stimulated luminescent dosimeter (OSL). These devices measure the level of radiation in a defined space and report the radiation present in terms of dose. The radiation dose measured by these devices is typically measured quarterly and the results are summed to determine the annual radiation dose.

5.3.1.1 Initial screening of radiological data

ATSDR followed the initial screening methodology described in Section 5.2. to evaluate the U.S. DOE PEGASIS/ASER outdoor air monitoring data. Table 7 summarizes initial screening of the outdoor air monitoring data by radionuclide with information on the radioisotopes analyzed, number of total analyses, number of analyses with radiological concentrations below the MDA, percent (%) of analyses with concentrations below the MDA, number of analyses with radiological concentrations above the MDA, and percent (%) of analyses with concentrations above the MDA.

As shown in Table 7, more than 95% of the samples analyzed for neptunium-237, plutonium-238, plutonium-239/240, and uranium-235/236 showed the results less than the MDA. This indicates that for these radionuclides, the majority of radiological concentrations were below the statistical detection limit and the results would be considered zero (0); that is, not detectable in the outdoor air. The total uranium and uranium isotopes (uranium-233/234, and uranium-238) have a low percentage of non-detects.

Table 7. Summary of initial screening of U.S. DOE PEGASIS/ASER outdoor air monitoring data by radionuclide

Radionuclides	Total analyses	Number of analyses with concentrations below MDA	Percent (%) of analyses with concentrations below MDA	Number of analyses with concentrations above the MDA	Percent (%) of analyses with concentrations above the MDA
Americium-241	196	189	96	7	4
Neptunium-237	229	223	97	6	3
Plutonium-238	183	183	100	0	0
Plutonium-239/240	183	183	100	0	0
Technetium-99	539	244	45	295	55
Uranium-233/234	545	351	64	194	36
Uranium-235/236	545	536	98	9	2
Uranium-238	545	368	68	177	32

MDA = minimal detectable activity

5.3.1.2 Media-specific screening

Air particulate radionuclides concentrations

ATSDR averaged the radionuclide concentrations measured in outdoor air over a 5-year period covering 2016-2020 at both onsite and offsite U.S. DOE air monitoring stations. These results are given in Table 8. These measured radiological concentrations, not adjusted for background radiation levels, are expressed as activity per cubic meter of air multiplied by 100,000 (pCi/m^3 x 100,000). This adjustment by 100,000 allows the reader to easily compare the radiological concentrations at each of the monitoring stations with the background concentrations without a large number of leading zeros. For example, the measured five-year average radiological concentration of 0.000011 pCi/m^3 when multiplied by 100,000 would be shown as 1.1 (pCi/m^3 *100,000) in Table 8. Furthermore, this adjustment demonstrates how small the reported measured radionuclide concentrations are in the air monitoring samples.

Table 8. Five-year average radionuclide concentrations measured in radioisotopes (particulates) collected in outdoor air at both on-site and off-site U.S. DOE air monitoring stations from 2016-2020

Radionuclides Picocuries per cubic meter x 100,000, (pCi/m^3 x 100,000) *	A37 Background location (off-site)	A6 (off-site)	A9 (off-site)	A23 (off-site)	A41A (off-site)	A24 (off-site)	A12 (on-site)	A29 (on-site)	A36 (on-site)
Americium-241	1.1	2.3	0.7	0.7	0.8	0.8	0.5	0.6	1.3
Neptunium-237	0.2	725	0.1	0.2	4	0.1	0.1	0.2	0.4
Plutonium-238	0.4	0.1	0.3	0.3	0.3	0.3	0.3	0.4	0.5
Plutonium-239/240	0.4	0.4	0.5	0.5	0.5	0.4	0.5	0.6	0.5
Technetium-99	731	935	917	826	593	726	818	908	662
Uranium-233/234	4.1	6.5	21.4	10.3	5.6	12.2	6.4	8.7	22.8
Uranium-235/236	0.4	1.4	0.6	0.8	0.4	0.7	0.6	0.6	1.7
Uranium-238	4.3	3.8	5.9	8.8	4.6	10	4.8	6.1	12.8

Source: ASER 2016; ASER 2017; ASER 2018; ASER 2019; ASER 2020

* To calculate the reported radionuclide concentration measured at a monitoring station, divide the radionuclide concentration in Table 8 by 100,000. For example, a Table 8 value of 1.1 (pCi/m3 × 100,000) would be reported in the ACER as 0.000011 pCi/m3 (1.1E-05 pCi/m3).

To determine the contribution of radiological concentrations of materials in outdoor air from PORTS, the 5-year average background concentrations measured at Station A37 in Otway were subtracted from 5-year average concentrations at the other stations to give an estimate of the annual net radioactive concentrations in the air not related to the background radiation. In Table 9, the estimated net annual radiation concentrations above background for each radionuclide, are presented for each U.S. DOE air monitoring station. These net annual radiation concentrations, adjusted for background radiation levels, are expressed as activity per cubic meter of air (picocuries per cubic meter x 100,000, pCi/m^3 x 100,000). In this table, a value of zero (0) indicates that A37 monitoring station background concentration was higher than the concentration at the respective station. These net annual radiation concentrations for each radionuclide at each monitoring station are compared to the radiation concentration limits in air for the public contained in U.S. NRC 10 CFR 20. These radiological air concentration limits for members of the pubic would give a dose of 50 mrem/year or one half of the ATSDR MRL.

In Table 9, the only transuranic radioisotopes exceeding the background concentrations were americium-241 at monitoring station A6, Neptunium-237 at monitoring stations A6 (northwest Piketon) and A41A (Zahn's Corner Middle School), and plutonium-239/240 at monitoring stations A23 and A29. Of interest is that americium-241 and Neptunium-237 were not detected above background at the three on-site monitoring locations evaluated by ATSDR. The man-made element technetium-99 was elevated above background at offsite monitoring stations A6, A9, and A23. Technetium-99 was elevated at the on-site stations A12 and A29. With respect to the uranium radioisotopes, the concentrations of uranium-234 were greater than expected from the uranium-238 concentrations at all stations evaluated by ATSDR.

In Table 9, none of the radionuclides (americium-241, neptunium-237, plutonium-238, plutonium 239/240, technetium-99, uranium-233/234, uranium-235/236, uranium-238) were present at concentrations greater than the U.S. NRC 10 CFR 20 standard. Because the estimated annual net radiation doses are less than 50 mrem/year, based on the 10 CFR 20 concentration limits, ATSDR does not expect adverse radiologic health effects to occur in people inhaling these radionuclides in outdoor air near monitoring stations from 2016 to 2020. Therefore, the concentrations of these radionuclides in the outdoor air do not pose a public health hazard and do not require any additional evaluation in this health consultation for the outdoor air exposure pathway for these contaminants.

Table 9. Estimated annual net radiation concentrations* above background measured in radioisotopes (particulates) collected in outdoor air at both on-site and off-site U.S. DOE air monitoring stations from 2016-2020 and compared to U.S. NRC 10 CFR 20 standard concentration limits

Radionuclides Picocuries/cubic meter x100,000† (pCi/m^3 x 100,000)	A6 (off-site)	A9 (off-site)	A23 (off-site)	A41A (off-site)	A24 (off-site)	A12 (on-site)	A29 (on-site)	A36 (on-site)	U.S. NRC 10 CFR 20 Air radiation concentration limits
Americium-241	1.2	0	0	0	0	0	0	0.2	2000
Neptunium-237	725	0	0	3.8	0	0	0	0.2	1000
Plutonium-238	0	0	0	0	0	0	0	0.1	2000
Plutonium-239/240	0	0	0.1	0.2	0	0.1	0.2	0.1	2000
Technetium-99	204	186	95	0	0	87	177	0	90,000,000
Uranium-233/234	2.4	17.4	6.3	1.5	8.2	2.4	4.6	18.8	5000
Uranium-235/236	1	0.2	0.4	0.1	0.4	0.3	0.3	1.3	6000
Uranium-238	0	1.6	4.5	0.3	5.7	0.5	1.8	8.5	6000

* The annual net radiation concentrations are adjusted for background radiological concentrations.

† In this table, annual net radiation concentration is calculated by multiplying the annual net radiation concentration by 100,000 to make it easier for the reader to compare the annual net radiation concentration at each monitoring station to the U.S. NRC 10 CFR 20 air radiation concentration limits. To calculate the annual net radiation concentration at a monitoring station, divide the 5-year annual net radiation concentration in Table 8 by 100,000. For example, a Table 8 value of 1.2 (pCi/m3 × 100,000) would be reported in the ACER as 0.000012 pCi/m3 (1.2E-05 pCi/m3).

U.S. NRC 10 CFR 20 = Nuclear Regulatory Commission 10 Code of Federal Regulations Part 20 Standard for Protection Against Radiation

To further show how low these radiological concentrations in air are in relationship to a radiation dose, ATSDR used the concentrations in Table 9 and converted them to a radiation doses shown in Table 10. To calculate the dose, ATSDR multiplied the radiologic concentrations at each evaluated air monitoring station by 50 and divided by the 10 CFR 20 limit. ATSDR multiplied by 50 because the concentration in the 10 CFR 20 standard is the concentration in air that results in dose of 50 mrem/year [U.S. NRC 10 CFR 20 Appendix B Table 2].

On first evaluation, the maximum neptunium-237 dose is greater than all the other radionuclides doses combined; however, detailed analysis indicates all the radiation doses in Table 10 are not necessarily a

public health concern when compared to dose-based human studies. Human health impacts of neptunium-237 exposure have not been observed [Taylor, 1989].

Uranium isotopes and transuranics, including neptunium-237, are alpha emitting radioactive substances, and the human body does not recognize one alpha particle from another as the only difference is the energy of the alpha particle, and the alpha energies are similar for these radionuclides. Furthermore, the alpha particles' energies for these radionuclides are similar to that of radium-226. These alpha emitting elements, including the radium, are considered bone-seeking and should have similar human health effects when present at sufficient concentrations to cause observable health effects. Most human studies of alpha emitting radioactive substances have involved the radium dial painters exposed to radium-226 in watch paint of the early 20th century.

Radium-226 was widely used in watches, clocks, and dials in the early and mid-20th century. As a result of its usage (and at that time unrecognized health effects), human studies have been able to identify health effects associated with the intake of radium isotopes. In studies reviewed by Rowland in his book Radium in Humans. A review of US studies, tumor production from radium-226 was not observed until a radiation dose of 1,000 rads (equal to approximately 20,000,000 millirem) was delivered [Rowland, 1994]. The estimated doses from neptunium-237 in outdoor air is about 50 thousand times less than the radium-226 dose that resulted in observed human bone tumors. The maximum dose of 600 mrem for total uranium and its uranium isotopes is more than 33,000 times less than the radium-226 dose that resulted in observed human bone tumors. Therefore, people are not likely to exhibit an increased risk of cancer or other health problems from breathing neptunium-237, total uranium, or uranium isotopes in outdoor air near the U.S. DOE air monitors from 2016 to 2020. The radiological concentrations of radionuclides detected in the outdoor air samples are not at levels that cause harmful health effects. ATSDR concludes that inhalation exposure to the radioactive concentrations of neptunium-237, total uranium, or uranium isotopes detected in the outdoor air samples is not expected to harm people's health.

Table 10. Estimated radiation dose from radioisotopes (particulates) in the outdoor air at the U.S. DOE monitoring stations.

Radionuclides (Millirem per year, mrem/yr)	A6 (off-site)	A9 (off-site)	A23 (off-site)	A41A (off-site)	A24 (off-site)	A12 (on-site)	A29 (on-site)	A36 (on-site)
Americium-241	0.03	0	0	0	0	0	0	0.01
Neptunium-237	36	0	0	0.2	0	0	0	0.01
Plutonium-238	0	0	0	0	0	0	0	0
Plutonium-239/240	0	0	0	0.01	0	0	0.01	0
Technetium-99	0	0	0	0	0	0	0	0
Uranium-233/234	0.02	0.2	0.1	0.02	0.2	0.02	0.05	0.2
Uranium-235/236	0.01	0	0	0	0	0	0	0.01
Uranium-238	0	0.01	0.04	0	0.1	0	0.02	0.1

Evaluation of the uranium isotopic data in Table 9 also shows that the ratio of uranium-234 and uranium-238 are outside the expected natural ratio. In nature, the activity concentration of uranium-234 is essentially equal to the uranium-238 activity concentration. This is considered secular equilibrium. The equilibrium condition is especially true when soils have not been impacted by human activities. Since the dusts in air are normally derived from the soils, one can compare dusts and soils similarly. The uranium data in Table 9 indicates the concentration of uranium-234 in air is about 2.7 times higher than the uranium-238 concentration in air; that is, the equilibrium is not present. One possible reason for this is that the stations with higher concentrations may have more products of the gaseous diffusion process present in the soil or dusts being produced during site demolition and disposal. However, the aim of this document is not to determine the source of contamination.

Ambient external radiation dose

To evaluate the ambient external radiation dose, Table 11 compares these annual ambient radiation doses and the five-year average ambient radiation doses measured at U.S. DOE air monitoring stations from 2016 to 2020 to the average annual dose from naturally occurring background radiation in the United States (310 mrem/year) and the ATSDR chronic MRL (100 mrem/year above background) for ionizing radiation. The annual background dose of 310-360 mrem/year has not been associated with adverse health effects in humans and animals. The MRL of 100 mrem/year is below levels that might cause noncancer health effects in the most sensitive people. These data showed that the ambient radiation dose levels around the selected air monitoring stations were almost identical to each other and the five-year average ambient radiation doses at the air monitoring stations are lower than the national natural background radiation levels and the ATSDR MRL. Therefore, ATSDR does not expect health effects to occur from exposures to external radiation doses around all the monitoring stations during this time period.

Table 11. Annual ambient radiation doses by year (mrem/y) and the five-year average ambient radiation doses measured at U.S. DOE air monitoring stations from 2016 to 2022 compared to natural background radiation and the ATSDR MRL for ionizing radiation

U.S. DOE Air monitoring station	2016 Annual radiation dose in millirem per year (mrem/year)	2017 Annual radiation dose in millirem per year (mrem/year)	2018 Annual radiation dose in millirem per year (mrem/year)	2019 Annual radiation dose in millirem per year (mrem/year)	2020 Annual radiation dose in millirem per year (mrem/year)	5-year average Annual radiation dose in millirem per year (mrem/year)	Percent comparison with national natural background radiation (310 mrem/year)* (percent of background)	Percent comparison with ATSDR MRL (100 mrem/year) (percent of MRL)
A6 (On-site)	21.2	21.5	21.5	23.6	22.4	22.0	7.0	22.0
A23 (On-Site	22.1	21.8	21.1	23.1	22.5	22.1	7.1	22.1
A24 (On-site)	23.0	23.2	22.2	23.6	23.0	23.0	7.4	23.0
A9 (On-site)	22.3	22.3	21.0	23.9	21.9	22.3	7.1	22.2
A41A (On-site)	No data available	NA	NA	NA	NA	NA	NA	NA
A12 (Off-site)	22.7	21.5	20.8	23.2	21.7	22.0	7.0	22.0
A29 (Off-site)	21.2	23.0	21.0	23.8	22.3	22.3	7.4	22.3
A36 (Off-site)	21.3	21.1	19.8	21.5	21.0	20.9	6.7	20.9
Background (A37)	No data available	NA	NA	NA	NA	NA	NA	NA

* National and Ohio background soil measurements, see table 18

MRL = ATSDR Minimal Risk Level for ionizing radiation is 100 millirem per year (mrem/year) for an external radiation dose

5.3.2 Ohio Department of Health Outdoor Air Data

ATSDR evaluated Ohio Department of Health (ODH) radiological outdoor air monitoring data collected at eight (8) on-site and off-site monitoring stations co-located with U.S. DOE's monitoring stations from October 2020 to December 2022 at PORTS [ODH 2021]. ATSDR compared state results to the U. S. DOE 5-year average concentration for each radionuclide from 2016-2020 to the ODH 2-year average concentrations. For these data, no quantitative values were given for the MDA. However, the state did include the data qualifiers. These data qualifiers follow the US EPA guidance on environmental data verification.

The data comparisons between the state and US DOE air monitors were such that more than 90% of the samples were either "U" or "UJ" qualified indicating the samples below the detection limit. Therefore, we found no significant difference between the air concentrations measured by U.S. DOE and ODH. The comparison of the state and US DOE data are given in Appendix B and shown in Table B1.

5.3.2.1 Initial screening of radiological data

ATSDR followed the initial screening methodology described in Section 5.2. to evaluate the ODH outdoor air monitoring data. Table 12 summarizes the initial screening of the outdoor air monitoring data by radionuclide. As observed in Table 12, all analyses for transuranic radionuclides and a large percentage (>98%) of analyses for uranium-233/234, and uranium-238 radioactive concentrations are below the MDA. Less than 23% of technetium-99, total uranium, and uranium-235/236 have concentrations detected above the MDA; that is, more than 77% of the analyses were below the MDA. This indicates that for these radionuclides, the majority of radiological concentrations were below the statistical detection limit and the results would be zero (0); that is, not detectable in the outdoor air. In all the ODH outdoor air samples the measured concentrations are close to the MDA, indicating high uncertainties in the measurement. Therefore, the estimated radiological concentrations are not meaningful. ATSDR determined an associated radiological dose estimate would also not be meaningful. In addition, these estimated doses would be so low that ATSDR would not expect any observable adverse health effects. ATSDR concludes that the radioactive concentrations of radionuclides detected in the ODH outdoor air samples are not at levels expected to harm people's health.

Table 12. Summary of initial screening of Ohio Department of Health outdoor air monitoring data by radionuclide

Radionuclide	Total analyses	Number of analyses with concentrations below MDA	Percent (%) of analyses with concentrations below MDA	Number of analyses with concentrations above the MDA	Percent (%) of analyses with concentrations above the MDA
Americium-241	48	48	100.0	0	0
Neptunium-237	48	48	100.0	0	0
Plutonium-238	48	48	100.0	0	0

Plutonium-239/240	48	48	100.0	0	0
Technetium-99	145	116	80.0	29	20
Total Uranium	145	112	77.2	33	22.8
Uranium-233/234	145	144	99.3	1	0.7
Uranium-235/236	145	117	80.7	28	19.3
Uranium-238	145	143	98.6	2	1.4

MDA = minimum detectable activity

5.3.3 U.S. DOE Radiological Assistance Program Team 3 Indoor/Outdoor Air Data

ATSDR evaluated RAP-3's five air samples collected inside the Zahn's Corner Middle School and two outdoor air samples collected on the school grounds in May 2019 [NNSA RAP 2019]. These air samples were shipped to the Savannah River Site for radiochemical separation and analysis by alpha spectrometry. The air samples were analyzed for transuranic radionuclides (americium-241, neptunium-237, plutonium-238, and plutonium-239) and uranium isotopes (uranium-234, uranium-235, and uranium-238).

5.3.3.1 Initial screening of radiological data

ATSDR followed the initial screening methodology described in Section 5.2. to evaluate the RAP-3 air sampling data and summarizes the initial screening of the air sampling data by radionuclide in Table 13. U.S. DOE RAP-3 used a forensic methodology that were 1,000 to 10,000 times more sensitive than data reported elsewhere in this document. Therefore, under normal detection methodologies, the detected concentrations in the RAP-3 data would normally be considered non-detects. As shown in Table 13, all the analyses for transuranic radionuclides and uranium-235 sample analyses were below the MDA. Less than 14% of uranium-234 and uranium-238 sample analyses had radioactive concentrations below the MDA. However, all the measured radioactive concentrations in the RAP-3 indoor and outdoor air samples are either below the MDA or close to the MDA with high uncertainties in the measurements. Therefore, ATSDR determined these radiological concentrations are not meaningful and the associated radiological dose estimate also would not be meaningful. In addition, these estimated doses would be so low that ATSDR would not expect any observable adverse health effects. ATSDR concludes that the radioactive concentrations of radionuclides detected in the RAP-3 indoor and outdoor air samples are not at levels expected to harm people's health.

Table 13. Summary of radionuclides in outdoor and indoor air monitoring data from U.S. DOE RAP-3

Radioisotope*	Total analyses	Number of analyses with concentrations below the MDA	Percent (%) of analyses with concentrations below MDA	Number of analyses with concentrations above the MDA	Percent (%) of analysis with concentrations above the MDA
Americium-241	7	7	100	0	0
Neptunium-237	7	7	100	0	0
Plutonium-238	7	7	100	0	0
Plutonium-239	7	7	100	0	0
Uranium-234	7	1	14	6	86
Uranium-235	7	7	100	0	0
Uranium-238	7	0	0	7	100

* All radioisotopes were analyzed by alpha spectroscopy with results reported as microcuries per cubic meter of air.

MDA = minimal detectable activity

5.3.4 Northern Arizona University Outdoor Air Data

5.3.4.1 Initial screening of radiological data

ATSDR evaluated NAU results of their ICP-MS analyses of air filter sections from a local resident's private air monitoring network (May to October 2019), a private air monitor in Seal Township (April 2020 to January 2023), and private air sampler in Scioto Township (August 2019 to July 2022). The NAU data objectives were to determine what transuranic radionuclides or uranium isotopes detected in off-site outdoor air were released from PORTS. The NAU letters dated March 27, 2020, and April 5, 2023, reported the activity measured on the filter for neptunium-237 and uranium isotopes (uranium- 234, uranium-235, uranium-236, and uranium-238) in picocuries per gram of filter material (picocuries/gram) and the mass ratios of uranium isotopes using the number of atoms as the baseline for their results.

In an earlier NAU letter, NAU did not report the amount (volume) of air that passed through the air filters nor did their radioanalytical laboratory results report the results in units of radioactive concentrations, the uncertainty in the measurement of these results, and the MDA. Without this

information ATSDR cannot estimate the radioactive concentration of radiological isotopes per volume of outdoor air (picocuries per cubic meter of air) and determine the validity of outdoor air concentration of radiological isotopes. Therefore, ATSDR is not able to use the NAU results to conduct a public health effects evaluation of radionuclides detected in the outdoor air by local residences.

Table 14 summarizes the results of the NAU ICP-MS analysis of air filter materials collected in Scioto Township and Seal Township from August 10, 2019, through July 24, 2022. These results are presented in picocuries per gram of filter material (picocuries/gram) and the ratios of uranium isotopes are given. The data do show the presence of neptunium-237 and the presence of uranium isotopes collected on the air filters. We can compare the uranium detected on the filters with what would be expected based on the natural distribution of the uranium radioisotopes. For example, in nature the amount of uranium-238 in a gram of natural uranium is about 0.33 µCi/g, the amount of uranium-234 is about 0.34 µCi/g, and the amount of uranium-235 is about 0.015 µCi/g. On a mass basis, these values are about 99.27%, 0.00006%, and 0.72% for uranium-238, uranium-234, and uranium-235, respectively. The values reported by NAU are different from the expected natural abundance of uranium. Without knowing more information regarding the NAU sample collection and methods of analyses, no additional conclusions can be made for these data. It is interesting to note, however, that the values detected in Scioto Township are lower than the values detected in Seal Township although Scioto Township is closer to PORTS.

Table 14. Summary of NAU inductively coupled plasma mass spectroscopy (ICP-MS) analysis of radionuclides in outdoor air monitoring data collected in Scioto Township and Seal Township August 10, 2019, through July 24, 2022

Radioisotope	Scioto Township (picocuries/gram)	Seal Township (picocuries/gram)	Natural (picocuries/gram)
Neptunium-237	0.84 ± 0.01*	1.43 ± 0.92	N/A
Uranium-234/ Uranium-238	0.000151 ± 0.00012	0.000219 ± 0.00021	0.000055
Uranium-235/ Uranium-238	0.0215 ± 0.018	0.0291 ± 0.027	0.0073
Uranium-236/ Uranium-238	0.000021 ± 0.000024	0.000062 ± 0.000140	Uranium-236 is not naturally occurring
Uranium-238 (micrograms/gram)	0.434 ± 0.51	0.633 ± 0.86	Uranium in soil is present at about 3 micrograms per gram of soil (3 parts per million)

* The value following the ± is the standard deviation of the average reported value. If the standard deviation is greater than the reported average, this indicates that the average is highly variable, and the average may be zero.

N/A = not available, transuranic material is not present in the natural background

5.3.5 Health Effects Evaluation of Outdoor and Indoor Air

Based on ATSDR's evaluation of radiological contaminants in ambient (outdoor) air collected from January 2016 to September 2022, ATSDR concludes potential inhalation of radiological contaminants in ambient (outdoor) air by the population living near the PORTS facility is not likely to harm people's health. Based on the initial screening and media-specific screening of the outdoor air datasets, the measured concentrations of radiological contaminants in outdoor air are not at levels likely to cause health effects.

Based on the initial screening evaluation of the radiological contaminants in the indoor air collected at Zahn's Corner Middle School in May 2019, ATSDR concludes that breathing indoor air at Zahn's Corner Middle School is not expected to harm people's health. The reason for this is that the measured radioactive concentrations detected in the school air for individual radionuclides are below the MDA. The large uncertainty in the measured radioactive concentrations make any estimated radiological dose not meaningful. The large uncertainty in concentrations results in large uncertainties in the respective radiation dose which would also not be meaningful; that is, the doses would be so low that ATSDR would not expect any observable adverse health effects as a result of these exposures. Therefore, the radioactive concentrations of radionuclides detected in the indoor air samples are not at levels expected to harm cause harmful health effects.

5.4 Indoor Dust Evaluation

5.4.1 U.S. DOE Radiological Assistance Program (RAP-3)

5.4.1.2 Initial screening of radiological data

In Table 15, the ISP dust sample results show more that 75 percent of the concentrations were below the MDA for the transuranic isotopes americium-241, neptunium-237, plutonium-239, and plutonium-238. Uranium-234, uranium-235, and uranium-238 concentrations were nearly 100 percent above the MDA. The RAP-3 team did not report any results for technetium-99.

5.4.1.2 Media-specific screening

ATSDR evaluated the results of the five RAP-3 swipe samples collected inside the closed Zahn's Corner Middle School in May 2019 [NNSA RAP 2019]. Swipe samples are used to determine if any radioisotopes are present in dusts that have deposited on a surface and, if the material is removable, the swipe samples will give the amount that can be removed. To give a reference area for the swipes, the swipe samples are collected over an area of 100 square centimeters, equal to about 15.5 square inches. The concentration removed is then compared to the limit listed in the Multi-Agency Radiation Survey and Assessment of Materials and Equipment Manual (MARSAME) in Appendix E, Table E.1 which is traceable to 10 CFR 835 Appendix D. The MARSAME is a multi-agency consensus document developed collaboratively by four Federal agencies having authority and control over radioactive materials: Department of Defense (DOD), Department of Energy (DOE), Environmental Protection Agency (EPA), and Nuclear Regulatory Commission (NRC). MARSAME provides information on planning, conducting,

evaluating, and documenting radiological disposition surveys for the assessment of materials and equipment and supplements Multi-Agency Radiation Survey and Site Investigation Manual (MARSSIM).

The RAP-3 swipe samples (Table 15) show that the amounts of radioisotopes that could be removed and were present in the interior dust were less than 0.1% of the applicable amounts allowed. ATSDR concludes that the removable amount of radioactivity in the swipe samples is not at levels expected to harm people's health.

Table 15. Summary of initial screening and radiation concentrations in RAP-3 swipe samples from inside the Zahn's Corner Middle School in May 2019

Isotope	Percent of analyses with concentrations below MDA* (percent)	Average dpm/100 cm^2* adjusted for non-detected levels (1/2 the MDA)	MARSAME Limit for removable radioactivity (dpm/100 cm^2)	Percent of MARSAME Limit for removable radioactivity (percent)
Americium-241	75	0.02	20	0.09
Neptunium-237	100	0.01	20	0.07
Plutonium-239	75	0.02	20	0.08
Plutonium-238	75	0.02	20	0.08
Uranium-234	0	0.09	1000	0.009
Uranium-235	0.01	75	1000	0.002
Uranium-238	0.1	0	1000	0.01

* Disintegrations per minute (dpm) where 1 picocurie is equal to 2.22 dpm

MDA = minimal detectable activity

5.4.2 Independent Sampling Plan Dust Data

ATSDR evaluated the results of the 228 ISP swipe samples (settled dust on interior surfaces) collected within the 6-mile study area from September 2020 to February 2021. This sampling effort was designed to show if any radioisotopes were present on the surface and if that radioactive material could be removed. As ATSDR evaluated the RAP-3 swipe samples, the same procedure was used to evaluate the ISP surface wipe data.

5.4.2.1 Initial screening of radiological data

The ISP dust sample results in Table 16 show more that 75 percent of the results were below the MDA for the transuranic isotopes americium-241, neptunium-237, plutonium-239, and plutonium-238. Also, the technetium-99 had 98 percent of results below the MDA. More than 70 percent of the uranium-234 and uranium-238 results were present above the MDA and 97 percent of uranium-235 results were below the MDA.

5.4.2.2 Media-specific screening

In Table 16, the ISP surface swipes (dusts) show that statistically, no transuranic elements are present in these dust samples. A value of less than 1 disintegrations per minute (dpm) should be considered a non-detect; that is, not detectable on the surface wipe. This does not mean the surfaces are not contaminated, only any contamination present on the surfaces is fixed in place and not removeable by ordinary means. The evaluation of the uranium isotopes suggests that the dust on the surface swipes is derived from normal dust or soils present in the area. Additionally, the removable uranium-234 and uranium-238 were present at equal activities indicating these samples are most likely related to the natural soil concentrations of uranium in nature.

In Table 16, The ISP interior dust concentration results (Table 16) show that the amounts of radioisotopes that could be removed and were present in the interior dusts were less than 2% of the applicable amounts allowed. ATSDR concludes that the removable amount of radioactivity in the swipe samples is not at levels expected to harm people's health.

Table 16. Summary of initial screening of radiation concentrations in Independent Sampling Plan settled dust on interior surface swipes from September 2020 to February 2011

Isotope	Percent of analyses with concentrations below MDA* (percent)	Average dpm*/100 cm^2 adjusted for non-detected levels (1/2 the MDA)	MARSAME Limit for removable radioactivity (dpm/100 cm^2)	Percent of MARSAME Limit for removable radioactivity (percent)
Americium-241	82	0.2	20	1
Neptunium-237	97	0.2	20	1
Plutonium-239	87	0.4	20	2
Plutonium-238	68	0.2	20	1
Technetium-99	98	4	1000	0.4
Uranium-233/234	24	1	1000	0.1
Uranium-235/236	97	0.2	1000	0.02
Uranium-238	23	1	1000	0.1

* Disintegrations per minute (dpm) where 1 picocurie is equal to 2.22 dpm. A value of less than 1 dpm should be considered a non-detect; that is, not detectable on the surface wipe.

† The natural atom ratio was calculated by determining the number of atoms in a picocurie of each radionuclide.

5.4.3 Northern Arizona University Dust Data

In 2022, a local resident performed surface swipes in his attic using “baby wipes” to collect dust in the attic and living spaces in a residence in Lucasville, Ohio. The resident sent these swipes to a representative of NAU for analysis. NAU analyzed the samples by treating the samples with an ion exchange system that removes the uranium. The uranium was then washed from the ion exchange media and then was evaluated by the ICP-MS system for uranium isotopes (uranium-234, uranium-235, uranium-238, and uranium-236). The results of these analyses were sent to the resident and the findings discussed in a letter dated June 21, 2022. See Table 17 for the results and the ATSDR analyses of these surface swipes.

5.4.3.1 Initial screening of radiological data

ATSDR evaluated the results in the NAU letter dated June 21, 2022, of nine “baby wipe” fabric wipe samples. Included with the samples were baby wipes unused by the resident to serve as blanks. These blanks also contained uranium as indicated. ATSDR was not able to review the results of these samples for the purposes of a public health discussion since the results were only given in terms of atom ratios and there was no indication of the size (area) covered by the surface swipes. We would have to have the data presented in terms of atoms per square centimeter or picocuries per square centimeter for the data to be usable for public health purposes.

5.4.3.2 Media-specific screening

ATSDR reviewed the results submitted in the June 2022 letter in which the results were not expressed as activity per square centimeter or per 100 square centimeters. Unlike the RAP-3 data or the ISP data, NAU reported their results in terms of a ratio of the mass of the detected uranium isotopes. Using a ratio for the purposes of a public health determination is not a valid method unless one knows one of the concentrations of a component of the ratio. NAU did state, however, that the mass ratio of uranium-235/uranium-238 was not significantly different from the naturally occurring ratio. The results of the NAU analysis are shown in Table7. ATSDR also compared the ratio reported by NAU to the expected ratio associated with naturally occurring uranium. The ratios reported by NAU were in excess of the expected ratio; however, there was little difference percentage wise between the ratio of uranium-235/uranium-238 and uranium-234/uranium-238.

ATSDR cannot compare the removable radioactive concentrations on the baby wipe samples to the limit listed in the MARSAME because the NAU results were not expressed as activity per square centimeter or per 100 square centimeters. Therefore, ATSDR is not able to use the NAU dust swipe results to conduct a public health effects evaluation of removable radionuclides in dust samples collected by local residents.

Table 17. Residential surface wipe samples and comparison to natural ratio of uranium radionuclides

Sample description*	Uranium-235/Uranium-238 ratio	Percent of the natural atom ratio†	Uranium-234/Uranium-Uranium-238	Percent of the natural atom ratio
Roof and dust rafter lying there	0.0236	321	0.000175	313
Rafter, attic east side	0.0094	128	0.000071	127
North end attic, below vent looks like a ledge	0.0092	125	0.000069	123
Dust from attic door cover	0.0306	416	0.000218	389
Dust off cold air return - attic	0.0211	287	0.000157	280
Wipe inside	0.0114	287	0.000096	171
Air conditioner coil	0.014	190	0.000112	200
1/11/22 vent from furnace to dining room	0.0172	234	0.000136	243
Air conditioner coil drain	0.0163	222	0.000131	234

* The sample descriptions are as stated in the June 21, 2022, letter.

† The natural atom ratio was calculated by determining the number of atoms in a picocurie of each radionuclide.

5.4.4 Health Effects Evaluation of Interior Dust

Based on media specific screening of the radiological contaminants in the interior dust samples collected inside residences and buildings within the 6-mile study area during the time period of May 2019 to June 2022, ATSDR concludes potential incidental ingestion, inhalation, or direct contact with the amounts of radioisotopes that could be removed and were present in the interior dust are not at levels that could cause harmful health effects to people living near the PORTS facility. ATSDR concludes that the removable amount of radioactivity in the swipe samples is not expected to harm people's health.

5.5 Soil Evaluation

ATSDR evaluated the potential exposure pathway via incidental ingestion of radiological contaminants in soil to the general population living near the PORTS facility. To evaluate the soil pathway, ATSDR screened available soil data provided by the ISP and U.S. DOE. Each organization's sampling results are discussed separately. However, the supporting information discussing environmental levels reported by other groups is identical and is discussed next.

In the environment, concentrations of transuranic isotopes are highly variable (See Table 18). In a 1999 study, Kelly, Bond, and Beasley determined the amounts of both neptunium-237 and plutonium isotopes in soil samples from 54 locations around the world. Included in those 54 sample locations were 21 samples collected in the United States. The results were given in units of atoms per square meter (Kelly, et al., 1999). After converting the square meters to grams of soil at a depth of 1 centimeter and using an average soil density of 1.6 g/cm^3, ATSDR estimates the neptunium-237 in the United States to be 0.00033 pCi/g and the concentration of plutonium-239 to be about 0.12 pCi/g. There were two places in the United States where the concentrations of neptunium-237 and plutonium-239 were elevated, Hawaii was elevated for neptunium-237 and the Nevada Test Site was elevated for plutonium-239 (Kelly, et al., 1999). ATSDR also converted these atom concentrations to activity concentrations. The converted values showed that the neptunium-237 was about 0.0003 pCi/g and the concentration of plutonium-239 was 0.069 pCi/g. A study of sediments collected in Alaska reported the levels of plutonium-238 were less than 0.002 pCi/g, the levels of plutonium-239/240 were less than 0.013 pCi/g, and the levels of americium-241 were less than 0.003 pCi/g [Efurd, et al., 1997]. However, the latitude of the sampling locations impacts the plutonium concentrations. For example, Hardy, Krey, and Volchok in 1973 reported that the plutonium-239/240 deposition in latitudes similar to PORTS was 1.8 millicuries per square kilometer; however, in Alaska, the deposition was 0.36 millicuries per square kilometer. Following the explosion of the Chernobyl nuclear power plant in 1986, the radionuclides released to the atmosphere did not release significant amounts of plutonium and the ratio of the released plutonium-240 to the released plutonium-239 was much different from global fallout (about 0.5 versus about 0.2 for global fallout). These results were reported by Meusburger and coworkers in 2020 [Meusburger et al., 2020]. See Table 18 for examples of the background concentrations of transuranic elements and uranium in the environment.

Studies evaluating the typical naturally occurring concentrations of uranium across the globe are well-documented. In general, the average natural background uranium-238 concentration in soil is about 1 pCi/g, but this is highly dependent on soil type. Soils high in sand are typically low in uranium. Soils from other rock types, including fertilizers and coal, can be quite high in uranium [Eisenbud, 1987]. In 1983, Myrick and coworkers collected soil samples across the United States. In this study, 12 samples were collected throughout Ohio. The uranium-238 national average concentration was measured at 1.0 ± 0.83 pCi/g ranging from 0.12 to 3.8 pCi/g. In Ohio, the average uranium-238 concentration was 1.4 ± 0.79 pCi/g with a range of 0.76 to 2.2 pCi/g [Myrick, et al., 1983].

Table 18. Typical environmental background concentrations of radioisotopes in soil and sediments

Radionuclide	Typical concentrations in soils and sediment (pCi/g)
Americium-241	0.002§
Neptunium-237	0.0003†
Plutonium-238	~0.02 to 0.04 pCi/m^2*
Plutonium-239/240**	0.003§ 0.07†
Technetium-99	Typically not detected or reported
Uranium-233/234	1.0#
Uranium-235/236	0.005@
Uranium-238	1.00 (Ohio range 0.72 – 2.2‡)

* Hardy, EP, Krey PW, and Volchok, HL (1973). Nature 241:444-445. These values are decay corrected to 2022. Continental U.S. ranges depend on latitude.
† Kelly, JM, Bond, LA, and Beasley, TM (1999) Science of the Total Environment 237/238:483-500.
‡ Myrick, TE, Berven, BA, and Haywood, FF (1983) Health Physics 45:631-642.
§ Harrison JJ, Zawadzki A, Chisari, R and Wong HKY (2011) J Environmental Radioactivity 102:896-900.
# USA, calculated from uranium-238.
@ Calculated based on chemical abundance in natural uranium.
** When a radioisotope is identified with two numbers such as plutonium-239/240, this indicates that the analytical procedure is not designed to separate the two forms of the radionuclide. This is also true for uranium-233/234 and uranium-235/236.

pCi/g = picocurie per gram

5.5.1 Independent Sampling Plan Soil Data

See Table 19 below for the number of sample analyses for soil. ATSDR screened available soil data to determine whether radiological concentrations were above natural background levels and/or ATSDR's comparison values.

Table 19: Number of soil radiological sample analyses

	ISP soil data	U.S. DOE soil data
Total number of sample analyses	6518	697

ATSDR evaluated ISP soil samples collected from the off-site locations within 6 miles of the perimeter of the PORTS industrial area from October 4, 2020, through February 17, 2022. This study area size was selected by the CCSE to focus on residential properties or those properties for which people were most likely to be exposed to PORTS releases [Solutient 2020]. The soil samples were analyzed for transuranic radionuclides (americium-241, neptunium-237, plutonium-238, and plutonium-239/240), technetium-

99, and uranium isotopes (uranium-234, uranium-235, and uranium-238). The ATSDR evaluation of these soil samples is shown in Table 20.

5.5.1.1 Initial screening of radiological data

As shown in Table 20, more than 82% of the analyses for neptunium-237, plutonium-238, and technetium-99 showed the results were less than the MDA. This indicates that for these radionuclides, the majority of radiological concentrations were below the statistical detection limit and the results would be considered zero (0); that is, not detectable in the soil. Americium-241 had 72 percent and plutonium-239/240 had 46 percent of analyses with radioactive concentrations below the MDA. The uranium-234, uranium-235, and uranium-238 have a low percentage of less than 2 percent of sample analyses with concentrations below the MDA, are naturally occurring at higher concentrations and therefore easier to detect. To adjust for concentrations below the MDA, ATSDR replaced all the non-detect values (less than MDA) with ½ of the MDA. This allows ATSDR to still evaluate these data despite limitations in method detection. Therefore, all sample analyses were included to estimate the average radiation concentration of each radionuclide in soil.

Table 20. Summary of initial screening of Independent Sampling Plan off-site soil data by radionuclide

Radionuclides	Number of analyses	Number of analyses with concentrations below MDA	Percent of analyses with concentrations below MDA	Average soil concentration (pCi/g)†	Typical natural background levels (pCi/g)
Americium-241	983	705	72	0.01	0
Neptunium-237	1075	1019	95	0.007	0
Plutonium-239/240	1075	493	46	0.01	0
Plutonium-238	1075	970	90	0.007	0
Technetium-99	1079	887	82	0.3	0
Uranium-234	1075	1	<0.1	1.2	1.4*
Uranium-235	1075	19	1.8	0.06	0.06*
Uranium-238	1075	0	0	1.3	1.4 ± 0.79‡

* Myrick, TE, Berven, BA, and Haywood, FF (1983) Health Physics 45:631-642

† The average concentrations have been adjusted to compensate for those samples below the MDA, using ½ the MDA as the reported concentration.

‡ Calculated from the natural distribution of uranium and the radioactive ratio of uranium-235/uranium-238.

MDA = minimal detectable activity

5.5.1.2 Media-specific screening

Average concentrations of the uranium radionuclides in the soil are close to the typical natural background levels (Table 20) and as previously reported by Myrick, et al. [1983] for Ohio soils (see Section 5.6 for supporting discussion). There is no significant difference between the reported average uranium isotopic concentrations and the reported concentrations found in nature. The concentration of the transuranic elements and technetium-99 are in excess of the typical background concentrations.

Prior to atmospheric testing of nuclear weapons and the atomic age, transuranic elements were not found in the environment. The element technetium was not discovered until 1937 and only after nuclear reactors were constructed were large amounts produced. The presence of these materials is considered zero (0) in the natural background. If one considers the presence of fallout materials as part of the "natural" or man-made environment, then they are present. For this health consultation, we are using natural background prior to atmospheric testing. That is, transuranic and technetium are not present.

Because the transuranic elements and the concentration of technetium-99 were greater than the expected background concentrations, ATSDR performed a generic dose calculation for an individual who may ingest some of these contaminated soils. We used a default ingestion of 100 milligrams of soil every day for one year. The results indicate that estimated dose for the transuranic elements was less than 1 mrem/year for an internal dose. The estimated dose from the technetium-99 is also less than 1 mrem using the radiation dose coefficients summarized and published in ICRP Publication 119. Because these estimated radiological doses are extremely low, ATSDR would not expect any observable adverse health effects. ATSDR concludes that the radioactive concentrations of radionuclides detected in the ISP soil samples are not at levels expected to harm people's health.

5.5.2 U.S. DOE PEGASIS Soil Data

ATSDR evaluated U.S. DOE PEGASIS soil sampling data collected from 2016 to 2020 at several areas within the fence line of PORTS as well as outside the primary plant boundary. The soil samples were analyzed for transuranic radionuclides (a-241, neptunium-237, plutonium-238, and plutonium-239/240), technetium-99, and uranium isotopes (uranium-234, uranium-235, and uranium-238).

5.5.2.1 Initial screening of radiological data

As shown in Table 21, more than 84% of the analyses for plutonium-238, neptunium-237, and technetium-99 showed the results were less than the MDA. This indicates that for these radionuclides, the majority of radiological concentrations were below the statistical detection limit and the results would be zero (0); that is, considered not present in the soil. Americium-241 had 73 percent and plutonium-239/240 had 24 percent of analyses with radioactive concentrations below the MDA. As previously discussed, natural background does not contain either transuranics or technetium. However, their presence is seen as a result of human activities. It is possible that the presence of these materials is either related to fallout or operations at PORTS. Since the majority of the samples were below the detection limit, ATSDR concludes that there is no hazard to public health from these extremely low concentrations.

Uranium-234, uranium-235, and uranium-238 had all (100%) of the sample analyses with radioactive concentrations above the MDA. In comparing the reported results to the natural background concentrations of uranium in soils from Ohio, there is no significant difference to previously reported results from the 1983 Myrick paper [Myrick, et al., 1983].

Although the detected levels of the transuranic elements and technetium are close to the MDA, ATSDR used standard intake values to estimate a radiological dose following the intake of 100 milligrams of soil every day for a year. Using the dose coefficients published in ICRP 119, the estimated radiological dose from americium-241, plutonium isotopes, and technetium-99 was less than 1 mrem/year. Since the dose is so low, and based on studies of radium dial painters [Rowland, 1994], ATSDR concludes the soil dose is below levels expected to harm people's health.

Table 21. Summary of initial screening of U.S. DOE PEGASIS soil data by radionuclide

Radionuclides	Number of analyses	Number of analyses with concentrations below MDA	Percent of analyses with concentrations below MDA	Average soil concentration (pCi/g) #	Typical natural background levels (pCi/g)
Americium-241	85	64	73	0.01	0*
Neptunium-237	85	71	84	0.007	0
Plutonium-239/240	85	77	91	0.01	0
Plutonium-238	85	75	89	0.007	0
Technetium-99	85	20	24	0.3	0
Uranium-234	85	0	0	1.2	1.4†
Uranium-235	85	0	0	0.06	0.06†
Uranium-238	85	0	0	1.3	1.4 ± 0.79‡

* The transuranic elements are considered not naturally occurring and are only present in environmental samples because of human activities.
† Calculated from the activity of uranium-238 and based on radioactive decay kinetics (secular equilibrium).
‡ Calculated from the natural distribution of uranium and the radioactive ratio of uranium-235/uranium-238.
§ The uranium-238 concentration background levels are for Ohio as reported by Myrick in 1983.
# Average concentrations have been adjusted to compensate for those samples below the MDA, using ½ the MDA as the reported concentration.

MDA = minimal detectable activity; pCi/g - picocuries per gram

5.5.2.2 Media-specific screening

The ATSDR evaluation of U.S. DOE radioisotopes in soils is the same procedure we used for the ISP soils.

Average concentrations of the uranium radionuclides in the soil are close to the typical natural background concentrations (Table 21) and as previously reported by Myrick, et al. [1983] for Ohio soils (see Section 5.6 for supporting discussion). There is no significant difference between the reported average uranium isotopic concentrations and the reported concentrations found in nature. The concentration of the transuranic elements and technetium-99 are in excess of the typical background concentrations.

In some respects, the data are not sufficient to perform a detailed human radiological dose assessment, either. From the information available, ATSDR concludes the current levels in the environment are sufficiently low as to not be a public health hazard to the surrounding population. This determination is based on peer reviewed human health studies of former radiation dial painters whose radiation doses

were thousands of times higher than the estimated the average radiation doses from these materials in the environment around PORTS as discussed previously and cited by Rowland (1994).

Because the transuranic elements and the concentration of technetium-99 were greater than the expected natural background concentrations, ATSDR performed a generic dose calculation for an individual who may ingest some of these contaminated soils. We used a default ingestion of 100 milligrams of soil every day for one year. The results indicate that estimated dose for the transuranic elements was less than 1 mrem/year for an internal dose. The estimated dose from the technetium-99 is also less than 1 mrem using the radiation dose coefficients summarized and published in ICRP Publication 119. Because these estimated radiological doses are extremely low, ATSDR would not expect any observable adverse health effects. ATSDR concludes that the radioactive concentrations of radionuclides detected in the ISP soil samples are not at levels expected to harm people's health.

5.5.3 Health Effects Evaluation of Soil

Based on media specific screening of the radiological contaminants in soil samples collected between 2016 and 2022 within the 6-mile study area outside the PORTS boundary and within the fence line of PORTS. ATSDR concludes potential incidental ingestion or dermal contact with the amounts of radioisotopes in soils is not likely to harm people living near the PORTS facility. The radiological concentrations of radionuclides detected in the soil are not at levels known to cause observable health effects and ATSDR concludes that levels are not expected to harm people's health.

5.6 Sediment Evaluation

Radioisotopes in sediments were evaluated using the same procedures as soils. In many respects, the sediment will contain the same isotopes as in soils (see Section 5.6). Sediments represent the soils that water passes through and these materials will settle out forming creek and riverbeds. Using the concentrations of radioisotopes in soils as an indicator of the concentrations in sediment is an acceptable method of comparison. ATSDR evaluated the potential exposure pathway via incidental ingestion and dermal contact exposure of the general population living near the PORTS facility to radiological contaminants in sediments near PORTS NPDES outfalls, Big Beaver Creek, Little Beaver Creek, Scioto River, and retention ponds. To evaluate the sediment exposure pathway, ATSDR screened available sediment data provided by the ISP and U.S. DOE to determine whether radiological concentrations were above natural background levels and/or ATSDR's comparison values.

5.6.1 Independent Sampling Plan Sediment Data

ATSDR evaluated the 32 ISP radiological sediment sampling data collected in creeks, ponds, and the Scioto River within the 6-mile radius surrounding the PORTS property boundary from October 4, 2020, through February 17, 2022. The sediment samples were analyzed for transuranic radionuclides (americium-241, neptunium-237, plutonium-238, and plutonium-239/240), technetium-99, uranium, and uranium isotopes (uranium-234, uranium-235, and uranium-238). The ATSDR analysis of these data is presented in Table 20.

5.6.1.1 Initial Screening of radiological data

As shown in Table 22, more than 91% of the sediment analyses for neptunium-237, plutonium-238, and technetium-99 showed the results was less than the MDA. This indicates that for these radionuclides,

the majority of radiological concentrations were below the statistical detection limit and the results would be considered zero (0); that is, not detectable in the sediment. Americium-241 had 66 percent and plutonium-239/240 had 56 percent of analyses with radioactive concentrations below the MDA. All uranium-234, uranium-235, and uranium-238 concentrations were above the MDA are naturally occurring at high concentrations and therefore easier to detect.. To adjust for concentrations below the MDA, ATSDR replaced all the non-detect values (less than MDA) with ½ of the MDA. This allows ATSDR to still evaluate these data despite limitations in method detection. Therefore, all sample analyses were included to estimate the average radiation concentration of each radionuclide in sediment.

Table 22. Summary of initial screening of Independent Sampling Plan sediment data by radionuclide

Radionuclides	Number of analyses	Number of analyses with concentrations below MDA	Percent of analyses with concentrations below MDA	Average sediment concentration (pCi/g)	Typical natural background levels in soils (pCi/g)
Americium-241	32	21	66	0.0076	0
Neptunium-237	32	30	94	0.006	0
Plutonium-239/240	32	18	56	0.0085	0
Plutonium-238	32	29	91	0.0056	0
Technetium-99	33	32	97	0.16	0
Uranium-234	32	0	0	1.49	1.4†
Uranium-235	32	0	0	0.062	0.06†
Uranium-238	32	0	0	1.43	0.79‡

* Average concentrations have been adjusted to compensate for those samples below the MDA, using ½ the MDA as the reported concentration.
† Calculated from the activity of uranium-238 and based on radioactive decay kinetics (secular equilibrium).
‡ Calculated from the natural distribution of uranium and the radioactive ratio of uranium-235/uranium-238.
§ The uranium-238 concentration background levels are for Ohio as reported by Myrick in 1983.
MDA = minimal detectable activity; pCi/g = picocuries per gram

5.6.1.2 Media-specific screening

The independent sampling effort collected sediment samples from several creeks in their 6-mile radius study area around the PORTS property boundary. The samples were analyzed from several transuranic elements, uranium isotopes, and the fission product technetium-99, a beta emitter. In the natural environment, only uranium is found with any regularity as the other materials are considered either fallout products or could have been released from PORTS operations. In this public health consultation, ATSDR is not tasked with the determination of the source these materials, only if they are present at a concentration that might impact the health of the residents around PORTS.

In the case of the uranium isotopes, there does not appear to be any significant excess uranium in the environment as the detected uranium in the sediments is essentially identical to the typical background levels of uranium in the state of Ohio as reported by Myrick, et al. (1983) and discussed previously in Section 5.6.

The results of the transuranic analyses are greater than the reported sediment concentrations as reported by Hardy and coworkers in 1973. However, the atmospheric deposition of the transuranics has been shown also to be dependent on the latitude of the sampling locations. For example, in Alaska, the deposition of plutonium isotopes was about 0.36 millicuries per square kilometer but in latitudes similar to PORTS, the deposition was about 1.8 millicuries per square kilometer. This difference in latitude deposition may explain why the isotope concentrations in sediment samples collected by ISP are higher than those reported by Efurd and coworkers in 1997.

Although the detected levels of the transuranic elements were higher than previously reported levels in sediment, the concentrations are close to the MDAs. A preliminary dose assessment was made using a standard intake of 100 milligrams of sediment daily for a year. This assessment gave an estimated radiological dose from americium-241, plutonium isotopes, and technetium-99 of less than 1 mrem/year. Since the dose is so low, and based on previously discussed studies of radium dial painters, ATSDR concludes the sediment dose is below levels expected to harm people's health.

5.6.2 U.S. DOE PEGASIS & ASER Sediments

ATSDR evaluated U.S. DOE PEGASIS sediment sampling data collected from several creeks, NPDES outfalls, and retention ponds within the fence line of PORTS from 2016 to 2020. These locations include the NPDES outfalls on the east and west sides of PORTS and a location on Big Beaver Creek upstream from the confluence with Little Beaver Creek. The sediment samples were analyzed for transuranic radionuclides (americium-241, neptunium-237, plutonium-238, and plutonium-239/240),technetium-99, uranium, and uranium isotopes (uranium-234, uranium-235, and uranium-238).

5.6.2.1 Initial screening of radiological data

As shown in Table 23, more than 83% of the analyses for neptunium-237, plutonium-238, and technetium-99 showed the results were less than the MDA. This indicates that for these radionuclides, the majority of radiological concentrations were below the statistical detection limit and the results would be zero (0); that is, not detectable in the sediment. Americium-241 had 85 percent and plutonium-239/240 had 67 percent of analyses with radioactive concentrations below the MDA. All the uranium-233/234 and uranium-238 concentrations were above the MDA. Uranium-235/236 had 92% of concentrations above the MDA. The uranium isotopes are naturally occurring at high concentrations and therefore easier to detect. To adjust for concentrations below the MDA, ATSDR replaced all the non-detect values (less than MDA) with ½ of the MDA. This allows ATSDR to still evaluate these data despite limitations in method detection. Therefore, all sediment analyses were included to estimate the average radiation concentration of each radionuclide in sediment.

Table 23. Summary of initial screening of the U.S. DOE sediment data by radionuclide

Radionuclides	Number of analyses	Number of analyses with concentrations below MDA	Percent of analyses with concentrations below MDA	Average sediment concentration (pCi/g)	Typical natural radiological background levels in soils (pCi/g)

Americium-241	100	85	85	0.0044	0
Neptunium-237	100	83	83	0.005	0
Plutonium-239/240	100	67	67	0.007	0
Plutonium-238	100	95	95	0.004	0
Technetium-99	100	56	56	1.1	0
Uranium-233/234	102	0	0	1.4	1.4†
Uranium-235/236	102	9	8	0.07	0.06†
Uranium-238	102	0	0	0.7	0.79‡

* Average concentrations have been adjusted to compensate for those samples below the MDA, using ½ the MDA as the reported concentration.
† Calculated from the activity of uranium-238 and based on radioactive decay kinetics (secular equilibrium)
‡ Calculated from the natural distribution of uranium and the radioactive ratio of uranium-235/uranium-238.
§ The uranium-238 concentration background levels are for Ohio as reported by Myrick in 1983.

MDA= minimal detectable activity; pCi/g= picocuries per gram

5.6.2.2 Media-specific screening

The U.S. DOE sediment sampling effort collected sediment samples from several creeks around the PORTS facility. The samples were analyzed from several transuranic elements, uranium isotopes, and the fission product technetium-99, a beta emitter. In the natural environment, only uranium is found with any regularity as the other materials are considered either fallout products or could have been released from PORTS operations. In this public health document, ATSDR is not tasked with the determining the source of these materials, only if they are present at a concentration that might impact the health of the residents around PORTS.

In the case of the uranium isotopes, there does not appear to be any significant excess uranium in the environment as the detected uranium in the sediments is essentially identical to the typical background levels of uranium in the state of Ohio as reported by Myrick, et al. [1983]. Although the uranium-238 sediment concentration was lower than expected, the uranium chemical form will greatly affect its water solubility ATSDR [1999]. No other conclusions on the uranium concentrations are made from these particular results.

The concentrations of the transuranic elements and technetium-99 in soils and sediments are more varied that uranium. The variations are related to fallout distributions across the globe. Please see previous discussion on the variability of the transuranic elements above.

Although the detected levels of the transuranic elements and technetium-99 were higher than previously reported levels in sediment, the concentrations reported by U.S. DOE are very low. A preliminary dose assessment was made using a standard intake of 100 milligrams of sediment daily for a year. This assessment gave an estimated radiological dose from americium-241, plutonium isotopes, and technetium-99 of less than 1 mrem/year. Since the dose is so low, and based on previously discussed

studies of radium dial painters, ATSDR believes the sediment dose is below levels expected to harm people's health.

5.6.3 Health Effects Evaluation of Sediment

Based on media-specific screening of the radiological contaminants in sediment samples collected between 2016 and 2022, and within the 6-mile study area outside the PORTS boundary and within the fence line of PORTS, ATSDR concludes potential incidental ingestion or dermal contact with the amount of radioisotopes in sediments is not likely to harm people living near the PORTS facility. The reason is that the concentrations of radionuclides detected in the sediment are not at levels known to cause observable health effects. ATSDR concludes that the radioactive concentrations of radionuclides detected in the sediment are not at levels expected to harm people's health.

5.7 Surface Water Evaluation

5.7.1 Independent Sampling Plan

ATSDR evaluated ISP radiological surface water data collected in creeks, rivers, and ponds within 6 miles of the perimeter of PORTS industrial area from October 4, 2020, through February 17, 2022.

5.7.1.1 Media-specific screening

For the evaluation of surface water, typical surface water concentrations do not exist as the radioisotopes dissolved in water depend greatly on the soils in which the water flows and the source of the groundwater that intersects the surface water. Also affecting the concentration of the materials possibly dissolved in water are the water temperature and the characteristics and quality of the water itself.

The average surface water concentrations of the transuranic elements in the ISP reports were less than 0.5 pCi/L as shown in Table 25. The average concentration of Technetium-99 was less than 3 pCi/L; whereas, the average concentrations of uranium radioisotopes were less than 0.4 pCi/L. To determine if these concentrations were of public health concern, ATSDR evaluated the data against U.S. EPA maximum contaminant levels and the regulatory limit of 4 mrem/year when ingesting two (2) liters of water per day.

As a surrogate for the evaluation of surface waters, ATSDR applies the contaminant levels that are enforced by the U.S. EPA for the consumption of drinking water supplied by public water systems (not private wells). These concentrations are known as the U.S. EPA MCLs, and there are specific MCL values for only a few radioisotopes. The U.S. EPA drinking water radiation dose limit is 4 mrem/year regardless of radioisotope. Therefore, other radioisotopes' MCL can be derived. Different dosimetric methods can be used to derive the 4 mrem/year MCL using radiologic dose coefficients that have been developed by national and international radiation protection organizations. ATSDR calculated estimated derived radiological MCLs that will yield a radiologic dose of 4 mrem/year if it were the only radioisotope ingested in drinking water. These calculated radiological MCLs are presented in Table 24.

Table 24. ATSDR derived maximum contaminant levels (MCLs) for PORTS radionuclides found in surface waters

Radionuclide	U.S. EPA MCL based on the 2000 U.S. EPA rule (pCi/L)	Federal Guidance Report 13 (FGR 13) dose coefficient (rem/curie)	ATSDR derived radiological MCL (pCi/L) based on a dose of 4 mrem per year
Americium-241	15 (gross alpha MCL)	755000	7.3
Neptunium-237	15 (gross alpha MCL)	396000	14
Plutonium-238	Not given	844000	6.5
Plutonium-239/240	15 (gross alpha MCL)	928000	5.9
Technetium-99	Not given	2370	2310
Uranium (natural)	30 micrograms per liter (chemical MCL)	404500 (Derived from isotopic abundance)	15
Uranium-234	Not given	183000	30
Uranium-235	Not given	173000	32
Uranium-238	Not given	165000	33

* ATSDR derived radiological MCLs were calculated by dividing 4 mrem/year by 730 liters of water intake and by the FGR 13 dose coefficient.

U.S. EPA MCL = U.S. Environmental Protection Agency, 40 CFR 141; pCi/L= picocuries per liter; rem/curie – rem per curie

Surface waters were sampled during the ISP effort and the results are shown in Table 25. All detected isotopes were less than the ATSDR derived radiological MCLs and the estimated doses are less than 4 mrem/year. ATSDR concludes that the radioactive concentrations of radionuclides detected in the surface water are not levels expected to harm people's health.

Table 25. ISP radioisotope concentrations in surface water compared to the ATSDR derived concentration to give 4 millirem per year

Radioisotope	Average concentration (pCi/L)	ATSDR derived radiological MCL	Total analyses	Number below MDA	% below MDA
Americium-241	0.07	7.3	53	42	79.2
Plutonium-238	0.05	6.5	53	48	90.6
Plutonium-239/240	0.4	5.9	53	36	67.9
Technetium-99	2.3	14	48	48	100
Neptunium-237	0.07	2310	53	53	100
Uranium-234	0.3	30	53	16	30.2
Uranium-235	0.05	32	53	51	96.2
Uranium-238	0.2	33	53	17	32.1

* The total analyses number includes samples collected for determination of background levels as well as samples collected in the study around PORTS. Also included in the total analyses are any duplicate samples collected for quality control and quality assurance.

5.7.2 Health Effects Evaluation of Surface Water

Based on media-specific screening of the radiological contaminants in surface water samples collected within the 6-mile study area from 2020 2022, ATSDR concludes potential incidental ingestion with the amount of radioisotopes in surface water is not likely to harm the health of people living near the PORTS facility. The reason is that the radiological concentrations of radionuclides detected in the surface water are not at levels known to cause observable health effects and are below the regulatory levels for public water supplies. ATSDR concludes that the radioactive concentrations of radionuclides detected in the surface water are not levels expected to harm people's health.

5.8 Summary of Limitations and Uncertainties

Throughout this public health consultation, ATSDR has discussed several limitations to the data the agency received and analyzed. These limitations are summarized in this section. The presence of limitations in the data are not necessarily significant when taken individually but could affect the overall conclusions of the document.

1. The data supplied to ATSDR was quite extensive in that large number of samples were collected by both the U.S. DOE and Solutient for the Independent Sampling Plan. The number of samples was not the limitation. However, the number of samples in which the results were greater than the MDA was very low. Since the majority of the samples were below the MDA, the overall sample averages and the spatial distribution of those samples does not allow for a detailed analysis of contaminant location in the environment.

2. During the ATSDR site visit in 2022, we travelled to the Otway area but were unable to find the background air monitoring station. Although this not a severe limitation, knowing the surrounding environment near a background can give an assessor insight into the activities that might alter background determinations.

3. The data ATSDR received from the Northern Arizona University researcher was given in terms of atoms or a ratio of atoms. We did not receive information on the air flow through the filters (the volume of air needed to calculate concentrations). For the surface swipes, we did not receive the swipe areas. Without knowing the activities detected per square centimeter, we could not determine if the materials detected were at levels of public health concern.

4. Uncertainties in radiation counting and radiation detection are important factors to consider. All determinations of radioactivity are statistical in nature. This means that there is always an unknown contribution to the various results. These uncertainties are a function of the sample collection, laboratory preparation of the environmental samples, and the radiation detection instrumentation itself. As the amount of radioactivity to be detected decreases, the uncertainty increases until at some point, one cannot differentiate a radiation detection to either a background contribution or true instrument response. This is similar to meeting the requirements for the MDA.

How ATSDR addressed these limitations has been discussed previously such as replacing those values below the MDA with a value of ½ the MDA. Our reasoning is that if you replace the MDA with zero (0), you artificially lower the overall average. Likewise, replacing the non-detect result with the MDA will artificially raise the overall true but unknown average. We believe that substituting the non-detect result with a value of ½ the MDA gives a better understanding of the sample distributions.

In the case of performing an initial dose assessment, using the adjusted averages when using the ½ MDA method and using default standardized assumptions for soil intakes, water intakes, or breathing rates we believe gives a median estimate of the dose. A more detailed dose assessment requires more precise estimates of the environmental conditions than what we have for this site.

6. Conclusions

ATSDR concludes that exposure to radionuclides in the off-site outdoor air, soil, sediment, indoor dust, and surface water within a 6-mile radius of the U.S. DOE PORTS facility from 2016 to 2022 is not expected to harm people's health. The reason for this is the environmental samples collected in this off-site area and timeframe contained radionuclides at levels not expected to cause harmful health effects.

6.1 Basis for conclusion:

- Based on the available environmental samples collected in this off-site area and timeframe, almost all the radionuclides were detected in each of media at radiological concentrations below media-specific screening values considered safe and are much lower than concentrations observed to cause adverse health effects in human studies. For the various uranium radionuclides, the radiological concentrations were within background concentration ranges of radionuclides found in Ohio and across the globe. For the few environmental samples with

transuranic radionuclides detected above screening values and above background levels, the measured concentrations resulted in estimated radiological doses that are more than ten thousand times lower than doses that have been observed to cause adverse health effects in human studies as reported in the peer-reviewed scientific literature.

The basis for the no public health hazard conclusion is presented below by media.

6.1.1 Outdoor Air

6.1.1.1 U.S. DOE air monitoring stations from 2016-2020

- The concentrations of americium-241, neptunium-237, plutonium-237, plutonium-238, plutonium 239/240, technetium-99, uranium-233/234, uranium-235/236, and uranium-238 in the outdoor air at U.S. DOE air monitoring stations is less than the NRC 10 CFR 20 regulatory radiological air concentration limits for members of the public.

- Estimated radiation doses from breathing americium-241, neptunium-237, plutonium-237, plutonium-238, plutonium 239/240, technetium-99, and uranium isotopes (uranium-233/234, uranium-235/236, and uranium-238) in outdoor air at the U.S. DOE air monitoring stations are at least 30 thousand times less than doses that resulted in observed bone tumors in human studies of alpha emitting radioactive substances.
- The annual and five-year average ambient external radiation doses at the U.S. DOE air monitoring stations are lower than the national natural background radiation dose and the ATSDR minimal risk level (MRL).

6.1.1.2 ODH air monitoring stations from 2020 to 2022

- Based on the initial screening of the radiation concentrations detected in the outdoor air samples, the majority of radiological concentrations were below the MDA and the results would be considered zero (0); that is, not present in the outdoor air.

- The radioisotope concentrations measured above the MDA are near the MDA resulting in high uncertainties in the measurements. This makes estimated radiological concentrations and any associated radiological dose estimates not meaningful. These estimated doses would be so low that ATSDR would not expect to see any observable adverse health effects.

6.1.1.3 ***U****.S. DOE Radiological Assistance Program Team 3 at Zahn's Corner Middle School in May 2019*

- Based on the initial screening of the radiation concentrations detected in the outdoor air samples, all the radiological concentrations for transuranic radionuclides and uranium-235 were below the MDA.

- All the measured radioisotope concentrations measured above the MDA are near the MDA resulting in high uncertainties in the measurements. This makes estimated radiological concentrations and any associated radiological dose estimates not meaningful. These estimated

doses would be so low that ATSDR would not expect to see any observable adverse health effects.

6.1.1.4 Northern Arizona University analysis of air sampling from local private air monitors from May 2019 to January 2022

- ATSDR was not able to use the NAU results to conduct a public health effects evaluation of radionuclides detected in the outdoor air samples collected by local residents.

- NAU reported activity in picocuries/gram of filter material, to quantify number of atoms and mass ratio of uranium isotopes and not air concentrations (picocuries/cubic meter of air) that ATSDR uses to compare to relevant air screening and health guideline levels.

- The NAU data objectives were to determine what transuranic radionuclides or uranium isotopes detected in off-site outdoor air were released from PORTS.

6.1.2 Indoor Air

6.1.2.1 U.S. DOE Radiological Assistance Program Team 3 sampling at Zahn's Corner Middle School

- Based on the initial screening for the radiation concentrations in the indoor air samples, all the radiological concentrations for transuranic radionuclides were below the MDA and the results would be considered 0 (zero); that is, not detectable in the indoor air.

- All the measured radioactive concentrations are either below the MDA or close to the MDA (uranium-235 and uranium-234) resulting in high uncertainties in the measurement which makes the very low radiological concentrations estimates and any associated radiological dose estimates not meaningful.

- Also, any estimated doses would be so low that ATSDR would not expect to see any observable adverse health effects.

6.1.3 Dust Samples on Interior Surfaces

6.1.3.1 U.S. DOE Radiological Assistance Program Team 3 sampling at Zahn's Corner Middle School

- The radiological concentrations of radionuclides in RAP-3 dust swipe samples show that the amount of radioisotopes that could be removed from the interior dust were less than 0.1% of the applicable allowable limits listed in the in the Multi-Agency Radiation Survey and Assessment of Materials and Equipment Manual (MARSAME).

6.1.3.2 Independent Sampling Plan interior settled dust collected from September 2020 to February 2021.

- The radiological concentration results of ISP interior settled dust samples show that the amount of radioisotopes that could be removed from the interior dust were less than 2% of the applicable allowable limits listed in MARSAME.

6.1.3.3 Northern Arizona University dust collected from attic and living spaces of a residence in 2023.

- ATSDR is not able to compare the removable radioactive concentrations detected on the baby wipe samples to the applicable allowable limits listed in the MARSAME because the NAU results were not expressed as activity per square centimeter or per 100 square centimeters. Therefore, ATSDR is not able to use the NAU dust wipe results to conduct a public health effects evaluation of removable radionuclides in dust samples collected by local residents.

6.1.4. Soil

6.1.4.1 Independent Sampling Plan soil collected in the 6-mile study area October 4, 2020, through February 17, 2022.

- The estimated internal radiological dose for the transuranic elements is less than 1 millirem per year (mrem/year) and the estimated internal dose from the technetium-99 is also less than 1 millirem. At these extremely low radiological doses, ATSDR would not expect to see any observable adverse health effects.

6.1.4.2 U.S. DOE Portsmouth/Paducah Project Office Environmental Geographic Analytical Spatial Information System (PEGASIS) soil samples collected within and outside PORTS boundary from 2016 to 2020.

- Estimated internal radiological dose from americium-241 and plutonium isotopes in soil is less than 1 mrem/year which is more than 30 times less than doses observed to cause bone tumor in human studies of radium dial painters. The radiological dose of technetium-99 in soil is also less than 1 mrem/year. Since these doses are so low, these doses are not expected to harm people's health.

- The radioactive concentrations of uranium-234, uranium-235, and uranium-238 are not significantly different than natural background concentrations of uranium reported in Ohio soil by Myrick in 1983.

6.1.5 Sediment

6.1.5.1 Independent Sampling Plan sediment collected in the 6-mile study area October 4, 2020, through February 17, 2022.

- The estimated radiological dose from americium-241, plutonium isotopes, and technetium-99 is less than 1 mrem/year. The dose is so low that ATSDR concludes the sediment dose is below levels expected to harm people's health.

- There does not appear to be any significant excess uranium in the environment as the detected uranium in the sediments is essentially identical to the typical background levels of uranium in the state of Ohio as reported by Myrick, et al. [1983].

6.1.5.1 U.S. DOE PEGASIS sediment collected within and outside PORTS boundary from 2016 to 2020.

- The estimated radiological dose from americium-241, plutonium isotopes, and technetium-99 is less than 1 mrem/year. The dose is so low ATSDR concludes the sediment dose is below levels expected to harm people's health.

- There does not appear to be any significant excess uranium in the environment as the detected uranium in the sediments is essentially identical to the typical background levels of uranium in the state of Ohio as reported by Myrick, et al. [1983].

6.1.6 Surface Water

6.1.6.1 Independent Sampling Plan surface water collected in the 6-mile study area October 4, 2020, through February 17, 2022.

- All detected radiological isotopes were less than the ATSDR derived radiological MCL and the estimated doses are less than 4 mrem/year.

7. Recommendations

Having evaluated the available environmental sampling data from 2016 to 2022, ATSDR recommends:

1. U.S. DOE inform and make the data available to the public in timely manner when contaminant concentrations are detected above a regulatory limit or significantly elevated above normal.
2. Upon request, ATSDR will review sampling data, comment on public health implications, and make recommendations to protect public health.
3. U.S. DOE continue its preventative measures to reduce or prevent any future releases of contaminants to the off-site air, soil, groundwater, and surface water during the decontamination, disassembly, demolition, and transportation of the large process buildings, other structures, and infrastructures that require disposal in off-site waste facilities and the on-site OSWDF.
4. U.S. DOE continue to conduct on-site and off-site radiological and non-radiological environmental monitoring to ensure compliance with laws and regulations and to prevent unnecessary exposures of workers and the assure the public to that their exposure to contaminants is minimal.

8. Public Health Action Plan (PHAP)

The Public Health Action Plan describes actions to be taken at and near PORTS by ATSDR and other government agencies after the completion of this public health consultation. The PHAP purpose is to ensure that this public health consultation not only identifies public health hazards, but that it also provides a plan of action designed to mitigate and prevent adverse human health effects resulting from exposure to hazardous substances in the environment. If additional information about PORTS releases becomes available, that information could change any conclusion or conclusions of this public health assessment. Human exposure pathways would be reevaluated, and these conclusions and recommendations would be amended, as necessary, to protect public health.

1. ATSDR will continue to work with the ODH and the PCGHD to determine the best way to communicate the results of this health consultation evaluation to the people in the community.

2. As new environmental sampling data become available and as requested by the community or health department, ATSDR will review and comment on sampling data.

3. ATSDR will develop and implement additional environmental health education materials as necessary to help community members understand the public health findings in this health consultation on the recent environmental sampling data.

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Appendix

Appendix A - Radiation Terminology

Definitions of Radiation terms [Cember and MARLAP vol 1; ATSDR 1999]

Background radiation – radiation resulting from cosmic rays and naturally occurring radioactive material. Background radiation is always present, and its level can change with altitude and the amount of radioactive material present in soil and building materials. The predominant radioactive elements comprising background radiation are various forms of uranium and thorium. These forms are called radioisotopes or radionuclides. All forms of uranium and thorium are radioactive; that is, they give off particles and energy. The uranium and thorium, as they decay, form other types of radionuclides until they ultimately decay into non-radioactive forms of the metal lead. The amounts and activities of these naturally occurring radioisotopes found in nature are much lower than the amount of radiation known to be harmful. Each of these elements have different hazards based on their concentration; however, it is safe to say they are more than a million times lower than the known hazardous radioactive concentrations.

MDA – The minimum detectable activity (MDA) is important in low-level counting, when the count rate of a sample is almost the same as the count rate of the background radiation. The MDA is defined as the smallest quantity of radioactivity that can be distinguished from the blank under specified conditions. The MDA depends on the Lower Limit of Detection (LLD) and on the counting efficiency of the radiation detectors and the counting system. The lower limit of detection is based on probabilities that the sample results have a 95% probability of being greater than zero (0); that is, the measurement is considered a real detection.

Radiation counting statistics – All radioactive decay is statistical in nature with a radioactive element decaying at some time which cannot be predicted; that is, the decay is random. Because there are so many radioactive atoms in any amount of material that can be measured, the radioactive decay appears to constant. When measuring the radioactive decay, the results appear to fit a defined shape called a normal curve (see Figure A1) with the average number (the mean) of counts signified by the Greek letter μ (mu). How the values vary from the mean is called a standard deviation (SD) signified by the Greek letter σ (sigma). Without going into the mathematics of the curve, we know that about 68% of all detected values are within 1 sigma and 96% of the detected numbers are contained with 2 sigma. When evaluating any data, scientists want, at a minimum, to be sure that the number is at least 95% true (the upper 95% confidence level or 1.96 σ). Therefore, MDA and LLD can be used to determine if there is a 95% probability that the measured value is either above natural background or above the inherent "noise" of the radiation detection instruments.

Radiation – any type of energy that comes from a source and can travel through air. The radiation can be in the form of particles or in waves like visible light but with different wavelengths that people cannot see. The radiation, when sufficiently energetic, is called ionizing radiation. Radioactive decay is considered ionizing radiation.

Radioactivity – the process whereby certain atoms give off (emit) energy in the form of ionizing radiation. Some atoms emit only particles (alpha particles or beta particles) and others emit both particles and radiation called gamma radiation. Gamma radiation is made of waves that travel at the speed of light.

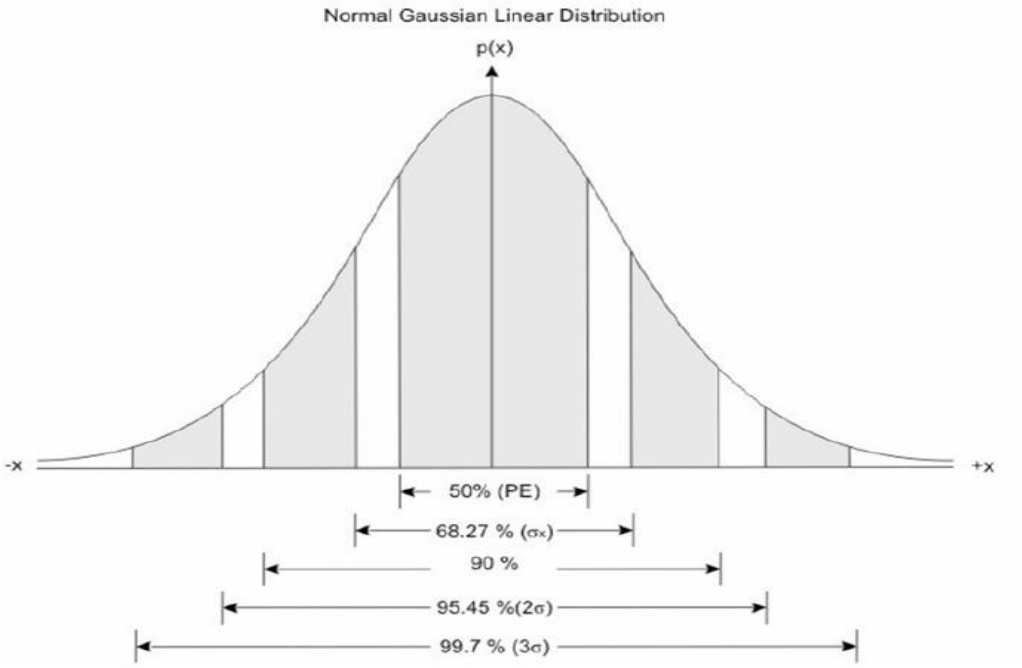

Figure A1. Properties of a normal distribution

Transuranic elements – There are 92 naturally occurring elements. Each element has a specific number of a subatomic particle called the proton. The number of protons defines the element. For example, all atoms that contain eight (8) protons are oxygen atoms and all atoms that contain 26 protons are atoms of iron. The number, 92, indicates the atom is uranium and if elements have more than 92 protons, they are called transuranic elements; all transuranic elements are man-made and radioactive.

Appendix B - Comparison of U.S. DOE and Ohio Department of Health Air Monitoring Results

In 2020, the Ohio Department of Health (ODH) co-located air monitors with U.S. DOE air monitoring stations. ATSDR compared the U. S. DOE 5-year average concentration for each radionuclide from 2016-2020 to the ODH 2-year average concentrations from 2020-2021 and found no significant difference between the air concentrations measured by U.S. DOE and ODH. For these data, no quantified values were given for the MDA. However, the state did include the data qualifiers. These data qualifiers follow the USEPA guidance on environmental data verification. For more discussion on data qualifiers, please see https://www.epa.gov/quality/guidance-environmental-data-verification-and-data-validation (last accessed on August 30, 2023).

Over 90% of the data validation qualifiers in the Ohio air data and the US DOE air data were "U" or "UJ" qualified. For those samples coded with a "U", the radionuclide was not detected above the sample quantitation limit (MDA). Those coded with "UJ" indicate the sample was below the MDA and was so low that the amount in the sample was too low to accurately measure the amount in the sample. This indicates that these samples are below detection limits and there is no significant difference between the air concentrations measured by U.S. DOE and ODH since the samples are below the detection level.

Furthermore, when compared to the US NRC 10 CFR 20 regulatory limits, the ATSDR estimated average concentrations that were reported by both the state and US DOE, the average values were well below the air limits regulated by the US NRC (Table B1).

Table B1. Comparison of U.S. DOE (2016-2020) and Ohio Department (2-20-2022) Average Radiological Concentrations Measured at Co-located Air Monitoring Stations and Compared to the US NRC regulatory limits.

Radionuclide	US NRC 10 CFR 20* (pCi/m^3)	U.S. DOE Average (pCi/m^3) 2016 - 2020	ODH Average (pCi/m^3) 2020 - 2021
Americium-241	2E-03	4.97E-05	2.26E-06
Neptunium-237	1E-03	1.19E-04	1.78E-06
Plutonium-238	2E-03	3.87E-05	2.63E-06
Plutonium-39/240	2E-03	3.92E-05	1.54E-06
Technetium-99	9E02	3.23E-02	1.03E-04
Total Uranium	9E02	8.59E-04	1.05E-04
Uranium-233/234	5E-3	3.55E-04	4.06E-05
Uranium-235/236	6E-03	3.21E-05	2.45E-06
Uranium-238	6E-03	2.83E-04	3.48E-05

* The standard concentration of the respective radionuclide would provide a radiological dose of 100 millirem in one year if continuously inhaled by a member of the public.

U.S. DOE Standard = U.S. DOE Standard Derived Concentration Technical Standard. DOE-STD-1196-2011 (April 2011); ODH =Ohio Department of Health; pCi/m^3 = picocuries per meter cubed