

REPORT

BCLDP-072794

BCLDP

**Site Environmental
Report for Calendar
Year 1993**

**on Radiological
and Nonradiological
Parameters**

To

U.S. Department of Energy

DOE Operations Office, Chicago

July 27, 1994

by: Safety, Health and Environmental Support



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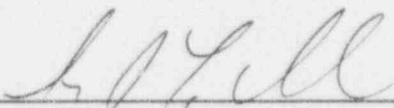
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Decommissioning Project**

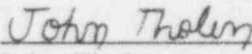


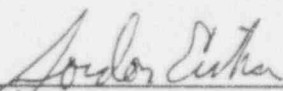
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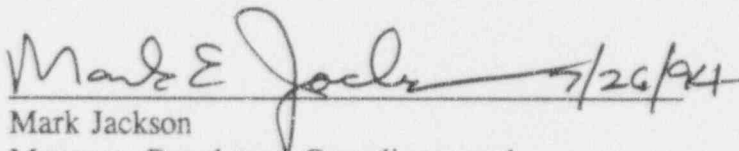
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FOREWORD

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 except for certain plutonium, strontium, thorium, and uranium analyses performed by IT Corporation in St. Louis, Missouri, and Ecotek, Inc., Atlanta, Georgia. Thermoluminescence dosimeter analyses were performed by Landaeur, Inc. Non-radiological analyses of environmental water samples were performed by 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 1993 and for the period of time within the first quarter of 1994 prior to the release of this report to the DOE. The summary includes environmental statutes, including a Part B permit, regulations, and DOE Orders. The Part B permit issue involves only Battelle Columbus Operations and does not pertain to the DOE or the BCLDP activities conducted at Battelle.

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Executive Summary

Battelle Memorial Institute's nuclear research facilities are currently being maintained in a surveillance and maintenance (S&M) mode with increasing decontamination and decommissioning (D&D) activities under Department of Energy (DOE) Contract W-7405-ENG-92. These activities are referred to under the Contract as the Battelle Columbus Laboratories Decommissioning Project (BCLDP). Operations referred to in this report are those activities in support of S&M and D&D. Environmental monitoring was continued in order to demonstrate compliance by Battelle with federal, state, and local regulations. The only routine non-radiological monitoring in association with the BCLDP is done for the National Pollutant Discharge Elimination System (NPDES) Permit 41N00004-DD for the West Jefferson Nuclear Sciences Area, and groundwater monitoring wells at the West Jefferson site. Groundwater wells are a source of potable water for the West Jefferson area and city water is the source of potable water for the King Avenue area.

Routine monitoring of liquid and atmospheric emissions at the King Avenue and West Jefferson Nuclear Sciences Area was conducted. In addition, samples of various environmental media including air, water, grass, fish, field and garden crop, sediment, and soil were collected from the region surrounding the two sites and analyzed. The environmental surveillance activities were performed in accordance with standard operating procedures as established by Battelle's Environmental Monitoring Program. Battelle's King Avenue facility is not considered in this report to the extent as is the West Jefferson site because the source term at King Avenue is a small fraction of the source term at West Jefferson and the vast majority of material associated with the BCLDP at King Avenue is fixed contamination. Off-site levels of radionuclides that could be attributable to the West Jefferson and King Avenue nuclear operation were indistinguishable from background levels at specific locations for air, water, and direct radiation measurement.

The Annual Radionuclide Release Inventory is a list of minimum detectable quantities of isotopes suspected but not identified in samples. Suspected isotopes are those expected to be found in the residual contamination left from previous nuclear fuel work.

The data are summarized as follows: (1) No isotopes were present above minimum detectable levels (MDL) for air releases or for liquid discharges to Big Darby Creek from the West Jefferson Nuclear Science Area, (2) MDL values for specific isotopes not detected were used to determine the percentage of the respective DOE 5400.5 derived concentration guide (DCG) for an individual radionuclide released to an unrestricted area, (3) Concentrations observed at downstream sampling locations were statistically indistinguishable from background levels.

West Jefferson nuclear operations during 1993 caused no distinguishable impact on concentrations of airborne radionuclides or on external radiation doses measured adjacent to the West Jefferson Nuclear Sciences site and the Battelle site boundary. Radionuclides detected in soil samples (e.g., uranium or cesium-137) were attributed to previous atmospheric nuclear tests, Chernobyl fallout, or natural sources.

The estimated effective dose equivalent to a nearby resident from nuclear operations at the West Jefferson site was calculated using CAP88-PC⁽¹¹⁾ to be 0.037 mrem/yr, with a maximum organ dose to the endosteum of 0.157 mrem/yr.

The whole body "fence-post" exposure during 1993, for external radiation at the site boundary line, was at background levels at Ken Jockety Camp, the Girl Scout camp adjacent to the Battelle West Jefferson property line located approximately 0.4 km northeast of the boundary of the nuclear site. An estimated dose of 120 mrem/yr was verified through the use of thermoluminescence dosimeters (TLDs) placed at fixed locations on the site boundary. This is the same as the national average for total background radiation. A discussion of how the "fence-post" exposure was determined is in the section on *Environmental Radiological Monitoring for the West Jefferson Site*.

The estimated collective population dose (effective dose equivalent) for the total population within 80 km of the West Jefferson site is 0.136 person-rem/year. The doses presented in this report are calculated, rather than measured, and they represent potential rather than actual doses.

The values reported for uranium isotopes are recorded in units of Curie (Ci) and gram (g) as per requirements of DOE Order 5400.5. Conversion factors for the calculations performed for the reported values were obtained from 10 CFR Part 20.

D&D activities during the year involved site and building characterization at West Jefferson, and room and/or building characterization at King Avenue with actual decontamination and decommissioning primarily performed in Building 2 and Building 3 at the King Avenue site as well as in Buildings 1, 4, 5, 6, and 7.

Introduction

Surveillance and maintenance (S&M) activities, performed for the U.S. Department of Energy (DOE) under Contract No. W-7405-ENG-92, Memorandum of Understanding, August 14, 1986, were conducted at Battelle's King Avenue site and the West Jefferson Nuclear Science Area site. Figure 1 is a regional area map, covering an 80-km (50-mile) radius and shows both sites. Some Nuclear Regulatory Commission (NRC) licensed activities are conducted at both sites, but are not addressed specifically in this report. This report makes no distinction between effluents that may result from contract or licensed activities.

Site Descriptions

The Battelle King Avenue facility is located at 39° 59'N, 83° 03'W in the western central portion of the city of Columbus, Ohio. The 58.3-acre plot, accommodating 21 buildings, is bounded on the north by King Avenue, Battelle Boulevard to the east, by Third Avenue to the south, and the Olentangy River to the west. Figure 2 shows the property boundary of the Battelle King Avenue site. It indicates the location of Building 3, which houses facilities formerly used in uranium handling. During 1993, decontamination and decommissioning (D&D) activities were also conducted in Buildings 1, 2, 4, 5, 6, and 7.

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 1,000-acre tract that accommodates the Engineering Area in the southeastern portion, the Middle Area in the east central portion, and the Nuclear Sciences Area in the northern portion. The northern boundary of the site lies approximately one-half mile south of Interstate Highway 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 southern boundary. The Georgesville-Plain City Road defines the western boundary of the site.

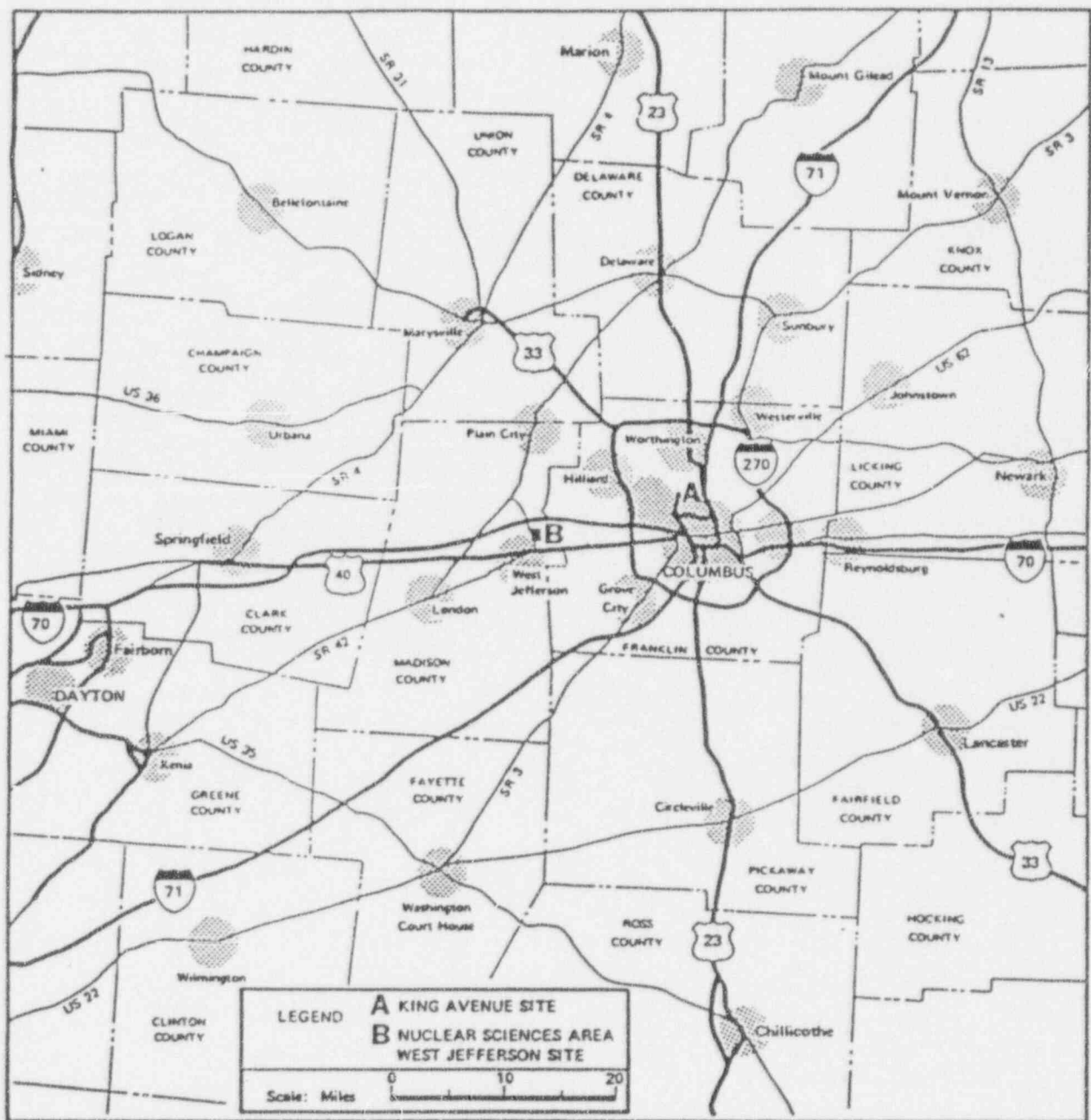
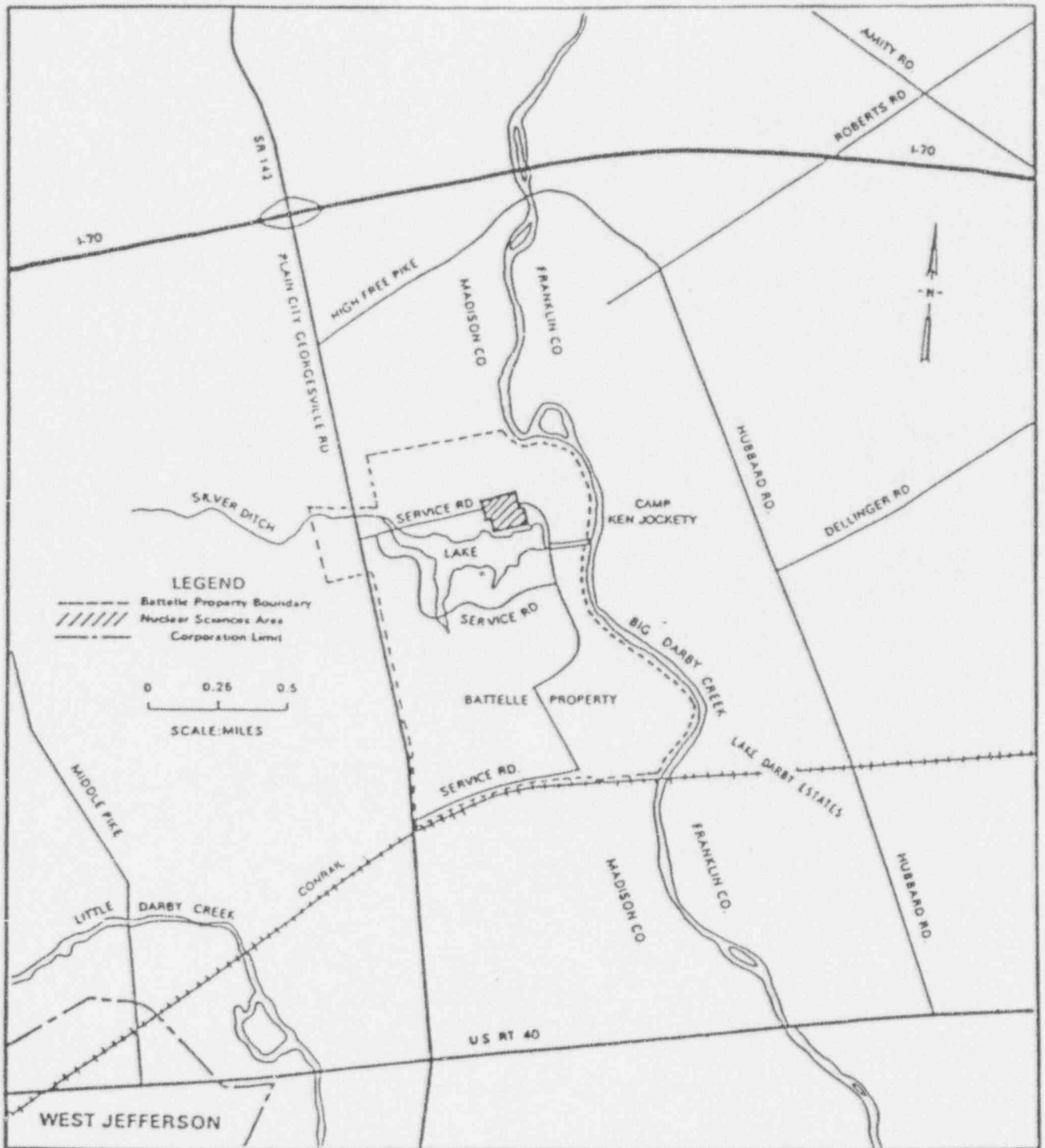


FIGURE 1. REGIONAL MAP FOR KING AVENUE AND WEST JEFFERSON SITES



FIGURE 2. LOCAL VICINITY MAP OF KING AVENUE SITE



**FIGURE 3. LOCAL VICINITY MAP OF NUCLEAR SCIENCES AREA—
WEST JEFFERSON SITE**

For this report, the focus of interest is the Nuclear Sciences Area at the West Jefferson site. It is indicated by the shaded area of Figure 3. The Nuclear Sciences Area consists of a 10-acre fenced area enclosing a guardhouse, four buildings, and two other small structures on a flat bluff; Battelle Lake lies to the south and Big Darby Creek lies to the east. 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. Some land is leased to farmers, typically for raising field crops such as corn or soybeans. The site includes two narrow wooded strips, one along the northern portion of the fence around the Nuclear Sciences facility, and the other about 1,000 feet to the northeast of the center of the site. To the east, within the Big Darby floodplain and along the bluffs to the east of the Creek, the land is heavily vegetated with deciduous trees, shrubbery, and high grasses.

Demography

The King Avenue site is located east of State Route 315 and is bordered by Perry Street and Battelle Boulevard to the east, King Avenue to the north, the Olentangy River to the west, and Third Avenue to the south. 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. The boundary of the district meets the boundary of the King Avenue site on the east and northeast. The land owned by Battelle from Fifth Avenue south to Third Avenue is located within the district.

The area to the north of the King Avenue site, north of King Avenue, is within the city's University District. The Ohio State University, 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 borders 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 includes data on the population distribution within a 50-mile radius of the King Avenue facility, based on 1990 census data prepared by the Ohio Department of Development.

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 this data was not included in the 1990 Census.

The area immediately adjacent to the West Jefferson site has a low population density. Table 2 gives the population distribution, by direction and distance, within 50 miles of Battelle's West Jefferson site. Camp Ken Jockety, a Girl Scout camp, is located on a bluff on the east side of the Big Darby Creek with the western boundary of the camp at a distance of 1,640 feet from the center of the West Jefferson site and a residence within the camp located approximately 3,300 feet from the center of the site. The nearest residences to the Nuclear Sciences area are Lake Darby Estates. This subdivision is located approximately 2,500 feet southeast of the site 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.

The primary agricultural activity in the area is raising field crops such as corn and soybeans. 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, i.e., two and one-half times the 10-mile population distribution for 1965.

Climatology

Climate for the West Jefferson and King Avenue sites is typical of the south-central Ohio region. Climatology of the south-central Ohio region may be described as continental-temperate. 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. The mean for the months of December, January, and February is 31.2 F. The number of days per year with temperatures below 32 F and below 0 F are 122 and 4, respectively.

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).

Precipitation is distributed fairly uniformly during the year, although 60 percent falls during the spring-summer seasons. The annual average monthly rainfall is about 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 later 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 sufficiently strong 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 frequently by tornadic activity. Of the 567 tornadoes recorded within 144 miles of the Battelle facilities during the period 1950-1975, 163 have occurred in the month of April.

The regional climatological data gathered by the National Weather Service at Port Columbus, seven miles east-northeast of the King Avenue facility, is generally representative of the local climatic conditions at the Columbus site. Data from Port Columbus are used to prepare wind rose patterns and tables of average wind speed and direction. Detailed meteorological data for the Columbus, Ohio area is also included in the air model (CAP88-PC) used to prepare this Site Environmental Report.

Geology

The arrangement of 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 of 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 about 80 to

100 feet below the surface. They 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 the surface soils is represented by the Brookston-Crosby Association with little more than traces representing the remaining types. All of these soil types exhibit relatively low permeability; all grade into till clay at depths of 55 to 60 inches where the impermeability of the near-surface geology greatly impedes further percolation.

No recorded earthquakes have occurred within 50 miles of the area of interest, although in 1937 a strong quake was experienced at Anna, Ohio, a little over 50 miles to the northwest of the West Jefferson site. The Columbus-West Jefferson areas are, however, considered to be in a nonseismic region. The Battelle facilities are in a Universal Building Code (UBC) Seismic Zone 1 low-risk area.

Hydrology

Two aquifers, or underground sources of water, are located in the West Jefferson site area. The shallow aquifer is in the dense clay till. The deep or principal aquifer is 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 Battelle site is probably within the range of the former figure, since the hydraulic gradient of the water table in the area is only slightly greater than one percent.

The present supply wells at the Battelle West Jefferson facility lie below the surface of the bedrock. 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. Bedrock was encountered at approximately 103 feet below the surface in drilling these wells.

A man-made hydrologic feature of the site is the artificial lake. It covers an area of about 25 acres and was formed by damming Silver Ditch southeast of and down gradient from the Nuclear Sciences area. The normal surface elevation of the lake is 888 feet MSL (mean sea level).

The source of groundwater in the site area is local precipitation. Recharge to the shallow aquifer takes place relatively uniformly over the area. Contours of the water table, which are about 40 feet below the surface, are a subdued reflection of the surface topography. Groundwater moves down slope at right angles to the contours and follows a path similar to surface runoff. At the Nuclear Sciences area surface runoff moves downslope into the lake, then through the controlled dam on the site into Big Darby Creek.

Test borings carried out in 1970 for an addition to the Hot Cell Laboratory (discussed in the *Facility Description* section) reaffirmed the geology described above. Only isolated pockets of groundwater were encountered during boring and foundation-piling excavation operations. These pockets were readily pumped out and remained dry, which indicated that there is no interconnection of the pockets with the lake.

Flood water calculations for the lake indicates a capacity of releasing water that is about three times the inflow rate measured during the January 1959 floods. It is concluded that the lake has not adversely affected the hydrology of the area.

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

Background Radiological Characteristics

Radiation occurs from sources found in nature, as well as from man-made sources. The four primary sources of natural radiation are: cosmic radiation from the sun and outer space, terrestrial radiation from the decay of radioactive elements in the earth; the decay of naturally occurring elements in the human body; and radon and its daughter products from the decay of uranium and thorium in rocks and soil.

In the United States, these natural sources of radiation produce an average dose of approximately 300 mrem per year.⁽²⁾ Of this number about 55 percent or 162 mrem/yr comes from radon. In 1966, the natural terrestrial background for the region surrounding Battelle was measured as 60 mrem/yr by an aircraft equipped with radiation instrumentation.⁽³⁾ This number is greater than the national average of approximately 29 mrem/yr.⁽²⁾ The cosmic background for the State of Ohio is averaged to be 50 mrem/yr, compared to a U.S average of 29 mrem/yr.⁽²⁾ The estimate for internal emitters within the body is considered to be approximately 40 mrem/yr for the United States with only minor regional variations.⁽²⁾ 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/yr.

Facility Description

The center of D&D activities at the Battelle King Avenue site is the former U-235 handling facility, located on the first floor of Building 3. It was the nuclear materials management point for all transactions involving nuclear material at the King Avenue site. Figure 4 shows the location of Building 3 in the King Avenue site building complex.

At the West Jefferson Nuclear Sciences Area, the major S&M operations are the result of research and development (R&D) on the properties of 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. Only residual fuel contamination and small contained sources remain onsite. Nuclear support and S&M activities are conducted in 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 during the year involved site and building characterization at West Jefferson, room and/or building characterization at King Avenue, and the actual D&D of primarily Buildings 2 and 3, and to some extent Buildings 1, 2, 4, 5, 6, and 7 at the King Avenue site.

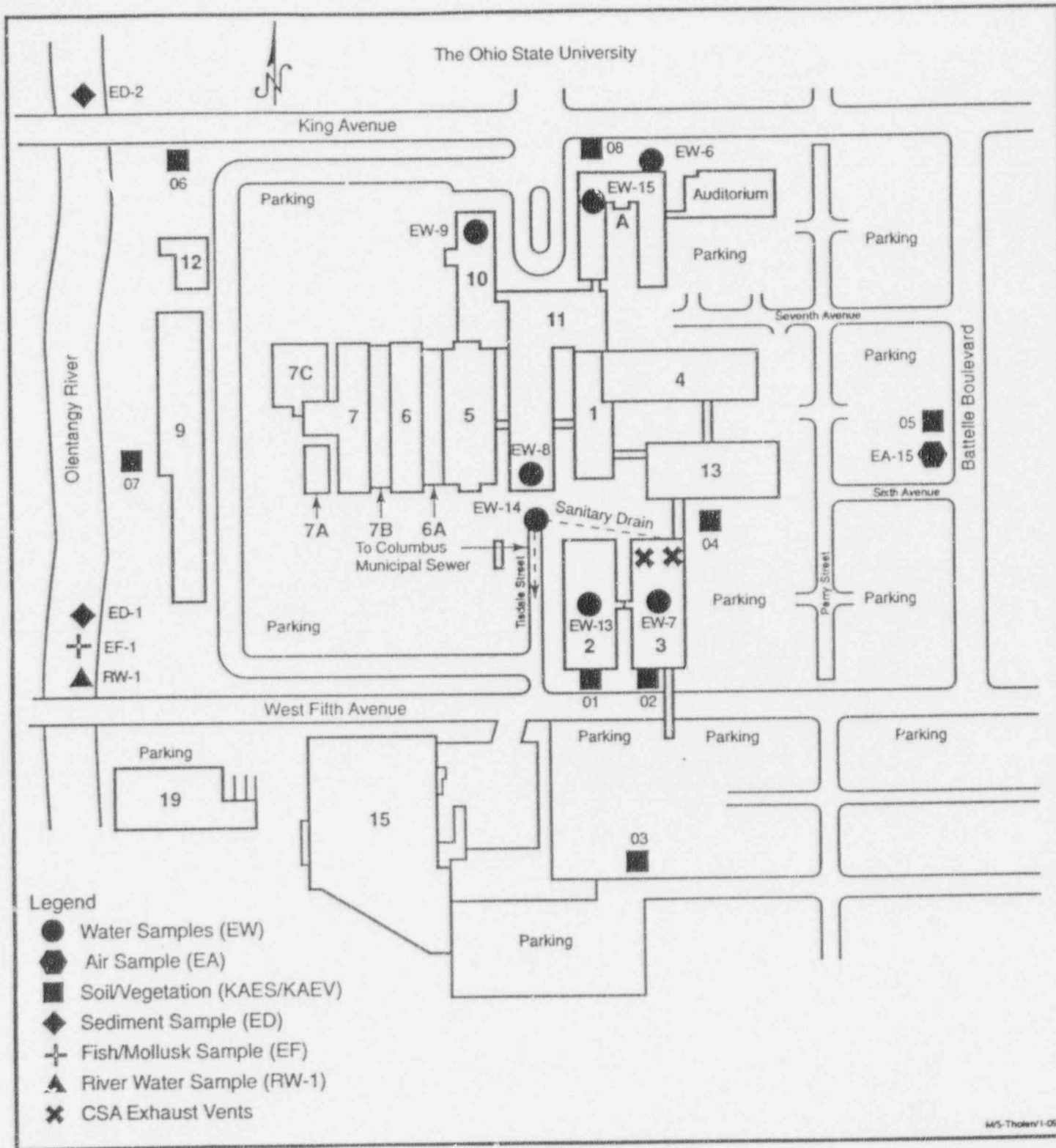


FIGURE 4. BATTELLE KING AVENUE LABORATORIES

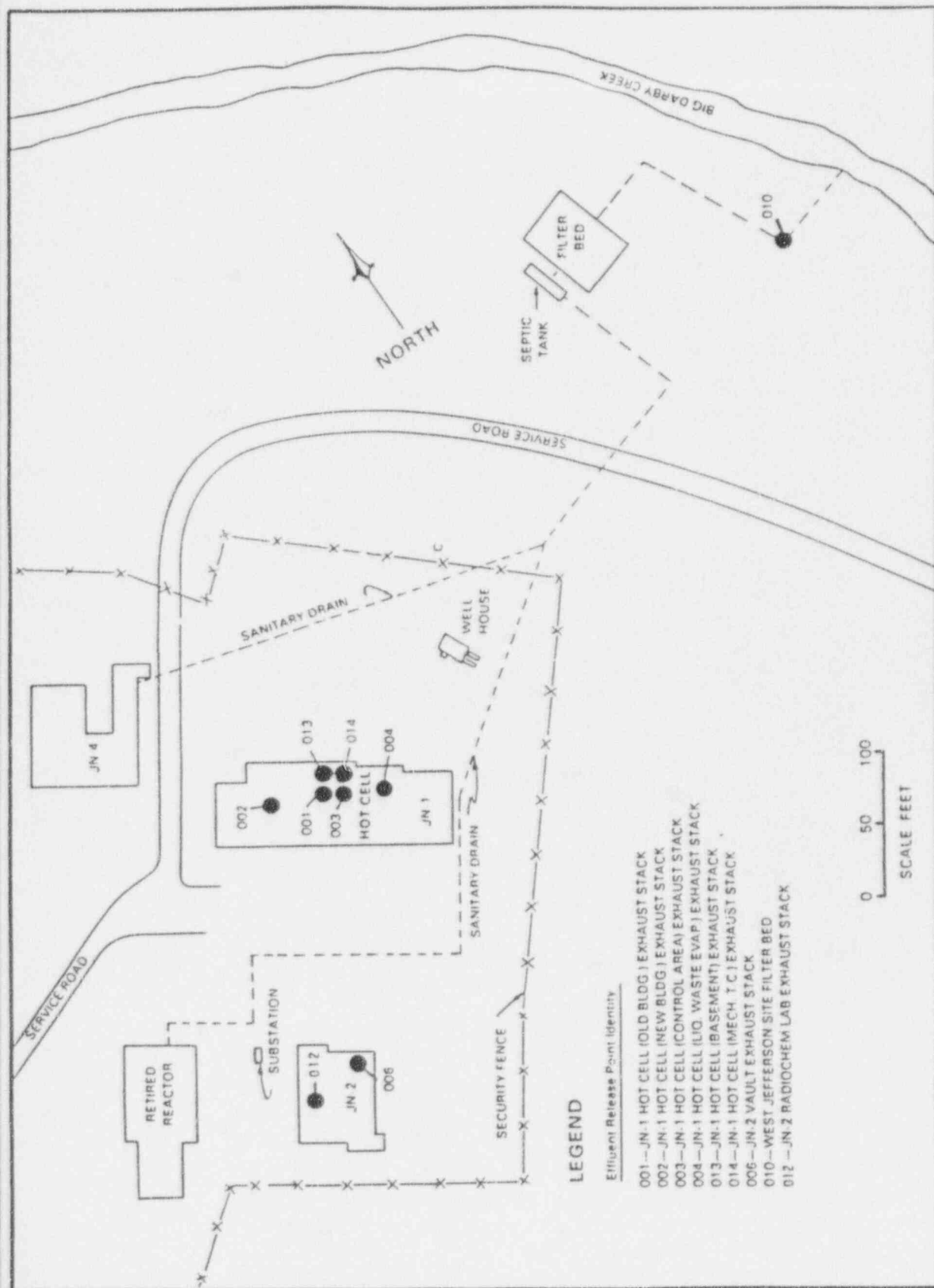


FIGURE 5. NUCLEAR SCIENCES AREA WEST JEFFERSON SITE

The King Avenue Site

The former U-235 handling facility is located in Building 3 of the King Avenue site. This facility was constructed in the mid-1950s. It served until the late 1960s as an exclusion area specifically designed for the control and storage of unirradiated enriched uranium utilized on various government and industrial R&D programs. Presently Building 3 is used for several activities, including waste storage and characterization. Access to the U-235 area is limited and entry doors to the area are locked. A vault was used for the temporary storage of limited quantities of unirradiated enriched uranium. The U-235 area also served as a receipt and shipping, sampling, and measurement area for shipments of source materials and small quantities of unirradiated uranium that had been used on programs performed at the King Avenue site.

The West Jefferson Site

Figure 5 shows the location of the four principal buildings at the West Jefferson Nuclear Sciences area: JN-1, the Hot Cell Laboratory; JN-2, the Administrative Building; JN-3, a retired Research Reactor; and JN-4, the Hazardous Material Research Facility (Decommissioned Plutonium Laboratory). Each of these facilities is described in the following paragraphs.

Hot Cell Laboratory, JN-1

This laboratory contains approximately 22,000 square feet of space. 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
- Postirradiation 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 and connecting pool, five smaller cells, and supporting facilities. The high-energy cell and pool are capable of handling complete power reactor fuel assemblies. The smaller cells are the high-level and low-level cells, the two mechanical test cells, and a segmented alpha gamma cell. The support 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 surveillance and maintenance while awaiting decommissioning.

Administrative Building, JN-2

This building was designed and constructed for use as a critical assembly laboratory. It was used for critical experiments from 1957 through 1963. Since the cessation of critical experiments, the facility has been used for several nuclear-related projects, including direct conversion concepts, irradiation experiment assembly, and special nuclear materials handling. The operating license was terminated by Battelle in 1970 when project work was ended. These activities have made it necessary to maintain it on the S&M schedule.

Offices and small laboratories are used by nuclear supporting services staff including Environmental Monitoring, Quality Assurance, Instrument Maintenance, and a Radio-analytical Laboratory for the assay of routine health physics and environmental samples. These activities are the major building activities at this time. The building also currently houses a vault for storage of special nuclear materials.

Retired Battelle Research Reactor, JN-3

The Battelle Research Reactor began operations October 29, 1956. Operations were terminated on December 31, 1974, and dismantling was initiated. The dismantling was completed without incident during 1975 and the license changed to a possession only status. Storage of waste awaiting shipment for burial is the only licensed activity conducted in JN-3 at this time.

Decommissioned Plutonium Laboratory, JN-4

Building JN-4 was built in 1960 to house activities in plutonium research and processing. These operations were terminated in 1978 and dismantling of the laboratory portion was completed in 1985. A hazardous materials research facility now operates in JN-4. The current activities involve nonradioactive materials only.

Compliance Summary

Calendar Year 1993

The 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 1993 or the first quarter (January 1 through March 3) of 1994. No lawsuits by regulatory agencies or citizen suits were brought against Battelle, and there were no BCLDP compliance issues in 1993 or the first quarter of 1994. There were no unresolved BCLDP compliance issues during 1992 that needed to be addressed in 1993. If there are any unresolved compliance issues in 1993, they will be addressed in the 1994 *Site Environmental Report*.

Compliance Status in Specific Regulatory Areas

Comprehensive Environmental Response, Compensation and Liability Act (CERCLA)

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

Resource Conservation and Recovery Act (RCRA)

No violations have occurred and no enforcement actions were taken in connection with the BCLDP. RCRA compliance is the responsibility of Battelle's corporate operations. DOE has liability only for radioactive issues; and thus only for those hazardous wastes which have collateral radioactivity. Battelle's permitted storage facilities are utilized by BCLDP as necessary to maintain cost-effective packaging and shipping operations. Waste operations for Battelle's corporate operations are currently conducted under Ohio Hazardous Waste Facility Installation and Operation Permit and further considered in Battelle's Part B permit

application for continued waste operations. The Part B permit applies only to Battelle corporate operations and not to the BCLDP related activities that are conducted at Battelle.

Battelle's Part B application for continued waste operations was reviewed by the Ohio EPA and found to be technically complete and adequate. The application was forwarded to the agency that actually issues the permit (i.e., the Hazardous Waste Facility Board or HWFB) for review. HWFB conducted a public hearing to solicit comments from the public. No one gave oral testimony at the hearing. A Siting Criteria Document was prepared for the HWFB. In response to HWFB's review of the Siting Criteria Document and the Part B application, Battelle provided answers to approximately 335 interrogatories and public hearing comments and questions. Ohio EPA issued a public notice on the issuance of a draft RCRA Hazardous Waste Installation & Operation Facility Permit allowing continued waste operations until the waste management building is renovated to meet the Part B requirements. A public notice was also issued for the draft Federal RCRA Hazardous & Solid Waste Amendments of 1984 (HSWA) permit. This notice raised considerable interest with some of Battelle's neighbors near the King Avenue site and one environmental citizens group. After four (4) extensions of the public comment period, it is expected that Battelle will receive the Ohio EPA permit by mid-1994 and the corrective action permit will be issued with the Part B permit by mid-1994.

Battelle has conducted tours of the current and proposed hazardous waste facility for various neighborhood groups, the media and government representatives. Several civic association meetings have also been attended by Battelle representatives to give presentations and answer questions.

National Environmental Policy Act (NEPA)

Activities performed during this period were consistent with the existing Environmental Assessment and Finding of No Significant Impact (FONSI) issued in 1990.

Clean Air Act (CAA)

Requirements under the act, including the National Emissions Standards for Hazardous Air Pollutants (NESHAPS), were met and no citations were issued.

Clean Water Act (CWA)

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

Safe Drinking Water Act (SDWA)

Battelle had one positive total coliform test on drinking water at the north well house at the West Jefferson North site. Six (6) subsequent samples, as required by the OEPA regulations, were tested and were all negative. The West Jefferson employees were notified of this exceedance as required. There was no impact on the environment from the exceedance and there was no further enforcement action.

Toxic Substances Control Act (TSCA)

No violations have occurred and no enforcement actions were taken in connection with the BCLDP. PCB wastes were properly stored and removed within regulatory limits.

Superfund Amendments and Reauthorization Act (SARA) Title III

This act is not applicable to the BCLDP; however, 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. Pesticides are not used in BCLDP activities.

Endangered Species Act (ESA)

No endangered species have been identified in the areas around Battelle's King Avenue facility. At the West Jefferson Site, no additional species have been identified in 1993.

Federal Wild and Scenic Rivers Act

The Big Darby Creek has been designated as a component of the National Wild and Scenic River System. Additionally, the State of Ohio proposes to restrict new construction activities within a 150-foot buffer zone along both sides of Big Darby Creek. At the present time, the BCLDP activities would not be subject to these requirements unless they affect the free-flowing nature of the Big Darby Creek. There may be additional state or local requirements in the future.

National Historic Preservation Act (NHPA)

Several lots located on the east and southeast portions of the Battelle King Avenue site, as well as one small apartment building located on the south-central portion of the site, are considered to be within the boundaries of the Near Northside Historic District. These areas are subject to provisions in 36 CFR 800 and 36 CFR 636. 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. Several buildings on the King Avenue site are located in the 100-year floodplain of the Olentangy River. The Battelle facilities are separated from the river by a levee, the crest of which is above the 100-year flood level. Battelle is working with the Federal

Emergency Management Agency to certify the adequacy of the levee and thereby to reclassify the location of the facilities as not in the floodplain. Since BCLDP activities during this period incurred no adverse impacts associated with the occupancy, modification, or development of these floodplains, this order had no applicability to the project.

Executive Order 11990 "Protection of Wetlands"

This order is not applicable. Wetlands have not been identified at BCLDP sites.

Environmental Permits

Battelle prepared and submitted to the Ohio EPA, applications for a Permit to Install/Permit to Operate for air emissions at the King Avenue Site. Several of the air emission sources are associated with BCLDP activities. Preparation of a permit application for the West Jefferson site was initiated.

List of Environmental Permits

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

Columbus Laboratory

a. Air (PTO: Permit to Operate)

1. Building 3 - Beryllium lab hood, PTO #0125040520/P001
2. Building 5 - Beryllium Machine Shop, PTO #0125040520/P002

b. Water

NPDES permits for King Avenue are not associated with BCLDP operations.

c. Hazardous Waste

1. Ohio Hazardous Waste Facility Installation and Operation Permit #01-25-0572
2. US EPA interim status - Part A and PCB notification OHD007901598

3. Public Utilities Commission of Ohio (PUCO) Hazardous Waste Transporter Registration - 310-HW, Annual Stamp No. 005531
4. Public Utilities Commission of Ohio (PUCO) Hazardous Materials Carrier Registration, Ohio Motor Carrier (OMC#) 018903
5. U.S. DOT Hazardous Materials Certificate of Registration, No. 05 2493 004 024B
6. Tennessee Delivery License No. T-OH004-L94

West Jefferson Laboratory

a. Air

1. Building JN-1 Boilers - 0149000074/B001, on registration status with Ohio EPA
2. Building JN-2 Boiler - 0149000077/B002, on registration status with Ohio EPA
3. JN-1 underground storage tank - PTI # 0149000077/T001, on registration status with Ohio EPA
4. Building JN-3 Boiler #0149000074/B003, on registration status with Ohio EPA

b. Water

1. NPDES Permit 4IN00004*DD
2. Ohio EPA License to Operate or Maintain a Public Water System, PWSID: 4930212

c. Hazardous Waste

1. Hazardous waste generator identification number - OHT400013892
2. Public Utilities Commission of Ohio (PUCO) Hazardous Materials Carrier Registration, Ohio Motor Carrier (OMC#) 018903
3. U.S. DOT Hazardous Materials Certificate of Registration, No. 05 2493 004 024B
4. Tennessee Delivery License No. T-OH004-L94

Environmental Program Information

The Battelle Columbus Laboratories Decommissioning Project (BCLDP) has an environmental program that consists of an environmental monitoring program, environmental compliance awareness and evaluation activities, and programs for waste minimization and pollution prevention.

There is a Waste Minimization and Pollution Prevention Plan for the BCLDP. The plan addresses only the minimization of radioactive waste, because the program involves only D&D of existing contaminated (or radioactive) facilities. No other operations or activities generate significant quantities of waste (other than paper, which is recycled) that could be effectively minimized. The BCLDP Waste Manager is responsible for the annual review and updating of the Waste Minimization and Pollution Prevention Plan. Waste minimization is also included in the Waste Quality Assurance (QA) Plan, Low-Level Waste (LLW) Certification Plan, Transuranic (TRU) Waste Certification Plan, and D&D Work Plans.

A program for training employees in pollution prevention awareness is in place. The BCLDP Program Manager has issued a copy of DOE's Environmental Policy Statement, and specific instructions for compliance, to all persons involved in BCLDP operations. Pollution prevention training and awareness are addressed in the Waste Minimization and Pollution Prevention Plan and pollution prevention is also included in the support/commitment and policy statements of this plan.

The BCLDP Emergency Management Plan and associated procedures support an effective emergency preparedness program that: (1) has clearly defined command and control authorities, and (2) is compatible with other Battelle Columbus emergency management programs. The Safety, Health and Environmental Support (SH&ES) Manager for the BCLDP is delegated the responsibility and the authority from the Office of the Battelle Chief Executive Officer (CEO), through the Program Manager for the BCLDP, to maintain the emergency response capability for all BCLDP areas.

Emergency Operations Centers (EOCs) equipped with telephones, area maps, status boards, and other supplies are located at both the King Avenue and West Jefferson sites. Communications capabilities and notification pathways are well organized internally to facilitate notification of off-site responders and authorities, as well as Battelle senior management. Battelle is committed to using its expertise to support and protect off-site responders and the environment from site hazards during an emergency.

General training on emergency procedures is provided to employees including management, subcontractor personnel, and off-site responders. Training takes many forms, including briefings, mini-drills, table-top exercises, coached drills, and full-scale exercises. As part of the emergency preparedness program, the BCLDP sponsored an integrated emergency exercise at its West Jefferson facility on August 8, 1993. Those participating in this emergency drill included The Ohio State University Medical Center, Jefferson Township Fire Department, and local law enforcement agencies.

The impact of operations on the health and safety of the public is evaluated routinely by an environmental monitoring program that has been in effect since 1955. The basic objective of the environmental monitoring program is to evaluate the effectiveness of the waste management program including effluent releases at both sites. Concentrations of radioactive and nonradioactive wastes are controlled so that effluent levels are maintained as low as reasonably achievable and well within applicable standards. Effluents involving potentially polluting materials are contained within the operating facilities to the extent possible and are disposed of as packaged wastes by authorized services.

Environmental monitoring under the BCLDP is limited by the nature of the S&M and D&D activities. With few exceptions, only radiological monitoring is being performed routinely under S&M. D&D operations include radiological precharacterization and characterization of facilities, equipment removal, decontamination of facilities, and disposal of waste. Nonradiological monitoring performed in connection with the BCLDP is presented in a separate section following the section pertaining to radiological monitoring.

The BCLDP continued to implement a formal environmental oversight program during 1993. The oversight group consists of ES&H staff at Battelle whose mission is to independently verify that the BCLDP programs for environmental compliance and environmental monitoring meet Federal, State, and local environmental requirements. The oversight group assists in compliance by providing technical support in evaluating applicability of requirements and conducting independent assessments and surveillances of on-going activities.

Environmental Radiological Monitoring

West Jefferson Site

An inventory of suspected radionuclides and effluents for air and water is presented in Table 3. Both inventories are based on minimum detectable levels (MDL) of listed isotopes. Weekly samples are screened for possible elevated levels of radioactivity by counting for gross α (alpha) and gross β - γ (beta-gamma). Weekly samples are composited into monthly and quarterly samples for isotopic analysis. For radionuclide concentrations that are too low to be measurable, the minimum detectable levels are assumed to be positive releases. This is performed as a conservative measure for purposes of establishing a release inventory and estimating maximum possible doses to the public.

Air Monitoring

In-stack air samplers continuously monitor the exhaust stack effluent release from the major source contributors (i.e., JN-1, JN-2) to assess the effectiveness of systems controlling airborne emissions. Eight continuous stack monitors ensure detection of any inadvertent release of radioactive materials and provide data for the prompt assessment of the environmental impact, if any (see Figure 5 for location). Particulate samples of the effluent are collected from each exhaust stack. The particulate samples are collected on Type AE glass fiber filter paper. The air is sampled at an average rate of 2.85×10^4 cc/min. The filters are changed weekly, which represents an average sample volume of 287 m^3 . This volume was selected to facilitate statistical calculations for activity concentrations that are well below regulatory standards.

Analyses are performed on filters on a weekly basis for gross α and gross β for stacks 001 through 004, 006, 012, 013, and 014. The results are summarized in Table 4. The cumulative average concentration of the α and β mixture emitted from the stacks was many orders of magnitude below the derived concentration guide (DCG) value at the site boundary. These filters are composited on a monthly basis for gamma analysis and on a

TABLE 3. ANNUAL RADIONUCLIDE INVENTORY^(a)
WEST JEFFERSON SITE — 1993

Air	Activity (μ Ci)	Activity (g)
Co-57	2.10	--
Co-60	5.60	--
Sr-90	0.02	--
Sb-125	12.96	--
Cs-134	4.48	--
Cs-137	5.20	--
Eu-152	19.04	--
Eu-154	4.35	--
U-235	21.86	1.02E+03
U-238	247.10	7.42E+02
Pu-238	0.02	--
Pu-239	0.01	--
Am-241	15.94	--
Water	Activity (μ Ci)	Activity (g)
Co-57	216.4	--
Co-60	360.6	--
Sr-90	18.5	--
Sb-125	757.4	--
Cs-134	216.9	--
Cs-137	282.8	--
Eu-152	636.5	--
Eu-154	420.2	--
Ra-226	27.3	--
Ra-228	30.8	--
I-129	162.3	--
U-235	59.98	2.80E+03
U-238	59.98	1.80E+02
Pu-238	6.8	--
Pu-239	3.2	--
Am-241	59.98	--

(a) Inventory is made up of suspected radionuclides and effluents for air and water, based on MDL values. See Tables 5 and 7 for details of West Jefferson site air and water discharge.

**TABLE 4. SUMMARY OF ATMOSPHERIC RADIOACTIVE EMISSIONS
WEST JEFFERSON SITE -- 1993**

Species	Stack Locations	Number of Stack Samples	Stack Volume 10^{10} l/yr	Activity $\mu\text{Ci/yr}$	Stack 10^{-14} $\mu\text{Ci/ml}$	Site Boundary ^(a) 10^{-20} $\mu\text{Ci/ml}$
Gross α	001	52	2.5	0.04	0.16 ± 0.09	0.52 ± 0.32
Gross β	001	52	2.5	0.20	0.79 ± 0.15	2.68 ± 0.51
Gross α	002	52	11.1	0.10	0.09 ± 0.05	0.31 ± 0.18
Gross β	002	52	11.1	0.39	0.35 ± 0.08	1.21 ± 0.27
Gross α	003	52	4.62	0.03	0.06 ± 0.05	0.20 ± 0.16
Gross β	003	52	4.62	0.15	0.33 ± 0.08	1.13 ± 0.27
Gross α	004	52	0.84	0.01	0.12 ± 0.06	0.41 ± 0.20
Gross β	004	52	0.84	0.08	0.95 ± 0.10	3.25 ± 0.35
Gross α	013	52	0.76	0.01	0.13 ± 0.05	0.45 ± 0.17
Gross β	013	52	0.76	0.02	0.26 ± 0.08	0.90 ± 0.26
Gross α	014	52	1.84	0.01	0.05 ± 0.05	0.18 ± 0.17
Gross β	014	52	1.84	0.07	0.38 ± 0.08	1.29 ± 0.27
Gross α	012	52	0.25	0.02	0.80 ± 0.05	2.73 ± 0.17
Gross β	012	52	0.25	0.09	3.60 ± 0.08	12.28 ± 0.26
Gross α	006	52	0.38	0.003	0.08 ± 0.05	0.26 ± 0.17
Gross β	006	52	0.38	0.02	0.53 ± 0.09	1.79 ± 0.31

(a) Site boundary concentrations were calculated by multiplying stack concentrations by the atmospheric dispersion parameter (3.41×10^{-6}) computed for the site boundary using computer code CAP88-PC.

quarterly basis for radiochemical analysis. Gamma spectrometric analyses were performed using an intrinsic germanium detector coupled to a Nuclear Data Model ND66 multichannel analyzer. The concentrations of the radionuclides identified were at least 20,000 times less than the applicable DCG values at the site boundary (Table 5). The results reported represent total annual average concentration at specific stacks. The site boundary concentrations (see Tables 4 and 5) for the various exhaust stack locations were calculated by multiplying the individual stack concentrations by the atmospheric dispersion parameter computed using the atmospheric dispersion model incorporated in computer code CAP88-PC (see reference 11).

Supplementary air sampling was performed at four site perimeter locations during 1993 (Figure 6). These air samples were collected continuously and analyzed on a weekly basis for gross α and β activities. Quarterly composite air samples from the four site boundary locations were analyzed for Pu-238, Pu-239, Sr-90, natural-U, and gamma-emitting radionuclides (Table 6).

Water Monitoring

A sanitary sewage system, which is operated in accordance with State of Ohio regulations under NPDES Permit 41N00004*DD, handles all sanitary sewerage 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-foot contained sand and gravel filter bed (Figure 5). From the filter bed the effluent goes to a chlorinating system prior to release to Big Darby Creek.

A continuous water sampling system is used to sample sanitary liquid effluents from the Nuclear Sciences Area to Big Darby Creek after discharge from the chlorinating system. The effluent samples are analyzed weekly for gross α and β activity in suspended and dissolved fractions. Any sample exceeding $3 \times 10^{-8} \mu\text{Ci/ml}$ receives a supplementary gamma isotopic analysis and/or an alpha spectrometric analysis as appropriate. The weekly samples are held, composited, and subjected to gamma spectrometric analyses as well as specific analyses for Pu-238, Pu-239, I-129, Sr-90, Ra-226, and Ra-228 at the end of each month. The concentrations of gross α and gross β activity in suspended and dissolved fractions as

TABLE 5. SUMMARY OF SPECIFIC RADIONUCLIDES FROM
STACK EMISSIONS — WEST JEFFERSON SITE — 1993

Species	Activity $\mu\text{Ci/yr}$	Site Boundary ($\times 10^{-20}$) $\mu\text{Ci/ml}$	Derived Concentration Guide Limit $\mu\text{Ci/ml}$	Percent of DCG at the Site Boundary
Co-57	2.10	20.8	2E-09	1.04E-08
Co-60	5.60	65.7	8E-11	8.21E-07
Sr-90	0.02	0.21	9E-12	2.33E-08
Sb-125	12.96	122	1E-09	1.22E-07
Cs-134	4.48	46.5	2E-10	2.33E-07
Cs-137	5.20	55.7	4E-10	1.39E-07
Eu-152	19.05	196	5E-11	3.91E-06
Eu-154	4.35	46.2	5E-11	9.24E-07
U-235	21.86 (1.02E03 g/yr)	223 (1.04E-16 g/ml)	1E-13 (4.67E-12 g/ml)	2.23E-03
U-238	247.1 ((7.41E02 g/yr)	2270 (6.81E-17 g/ml)	3E-14 (9.00E-14 g/ml)	7.56E-02
Pu-238	0.02	0.18	3E-14	5.92E-06
Pu-239	0.01	0.06	2E-14	3.18E-06
Am-241	15.94	151	2E-14	7.54E-03

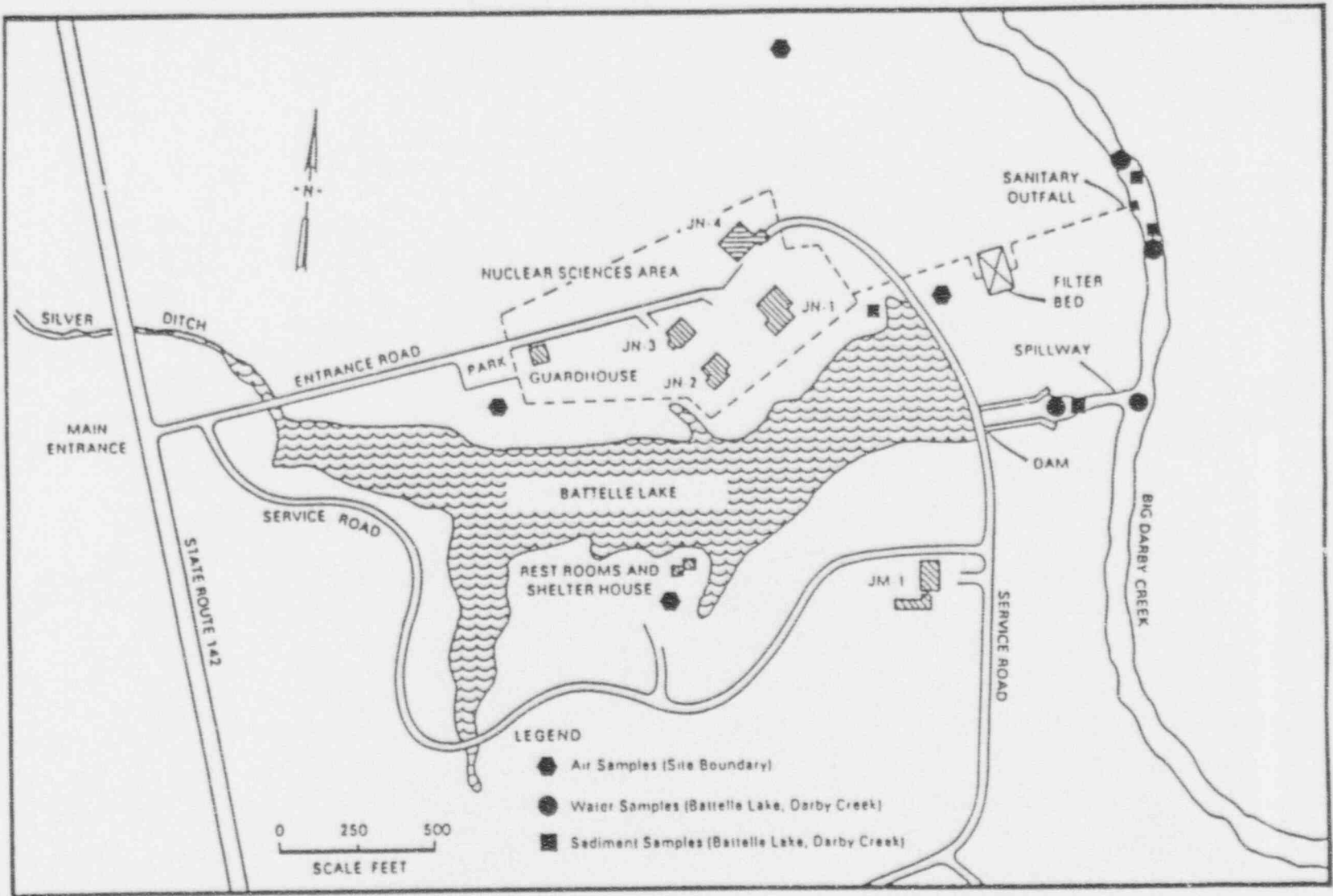


FIGURE 6. MAP OF SITE BOUNDARY AIR SAMPLING LOCATIONS AND BATTELLE LAKE AND BIG DARBY CREEK WATER AND SEDIMENT SAMPLING LOCATIONS

TABLE 6. SUMMARY OF SITE BOUNDARY AIR SAMPLE ANALYSES
WEST JEFFERSON SITE — 1993^(a)

Nuclide	10 ⁻¹⁵ μCi/ml ^(b)			
	North	East	South	West
Gross α	1.28 ± 0.51	1.19 ± 0.50	1.37 ± 0.54	1.33 ± 0.54
Gross β	12.0 ± 1.07	12.7 ± 1.12	13.5 ± 1.16	14.4 ± 1.19
Co-57	< 1.99	< 0.34	< 0.38	< 0.29
Co-60	< 1.81	< 0.72	< 0.62	< 0.51
Sr-90 ^(c)	< 0.06	< 0.05	< 0.05	< 0.05
Sb-125	< 3.05	< 1.57	< 1.46	< 1.14
Cs-134	< 1.36	< 0.43	< 0.58	< 0.41
Cs-137	< 1.94	< 0.69	< 0.61	< 0.50
Eu-152	< 4.62	< 0.86	< 0.94	< 0.73
Eu-154	< 3.18	< 0.59	< 0.65	< 0.50
U-235 (μg/ml)	< 9.39 < 4.39E-07	< 1.89 < 8.83E-08	< 1.18 < 5.51E-08	< 1.53 < 7.15E-08
U-238 (μg/ml)	< 1150.0 ^(d) < 3.45E-06	< 62.3 < 1.87E-07	< 181.0 < 5.43E-07	< 39.6 < 1.19E-07
Pu-238 ^(c)	< 0.007	< 0.01	< 0.009	< 0.008
Pu-239 ^(c)	< 0.003	< 0.004	< 0.003	< 0.003
Am-241	< 5.64	< 0.68	< 1.92	< 0.67
Nat-U (μg/ml)	0.04 5.91E-11	0.04 5.91E-11	0.04 5.91E-11	0.04 5.91E-11

- (a) Locations are shown in Figure 6. North Quadrant Station (137.2 m north of JN-4 stacks); East Quadrant Station (21.9 m east of JN-1 stacks); South Quadrant Station (228.6 m south of JN-2 stacks); West Quadrant Station (121.9 m west of JN-2 stacks).
- (b) All isotopic values represent average MDL values (a posteriori). U-235, U-238, and Am-241 associated γ produce higher values than gross α and β results would indicate. Gross α MDL is 3.0×10^{-16} μCi/ml and gross β MDL is 6.0×10^{-16} μCi/ml (a priori).
- (c) Detection limit is $4.66 \times$ standard deviation of the background, divided by the efficiency, assuming a 50% recovery of the spike and a flow volume of $2.7 \text{ E}+9$ ml.
- (d) The isotopic value is the result of an isolated higher MDA for the first quarter of analysis. The annual gross α of 1.28×10^{-15} μCi/ml best reflects the true value for this parameter.

well as the concentrations of specific radionuclides identified in the sample are summarized in Table 7. In most cases, the activity in the samples has been due to a mixture of nuclides.

The noncommunity drinking water supply at the West Jefferson site is exempt from radiological monitoring per OEPA review.⁽⁶⁾ However, weekly drinking water samples are collected from a tap at the Nuclear Sciences Area to verify compliance with applicable water quality standards for radioactivity in drinking water. The weekly drinking water samples are composited and analyzed monthly for gross α and β activity in suspended and dissolved fractions. Any sample exceeding $1.5 \times 10^{-5} \mu\text{Ci/ml}$ for gross α activity receives a supplementary gamma isotopic analysis and/or an alpha spectrometric analysis as appropriate. In 1993, the average concentrations of gross α were $(3.35 \pm 2.63) \times 10^{-6} \mu\text{Ci/ml}$ (soluble) and $(0.13 \pm 0.30) \times 10^{-6} \mu\text{Ci/ml}$ (insoluble) for a total concentration of gross α of $(3.48 \pm 5.30) \times 10^{-6} \mu\text{Ci/ml}$. The average concentrations of gross β were $(2.05 \pm 0.77) \times 10^{-6} \mu\text{Ci/ml}$ (soluble) and $(0.49 \pm 0.44) \times 10^{-6} \mu\text{Ci/ml}$ (insoluble) for a total concentration of gross β of $(2.54 \pm 1.78) \times 10^{-6} \mu\text{Ci/ml}$. The values are listed in Table 8. The average total gross α activity represents about 23 percent of the EPA standard of $1.5 \times 10^{-5} \mu\text{Ci/ml}$ for gross α particulate activity in drinking water.

Supplementary water samples are collected weekly at sampling points located 18.3 m above and 18.3 m below the sanitary drain outfall at Big Darby Creek. Water samples are also collected weekly below the Battelle Lake dam and at the drain spillway at Big Darby Creek (Figure 6). The supplementary water samples are analyzed monthly for mixed α and β activity. The average concentrations of total activity in the downstream water samples and below the dam water samples were less than $3.66 \times 10^{-9} \mu\text{Ci/ml}$ for α and less than $6.20 \times 10^{-9} \mu\text{Ci/ml}$ for β activity and showed no significant difference from the upstream control sample (Table 9). These findings show that liquid effluent releases from the site to Big Darby Creek do not exceed background levels of radioactivity already present in Big Darby Creek.

TABLE 7. SUMMARY OF LIQUID RADIOACTIVE EMISSIONS
WEST JEFFERSON SITE^(a) — 1993

Species	Number of Samples	Activity, $\mu\text{Ci}/\text{yr}^{(b)}$	Average Concentration, $\mu\text{Ci}/\text{ml}$	DCG, $\mu\text{Ci}/\text{ml}$	Percentage of DCG, %
Gross α	52	--	$(2.87 \pm 2.55) \times 10^{-9}$	--	-- ^(c)
Gross β	52	--	$(8.04 \pm 1.66) \times 10^{-9}$	--	--
Co-57	12	216.4	1.04×10^{-8}	1.0×10^{-4}	0.01
Co-60	12	360.6	1.73×10^{-8}	5.0×10^{-6}	0.35
Sr-90	12	18.5	8.83×10^{-10}	1.0×10^{-6}	0.09
Sb-125	12	757.4	3.62×10^{-8}	5.0×10^{-5}	0.07
Cs-134	12	216.9	1.04×10^{-8}	2.0×10^{-6}	0.52
Cs-137	12	282.8	1.35×10^{-8}	3.0×10^{-6}	0.45
Eu-152	12	636.5	3.05×10^{-8}	2.0×10^{-5}	0.15
Eu-154	12	420.2	2.01×10^{-8}	2.0×10^{-5}	0.10
Ra-226	12	27.3	1.31×10^{-9}	1.0×10^{-7}	1.31
Ra-228	12	30.8	1.48×10^{-9}	1.0×10^{-7}	1.48
I-129	12	162.3	7.77×10^{-9}	5.0×10^{-7}	1.55
U-235 ($\mu\text{l}/\text{ml}$)	12	59.98 $2.8 \times 10^3 \text{ g}/\text{yr}$	2.86×10^{-9} 1.34×10^{-1}	6.0×10^{-7} 28.0×10^1	0.47
U-238 ($\mu\text{g}/\text{ml}$)	12	59.98 $1.8 \times 10^2 \text{ g}/\text{yr}$	2.86×10^{-9} 8.59×10^{-3}	6.0×10^{-7} 1.8×10^1	0.47 ^(d)
Pu-238	12	6.8	3.23×10^{-10}	4.0×10^{-8}	0.81
Pu-239	12	3.2	1.52×10^{-10}	3.0×10^{-8}	0.51
Am-241	12	59.98	2.86×10^{-9}	3.0×10^{-8}	9.53 ^(d)
Nat-U ($\mu\text{g}/\text{ml}$)	4	23.2 $3.4 \times 10^1 \text{ g}/\text{yr}$	1.11×10^{-9} 1.64×10^{-3}	6.0×10^{-7} 8.9×10^{-1}	0.19

- (a) Annual average flow in Big Darby Creek; $429 \text{ cu ft}/\text{sec} = 3.82 \times 10^{11} \text{ l}/\text{yr}$. Total volume of liquid effluent discharge for 1993 = $2.09 \times 10^7 \text{ l}$. See Figure 5 for sample location 010.
- (b) 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 MDL values (a posteriori) 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% of α activity.
- (c) No DCG listing for mixture of gross α and β . Value represents percent of total activity using 10 CFR Part 20, Appendix B limit (3×10^{-8}) for mixture, not containing Sr-90, I-129, Ra-226, and Ra-228.
- (d) As discussed in the text, these values are calculated from MDL values.

TABLE 8. SUMMARY OF ALPHA/BETA RADIOLOGICAL ANALYSES OF DRINKING WATER SAMPLES WEST JEFFERSON/KING AVENUE SITES — 1993

West Jefferson	Activity ($\mu\text{Ci/ml}$)	Activity ($\mu\text{g/ml}$)
Gross α	$(3.48 \pm 5.30) \times 10^{-6}$	
Gross β	$(2.54 \pm 1.78) \times 10^{-6}$	
Co-57	2.58E-09	
Co-60	2.85E-09	
Sb-125	7.07E-09	
Cs-134	2.56E-09	
Cs-137	2.58E-09	
Eu-152	5.20E-09	
Eu-154	3.74E-09	
U-235	3.09E-09	1.44E-01
U-238	3.78E-08	1.14E-01
Am-241	9.12E-09	
Pu-238 ^(a)	3.57E-10	
Pu-239 ^(a)	2.19E-10	
Ra-226 ^(a)	7.54E-10	
Ra-228 ^(a)	2.31E-09	
Sr-90 ^(a)	2.15E-09	
Nat-U ^(a)	*3.96E-10	5.85E-04
King Avenue	Activity ($\mu\text{Ci/ml}$)	Activity ($\mu\text{g/ml}$)
Gross α	$(1.28 \pm 2.82) \times 10^{-6}$	
Gross β	$(4.55 \pm 1.84) \times 10^{-6}$	
Co-57	1.53E-09	
Co-60	1.81E-09	
Sb-125	4.87E-09	
Cs-134	1.72E-09	
Cs-137	1.91E-09	
Eu-152	4.15E-09	
Eu-154	2.91E-09	
U-235	2.97E-09	1.39E-01
U-238	3.56E-08	1.07E-01
Am-241	3.67E-09	
Th-228	3.49E-10	
Th-230	3.93E-10	
Th-232	3.51E-10	
Nat-U ^(a)	9.50E-11	1.40E-04

All values are actual MDAs unless otherwise indicated (*)
(a) Denotes analysis on annual composite only.

**TABLE 9. SUMMARY OF RADIOLOGICAL ANALYSES
OF ENVIRONMENTAL WATER SAMPLES
WEST JEFFERSON SITE — 1993**

Location ^(a) (Direction and Distance from Nuclear Sciences Area)	Number of Samples ^(b)	10 ⁻⁹ μCi/ml ^(c)	
		Gross α	Gross β
Big Darby Creek Upstream (18.3 m above sanitary outfall)	12	4.08 ± 4.90	5.99 ± 2.06
Big Darby Creek Downstream (18.3 m below sanitary outfall)	12	3.66 ± 4.80	6.20 ± 2.10
Big Darby Creek Downstream (186.3 m below sanitary outfall)	12	3.19 ± 4.28	5.69 ± 2.02
Battelle Lake Spillway (18.3 m below dam)	12	2.40 ± 3.62	5.58 ± 1.96

(a) Locations are shown in Figure 6.

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

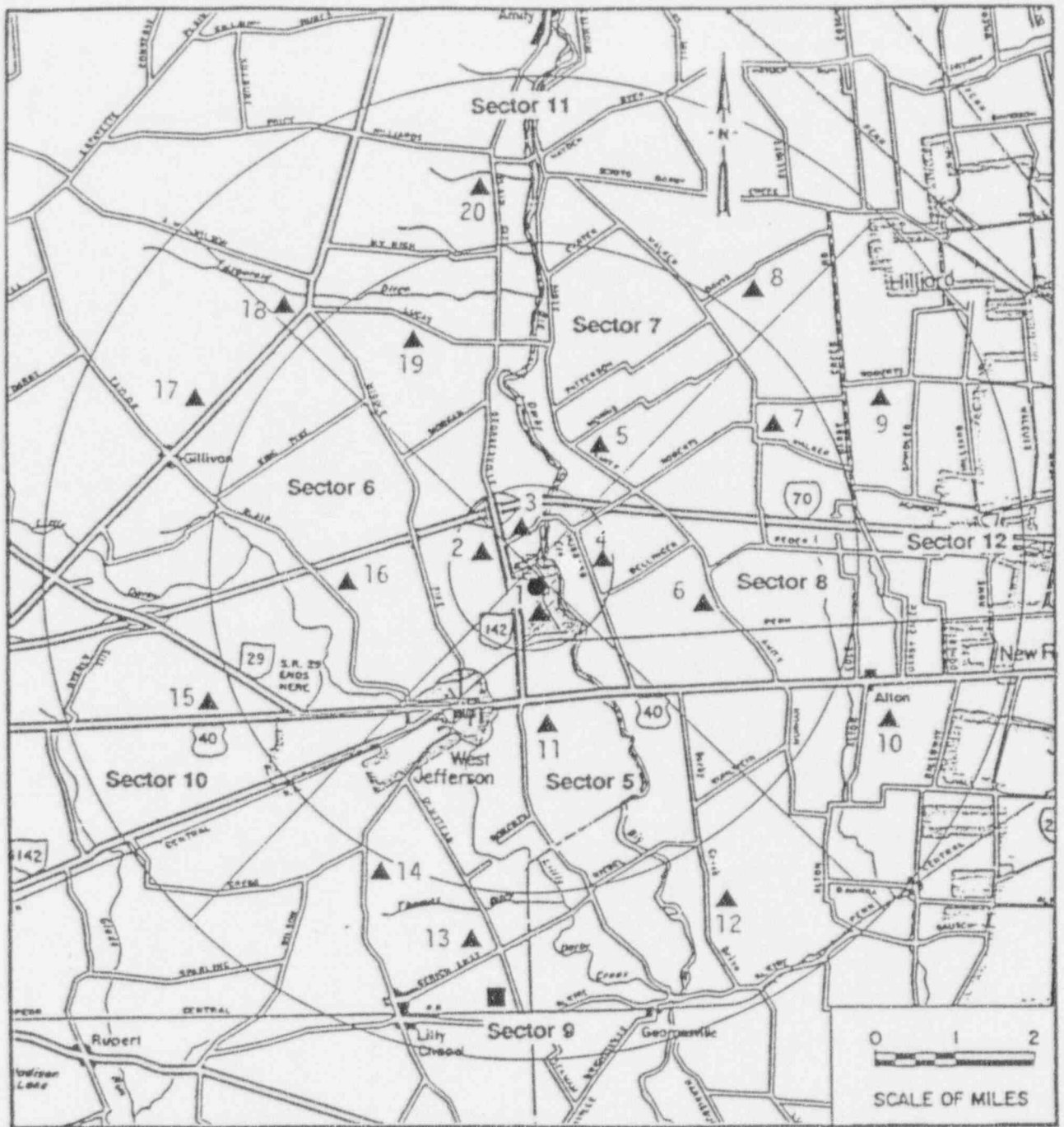
(c) A priori minimum detection limit for gross α is 6.5 x 10⁻⁹ μCi/ml and 4.8 x 10⁻⁹ μCi/ml for gross β.

Grass and Field Crops

Grass and field crop samples are collected 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 are chosen at maximum deposition locations predicted by meteorological studies. Grass and field crop (soybean or field corn) samples are collected at varying distances and directions within a 6-mile (9.6-km) radius of the Nuclear Sciences Area as shown in Figure 7. Sampling locations falling within the same sector are composited. The samples are analyzed for Pu-238, Pu-239, Sr-90, and natural-U. A qualitative analysis by gamma scan is also performed. The results of the grass and field crop analyses are summarized in Tables 10 and 11. In both the grass and field crops, the levels of Pu-238, Pu-239, and Sr-90 were at or below the minimum detectable level or not statistically significant for each isotope.

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 is 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. A gamma isotopic and Pu-238, Pu-239, Sr-90, and natural-U analyses were performed. The results of the analyses are shown in Table 12. A comparison of sample locations shows that there were no statistically significant radionuclides detected in either sample location. Therefore, there is no impact to the on-site garden.



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

FIGURE 7. MAP OF GRASS, FIELD CROP, AND SOIL SAMPLING LOCATIONS

TABLE 10. SUMMARY OF RADIOLOGICAL ANALYSES OF GRASS — WEST JEFFERSON SITE — 1993

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

Nuclide	Identification No. ^(a)											
	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	0.03	0.06	0.09	0.11	0.08	0.05	0.10	0.07	0.07	0.05	0.08	0.05
Co-60	0.05	0.12	0.16	0.22	0.16	0.09	0.19	0.11	0.13	0.11	0.15	0.11
Sr-90	0.55	0.51	0.62	0.56	0.53	0.53	0.50	0.48	0.46	0.57	0.55	0.56
Sb-125	0.13	0.29	0.44	0.50	0.37	0.23	0.44	0.31	0.33	0.25	0.37	0.24
Cs-134	0.05	0.11	0.14	0.19	0.14	0.08	0.17	0.12	0.12	0.10	0.13	0.10
Cs-137	0.05	0.12	0.16	0.20	0.15	0.09	0.20	0.12	0.14	0.11	0.16	0.11
Eu-152	0.09	0.18	0.27	0.32	0.24	0.15	0.29	0.21	0.21	0.14	0.23	0.14
Eu-154	0.70	0.13	0.19	0.22	0.17	0.11	0.20	0.15	0.15	0.10	0.16	0.10
U-235	0.07	0.14	0.03	0.19	1.49	1.03	1.81	1.38	0.62	0.45	0.65	0.43
($\mu\text{g/g}$)	3.27	6.54	1.40	8.88	69.6	48.1	84.6	64.5	29.0	21.0	30.3	20.1
U-238	0.66	1.62	2.01	7.27	2.05	1.12	6.89	2.07	1.81	1.72	5.09	1.63
($\mu\text{g/g}$)	1.98	4.86	6.04	21.8	6.16	3.36	20.7	6.22	5.44	5.17	15.3	4.89
Pu-238	0.02*	0.01*	0.02*	0.01*	0.01*	0.02*	0.01*	0.04*	0.005*	0.02*	0.03	0.03
Pu-239	0.01	0.004*	0.004*	0.003*	0.01	0.004*	0.008	0.006	0.005	0.02	0.02	0.02
Am-241	0.06	0.14	0.19	1.02	0.17	0.10	0.94	0.18	0.16	0.14	0.76	0.13
Nat-U	0.31	0.25	0.41	0.08	0.17	0.28	0.38	0.12	0.15	0.20	0.18	0.09
($\mu\text{g/g}$)	0.46	0.37	0.61	0.12	0.25	0.41	0.56	0.18	0.22	0.30	0.27	0.13

(a) Locations are shown in Figure 7.

**TABLE 11. SUMMARY OF RADIOLOGICAL ANALYSES OF FIELD CROPS
WEST JEFFERSON SITE — 1993**

pCi/g dry weight

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

Nuclide	Identification No. ^(a)											
	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	0.008	0.016	0.007	0.012	0.012	0.011	0.010	0.023	0.011	0.011	0.017	0.009
Co-60	0.007	0.011	0.010	0.034	0.021	0.017	0.014	0.022	0.011	0.012	0.022	0.012
Sr-90	0.056	0.022	0.028	0.007	0.009	0.011	0.014	0.011	0.016	0.012	0.010	0.007
Sb-125	0.032	0.056	0.011	0.047	0.028	0.033	0.037	0.056	0.029	0.034	0.065	0.032
Cs-134	0.011	0.014	0.007	0.012	0.009	0.019	0.011	0.020	0.010	0.016	0.015	0.013
Cs-137	0.014	0.026	0.011	0.025	0.014	0.020	0.020	0.023	0.014	0.016	0.020	0.015
Eu-152	0.022	0.042	0.020	0.037	0.035	0.033	0.030	0.063	0.032	0.028	0.047	0.028
Eu-154	0.017	0.028	0.016	0.025	0.025	0.023	0.021	0.042	0.021	0.020	0.032	0.019
U-235	0.066	0.076	0.068	0.075	0.089	0.100	0.078	0.160	0.057	0.064	0.153	0.073
($\mu\text{g/g}$)	3.084	3.551	3.178	3.505	4.159	4.673	3.644	7.477	2.664	2.991	7.150	3.411
U-238	0.788	0.708	0.617	0.747	0.936	0.750	1.030	0.713	0.706	1.090	0.706	0.717
($\mu\text{g/g}$)	2.366	2.126	1.853	2.243	2.811	3.003	3.094	2.141	2.120	3.273	2.120	2.153
Pu-238	0.018*	0.071	0.020	0.085	0.022	0.048	0.058*	0.034	0.064*	0.048	0.024	0.024
Pu-239	0.004	0.012	0.013*	0.016	0.011	0.009	0.012	0.015	0.013*	0.027	0.005	0.013
Am-241	0.038	0.077	0.070	0.066	0.097	0.072	0.057	0.059	0.074	0.067	0.061	0.027
Nat-U	0.0002	0.0004	0.0004	0.0004	0.0004	0.0005*	0.004	0.0003	0.0004	0.0003*	0.0010*	0.0008*
($\mu\text{g/g}$)	0.0003	0.0006	0.0006	0.0006	0.0006	0.0007*	0.006	0.0004	0.0006	0.0004*	0.0015*	0.0012*

(a) Locations are shown in Figure 7.

**TABLE 12. SUMMARY OF RADIOLOGICAL
ANALYSES OF GARDEN CROPS^(a)
WEST JEFFERSON SITE -- 1993**

Sample	pCi/g dry weight	
	On-Site ^(b)	Off-Site ^(b)
Co-57	<0.047	<0.034
Co-60	<0.120	<0.048
Sr-90	<0.038	<0.020
Sb-125	<0.215	<0.093
Cs-134	<0.063	<0.040
Cs-137	<0.070	<0.031
Eu-152	<0.132	<0.099
Eu-154	<0.102	<0.062
U-235	<0.541	<0.276
($\mu\text{g/g}$)	<0.799	<0.408
U-238	<2.11	<0.589
($\mu\text{g/g}$)	<6.34	<1.77
Pu-238	0.002	0.002
Pu-239	0.0002	0.002
Am-241	<0.113	<0.041
Nat-U	<0.0007	<0.008

- (a) Garden crops collected at the end of the growing season.
 (b) Locations are shown in Figure 7.

Sediment

Sediment samples were collected in June and November at five locations, i.e., Big Darby Creek 18.29 m above and 18.29 m below the point of sanitary effluent release to Big Darby Creek, the storm sewer outfall leading to Battelle Lake, the liquid effluent discharge point into Big Darby Creek, and at the dam spillway to Big Darby Creek (see Figure 6). The purpose of collecting sediment samples semi-annually is to estimate the inventory of certain radionuclides deposited in the Big Darby Creek and document it for future reference. The sediment samples were analyzed for Pu-238, Pu-239, Sr-90, and natural-U. A quantitative gamma isotopic analysis was also performed and showed positive results of 0.402 pCi/g of Cs-134, 34.9 pCi/g of Cs-137, and 8.75 pCi/g of Co-60 at the storm sewer outfall (ED-1, near JN-1 on Figure 6). This area is contained on site, behind a security fence which precludes public exposure and is not considered to be a risk to the public. The area has been under study for remediation. Samples taken from other points indicate the levels are at or below upstream levels. The complete results of the sediment analyses are summarized in Table 13.

Soil

Soil samples are collected annually from 20 locations at varying distances and directions within a 6-mile (9.6-km) radius of the Nuclear Science Area. Locations (Figure 7) falling within the same sector are composited. The soil samples are collected to a depth of 10 cm using a 10-cm soil plugging tool. Each soil sample consists of a composite of five "plugs" of soil collected at random from an area of approximately 1 m². Prior to analysis, the composite samples are air dried and then blended in a pulverizing mill. The soil samples are analyzed for Pu-238, Pu-239, Sr-90, and natural-U. A qualitative analysis by a gamma spectrometry scan is also performed. The results of the analyses are summarized in Table 14.

Results for Sr-90, Pu-238, and Pu-239 were at or below the minimum detectable level or not statistically significant for these isotopes. Gamma isotopic analyses of the soil samples showed detectable concentration of Cs-137, U-235, and U-238 in all twelve sectors. The cesium is believed to be attributable to the settling out of the atmospheric releases from off-site, and not on-site activities. The uranium is attributed to the natural component in soil.

**TABLE 13. SUMMARY OF RADIOLOGICAL ANALYSES
OF SEDIMENT SAMPLES^(a)
WEST JEFFERSON SITE — 1993**

Nuclide	pCi/g dry wt. ^(b) Avg.				
	ED-1	ED-2	ED-3	ED-4	ED-5
Co-57	<0.049	<0.012	<0.015	<0.009	<0.012
Co-60	8.75	<0.021	<0.013	<0.019	<0.018
Sr-90	1.40	0.880	0.350	2.33	0.360
Sb-125	<0.232	<0.048	<0.035	<0.038	<0.495
Cs-134	0.402	<0.017	<0.013	<0.008	<0.014
Cs-137	34.9	0.167	0.118	0.227	0.076
Eu-152	<0.138	0.033	<0.021	<0.025	<0.034
Eu-154	<0.094	<0.025	<0.015	<0.017	<0.023
U-235	<0.380	0.135	0.132	0.074	0.100
(μ g/g)	<17.76	6.308	6.168	3.458	4.673
U-238	<1.13	1.030	0.893	0.845	1.31
(μ g/g)	<3.39	3.093	2.682	2.538	3.93
Pu-238	0.151	0.026	0.014	0.028	0.015
Pu-239	3.06	0.019	0.008	0.027	0.009
Am-241	2.69	<0.037	<0.017	<0.018	<0.023
Nat-U	2.93	1.61	1.79	0.745	2.16
(μ g/g)	4.33	2.38	2.64	1.100	3.19

(a) Locations are shown in Figure 6.

(b) No standards for radionuclides in sediment have been established.

TABLE 14. SUMMARY OF SOIL ANALYSES-WEST JEFFERSON SITE--1993

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

Nuclide	Identification No. (a)											
	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	0.014	0.014	0.013	0.014	0.011	0.011	0.009	0.014	0.013	0.010	0.011	0.009
Co-60	0.017	0.017	0.011	0.015	0.015	0.011	0.016	0.013	0.013	0.013	0.010	0.016
Sr-90	1.13	0.130	0.140	0.740	0.230	0.210	0.130	0.040	-0.030	0.970	0.650	0.490
Sb-125	0.050	0.048	0.038	0.043	0.040	0.037	0.038	0.041	0.040	0.035	0.034	0.038
Cs-134	0.015	0.016	0.012	0.014	0.013	0.011	0.013	0.013	0.013	0.011	0.011	0.013
Cs-137	0.591*	0.234*	0.148*	0.310*	0.586*	0.669*	0.478*	0.384*	0.353*	0.254*	0.310*	0.261*
Eu-152	0.040	0.040	0.039	0.039	0.031	0.033	0.025	0.041	0.036	0.028	0.033	0.025
Eu-154	0.028	0.028	0.027	0.028	0.022	0.024	0.018	0.029	0.026	0.020	0.023	0.018
U-235	0.257*	0.296*	0.210*	0.186*	0.154*	0.163*	0.178*	0.215*	0.189*	0.173*	0.195*	0.211*
(µg/g)	12.01*	13.83*	9.813*	8.692*	7.196*	7.617*	8.318*	10.05*	8.832*	8.084*	9.112*	9.860*
U-238	1.81*	1.52*	1.45*	1.13*	2.09*	1.28*	1.45*	1.56*	1.54*	1.70*	1.34*	1.54*
(µg/g)	5.44*	4.56*	4.35*	3.39*	6.28*	3.84*	4.35*	4.68*	4.62*	5.11*	4.02*	4.62*
Pu-238	0.056	0.032	0.082	0.018	0.035	0.022	0.072	0.196*	0.024	0.049	0.034	0.032
Pu-239	0.056	0.009	0.050*	0.018	0.013	0.023*	0.044*	0.098	0.041*	0.034*	0.009	0.032
Am-241	0.035	0.035	0.036	0.035	0.099	0.030	0.055	0.039	0.032	0.089	0.030	0.055
Nat-U	1.97	2.50	2.38	2.64	2.65	2.27	2.37	2.57	2.81	2.72	2.45	2.53
(µg/g)	2.91	3.69	3.52	3.90	3.91	3.35	3.50	3.80	4.15	4.02	3.62	3.74

(a) Locations are shown in Figure 7.

Fish

Fish are collected semi-annually from Battelle Lake and Big Darby Creek, as available, to determine if any radioactive material is entering the food chain. Fish collection in Big Darby Creek is limited to within a hundred yards of the liquid effluent outfall and the Battelle Lake spillway. The fish tissue is analyzed for gamma isotopes, Pu-238, Pu-239, Sr-90, and natural-U. The results of the analyses were at or below minimum detectable levels or not statistically significant for each isotope. Fish were not able to be collected from Big Darby Creek during 1993, although fish were present and apparently healthy. Table 15 summarizes the 1993 data from the analyses.

Background Radiation Levels

The radiation exposure limit established for the general public by the Department of Energy is 100 mrem/yr.⁽⁷⁾ This value does not include the contribution from natural background radiation, which, in previous years, averaged approximately 130 mrem/yr off site from all 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. 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 1993 annual average dose including background at the site boundary is 120 ± 10 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 16.

Fence Post Dose Estimate

The "fence post" dose is the maximum measured cumulative dose of radiation possible to an individual having access to an uncontrolled area. It does not include ingestion and inhalation pathways. The "fence post" dose for 1993 was equal to or less than the annual average TLD background reading of 120 mrem measured at off-site background monitoring stations.

TABLE 15. SUMMARY OF FISH TISSUE ANALYSES
WEST JEFFERSON SITE — 1993

Sample	Battelle Lake Samples ^(a) (pCi/g raw weight)		
	1st Half	2nd Half	Average
Co-57	<0.008	<0.004	<0.006
Co-60	<0.019	<0.006	<0.012
Sr-90	0.040	<0.453	0.247
Sb-125	<0.019	<0.015	<0.017
Cs-134	<0.008	<0.005	<0.007
Cs-137	<0.017	<0.007	<0.012
Eu-152	<0.023	<0.012	<0.017
Eu-154	<0.014	<0.008	<0.011
U-235	<0.059	<0.008	<0.034
($\mu\text{g/g}$)	<2.757	<0.374	<1.589
U-238	<0.388	<0.082	<0.235
($\mu\text{g/g}$)	<1.165	<0.246	<0.706
Pu-238	<0.002	0.115	0.059
Pu-239	0.002	<0.051	0.026
Am-241	<0.011	<0.011	<0.011
Nat-U	0.005	0.014	0.009
($\mu\text{g/g}$)	0.007	0.021	0.013

(a) Fish samples were collected from various locations within Battelle Lake.

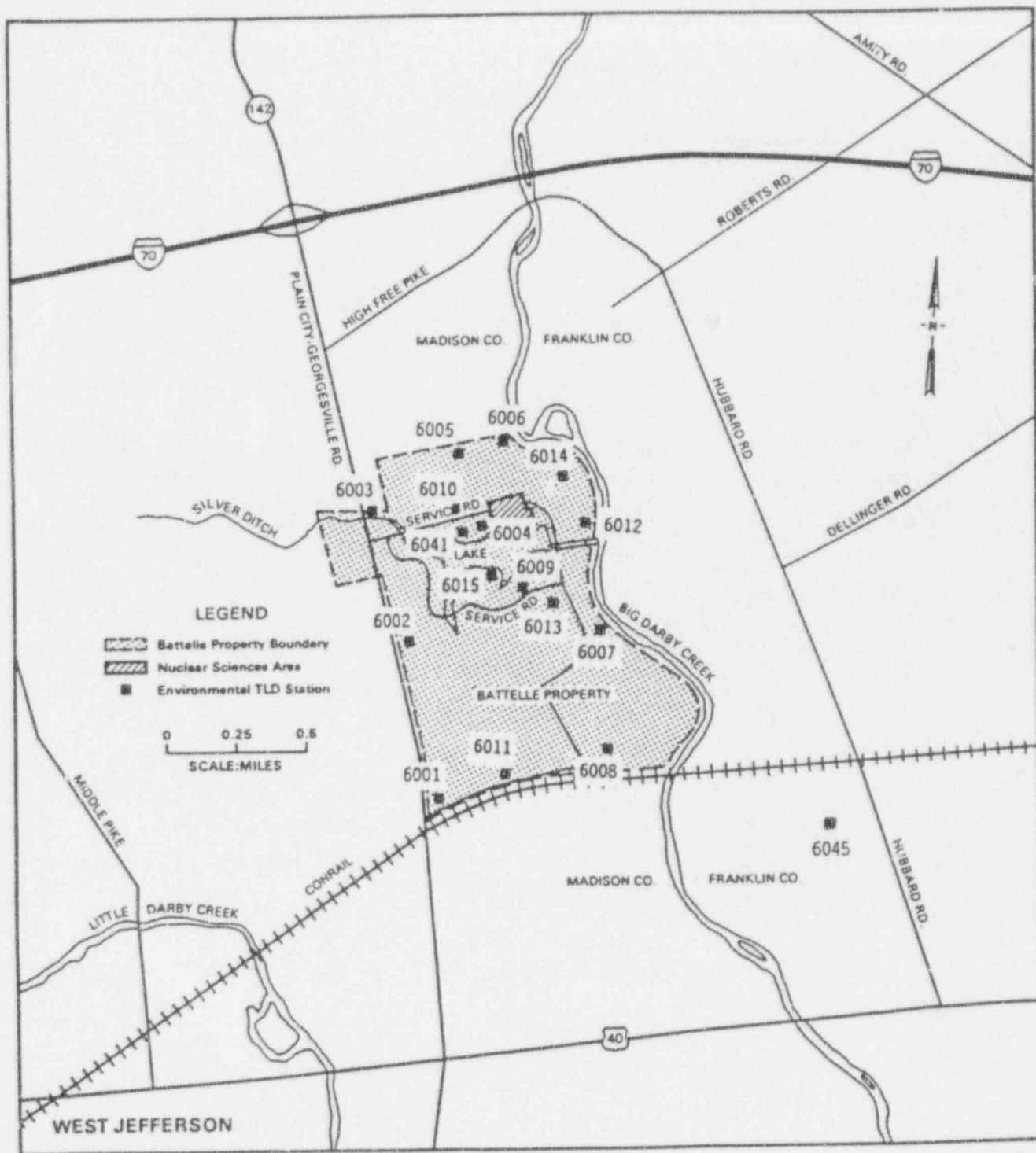


FIGURE 8. MAP OF TLD LOCATIONS WITHIN 3/4-MILE RADIUS OF THE NUCLEAR SCIENCES AREA

**TABLE 16. INTEGRATED EXTERNAL BACKGROUND
RADIATION MEASUREMENTS AT RECREATION
AREA AND PROPERTY BOUNDARY LINE
WEST JEFFERSON SITE — 1993**

Location and Distance ^(a)	Integrated TLD Measurements in rem				Total for Year
	1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.	
<u>Southwest</u>					
121.9 m (400 ft)	<0.030	<0.030	<0.030	<0.030	<0.120
420.6 m (600 ft)	<0.030	<0.030	<0.030	<0.030	<0.120
731.5 m (2400 ft)	<0.030	<0.030	<0.030	<0.030	<0.120
1234.5 m (4050 ft)	<0.030	<0.030	<0.030	<0.030	<0.120
<u>West</u>					
152.4 m (500 ft)	<0.030	<0.030	<0.030	<0.030	<0.120
630.9 m (2070 ft)	<0.030	<0.030	<0.030	<0.030	<0.120
<u>Southeast</u>					
365.8 m (1200 ft)	<0.030	<0.030	<0.030	<0.030 ^(b)	<0.120
1005.9 m (3300 ft)	<0.030	<0.030	<0.030	<0.030	<0.120
<u>South</u>					
395.9 m (1200 ft)	<0.030	<0.030	<0.030	<0.030	<0.120
411.5 m (1350 ft)	<0.030	<0.030	<0.030	<0.030	<0.120
548.6 m (1800 ft)	<0.030	0.030	<0.030	<0.030	<0.120
1097.3 m (3600 ft)	<0.030	<0.030	<0.030	<0.030	<0.120
<u>East</u>					
420.6 m (1380 ft)	<0.030	<0.030	<0.030	<0.030	<0.120
<u>Northeast</u>					
395.9 m (1200 ft)	<0.030	<0.030	<0.030	<0.030	<0.120
<u>Northwest</u>					
402.3 m (1320 ft)	<0.030	<0.030	<0.030	<0.030	<0.120
<u>North</u>					
457.2 m (1500 ft)	<0.030	<0.030	<0.030	<0.030	<0.120

(a) Refer to Figure 8. Average off-site background for year <0.120 rem.

(b) Estimated 4th quarter value due to lost TLD from area construction.

King Avenue Site

An inventory of suspected radionuclides for the east central and west central staging areas for the King Avenue site for air is presented in Table 17. Both release inventories are based on minimum detectable levels (MDL) of listed isotopes. Weekly samples are screened for possible elevated levels of radioactivity by counting for gross α (alpha) and gross β - γ (beta-gamma). Weekly samples are composited into monthly and quarterly samples for isotopic analysis. As a conservative measure, the minimum detectable levels are assumed as positive releases for purposes of establishing an inventory and estimating maximum possible doses to the public.

Air Monitoring

The exhaust vent effluent release from the major source contributors (central staging area of Building 3) are continuously sampled and analyzed on a weekly basis. Particulate samples of the effluent are collected from each exhaust stack on the downstream of the HEPA. The particulate samples are collected on Type AE glass fiber filter paper. The results are calculated using CAP88-PC and are summarized in Table 18. These filters are composited on a monthly basis for gamma analysis. There were no radiological releases from stacks at the King Avenue site in 1993.

One environmental air sample was collected at the east boundary of Battelle property along Battelle Boulevard. This sample can serve as a reference for future D&D activities and can provide evidence to the neighborhood that no radiological impact has resulted from the BCLDP operations. The results of the radiological analyses of the environmental air sample are listed in Table 19. These results are considered to be background levels for gross α and gross β . Table 19 also includes the results of the gamma spectrometry scans done for the King Avenue sample. The results are all below the detection limit.

TABLE 17. ANNUAL RADIONUCLIDE INVENTORY^(a)
KING AVENUE SITE — 1993

West Central Staging Area		
Air	Activity (μ Ci)	Activity (g)
Co-57	0.05	--
Co-60	0.07	--
Sb-125	0.16	--
Cs-134	0.07	--
Cs-137	0.07	--
Eu-152	0.09	--
Eu-154	0.07	--
U-235	0.13	6.07
U-238	0.67	2.01
Am-241	0.09	--

East Central Staging Area		
Air	Activity (μ Ci)	Activity (g)
Co-57	0.05	--
Co-60	0.07	--
Sb-125	0.17	--
Cs-134	0.07	--
Cs-137	0.07	--
Eu-152	0.10	--
Eu-154	0.07	--
U-235	0.14	6.54
U-238	0.63	1.89
Am-241	0.08	--

(a) Inventory is made up of suspected radionuclides and effluents for air at the west central and east central staging areas for the King Avenue site.

TABLE 18. SUMMARY OF SPECIFIC RADIONUCLIDES FROM
STACK EMISSIONS — KING AVENUE SITE — 1993

Species	Activity $\mu\text{Ci}/\text{yr}$	Site Boundary ($\times 10^{-20}$) $\mu\text{Ci}/\text{ml}$	Derived Concentration Guide Limit $\mu\text{Ci}/\text{ml}$	Percent of DCG at the Site Boundary
Co-57	0.10	3.5	1.05E-15	<0.01
Co-60	0.14	5.5	1.46E-15	<0.01
Sb-125	9.33	0.13	3.45E-15	<0.01
Cs-134	0.14	5.0	1.46E-15	<0.01
Cs-137	0.14	5.2	1.46E-15	<0.01
Eu-152	0.19	7.1	1.99E-15	<0.01
Eu-154	0.14	5.1	1.46E-15	<0.01
U-235	0.27	0.10	2.82E-15	<0.01
U-235	12.6 g/yr	4.67 g/ml	1.32E-13 g/ml	
U-238	1.30	0.49	1.36E-14	<0.01
U-238	0.51 g/yr	1.47 g/ml	4.08E-14 g/ml	
Am-241	0.17	6.4	1.78E-15	<0.01

Stack volumes for each of the Building 3 central staging area exhaust vents are $4.78\text{E}10$ l/yr for a total annual discharge volume of $9.56\text{E}10$ l/yr.

TABLE 19. RADIOLOGICAL ANALYSES OF ENVIRONMENTAL AIR SAMPLES^(a) — KING AVENUE SITE — 1993

Nuclides	Number of Samples	Average concentration $\mu\text{Ci/ml} \times 10^{-15}$	Total Concentration $\mu\text{Ci/ml} \times 10^{-15} \pm 2 \text{ sigma}$	DCG ^(b) $\mu\text{Ci/ml}$	Percent of DCG (%)
Gross α	52	--	1.19 ± 0.24	-- ^(c)	--
Gross β	52	--	12.7 ± 0.55	-- ^(c)	--
Co-57	4	<0.851	3.40	$<2.0 \times 10^{-9}$	<0.01
Co-60	4	<2.66	10.6	$<8.0 \times 10^{-11}$	0.01
Sb-125	4	<3.34	14.36	$<1.0 \times 10^{-9}$	<0.01
Cs-134	4	<1.19	4.76	$<2.0 \times 10^{-10}$	<0.01
Cs-137	4	<2.23	8.92	$<4.0 \times 10^{-10}$	<0.01
Eu-152	4	<1.99	7.96	$<5.0 \times 10^{-11}$	<0.02
Eu-154	4	<1.34	5.36	$<5.0 \times 10^{-11}$	<0.02
U-235	4	<5.37	21.5	$<1.0 \times 10^{-13}$	21.5
U-235		$<2.51 \times 10^{-13} \text{ g/ml}$	$1.00 \times 10^{-12} \text{ g/ml}$	$<4.67 \times 10^{-12} \text{ g/ml}$	
U-238	4	<1.06	42.4	$<1.0 \times 10^{-13}$	42.4
U-238		$<3.18 \times 10^{-15} \text{ g/ml}$	$1.27 \times 10^{-13} \text{ g/ml}$	$<3.00 \times 10^{-13} \text{ g/ml}$	
Th-228	4	0.05	0.22	$<2.0 \times 10^{-12}$	0.01
Th-230	4	0.08	0.33	$<4.0 \times 10^{-14}$	0.83
Th-232	4	0.05	0.22	$<7.0 \times 10^{-15}$	3.14
Am-241	4	<1.13	4.52	$<2.0 \times 10^{-14}$	22.6
Nat-U	4	0.06	0.27	$<2.0 \times 10^{-12}$	0.01
Nat-U		$1.80 \times 10^{-11} \text{ g/ml}$	$8.10 \times 10^{-16} \text{ g/ml}$	$<6.00 \times 10^{-12} \text{ g/ml}$	

- (a) Sample location EA-15 identified in Figure 4.
 (b) Derived Concentration Guides from DOE Order 5400.4, Figure III-1.
 (c) DOE Order 5400.5 does not list DCG limits for mixed α and β activity.

Water Monitoring

Wastewater discharges to the Columbus Municipal Waste Water Treatment Plant via the sewer system, are monitored at six locations. See Figure 4 for the locations. Sampling of liquid discharges from the Building 2 and Building 3 sumps to the municipal sewer system is performed on a monthly basis. This discharge consists of the liquid wastes from the building laboratory drain systems. Beginning in October, the six King Avenue wastewater monitoring points were sampled on a weekly instead of monthly basis. Monthly composites were then prepared from these weekly collections and received gross alpha and gross beta, and gamma isotopic analysis. These results are summarized in Table 20. The average concentrations at all discharge points were well below NRC standards as well as the DOE's DCG for the most restrictive β activity in the uranium decay chain.

Soil Monitoring

Nine soil samples were collected at various points around the King Avenue site (Figure 4). Sample KAES-09 was collected from The Ohio State University Agriculture campus north 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 21. There was evidence of U-235, U-238, and natural-U in the soil samples above detectable levels in all the on-site samples. There was also comparable levels of U-235, U-238, and natural-U detected in the background sample. There was also evidence of Cs-137 in the King Avenue site soils. It was also detected in the background sample at similar levels. The cesium is in the same range as that seen in West Jefferson off-site samples although no operations involving cesium are conducted at King Avenue. This suggests that the cesium is from fallout and not Battelle operations. Th-228 was detected in the samples including the off-site King Avenue location except for locations #2 and #5. Th-230 and Th-232 were detected in the samples including the off-site location. The presence of these radioisotopes in soil is not attributable to BCI DP operations.

TABLE 20. RADIOLOGICAL ANALYSES OF LIQUID DISCHARGES--KING AVENUE SITE --1993

$\mu\text{Ci/ml}$
All values reported are less than MDA values

Nuclide	Identification No. ^(a)						Average	DCG $\mu\text{Ci/ml}$	% DCG
	EW-6	EW-7	EW-8	EW-9	EW-13	EW-14			
Gross α ($\mu\text{Ci/ml} \times 10^{-6}$)	9.85 \pm 3.40	9.22 \pm 19.18	2.99 \pm 2.22	7.14 \pm 3.31	6.69 \pm 3.33	4.15 \pm 3.02	--	--	--
Gross β ($\mu\text{Ci/ml} \times 10^{-6}$)	16.15 \pm 1.42	48.73 \pm 7.37	19.26 \pm 1.52	20.94 \pm 1.62	18.05 \pm 2.03	28.79 \pm 1.82	--	--	--
Co-57	<3.96E-09	<3.89E-09	<3.74E-09	<3.16E-09	<3.61E-09	<3.24E-09	3.60E-09	1.0E-04	0.00
Co-60	<3.80E-09	<3.35E-09	<3.88E-09	<2.88E-09	<3.16E-09	<3.03E-09	3.35E-09	5.0E-06	0.07
Sb-125	<1.03E-08	<9.44E-09	<9.94E-09	<7.78E-09	<8.71E-09	<8.22E-09	9.07E-09	5.0E-05	0.02
Cs-134	<3.74E-09	<3.50E-09	<3.73E-09	<2.82E-09	<3.29E-09	<3.01E-09	3.35E-09	2.0E-06	0.17
Cs-137	<3.72E-09	<3.26E-09	<3.60E-09	<2.80E-09	<3.08E-09	<2.98E-09	3.24E-09	3.0E-06	0.11
Eu-152	<7.67E-09	<7.21E-09	<6.92E-09	<6.18E-09	<6.74E-09	<5.88E-09	6.77E-09	2.0E-05	0.03
Eu-154	<5.47E-09	<5.17E-09	<4.92E-09	<4.33E-09	<4.84E-09	<4.22E-09	4.83E-09	2.0E-05	0.02
U-235 ($\mu\text{g/ml}$)	<5.07E-09 <2.37E-01	<4.68E-09 <2.19E-01	<4.64E-09 <2.17E-01	<3.64E-09 <1.70E-01	<1.26E-08 <5.88E-01	<3.62E-09 <1.69E-01	5.71E-09 2.67E-01	6.0E-07 2.8E+01	0.95 --
U-238 ($\mu\text{g/ml}$)	<5.81E-08 <1.74E-01	<5.58E-08 <1.67E-01	<5.61E-08 <1.68E-01	<5.42E-08 <1.63E-01	<5.38E-08 <1.62E-01	<4.36E-08 <1.31E-01	5.36E-08 1.61E-01	6.0E-07 1.8E+00	8.93 --
Am-241	<8.30E-09	<8.26E-09	<9.97E-09	<1.00E-08	<8.29E-09	<8.11E-09	8.82E-09	3.0E-08	29.41

(a) Locations identified in Figure 4.

TABLE 21. RADIOLOGICAL ANALYSES OF SOIL SAMPLES — KING AVENUE SITE — 1993

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

Nuclide	Identification No. ^(a)								
	KAES-01	KAES-02	KAES-03	KAES-04	KAES-05	KAES-06	KAES-07	KAES-08	KAES-09
Co-57	0.003	0.004	0.004	0.003	0.004	0.003	0.003	0.003	0.004
Co-60	0.006	0.005	0.005	0.006	0.005	0.005	0.005	0.005	0.005
Sb-125	0.014	0.014	0.013	0.014	0.013	0.013	0.012	0.014	0.013
Cs-134	0.005	0.004	0.005	0.004	0.004	0.004	0.004	0.004	0.004
Cs-137	0.064*	0.043*	0.035*	0.030*	0.021*	0.055*	0.020*	0.074*	0.031*
Eu-152	0.009	0.010	0.010	0.009	0.010	0.008	0.009	0.008	0.010
Eu-154	0.006	0.007	0.007	0.007	0.007	0.006	0.007	0.006	0.007
U-235	0.050*	0.037*	0.038*	0.040*	0.033*	0.027*	0.036*	0.037*	0.040*
($\mu\text{g/g}$)	2.336*	1.729*	1.776*	1.869*	1.542*	1.262*	1.682*	1.729*	1.869*
U-238	0.354*	0.284*	0.382*	0.247*	0.381*	0.188*	0.348*	0.247*	0.273*
($\mu\text{g/g}$)	1.063*	0.853*	1.147*	0.742*	1.144*	0.565*	1.045*	0.742*	0.820*
Th-228	0.939*	0.917	1.260*	0.880*	1.450	0.755*	0.718*	0.786*	0.962*
Th-230	2.400*	2.370*	2.790*	2.650*	2.750*	2.000*	1.950*	2.400*	2.780*
Th-232	0.941*	1.040*	1.300*	0.788*	0.867*	1.070*	0.650*	0.700*	0.882*
Am-241	0.020	0.031	0.032	0.021	0.032	0.018	0.030	0.019	0.035
Nat-U	3.090*	3.220*	3.290*	3.220*	2.920*	2.730*	3.090*	2.840*	2.600*
($\mu\text{g/g}$)	4.564*	4.756*	4.860*	4.756*	4.313*	4.032*	4.564*	4.195*	3.840*

(a) Locations are identified in Figure 4, except KAES-09, which is an off-site sample taken from The Ohio State University Agriculture campus.

Vegetation Monitoring

Nine samples of vegetation were collected at points around the King Avenue site from the same locations as the soil samples, including the off-site background, reference location (Figure 4). Eight of these samples were collected on Battelle's property. The samples were analyzed for gamma isotopic analysis, thorium, and natural-uranium. Th-228 was detected in three of the samples (locations #1, #2, and #8); Th-232 was detected in the samples except for locations #5, #6, and #9; Th-230 was detected in the samples except for location #9. The presence of these isotopes in vegetation is not attributed to BCLDP operations due to the regulating practices conducted at Battelle for constituents used in operations performed at Battelle. Natural-uranium was detected in the samples, including the off-site sector. Data from these analyses is presented in Table 22.

Sediment Monitoring

Sediment samples were collected in December 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 Ohio State University campus north of King Avenue (KAED-2) (see Figure 4). The purpose of collecting the sediment sample is to estimate the inventory of certain radionuclides in this waterway and document it for future reference. A quantitative gamma isotopic and natural uranium was performed. The complete results of the sediment analyses are summarized in Table 23. U-235, U-238, and natural-U were detected in samples collected at both locations. Cs-137 was detected slightly above MDA in the sample collected near the storm sewer outfall.

Drinking Water Monitoring

The drinking water supply at the King Avenue site is exempt from radiological monitoring per OEPA review⁽⁶⁾. However, weekly drinking water samples are collected from a tap at the King Avenue Site in Building A to verify compliance with applicable water

TABLE 22. RADIOLOGICAL ANALYSES OF VEGETATION SAMPLES — KING AVENUE SITE — 1993

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

Nuclide	Identification No. ^(a)								
	KAEV-01	KAEV-02	KAEV-03	KAEV-04	KAEV-05	KAEV-06	KAEV-07	KAEV-08	KAEV-09
Co-57	0.02	0.02	0.03	0.03	0.07	0.05	0.03	0.02	0.02
Co-60	0.06	0.04	0.04	0.06	0.06	0.07	0.07	0.05	0.05
Sb-125	0.08	0.08	0.11	0.11	0.15	0.17	0.13	0.12	0.10
Cs-134	0.03	0.03	0.04	0.05	0.08	0.07	0.05	0.04	0.04
Cs-137	0.04	0.03	0.04	0.05	0.05	0.08	0.07	0.03	0.05
Eu-152	0.05	0.05	0.07	0.07	0.08	0.13	0.07	0.07	0.06
Eu-154	0.03	0.04	0.05	0.05	0.06	0.09	0.05	0.05	0.04
U-235	0.03	0.05	0.06	0.06	0.04	0.07	0.04	0.05	0.05
($\mu\text{g/g}$)	1.40	2.34	2.80	2.80	1.87	3.27	1.87	2.34	2.34
U-238	0.80*	0.40	0.63	0.71	0.63	0.96	0.51	0.55	0.62
($\mu\text{g/g}$)	2.40*	1.20	1.89	2.13	1.89	2.88	1.53	1.65	1.86
Th-228	0.50*	0.21*	0.10	0.05	0.03	0.28	0.06	0.06*	0.94
Th-230	0.86*	0.70*	0.51*	0.23*	0.07*	0.43*	0.10*	0.20*	0.72
Th-232	1.42*	0.34*	0.87*	0.06*	0.05	0.19	0.06*	0.07*	0.55
Am-241	0.10	0.04	0.06	0.07	0.27	0.43	0.14	0.05	0.05
Nat-U	0.30*	0.71*	0.60*	0.31*	0.90*	0.50*	0.14*	0.26*	0.22*
($\mu\text{g/g}$)	0.44*	1.05*	0.89*	0.46*	1.33*	0.74*	0.21*	0.38*	0.32*

(a) Locations are identified in Figure 4, except KAEV-09, which is an off-site sample taken from The Ohio State University Agriculture campus.

TABLE 23. RADIOLOGICAL ANALYSES OF SEDIMENT
SAMPLES KING AVENUE SITE — 1993

Nuclide	pCi/g dry wt. ^(a) Avg.	
	KAED-1 ^(b)	KAED-2 ^(c)
Co-57	<0.010	<0.009
Co-60	<0.016	<0.017
Sb-125	<0.042	<0.038
Cs-134	<0.015	<0.015
Cs-137	0.046	<0.021
Eu-152	<0.027	<0.024
Eu-154	<0.020	<0.017
U-235	0.075	0.085
($\mu\text{g/g}$)	3.505	3.972
U-238	0.412	0.527
($\mu\text{g/g}$)	1.237	1.583
Am-241	<0.020	<0.019
Nat-U	2.44	3.06
($\mu\text{g/g}$)	3.60	4.52

- (a) No standards for radionuclides in sediment have been established.
- (b) Located along the Olentangy River near the storm sewer outfall at the low-head dam.
- (c) Located along the Olentangy River north of King Avenue and south of the Ohio State University campus.

quality standards for radioactivity in drinking water. The weekly drinking water samples are composited and analyzed monthly for gross α and gross β in suspended and dissolved fractions and gamma isotopic analysis. In 1993, the average concentrations of gross α was $(1.20 \pm 1.39) \times 10^{-6} \mu\text{Ci/ml}$ (soluble) and $(0.09 \pm 0.29) \times 10^{-6} \mu\text{Ci/ml}$ (insoluble). The total concentrations are $(1.28 \pm 2.82) \times 10^{-6} \mu\text{Ci/ml}$ for gross α and $(4.55 \pm 1.84) \times 10^{-6} \mu\text{Ci/ml}$ for gross β . The total concentrations are listed in Table 8. The total gross α activity represents about 8.5 percent of the EPA standard of $1.5 \times 10^{-5} \mu\text{Ci/ml}$ for gross α particulate activity in drinking water.

One river water sample is collected annually from the Olentangy River at a sampling point located south of the West Fifth Avenue bridge (Figure 4). The water sample is analyzed for mixed α and β activity and gamma isotopic analysis. The average concentration of total activity in the water sample is less than $(8.07 \pm 7.50) \times 10^{-9} \mu\text{Ci/ml}$ for α and less than $(12.93 \pm 4.07) \times 10^{-9} \mu\text{Ci/ml}$ for β activity (Table 24). The values for the drinking water and river water samples were below the reported MDLs.

Direct Radiation Measurement

Fifteen thermoluminescence dosimeters (TLDs) were put in place around the King Avenue property line for the 4th quarter of 1993. With the exception of one TLD located along the northeast sector, all readings were less than MDA (0.030 rem) for the quarter. TLD #2 reported a reading of 0.070 rem. No source could be identified which would account for this above-site average reading and is not considered attributable to BCLDP. TLD #2 results received for the 1st quarter of 1994 were reported to be less than MDA (0.030 rem). The results are summarized in Table 25.

TABLE 24. RADIOLOGICAL ANALYSIS OF
 OLENTANGY RIVER WATER SAMPLES
 KING AVENUE SITE^(a) — 1993

Nuclide	KARW-1 (10^{-9} μ Ci/ml) ^(b)
Gross α	8.07 \pm 7.50
Gross β	12.93 \pm 4.07
Co-57	<1.52
Co-60	<1.36
Sb-125	<4.20
Cs-134	<1.45
Cs-137	<1.58
Eu-152	<4.32
Eu-154	<3.07
U-235	<2.86
(μ g/ml)	<0.13
U-238	<40.1
(μ g/ml)	<0.12
Am-241	<4.68
Nat-U	UA ^(c)

- (a) Located south of the West Fifth Avenue bridge (Figure 4).
 (b) A priori minimum detection limit for gross α is 6.5×10^{-9} μ Ci/ml
 and 4.8×10^{-9} μ Ci/ml for gross β
 (c) UA - Denotes data unavailable

TABLE 25. INTEGRATED EXTERNAL BACKGROUND RADIATION
 MEASUREMENTS AT THE PROPERTY LINE
 KING AVENUE SITE — 1993^(a)

TLD #	Sector	Integrated TLD Measurements in rem
1	East	<0.030
2	North east	0.070
3	North west	<0.030
4	North	<0.030
5	North	<0.030
6	Northwest	<0.030
7	Northwest	<0.030
8	West	<0.030
9	West	<0.030
10	Southwest	<0.030
11	Southwest	<0.030
12	South	<0.030
13	South	<0.030
14	Southeast	<0.030
15	East	<0.030

(a) 4th quarter 1993

Environmental Nonradiological Program Information

The drinking water system at the West Jefferson site is monitored under OEPA regulations, which regulate all public water supplies. As a noncommunity water supply, Battelle was required to perform the following tests in 1993:

- Volatile organic compounds (VOCs) — quarterly
- Total coliform for microbiological contamination — quarterly
- Nitrate — once during last half of the year
- Nitrite — once during last half of the year
- Lead and Copper — once during last half of the year.

VOC sampling results indicated that no VOCs at the north well and north softener were detected (detection limits are 0.5 ppb for all VOCs). The north well tested positive once for microbiological contamination (>1 colony/100 ml) which required subsequent sampling. The results of the subsequent samples were negative. Public notice was provided for the positive result. Sampling error may have been the source of the bacteriological contamination since the procedures for obtaining an uncontaminated sample are time-consuming. Nitrate and nitrite were both measured and found to be well below the established Maximum Contamination Level (MCL) value of 10 mg/l for nitrates and 1.0 mg/l for nitrites. Lead and copper results were below the action levels requiring additional monitoring.

Liquid effluents discharged from the West Jefferson Facility are subject to the restrictions on an NPDES permit. Battelle monitors and reports on a monthly basis to the OEPA. Table 26, Nonradiological Water Effluent Analyses--West Jefferson Site, 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 Sanitary Sewer were obtained in accordance with the NPDES Permit 41N00004*DD issued by the OEPA. All readings were within acceptable limits as specified in the permit for 1993, except for the total suspended solids level in January.

TABLE 26. NON-RADIOLOGICAL WATER EFFLUENT ANALYSES
WEST JEFFERSON SITE-1993

	North Sanitary System Sewer ^(a)				Permit Requirements ^(c) Discharge Limitations			
	Avg.	Max.	Min.	kg/Day	Loading kg/Day		Concentration ^(e)	
				Avg. ^(b)	30-Day	Daily	30-Day	Daily
Flow Rate (l/day) ^(d)	58,082	126,511	17,580	—	(d)	(d)	(d)	(d)
Residual Chlorine (mg/l)	0.09	0.17	0.01	0.004			—	0.5
pH Value (S.U.)	7.9	8.7	7.3	—			6.5	9.0
Fecal Coliform (#/100 ml)	11	33	1	—			1,000	2,000
Dissolved Oxygen (mg/l)	8.0	8.4	7.6	—			6.0 (min)	6.0 (min)
Total Suspended Solids (mg/l)	2.0	5.0	1.0	0.1	0.49	0.98	10	20
BOD (5-day) (mg/l)	4.1	4.8	3.5	0.20	1.23	1.87	25	38
Ammonia (mg/l) ^(d)	1.14	6.32	0.12	—	(d)	(d)	(d)	(d)

- (a) Sampling site location is labeled 010 on Figure 5 (referred to as 001 in monthly NPDES reports). Includes discharge from Middle Area Sanitary System.
- (b) Based on a flow rate of 0.013 MGD.
- (c) Permit requirement discharge limitations based on NPDES Permit 41N00004*DD.
- (d) No restrictions for flow or ammonia under the NPDES Permit.
- (e) Units specified in left column.

The values listed in Table 26 represent an average of the monthly data collected during the 12-month period starting January 1, 1993, and ending December 31, 1993. The table illustrates the actual performance against permit limits/restrictions. The results in the table are for discharge point 001 which includes the discharge from the West Jefferson North area. The only significant change in the permit in 1993 was the deletion of the monitoring requirement for *E. coli* at discharge point 001. For 1994, tests for MCL inorganics, asbestos, and organic chemicals have been added to the drinking water requirements.

Additional nonradiological monitoring was done on three monitoring wells at the West Jefferson site. A discussion of the results can be found in the following section.

The BCLDP does no environmental air monitoring for nonradiological parameters at either the King Avenue or West Jefferson sites.

The BCLDP is not required to report under SARA Title III because the quantities of extremely hazardous substances stored or used are well below any threshold planning quantities. Battelle has made annual submissions to the proper authorities for hazardous materials that exceeded the planning quantities. At the King Avenue facility, chlorine gas for water purification is reported. At the West Jefferson site, liquid nitrogen storage is reported. Diesel fuel storage is also reported for both sites.

Groundwater Protection

Groundwater monitoring at the West Jefferson site included a total of 18 shallow and deep wells. These include two supply wells (JN and JM) at a depth of approximately 150 feet, three wells designed for chemical monitoring (C03, C09, and C16) at a depth of approximately 30 to 35 feet, and 13 shallow wells at a depth of approximately 10 to 15 feet. The three wells designed for chemical sampling and 13 shallow wells were installed late in 1989. Figures 9 and 10 indicate the location of shallow and chemical monitoring wells. The supply wells are associated with facilities identified in Figures 6 and 9, but are off the scale of the map. Detailed chemical monitoring was performed and reported in Interim Report on Site Characterization, West Jefferson North Site, Stage 1 Sampling and Analysis: Chemical Sampling Summary Report, dated December 22, 1989. No contamination was found in groundwater samples collected at that time.⁽¹⁰⁾

Detailed chemical analyses were performed on groundwater samples collected December 29, 1993, from the three chemical monitoring wells. Samples from all three wells were analyzed for eight heavy metals, 26 pesticide and PCB compounds, 35 VOCs, 65 semivolatile organic compounds, oil and grease, and pH. The compounds in the samples were below the levels of detection or quantification, except for 1,1,1-trichloroethane in the sample from well C16, where the concentration was 7 $\mu\text{g/l}$ (Table 27). The EPA regulatory concentration limit for this chemical in drinking water is 200 $\mu\text{g/l}$. Concentrations of this chemical will be specifically reviewed in subsequent quarterly samplings to determine if there are any trends.

Phenol detected in well C03 at 17 parts per billion in 1991 was not detected in 1992 or 1993. No chemical contamination had been found in any of the wells prior to 1991. Possible detection of this chemical will be tracked in subsequent sampling.

Annual radiological monitoring results are presented in Tables 28 and 29. The highest combined α and β activity is shown to be in well 110, where radioactivity remains in a former remediated filter bed. These data are consistent with previous monitoring data collected since installation of the wells in 1989. 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.

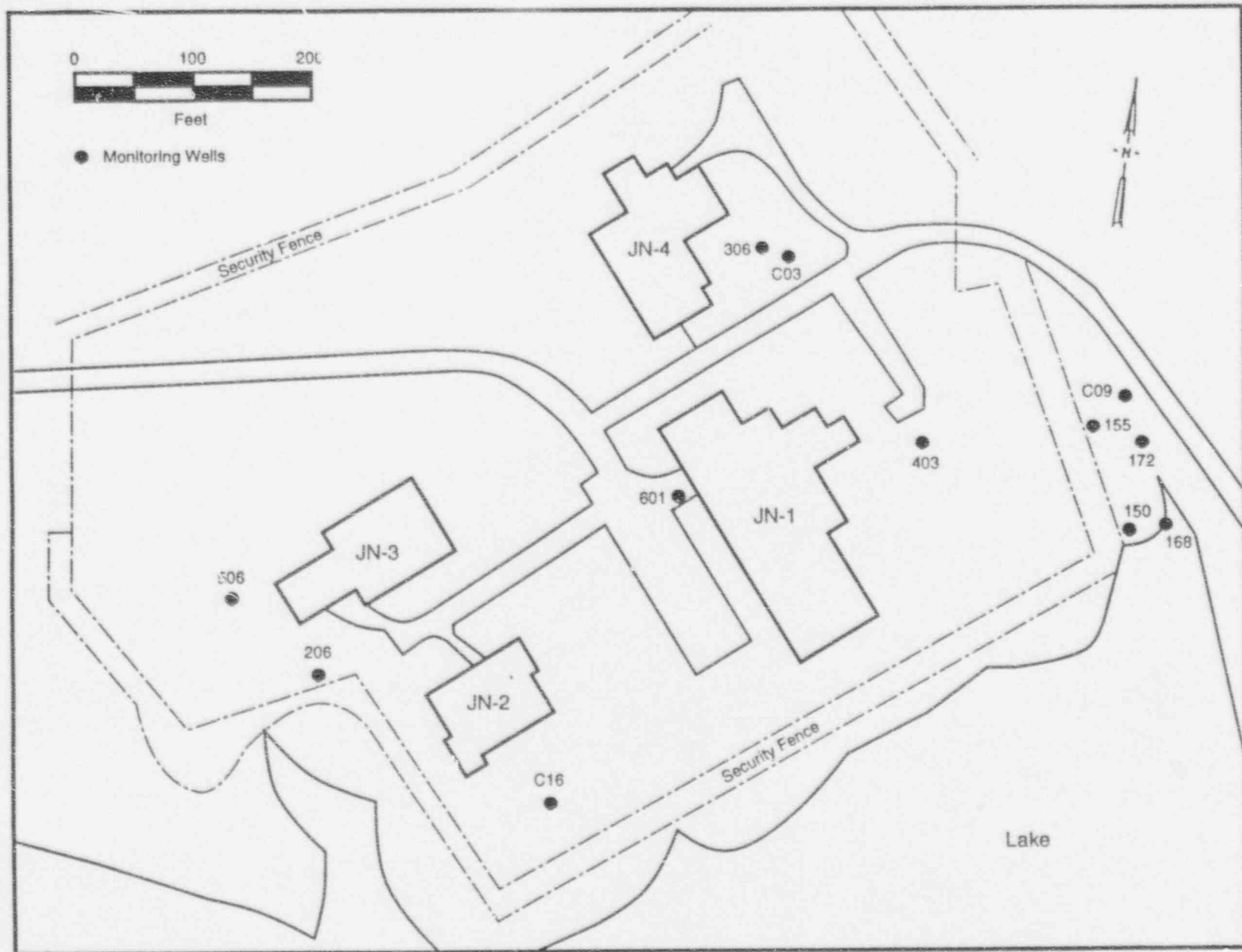


FIGURE 9. NORTH SITE GROUNDWATER MONITORING WELLS

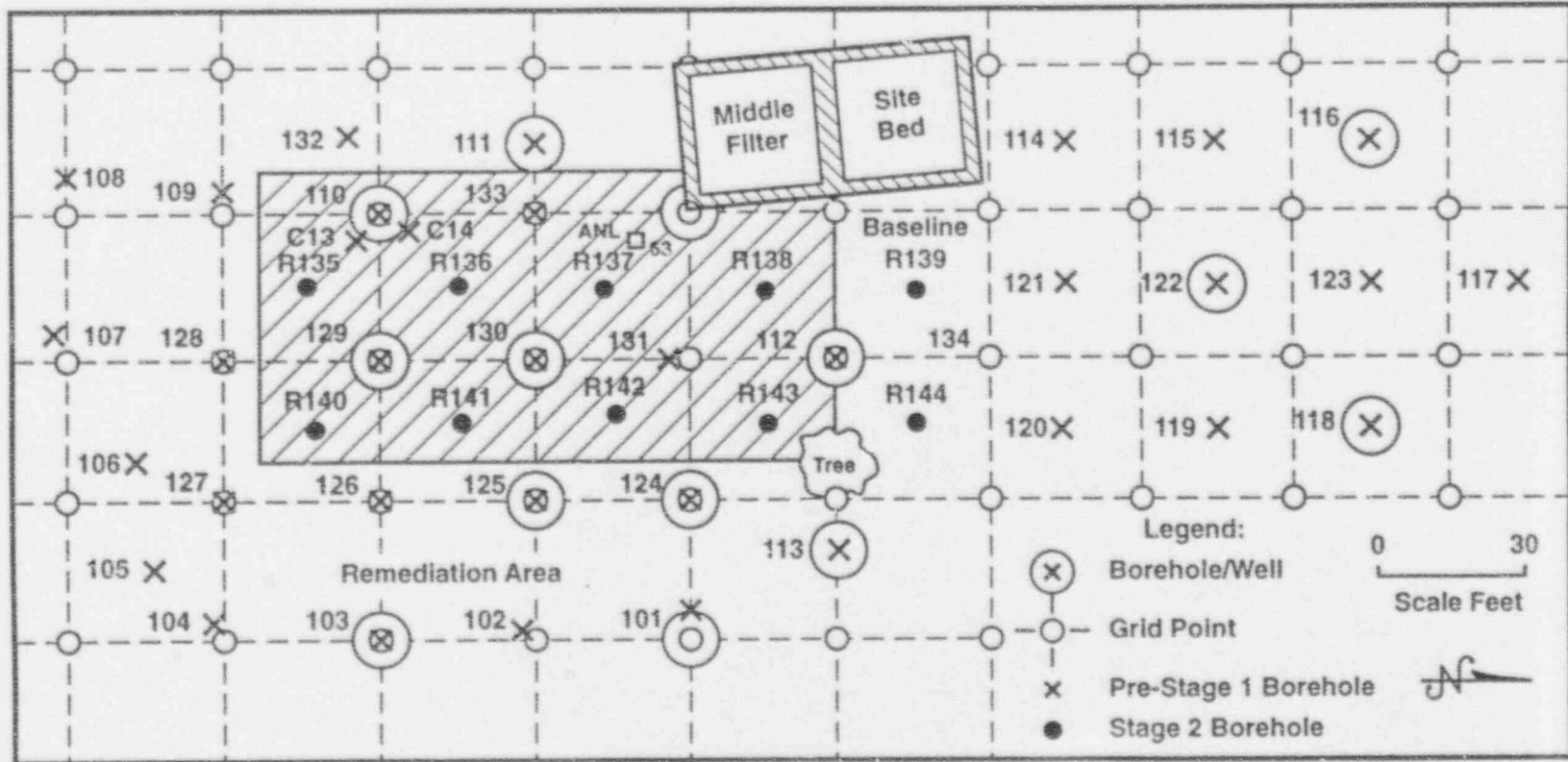


FIGURE 10. RECOMMENDED REMEDIAL ACTION FOR REMEDIATED FILTER BED AREA (SHADED AREA)

**TABLE 27. NONRADIOLOGICAL ANALYSES OF GROUNDWATER
WEST JEFFERSON SITE — 1993**

Chemical Parameter	Well C03 ^(a)	Well C09 ^(a)	Well C16 ^(a)
Total Metals (mg/l)			
As	<0.2	<0.2	<0.2
Ba	0.04	0.1	0.1
Cd	<0.02	<0.02	<0.02
Cr	<0.04	<0.04	<0.04
Pb	<0.2	<0.2	<0.2
Hg	<0.05	<0.005	<0.005
Se	<0.2	<0.2	<0.2
Ag	<0.02	<0.02	<0.02
Pesticides and PCBs (mg/l)			
26 compounds	below detection limit	below detection limit	below detection limit
Volatile Organics ($\mu\text{g/l}$)			
35 compounds	below detection limit	below detection limit	1,1,1 trichloroethane = 7 $\mu\text{g/l}$; others: below detection limit
Semivolatile Compounds ($\mu\text{g/l}$)			
65 compounds	below detection limit	below detection limit	below detection limit
Oil & Grease (mg/l)			
	<1	<1	<1
pH	6.7	6.5	7.0

(a) Locations are shown in Figures 9 and 10.

TABLE 28. SUMMARY OF ALPHA/BETA RADIOLOGICAL ANALYSES OF GROUNDWATER^(a)
WEST JEFFERSON SITE — 1993

Well Identification	Number of Samples	pCi/l ^(b)					
		Gross α ± 2 sigma			Gross β ± 2 sigma		
JN	1	1.09	\pm	5.44	2.41	\pm	2.62
JM	1	7.91	\pm	8.19	4.81	\pm	2.92
C03	1	8.89	\pm	9.19	10.14	\pm	3.58
C09	1	14.05	\pm	11.95	37.90	\pm	5.87
C16	1	17.60	\pm	12.95	4.85	\pm	3.12
101	1	9.39	\pm	11.06	18.75	\pm	4.56
103	1	2.34	\pm	13.42	13.30	\pm	3.90
110	1	37.62	\pm	20.76	108.07	\pm	9.74
118	1	42.08	\pm	24.13	63.68	\pm	7.90
150	1	9.16	\pm	8.52	9.59	\pm	3.43
155	1	10.72	\pm	11.09	19.19	\pm	4.55
168	1	10.99	\pm	10.22	25.49	\pm	4.92
172	1	4.28	\pm	7.49	20.63	\pm	4.50
206	1	33.91	\pm	19.44	51.12	\pm	6.93
306	1	10.62	\pm	10.99	14.63	\pm	4.14
403	1	35.79	\pm	19.06	42.58	\pm	6.34
506	1	7.23	\pm	10.07	16.89	\pm	4.38
601	1	8.69	\pm	15.21	13.16	\pm	2.24

(a) Locations are shown in Figures 9 and 10.

(b) Minimum detection limit (MDL):

gross α : 1.0 pCi/l

gross β : 2.9 pCi/l

**TABLE 29. SUMMARY OF RADIOLOGICAL ANALYSES OF GROUNDWATER--
WEST JEFFERSON SITE--1993**

volume = 1900 ml 1×10^{-9} $\mu\text{Ci/ml}$
All values are "less than" values except where indicated (*)

Nuclide	Well Identification No. (a)																	
	101	103	110	118	150	155	168	172	206	306	403	506	601	C-03	C-09	C-16	JM-W	JN-W
Co-57	2.15	1.22	2.03	2.00	1.79	1.24	2.19	1.14	1.23	2.12	1.76	1.21	2.02	1.75	1.20	2.23	1.21	1.99
Co-60	2.85	1.11	3.63	3.59	2.07	1.53	2.93	1.14	1.50	2.70	2.00	1.07	3.82	1.99	3.29*	2.47	1.14	3.30
Sr-90	2.19	2.40	1.70	8.15*	2.45	2.44	5.18*	4.82*	2.07	2.06	1.75	2.81*	4.60*	2.05	9.13*	1.37	1.47	1.53
Sb-125	7.41	3.36	8.95	8.12	5.64	3.85	7.64	3.17	4.10	7.40	5.74	3.46	8.02	5.79	3.99	7.05	3.39	8.55
Cs-134	2.61	1.19	3.03	2.83	1.97	1.47	2.44	1.11	1.51	2.41	1.98	1.16	2.90	1.97	1.52	2.63	1.18	2.76
Cs-137	2.76	1.30	60.90*	3.51	2.20	1.66	2.90	1.17	1.60	2.81	2.12	1.30	3.13	2.14	1.69	2.85	1.22	3.18
Eu-152	6.06	3.43	5.74	5.66	5.01	3.47	6.15	3.21	3.44	5.90	4.87	3.40	5.65	4.88	3.33	6.17	3.39	5.54
Eu-154	4.28	2.45	4.05	4.03	3.50	2.43	4.27	2.26	2.39	4.17	3.42	2.32	3.92	3.48	2.35	4.32	2.37	3.90
U-235	3.28	2.34	3.65	3.60	3.37	2.67	3.34	2.20	2.59	3.24	3.36	2.29	3.46	3.34	2.60	3.27	2.29	3.39
($\mu\text{g/ml}$)	0.15	0.11	0.17	0.17	0.16	0.13	0.16	0.10	0.12	0.15	0.16	0.11	0.16	0.16	0.12	0.15	0.11	0.16
U-238	45.80	32.10	38.80	37.70	37.90	34.80	44.20	30.70	35.00	44.60	37.90	31.90	37.70	37.80	34.40	44.80	32.20	36.80
($\mu\text{g/ml}$)	0.14	0.10	0.12	0.11	0.11	0.10	0.13	0.09	0.11	0.13	0.11	0.10	0.11	0.11	0.10	0.13	0.10	0.11
Pu-238	0.40	0.52	0.46	0.50	0.44	0.66	0.52	0.48*	0.33	0.47	0.54	0.75	0.31	0.42	0.35	0.51	0.43	0.48
Pu-239	0.40	0.12	0.31	0.10	0.30	0.11	0.08	0.18	0.33	0.32*	0.24	0.17	0.31	0.09	0.10	0.08	0.09	0.11
Am-241	13.50	3.51	10.30	10.40	3.88	3.47	13.70	3.35	3.56	12.80	3.81	3.40	10.70	3.82	3.48	12.90	3.51	10.20
Ra-226	3.29*	2.27*	4.55*	9.48*	3.80*	4.47*	2.47*	1.18	5.09*	1.18	4.19*	4.64*	4.16*	1.77*	1.17	0.73	1.11	0.76
Ra-228	2.80	25.10*	7.00*	5.02*	4.21	9.33*	3.80	3.64	3.60	22.20*	2.55	4.21	4.21	6.74*	4.40	2.63	3.28	2.49
Nat-U	0.72*	2.27*	3.89*	3.52*	0.96*	4.90*	2.14*	6.52*	2.79*	5.40*	2.09*	10.70*	2.49*	4.03*	1.43*	1.45*	0.83*	0.75*
($\mu\text{g/ml}$)	0.001	0.003	0.006	0.005	0.001	0.007	0.003	0.010	0.004	0.008	0.003	0.016	0.004	0.006	0.002	0.002	0.001	0.001

(a) Locations are shown in Figures 9 and 10.

Evaluation of Dose to the Public

Estimated Dose to the Public from the King Avenue Site Emissions During 1993

Battelle's King Avenue facility is not considered in this report to the same extent of the West Jefferson site because the source term at King Avenue is a fraction of the source term at West Jefferson and the vast majority of material associated with the BCLDP at King Avenue is fixed contamination. Only insignificant amounts of loose contamination that are localized and contained, are present at the King Avenue facility. A prediction of internal doses to the public from activities at the King Avenue site was done several years ago and showed the weighted sum effective dose equivalent to the maximum individual was 1.22×10^{-5} mrem/yr. That prediction is from the Environmental Assessment⁽⁵⁾. The radiological survey data from the Radiation Protection Program indicates that this prediction is correct.

Estimated Dose to the Public from the West Jefferson Site Emissions During 1993

The environmental monitoring data for 1993 presents information for determining sources of environmental radiation resulting from past or current nuclear activities and from atmospheric nuclear tests or natural radioactivity conducted by operations not involving Battelle. Contributions from Battelle's nuclear operations were indistinguishable from other sources. The radiological impact of Battelle's nuclear activities is calculated from the quantity of radionuclides assumed directly in effluents from facilities operating in 1993, from the annual deposition of airborne radionuclides on vegetation and field crops, and from residual radionuclides in stream sediment associated with past operations.

Atmospheric Discharges

Calculated releases and ground level annual average concentrations at the site boundary during 1993 for the West Jefferson site are summarized in Tables 3, 4, 5, and 6. The downwind position from the facility where annual ground level concentrations will be the greatest is at the north site fence line which determines the perimeter for uncontrolled exposure. This fence line is surrounded by additional land within the Battelle site boundary line. Table 5 shows that the total mixed fission and TRU product releases for 1993 amounted to 338.69 μCi , with an estimated maximum effective dose equivalent to a nearby resident of 3.74×10^{-2} mrem/yr. The total isotopic composition of the effluents assumed to be emitted from the seven stacks of the JN-1 facility and two stacks of JN-2 was used in evaluating the off-site dose to the public.

The estimated collective population dose (effective dose equivalent) for the total population within 80 km is 0.136 person-rem/year. The doses presented in this report are calculated rather than measured, and they represent potential rather than actual doses.

Contributions of nuclides to dose are:

Nuclide	Individual	Population
U-238	56%	54%
Am-241	37%	39%
U-235	5%	5%
Eu-152	1%	1%
Others	1%	1%

Assumptions for the model included that:

- (1) State-specific agricultural data were used (CAP88-PC default).
- (2) Meteorological and site-specific population files supplied with CAP88-PC were used.
- (3) Emissions from stacks 013 and 014, which have the same height and diameter, were combined in a single stack of that height with an equivalent flow volume.

Liquid Discharges

Measured aqueous releases and effluent concentrations during 1993 for the West Jefferson site are summarized in Table 7. The concentration values apply to the water discharged into Big Darby Creek after passage through a treatment system consisting of a settling tank and enclosed surface sand filter. Based on a knowledge of the isotopic composition of radionuclide concentrations released to the surface sand filter, emissions should be due to very limited elution of contaminants from the surface sand filter that were delivered to the bed in the past few years. In order to be conservative, the release inventory values are based on the minimum detectable limits of isotopes listed in Table 7. The actual release values would be lower.

Calculation of Atmospheric Dispersion Parameters

Meteorological data from the Columbus area were used as input to compute the dispersion parameters for the West Jefferson and King Avenue sites. CAP88-PC,⁽¹¹⁾ programmed for localized applications (see Table 30), was used to generate detailed X/Q. Values of X/Q represent potential releases (measured in Ci) in relation to wind speed (measured in seconds) at a designated distance. Thus, X/Q values were developed for a series of concentric rings extending from the site boundary out to a distance of 80 km (50 miles). The rings were broken down into sixteen sections corresponding to the normal wind rose pattern. The minimum X/Q values for the radionuclides considered are presented in Tables 31 and 32.

Computation of Dose Equivalent Rates to Nearby Individuals and Population Groups

The annual radiation dose from particulate radionuclides assumed to be discharged into the atmosphere was computed for a person continuously immersed in an infinite hemispherical cloud containing the radionuclides. Stack release data (see Table 5) are used

TABLE 30. ARITHMETIC AVERAGE WIND SPEEDS AND FREQUENCY (WIND TOWARDS)

Dir	Pasquill Stability Class							Frequency
	A	B	C	D	E	F	G	
N	1.467	2.317	3.320	4.564	2.197	0.000	0.000	0.111
NNW	1.525	2.463	3.228	4.162	2.083	0.000	0.000	0.064
NW	1.588	2.115	3.452	4.166	2.058	0.000	0.000	0.060
WNW	0.997	2.414	3.505	4.015	1.924	0.000	0.000	0.059
W	1.540	2.230	3.421	3.950	1.875	0.000	0.000	0.050
WSW	1.467	2.634	3.611	4.227	1.924	0.000	0.000	0.045
SW	1.456	2.449	3.697	4.026	1.870	0.000	0.000	0.042
SSW	1.372	2.488	3.700	4.212	1.918	0.000	0.000	0.047
S	1.533	2.292	3.456	4.334	1.861	0.000	0.000	0.078
SSE	1.243	2.363	3.615	4.945	2.137	0.000	0.000	0.066
SE	1.413	2.490	3.766	5.271	2.416	0.000	0.000	0.055
ESE	1.560	2.376	4.272	5.803	2.647	0.000	0.000	0.063
E	1.513	2.226	4.532	5.975	2.812	0.000	0.000	0.064
ENE	1.543	2.319	4.400	6.400	3.106	0.000	0.000	0.049
NE	1.420	2.474	4.431	6.138	2.870	0.000	0.000	0.062
NNE	1.447	2.692	4.059	5.394	2.517	0.000	0.000	0.086

**TABLE 31. MINIMUM X/Q DISPERSION VALUES
AT THE WEST JEFFERSON SITE FROM
JN-1 AND JN-2 STACKS**

Nuclide	X/Q
Co-57	6.10 x 10 ⁻⁶
Co-60	6.56 x 10 ⁻⁶
Sr-90	6.27 x 10 ⁻⁶
Sb-125	5.90 x 10 ⁻⁶
Cs-134	6.22 x 10 ⁻⁶
Cs-137	6.27 x 10 ⁻⁶
Eu-152	6.20 x 10 ⁻⁶
Eu-154	6.30 x 10 ⁻⁶
U-235	6.17 x 10 ⁻⁶
U-238	5.91 x 10 ⁻⁶
Pu-238	6.13 x 10 ⁻⁶
Pu-239	6.99 x 10 ⁻⁶
Am-241	6.11 x 10 ⁻⁶

These minimums occur at the boundary of the Battelle property on the north side of the site.

to estimate the nearby individual and population group concentrations using actual dispersion conditions, if known. If the conditions are unknown, worst-case data were used. The radionuclide composition and concentration of the atmospheric emissions was used to compute critical organ doses assuming the more sensitive biological form (soluble or insoluble) was present. The dose estimates obtained for the nearby individual assume a full-time resident at Camp Ken Jockey.

The effective dose equivalent rate for the nearby individual was computed using CAP88-PC following requirements of 40 CFR 61.93(a). The value at the camp is 0.037 mrem/yr, with the highest organ dose being 0.157 mrem to the endosteum. In comparison, exposure of persons to natural background radiation in the area would be approximately 120 mrem/yr as measured by TLD stations. The US EPA has set the exposure limit to 10 mrem/yr to any member of the general public from all sources of radionuclides.

**TABLE 32. MINIMUM X/Q DISPERSION VALUES
AT THE KING AVENUE SITE
FROM THE EAST CENTRAL AND
WEST CENTRAL STAGING AREAS**

Nuclide	X/Q
Co-57	1.179 x 10 ⁻⁵
Co-50	1.179 x 10 ⁻⁵
Sb-125	1.179 x 10 ⁻⁵
Cs-134	1.179 x 10 ⁻⁵
Cs-137	1.179 x 10 ⁻⁵
Eu-152	1.179 x 10 ⁻⁵
Eu-154	1.179 x 10 ⁻⁵
U-235	1.179 x 10 ⁻⁵
U-238	1.179 x 10 ⁻⁵
Am-241	1.179 x 10 ⁻⁵

These minimums occur at the boundary of the Battelle property on the north side of the site.

For the total population within 80 km of the West Jefferson site, the estimated collective population dose (effective dose equivalent) is 0.136 person-rem/year for 1993.

Estimated Radiation Dose to the Public from Liquid Discharges

Radiation Dose from Swimming (External Whole Body)

Due to the shallow nature of Big Darby Creek at the West Jefferson site, there does not appear to be a significant pathway for exposure to swimmers. Based on previous years' releases and calculations, it can be assumed that no measurable exposure is attributable to releases from the West Jefferson site.

Radiation Dose During Boating and Waterskiing

Big Darby Creek is too shallow to allow any significant boating or water skiing. Thus, no dose has been calculated for this pathway.

Radiation Dose from Drinking Water

Water from 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; therefore, the dose contribution from this source is negligible.

Quality Assurance

Several methods are used to assure that the data collected each year are representative of actual concentrations in the environment. Extensive environmental data are collected to eliminate an unrealistic reliance on only a few results. 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 site, as well as upstream and downstream on 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, all of the routine radioanalyses for the Battelle environmental surveillance program are performed at the radiochemistry facility located at the West Jefferson nuclear site. Two outside radiochemistry laboratories (Ecotek, located in Atlanta, GA; and IT, located in St. Louis, MO) were chosen as a backup service for overflow samples, and performed certain plutonium, thorium, uranium, and strontium analyses. Both laboratories maintain internal quality assurance programs that involve routine calibration of counting instruments, daily source and background counts, routine yield determinations of radiochemical procedures, and replicate analyses to check precision. The accuracy of radionuclide determination is assured through the use of standards traceable to the National Institute of Standards and Technology (NIST).

Assurance of the dose calculation quality is provided in the following ways. Since doses are similar from year to year, a comparison is made against past calculated doses and any differences are validated. All computed doses are double checked by the originator and by an independent third party, who also checks all input data and assumptions used in calculation. Information necessary to perform all of the calculations is fully documented.

The Battelle Radioanalytical Laboratory participates in the semi-annual Environmental Measurements Laboratory (EML) program. This program is designed to monitor a laboratory's performance by submitting samples of known isotopes and quantified activities for analysis. Four types of samples in different matrices are submitted for analysis. These consist of air, water, soil and vegetation.

All matrices in 1993 for gamma isotopic analyses were within the EML's stated activity boundaries, except potassium 40 (K-40) which was less than ten percent out.

Of the 14 reported analyses for plutonium, ten were within boundaries, two analyses were 3 percent out, one analysis was 25 percent out, and the remaining analysis was reported conservatively high.

Remaining results for all isotopes reported were within the EML's stated boundaries.

Minimum detection levels (MDLs) for radionuclide analyses were determined to a 95 percent confidence level. The minimum detectable level (MDL) was calculated using the Ortec OMNIGAM MAESTRO II computer system or the Canberra Nuclear, Inc., Procount VAX system. During 1993, a conversion of detection systems was implemented.

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).

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.

cosmic radiation. Radiation of many types with very high energies, originating outside the earth's atmosphere. Cosmic radiation is one source contributing to natural background radiation.

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

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

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

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

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

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

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

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.

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/concentration (MDA/MDC). The smallest amount of activity/concentration of a radioelement 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 radiation, 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 radioactivity 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).

sievert (Sv). International System of Units (SI) unit for radiation dose (1 sievert = 100 rem).

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.

uncontrolled area. An area to which access is not controlled for the purpose of protecting individuals from exposure to radiation and radioactive materials. The area beyond the boundary of the RFP is an uncontrolled area.

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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Appendix

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