REPORT

BCLDP-093098

BCLDP Site Environmental Report for Calendar Year 1997 on Radiological and Nonradiological Parameters

To

U.S. Department of Energy

Ohio Field Office, Miamisburg

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September 30, 1998

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by: Safety, Health and Environmental Support

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FOREWORD

This report was prepared for the Battelle Columbus Laboratories Decommissioning Project (BCLDP) by staff in the Safety, Health and Environmental Support 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, 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; The Columbus Water and Chemical Testing Laboratory, Columbus, Ohio; and Kemron Environmental Services, Marietta, Ohio.

An environmental compliance summary is included for the calendar year (CY) 1997. 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 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, because the source term at this facility is larger than the source term at Battelle's King Avenue site.

The contamination found at the King Avenue site consists of small amounts of residual radioactive material in solid form, which has become embedded or captured in nearby surfaces such as walls, floors, ceilings, drains, laboratory equipment, and soils. By the end of calendar year (CY) 1997, most remediation activities were completed at the King Avenue site.

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

During CY 1997, multiple tests at the West Jefferson Nuclear Sciences Area found no isotopes present above the minimum detectable activity (MDA) 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 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 King Avenue and the West Jefferson sites were compliant with the Section 61.102 dose standard and exempt from the Section 61.104 reporting requirements cited in 40 CFR 61 Subpart I for CY 1997.

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

BCLDP performed dose assessments using the CAP88PC air dispersion modeling computer program. The CAP88PC program calculated the effective dose equivalent (EDE) to the nearest receptor located adjacent to the West Jefferson site to be 1.08 x 10^{-3} mrem/year.

West Jefferson nuclear operations during 1997 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 1997 at the site boundary was measured at background levels for Camp Ken Jockety, 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 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 and King Avenue 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*FD and monitoring the groundwater system for the West Jefferson North site. Groundwater wells are the source of potable water for the West Jefferson area, and city water is the source of potable water for the King Avenue area.

In addition to routine monitoring of liquid and atmospheric emissions at the King Avenue and 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 two sites. BCLDP performed all sampling activities in accordance with standard operating procedures established by Battelle's Environmental Monitoring Program.

Results of the environmental sampling indicate no negative impact to the environment or human health.

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INTRODUCTION

On April 16, 1943, Battelle Memorial Institute, a private not-for-profit organization, entered into Contract No. W-7405-ENG-92 with the Manhattan Engineering District to perform atomic energy research and development (R&D) activities. Since that time, Battelle has performed R&D work under the contract at its facilities for the United States Department of Energy (DOE) and its predecessor agencies. Battelle conducted S&M and D&D activities for DOE under this contract at its King Avenue and West Jefferson facilities during CY 1997 (Memorandum of Understanding, dated August 14, 1986). Battelle also conducted Nuclear Regulatory Commission (NRC) licensed activities at both sites. This report concerns effluents that resulted from licensed activities, whether commercial or DOE.

Site Descriptions

The relationship between the Battelle King Avenue site and the Nuclear Science Area at the West Jefferson site is illustrated in Figure 1, which represents a regional map covering an 80-km (50-mile) radius.

The Battelle King Avenue facility is located at 39° 59'N, 83° 03'W in the western central portion of Columbus, Ohio. The 58.3-acre plot, accommodating 21 buildings, is bordered by King Avenue to the north, Battelle Boulevard and Perry Street to the east, Third Avenue to the south, and the Olentangy River to the west. Figure 2 shows the property boundaries of the Battelle King Avenue site.

During 1997, Battelle conducted D&D activities in Buildings 2, 6, and A.

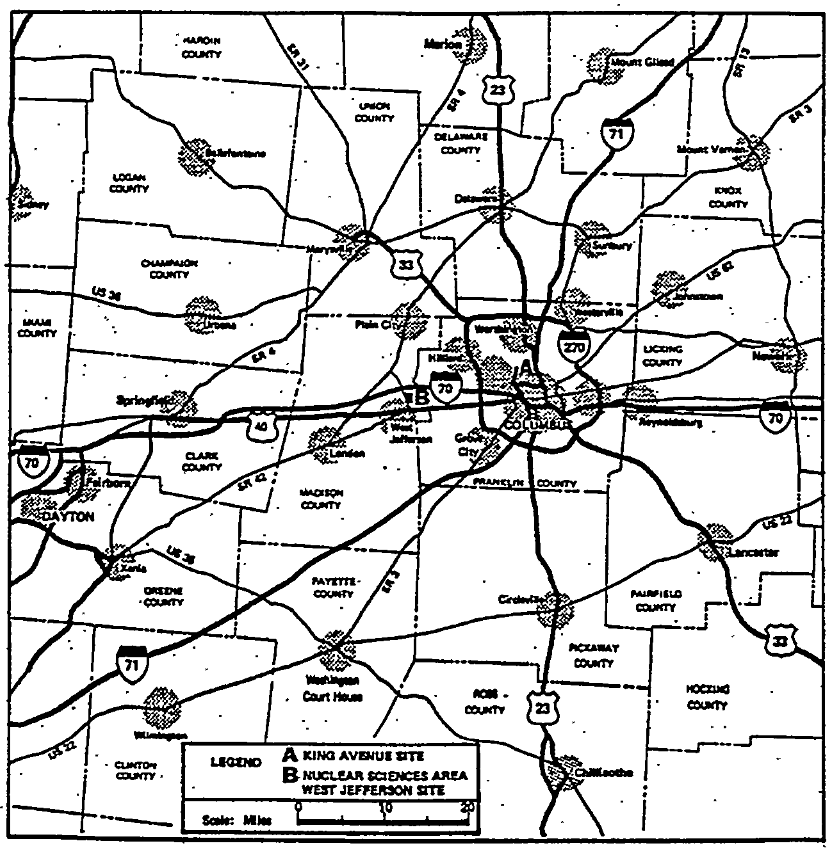

Figure 1. Regional Map for King Avenue and West Jefferson Sites

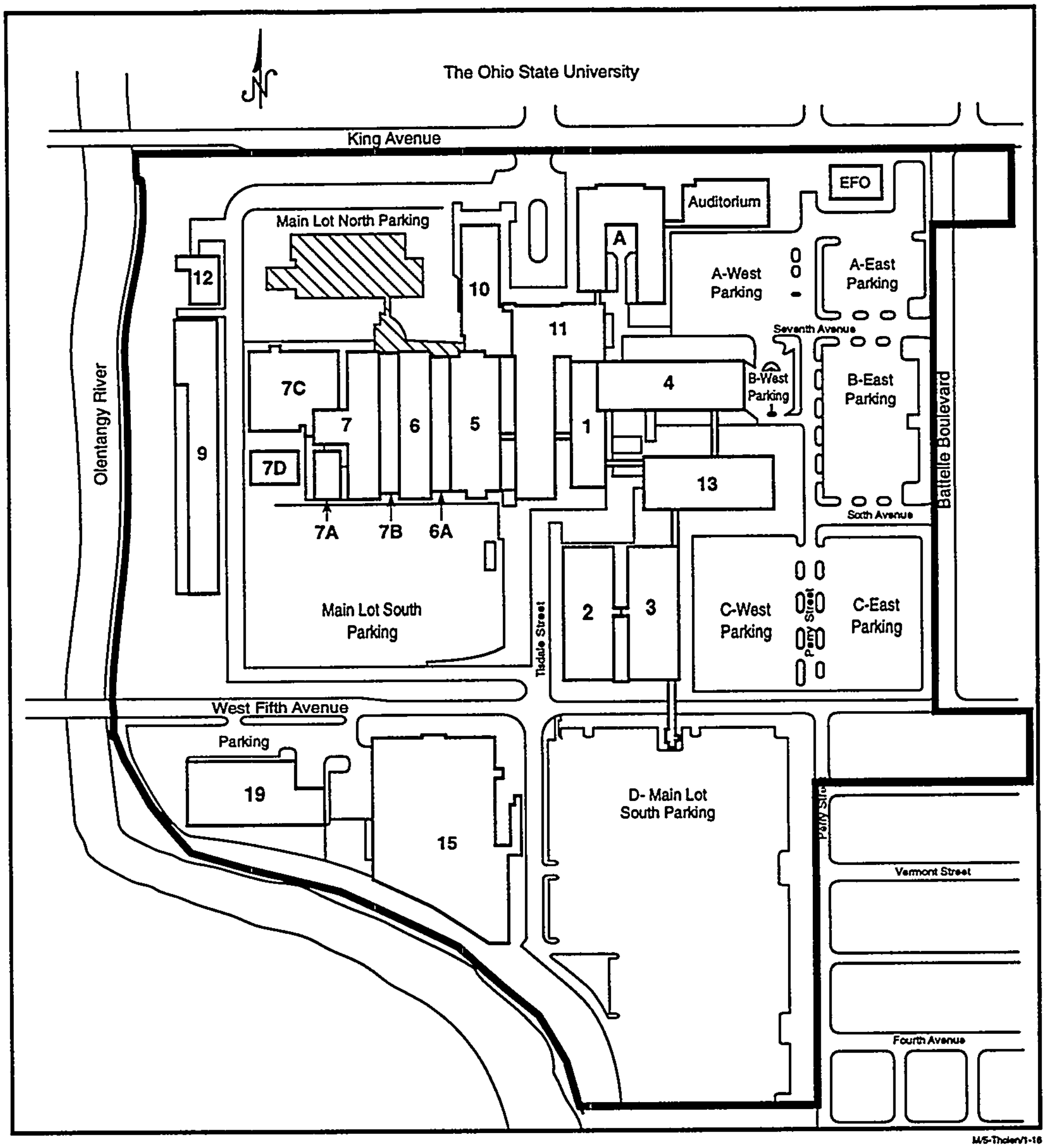

Figure 2. Local Vicinity Map of King Avenue Site

The West Jefferson site (Figure 3) is located at 39° 58'N, 83° 15'W, approximately 15 statute miles west of the King Avenue facility. The 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 Georgesville-Plain City 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 Georgesville-Plain City 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 shaded area of Figure 3. The Nuclear Sciences Area is a 10-acre, fenced site consisting of a guardhouse, four buildings, and two other 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 feet to 870 feet 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 feet to the northeast from the center of the site. The land

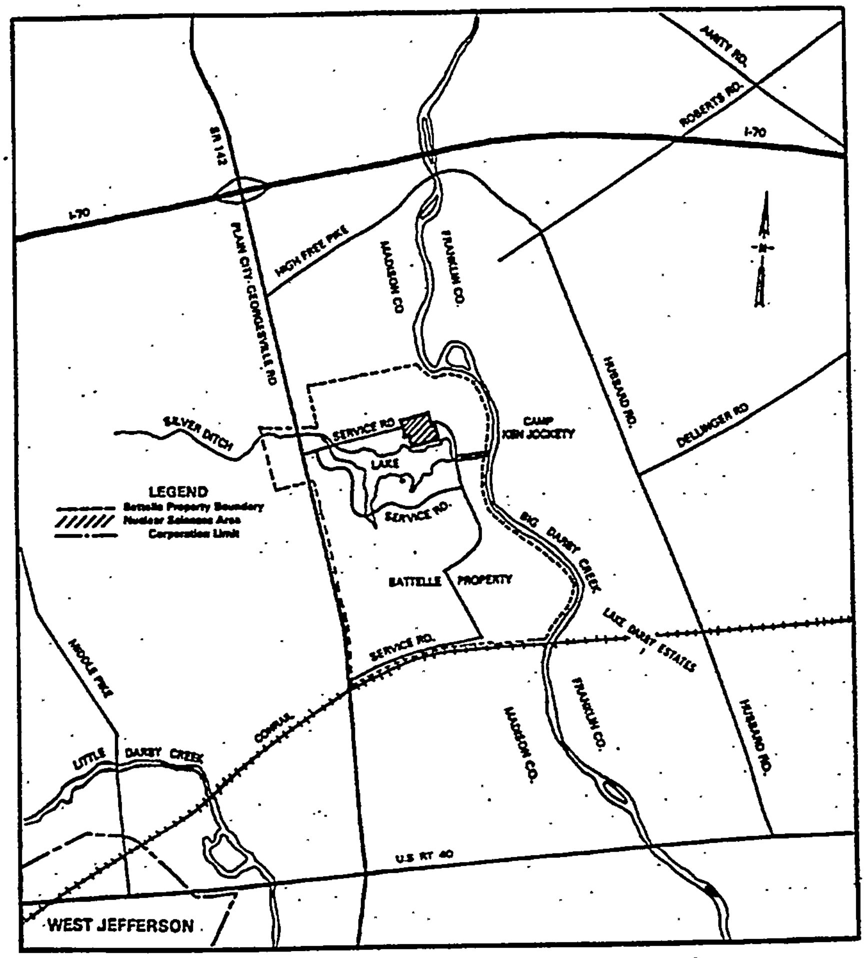

Figure 3. Local Vicinity Map of Nuclear Sciences Area — West Jefferson Site

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

The King Avenue site is located east of State Route 315. The area within two miles of the King Avenue site to the east and south consists of predominantly single-family, urban residential neighborhoods. The Near Northside Historic District, listed on the National Register of Historic Places, encompasses these neighborhoods. A small portion of the King Avenue site is located within the Near Northside Historic District. No research buildings are included in this district; however, this portion does include land owned by Battelle from Fifth Avenue south to Third Avenue.

The portion of the King Avenue site that is north of Fifth Avenue, as well as the area to the east and north of the site, is within the city's University District. The Ohio State University (OSU), with a student enrollment of approximately 50,000 and a staff of approximately 29,000, is adjacent to the King Avenue site on the north. The Olentangy River constitutes the west boundary of the King Avenue site. The area west of the Olentangy River consists mainly of small business and light industrial properties, with scattered residential patches. Table 1,[1] *Battelle King Avenue Site Population Within 50-Mile Radius*, includes data on the population distribution, by direction and distance, within a 50-mile radius of the King Avenue facility.

Similarly, Table 2, *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.

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[1] References are listed on page 41. Tables are located in Appendix A of this document.

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 feet from the center of the West Jefferson site, and a residence within the camp is located approximately 3,300 feet 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 feet southeast of the site center on the eastern side of the Big Darby Creek and consists of 965 single family units (Figure 3). 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 both Battelle sites 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 31.2°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 inches. The greatest recorded rainfall for any 24-hour period was 5.16 inches 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 tornados. Of the 631 tornados recorded in Ohio from 1953-1993, 22 percent have occurred in the month of May. The largest number of tornados 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 (SER).

Geology

The geological strata underlying the West Jefferson and King Avenue areas consist 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 feet 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 inches, 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

Hydrology at the King Avenue site is not a major concern. The five groundwater wells in place supply only non-contact cooling water for facility chillers. Drinking water and some cooling water at the King Avenue site are supplied by the City of Columbus-Division of Water. Liquid effluents, except for non-contact cooling water and boiler blowdown, are discharged into the city sanitary sewer system and monitored by BCLDP. Extensive analysis of Battelle's liquid effluent has demonstrated that pretreatment and permitting by the city of Columbus is not necessary. Non-contact cooling water and boiler blowdown are discharged to the Olentangy River in accordance with NPDES permit guidelines.

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 feet, 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 foot per 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 the former figure, 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 wells located throughout the facility. The north well is 130 feet deep; the centrally located well in the Middle area is 162 feet deep; and the South area well is 138 feet 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 feet 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. 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 feet above mean sea level.

Flood water calculations for the region measured during the January 1959 floods indicate a release rate for water that is about three times the inflow rate. Test borings drilled in 1970 for an addition to the Hot Cell Laboratory (discussed in the *Facility Description* section) 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.

Big Darby Creek accounts for the West Jefferson facility's principal surface water flow. The Darbyville gauging station, which is located 40.46 river miles south of the West Jefferson facility, is the only continuous recording gauge on Big Darby Creek. Normal flow recorded at Darbyville is 430 cubic feet per second (cfs).

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 per year.(2) Of this number, approximately 67 percent or 200 mrem/year comes from radon. In 1966, the natural terrestrial background for the region surrounding Battelle was measured to be 60 mrem/year by an aircraft equipped with radiation instrumentation.(3) This number is greater than the national average of approximately 28 mrem/year.(2) The cosmic background for the State of Ohio is averaged to be 50 mrem/year, compared to a U.S. average of 27 mrem/year.(2) The estimate for internal emitters within the body is considered to be approximately 39 mrem/year for the United States with only minor regional variations.(4) As indicated in the section entitled *Evaluation of Dose to the Public*, the impact from Battelle's atmospheric discharges from operations is significantly less than 1 mrem/year.

Facility Description

The centers of D&D activity at the Battelle King Avenue site during 1997 were the former metalworking laboratory (Building 2), Battelle Headquarters (Building A), and external areas adjacent to Building 6. Figure 4 shows the location of these buildings at the King Avenue 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 and small contained sources remain onsite.

In 1997, 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 (JN-3). Figure 5 shows the locations of these nuclear facilities in the Nuclear Sciences Area building complex.

D&D Activities at the King Avenue Site

The D&D activities at the King Avenue campus centered around the former metalworking, welding, heat treat, and electrochemistry facilities in Building 2 and sub-basement/tunnel areas in Building A. Activities in Building 2 included material and mechanical systems removal; asbestos abatement; wall, floor, and overhead surface area decontamination, and drain system removal in the north half of the building; and removal/replacement of the entire building roof, including a portion of the supporting structure. Underground drain decontamination and removal continued in the utility tunnels and sub-basement areas of Building A and outside the southeast corner of Building 6. 21,422 cubic feet of contaminated waste were shipped for disposal.

D&D Activities at the West Jefferson Site

The D&D activities at the West Jefferson facility during CY 1997 included water removal and evaporation of 123,000 gallons of processed spent fuel pool water. The spent fuel pool water was tested for radiological activity and released in accordance with BCLDP's volumetric release procedure as having met all applicable release criteria prior to evaporation. A total of 147,000 gallons of water was removed over a two year period. This operation was concluded in 1997. 6,200 cubic feet of contaminated material and waste were shipped for disposal.

Figure 5 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 Facility (JN-4). Each of these facilities is described in the following paragraphs.

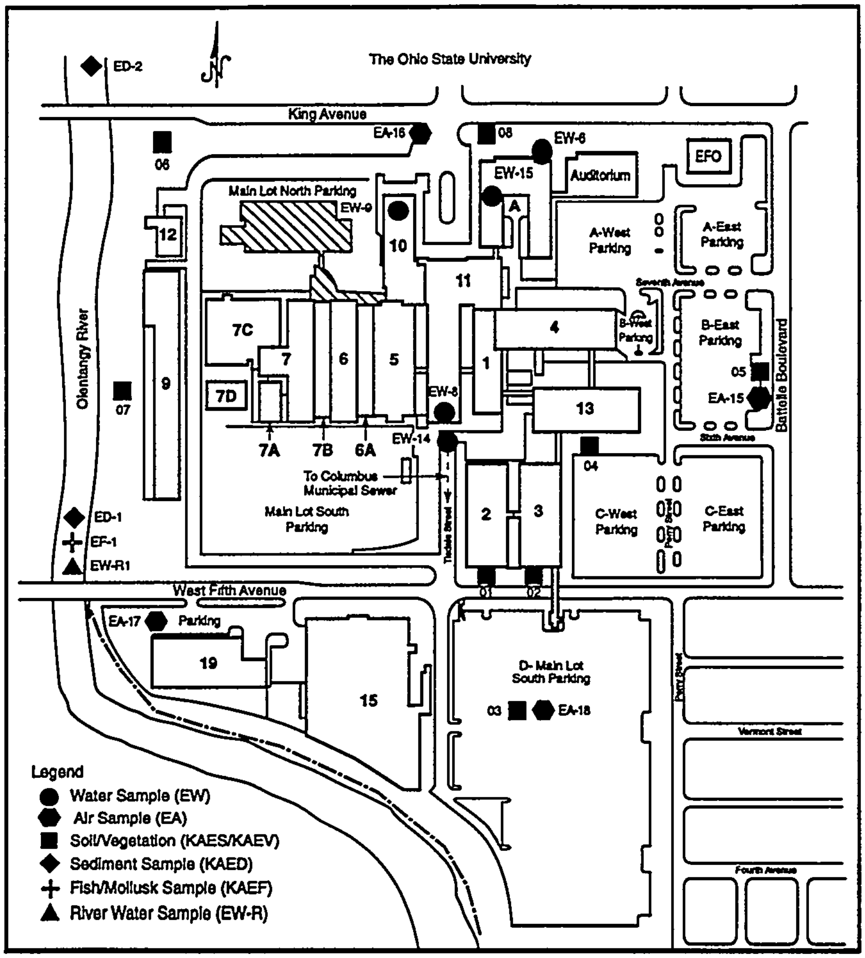

Figure 4. Battelle King Avenue Monitoring Locations

Hot Cell Laboratory, JN-1

The Hot Cell Laboratory contains approximately 22,000 square feet of space. At one time it was considered to be one of the most completely equipped installations available to the nuclear community. The Hot Cell Laboratory was capable of providing research and technical assistance in the following areas:

- Power reactor fuel performance evaluations
- Pressure vessel irradiation surveillance, and capsule examinations and evaluations
- Post-irradiation examinations of nuclear materials and components
- Radiation source encapsulation
- Physical and mechanical property studies of irradiated materials and structures

The Hot Cell Laboratory consists of a large, high-energy cell with a connected fuel handling pool, five smaller cells, and supporting facilities. The high-energy cell and pool were capable of handling complete power reactor fuel assemblies. The smaller cells consist of the high-level and low-level cells, two mechanical test cells, and a segmented alpha-gamma cell. The supporting facilities include areas for cask handling, solid and liquid-waste disposal, contamination control, equipment decontamination, and other miscellaneous operations. All of these operations have contributed to the need for S&M activities while awaiting decommissioning.

Administrative Building, JN-2

Battelle originally designed and built the Administrative Building for use as a critical assembly laboratory. It was used for criticality experiments from 1957 through 1963. Since the cessation of criticality experiments, Battelle has used the facility for several nuclear-related projects, including direct conversion concepts, irradiation experiment assembly, and special nuclear materials (SNM) handling. Battelle terminated the operating license in 1970 when project work was ended. These activities have made it necessary to maintain this area on the S&M schedule.

Current support staff, including the Environmental Monitoring, Instrument Maintenance, and a Radioanalytical Laboratory for the assay of routine health physics and environmental sampling activities, use offices and small utilities within JN-2.

Retired Battelle Research Reactor, JN-3

The Battelle Research Reactor began operation on October 29, 1956, and ended on December 31, 1974. Battelle completed the subsequent dismantling process in 1975 without incident. Storage of waste awaiting shipment for burial is the principal licensed activity conducted in JN-3 at this time. S&M also is conducted in JN-3 in support of a Reactor Facility Surveillance Report submitted annually to the NRC.

Decommissioned Plutonium Laboratory, JN-4

Building JN-4 was built in 1960 to house activities for plutonium research and processing. These activities were terminated in 1978 and the laboratory portion was dismantled in 1985. A hazardous materials research facility now operates in JN-4.

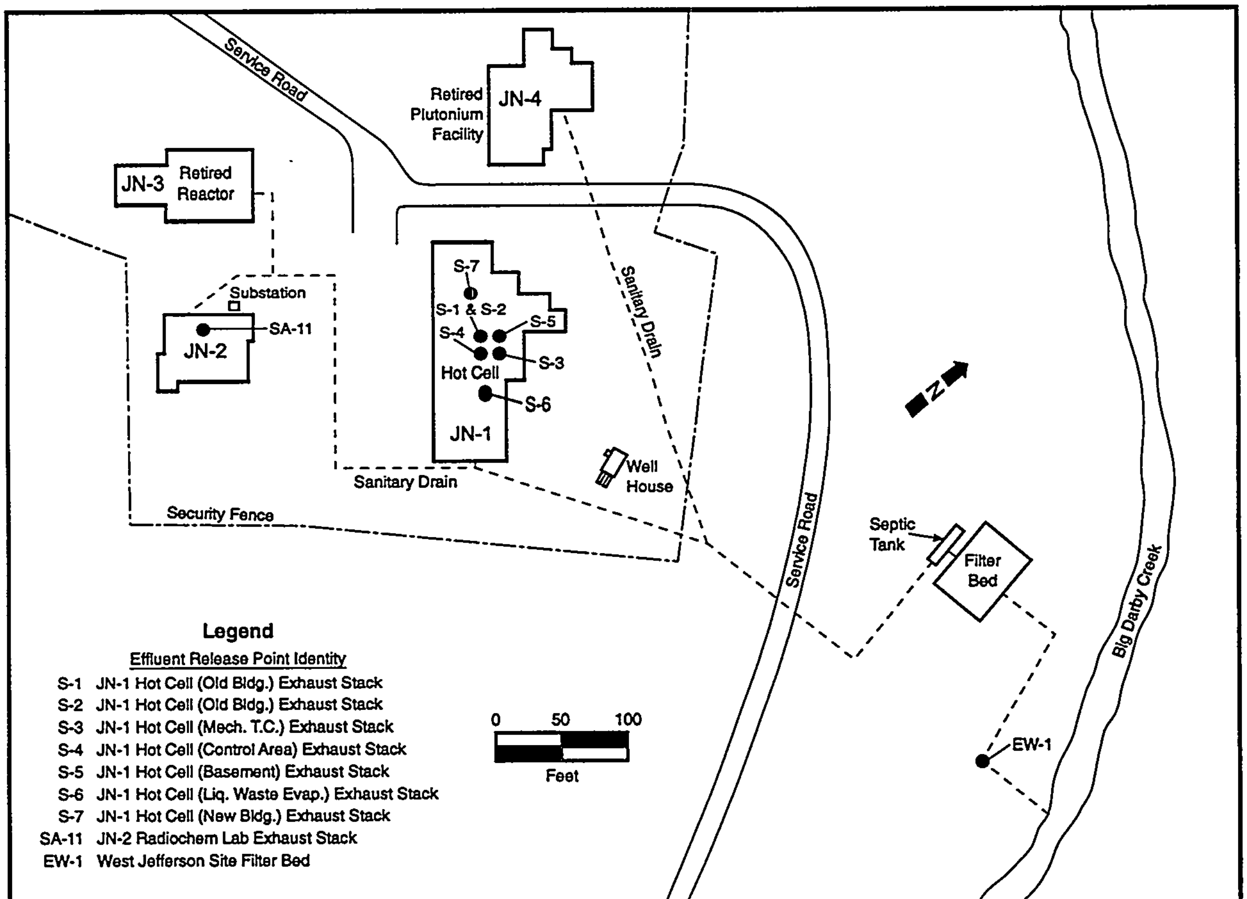

Figure 5. Nuclear Sciences Area — West Jefferson Site

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 1997. No lawsuits by regulatory agencies or citizens were brought against Battelle. There were no United States Environmental Protection Agency (USEPA) or Ohio Environmental Protection Agency (OEPA) compliance issues in 1997 attributable to BCLDP operations. There were no unresolved BCLDP compliance issues during 1996 that needed to be addressed in 1997.

Compliance Status in Specific Regulatory Areas

Comprehensive Environmental Response, Compensation and Liability Act (CERCLA)

No violations occurred and no enforcement actions were taken in connection with BCLDP in 1997. There were no releases of hazardous substances that required notification under CERCLA.

Resource Conservation and Recovery Act (RCRA)

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 (TSDF).

Battelle withdrew the Ohio Hazardous Waste Facility Installation and Operation Permit renewal application and the Hazardous Waste Facility Installation and Operation Permit on January 13, 1995. Battelle is currently undergoing RCRA closure.

Battelle submitted an amended closure plan on August 12, 1996, which was approved in March 1997 by the OEPA.

Federal Facility Compliance Act (FFCA)

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

In December 1997, the BCLDP provided OEPA with an annual update of the STP for 1997 in compliance with the Director's Findings & Orders.

National Environmental Policy Act (NEPA)

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

Clean Air Act (CAA)

The NRC regulates Battelle through the SNM-7 license. Current practices at Battelle are to limit release to 10 mrem/yr 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.

Clean Water Act (CWA)

This Act is administered in Ohio by the OEPA. Battelle received one Notice of Violation (NOV) in 1997 on exceedance of the total residual chlorine limit. The exceedance was not attributable to BCLDP operations.

Safe Drinking Water Act (SDWA)

This Act is administered in Ohio by the OEPA. No violations have occurred and no enforcement actions were taken in connection with the BCLDP in 1997.

Toxic Substances Control Act (TSCA)

No violations have been cited by the OEPA and no enforcement actions were taken in connection with BCLDP. Polychlorinated biphenyl (PCB) wastes were properly stored. By the end of 1997, OEPA had been notified that 4,386 kg of low-level radioactive PCB solid waste remained onsite for over one year due to lack of treatment and disposal facilities.

Superfund Amendments and Reauthorization Act (SARA) Title III

In 1997, 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 (MSDS)/Chemical Inventory. This is for storage of chlorine in cylinders used for water disinfection and aboveground and underground tank storage of #2 Fuel Oil for backup fuel for boilers and emergency generators.

Battelle is voluntarily participating in the group locally responsible for implementing SARA Title III.

Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA)

This Act is not applicable to BCLDP. Pesticides used in BCLDP areas are USEPA registered and purchased from a registered establishment.

Endangered Species Act (ESA)

No endangered species have been identified in the areas around Battelle's King Avenue facility. At the West Jefferson Site, the following species have been identified:

Federal and Ohio Lists

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

Ohio List

- Rabbitsfoot (Quadrula cyclindrica cylindrica)

Ohio Special Interest Species

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

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 this 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 (NHPA)

Several lots located on the east and southeast portions of the Battelle King Avenue site are within the boundaries of the Near Northside Historic District. These areas are subject to provisions in 36 CFR 636 and 36 CFR 800. BCLDP activities did not take place within the historic district.

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 December 11, 1995, Letter of Map Revision (LOMR) from the Federal Emergency Management Agency (FEMA) certified the adequacy of the levee on the Olentangy River and thereby reclassified the location of the Battelle King Avenue facilities from the 100-year floodplain to the 500-year floodplain. Because the West Jefferson BCLDP buildings and the King Avenue campus are not in the 100-year floodplain, this order has no applicability to the project.

Executive Order 11990 "Protection of Wetlands"

This order is not applicable. BCLDP operations did not have any adverse impact to these areas in 1997.

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

Number	Type	Description	Number
King Avenue Campus			
1	Water	NPDES Permit	4IN00012*DD
1	Water	NPDES-Stormwater General Permit for Industrial Activity	OHR000113
1	Waste	Part A Interim Status Acknowledgment	OHD007901598
1	Waste	PCB Notification	OHD007901598
1*	Transportation	OH PUCO Hazardous Materials Uniform Program Credentials	UPM-0103830-OH
1	Transportation	Tennessee Radioactive Waste License-for-Delivery	T-OH002-L97
1*	Radioactive Waste	US NRC Materials License	SNM-7
West Jefferson Laboratory			
1	Air	Boiler Building JN-1 Registration	0149000074/B001
1	Air	Boiler Building JN-2 Registration	0149000077/B002
1	Air	Boiler Building JN-3 Registration	0149000074/B003
1	Air	Underground Storage Tank Building JN-1 Registration	0149000077/T001
1	Air	Emergency Generator Building JN-6 Registration	0149000077/B012
1	Water	NPDES Permit	4IN00004*FD
1	Water	License to Operate/Maintain Public Water System-Drinking Water Wells	97-4930212
1	Waste	Hazardous Waste Generator Registration	OHT400013892
1	Transportation	Tennessee Radioactive Waste License-for-Delivery	T-OH007-L97
1*	Transportation	US DOT Hazardous Materials Registration	061096009005F
1*	Radioactive Waste	US NRC Materials License	SNM-7

* In effect for both sites

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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.

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 effectiveness of the waste management program, including control of effluent releases at both sites. 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.

Environmental monitoring under BCLDP is limited by the nature of the S&M and D&D activities. With few exceptions, Battelle performs 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

On October 29, 1997, the BCLDP project completed 1 million safe work hours without a lost time accident and finished the year with 1,045,592 safe work hours. This translates into more than 850 safe work days. This outstanding safety record can be attributed to worker compliance with health and safety policies, training, supervision, and the proper use of personal protective equipment.

Environmental Oversight

BCLDP continued its formal environmental oversight program during 1997. Oversight is performed by BCLDP's Regulatory Compliance and Environmental Safety and Health Oversight (RC&ESHO) personnel and also by Battelle Columbus Operations Environmental Safety & Health (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 was updated and revised on May 27, 1997. The Plan primarily addresses the minimization of low-level radioactive 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 97 were:

- The radiological free-release and shipment of 30 cubic feet of concrete for processing and reuse as road base material instead of managing it as LLW
- The shipment of 1,520 cubic feet of surface-contaminated I-beam steel for decontamination, radiological free-release and recycle
- The shipment of 850 pounds of lead for decontamination, radiological free-release and recycle to GTS-Duratek in Oak Ridge, TN

- The shipment of 5,930 pounds of contaminated metal for melting to GTS-Duratek in Oak Ridge, TN, for reuse as shielding blocks and shipping containers
- The shipment of a mildly contaminated surplus fuel pool boat to West Valley Nuclear Services for reuse. This action avoided the disposal of 475 cubic feet of LLW.

The BCLDP Manager of Waste Management 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 (QA) Plan, LLW Certification Plan, Transuranic (TRU) Waste Certification Plan and incorporated into each D&D Work Plan. A training program for training employees in pollution prevention awareness is in place.

WasteWi$e

Under the Battelle charter membership, the BCLDP contributes to the overall success of the site's WasteWi$e program. WasteWi$e 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 WasteWi$e program promotes environmental awareness and improvement in three target areas: waste prevention, the increased usage of recycled products, and recycling.

BCLDP made significant contributions to each of the three WasteWi$e target areas. In the area of waste prevention, double sided copying and using electronic mail for internal communications is encouraged. In the area of purchasing recycled products, BCLDP continually seeks to use products with high post-consumer content. Project staff members also serve on the recycling committee. One of the committee's annual goals is the continued expansion of the recycling program. To meet this objective, they evaluate the suitability of additional materials that may be included in the recycling program. The following is a list of recycled materials as reported to the USEPA for 1997.

1997 Recycling Totals (lbs)	
Corrugated Paper	20,565
White Office Paper	71,708
Mixed Office Paper	126,983
Magazines	7,930
Newspaper	7,930
Aluminum Cans	477
Other Nonferrous Metals	9,007
Steel	160,160
Other Ferrous Metals	225,200
Other (batteries, etc.)	4,657
Total	634,617

Emergency Response

The BCLDP has implemented 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).

Response capabilities are structured based on the Incident/Unified Command System which promotes the timely combining 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, information exchange, and emergency response. Agreements are maintained with the: (1) Emergency Management Agency (EMA) of Franklin County, (2) Columbus Health Department, (3) OSU Medical Center, (4) City of Columbus Division of Police, (5) EMA of Madison County, (6) Jefferson Township Fire Department, and (7) State of Ohio EMA.

Battelle participates in the community emergency response planning process by maintaining an active presence in the local emergency planning committees (LEPCs) of both Franklin and Madison Counties. In Franklin County, Battelle personnel serve on three LEPC subcommittees: (1) The Hazard Analysis Committee, (2) The Public Information Committee and (3) The Training Committee.

In January 1997, BCLDP personnel activated and operated the Emergency Operations Center (EOC) for 55 hours in response to a written bomb threat. Since this event resulted in the activation of the BCLDP Emergency Management Organization, it is considered to have constituted the annual 1997 emergency exercise; this then allowed assessment of individual emergency responders to varying scenario narratives during October and November.

Consistent with Battelle's private/public sector partnering philosophy, the Emergency Management Agency for Franklin County and the Madison County Emergency Management Agency were provided courtesy notification early in the event, following notification to DOE. The NRC was notified within 24 hours of event recognition.

The bomb threat event demonstrated that the BCLDP emergency management program had reached maturity within the greater Columbus area emergency management community. Public sector emergency management and response personnel occupied space in the Battelle EOC in unified command fashion, provided input, and remained ready to take command if conditions warranted.

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ENVIRONMENTAL RADIOLOGICAL MONITORING

West Jefferson Site

An inventory of suspected radionuclide effluents for air and water media is presented in Appendix A, Table 3, *Annual Radionuclide Release Inventory, West Jefferson Site — 1997.* 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 purposes of calculating dose assessments. This assumption is a conservative measure performed to establish a release inventory and estimate maximum possible doses to the public.

Air

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

Stack air samplers continuously monitor the exhaust stack emissions from the major 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 5 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 volume of 1.0 cubic feet/minute (cfm). This volume was selected to facilitate statistical calculations for activity concentrations that are well below regulatory standards.

Table 4, *Annual Average Radionuclide Concentrations from Stack Emissions, West Jefferson Site — 1997* provides a summary of the average annual radionuclide concentrations and the corresponding release rates for designated stacks (see Figure 5). 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 many orders of magnitude below those concentration guidelines specified in 10 CFR 20, Appendix B, Table 2, as well as the Derived Concentration Guide (DCG) values specified in DOE Order 5400.5. The radionuclide concentrations for the West Jefferson site are cited in Table 4. These radionuclide concentrations represent maximum values calculated using CAP88PC air dispersion modeling.

BCLDP collected stack air effluent samples weekly, screened them for gross alpha and gross beta-gamma radioactivity, and used them to: (1) trend 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 also performed supplemental air sampling at four site perimeter locations (EA-1, EA-2, EA-3, and EA-4) during 1997 (Figure 6). These sample filters were analyzed on a weekly basis for gross alpha and gross beta-gamma activities and the data were combined into quarterly composites. BCLDP then analyzed for Pu-238, Pu-239, Sr-90, natural-U, and gamma-emitting radionuclides (Table 5, *Summary of Site Boundary Air Sample Analyses, West Jefferson Site—1997*). Collectively, these air sampling data were used to demonstrate, by field measurements, that radionuclide emissions emanating as a result of BCLDP activities are compliant with Federal, State, and local regulatory statutes and pose no

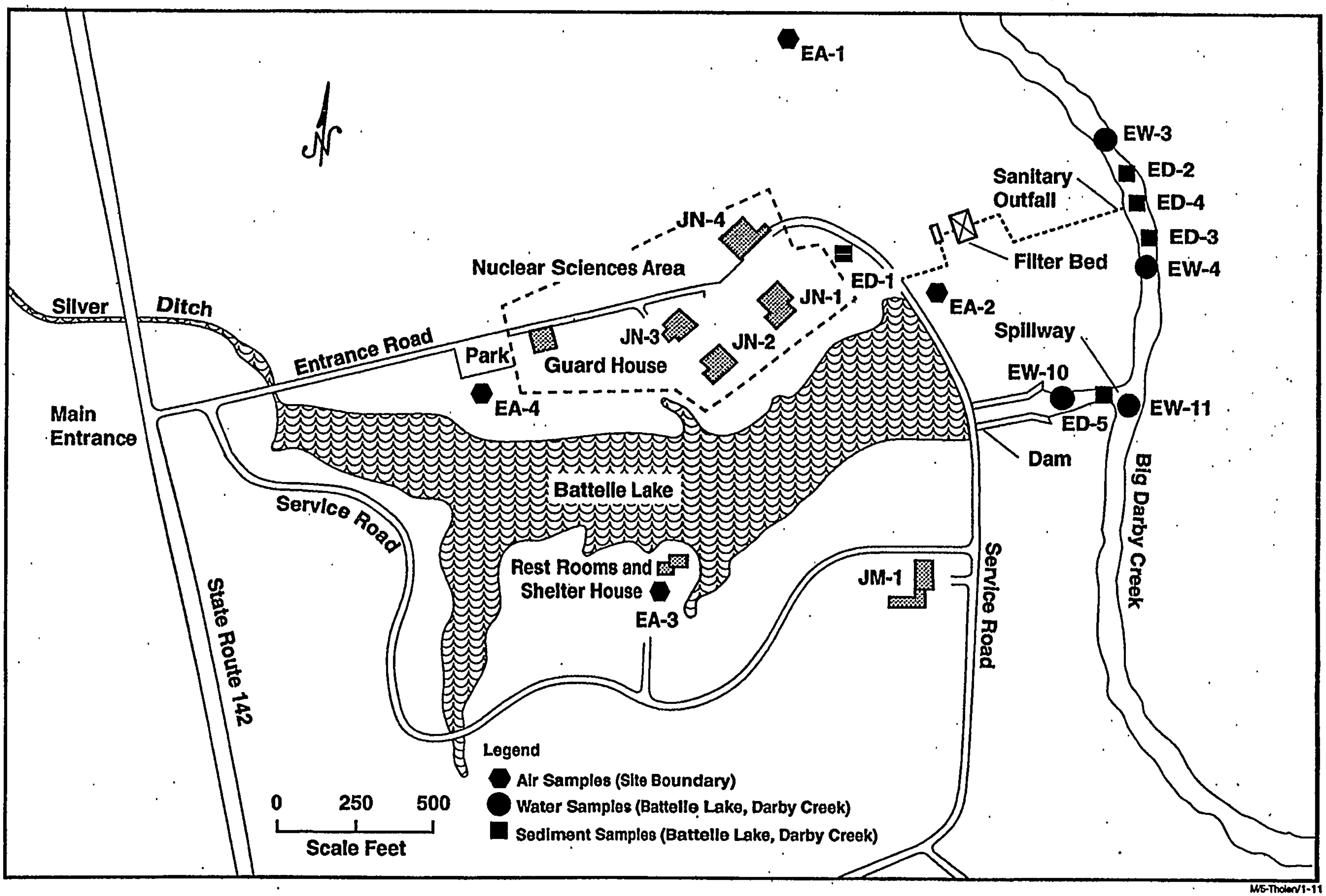


Figure 6. Map of Site Water Sampling Locations, Site Boundary Air Sampling Locations, and Battelle Lake and Darby Creek Water and Sediment Sampling Locations

significant threat to human health or the environment.

Water

A wastewater treatment system, which is operated in accordance with State of Ohio regulations under NPDES Permit 4IN00004*FD, 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-sq. ft. contained sand and gravel filter bed (Figure 5). 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 6, *Summary of Liquid Radiological Emissions, West Jefferson Site—1997.* In most cases, the total activity in the samples is attributed to a mixture of radionuclides.

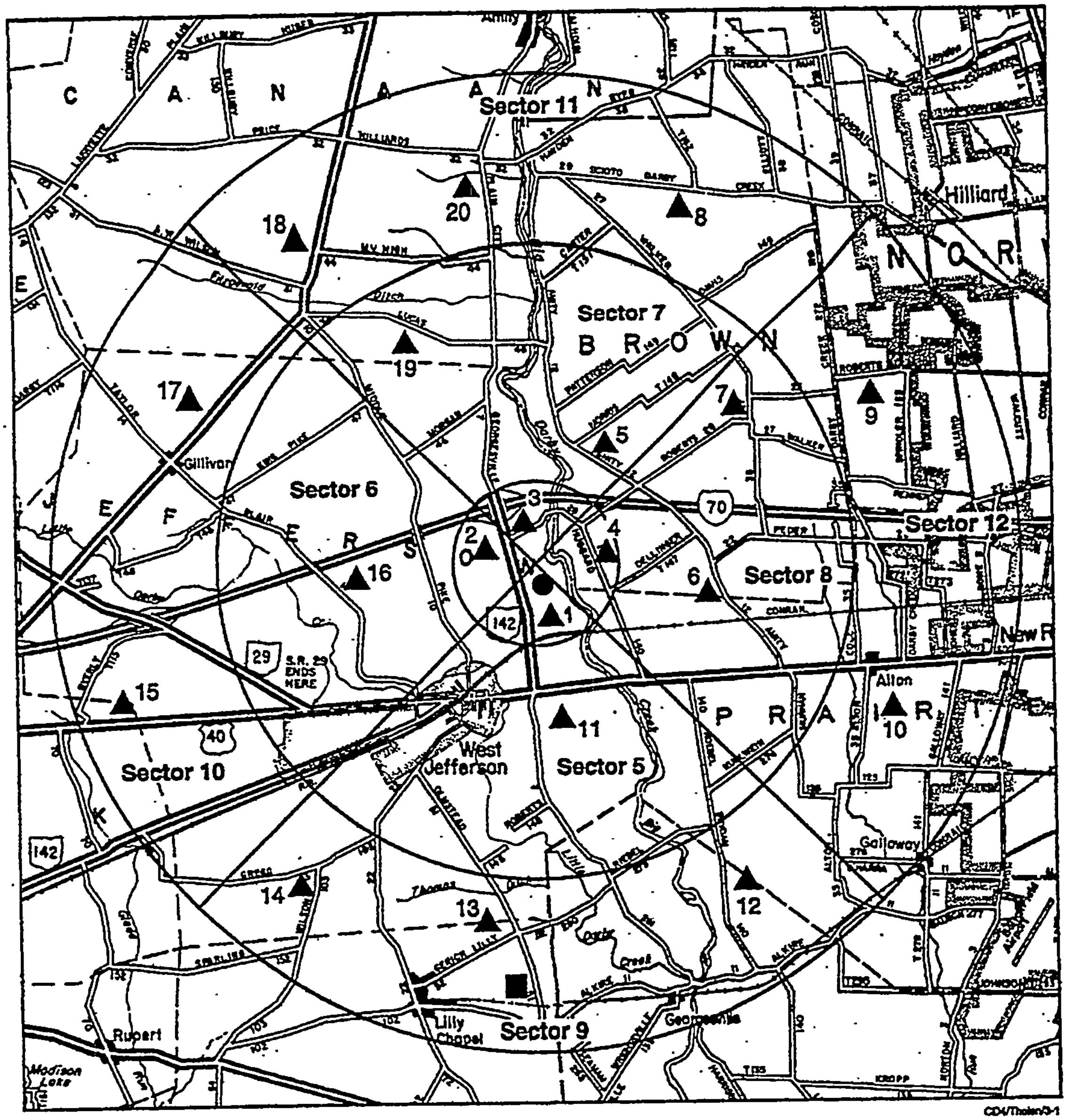
The noncommunity drinking water supply at the West Jefferson site is exempt from radiological monitoring per OEPA review.[6] However, BCLDP collected weekly drinking water samples from a tap at the Nuclear Sciences Area to verify compliance with applicable water quality standards for radioactivity in drinking water. Drinking water samples were composited and analyzed monthly for gross alpha and beta activity in suspended and dissolved fractions. A supplementary gamma isotopic analysis was performed on a quarterly composite, and alpha spectroscopy and Sr-90 analysis were performed on an annual composite (see Table 7, *Summary of Radiological Analyses of Drinking Water Samples, West Jefferson/King Avenue Sites— 1997*).

In 1997, the average concentrations in drinking water of gross alpha were $(4.29 \pm 5.96) \times 10^{-9}$ µCi/mL (soluble) and $(0.77 \pm 1.74) \times 10^{-9}$ µCi/mL (insoluble) for a total concentration of gross alpha of $(5.06 \pm 6.22) \times 10^{-9}$ µCi/mL. The average concentrations of gross beta were $(3.62 \pm 2.64) \times 10^{-9}$ µCi/mL (soluble) and $(1.66 \pm 2.88) \times 10^{-9}$ µCi/mL (insoluble) for a total concentration of gross beta of $(5.28 \pm 3.92) \times 10^{-9}$ µCi/mL. The USEPA standard for gross alpha particulate activity in drinking water is 1.5×10^{-5} µCi/mL.

BCLDP collected supplementary water samples weekly at sampling points located 18.3 m above and 18.3 m below the sanitary drain outfall, below the Battelle Lake dam, and at the drain spillway at Big Darby Creek (Figure 6). 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 less than $5.08 \pm 5.08 \times 10^{-9}$ µCi/mL for alpha and less than $8.10 \pm 3.90 \times 10^{-9}$ µCi/mL for beta activity and showed no significant difference from the upstream control sample (Table 8, *Summary of Radiological Analyses of Environmental Water Samples, West Jefferson Site—1997*).

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 6-mile (9.6-km) radius of the Nuclear Sciences Area as shown in Figure 7. Samples collected from the same sector were combined and 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 9, *Summary of Radiological Analyses of Grass, West Jefferson Site — 1997* and Table 10, *Summary of Radiological Analyses of Field Crops, West Jefferson Site — 1997.* 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.



CD4/Tholen/3-1

Legend: ▲ Field Crop, Soil, and Vegetation
● On-Site Garden Crops
■ Off-Site Garden Crops

Scale: 1/2-inch = 1 mile

Figure 7. Map of 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 at the West Jefferson site. A composite sample of various vegetables from the Battelle employee garden area was compared to a composite of garden vegetables taken from an off-site location. Figure 7 shows the locations of the on-site and off-site garden plots. Gamma isotopic, Pu-238, Pu-239, Sr-90, U-235, and U-238 analyses were performed. The results of the analyses are shown in Table 11, *Summary of Radiological Analyses of Garden Crops, West Jefferson Site — 1997.* 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 on-site garden.

Sediment

BCLDP collected sediment samples in April and November at five locations (see Figure 6), 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 12, *Summary of Radiological Analyses of Sediment Samples, West Jefferson Site—1997.* Sample location ED-1 showed Sr-90 activity at a higher level than the other four locations. Although no standards for radionuclides in sediment have been established, the reported value of 0.943 pCi/g is well below the regulatory limit for both water and soil. Samples collected in four locations showed only slight variations in activity as the upstream location. The results of the analyses indicate no impact to the Big Darby Creek from BCLDP operations.

Soil

Using a 10-cm soil plugging tool, BCLDP collected annual soil samples from 20 locations at varying distances and directions within a 6-mile (9.6-km) radius of the Nuclear Sciences Area. Locations (Figure 7) falling within the same sector are composited. Each soil sample consisted of a composite of five "plugs" of soil collected randomly from an area of approximately 1 m^2. Prior to analysis, the composite samples were air dried and blended in a pulverizing mill. The soil samples were analyzed for Pu-238, Pu-239, Sr-90, U-235, and U-238, and a gamma spectroscopy scan was performed for qualitative analysis. The results of the analyses are summarized in Table 13, *Summary of Radiological Analyses of Soil, West Jefferson Site—1997.*

Results for Sr-90, Pu-238, Pu-239, U-234, and U-235 were at or below the MDA or not statistically significant from background. The U-238 activity in sectors 2, 4, and 9 was reported at levels higher than the average value for the other sectors. 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 twelve 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 were collected semi-annually from Battelle Lake (June and September 1997) and as available from Big Darby Creek (June and September 1997) to determine if any radioactive material is entering the food chain. In Big Darby Creek, fish collection was limited to a 100-yard radius of the liquid effluent outfall and the Battelle Lake spillway. 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 14, *Summary of Radiological Analysis of Fish Tissue, West Jefferson Site— 1997*, summarizes the 1997 data from the analyses.

Background Radiation Measurement

The radiation dose limit established for the general public by the DOE is 100 mrem/yr.[7] 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 8 shows the location of the 16 dosimetry stations that continuously monitor the external radiation background levels at the West Jefferson site.

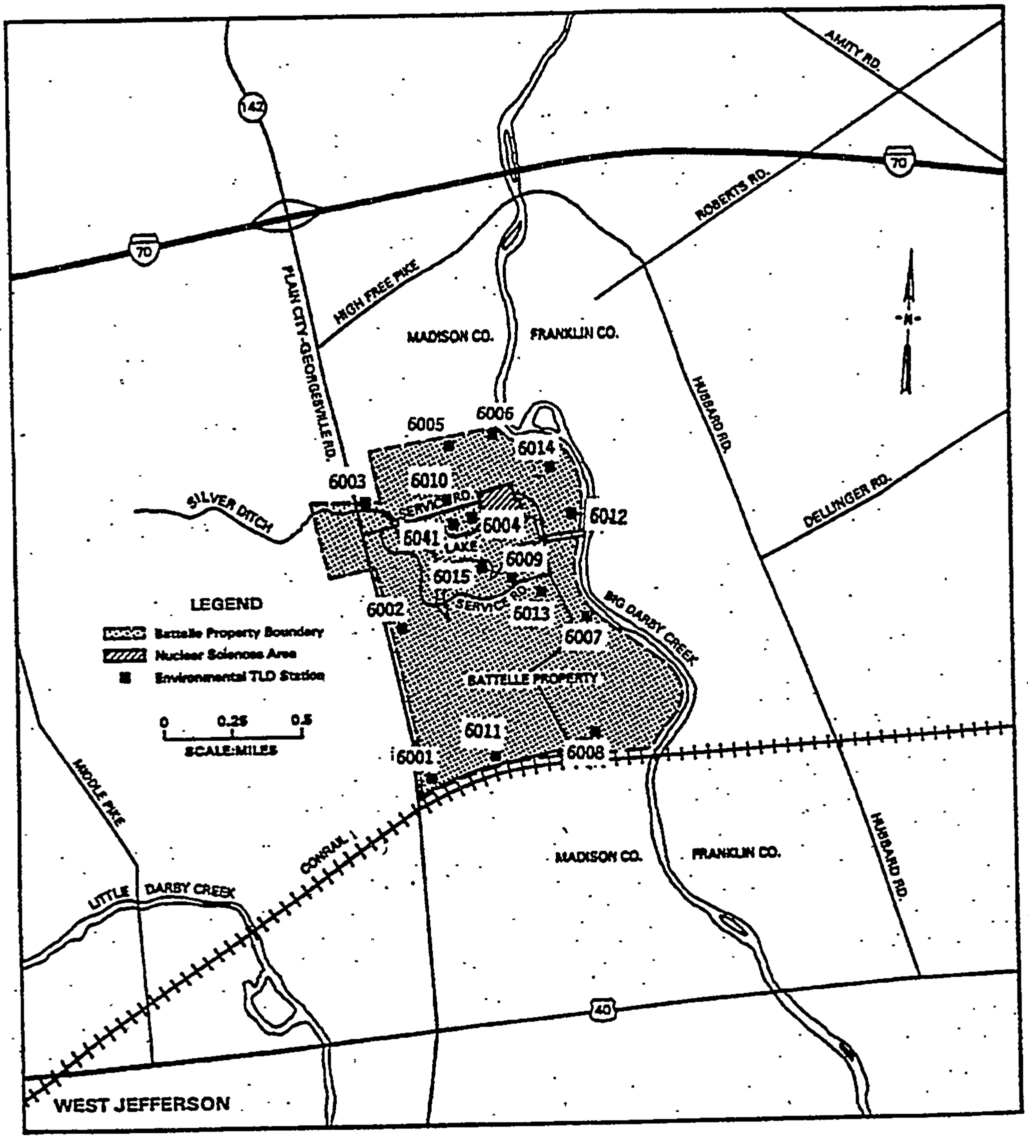


Figure 8. Map of TLD Locations Within 3/4-Mile Radius of the Nuclear Sciences Area

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 1997 annual average dose equivalent including background at the site boundary is less than 100 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 15, *Integrated External Background Radiation Measurements at Recreation Area and Property Boundary Line, West Jefferson Site—1997.*

"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 1997 was equal to the annual average TLD background reading of less than 100 mrem measured at off-site background monitoring stations.

King Avenue Site

The BCLDP Radiological Technical Support staff maintains a comprehensive radionuclide inventory representing the quantity of radioactive materials available for release at the King Avenue site. The group compiles these data annually to calculate an EDE and to perform a dose assessment for the public. BCLDP uses this assessment to demonstrate compliance with the dose standard cited in 10 CFR 20, Subpart B.

Air

BCLDP maintains EA samplers that continuously monitor air effluents at the King Avenue site boundary (see Figure 4). Analyses of these air samples are used to assess, by field measurement, the potential environmental impact posed to the neighboring community.

BCLDP screened air samples collected from these continuous EA samplers weekly for gross alpha and gross beta-gamma radioactivity. Analyses from these weekly air samples were reviewed to determine trends in radionuclide emissions and to assess any potential impact posed to the environment. BCLDP also analyzed quarterly composites of the EA samples for specific gamma emitting radionuclides and performed additional radiochemical analysis for alpha and beta emitting isotopes on a quarterly basis. Radioanalytic results obtained for each of the sampling locations were below the MDA of the specific counting instrumentation. Table 16, *Summary of Site Boundary Air Sample Analyses, King Avenue Site—1997*, provides a summary of the radioanalytical data pertaining to the King Avenue site perimeter air sampling program. These data show that radionuclide emissions from BCLDP activities at Battelle's King Avenue site posed no significant environmental threat to the neighboring community in 1997.

Liquid Discharges

Sanitary and industrial wastes at the King Avenue site go to the Columbus Municipal Waste Water Treatment Plant through the sanitary sewer system. Effluent from this system is discharged under the publicly-owned treatment works' (POTW's) NPDES permit. Effluents discharged by Battelle must meet requirements imposed by the POTW to be in compliance with environmental regulations. Battelle's discharge-to-drain permitting procedure evaluates all proposed effluents and approves those which meet these standards. All liquid discharges resulting from BCLDP operations were approved prior to their release. Radiological activity detected in these permitted discharges is either well below regulatory standards for effluent discharges to the POTW and/or the result of naturally occurring isotopes.

In addition to meeting prerelease permit standards, BCLDP monitored the site's wastewater discharges to the POTW at four locations (see Figure 4 for the locations). Liquid discharges that connect to the municipal sewer system were sampled on a weekly basis. Monthly composites were then prepared from these weekly collections, and gross alpha, gross beta, and gamma isotopic analyses were performed. In addition, thorium-isotopic and uranium analyses were performed on quarterly composites. These results are summarized in Table 17, *Radiological Analyses of Liquid Discharges, King Avenue Site—1997.* The average concentrations at all discharge points were well below NRC standards as well as the DOE's DCG for the most restrictive beta activity in the uranium decay chain.

Soil

Eight soil samples were collected at various points around the King Avenue site (Figure 4). A ninth sample, KAES-09, was collected from the OSU Agriculture campus northwest of the Battelle site as a background reference. The same technique was used as that for soil collected for the West Jefferson off-site soil samples. The data from these collections are presented in Table 18, *Radiological Analyses of Soil Samples, King Avenue Site—1997.* Cs-137 detected in King Avenue soils was comparable to the background sample levels. Cesium is in the same range as that seen in West Jefferson off-site samples. This suggests that the cesium is from fallout, not Battelle operations. U-234, U-235, U-238, and Th-232 were also detected in the samples including the off-site King Avenue location. The values for sample KAES-02 are consistent with historical data for the same location. The King Avenue soils are under evaluation by the BCLDP Characterization Group.

Vegetation

Nine samples of vegetation were collected from the same locations as the soil samples, including the off-site background reference location (Figure 4) and received gamma isotopic, thorium, and uranium analyses. Data from these analyses are presented in Table 19, *Radiological Analyses of Vegetation Samples, King Avenue Site—1997*. U-234, U-235, U-238, and Th-232 were detected in the samples, including the off-site King Avenue location. The detections of these isotopes were not statistically significant from the background sample. Therefore, the presence of the radioisotopes in vegetation was not attributable to BCLDP operations.

Sediment

Sediment samples were collected in September at two locations in the Olentangy River, one near the storm sewer outfall at the low-head dam on the river, just north of Fifth Avenue (KAED-1), and the other one south of the OSU campus north of King Avenue (KAED-2) (see Figure 4). A quantitative gamma isotopic and uranium analysis was performed on these samples. The purpose of collecting the sediment samples was to determine if certain radionuclides were present in this waterway and to document this for future reference. The complete results of the sediment analyses are summarized in Table 20, *Radiological Analyses of Sediment Samples, King Avenue Site—1997*. Th-232, U-234, U-235, and U-238 were present in samples collected at both locations. In addition, Cs-137 was present slightly above MDA in both sample locations. The presence of these radioisotopes in both the upstream and downstream sediment locations indicates that these radioisotopes are not attributable to BCLDP operations.

Drinking Water

The drinking water supply at the King Avenue site is exempt from radiological monitoring per OEPA review.[6] However, weekly drinking water samples were collected from a tap at the King Avenue Site in Building A to verify compliance with applicable water quality standards[8] for radioactivity in drinking water. The weekly drinking water samples were composited and analyzed monthly for gross alpha and gross beta in suspended and dissolved fractions and gamma isotopic analysis. The isotopic results are listed in Table 7, *Summary of Radiological Analyses of Drinking Water Samples, West Jefferson/King Avenue Sites — 1997*. In 1997, the average concentrations of gross alpha was $(0.25 \pm 3.40) \times 10^{-9}$ µCi/mL (soluble) and $(0.87 \pm 1.78) \times 10^{-9}$ µCi/mL (insoluble). The total concentrations were $(1.12 \pm 3.84) \times 10^{-9}$ µCi/mL for gross alpha. The average concentrations of gross beta was $(3.44 \pm 2.44) \times 10^{-9}$ µCi/mL (soluble) and $(0.87 \pm 1.41) \times 10^{-9}$ µCi/mL (insoluble) for a total concentration of $(4.31 \pm 3.72) \times 10^{-9}$ µCi/mL. The reported values are several orders of magnitude below the DOE's DCG and the NRC's standard for ingested water.

Water

BCLDP collected one river water sample from the Olentangy River at a sampling point located north of the West Fifth Avenue bridge (Figure 4). The water sample was analyzed for mixed alpha and beta activity, gamma isotopic analysis, thorium, and uranium. The average concentration of total activity in the water sample was less than $(1.45 \pm 3.59) \times 10^{-9}$ µCi/mL for alpha and less than $(1.31 \pm 1.74) \times 10^{-9}$ µCi/mL for beta activity (see Table 21, *Radiological Analyses of Olentangy River Water Samples, King Avenue Site—1997*). The reported values were below MDA or not statistically significant.

Fish

An annual fish sample was collected from the Olentangy River during June at a location just north of the West Fifth Avenue bridge (see Figure 4). The results of the analyses were at or below minimum detectable levels or not statistically significant for each isotope (see Table 22, *Summary of Radiological Analyses of Fish Tissue, King Avenue Site—1997*).

Background Radiation Measurement

Fifteen TLDs were exchanged and evaluated on a quarterly basis around the King Avenue property line for CY 1997 (see Figure 9). A sixteenth TLD was also placed at the King Avenue site as a replicate. The annual totals for all TLDs read were less than MDA (120 mrem) for 1997. TLD #10, located along Fifth Avenue near the

Olentangy River (see Figure 9), reported a reading of 53 mrem for the first quarter, while remaining below a 120 mrem annual total. No source could be identified for this above site average reading and it is not considered attributable to BCLDP.

The results are summarized in Table 23, *Integrated External Background Radiation Measurements at the Property Line, King Avenue Site—1997.*

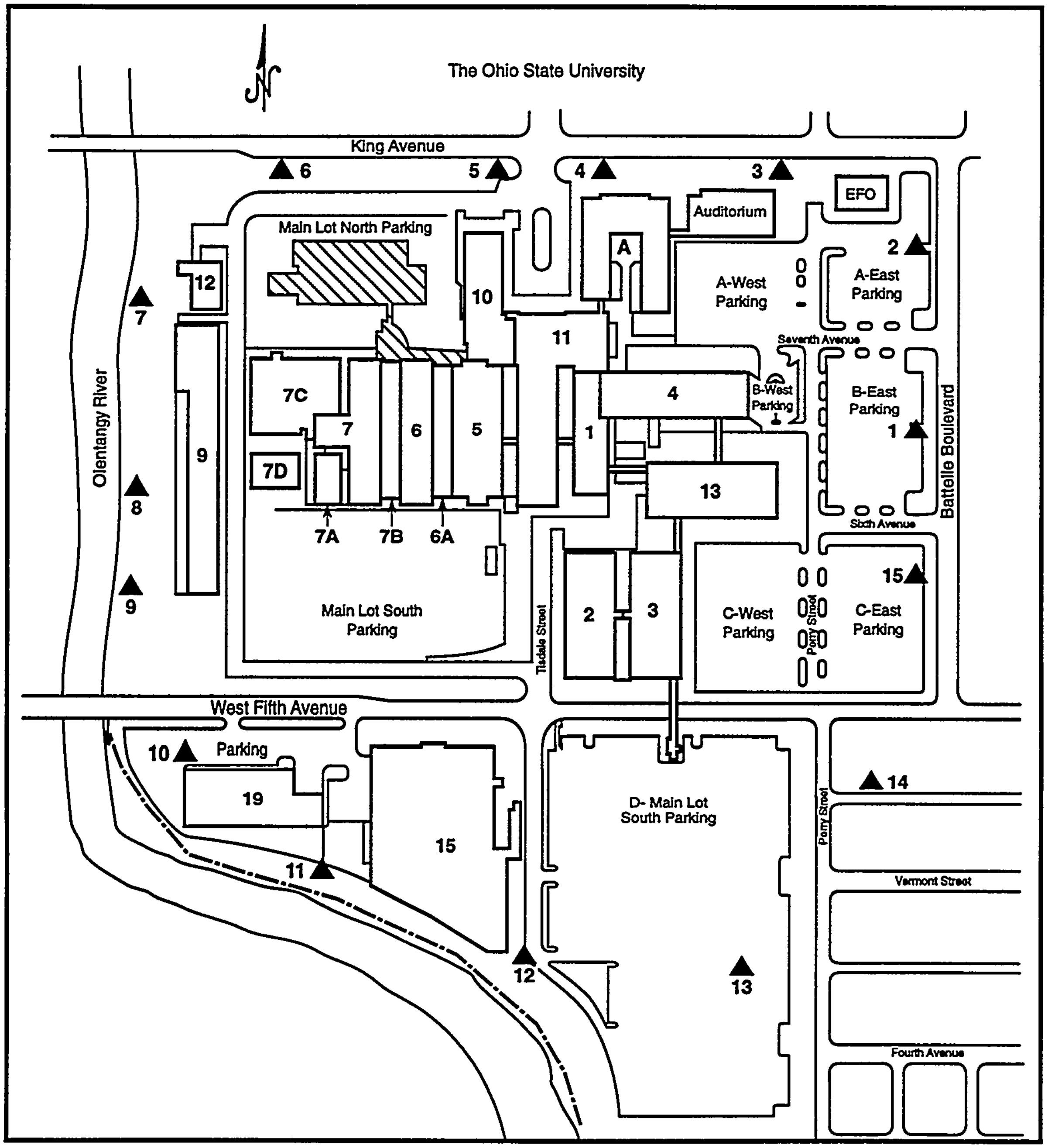


Figure 9. King Avenue Site TLD Locations

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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 noncommunity water supply, Battelle was required to perform the following tests in 1997:

- Total coliform for microbiological contamination—quarterly

  All tests for total coliform were negative.

- Volatile organic chemicals (VOCs)—once during the last half of the year

  Battelle did perform Volatile Organic Chemical (VOC) sampling during CY 1997. Results indicated that no VOCs were present in the water supply above detection limits of 0.5 μg/L.

- Synthetic organic chemicals (SOCs)—once during the first quarter of the year

  Results showed that none of the five SOCs tested for (atrazine, alachlor, metolachlor, metribuzin, and simazine) were detected.

- Nitrates—once during last half of the year

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

- MCL inorganics—once during the last half of the year

  Analyses performed for Antimony, Arsenic, Barium, Beryllium, Cadmium, Chromium, Fluoride, Mercury, Nickel, Selenium, and Thallium. Results showed all levels to be well below the established MCL values.

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 24, *Nonradiological Water Effluent Analyses, West Jefferson Site— 1997*, 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 the NPDES Permit 4IN00004*FD issued by the OEPA. All readings were within acceptable limits as specified in the permit for 1997, except for the residual chlorine level in August.

The values listed in Table 24 represent an average of the monthly data collected during the 12-month period starting January 1, 1997, and ending December 31, 1997. 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 5.

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GROUNDWATER MONITORING AND PROTECTION PROGRAM

Groundwater monitoring at the West Jefferson site included a total of 19 shallow and deep wells. These include three supply wells (JN, JM, and JS) at a depth of approximately 130 to 160 feet, three wells designed for chemical monitoring (C03, C09, and C16) at a depth of approximately 9 to 15 feet, and 13 shallow wells at a depth of approximately 9 to 20 feet. Battelle installed the three wells designed for chemical sampling and 13 shallow wells late in 1989. Figures 10 and 11 indicate the location of shallow and chemical monitoring wells. The supply wells are associated with facilities identified in Figures 6 and 10, but are off the scale of the map. 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 November 1997 from the traditional three chemical monitoring wells. Samples from all three wells were analyzed for eight heavy metals, 26 pesticide and PCB compounds, 36 VOCs, 65 SOCs, oil and grease, and pH. The results of the analyses are summarized in *Table 25, Non-radiological Analyses of Groundwater, West Jefferson Site—1997).* 1,1,1-Trichloroethane was detected at a concentration of 5.9 μg/L in well C-16, which is below the MCL of 200 μg/L. In addition, oil and grease was detected at a concentration of 3.0 mg/L. None of the above contaminants were detected in well C-03 or well C-09. Low barium levels were reported in wells C-09 and C-16. These concentrations were below the drinking water standard of 2,000 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. The results of the analyses showed no contaminants above the reporting limits or MCL established for drinking water.

Radiological groundwater monitoring was conducted in June and December. The average annual radiological monitoring results are presented in Table 26, *Summary of Alpha/Beta Radiological Analyses of Groundwater, West Jefferson Site— 1997*, and Table 27, *Summary of Radiological Analyses of Groundwater, West Jefferson Site— 1997.* Activity levels range from (-1.15 ± 2.73) to (15.20 ± 8.76) pCi/L for gross alpha and (2.10 ± 2.54) to (31.60 ± 4.92) 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 168, 172, and C-09 was reported at levels 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 11). 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 hydro geologic framework, characterize potential contaminant pathways, identify possible leakage points in buried pipelines and drainage tile, and to install piezometers.

The geophysical technologies utilized in the study included seismic refraction profiling, electrical resistivity depth sounding, electromagnetic conductivity profiling, electromagnetic conductivity mapping, magnetic gradiometry, and ground penetrating radar.

The geophysical investigation was used to establish the geologic framework in the floodplain area and to guide the placement of cone penetrometer (CPT) testing sites and piezometer locations. Seventeen CPT sites were investigated and a total of six shallow piezometers were installed near the retired filter bed area during September of CY 1995.

The six new wellpoints were sampled on October 10, 1995 and received gamma spectroscopy analyses. Results from the analyses showed there were no radionuclides present. An additional sampling event of the same six wellpoints conducted on June 5, 1996, yielded identical results.

The geophysical investigation yielded an improved understanding of the geology of the filter bed area and of the floodplain of Big Darby Creek. The study established that the preferred groundwater pathway is associated with a laterally extensive silty sand to sand deposit that is less than 12 feet deep in the floodplain area.

During August and September, 1997, work was initiated on the installation of new monitoring wells and the abandonment of damaged wells in the north area. Three new wells were installed: #100, #100-R, and #116-R (see Figure 11). Two of the new installations replaced abandoned wells that were damaged (#110) or silt filled (#116), while well #100 was established as a down-gradient well for the retired filter bed. Damaged wells #158 and #403 were abandoned and one existing well (#300) repaired (see Figure 10). In addition, seven shallow wells installed in 1989 in the retired filter bed area were abandoned: #112, #113, #122, #124, #125, #129, and #130 (see Figure 11). These wells had been installed in 1989 and had been evaluated as no longer necessary to the BCLDP groundwater monitoring program.

Chemical analyses were performed on the three new wells (#100, #110-R, #116-R) and the repaired well (#300) in November 1997, as part of the BCLDP annual groundwater monitoring program. No contaminants were detected in the four wells. Low barium concentrations were reported in three of the wells, but at levels below the drinking water standard of 2,000 µg/L. In addition, these new wells also received radiological analyses in December 1997. The results, summarized in Table 27, *Summary of Radiological Analyses of Groundwater, West Jefferson Site — 1997*, are consistent with previous monitoring data collected from other site wells.

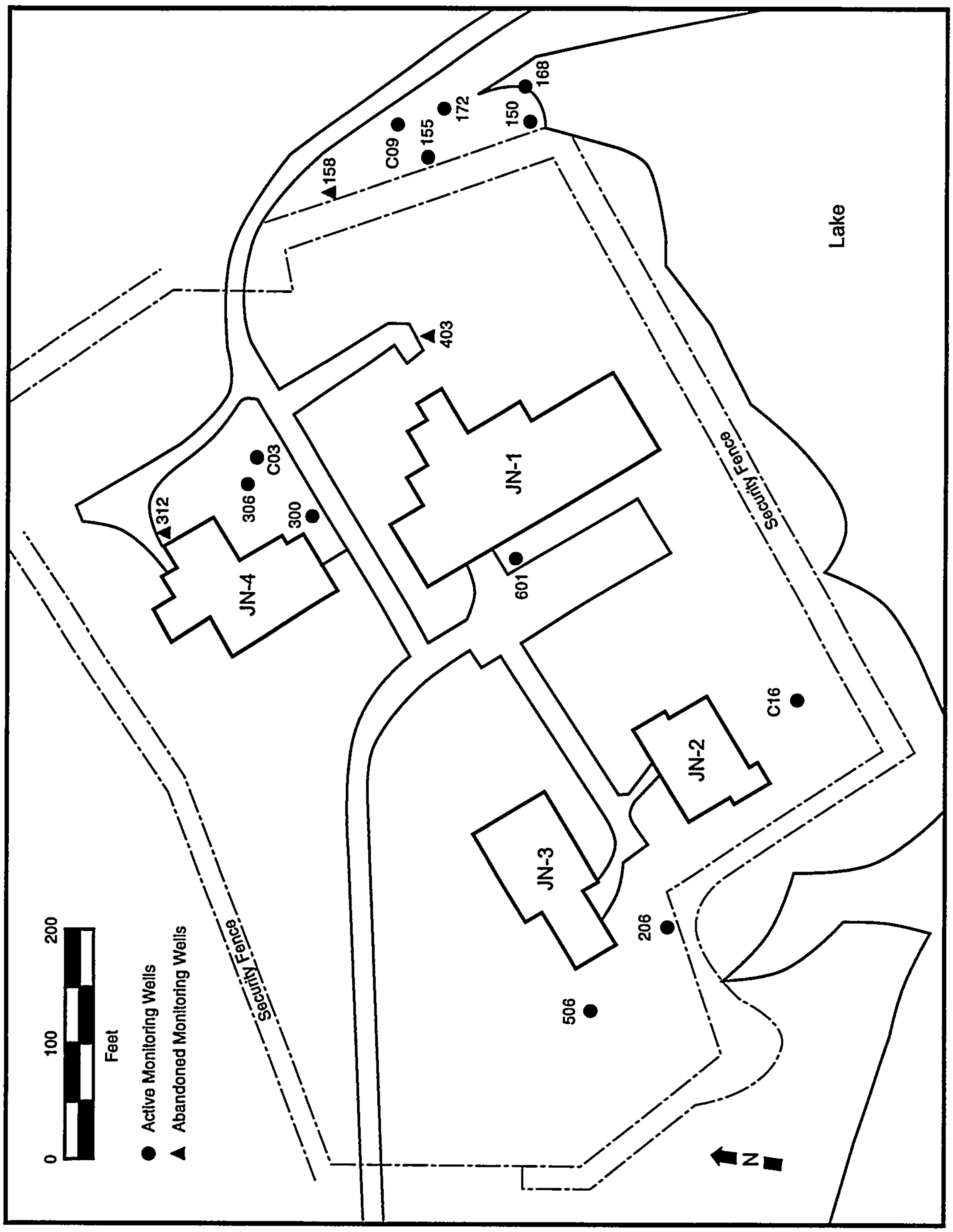

Figure 10. North Site Groundwater Monitoring Wells

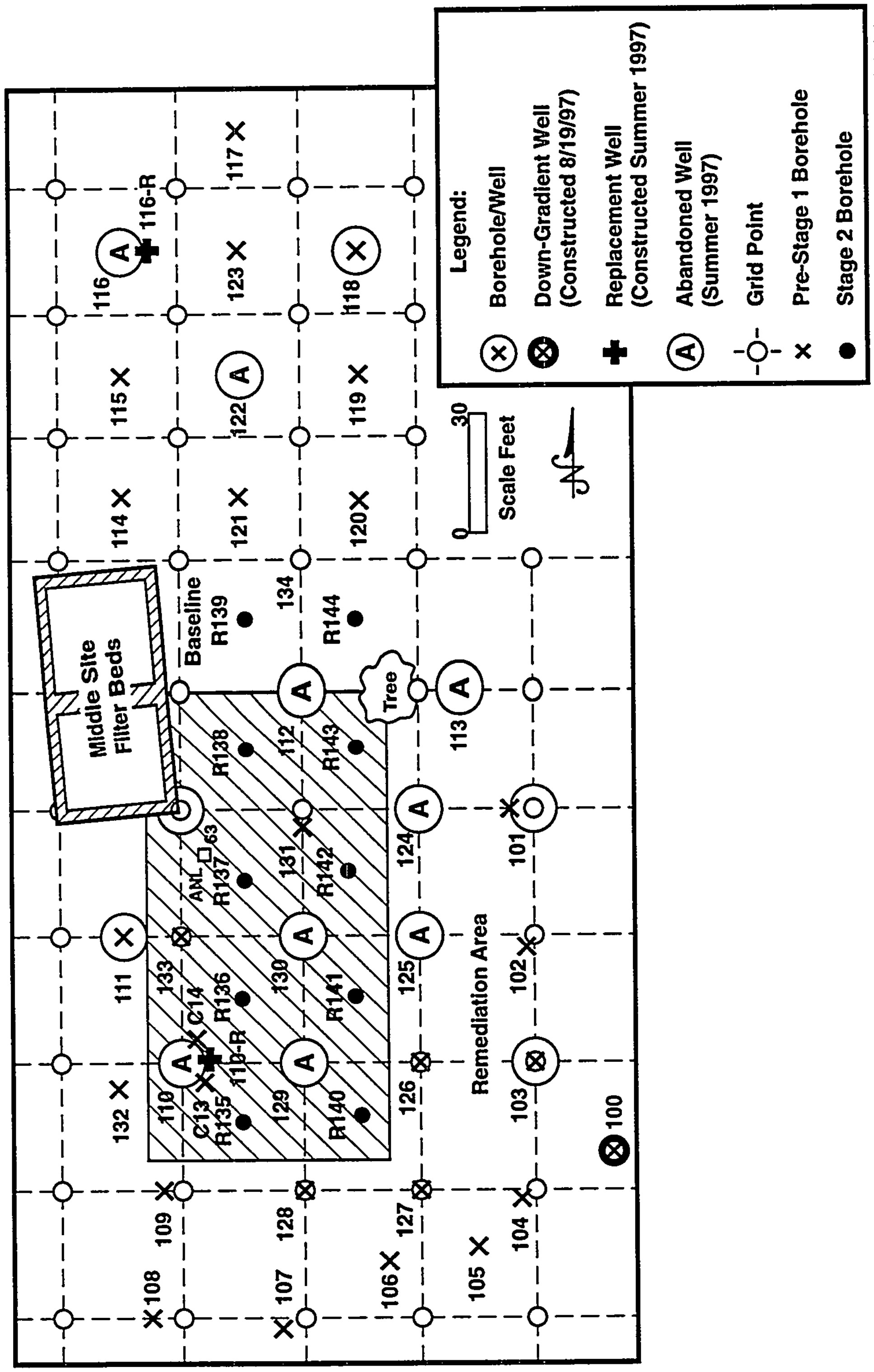

Figure 11. Groundwater Monitoring — Remediated Filter Bed Area (Shaded Area)

EVALUATION OF ESTIMATED DOSE TO THE PUBLIC

Estimated Dose to the Public from King Avenue Site Emissions During 1997

Battelle demonstrated compliance with the emission standard cited in 10 CFR 20 Subpart B for the BCLDP operations at the King Avenue site through the use of the USEPA computer code COMPLY (level 4).[11] The results indicate that the dose to any member of the general public due to BCLDP radionuclide emissions at King Avenue is less than 10 mrem/year. Therefore, BCLDP is in compliance with 10 CFR 20.1101(d) and therefore not required to report. In addition, BCLDP airborne emissions at the King Avenue site pose no significant threat to human health or the environment.

Estimated Dose to the Public from West Jefferson Site Emissions During 1997

BCLDP calculates dose assessments for radionuclide emissions emanating from the West Jefferson site using both the COMPLY (level 4) and the CAP88PC[12] air dispersion models. Each of these models integrates an 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 many orders of magnitude below the 10 CFR 20 Subpart B dose standard of 10 mrem/year, 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) because additional data such as annual average radionuclide concentrations at various distances, exposure to critical organs, and a collective EDE for person-rem/year can also be collected.

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 1997 from the West Jefferson site are summarized in Tables 3, 4, and 5. The down wind 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. The CAP88PC program estimated a 6.64×10^{-4} person-rem/year 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 1997 for the West Jefferson site are summarized in Table 6. 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 MDL of isotopes listed in Table 6. 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 U.S. Geological Survey (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 (see Table 4) 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, assuming that the more sensitive biological form (soluble or insoluble) of the radionuclide was present. The dose estimates obtained for the nearest individual assume a full-time resident at Camp Ken Jockety, 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 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, source and background counts, routine yield determinations of radiochemical procedures, and replicate analyses to check precision. Battelle assures the accuracy of radionuclide determination through the use of standards traceable to the National Institute of Standards and Technology (NIST).

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 (QAP). 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.

The majority of the analyte concentrations measured by the RAL in 1997 were well within the EML's activity boundaries.

Table 30 lists the RAL results and compares the measured concentrations with the EML set reported concentrations for the four sample types included in EML set QAP 46 and QAP 47. The RAL was outside of acceptable limits for Co-57, Ce-144, and Cs-134 in air filter matrix for QAP 46. The laboratory evaluation for QAP 47 was well within the reported EML acceptable limits for Co-57, Ce-144 and Cs-134 in air filter matrix. The EML air filters are produced by EML and each sample has a statistical error associated with the air filter. Based on EML's values for Co-57, Ce-144, and Cs-134, the laboratory's results were biased high. The RAL's known air filter used to verify results for the air filter sample were well within EML's reported values for Co-57, Ce-144, and Cs-134. These EML errors should not impact the analysis of the routine environmental samples submitted to the RAL.

In addition, the RAL participates in the USEPA Performance Evaluation Study (PES). This interlaboratory comparison is designed to monitor a laboratory's performance by submitting water samples of known isotopes and quantified activities for analysis. The activity levels in the PES are representative of environmental activity levels of routine samples analyzed by the RAL.

The RAL has participated in 24 of the USEPA round robins since June of 1996. All of the analysis results were within acceptable limits for the RAL. The RAL has always reported results for Cs-134 that are within acceptable limits.

The RAL received the State of Utah Certification for radiological analyses in July of 1996 and was recertified in 1997. The RAL went through an intensive quality assessment by the State of Utah auditor in order to receive the certification.

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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 (μCi).*** 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, 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.

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 non-radioactive.

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.

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. 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.

uncontrolled 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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(2) *Ionizing Radiation Exposure of the Population of the United States*, National Council on Radiation Protection and Measurements, NCRP Report No. 93, 1987.

(3) Civil Effects Operations (LEX 59.4.23) Aeroradioactivity Surveys and A Real Geology of Parts of Ohio and Indiana (ARMS-1), May 1966.

(4) "Estimates of Ionizing Radiation Doses in the United States 1960-2000", U.S. Environmental Protection Agency, ORP/CSD 72-1.

(5) *Environmental Assessment for Battelle Columbus Laboratories Decommissioning Project*, Battelle, Columbus, Ohio, 1990.

(6) Letter to John Paulian from Karen H. Cooper, Ohio EPA-Division of Public Water Supply, dated September 20, 1983.

(7) *Radiation Protection to the Public and the Environment*, Operational and Environmental Safety Division, DOE Order 5400.5, U.S. Department of Energy, Washington, DC, February 1990.

(8) National Revised Primary Drinking Water Regulations, Chapter I Environmental Protection Agency, 40 CFR Part 141, July 1, 1990.

(9) *Interim Report on Site Characterization West Jefferson North Site Stage 1 Sampling and Analysis—Chemical Sampling Summary Report*, Battelle Columbus Operations, M.J. Stenhouse and T. C. Beard, December 22, 1989.

(10) *"Final Assessment of the Radiological Status of Battelle's Nuclear Sciences Area,"* Battelle Columbus Operations, M.J. Stenhouse, January 1991.

(11) *User's Guide for the COMPLY Code, Version 2*, United States Environmental Protection Agency, Office of Radiation and Indoor Air, Washington, DC, EPA 520/1-89-003, October 1989.

(12) *User's Guide for CAP88PC, Version 1.0*, United States Environmental Protection Agency, Office of Radiation and Indoor Air, Las Vegas Facility, EPA/402-B-92-001, March 1992.

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ACRONYMS

BCLDP	Battelle Columbus Laboratories Decommissioning Project
BCOES&H	Battelle Columbus Operations Environmental Safety & Health
CAA	Clean Air Act
CERCLA	Comprehensive Environmental Response Compensation and Liability Act
CFR	Code of Federal Regulations
CPT	Cone Penetrometer
CWA	Clean Water Act
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
EIS/ODIS	Effluent Information System/Onsite Discharge Information System
EMA	Emergency Management Agency
EML	Environmental Measurements Laboratory
EOC	Emergency Operations Center
EPCRA	Emergency Planning & Community Right-to-Know Act
ESA	Endangered Species Act
FEMA	Federal Emergency Management Agency
FFCA	Federal Facility Compliance Act
FIFRA	Federal Insecticide, Fungicide, and Rodenticide Act
FONSI	Finding of No Significant Impact
LEPC	Local Emergency Planning Committees
LLW	Low-Level Waste
LOMR	Letter of Map Revision
MCL	Maximum Contamination Level
MDA	Minimum Detectable Activity
MGD	Million Gallons per Day
MLLW	Mixed Low-Level Waste
MSDS	Material Safety Data Sheet
MSL	Mean Sea Level
NEPA	National Environmental Policy Act
NESHAP	National Emission Standards for Hazardous Air Pollutants
NHPA	National Historic Preservation Act
NIST	National Institute of Standards & Testing
NOV	Notice of Violation
NPDES	National Pollutant Discharge Elimination System
NRC	Nuclear Regulatory Commission

Acronyms (continued)

OAC	Ohio Administrative Code
OEPA	Ohio Environmental Protection Agency
OSU	Ohio State University
PCB	Polychlorinated Biphenyl
PES	Performance Evaluation Study
POTW	Publicly-owned Treatment Works
QA	Quality Assurance
QAP	Quality Assessment Program
R&D	Research and Development
RAL	Radioanalytical Laboratory
RCRA	Resource Conservation and Recovery Act
RC&ESHO	Regulatory Compliance and Environmental Safety and Health Oversight
S&M	Surveillance and Maintenance
SARA	Superfund Amendments and Reauthorization Act
SDWA	Safe Drinking Water Act
SER	Site Environmental Report
SH&ES	Safety, Health, and Environmental Support
SNM	Special Nuclear Materials
SOC	Synthetic Organic Chemical
STP	Site Treatment Plan
TLD	Thermoluminescent Dosimeter
TRU	Transuranic
TSCA	Toxic Substances Control Act
TSDF	Treatment, Storage, or Disposal Facility
USEPA	United States Environmental Protection Agency
USGS	United States Geological Survey
VOC	Volatile Organic Compound

Appendix A

Tables

TABLE 1. BATTELLE KING AVENUE 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	415	7,073	4,743	9,300	6,266	41,589	17,811	24,971	10,235	50,510	172,913
NNE	2,890	12,472	12,223	9,305	9,961	69,843	32,146	7,108	9,115	12,899	177,962
NE	2,304	9,800	4,582	12,052	10,715	33,559	19,594	8,583	11,405	26,489	139,083
ENE	1,901	2,128	5,107	3,126	6,195	27,062	9,099	12,645	25,754	7,274	100,291
E	2,379	1,105	4,986	5,327	7,225	36,093	36,855	19,378	46,659	11,822	171,829
ESE	1,134	364	7,640	10,947	8,032	68,632	34,961	13,446	10,027	13,757	168,940
SE	457	428	5,398	15,858	8,735	14,322	12,705	41,722	13,018	15,378	128,021
SSE	0[(2)]	1,565	2,348	8,386	4,042	21,398	8,243	10,362	7,901	4,567	68,812
S	0[(2)]	3,513	3,573	1,168	758	2,783	5,905	15,197	6,738	43,264	82,899
SSW	0	4,735	3,973	4,015	3,088	23,462	10,011	2,354	4,402	12,858	68,898
SW	8	1,475	7,100	13,473	8,479	11,219	6,709	4,478	19,966	7,430	80,337
WSW	699	41	2,991	7,369	4,328	30,307	3,473	11,698	5,024	20,726	86,656
W	1,534	2,600	1,316	2,225	2,327	5,477	10,245	7,340	25,726	99,540	158,330
WNW	1,046	4,706	3,913	1,082	1,964	14,483	3,634	5,161	16,047	13,706	65,742
NW	82	3,972	4,742	5,617	6,143	18,169	9,512	15,678	4,592	18,042	86,549
NNW	21	669	702	5,487	4,489	47,202	31,149	6,090	8,483	6,158	110,450
Total	14,870	56,646	75,337	114,737	92,747	465,600	252,052	206,211	225,092	364,420	1,867,712

(1) 1990 Census of Population and Housing, U.S. Bureau of the Census. Prepared by: Ohio Department of Development (8/92).
(2) Occupied houses do exist within one mile south and southeast of the King Avenue site, however, these data were not included in the 1990 Census.

TABLE 2. 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	14	20	87	77	121	3,010	4,403	49,11	9,357	48,786	70,786
NNE	8	25	108	90	188	1,789	18,941	26,667	7,577	16,527	71,920
NE	10	33	48	96	139	17,835	101,970	13,361	9,652	14,445	157,589
ENE	10	39	75	192	1,239	17,796	247,639	48,962	12,038	16,592	344,582
E	150	37	56	273	912	39,983	267,165	100,498	23,451	68,444	500,969
ESE	689	166	193	121	376	38,556	62,298	24,406	50,876	17,140	194,821
SE	262	1,172	46	71	274	4,158	12,216	14,489	12,904	7,876	53,468
SSE	42	257	51	52	78	3,158	10,623	4,625	13,120	42,261	74,267
S	25	84	66	116	123	804	4,208	2,886	4,595	12,227	25,134
SSW	5	497	361	133	80	516	1,228	3,976	20,525	6,530	33,851
SW	3	323	2,867	596	51	748	978	3,650	8,110	18,019	35,345
WSW	3	25	290	236	18	951	12,858	5,606	21,156	185,260	226,403
W	6	24	104	153	110	629	5,146	68,712	50,990	80,285	206,159
WNW	9	14	23	39	67	881	3,429	16,462	6,744	7,915	35,583
NW	14	13	31	70	114	357	1,464	4,736	20,819	12,691	40,309
NNW	14	12	45	484	94	665	12,097	5,189	3,851	6,905	29,356
Total	1,264	2,741	4,451	2,799	3,984	131,836	766,663	349,136	275,765	561,903	2,100,542

(1) 1990 Census of Population and Housing, U.S. Bureau of the Census. Prepared by: Ohio Department of Development (8/92).

TABLE 3. ANNUAL RADIOLOGICAL RELEASE INVENTORY(1) WEST JEFFERSON SITE — 1997

Nuclide	S-1 & S-2	S-3	S-4	S-5	S-6	S-7	S-11	Total
Co-57	1.32E-07	4.24E-08	1.06E-07	2.21E-08	3.56E-08	2.10E-07	5.05E-09	5.54E-07
Co-60	2.50E-07	9.22E-08	2.12E-07	5.01E-08	7.61E-08	4.61E-07	9.56E-09	1.15E-06
Sr-90	1.06E-09	2.49E-09	1.70E-09	3.24E-10	4.57E-10	3.68E-09	4.62E-11	9.76E-09
Sb-125	5.99E-07	2.17E-07	4.99E-07	1.19E-07	1.77E-07	1.43E-06	2.31E-08	3.07E-06
Cs-134	2.32E-07	8.11E-08	1.83E-07	4.49E-08	6.93E-08	4.09E-07	8.88E-09	1.03E-06
Cs-137	2.37E-07	9.31E-08	2.00E-07	4.78E-08	7.54E-08	4.44E-07	9.38E-09	1.11E-06
Eu-152	3.72E-07	1.20E-07	3.01E-07	6.24E-08	1.00E-07	5.92E-07	1.42E-08	1.56E-06
Eu-154	2.63E-07	8.48E-08	2.13E-07	4.42E-08	7.07E-08	4.23E-07	1.02E-08	1.11E-06
Pu-238	3.14E-10	2.40E-10	1.71E-10	3.73E-11	6.08E-11	6.08E-10	1.86E-11	1.45E-09
Pu-239	5.66E-10	1.66E-10	2.92E-10	1.16E-10	1.10E-10	7.90E-10	2.38E-11	2.06E-09
U-234	3.44E-09	3.51E-09	2.73E-09	6.73E-10	9.34E-10	5.26E-09	1.06E-10	1.66E-08
U-235	2.51E-10	3.81E-10	2.15E-10	5.25E-11	7.31E-11	3.01E-10	9.59E-12	1.28E-09
U-238	2.83E-09	3.38E-09	2.70E-09	6.38E-10	8.91E-10	4.21E-09	1.17E-10	1.48E-10
Th-234	2.24E-06	8.29E-07	1.98E-06	3.78E-07	5.99E-07	3.80E-06	8.95E-08	9.91E-06
Am-241	2.25E-07	1.17E-07	4.00E-07	5.58E-08	1.24E-07	3.61E-07	1.13E-08	1.29E-06

(1) Total annual radionuclide stack emissions for each EIS point source and total radionuclide air emissions for the West Jefferson North Site (expressed in curies/year).

TABLE 4. ANNUAL AVERAGE RADIOLOGICAL CONCENTRATIONS FROM STACK EMISSIONS[1] WEST JEFFERSON SITE — 1997

Nuclide	S-1 & S-2	S-3	S-4	S-5	S-6	S-7	S-11	Site Boundary[2]	DCG	%DCG
Co-57	5.17E-15	2.37E-15	2.60E-15	1.70E-15	1.98E-15	2.61.E-15	2.82E-15	8.60E-20	2.00E-09	4.30E-11
Co-60	9.81E-15	5.15E-15	5.18E-15	3.85E-15	4.23E-15	5.72E-15	5.34E-15	1.80E-19	8.00E-11	2.25E-09
Sr-90	4.14E-17	1.39E-16	4.16E-17	2.49E-17	2.54E-17	4.57E-17	2.58E-17	1.50E-21	9.00E-12	1.67E-10
Sb-125	2.35E-14	1.21E-14	1.22E-14	9.17E-15	9.84E-15	1.78E-14	1.29E-14	4.50E-19	1.00E-09	4.50E-10
Cs-134	9.09E-15	4.53E-15	4.47E-15	3.45E-15	3.85E-15	5.07E-15	4.96E-15	1.60E-19	2.00E-10	8.00E-10
Cs-137	9.31E-15	5.20E-15	4.88E-15	3.68E-15	4.19E-15	5.51E-15	5.24E-15	1.70E-19	4.00E-10	4.25E-10
Eu-152	1.46E-14	6.70E-15	7.37E-15	4.80E-15	5.58E-15	7.34E-15	7.95E-15	2.40E-19	5.00E-11	4.80E-09
Eu-154	1.03E-14	4.74E-15	5.22E-15	3.40E-15	3.93E-15	5.25E-15	5.68E-15	1.70E-19	5.00E-11	3.40E-09
Pu-238	1.23E-17	1.34E-17	4.17E-18	2.87E-18	3.38E-18	7.54E-18	1.04E-17	2.20E-22	4.00E-14	5.50E-09
Pu-239	2.22E-17	9.28E-18	7.13E-18	8.94E-18	6.10E-18	9.80E-18	1.33E-17	3.20E-22	4.00E-14	8.00E-09
U-234	1.35E-16	1.96E-16	6.67E-17	5.18E-17	5.19E-17	6.52E-17	5.93E-17	2.70E-21	9.00E-14	3.00E-08
U-235	9.84E-18	2.13E-17	5.26E-18	4.04E-18	4.06E-18	3.74E-18	5.36E-18	2.20E-22	1.00E-13	2.20E-09
U-238	1.11E-16	1.89E-16	6.59E-17	4.91E-17	4.95E-17	5.22E-17	6.52E-17	2.40E-21	1.00E-13	2.40E-08
Th-234	8.79E-14	4.63E-14	4.84E-14	2.91E-14	3.33E-14	4.71E-14	5.00E-14	1.50E-19	4.00E-10	3.75E-10
Am-241	8.83E-15	6.56E-15	9.77E-15	4.29E-15	6.90E-15	4.48E-15	6.29E-15	2.10E-19	2.00E-14	1.05E-05
Release Rate[3]	24.89	12.70	17.78	17.53	17.53	35.05	20.83			
Volume[4]	2.55E+13	1.79E+13	4.09E+13	1.30E+13	1.80E+13	8.06E+13	1.79E+13			

(1) Stack data representing annual average radionuclide concentrations (expressed in μCi/mL) for EIS effluent point source.
(2) Site boundary concentrations reflect CAP88PC air dispersion modeling calculations at the West Jefferson North site (expressed in μCi/mL).
(3) m/s
(4) mL/yr

TABLE 5. SUMMARY OF SITE BOUNDARY AIR SAMPLE ANALYSES WEST JEFFERSON SITE — 1997(1)

Nuclide	EA-1	EA-2	EA-3	EA-4
Co-57	2.60E-16	2.80E-16	2.61E-16	2.73E-16
Co-60	5.84E-16	5.30E-16	5.27E-16	5.12E-16
Sb-125	1.30E-15	1.34E-15	1.33E-15	1.18E-15
Cs-134	5.32E-16	4.87E-16	5.08E-16	4.31E-16
Cs-137	5.28E-16	4.65E-16	5.43E-16	4.57E-16
Eu-152	7.43E-16	7.90E-16	7.42E-16	7.74E-16
Eu-154	5.12E-16	5.68E-16	5.13E-16	5.46E-16
Th-234	4.32E-15	4.99E-15	5.22E-15	4.46E-15
Am-241	6.51E-16	8.24E-16	7.94E-17	7.93E-16
Sr-90	5.79E-17	5.26E-17	4.33E-17	4.70E-17
U-234	5.18E-17	5.64E-17	5.10E-17	4.50E-17
U-235	3.88E-18	3.49E-18	3.85E-18	2.71E-18
U-238	4.59E-17	4.36E-17	4.14E-17	4.16E-17
Pu-238	6.49E-18	8.56E-18	8.66E-18	6.30E-18
Pu-239	4.54E-18	6.91E-18	1.07E-17	4.51E-18

(1) Locations are shown in Figure 6.

Note: All isotopic values represent average MDA values expressed in µCi/mL. Detection limit is 4.66 multiplied by the standard deviation of the background, divided by the efficiency, assuming a 50 percent recovery of the spike, and a flow volume of 2.70E09 mL.

TABLE 6. SUMMARY OF LIQUID RADIOLOGICAL EMISSIONS WEST JEFFERSON SITE[1] — 1997

Nuclide	Number of Samples	Activity, µCi/yr[2]	Average Concentration, µCi/mL	DCG, µCi/mL	Percentage of DCG, %
Co-57	12	43.8	1.72 E-9	1.0 E-4	0.00
Co-60	12	47.2	1.85 E-9	5.0 E-6	0.04
Sr-90	4	41.3	1.62 E-9	1.0 E-6	0.16
Sb-125	12	141.6	5.54 E-9	5.0 E-5	0.01
Cs-134	12	49.3	1.93 E-9	2.0 E-6	0.10
Cs-137	12	53.4	2.09 E-9	3.0 E-6	0.07
Eu-152	12	126.3	4.95 E-9	2.0 E-5	0.02
Eu-154	12	88.5	3.47 E-9	2.0 E-5	0.02
Am-241	12	133.4	5.23 E-9	3.0 E-8	17.42[3]
Pu-238	4	1.8	7.14 E-11	4.0 E-8	0.18
Pu-239	4	3.6	1.39 E-10	3.0 E-8	0.46
U-235	12	343.8	1.35 E-8	6.0 E-7	2.24
U-238	12	1122.2	4.40 E-8	6.0 E-7	7.33
U-234[4]	4	32.4	1.27 E-9	5.0 E-7	0.25
U-235[4]	4	1.2	4.57 E-11	6.0 E-7	0.01
U-238[4]	4	11.6	4.56 E-10	6.0 E-7	0.08

(1) Annual average flow in Big Darby Creek; 429 cu ft/sec = 3.82 E-11 L/yr. Total volume of liquid effluent discharge for 1997 = 2.55 E-7 L. See Figure 5 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 7. SUMMARY OF RADIOLOGICAL ANALYSES OF DRINKING WATER SAMPLES WEST JEFFERSON/KING AVENUE SITES — 1997

West Jefferson	Activity (µCi/mL)
Co-57	2.00E-09
Co-60	2.53E-09
Sr-90(1)	4.05E-10*
Sb-125	6.94E-09
Cs-134	2.42E-09
Cs-137	2.62E-09
Eu-152	5.52E-09
Eu-154	3.86E-09
Am-241	7.53E-09
U-235	1.49E-08
U-238	4.51E-08
U-234(1,3)	9.47E-10*
U-235(1,3)	2.62E-11*
U-238(1,3)	2.25E-10*
Pu-238(1,3)	6.16E-11
Pu-239(1,3)	4.88E-11
Ra-226(1,3)	1.36E-10*
RA-228(1,3)	6.22E-09*
King Avenue	**Activity (µCi/mL)**
Co-57	1.72E-09
Co-60	1.94E-09
Sb-125	5.76E-09
Cs-134	1.95E-09
Cs-137	2.13E-09
Eu-152	4.95E-09
Eu-154	3.45E-09
Am-241	6.41E-09
U-235	1.35E-08
U-238	4.38E-08
U-234(2,3)	6.20E-11*
U-235(2,3)	2.98E-11
U-238(2,3)	4.71E-11*
Th-230(2,3)	4.08E-11
Th-232(2,3)	6.68E-11

All values are actual MDA unless otherwise indicated *
(1) Analysis on annual composite only.
(2) Analysis on quarterly composite only.
(3) Analysis performed by alpha spectroscopy.

TABLE 8. SUMMARY OF RADIOLOGICAL ANALYSES OF ENVIRONMENTAL WATER SAMPLES WEST JEFFERSON SITE — 1997

Location(1) (Direction and Distance from Nuclear Sciences Area)	Number of Samples(2)	10^{-9} µCi/mL(3)	
		Gross α	Gross β
Big Darby Creek Upstream (18.3 m above sanitary outfall)	12	5.22 ± 4.90	6.81 ± 3.82*
Big Darby Creek Downstream (18.3 m below sanitary outfall)	12	5.08 ± 5.08	8.10 ± 3.90*
Big Darby Creek Downstream (186.3 m below sanitary outfall)	12	5.57 ± 4.72	8.81 ± 3.90*
Battelle Lake Spillway (18.3 m below dam)	12	4.93 ± 3.86	8.72 ± 3.80*

(1) Locations are shown in Figure 6.
(2) Big Darby Creek and Battelle Lake Spillway samples are monthly composite samples of weekly collections.
(3) MDA is 6.5 E-9 µCi/mL for gross α and 4.8 E-9 µCi/mL for gross β.
* Indicates activities greater than MDA.

TABLE 9. SUMMARY OF RADIOLOGICAL ANALYSES OF GRASS WEST JEFFERSON SITE — 1997

pCi/g dry weight
All values are less than MDA values except where indicated (*)

Nuclide	Identification No.[1] Sector 1	Sector 2	Sector 3	Sector 4	Sector 5	Sector 6	Sector 7	Sector 8	Sector 9	Sector 10	Sector 11	Sector 12
Co-57	0.068	0.056	0.066	0.034	0.044	0.037	0.049	0.056	0.046	0.048	0.037	0.055
Co-60	0.115	0.133	0.119	0.067	0.118	0.064	0.124	0.107	0.064	0.095	0.061	0.126
Sr-90	0.260*	0.070*	0.100*	0.130*	0.080*	0.260*	0.250*	0.080*	0.230*	0.110*	0.170*	0.090*
Sb-125	0.267	0.322	0.286	0.162	0.222	0.150	0.267	0.247	0.179	0.223	0.157	0.293
Cs-134	0.098	0.112	0.113	0.061	0.093	0.059	0.102	0.102	0.062	0.095	0.059	0.109
Cs-137	0.242*	0.125	0.126	0.072	0.426*	0.283*	0.318*	0.107	0.309*	0.109	0.246*	0.143
Eu-152	0.188	0.157	0.180	0.094	0.124	0.102	0.137	0.154	0.128	0.133	0.101	0.151
Eu-154	0.134	0.110	0.128	0.066	0.087	0.072	0.095	0.109	0.089	0.091	0.071	0.108
Am-241	0.566	0.307	0.155	0.096	0.237	0.098	0.296	0.135	0.111	0.130	0.093	0.298
Pu-238	0.028	0.022	0.008	0.025	0.005*	0.004	0.003	0.004*	0.032	0.011	0.016	0.001*
Pu-239	0.017	0.019*	0.014*	0.006	0.010*	0.015*	0.008*	0.006*	0.007*	0.009*	0.006	0.007*
U-235	0.474	0.447	0.543	0.277	0.341	0.305	0.381	0.463	0.367	0.409	0.294	0.451
U-238	1.430	1.113	1.556	2.024*	0.821	2.127*	1.002	1.363	0.973	1.292	0.891	1.052
U-234[2]	1.070*	0.684*	0.307*	1.549*	0.241*	0.390*	0.233*	0.130*	0.633*	0.296*	0.962*	0.210*
U-235[2]	0.061*	0.051*	0.020*	0.097*	0.012*	0.027*	0.018*	0.006*	0.051*	0.019*	0.044*	0.013*
U-238[2]	0.975*	0.675*	0.353*	1.492*	0.296*	0.397*	0.254*	0.125*	0.656*	0.319*	1.030*	0.244*

(1) Locations are shown in Figure 7.
(2) Analysis performed by alpha spectroscopy.

TABLE 10. SUMMARY OF RADIOLOGICAL ANALYSES OF FIELD CROPS WEST JEFFERSON SITE — 1997

pCi/g dry weight[1]
All values are less than MDA values except where indicated (*)

Nuclide	Identification No.[2]											
	Sector 1 Soybean 58.60	Sector 2 Corn 58.46	Sector 3 Corn 55.10	Sector 4 Soybean 54.03	Sector 5 Soybean 55.87	Sector 6 Soybean 53.09	Sector 7 Soybean 52.26	Sector 8 Soybean 46.44	Sector 9 Corn 50.23	Sector 10 Soybean 51.12	Sector 11 Corn 55.61	Sector 12 Soybean 54.09
Co-57	0.021	0.022	0.021	0.042	0.021	0.027	0.023	0.028	0.031	0.022	0.060	0.041
Co-60	0.035	0.046	0.047	0.077	0.039	0.075	0.042	0.054	0.046	0.051	0.095	0.107
Sr-90	0.018*	0.032*	0.020*	0.031*	0.002*	0.036*	0.036*	0.040*	0.043*	0.033*	0.025*	0.041*
Sb-125	0.092	0.105	0.109	0.182	0.092	0.147	0.101	0.129	0.116	0.120	0.237	0.221
Cs-134	0.037	0.039	0.043	0.063	0.038	0.059	0.041	0.048	0.045	0.047	0.082	0.088
Cs-137	0.036	0.044	0.045	0.070	0.037	0.066	0.041	0.055	0.046	0.051	0.091	0.084
Eu-152	0.060	0.065	0.060	0.120	0.061	0.078	0.066	0.079	0.088	0.063	0.169	0.114
Eu-154	0.042	0.045	0.042	0.086	0.043	0.056	0.046	0.056	0.062	0.044	0.119	0.083
Am-241	0.051	0.056	0.057	0.355	0.053	0.153	0.058	0.070	0.069	0.063	0.386	0.172
Pu-238	0.001*	0.003*	0.001	0.004*	0.001*	0.004*	0.004*	0.000	0.003*	0.003*	0.003*	0.003*
Pu-239	0.000	0.003*	0.000	0.002*	0.000	0.002*	0.003*	0.000	0.002*	0.003*	0.002*	0.001
U-235	0.177	0.193	0.182	0.313	0.188	0.213	0.205	0.237	0.254	0.194	0.475	0.335
U-238	0.515	0.550	0.603	0.926	0.537	0.538	0.579	0.692	0.657	0.650	1.094	0.707
U-234[3]	0.004*	0.006*	0.013*	0.003*	0.007*	0.003*	0.004*	0.005*	0.005*	0.004*	0.004*	0.003*
U-235[3]	0.001*	0.002*	0.002	0.001	0.002*	0.002	0.001	0.003	0.001*	0.001	0.002	0.001*
U-238[3]	0.003*	0.002*	0.010*	0.002*	0.003*	0.001	0.001*	0.001	0.003*	0.002*	0.004*	0.001

(1) MDAs based on average sample volume of 53.74 g.
(2) Locations are shown in Figure 7.
(3) Analysis performed by alpha spectroscopy.

TABLE 11. SUMMARY OF RADIOLOGICAL ANALYSES OF GARDEN CROPS[1] WEST JEFFERSON SITE — 1997

	pCi/g dry weight	
Nuclide	**On-Site[2]**	**Off-Site[2]**
Co-57	<0.024	<0.026
Co-60	<0.053	<0.048
Sr-90	0.124	0.071
Sb-125	<0.120	<0.112
Cs-134	<0.049	<0.044
Cs-137	<0.053	<0.045
Eu-152	<0.071	<0.076
Eu-154	<0.048	<0.055
Am-241	<0.069	<0.070
Pu-238	<0.007	<0.006
Pu-239	0.008	<0.012
U-235	<0.215	<0.234
U-238	<0.689	<0.673
U-234[3]	0.007	0.002
U-235[3]	0.001	0.001
U-238[3]	0.004	0.015

(1) Garden crops collected at the end of the growing season.
(2) Locations are shown in Figure 7.
(3) Analysis performed by alpha spectroscopy.

Note: < indicates less than MDA.

TABLE 12. SUMMARY OF RADIOLOGICAL ANALYSES OF SEDIMENT SAMPLES[1] WEST JEFFERSON SITE — 1997

	pCi/g dry wt.[2] Avg.				
Nuclide	ED-1	ED-2	ED-3	ED-4	ED-5
Co-57	<0.032	<0.031	<0.035	0.143	<0.024
Co-60	<0.054	<0.043	<0.053	<0.055	<0.050
Sr-90	0.943	0.179	0.190	0.155	0.197
Sb-125	<0.133	<0.123	<0.143	<0.149	<0.111
Cs-134	<0.046	<0.043	<0.050	<0.049	<0.043
Cs-137	0.573	0.266	0.193	0.834	<0.048
Eu-152	<0.094	<0.089	<0.101	<0.414	<0.069
Eu-154	<0.066	<0.062	<0.073	<0.080	<0.049
Am-241	<0.073	<0.059	<0.178	<0.178	<0.083
Pu-238	0.019	<0.017	<0.024	<0.034	<0.010
Pu-239	0.025	<0.007	<0.011	0.025	0.007
U-235	<0.282	<0.271	<0.295	<0.296	<0.205
U-238	1.890	1.405	1.019	1.075	0.096
U-234[3]	1.471	1.102	0.941	0.997	0.811
U-235[3]	0.076	0.067	0.051	0.066	0.049
U-238[3]	1.558	1.142	0.998	1.143	0.891

(1) Locations are shown in Figure 6.
(2) No standards for radionuclides in sediment have been established.
(3) Analysis performed by alpha spectroscopy.

Note: < indicates less than MDA.

TABLE 13. SUMMARY OF RADIOLOGICAL ANALYSES OF SOIL WEST JEFFERSON SITE — 1997

pCi/g dry weight
All values are less than MDA values except where indicated (*)

Nuclide	Identification No.[1]											
	Sector 1	Sector 2	Sector 3	Sector 4	Sector 5	Sector 6	Sector 7	Sector 8	Sector 9	Sector 10	Sector 11	Sector 12
Co-57	0.042	0.040	0.026	0.028	0.025	0.023	0.026	0.024	0.042	0.024	0.025	0.041
Co-60	0.063	0.060	0.062	0.064	0.055	0.039	0.033	0.044	0.070	0.037	0.061	0.066
Sr-90	0.160	0.160	0.330	0.180	0.170	0.290	0.290	0.250	0.230	0.280	0.880	0.180
Sb-125	0.172	0.162	0.148	0.153	0.143	0.098	0.100	0.115	0.163	0.096	0.132	0.165
Cs-134	0.058	0.053	0.050	0.057	0.049	0.036	0.035	0.044	0.060	0.035	0.052	0.056
Cs-137	0.532*	0.146*	0.233*	0.393*	0.489*	0.475*	0.479*	0.398*	0.562*	0.818*	0.437*	0.328*
Eu-152	0.115	0.109	0.071	0.075	0.068	0.060	0.070	0.064	0.114	0.063	0.068	0.110
Eu-154	0.080	0.075	0.050	0.053	0.048	0.043	0.049	0.045	0.080	0.045	0.047	0.077
Am-241	0.341	0.327	0.152	0.163	0.141	0.060	0.063	0.069	0.338	0.062	0.146	0.344
Pu-238	0.017	0.024*	0.018	0.017	0.015*	0.011*	0.012*	0.004*	0.023*	0.017	0.020*	0.018*
Pu-239	0.033*	0.029*	0.024*	0.045*	0.058*	0.040*	0.056*	0.046*	0.046*	0.054*	0.026*	0.032*
U-235	0.302	0.283	0.203	0.211	0.200	0.186	0.209	0.203	0.304	0.190	0.187	0.296
U-238	0.912	4.324*	1.960*	3.100*	2.475*	1.992*	1.549*	1.751*	4.344*	1.792*	2.147*	0.936
U-234[2]	1.529*	1.530*	1.367*	1.740*	1.250*	1.467*	1.288*	1.630*	1.436*	1.382*	1.392*	1.682*
U-235[2]	0.071*	0.118*	0.080*	0.113*	0.087*	0.063*	0.084*	0.085*	0.098*	0.085*	0.057*	0.075*
U-238[2]	1.339*	1.538*	1.479*	1.739*	1.328*	1.351*	1.373*	1.749*	1.593*	1.413*	1.540*	1.785*

(1) Locations are shown in Figure 7.
(2) Analysis performed by alpha spectroscopy.

TABLE 14. SUMMARY OF RADIOLOGICAL ANALYSES OF FISH TISSUE WEST JEFFERSON SITE — 1997

All values are less than MDA values except where indicated (*)

	Battelle Lake Samples[1] (pCi/g raw weight)			Darby Creek Samples (pCi/g raw weight)		
Nuclide	**1st Half**	**2nd Half**	**Average**	**1st Half**	**2nd Half**	**Average**
Co-57	0.038	0.035	0.036	0.021	0.024	0.023
Co-60	0.064	0.065	0.064	0.047	0.050	0.048
Sr-90	0.136*	0.117*	0.126	0.074*	0.092*	0.083
Sb-125	0.158	0.143	0.151	0.104	0.115	0.110
Cs-134	0.059	0.055	0.057	0.042	0.042	0.042
Cs-137	0.062	0.056	0.059	0.043	0.048	0.045
Eu-152	0.108	0.100	0.104	0.059	0.072	0.065
Eu-154	0.074	0.070	0.072	0.042	0.049	0.045
Am-241	0.316	0.288	0.302	0.061	0.062	0.061
Pu-238	0.012*	0.003	0.008	0.007*	0.009*	0.008
Pu-239	0.009*	0.003*	0.006	0.006*	0.008*	0.007
U-235	0.276	0.262	0.269	0.185	0.216	0.201
U-238	0.809	0.736	0.773	0.583	0.622	0.602
U-234[2]	0.008*	0.014*	0.011	0.018*	0.009*	0.013
U-235[2]	0.002*	0.001*	0.001	0.002*	0.003	0.002
U-238[2]	0.006*	0.012*	0.009	0.009*	0.006*	0.008

(1) Fish samples were collected from various locations within Battelle Lake.
(2) Analysis performed by alpha spectroscopy.

TABLE 15. INTEGRATED EXTERNAL BACKGROUND RADIATION MEASUREMENTS AT RECREATION AREA AND PROPERTY BOUNDARY LINE WEST JEFFERSON SITE — 1997

Location and Distance(1)	TLD #	Integrated TLD Measurements in mrem				Total for Year
		1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.	
Southwest						
121.9 m (400 ft)	6004	20	24	24	27	95
420.6 m (600 ft)	6041	18	23	27	28	96
731.5 m (2400 ft)	6002	17	21	23	26	87
1234.5 m (4050 ft)	6001	23	24	25	27	99
West						
152.4 m (500 ft)	6010	22	22	23	28	95
630.9 m (2070 ft)	6003	19	24	24	23	90
Southeast						
365.8 m (1200 ft)	6013	17	18	18	25	78
548.6 m (1800 ft)	6007	17	20	18	22	77
1005.9 m (3300 ft)	6008	18	21	21	25	85
South						
395.9 m (1200 ft)	6015	17	25	20	23	86
411.5 m (1350 ft)	6009	18	25	23	28	94
1097.3 m (3600 ft)	6011	18	22	23	30	93
East						
420.6 m (1380 ft)	6012	20	25	24	27	97
Northeast						
395.9 m (1200 ft)	6014	21	25	25	21	92
Northwest						
402.3 m (1320 ft)	6005	20	23	26	28	96
North						
457.2 m (1500 ft)	6006	19	22	24	24	98

(1) Refer to Figure 8. Average off-site background for year 120 mrem. Distances measured from center of Nuclear Sciences Area.

TABLE 16. SUMMARY OF SITE BOUNDARY AIR SAMPLE ANALYSES KING AVENUE SITE — 1997(1)

Nuclide	EA-15	EA-16	EA-17	EA-18
Co-57	2.35E-16	2.88E-16	2.96E-16	2.31E-16
Co-60	4.61E-16	5.61E-16	5.26E-16	4.60E-16
Sb-125	1.04E-15	1.36E-15	1.36E-15	1.11E-15
Cs-134	4.29E-16	4.96E-16	5.20E-16	4.07E-16
Cs-137	4.62E-16	5.45E-16	5.65E-16	4.34E-16
Eu-152	6.69E-16	8.25E-16	8.42E-16	6.54E-16
Eu-154	4.66E-16	5.81E-16	5.82E-16	4.66E-16
Th-234	4.60E-15	4.83E-15	5.50E-15	4.11E-15
Am-241	3.66E-16	9.17E-16	1.25E-15	4.83E-16
Th-232	9.59E-17	1.96E-17	7.78E-17	4.25E-17
U-234	5.46E-17	6.13E-17	6.24E-17	5.73E-17
U-235	2.26E-18	4.90E-18	4.46E-18	3.70E-18
U-238	5.47E-17	5.91E-17	6.84E-17	6.39E-17

(1) Locations are shown in Figure 4.

Note: All isotopic values represent average MDA values expressed in μCi/mL. Detection limit is 4.66 multiplied by the standard deviation of the background, divided by the efficiency, assuming a 50 percent recovery of the spike, and a flow volume of 2.70E09 mL.

TABLE 17. RADIOLOGICAL ANALYSES OF LIQUID DISCHARGES KING AVENUE SITE —1997

Expressed in µCi/mL
All values reported are less than MDA values unless otherwise indicated (*)

	Identification No.[1]						
Nuclide	EW-6	EW-8	EW-9	EW-14	Average	DCG µCi/mL	% DCG
Co-57	1.82E-09	1.82E-09	1.52E-09	1.89E-09	1.76E-09	1.0E-04	0.00%
Co-60	2.14E-09	2.12E-09	1.80E-09	2.32E-09	2.10E-09	5.0E-06	0.04%
Sb-125	6.01E-09	6.14E-09	5.14E-09	6.55E-09	5.96E-09	5.0E-05	0.01%
Cs-134	2.08E-09	2.11E-09	1.80E-09	2.26E-09	2.06E-09	2.0E-06	0.10%
Cs-137	2.28E-09	2.30E-09	1.96E-09	2.44E-09	2.25E-09	3.0E-06	0.07%
Eu-152	5.23E-09	5.21E-09	4.38E-09	5.47E-09	5.07E-09	2.0E-05	0.03%
Eu-154	3.65E-09	3.67E-09	3.08E-09	3.82E-09	3.56E-09	2.0E-05	0.02%
Am-241	5.74E-09	6.57E-09	5.86E-09	8.71E-09	6.72E-09	3.0E-08	22.40%
U-235	1.41E-08	1.42E-08	1.18E-08	1.46E-08	1.37E-08	6.0E-07	2.28%
U-238	4.43E-08	4.28E-08	4.00E-08	4.43E-08	4.29E-08	6.0E-07	7.14%
U-234[2]	1.72E-10*	2.46E-10*	4.94E-10*	1.88E-10*	2.75E-10	5.0E-07	0.06%
U-235[2]	3.42E-11	1.70E-11*	2.41E-11*	3.06E-11*	2.65E-11	6.0E-07	0.00%
U-238[2]	1.24E-10*	2.15E-10*	3.58E-10*	1.26E-10*	2.06E-09	6.0E-07	0.030%
Th-230[2]	3.76E-11*	6.65E-11	6.44E-11	5.06E-11	5.48E-11	3.0E-07	0.14%
Th-232[2]	5.03E-11	7.00E-11	8.51E-11	7.74E-11	7.07E-11	5.0E-08	0.02%

(1) Locations identified in Figure 4.
(2) Analysis performed by alpha spectroscopy on a quarterly basis.

TABLE 18. RADIOLOGICAL ANALYSES OF SOIL SAMPLES KING AVENUE SITE — 1997

Expressed in pCi/g dry weight
All values are less than MDA values except where indicated (*)

	Identification No.[1]								
Nuclide	KAES-01	KAES-02	KAES-03	KAES-04	KAES-05	KAES-06	KAES-07	KAES-08	KAES-09
Co-57	0.025	0.027	0.031	0.021	0.026	0.021	0.025	0.048	0.022
Co-60	0.049	0.037	0.056	0.035	0.071	0.039	0.051	0.088	0.036
Sb-125	0.116	0.111	0.142	0.090	0.143	0.095	0.133	0.208	0.093
Cs-134	0.044	0.037	0.052	0.034	0.055	0.033	0.048	0.076	0.035
Cs-137	0.716*	0.474*	0.065	0.252*	0.069*	0.041*	0.712 *	0.835*	0.141
Eu-152	0.071	0.079	0.090	0.061	0.075	0.060	0.073	0.137	0.064
Eu-154	0.050	0.056	0.062	0.043	0.052	0.042	0.050	0.098	0.046
Am-241	0.069	0.073	0.064	0.062	0.159	0.060	0.071	0.432	0.064
U-235	0.221	0.241	0.286	0.188	0.219	0.179	0.219	0.375	0.190
U-238	2.088*	3.018*	2.031*	2.149*	2.441*	1.806*	1.824*	1.186*	1.983*
U-234[2]	1.995*	4.524*	1.594*	2.362*	1.468*	1.883*	1.403*	1.602*	1.723*
U-235[2]	0.095*	0.223*	0.122*	0.131*	0.088*	0.114*	0.101*	0.095*	0.112*
U-238[2]	1.876*	3.547*	1.772*	2.379*	1.713*	1.974*	1.362*	1.871*	1.981*
Th-232[2]	0.824*	0.888*	0.864*	1.013*	0.767*	0.828*	0.691*	0.796*	0.872*

(1) Locations are identified in Figure 4, except KAEV-09, which is an off-site sample taken from the OSU Agriculture campus.
(2) Analysis performed by alpha spectroscopy.

TABLE 19. RADIOLOGICAL ANALYSES OF VEGETATION SAMPLES KING AVENUE SITE — 1997

Expressed in pCi/g dry weight
All values are less than MDA values except where indicated (*)

Nuclide	Identification No.[1]								
	KAEV-01	KAEV-02	KAEV-03	KAEV-04	KAEV-05	KAEV-06	KAEV-07	KAEV-08	KAEV-09
Co-57	0.060	0.040	0.078	0.048	0.044	0.041	0.100	0.056	0.040
Co-60	0.157	0.072	0.123	0.113	0.091	0.091	0.175	0.149	0.070
Sb-125	0.323	0.196	0.322	0.270	0.213	0.227	0.436	0.307	0.173
Cs-134	0.130	0.074	0.113	0.098	0.080	0.083	0.149	0.115	0.068
Cs-137	0.152	0.213*	0.130	0.130	0.088	0.090	0.168	0.122	0.068
Eu-152	0.172	0.114	0.222	0.139	0.127	0.118	0.284	0.158	0.113
Eu-154	0.121	0.080	0.156	0.097	0.090	0.083	0.203	0.117	0.081
Am-241	0.339	0.101	0.649	0.278	0.111	0.114	0.807	0.313	0.101
U-235	0.481	0.353	0.564	0.380	0.385	0.366	0.746	0.445	0.339
U-238	1.176	3.040*	1.714	1.050	1.124	1.182	2.172	1.090	1.009
U-234[2]	0.340*	1.772*	0.889*	1.341*	0.595*	0.292*	0.168*	0.027*	0.147*
U-235[2]	0.017*	0.089*	0.046*	0.062*	0.033*	0.016*	0.009*	0.004*	0.009*
U-238[2]	0.343*	1.625*	0.963*	1.388*	0.603*	0.310*	0.174*	0.040*	0.143*
Th-232[2]	0.084*	0.295*	0.291*	0.319*	0.312*	0.119*	0.066*	0.013*	0.027*

(1) Locations are identified in Figure 4, except KAEV-09, which is an off-site sample taken from the OSU Agriculture campus.
(2) Analysis performed by alpha spectroscopy.

TABLE 20. RADIOLOGICAL ANALYSES OF SEDIMENT SAMPLES KING AVENUE SITE — 1997

Nuclide	pCi/g dry wt.[1] Avg. KAED-1[2]	pCi/g dry wt.[1] Avg. KAED-2[3]
Co-57	<0.035	<0.020
Co-60	<0.046	<0.041
Sb-125	<0.133	<0.100
Cs-134	<0.045	<0.038
Cs-137	0.250	0.141
Eu-152	<0.105	<0.059
Eu-154	<0.075	<0.042
Am-241	<0.066	<0.062
Th-232[4]	0.667	0.948
U-235	<0.320	<0.183
U-238	2.010	1.880
U-234[4]	1.780	2.040
U-235[4]	0.094	0.129
U-238[4]	1.970	2.080

(1) No standards for radionuclides in sediment have been established.
(2) Located along the Olentangy River near the storm sewer outfall at the low-head dam.
(3) Located along the Olentangy River north of King Avenue and south of the OSU campus.
(4) Analysis performed by alpha spectroscopy.

Note: < indicates less than MDA.

TABLE 21. RADIOLOGICAL ANALYSES OF OLENTANGY RIVER WATER SAMPLE KING AVENUE SITE[1] — 1997

Nuclide	KARW-1 (10^{-9} µCi/mL)
Co-57	<1.89
Co-60	<2.30
Sb-125	<6.57
Cs-134	<2.20
Cs-137	<2.47
Eu-152	<5.54
Eu-154	<3.85
Am-241	< 5.77
U-235	<15.57
U-238	<52.76
U-234[2]	1.15
U-235[2]	<0.03
U-238[2]	1.23
Th-230[2]	<0.03
Th-232[2]	<0.01

(1) Located north of the West Fifth Avenue bridge (Figure 4).
(2) Analysis performed by alpha spectroscopy.

Note: < indicates less than MDA.

TABLE 22. SUMMARY OF RADIOLOGICAL ANALYSES OF FISH TISSUE KING AVENUE SITE(1) — 1997

Nuclide	Olentangy River Samples (pCi/g raw weight)
Co-57	<0.035
Co-60	<0.040
Sb-125	<0.126
Cs-134	<0.042
Cs-137	<0.045
Eu-152	<0.099
Eu-154	<0.070
U-235	<0.288
U-238	<0.613
Am-241	<0.056
U-234(2)	0.035
U-235(2)	0.002
U-238(2)	0.029
Th-230(2)	0.025
Th-232(2)	0.019

(1) Fish samples were collected north of the West Fifth Avenue bridge (Figure 4).
(2) Analysis performed by alpha spectroscopy.

Note: < indicates less than MDA.

TABLE 23. INTEGRATED EXTERNAL BACKGROUND RADIATION MEASUREMENTS AT THE PROPERTY LINE KING AVENUE SITE — 1997

TLD Location[1]	TLD #	Integrated TLD Measurements in mrem 1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.	Total for Year
East	1	26	20	21	29	96
Northeast	2	22	19	22	30	93
	3	21	27	24	29	102
North	4	19	21	23	26	89
	5	29	34	26	25	114
Northwest	6	15	22	23	24	83
	7	18	18	17	25	78
West	8	17	18	16	24	75
	9	18	17	17	22	74
Southwest	10	53	19	19	23	114
	11	15	17	17	20	68
South	12	19	18	20	20	77
	13	15	17	21	18[2]	71
Southeast	14	19	22[2]	19	27	87
East	15	23	22	24	27	96
Replicate #1	16	22	20	17	25	84

(1) Refer to Figure 9.
(2) TLD was lost or damaged. In calculating the total, it was assumed that the average for the remaining quarters was appropriate.

TABLE 24. NONRADIOLOGICAL WATER EFFLUENT ANALYSES WEST JEFFERSON SITE—1997

	North Wastewater Treatment System(1)				Permit Requirements(3) Discharge Limitations			
				kg/Day	Loading kg/Day		Concentration(5)	
	Avg.	Max.	Min.	Avg.(2)	30-Day	Daily	30-Day	Daily
Monthly Flow Rate (L/day)(4)	70,009	85,034	57,487	—	(4)	(4)	(4)	(4)
Residual Chlorine (mg/L)	0.17	0.95	0.01	0.0005			—	0.5
pH Value (S.U.)	7.8	8.1	7.5	—			6.5	9.0
Fecal Coliform (#/100 mL)	2.8	6.0	1.0	—			1,000	2,000
Dissolved Oxygen (mg/L)	9.7	10.6	8.3	—			6.0 (min)	6.0 (min)
Total Suspended Solids (mg/L)	2.5	7.0	1.0	0.10	0.76	1.51	10	20
Carbonaceous Biochemical Oxygen Demand (5-day) (mg/L)	4.4	4.9	4.1	0.21	0.76	1.51	10	20
Ammonia (mg/L)(4)	0.040	0.51	0.13	—	(4)	(4)	(4)	(4)

(1) Sampling site location is labeled EW-1 on Figure 5 (referred to as 001 in monthly NPDES reports). Includes discharge from Middle Area Sanitary System.
(2) Based on a flow rate of 0.020 million gallons/day (MGD).
(3) Permit requirement discharge limitations based on NPDES Permit 4IN00004*FD.
(4) No restrictions for flow or ammonia under the NPDES Permit.
(5) Units specified in left column.

TABLE 25. NONRADIOLOGICAL ANALYSES OF GROUNDWATER WEST JEFFERSON SITE — 1997

Chemical Parameter	Well C-03[1]	Well C-09[1]	Well C-16[1]	Well 100[1]	Well 110-R[1]	Well 116-R[1]	Well 300[1]
Total Metals (µg/L)							
As	ND	ND	ND	ND	ND	ND	ND
Ba	ND	0.10	0.20	0.10	ND	0.20	0.20
Cd	ND	ND	ND	ND	ND	ND	ND
Cr	ND	ND	ND	ND	ND	ND	ND
Pb	ND	ND	ND	ND	ND	ND	ND
Hg	ND	ND	ND	ND	ND	ND	ND
Se	ND	ND	ND	ND	ND	ND	ND
Ag	ND	ND	ND	ND	ND	ND	ND
Pesticides and PCBs (mg/L)							
26 compounds	ND	ND	ND	ND	ND	ND	ND
Volatile Organics (µg/L)							
36 compounds	ND	ND	1,1,1-Tri-chlorethane = 5.9 µg/L; others ND	ND	ND	ND	ND
Semivolatile Compounds (µg/L)							
65 compounds	ND	ND	ND	ND	ND	ND	ND
Oil & Grease (mg/L)	ND	ND	3.0	ND	ND	ND	1.0
pH	6.5	6.5	7.2	6.8	6.7	6.6	7.2

(1) Locations are shown in Figures 10 and 11.
Note: ND = not detected

TABLE 26. SUMMARY OF ALPHA/BETA RADIOLOGICAL ANALYSES OF GROUNDWATER[(1)] WEST JEFFERSON SITE — 1997

Well Identification	Number of Samples	pCi/L[(2)]					
		Gross α ± 2 sigma			Gross β ± 2 sigma		
JN	2	-1.15	±	2.73	2.28	±	2.53
JM	2	10.30	±	6.02	4.96	±	2.88
JS	2	3.19	±	4.03	2.10	±	2.54
C03	2	5.11	±	5.34	9.19	±	3.32
C09	2	6.35	±	6.61	2.59	±	4.61
C16	2	7.35	±	7.17	6.50	±	3.38
100	1	12.30	±	8.38	15.20	±	4.00
101	2	1.80	±	6.03	8.43	±	3.50
103	2	3.82	±	4.81	11.20	±	3.43
110	2	11.50	±	8.24	31.60	±	4.92
116	1	15.20	±	8.76	11.60	±	3.72
118	2	7.65	±	6.71	15.40	±	3.88
150	2	4.52	±	4.86	6.09	±	2.97
155	2	4.09	±	5.14	4.12	±	2.86
168	2	5.72	±	6.04	22.10	±	4.27
172	2	5.87	±	5.79	17.00	±	3.94
206	2	5.72	±	5.74	5.59	±	3.04
300	1	11.30	±	5.59	7.52	±	3.06
306	2	0.12	±	4.91	6.72	±	3.23
403	1	0.92	±	4.36	2.86	±	2.70
506	2	13.50	±	7.43	13.00	±	3.62
601	2	-0.15	±	6.49	10.10	±	3.80

(1) Locations are shown in Figures 10 and 11.
(2) MDA: gross α: 1.0 pCi/L; gross β: 2.9 pCi/L

TABLE 27. SUMMARY OF RADIOLOGICAL ANALYSES OF GROUNDWATER WEST JEFFERSON SITE — 1997

Expressed in 1 x 10^{-9} µCi/mL
All values are less than MDA values except where indicated (*)

	Well Identification No.[1]															
Nuclide	100	101	103	110	118	116-R	150	155	168	172	206	300	306	403	506	601
Co-57	2.18	1.88	1.49	9.34	1.63	1.75	1.67	2.44	1.63	2.18	2.40	1.70	1.44	2.66	2.08	1.74
Co-60	2.44	1.60	1.85	2.05	1.70	1.53	1.74	3.45	1.78	3.05	2.81	1.57	1.57	4.52	2.28	1.92
Sr-90	3.07*	3.27*	3.80*	3.64*	5.85*	1.76*	1.75*	4.35*	9.59*	8.56*	2.15*	1.74*	3.68*	1.78*	3.28*	1.87*
Sb-125	7.49	5.62	5.30	5.95	5.25	5.29	5.52	9.81	5.55	8.22	8.12	4.95	4.97	10.70	6.94	5.80
Cs-134	2.46	1.81	1.95	2.00	1.87	1.73	1.88	3.35	1.88	2.91	2.85	1.67	1.73	3.72	2.49	1.96
Cs-137	2.62	1.91	2.16	3.86	1.90	1.83	1.96	3.54	2.01	3.26	3.22	1.81	1.88	4.19	2.59	2.06
Eu-152	6.56	5.58	4.41	5.34	4.79	5.19	4.92	7.18	4.80	4.59	7.05	4.96	4.22	7.89	6.10	5.08
Eu-154	4.50	3.93	3.12	3.78	3.37	3.60	3.44	5.03	3.36	5.75	4.93	3.53	2.92	5.45	4.25	3.58
Am-241	7.43	5.85	5.67	6.29	5.32	5.29	6.20	11.60	5.93	11.00	13.70	4.91	4.87	14.60	12.70	5.55
Pu-238	0.10	0.13*	0.36*	0.21*	0.18*	0.05	0.30*	0.13*	0.13*	0.24*	0.28*	0.26	0.29*	0.12*	0.30*	0.22*
Pu-239	0.09*	0.18*	0.18*	0.23*	0.15*	0.34*	0.29*	0.08*	0.16*	0.14*	0.14*	0.14*	0.20*	0.26*	0.20*	0.11*
U-235	18.40	15.00	12.20	15.00	13.00	14.10	13.70	19.60	13.20	17.70	18.90	13.40	11.50	20.10	16.20	13.70
U-238	54.70	42.30	44.30	46.20	42.40	41.40	43.80	53.40	43.40	47.60	56.10	40.20	41.10	50.10	49.10	45.50
U-234[2]	2.17*	0.64*	1.00*	1.76*	2.05*	3.11*	0.77*	2.82*	1.20*	4.85*	1.83*	2.19*	1.56*	1.60*	4.73*	1.09*
U-235[2]	0.14*	0.05	0.07	0.0.8	0.06	0.04	0.11	0.25*	0.05	0.28*	0.11	0.07*	0.06	0.08	0.18*	0.10
U-238[2]	1.67*	0.56*	0.80*	1.23*	1.64*	3.26*	0.81*	2.62*	1.29*	4.85*	9.36*	0.77*	1.49*	0.87*	3.52*	1.00*

(1) Locations are shown in Figures 10 and 11.
(2) Analyses performed by alpha spectroscopy.

TABLE 27. (continued)

Expressed in 1 x 10^{-9} µCi/mL
All values are less than MDA values except where indicated (*)

	Well Identification No. [1]					
Nuclide	C-03	C-09	C-16	JM-W	JN-W	JS-W
Co-57	1.64	1.48	1.41	2.18	2.35	1.98
Co-60	1.73	1.91	1.36	3.04	2.98	3.04
Sr-90	3.01*	11.50*	1.27*	2.37*	1.43*	1.16*
Sb-125	5.28	5.48	4.49	7.66	8.00	7.90
Cs-134	1.75	1.92	1.51	2.78	2.78	2.95
Cs-137	1.94	2.20	1.62	2.88	3.10	3.29
Eu-152	4.78	4.34	4.14	6.34	6.86	5.74
Eu-154	3.31	2.98	2.90	4.43	4.79	4.08
Am-241	5.44	5.46	4.77	9.91	14.00	9.85
Pu-238	0.30*	0.26*	0.32*	0.09*	0.15*	0.16*
Pu-239	0.30*	0.17*	0.55*	0.14*	0.11*	0.15*
U-235	13.10	11.90	11.30	17.30	18.50	16.10
U-238	42.70	42.70	38.50	45.60	55.90	46.30
U-234[2]	2.58*	3.92*	0.91*	2.07*	1.15*	1.58*
U-235[2]	0.15*	0.14*	0.03	0.09	0.06	0.03
U-238[2]	2.42*	2.55*	1.08*	0.49*	0.32	0.54

(1) Locations are shown in Figures 10 and 11.
(2) Analyses performed by alpha spectroscopy.

TABLE 28. ARITHMETIC AVERAGE WIND SPEEDS (m/sec) and FREQUENCY (wind towards)

	Pasquill Stability Class							
Dir	A	B	C	D	E	F	G	Frequency
N	2.020	2.490	3.090	3.880	2.880	1.440	0.000	0.105
NNW	1.950	2.220	2.690	3.370	2.650	1.190	0.000	0.062
NW	2.020	2.190	2.750	3.020	2.620	1.140	0.000	0.057
WNW	2.030	2.320	2.790	3.110	2.760	1.160	0.000	0.038
W	1.850	2.600	3.370	3.310	2.840	1.180	0.000	0.042
WSW	1.420	2.680	3.300	3.170	2.870	1.240	0.000	0.049
SW	2.050	2.750	3.160	3.400	2.930	1.300	0.000	0.049
SSW	2.020	2.520	3.360	3.450	2.990	1.370	0.000	0.047
S	2.160	2.740	3.390	3.560	3.060	1.410	0.000	0.074
SSE	2.140	2.800	3.620	3.870	3.240	1.480	0.000	0.051
SE	2.030	2.830	3.440	4.260	3.310	1.530	0.000	0.053
ESE	1.960	2.640	3.850	4.810	3.520	1.500	0.000	0.063
E	2.140	2.840	3.880	4.990	3.530	1.570	0.000	0.090
ENE	2.170	2.880	3.800	4.530	3.340	1.510	0.000	0.068
NE	2.000	2.680	3.810	4.530	3.340	1.550	0.000	0.076
NNE	1.960	2.700	3.620	4.300	3.090	1.560	0.000	0.076

Appendix B

Environmental Report External Distribution List

Appendix B

Environmental Report External Distribution List

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