REPORT

BCLDP 10192

SITE ENVIRONMENTAL REPORT For Calendar Year 1991 on Radiological and Nonradiological Parameters

To

United States Department of Energy

DOE Field Office, Chicago

October 1, 1992

Battelle

Putting Technology To Work

BCLDP-10192

BATTELLE COLUMBUS LABORATORIES
DECOMMISSIONING PROJECT

SITE ENVIRONMENTAL REPORT
FOR
CALENDAR YEAR 1991

on

RADIOLOGICAL AND NONRADIOLOGICAL PARAMETERS

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UNITED STATES DEPARTMENT OF ENERGY
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October 1, 1992

Prepared by

Regulatory Compliance and
Environment, Safety, and
Health Oversight

Battelle Columbus Laboratories
Decommissioning Project

Battelle

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FOREWORD

This report was prepared for the Battelle Columbus Laboratories Decommissioning Project (BCLDP) by staff in the Regulatory Compliance and Environment, Safety, and Health Oversight group. The radiological monitoring data were supplied by environmental and operational health physics staff. All radioanalyses of environmental air, water, grass, soil, sediment, and food crop samples were performed by the BCLDP Radioanalytical Laboratory. Nonradiological analyses of environmental water samples were performed by the Columbus Water and Chemical Testing Laboratory, Columbus, Ohio, and Kemron Environmental Services, Marietta, Ohio.

SUMMARY

Battelle Memorial Institute's nuclear research facilities are currently being maintained under a surveillance and maintenance (S&M) mode with increasing decontamination and decommissioning (D&D) activities under Department of Energy (DOE) Contract W-4-7405-ENG-92. These activities are referred to under the Contract as the Battelle Columbus Laboratories Decommissioning Project (BCLDP). All operations referred to in this report are those activities in support of S&M and D&D. Environmental monitoring was continued to demonstrate compliance by Battelle with all federal, state, and local regulations. The only routine nonradiological monitoring in association with the BCLDP is done for the National Pollution Discharge Elimination System (NPDES) Permit 41N00004*DD for the West Jefferson Nuclear Sciences Area, and groundwater monitoring wells at the West Jefferson site.

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, food crop, sediment, and soil were collected from the region surrounding the two sites and analyzed. Off-site levels of radionuclides that may be attributable to the West Jefferson 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 fuel contamination left from previous fuel work.

The data are summarized as follows:

There were slightly elevated readings of total residual chlorine and total suspended solids in a monthly sample required under the West Jefferson NPDES Permit. These readings were reported to Ohio Environmental Protection Agency (OPEA) and follow-up sampling has revealed no further problems. None of these conditions are directly attributable to BCLDP activities. A discussion of releases is found in the section on ENVIRONMENTAL NON-RADIOLOGICAL PROGRAM INFORMATION on page 53 of this report.

No isotopes were present above minimum detectable levels (MDL) for air releases or for liquid discharges to Darby Creek from the West Jefferson Nuclear Science Area. 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. Concentrations observed at downstream sampling locations were statistically indistinguishable from background levels.

West Jefferson nuclear operations during 1991 caused no distinguishable impact on concentrations of airborne radionuclides nor on external radiation doses measured adjacent to the West Jefferson site and the site boundary. Radionuclides detected in food crop, grass, creek bottom sediment, fish, and soil samples (e.g., Cs-137) were all attributed to previous atmospheric nuclear tests, Chernobyl fallout, or natural sources.

The estimated dose equivalent to a nearby resident from nuclear operations at the West Jefferson site was calculated to be 0.0066 mrem/yr, with a maximum organ dose to the endosteum of 0.038 mrem/yr. These dose calculations assume impacts due to the presence of radionuclides at MDL levels, although such radionuclides were not found in detectable concentrations during the year's environmental sampling program.

The whole body "fence-post" exposure during 1991, for external radiation at the site boundary line, was at background levels at Ken Jockety Camp, the Girl Scout camp adjacent to the Battelle property line 0.4 km east-southeast 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 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 given in the text on page 45.

D&D activities during the year involved site and building characterization at West Jefferson, and room and/or building characterization at King Avenue. Some of the radioactively contaminated sump sludge waste at the King Avenue site was identified as TSCA or RCRA mixed waste. This waste was

removed, packaged, and shipped for disposal at a DOE facility managed by the Westinghouse Hanford Company in Richland, Washington. Additional sump sludge has undergone further characterization and its disposal is a focal point for 1992 D&D activities.

Building 9 was removed from the S&M program after decontamination was completed.

INTRODUCTION

Surveillance and maintenance (S&M) activities, performed 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 10-acre plot, accommodating 21 buildings, is bounded on the north by King Avenue, Battelle Boulevard to the east, partly by Fourth Avenue and Fifth 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 processing.

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, which 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 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.

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

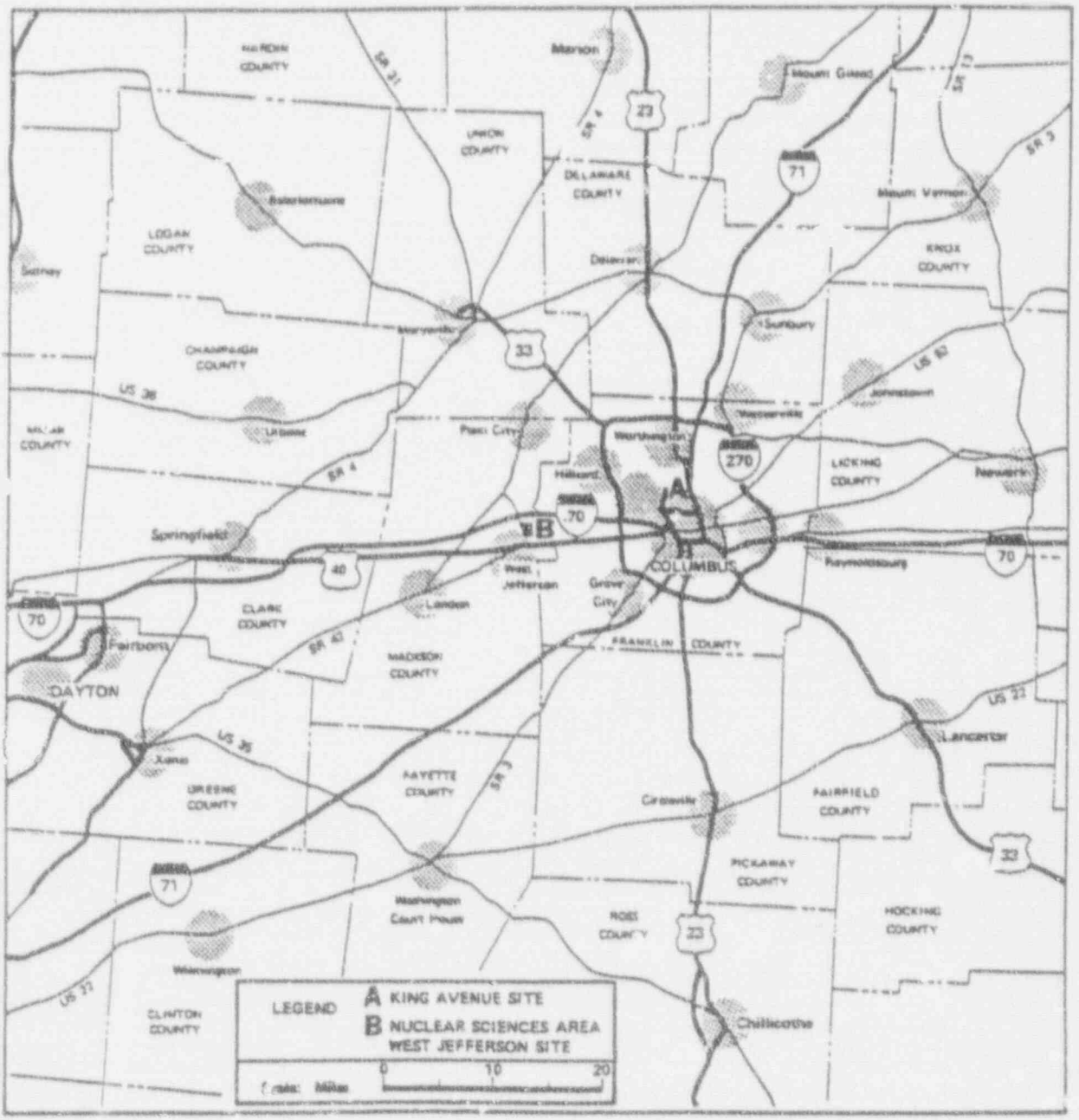


FIGURE 1. REGIONAL MAP FOR KING AVENUE AND WEST JEFFERSON SITES

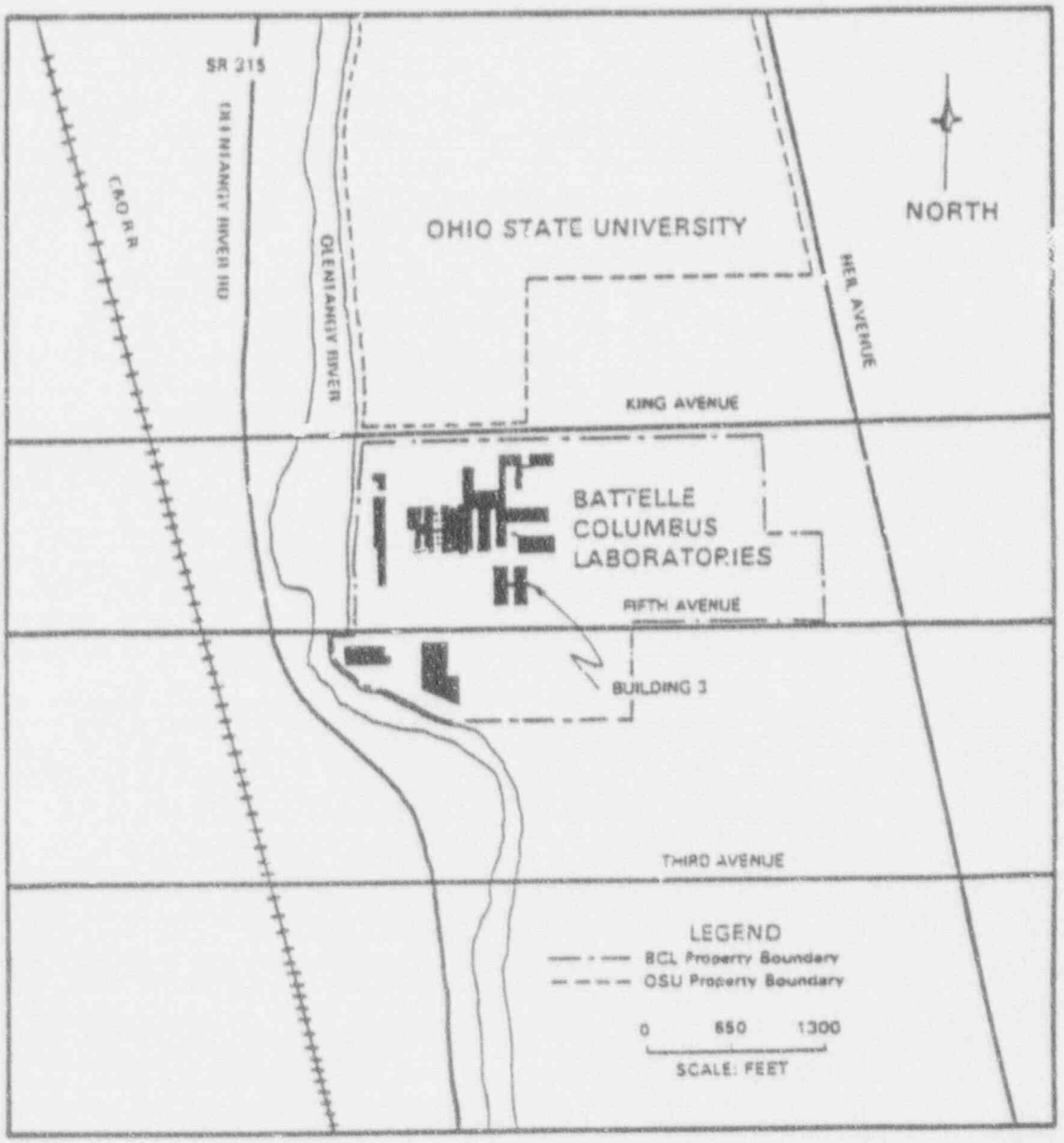


FIGURE 2. LOCAL VICINITY MAP OF KING AVENUE SITE

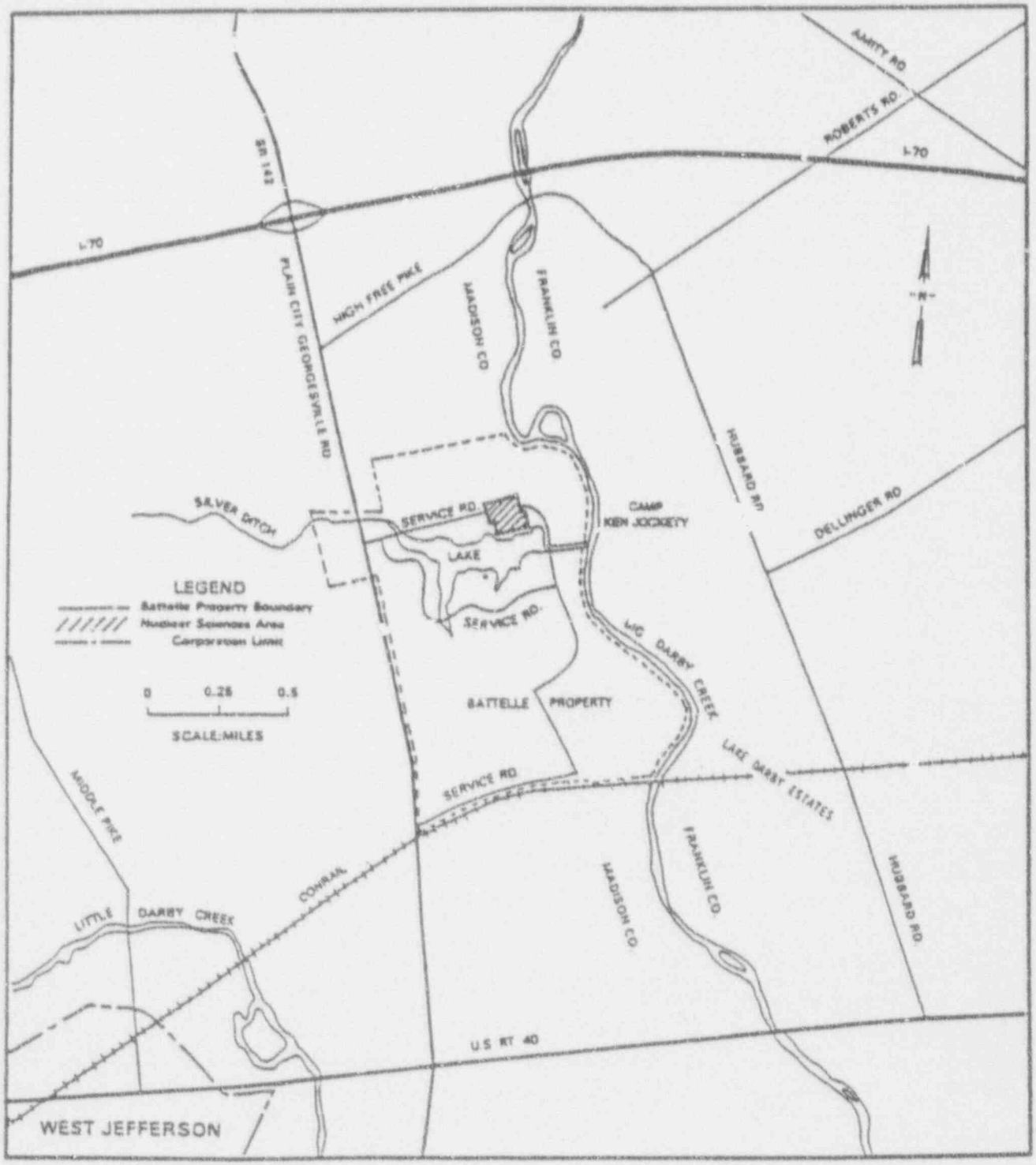


FIGURE 3. LOCAL VICINITY MAP OF NUCLEAR SCIENCES AREA--WEST JEFFERSON SITE

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 is leased to farmers, typically for raising field crops such as corn or soy beans. 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, scrub, and high grasses.

Demography

The area within a two-mile radius of the Battelle King Avenue facility to the east and south can be characterized as high-density residential. The Ohio State University, with a student enrollment of approximately 60,000 and an employee staff of approximately 29,700, is adjacent to the King Avenue facility on the north. The area west of the Olentangy River consists mainly of small business and light industrial properties, with scattered residential patches. Table 1 gives data on the population distribution within a 50-mile radius of the King Avenue facility.

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. The nearest residences to the Nuclear Sciences area are two houses located 2,500 feet to the northwest and southwest, respectively. Camp Ken Jockety, a Girl Scout camp, is located on a bluff on the east side of the Big Darby Creek at a distance of 1,640 feet from the center of the site. Four thousand feet to the southeast, on the eastern side of the Big Darby Creek, the Lake Darby Estates residential subdivision (Figure 3) currently contains a total of 965 single family units. A second subdivision, West Point, east of the Lake Darby Estates and Hubbard Road, has approximately 540 housing units.

TABLE 1. BATTELLE KING AVENUE SITE POPULATION WITHIN 80-KM (50-MILE) RADIUS[1]

	Distance in km (miles)										
	0-1.6 (0-1)	1.6-3.2 (1-2)	3.2-4.8 (2-3)	4.8-6.4 (3-4)	6.4-8.1 (4-5)	8.1-16.1 (5-10)	16.1-32.2 (10-20)	32.2-48.3 (20-30)	48.3-64.4 (30-40)	64.4-80.5 (40-50)	Total
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	1,565	2,348	8,386	4,042	21,398	8,243	10,362	7,901	4,567	68,812
S	0	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	4,189	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

TABLE 2. BATTELLE WEST JEFFERSON SITE POPULATION WITHIN 80-KM (50-MILE) RADIUS[1]

	Distance in km (miles)										
	0-1.6 (0-1)	1.6-3.2 (1-2)	3.2-4.8 (2-3)	4.8-6.4 (3-4)	6.4-8.1 (4-5)	8.1-16.1 (5-10)	16.1-32.2 (10-20)	32.2-48.3 (20-30)	48.3-64.4 (30-40)	64.4-80.5 (40-50)	Total
N	14	20	87	77	121	3,010	4,403	4,911	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	13,351	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	24,405	50,876	17,140	194,821
SE	262	1,172	46	71	274	4,158	12,216	14,48.	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	37,702
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	25,505
Total	1,264	2,741	4,451	2,799	3,984	131,836	766,663	349,136	275,765	561,903	2,100,542

Currently 18 industries are located within a 10-mile radius. Of these, only four employ more than 100 people. Each of these is located at least 8 miles from the facility. Closest to the site are three small industries within West Jefferson that individually employ less than 60 people. 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 industrial growth. It is estimated that the industrial 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

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 mont 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.

Precipitation is distributed fairly uniformly during the year, although 60 percent falls during the spring-summer seasons. The annual monthly average rainfall is about 3.5 inches. The greatest recorded rainfall for any 24-hour period was 3.87 inches in July of 1947.

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 (see Figure 11 and Table 23 later in this report).

Geology

The arrangement of geological strata underlying the Battelle facilities area consists 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 trace 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 nearly precludes 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 Zone 1 low-risk area.

Hydrology

Two aquifers, or underground sources of water, are located in the 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 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.

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 replica of the surface topography. Groundwater moves downslope at right angles to the contours and follows a path similar to surface runoff.

At the Nuclear Sciences area surface runoff moves downslope into 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 Laboratory reaffirmed the geology described above. Only isolated pockets of water 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 calculation 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 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

In 1966, ground level radiation for the region, including Battelle facilities, was measured using an aircraft equipped with radiation instrumentation. The measurements showed that the natural terrestrial background for the area surrounding Battelle was 60 mrem/yr.[2] This number is equal to the average natural terrestrial background for the United States. The cosmic background for the State of Ohio is averaged to be 50 mrem/yr, compared to a U.S. average of 45 mrem/yr. The estimate for natural whole-body internal background is considered to [illegible] mrem/yr for the United States with only minor regional variations.[3] Based on these figures, the total natural background radiation near the Battelle facilities is estimated to be approximately 130 mrem/yr. This is the same as the national average for the United States as a whole.

FACILITY DESCRIPTION

The center of S&M activities at the Battelle King Avenue site is the former U-235 Processing 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 actual D&D of Building 9.

The King Avenue Site

The former U-235 Processing 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 processing and storing 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 processing 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.

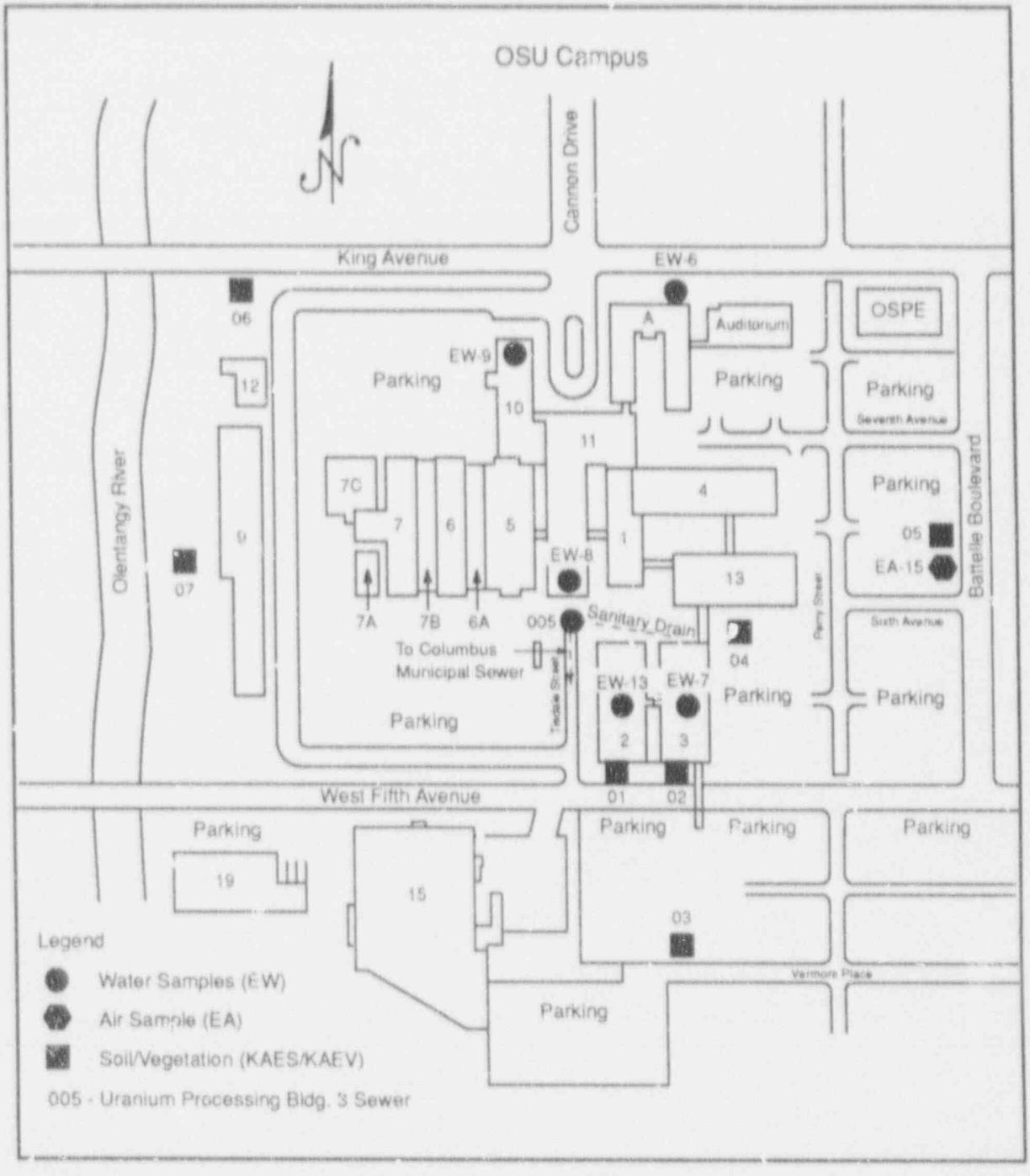


FIGURE 4. BATTELLE KING AVENUE LABORATORIES

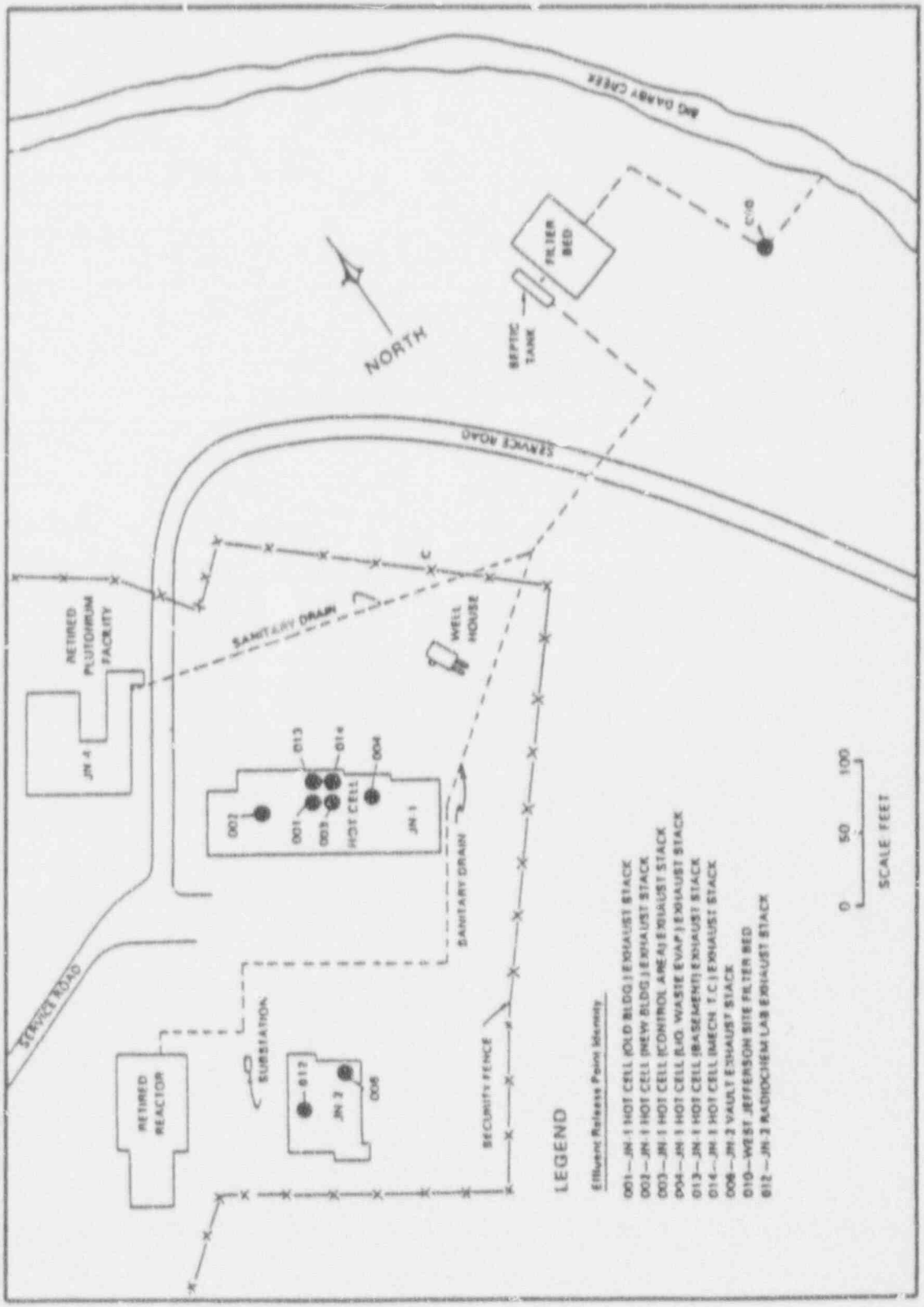


FIGURE 5. NUCLEAR SCIENCES AREA--WEST JEFFERSON SITE

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 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 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 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 supporting facilities include areas for cask handling, solid and liquid-waste disposal, contamination control, equipment decontamination, and other miscellaneous operations. All of these operations have contributed to the need for 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 Section Administration, Health Physics Services, Nuclear Materials Accountability, Quality Assurance, and Instrument Maintenance. These activities are the major building activities at this time. The building also currently houses a vault for storage of special nuclear materials and a radiochemistry laboratory for the assay of routine health physics and environmental samples.

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. These activities involve nonradioactive materials only.

COMPLIANCE SUMMARY

CALENDAR YEAR 1991

The BCLDP continues to maintain a state of compliance with all applicable environmental statutes, regulations, or DOE orders. No fines, penalties, or administrative orders were imposed on Battelle during 1991. No lawsuits by regulatory agencies or citizen suits were brought against Battelle in 1991. There were no unresolved compliance issues during 1990 that needed to be addressed in 1991. A minor violation in the areas of NPDES limits was noted and has been corrected by Battelle. However, this violation was not attributed to BCLDP activities, because it was a result of other Battelle operations. Only those issues that may be related to the BCLDP are reported here.

Compliance Status in Specific Regulatory Areas

a. Comprehensive Environmental Response, Compensation and Liability Act (CERCLA)

No violations have occurred and no enforcement actions were taken in connection with BCLDP.

b. Resource Conservation and Recovery Act (RCRA)

No violations have occurred and no enforcement actions were taken in connection with the BCLDP. Battelle's Part B permit application for waste storage and treatment at the King Avenue site was revised in response to comments made by OEPA. The revised application is being reviewed by OEPA; USEPA is reviewing the Corrective Action portion of the application.

c. National Environmental Policy Act (NEPA)

No activities were performed during this period that would trigger noncompliance with NEPA.

d. Clean Air Act (CAA)

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

e. Clean Water Act (CWA)

This act is administered in Ohio by the OEPA. The NPDES permit for the West Jefferson facility was renewed in 1991. It contained more stringent monitoring conditions than the prior permit. The monitoring done to meet the permit was adjusted accordingly. Three minor permit limit exceedences occurred; two of these were due to suspended solids, the other was due to a total residual chlorine level. No enforcement actions were taken in connection with Battelle or the BCLDP.

f. Safe Drinking Water Act (SDWA)

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

g. 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 the regulatory time limits.

h. Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA)

This act is not applicable. No pesticides are used in BCLDP activities.

i. Endangered Species Act (ESA)

This act is not applicable. No endangered species have been identified in the areas around Battelle.

j. National Historic Preservation Act (NHPA)
This act is not applicable. No areas or structures at Battelle have been identified as subject to requirements of this Act.

k. Executive Order 11988 "Floodplain Management"
This order is not applicable. The reference is Environmental Assessment (EA) for Battelle Columbus Laboratories Decommissioning Project, Table 4-5.[4]

l. Executive Order 11990 "Protection of Wetlands"
This order is not applicable. No wetlands have been identified at Battelle.

Environmental Permits

No new environmental permits were applied for under the BCLDP. OEPA did review new information on a source that they had previously exempted from air permitting. The Agency confirmed that no permit was required for the source. The BCLDP applied to the OEPA for two air permits related to project activities. The OEPA determined that neither sources required air permitting due to the insignificant impact of the releases and the short duration of the source.

List of Environmental Permits

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

Columbus Laboratory

a. Air (PTO: Permit to Operate)
   1. Bldg. 3--Beryllium lab hood, PTO #0125040520/P002
   2. Bldg. 5--Beryllium Machine shop, PTO #0125040520/P003

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

c. Hazardous Waste

1. Ohio Hazardous Waste Permit #01-25-0572.
2. USEPA interim status--Part A Permit OHD007901598.
3. Public Utilities Commission of Ohio (P.U.C.O.) hazardous waste transporter--MC 18902; 310-HW.

West Jefferson Laboratory

a. Air

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

b. Water

1. NPDES Permit 4IN00004*DD

c. Hazardous Waste

1. Hazardous waste generation identification number--OHT400013892.

JANUARY 1, 1992 - APRIL 1, 1992

The BCLDP continues to maintain a state of compliance with all applicable environmental statutes, regulations, or DOE orders. No fines, penalties, administrative orders, or notices of noncompliance were imposed on Battelle during the first quarter of 1992. No lawsuits by regulatory agencies or citizen suits were brought against Battelle during the same periods. Only those issues that may be related to the BCLDP are reported here.

Compliance Status in Specific Regulatory Areas

a. Comprehensive Environmental Response, Compensation and Liability Act (CERCLA)

No violations have occurred and no enforcement actions were taken in connection with the BCLDP.

b. Resource Conservation and Recovery Act (RCRA)

No violations have occurred and no enforcement actions were taken in connection with the BCLDP. Battelle's Part B application is being reviewed by OEPA; USEPA is reviewing the Corrective Action portion of the application.

c. National Environmental Policy Act (NEPA)

No activities were performed during this period that would trigger noncompliance with NEPA.

d. Clean Air Act (CAA)

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

e. Clean Water Act (CWA)

This act is administered in Ohio by the OEPA. No violations have occurred and no enforcement actions were taken.

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 Plan for the BCLDP. The plan addresses only the minimization of radioactive waste, because the program involves only decontamination and decommissioning (D&D) of existing contaminated (or radioactive) facilities. No other operations or activities generate waste (other than paper, which is recycled) that could be minimized. The BCLDP Waste Manager is responsible for the annual review and updating of the Waste Minimization 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 Plan, and pollution prevention is also included in the support/commitment and policy statements of this plan.

One key element in the Pollution Prevention Awareness Program to help prevent the spread of pollution is the issuance to each employee of site-specific Emergency Plans. They address steps to take in the event of any number of emergencies, providing information such as whom to notify for each type of emergency and which emergency teams are assigned to respond, depending on which site is involved in the emergency. They address major items such as fire and spill of hazardous and radiological materials. The Hazardous Materials Response Team is under the direction of the BCO Environment, Health and Safety Office. The team receives training in spill control, which includes awareness of new pollutants and how to prevent their release into the environment. A separate and detailed "Emergency Plan and Procedures - West Jefferson North" notebook addresses the handling of emergencies involving the release of radiological materials from the West Jefferson North site. West

Jefferson personnel experienced in the handling of radioactive materials are assigned to various teams to respond to potentially larger radiological hazards and releases to the environment. At King Avenue the BCO Radiological Safety Officer coordinates the response to radiological spills.

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 of all operations. Concentrations of radioactive and nonradioactive wastes are controlled so that effluent levels are maintained as low as reasonably achievable and well within applicable standards. All 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 have been limited to radiological precharacterization and characterization of facilities and disposal of waste. Disposal of sludge waste from King Avenue sumps did require nonroutine analysis of sludge to determine compliance with RCRA and TSCA disposal criteria. This led to the removal and packaging of 185 drums of radioactively contaminated TSCA or RCRA waste. This operation was conducted throughout the year and the material was shipped off site in three shipments in 1991. Nonradiological monitoring performed in connection with the BCLDP is presented in a separate section following the section pertaining to radiological monitoring.

ENVIRONMENTAL RADIOLOGICAL MONITORING

An inventory of suspected radionuclides and resultant effluent releases for air and water is presented in Table 3. Both release inventories are based on minimum detectable levels (MDL) of listed isotopes.* Weekly

*A discussion of how MDLs are calculated for radionuclide analyses can be found in the Quality Assurance Section at the end of this report.

TABLE 3. ANNUAL RADIONUCLIDE RELEASE INVENTORY(a)--
WEST JEFFERSON SITE--1991

Air	Activity (μCi)
Co-57	0.72
Co-60	1.50
Sr-90	0.13
Sb-125	3.30
Cs-134	1.05
Cs-137	1.47
Eu-152	2.73
Eu-154	4.20
U-235	2.93
U-238	1.73
Pu-238	0.04
Pu-239	0.01
Am-241	1.79
Water	**Activity (μCi)**
Co-57	106.7
Co-60	166.5
Sr-90	24.9
Sb-125	344.9
Cs-134	123.6
Cs-137	187.1
Eu-152	369.2
Eu-154	439.5
Ra-226	15.9
Ra-228	13.5
I-129	135.2
U-235	993.5
U-238	6029
Pu-238	2.7
Pu-239	2.5
Am-241	395.5

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

samples are screened for 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, minimum detectable levels are assumed as positive releases for purposes of establishing a release inventory and estimating doses to the public.

WEST JEFFERSON SITE

Air--Radioactive

In-stack air samplers continuously monitor the exhaust stack effluent release from each facility 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 is selected to facilitate the detection activity in concentrations 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 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. The results are summarized in Table 4. Note γ is implied in the table references to β. These filters are composited on a monthly basis for gamma analysis and on a 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 all less than 7.1×10^{-5} percent of 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

TABLE 4. SUMMARY OF ATMOSPHERIC RADIOACTIVE EMISSIONS--WEST JEFFERSON SITE--1991

Species	Stack Locations	Number of Stack Samples	Stack Volume 10^{10} L/yr	Activity μCi/yr	Stack 10^{-14} μCi/mL	Site Boundary[a] 10^{-20} μCi/mL
Gross α	001	52	2.5	0.07	0.17 ± 0.11	0.17 ± 0.11
Gross β	001	52	2.5	0.19	1.12 ± 0.19	1.12 ± 0.19
Gross α	002	52	11.1	0.26	0.11 ± 0.12	0.11 ± 0.12
Gross β	002	52	11.1	0.87	0.58 ± 0.10	0.58 ± 0.10
Gross α	003	52	4.62	0.11	0.11 ± 0.12	0.11 ± 0.12
Gross β	003	52	4.62	0.30	0.46 ± 0.18	0.47 ± 0.18
Gross α	004	52	0.84	0.02	0.13 ± 0.12	0.13 ± 0.12
Gross β	004	52	0.84	0.06	0.53 ± 0.19	0.53 ± 0.19
Gross α	013	52	0.76	0.02	0.12 ± 0.12	0.12 ± 0.12
Gross β	013	52	0.76	0.06	0.58 ± 0.19	0.58 ± 0.19
Gross α	014	52	1.84	0.04	0.08 ± 0.11	0.08 ± 0.11
Gross β	014	52	1.84	0.12	0.47 ± 0.18	0.47 ± 0.18
Gross α	012	51	2.48	0.06	0.12 ± 0.17	0.12 ± 0.17
Gross β	012	51	2.48	0.29	0.56 ± 0.26	0.56 ± 0.26
Gross α	006	52	0.38	0.05	0.09 ± 0.08	0.09 ± 0.08
Gross β	006	52	0.38	0.37	0.72 ± 0.22	0.72 ± 0.22

(a) Site boundary concentrations were calculated by multiplying stack concentrations by the average atmospheric dispersion parameter (1.0 x 10^{-6}) computed for the site boundary using computer code AIRDOS-EPA (see Table 24 for data sets).

TABLE 5. SUMMARY OF SPECIFIC RADIONUCLIDES FROM STACK EMISSIONS--WEST JEFFERSON SITE--1991

Species[a]	Activity $\mu Ci/yr$[b]	Release Concentration ($x10^{-14}$) $\mu Ci/mL$[c]	Site Boundary ($x10^{-20}$) $\mu Ci/mL$[d]	Derived Concentration Guide Limit[e] $\mu Ci/mL$	Percent of DCG at the Site Boundary
Co-57	0.72	0.29	0.29	2.0×10^{-9}	1.5×10^{-10}
Co-60	1.50	0.61	0.61	8.0×10^{-11}	7.6×10^{-9}
Sr-90	0.13	0.05	0.05	9.0×10^{-12}	5.6×10^{-9}
Sb-125	3.30	1.35	1.35	1.0×10^{-9}	1.8×10^{-8}
Cs-134	1.05	0.43	0.43	2.0×10^{-10}	2.15×10^{-9}
Cs-137	1.47	0.60	0.60	4.0×10^{-10}	1.5×10^{-9}
Eu-152	2.73	1.12	1.12	5.0×10^{-11}	5.6×10^{-8}
Eu-154	4.20	1.71	1.71	5.0×10^{-11}	3.4×10^{-8}
U-235	2.93	1.20	1.20	1.0×10^{-13}	1.2×10^{-6}
U-238	1.73	7.06	7.06	1.0×10^{-13}	7.1×10^{-6}
Pu-238	0.04	0.01	0.01	3.0×10^{-14}	3.3×10^{-7}
Pu-239	0.01	<0.01	<0.01	2.0×10^{-14}	2.9×10^{-7}
Am-241	1.79	0.73	0.73	2.0×10^{-14}	3.7×10^{-5}

(a) Identification of radionuclides in stack particulate emissions was by gamma spectrometric analysis of stack particulate air filters composite by stack location by month. In the absence of deteciable activity, calculated MDL values (a posteriori) were used to establish inventory of suspected radionuclides (based on age of residual fuel contamination).

(b) Activity is the sum of isotopic results for individual stacks identified in Table 5 and Figure 5.

(c) Release Concentration is the result of Activity divided by the total stack volume of 2.451×10^{11} L/yr.

(d) Site boundary concentrations were calculated by multiplying stack concentration by the average atmospheric dispersion parameter (1.0×10^{-6}) computed for the site boundary using computer code AIRDOS-EPA (see Table 24).

(e) DOE Order 5400.5, U.S. Department of Energy, Washington, D.C., February 1990.

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 AIRDOS-EPA (see reference 11).

Supplementary air sampling was performed at four site perimeter locations during 1991 (Figure 6). These air samples were collected continuously and analyzed on a weekly basis for gross α and β activities. The average concentrations of activity at each of these locations were all statistically lower than the average gross α and β activities found at six off-site background air sampling locations previously surveyed weekly at distances varying 5 to 44 miles from the Nuclear Sciences Area. Quarterly composite air samples from the four site boundary locations were analyzed for Pu-238, Pu-239, Sr-90, and gamma-emitting radionuclides (Table 6).

Water Monitoring--Radioactive

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.

Sampling of all sanitary liquid effluents from the Nuclear Sciences Area to Big Darby Creek is performed using a continuous water sampling system after discharge from the chlorinating system. The effluents samples are analyzed weekly for gross α and β activity in suspended and dissolved fractions. Any sample exceeding 3×10^{-8} μCi/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 plutonium-238, plutonium-239, iodine-129, strontium-90, radium-226, and radium-228 at the end of each month. The concentrations of gross α and gross β activity in suspended and dissolved fractions as 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 average concentration of

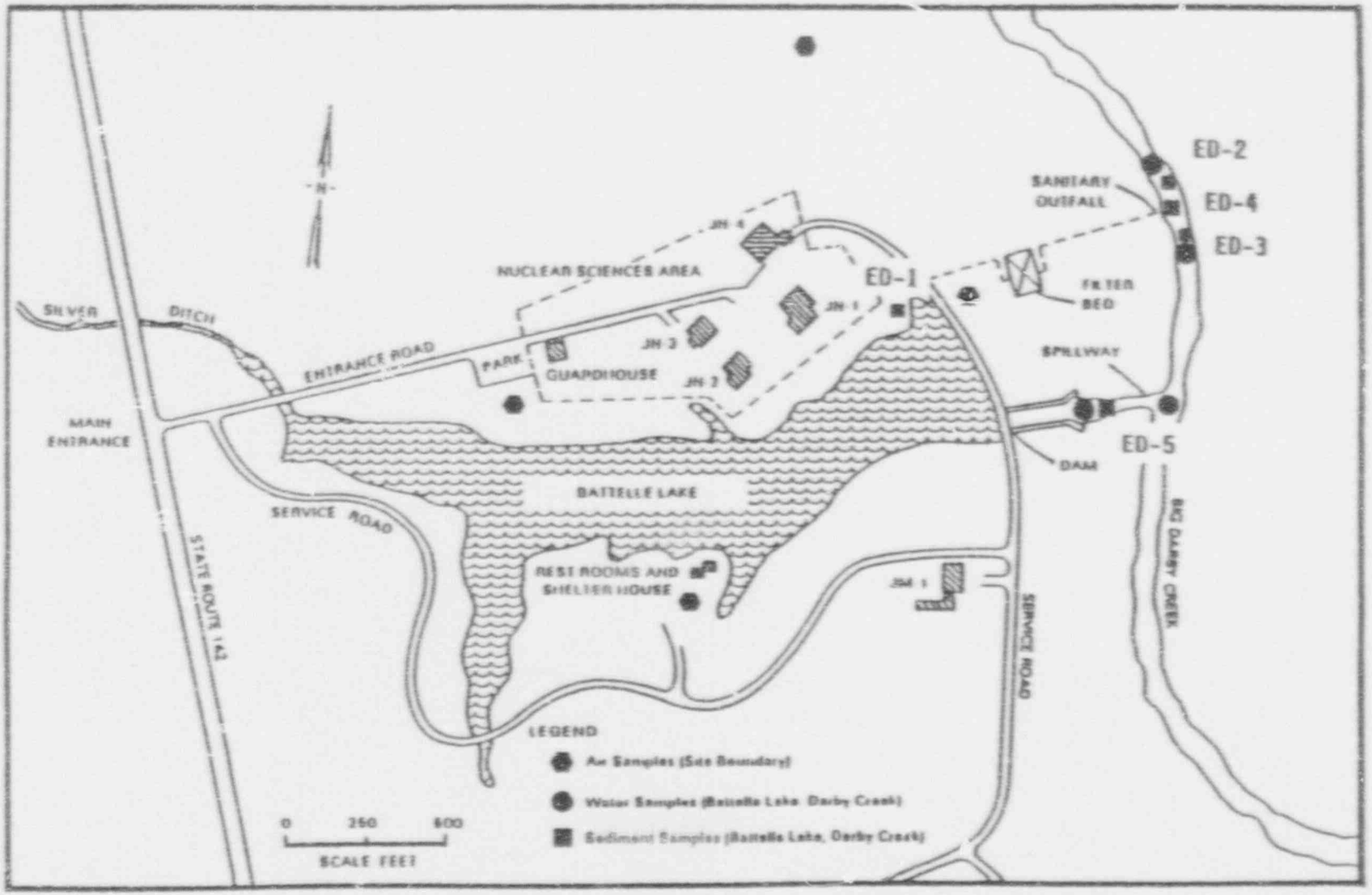


FIGURE 6. MAP OF SITE BOUNDARY AIR SAMPLING LOCATIONS AND BATTELLE LAKE AND DARBY CREEK WATER AND SEDIMENT SAMPLING LOCATIONS

TABLE 6. SUMMARY OF SITE BOUNDARY AIR SAMPLE ANALYSES--WEST JEFFERSON SITE--1991[a]

Nuclide	10^{-16} μCi/mL[b]			
	North	East	South	West
Gross α	1.44 ± 0.54	1.52 ± 0.56	1.39 ± 0.56	1.09 ± 0.47
Gross β	14.0 ± 1.13	15.7 ± 1.21	14.4 ± 1.19	14.0 ± 1.12
Co-57	<1.08	<1.06	<1.06	<1.06
Co-60	<2.52	<2.45	<2.40	<2.44
Sr-90[c]	<0.44	<0.44	<0.44	<0.44
Sb-125	<4.64	<4.2[illegible]	<4.28	<4.53
Cs-134	<1.76	<1.65	<1.70	<1.72
Cs-137	<2.21	<2.13	<2.09	<2.06
Eu-152	<4.65	<4.64	<4.59	<4.61
Eu-154	<6.96	<6.79	<6.76	<6.59
U-235	<4.69	<3.33	<3.33	<4.58
U-238	<25.9	<24.2	<27.4	<26.8
Pu-238[c]	<0.057	<0.057	<0.057	<0.057
Pu-239[c]	<0.057	<0.057	<0.024	<0.024
Am-241	<2.75	<2.64	<2.75	<2.76

(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 isotropic 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 x 10^{-16} μCi/mL and gross β MDL is 6.0 x 10^{-16} μCi/mL (a priori).

(c) Detection limit is 4.66 x standard deviation of the background, divided by the efficiency, assuming a 50% recovery of the spike and a flow volume of 2.7 E+9 mL.

TABLE 7. SUMMARY OF LIQUID RADIOACTIVE EMISSION--WEST JEFFERSON SITE[a]--1991

Species	Number of Samples	Activity, μCi/yr[b]	Average Concentration μCi/mL	DCG μCi/mL	Percentage of DCG
Gross α	52	30.9	(3.68 ± 3.10) x 10^{-9}	--	0.48[c]
Gross β	52	173	(2.06 ± 0.17) x 10^{-8}	--	--
Co-57	12	107	1.3 x 10^{-8}	1.0 x 10^{-4}	0.02
Co-60	12	167	2.0 x 10^{-8}	5.0 x 10^{-6}	0.60
Sr-90	12	25	3.0 x 10^{-9}	1.0 x 10^{-6}	0.08
Sb-125	12	345	4.1 x 10^{-8}	5.0 x 10^{-5}	0.13
Cs-134	12	124	1.5 x 10^{-8}	2.0 x 10^{-6}	1.20
Cs-137	12	187	2.2 x 10^{-8}	3.0 x 10^{-6}	0.97
Eu-152	12	368	4.4 x 10^{-8}	2.0 x 10^{-5}	0.32
Eu-154	12	440	5.2 x 10^{-8}	2.0 x 10^{-5}	0.43
Ra-226	12	16	1.9 x 10^{-9}	1.0 x 10^{-7}	1.50
Ra-228	12	14	1.6 x 10^{-9}	1.0 x 10^{-7}	0.90
I-129	12	135	1.6 x 10^{-8}	5.0 x 10^{-7}	0.98
U-235	12	994	1.2 x 10^{-8}	6.0 x 10^{-7}	8.89
U-238	12	30.9	3.7 x 10^{-9}	6.0 x 10^{-7}	0.62
Pu-238	12	6.0	6.8 x 10^{-10}	4.0 x 10^{-8}	0.40
Pu-239	12	3.0	2.9 x 10^{-10}	3.0 x 10^{-8}	0.13
Am-241	12	30.9	3.7 x 10^{-9}	3.0 x 10^{-8}	0.12

(a) Annual average flow in Big Darby Creek = 429 cu ft/sec = 3.82 x 10^{11} L/yr. Total volume of liquid effluent discharge for 1991 = 8.41 x 10^{6} liters. 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 x 10^{-6}) for mixture, not containing Sr-90, I-129, Ra-226 and Ra-228.

the mixture was 0.48 percent of the limit value given in 10 CFR Part 20, Appendix B. The maximum concentrations of gamma-emitter suspected radionuclides in the mixture was 8.89 percent for the DCG for U-235 and 0.40 percent of the DCG for Pu-238, 0.13 percent for Pu-239, 0.08 percent for Sr-90, 1.50 percent for Ra-226, and 0.90 percent for the Ra-228.

The noncommunity drinking water supply at the West Jefferson site is exempt from radiological monitoring per OEPA review.[5] However, weekly tap water samples are collected at the Nuclear Sciences Area to verify compliance with applicable water quality standards for radioactivity in drinking water. The weekly tap water samples are composited and analyzed monthly for gross α and β activity in suspended and dissolved fractions. Any sample exceeding 15 pCi/mL for gross α activity receives a supplementary gamma isotopic analysis and/or an alpha spectrometric analysis as appropriate. In 1991, the average concentrations of gross α was 5.31 $\pm$ 3.04 pCi/L (soluble) and 0.86 $\pm$ 1.0 pCi/L (insoluble). The average concentrations of gross β were 2.37 $\pm$ 0.83 pCi/L (soluble) and 0.86 $\pm$ 0.54 pCi/L (insoluble). The total gross α activity represents about 41 percent of the EPA standard of 15 pCi/L for gross α particulate activity in drinking water.

Supplementary water samples are collected weekly 18.29 m above and 18.29 m below the sanitary drain outfall at Darby Creek. Water samples are also collected weekly below the Battelle Lake dam and at the drain spillway at 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 7.98×10^{-9} μCi/mL for α and less than 12.64×10^{-9} μCi/mL for β activity and showed no significant difference from the upstream control sample (Table 8). These findings show that liquid effluent releases from the site to Darby Creek do not exceed background levels of radioactivity already present in Darby Creek.

Grass and Food Crops--Radioactive

Grass and food crop samples are collected from the surrounding area. The intent of this portion of the Environmental Monitoring Program is

TABLE 8. SUMMARY OF RADIOLOGICAL ANALYSES OF ENVIRONMENTAL WATER SAMPLES--WEST JEFFERSON SITE--1991

Location[a] (Direction and Distance from Nuclear Sciences Area)	Number of Samples[b]	10^{-9} µCi/mL[c] Gross α ± 2 sigma	Gross β ± 2 sigma
Darby Creek Upstream (18.3 m above sanitary outfall)	12	4.28 ± 5.82	8.12 ± 2.42
Darby Creek Downstream (18.3 m below sanitary outfall)	12	7.98 ± 6.98	12.64 ± 2.78
Darby Creek Downstream (186.3 m below sanitary outfall)	12	7.41 ± 6.30	7.47 ± 2.32
Battelle Lake Spillway (18.3 m below dam)	12	4.29 ± 4.68	6.17 ± 2.14

(a) Locations are shown in Figure 6.
(b) 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.

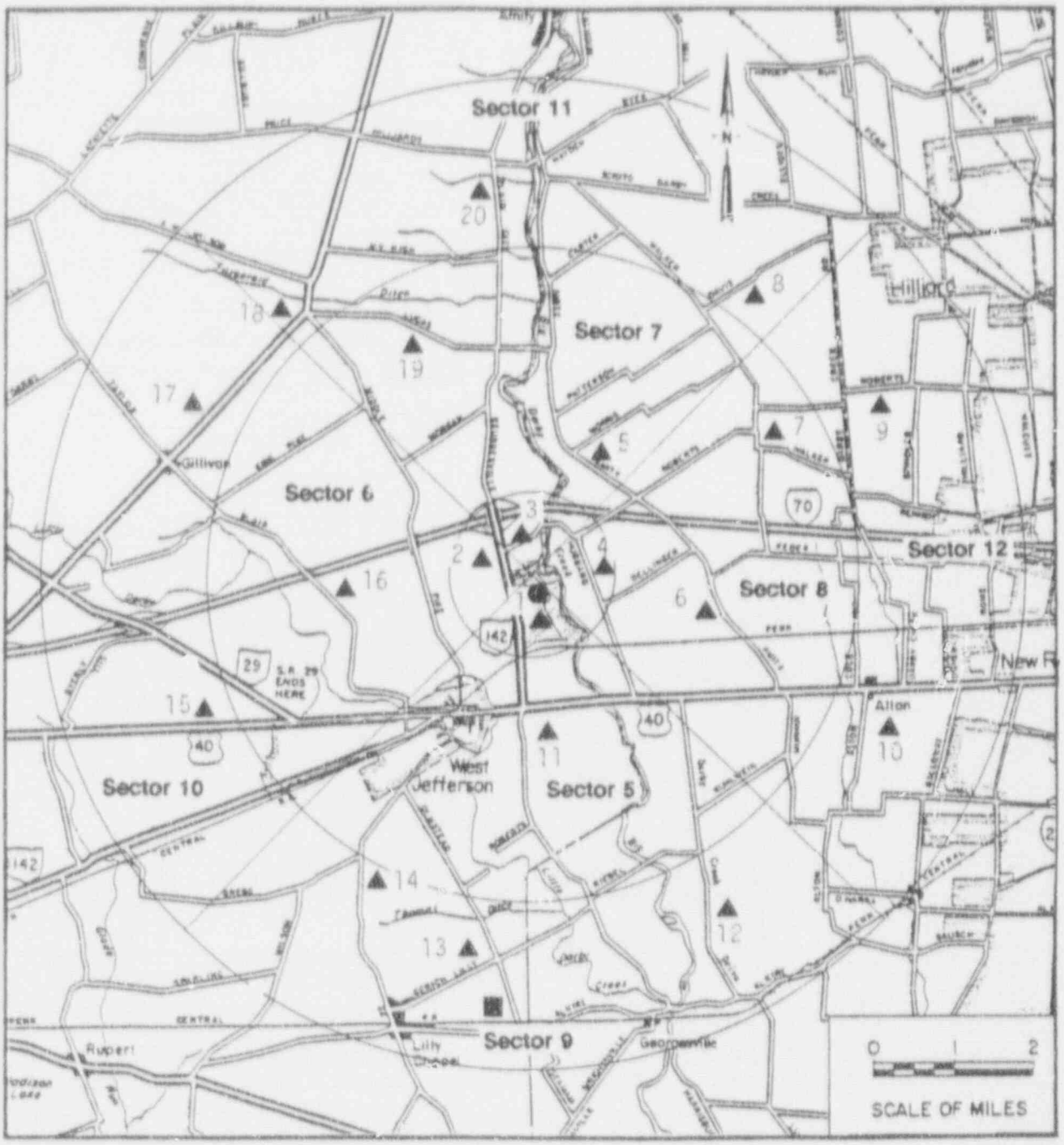
to determine whether there is uptake and concentration of radionuclides by plant or animal life. Where possible, sampling sites are chosen at maximum deposition locations predicted by meteorological studies. Grass and food crop (soybean or field corn) samples are collected at varying distances and directions 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 plutonium-238, plutonium-239, and strontium-90. A qualitative analysis by gamma scan is also performed. The results of the grass and food crop analyses are summarized in Tables 9 and 10. In both the grass and food crops, the levels of strontium-90, plutonium-238, and plutonium-239 were below the minimum detectable level for each isotope. Cesium-137 in grass was detected in insignificant amounts in Sectors 2, 4, and 5.

Garden Crops--Radioactive

There are two samples collected annually to access the 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 plutonium-238, plutonium-239, and strontium-90 analyses were performed. The results of the analyses are shown in Table 11. A comparison of sample locations shows that there is no real difference in the data values. Therefore, there is no impact to the on-site garden.

Sediment--Radioactive

Sediment samples were collected at five locations, i.e., Darby Creek 18.29 m above and 18.29 m below the point of sanitary effluent release to Darby Creek, the storm sewer outfall leading to Battelle Lake, the liquid effluent discharge point into Darby Creek, and at the dam spillway to Darby Creek (see Figure 6). The purpose of collecting sediment samples is to estimate the inventory of certain radionuclides deposited in this waterway and



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

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

TABLE 9. SUMMARY OF RADIOLOGICAL ANALYSES OF GRASS[a]--WEST JEFFERSON SITE--1991

	pCi/g dry wt.											
Nuclide	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	<0.07	<0.07	<0.08	<0.28	<0.29	<0.27	<0.08	<0.10	<0.09	<0.10	<0.12	<0.11
Co-60	<0.13	<0.12	<0.14	<0.64	<0.67	<0.61	<0.16	<0.18	<0.15	<0.19	<0.20	<0.20
Sr-90	<0.06	<0.06	<0.06	<0.06	<0.06	<0.06	<0.06	<0.06	<0.06	<0.06	<0.06	<0.06
Sb-125	<0.25	<0.26	<0.27	<1.17	<1.23	<1.14	<0.28	<0.30	<0.27	<0.30	<0.30	<0.35
Cs-134	<0.09	<0.09	<0.11	<0.41	<0.43	<0.39	<0.11	<0.10	<0.11	<0.14	<0.12	<0.13
Cs-137	<0.11	0.05	<0.15	0.45	0.48	<0.48	<0.12	<0.15	<0.13	<0.17	<0.19	<0.17
Eu-152	<0.27	<0.24	<0.30	<1.31	<1.38	<1.16	<0.32	<0.34	<0.32	<0.40	<0.39	<0.40
Eu-154	<0.38	<0.41	<0.39	<1.62	<1.70	<1.56	<0.47	<0.41	<0.40	<0.53	<0.60	<0.52
U-235	<0.13	<0.13	<0.15	<0.90	<0.95	<0.85	<0.85	<0.66	<0.62	<0.85	<0.82	<0.80
U-238	<2.38	<2.53	<2.70	<11.10	<11.70	<10.50	<2.74	<3.06	<2.63	<3.29	<3.78	<3.49
Pu-238	<0.006	<0.006	<0.006	<0.006	<0.006	<0.006	<0.006	<0.006	<0.006	<0.006	<0.006	<0.006
Pu-239	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003
Am-241	<0.27	<0.28	<0.31	<0.98	<1.03	<0.89	<0.30	<0.33	<0.34	<0.38	<0.43	<0.38

(a) Locations are shown in Figure 7.

TABLE 10. SUMMARY OF RADIOLOGICAL ANALYSES OF FOOD CROPS[a]--WEST JEFFERSON SITE--1991

	pCi/g dry wt.											
Nuclide	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	<0.04	<0.04	<0.03	<0.04	<0.04	<0.04	<0.03	<0.03	<0.03	<0.03	<0.04
Co-60	<0.06	<0.08	<0.09	<0.06	<0.09	<0.08	<0.07	<0.06	<0.07	<0.05	<0.05	<0.08
Sr-90	<0.06	<0.06	<0.06	<0.06	<0.06	<0.06	<0.06	<0.06	<0.06	<0.06	<0.06	<0.06
Sb-125	<0.01	<0.13	<0.13	<0.10	<0.15	<0.15	<0.11	<0.11	<0.12	<0.10	<0.11	<0.12
Cs-134	<0.04	<0.05	<0.04	<0.04	<0.05	<0.05	<0.05	<0.04	<0.04	<0.04	<0.04	<0.05
Cs-137	<0.05	<0.05	<0.06	<0.05	<0.06	<0.05	<0.05	<0.04	<0.06	<0.05	<0.04	<0.06
Eu-152	<0.12	<0.13	<0.13	<0.12	<0.13	<0.15	<0.13	<0.14	<0.11	<0.12	<0.12	<0.13
Eu-154	<0.14	<0.25	<0.22	<0.16	<0.28	<0.20	<0.18	<0.16	<0.16	<0.15	<0.17	<0.22
U-235	<0.25	<0.07	<0.27	<0.23	<0.29	<0.27	<0.27	<0.06	<0.25	<0.06	<0.24	<0.07
U-238	<1.05	<1.00	<1.00	<1.04	<0.89	<1.19	<1.22	<1.05	<1.20	<1.07	<1.01	<1.01
Pu-238	<0.006	<0.06	<0.06	<0.06	<0.06	<0.06	<0.06	<0.06	<0.06	<0.06	<0.06	<0.06
Pu-239	<0.003	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03
Am-241	<0.12	<0.14	<0.14	<0.12	<0.15	<0.13	<0.13	<0.12	<0.12	<0.11	<0.12	<0.13

(a) Locations are shown in Figure 7.

TABLE 11. SUMMARY OF RADIOLOGICAL ANALYSES OF GARDEN CROPS[a]--WEST JEFFERSON SITE--1991

	pCi/g dry wt.	
Nuclide	On-Site[b]	Off-Site[b]
Co-57	<0.03	<0.15
Co-60	<0.07	<0.36
Sr-90	<0.02	<0.08
Sb-125	<0.11	<0.64
Cs-134	<0.04	<0.25
Cs-137	0.05	<0.30
Eu-152	<0.12	<0.72
Eu-154	<0.18	<1.0
U-235	<0.06	<0.73
U-238	<1.12	<4.58
Pu-238	<0.009	<0.02
Pu-239	<0.006	<0.009
Am-241	<0.12	<0.52

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

document it for future reference. The sediment samples were analyzed for plutonium-238, plutonium-239, and strontium-90. A quantitative gamma isotopic analysis was also performed and shows a positive result of 12.5 pCi/g of Am-241, 30.8 pCi/g of Cs-137, and 22.4 pCi/g of Co-60 at the storm sewer outfall (ED-1 on Figure 6). The outfall 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 12.

Soil--Radioactive

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 m^2. Prior to analysis, the composite samples are air dried and then blended in a pulverizing mill. The soil samples are analyzed for plutonium-238, plutonium-239, and strontium-90. A qualitative analysis by a gamma spectrometry scan is also performed. The results of the analyses are summarized in Table 13.

Strontium-90 and plutonium results were below the minimum detectable level for these isotopes. Gamma isotopic analyses of the soil samples showed the maximum average concentration of cesium-137 to be 0.72 pCi/g. The cesium is believed to be attributable to the settling out of the atmospheric releases from off-site, and not on-site activities.

Fish--Radioactive

Fish are collected on a quarterly basis from Battelle Lake and Darby Creek, as available, to determine if any radioactive material is getting into the food chain. Fish collection in 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, plutonium-238, plutonium-239,

TABLE 12. SUMMARY OF RADIOLOGICAL ANALYSES OF SEDIMENT SAMPLES--WEST JEFFERSON SITE--1991

	pCi/g dry wt.[a] Avg.				
Nuclide	ED-1[b]	ED-2	ED-3	ED-4	ED-5
Co-57	<0.03	<0.02	<0.03	<0.04	<0.03
Co-60	22.4	<0.05	<0.05	<0.06	<0.06
Sb-125	<0.40	<0.08	<0.08	<0.09	<0.09
Cs-134	0.59	<0.03	<0.03	<0.03	<0.04
Cs-137	30.8	1.52	0.09	0.76	<0.03
Eu-152	<0.35	<0.08	<0.09	<0.10	<0.10
Eu-154	<0.29	<0.12	<0.12	<0.14	<0.15
U-235	<0.05	<0.03	<0.03	<0.03	<0.04
U-238	<1.49	<0.55	<0.52	<1.03	<1.03
Sr-90	4.17	0.52	<0.40	<0.40	0.80
Pu-238	1.38	0.09	0.06	0.05	0.11
Pu-239	55.90	0.04	0.04	0.03	0.05
Am-241	12.5	<0.09	<0.14	<0.12	<0.12

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

(b) Location ED-1 has undergone more detailed evaluation. Results are documented in FINAL ASSESSMENT OF THE RADIOLOGICAL STATUS OF BATTELLE'S NUCLEAR SCIENCES AREA dated January 1991. See Figure 6 for locations.

TABLE 13. SUMMARY OF SOIL ANALYSES[a]--WEST JEFFERSON SITE--1991

Nuclide	pCi/g dry wt.											
	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	<0.03	<0.03	<0.03	<0.04	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03
Co-60	<0.07	<0.07	<0.06	<0.06	<0.07	<0.06	<0.06	<0.06	<0.06	<0.05	<0.06	<0.07
Sr-90	<0.40	<0.40	<0.40	<0.40	<0.40	<0.40	<0.40	<0.40	<0.40	<0.40	<0.40	<0.40
Sb-125	<0.11	<0.11	<0.10	<0.12	<0.12	<0.11	<0.12	<0.11	<0.10	<0.10	<0.10	<0.11
Cs-134	<0.04	<0.04	<0.04	<0.04	<0.05	<0.04	<0.04	<0.04	<0.03	<0.04	<0.04	<0.04
Cs-137	0.25	0.20	0.11	0.44	0.72	0.62	0.40	0.31	0.59	0.30	0.36	0.26
Eu-152	<0.12	<0.11	<0.11	<0.12	<0.12	<0.10	<0.13	<0.13	<0.11	<0.10	<0.11	<0.11
Eu-154	<0.18	<0.19	<0.17	<0.18	<0.19	<0.15	<0.16	<0.16	<0.17	<0.16	<0.16	<0.17
U-235	<0.04	<0.04	<0.04	<0.04	<0.04	<0.04	<0.04	<0.07	<0.04	<0.04	<0.04	<0.04
U-238	<0.62	<0.61	<0.60	<0.061	<0.65	<0.60	<0.62	<0.01	<0.57	<0.57	<0.56	<0.57
Pu-238	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03
Pu-239	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Am-241	<0.14	<0.15	<0.13	<0.15	<0.16	<0.13	<0.14	<0.14	<0.12	<0	0.13	<0.15

(a) Locations are shown in Figure 7.

and strontium-90. Table 14 summarizes the 1991 data from the analyses. All of the analyses showed undetected levels except for very low levels of Cesium-137, which is believed to be from radioactive fallout not associated with the Battelle facility. No fish were collected from Darby Creek in 1991 due to poor collection conditions.

Background Radiation Levels

The limit established for the general public by the Department of Energy is 100 mrem/yr.[6] This value does not include the contribution from natural background radiation, which, in previous years, averaged approximately 130 mrem/yr off site. 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 1991 annual average dose including background at the site boundary is 120 ± 10 mrem. The results are summarized in Table 15.

Fence Post Dose Estimate

The "fence post" dose is the maximum measured cumulative dose possible to an individual having access to an uncontrolled area. It does not include ingestion and inhalation pathways. The "fence post" dose for 1991 was equal to or less than the annual average TLD background reading of 120 mrem measured at off-site background monitoring stations.

KING AVENUE SITE

Air--Radioactive

There were no radiological releases from stacks at the King Avenue site in 1991. However, one environmental air sample was collected at the east boundary of Battelle property along Battelle Boulevard. This sample may serve as a reference for future D&D activities and will provide evidence to the

TABLE 14. SUMMARY OF FISH TISSUE ANALYSES[a]--WEST JEFFERSON SITE--1991

Sample Quarter	pCi/g raw wt.				
	1st[b]	2nd	3rd	4th	Avg.
Co-57	<0.51	<0.28	<0.23	<0.49	<0.38
Co-60	<1.01	<0.40	<0.36	<0.76	<0.63
Sr-90	<0.04	<0.06	<0.05	<0.08	<0.05
Sb-125	<2.07	<0.79	<0.72	<1.57	<1.29
Cs-134	<0.70	<0.27	<0.28	<0.56	<0.45
Cs-137	<0.87	0.18	<0.30	<0.63	0.49
Eu-152	<1.85	<0.77	<0.73	<0.163	<1.25
Eu-154	<2.55	<0.94	<0.96	<2.13	<1.65
U-235	<2.98	<0.49	<0.50	<1.08	<1.26
U-238	<16.00	<13.20	<4.90	<13.20	<11.83
Pu-238	<0.04	<0.02	<0.02	<0.02	<0.02
Pu-239	<0.02	<0.01	<0.01	<0.02	<0.01
Am-241	<1.92	<0.53	<0.52	<1.15	<1.03

NR = Data not received from laboratory.

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

(b) First quarter results are average for bottom and non-bottom feeders, all others are for non-bottom feeders only.

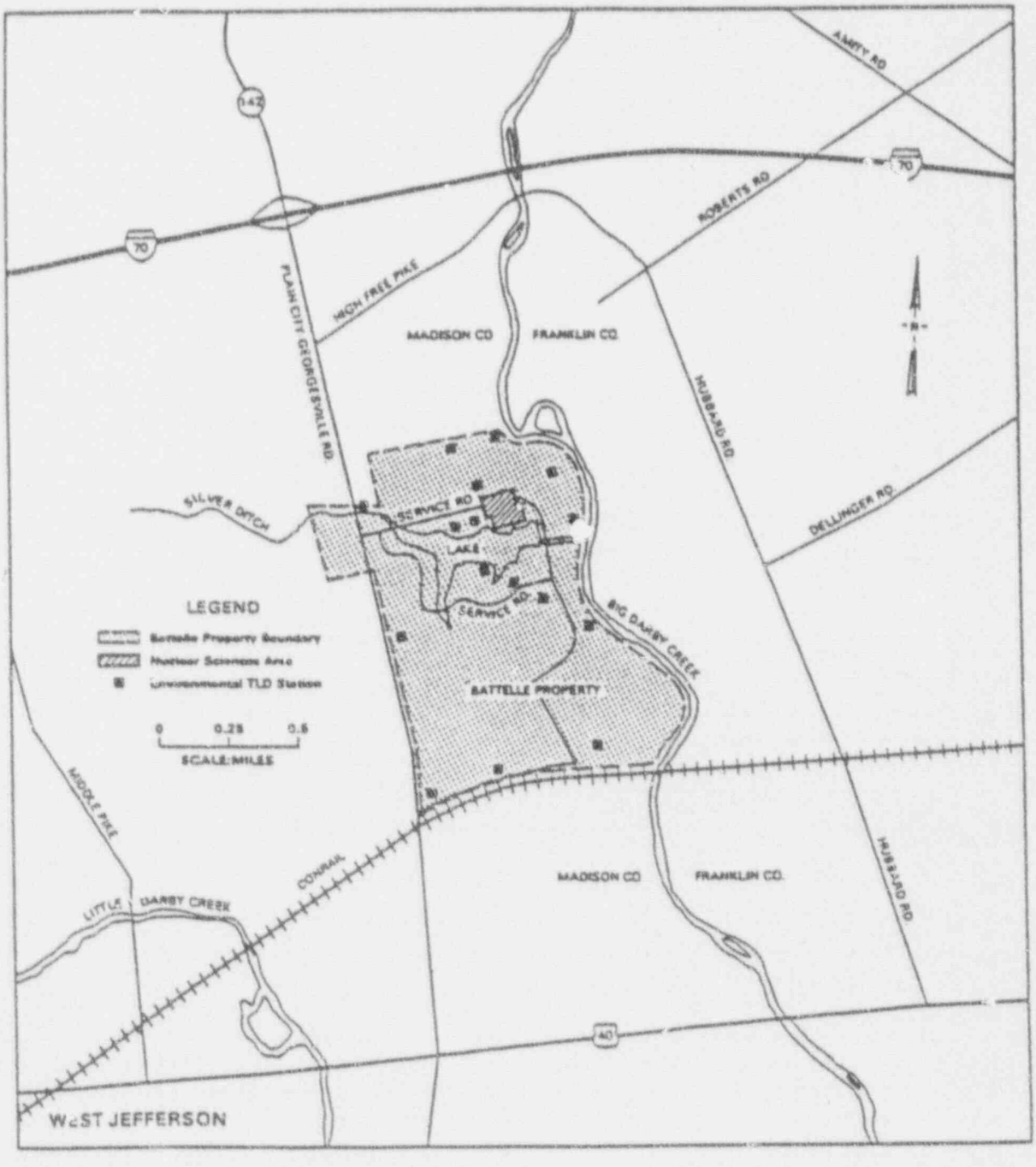


FIGURE 8. MAP OF TLD LOCATIONS WITHIN 3/4-MILE RADIUS OF THE NUCLEAR SCIENCES AREA

TABLE 15. INTEGRATED EXTERNAL BACKGROUND RADIATION MEASUREMENTS AT RECREATION AREA AND PROPERTY BOUNDARY LINE--WEST JEFFERSON SITE--1991

Location and Distance[a]	Integrated TLD Measurements in rem				Total for Year
	1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.	
Southwest					
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
West					
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
Southeast					
365.8 m (1200 ft)	0.030	0.030	0.030	<0.030	<0.120
1005.9 m (3300 ft)	0.030	0.030	<0.030	<0.030	<0.120
South					
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
East					
420.6 m (1380 ft)	0.030	0.030	0.030	<0.030	<0.120
Northeast					
395.9 m (1200 ft)	0.030	0.030	0.030	<0.030	<0.120
Northwest					
402.3 m (1320 ft)	0.030	0.030	0.030	<0.030	<0.120
North					
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.

neighborhood that no radiological impact has resulted from the BCLDP operations. The results in Table 16 are considered to be background levels of 1.43×10^{-15} μCi/mL gross α and 1.43×10^{-14} μCi/mL gross β. Table 16 also includes the results of the gamma spectrometry scans done for the King Avenue samples. The results are all below the detection limit.

Water--Radioactive

Sampling of liquid discharges from the Building 3 sump to the Columbus municipal sewerage system is performed on a monthly basis (Figure 4). This discharge consists of the liquid wastes from the building laboratory drain systems. The building sump samples are routinely analyzed for gross α and gross β activities. Any sample exceeding 4×10^{-7} μCi/mL (400 pCi/L) receives a gamma isotopic analysis and/or an alpha spectrometric analysis as necessary. The concentrations of gross α and gross β activity are summarized in Table 17. 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--Radioactive

Seven soil samples were collected at various points around the King Avenue site (Figure 4). One 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 18. There was no evidence of uranium in the soil sample above detectable levels. There was, however, evidence of Cs-137 in the King Avenue site soil while none was detected in the background sample. No cesium operations are being conducted at King Avenue. The cesium is in the same range as that seen in West Jefferson off-site samples. This suggests that the cesium is from fallout and not operations.

TABLE 16. RADIOLOGICAL ANALYSES OF ENVIRONMENTAL AIR SAMPLES[a]--KING AVENUE SITE--1991

Nuclides	Number of Samples	Average Concentration μCi/mL ± 2 sigma	Percent of DCG
Gross α	51	$1.43 \pm 0.58 \times 10^{-15}$	---[b]
Gross β	51	$1.43 \pm 0.12 \times 10^{-14}$	---[b]
Co-57	4	<1.06	5.3×10^{-5}
Co-60	4	<2.31	2.9×10^{-3}
Sb-125	4	<4.63	4.6×10^{-4}
Cs-134	4	<1.71	8.6×10^{-4}
Cs-137	4	<2.06	5.2×10^{-4}
Eu-152	4	<4.51	9.0×10^{-3}
Eu-154	4	<6.35	1.3×10^{-2}
U-235	4	<7.04	7.0
U-238	4	<27.6	27.6
Am-241	4	<2.69	13.4

(a) Sample location EA-15, identified in Figure 4.
(b) DOE 5400.5 does not list DCG limits for mixed α and β activity.

TABLE 17. RADIOLOGICAL ANALYSES OF LIQUID DISCHARGES[a]--KING AVENUE SITE--1991

Sample[a]	Species	Number of Samples	Average Concentration pCi/L ± 2 sigma
005[b]	Gross α	12	4.0 ± 4.4
	Gross β	12	7.6 ± 2.3
EW-6[c]	Gross α	12	4.1 ± 5.0
	Gross β	12	21.4 ± 3.3
EW-7	Gross α	12	5.5 ± 4.8
	Gross β	12	7.0 ± 2.2
EW-8	Gross α	12	3.4 ± 4.2
	Gross β	12	10.6 ± 2.5
EW-9	Gross α	12	6.2 ± 5.6
	Gross β	12	18.6 ± 3.2
EW-13	Gross α	12	3.2 ± 3.9
	Gross β	12	6.3 ± 2.1

(a) Locations identified in Figure 4.
(b) Also identified as EW-14.
(c) EW samples are supplemental samples collected from various sumps and discharge points throughout the King Avenue Site.

TABLE 18. RADIOLOGICAL ANALYSES OF SOIL SAMPLES--KING AVENUE SITE--1991

Sample[a]	Nuclide (pCi/g)		
	U-238	U-235	Cs-137
KAES-01	<0.60	<0.04	0.97
KAEA-02	<0.57	<0.04	0.48
KAES-03	<0.60	<0.04	0.27
KAES-04	<0.60	<0.04	0.18
KAEA-05	<0.60	<0.04	0.17
KAES-06	<0.60	<0.04	0.19
KAEA-07	<0.60	<0.04	0.28
KAES-08	<0.61	<0.04	<0.02

(a) Locations are identified in Figure 4, except KAES-08, which is an off-site sample taken from The Ohio State University Agriculture Campus.

Vegetation--Radioactive

Eight samples of vegetation were collected at points around the King Avenue site. Seven of these samples were collected on Battelle's property. See Figure 4 for exact locations. Another sample was collected from The Ohio State University Agriculture campus north of the Battelle site as a background reference. The samples were analyzed for Uranium-235, Uranium-238, and Cesium-137. Data from these analyses is represented in Table 19. There was no evidence of either uranium isotope above detectable levels in any of the samples. There were detectable levels of cesium in both the on-site and off-site samples. The source of cesium is believed to be from fallout and not site operations.

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 non-community water supply, Battelle is required to perform quarterly sampling for microbiological contamination, quarterly sampling for volatile organic compounds (VOCs), and a nitrate analysis every three years[7]. The results of the quarterly tests for microbiological contamination all showed no contamination (<1 colony/100 mL) and were reported as being "safe." VOC sampling showed some VOCs at just above the detection level.* The source of VOC contamination is believed to be sampling error rather than groundwater contamination. The suspected sources of contamination are being investigated. The last nitrate analyses were below the established Maximum Contamination Level (MCL) value of 10 mg/L. Battelle has complied with the public notification regulations enacted to warn of the dangers of lead in drinking water.

Presently, liquid effluents discharged from the West Jefferson Facility are subject to the restrictions of an NPDES Permit. Battelle monitors and reports on a monthly basis to the OEPA. Table 20, Nonradiological

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*Total xylenes were found in the first and third quarters of a concentration of around 1 μg/L. The EPA's maximum contaminant level for drinking water is 10,000 μg/L.

TABLE 19. RADIOLOGICAL ANALYSES OF VEGETATION SAMPLES--
KING AVENUE SITE--1991

Sample[a]	Nuclide (pCi/g)		
	U-238	U-235	Cs-137
KAEV-01	<7.31	<0.75	0.70
KAEV-02	<10.70	<0.87	<0.52
KAEV-03	<1.33	<1.33	<0.81
KAEV-04	<7.01	<0.69	<0.40
KAEV-05	<10.10	<0.82	<0.50
KAEV-06	<11.10	<0.90	<0.51
KAEV-07	<13.60	<1.11	<0.71
KAEV-08	<7.75	<2.07	<0.40

(a) Locations are identified in Figure 4, except KAEV-08, which is an off-site sample taken from The Ohio State University Agriculture Campus.

TABLE 20. NONRADIOLOGICAL WATER EFFLUENT ANALYSES--WEST JEFFERSON SITE--1991

	North Sanitary System Sewer[a]				Permit Requirements[c] Discharge Limitations			
				kg/Day	Loading kg/Day		Concentration Other Units	
	Avg.	Max.	Min.	Avg.[b]	30-Day	Daily	30-Day	Daily
Flow Rate (l/day)[d]	23,041	37,415	1,340	-			[d]	
Residual Chlorine (mg/L)	0.49	1.8	<0.1	0.01			-	0.5
pH Value (S.U.)	7.90	8.48	7.45	-			6.5 to	9.0
Fecal Coliform (#/100 mL)	230.2	1,150	0	-			1,000	2,000
Dissolved Oxygen (mg/L)	7.6	9.3	6.7	-			6.0	6.0
Total Suspended Solids (mg/L)	2.3	8.0	0.0	0.05	0.49	0.098	10	20
B.O.D. (5-day) (mg/L)	3.6	4.5	3.1	0.08	1.23	1.87	25	38
Ammonia (mg/L)	0.31	0.56	0.24	-				

(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 6,082 gpd.
(c) Permit requirement discharge limitations based on NPDES Permit 41N00004*DD.
(d) No restrictions for flow or ammonia under the NPDES Permit.

Water Effluent Analyses--West Jefferson Site, includes a list of parameters for which Battelle is presently required to analyze and report.

The data provided for the North Sanitary Sewer were obtained in accordance with the NPDES Permit 41N00004*DD issued by the OEPA. The conditions of Battelle's NPDES Permit were determined by the OEPA following an extensive study of the Scioto River Basin,[8] of which Battelle's West Jefferson site is a part. All readings were within acceptable limits as specified in the permit for 1991, except for the total suspended solids readings in January and May, and total residual chlorine levels in July.

The values listed in Table 20 represent an average of the monthly data collected during the 12-month period commencing January 1, 1991, and ending December 31, 1991. The table serves to illustrate actual performance against those limits or restrictions defined in Battelle's permit. Battelle was issued a renewal to its NPDES Permit in July 1991. The new permit contained additional parameters to monitor in the effluent, but no substantial change to the allowable discharge limits.

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.

GROUNDWATER PROTECTION

Groundwater monitoring has been increased at the West Jefferson site to include a total of 18 shallow and deep wells. These include three supply wells at a depth of approximately 150 feet, three wells designed for chemical monitoring at a depth of approximately 30 to 35 feet, and 13 shallow wells at a depth of approximately 10 to 15 feet. Figures 9 and 10 indicate the location of shallow and chemical monitoring wells. The supply wells are associated with facilities identified in Figures 5 and 6. Detailed chemical monitoring was performed and reported in Interim Report on Site Characterization--West Jefferson North Site--Stage 1 Sampling and Analysis: Chemical

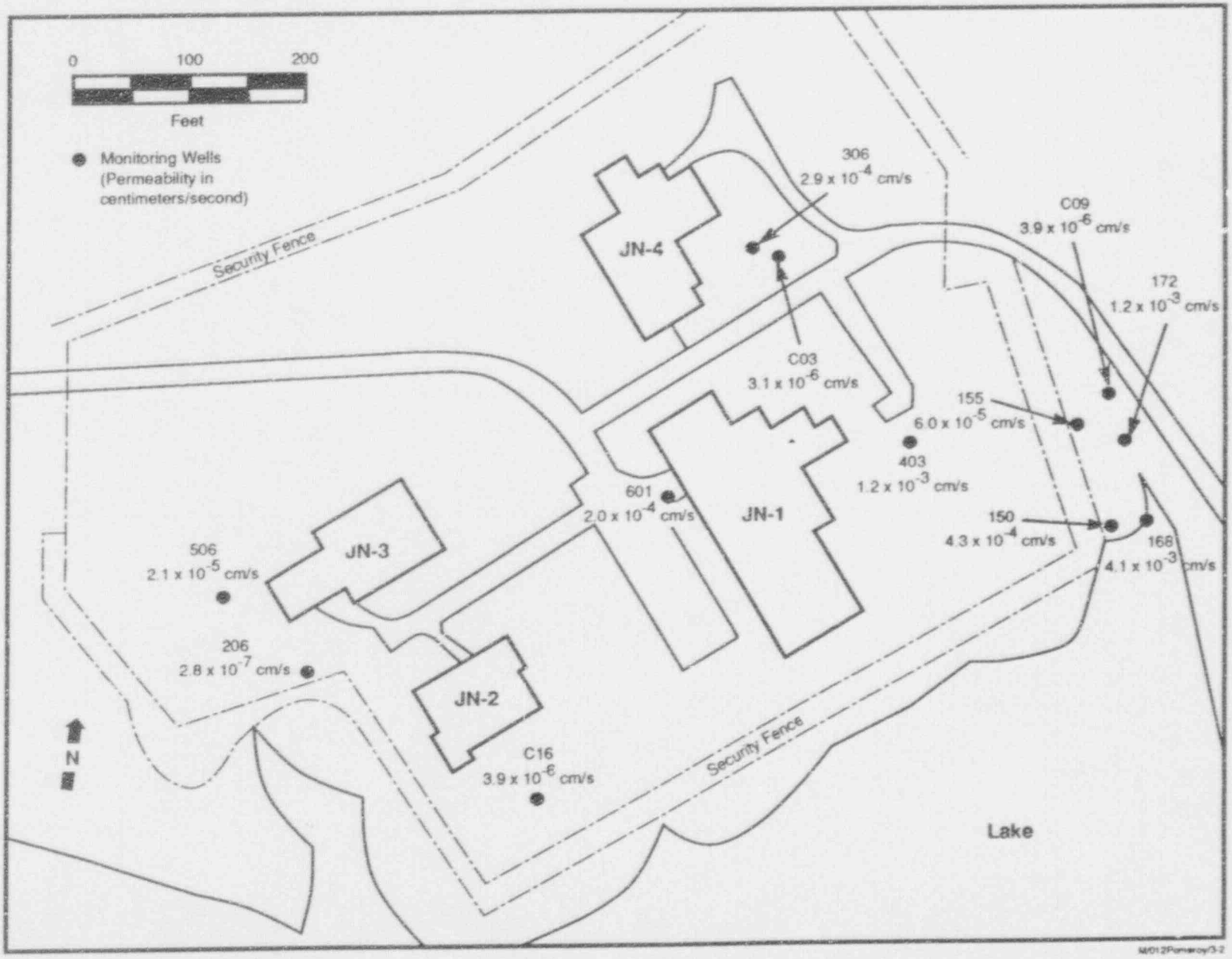

FIGURE 9. NORTH SITE GROUNDWATER MONITORING WELLS

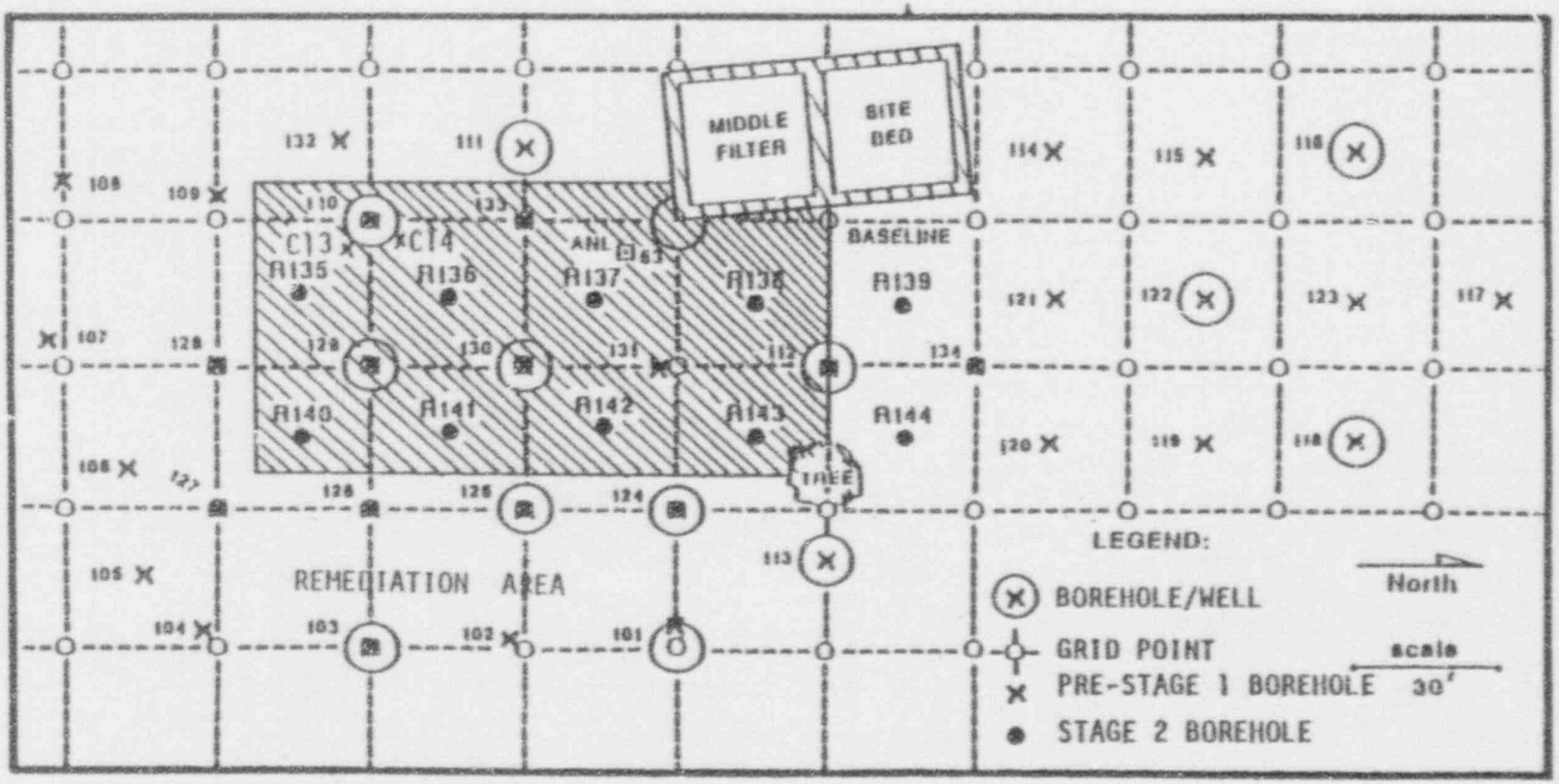

FIGURE 10. RECOMMENDED REMEDIAL ACTION FOR REMEDIATED FILTER BED AREA (SHADED AREA)

Sampling Summary Report, dated December 22, 1989. No contamination was found in grcundwater samples collected at that time.[9]

Annual radiological monitoring results are presented in Table 21. The highest activity is shown to be in well 110, where radioactivity remains in a former remediated filter bed. 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.

Detailed chemical analyses were performed on groundwater samples collected December 27, 1991, from the three chemical monitoring wells. Samples from all three wells were analyzed for eight heavy metals, 27 pesticide and PCB compounds, 35 VOCs, 66 semivolatile organic compounds, oil and grease, and pH. All compounds in all of the samples were below the levels of detection or quantification, except for phenol in the sample from well C03, where the phenol concentration was 17 µg/L (Table 22). Phenol is a naturally occurring compound in the environment and there are no known or suspected sources of phenol at the site. Phenol concentrations will be reviewed in subsequent samplings to determine if there are any trends.

TABLE 21. RADIOLOGICAL ANALYSES OF GROUNDWATER--WEST JEFFERSON SITE--1991

Well Identification	Number of Samples	pCi/L[a] Gross α ± 2 sigma	pCi/L[a] Gross β ± 2 sigma
JN	1	3.5 ± 4.9	6.3 ± 2.0
JM	1	5.1 ± 5.4	4.0 ± 1.8
JM-1	1	2.6 ± 4.6	4.8 ± 1.8
C03	1	15.0 ± 9.1	11.0 ± 2.5
C09	1	8.9 ± 7.7	42.5 ± 4.3
C16	1	2.5 ± 6.0	4.8 ± 2.0
101	1	70.5 ± 32.7	77.4 ± 9.0
104	1	36.4 ± 18.4	30.8 ± 5.6
110	1	55.2 ± 35.0	134.0 ± 12.1
150	1	12.3 ± 7.8	12.1 ± 2.5
155	1	6.8 ± 7.1	8.2 ± 2.3
168	1	9.7 ± 7.8	20.8 ± 3.1
172	1	39.8 ± 18.0	46.3 ± 6.5
206	1	11.1 ± 8.9	20.2 ± 3.2
306	1	8.1 ± 8.5	13.3 ± 2.8
403	1	11.3 ± 13.6	18.4 ± 4.9
506	1	49.2 ± 26.5	52.8 ± 7.5
601	1	17.0 ± 20.4	29.2 ± 6.2

(a) Minimum Detection Limit (MDL) for gross α: 1.0 pCi/L; gross β: 2.9 pCi/L.

TABLE 22. NONRADIOLOGICAL ANALYSES OF GROUNDWATER--WEST JEFFERSON SITE--1991

Chemical Parameter	Well C03	Well C09	Well C16
Total Metals (mg/L)			
As	<0.04	<0.04	<0.04
Ba	<1	<1	<1
Cd	<0.1	<0.1	<0.1
Cr	<0.2	<0.2	<0.2
Pb	<2	<2	<2
Hg	<0.005	<0.005	<0.005
Se	<0.04	<0.04	<0.04
Ag	<0.4	<0.4	<0.4
Pesticides and PCBs (µg/L)			
27 compounds	BDL[a]	BDL	BDL
Volatile Organics (µg/L)			
35 compounds	BQL[b]	BQL	BQL
Semivolatile Compounds (µg/L)			
66 compounds	Phenol: 17 µg/L Others: BQL	BQL	BQL
Oil and Grease (mg/L)	<1	<1	<1
pH	7.1	6.9	7.2

(a) BDL = Below Detection Limit.
(b) BQL = Below Practical Quantification Limit.

EVALUATION OF DOSE TO THE PUBLIC

ESTIMATED DOSE TO THE PUBLIC FROM WEST JEFFERSON SITE EMISSIONS DURING 1991

The environmental monitoring data for 1991 presents information for determining sources of environmental radiation resulting from past or current nuclear activities and from atmospheric nuclear tests or natural radioactivity. Contributions from Battelle's nuclear operations were indistinguishable from other sources with two exceptions. These include minimal airborne releases of mixed fission products from Hot Cell Laboratory activities and very low concentrations of mixed fission products in liquid effluents at the West Jefferson Nuclear Sciences Area. The radiological impact of Battelle's nuclear activities is calculated from the quantity of radionuclides assumed directly in effluents from facilities operating in 1991, from the annual deposition of airborne radionuclides on vegetation and food 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 1991 for the West Jefferson site are summarized in Tables 3, 4, 5, and 6. The downwind position from the facility where the annual ground level concentrations will be highest is considered coincident with the site boundary, which determines the perimeter for uncontrolled exposure. This point is on Battelle property within the site boundary line. The gross data in Table 4 show that the total mixed fission product releases for 1991 amounted to 2.8 μCi, with a total average concentration at the site boundary of about 1×10^{-20} μCi/mL. If all the alpha emissions are considered to be plutonium-239 only, the annual average concentration at the site boundary still would be less than 2×10^{-21} μCi/mL. 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.

Liquid Discharges

Measured aqueous releases and effluent concentrations during 1991 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 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. The release inventory values are based on minimum detectable limits of isotopes listed in Table 7.

ESTIMATED RADIATION DOSE TO THE PUBLIC FROM ATMOSPHERIC DISCHARGES

Calculation of Atmospheric Dispersion Parameters

Average meteorological data from the Columbus area were used as input to compute the average dispersion parameters for the site. The computer code, COMPLY,[18] was run to further establish the minimal impact of site air emissions when it became apparent that certain nuclides listed in the inventory were not listed in AIRDOS-PC[11] nuclide library. AIRDOS-EPA,[12] programmed for localized applications (see Table 23), was used to generate detailed X/Q data presented in Table 24. Thus, average 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 sectors corresponding to the normal wind rose pattern (refer to Figure 11).

TABLE 23. AVERAGE PERCENT FREQUENCY OF WIND DIRECTION AND AVERAGE WIND SPEED

Direction	Percent	Average Speed (m/s)
N	4.5	4.7
NNE	4.1	4.2
NE	4.8	4.0
ENE	5.0	4.1
E	5.8	4.4
ESE	4.7	3.8
SE	5.0	4.3
SSE	4.3	3.8
S	5.5	4.5
SSW	8.1	4.9
SW	11.5	5.5
WSW	8.3	5.3
W	7.8	5.1
WNW	6.5	4.9
NW	6.1	4.6
NNW	4.2	4.2
CALM	3.8	--
TOTAL	100.0	4.5

TABLE 24. AVERAGE ATMOSPHERIC DISPERSION AROUND THE WEST JEFFERSON SITE FROM AN 18-METER HEIGHT STACK RELEASE[a]--1991

Direction	Range in km (miles)										
	0.65 (0.4)	1.15 (0.7)	3.0 (1.9)	4.25 (2.6)	5.05 (3.1)	6.4 (4.0)	9.6 (6.0)	18 (11.2)	32 (20)	48 (30)	64 (40)
N	9.39 E-7	4.15 E-7	1.48 E-7	1.04 E-7	8.59 E-8	6.46 E-8	3.70 E-8	1.55 E-8	5.17 E-9	2.82 E-9	1.34 E-9
NNE	1.38 E-6	6.09 E-7	1.91 E-7	1.29 E-7	1.06 E-7	7.87 E-8	4.48 E-8	1.88 E-8	6.69 E-9	3.70 E-9	1.93 E-9
NE	1.60 E-6	6.98 E-7	2.09 E-7	1.40 E-7	1.14 E-7	8.46 E-8	4.81 E-8	2.02 E-8	7.31 E-9	4.07 E-9	2.19 E-9
ENE	1.16 E-6	5.05 E-7	1.67 E-7	1.15 E-7	9.46 E-8	7.08 E-8	4.05 E-8	1.70 E-8	5.82 E-9	3.19 E-9	1.60 E-9
E	1.09 E-6	4.75 E-7	1.61 E-7	1.11 E-7	9.16 E-8	6.87 E-8	3.93 E-8	1.65 E-8	5.59 E-9	3.06 E-9	1.51 E-9
ESE	1.11 E-6	4.90 E-7	1.64 E-7	1.13 E-7	9.34 E-8	7.00 E-8	4.00 E-8	1.68 E-8	5.73 E-9	3.14 E-9	1.56 E-9
SE	1.04 E-6	4.61 E-7	1.58 E-7	1.10 E-7	9.05 E-8	6.79 E-8	3.89 E-8	1.63 E-8	5.52 E-9	3.02 E-9	1.47 E-9
SSE	7.17 E-7	3.18 E-7	1.27 E-7	9.09 E-8	7.60 E-8	5.77 E-8	3.32 E-8	1.39 E-8	4.41 E-9	2.38 E-9	1.05 E-9
S	7.68 E-7	3.40 E-7	1.32 E-7	9.37 E-8	7.82 E-8	5.92 E-8	3.40 E-8	1.43 E-8	4.58 E-9	2.47 E-9	1.11 E-9
SSW	7.01 E-7	3.10 E-7	1.25 E-7	8.97 E-8	7.51 E-8	5.70 E-8	3.28 E-8	1.37 E-8	4.33 E-9	2.33 E-9	1.02 E-9
SW	1.08 E-6	4.95 E-7	1.69 E-7	1.17 E-7	9.62 E-8	7.21 E-8	4.12 E-8	1.75 E-8	6.09 E-9	3.36 E-9	1.67 E-9
WSW	8.54 E-7	3.77 E-7	1.40 E-7	9.85 E-8	8.19 E-8	6.18 E-8	3.55 E-8	1.49 E-8	4.86 E-9	2.64 E-9	1.22 E-9
W	9.91 E-7	4.38 E-7	1.53 E-7	1.07 E-7	8.82 E-8	6.62 E-8	3.79 E-8	1.59 E-8	5.34 E-9	2.92 E-9	1.41 E-9
WNW	1.06 E-6	4.85 E-7	1.67 E-7	1.15 E-7	9.53 E-8	7.14 E-8	4.08 E-8	1.73 E-8	6.02 E-9	3.32 E-9	1.65 E-9
NW	8.54 E-7	3.77 E-7	1.40 E-7	9.85 E-8	8.19 E-8	6.18 E-8	3.55 E-8	1.49 E-8	4.86 E-8	2.64 E-9	1.22 E-9
NNW	9.70 E-7	4.46 E-7	1.58 E-7	1.10 E-7	9.11 E-8	6.84 E-8	3.92 E-8	1.66 E-8	5.69 E-9	3.13 E-9	1.52 E-9

(a) Units are SEC/M3. Distances are given to the center of the sector; 64 km extends to 80 km. Atmospheric dispersion table is taken from output of computer code AIRDOS-EPA.[8]

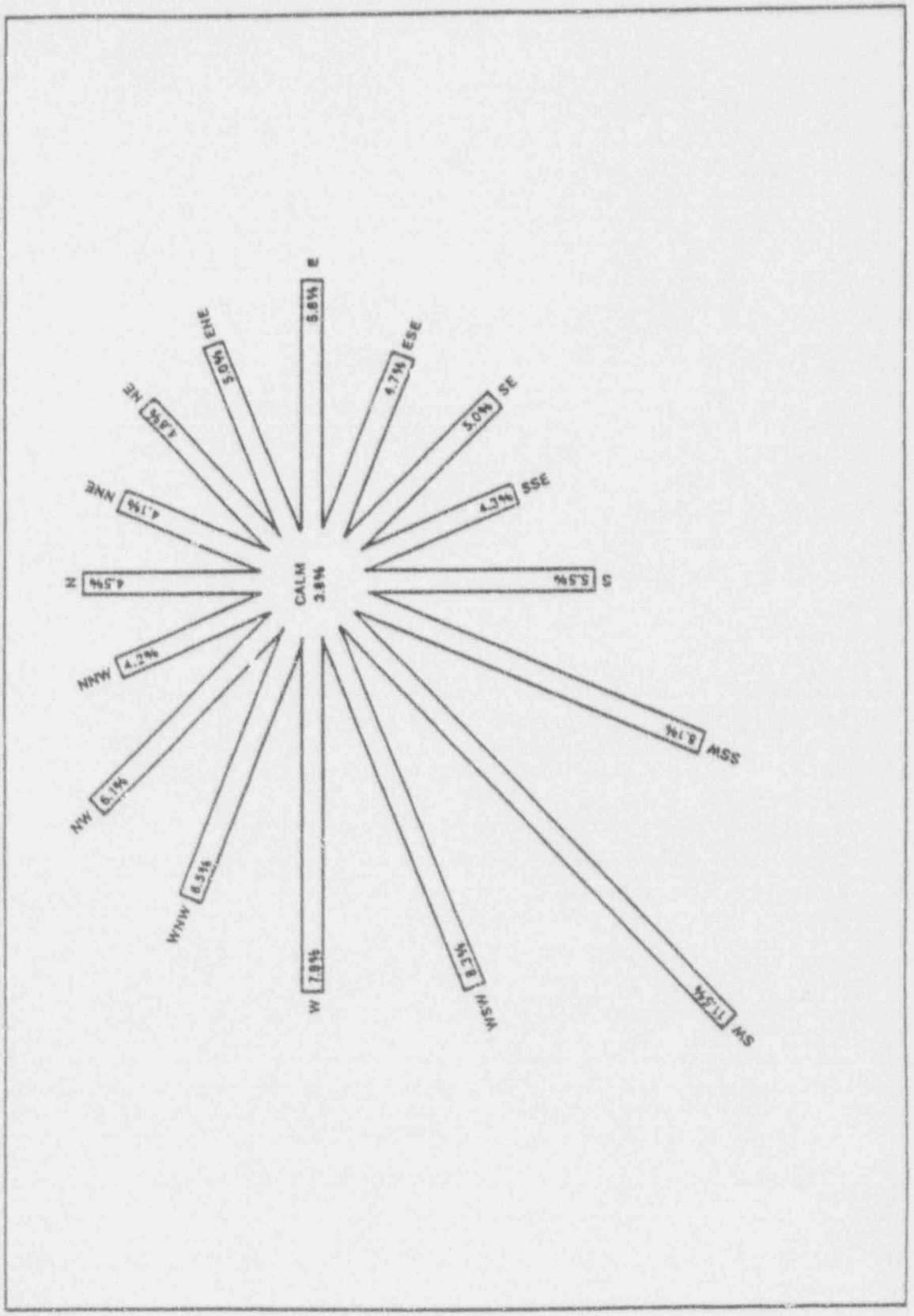

FIGURE 11. WIND ROSE PATTERN FOR WEST JEFFERSON SITE

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 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 Jockety.

The effective dose equivalent rate for the nearby individual was computed using AIRDOS-PC following requirements of 40 CFR 61.93(a). The value at the camp is 0.0066 mrem/yr, with the highest organ dose being 0.038 to the endosteum. In comparison, exposure of persons to natural background radiation in the area would be approximately 130 mrem/yr as measured by TLD stations. The EPA has set the exposure limit to 10 mrem/yr to any member of the general public from all sources of radionuclides.

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 other water recreation sports. 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 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.

All of the routine radioanalyses for the Battelle environmental surveillance program are performed at the radiochemistry facility located at the West Jefferson nuclear site. An outside radiochemistry laboratory was chosen as a backup service for overflow samples, but was not used in 1991. 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), formerly the National Bureau of Standards.

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.

Battelle also participates in the DOE-sponsored Quality Assessment Program, which is administered by the Environmental Measurements Laboratory (EML) and requires the qualitative analyses of spiked air, water, soil,

vegetation, and tissue samples furnished by DOE/EML semiannually. The spiked media samples are analyzed by the radiochemistry facilities serving the Environmental Monitoring Program and the results reported to DOE/EML for verification of accuracy.

Minimum detection levels (MDLs) for radionuclide analyses were determined to a 95 percent confidence level. The minimum detectable level (MDL) was calculated using the Nuclear Data, Inc. ND680 Computer System. The MDL was defined by:

$$MDL = (KI + KII)(S)(CF)$$

where

KI = The value of the upper percentile of the standardized normal variate corresponding to the preselected risk (5 percent) of a type I error.

KII = The value of the upper percentile of the standardized normal variate corresponding to the preselected risk (5 percent) of a type II error.

S = Established standard error for the net counting rate of the sample.

CF = The conversion factor from count rate to activity.

Using a 95 percent confidence level, the MDL can be defined by:

$$MDL = 4.66\ SQRT(BCR)\ CF$$

where

SQRT(BCR) = The square root of the background counting rate.

The conversion factor takes many variables into account, so it is different with each isotope and measurement. The correction factor accounts for total chemical yield, sample size, detector efficiency, branching fraction, decay fraction (decay prior to analysis), unit conversion, and counting interval. The a posteriori MDL is determined by adding the 2 sigma (95 percent confidence level) value to the calculated value, even when it is negative.

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