



Paducah Gaseous Diffusion Plant
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Organization: Environmental Stewardship
Document Number: FRNP-19-2657/CP2-EC-0002/FR2 Number of Pages: 155
Accession Number (DMC only):
Document Title/Date: Del No. 35—Draft National Emission Standards for Hazardous Air Pollutants Management
Plan for Emission of Radionuclides for DOE Operations at the Paducah Site, Paducah, Ky
Author: Katrina Hall Corporate Author: FRNP
Media (Check all that apply):
Paper Photo Diskette Drawing Video CD/DVD Report/Letter Other:
Project Subcontract/Task Order: C11SPM
Requestor/Purpose of Release: DOE, EPA, and KDEP

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**National Emission Standards for
Hazardous Air Pollutants Management Plan for
Emission of Radionuclides for the
U.S. Department of Energy Operations at the Paducah Site,
Paducah, Kentucky**



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Date Issued—October 2019

Prepared for the
U.S. DEPARTMENT OF ENERGY
Office of Environmental Management

Prepared by
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managing the
Deactivation and Remediation Project at the
Paducah Gaseous Diffusion Plant
under contract DE-EM0004895

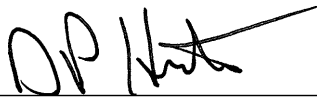
APPROVALS

**National Emission Standards for
Hazardous Air Pollutants Management Plan for
Emission of Radionuclides for the
U.S. Department of Energy Operations at the Paducah Site,
Paducah, Kentucky**

CP2-EC-0002

October 2019

Approved by:



David Hutchison
Director, Environmental Services

10/3/19
Date

Effective Date:	<u>10-3-19</u>
Required Review Date:	<u>10-3-2022</u>
Nuclear Safety Documentation:	<u>N/A</u>

REVISION LOG

REVISION NUMBER	DATE	DESCRIPTION OF CHANGES	PAGES AFFECTED
FR0	9/20/2018	Initial issuance	All
FR1	9/25/2018	Non-intent changes including, changing 'Conversation' to 'Conversion' in Section 2.1, changing 'procedures' to 'process' in Section 8, adding a revision log, and adding CP2-EC-0002 FR1 to header on all pages.	All
FR2	10/01/2019	Updated sections throughout plan to describe current site operations better.	All

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ACRONYMS

CAP-88	Clean Air Act Assessment Package-88
<i>CFR</i>	<i>Code of Federal Regulations</i>
DOE	U.S. Department of Energy
EDE	effective dose equivalent
EPA	U.S. Environmental Protection Agency
ISCST3	Industrial Source Complex Short Term, Version 3
KDAQ	Kentucky Division for Air Quality
NESHAP	National Emission Standards for Hazardous Air Pollutants
PGDP	Paducah Gaseous Diffusion Plant

EXECUTIVE SUMMARY

The U.S. Department of Energy (DOE) has developed this National Emission Standards for Hazardous Air Pollutants (NESHAP) Management Plan for the Paducah Site to ensure that the program is managed in accordance with regulatory requirements. This plan will assist DOE in demonstrating all activities for the Paducah Site are in compliance with NESHAP requirements.

Facilities owned by DOE that emit radionuclides into the air must meet the requirements of 40 *CFR* Part 61, Subparts A (National Emission Standards for Hazardous Air Pollutants—General Provisions) and H (National Emission Standards for Emissions of radionuclides other than Radon from Department of Energy Facilities). Regulations in Subpart H include monitoring point stacks and estimating the dose to the general public. Subpart H also requires that a NESHAP Report be submitted by June 30 annually (40 *CFR* Part 61.94(a)). The Kentucky Division for Air Quality was delegated authority of this program by the U.S. Environmental Protection Agency in July 1999 and is responsible for its enforcement.

1. INTRODUCTION

1.1 PURPOSE

The U.S. Department of Energy (DOE) National Emission Standards for Hazardous Air Pollutants (NESHAP) Management Plan for the Paducah Site documents how DOE operations comply with 40 *CFR* Part 61, Subpart H, requirements. The DOE NESHAP Management Plan will be reviewed every three years or earlier, if needed, by the assigned contractor and revised, as needed. References in this report to the “Paducah Site” generally mean the property owned by DOE. The DOE-owned Paducah Site contains the Paducah Gaseous Diffusion Plant (PGDP); the Paducah Depleted Uranium Hexafluoride (DUF₆) Conversion Facility; miscellaneous active and inactive industrial areas; and an undisturbed buffer area.

1.2 PLAN OBJECTIVES

DOE has established the following objectives for the Paducah Site NESHAP Management Plan:

- Assure that the regulatory requirements set forth in 40 *CFR* Part 61, Subpart H, are met;
- Use U.S. Environmental Protection Agency (EPA)-approved methods for determining compliance;
- Determine compliance with the standard of less than 10 mrem/year effective dose equivalent (EDE) for public exposure from all Paducah Site sources (40 *CFR* § 61.92) (see Section 2.3);
- Monitor airborne radionuclide emissions using EPA-approved methods;
- Obtain prior approval of new construction or modifications if the estimated dose is more than 1% of the standard;
- Evaluate site activities that have potential radionuclide emissions;
- Provide a mechanism for information to be obtained and included in the annual report about fugitive and diffuse sources; and
- Gather information necessary to provide an annual report to the regulatory agencies.

2. SITE OPERATIONS AND RESPONSIBILITY

2.1 SITE DESCRIPTION

Construction of a gaseous diffusion facility to enrich uranium at the Paducah Site began in 1951 with operations starting in 1952 and ceasing in 2013. DOE has additional activities related to uranium enrichment. The additional activities include a DUF₆ Conversion Facility to convert DUF₆ to a stable uranium oxide. Construction of the DUF₆ Conversion Facility began in 2004 and operations began in 2011.

Other sources of radionuclide emissions at the Paducah Site include the following: environmental restoration activities; remediation of historic releases of pollutants; and decontamination and decommissioning of inactive facilities. Radionuclides also can be emitted by waste management activities. These activities include treatment and repackaging of radioactive contaminated waste and disposal of waste with radioactive contamination. Small amounts of radionuclides may be released as fugitive emissions from historical radioactive contamination areas.

DOE owns the Paducah Site, which is located approximately 10 miles west of Paducah, Kentucky, and approximately 3.5 miles south of the Ohio River (see Figure 1). DOE owns approximately 3,500 acres with approximately 800 acres of industrial area. (The industrial area includes the PGDP fenced area, the DUF₆ Conversion Facility, the Northeast Plume Containment System, Northwest Plume Groundwater Treatment System, and the C-746-U Landfill.) DOE licenses approximately 2,000 acres outside the industrial area to the Commonwealth of Kentucky's Department of Fish and Wildlife Resources. This results in an industrial area surrounded by a restricted access buffer area and a wildlife management area. These buffer areas are important when determining dose to the public. The site and wildlife area are in a lightly populated farmland area.

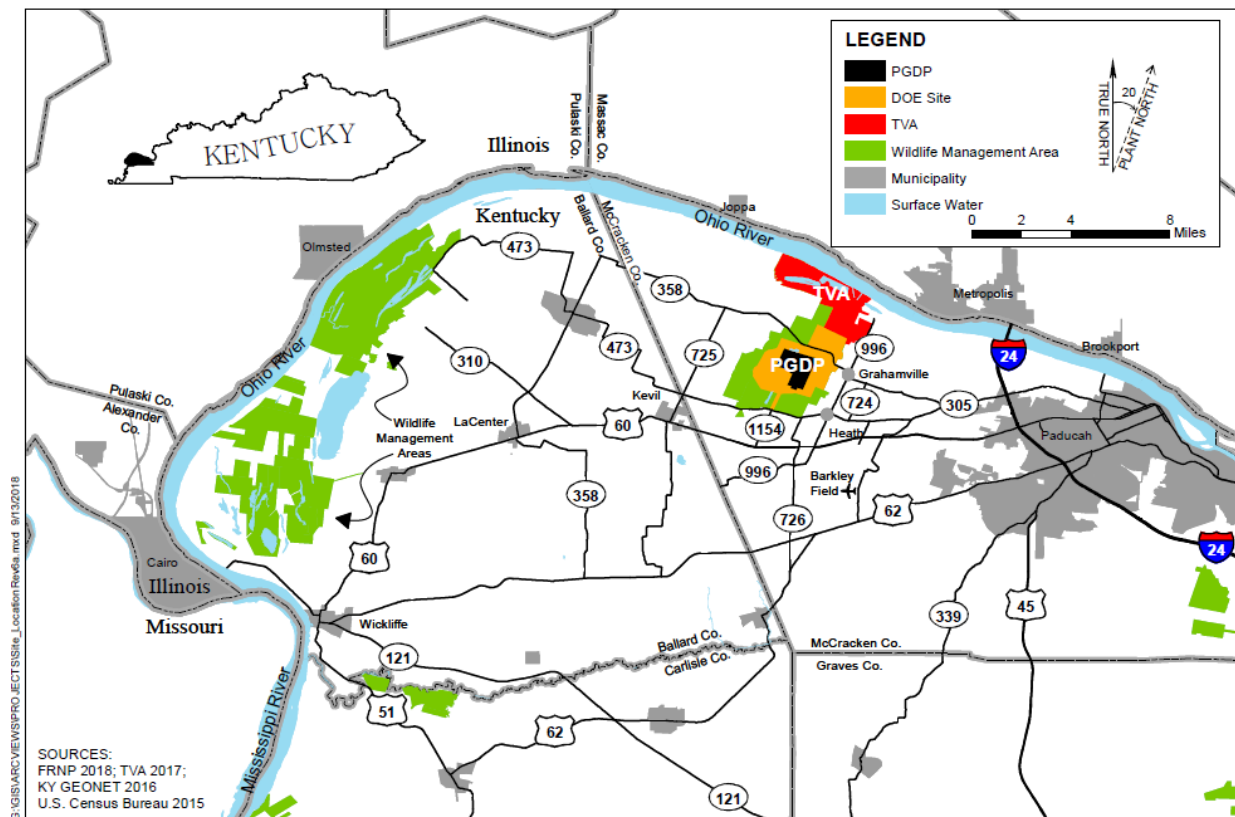


Figure 1. Location of the Paducah Site

The population within the 50-mile radius is approximately 535,000 persons based on the 2010 census. The unincorporated communities of Grahamville and Heath are 1.24 and 1.86 miles east of the plant, respectively. Portions of 4 states—Kentucky, Missouri, Illinois, and Tennessee—are within the 50-mile radius of the plant. Larger cities in the region include Paducah, Kentucky, located approximately 10 air miles east of the plant; Cape Girardeau, Missouri, located approximately 40 air miles to the west; and Metropolis, Illinois, located approximately 6 air miles to the northeast.

The Paducah Site is located in the humid subtropical zone. Summers are generally dry; precipitation occurs mainly in the spring and fall. Winters are characterized by moderately cold days; the average temperature during January averages about 35°F. The average temperature in July is 70°F. Yearly precipitation averages about 44 inches. Based on data provided by the National Climatic Data Center, the prevailing wind direction is from the south to southwest with dominant wind speeds in the 3.1 to 6 m/s range.

The uranium enrichment facility consists of a diffusion cascade and extensive support facilities. The cascade, including product and tails withdrawal, is housed in 6 process buildings covering a total of approximately 80 acres. The enrichment facility primarily was fed with UF₆, in which the uranium isotopic abundance was at natural assay. The enrichment facility was designed to concentrate the uranium isotope, uranium-235 (U-235), via a physical separation process.

During enrichment operations from 1953 to 1975, a feed material called “reactor tails,” from government reactors, also was used intermittently in addition to the normal feed material. Reactor tails are the fuel from nuclear reactors that has had the U-235 content depleted, has been reprocessed to remove most of the fission products, and must have the U-235 content replenished before it can be reused. The reactor fuel rods were processed at other DOE facilities (where most of the fission products were removed), and the enriched uranium and remaining fission products were brought to the Paducah Site as a product and fed into the cascade system. Use of the reactor tails resulted in introduction of small amounts of technetium-99 (Tc-99), a fission by-product, and transuranics, most notably neptunium-237 and plutonium-239, into the cascade. Additional radionuclides also may have been processed at the site through various activities conducted for other DOE sites. The DUF₆ Conversion Facility uses a continuous conversion process. DUF₆ is vaporized and converted to uranium oxide (U₃O₈) by reaction with steam and hydrogen. A depleted U₃O₈ powder produced by the conversion process is packaged for disposition. The DUF₆ Conversion Facility and support structures occupy about 10 acres.

2.2 RESPONSIBILITIES

DOE reports all emissions from DOE-owned emission sources at the Paducah Site. Pursuant to 40 *CFR* § 61.94, DOE certifies and reports the airborne radiological emissions from activities controlled by DOE. DOE-owned properties may be leased to private entities for activities that may have airborne radiological emissions. If DOE does not control these activities, then the private entity will certify its own emissions. The emissions from DOE-owned properties leased to private entities will be included in DOE reporting.

In 2014, the United States Enrichment Corporation ended its lease agreement with DOE after uranium enrichment activities ceased at the site in 2013. DOE currently is responsible for the enrichment facilities, including quantification and certification of airborne radiological emissions. DOE may establish other uses of the Paducah Site in the future, including possible activities identified as part of a community reuse effort.

DOE controlled emission sources include the DUF₆ Conversion Facility, demolition of inactive structures, remedial activities in support of site cleanup, various waste management emissions, and fugitive emission sources.

DOE will continue to submit an annual NESHAP Report to the Kentucky Division for Air Quality (KDAQ) and EPA, as required by 40 *CFR* § 61.94. The report will include emissions from all Paducah Site sources, including the DUF₆ Conversion Facility, and all other DOE controlled emission sources.

2.3 NESHAP STANDARD

The NESHAP standard, 40 *CFR* § 61.92, for airborne emissions from a facility is an EDE of 10 mrem/yr. DOE is converting to use the term of “effective dose” (e.g., Occupational Radiation Protection regulations, 10 *CFR* § 835). Other reference materials that use the term effective dose include EPA Federal Guidance Report No. 13 and DOE Order 458.1. For DOE airborne emissions of radionuclides at the Paducah Site, DOE assumes that the terms are equivalent for 40 *CFR* § 61.92 compliance. This will allow the use of either term if the regulatory community converts to the effective dose terminology.

Effective Dose Equivalent (40 *CFR* § 61.91, Subpart H)—The sum of the products of absorbed and appropriate factors to account for differences in biological effectiveness due to quality of radiation and its distribution in the body of reference man. The unit of the effective dose equivalent is the rem. For purposes of Subpart H, doses caused by radon-222 and its respective decay products formed after the radon is released from the facility are not included. Radon-222 is covered under 40 *CFR* § 61.91, Subpart Q. The method for calculating effective dose equivalent and the definition of reference man are outlined in the International Commission on Radiological Protection’s Publication No. 26.

Effective Dose (10 *CFR* § 835)—The summation of the products of the equivalent dose received by specified tissues or organs of the body (H_T) and the appropriate tissue weighting factor (w_T)—that is, $E = \sum w_T H_T$. It includes the dose from radiation sources internal and/or external to the body. For purposes of compliance with this Order, equivalent dose to the whole body may be used as effective dose for external exposures. The effective dose is expressed in units of rems (or sieverts).

3. SOURCE DESCRIPTION

Potential airborne radionuclide sources at the Paducah Site are discussed in this section. As the use of the site changes, specific sources will change. Future emission sources will be evaluated as required by applicable statutes and regulations, including 40 *CFR* Part 61, Subpart H.

3.1 URANIUM ENRICHMENT EMISSIONS

Operation of the gaseous diffusion uranium enrichment plant ceased in 2013, which resulted in reduced radionuclide emissions. The Paducah Site will continue to operate the following sources while the plant undergoes deactivation activities.

- C-310 stack
- Grouped sources
 - C-709/710 laboratory
 - Wet air/seal exhaust group
 - Seal exhaust/wet air systems
 - Building ventilation not included in any other group
 - Unplanned releases
 - C-335 UF₆/R-114 Separation System
 - Pigtail operations (other than C-360)
- Fugitive emissions (see Chapter 4)

Because uranium enrichment operations were ceased in 2013, the enrichment facilities are now inactive and potential radionuclide emissions have decreased. Additionally, the continuous monitoring of the C-310 stack is currently inactive; however, an alternate monitoring plan has been approved for use when the C-310 stack is activated in the future to aid in deactivation activities.

The potential radionuclide emissions consist primarily of uranium with a slight potential for emissions of technetium-99, neptunium-237, plutonium-239, and the thorium daughter products of uranium.

3.2 DEPLETED URANIUM HEXAFLUORIDE CONVERSION FACILITY EMISSIONS

During the enrichment process, UF_6 that had been depleted of its U-235 content (DUF_6) was placed in large steel cylinders for storage. DOE operates the DUF_6 Conversion Facility to convert the DUF_6 resultant from the uranium enrichment process into a stable uranium oxide, primarily U_3O_8 .

A single stack on the conversion building is monitored for radionuclide emissions. There may be fugitive radionuclide emissions from the DUF_6 Conversion Facility and the DUF_6 cylinder storage yards. Potential sources of fugitive radionuclide emissions include pigtail operations. The air emissions from the DUF_6 Conversion Facility are permitted by KDAQ.

3.3 ENVIRONMENTAL REMEDIATION AND WASTE MANAGEMENT EMISSIONS

The Paducah Site is listed on the National Priorities List for cleanup of past contamination releases, radioactive as well as hazardous chemical contamination. The cleanup usually is conducted as a series of projects. The radiological emissions from these activities vary with the nature of each individual project. Projects include groundwater treatment units, waste management activities, soil disturbance, and demolition.

The Northwest Plume Interim Remedial Action and Northeast Plume Containment System are current groundwater pump-and-treat units. Radionuclide air emissions could be generated when groundwater containing Tc-99 passes through an air stripper. The amount of Tc-99 emitted is estimated by analyzing samples of the water entering each treatment unit and by either applying a mass balance or using the 40 *CFR* § 61, Appendix D, liquid emission factor. Sampling has demonstrated that this approach is conservative and results in an estimate that is greater than actual emissions. Future remediation projects could include additional groundwater treatment units.

Emission of radionuclides from C-752-A for waste management activities is estimated based on sampling analysis of the waste, personnel air monitoring, and 40 *CFR* § 61, Appendix D, emission factors. Waste management activities also may emit radionuclides. These activities include treatment and repackaging of radioactive contaminated waste and disposal of waste with radioactive contamination.

Emissions from remediation activities involving soil disturbance, such as excavation, may be analyzed using soil sampling data and appropriate emission factors or may be analyzed as fugitive emissions. EPA guidance, *Methods for Estimating Fugitive Air Emissions of Radionuclides from Diffuse Sources at DOE Facilities*, September 3, 2004, states that, in many cases, these emission sources are considered diffuse sources, as their emissions tend not to be collected and actively ventilated into the atmosphere.

Building demolition emissions may be estimated by waste characterization analyses and demolition emission factors. Alternatively, DOE may choose to analyze building demolition emissions as fugitive

emissions. Future environmental remediation, demolition, and waste management activities will be evaluated for NESHAP compliance and are anticipated to primarily be analyzed as fugitive emissions.

3.4 LOW EMISSION SOURCES

Many of the emission sources at the Paducah Site have the potential to emit radionuclides that would result in a dose of less than 0.1 mrem/yr EDE. The NESHAP regulations, 40 *CFR* § 61.93(b)(4)(i), require periodic confirmatory measurements to verify low emissions of these sources. These low emission sources include point sources and fugitive emissions. The frequency of periodic confirmation will be determined by the variability of the emission rate. Confirmation may include direct air stream measurement by grab samples or other analysis. Other techniques also may be used for confirmation; these include source material analytical data, health physics data, radionuclide inventory data, appropriate emission factors, engineering estimates and judgment, or other technically justifiable method.

4. FUGITIVE EMISSIONS

Fugitive sources include any source that is distributed spatially, diffuse in nature, or not emitted with forced air from a stack, vent, or other confined conduit. Fugitive sources also include emissions from sources where forced air is not used to transport the radionuclides to the atmosphere. In this case, radionuclides are transported entirely by diffusion and/or air currents. Typical examples of fugitive sources at the Paducah Site include emissions from building breathing; building demolition; excavation or resuspension of contaminated soils, debris, or other materials; unventilated tanks; ponds, lakes, and streams; wastewater or groundwater treatment systems; outdoor storage and processing areas; and leaks in piping, valves, or other process equipment. Based on prior health physics data, historical ambient air monitoring, and characterization analyses, it is unlikely that any of these potential sources are significant; however, ambient air monitoring is being conducted around the Paducah Site to verify the fugitive sources have a low emission rate.

4.1 ENVIRONMENTAL REMEDIATION EMISSIONS

Many environmental remediation emissions are considered fugitive emissions. These include, but are not limited to, contaminated soil excavation and treatment, and treatment of contaminated groundwater. Most remediation activities will have been characterized and have analyses indicative of contaminations present and estimated amounts to be remediated. Anticipated remediation low emission rates include emissions from decontamination of remediation equipment and disposal of contaminated material in an on-site landfill.

4.2 DEMOLITION EMISSIONS

Most demolitions will generate fugitive emissions. Buildings usually are decontaminated or deactivated prior to demolition to minimize emissions during demolition. Results from waste analyses from decontamination, deactivation, or other sampling will be used to indicate whether contaminants are present prior to subsequent demolition. Emissions from inactive buildings awaiting demolition and disposal of contaminated debris in an on-site landfill are considered to be low emission sources.

4.3 AMBIENT AIR MONITORING

The Paducah Site utilizes ambient air monitoring data to verify that airborne radionuclide emissions are in compliance with 40 *CFR* § 61.92. Ambient air monitoring stations have been placed outside of the Paducah Site industrial area, but still are on DOE property. A background monitoring station has been placed off DOE property, away from the Paducah Site, so that the monitoring results are not influenced by site emissions. The data from these ambient air monitoring stations are assessed to determine whether fugitive emissions at the Paducah Site may be affecting air quality. The protocol for the analysis of air filters from the ambient air-monitoring network is provided in Chapter 7.

5. POTENTIAL NEW SOURCE EVALUATION

Potential new or modified DOE controlled sources will be identified and evaluated for compliance with 40 *CFR* Part 61, Subpart H, prior to construction or modification of the source.

New sources include new emissions from point sources. Fugitive and low emission sources, such as nonradiological areas or activities that do not require worker respiratory protection, will not be evaluated as new sources because they will emit less than 1% of the standard.

For any activities that meet the definition of construction under 40 *CFR* § 61.02, or any activities such as fabrication, erection or installation of a new building or structure within a facility that emits radionuclides, the potential emissions must be evaluated against the 40 *CFR* Part 61, Subpart H requirements. If the EDE caused by all emissions from the new construction or modification within an existing facility is less than 1% of the standard prescribed in Section 61.92, then an application for approval under Section 61.07 or notification of start-up under Section 61.09 does not need to be filed. See 40 *CFR* § 61.96. The dose shall be calculated in accordance with 40 *CFR* Part 61, Subpart H.

An estimate of potential emissions of a new or modified source and resulting dose is needed for two reasons: (1) to determine which sources require continuous sampling as required by 40 *CFR* § 61.93, and (2) to determine which sources require reporting. The evaluation of potential new sources is documented and available for review in the project file.

6. COMPUTER MODELING METHODOLOGY

Computer modeling may be utilized for demonstration of compliance of point sources that are DOE's responsibility. This modeling is not utilized for measuring fugitive emissions. DOE demonstrates compliance with the 10 mrem/year EDE by measuring and estimating emissions of radionuclides and modeling those emissions using the EPA-approved Clean Air Act Assessment Package-88 (CAP-88) of computer codes or AIRDOS PC. The CAP-88 software utilizes the appropriate regulatory and federal guidance to estimate radiation dose.

The CAP-88 program utilizes local meteorology data. A historical data set from the Paducah Site meteorological tower may be used. This historical data set is a five-year distribution from the 60-m station Paducah Site meteorological tower for the years 1988 through 1992. This historical data set has the advantage of being representative of site conditions. More recent meteorological data sets from the National Weather Service or commercial sources also may be used. The advantage of using the updated

data sets is that they would be more recent than the historical data set, although they would not be site specific.

The most recent version of CAP-88 and the NESHAP standard estimate dose in units of EDE. Much of the regulatory community and DOE Order 458.1 use total effective dose. For the potential radionuclides emitted at the Paducah Site, DOE assumes that the terms are equivalent. This will allow the use of the most recent and potential future dose estimation methods in determining compliance with the standard. Emission factors and methodologies are provided on an annual basis for modeling. Model inputs are documented and provided in the Annual NESHAP Report along with the results of the calculations.

7. AMBIENT AIR MONITORING

Ambient air monitoring at the Paducah Site is utilized to monitor all Paducah Site emissions, including fugitive emissions for DOE radiological areas. Experience indicates that these fugitive emissions are low emission sources. DOE may choose to utilize ambient air monitoring to demonstrate compliance with the standard in accordance with 40 *CFR* § 61.93(b)(5). This monitoring is used to confirm the fugitive emissions are low emission sources. Figure 2 is a map showing the ambient air monitoring stations operated by DOE. The ambient air network includes a background station at a location several miles away that is south of the Paducah Site.

Ambient air monitoring stations are located around the emission sources at the Paducah Site. Ambient air monitoring stations operate continuously, drawing ambient air through filters. The filters are collected, then nondestructively screened for alpha and beta activity. The initial screening provides a timely indication of an unusual radionuclide release. The data from this initial screening are assessed against past results to determine whether emissions from the Paducah Site may be affecting air quality. After the screening, the filters from each location then are composited, each quarter the composited samples are analyzed for isotopes present, and the results are compared to 40 *CFR* Part 61, Appendix E, Table 2, values. The samples are composited in order to detect isotopes at low concentrations.

The values included in 40 *CFR* Part 61, Appendix E, Table 2 are in a list of radionuclides and the concentration for each that could result in a noncompliance with the standard. Multiple radionuclides have the potential to be emitted from activities at the Paducah Site because such initial compliance is demonstrated in two ways. The first is a comparison of each radionuclide individually against the values in Table 2. Additionally, when the sum of fractions that results when each measured concentration value is divided by the value in Table 2 for each radionuclide, this value should be less than 1. If the sum of fractions is greater than 1 or if any individual concentration is greater than the value listed in Table 2, that is an indication that fugitive emission could be contributing to the dose to the public.

If it is determined that fugitive emissions could be contributing to the dose to the public, that does not indicate that the facility is out of compliance, it just indicates that a dose must be calculated using the data collected from the ambient air monitors. This dose then is compared against the standard of 10 mrem. To determine dose from the ambient air monitors, CAP-88 is used to calculate the maximum atmospheric dispersion coefficient (Chi/Q) for the facility. This Chi/Q then is used to determine the maximum possible dose to the public at the ambient air monitor. This value then is utilized to determine if a noncompliance with 40 *CFR* 61 subpart H has occurred.

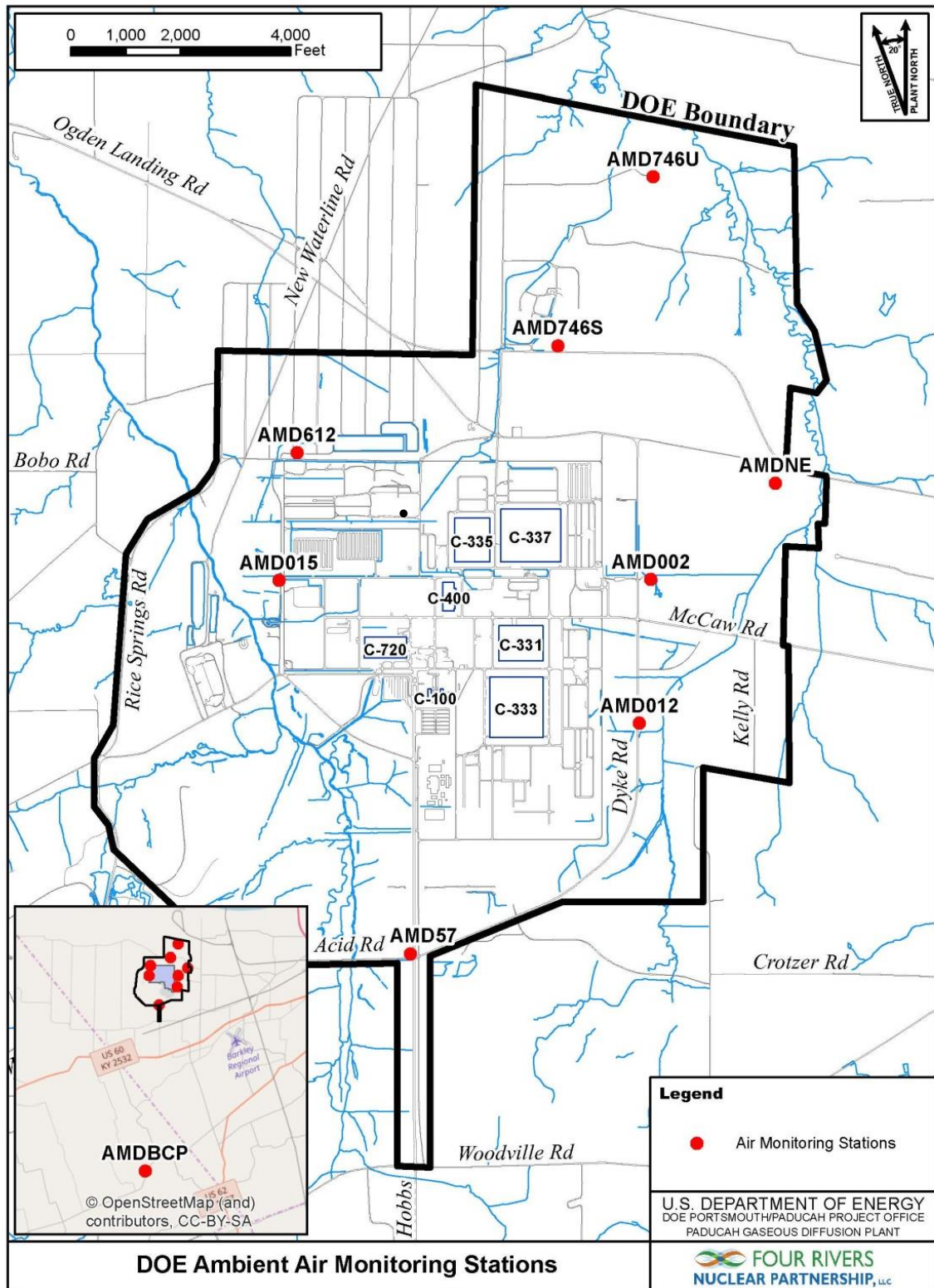


Figure 2. Locations of the DOE Ambient Air Monitoring Stations

Ambient Air Siting. The ambient air monitoring stations are placed around the Paducah Site. The locations were determined by various factors including ease of access, power availability, solar access, and freedom from nearby air flow obstructions. The placement of the stations was aided by modeling using Industrial Source Complex Short Term, Version 3 (ISCST3). The results of the ISCST3 analysis were included in the 2000 NESHAP Management Plan, BJC/PAD-141. Due to site activities, some of the original monitoring station locations have been changed. Due to construction of the DUF₆ Conversion Facility AMD57 now is located approximately 3,000 ft south of the DUF₆ Conversion Facility. In response to increased disposal of less than authorized limits of radiologically contaminated waste in the C-746-U Landfill, a new station, AMD746U, has been located approximately 1,000 ft southeast of the landfill. The selection of the new air monitor locations was consistent with the air dispersion siting methodology used for the previously installed stations.

8. NESHAP REPORTING REQUIREMENTS

An annual report to EPA is due on or before June 30 each year, 40 *CFR* § 61.94(a). The purpose of the report is to document that the dose standard is being met. This report must include the following:

- Monitoring results and dose calculations for point sources;
- Name and location of the facility;
- List of radioactive materials used at the facility;
- Description of handling and processing that the radioactive materials undergo at the facility;
- List of stacks or vents or other point where radioactive materials are released to the atmosphere;
- Description of the effluent controls used on each stack, vent or other release point and an estimate of the efficiency of each control device;
- Distance from release points to nearest residence, school, business, or office and nearest farms, producing vegetables, milk, and meat;
- Values of all input parameters for computer models and sources of this data;
- Description of all construction and modification completed for which regulatory approval was waived during the calendar year; and
- Provide a statement certifying the report's accuracy and completeness for DOE controlled emissions, and signed and dated by an official in charge.

If the standard is not met, then monthly reports to EPA are required and should include the following:

- Same information as the annual report, and
- Change to bring the facility into compliance.

To allow independent verification of compliance, the facility must document sources of information used to demonstrate compliance. Such information typically includes, at a minimum, results of measurements, calculations, and/or analytical methods used and the process used to determine EDE.