

REPORT

BCLDP-100101

BCLDP

**Site Environmental
Report for Calendar**

Year 2000

**on Radiological
and Nonradiological
Parameters**

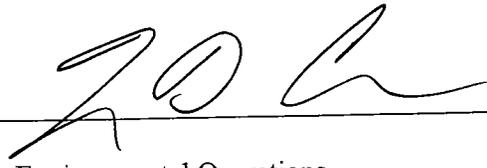
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U.S. Department of Energy

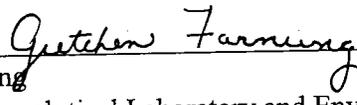
Ohio Field Office, Miamisburg

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FOREWORD

This report was prepared for the Battelle Columbus Laboratories Decommissioning Project (BCLDP) by staff in the Environmental Operations Group for submission to the U.S. Department of Energy (DOE). The radiological monitoring data were supplied by environmental and operational health physics staff. Radioanalyses of environmental air, water, fish, grass, soil, sediment, and field and garden crop samples were performed by the BCLDP Radioanalytical Laboratory. Thermoluminescent dosimeter (TLD) analyses were performed by Landauer, Glenwood, Illinois. Nonradiological analyses of environmental water samples were performed by Burgess & Niple Laboratory, Columbus, Ohio; and The Columbus Water and Chemical Testing Laboratory, Columbus, Ohio.

An environmental compliance summary is included for the calendar year (CY) 2000. The summary includes environmental statutes, regulations, and Executive Orders.

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EXECUTIVE SUMMARY

Battelle Memorial Institute currently maintains its retired nuclear research facilities in a surveillance and maintenance (S&M) mode and continues decontamination and decommissioning (D&D) activities under U. S. Department of Energy (DOE) Contract W-7405-ENG-92. The contract refers to these activities as the Battelle Columbus Laboratories Decommissioning Project (BCLDP). Operations referenced in this report are performed in support of S&M and D&D activities. The majority of this report is devoted to discussion of the West Jefferson facility.

The contamination found at the King Avenue site consisted of small amounts of residual radioactive material in solid form, which had become embedded or captured in nearby surfaces such as walls, floors, ceilings, drains, laboratory equipment, and soils. At the end of calendar year (CY) 1998, planned remediation activities were completed at the King Avenue site. Should it be determined that further remediation is required, environmental monitoring efforts may resume at the King Avenue site.

The contamination found at the West Jefferson site is the result of research and development activities involving radioactive materials.

During CY 2000, multiple tests at the West Jefferson Nuclear Sciences Area found no radioactive isotopes present above the regulatory limit for air releases or for liquid discharges to Big Darby Creek. Data obtained from downstream sampling locations were statistically indistinguishable from background levels. BCLDP used minimum detectable activity (MDA) values for specific undetected isotopes to determine the percentage of the respective DOE Order 5400.5, *Radiation Protection of the Public and the Environment*, derived concentration guide (DCG) values for an individual radionuclide released to an unrestricted area.

Radionuclide emissions emanating from BCLDP operations conducted at the West Jefferson site for CY 2000 were compliant with the dose standard set forth in 10 CFR 20, Subpart D.

Radioanalyses of air filters collected from the site perimeter environmental air (EA) samplers indicate that radionuclide concentrations were significantly below the maximum allowable DCG values and the concentration values cited in 10 CFR 20, Appendix B, Table 2.

West Jefferson nuclear operations during 2000 caused no distinguishable impact on concentrations of airborne radionuclides or on external radiation doses measured adjacent to the West Jefferson Nuclear Sciences Area and the Battelle site boundary. Whole-body dose due to external radiation during 2000 at the site boundary was measured at background levels for Camp Ken Jockey, a Girl Scout camp located approximately 0.4 km (1,312 ft) northeast of the West Jefferson North site boundary. BCLDP verified an estimated individual dose from all sources of less than 100 mrem/yr including background radiation by using thermoluminescent dosimeters (TLDs) placed at fixed locations around the site boundary. A discussion of how this "fence post" dose was determined is presented in the section titled, "Environmental Radiological Monitoring for the West Jefferson Site."

Off-site levels of radionuclides that could be attributed to the West Jefferson nuclear operations were indistinguishable from background levels at specific locations where air, water, and direct radiation measurements were performed.

Battelle continues environmental monitoring to demonstrate compliance with federal, state, and local regulations. Routine, nonradiological activities performed in association with BCLDP include monitoring liquid effluents under the direction of the National Pollutant Discharge Elimination System (NPDES) Permit 4IN00004*GD and monitoring the groundwater system for the West Jefferson North site. Three groundwater wells are the source of potable water for the Battelle West Jefferson site.

In addition to routine monitoring of liquid and atmospheric emissions at the West Jefferson Nuclear Sciences Area, BCLDP collected and analyzed samples of various environmental media including air, water, grass, fish, field and garden crops, sediment, and soil from the region surrounding the site. BCLDP performed all sampling activities in accordance with standard operating procedures established by Battelle's Environmental Monitoring Program.

Results of BCLDP environmental sampling indicate no negative impact to the environment or human health. Tables citing results are provided in Appendix A.

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West Jefferson site consists of a 1,183-acre tract, of which only 500 acres are occupied by the Engineering Area in the southeastern portion, the Middle Area in the east central portion, and the retired Nuclear Sciences Area in the northern portion. The northern boundary of the site lies approximately one-half mile south of Interstate 70 and extends from the Plain City-Georgesville Road eastward to the Big Darby Creek. The eastern boundary of the site roughly parallels the valley of the Big Darby Creek southward to the Conrail tracks, which constitute the site's southern boundary. The Plain City-Georgesville Road defines the western boundary of the site.

For this report, the focus of interest is the Nuclear Sciences Area at the West Jefferson site, which is indicated by the hatched area of Figure 2. The Nuclear Sciences Area is a 10-acre, fenced site consisting of a guardhouse, four buildings, and several small structures, all located on a flat bluff. Battelle Lake (Silver Lake) lies to the south and the Big Darby Creek lies to the east of this area. The eastern edge of the bluff drops rather abruptly from an average elevation of 910 ft to 870 ft mean sea level (MSL), then more gradually to the 860-foot elevation of the Big Darby Creek floodplain. Battelle property extends to the north, west, and south. The site includes two narrow wooded strips, one along the

northern portion of the fence around the Nuclear Sciences facility, and the other approximately 1,000 ft to the northeast from the center of the site. The land to the east, within the Big Darby floodplain and along the bluffs to the east of the Creek, is heavily vegetated with deciduous trees, shrubbery, and high grasses. Battelle leases a portion of its West Jefferson land to farmers, typically for raising field crops such as corn or soybeans.

Demography

Table 1⁽¹⁾ (see Appendix A), Battelle West Jefferson Site Population Within 50-Mile Radius, gives the population distribution, by direction and distance, within 50 miles of the Battelle West Jefferson site. The area immediately adjacent to the West Jefferson site has a low population density. Camp Ken Jockety, a Girl Scout camp, is located on a bluff on the east side of the Big Darby Creek. The western boundary of the camp is located approximately 1,600 ft from the center of the West Jefferson site, and a residence within the camp is located approximately 3,300 ft from the center of the Battelle site. The residences nearest to the Nuclear Sciences Area are located in Lake Darby Estates. This subdivision is located approximately 2,550 ft southeast of the site center on the eastern side of the Big Darby Creek and

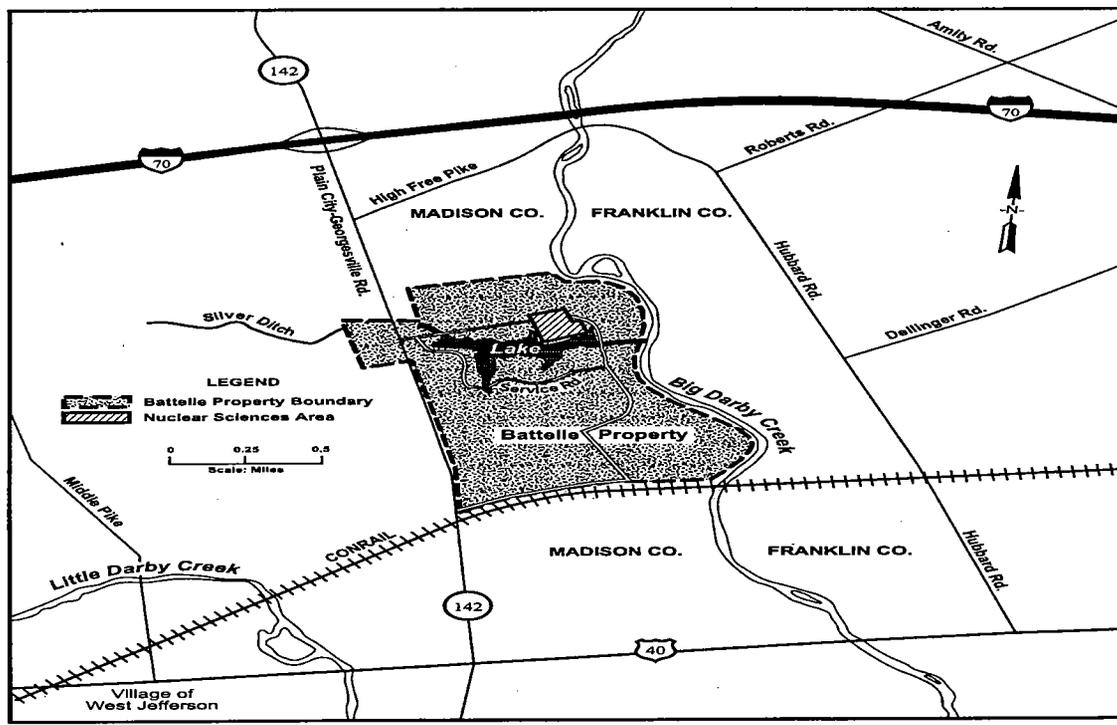


Figure 2. Local Vicinity Map of Nuclear Sciences Area – West Jefferson Site

consists of 965 single-family units. A second subdivision, West Point, located east of Lake Darby Estates and Hubbard Road, has approximately 540 housing units.

Local agricultural activity consists of growing field crops such as corn, soybeans, and wheat. Approximately 10 percent of the land area in agricultural use is devoted to pasturing beef cattle.

Two major highways, I-70 and I-270, are near the West Jefferson site. The junction of these highways, which lies near the eastern edge of the 10-mile perimeter around the Nuclear Sciences Area, has proven to be a popular area for commercial growth. It is estimated that the commercial population has shown an increase equivalent to that of the general population in this area during the past three decades.

Climatology

Climatic conditions at the Battelle West Jefferson site may be described as continental-temperate, the designation for Ohio's south-central region. As such, the region is subject to a wide seasonal range in temperature. Summers are quite warm; the mean temperature for the months of June, July, and August is 73.3° F. Temperatures of 90° F or above are expected for about 15 days during these months. Conversely, the mean for the months of December, January, and February is 28° F. The average number of days per year with temperatures below 32° F and below 0° F are 122 and 4, respectively.

Precipitation is distributed uniformly during the year, with 60 percent falling during the spring and summer seasons. The annual average monthly rainfall is approximately 3.5 in. The greatest recorded rainfall for any 24-hour period was 5.16 in. in July of 1992.

Changeable wind directions are characteristic of the region because of the incursion of maritime tropical air masses from the Gulf of Mexico and outbreaks of continental polar air masses from Canada. Warm air mass inversion is most common during the late spring and summer and frequently results in frontal showers and thundershowers. Tropical air mass thunderstorms are also common during the summer and are frequently accompanied by high winds. Additionally, it is not uncommon for hot air mass thunderstorm development to be strong enough to spawn tornado activity. Cold fronts that invade

the region, principally during the late fall, winter, and early spring, also bring showers and thunderstorms.

During the late spring, fast-moving cold fronts, with large temperature discontinuities ahead of and behind the frontal surface, travel through the region and are often accompanied by thunderstorms and tornadoes. The average yearly number of Ohio tornadoes recorded by the National Weather Service from 1950 through 1997 is 14. Of the 681 tornadoes recorded in this period, the largest percentage has occurred in the month of May. The largest number of tornadoes in Ohio in one year was 61 in 1992. In some years, such as 1988, no tornado activity was recorded in Ohio.

The regional climatological data gathered by the National Weather Service at Port Columbus, seven miles east-northeast of the King Avenue facility, are generally representative of the local climatic conditions at the Columbus site. Detailed meteorological data for the Columbus, Ohio, area also are included in the air model CAP88PC used to prepare this Site Environmental Report.

Geology

The geological strata underlying the West Jefferson area consists of glacial till and outwash with formations of clay, sands, and gravel. The sands and gravel from the outwash are found in scattered, thin, discontinuous lenses within the till, which is composed of unstratified clay containing fragments of rock. The unglaciated basement formations in the West Jefferson area lie at depths ranging from approximately 80 to 100 ft below the surface. These formations consist of nearly horizontal beds of limestone, dolomite, and shale several hundreds of feet thick. Surface soils consist of patches and mixtures of Brookston silty clay loam, Crosby silt loam, Lewisburg silt loam, Celina silt loam, and Miamian silt loam. The greatest portion of surface soils is represented by the Brookston-Crosby association with little more than traces representing the remaining types. These soil types exhibit relatively low permeability and grade into till clay at depths of 55 to 60 in., where the impermeability of the near-surface geology greatly impedes further percolation.

No major recorded earthquakes have occurred within 50 miles of the area of interest; although in 1937, a strong quake was experienced at Anna,

Ohio, located approximately 50 miles northwest of the West Jefferson site. A number of earthquakes with origins outside of Ohio have been detected in the central Ohio area, but none have caused any damage. Two minor earthquakes occurred in counties adjacent to Madison County during the 1980s: one in Greene County (1980), located southwest of Madison, and another in Fayette County (1985), located south of Madison. Both of these earthquakes were classified as level I-III on the Modified Mercalli Intensity Scale, ranging from 1.5 to 2.4 on the Richter Magnitude Scale. The Columbus-West Jefferson areas are considered to be in a nonseismic region. The Battelle facilities are in a Universal Building Code Seismic Zone 1 low-risk area.

Hydrology

Two aquifers, underground sources of water, are located in the West Jefferson site area. A shallow aquifer is located in the dense clay till, and a deep, or principal, aquifer is located in the limestone bedrock underlying the till. Earlier wells in the site area ranged in depth from 10 to 40 ft, which placed them in the glacial deposits. Till is not very permeable and yields water slowly. The effective velocity of water moving through clay under a hydraulic gradient of one percent is reported to be less than 0.004 ft/day; for water moving through silt, sand, and loess under the same gradient, the rate is between 0.0042 and 0.065 foot per day. Water movement in the till at the West Jefferson site is estimated to be within the range of 0.004 foot per day, because the hydraulic gradient of the water table in the area is only slightly greater than one percent.

BCLDP takes samples of the West Jefferson groundwater supply from three potable wells located throughout the facility. The North area well is 130 ft deep; the centrally located well in the Middle area is 162 ft deep; and the South area well is 138 ft deep. The source of groundwater in the site area is local precipitation. Recharge to the shallow aquifer occurs in a relatively uniform fashion throughout the year. Contours of the water table, which are approximately 40 ft below the surface, are a subdued reflection of the surface topography. Groundwater moves downslope at right angles to the contours and follows a path similar to surface runoff. Test borings drilled in 1970 for an addition to the Hot Cell Laboratory reaffirmed the geology described

above. Drilling operations encountered isolated pockets of groundwater, which were readily pumped out. These pockets remained dry, which indicates that there is no interconnection between the groundwater pockets and the lake. Battelle concludes that the lake has not adversely affected the hydrology of the area. At the Nuclear Sciences Area, surface runoff moves downslope into Battelle Lake, then through the controlled dam on the site into the Big Darby Creek.

Battelle Lake was formed in 1968 by damming Silver Ditch southeast of and down gradient from the Nuclear Sciences Area. It covers an area of about 25 acres and has a normal surface elevation of 888 ft above MSL.

Big Darby Creek accounts for the West Jefferson facility's principal surface water flow. The U.S. Geological Survey (USGS) Darbyville gauging station (USGS #03230500), which is located 40.46 river miles south of the West Jefferson facility, is the only continuous recording gauge on Big Darby Creek. The annual mean flow recorded at Darbyville is 471 ft³/second.

Floodwater calculations for the region measured during the January 1959 floods indicate a release rate for water that is about three times the inflow rate.

Background Radiological Characteristics

Environmental radiation can result from both man-made and natural sources. The four primary sources of natural radiation are radon and its daughter products resulting from the decay of uranium and thorium in rocks and soil, terrestrial radiation resulting from the decay of radioactive elements in the earth, cosmic radiation emitted from the sun and outer space, and the decay of naturally occurring elements in the human body.

In the United States, these natural sources of radiation produce an average dose of approximately 300 mrem/yr.⁽²⁾ Of this number, approximately 67 percent or 200 mrem/yr comes from radon. In 1966, the natural terrestrial background for the region surrounding Battelle was measured to be 60 mrem/yr by an aircraft equipped with radiation instrumentation.⁽³⁾ This number is greater than the national average of approximately 28 mrem/yr.⁽²⁾ The cosmic background for the State of Ohio is averaged to be 50 mrem/yr, compared to a U.S. average of 27 mrem/yr.⁽²⁾ The estimate for internal emitters within the body is considered to be approximately 39 mrem/yr for

the United States with only minor regional variations.⁽⁴⁾ As indicated in the section entitled "Evaluation of Estimated Dose to the Public," the impact from Battelle's atmospheric discharges from operations is less than 10 mrem/yr.

Project Description

S & M Activities at the West Jefferson Site

At the West Jefferson Nuclear Sciences Area, major S&M operations are necessary to contain the remnants of past R&D activities with irradiated materials. This work was performed in the Hot Cell Laboratory (JN-1) and involved examination and testing of irradiated reactor fuel, nuclear pressure vessel material, and fuel cladding material. Approximately 3 kg of residual fuel waste and small, contained sources remain on-site.

In 2000, nuclear support and S&M activities were conducted in the Hot Cell Laboratory (JN-1), the Administrative Building (JN-2), and the retired Battelle Research Reactor Building (JN-3). Figure 3 shows the locations of these nuclear facilities in the Nuclear Sciences Area building complex.

The scope of the S&M Program provides essential surveillance, inspection, control, and maintenance activities for the elimination, control, and prevention of hazard exposure to staff, public, environment, and property. The primary activities performed are Inspection and Maintenance, Radiological Monitoring and Surveillance, Health and Safety Monitoring and Surveillance, Environmental Monitoring and Surveillance, and Hazard Containment and Stabilization. All activities are responsive to regulatory compliance requirements.

■ *Inspection and Maintenance* includes the inspection and observance of facilities; equipment and instrument readings; testing and calibration of systems, instruments, and equipment; and the assessment of information from inspection data. The maintenance of critical elements of facilities, systems, equipment, and instruments to ensure positive control of potentially hazardous exposure environments is also included in Inspection and Maintenance activities. Procedures provide direction for the execution of inspection and maintenance requirements.

■ *Radiological Monitoring and Surveillance* is the performance of those activities necessary to

determine the radiological status of areas and ensure the radiation protection of the public and workers, including radiological surveys, monitoring and evaluation of changing radiological conditions, and implementation of a comprehensive radiation protection program and procedures.

■ *Health and Safety Monitoring and Surveillance* includes performing those activities necessary to determine the general safety status of areas and ensure worker health and safety by the implementation of a comprehensive health and safety program and procedures.

■ *Environmental Monitoring and Surveillance* is the performance of those activities necessary to determine the general status of the environment surrounding the BCLDP facilities, including environmental surveys and sampling, evaluation of changing conditions and trends, monitoring of transport pathways, and implementation of a comprehensive environmental monitoring program and procedures.

■ *Hazard Containment and Stabilization* is the performance of processes based on acceptable methodologies for the control and stabilization of recognized hazards to ensure that the present limit of hazardous conditions does not expand. This requirement is achieved by implementing engineering controls and limited decontamination work to contain hazardous materials and return areas to previous conditions.

Emergency Management at the West Jefferson Site

The radiological status of the BCLDP facilities is maintained through the *Emergency Management Program* in the event of radiological and/or medical emergencies and threats to security that must be quickly and effectively mitigated and resolved. The BCLDP Emergency Management Plan and procedures are integrated with the Battelle corporate emergency plan and agreements with various civil emergency response organizations.

D&D Activities at the West Jefferson Site

D&D activities at the West Jefferson site during CY 2000 concentrated on activities associated with classification and removal of contaminated waste using facilities in Building JN-1 and preparations for decontamination, radiological free release, and demolition of Building JN-3.

Transuranic (TRU) waste sorting, segregation, and packaging continued in the JN-1 High Energy Cell (HEC) and Mechanical Test Cell. Packaged TRU waste is being stored in the JN-1 fuel storage pool and a large shielded storage unit placed in the high bay. Low-level waste compaction operations were carried out on a periodic basis in the Charpy Cell. The basement Alpha-Gamma Cells were disassembled, and seven of the nine lead-filled cell doors were removed from the area for off-site disposal. A mop/rag laundering system and a wastewater polishing system were installed in the JN-1 Pump Room and placed into service. The ultrasonic (Sonatol) decontamination system was deactivated in preparation for its disassembly and removal.

The removal of materials and excess utilities began in JN-3. Diamond wire saw technology

was used to cut apart and remove the massive concrete reactor pool and bioshield structure. Activated material was removed from dry storage wells in the JN-3 Annex, and a number of the wells were saw cut and removed from the floor because they could not be opened for inspection.

An inactive discharge pipe running from an abandoned filter bed to the Big Darby Creek, a National and State Scenic River, was excavated and removed with no impact on the creek. The trench was refilled, graded and seeded.

Figure 3 shows the location of the four principal buildings at the West Jefferson Nuclear Sciences Area, including the Hot Cell Laboratory (JN-1), the Administrative Building (JN-2), a retired Research Reactor (JN-3), and the Hazardous Material Research Center (JN-4).

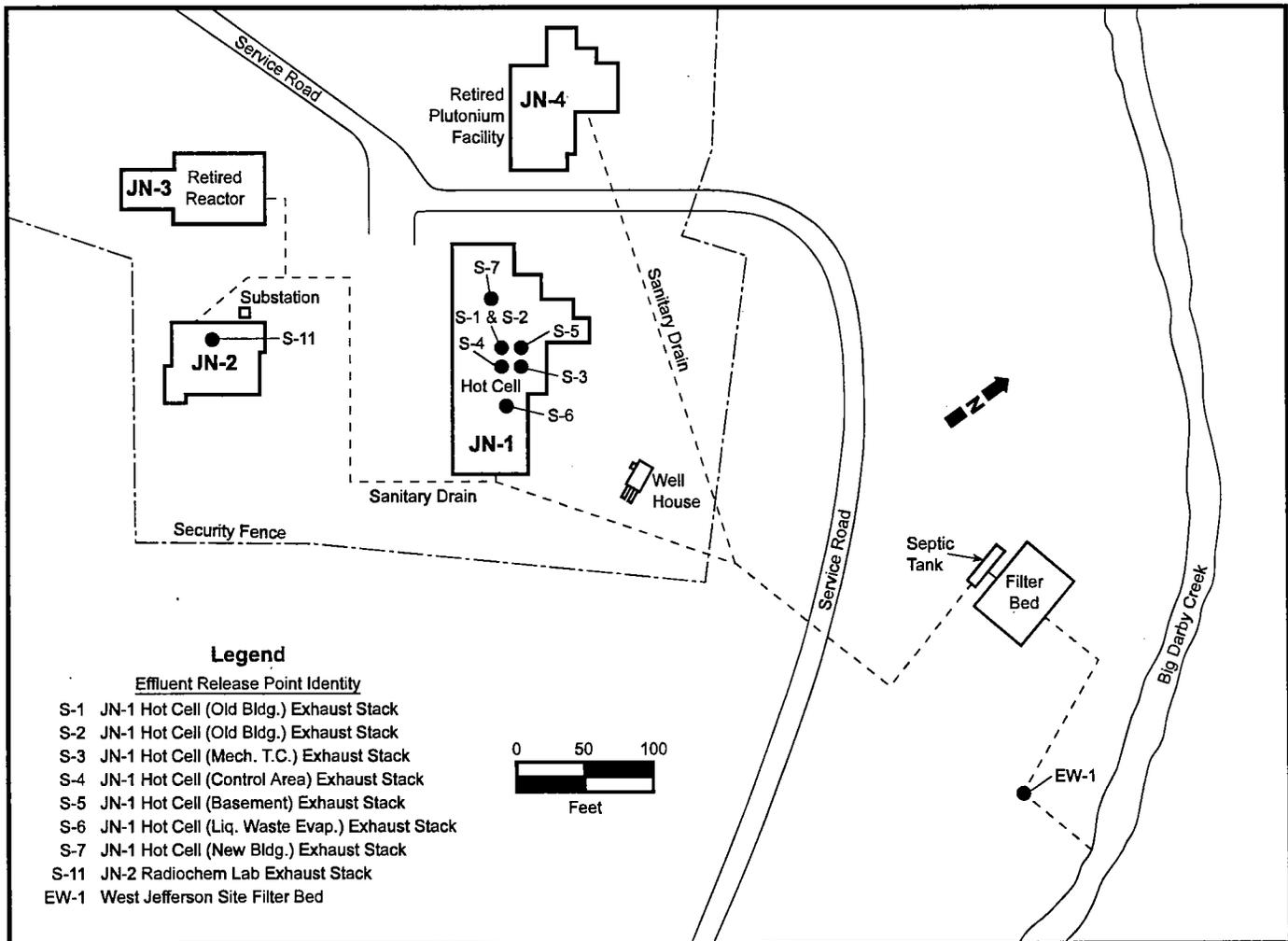


Figure 3. Nuclear Sciences Area – West Jefferson Site

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COMPLIANCE SUMMARY

BCLDP continues to maintain a state of compliance with applicable environmental statutes, regulations, and DOE orders. No fines, penalties, or administrative orders were imposed on BCLDP during 2000. No lawsuits by regulatory agencies or citizens were brought against Battelle. No United States Environmental Protection Agency (USEPA) or Ohio Environmental Protection Agency (OEPA) compliance issues in 2000 were attributable to BCLDP operations. No unresolved BCLDP compliance issues during 1999 needed to be addressed in 2000.

Comprehensive Environmental Response, Compensation, and Liability Act

No violations occurred and no enforcement actions were taken in connection with BCLDP in 2000. There were no releases of hazardous substances that required notification under the Comprehensive Environmental Response, Compensation, and Liability Act.

Resource Conservation and Recovery Act

Resource Conservation and Recovery Act (RCRA) compliance is the responsibility of Battelle's Hazardous Waste Operations Group. DOE has liability only for radioactive issues, and thus only for those hazardous wastes that have collateral radioactivity. BCLDP uses Battelle's 90-day generator storage facilities as necessary to maintain cost-effective packaging and shipping operations. Battelle currently conducts hazardous waste operations under OEPA generator regulations. Battelle is not operating as a hazardous waste treatment, storage, or disposal facility.

Battelle withdrew the Ohio Hazardous Waste Facility Installation and Operation Permit renewal application and the Hazardous Waste Facility Installation and Operation Permit for its King Avenue site on January 13, 1995. Battelle's King Avenue site is currently undergoing RCRA closure.

Battelle submitted an amended closure plan for closure of the XP-pad on August 5, 1999. The plan was approved by the OEPA on June 14, 2000. Closure of the Building 15 garages was completed and certified by Battelle in June 1997. The OEPA issued a letter signifying an acceptable

closure effort and granted Battelle permission to raze the building, which was completed in the fall of 1998. Although unrelated to BCLDP activities, full RCRA closure remains contingent upon closure of the XP-pad. Battelle completed the remediation and restoration of the XP-pad area on October 27, 2000, and submitted a closure report and certification to OEPA on December 6, 2000. The OEPA will release Battelle from the financial assurance requirements when the XP-pad closure is reviewed and approved.

Federal Facility Compliance Act

The amended proposed BCLDP Site Treatment Plan (STP) was submitted to the OEPA in October 1995. This STP fulfills the requirements in the Federal Facility Compliance Act of 1992 and RCRA Section 3021. The OEPA Director's Findings and Orders, effective October 4, 1995, covers implementation of the STP.

In 2000, the BCLDP provided OEPA with an annual update of the STP for 2000 in compliance with the Director's Findings and Orders.

National Environmental Policy Act

Activities performed during this period were consistent with the existing BCLDP Environmental Assessment⁽⁵⁾ and Finding of No Significant Impact.

Clean Air Act

The NRC regulates Battelle through the SNM-7 license. Current practices at Battelle are to limit release to less than 10 mrem/yr (constraint level of NRC/USEPA) nearest receptor dose from facility operations. Battelle currently meets the constraint level.

In a letter from the director received on August 9, 1996, the OEPA exempted the BCLDP from the requirements to obtain a permit to install under Ohio Administrative Code (OAC) 3745-31-03 (A)(3)(g) and a permit to operate under OAC 3745-35. The exemption expires on August 31, 2001, unless a written request for extension is made by Battelle.

Clean Water Act

The Clean Water Act is administered in Ohio by the OEPA. Battelle received no Notice of Violation (NOV) in 2000.

Safe Drinking Water Act

The Safe Drinking Water Act is administered in Ohio by the OEPA. Battelle received no NOV in 2000.

Toxic Substances Control Act

Battelle has not been cited by USEPA Region 5 for violations and no enforcement actions have been taken in connection with the BCLDP. Polychlorinated biphenyl (PCB) wastes have been stored in compliance with 40 CFR 761.65, with the exception of the accumulation time specified in 761.65(a). The BCLDP provided pertinent waste inventory information to the DOE to report to the USEPA was redundant since the information was already included in the annual site Toxic Substances Control Act (TSCA) inventory report. The BCLDP provided pertinent waste shipment and certification of disposal documentation to Battelle Columbus Operations Environment, Safety and Health (BCOES&H) to be included in the CY 2000 site TSCA inventory.

Due to a lack of treatment capacity for PCB wastes, which was remedied by a revised 40 CFR 761, Battelle was unable to ship the remaining 2,703 kg of low-level radioactive PCB solid remediation waste until October 5, 2000. It was shipped to Envirocare of Utah, Inc. in Clive, UT, for RCRA, Subtitle C, Landfill Disposal. This shipment represented the entire inventory volume of BCLDP waste that exceeded the accumulation time specified in 40 CFR 761.65(a). Prior to this shipment to Envirocare, no other disposal options were available to the BCLDP. Both the USEPA and OEPA were aware of this situation. Therefore, no violation was issued.

Superfund Amendments and Reauthorization Act Title III

In 2000, Battelle was not required to report under Emergency Planning and Community Right-to-Know Act (EPCRA) 302-303: Planning Notification; EPCRA 304: EHS Release Notification; or EPCRA 313: TRI Reporting. Battelle reports under EPCRA 311-312; Material Safety

Data Sheet/Chemical Inventory, which applies to storage of chlorine in cylinders used for water disinfection and aboveground and underground tank storage of #2 fuel oil, gasoline, and kerosene for backup fuel for boilers and emergency generators.

Battelle is voluntarily participating in the group locally responsible for implementing Superfund Amendments and Reauthorization Act, Title III.

Federal Insecticide, Fungicide, and Rodenticide Act

The Federal Insecticide, Fungicide, and Rodenticide Act is not applicable to BCLDP. Pesticides used in BCLDP areas are USEPA registered and purchased from a registered establishment.

Endangered Species Act

At the West Jefferson site, the following species of mussels have been identified:

Federal and Ohio Lists

- Clubshell (*Pleurobema clava*)
- Northern riffleshell (*Epioblasma torulosa rangiana*)

Ohio List

- Elephant-ear (*Elliptio crassidens*)
- Pocketbook (*Lampsilis ovata*)
- Rabbitsfoot (*Quadrula cylindrical*)
- Rayed Bean (*Villosa fabalis*)
- Snuffbox (*Epioblasma triquetra*)
- Washboard (*Megaloniais nervosa*)

Ohio Special Interest Species

- Wavy-rayed lampmussel (*Lampsilis fasciola*)
- Round pig-toe (*Pleurobema sintoxia*).

At the West Jefferson site, the following species of fish have been identified:

Federal and Ohio Lists

- Scioto Madtom (*Noturus trautmani*)

Ohio List

- Goldeye (*Hiodon alosoides*)
- Northern Brook Lamprey (*Ichthyomyzon fossor*)
- Northern Madtom (*Noturus stigmosus*)
- Spotted Darter (*Etheostorna maculatum*)

Federal Wild and Scenic Rivers Act

The Big Darby Creek has been designated as a component of the National Wild and Scenic Rivers System. At the present time, BCLDP activities are not subject to the requirements under the Federal Wild and Scenic Rivers Act because they do not affect the free flowing nature of the Big Darby Creek. Additional state or local requirements may be implemented in the future.

National Historic Preservation Act

The Resource Protection and Review Department of the Ohio Historic Preservation Office has determined that the West Jefferson nuclear facilities are not eligible for the National Register of Historic Places. Therefore, demolition of the facility will have no effect on the properties listed in or eligible for the National Register.

Executive Order 11988 "Floodplain Management"

Although portions of the West Jefferson site are located in the 100-year floodplain for the Big Darby Creek, the JN-1, JN-2, and JN-3 buildings are not located in the floodplain. The soil remediation planned for the abandoned north filter beds has been designed to minimize impact to or within the floodplain.

Executive Order 11990 "Protection of Wetlands"

BCLDP operations did not have any adverse impact on wetlands in 2000.

List of Environmental Permits

The following is a list of active environmental permits for Battelle Columbus Operations that are associated with the BCLDP.

Summary of Current Permits/Licenses/Registrations

Type	Description	Number
West Jefferson Laboratory		
Air	Boiler Building JN-1 Registration	0149000074/B001
Air	Boiler Building JN-2 Registration	0149000077/B002
Air	Boiler Building JN-3 Registration	0149000074/B003
Air	Underground Storage Tank Building JN-1 Registration	0149000077/T001
Air	Emergency Generator Building JN-6 Registration	0149000077/B012
Water	NPDES Permit	4IN00004*GD
Water	License to Operate or Maintain a Public Water System	00-4930212
Waste	Permit to Install – Sewage Holding Tanks	01-7110
Waste	Hazardous Waste Generator Registration	OHT400013892
Transportation	Tennessee Radioactive Waste Delivery License – BCLDP	T-OH007-L00
Transportation	US DOT Hazardous Materials Registration	0616000080221
Radioactive Materials	US NRC Materials License	SNM-7

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ENVIRONMENTAL PROGRAM INFORMATION

The BCLDP's environmental program consists of an environmental monitoring program, a health and safety program, environmental compliance oversight and evaluation activities, programs for waste minimization and pollution prevention, and emergency response programs.

Environmental Monitoring

Since 1955, Battelle's environmental monitoring program has evaluated the impact of operations on the health and safety of the public. The basic objective of the environmental monitoring program is to evaluate the control of effluent releases. The program assures control of radioactive and nonradioactive waste concentrations so that effluent levels are maintained as low as reasonably achievable and well below applicable standards. Effluents involving potentially polluting materials are evaluated prior to discharge or are disposed of as packaged wastes by authorized services as deemed appropriate.

With few exceptions, Battelle performs environmental radiological monitoring only under S&M. D&D operations include radiological pre-characterization and characterization of facilities, equipment removal, decontamination of facilities, and disposal of waste.

Nonradiological monitoring performed in connection with BCLDP is presented in a separate section following the section pertaining to radiological monitoring.

Health and Safety

One truly significant safety milestone was achieved by the project in 2000: the BCLDP Team accumulated five years or 1,849,167 exposure hours without a lost-time accident (LTA), involving days away from work, on August 19, 2000. The previous LTA had occurred on August 19, 1995. Through December 4, 2000, the BCLDP accumulated 1936 days and 1,937,113 hours without an LTA.

On Tuesday afternoon, December 5, 2000, a personal injury accident occurred when a project team member received multiple lacerations and a concussion as the result of jumping from a step-ladder to escape the path of an extremely heavy

cell door, which fell to the floor. The injured staff member missed 18 days of work during 2000 but has returned to work.

During 2000, project staff worked 279,035 hours. As of December 31, 2000, BCLDP staff have worked 25 days or 14,858 hours since the last LTA on December 5, 2000.

These data for the BCLDP involve not only Battelle employees, but also all subcontractor personnel working on the project, including health physicists, decontamination technicians, laborers, asbestos abatement contractors, moving/hoisting/rigging contractors, equipment operators, backhoe operators, concrete cutters, maintenance mechanics and other craft workers.

Environmental Oversight

BCLDP continued its formal environmental oversight program during 2000. Oversight is performed by BCLDP's Regulatory Compliance and Environment, Safety and Health Oversight personnel and also by BCOES&H personnel. Their mission is to independently verify that BCLDP programs for environmental compliance and environmental monitoring meet federal, state, and local environmental requirements. The oversight groups assist with compliance by providing technical support to evaluate the applicability of requirements and also conduct independent assessments and surveillances of ongoing activities.

Waste Minimization and Pollution Prevention

The Waste Minimization and Pollution Prevention Plan for the BCLDP primarily addresses the minimization of low-level waste (LLW) and RCRA mixed low-level radioactive waste (MLLW) at the source prior to generation through material substitution and process modification. Accomplishments for the BCLDP in waste minimization for CY 00 were:

- The radiological free-release and shipment of 1,230 ft³ of concrete for processing and reuse as road base material instead of managing it as LLW, realizing a cost savings of \$56,500

- The shipment of 1,280 cubic ft of lead shielding for decontamination, radiological free-release, and recycle to the Alaron Corporation in Wampum, PA, for a cost savings of \$38,000
- The avoidance of disposal of 46 ft³ of RCRA-regulated material as MLLW through the radiological free release program, for a cost savings of \$36,520
- The segregation, characterization, and radiologically free release of 3,761 ft³ of LLW soil, water, and trash for municipal disposal, resulting in a cost savings of \$3,222.

The BCLDP Field Operations Manager is responsible for annual reviews and updates of the Waste Minimization and Pollution Prevention Plan. Waste minimization is also included in the Waste Quality Assurance Plan, LLW Certification Plan, and TRU Waste Certification Plan and is incorporated into each D&D work plan. A program for training employees in pollution prevention awareness is in place.

WasteWise

Under Battelle's charter membership, the BCLDP contributes to the overall success of the site's WasteWise program. WasteWise was launched in January 1994 by the USEPA as a voluntary partnership designed to help businesses implement practical methods for reducing municipal solid waste. The WasteWise program promotes environmental awareness and improvement in three target areas: waste prevention, the increased usage of recycled products, and recycling.

In the area of purchasing recycled products, BCLDP continually seeks to use products with high post-consumer content.

BCLDP Emergency Management and Response

The BCLDP maintains a comprehensive and fully integrated emergency management program that combines adherence to regulatory requirements with public sector emergency response partnering. The program is administered and maintained based on NUREG-0654, NRC Guide 3.67, ICRP 60 recommendations and 29 CFR 1910.120 (q).

The structure of response capabilities is based on the Incident/Unified Command System, which promotes the timely combination of resources and integration of activities along functional lines at all levels, and to the extent possible, across all hazards. A preplanned unified command agreement is maintained between Battelle and the Jefferson Township Fire Department, which combines decision-making authorities at three levels: (1) incident command, (2) safety, and (3) medical.

To ensure successful partnering within the central Ohio emergency management and response community, Battelle maintains seven Letters of Cooperative Agreement with public sector agencies that commit parties to combined training and information exchange.

Battelle participates in the community emergency response planning process by maintaining an active presence in the local emergency planning committees of both Franklin and Madison Counties.

Emergency response to the December 5, 2000, accident during which an employee was injured was quick and in accordance with site procedures. Onsite emergency responders began rendering first aid and stabilized the injured party within minutes of the accident. Local fire and emergency personnel arrived at the site within six minutes of notification. The successful response was determined to be directly attributable to corrective actions and lessons learned from previous exercises hosted by the site.

ENVIRONMENTAL RADIOLOGICAL MONITORING FOR THE WEST JEFFERSON SITE

Inventories of measured radionuclide emissions in air and water media are presented in Table 2, Annual Radiological Release Inventory, West Jefferson Site – 2000, and Table 5, Summary of Liquid Radiological Effluent, West Jefferson Site – 2000. The values for the inventoried isotopes for both air and water media are based on the MDA values calculated for each of the listed isotopes.

BCLDP screened weekly samples for possible elevated levels of radioactivity by counting for gross alpha and gross beta-gamma. Weekly samples were then composited into monthly and quarterly samples for isotopic analysis. For radionuclide concentrations that were too low to be measurable, the MDAs were assumed to be positive releases for the purpose of calculating dose assessments. This assumption is conservative to establish a release inventory and estimate maximum possible doses to the public.

Air

Battelle collects and measures radionuclide emissions based on the principles cited in 40 CFR 61 Appendix B, Method 114.

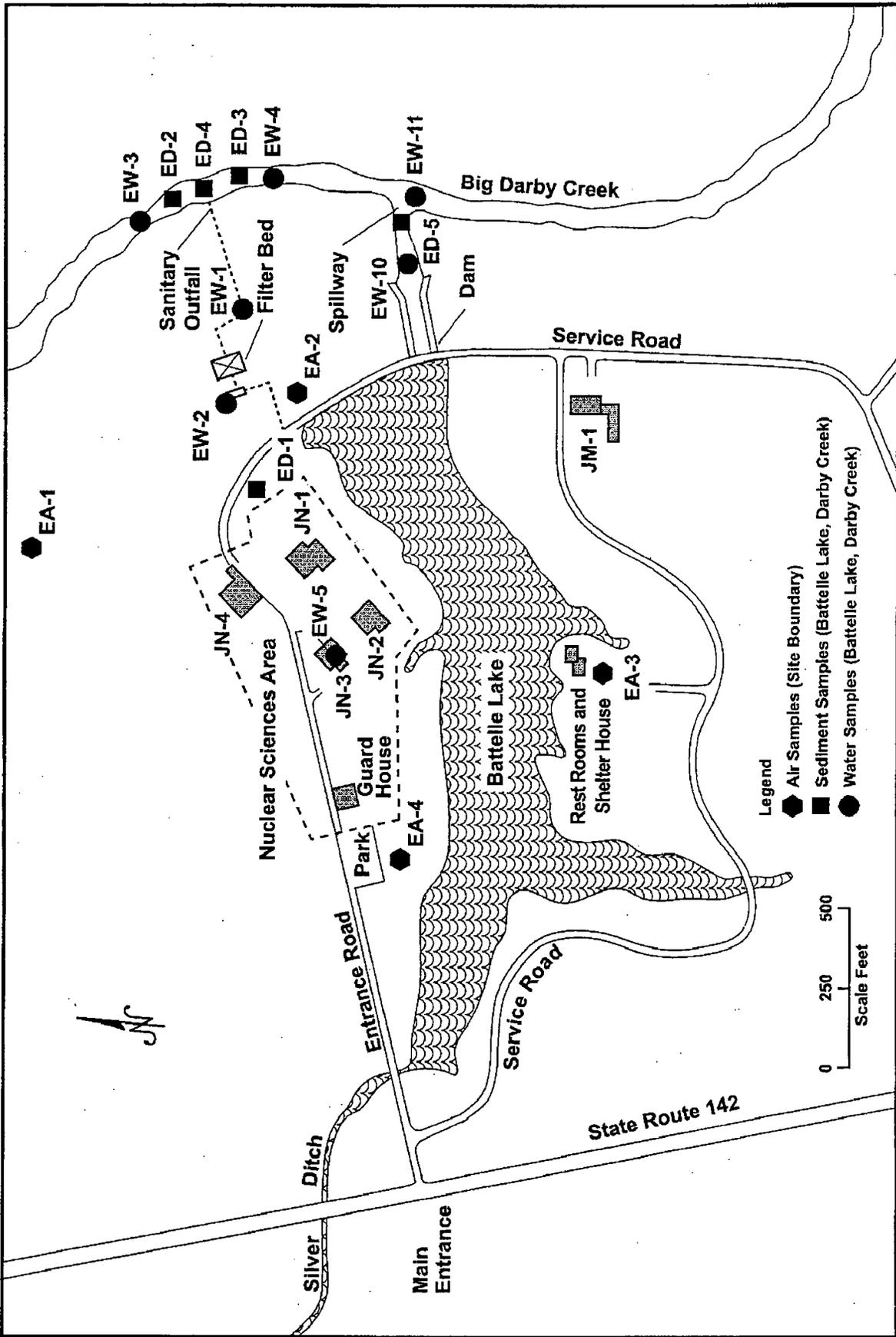
Stack air samplers continuously monitor the exhaust stack emissions from the potential source contributors (i.e., JN-1, JN-2) to assess the effectiveness of the systems controlling airborne emissions. Radiological stack monitors ensure detection of an inadvertent release of radioactive materials and provide data for the prompt assessment of possible environmental impact (see Figure 3 for locations). BCLDP collected representative particulate samples of the air effluent from each exhaust stack on Type AE glass fiber filter paper. The air was sampled at an average rate of 1.0 ft³/minute. This rate was selected to facilitate statistical calculations for activity concentrations that are well below regulatory standards.

Table 3, Annual Average Radiological Concentrations from Stack Emissions, West

Jefferson Site – 2000, provides a summary of the average annual radionuclide concentrations and the corresponding release rates for designated stacks (see Figure 3). Calculations were performed using CAP88PC air dispersion modeling to determine the annual average radionuclide concentration that would potentially exist at the West Jefferson site boundaries. These modeling results determined that the annual average concentration at the site boundaries was below the DCG values specified in DOE Order 5400.5, as well as the concentration guidelines specified in 10 CFR 20, Appendix B, Table 2.

BCLDP collected stack air effluent samples weekly, screened them for gross alpha and gross beta-gamma radioactivity, and used them to (1) plot trends for routine emissions from BCLDP activities and (2) ensure that preventative measures are implemented to detect a possible inadvertent release of radioactive materials to the environment. Subsequent monthly composites of these stack air effluent samples were compiled and analyzed for specific gamma-emitting radionuclides. Additional radiochemical analyses were also performed on a quarterly basis for alpha- and beta-emitting radionuclides.

BCLDP performed supplemental air sampling at four site perimeter locations (EA-1, EA-2, EA-3, and EA-4) during 2000 (Figure 4). These sample filters were analyzed on a weekly basis for gross alpha and gross beta-gamma activities. The filters were combined into quarterly composites. BCLDP then analyzed for Pu-238, Pu-239, Sr-90, natural-U, and gamma-emitting radionuclides (Table 4, Summary of Site Boundary Air Sample Analyses, West Jefferson Site – 2000). Collectively, these air sampling data were used to demonstrate that radionuclide emissions emanating as a result of BCLDP activities are compliant with federal, state, and local regulatory statutes and pose no significant threat to human health or the environment.



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Figure 4. Map of Site Water Sampling Locations, Site Boundary Air Sampling Locations, and Battelle Lake and Darby Creek Water and Sediment Sampling Locations

Water

A wastewater treatment system is operated in accordance with State of Ohio regulations under an NPDES Permit. Battelle operated under NPDES Permit 4IN00004*FD from January 1 through February 28. A new permit, 4IN00004*GD, became effective on March 1. The treatment system handles the wastewater generated on the West Jefferson North site. The liquids are first treated in a 2,500-gallon septic tank and then released to a 2,160 ft² contained sand and gravel filter bed (Figure 4). From the filter bed the effluent goes to a chlorinating system prior to release to the Big Darby Creek.

BCLDP used a continuous water sampling system to sample wastewater effluents from the Nuclear Sciences Area to Big Darby Creek after discharge from the chlorinating system. The weekly samples were held, composited on a monthly basis, and subjected to gamma spectroscopy. Specific analyses for Pu-238, Pu-239, Sr-90, U-234, U-235, and U-238 were performed on quarterly composites. The concentrations of specific radionuclides identified in the samples are summarized in Table 5, Summary of Liquid Radiological Effluent, West Jefferson Site – 2000. In most cases, the total activity in the samples is attributed to a mixture of radionuclides.

The noncommunity drinking water supply at the West Jefferson site is exempt from radiological monitoring per OEPA review.⁽⁶⁾ However, BCLDP collected weekly drinking water samples from a tap at the Nuclear Sciences Area to verify compliance with applicable water quality standards,⁽⁷⁾ for radioactivity in drinking water. Drinking water samples were composited and analyzed monthly for gross alpha and gross beta activity in suspended and dissolved fractions. A supplementary gamma isotopic analysis was performed on a quarterly composite, and alpha spectroscopy, along with I-129, Ra-226, Ra-228, and Sr-90 analysis were performed on an annual composite (see Table 6, Summary of Radiological Analyses of Drinking Water Samples, West Jefferson Site – 2000).

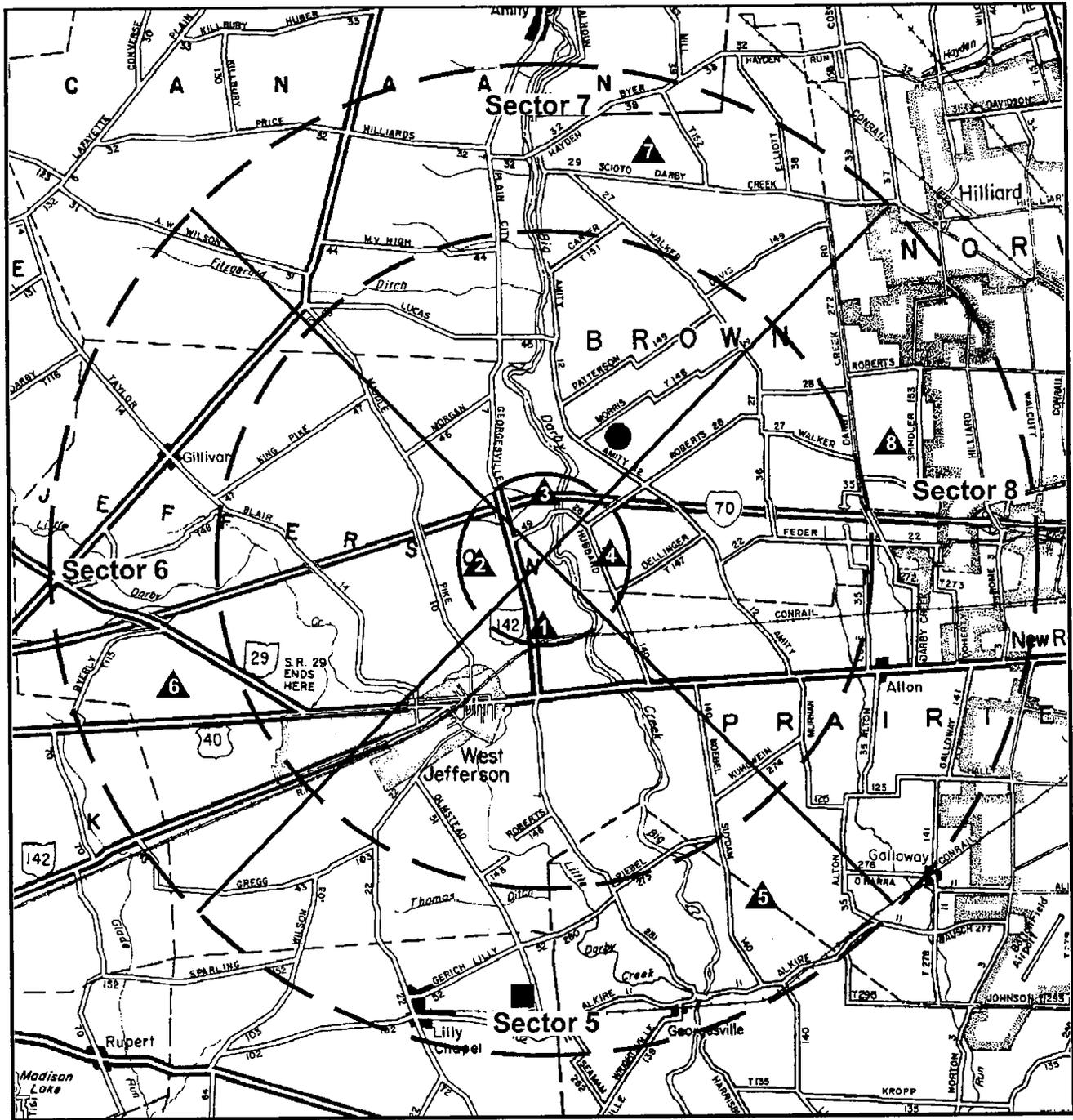
In 2000, the average concentrations in drinking water of gross alpha were $(2.34 \pm 7.36) \times 10^{-9}$ $\mu\text{Ci/mL}$ (soluble) and $(0.00 \pm 3.40) \times 10^{-9}$ $\mu\text{Ci/mL}$ (insoluble) for a total concentration of gross alpha of $(2.34 \pm 8.10) \times 10^{-9}$ $\mu\text{Ci/mL}$. The

average concentrations of gross beta were $(1.82 \pm 3.36) \times 10^{-9}$ $\mu\text{Ci/mL}$ (soluble) and $(1.23 \pm 4.92) \times 10^{-9}$ $\mu\text{Ci/mL}$ (insoluble) for a total concentration of gross beta of $(3.04 \pm 5.96) \times 10^{-9}$ $\mu\text{Ci/mL}$. The USEPA standard for gross alpha particulate activity in drinking water is 1.5×10^{-8} $\mu\text{Ci/mL}$.

BCLDP collected supplementary water samples weekly at sampling points located 18.3 m above (EW-3), 18.3 m (EW-4) and 186.3 m (EW-11) below the sanitary drain outfall, below the Battelle Lake dam, and at the dam spillway (EW-10) at Big Darby Creek (Figure 4). The supplementary water samples were analyzed monthly for mixed alpha and beta activity. The average concentrations of total activity in the downstream water samples were $(2.88 \pm 7.70) \times 10^{-9}$ $\mu\text{Ci/mL}$ for alpha and $(5.84 \pm 6.06) \times 10^{-9}$ $\mu\text{Ci/mL}$ for beta (EW-4), $(2.57 \pm 7.40) \times 10^{-9}$ $\mu\text{Ci/mL}$ alpha and $(5.48 \pm 6.00) \times 10^{-9}$ $\mu\text{Ci/mL}$ beta (EW-11). Neither downstream sample showed a significant difference from the upstream control sample (Table 7, Summary of Radiological Analyses of Environmental Water Samples, West Jefferson Site – 2000).

Grass and Field Crops

BCLDP collected grass and field crop samples from the surrounding area. The intent of this portion of the Environmental Monitoring Program is to determine whether there is uptake and concentration of radionuclides by plant or animal life. Where possible, sampling sites were chosen at maximum deposition locations predicted by meteorological studies. Grass and field crop (soybean or field corn) samples were collected at varying distances and directions within a 6-mile (9.6-km) radius of the Nuclear Sciences Area as shown in Figure 5. The eight samples collected were analyzed for Pu-238, Pu-239, Sr-90, U-234, U-235, and U-238. A qualitative analysis by gamma scan was also performed. The results of the grass and field crop analyses are summarized in Table 8, Summary of Radiological Analyses of Grass, West Jefferson Site – 2000, and Table 9, Summary of Radiological Analyses of Field Crops, West Jefferson Site – 2000. In both the grass and field crops, the levels of Pu-238, Pu-239, Sr-90, and uranium were at or below the MDA or not statistically significant for each isotope.



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- Legend:**
- ▲ Field crop, soil, and vegetation
 - Downwind garden crops location
 - Upwind garden crops location

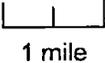


Figure 5. Field Crop, Soil, and Vegetation Sampling Locations – West Jefferson Site

Garden Crops

Two samples are collected annually to assess the possible impact on garden crops grown near the West Jefferson site. A composite sample of various vegetables from a location less than three

miles downwind of the Battelle site was compared to a composite of garden vegetables taken from a location upwind of the site. Figure 5 shows the locations of the downwind and upwind garden plots. Gamma isotopic, Pu-238, Pu-239, Sr-90, U-234, U-235, and U-238 analyses were

performed. The results of the analyses are shown in Table 10, Summary of Radiological Analyses of Garden Crops, West Jefferson Site – 2000. A comparison of sample locations shows that all radionuclides were at or below MDA or not statistically significant. Therefore, there is no impact to the downwind garden location.

Sediment

BCLDP collected sediment samples in June and December at five locations (see Figure 4), at approximately 18.3 m above (ED-2) and 18.3 m below (ED-3) the point of sanitary effluent release to the Big Darby Creek, at the storm sewer outfall leading to Battelle Lake (ED-1), at the liquid effluent discharge point into the Big Darby Creek (ED-4), and at the dam spillway to the Big Darby Creek (ED-5). The sediment samples were analyzed for Pu-238, Pu-239, Sr-90, U-234, U-235, and U-238. Quantitative gamma isotopic analysis was also performed. The average results of the sediment analyses are summarized in Table 11, Summary of Radiological Analyses of Sediment Samples, West Jefferson Site – 2000.

Soil

Using a 10-cm soil-plugging tool, BCLDP collected annual soil samples from eight locations at varying distances and directions within a 6-mile (9.6-km) radius of the Nuclear Sciences Area (Figure 5). Each soil sample consisted of a composite of five “plugs” of soil collected randomly from an area of approximately 1 square meter. Prior to analysis, the composite samples were oven dried and blended in a pulverizing mill. The soil samples were analyzed for Pu-238, Pu-239, Sr-90, U-234, U-235, and U-238, and a gamma spectroscopy scan was performed for qualitative analysis. The results of the analyses are summarized in Table 12, Summary of Radiological Analyses of Soil, West Jefferson Site – 2000.

Results for Sr-90, Pu-238, Pu-239, U-234, U-235, and U-238 were at or below the MDA or not statistically significant from background. U-238 is naturally occurring in soil, and activity

levels may vary among sample locations. Gamma isotopic analyses of the soil samples showed detectable concentrations of Cs-137 in all eight sampled sectors. The Cs-137 values are typical of increases seen after Chernobyl’s radioactive fallout and are not believed to be attributable to on-site activities.

Fish

Fish samples were collected from Battelle Lake (June and November 2000) and from Big Darby Creek (May 2000) to determine if any radioactive material is entering the food chain. Fish tissue was analyzed for gamma-emitting isotopes, Pu-238, Pu-239, Sr-90, U-234, U-235, and U-238. The results of these analyses were at or below MDAs or not statistically significant for each isotope. Table 13, Summary of Radiological Analyses of Fish Tissue, West Jefferson Site – 2000, summarizes the 2000 data from the analyses.

Background Radiation Measurement

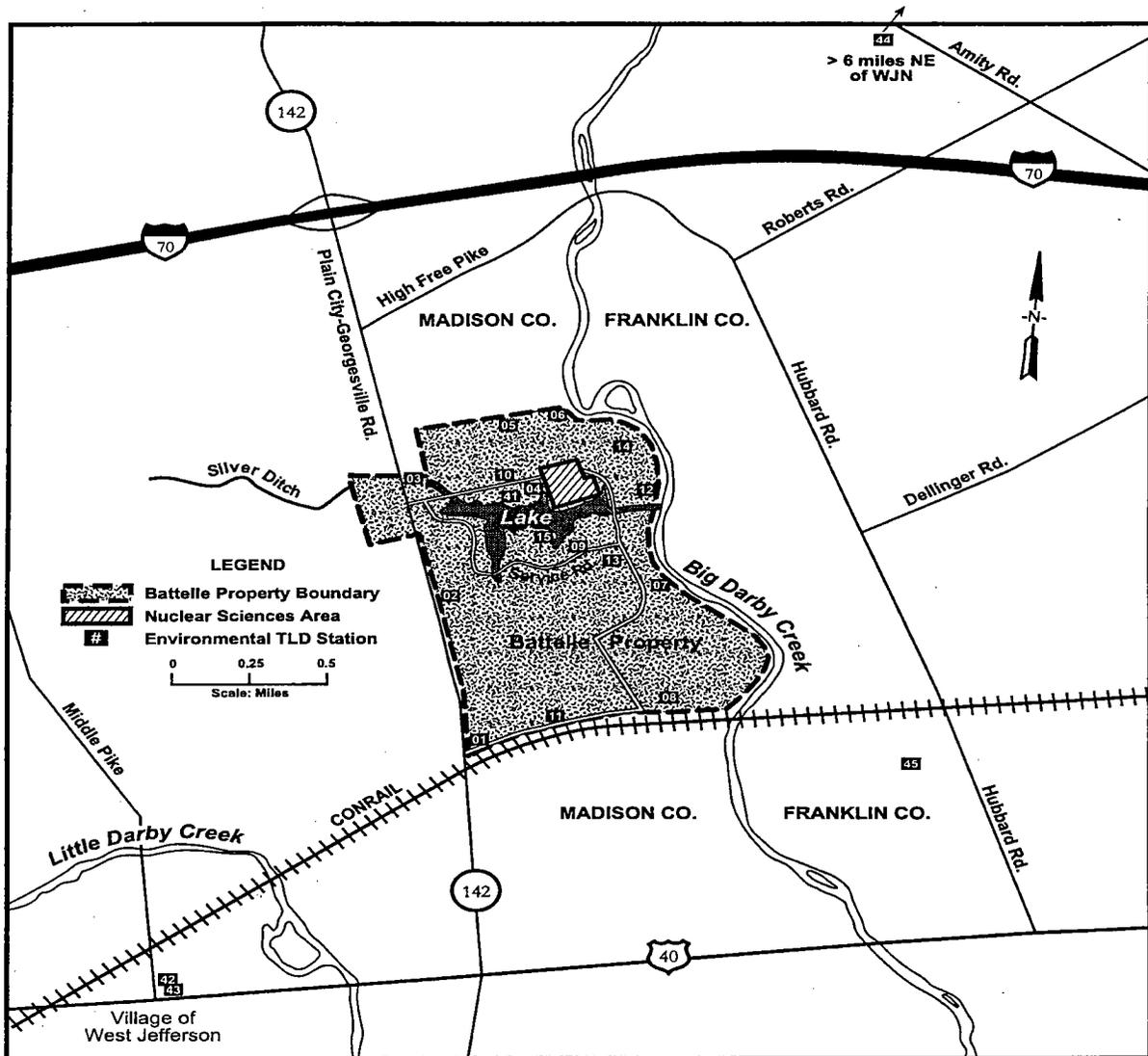
The radiation dose limit established for the general public by the DOE is 100 mrem/yr.⁽⁸⁾ This value does not include the contribution from natural background radiation, which, in previous years, averaged less than 120 mrem/yr from all off-site sources except radon. Figure 6 shows the location of the 16-dosimetry stations that continuously monitor the external radiation background levels at the West Jefferson site.

The dosimetry stations are equipped with commercially available environmental TLD packets that are changed and evaluated each calendar quarter. Based on data provided by the 16 dosimeter stations, the 2000 annual average dose equivalent, including background at the site boundary, is less than 120 mrem. Therefore, there is no measurable contribution from the West Jefferson facilities to off-site public, external radiation doses. The results are summarized in Table 14, Integrated External Background Radiation Measurements at Recreation Area and Property Boundary Line, West Jefferson Site – 2000.

“Fence Post” Dose Estimate

The “fence post” dose is the maximum measured cumulative dose of radiation possible to an individual at the site boundary. It does not

include ingestion and inhalation pathways. The “fence post” dose for 2000 was consistent with the annual average TLD background reading of 120 mrem measured at off-site background monitoring stations.



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Figure 6. Map of TLD Locations Within $\frac{3}{4}$ -Mile Radius of the Nuclear Sciences Area

ENVIRONMENTAL NONRADIOLOGICAL PROGRAM INFORMATION

Drinking Water

The drinking water system at the West Jefferson site is monitored under OEPA regulations, which are applicable to all public water supplies. Because this is a non-community water supply, Battelle was required to perform the following tests in 2000:

- Total coliform for microbiological contamination – quarterly

All tests for total coliform were negative.

- Volatile organic compounds (VOCs)—once during the second quarter of the year

Battelle performed VOC sampling during CY 2000. Results indicated that no VOCs were present in the water supply above detection limits of 0.5 µg/L.

- Nitrates – once during last half of the year

Nitrate levels were found to be well below the established Maximum Contaminant Level (MCL) value of 10 mg/L.⁽⁷⁾

Liquid Effluents

Liquid effluents discharged from the West Jefferson facility are subject to the restrictions on an NPDES permit. Battelle monitors these effluents and reports the results to the OEPA on a monthly basis. Table 15, Nonradiological Water Effluent Analyses, West Jefferson Site – 2000,

includes a list of parameters for which Battelle is presently required to analyze and report at the North site. The data provided for the North Wastewater Treatment System were obtained in accordance with NPDES Permits 4IN00004*FD (Jan. 1 – Feb. 28) and 4IN00004*GD (Mar. 1 – Dec. 31) issued by the OEPA. All readings were within acceptable limits as specified in the permits for 2000.

The values listed in Table 15 represent an average of the monthly data collected during the 12-month period starting January 1, 2000, and ending December 31, 2000. The table illustrates the actual performance against permit limits/restrictions. The results in the table are for NPDES discharge point 001, which includes the discharge from the West Jefferson North area and is shown as point EW-1 in Figure 4.

Battelle has been a participant in the Ohio Department of Natural Resources – Stream Quality Monitoring Project since 1994. In this voluntary program, a field assessment of water conditions is performed based upon the number and types of macroinvertebrates collected in the creek. The assessments are conducted in Big Darby Creek during the warm weather months (generally May to October) at a location just south (downstream) of the Battelle north sanitary outfall. The index values recorded through the years have consistently been in the excellent category (a score greater than 22). Thirty (30) assessments have been conducted since June 1994 with 29 assessments falling in the excellent category and one (1) in the good category (17 to 22 range)

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GROUNDWATER MONITORING AND PROTECTION PROGRAM

Groundwater monitoring at the West Jefferson site included a total of 21 shallow and deep wells (Figures 7, 8, and 9). These include three supply wells (JN, JM, and JS) (Figure 9) at a depth of approximately 130 to 160 ft, three wells designed for chemical monitoring (C03, C09, and C16) (Figure 7) at a depth of approximately 9 to 15 ft, and 15 shallow wells (Figures 7 and 8) at a depth of approximately 9 to 20 ft. Battelle installed the three wells designed for chemical sampling and 13 shallow wells late in 1989. Figures 7 and 8 indicate the location of shallow and chemical monitoring wells. Battelle performed detailed chemical monitoring, and the results were reported in *Interim Report on Site Characterization, West Jefferson North Site, Stage 1 Sampling and Analysis: Chemical Sampling Summary Report*,⁽⁹⁾ dated December 22, 1989. No contamination was found in groundwater samples collected at that time.

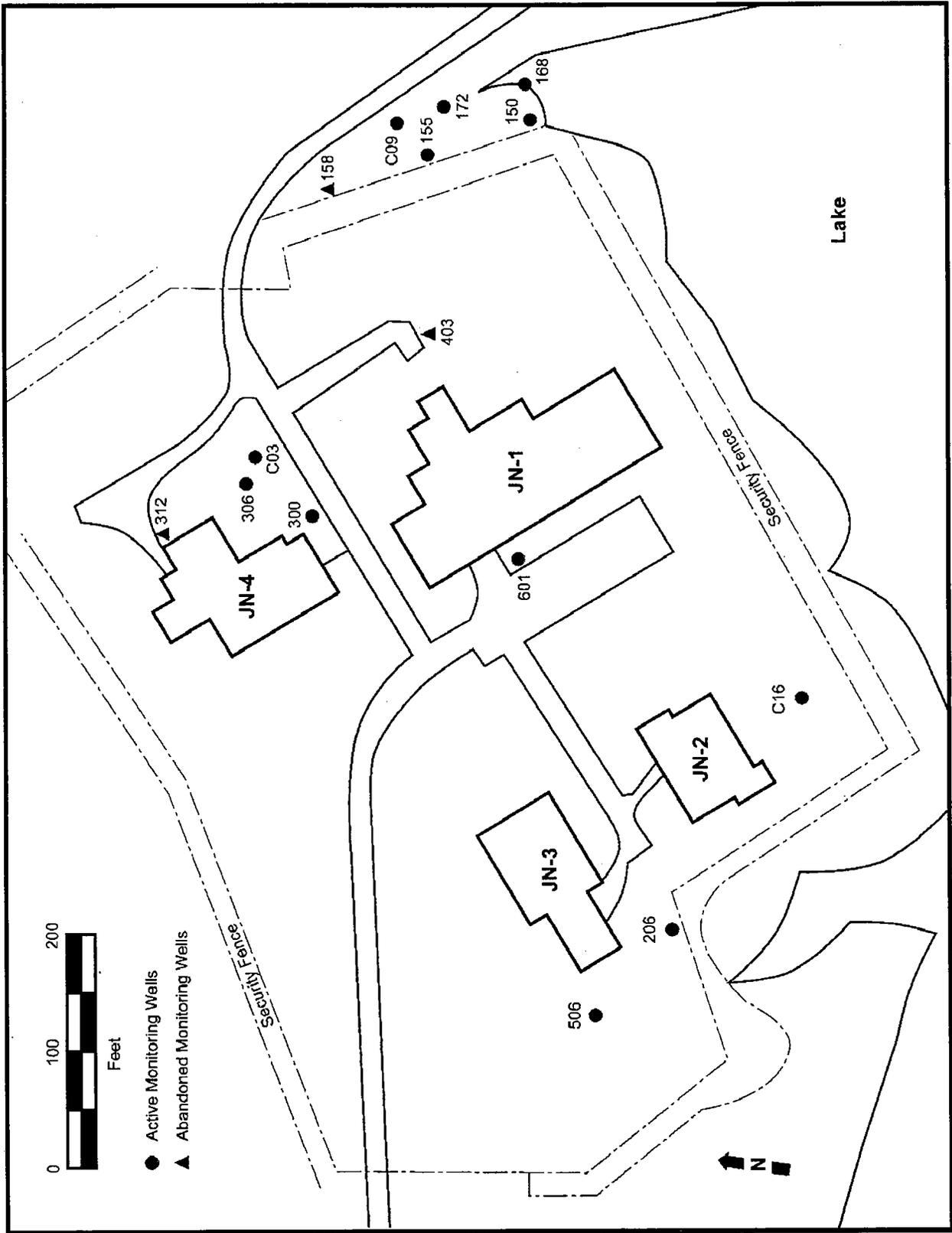
Battelle also performed detailed chemical analyses on groundwater samples collected during December 2000 from the three traditional chemical monitoring wells. Samples from all three wells were analyzed for eight heavy metals, 28 pesticide and PCB compounds, 67 VOCs, 66 synthetic organic chemicals, oil and grease, and pH. The results of the analyses are summarized in Table 16, Nonradiological Analyses of Groundwater, West Jefferson Site – 2000. Trichloroethene was detected in well C16 at a concentration of 6.0 µg/L, which is slightly above the MCL of 5.0 µg/L. Trichloroethene was not detected in well C03 or well C09. 1,1,1-Trichloroethane was detected at a concentration of 10.0 µg/L in well C16, which is below the MCL of 200 µg/L. The above contaminant was not detected in well C03 or well C09. A low barium level was reported in all three wells. The concentration was well below the drinking water standard of 2,000 µg/L. In addition, arsenic was detected in well C09 at a concentration of

10.7 µg/L. This level was also below the drinking water standard of 50 µg/L.

Battelle found no chemical contamination in any of the wells prior to 1991. The shallow wells were constructed solely for monitoring purposes. Although groundwater from these shallow monitoring wells does not represent site drinking water, the results are compared to USEPA Primary Drinking Water Standards to put any observed concentrations in perspective.

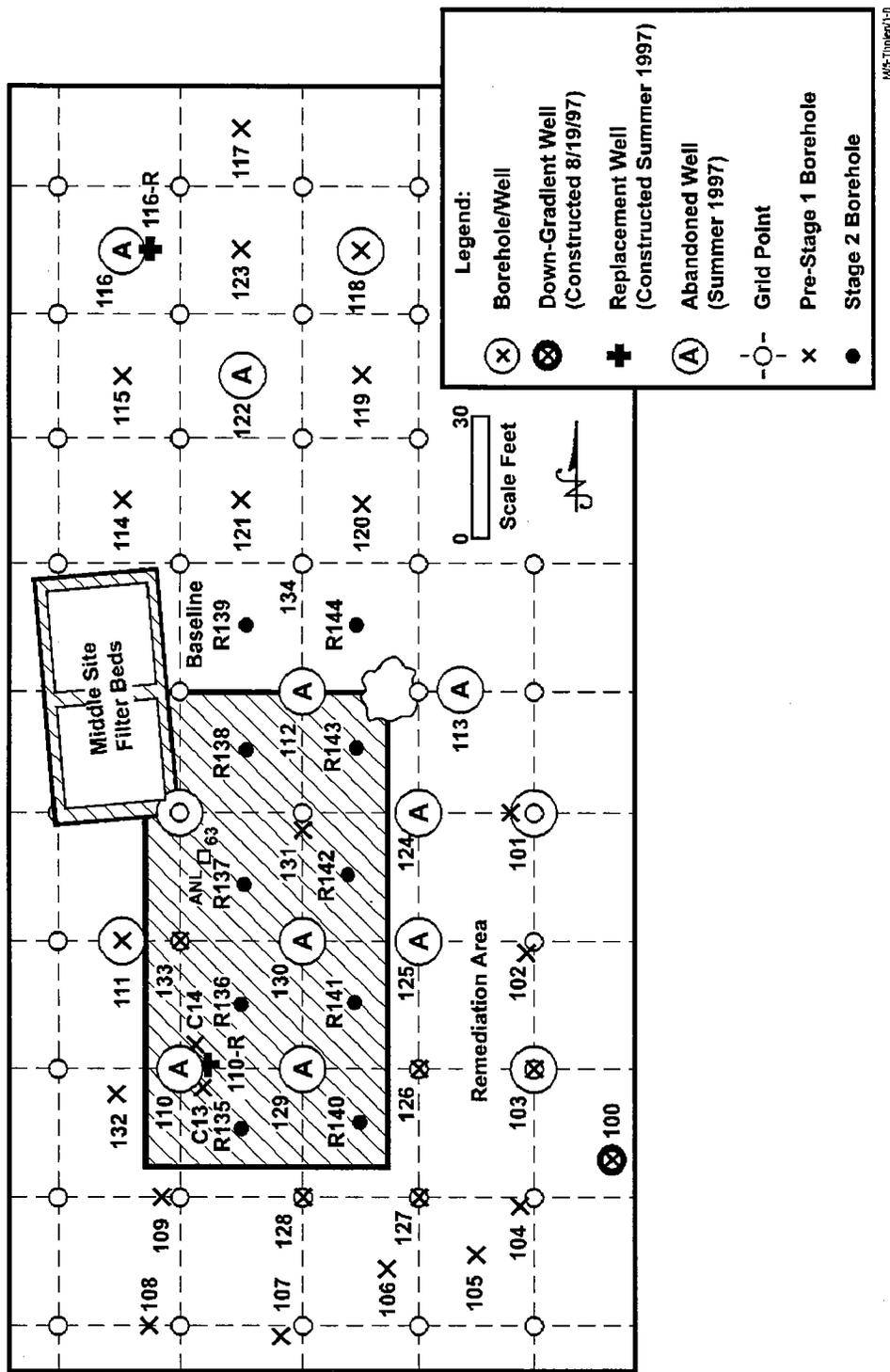
Radiological groundwater monitoring was conducted in June and November 2000. The average annual radiological monitoring results are presented in Table 17, Summary of Alpha/Beta Radiological Analyses of Groundwater, West Jefferson Site – 2000; Table 18, Summary of Radiological Analyses of Groundwater, West Jefferson Site – 2000; and Table 19, Summary of Radiological Analyses of Supply Wells, West Jefferson Site – 2000. Activity levels range from 6.35 ± 3.06 to 28.25 ± 7.67 pCi/L for gross alpha and 2.87 ± 1.35 to 30.00 ± 3.42 pCi/L for gross beta. Because the units are in pCi/L, the disparity in the range of values presented is not statistically significant. The Sr-90 activity in wells 101, 103, 118, 168, 172, and C09 was reported at levels slightly higher than the average value for the other site monitoring wells, but these levels are well below regulatory limits. These data are consistent with previous monitoring data collected since installation of the wells in 1989.

During the last half of CY 1995, an environmental geophysics study was conducted at the retired filter bed area at the West Jefferson site (Figure 3). This area has been recommended for further remediation in the *Final Assessment of the Radiological Status of Battelle's Nuclear Sciences Area*, dated January 1991.⁽¹⁰⁾ The study was conducted to define the hydrogeologic framework, characterize potential contaminant pathways, identify possible leakage points in buried pipelines and drainage tile, and to install piezometers.



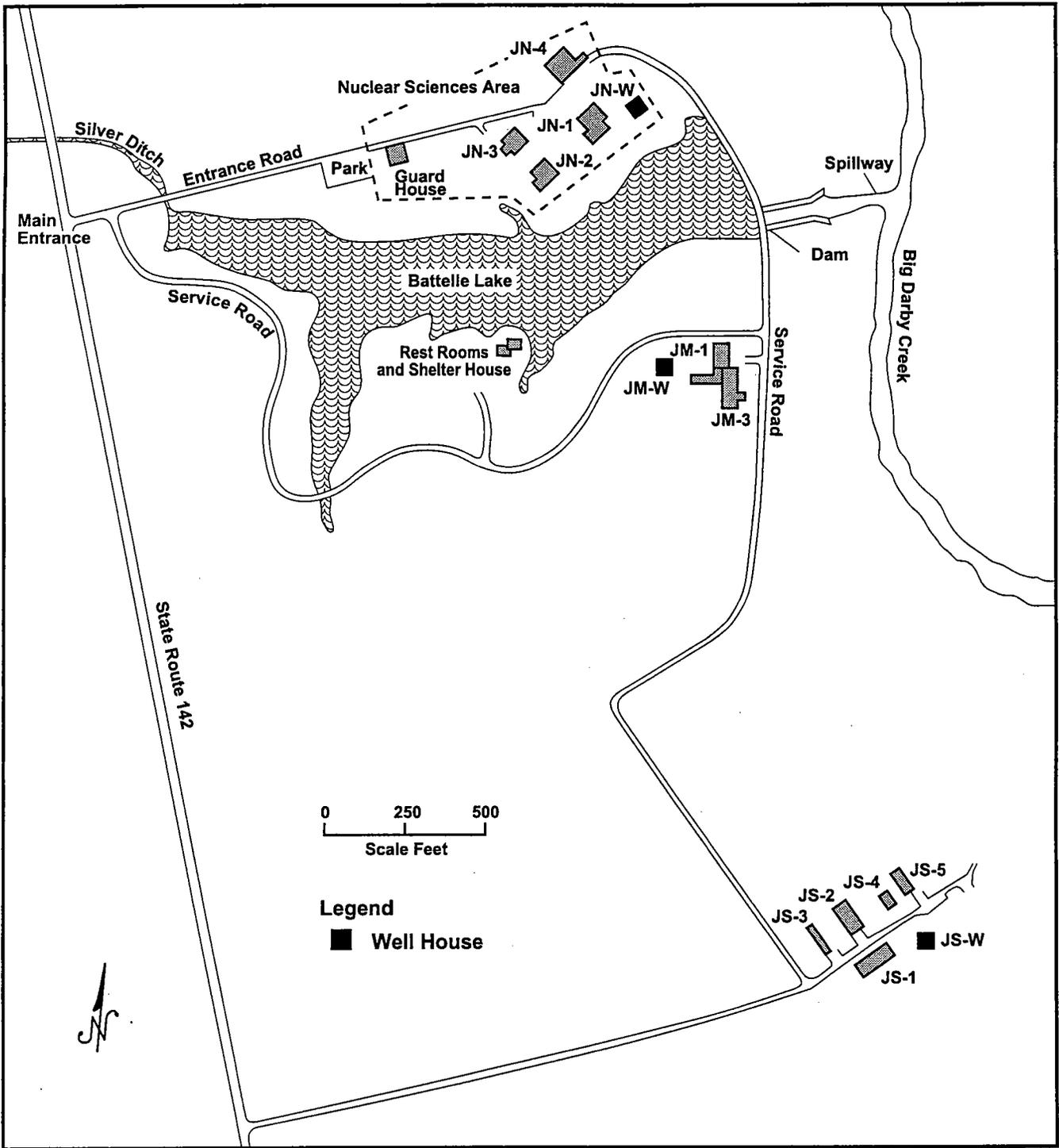
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Figure 7. North Site Groundwater Monitoring Wells



M/S-Threat'00

Figure 8. Groundwater Monitoring – Remediated Filter Bed Area (Shaded Area)



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Figure 9. West Jefferson Site Supply Wells

EVALUATION OF ESTIMATED DOSE TO THE PUBLIC

BCLDP calculates dose assessments for radionuclide emissions emanating from the West Jefferson site using both the COMPLY⁽¹¹⁾ and the CAP88PC⁽¹²⁾ air dispersion models. Each of these models integrates an effective dose equivalent (EDE) to members of the general public by considering various environmental pathways and site-specific meteorological data. Not only does each of the models demonstrate that radionuclide emissions occurring from BCLDP operations were below the 10 CFR 20 Subpart B constraint dose standard of 10 mrem/yr, but each model predicted a unit of risk based upon either actual measurements from collected environmental field samples or the quantity of radioactive materials that were utilized by the facility during a calendar year.

BCLDP uses the COMPLY model because (1) this model derives an EDE based upon the annual quantity of radioactive materials used by BCLDP without bias associated with the inherent limitation of radioanalytic counting statistics, and (2) it is an acceptable method used to demonstrate compliance with 10 CFR 20.1101(d) as specified in Reg. Guide 4.20, "Constraints on Releases of Airborne Radioactive Materials to the Environment for Licensees Other than Power Reactors."

In comparison, BCLDP selected the CAP88PC air dispersion model to evaluate the potential risk posed to members of the general public because (1) the calculated EDE derived from this model correlates to the field sample data collected, such as stack effluent samples; (2) site specific data, such as stack height, plume rise, and local population distributions are used to better evaluate a unit of risk; and (3) additional data such as annual average radionuclide concentrations at various distances, exposure to critical organs, and a collective EDE for person-rem/yr can also be calculated.

In summary, BCLDP used both air dispersion models to calculate a unit of risk, which demonstrated that radionuclide emissions emanating from BCLDP operations remain compliant with applicable regulatory standards

and pose no significant threat to human health or the environment.

Atmospheric Discharges

Calculated releases and ground-level annual average concentrations at the site boundary during 2000 from the West Jefferson site are summarized in Tables 2, 3, and 4. The downwind position from the facility where ground-level radionuclide concentrations would be the greatest is the north site fence line, which determines the perimeter for uncontrolled exposure. BCLDP used the isotopic composition of the effluents assumed to be emitted from the seven stacks in JN-1 and one stack of JN-2 to evaluate the off-site dose to the public using the CAP88PC program, which estimated a 7.62×10^{-4} person-rem/yr collective population dose for the total population within 80 km of the West Jefferson site. The doses presented in this report are calculated, rather than measured, and represent an estimate of doses.

Liquid Discharges

Measured aqueous releases and effluent concentrations during 2000 for the West Jefferson site are summarized in Table 5. The concentration values apply to the water discharged into the Big Darby Creek after passage through a treatment system consisting of a settling tank and a sand filter. Based on a knowledge of the isotopic composition of radionuclide concentrations released to the surface sand filter, BCLDP estimates that emissions are caused by very limited elution of contaminants from the surface sand filter that were delivered to the bed in the past few years. To be conservative, the release inventory values were based on the MDA of isotopes listed in Table 5. The actual release values would be lower.

Because of the shallow nature of Big Darby Creek at the West Jefferson site, significant pathways for exposure to boaters, swimmers, or water skiers are not likely. In addition, water from the Big Darby Creek below the outfall is not used for

drinking prior to its confluence with the Scioto River, according to the USGS. Therefore, the dose contribution from this source is negligible.

Computation of Dose Equivalent Rates to Nearest Individuals and Population Groups

BCLDP computed the annual radiation dose from particulate radionuclides assumed to be discharged into the atmosphere for a person continuously immersed in an infinite semispherical cloud containing the radionuclides. Stack release data

(Table 3) were used to estimate the dose to the nearest individual and population group using actual dispersion conditions. If the conditions were unknown, data representative of a worst case scenario were used. The radionuclide composition and concentration of the atmospheric emissions were used to compute critical organ doses. The dose estimates obtained for the nearest individual assume a full-time resident at Camp Ken Jockey, which is adjacent to the West Jefferson site. Based on these estimates, the general public receives no measurable dose from BCLDP operations.

QUALITY ASSURANCE

Battelle uses several methods to assure that the data collected each year are representative of actual concentrations in the environment. BCLDP collects extensive environmental data so an accurate assessment of environmental impact can be made. Newly collected data are compared with historical data for each environmental medium to assure that current values are consistent with previous results. This comparison allows for timely investigation of any unusual results. Samples are collected using identical methods near to and far from the Nuclear Sciences Area, as well as upstream and downstream on the Big Darby Creek, to provide for identification of any net differences that may be attributable to the West Jefferson nuclear operations. These procedures, in conjunction with a program to demonstrate the accuracy of radiochemical analyses, assure that the data accurately represent environmental conditions.

With minor exceptions, Battelle performs all of the routine radioanalyses for the environmental surveillance program at the radiochemistry facility located at the West Jefferson Nuclear Sciences Area. The Battelle Radioanalytical Laboratory (RAL) maintains an internal quality assurance program that includes routine calibration of counting instruments for efficiency and background, subtraction, routine yield determinations of radiochemical procedures, replicate analyses to check precision, and matrix/blank spikes to verify accuracy. Battelle assures the accuracy of radionuclide determination through the use of standards traceable to the National Institute of Standards and Technology.

Battelle provides assurance of the dose calculation quality in a number of ways. Because doses are similar from year to year, comparisons are made against past calculated doses, and any differences are validated. All computed doses are reaffirmed by the originator and by an independent third party, who also checks all data input and assumptions used in calculation. Information necessary to perform all of the calculations is fully documented.

The RAL participates in the semi-annual DOE Environmental Measurements Laboratory (EML) Quality Assessment Program. This program is designed to monitor a laboratory's performance by submitting samples of known isotopes and quantified activities for analysis. EML submits four types of samples in different matrices for analysis. These samples consist of water, soil, vegetation, and an air filter. All of the analyte concentrations measured by the RAL in 2000 were within EML's activity boundaries.

In addition, the RAL participates in the Environmental Resource Associates (ERA) Performance Test (PT) study for gross alpha/beta in water. ERA submits water samples of known activities for analysis. The activity levels in the PT are representative of environmental activity of the routine samples analyzed in the RAL. The RAL participated in three PT sample studies in 2000. All of the gross alpha/beta results were within ERA's activity boundaries.

The RAL has maintained the State of Utah Certification for radiological analysis since July of 1996. This certification must be maintained in order to ship waste to Utah.

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GLOSSARY

alpha particle. A positively charged particle emitted from the nucleus of an atom having the same charge and mass as that of a helium nucleus (2 protons, 2 neutrons).

alpha spectroscopy. The process of measuring alpha particle energies and using those energies to identify specific radionuclides in a sample.

atom. Smallest particle of an element capable of entering into a chemical reaction.

beta particle. A negatively charged particle emitted from the nucleus of an atom having a mass and charge equal to that of an electron.

contamination. The deposition of unwanted radioactive or hazardous material on the surfaces of structures, areas, or objects.

curie (Ci). The traditional unit for measurement of radioactivity based on the rate of radioactive disintegration. One curie is defined as 3.7×10^{10} (37 billion) disintegrations per second. Several fractions and multiples of the curie are in common usage.

millicurie (mCi). 10^{-3} Ci, one-thousandth of a curie; 3.7×10^7 disintegrations per second.

microcurie (Ci). 10^{-6} Ci, one-millionth of a curie; 3.7×10^4 disintegrations per second.

picocurie (pCi). 10^{-12} Ci, one-trillionth of a curie; 3.7×10^{-2} disintegrations per second.

decay, radioactive. The spontaneous transformation of one radionuclide into a different radioactive or nonradioactive nuclide, or into a different energy state of the same radionuclide.

Derived Concentration Guide (DCG). Secondary radioactivity in air and water concentration guides used for comparison to measured radioactivity concentrations. Calculation of DCG assumes that the exposed individual inhales 8,400 cubic meters of air per year or ingests 730 liters of water per year at the specified radioactivity DCG with a resulting radiation dose of 0.1 rem (100 mrem) EDE.

dose, absorbed. The amount of energy deposited by radiation in a given mass of material. The unit of absorbed dose is the rad.

dose equivalent. A modification to absorbed dose that expresses the biological effects of all types of radiation (e.g., alpha, beta, and gamma) on a common scale. The unit of dose equivalent is the rem or the sievert (1 sievert = 100 rem).

effective dose equivalent (EDE). The sum of the dose equivalents received by all organs or tissues of the body after each one has been multiplied by an appropriate weighting factor.

exposure. A measure of the ionization produced in air by x-ray or gamma radiation. The special unit of exposure is the roentgen (R).

fence post dose estimate. Annual cumulative dose of radiation an individual would receive at the site boundary.

free release. The process of ensuring that the level of radioactive material is acceptable for the unrestricted use of property.

gamma-ray. High-energy, short-wavelength electromagnetic radiation emitted from the nucleus of an atom. Gamma radiation frequently accompanies the emission of alpha or beta particles. Gamma rays are identical to x-rays except for the source of the emission.

gamma spectroscopy. The process of measuring gamma ray energies and using those energies to identify specific radionuclides in a sample.

half-life, radioactive. The time required for a given amount of a radionuclide to lose half of its activity by radioactive decay. Each radionuclide has a unique half-life.

isotopes. Various forms of a chemical element having the same number of protons in their nuclei and differing in the number of neutrons. An element may have many isotopes; some may be radioactive and some may be nonradioactive.

lost time accident (LTA). A work-related accident or illness that renders an employee unable to work in any capacity on the next regularly scheduled work day.

maximum contaminant level (MCL). The maximum permissible level of a contaminant in water that is delivered to any user of a public water system.

minimum detectable activity (MDA). The smallest amount of activity/concentration of a radionuclide that can be distinguished in a sample by a given measurement system in a pre-selected counting time at a given confidence level.

natural radiation. Radiation arising from cosmic sources and from naturally occurring radionuclides (such as radon) present in the human environment.

outfall. The place where a storm sewer or effluent line discharges to the environment.

part per billion (ppb). Concentration unit approximately equivalent to micrograms per liter.

part per million (ppm). Concentration unit approximately equivalent to milligrams per liter.

person-rem. The traditional unit of collective dose to a population group. For example, a dose of 1 rem to 10 individuals results in a collective dose of 10 person-rem.

piezometer. An instrument for measuring pressure, especially hydrostatic pressure.

rad. A traditional unit of absorbed dose. The International System of Units (SI) unit of absorbed dose is the gray (1 gray = 100 rads).

radioactivity. The spontaneous emission of energy, generally alpha or beta particles, often accompanied by gamma rays, from the unstable nucleus of an atom.

radionuclide. An atom having an unstable ratio of neutrons to protons so that it will tend toward stability by undergoing radioactive decay. A radioactive nuclide.

rem. The traditional unit of dose equivalent. Dose equivalent is frequently reported in units of millirem (mrem), which is one-thousandth of a rem. The International System of Units (SI) unit of dose equivalent is the sievert (1 sievert = 100 rem).

roentgen (R). The traditional unit of exposure to x-ray or gamma radiation based on the ionization in air caused by the radiation. One roentgen is equal to 2.58×10^{-4} coulombs per kilogram of air. A common expression of radiation exposure is the milliRoentgen (1R = 1000 mR).

source term. The amount of radioactive material available for release for modeling purposes. The units of this value are generally curies per unit time or total.

thermoluminescent dosimeter (TLD). A device used to measure external sources (i.e., outside the body) of penetrating radiation such as x-rays or gamma rays.

transuranic waste (TRU). Waste contaminated with alpha-emitting radionuclides of atomic number greater than 92, with half-lives greater than 20 years and are present in concentrations greater than 100 nanocuries per gram of waste (DOE definition).

uncontrolled/unrestricted area. An area to which access is not controlled for the purpose of protecting individuals from exposure to radiation and radioactive materials.

worldwide fallout. Radioactive debris from atmospheric weapons testing that is either airborne and cycling around the earth or has been deposited on the earth's surface.

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ACRONYMS

BCLDP	Battelle Columbus Laboratories Decommissioning Project
BCOES&H	Battelle Columbus Operations Environment, Safety and Health
CFR	Code of Federal Regulations
CY	Calendar Year
D&D	Decontamination and Decommissioning
DCG	Derived Concentration Guide
DOE	Department of Energy
EA	Environmental Air (used as sample locator)
EDE	Effective Dose Equivalent
EML	Environmental Measurements Laboratory
EPCRA	Emergency Planning and Community Right-to-Know Act
ERA	Environmental Resource Associates
FIFRA	Federal Insecticide, Fungicide, and Rodenticide Act
HEC	High Energy Cell
LLW	Low-Level Waste
LTA	Lost Time Accident
MCL	Maximum Contaminant Level
MDA	Minimum Detectable Activity
MGD	Million Gallons per Day
MLLW	Mixed Low-Level Waste
MSL	Mean Sea Level
NOV	Notice of Violation
NPDES	National Pollutant Discharge Elimination System
NRC	Nuclear Regulatory Commission
OAC	Ohio Administrative Code
OEPA	Ohio Environmental Protection Agency
PCB	Polychlorinated Biphenyl
PT	Performance Test
R&D	Research and Development
RAL	Radioanalytical Laboratory
RCRA	Resource Conservation and Recovery Act
S&M	Surveillance and Maintenance
SNM	Special Nuclear Materials
STP	Site Treatment Plan

TLD	Thermoluminescent Dosimeter
TRU	Transuranic
TSCA	Toxic Substances Control Act
USEPA	United States Environmental Protection Agency
USGS	United States Geological Survey
VOC	Volatile Organic Compound

Appendix A

Tables

TABLE 1. BATTELLE WEST JEFFERSON SITE POPULATION WITHIN 50-MILE RADIUS⁽¹⁾

Direction	Distance, miles										Total
	0 to 1	1 to 2	2 to 3	3 to 4	4 to 5	5 to 10	10 to 20	20 to 30	30 to 40	40 to 50	
N	13	17	98	118	172	3,565	5,504	5,365	9,785	47,453	72,090
NNE	8	34	147	116	192	2,648	33,177	32,783	7,950	19,933	96,988
NE	13	46	76	136	581	30,040	121,109	24,423	11,754	14,779	202,957
ENE	14	257	96	200	2,386	36,041	244,383	71,416	12,862	16,441	384,096
E	309	441	130	203	4,059	41,891	247,925	133,142	25,911	76,727	530,738
ESE	769	589	219	114	332	54,788	73,058	37,024	50,406	20,607	237,906
SE	297	1,046	43	65	419	5,986	18,009	15,228	13,430	9,535	64,058
SSE	45	256	47	54	77	3,349	17,226	5,499	14,437	43,088	78,078
S	26	85	82	116	115	860	4,671	3,116	5,026	12,733	26,830
SSW	7	489	260	135	96	584	1,220	3,925	21,493	7,859	36,068
SW	2	324	2,971	514	42	806	1,019	3,647	8,812	20,209	38,346
WSW	3	24	307	126	14	1,269	9,620	5,916	19,660	173,870	210,809
W	5	23	121	173	163	694	9,880	63,943	53,643	81,331	209,976
WNW	8	14	20	36	94	1,061	3,625	17,383	7,528	7,923	37,692
NW	14	15	29	88	83	439	1,369	5,833	22,469	13,509	43,848
NNW	17	4	45	495	87	676	14,262	10,010	4,361	7,133	37,0910
Total	1,550	3,664	4,691	2,689	8,912	184,697	800,057	438,653	289,527	573,130	2,307,570

⁽¹⁾ 2000 Census of Population and Housing, U.S. Bureau of the Census. Prepared by: Ohio Department of Development (8/92).

**TABLE 2. ANNUAL RADIOLOGICAL RELEASE INVENTORY⁽¹⁾
WEST JEFFERSON SITE — 2000**

Nuclide	S 1	S 2	S 3	S 4	S 5	S 6	S 7	S 11	Total
Co-60	6.10E-08	6.38E-08	1.13E-07	2.00E-07	8.14E-08	9.65E-08	4.11E-07	8.82E-08	1.12E-06
Sr-90	1.42E-09	1.34E-10	1.93E-09	4.25E-09	9.43E-10	1.71E-09	8.46E-09	7.41E-10	2.08E-08
Sb-125	1.44E-07	1.45E-07	2.74E-07	4.46E-07	1.72E-07	2.24E-07	1.32E-06	2.06E-07	2.93E-06
Cs-134	5.89E-08	5.53E-08	1.01E-07	1.76E-07	6.51E-08	9.04E-08	3.71E-07	8.14E-08	9.99E-07
Cs-137	6.08E-08	6.63E-08	1.17E-07	2.04E-07	7.57E-08	9.70E-08	4.01E-07	8.99E-08	1.11E-06
Eu-152	8.99E-08	7.40E-08	1.66E-07	2.59E-07	8.81E-08	1.28E-07	5.24E-07	1.18E-07	1.45E-06
Eu-154	6.21E-08	5.25E-08	1.19E-07	1.82E-07	6.14E-08	9.06E-08	3.68E-07	8.36E-08	1.02E-07
Pu-238	5.43E-11	2.56E-11	1.86E-10	3.64E-11	2.31E-11	2.67E-11	2.17E-10	8.29E-11	5.99E-10
Pu-239	3.23E-11	5.87E-12	1.50E-10	7.81E-11	2.20E-11	2.36E-11	1.23E-10	2.88E-11	4.63E-10
U-234	8.19E-10	7.50E-10	3.45E-09	2.43E-09	6.99E-10	1.09E-09	5.00E-09	1.24E-09	1.55E-08
U-235	8.34E-11	4.71E-11	2.88E-10	2.24E-10	2.37E-10	7.30E-11	3.47E-10	8.65E-11	1.39E-09
U-238	7.86E-10	7.91E-10	3.44E-09	2.39E-09	6.24E-10	1.16E-09	4.73E-09	1.08E-09	1.50E-08
Am-241	5.60E-08	4.58E-08	2.69E-07	2.41E-07	1.16E-07	1.20E-07	4.26E-07	6.71E-08	1.34E-06

(1) Total annual radiological stack emissions for each point source and total radiological air emissions for the West Jefferson North site (expressed in curies/year). Locations are shown in Figure 3.

**TABLE 3. ANNUAL AVERAGE RADIOLOGICAL CONCENTRATIONS FROM STACK EMISSIONS⁽¹⁾
WEST JEFFERSON SITE — 2000**

Nuclide	S 1	S 2	S 3	S 4	S 5	S 6	S 7	S 11	Site Boundary ⁽²⁾	DCG	%DCG
Co-60	4.52 E-15	5.36 E-15	6.34 E-15	4.90 E-15	6.26 E-15	5.39 E-15	5.10 E-15	4.93 E-15	2.80 E-19	8.00 E-11	3.50 E-07
Sr-90	*1.05 E-16	*1.13 E-16	*1.08 E-16	*1.04 E-16	*7.25 E-17	*9.54 E-17	*1.05 E-16	*4.14 E-17	5.20 E-21	9.00 E-12	5.78 E-08
Sb-125	1.07 E-14	1.22 E-14	1.53 E-14	1.09 E-14	1.32 E-14	1.25 E-14	1.64 E-14	1.15 E-14	7.50 E-19	1.00 E-09	7.50 E-08
Cs-134	4.36 E-15	4.65 E-15	5.64 E-15	4.31 E-15	5.01 E-15	5.05 E-15	4.60 E-15	4.55 E-15	2.50 E-19	2.00 E-10	1.25 E-07
Cs-137	4.50 E-15	5.57 E-15	6.54 E-15	4.98 E-15	5.82 E-15	5.42 E-15	4.98 E-15	5.02 E-15	2.08 E-17	4.00 E-10	5.20 E-06
Eu-152	6.66 E-15	6.22 E-15	9.30 E-15	6.33 E-15	6.78 E-15	7.14 E-15	6.50 E-15	6.57 E-15	3.60 E-19	5.00 E-11	7.20 E-07
Eu-154	4.60 E-15	4.41 E-15	6.66 E-15	4.44 E-15	4.72 E-15	5.06 E-15	4.57 E-15	4.67 E-15	2.50 E-19	5.00 E-11	5.00 E-07
Pu-238	*4.02 E-18	*2.15 E-18	*1.04 E-17	*8.90 E-19	*1.78 E-18	*1.49 E-18	*2.69 E-18	*4.63 E-18	1.30 E-22	4.00 E-14	3.25 E-07
Pu-239	*2.39 E-18	*4.39 E-18	*8.36 E-18	*1.91 E-18	*1.69 E-18	*1.32 E-18	*1.52 E-18	*1.61 E-18	1.00 E-22	4.00 E-14	2.50 E-07
U-234	*6.07 E-17	*6.30 E-17	*1.93 E-16	*5.95 E-17	*5.38 E-17	*6.08 E-17	*6.20 E-17	*6.90 E-17	3.50 E-21	9.00 E-14	3.89 E-06
U-235	*6.18 E-18	*3.96 E-18	*1.61 E-18	*5.48 E-18	*1.82 E-17	*4.08 E-18	*4.31 E-18	*4.83 E-18	3.30 E-22	1.00 E-13	3.30 E-07
U-238	*5.82 E-17	*6.65 E-17	*1.92 E-16	*5.84 E-17	*4.80 E-17	*6.48 E-17	*5.87 E-17	*6.03 E-17	3.40 E-21	1.00 E-13	3.40 E-06
Am-241	4.15 E-15	3.85 E-15	1.50 E-14	5.90 E-15	8.89 E-15	6.73 E-15	5.29 E-15	3.75 E-15	3.30 E-19	2.00 E-14	1.65 E-03
Release Rate ⁽³⁾	24.89	24.89	12.70	17.78	17.53	17.53	35.02	20.83			
Volume ⁽⁴⁾	1.35 E+13	1.19 E+13	1.79 E+13	4.09 E+13	1.30 E+13	1.79 E+13	8.06 E+13	1.79 E+13			

- (1) Stack data representing annual average radiological concentrations (expressed in $\mu\text{Ci/mL}$) for emission point sources. Locations are shown in Figure 3. All isotopic values represent MDA values except where indicated (*).
- (2) Site boundary concentrations reflect CAP88PC air dispersion modeling calculations at the West Jefferson North site (expressed in $\mu\text{Ci/mL}$).
- (3) Meters/second (m/s).
- (4) mL/yr.

**TABLE 4. SUMMARY OF SITE BOUNDARY AIR SAMPLE ANALYSES
WEST JEFFERSON SITE — 2000⁽¹⁾**

Nuclide	EA-1	EA-2	EA-3	EA-4
Co-60	5.36 E-16	5.35 E-16	4.39 E-16	4.58 E-16
Sb-125	1.28 E-15	1.19 E-15	1.05 E-15	1.11 E-15
Cs-134	4.81 E-16	4.33 E-16	4.29 E-16	4.21 E-16
Cs-137	5.24 E-16	4.82 E-16	4.60 E-16	4.45 E-16
Eu-152	7.22 E-16	7.08 E-16	5.96 E-16	5.62 E-16
Eu-154	5.12 E-16	5.04 E-16	4.24 E-16	4.03 E-16
Am-241	1.58 E-15	8.23 E-16	3.58 E-16	4.36 E-16
Sr-90	*1.22 E-16	8.83 E-17	8.17 E-17	1.16E-16
U-234	*6.27 E-17	*6.46 E-17	*6.66 E-17	*6.73 E-17
U-235	*6.27 E-18	*3.88 E-18	*4.88 E-18	*4.49 E-18
U-238	*6.16 E-17	*6.79 E-17	*6.44 E-17	*6.50 E-17
Pu-238	*3.85 E-18	2.37 E-18	2.55 E-18	*1.52 E-18
Pu-239	*1.83 E-18	7.64 E-19	1.18 E-18	*2.03 E-18

(1) Locations are shown in Figure 4. All values expressed in $\mu\text{Ci/mL}$. All isotopic values represent average MDA values except where indicated (*). Annual flow volume of $2.70 \text{ E}+09 \text{ mL}$.

**TABLE 5. SUMMARY OF LIQUID RADIOLOGICAL EFFLUENT
WEST JEFFERSON SITE⁽¹⁾ — 2000**

Nuclide	Number of Samples	Activity, $\mu\text{Ci}/\text{yr}$⁽²⁾	Average Concentration, $\mu\text{Ci}/\text{mL}$	DCG, $\mu\text{Ci}/\text{mL}$	Percentage of DCG, %
Co-60	12	40.1	1.80 E-09	5.0 E-06	0.04
Sr-90	4	40.3	1.81 E-09	1.0 E-06	0.18
Sb-125	12	102.7	4.60 E-09	5.0 E-05	0.01
Cs-134	12	36.2	1.62 E-09	2.0 E-06	0.08
Cs-137	12	41.0	1.84 E-09	3.0 E-06	0.06
Eu-152	12	91.5	4.10 E-09	2.0 E-05	0.02
Eu-154	12	64.0	2.87 E-09	2.0 E-05	0.01
Am-241	12	98.8	4.43 E-09	3.0 E-08	14.76 ⁽³⁾
Pu-238 ⁽⁴⁾	4	2.7	1.21 E-10	4.0 E-08	0.30
Pu-239 ⁽⁴⁾	4	1.0	4.46 E-11	3.0 E-08	0.15
U-235	12	63.9	2.86 E-08	6.0 E-07	0.48
U-238	12	818.5	3.67 E-08	6.0 E-07	6.11
U-234 ⁽⁴⁾	4	31.8	1.42 E-09	5.0 E-07	0.28
U-235 ⁽⁴⁾	4	1.1	4.82 E-11	6.0 E-07	0.01
U-238 ⁽⁴⁾	4	11.3	5.07 E-10	6.0 E-07	0.08

- (1) Annual average flow in Big Darby Creek; 471 cu ft/sec = 3.82 E+11 L/yr. Total volume of liquid effluent discharge for 2000 = 2.23 E+07 L. See Figure 4 for sample location EW-1.
- (2) Isotopic data for effluents released at this location were obtained from gamma and radiochemical analysis of monthly composite samples where possible. In the absence of detectable activity, calculated MDA values were used to establish inventory on suspected radionuclides. Gross α values were used for alpha emitters U-238 and Am-241 using a conservative 100 percent of α activity.
- (3) As discussed in the text, these values are calculated from MDA values.
- (4) Analysis performed by alpha spectroscopy.

**TABLE 6. SUMMARY OF RADIOLOGICAL ANALYSES
OF DRINKING WATER SAMPLES (EW5)
WEST JEFFERSON — 2000⁽¹⁾**

West Jefferson	Activity ($\mu\text{Ci/mL}$)
Co-60	1.71 E-09
Sr-90 ⁽¹⁾	9.39 E-10
Sb-125	4.66 E-09
Cs-134	1.65 E-09
Cs-137	1.88 E-09
Eu-152	4.02 E-09
Eu-154	2.85 E-09
Am-241	4.51 E-09
U-235	2.81 E-09
U-238	3.63 E-08
U-234 ^(2,3)	1.55 E-09*
U-235 ^(2,3)	5.70 E-11*
U-238 ^(2,3)	3.68 E-10*
Pu-238 ^(2,3)	1.51 E-10
Pu-239 ^(2,3)	4.39 E-11
Ra-226 ⁽²⁾	4.41 E-10
Ra-228 ⁽²⁾	4.37 E-09
I-129 ⁽¹⁾	2.68 E-09

- (1) Locations are shown in Figure 4. All values are actual MDA unless otherwise indicated (*).
- (2) Analysis on annual composite only.
- (3) Analysis performed by alpha spectroscopy.

**TABLE 7. SUMMARY OF RADIOLOGICAL ANALYSES
OF ENVIRONMENTAL WATER SAMPLES
WEST JEFFERSON SITE — 2000**

Sample #	Location ⁽¹⁾ (Direction and Distance from Nuclear Sciences Area)	Number of Samples ⁽²⁾	10 ⁻⁹ μCi/mL ⁽³⁾	
			Gross α	Gross β
EW-3	Big Darby Creek Upstream (18.3 m above sanitary outfall)	12	1.37 ± 7.22	4.78 ± 5.92
EW-4	Big Darby Creek Downstream (18.3 m below sanitary outfall)	12	2.88 ± 7.78	5.84 ± 6.06
EW-10	Battelle Lake Spillway (18.3 m below dam)	12	1.04 ± 6.56	4.36 ± 5.78
EW-11	Big Darby Creek Downstream (186.3 m below sanitary outfall)	12	2.57 ± 7.40	5.48 ± 6.00

(1) Locations are shown in Figure 4.

(2) Big Darby Creek and Battelle Lake Spillway samples are monthly composite samples of weekly collections.

(3) MDA is 6.7 E-09 μCi/mL for gross α and 9.6 E-09 μCi/mL for gross β.

**TABLE 8. SUMMARY OF RADIOLOGICAL ANALYSES OF GRASS
WEST JEFFERSON SITE — 2000**

Nuclide	Identification No. ⁽¹⁾							
	Sector 1	Sector 2	Sector 3	Sector 4	Sector 5	Sector 6	Sector 7	Sector 8
Co-60	0.096	0.066	0.062	0.090	0.109	0.063	0.088	0.107
Sr-90	0.072	0.069	0.069	0.078	0.072	0.072	0.068	0.078
Sb-125	0.186	0.143	0.151	0.205	0.229	0.147	0.167	0.244
Cs-134	0.070	0.054	0.055	0.085	0.092	0.058	0.060	0.088
Cs-137	0.082	0.064	0.061	0.096	0.113	0.070	0.083	0.095
Eu-152	0.094	0.090	0.106	0.116	0.178	0.094	0.093	0.180
Eu-154	0.069	0.064	0.074	0.083	0.127	0.064	0.066	0.121
Am-241	0.159	0.065	0.079	0.093	0.436	0.063	0.143	0.412
Pu-238 ⁽²⁾	0.004	0.004	0.004	0.005	0.005	0.006	0.003	0.005
Pu-239 ⁽²⁾	0.003	0.005	0.003	0.003*	0.003	0.001	0.003*	0.006
U-235	0.068	0.076	0.087	0.110	0.109	0.080	0.062	0.101
U-238	0.653	0.765	0.879	1.144	1.308	0.771	0.634	1.239
U-234 ⁽²⁾	0.211*	0.180*	0.031*	0.176*	0.263*	0.017*	0.246*	0.026*
U-235 ⁽²⁾	0.011*	0.010*	0.001	0.009*	0.014*	0.002*	0.017*	0.002*
U-238 ⁽²⁾	0.206*	0.185*	0.028*	0.192*	0.289*	0.022*	0.262*	0.026*

- (1) Locations are shown in Figure 5. All values are pCi/g dry weight. All values are less than MDA values except where indicated (*).
- (2) Analysis performed by alpha spectroscopy.

**TABLE 9. SUMMARY OF RADIOLOGICAL ANALYSES OF FIELD CROPS
WEST JEFFERSON SITE — 2000**

Nuclide	Identification No. ⁽¹⁾							
	Sector 1 Corn	Sector 2 Corn	Sector 3 Corn	Sector 4 Corn	Sector 5 Corn	Sector 6 Corn	Sector 7 Corn	Sector 8 Corn
Co-60	0.016	0.013	0.017	0.026	0.013	0.021	0.013	0.013
Sr-90	0.069	0.066	0.067	0.068	0.073	0.067	0.070	0.070
Sb-125	0.035	0.034	0.036	0.061	0.029	0.041	0.031	0.030
Cs-134	0.014	0.012	0.015	0.022	0.011	0.018	0.011	0.012
Cs-137	0.017	0.013	0.016	0.024	0.014	0.019	0.013	0.014
Eu-152	0.024	0.024	0.022	0.044	0.020	0.024	0.023	0.020
Eu-154	0.017	0.017	0.015	0.030	0.014	0.017	0.016	0.014
Am-241	0.017	0.018	0.017	0.101	0.013	0.037	0.017	0.014
Pu-238 ⁽²⁾	0.002	0.003	0.005	0.006	0.004	0.003	0.003	0.003
Pu-239 ⁽²⁾	0.004*	0.003	0.003	0.001	0.002	0.002	0.002	0.001
U-235	0.019	0.019	0.020	0.025	0.017	0.016	0.018	0.017
U-238	0.195	0.194	0.205	0.307	0.159	0.158	0.186	0.165
U-234 ⁽²⁾	0.007*	0.011*	0.011*	0.006*	0.002*	0.009*	0.008*	0.004
U-235 ⁽²⁾	0.003	0.003	0.001	0.001	0.003	0.004	0.001	0.001
U-238 ⁽²⁾	0.004*	0.011*	0.007*	0.006*	0.004*	0.007*	0.006*	0.006*

(1) Locations are shown in Figure 5. All values are pCi/g dry weight. All values are less than MDA values except where indicated (*).

(2) Analysis performed by alpha spectroscopy.

**TABLE 10. SUMMARY OF RADIOLOGICAL
ANALYSES OF GARDEN CROPS⁽¹⁾
WEST JEFFERSON SITE — 2000**

Nuclide	pCi/g dry weight	
	Upwind ⁽²⁾	Downwind ⁽²⁾
Co-60	0.030	0.042
Sr-90	0.141	0.114
Sb-125	0.062	0.088
Cs-134	0.024	0.033
Cs-137	0.029	0.037
Eu-152	0.039	0.055
Eu-154	0.027	0.039
Am-241	0.030	0.043
Pu-238 ⁽³⁾	0.010	0.009
Pu-239 ⁽³⁾	0.007	0.002
U-235	0.031	0.043
U-238	0.318	0.448
U-234 ⁽³⁾	0.015*	0.016*
U-235 ⁽³⁾	0.002	0.002
U-238 ⁽³⁾	0.011*	0.018*

- (1) Garden crops collected at the end of the growing season. All values are less than MDA values except where indicated (*).
- (2) Locations are shown in Figure 5.
- (3) Analysis performed by alpha spectroscopy.

**TABLE 11. SUMMARY OF RADIOLOGICAL ANALYSES OF
SEDIMENT SAMPLES⁽¹⁾ WEST JEFFERSON SITE — 2000**

Nuclide	pCi/g dry wt. ⁽²⁾ Avg.				
	ED-1	ED-2	ED-3	ED-4	ED-5
Co-60	0.015*	0.016	0.026	0.025	0.021
Sr-90	0.677*	0.129	0.138	0.144	0.138
Sb-125	0.058	0.047	0.071	0.073	0.047
Cs-134	0.018	0.016	0.024	0.023	0.017
Cs-137	1.154*	0.315*	0.247*	1.607*	0.022
Eu-152	0.047	0.037	0.054	0.815*	0.034
Eu-154	0.033	0.026	0.038	0.054	0.024
Am-241	0.036	0.030	0.106	0.114	0.047
Pu-238 ⁽³⁾	0.022	0.032	0.020	0.021	0.024
Pu-239 ⁽³⁾	0.052*	0.012	0.015*	0.019*	0.015
U-235	0.181*	0.112*	0.042	0.120*	0.028
U-238	3.368*	1.284*	1.734*	0.914*	1.407*
U-234 ⁽³⁾	1.941*	1.540*	1.511*	1.367*	0.831*
U-235 ⁽³⁾	0.098*	0.108*	0.104*	0.088*	0.059*
U-238 ⁽³⁾	1.983*	1.526*	1.684*	1.429*	0.955*

- (1) Locations are shown in Figure 4. All values are less than MDA values except where indicated (*).
- (2) No standards for radionuclides in sediment have been established.
- (3) Analysis performed by alpha spectroscopy.

**TABLE 12. SUMMARY OF RADIOLOGICAL ANALYSES OF SOIL
WEST JEFFERSON SITE — 2000**

Nuclide	Identification No. ⁽¹⁾							
	Sector 1	Sector 2	Sector 3	Sector 4	Sector 5	Sector 6	Sector 7	Sector 8
Co-60	0.019	0.015	0.019	0.017	0.021	0.016	0.019	0.017
Sr-90	0.152	0.164	0.137	0.150	0.152	0.141	0.164	0.157
Sb-125	0.053	0.044	0.054	0.047	0.057	0.049	0.054	0.046
Cs-134	0.017	0.014	0.018	0.016	0.019	0.015	0.018	0.016
Cs-137	0.568*	0.194*	0.140*	0.377*	0.597*	0.865*	0.269*	0.582*
Eu-152	0.040	0.039	0.038	0.037	0.042	0.042	0.038	0.035
Eu-154	0.028	0.028	0.027	0.026	0.030	0.030	0.027	0.025
Am-241	0.032	0.028	0.035	0.032	0.035	0.030	0.036	0.030
Pu-238 ⁽²⁾	0.014	0.009	0.013	0.027	0.029	0.012	0.009	0.007
Pu-239 ⁽²⁾	0.007	0.005	0.009*	0.015	0.015	0.004	0.006	0.011*
U-235	0.264*	0.398*	0.035	0.242*	0.037	0.220*	1.147*	0.227*
U-238	1.646*	1.68*	1.598*	1.527*	1.798*	1.287*	1.566*	1.662*
U-234 ⁽²⁾	1.536*	1.37*	1.602*	1.702*	1.865*	1.270*	1.253*	1.615*
U-235 ⁽²⁾	0.116*	0.127*	0.095*	0.097*	0.111*	0.031	0.085*	0.102*
U-238 ⁽²⁾	1.687*	1.599*	1.710*	1.612*	1.732*	1.455*	1.421*	1.669*

(1) Locations are shown in Figure 5. All values are pCi/g dry weight. All values are less than MDA values except where indicated (*).

(2) Analysis performed by alpha spectroscopy.

**TABLE 13. SUMMARY OF RADIOLOGICAL ANALYSES OF FISH TISSUE
WEST JEFFERSON SITE — 2000**

Nuclide	Battelle Lake Samples ⁽¹⁾ (pCi/g raw weight)			Darby Creek Samples ⁽¹⁾ (pCi/g raw weight)		
	1st Half	2nd Half	Average	1st Half	2nd Half ⁽²⁾	Average
Co-60	0.027	0.017	0.022	0.036	N/A	0.036
Sr-90	0.118	0.124	0.121	0.114	N/A	0.114
Sb-125	0.048	0.038	0.043	0.083	N/A	0.083
Cs-134	0.019	0.015	0.017	0.032	N/A	0.032
Cs-137	0.021	0.018	0.019	0.035	N/A	0.035
Eu-152	0.027	0.022	0.025	0.062	N/A	0.062
Eu-154	0.019	0.016	0.018	0.044	N/A	0.044
Am-241	0.043	0.018	0.030	0.146	N/A	0.146
Pu-238 ⁽³⁾	0.025	0.010	0.018	0.008	N/A	0.008
Pu-239 ⁽³⁾	0.003	0.006	0.004	0.006	N/A	0.006
U-235	0.018	0.020	0.019	0.037	N/A	0.037
U-238	0.172	0.205	0.188	0.435	N/A	0.435
U-234 ⁽³⁾	0.007*	0.005	0.006	0.009*	N/A	0.009
U-235 ⁽³⁾	0.004	0.002	0.003	0.002	N/A	0.002
U-238 ⁽³⁾	0.001	0.002	0.002	0.007*	N/A	0.007

(1) Fish samples were collected from various locations within Battelle Lake. All values are less than MDA values except where indicated (*).

(2) No fish samples collected during the second half.

(3) Analysis performed by alpha spectroscopy.

N/A = Not applicable.

**TABLE 14. INTEGRATED EXTERNAL BACKGROUND RADIATION MEASUREMENTS
AT RECREATION AREA AND PROPERTY BOUNDARY LINE
WEST JEFFERSON SITE — 2000**

Location and Distance ⁽¹⁾	TLD #	Integrated TLD Measurements in mrem				Total for Year
		1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.	
<u>Southwest</u>						
121.9 m (400 ft)	04	26	27	24	25	102
420.6 m (600 ft)	41	30	28	28	26	112
731.5 m (2400 ft)	02	28	27	33	27	115
1234.5 m (4050 ft)	01	32	29	31	29	121
<u>West</u>						
152.4 m (500 ft)	10	30	32	28	28	118
630.9 m (2070 ft)	03	27	28	25	26	106
<u>Southeast</u>						
365.8 m (1200 ft)	13	23	24	23	23	93
548.6 m (1800 ft)	07	27	28	24	26	105
1005.9 m (3300 ft)	08	28	26	25	27	106
<u>South</u>						
395.9 m (1200 ft)	15	25	28	23	23	99
411.5 m (1350 ft)	09	24	28	26	28	106
1097.3 m (3600 ft)	11	26	31	27	27	111
<u>East</u>						
420.6 m (1380 ft)	12	28	28	27	29	112
<u>Northeast</u>						
395.9 m (1200 ft)	14	30	33	28	27	118
<u>Northwest</u>						
402.3 m (1320 ft)	05	29	30	29	28	116
<u>North</u>						
457.2 m (1500 ft)	06	28	29	26	27	110

(1) Refer to Figure 6. Average off-site background for year is less than 120 mrem. Distances measured from center of Nuclear Sciences Area.

**TABLE 15. NONRADIOLOGICAL WATER EFFLUENT ANALYSES
WEST JEFFERSON SITE — 2000**

	North Wastewater Treatment System ⁽¹⁾				Permit Requirements ^{(3) (4)} Discharge Limitations			
	Avg.	Max.	Min.	kg/Day	Loading kg/Day		Concentration ⁽⁵⁾	
				Avg. ⁽²⁾	30-Day	Daily	30-Day	Daily
Monthly Flow Rate (L/day) ⁽⁶⁾	61,163	73,354	46,697	—	(6)	(6)	(6)	(6)
Chloroform(µg/L) ⁽⁶⁾	—	7.0	<5.0	—	(6)	(6)	(6)	(6)
Residual Chlorine (mg/L)	0.01	0.01	0.01	0.01	—	—	—	0.038
pH Value (S.U.)	7.9	8.5	7.6	—	—	—	6.5	9.0
Fecal Coliform (#/100 mL)	7.0	14.0	3.0	—	—	—	1,000	2,000
Dissolved Oxygen (mg/L)	10.3	12.6	8.9	—	—	—	6.0 (min)	—
Total Suspended Solids (mg/L)	2.3	5.0	2.0	0.31	0.76	1.51	10	20
Carbonaceous Biochemical Oxygen Demand (5-day) (mg/L)	4.3	4.6	4.2	0.59	0.76	1.51	10	20
Ammonia (mg/L) ⁽⁶⁾	0.293	0.349	0.218	—	(6)	(6)	(6)	(6)

- (1) Sampling site location is labeled EW-1 on Figure 4 (referred to as 001 in monthly NPDES reports). Includes discharge from Middle Area Sanitary System.
- (2) Based on a flow rate of 0.016 million gallons/day (MGD).
- (3) Permit requirement discharge limitations based on NPDES Permit 4IN00004*FD (Jan. 1, 2000 through Feb. 28, 2000).
- (4) Permit requirement discharge limitations based on NPDES Permit 4IN00004*GD (Mar. 1, 2000 through Dec. 31, 2000).
- (5) Units specified in left column.
- (6) No restrictions for flow, ammonia, or chloroform under the NPDES Permit.

**TABLE 16. NONRADIOLOGICAL ANALYSES OF GROUNDWATER
WEST JEFFERSON SITE — 2000**

Chemical Parameter	Well C03⁽¹⁾	Well C09⁽¹⁾	Well C16⁽¹⁾
Total Metals (µg/L)			
As	ND	10.7	ND
Ba	0.12	0.26	0.37
Cd	ND	ND	ND
Cr	ND	ND	ND
Pb	ND	ND	ND
Hg	ND	ND	ND
Se	ND	ND	ND
Ag	ND	ND	ND
Pesticides and PCBs (mg/L)			
28 compounds	ND	ND	ND
Volatile Organics (µg/L)			
67 compounds	ND	ND	1,1,1-Trichlorethane = 10.0; Trichloroethene = 6.0; others ND
Semivolatile Organic Compounds (µg/L)			
66 compounds	ND	ND	ND
Oil and Grease (mg/L)			
	ND	ND	ND
pH	7.3	6.8	7.2

(1) Locations are shown in Figure 7.
ND = not detected

**TABLE 17. SUMMARY OF ALPHA/BETA RADIOLOGICAL
ANALYSES OF GROUNDWATER⁽¹⁾
WEST JEFFERSON SITE — 2000**

Well Identification	Number of Samples	pCi/L ⁽²⁾					
		Gross $\alpha \pm 2$ sigma			Gross $\beta \pm 2$ sigma		
100	2	13.25	±	5.42	5.98	±	2.13
101	2	18.80	±	5.12	14.30	±	2.40
103	2	11.10	±	5.99	13.32	±	2.76
110-R	2	20.90	±	6.96	15.25	±	2.73
116-R	2	28.25	±	7.67	16.50	±	2.78
118	2	25.98	±	7.26	22.40	±	3.06
150	2	7.73	±	4.47	6.25	±	2.18
155	2	6.36	±	4.59	6.53	±	2.23
168	2	9.38	±	5.89	19.90	±	3.25
172	2	14.65	±	6.52	27.70	±	3.54
206	2	8.22	±	5.15	7.60	±	2.33
300	2	7.94	±	23.10	11.70	±	2.63
306	2	9.71	±	4.67	8.76	±	2.31
506	2	13.05	±	6.17	8.95	±	2.45
601	2	18.95	±	5.61	10.35	±	2.29
C03	2	8.39	±	4.95	8.43	±	2.38
C09	2	8.77	±	4.76	30.00	±	3.42
C16	2	7.97	±	4.74	3.80	±	2.00
JN	2	8.93	±	3.17	2.87	±	1.35
JM	2	7.99	±	3.42	5.00	±	1.51
JS	2	6.35	±	3.06	4.93	±	1.49

- (1) Locations are shown in Figures 7, 8, and 9.
(2) MDA: gross $\alpha = 3.2$ pCi/L; gross $\beta = 3.8$ pCi/L

**TABLE 18. SUMMARY OF RADIOLOGICAL ANALYSES OF GROUNDWATER
WEST JEFFERSON SITE — 2000**

Nuclide	Well Identification No. ⁽¹⁾																	
	100	101	103	110-R	116-R	118	150	155	168	172	206	300	306	506	601	C03	C09	C16
Co-60	2.13	1.69	1.91	2.28	1.93	1.65	1.85	1.76	2.20	1.62	1.76	1.80	1.70	1.75	1.84	1.74	1.90	1.76
Sr-90	1.64	3.52*	4.31*	1.58	1.63	7.11*	1.62	2.21	9.98*	10.75*	1.66	1.51	2.32	2.34	1.72	1.61	18.17*	1.67
Sb-125	5.44	4.58	5.09	5.98	4.92	4.22	4.94	4.61	5.90	4.45	4.45	4.46	4.49	4.71	4.75	4.44	4.65	4.57
Cs-134	1.89	1.57	1.77	2.05	1.69	1.49	1.73	1.69	1.94	1.54	1.58	1.66	1.68	1.65	1.74	1.65	1.61	1.65
Cs-137	2.18	1.74	2.24	2.59	1.84	1.76	1.91	1.79	2.23	1.74	1.80	1.82	1.90	1.81	1.85	1.84	1.90	1.86
Eu-152	4.82	4.36	4.32	5.19	4.45	3.83	4.63	4.25	4.83	4.22	3.95	3.72	4.12	4.14	4.25	3.83	3.88	4.04
Eu-154	3.39	3.10	3.07	3.64	3.08	2.71	3.26	2.99	3.44	2.98	2.75	2.59	2.87	2.92	2.99	2.70	2.74	2.88
Am-241	5.48	5.36	4.98	6.02	5.20	4.69	5.35	5.05	5.78	4.99	4.42	4.39	4.60	4.56	4.69	4.40	4.60	4.52
Pu-238	0.16	0.16	0.08	0.12	0.14	0.13	0.10	0.12	0.12	0.16	0.13	0.13	0.13	0.15	0.14	0.14	0.09	0.09
Pu-239 ⁽²⁾	0.06*	0.03*	0.07*	0.05*	0.05*	0.09	0.07*	0.09	0.07*	0.08	0.10	0.07	0.09*	0.09*	0.06*	0.07	0.10*	0.07*
U-235 ⁽²⁾	3.29	2.94	3.09	3.43	3.08	2.71	3.06	2.97	3.34	2.80	2.76	2.70	2.85	2.87	2.92	2.76	2.84	2.82
U-238	40.83	36.31	39.76	41.51	38.99	35.63	38.19	37.63	41.22	35.93	36.43	36.88	37.02	36.72	37.23	37.30	37.50	36.96
U-234 ⁽²⁾	2.79*	0.94*	1.44*	2.24*	2.96*	3.07*	0.58*	2.45	2.08*	4.70*	2.54*	1.72*	3.29*	6.37*	0.92*	3.01*	2.99*	1.01*
U-235 ⁽²⁾	0.20*	0.16*	0.09*	0.15*	0.19*	0.12*	0.04*	0.16	0.13*	0.26*	0.12*	0.10*	0.51*	0.26*	0.07*	0.24*	0.12*	0.09*
U-238 ⁽²⁾	2.18*	0.86*	1.37*	1.98*	2.96*	2.51*	0.63*	2.36	2.26*	4.49*	1.33*	0.70*	3.13*	4.28*	0.90*	3.12*	2.17*	0.82*

(1) Locations are shown in Figures 7 and 8. Expressed in 1×10^{-9} $\mu\text{Ci/mL}$. All values are less than MDA values except where indicated (*).

(2) Analyses performed by alpha spectroscopy.

**TABLE 19. SUMMARY OF RADIOLOGICAL ANALYSES OF SUPPLY WELLS
WEST JEFFERSON SITE — 2000**

Nuclide	Well Identification No. ⁽¹⁾		
	JM-W	JN-W	JS-W
Co-60	2.21	1.62	2.08
Sr-90	1.55	1.54	1.74
Sb-125	5.83	4.69	5.42
Cs-134	2.07	1.53	1.88
Cs-137	2.27	1.66	2.13
Eu-152	5.16	4.40	4.53
Eu-154	3.66	3.12	3.16
Am-241	6.04	5.28	5.31
Pu-238 ⁽²⁾	0.09	0.09	0.12
Pu-239 ⁽²⁾	0.09	0.02	0.04
U-235	3.46	2.94	3.17
U-238	41.66	35.98	41.50
U-234 ⁽²⁾	1.72*	1.97*	1.52*
U-235 ⁽²⁾	0.05*	0.03*	0.05*
U-238 ⁽²⁾	0.51*	0.43*	0.48*

(1) Locations are shown in Figure 9. Expressed in 1×10^{-9} $\mu\text{Ci/mL}$. All values are less than MDA values except where indicated (*).

(2) Analyses performed by alpha spectroscopy.

Appendix B

*Environmental Report
External Distribution List*

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