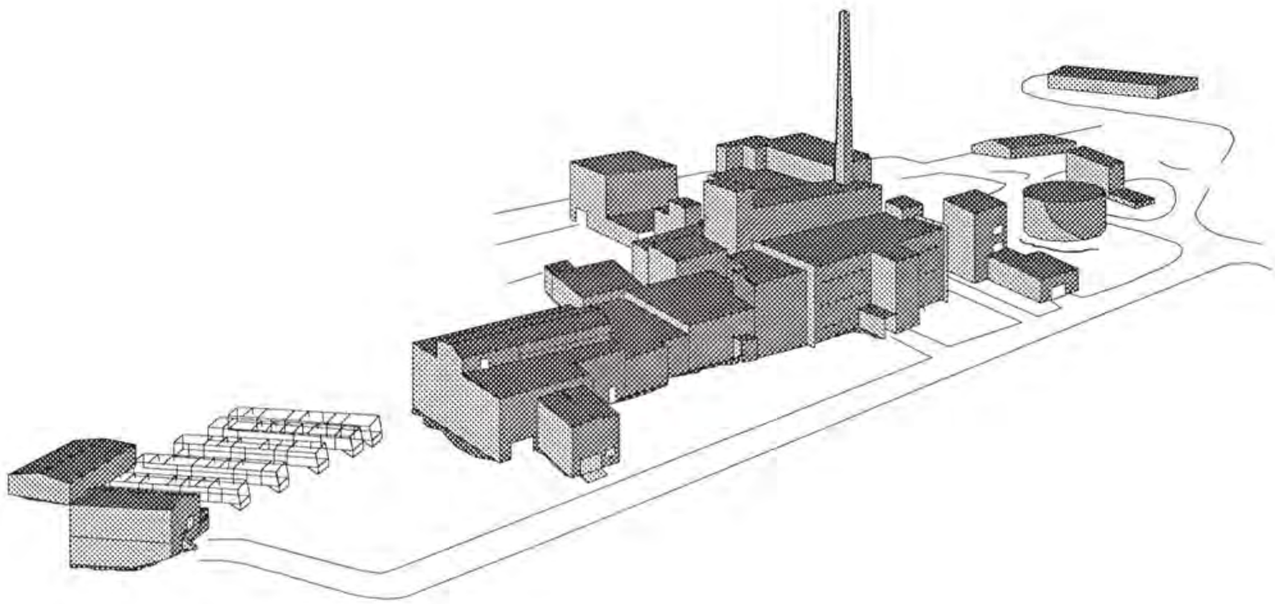
WEST VALLEY DEMONSTRATION PROJECT
SITE ENVIRONMENTAL REPORT
CALENDAR YEAR 1994



West Valley Nuclear Services Company, Inc.

and

Dames & Moore

Prepared for:
U.S. Department of Energy
Ohio Field Office
West Valley Area Office
Under contract DE-AC07-81NE44139

May 1995
P.O. Box 191
10282 Rock Springs Road
West Valley, New York 14171-0191

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Preface

Environmental monitoring at the West Valley Demonstration Project (WVDP) is conducted by the West Valley Nuclear Services Company, Inc. (WVNS), under contract to the U.S. Department of Energy (DOE). The data collected provide an historical record of radionuclide and radiation levels from natural and manmade sources in the survey area. The data also document the quality of the groundwater on and around the site and the quality of the air and water discharged by the WVDP.

This report represents a single, comprehensive source of off-site and on-site environmental monitoring data collected during 1994 by environmental monitoring personnel. The environmental monitoring program and results are discussed in the body of this report. The monitoring data are presented in the appendices. Appendix A is a summary of the site environmental monitoring schedule. Appendix B lists the environmental permits and regulations pertaining to the West Valley Demonstration Project. Appendices C through F contain summaries of data obtained during 1994 and are intended for those interested in more detail than is provided in the main body of the report.

Requests for additional copies of the 1994 Site Environmental Report and questions regarding the report should be referred to the WVDP Community Relations Department, P.O. Box 191, 10282 Rock Springs Road, West Valley, New York 14171-0191 (Phone: 716-942-4610).

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CHAPTER 2. ENVIRONMENTAL MONITORING

The West Valley Demonstration Project's environmental monitoring program includes monitoring and sampling of liquid and air effluents both on- and off-site. Deer, fish, milk, hay, and various fruits and vegetables are also sampled.

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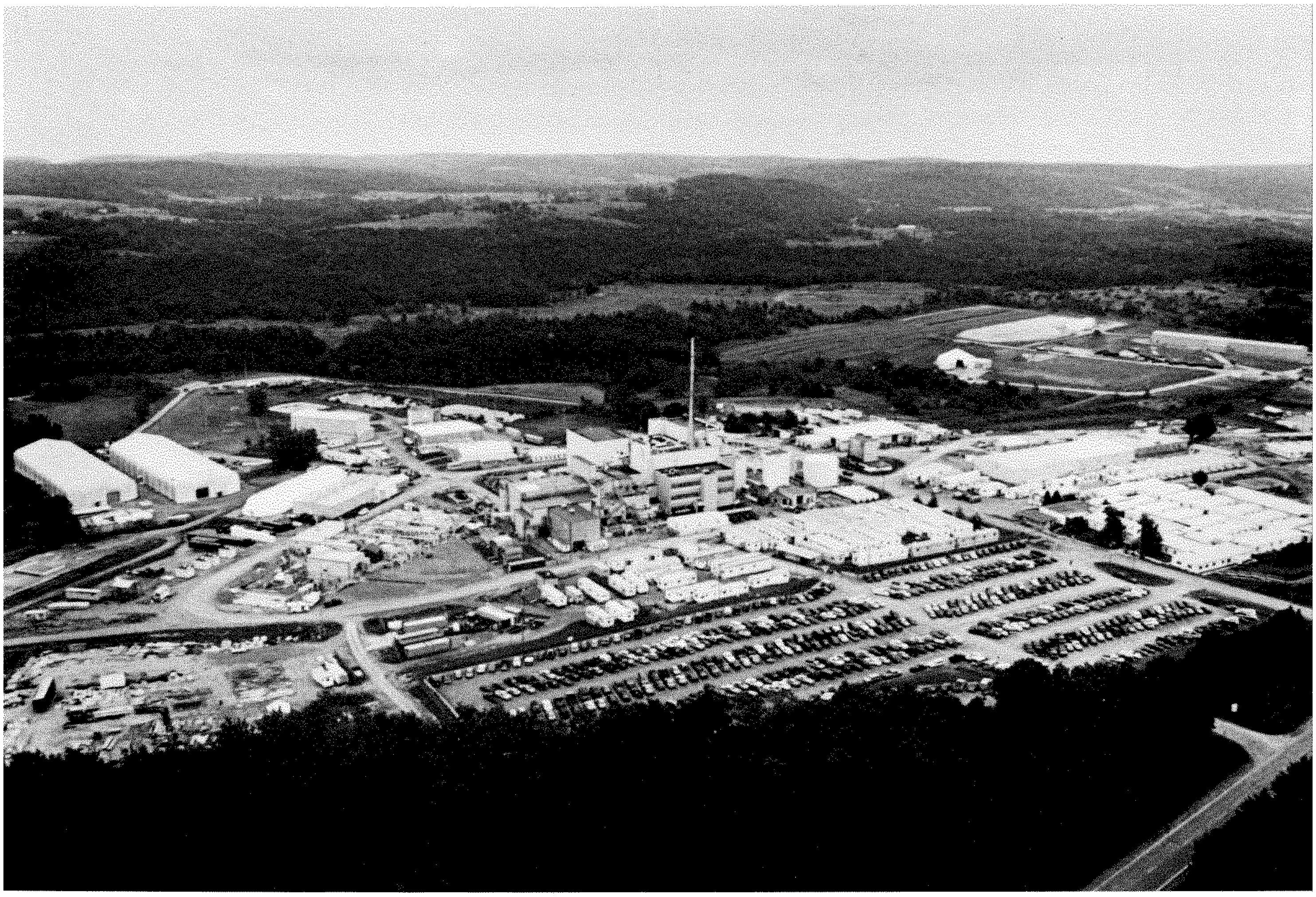


The West Valley Demonstration Project

EXECUTIVE SUMMARY

The West Valley Demonstration Project (WVDP) monitors the surrounding environment and effluent from on-site facilities to fulfill federal and state requirements. The results of this program show that during the course of activities at the WVDP, public health and safety and the environment are being protected.

This annual report summarizes the environmental monitoring data collected during calendar year 1994. On-site and off-site radiological monitoring in 1994 confirmed that site activities were conducted well within state and federal regulatory limits. (A description of regulatory issues is found in the *Environmental Compliance Summary: Calendar Year 1994.*) Although nonradiological monitoring carried out in 1994 identified several exceedances of the site's water effluent permit, none of these resulted in adverse effects upon public health or the environment.

The monitoring activities described in this report support the primary Project mission to solidify the high-level radioactive waste left at the site from the original nuclear fuel reprocessing activities.

An important step toward final solidification of the high-level waste, initiated in late 1994 and completed in January 1995, was to combine two of the high-level waste streams in one underground storage tank. The final step, vitrification of the high-level waste residues, currently is scheduled to start in 1996. More site information is detailed in *Chapter 1, Environmental Monitoring Program Information.*

Compliance

The WVDP operates under U.S. Department of Energy (DOE) requirements for radiation protection of the public and the environment. Limits on radioactivity concentrations and exposures to radiation are specified in DOE Orders. The Project did not exceed or approach any of the limits on radioactivity or radiation doses in 1994, including the emission standards promulgated by the U.S. Environmental Protection Agency (EPA) and incorporated in DOE Orders.

Nonradiological plant effluents are regulated by the New York State Department of Environmental Conservation (NYSDEC) and the EPA. Surface effluent water quality, regulated by NYSDEC, is tested for pH, biochemical oxygen demand (BOD), and other chemical constituents under a State Pollutant Discharge Elimination System (SPDES) permit, which identifies discharge water quality limits.

The site's SPDES permit limits were exceeded several times in 1994. In April and September the BOD limit was exceeded at outfall 001 as a result of the growth of algae in lagoon 3. In November, also at outfall 001, the level of total suspended solids slightly exceeded its permit limit due to the wind resuspending sediments in lagoon 3. Methods being examined to help reduce solids and BOD discharges include filtration and addition of hydrogen peroxide. Samples of discharges from outfall 001 in May showed pH values both above and below the permitted range. New pH monitoring equipment at outfall 001 has been installed to assist the site in meeting the more stringent pH limits received from NYSDEC in 1994 when the Project's SPDES permit was renewed. BOD exceedances at the wastewater treatment plant outfall (007) in April have been addressed through enhanced preventive maintenance of the site cafeteria grease trap and equipment in the wastewater treatment plant.

In all cases, appropriate actions were taken to notify NYSDEC in accordance with permit requirements and to keep the agency apprised of ongoing efforts to prevent recurrence. None of these exceedances resulted in notices of violation being issued by NYSDEC. In no case did any exceedance result in any significant effect on public health or the environment. (See the *Environmental Compliance Summary: Calendar Year 1994* for a more detailed description.)

Groundwater quality is regulated by NYSDEC and the EPA. Groundwater sampling and analyses confirm that on-site groundwater quality has been and continues to be affected both radiologically and nonradiologically by past facility operations. Evaluation of well sampling results for 1994 continues to define some of these effects. Although radiological and nonradiological constituents are being detected in localized, on-site surface and groundwaters, these do not affect public health or the off-site environment.

In 1994 the WVDP continued the actions that were required by a RCRA 3008 (h) Administrative Order on Consent. This agreement, made in 1992 between the EPA, NYSDEC, the DOE, and the New York State Energy Research and Development Authority (NYSERDA), specifies the measures that must be taken to provide information about hazardous wastes or constituents that may have the potential for release to the environment from identified solid waste management units (SWMUs). As required by the Consent Order, a RCRA Facility Investigation (RFI) Work Plan (West Valley Nuclear Services Co., Inc. December 1993) was developed to be used in gathering this information. In 1994 all field work associated with this work plan was completed.

The WVDP continued to operate under and comply with a 1994 Federal and State Facility Compliance Agreement that addresses radioactive mixed waste management issues. A draft site treatment plan also related to mixed waste management was developed and submitted to NYSDEC in 1994, as required by the Federal Facility Compliance Act. (See the *Environmental Compliance Summary*.)

Waste minimization and pollution prevention initiatives continued to be aggressively pursued in 1994. Compared to 1993 waste-generation rates, the generation of low-level radioactive waste was reduced by 29% and radioactive mixed waste by 62%.

Preparation of the draft environmental impact statement for Project completion by the DOE and closure or long-term management of facilities at the Western New York Nuclear Service Center (WNYNSC) by NYSERDA continued in 1994. Six alternatives for closure have been developed and are being evaluated.

Effluent and Environmental Monitoring Program

In 1994 radiological and nonradiological site effluents and related on-site and off-site samples were measured and evaluated. Air and surface water samples were collected to monitor the two major pathways by which radioactive material could migrate off-site.

Testing of animal, soil, and vegetation samples from the area surrounding the Project provided data to calculate the risk of exposure to radioactivity through eating, drinking, or breathing the air. Control (background) samples were also taken to compare with on- or near-site samples.

Air Pathway Monitoring

Airborne particulate radioactivity was sampled continuously at six WNYNSC perimeter locations and four remote locations during 1994. (See *Chapter 2, Environmental Monitoring.*) Sample filters were collected weekly; samples were analyzed weekly for gross alpha and gross beta radioactivity and quarterly for other isotopes. Airborne gross radioactivity around the site boundary was, in all cases, indistinguishable from background concentrations measured at the remote locations.

Direct monitoring of airborne effluents at the main plant stack and other permitted release points showed all discharges to be well below DOE and EPA effluent limitations.

Surface Water Pathway Monitoring

Automatic samplers collected surface water at six locations along site drainage channels. Samples were analyzed for gross alpha, gross beta, and gamma activity, and for tritium and strontium-90. Analyses for carbon-14, iodine-129, uranium and plutonium isotopes, and americium-241 are also program requirements at several collection points.

As a result of past site activities and continuing releases of treated liquids, gross radioactivity concentrations remained slightly higher in Buttermilk Creek below the West Valley Project site than at the upstream background sample point. However, yearly average concentrations in water below the Project site in Cattaraugus Creek during 1994 were indistinguishable from background concentrations measured in Buttermilk Creek upstream of the Project facilities. All Cattaraugus Creek concentrations observed were well below DOE regulatory guidelines (derived concentration guides [DCGs]). Concentrations of cesium-137 and other gamma emitters, strontium-90 and other beta emitters, tritium, and uranium and plutonium isotopes were below DOE DCGs at all surface water sampling locations, including Frank's Creek downstream of the Project at the inner site security fence, which is more than 4.8 kilometers (3 mi) upstream of Cattaraugus Creek.

The low-level liquid waste treatment facility (LLWTF) contributes most of the activity released from the site in liquid discharges. The 1994 annual average liquid effluent concentrations of radionuclides were below DOE release guidelines at the point of discharge.

Food Pathway Monitoring

Radioactivity that could pass through the food chain was measured by sampling milk, beef, hay, corn, apples, beans, fish, and venison. With the exception of strontium-90 from bottom-feeding fish from above the Springville dam, no statistically significant differences in radionuclide concentrations between background (control) samples and near-site samples were measured in any of these media. (See *Chapter 4, Radiological Dose Assessment.*)

Direct Environmental Radiation Monitoring

Direct environmental radiation was measured continuously during each calendar quarter in 1994 using thermoluminescent dosimeters (TLDs) placed at forty-three locations around the WNYNSC perimeter, along the site access road, at points around the Project site, and at various background locations. No real differences could be found between exposure rates measured at background stations and those at the WNYNSC perimeter locations. TLD measurements also were taken inside the restricted area boundary and reflect low-level radiation from nearby radioactive waste handling and storage facilities.

Small Mammal Study

In 1994 a special study was conducted to determine the significance of uncontrolled small mammal activity on-site as a mechanism for the transport of radioactivity. The study suggests that potential contaminant transport by small mammals is localized in restricted facility areas. Transport was not observed in radioactive waste management or disposal areas.

Nonradiological Monitoring

Nonradiological discharges from the site are regulated by NYSDEC; however, no special monitoring and reporting of nonradiological airborne effluents is required.

Nonradiological liquid discharges to an on-site stream from three permitted release points (outfalls) are monitored as required by the SPDES permit. Project effluents are monitored for BOD, suspended solids, ammonia, iron, pH, oil and grease, and other water quality indicators. Although the SPDES permit limits were exceeded several times in 1994, as noted above, monitoring and observation downstream indicated that nonradiological liquid discharges had no observed effects on the off-site environment.

Groundwater Monitoring

The WVDP is directly underlain by layers of unconsolidated sediments ranging from coarse gravels to fine clays. Permeabilities of these sediments are largely a function of grain sizes, with higher permeabilities reflected in coarser sediments. The targets of groundwater monitoring are those saturated units with relatively higher groundwater velocities that are thus potential pathways for contaminant migration.

The 1994 monitoring well network included both on-site wells for surveillance of SWMUs and off-site wells to monitor drinking water. The 1994 on-site groundwater monitoring network included ninety-one Project-related groundwater monitoring locations. (See Fig. 3-3 in *Chapter 3, Groundwater Monitoring*.) Although an additional twenty-one wells located around the New York State-licensed disposal area (SDA) are monitored separately by NYSERDA, data from those wells are also included in this report. (See *Appendix F*.)

The wells provided upgradient and downgradient monitoring of the low-level liquid waste treatment facility (LLWTF) lagoons, the high-level waste tank complex, the Nuclear Regulatory Commission (NRC)-licensed disposal area (NDA), and other SWMUs. Wells in the groundwater monitoring network were each sampled four times during 1994. The range of analyses performed was determined by technical regulatory guidelines and site-specific characterization needs.

Monitoring well data are grouped by hydrogeologic unit. Data from groundwater monitoring of the sand and gravel unit around the LLWTF lagoons indicate that radionuclides from past plant operations have affected groundwater quality: Compared to background, both tritium and gross beta concentrations in groundwater surrounding the lagoon system are elevated; however, the level of tritium contamination has declined steadily since 1982, as indicated by measurements at the french drain outfall WNSP008. Gross beta activity, which had increased previously, leveled off or declined in 1994 at the sand and gravel LLWTF monitoring points WNSP008 and 8605. Gross beta activity at well 111 continued to be elevated in 1994. (See **Groundwater Monitoring Results** in *Chapter 3, Groundwater Monitoring*.)

Monitoring data from around the high-level waste tanks do not suggest any effect of the stored high-level radioactive waste on the groundwater. However, significant radiological differences between upgradient and downgradient wells do indicate that previous site activities have affected groundwater in this area. Most notable are elevated levels of gross beta in sand and gravel wells 408, 501, and 502, which are downgradient of the main process plant facilities. Gross beta activity in 1994 at well 408 reached an historic high.

In all, there are nine wells on-site that exhibit elevated gross beta levels above a concentration of 1E-06 µCi/mL. This concentration corresponds to the Department of Energy DCG for an annual average strontium-90 surface discharge and is presented for comparison only. Strontium-90 has been identified as the primary contributor to gross beta activity in groundwater on-site and therefore is used as the limiting beta-emitting isotope. See *Appendix B*, Table B-1.

One of the streams originating in a swampy area on the Project premises was found in late 1993 to have increasing gross beta radioactivity. Upon examination, a small seasonal groundwater seep was discovered that appeared to be a major contributor of strontium-90 to this drainage path. An investigation was initiated to characterize the source of this seep, its effect on surface water quality, and to provide information for mitigative action, if deemed necessary. Groundwater and soil beneath and downgradient of the process building were sampled between July 14, 1994 and October 19, 1994. During this investigation groundwater was collected from eighty locations, and soil samples were collected from four locations. The groundwater and soil samples were collected with the Geoprobe®, a mobile, van-mounted sampling system designed to sample groundwater and/or soil at two-foot depth intervals.

Preliminary groundwater sampling results indicate that a narrow, elliptically shaped plume of elevated gross beta activity, extending northeastward from the south end of the process building to the construction and demolition debris landfill, is present in groundwater from the sand and gravel unit. The plume is approximately 300 feet in width and 800 feet in length. The highest gross beta activities in groundwater and soil were measured at two locations near the south end of the process building, reaching a maximum concentration of 3.6E-03 µCi/mL and 2.4E-02 µCi/g, respectively. Isotopic characterization of the groundwater and soil suggests that strontium-90 and its daughter product, yttrium-90, contribute most of the gross beta activity in groundwater and soil beneath and downgradient of the process building. At this time the primary source of contamination appears to be an area in the southwest corner of the process building associated with acid recovery operations conducted by the previous site operator, Nuclear Fuel Services, Inc. (NFS), prior to any WVDP activities. A final report describing the principal findings of the investigation, including potential sources, is scheduled to be completed in May 1995.

In the meantime, steps are being taken to remove strontium-90 from the groundwater flow path, if it should become necessary. A mobile ion-exchange treatment system for surface water was permitted by NYSDEC in 1994. In addition, preparations are under way to mitigate strontium-90 movement near the leading edge of the plume.

Elsewhere, other measured parameters such as pH and conductivity have shown significant differences between upgradient and downgradient hydrogeologic unit locations. Downgradient sand

and gravel well 103 continued to demonstrate high pH, sodium, and hydroxide ion levels in 1994 samples. This well is located in the vicinity of a spill of sodium hydroxide solution that occurred because of a transfer pipe failure in 1984. Downgradient till-sand well 202 also shows an elevated pH. Recent data suggest that high pH in this well is an artifact of well construction rather than historical waste management unit releases or spills.

Organic contaminants were identified in groundwater in the vicinity of three super solid waste management units (SSWMUs). Tributyl phosphate, detected in the vicinity of the low-level waste treatment facility (SSWMU #1), is probably related to the migration of wastes generated by the NFS solvent extraction process. Radioactive contaminants have historically been present in the same area. Three chlorinated organic compounds were detected in the vicinity of the construction and demolition debris landfill (SSWMU #8) and near the high-level waste storage and processing area (SSWMU #4). Refer to **Results of Sampling for Groundwater Quality Parameters** in *Chapter 3, Groundwater Monitoring*, for a more detailed explanation.

Tritium has been detected in wells in the near-surface weathered Lavery till in the vicinity of the SDA and the NDA. Elevated tritium has not been observed in the monitoring wells in the deeper Kent recessional sequence, supporting the expectation that this geologic unit acts as a barrier.

Ongoing environmental characterization and RCRA facility investigations are being used to assess the groundwater in greater detail. (See *Chapter 3, Groundwater Monitoring*.)

A control and remediation effort within the NDA included installation in 1990 of a gravel-backfilled interceptor trench downgradient of soils known to be contaminated by tributyl phosphate and n-dodecane. As in previous years, no solvent was found in the water collected from this interceptor trench in 1994.

In addition to on-site monitoring, the potential effect of Project activities on off-site groundwater is monitored by annual sampling of designated private drinking water wells. Monitoring of these wells continues to demonstrate that the site has had no effect on residential drinking water supplies in the vicinity. In addition, on-site groundwaters flowing to the surface with above-background levels of radioactivity are quickly diluted by natural stream flow so that levels of radioactivity, as seen in Cattaraugus Creek at the first point of public access, continue to be at or below background levels.

Radiological Dose Assessment

Potential radiation doses to the public from airborne and liquid effluent releases of radioactivity from the site during 1994 were estimated using computer models.

The EPA-approved computer program CAP88-PC was used to calculate potential radiation doses from airborne discharges from the permanent stacks. These potential doses are measured in millirems or millisieverts and express a combination of organ and tissue doses into a single "effective" whole body dose. (See **Units of Measure** in *Chapter 4, Radiological Dose Assessment*.) The highest annual effective dose equivalent (EDE) to a nearby resident was estimated to be 3.2E-04 mrem (3.2E-06 mSv), which is 0.003% of the 10 mrem EPA standard. The collective dose to all persons within an 80-kilometer (50-mi) radius was estimated to be 3.7E-03 person-rem (3.7E-05 person-Sv) effective dose equivalent.

The highest individual calculated EDE for liquid effluents was 2.2E-02 mrem (2.2E-04 mSv), with an annual EDE to the population within 80 kilometers (50 mi) estimated to be 8.1E-02 person-rem (8.1E-04 person-Sv).

The total calculated dose estimates from 1994 Project effluents result in a maximum EDE to an individual of 2.3E-02 mrem (2.3E-04 mSv), which is 0.02% of the 100 mrem DOE limit. Overall, the annual EDE from air and liquid discharges to people within an 80-kilometer (50-mi) radius of the site was calculated to be 8.4E-02 person-rem (8.4E-04 person-Sv). More detailed explanations of these dose calculations are found in *Chapter 4, Radiological Dose Assessment*, **Dose Assessment Methodology**.

With the exception of strontium-90 in bottom-feeding fish taken from Cattaraugus Creek above the dam, concentrations of radionuclides in locally produced foods are statistically indistinguishable from background concentrations. The measured concentration corresponds to an EDE of 0.04 mrem/yr above background if 21 kilograms (46 lbs) of fish were eaten in 1994.

The potential calculated doses presented above should be considered in relation to an average dose of 300 mrem per year to a U.S. resident from natural background radiation. The dose assessment described in *Chapter 4, Radiological Dose Assessment*, predicts an insignificant effect on the public's health as a result of radiological releases from the WVDP.

Quality Assurance

The environmental monitoring quality assurance program includes provisions for evaluating and controlling data generated from both on-site and off-site measurements. Both on-site and off-site laboratories and their internal quality assurance programs are routinely reviewed by site personnel. In addition, commercial laboratories must satisfactorily perform blind analyses of standard or duplicate samples submitted by the WVDP Environmental Laboratory.

WVDP monitoring activities are subject to quality control checks from the time of sample collection through sample analysis and data reduction. Each analytical test of the samples analyzed in the on-site Environmental Laboratory is reviewed in detail. Specific quality checks include external review of sampling procedures, accurate calibrations using primary standard materials, participation in formal laboratory crosscheck programs (for example, with the EPA and the DOE), and assessments by independent organizations that include the New York State Department of Health (NYSDOH), the NRC, the DOE, and Westinghouse Electric Corporation.

Environmental sample sharing and co-location of measurement points with NYSDOH and the NRC continued in 1994, ensuring that selected samples and locations were routinely measured by two or more independent organizations.

Participation in crosscheck programs, coupled with other internal quality control procedures and external laboratory checks, verified the quality of data gathered in 1994. General program adequacy and specific issues of quality assurance were audited by the WVNS quality assurance department in 1994. Four self-assessments, conducted by an independent team of environmental monitoring staff, identified areas needing improvement and tracked the actions taken. (See *Chapter 5, Quality Assurance*.)

Project Assessment Activities

A number of important external assessment activities were carried out at the WVDP in 1994. The U.S. Department of Transportation and the New York State Department of Transportation jointly inspected the WVDP in July and October 1994 for compliance with hazardous waste shipping regulations. The July inspection identified one finding pertaining to the requirement for the site to have a continuously monitored telephone number that can be called in the event of a transportation emergency. The finding was addressed immediately, and the October inspection did not identify any findings.

The most significant external environmental overview activity in 1994 was a comprehensive Environmental, Safety, Health and Quality Assurance functional appraisal carried out by the DOE Idaho Operations office. This appraisal, along with routine inspections by NYSDEC, the EPA, and the Cattaraugus County Health Department, confirmed the high quality of the environmental monitoring program at the WVDP and the Project's commitment to environmental compliance.

INTRODUCTION

History of the West Valley Demonstration Project

In the early 1950s interest in promoting peaceful uses of atomic energy led to the passage of an amendment to the Atomic Energy Act that allowed the Atomic Energy Commission to encourage commercialization of nuclear fuel reprocessing as a way of developing a civilian nuclear industry. The Atomic Energy Commission made its technology available to private industry and invited proposals for the design, construction, and operation of reprocessing plants.

In 1961 the New York Office of Atomic Development acquired 1,335 hectares (3,330 acres) near West Valley, New York and established the Western New York Nuclear Service Center (WNYNSC). Davison Chemical Co., together with the New York State Atomic Research and Development Authority, which later became the New York State Energy Research and Development Authority (NYSERDA), undertook construction and operation of a nuclear fuel reprocessing plant under a co-license issued by the Atomic Energy Commission. Nuclear Fuel Services, Inc. (NFS) was formed by Davison Chemical Co. to operate the plant as a commercial facility. NFS leased the property at the Western New York Nuclear Service Center and in 1966 began operations to recycle fuel from both commercial and federally owned reactors.

In 1972, while the plant was closed for modifications and expansion, federal and state safety regulations, which were more rigorous than those previously in existence, were imposed. Most of the changes concerned the disposal of high-level radioactive liquid waste and the prevention of earthquake damage to the facilities. NFS decided that compliance with the new regulations was not economically feasible, and in 1976 NFS notified NYSERDA that it would not continue in the fuel reprocessing business.

Following this decision, the reprocessing plant was shut down. Under the original agreement between NFS and New York State, the state was ultimately responsible for both the radioactive wastes and the facility. Numerous studies followed the closing, leading eventually to the passage of Public Law 96-368, the West Valley Demonstration Project Act, which authorized the U.S. Department of Energy (DOE) to demonstrate a method for solidifying the 2.5 million liters (660,000 gal) of liquid high-level waste that remained at the West Valley site. Congress anticipated that the technologies developed at West Valley would be used at other facilities throughout the United States.

West Valley Nuclear Services Co., Inc. (WVNS), a subsidiary of Westinghouse Electric Corporation, was chosen by the DOE to be the management and operating contractor for the West Valley Demonstration Project (WVDP). The WVDP Act specifically states that the facilities and the high-level radioactive waste on-site shall be made available (by the state of New York) without the transfer of title for such a period as may be required for the completion of the Project.

The purpose of the WVDP is to solidify the high-level radioactive waste left at the site from the original nuclear fuel reprocessing activities, develop suitable containers for holding and transporting the solidified waste, arrange transportation of the solidified waste to a federal repository, dispose of any Project low-level and transuranic waste resulting from the solidification of high-level waste, and decontaminate and decommission the Project facilities.

The high-level waste was contained in underground storage tanks and had settled into two layers, a liquid supernatant and a precipitate sludge. Various subsystems were constructed that permitted the successful start-up in May 1988 of the integrated radwaste treatment system (IRTS). The system stripped radioactivity from the liquid supernatant, allowing the major portion of the liquid to be treated as low-level waste. Treatment of the supernatant liquid from the high-level waste tanks through the IRTS was completed in 1990.

The next step in the process, washing the remaining sludge with water to remove soluble constituents, began in late 1991 and was completed in 1994. (See *Chapter 1, Environmental Monitoring Program Information* for a more detailed description.) The final step will be vitrification of the remaining high-level waste residues.

This annual environmental monitoring report is published to inform the public about environmental monitoring conditions at the WVDP. The report presents a summary of the environmental monitoring data gathered during the year in order to characterize the performance of the WVDP's environmental management, confirm compliance with standards and regulations, and highlight significant programs.

The geography, economy, climate, ecology, and geology of the region are principal factors in assessing possible effects of site activities on the surrounding population and environment and are an integral consideration in the design and structure of the environmental monitoring program.

Location

The WVDP site is located about 50 kilometers (30 mi) south of Buffalo, New York (Fig. 1-1). The WVDP site facilities occupy a fenced area of about 80 hectares (200 acres) within the 1,335-hectare (3,330-acre) Western New York Nuclear Service Center. This security-fenced area is referred to as the Project premises, or the restricted area.

The WVDP is located on New York State's Allegheny plateau at an average elevation of 400 meters (1,300 ft). The communities of West Valley, Riceville, Ashford Hollow, and the village of Springville are located within 8 kilometers (5 mi) of the plant. Several roads and a railway pass through the WNYNSC, but the public does not have access to the WNYNSC. Generally, hunting, fishing, and human habitation on the WNYNSC are prohibited. A NYSERDA-sponsored pilot program to control the deer population was initiated in 1994. Limited hunting permits were issued to local residents, and community response was favorable.

Socioeconomics

The WNYNSC lies within the town of Ashford in Cattaraugus County. The nearby population,

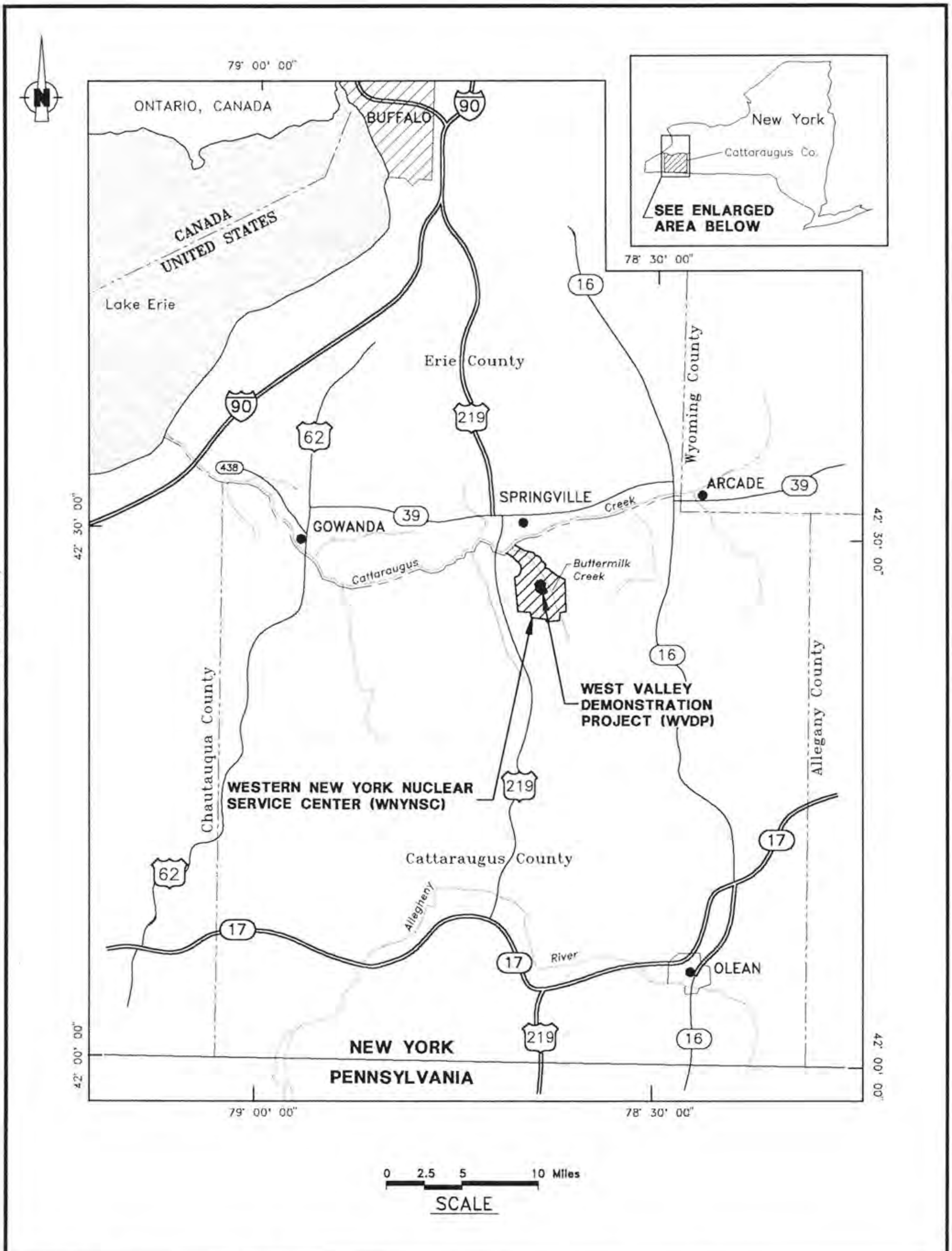


Figure 1-1. Location of the Western New York Nuclear Service Center.

approximately 9,200 residents within 10 kilometers (6.2 mi) of the Project, relies primarily on an agricultural economy. No major industries are located within this area.

The land immediately adjacent to the WNYNSC is used primarily for agriculture and arboriculture. Cattaraugus Creek is used locally for swimming, canoeing, and fishing. Although some water to irrigate nearby golf course greens and tree farms is taken from Cattaraugus Creek, no public water supply is drawn from the creek downstream of the WNYNSC before the creek flows into Lake Erie near Buffalo, New York. Waters from Lake Erie are used as a public water supply.

Climate

Although there are recorded extremes of 37°C (98.6°F) and - 42°C (- 43.6°F) in Western New York, the climate is moderate, with an average annual temperature of 7.2°C (45.0°F). Rainfall is relatively high, averaging about 104 centimeters (41 in) per year. Precipitation in 1994 totaled 101.9 centimeters (40.13 in). Precipitation is evenly distributed throughout the year and is markedly influenced by Lake Erie to the west and, to a lesser extent, by Lake Ontario to the north. Regional winds are generally from the west and south at about 4 m/sec (9 mph).

Biology

The WNYNSC lies within the northern deciduous forest biome, and the diversity of its vegetation is typical of the region. Equally divided between forest and open land, the site provides a habitat especially attractive to white-tailed deer and various indigenous birds, reptiles, and small mammals. No species on the federal endangered list are known to be present on the WNYNSC.

Geology and Groundwater Hydrology

The WVDP site is located on the west shoulder of a steep-sided glacially scoured bedrock valley that is filled with a thick sequence of glacial sediments. (See Figs. 3-1 and 3-2 in *Chapter 3, Groundwater Monitoring*.) The WVDP site is bordered by two stream valleys (Frank's Creek and Quarry Creek) and divided by a third stream valley (Erdman Brook) into two portions, the north and south plateaus. (See Fig. 3-3 in *Chapter 3, Groundwater Monitoring*.)

The uppermost layer of glacial sediments on the south plateau consists of a silty clay till, the Lavery till. The Lavery till does not transmit significant quantities of water except where it is exposed at ground surface, where weathering has

A Young White-tailed Resident

created an extensive fracture system. Groundwater flow in the weathered till has both a vertically downward component and a horizontal component to the northeast. Groundwater flow in the unweathered portion of the till, beneath the exposed weathered till, is predominantly vertically downward.

On the north plateau a relatively permeable alluvial sand and gravel layer overlies the glacial sequence of sediments (i.e., the Lavery till, the Kent recessional sequence, and the Kent till). Groundwater flow in the sand and gravel unit of the north plateau is predominantly horizontal, towards the northeast, discharging to seeps and streams along the plateau's edge and to evapotranspiration.

Within the Lavery till on the north plateau is a silty, sandy unit of limited areal extent, the Lavery till-sand. The flow of groundwater within the till-sand appears to be very limited. Surface discharge points have not been observed, but gradients indicate flow to the southeast.

The Kent recessional sequence that underlies the Lavery till beneath both north and south plateaus is composed of silt and silty sand with small pockets of gravel. Groundwater flow in the Kent recessional sequence is also towards the northeast and discharges ultimately to Buttermilk Creek.

Within the Lavery till on both the north and south plateaus are other localized permeable units capable of letting groundwater flow through. The uppermost few feet of shale bedrock has also demonstrated the ability to let significant quantities of groundwater flow through via fractures.

Information in this Report

Format and Content

Individual chapters in this report include information on compliance with regulations, general information about the monitoring program and significant activities in 1994, summaries of the results of radiological and nonradiological monitoring, and calculations of radiation doses to the population within 80 kilometers of the site. Where appropriate, graphs and tables are included to illustrate important trends and concepts. The bulk of the supporting data is furnished separately in the appendices following the text.

Appendix A summarizes the 1994 environmental monitoring program at both on-site and off-site locations. Samples are designated by a coded abbreviation indicating sample type and location. (A complete listing of the codes is found in the index to *Appendix A*.) *Appendix A* lists the kinds of samples taken, the frequency of collection, the parameters analyzed, the location of the sample points, and a brief rationale for the monitoring activities conducted at each location.

Appendix B provides a list of those radiation protection standards most relevant to the operation of the WVDP as set by the DOE. It also lists federal and state regulations that affect the WVDP and environmental permits held by the site.

Appendix C summarizes analytical data from air, water, sediment, soils, and biological samples (meat, milk, food crops, and fish) as well as direct radiation measurements and meteorological monitoring.

Appendix D provides data from the comparison of results of analyses of identically prepared samples (crosscheck analyses) by both the WVDP and independent laboratories. Radiological concentrations in crosscheck samples of air, water, soil, milk, and vegetation are reported here, as are chemical concentrations from water crosscheck samples. *Appendix D* also lists the comparisons of direct radiation measurements from thermoluminescent dosimeters (TLDs) monitored by the WVDP and measurements from dosimeters placed in the same locations by the U.S. Nuclear Regulatory Commission (NRC).

Appendix E summarizes the data collected from on-site groundwater monitoring. Tables and graphs report concentrations at various locations for parameters such as gross alpha and gross beta, tritium, gamma-emitting isotopes, organic compounds, and dissolved metals.

Appendix F contains groundwater monitoring data for the New York State-licensed disposal area (SDA) provided by NYSERDA.

Acronyms

Acronyms often are used in technical reports to speed up the reading process. Although using acronyms can be a practical way of referring to agencies or systems with long, unwieldy names, having to look up rarely used acronyms can defeat the purpose of using them. Accordingly, full names of agencies and systems have been used in this report where it will help the reader. However, common acronyms that the reader is apt to be familiar with (e.g., DOE, EPA, NRC, NYSDEC) or that are used often in this report (e.g., WVDP, WNYNSC) are spelled out only at the beginning of sections. A list of acronyms may be found at the end of this report.

Environmental Monitoring Program

The environmental monitoring program for the WVDP began in February 1982. The primary program goal is to detect changes in the environment resulting from Project activities and to assess the effect of any such changes on the human population and the environment surrounding the site.

The monitoring network and sample collection schedule have been structured to accommodate specific biological and physical characteristics of the area. Among the several factors considered in designing the environmental monitoring program were the kinds of wastes and other byproducts resulting from the processing of high-level waste; possible routes that radiological and nonradiological contaminants could follow into the environment; geologic, hydrologic, and meteorologic site conditions; quality assurance standards for monitoring and sampling procedures and analyses; and the limits and standards set by federal and state governments and agencies. As new processes and systems become part of the program, additional monitoring is provided.

Monitoring and Sampling

The environmental monitoring program consists of on-site effluent monitoring and on-site and off-site environmental surveillance in which samples are measured for both radiological and nonradiological constituents. (See the *Glossary* for more detailed definitions of effluent monitoring and environmental surveillance.) Monitoring and surveillance include both the continuous recording of data and the collecting of soil, sediment, water, air, and other samples at specific times.

Monitoring and sampling of environmental media provide two ways of assessing the effects of on-site radioactive waste processing. Monitoring generally is a continuous process of measurement that allows rapid detection of any potential effects on the environment from site activities. Sampling is the collection of media at scheduled times; sampling is slower than direct monitoring in indicating results because the samples collected must be analyzed in a laboratory to obtain data, but it allows much smaller quantities of radioactivity to be detected through the analysis.

Permits and Regulations

Data gathering, analysis, and reporting to meet stringent federal and state requirements and standards are an integral part of the monitoring program. The current program meets the requirements of DOE Orders 5400.1 and 5400.5 and DOE Regulatory Guide DOE/EH-0173T.

The West Valley Demonstration Project also possesses a State Pollutant Discharge Elimination System (SPDES) permit as required by the New York State Department of Environmental Conservation (NYSDEC), which regulates liquid effluent discharges containing nonradiological pollutants. The SPDES permit identifies the outfalls where liquid effluents are released to site drainage and specifies the sampling and analytical requirements for each outfall.

In addition, the site operates under state-issued air discharge permits for nonradiological plant effluents. Radiological air discharges must also comply with the National Emissions Standards for Hazardous Air Pollutants (NESHAPs).

For more information see the *Environmental Compliance Summary: Calendar Year 1994*. Environmental permits are listed in *Appendix B*.

Exposure Pathways Monitored at the West Valley Demonstration Project

The major near-term pathways for potential movement of possible contaminants away from the site are by surface water drainage and airborne transport. For this reason the environmental monitoring program emphasizes the collection of air and surface water samples. Samples are collected on-site from locations such as plant ventilation stacks as well as various water effluent points and surface water drainage locations. Samples of air, water, soils, and biota from the environment surrounding the site would indicate any radioactivity that might reach the public from site releases. Extensive groundwater monitoring addresses many long-term pathway concerns.

Water and Sediment Pathways

Process waters are collected in a series of on-site lagoons for treatment before being discharged. (The location of the lagoons is noted on Fig. 2-3 in *Chapter 2, Environmental Monitoring*.) Samples of this effluent and the effluent at three other discharge points are collected regularly or, in the case of lagoon 3, when the lagoon water is released. The samples are analyzed for radiological parameters, including gross alpha and gross beta, tritium, strontium-90, and gamma isotopes, and for nonradiological parameters, including pH and conductivity. Additional analyses of composite samples determine metals content, solids, biochemical oxygen demand, nitrates, nitrites, ammonia, sulfate, organic chemicals, and specific isotopic radioactivity.

On-site groundwater and surface water samples are collected regularly and analyzed, at a minimum, for gross alpha and beta radioactivity, tritium, and pH. Selected samples are analyzed for conductivity, chlorides, metals, volatile organic compounds, and other parameters. Potable water on the site is analyzed monthly for radioactivity and annually for chemical constituents. Residential drinking water wells located near the site are sampled annually and analyzed for gross alpha and gross beta radioactivity, tritium, gamma isotopes, pH, and conductivity.

Off-site surface waters, primarily from Cattaraugus Creek and Buttermilk Creek, are sampled both upstream of the Project for background radioactivity and downstream to measure possible Project contributions. Sediments deposited downstream of the facility and at upstream background locations are collected semiannually and analyzed for gross alpha, gross beta, and specific radionuclides. (See *Appendix C-1* for water and sediment data summaries.)

Groundwater Pathways

Groundwater discharge at the WVDP site occurs as springs, seeps along stream channels, direct discharge to streams, evapotranspiration, vertical groundwater outflow, and discharge to artificial draining systems and lagoons. All of these discharges vary with the seasons. Discharge from springs and seeps is highest during the spring. Evapotranspiration is at a maximum during the summer. Groundwater discharge is, in general, lowest during the winter because the ground surface is frozen.

Routine monitoring of groundwater includes sampling for indicator and groundwater quality parameters. Additional sampling for radiological and nonradiological parameters (e.g., volatiles, semivolatiles, metals, pesticides, and PCBs [polychlorinated biphenyls]) is included under the expanded groundwater characterization monitoring program.

Air Pathways

Effluent air emissions are continuously monitored for alpha and beta activity. Remote alarms indicate any unusual rise in radioactivity. Air particulate sampling filters, which are retrieved and analyzed weekly for gross radioactivity, are also composited quarterly and analyzed for strontium-90 and specific gamma- and alpha-emitting nuclides.

Iodine-129 and tritium also are measured in effluent ventilation air. At two locations silica gel-filled columns are used to extract water vapor that is then distilled from the desiccant and analyzed for tritium. Four samplers contain activated charcoal adsorbent that is analyzed for radioiodine. The silica gel columns are analyzed weekly; the charcoal is collected weekly and composited for quarterly analysis.

Off-site sampling locations include those considered most representative of background conditions and those most likely to be downwind of airborne releases. Among the criteria used to position off-site air samplers are prevailing wind direction, land usage, and the location of population centers.

Off-site air is continuously sampled at ten locations. Background samplers are located far from the site in Great Valley and Dunkirk, New York. Nearby-community samplers are in Springville and West Valley, New York. (See Fig. A-9 in *Appendix A* for these four off-site air sampling locations.) Six samplers are located on the perimeter of the WNYNSC. (See Fig. 2-2 in *Chapter 2, Environmental Monitoring*.) These samples are analyzed for parameters similar to the effluent air samples. (See *Appendix C-2* for air monitoring data summaries.)

Atmospheric Fallout

An important contributor to environmental radioactivity is atmospheric fallout. Sources of fallout include earlier atmospheric testing of atomic explosives and residual radioactivity from accidents such as occurred at Chernobyl. Four site perimeter locations and one on-site location currently are sampled for fallout using pot-type samplers that are collected every month. Long-term fallout is determined by analyzing soil collected annually at each of the six perimeter and four off-site air samplers. (See *Appendix C-2* for fallout data summaries and *Appendix C-1* for soil data summaries.)

Food Pathways

A potentially significant pathway of radioactivity to humans is through eating produce and domesticated farm animals raised near the WVDP and through game animals and fish that include the WVDP in their range. Animal and fish samples from potentially affected areas are gathered and analyzed for radionuclide content in order to reveal any long-term trends. Fish are collected at several locations along Cattaraugus Creek and its tributaries at various distances downstream from the WVDP. Beef, milk, hay, and produce are collected at nearby farms and at selected locations well away from any possible WVDP influence. (See *Appendix C-3* for biological data summaries.)

Direct Radiation Measurement

Direct penetrating radiation is measured using thermoluminescent dosimeters (TLDs) located on- and off-site. Measurement points within the site are placed near selected waste management units and around the inner security fence. Other measurement locations are situated around the site perimeter and access road and at background locations remote from the WVDP. The TLDs are retrieved quarterly and read out on-site to obtain the integrated gamma exposure. Forty-one measurement points were used in 1994. See *Appendix C-4* for a summary of the direct radiation data.

Meteorological Monitoring

Meteorological data are continuously gathered and recorded on-site. Wind speed and direction, barometric changes, dew point, temperature, and rainfall are all measured. Such data are valuable in evaluating long-term geohydrological trends and in developing airborne dispersion models. In the event of an emergency, immediate access to the most recent data is indispensable for predicting the path and concentration of any materials that become airborne. (See *Appendix C-6* for meteorological data summaries.)

Quality Assurance and Control

The work performed by and through the on-site Environmental Laboratory is regularly reviewed by several agencies for accuracy and compliance with applicable regulations. Audits of the laboratory routinely focus on proper record keeping and reporting, timely calibration of equipment, training of personnel, adherence to accepted procedures, and general laboratory safety.

The Environmental Laboratory also participates in several quality assurance crosscheck programs administered by federal or state agencies. All the radiological crosscheck results in 1994 from the Environmental Laboratory were within acceptance levels. (See *Appendix D* for a summary of crosscheck performance.) Outside laboratories contracted to perform analyses for the WVDP also are regularly subjected to performance audits.

Environmental monitoring management continued to strengthen its formal self-assessment program, developing and implementing new strategies and procedures for ensuring high quality data. Experienced senior scientists and specialists in varying disciplines follow an annual schedule of self-assessments, produce formal reports with recommended corrective actions, and track the planned actions for their implementation.

ENVIRONMENTAL COMPLIANCE SUMMARY

CALENDAR YEAR 1994

Introduction: Compliance Program

The mission of the West Valley Demonstration Project (WVDP) is to develop and demonstrate a safe method of solidifying high-level radioactive waste. Vitrification, the selected method, involves a complex technology that uses both radioactive and nonradioactive materials and processes, which are regulated by various federal and state laws in order to protect the public, workers, and the environment.

The U.S. Department of Energy (DOE), the federal agency that oversees the WVDP, established its policy concerning environmental protection in DOE Order 5400.1, General Environmental Protection Program. This Order lists the regulations, laws, and required reports that are applicable to DOE-operated facilities. This annual monitoring report is required by DOE Order 5400.1 and is intended to summarize environmental data gathered during the calendar year, describe significant programs, and confirm compliance with environmental regulations.

The major federal environmental laws and regulations that apply to the West Valley Demonstration Project are the Resource Conservation and Recovery Act, the Clean Air Act, the Emergency Planning and Community Right-to-Know Act, the Clean Water Act, the Safe Drinking Water Act, the Toxic Substances Control Act, and the National Environmental Policy Act. The laws are implemented by the U.S. Environmental Protection Agency (EPA) and the New York State Department of Environmental Conservation (NYSDEC) through regulatory requirements such as permitting, reporting, inspecting, and performing audits.

In addition, because the emission of radiological and nonradiological materials from an active facility can not be completely prevented, the EPA, NYSDEC, and the DOE have established exposure standards for such emissions that protect human health and the environment. The WVDP applies to NYSDEC and the EPA for permits that allow the site to release very limited concentrations of radiological and nonradiological constituents through controlled and monitored discharges of water and air. These concentrations have been determined to be not harmful to human health or the environment. The permits describe the discharge points, list the limits on those pollutants likely to be present, and define the sampling and analysis schedule.

Inspections and audits are conducted routinely by the EPA, NYSDEC, the New York State Department of Health (NYSDOH), and the Cattaraugus County Health Department. On-site and off-site radiological monitoring in 1994 confirmed that site activities were conducted well within state and federal regulatory limits. However, several nonradiological State Pollutant Discharge Elimination System (SPDES) permit limits were exceeded. These are described in more detail under the **Clean Water Act** below. No notices of violation were issued and efforts have been made to eliminate the potential for these exceedances to recur.

Management at the WVDP continued to provide strong support for environmental compliance issues. Department of Energy Orders and all state and federal statutes and regulations are integrated into the compliance program at the Project, demonstrating a commitment to protecting the public and the environment while successfully approaching the WVDP goal of high-level radioactive waste vitrification.

A major review of the site Environmental, Safety, Health and Quality Assurance Program was conducted by the DOE Idaho Operations Office in April 1994. While areas for improvement were noted, the overall conclusion of the assessment team was that the WVDP continued to have a well-established and appropriately implemented environmental program.

The following environmental compliance summary describes the federal and state laws and regulations that are applicable to the WVDP, the relevant on-site activities that occurred during the year, and any permit compliance issues.

Compliance Status

Resource Conservation and Recovery Act (RCRA)

The Resource Conservation and Recovery Act is intended to ensure that hazardous wastes are managed in a manner that protects human health and the environment. RCRA and its implementing regulations govern the management of hazardous wastes during generation, treatment, storage, and disposal. Under RCRA, the generator is responsible for the treatment, storage, and disposal of the waste.

Various federal agencies have specific responsibilities under RCRA. The EPA is responsible for issuing guidelines and regulations for the proper management of solid waste. The U.S. Department of Transportation is responsible for regulating the labeling, packaging, and spill-reporting provisions for hazardous wastes in transit.

Each DOE facility that treats, stores, or disposes of hazardous waste must apply for a permit from the EPA or the state, if authorized. The permit defines the process, the design capability, and the hazardous waste to be handled.

In 1984 the DOE notified the EPA of hazardous waste activities at the WVDP, identifying the WVDP as a generator of hazardous waste. In 1991 the WVDP filed a Part A permit application as an operator of a hazardous waste treatment and storage facility.

Because the WVDP generates, stores, and treats radioactively contaminated hazardous waste (see *Glossary*, MIXED WASTE), it has been operating under RCRA interim status. After the original permit application was filed, several modifications were made via letters to NYSDEC. In April 1991 the WVDP amended its RCRA interim status application to incorporate all these modifications. This included the addition of the hazardous waste storage lockers and specification of RCRA waste codes for contained storage units on-site. Last modified in April 1993, the WVDP's permit application continues to be updated as changes to the site's hazardous or mixed waste storage status occurs.

Under Subtitle C of RCRA, the state of New York has been authorized by the EPA to administer and enforce a radioactive mixed waste program.

Hazardous Waste Management Program

To dispose of hazardous wastes generated from on-site activities, the WVDP uses licensed transportation services to ship RCRA-regulated wastes to permitted treatment or disposal facilities. Using these services, the WVDP disposed of approximately 6,086.5 kilograms (13,418.4 lbs) of nonradioactive, hazardous waste off-site in 1994. Of this amount, 1,047 kilograms (2,308 lbs) were recycled by the disposal facilities.

Hazardous waste shipments and their receipt at designated disposal facilities are documented by signed manifests that accompany the shipment. If the signed manifest is not returned to the generator of the waste within the New York State statutory limit of twenty days from shipment, an exception report must be filed and attempts made to locate the waste. One exception report was filed in 1994. Even though the waste shipment arrived at the designated disposal facility, the facility operator did not return the manifest within the time allotted by the state of New York. The disposition of the waste was quickly determined and the manifest was forwarded as required to the EPA and NYSDEC. The facility did return the signed manifest within the federal guidelines, which are not as restrictive as the state of New York guidelines.

Hazardous waste activities must be reported to NYSDEC and the EPA every year. The report summarizes the hazardous waste activities during the previous year, lists the quantities of each waste type generated, the disposal facilities used, and the type of treatment the wastes received. The report must be filed annually as directed by New York State regulations. In addition, a hazardous waste reduction plan must be filed every two years and updated annually. This plan, which documents the efforts to minimize the generation of hazardous waste, was submitted to the EPA and NYSDEC in 1993. Updates were submitted in June 1994.

Annual inspections to assess compliance with hazardous waste regulations were conducted by NYSDEC (March 25, 1994) and the EPA (September 28, 1994). No deficiencies were noted during the inspections.

Nonhazardous, Regulated Waste Management Program

The WVDP transported approximately 36.7 metric tons (40.4 tons) of nonradioactive, nonhazardous material off-site to permitted facilities in 1994. Of this amount, 5.1 metric tons (5.6 tons) were recycled by the disposal facility. The industrial waste materials included items such as concrete, monitoring-well purge water, and neutralized acids. Some of the regulated wastes recycled included lead acid batteries and oil, which were all sent to permitted facilities. In 1994 the WVDP also shipped approximately 904 metric tons (996.4 tons) of sewage-treatment waste to a permitted wastewater treatment facility.

Radioactive Mixed Waste (RMW) Management Program

Radioactive mixed waste (RMW) contains both a radioactive constituent, which is regulated by the Atomic Energy Act (AEA), and a hazardous component, which is regulated under RCRA. Both the EPA and NYSDEC oversee radioactive mixed waste management at the WVDP. Radioactive mixed waste activities are covered under interim status because of the hazardous waste component.

Potential conflicts between DOE Orders regarding RMW and RCRA regulations led to the WVDP initiating discussions with the regulatory agencies to resolve these conflicts. In 1992 the WVNS completed negotiations with the EPA and NYSDEC for a Federal and State Facility Compliance Agreement (FSFCA) regarding compliance with radioactive mixed waste management requirements, including RCRA land disposal restrictions (LDRs). The FSFCA also provides a plan to address storage and historical waste analysis issues at the WVDP. This agreement provides the means whereby the WVDP can comply with both RCRA regulations and with the requirements of the AEA.

The Federal Facilities Compliance Act (FFC Act) of 1992, an amendment to RCRA, was signed into law on October 6, 1992. As a result of this law, federal agencies are subject to the full range of available enforcement tools provided in federal, state, or local environmental law. A waiver of sovereign immunity became effective on October 6, 1992, except as it relates to certain mixed waste storage requirements for which the FFC Act provides a three-year delay period. During this three-year period, DOE facilities that are generating or storing mixed waste are to develop site treatment plans to identify and select options for treating and reducing their mixed waste inventories.

Site treatment plans at DOE facilities are developed in three steps:

- A conceptual site treatment plan is prepared to identify the technology needs, treatment capabilities, and existing plans and alternatives for treating mixed wastes. The WVDP's Conceptual Site Treatment Plan was submitted to New York State in October 1993 for review.
- A draft site treatment plan is then developed that evaluates the identified treatment options and the preferred method of treatment. The WVDP submitted a draft plan in August 1994.
- A final proposed site treatment plan is submitted for review and approval. The WVDP submitted the final proposed site treatment plan in March 1995. Following approval by NYSDEC, the plan will be incorporated into a consent order.

RCRA Facility Investigation (RFI) Program

The DOE and the New York State Energy Research and Development Authority (NYSERDA) entered into a 3008(h) Administrative Order on Consent under RCRA with NYSDEC and the EPA in March 1992. The Consent Order requires NYSERDA and the DOE West Valley Area Office (DOE-WV) to conduct RCRA facility investigations at thirty individual solid waste management units (SWMUs) to determine if there has been a release or if there is a potential for release of RCRA-regulated hazardous waste or hazardous constituents from SWMUs. Twenty-four of the thirty SWMUs identified in the Consent Order are being investigated by the DOE. NYSERDA is responsible for the investigation of the remaining six SWMUs.

The WVDP identified an additional eighteen SWMUs after the Consent Order was signed that are also under evaluation.

Due to the proximity of some of the units, twenty-five SWMUs were grouped into twelve super solid waste management units (SSWMUs) to assist in monitoring efforts under the RFI.

The primary goal of the RFI is to collect and evaluate information to determine which of the following actions are appropriate for each SWMU or SSWMU: no further action; a corrective measures study; or additional investigations to support one of the other actions.

The RFI addresses RCRA-regulated hazardous wastes or hazardous constituents. The WVDP has reviewed existing information; collected and analyzed more than two hundred surface soil, subsurface soil, and sediment samples; and collected and reviewed groundwater data in order to define and assess the environmental setting, unit and waste characteristics, and the potential sources and extent of nonradiological contamination.

Of the twelve SSWMUs, two — #10, the integrated radwaste treatment system (IRTS) drum cell and # 12, the hazardous waste storage lockers — have been identified as requiring no further action. The remaining ten SSWMUs are included in the RFI program to determine the appropriate actions to be taken.

The potential for releases of hazardous waste or hazardous constituents from the eighteen SWMUs identified after the Consent Order had been signed are documented in SWMU assessment reports. These reports note the function, location, and capacity of the SWMU and describe wastes that were placed in the unit and any known releases or spills. Several assessment reports have been submitted to NYSDEC and the EPA. "No further action" determinations have been received for five of these SWMUs.

Sixteen rooms previously used for nuclear fuel reprocessing operations and support were evaluated as SWMUs in the Sealed Rooms Paper Characterization Report, as required by the Consent Order. The EPA and NYSDEC have reviewed the data in the report and have issued "no further action" determinations for eight of the rooms. Additional information on the remaining eight rooms has been requested.

Waste Minimization and Pollution Prevention

The WVDP has initiated an aggressive, long-term program to reduce the generation of low-level radioactive waste, radioactive mixed waste, hazardous waste, and industrial waste as directed by Executive Order 12856. Using 1993 waste-generation rates as a baseline for comparison, the WVDP plans to reduce the generation of low-level radioactive waste, radioactive mixed waste, and hazardous waste by 50% by December 1, 1999. The generation of industrial waste will be reduced by 30% by the same date.

Reductions of 10% in each of these four waste categories were targeted for 1994. Although the target for hazardous waste reduction was missed, waste reductions for the other waste categories greatly exceeded the 10% goal. Low-level radioactive waste generation was reduced by 29%, radioactive mixed waste generation by 62%, and industrial waste generation by 21%. Hazardous waste generation was increased by 5% due to the generation of a large, nonroutine waste stream (1,941 kg of vitrification test facility condensate containing 16 ppm chromium) in December 1994.

Specific accomplishments in waste minimization and pollution prevention during 1994 included the following:

- The WVDP instituted a site-wide paper recycling program in March 1993. In 1994, 137,500 kilograms (303,200 lbs) of paper were recycled, 69% more than in 1993.
- 1,047 kilograms (2,309 lbs) of hazardous waste were recycled.
- 5.1 metric tons of nonhazardous, regulated waste were recycled in 1994.
- The dismantling of a structure in the NRC-licensed disposal area (NDA) produced 7,115 kilograms (15,686 lbs) of radioactively contaminated aluminum. After decontamination, segregation, and monitoring for radioactivity, 6,850 kg (15,102 lbs) of aluminum were staged for recycling, leaving 265 kilograms (584 lbs) to be dispositioned as radioactive

waste. The WVDP is expected to realize $5,286 from recycling the aluminum. An estimated $99,000 was saved by avoiding the cost of packaging, storing, monitoring, and disposing of 15.8 cubic meters (560 cubic feet) of radioactively contaminated metal.

- During construction of the load-in facility, which will be used to transfer canisters of vitrified, radioactive material, a diamond wire-cutting technique and conventional concrete scabbling were used to reduce the quantity of radioactively contaminated concrete from 25.1 cubic meters (887 cubic feet) to less than 0.4 cubic meters (15 cubic feet). The WVDP saved an estimated $154,000 by avoiding the costs of packaging, storing, monitoring, and disposing of the 24.7 cubic meters (872 cubic feet) of concrete.

Underground Storage Tanks Program

RCRA regulations also cover the use and management of underground storage tanks and establish minimum design requirements in order to protect groundwater resources from releases. The regulations, codified in 40 CFR 280, require underground storage tanks to be equipped with overfill protection, spill prevention, corrosion protection, and leak detection systems. New tanks must comply with regulations at the time of installation. Tanks in service on December 22, 1988 were allowed a grace period for installing the upgrades.

New York State also regulates underground storage tanks through two programs, petroleum bulk storage and chemical bulk storage. The registration and minimum design requirements are similar to those of the federal program except that petroleum tank fill ports must be color-coded using American Petroleum Institute standards to indicate the product being stored.

The WVDP stores petroleum products in three regulated, 2,000-gallon underground tanks. Two of the tanks contain unleaded gasoline. The third tank contains low-sulfur diesel fuel. Procedural controls in conjunction with metered delivery provide overfill protection and spill prevention. Leak detection requirements are met through daily tank gauging, inventory records, and monthly reconciliations of the product added, product removed, and the current contents. Tank tightness and integrity is tested annually and was last performed in December 1994. Corrosion-prevention systems must be installed before December 22, 1998 because these tanks are defined under current regulations as "unprotected." The tank fill ports are color-coded as required.

A fourth tank, a 550-gallon underground storage tank, is used to store diesel fuel for the standby power plant for the supernatant treatment ventilation blower system. This tank is filled by a metered delivery system, is monitored through daily gauging and monthly reconciliations, and is a double-walled tank with an interstitial leak detection system. The tank's fill port also is properly color-coded.

Registration for all of the tanks is renewed with NYSDEC as required. An inspection by NYSDEC on November 11, 1994 verified compliance with petroleum bulk storage regulations.

New York State-regulated Aboveground Storage Tanks

Aboveground petroleum storage is regulated by New York State petroleum bulk storage regulations under 6 NYCRR Parts 612, 613, and 614. Aboveground hazardous chemical storage is regulated by the chemical bulk storage regulations under 6 NYCRR Part 595 et seq. These regulations require secondary containment, external gauges to measure the current reserves, monthly visual inspections of petroleum tanks, and documented internal inspections. Petroleum tank fill ports must also be color-coded, and chemical tanks must be labeled to indicate the product stored.

One petroleum and five chemical bulk storage aboveground tanks were permanently closed in 1994. At the end of 1994, seven aboveground petroleum tanks and twenty aboveground chemical storage tanks were registered. Two of the petroleum tanks contain No.2 fuel oil; the remainder contain diesel fuel. Eighteen of the chemical storage tanks contain nitric acid or nitric acid mixtures. Sulfuric acid and sodium hydroxide are stored in the remaining two tanks. All of the tanks are equipped with gauges and secondary containment systems. The Quality Assurance department inspects the aboveground petroleum tanks on a monthly basis.

Medical Waste Tracking

Medical waste poses a potential for exposure to infectious diseases and pathogens from contact with human bodily fluids. Medical evaluations, inoculations, and laboratory work at the on-site nurse's office regularly generate potentially infectious medical wastes that must be tracked in accordance with NYSDEC requirements (6 NYCRR 364.9). The WVDP has retained the services of a licensed waste hauler and disposal firm to manage the medical wastes generated. Medical wastes are autoclaved by the disposal firm to remove the associated hazard and then disposed. In 1994, 29 kilograms (64 lbs) were generated and disposed. This quantity includes some wastes generated in 1993 but disposed in 1994.

Clean Air Act (CAA)

The Clean Air Act, as amended, establishes a comprehensive federal and state framework that regulates air emissions from both stationary and mobile sources: any emission source of a CAA-regulated substance may require a permit or be subject to registration or notification requirements. Industrial operations, chemical process systems, waste processing systems, and other contaminant sources with air emission points are regulated under the CAA. These point sources may exhaust to the environment through stacks, ventilators, air ducts, or wall fans. Air emissions from non-point sources such as soil piles and open lagoons also fall under CAA regulation.

Under the CAA, the EPA established programs to develop and maintain ambient air quality standards and to limit the discharge of contaminants through permitting, monitoring, and enforcement. The discharge of hazardous air pollutants is controlled through the National Emissions Standards for Hazardous Air Pollutants (NESHAPs) program. The EPA can delegate the permitting and monitoring of air discharges to acceptable state programs. Radiological emissions, however, remain under direct control of the EPA. Other nonradiological hazardous air pollutants are regulated by the EPA, but authority to enforce those regulations has been delegated to NYSDEC.

In 1994 the WVDP initiated or maintained five permits-to-construct nonradiological air emission sources. Several of these sources also are regulated under NESHAPs. (See Table B-3 in *Appendix B*.) These sources include the cold chemical solids transfer system, the cold chemical vessel vent system, the cold chemical vessel dust collection hood, the vitrification off-gas treatment system, and the vitrification facility HVAC system. In addition, fifteen permits-to-construct were converted to certificates-to-operate. These included four scale-vitrification system emission points and eleven Environmental Analytical Annex Laboratory hood vents. The WVDP operated under a total of thirty active certificates-to-operate nonradiological emission sources and six permits for radiological emissions, regulated under the EPA's NESHAPs program. Permit applications to operate the vitrification facility HVAC system and the slurry-fed ceramic melter as radiological release points were submitted in 1993 to the EPA. NESHAPs permits are expected to be approved by 1995.

The annual inspection of the air discharges permitted by NYSDEC was conducted on June 21, 1994. The inspector indicated that the WVDP was in compliance regarding the permit renewal process, and no violations were noted. The annual inspection by EPA Region II to determine compliance with radionuclide NESHAPs requirements was conducted in August 1994 and indicated no noncompliance episodes or notices of violation. Calculations to demonstrate compliance with NESHAPs radionuclide emissions standards showed 1994 doses to be less than 1% of the 10 millirem standard.

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

The Comprehensive Environmental Response, Compensation, and Liability Act regulates cleanup of certain inactive hazardous waste disposal sites and response to spills of hazardous substances. The EPA collects data and ranks sites according to their potential to cause human health or environmental effects. The sites with the highest ranking are placed on the National Priority List.

On February 5, 1993 the WVDP was listed in the EPA's Federal Agency Hazardous Waste Compliance docket. This action resulted in an evaluation of the WVDP to ascertain its status relative to CERCLA requirements. On October 3, 1993, the WVDP submitted a CERCLA preliminary assessment to the EPA for review. This assessment evaluated waste management at the WVDP and the likelihood of releases and possible effects on human health and the environment. The DOE concluded in the assessment that the site does not qualify for the National Priority List, based on the score attained in the preliminary assessment and the fact that the Project facilities are currently being investigated in accordance with the provisions of the WVDP Act and the RCRA 3008(h) Order on Consent. No comments regarding the conclusions of the preliminary assessment have been received from the EPA.

Emergency Planning and Community Right-to-Know Act (EPCRA)

The Emergency Planning and Community Right-to-Know Act is an independent law enacted as Title III of the Superfund Amendments and Reauthorization Act (SARA). EPCRA was designed to create a working partnership between industry and business, state and local governments, public health and emergency response representatives, and interested citizens. It is intended to address concerns about the effects of chemicals used, stored, and released in communities as stated in the purpose of EPCRA.

The purposes of EPCRA are:

- to encourage communities to develop plans for responding to releases of hazardous substances from local facilities (Sections 301-303)
- to require facilities to provide state and local emergency planning committees, local emergency response groups, and the public with information about potential chemical hazards in their communities (Sections 311 and 312)
- to require facilities to report accidental releases of certain hazardous substances above specified reportable quantities to state emergency response commissions and local emergency planning committees (Section 304)
- to require facilities to submit an annual report to the EPA that identifies and quantifies routine releases of toxic chemicals (Section 313).

The WVDP submits reports to state and local emergency response organizations and local fire departments about quantities, locations, and any hazards associated with chemicals stored on-site. In 1994 the number of reportable chemicals stored on-site above regulatory threshold reporting quantities was reduced from thirteen to sixteen. Chlorine, a previously reported "extremely hazardous substance," is no longer stored or used on-site.

The information on reportable chemicals is updated in quarterly reports to these agencies. These updates ensure that the public and emergency responders have the most recent information about site conditions and operations. In 1994 all reports were submitted to the appropriate organizations on time.

Clean Water Act (CWA)

The Clean Water Act is the primary statute governing water pollution control programs in the United States. It regulates discharges to surface water and groundwater through a National Pollutant Discharge Elimination System (NPDES) permit program that requires permits to be issued specifying discharge standards and monitoring and reporting requirements. Authorized states such as New York are allowed to issue equivalent State Pollutant Discharge Elimination System (SPDES) permits.

SPDES-permitted Outfalls

All WVDP point source effluent discharges to surface waters are permitted through the New York SPDES program. The WVDP has three SPDES-permitted outfalls, all of which discharge to Erdman Brook. (See Figs. 2-3 and 2-16):

- Outfall 001 (WNSP001) discharges the treated wastewater from the low-level waste treatment facility (LLWTF). The treated wastewater is held in lagoon 3 while samples are being analyzed and is periodically released upon notifying NYSDEC.

  In 1994 treated wastewater from the LLWTF was discharged in eight batches that totaled 44.7 million liters (11.8 million gal) for the year. The annual average concentration of radioactivity at the point of release was 44% of the DOE's derived concentration guides (DCGs). None of the individual releases exceeded the DCGs. (See Table B-1 in *Appendix B*.)

- Outfall 007 (WNSP007) discharges the combined effluent from the site's sewage treatment plant and various nonradioactive industrial and potable water treatment systems. The average monthly flow in 1994 was 2.8 million liters (0.7 million gal).

- Outfall 008 (WNSP008) directs groundwater flow from the northeast side of the site's LLWTF lagoon system through a french drain. The average monthly flow in 1994 was 0.36 million liters (0.094 million gal).

The site's SPDES permit, renewed on February 1, 1994, now includes additional chemical monitoring requirements and, in some cases, applies more stringent effluent limitations. A more realistic method of calculation that accounts for naturally occurring variations in iron in discharges from the site also was instituted.

A Schedule of Compliance in the permit itemized a number of major compliance actions and the required completion date for each item. Compliance actions included preparing a best-management practices plan to prevent or minimize the potential for pollutants to reach waters of the state from plant runoff, spills, or raw product storage; acquiring permits and approvals to install equipment to monitor total dissolved solids in Frank's Creek; and the start-up of the new wastewater treatment facility. A modification to the SPDES permit in November 1994 added a requirement to monitor for dissolved sulfide and manganese at outfall 001 and changed the method of calculating the BOD released. The BOD modification instituted an average daily limit for the combined discharge of outfalls 001, 007, and 008. An addition to the Schedule of Compliance included investigating and reporting on the source and extent of groundwater contamination from the north plateau. An evaluation of alternative methods of removing the source of contamination is also required in the schedule.

SPDES permit limits exceeded in 1994 at outfalls 001 and 007 included the following:

- The daily average BOD limit of 5 mg/L in the April and September discharges was exceeded at outfall 001. The exceedance was related to growth of algae in lagoon 3, which can be held without being discharged for up to two months at a time. The dying and decaying algae in the collected samples affects the BOD measurement. Efforts are currently under way to control the growth of algae.

- Discharges from outfall 001 in May had measured pH values both below and above the acceptable range of 6.5 to 8.5 standard units. These pH fluctuations were also attributed to the growth of algae. Corrective measures to prevent a recurrence included modifying the sampling technique to obtain a more representative sample of the discharge stream and controlling algae growth. In addition, a pH meter equipped with control-limit alarms also was installed upstream of the discharge control valve.

- In September 1994, a selenium result from analysis of a grab sample of the 001 discharge was 0.0065 mg/L, which is above the limit of 0.004 mg/L. Because the discharge had been terminated prematurely, the usual composite sample could not be taken. As composite samples reflect continuous conditions and grab samples reflect immediate conditions, the exceedance probably was the result of the different sampling technique.

- In November 1994, total suspended solids were measured at 32.4 mg/L, slightly above the 30 mg/L limit. High winds were believed to have caused a resuspension of settled solids. Several BOD excursions also were reported in November 1994. However, the data associated with the November excursions are suspect: predischarge analysis did not reveal elevated results; historical results have always been lower than those reported during this period; and elevated spike recoveries by the off-site analytical laboratory show a consistent overall positive bias. Several avenues of corrective action are being pursued.

- Discharges from outfall 007 in April exceeded the BOD daily average limit of 5 mg/L and the BOD daily maximum limit of 10 mg/L on three occasions. Elevated levels of BOD were traced back to the site cafeteria grease trap. Preventive maintenance in this area is being emphasized. A biodegradable grease used to lubricate the clarifier drive chain during the period of exceedances may have also contributed to the elevated BOD results.

No notices of violation were issued as a result of any permit exceedances. Although these exceedances did not result in any significant effect on the environment, the WVDP is continuing to work closely with NYSDEC to prevent their recurrence.

Wetlands Delineation

A wetlands investigation conducted under the requirements of the Clean Water Act, Section 404, identified forty-five wetland units on a 550-acre area that includes the 200-acre WVDP site and adjacent parcels north, south, and east of the site. This area was chosen for study because it could be affected by Phase II activities. The study is part of the baseline environmental characterization that is being conducted to help plan future activities at the WVDP.

Three ecological parameters were assessed: hydrophytic vegetation, hydric soils, and wetland hydrology. The forty-five wetland units delineated as a result of the assessment comprise 34.3 acres.

A report documenting the wetlands investigation and delineation was submitted to the Army Corps of Engineers and NYSDEC in June 1994. NYSDEC reviewed the report and inspected the site, determining that a group of eight contiguous wetlands met the criteria for regulation as a single unit. The grouped wetlands will be included on the next available proposed amendment to the official New York State Freshwater Wetlands Map for Cattaraugus County. Consequently, any applications filed to perform work within this wetland area may require prior approval by NYSDEC. The Army Corps of Engineers and NYSDEC are routinely notified of any actions planned in the site's wetland areas.

Storm Water Permit Application

Precipitation can become contaminated with pollutants from industrial process facilities, stored industrial materials, material handling areas, access roads, or vehicle parking areas. To protect the environment, aquatic resources, and public health, regulations require the collection of characteristic information and the submission of an application for a storm water discharge permit in order to ascertain the significance of releases of pollutants from storm water collection and discharge systems.

The WVDP obtained the storm water characterization data through sampling and analysis in 1991 and submitted a storm water discharge permit application to NYSDEC on September 30, 1992. In early 1994, NYSDEC indicated that any future storm water monitoring requirements would be incorporated into the WVDP's existing SPDES permit. A new storm water discharge permit application and additional sampling and analysis will be required. (See **Current Issues and Actions** below.)

Petroleum Product Spill Reporting

The WVDP has enacted a Spill Notification and Reporting Policy to ensure that all spills are properly managed, documented, and remediated in accordance with applicable regulations. This policy identifies the departmental responsibilities for spill management and illustrates the proper spill control and clean-up procedures. The policy stresses the responsibility of each employee to notify the main plant operations shift supervisor upon discovery of a spill. This first-line reporting requirement helps to ensure that spills will not go unnoticed.

Under an agreement with NYSDEC, the WVDP reports on-site spills of petroleum products of 10 gallons or less onto an impervious surface (such as blacktop) in a monthly log. Spills greater than 10 gallons that do not affect ground- or surface water or enter a drainage system must be reported to NYSDEC within twenty-four hours and entered in the monthly log. Spills of any amount that travel to waters of the state (groundwater, surface water, drainage systems) must be reported immediately to the NYSDEC spill hotline and also are entered in the monthly log.

There were seventy-three minor spills of petroleum products in 1994 totaling approximately 90.8 liters (24 gal). These spills were typically associated with leaks from employee vehicles, heavy industrial construction equipment, and vendor delivery vehicles. Of the seventy-three spills, three required immediate notification of NYSDEC under the reporting protocol. Two of the reported spills entered the storm water drainage system, but the volumes released were only 60 milliliters (2 fluid oz) and 120 milliliters (4 fluid oz). The third was a release of 38 liters (10 gal) of diesel fuel to the soil from a portable generator. The soil was immediately removed and properly disposed.

Twenty-four releases of ethylene glycol (antifreeze) from employee and contractor vehicles were noted in the spill log. The largest release was estimated to be 0.9 liters (1 qt) of an ethylene glycol and water mixture. None of these spills entered the storm water system or were of sufficient volume to require immediate reporting.

All spills were cleaned up in a timely fashion in accordance with the WVDP Spill Notification and Reporting Policy, and the collected materials were characterized and properly disposed. None of the spills resulted in any adverse environmental effect.

Safe Drinking Water Act (SDWA)

The Safe Drinking Water Act requires that each federal agency having jurisdiction over a federally owned or maintained public water system must comply with all federal, state, and local requirements regarding safe drinking water. The drinking water quality program in the state of New York is administered by NYSDOH through county health departments.

The WVDP obtains its drinking water from surface water reservoirs on the Western New York Nuclear Service Center (WNYNSC) site and is considered a nontransient, noncommunity public water supplier. The Project's drinking water treatment facility purifies the water by settling, filtration, and chlorination before it is distributed on-site.

As an operator of a drinking water supply system, the WVDP collects routine drinking water samples to monitor water quality. The results of those analyses are reported to the Cattaraugus County Health Department every month. Less frequent sampling and analysis for organic and inorganic parameters is also conducted and reported. The Cattaraugus County Health Department also independently collects monthly samples of WVDP drinking water to determine bacterial and residual chlorine content. The microbiological samples collected in 1994 produced satisfactory results and the free chlorine residual measurements in the distribution system were positive on all occasions, indicating proper disinfection.

In 1993 and 1994 the WVDP conducted sampling and testing for lead and copper in the site's drinking water in accordance with EPA and NYSDOH regulations. The analytical results to date show lead levels to be above the action level of 15 µg/L at several locations in the distribution system. Consequently, regulations require an evaluation of potential water treatment actions and the preparation of a Corrosion Control Plan. This was submitted in March 1994 to the Cattaraugus County Health Department. The plan included recommendations for controlling lead and copper levels in the water distribution system. The WVDP is currently considering how best to implement the program to reduce the level of those metals in the treated water.

Employees at the WVDP are made aware of the elevated lead levels through a public education program. Though not required, notices have been posted at locations where elevated lead levels were measured advising employees not to consume water from that location.

Other than the lead action-level exceedance noted above, monitoring results in 1994 indicate that the Project's drinking water meets NYSDOH drinking water quality standards.

The Cattaraugus County Health Department conducted its annual inspection of the WVDP water supply system on November 1, 1994. No detrimental findings or notices of violation were issued.

There were several changes in the 1994 site drinking water program:

- A temporary clarifier was installed while a new clarifier is being constructed.
- Quarterly monitoring of drinking water for nitrates and nitrites was completed with satis-

factory results, allowing the Cattaraugus County Health Department to reduce the sampling frequency to once a year.

- Plans to install a new potable water storage tank were approved.

- During the annual inspection in November the water supply was assessed for its vulnerability to contamination from synthetic organic chemicals. The Cattaraugus County Health Department determined that initial monitoring requirements will be satisfied upon collection and analysis of one sample in August 1995. Quarterly sampling and analysis may be waived upon receipt of satisfactory results from the August sampling.

- NYSDEC flood control personnel inspected the water reservoir dams, which were found to be in satisfactory condition.

Toxic Substances Control Act (TSCA)

This act regulates the manufacture, processing, distribution, and use of chemicals, including PCBs (polychlorinated biphenyls). In 1994 the WVDP continued to manage radioactively contaminated PCB waste as mixed hazardous and radioactive wastes because PCBs are a listed hazardous waste in New York State. These wastes originated from a dismantled hydraulic power unit inside the former reprocessing facility and from several radiologically contaminated PCB capacitors containing PCB fluids. To comply with TSCA, the WVDP maintains an annual document log that details PCB use and storage on-site and any changes in storage or disposal status. The document log also lists several in-service PCB articles, including capacitors, a transformer, and several electrical bushings.

National Environmental Policy Act (NEPA)

The National Environmental Policy Act establishes the nation's policies for the protection of the environment. Its goals are to prevent or eliminate potential damage to the environment that could arise from federal legislative actions or proposed federal projects. The President's Council on Environmental Quality, established by NEPA, carries out this policy. Implementing regulations are found in the Code of Federal Regulations (CFR), Title 40, Parts 1500-1508 (40 CFR 1500-1508). Since 1990 the DOE has been revising its NEPA-compliance program, which was approved by the President's Council on Environmental Quality and was codified in 10 CFR 1021. This regulation went into effect on May 26, 1992.

NEPA requires that all federal agencies proposing major actions that could significantly affect the quality of human health and the environment prepare detailed environmental statements.

The DOE implements NEPA by requiring an environmental review of all proposed activities. If a proposed action will have an insignificant effect on the environment it is excluded from further environmental review under a categorical exclusion. If a proposed action could have an effect on the environment, then it is reviewed through an environmental assessment. If the results of the assessment indicate no significant effect on the environment, then a "finding of no significant impact" is issued. A proposed action that could have a significant effect on the environment is reviewed through an environmental impact statement.

Both environmental assessments and environmental impact statements are made available to the public. NEPA requires that the public be notified of and given the opportunity to review and comment on environmental impact statements. In 1993, the Secretary of Energy established guidelines that provide for public review and comment on environmental assessments.

1994 NEPA Activities

Seventeen proposed actions regarding facility maintenance and operation were evaluated under the Department of Energy's NEPA-implementing regulations during 1994. The proposed actions included activities such as dismantling the original meteorological tower, WVDP site characterization, and routine environmental monitoring activities. Thirteen of the seventeen proposed actions were categorically excluded. Four are eligible for categorical exclusion and are awaiting approval.

Two draft environmental assessments were prepared during 1994. The first assessment evaluated the construction and operation of a contaminated soil consolidation area to provide temporary storage of low-level radiologically contaminated soil that has been excavated at the WVDP.

The second environmental assessment evaluated a proposal for the off-site, commercial treatment of Class A low-level radioactive waste and low-level radioactive mixed waste generated at the WVDP. This proposal involves the shipment of the waste from the WVDP to a commercial facility for volume-reduction and return of the waste to the WVDP. The objective of this proposal is to maximize the use of existing storage facilities at the WVDP and to minimize the construction of new facilities.

Alternatives for the final disposition of the remaining spent nuclear fuel assemblies at the WVDP are being evaluated in a Programmatic Environmental Impact Statement for Spent Nuclear Fuel Management and Environmental Restoration and Waste Management Program at the Idaho National Engineering Laboratory. This environmental impact statement would provide NEPA documentation to support removal of the spent fuel from the WVDP and interim storage at another location.

Preparation of the draft environmental impact statement for Project completion by the DOE and closure or long-term management of facilities at the WNYNSC by NYSERDA continued in 1994. Six alternatives have been developed and are being evaluated. The draft environmental impact statement is scheduled for public review in 1995.

Summary of Permits

Environmental permits in effect at the Project during 1994 are listed in Table B-3 of *Appendix B*.

Current Issues and Actions

RCRA Facility Investigation

Identifying and evaluating all SWMUs at the WVDP is continuing in order to comply with the requirements of the RCRA Administrative Order on Consent. The potential for the release of hazardous wastes or constituents from the SWMUs is being evaluated and includes review of historical process knowledge, soil and sediment sampling and analysis results, and review of groundwater monitoring results. Additional investigations, if necessary to appropriately characterize individual SWMUs, may be conducted in the future.

The data from the investigations is compiled and presented in assessment reports that are prepared for newly identified SWMUs or in RCRA facility investigation (RFI) reports that are prepared for SWMUs identified in the Consent Order. The reports present collected information on the environmental setting, SWMU and waste characteristics, potential sources, and the environmental analytical results. The reports also recommend which of the following actions are appropriate: no further action, a corrective measures study, or additional investigations to support one of the other actions. EPA and NYSDEC concurrence with the report conclusions is requested, but additional information may be required to support the recommendations.

The current focus of the RFI program is on preparing and submitting scheduled SWMU assessment and RFI reports to the EPA and NYSDEC in 1995 and 1996.

Clean Water Act

SPDES Permit

The SPDES permit was renewed in February 1994 and modified in April and November. The permit and modifications included some changes to the parameters monitored and the monitoring methods. Adjustments have been made to the sampling and analysis program to accommodate the new requirements.

The renewed and modified permit also presented a Schedule of Compliance, listing actions to be completed and the due date for completion. One of the compliance actions included installing a flow augmentation device and flow measurement system in Frank's Creek to determine and maintain compliance with a new permit limit for total dissolved solids in the stream. The action also involved obtaining approvals of system construction and installation from several regulatory agencies such as NYSDEC and the Army Corps of Engineers. To date, regulatory approvals and the design of the flow monitoring and augmentation system have been completed, a contract has been placed for system installation, and construction is planned for mid-1995.

Groundwater Investigation

An increasing trend in gross beta radioactivity in water seeping from a localized area of wet ground northeast of the process building was identified in December 1993. Follow-up sampling and analysis in that vicinity has resulted in the identification of a groundwater seep location that has contributed a significant portion of the radioactivity originating from the Project premises in water releases from monitoring point WNDMPNE. Strontium-90 is the primary isotope responsible for the elevated gross beta levels.

An investigation to determine the nature and extent of the groundwater contamination plume, identify the source, and evaluate alternatives that will reduce the source of the contamination was also listed as a compliance action in the SPDES permit. To comply with the action requirements, the subsurface plume was investigated and potential sources were identified. At this time, the primary source of contamination appears to be an area in the southwest corner of the process building associated with acid recovery operations conducted by the previous site operator during fuel reprocessing.

To mitigate the release of radioactivity, the WVDP obtained and put in place a portable ion exchange system. This unit is capable of removing the radioactive contaminants and was intended to discharge through outfall 001. However, before it could be put into operation, the groundwater seep had subsided and no water was treated in 1994.

Currently, an evaluation of more comprehensive treatment techniques is under way. An interim mitigative measure may be undertaken in calendar year 1995 to contain contaminants at the leading edge of the contaminant plume.

Storm Water Permitting

An application for an individual permit for storm water discharges associated with industrial activity was submitted in 1992. The application included characteristic analytical results from sampling conducted at three locations in 1991. These monitoring locations comprised all storm water discharged from the WVDP but also included continuous base flows at the sample points. NYSDEC requested that the sampling points be moved to locations with no base flow to allow only the quality of the storm water discharges to be monitored. In response to the request, thirty-two on-site monitoring points were identified in 1994. Clean Water Act regulations allow petitioning to group substantially identical discharges for monitoring and reporting. NYSDEC accepted the WVDP's petition to group several of the discharge points. As a result, eleven storm water outfalls are scheduled for monitoring in 1995.

For storm water monitoring two samples are to be collected from each outfall: a first-flush sample collected within the first half-hour of the storm event and a flow-weighted composite collected during the first three hours of the storm event. Storm water samples will be analyzed for parameters identified in the existing SPDES permit.

Project Assessment Activities in 1994

As the management and operating contractor for the DOE at the WVDP, West Valley Nuclear Services Company, Inc. (WVNS) conducted more than 130 reviews of environmentally related activities in 1994. These included 3 assessments, 1 audit, 104 surveillances, and 26 line-management self-assessments. In addition, 20 reviews were conducted by organizations external to WVNS such as the DOE, NYSDEC, and the EPA. Overall results of the reviews reflect continuing, well-managed environmental programs at the WVDP.

Significant external environmental overview activities in 1994 included a comprehensive Environmental, Safety, Health and Quality Assurance combined functional appraisal by the DOE Idaho Operations Office, a routine annual inspection by the EPA and NYSDEC for compliance with NESHAPs, inspections by the EPA and NYSDEC for compliance with RCRA, an inspection by NYSDEC for compliance with SPDES requirements, and an annual inspection of the WVDP's potable water supply system by the Cattaraugus County Health Department. These appraisals and inspections did not reveal any environmental program findings and further demonstrated the WVDP's commitment to environmental compliance.

Inspections by the U.S. Department of Transportation (DOT) and the New York State Department of Transportation regarding waste shipments from the WVDP were conducted in 1994. Shipment of wastes must comply with U.S. DOT regulations that require the generator to use appropriate packaging, marking, and labeling and to prepare shipping documents, i.e., hazardous waste manifests. The hazardous waste manifests must identify the material being shipped and list the telephone number of a person with comprehensive emergency response and accident mitigation information or someone who has immediate access to a person with that information. The telephone number must be monitored twenty-four hours a day. Periodic inspections determine whether shipping facilities are in compliance with these regulations.

The U.S. DOT and the New York State DOT jointly inspected the WVDP on July 19, 1994 and October 25, 1994. During the July inspection a finding was identified when the inspector was inadvertently disconnected while trying to verify the phone number for spill response assistance that was listed on a recent waste manifest. To ensure that a similar incident would not recur, security personnel monitoring the WVDP telephones were rebriefed on the notification process and waste shipment operating procedures were modified. The WVDP also ensured that other recommendations were being followed, including internal reviews, adequate training, and proper completion of hazardous material shipping papers. The WVDP sent a letter, as requested, to the U.S. DOT describing the actions taken in response to the inspection.

The October inspection did not identify any findings.

1994 U.S. Department of Energy Audit

A comprehensive Environmental, Safety, Health and Quality Assurance functional appraisal was conducted by the DOE Idaho Operations Office from April 18, 1994 through April 22, 1994. The audit team evaluated environmental programs, construction safety, fire protection, nuclear safety, emergency preparedness, conduct of operations, radiological controls, industrial hygiene, firearms safety, and transportation programs. Performance-based criteria were used in assessing the overall effectiveness of the evaluated programs. The appraisal identified a total of eleven findings, twenty-three observations, and four concerns. WVNS responded to the audit items in an action plan submitted to the DOE on September 9, 1994. All items not resolved in the action plan are tracked through closure in the WVNS Open Items Tracking System. Currently, five items relating to this audit remain open. No deficiencies were found that represented conditions or actions posing a significant threat to public health or the environment.

Follow-up to the Department of Energy 1992 Environmental Audit

In November 1992, the U.S. Department of Energy Idaho Operations Office performed a combined functional appraisal of the WVDP. The appraisal team reviewed the WVDP environmental protection, quality assurance, emergency preparedness, and firearms safety programs. After receiving a final appraisal report from the Idaho Operations Office in December 1992, the WVDP issued its final action plan addressing DOE concerns on February 25, 1993. More than 80% of these concerns have been resolved by WVNS. Almost all of the remaining action items are long-term commitments related to continuing self-assessment.

Follow-up to the U.S. Department of Energy 1991 Environmental Audit

In March 1992, the WVDP received the final report by the DOE Headquarters Office of Environmental Audit on the 1991 environmental audit. The WVDP completed its final action plan and resubmitted it to DOE Headquarters in April 1992. As of December 1994 all of the identified action items had been resolved and are awaiting formal closure.

ENVIRONMENTAL MONITORING PROGRAM INFORMATION

Introduction

The high-level waste (HLW) presently stored at the West Valley Demonstration Project (WVDP) is the by-product of the reprocessing of spent nuclear fuel conducted during the late 1960s and early 1970s by Nuclear Fuel Services, Inc. (NFS).

Since the Western New York Nuclear Service Center (WNYNSC) is no longer an active nuclear fuel reprocessing facility, the environmental monitoring program focuses on measuring radioactivity and chemicals associated with the residual effects of NFS operations and the Project's high-level waste treatment operations. The following information about the operations at the WVDP and about radiation and radioactivity will be useful in understanding the activities of the Project and the terms used in reporting the results of environmental testing measurements.

Radiation and Radioactivity

Radioactivity is a process in which unstable atomic nuclei spontaneously disintegrate or "decay" into atomic nuclei of another isotope or element. (See *Glossary*.) The nuclei continue to decay until only a stable, nonradioactive isotope remains. Depending on the isotope, this process can take anywhere from less than a second to hundreds of thousands of years.

Radiation is the energy released as atomic nuclei decay. By emitting energy the nucleus moves towards a less energetic, more stable state. The energy that is released takes three main forms: alpha particles, beta particles, and gamma rays.

α *Alpha Particles*

An alpha particle is a fragment of a much larger nucleus. It consists of two protons and two neutrons (similar to a helium atom nucleus) and is positively charged. Alpha particles are relatively large and heavy and do not travel very far when ejected by a decaying nucleus. Alpha radiation, therefore, is easily stopped by a thin layer of material such as paper or skin. However, if radioactive material is ingested or inhaled, the alpha particles released inside the body can damage soft internal tissues because all of their energy is absorbed by tissue cells in the immediate vicinity of the decay.

β *Beta Particles*

A beta particle is an electron that results from the breakdown of a neutron in a radioactive nucleus. Beta particles are small compared to alpha particles, travel at a higher speed (close to the speed of light), and can be stopped by a material such as wood or aluminum less than an inch thick. If beta particles are released inside the body they do much less damage than an equal number of alpha particles. Because they are smaller and faster and have less of a charge, beta particles deposit energy in fewer tissue cells and over a larger volume than alpha particles.

γ *Gamma Rays*

Gamma rays are high-energy "packets" of electromagnetic radiation called photons. They are similar to x-rays but generally have a shorter wavelength and therefore are more energetic than x-rays. If the alpha or beta particle released by the decaying nucleus does not carry off all the energy made available by the nuclear disintegration, the excess energy may be emitted as gamma rays. If the released energy is high, a very penetrating gamma ray is produced that can only be effectively reduced by shielding consisting of several inches of a heavy element, such as lead, or of water or concrete several feet thick. Although large amounts of gamma radiation are dangerous, gamma rays are also used in many lifesaving medical procedures.

Measurement of Radioactivity

The rate at which radiation is emitted from a disintegrating nucleus can be described by the number of decay events or nuclear transformations that occur in a radioactive material over a fixed period of time. This process of emitting energy, or radioactivity, is measured in curies (Ci) or becquerels (Bq).

The curie is based on the decay rate of the radionuclide radium-226 (Ra-226). One gram of Ra-226 decays at the rate of 37 billion nuclear disintegrations per second (3.7×10^{10} d/s), so one curie equals 37 billion nuclear disintegrations per second. One becquerel equals one decay per second.

Very small amounts of radioactivity are sometimes measured in picocuries. A picocurie is one-trillionth (10^{-12}) of a curie or 2.22 disintegrations per minute.

Measurement of Dose

The amount of energy absorbed by the receiving material is measured in rads (radiation absorbed dose). A rad is 100 ergs of radiation energy absorbed per gram of material. (An erg is the amount of energy necessary to lift a mosquito about one-sixteenth of an inch.) "Dose" is a means of expressing the amount of energy absorbed, taking into account the effects of different kinds of radiation. Alpha, beta, and gamma radiation affect the body to different degrees. Each type of radiation is given a quality factor that indicates the extent of human cell damage it can cause compared with equal amounts of other ionizing radiation energy. Alpha particles cause twenty times as much damage to internal tissues as x-rays, so alpha radiation has a quality factor of 20 compared to gamma rays, x-rays, or beta particles, which have a quality factor of 1.

The unit of dose measurement to humans is the rem (roentgen equivalent man). Rems are equal to the number of rads multiplied by the quality factor for each type of radiation. Dose can also be expressed in sieverts. One sievert equals 100 rem.

Environmental Monitoring Program Overview

Human beings may be exposed to radioactivity primarily through air, water, and food. At the WVDP all three pathways are monitored, but air and surface water pathways are the two major means by which radioactive material can move off-site.

The geology of the site (kinds and structures of rock and soil), the hydrology (location and flow of surface and underground water), and meteorological characteristics of the site (wind speed, patterns, and direction) are all considered in evaluating potential exposure through the major pathways.

The on-site and off-site monitoring program at the WVDP includes measuring the concentration of solids containing alpha and beta radioactivity, conventionally referred to as "gross alpha" and "gross beta," in air and water effluents. Measuring the total alpha and beta radioactivity from key locations, which can be done within a matter of hours, produces a comprehensive picture of on-site and off-site levels of radioactivity from all sources. In a facility such as the WVDP, frequent updating and tracking of the overall levels of radioactivity in effluents is an important tool in maintaining acceptable operations.

More detailed measurements are also made for specific radionuclides. Strontium-90 and cesium-137 are measured because they are normally present in WVDP waste streams. Radiation from other important radionuclides such as tritium or iodine-129 are not sufficiently energetic to be detected by gross measurement techniques, so these must be analyzed separately using methods with greater sensitivity. Heavy elements such as uranium, plutonium, and americium require special analysis to be measured because, in comparison to background, they exist at such low levels at the WVDP. The radionuclides monitored at the Project are those that might produce relatively higher doses or that are most abundant in air and water effluents. Because sources of radiation at the Project have been decaying for more than twenty years, the monitoring program does not routinely include short-lived radionuclides, i.e., isotopes with a half-life of less than two years, which would have only 1/1,000 of the original radioactivity remaining. (See *Appendix A* for a schedule of samples and radionuclides measured and *Appendix B* for related Department of Energy protection standards.)

Ionizing Radiation

Radiation can be damaging if, in colliding with other matter, the alpha or beta particles or gamma rays knock electrons loose from the absorber atoms. This process is called ionization, and the radiation that produces it is referred to as ionizing radiation because it changes a previously electrically neutral atom, in which the positively charged protons and the negatively charged electrons balance each other, into a charged atom called an ion. An ion can be either positively or negatively charged. Various kinds of ionizing radiation produce different degrees of damage.

Data Reporting

Because no two samples are exactly the same, statistical methods are used to decide how a

Potential Effects of Radiation

The biological effects of radiation can be either somatic or genetic. Somatic effects are restricted to the person exposed to radiation. For example, sufficiently high exposure to radiation can cause clouding of the lens of the eye or loss of white blood cells.

Radiation also can cause chromosomes to break or rearrange themselves or to join incorrectly with others. These changes may produce genetic effects and may show up in future generations. Radiation-produced genetic defects and mutations in offspring of an exposed parent, while not positively identified in humans, have been observed in some animal studies.

The effect of radiation depends on the amount absorbed. An instantaneous dose of 100-200 rem (1-2 Sv) might cause temporary effects such as vomiting but usually would have no long-lasting side effects. At 50 rem (0.5 Sv) a single instantaneous dose might cause a reduction in white blood cell count.

Assessing biological damage from low-level radiation is difficult because other factors can cause the same symptoms as radiation exposure. Moreover, the body apparently is able to repair damage caused by low-level radiation.

The effect most often associated with exposure to relatively high levels of radiation appears to be an increased risk of cancer. However, scientists have not been able to demonstrate with certainty that exposure to low-level radiation causes an increase in injurious biological effects, nor have they been able to determine if there is a level of radiation exposure below which there are no biological effects.

Background Radiation

Background radiation is always present and everyone is constantly exposed to low levels of such radiation from both naturally occurring and manmade sources. In the United States the average total annual exposure to this low-level background radiation is estimated to be about 360 millirem (mrem) or 3.6 millisieverts (mSv). Most of this radiation, approximately 300 mrem (3 mSv), comes from natural sources. The rest comes from medical procedures and from consumer products.

Background radiation includes cosmic rays, the decay of natural elements such as potassium, uranium, thorium, and radon, and radiation from sources such as chemical fertilizers, smoke detectors, and televisions. Actual doses vary depending on such factors as geographic location, building ventilation, and personal health and habits.

particular concentration compares with concentrations from similar samples. The term *confidence level* is used to describe the range of concentrations above and below the test result within which the "true" value can be expected to lie, at a specified degree of statistical certainty. The WVDP environmental monitoring program uses the 95% confidence level.

The uncertainty range is the expected range of values that account for random nuclear decay and small measurement process variations. The uncertainty range around a concentration is indicated by the plus-or-minus (±) value following the result (e.g., 5.30±3.6E-09 μCi/mL, with the exponent of 10^{-9} expressed as "E-09." Expressed in decimal form, the number would be 0.0000000053±0.0000000036 μCi/mL). Within this range a result will be "true" 95% of the time. For example, a value recorded as 5.30±3.6E-09 μCi/mL means that 95% of the time the "true" value for this sample will be found between 1.7E-09 μCi/mL and 8.9E-09 μCi/mL.

If the uncertainty range is greater than the value itself (e.g., 5.30±6.5E-0 μCi/mL), the result is below the detection limit. The values listed in tables of radioactivity measurements in the appendices include both the value and uncertainty regardless of the detection limit value. If the uncertainty range is greater than the value itself, measurements of radiological parameters may be represented by a "less than" ("<"). Chemical data are expressed by the detection limit prefaced by a "<" if no analyte was measured. Also see **Data Reporting** in *Chapter 5, Quality Assurance*.

In general, the detection limit is the minimum amount of constituent or material of interest detected by an instrument or method that can be distinguished from background and instrument noise. Thus, the detection limit is the lowest value at which a sample result shows a statistically positive difference from a sample in which no constituent is present.

1994 Changes in the Environmental Monitoring Program

Minor updates to the 1994 monitoring program improved the environmental sampling network and supported current site characterization activities. The changes included upgrading air effluent monitoring points, increasing or decreasing selected analytes at specific locations, and upgrading sample collection protocol at the northeast surface water drainage point WNSWAMP.

Major program changes in 1994 included adding analytes to water effluent monitoring in response to two SPDES permit revisions, one in February and another in November 1994. The new wastewater treatment facility, completed in 1994, replaced the old sewage treatment plant and altered sampling requirements for effluent water and sludge.

Appendix A summarizes the program changes and lists the sample points and parameters measured in 1994.

High-level Waste Treatment

Waste from NFS operations was originally stored in two of four underground tanks (tanks 8D-2 and 8D-4). The waste in 8D-2, the larger of the active tanks, had settled into two layers: a liquid – the supernatant – and a precipitate layer on the tank bottom – the sludge.

To solidify the high-level waste, WVDP engineers designed and developed a process of pretreatment and vitrification.

Supernatant Pretreatment

The supernatant was composed mostly of sodium and potassium salts dissolved in water. Radioactive cesium in solution accounted for more than 99% of the total fission products in the supernatant. During pretreatment, sodium salts and sulfates were separated from the radioactive constituents in both the liquid portion of the high-level waste and the sludge layer in the bottom of the tank.

Pretreatment of the supernatant began in 1988. A four-part process, the integrated radwaste treatment system (IRTS), reduced the volume of the high-level waste needing vitrification by producing low-level waste stabilized in cement.

- The supernatant was passed through zeolite-filled ion exchange columns in the supernatant treatment system (STS) to remove more than 99.9% of the radioactive cesium.
- The resulting liquid was then concentrated by evaporation in the liquid waste treatment system (LWTS).
- This low-level radioactive concentrate was blended with cement in the cement solidification system (CSS) and placed in 269-liter (71-gal) steel drums. This cement-stabilized waste form has been accepted by the NRC.
- Finally, the steel drums were stored in an on-site aboveground vault, the drum cell.

Processing of the supernatant was completed in 1990. Eighty percent of the radioactivity in the liquid was removed and more than 10,000 drums of cemented waste were produced.

Pre-Vitrification Activities

The sludge that remains is composed mostly of iron hydroxide. Strontium-90 accounts for most of the radioactivity in the sludge.

Pretreatment of the sludge layer in high-level waste tank 8D-2 began in 1991. Five specially designed 50-foot-long pumps were installed in the tank to mix the sludge layer with water in order to produce a uniform sludge blend and to dissolve the sodium salts and sulfates that would interfere with vitrification. After mixing and allowing the sludge to settle,

Derived Concentration Guides

A derived concentration guide (DCG) is defined by the DOE as the concentration of a radionuclide in air or water that, under conditions of continuous exposure by one exposure mode (i.e., ingestion of water, submersion in air, or inhalation), for one year, would result in an effective dose equivalent of 100 mrem (1 mSv) to a "reference man." These concentrations (DCGs) are considered screening levels that enable site personnel to review effluent and environmental data and to decide if further investigation is needed.

DOE Orders require that the hypothetical dose to the public from facility effluents must be estimated using specific computer codes. (See Chapter 4.) The DCGs are used as a guideline to limit the dose that any individual could receive under extreme (unrealistic) conditions.

The actual calculated dose to the maximally exposed off-site individual from WVDP releases is orders of magnitude less than the 100 mrem DCG standard. Dose estimates are based on a sum of isotope quantities released and the dose equivalent effects for that isotope. In a similar manner, percentages of the DCGs for all radionuclides present are added: if the total percentage of the DCGs is less than 100, then the effluent released is in compliance with the DOE guideline.

Although DCGs for airborne radionuclides are given, the DOE applies the more stringent U.S. EPA NESHAPs standards to airborne effluents.

As a convenient reference point, comparisons with DCGs are made throughout this report for both air and water samples.

processing of the wash water through the integrated radwaste treatment system began. Processing removes radioactive constituents for later solidification into glass, and the wash water containing salts is then stabilized in cement.

1994 Activities at the West Valley Demonstration Project

Pre-Vitrification Activities

Sludge washing was completed in 1994 after approximately 765,000 gallons of wash water had been processed. About 8,000 drums of cement-stabilized wash water were produced. In all, through the supernatant treatment process and the sludge wash process, more than 1.3 million gallons of wash water had been processed by the end of 1994, producing a total of more than 18,000 drums of cemented low-level waste.

As one of the final steps preceeding vitrification, the ion-exchange material used in the integrated radwaste treatment system (IRTS) to remove radioactivity will be blended with the washed sludge in the glass-forming feed mixture.

A single reprocessing campaign of a special fuel containing thorium was conducted by the previous facility operators from November 1968 to January 1969. In preparation for vitrification, the high-level waste from this campaign was transferred into the underground storage tank holding the rest of the sludge. The transfer took place between late 1994 and January 1995. The high-level waste from this campaign will be added to the WVDP vitrification feed mixture.

Solidification into glass is scheduled to begin in 1996. The high-level waste mixture of sludge and zeolite from the ion-exchange process will be combined with glass-forming chemicals, fed to a ceramic melter, heated to approximately 2,000°F, and poured into stainless steel canisters. Approximately 300 stainless steel canisters, 10 feet long by 2 feet in diameter, will be filled with a uniform, high-level waste glass that will be suitable for eventual shipment to a federal repository.

Several major milestones have been reached in completing the Project's vitrification facility. Nonradioactive testing of a full-scale vitrification system was conducted from 1984 to 1989. In 1990 all vitrification equipment was removed to allow installation of shield walls for fully remote radioactive operations. The walls and shielded tunnel connecting the facility to the former reprocessing plant were completed in 1991.

The slurry-fed ceramic melter was fully assembled, bricked, and installed in 1993. In addition, the cold chemical building was completed, as was the sludge mobilization system that will transfer high-level waste to the melter. This system was fully tested in 1994. A number of additional major systems components also were installed in 1994: the canister turntable, which positions the vessels as they are filled with molten glass; the submerged bed scrubber, which cleans gases produced by the vitrification process; and the transfer cart, which moves filled canisters to the storage area. The canister load-in facility design was completed, construction was started, and the computer system controlling overall vitrification operations was programmed.

Low-level Waste Processing

Aqueous Radioactive Waste

Water containing added radioactive material from site cleanup operations is collected and treated in the low-level liquid waste treatment facility (LLWTF). (Water from the sanitary system, which does not contain added radioactive material, is managed in a separate system.)

The treated process water is held, sampled, and analyzed before it is released through a State Pollutant Discharge Elimination System (SPDES)-permitted outfall. In 1994, 44.7 million liters (11.8 million gal) of water were treated in the LLWTF and released through the lagoon 3 weir.

The discharge waters contained an estimated 55 millicuries of gross alpha plus gross beta radioactivity. Comparable releases during the previous eight years averaged about 43 millicuries per year. The 1994 release was about 28% above this average. (See **Radioactivity Concentrations On-site: Low-level Waste Treatment Facility** in *Chapter 2, Environmental Monitoring*.)

Approximately 1.03 curies of tritium were released in WVDP liquid effluents in 1994.

Non-Aqueous Radioactive Waste

In 1994, 763 liters (202 gal) of low specific activity radioactive waste oil was sent to Scientific Ecology Group in Oak Ridge, Tennessee for processing.

Solid Radioactive Waste

Low-level radioactive waste at the WVDP, stored in aboveground facilities, consists of various materials generated through site maintenance and cleanup activities. Metal piping and tanks are cut up and packaged in a special size-reduction facility, and dry compressible materials such as paper and plastic are compacted to reduce waste volume. For more details see the *Environmental Compliance Summary: Calendar Year 1994.*

Airborne Radioactive Emissions

Air used to ventilate the facilities where radioactive material cleanup processes are operated is passed through filtration devices before being emitted to the atmosphere.

Ventilated air from the various points in the IRTS process (high-level waste sludge treatment, main plant and liquid waste treatment system, cement solidification system, and the LLWTF) and other waste management activities centered in the main plant building is sampled continuously during operation. In addition to monitors that alarm if radioactivity increases above preset levels, the sample media is analyzed in the laboratory for the specific radioisotopes that are present in the radioactive materials being handled.

Air emissions in 1994, primarily from the main plant ventilation, contained an estimated 0.04 millicuries (mCi) of gross alpha plus gross beta radioactivity. This compares to less than 0.03 mCi of combined gross alpha and beta activity in 1993 and 0.02 mCi in 1992 and reflects current processing operations. See *Chapter 2, Environmental Monitoring*, for more detail.

Approximately 0.04 curies of tritium (as hydrogen tritium oxide [HTO]) were released in facility air emissions in 1994.

Waste Minimization Program

The WVDP formalized a waste minimization program in 1991 to reduce the generation of low-level waste, mixed waste, and industrial waste. By using source reduction, recycling, and other techniques, waste in all of these categories except hazardous waste was reduced. In 1994, the fourth year of the program, reductions in low-level radioactive waste, radioactive mixed waste, and industrial waste exceeded the 1993 reduction by more than 10%. For more details see the *Environmental Compliance Summary: Calendar Year 1994.*

Pollution Prevention Awareness Program

The WVDP's pollution prevention awareness program is a significant part of the Project's overall waste minimization program. The program includes hazard communication training and new employee orientation that provides information about the WVDP's Industrial Hygiene and Safety Manual, environmental pollution control procedures, and the Hazardous Waste Management Plan.

The WVDP's goal is to make all employees aware of the importance of pollution prevention both at work and at home.

1994 National Environmental Policy Act (NEPA) Activities

Under the National Environmental Policy Act, the Department of Energy is required to consider the overall environmental effects of its proposed legislative actions or proposed federal projects. The President's Council on Environmental Quality established a screening system of analyses and documentation that requires each proposed action to be categorized according to the extent of its potential environmental effect. The levels of documentation include categorical exclusions (CXs), environmental assessments (EAs), and environmental impact statements (EISs).

Categorical exclusions evaluate and document actions that will not have a significant effect on the environment. Environmental assessments evaluate the extent to which the proposed action will affect the environment. If a proposed action has the potential for significant effects, an environmental impact statement is prepared that describes proposed alternatives to an action and explains the effects.

Vitrification Phase NEPA Activities

NEPA activities at the WVDP generally involve facility maintenance and minor projects that support high-level waste vitrification. Most of these projects are documented and submitted for approval as categorical exclusions although environmental assessments are occasionally necessary. (See the *Environmental Compliance Summary* for a discussion of specific NEPA activities in 1994.)

Decommissioning Phase NEPA Activities

In December 1988 the DOE published a Notice of Intent to prepare an environmental impact statement for the completion of the WVDP and closure of the facilities at the WNYNSC. The environmental impact statement will describe the potential environmental effects associated with Project completion and various site closure alternatives. Completion and closure are decommissioning phase activities. In contrast, vitrification phase activities were described in a 1982 environmental impact statement.

In order to assess potential effects associated with alternative closure actions, an extensive multidisciplinary characterization of the site was necessary. Characterization activities began in 1989 and required data collection for several years. Site characterization studies include investigations in geomorphology, soils, geohydrology, surface water hydrology, geochemistry, water quality, air quality, seismology, demography, cultural resources, botany, and terrestrial and aquatic ecology. Many of these studies were completed in 1992.

In late 1992 the DOE selected an independent contractor, Science Applications International Corporation, to prepare the environmental impact statement for closure or long-term management of the WNYNSC. The draft EIS, which evaluates proposed actions and alternatives for the decontamination, decommissioning, and closure of the facilities at the WNYNSC, was being prepared in 1994.

On-site Environmental Training

The occupational safety of personnel who are involved in hazardous waste operations is protected by standards promulgated under OSHA. This act is a comprehensive law governing diverse occupational hazards such as electrical safety and protection from fire as well as the handling of hazardous materials. The purpose of OSHA is to maintain a safe and healthy working environment for employees.

OSHA 29 CFR 1910.120, Hazardous Waste Operations and Emergency Response, requires that employees at treatment, storage, and disposal facilities, who may be exposed to health and safety hazards during hazardous waste operations, receive training appropriate to their job function and responsibilities. The WVDP Environmental, Health, and Safety training matrix identifies the specific training requirements for affected employees.

The WVDP provides the standard twenty-four-hour hazardous waste operations and emergency response training. (Emergency response training includes controlling contamination to groundwater and spill response measures.) Training programs also contain information on waste minimization and pollution prevention. Besides this standard training, employees working in radiological areas receive additional training on subjects such as understanding radiation and radiation warning signs, dosimetry, and respiratory protection. In addition, specific qualification standards for specific job functions at the site are required and maintained. These programs have evolved into a comprehensive curriculum of knowledge and skills necessary to maintain the health and safety of employees and ensure the continued environmental compliance of the WVDP.

The WVDP maintains a hazardous materials team that is trained to respond to spills of hazardous materials. This team maintains its proficiency through classroom instruction and scheduled training drills.

Any person working at the WVDP that has a picture badge receives general employee training covering health and safety, emergency response, and environmental compliance issues.

All visitors to the WVDP also receive a site-specific briefing on safety and emergency procedures before being admitted to the site.

Self-Assessment

Self-assessments continued to be conducted regularly in 1994 to review the management and effectiveness of the WVDP environmental protection and monitoring programs. Results of these self-assessments are evaluated and corrective actions tracked through completion. Overall results of these self-assessments found that the WVDP continued to implement and in some cases improve the quality of the environmental protection and monitoring program.

ENVIRONMENTAL MONITORING

Pathway Monitoring

The effluent and environmental monitoring program provides data on surface waters, soils, sediments, food and produce, and on the effluent air and liquids that could provide pathways for the movement of radionuclides or hazardous substances from the facility to the public. Both radiological and nonradiological parameters are monitored in order to ascertain the effect of Project activities.

Sediments are sampled upstream and downstream of the West Valley Demonstration Project (WVDP). The food pathway is monitored by collecting samples of beef, hay, milk, and produce at both near-site and remote locations, samples of fish upstream and downstream of the site, and venison samples from the on-site deer herd and from background locations. Direct radiation on-site, at the perimeter of the site, and at background locations is also monitored to provide additional data.

The primary focus of the monitoring program, however, is on air and water pathways, as these would be the major means of transport of radionuclides from the site.

Air and Liquid Pathways

Air and liquid effluents are monitored on-site by collecting samples at locations where radioactivity or other regulated substances are released or might be released. These include plant ventilation stacks and various water effluent outfalls.

Surface water samples are collected from the tributaries of Cattaraugus Creek that flow through the Western New York Nuclear Service Center (WNYNSC) and from drainage channels within the Project site.

Both air and water samples are collected at perimeter locations where the highest concentrations of transported radionuclides might be expected. Samples are also collected at remote locations to provide background concentration data.

Sampling Codes

The complete environmental monitoring schedule is detailed in *Appendix A*. This schedule provides information on monitoring and reporting requirements and the types and extent of sampling and monitoring at each location. An explanation of the codes that identify the sample medium and the specific sampling or monitoring location is also found in *Appendix A*. For example, a sample location code such as AFGRVAL indicates an air sample (A), off-site (F), at the Great Valley (GRVAL) sampling station.

These codes are used throughout this report for ease of reference and to be consistent with the data reported in the appendices.

Air Sampler Location and Operation

Air samplers are located at points remote from the WVDP site, at the perimeter of the site, and on the site itself. Figure 2-1 shows the locations of the on-site air effluent monitors and samplers; Figure 2-2 and Figure A-9 in *Appendix A* show the location of the perimeter and remote air samplers.

Air samples are collected by drawing air through a very fine filter with a vacuum pump. The total volume of air drawn through the sampler is measured and recorded. The filter traps particles of dust that are then tested in the laboratory for radioactivity. At the Rock Springs Road, Great Valley, and New York State-licensed disposal area (SDA) locations samples are also collected for iodine-129 and tritium analyses. (A more detailed description of the air sampling program follows below.)

Water Sampler Location and Operation

Automatic samplers collect surface water at points along drainage channels within the WNYNSC that are most likely to show any radioactivity released from the site and at a background station upstream of the site. (Grab samples are collected at several other surface water locations both on- and off-site.) Figure 2-3 shows the location of the on-site surface water monitoring points. (In the past, on-site automatic samplers have operated at locations WNSP006, WNNDADR, and WNSW74A. In 1994, a fourth automated sampler was added at location WNSWAMP.) Figure 2-4 shows the location of the off-site automatic surface water monitoring points. (Off-site locations are WFBCTCB, WFFELBR, and the background location, WFBCBKG.)

Water samplers draw water through a tube extending to an intake below the stream surface. An electronically controlled battery-powered pump first blows air through the sample line to clear any debris. The pump then reverses to collect a sample, reverses again to clear the line, then resets itself. The cycle is repeated after a preset interval. The pump and sample container are housed in an insulated and heated shed to allow sampling throughout the year. (A more detailed description of the water sampling program follows below.)

Radiological Monitoring

Air Monitoring

On-site Ventilation Systems

Permits obtained from the U.S. Environmental Protection Agency (EPA) allow air to be released from plant ventilation stacks during normal operations. The air released must meet criteria that ensure that the environment and the public's health and safety are not adversely affected by these releases.

Parameters measured include gross alpha and gross beta, tritium, and various isotopes such as cesium-137 and strontium-90. When comparing concentrations with dose limits for screening purposes, gross alpha and beta radioactivities are assumed to come from americium-241 and strontium-90, respectively, because the derived concentration guides (DCGs) for these isotopes are the most stringent. (U.S. Department of En-

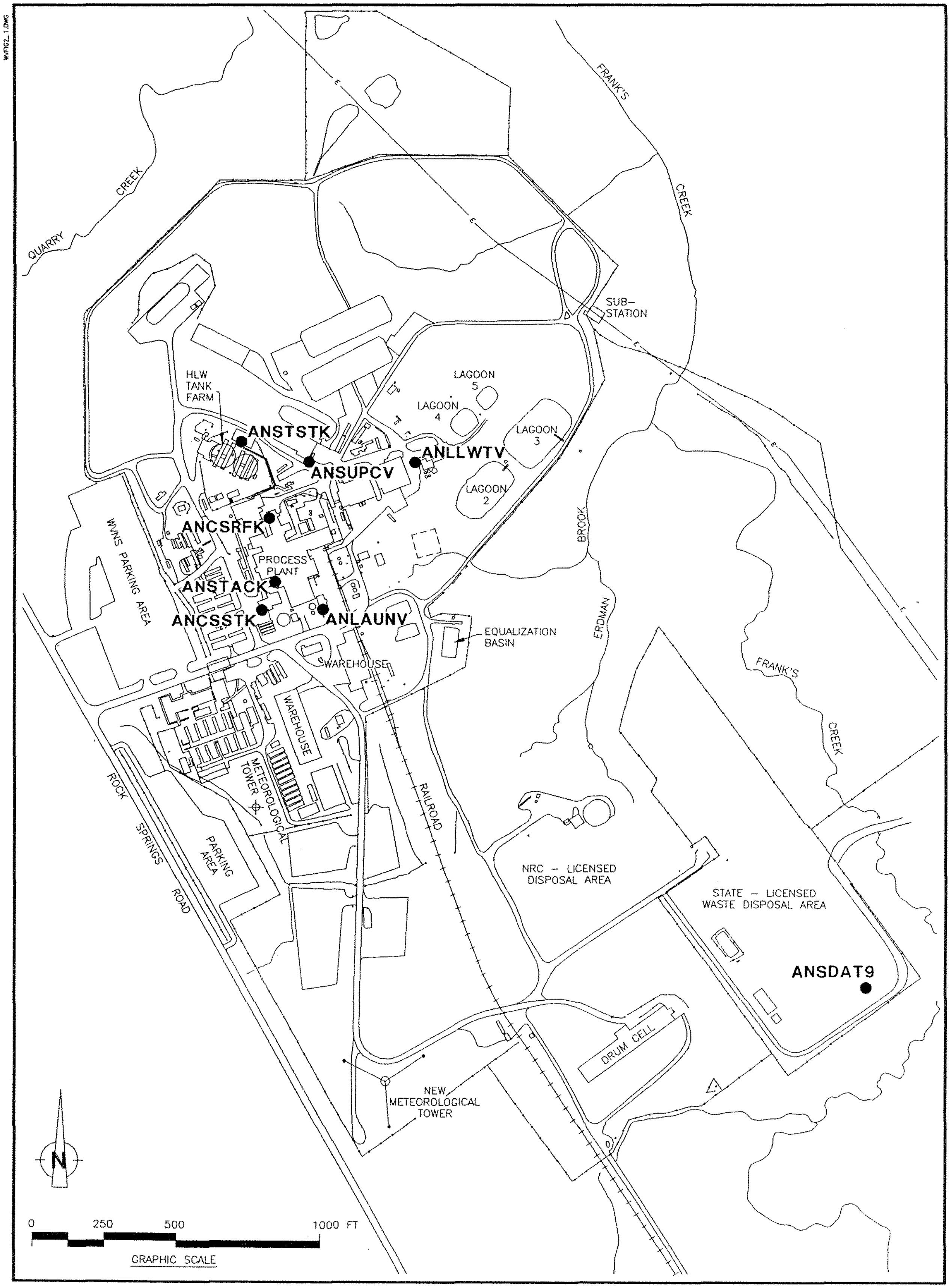


Figure 2-1. Location of On-site Air Monitoring Points.

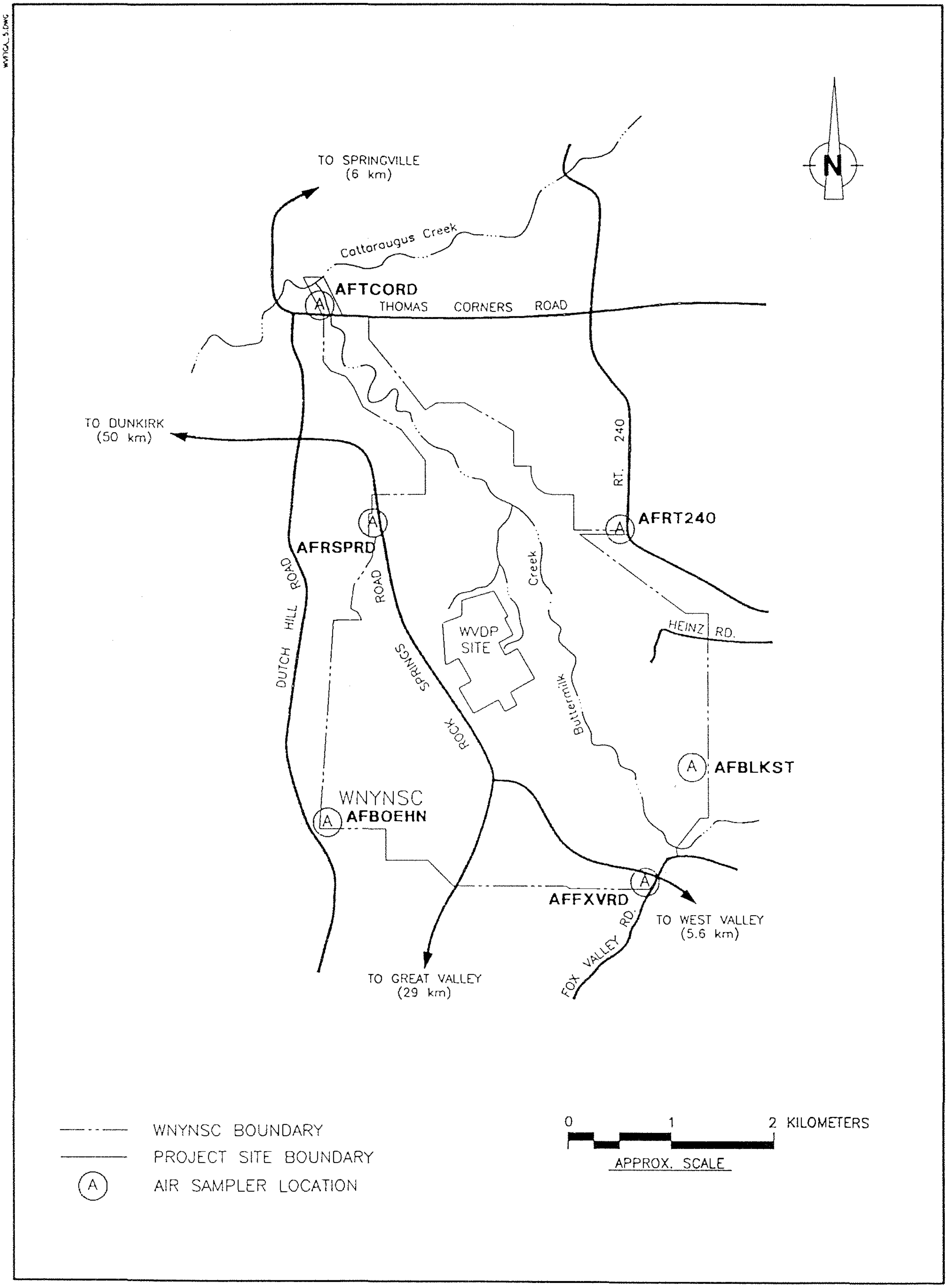


Figure 2-2. Location of Perimeter Air Samplers.

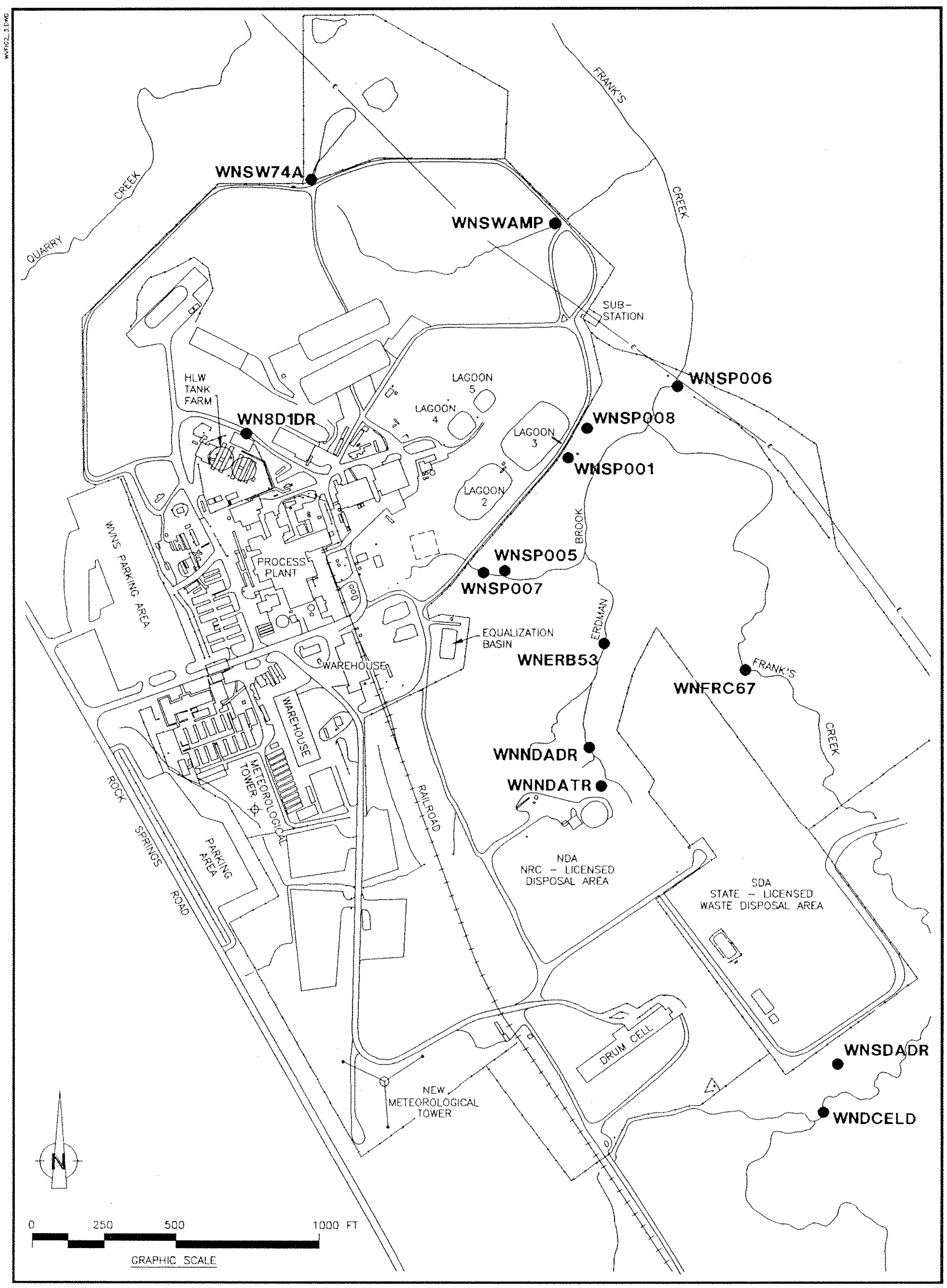


Figure 2-3. Sampling Locations for On-site Surface Water.

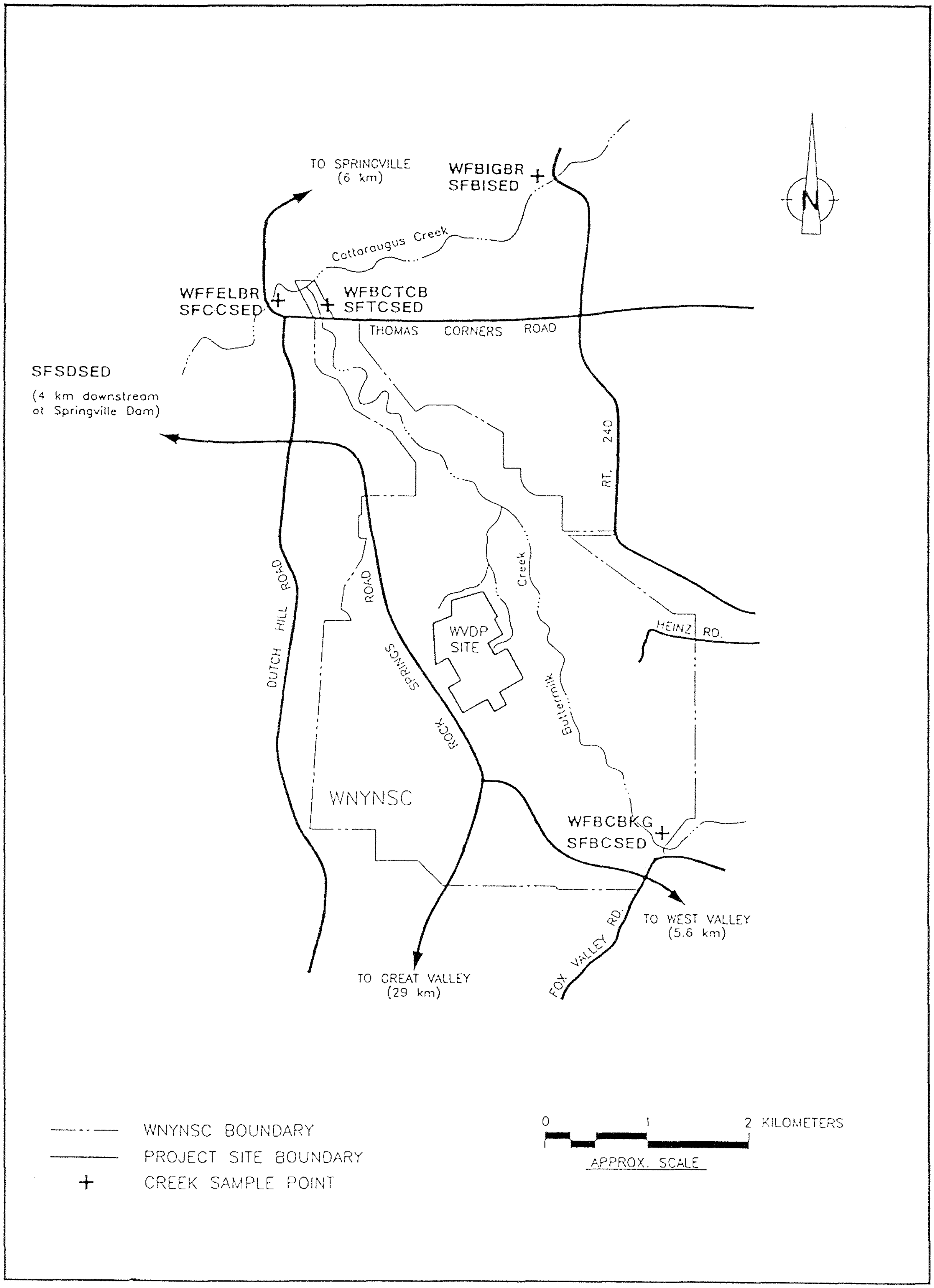


Figure 2-4. Location of Off-site Surface Water Samplers and Sediment Collection.

ergy [DOE] standards and DCGs for radionuclides of interest at the WVDP are found in *Appendix B*.)

The exhaust from each permitted fixed ventilation system on-site is continuously filtered, monitored, and sampled as it is released to the atmosphere. Specially designed isokinetic sampling nozzles continuously remove a representative portion of the exhaust air, which is then drawn through very fine glass fiber filters to trap any particles. Sensitive detectors continuously monitor the radioactivity on these filters and provide readouts of alpha and beta radioactivity levels.

A separate sampling unit on the ventilation stack of continuously operated systems contains another filter that is removed every week and tested in the laboratory. This sampling system also may contain an activated carbon cartridge used to collect a sample that is analyzed for iodine-129.

In addition to these samples, water vapor from the main plant ventilation stack (ANSTACK) and the supernatant treatment system (ANSTSTK) is collected by trapping moisture in silica gel desiccant columns. The trapped water is distilled from the silica gel desiccant and analyzed for tritium.

Because tritium, iodine, and other isotopic concentrations are quite low, the large-volume samples collected weekly from the main plant stack and from other emission-point samplers provide the only practical means of determining the amount of specific radionuclides released from the facility. In addition to scheduled sampling and analysis of ANSTACK filters for those parameters defined in *Appendix A* of this report, filters are routinely analyzed for strontium-89 and cesium-137 as part of operational monitoring.

Permitted portable outdoor ventilation enclosures (OVEs) are used occasionally to provide the ventilation necessary for the safety of personnel working with radioactive materials in areas outside permanently ventilated facilities. Air samples from OVEs are collected continuously while those emission points are discharging and data from these units are included in annual airborne emission evaluations.

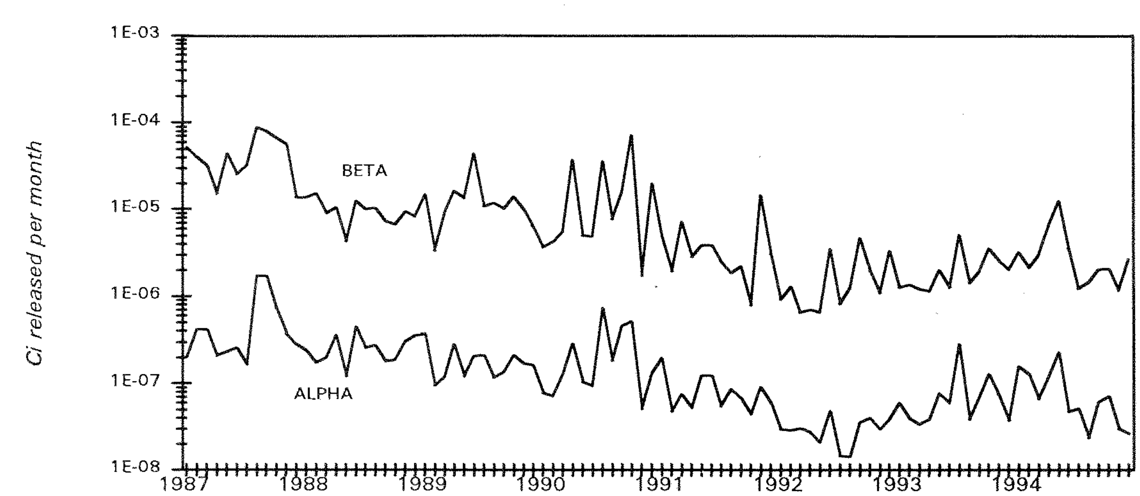


Figure 2-5. Eight-Year Trends of Gross Alpha and Gross Beta Concentrations at the Main Stack Sampling Location (ANSTACK)

- The Main Plant Ventilation Stack

The main ventilation stack sampling system monitors the most significant airborne effluent point. A high sample-collection flow rate through multiple intake nozzles ensures a representative sample for both the weekly filter sample and the on-line monitoring system. The total quantity of gross alpha, gross beta, and tritium (H-3) released each month from the main stack, based on weekly filter measurements, is shown in *Appendix C-2,* Table C-2.1. Figure 2-5 shows the eight-year trends for the main stack samples analyzed for gross alpha and gross beta activity. The figure indicates a steady five-year downward trend in activity observed for both gross alpha and gross beta from 1987 to mid-1992. Since then and throughout 1994 both gross alpha and beta activities appear to have risen slightly then leveled off.

Silica Gel Columns from the Main Ventilation Stack Sampler

Analyses of specific radionuclides in the four quarterly composites of the main stack effluent samples are listed in Table C-2.2. A comparison of the average concentrations of these measured isotopes with Department of Energy DCGs in Table C-2.3 shows that at the point of stack discharge, average radioactivity levels were already below concentration guidelines for airborne radioactivity in an unrestricted environment. Additionally, further dilution from the stack to the site boundary reduces the concentration by an average factor of about 200,000.

- Other On-site Sampling Systems

Sampling systems similar to those of the main stack monitor airborne effluents from the cement solidification system ventilation stack (ANCSSTK), the contact size-reduction facility ventilation stack (ANCSRFK), and the supernatant treatment system ventilation stack (ANSTSTK). The 1994 samples showed detectable gross radioactivity, including specific beta- and alpha-emitting isotopes, but did not approach any Department of Energy effluent limitations. Tables C-2.4 through C-2.9 in *Appendix C-2* show monthly totals of gross alpha and beta radioactivity and quarterly total radioactivity released for specific radionuclides for each of these sampling locations.

Three other operations are routinely monitored for airborne radioactive releases: the supercompactor volume-reduction ventilation system (ANSUPCV), the low-level waste treatment facility ventilation system (ANLLWTF), and the contaminated clothing laundry ventilation system (ANLAUNV). Results for samples collected in 1994 from the supercompactor ventilation (ANSUPCV) are presented in

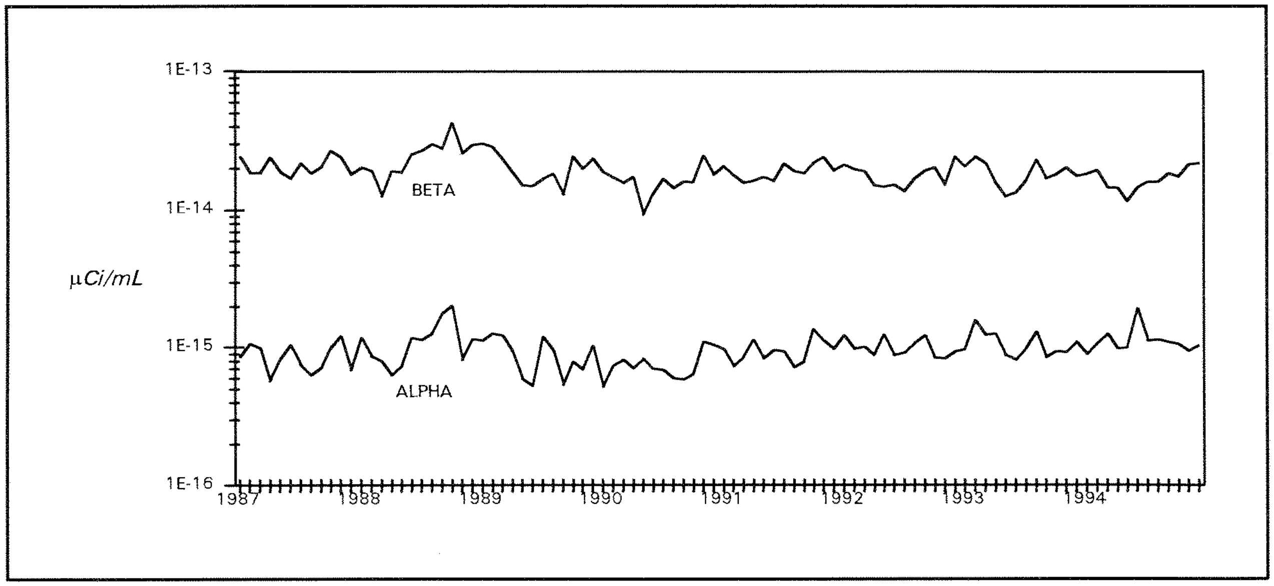


Figure 2-6. Eight-Year Trends of Gross Alpha and Gross Beta Concentrations at the Rock Springs Road Sampling Location (AFRSPRD)

Tables C-2.10 and C-2.11 in *Appendix C-2*. The supercompactor system was shut down in April 1994 due to reduced operational needs. Since then, it has operated only for short periods of one day to one week. While in operation the supercompactor stack is monitored continuously. ANLLWTF and ANLAUNV sampling points are sampled for gross alpha and gross beta radioactivity. In October 1994, new sampling equipment was brought on-line to upgrade the existing equipment to current new-equipment standards. This will also augment the site's ability to periodically confirm the low level of releases from these facilities. Data for these two facilities are presented in Tables C-2.25 through C-2.27 in *Appendix C-2.*

In 1994 average discharges at the point of release from portable outdoor ventilation units were well below DOE guidelines for alpha and beta radioactivity in an unrestricted environment. Dilution from the point of release to the site boundary would further reduce these concentrations.

Perimeter and Remote Air Sampling

As in previous years, airborne particulate samples for radiological analysis were collected continuously at six locations around the perimeter of the site and at four remote locations at Great Valley, West Valley, Springville, and Dunkirk, New York. (See Fig. 2-2 and Fig. A-9 in *Appendix A*.)

Perimeter locations — on Fox Valley Road, Rock Springs Road, Route 240, Thomas Corners Road, Dutch Hill Road, and at the site's bulk storage warehouse — were chosen to provide historical continuity or because the location would probably represent the highest potential airborne concentration of radioactivity. The eight-year trends of concentrations of gross alpha and gross beta at the Rock Springs Road location are shown in Figure 2-6.

The remote locations provide data from nearby communities — West Valley and Springville — and from natural background areas. Concentrations measured at Great Valley (AFGRVAL, 29 km south of the site) and Dunkirk (AFDNKRK, 50 km west of the site) are considered representative of natural background radiation.

The six perimeter samplers and the four remote samplers maintain an average flow of about 40 L/min (1.4 ft^3/min) through a 47-millimeter glass

Global Fallout Sampling

Global fallout is sampled at four of the perimeter air sampler locations and at the base of the original on-site meteorological tower. Precipitation from all of the locations is collected and analyzed every month. Results from these measurements are reported in nCi/m² per month for gross alpha and gross beta and in µCi/mL for tritium. (The 1994 data from these analyses are found in Appendix C-2, Table C-2.21. Table C-2.22 contains precipitation pH measurement data.)

Fallout-pot data indicate short-term effects. Long-term deposition is measured by surface soil samples collected annually near each air sampling station. Soil sample data are found in Table C-1.10 of Appendix C-1.

The measured concentrations are typical of normal background in the region, with one exception. Soil from the Rock Springs Road air sampler has consistently shown a higher-than-background cesium-137 concentration. This sampler is known to be within an extended area of elevated cesium activity that was identified by a 1979 survey, well before the Project was initiated.

fiber filter. The sampler heads for each of the locations are set at 1.7 meters above the ground, the height of the average human breathing zone.

Filters from off-site and perimeter samplers are collected weekly and analyzed after a seven-day "decay" period to remove interference from short-lived naturally occurring radioactivity. Gross alpha and gross beta measurements of each filter are made weekly using a low-background gas proportional counter. The gross alpha and gross beta ranges and annual averages for each of the off-site sampling points are provided in Tables 2-1 and 2-2. The concentration ranges observed are similar to those seen in 1993. Near-site sample concentrations are indistinguishable from background and they all reflect normal seasonal variations.

In addition, quarterly composites, each consisting of thirteen weekly filters from each sample station, are analyzed. Data from these samplers are provided in *Appendix C-2,* Tables C-2.12 through C-2.20 and C-2.23. Although tritium (as hydrogen-tritium oxide [HTO]) was positively detected at the Rock Springs Road location near the site, its concentration was identical to concentrations observed at the Great Valley background location. A positive strontium-90 value at location AFSPRVL in the first quarter of 1994 may be an anomaly (an unexplained isolated value that does not fit the expected pattern). Similar concentrations have not been observed at any other sample location closer to the site.

The 1994 data for the three samplers that have been in operation since 1982 — Fox Valley, Thomas Corners, and Route 240 — averaged about 1.56E-14 µCi/mL (5.77E-04 Bq/m³) of gross beta activity in air. This average is comparable to 1993 data. The average gross beta concentration at the Great Valley background station was 1.82E-14 µCi/mL (6.73E-04 Bq/m³) in 1993, and in 1994 averaged 4.02E-14 µCi/mL (1.49E-03 Bq/m³).

During the first ten months of 1994, four ambient air samplers at locations AFBOEHN, AFDNKRK, AFGRVAL, and AFWEVAL were operated in parallel with identical samplers located within one mile of their original positions in order to study the effects of relocating these sampling points to more open areas, where trees and other obstructions would not interfere with sample collection. The results of this study indicate that there is no appreciable difference in the data obtained from the analysis of the air filters collected from the original and the new samplers.

Table 2-1

1994 Gross Alpha Activity at Off-site and Perimeter Ambient Air Sampling Locations

Location	Number of Samples	Range		Annual Average	
		µCi/mL	Bq/m^3	µCi/mL	Bq/m^3
AFFXVRD	52	<7.22E-16 — 3.26E-15	<2.67E-05 — 1.21E-04	1.15±1.15E-15	4.24±4.25E-05
AFRSPRD	52	<5.00E-16 — 4.06E-15	<1.85E-05 — 1.50E-04	0.82±1.13E-15	3.03±4.17E-05
AFRT240	52	<7.67E-16 — 2.26E-15	<2.84E-05 — 8.36E-05	0.94±1.08E-15	3.48±4.01E-05
AFSPRVL	52	<6.55E-16 — 2.96E-15	<2.42E-05 — 1.10E-04	0.86±1.08E-15	3.17±3.98E-05
AFTCORD	52	<7.17E-16 — <2.48E-12	<2.65E-05 — <9.18E-02	-0.51±3.44E-13	-0.19±1.27E-02
AFWEVAL	52	<7.50E-16 — 2.30E-15	<2.78E-05 — 8.51E-05	1.09±1.10E-15	4.02±4.07E-05
AFGRVAL	52	<6.74E-16 — <1.50E-13	<2.49E-05 — <5.55E-03	0.30±2.14E-14	1.09±7.91E-04
AFBOEHN	52	<6.83E-16 — <5.93E-15	<2.53E-05 — <2.19E-04	0.91±1.55E-15	3.37±5.74E-05
AFDNKRK	52	<7.00E-16 — 2.36E-15	<2.59E-05 — 8.73E-05	1.05±1.11E-15	3.89±4.09E-05
AFBLKST	52	<7.33E-16 — <1.94E-15	<2.71E-05 — <7.18E-05	0.79±1.09E-15	2.93±4.02E-05

Table 2-2

1994 Gross Beta Activity at Off-site and Perimeter Ambient Air Sampling Locations

Location	Number of Samples	Range		Annual Average	
		µCi/mL	Bq/m^3	µCi/mL	Bq/m^3
AFFXVRD	52	1.03E-14 — 3.32E-14	3.81E-04 — 1.23E-03	1.89±0.34E-14	7.01±1.26E-04
AFRSPRD	52	7.19E-15 — 2.90E-14	2.66E-04 — 1.07E-03	1.68±0.34E-14	6.22±1.24E-04
AFRT240	52	7.05E-15 — 3.52E-14	2.61E-04 — 1.30E-03	1.70±0.33E-14	6.29±1.20E-04
AFSPRVL	52	5.77E-15 — 2.68E-14	2.13E-04 — 9.92E-04	1.45±0.31E-14	5.38±1.16E-04
AFTCORD	52	5.88E-15 — <5.42E-12	2.18E-04 — <2.01E-01	0.11±7.52E-13	0.04±2.78E-02
AFWEVAL	52	1.01E-14 — 3.93E-14	3.74E-04 — 1.45E-03	2.06±0.34E-14	7.61±1.26E-04
AFGRVAL	52	9.82E-15 — 8.26E-13	3.63E-04 — 3.06E-02	4.02±6.10E-14	1.49±2.26E-03
AFBOEHN	52	7.37E-15 — 2.97E-14	2.73E-04 — 1.10E-03	1.78±0.41E-14	6.59±1.50E-04
AFDNKRK	52	6.07E-15 — 3.71E-14	2.25E-04 — 1.37E-03	1.70±0.32E-14	6.27±1.20E-04
AFBLKST	52	8.87E-15 — 2.88E-14	3.28E-04 — 1.07E-03	1.76±0.34E-14	6.50±1.26E-04

In October 1994, the original samplers at AFBOEHN, AFGRVAL, and AFWEVAL were removed from service. The original AFDNKRK air sampler remains in service. The new AFDNKRK sampler was removed because of difficulties in maintaining a lease agreement for the property on which it was placed. Another suitable siting location is being considered. A new sampler (ANSDAT9) that monitors diffuse releases of radioactivity associated with the New York State Energy and Research Development Authority's (NYSERDA's) SDA was put in place in late 1993. Results of this monitoring are presented in *Appendix C-2*, Table C-2.24.

Off-site Surface Soil Sampling

Soil from the upper two inches of the ground near the perimeter air samplers is collected annually to measure the radioactivity deposited by worldwide fallout. Samples were collected in 1994 from ten locations: six points on the perimeter of the retained premises (WNYNSC), two in nearby communities, and two in locations 30 to 50 kilometers distant from the Project. Analyses for cesium-137, strontium-90, plutonium-239, and americium-241 at all ten locations and analyses for uranium isotopes at three points were compared among the sample locations and with results from the four previous years.

Springville Dam on Cattaraugus Creek

The 1994 results (Table C -1.10) show that with the exception of two cesium-137 results from the southeast and northwest perimeter sampler locations, detectable concentrations of potassium-40 (a naturally occurring radionuclide), strontium-90 and cesium-137 (both present in worldwide fallout), and natural uranium isotopes were within the same range of uncertainty as background samples. All values remain within the range observed at background locations during the past five years.

Surface Water and Sediment Monitoring

On-site Surface Water Sampling

The largest single source of radioactivity released to surface waters from the Project is the discharge from the low-level waste treatment facility through the lagoon 3 weir (WNSP001, Fig. 2-3) into Erdman Brook, a tributary of Frank's Creek. There were eight batch releases totaling about 44.7 million liters (11.8 million gal) in 1994. In addition to composite samples collected near the beginning and end of each discharge, forty-three daily effluent grab samples were collected and analyzed.

A water sampling station (WNSP006) is located on Frank's Creek where Project site drainage leaves the security-fenced area. (See Fig. 2-3.) This sampler collects a 50-mL aliquot (a small volume of water) every half-hour. Samples are retrieved weekly and composited both monthly and quarterly. (See Table C-1.5.) Weekly samples are analyzed for tritium and gross alpha and beta radioactivity as well as pH and conductivity. The monthly composite is analyzed for strontium-90 and gamma-emitting isotopes. A quarterly composite is analyzed for carbon-14, iodine-129, alpha-emitting isotopes, and total uranium. (See Table C-1.6.)

The north and northeast swamp drainages on the site's north plateau are two major channels for surface water and emergent groundwater to collect. Samples from the north swamp drainage are collected by an automated sampler at location WNSW74A every week. (See Fig. 2-3.) Grab samples were collected weekly from the northeast swamp drainage at sampling point WNSWAMP until March 1994, when an automatic sampler was installed at this location. (See Fig. 2-3.) Samples from both locations are analyzed weekly for gross alpha, gross beta, tritium, pH, and conductivity. Composites of weekly samples are also analyzed for a full range of specific isotopes. Semiannual grab samples from these locations are analyzed for important chemical parameters.

Sampling point WNSP005, which monitors drainage from behind and to the east of the main plant, and WNFRC67, which monitors surface waters draining from the east side of the SDA, are both grab-sampled on a monthly basis. Samples are analyzed for pH, gross alpha, gross beta, and tritium.

Another sampling point, WN8D1DR, is used to monitor surface and groundwater flow from the high-level waste tank farm area. The sample is collected from a storm sewer manhole access and is analyzed weekly for gross alpha and beta, tritium, and pH. A monthly composite is analyzed for gamma isotopes and strontium-90. (See **Special Monitoring**.)

The surface water drainage path downstream of the Nuclear Regulatory Commission-licensed disposal area (NDA) is monitored at location WNNDADR using an automated sampler. Weekly samples are composited and analyzed on a monthly basis for gross alpha, gross beta, tritium, and gamma-emitting isotopes. Quarterly composites analyzed for strontium-90 and iodine-129 and semiannual grab samples analyzed for chemical parameters provide data useful for confirming the effectiveness of NDA remediation efforts.

Downstream of WNNDADR, on Erdman Brook and to the west of the SDA, is sampling point WNERB53. Weekly samples collected from this point are analyzed for pH, gross alpha, gross beta, and tritium. In addition to samples collected by the WVDP, independent samples are collected and analyzed by the New York State Department of Health (NYSDOH) at this location and at WNFRC67, which monitors waters draining from the east side of the SDA.

Near-site Standing Water

In addition to sampling water from flowing streams, water from ponds and lakes within the retained premises also is sampled. Tests for gross alpha and beta radioactivity, tritium, pH, and various other water quality parameters are performed annually to verify that no major changes are occurring in standing water within the Project facility environs.

Off-site Surface Water Sampling

An off-site sampler (WFFELBR) is located on Cattaraugus Creek at Felton Bridge just downstream of Cattaraugus Creek's confluence with Buttermilk Creek, which is the major surface drainage from the WNYNSC. (See Fig. 2-4.) The sampler collects a 50-mL aliquot every half-hour from the creek. A chart recorder registers the stream depth during the sampling period so that a flow-weighted weekly sample can be proportioned into a monthly composite. The weekly samples are analyzed for gross alpha, gross beta, tritium, and pH each week, and the sample composite is analyzed for strontium-90 and gamma-emitting isotopes.

In addition to the Cattaraugus Creek sampler, two surface water monitoring stations are located on Buttermilk Creek both upstream and downstream of the WVDP. (See Fig. 2-4.) Samplers collect water from a background location upstream of the Project at Fox Valley Road (WFBCBKG) and from a location at Thomas Corners Road that is downstream of the plant and upstream of Buttermilk Creek's confluence with Cattaraugus Creek (WFBCTCB).

These samplers collect a 25-mL aliquot every half-hour. Samples are retrieved biweekly, composited monthly, and analyzed for tritium, gross alpha, and gross beta radioactivity. A quarterly composite of the biweekly samples is analyzed for gamma-emitting isotopes and strontium-90. Quarterly composite samples from WFBCBKG also are analyzed for carbon-14, iodine-129, alpha isotopes, and total uranium. (Table C-1.3 shows monthly and quarterly radioactivity concentrations upstream of the site at Fox Valley; Table C-1.4 shows monthly and quarterly radioactivity concentrations downstream of the site at Thomas Corners.)

Radioactivity Concentrations On-site: Low-level Waste Treatment Facility

The total amounts of radioactivity from specific radionuclides in the lagoon 3 effluent are listed in Table C-1.1. The observed annual average concentration of each radionuclide released is divided by its corresponding Department of Energy DCG in order to determine what percentage of the DCG was released. As a DOE policy, the sum of the percentages calculated for all radionuclides released must not exceed 100%. In 1994 the annual average isotopic concentrations from the lagoon 3 effluent discharge weir combined to be less than 44% of the DCGs, down from about 47% in 1993. (See Table C-1.2.)

In the course of preparing existing facility spaces to support vitrification, cleanup water from these spaces was processed in the low-level waste treatment facility (LLWTF). Waste stream transients (variations in waste stream constituents) noted within the last calendar year could have contributed to a shift in final liquid effluent isotopic ratios. Possibly related to these waste stream transients, higher concentrations of strontium-90 and uranium-232 have been observed in the lagoon 3 effluent during 1993 and 1994. Improved LLWTF operation has reduced cesium-137 concentrations in the final effluent since 1992.

Radioactivity Concentrations On-site: Surface Water Sampling Locations

North Swamp Sampling Location

Results for samples collected at location WNSW74A, which monitors drainage from the northern end of the site to Quarry Creek, are summarized in *Appendix C-1*,Tables C-1.14 and C-1.15. Gross beta concentrations at this location are three to four times higher than the average value observed at background location WFBCBKG but still are sixty times lower than the DCG for strontium-90. Tritium at this location is below the detection limit. The highest quarterly strontium-90 result at WNSW74A was less than 1.2% of its DCG.

Northeast Swamp Sampling Location

Sampling point WNSWAMP also monitors surface water drainage from the site's north plateau. (See Tables 2-3 and 2-4 and *Appendix C-1*, Tables C-1.12 and C-1.13.) Waters from this drainage run into Frank's Creek downstream of location WNSP006. Together with location WNDMPNE, results from this location also indicate the quality of emergent groundwaters in the area. An upward trend in gross beta concentration during 1993 and 1994 at location WNSWAMP is discussed in *Chapter 3, Groundwater Monitoring,* **Long-term Trends of Gross Beta and Tritium at Selected Groundwater Monitoring Locations** and **Subsurface Investigation of Gross Beta on the North Plateau**. The average tritium concentration at this location in 1994 was 4.04E-07 µCi/mL, which is above that observed at the background location WFBCBKG but well below the DCG for tritium of 2E-03 µCi/mL.

NDA Sampling Locations

Gross beta concentrations at location WNNDADR averaged 2.42E-07 µCi/mL in 1994. (See Table 2-4 and Table C-1.22 in *Appendix C-1*.) Concentrations at this location were above the average seen at background location WFBCBKG but are all well below the DCG for strontium-90 (1E-06 µCi/mL). In fact, the highest quarterly composite isotopic strontium-90 result was only 14% of its DCG. The overall trend for gross beta concentrations at this location has remained relatively

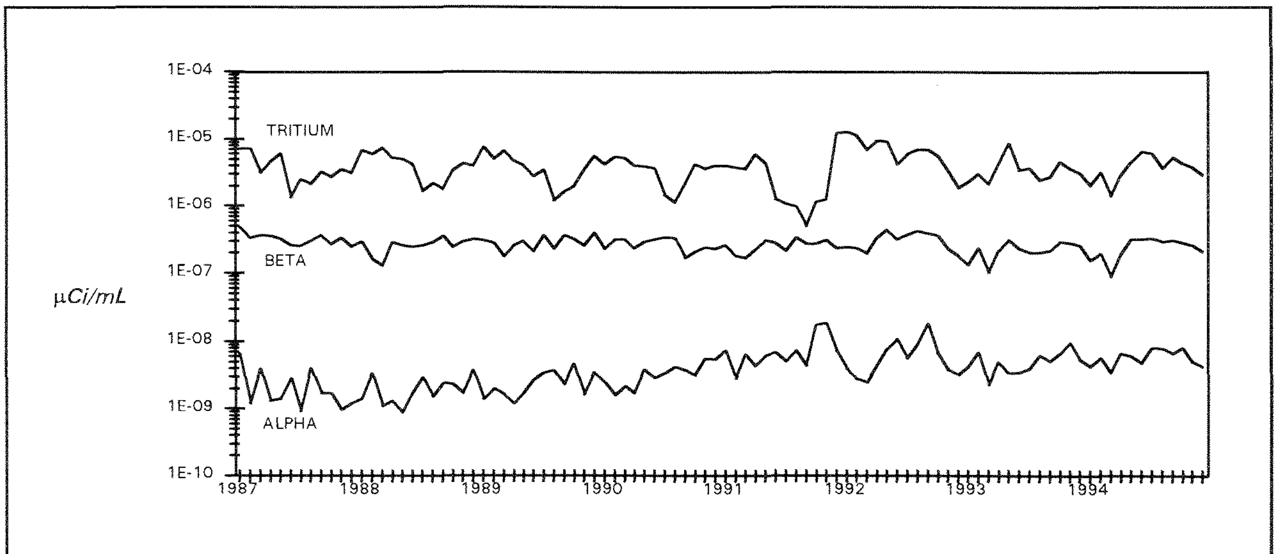


Figure 2-7. Eight-Year Trends of Gross Alpha, Gross Beta, and Tritium Concentrations at Sampling Location WNNDADR

Table 2-3

1994 Gross Alpha Activity at Surface Water Sampling Locations

Location	Number of Samples Analyzed	Range μCi/mL	Range Bq/L	Annual Average μCi/mL	Annual Average Bq/L
OFF-SITE					
WFBIGBR	12	<1.63E-09 — <3.92E-09	<6.02E-02 — <1.45E-01	-0.16±2.91E-09	-0.06±1.08E-01
WFBCBKG	12	<1.23E-09 — 5.79E-09	<4.55E-02 — 2.02E-01	0.61±2.48E-09	2.27±9.21E-02
WFBCTCB	12	<1.40E-09 — <3.76E-09	<5.18E-02 — <1.39E-01	0.13±2.48E-09	0.47±9.18E-02
WFFELBR	52	<1.36E-09 — <5.67E-09	<4.85E-02 — <2.10E-01	0.57±2.95E-09	0.21±1.09E-01
ON-SITE					
WNNDADR	12	<2.43E-09 — <7.90E-09	<9.00E-02 — <2.92E-01	-0.70±5.41E-09	-0.26±2.00E-01
WNSWAMP	52	<2.21E-09 — 1.76E-08	<8.18E-02 — 6.51E-01	3.04±6.87E-09	1.12±2.54E-01
WNSW74A	52	<1.13E-09 — <8.64E-09	<4.18E-02 — <3.20E-01	-0.21±5.28E-09	-0.08±1.94E-01
WNSP006	52	<1.44E-09 — <1.44E-08	<5.73E-02 — <5.33E-01	1.65±5.98E-09	0.61±2.21E-01

Table 2-4

1994 Gross Beta Activity at Surface Water Sampling Locations

Location	Number of Samples Analyzed	Range μCi/mL	Range Bq/L	Annual Average μCi/mL	Annual Average Bq/L
OFF-SITE					
WFBIGBR	12	<2.02E-09 — 5.44E-09	<7.47E-02 — 2.01E-01	2.75±2.07E-09	1.02±0.77E-01
WFBCBKG	12	<1.88E-09 — 1.41E-08	<6.96E-02 — 5.22E-01	3.62±1.88E-09	1.34±0.68E-01
WFBCTCB	12	5.81E-09 — 1.45E-08	2.15E-01 — 5.37E-01	9.20±2.35E-09	3.40±0.87E-01
WFFELBR	52	<1.57E-09 — 1.08E-08	<5.81E-02 — 4.00E-01	3.70±2.18E-09	1.37±0.81E-01
ON-SITE					
WNNDADR	12	8.81E-08 — 3.22E-07	3.26E+00 — 1.19E+01	2.42±0.13E-07	8.97±0.48E+00
WNSWAMP	52	7.46E-07 — 3.58E-06	2.76E+01 — 1.32E+02	1.59±0.04E-06	5.89±0.14E+01
WNSW74A	52	<4.96E-09 — 1.92E-08	<1.84E-01 — 7.10E-01	1.30±0.54E-08	4.82±2.00E-01
WNSP006	52	1.70E-08 — 6.52E-07	6.29E-01 — 2.41E+01	9.75±0.96E-08	3.61±0.36E+00

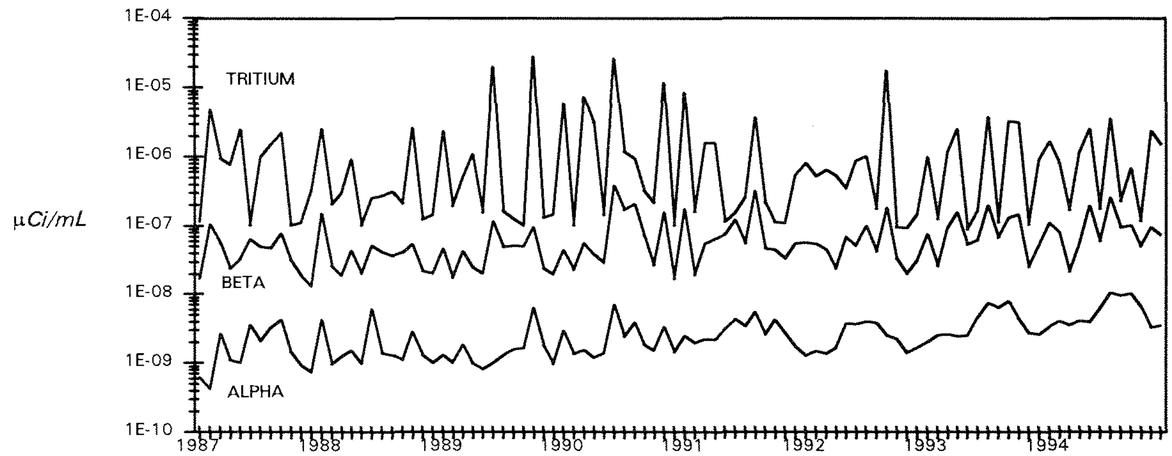


Figure 2-8. Eight-Year Trends of Gross Alpha, Gross Beta, and Tritium Concentrations at Sampling Location WNSP006

constant over time (Fig. 2-7). Except for seasonal variation, the same is true of tritium.

A key indicator of any possible migration of solvent from the NDA would be the presence of significant iodine-129 in samples from WNNDADR. (See **Special Monitoring** below.) The second, third, and fourth quarter 1994 iodine-129 values at WNNDADR were marginally positive, yet they were not significantly higher than the analytical detection limit. Iodine-129 values obtained from waters collected from the NDA interceptor trench, closer to the NDA, were all below the analytical detection limit.(See *Appendix C-1*, Table C-1.22.) It should be noted that while tritium activity in trench waters is higher than that seen at WNNDADR farther downstream, gross beta activity is actually higher downstream at WNNDADR than in waters from the interceptor trench. One possible explanation for this is that while the source of elevated tritium in the drainage may be the NDA, the major source of elevated gross beta activity may be contaminated soils outside and around the NDA.

Frank's Creek Sampling Location

At sampling location WNSP006 at the Project security fence more than 4 kilometers from the nearest public access point, the most significant beta-emitting radionuclides were measured at 2.36E-08 μCi/mL (0.87 Bq/L) for cesium-137 and 5.30E-08 μCi/mL (1.96 Bq/L) for strontium-90 during the month of highest concentration. This corresponds to 0.8% of the DCG for cesium-137 and 5.3% of the DCG for strontium-90. The annual average concentration of cesium at WNSP006 was less than 0.5% of the DCG and the strontium concentration was 3.2% of the strontium DCG. Tritium, at an annual average of 1.22E-06 μCi/mL (4.51E+01 Bq/L), was 0.06% of the DCG value. Of the fifty-two samples collected and analyzed for gross alpha during 1994, five were above the detection limit. The annual average was less than 6.27E-09 μCi/mL (2.32E-01 Bq/L) gross alpha or less than 20.9% of the DCG for americium-241. The eight-year trends of gross alpha, gross beta, and tritium concentrations at location WNSP006 are shown in Figure 2-8. The trend of baseline gross beta activity seems to be increasing slightly over time and possibly is related to either increases in direct

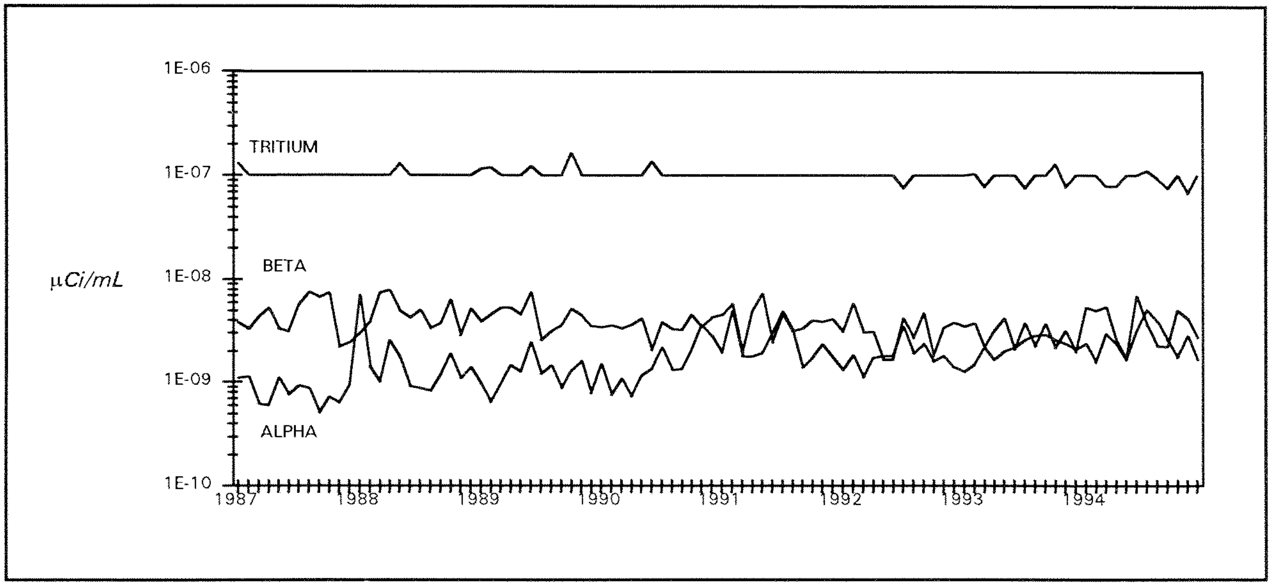


Figure 2-9. Eight-Year Trends of Gross Alpha, Gross Beta, and Tritium Concentrations at Sampling Location WFFELBR

effluent discharged or to the migration of historical site contamination. This trend is reflected in radiological measurements of stream flow during periods when lagoon 3 is not discharged and there is less surface runoff. This trend is not observed farther downstream at the Felton Bridge sampling location, the first point of public access.

Standing Pond Water

Four ponds within the retained premises (WNYNSC) were tested in 1994 and found to be within the historical range observed at these locations for gross alpha, gross beta, and tritium. These results were also compared to a background sample from a pond 14 kilometers (8.7 mi) north of the Project and were found to be statistically the same. (See Table C - 1.28.)

Radioactivity Concentrations Off-site: Surface Water Sampling Locations

Radiological concentration data from off-site sample points show that average gross beta radioactivity concentrations generally tend to be higher in Buttermilk Creek below the WVDP site, presumably because small amounts of radioactivity from the site enter Buttermilk Creek via Frank's Creek. This is particularly observable during periods of lagoon 3 discharge. Tables 2-3 and 2-4 list the ranges and annual averages for gross alpha and gross beta activity at surface water locations. Additional information is available in *Appendix C* tables for all off-site surface monitoring locations.

Thomas Corners Bridge Sampling Location

These data show that concentrations downstream of the site are only marginally higher than background concentrations upstream of the site. Because dairy cattle have access to waters at the Thomas Corners Bridge sampling point, this sample point represents a direct pathway to humans. In actuality, gross beta includes other isotopes from naturally occurring sources as well as manmade sources. If the maximum beta concentration in Buttermilk Creek downstream of the Project at Thomas Corners Bridge were attributable entirely to strontium-90, then the radioactivity would represent only 1.5% of the DCG.

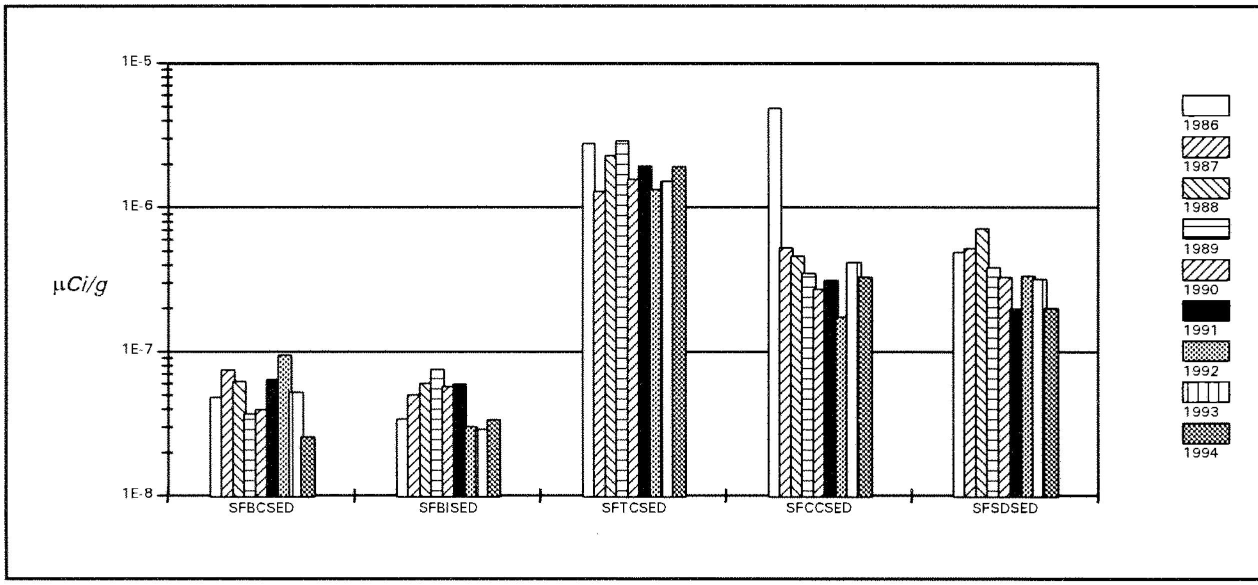


Figure 2-10. Nine-Year Trend of Cesium-137 (μCi/g dry) in Stream Sediment for Two Locations Upstream and Three Locations Downstream of the WVDP

Cattaraugus Creek at Felton Bridge Sampling Location

The highest concentrations in monthly composite water samples from Cattaraugus Creek during 1994 show strontium-90 to be only 0.7% of the DCG for water. There were no positive detections of cesium-137 in Cattaraugus Creek during 1994. (See Table C-1.7.) Yearly averages for Cattaraugus Creek gross beta activity at Felton Bridge are not significantly higher than background levels. Figure 2-9 shows the eight-year trends for Cattaraugus Creek samples analyzed for gross alpha, gross beta, and tritium. Note that for the most part, tritium concentrations represent method detection limits and not actually detected radioactivity. Gross beta activity appears to have declined at this location since 1987.

Sediment Sampling

Sediments are grab-sampled semiannually at or near three of the automatic water sampling locations and at two additional points. (See Fig. 2-4.) Downstream locations are Buttermilk Creek at Thomas Corners Road (SFTCSED), Cattaraugus Creek at Felton Bridge (SFCCSED), and Cattaraugus Creek at the Springville dam (SFSDSED). Upstream locations are Buttermilk Creek at Fox Valley Road (SFBCSED) and Cattaraugus Creek at Bigelow Bridge (SFBISED).

A comparison of annual averaged 1986 to 1994 cesium-137 concentrations for these five sampling locations is illustrated in Figure 2-10. As reported in previous years, cesium-137 concentrations in sediments collected downstream of the WVDP are higher than those observed in samples collected from background locations (SFBCSED or SFBISED). As the figure indicates, although the measured cesium-137 concentrations for 1994 generally were higher than previous years' values in a number of cases, overall the concentrations appear to be decreasing or staying constant with time at the downstream locations. While the cesium-137 activity in downstream Cattaraugus Creek sediments (at locations SFCCSED and SFSDSED) is elevated relative to upstream values, it is comparable to or less than normal background concentrations (as measured at SFGRVAL and SFDNKRK) in surface soil in Western New York. Use of these sediments in place of normal soil for farming or residential applications would result in a lower radiation

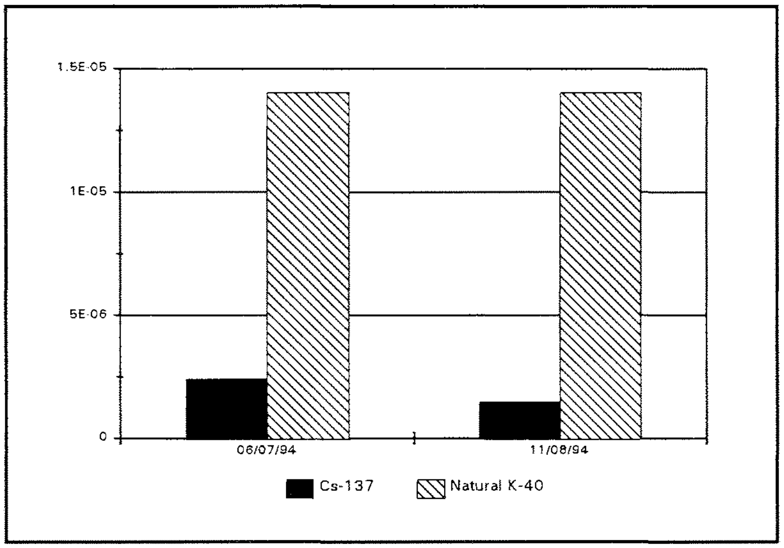


Figure 2-11. Comparison of Cesium-137 with Naturally Occurring Potassium-40 Concentrations in 1994 at Downstream Sampling Location SFTCSED

dose or a dose as small as that from the background cesium deposited by worldwide fallout. Although the concentration in Buttermilk Creek (at SFTCSED) below the Nuclear Fuel Services (NFS) plant site exceeds that of normal soil, these sediments would qualify for release for unrestricted use such as home building if typical regulatory criteria were applied.

A comparison of cesium-137 to the naturally occurring gamma-emitter potassium-40 (Fig. 2-11) for the downstream location nearest the Project (Buttermilk Creek at Thomas Corners Road – SFTCSED) indicates that cesium-137 is present at levels lower than naturally occurring gamma emitters. Results of sediment sampling upstream and downstream of the Project are tabulated in *Appendix C-1*, Table C-1.9. When alpha isotopic results for background location SFBCSED are compared to those for SFTCSED, downstream of the site, no significant differences are observed.

Radioactivity in the Food Chain

Each year food samples are collected from locations near the site and from remote locations (Fig. 2-12). Fish and deer are collected during periods when they would normally be taken by sportsmen for consumption. In addition, milk is collected monthly and beef semiannually from cows grazing near the site and at remote locations. Hay, corn, apples, and beans are collected at the time of harvest.

Fish

Ten fish samples are collected semiannually above the Springville dam from the portion of Cattaraugus Creek that is downstream of WNYNSC drainage (BFFCATC). Ten fish samples are also collected annually from Cattaraugus Creek below the dam (BFFCATD), including species that migrate nearly forty miles upstream from Lake Erie. These specimens are representative of sport fishing catches in the creek downstream of the dam at Springville.

Ten control fish are taken semiannually from waters that are not influenced by site runoff (BFFCTRL). These control samples, containing no radioactivity from WVDP effluents, allow comparisons with the concentrations found in fish taken from site-influenced waters. The control samples are representative of the species collected in Cattaraugus Creek downstream from the WVDP. A combined total of fifty fish were collected from the locations described above. Under a collector's permit, these fish are obtained by electrofishing, a method that temporarily stuns the fish, allowing them to be netted for collection. This also allows a more varied selection as compared to sport fishing, with unwanted fish being returned to the creek unharmed.

Radioactivity Concentrations in Fish Samples

The edible portion of each individual fish collected was analyzed for strontium-90 content and

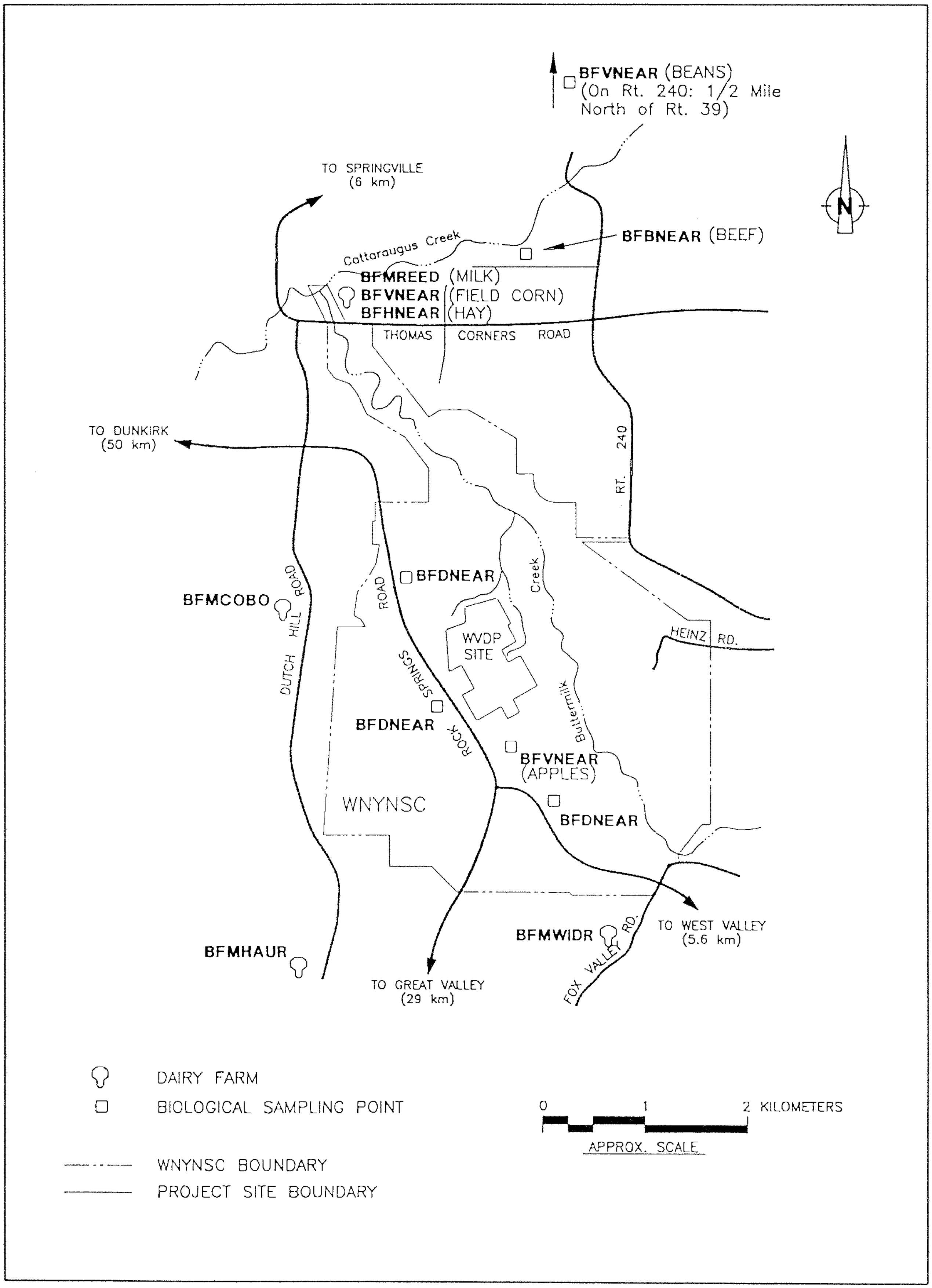


Figure 2-12. Near–site Biological Sampling Points.

the gamma-emitting isotopes cesium-134 and cesium-137. (See Table C-3.4 in *Appendix C-3* for a summary of the results.) Throughout the year concentrations of strontium-90 ranged from below the minimum detectable concentration (see *Glossary*) to a maximum of 3.40E-07 µCi/g at BFFCATC and from below the minimum detectable concentration to 1.10E-07 µCi/g at the control location (BFFCTRL). As discussed in *Chapter 4, Radiological Dose Assessment*, strontium-90 has been observed in marginally higher concentrations than background in the population of bottom-feeding fish downstream of the site but above the Springville dam. Despite this small difference, all downstream fish concentrations are still within the range of Project historical background values.

Although ten fish collected downstream of the site showed marginal positive detections for cesium-137, these cesium concentrations were all within the range of those seen at the background location. Two downstream fish samples had positive detections of cesium-134 but were not statistically different from concentrations in background fish.

Venison

Specimens from an on-site deer herd also are analyzed for radioactive components. Historically, concentrations of radioactivity in deer flesh have been very low and Project activities have not been shown to affect the local herd.

Radioactivity Concentrations in Venison

Venison from three deer taken from the area around the WNYNSC were analyzed and the data compared with those from deer collected in the towns of Portville, Portland, and Salamanca, New York, far from the site. Low levels of radioactivity were detected for both near-site and control samples for cesium-137 and naturally occurring potassium-40. Results for these samples are shown in Table C-3.2 in *Appendix C-3*. Concentrations in near-site deer were at or below background levels for those radioisotopes in 1994. The range in concentrations observed was similar to previous years. Neither strontium-90 nor cesium-134 were detected in near-site or control deer during 1994. Tritium concentrations in near-site deer were lower or the same as those found in background deer.

During the 1994 large game hunting season, local hunters were allowed guided access to the easternmost side of the WVDP premises in a controlled hunting program established by NYSERDA. Five deer were collected during this pilot program.

Beef

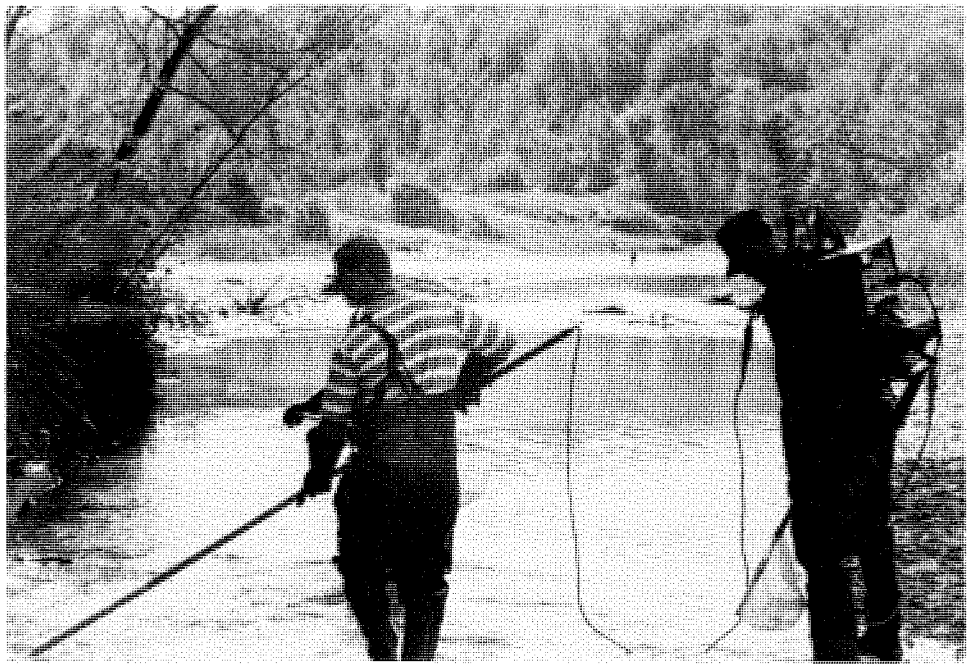
Again in 1994, as in previous years, very little difference in isotopic concentration has been observed between near-site and control herds. Beef samples taken semiannually from near-site and remote locations are analyzed for tritium, strontium-90, and gamma-emitting isotopes such as cesium-134 and cesium-137.

Radioactivity Concentrations in Beef Samples

In 1994 there was one marginally positive detection for both cesium-137 and strontium-90 in beef. In both cases these positive detections were in control samples. Results for all near-site and control samples were near or below the minimum detectable concentrations for tritium and cesium-134. These results are presented in Table C-3.2 in *Appendix C-3*.

Milk

Monthly milk samples were taken in 1994 from dairy farms near the site and from control farms at some distance from the site. (See Fig. 2-12.) Besides the quarterly composite of monthly samples from the maximally exposed herd to the north (BFMREED), a quarterly composite of milk from a nearby herd to the northwest (BFMCOBO) also was prepared. Single annual samples were taken from herds to the southeast (BFMWIDR) and the



Electrofishing in Cattaraugus Creek

tive detections were not statistically different. There were no positive detections of iodine-129 in any samples in 1994. Results for tritium analyses showed only one marginally positive result for near-site locations. The results of all of these analyses are shown in Table C-3.1 in *Appendix C-3.*

Fruit and Vegetables

Results from the analysis of beans, apples, sweet corn, and hay collected during 1994 are presented in Table C-3.3 in *Appendix C-3*. Tritium was detected in near-site corn, bean, and apple samples at levels that were not significantly higher than historical background samples.

Positive strontium-90 results were obtained in green bean and hay samples. Of these positive results, only the near-site bean sample indicated strontium at higher concentrations than its background in 1994. However, this value is statistically the same as historical background concentrations.

Cesium-137 was detected in near-site hay samples at concentrations statistically similar to background.

Cobalt-60 values were at or below minimum detectable concentrations in all samples collected. Overall results obtained for 1994 are comparable to previous years.

southwest (BFMHAUR). Monthly samples from control herds (BFMCTLN and BFMCTLS) were also prepared as quarterly composites. (See Fig. A-9 in *Appendix A* for control sample locations.)

Radioactivity Concentrations in Milk Samples

Each milk sample was analyzed for strontium-90, iodine-129, gamma-emitting isotopes (cesium-134 and -137), and tritium. Strontium-90 was detectable in all near-site and control samples. The strontium-90 results for near-site milk ranged from 1.3E-09 to 5.3E-09 µCi/mL (4.8E-02 to 2.0E-01 Bq/L), and the control milk samples ranged from 1.4E-09 to 3.10E-09 µCi/mL (5.2E-02 to 1.1E-01 Bq/L). Although the annual sample collected at near-site location BFMHAUR is higher than the highest control sample seen in 1994, it is statistically the same as the historical background values.

Three control samples and one near-site sample showed positive values for cesium-137. The posi-

Direct Environmental Radiation Monitoring

The current monitoring year, 1994, was the eleventh full year in which direct penetrating radiation was monitored at the WVDP using TLD-700 lithium fluoride (LiF) thermoluminescent dosimeters (TLDs). The dosimeters are processed on-site and are used solely for environmental monitoring. The environmental TLD package consists of five TLD chips laminated on a card bearing the location identification and other information. These cards are placed at each monitoring location for one calendar quarter (three months) and are then processed to obtain the integrated gamma radiation exposure.

Monitoring points are located around the WNYNSC perimeter and the access road, at the waste management units, at the site security fence, and at background locations remote from the WVDP site. (See Figs. 2-13 and 2-14 and Fig. A-9 in *Appendix A*.) The TLDs are numbered in order of their installation. The monitoring locations are as follows:

THE PERIMETER OF THE WNYNSC: TLDs #1-16, #20

THE PERIMETER OF THE WVDP SITE-SECURITY FENCE: TLDs #24, #26-29, #32-34

ON-SITE SOURCES OR SOLID WASTE MANAGEMENT UNITS: TLDs #18 and #32-36 (RTS drum cell); #18, #19, #33, #42, and #43 (SDA); #24 (component storage, near the WVDP site security fence); #25 (the maximum measured exposure rate at the closest point of public access); #38 (main plant and cement solidification system); #39 (parking lot security fence closest to the vitrification facility); #40 (high-level waste tank farm). Locations #42 and #43 were added during the third calendar quarter of 1994.

NEAR-SITE COMMUNITIES: TLDs #21 (Springville); #22 (West Valley)

BACKGROUND: TLDs #17 (Five Points Landfill in Mansfield); #23 (Great Valley); #37 (Dunkirk); #41 (Sardinia).

The statistical uncertainties of individual results and averages of those results were acceptable, and measured exposure rates were comparable to those of 1993. There was no significant difference between the pooled quarterly average background TLDs (#17, #23, #37, and #41) and the pooled average for the WNYNSC perimeter locations for the 1994 reporting period.

Appendix C-4 provides a summary of the results by calendar quarter for each of the environmental monitoring locations along with averages for comparison.

The quarterly averages and individual location results show very slight differences due to seasonal variation. The data obtained for all four calendar quarters compared favorably to the respective quarterly data in 1993. The quarterly average of the seventeen WNYNSC perimeter TLDs was 19.2 milliroentgen (mR) per quarter (18.4 mrem/quarter) in 1994.

The perimeter TLD quarterly averages since 1987, expressed in microroentgen per hour (μR/hr), are shown in Figure 2-15.

On-site Radiation Monitoring

The dosimeter at location #19 near the SDA routinely shows radiation exposures slightly above those seen at WNYNSC perimeter locations. Locations #25, #29, and #30 on the public access road west of the facility and #26 at the east security fence also showed small elevations above background. Although above background, the readings are relatively stable from year to year. (See *Appendix C-4*, Table C-4.1.)

Location #24 on the north inner facility fence is a co-location site for one Nuclear Regulatory Commission (NRC) TLD. (See *Appendix D*,

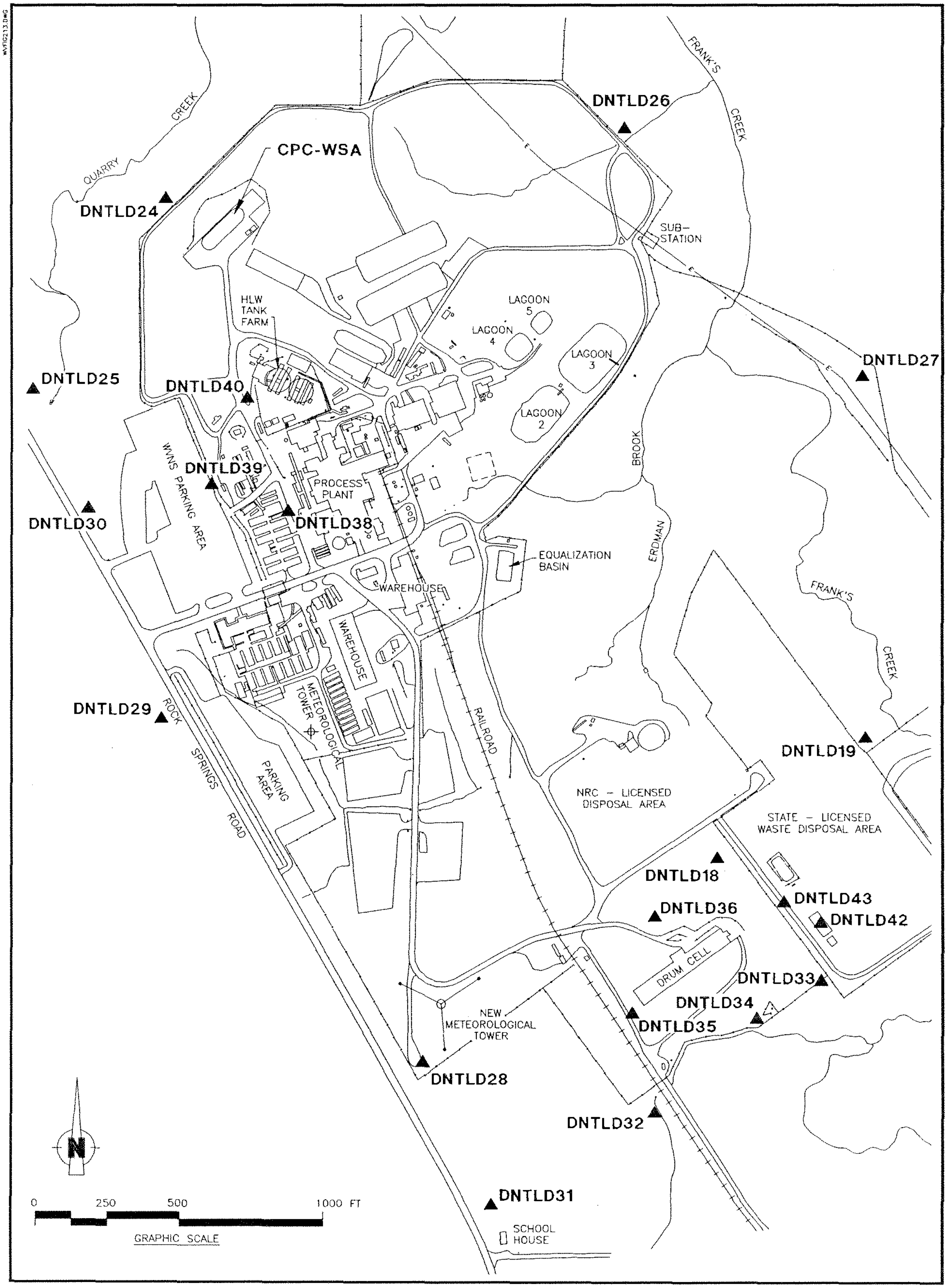


Figure 2-13. Location of On-site Thermoluminescent Dosimetry (TLD).

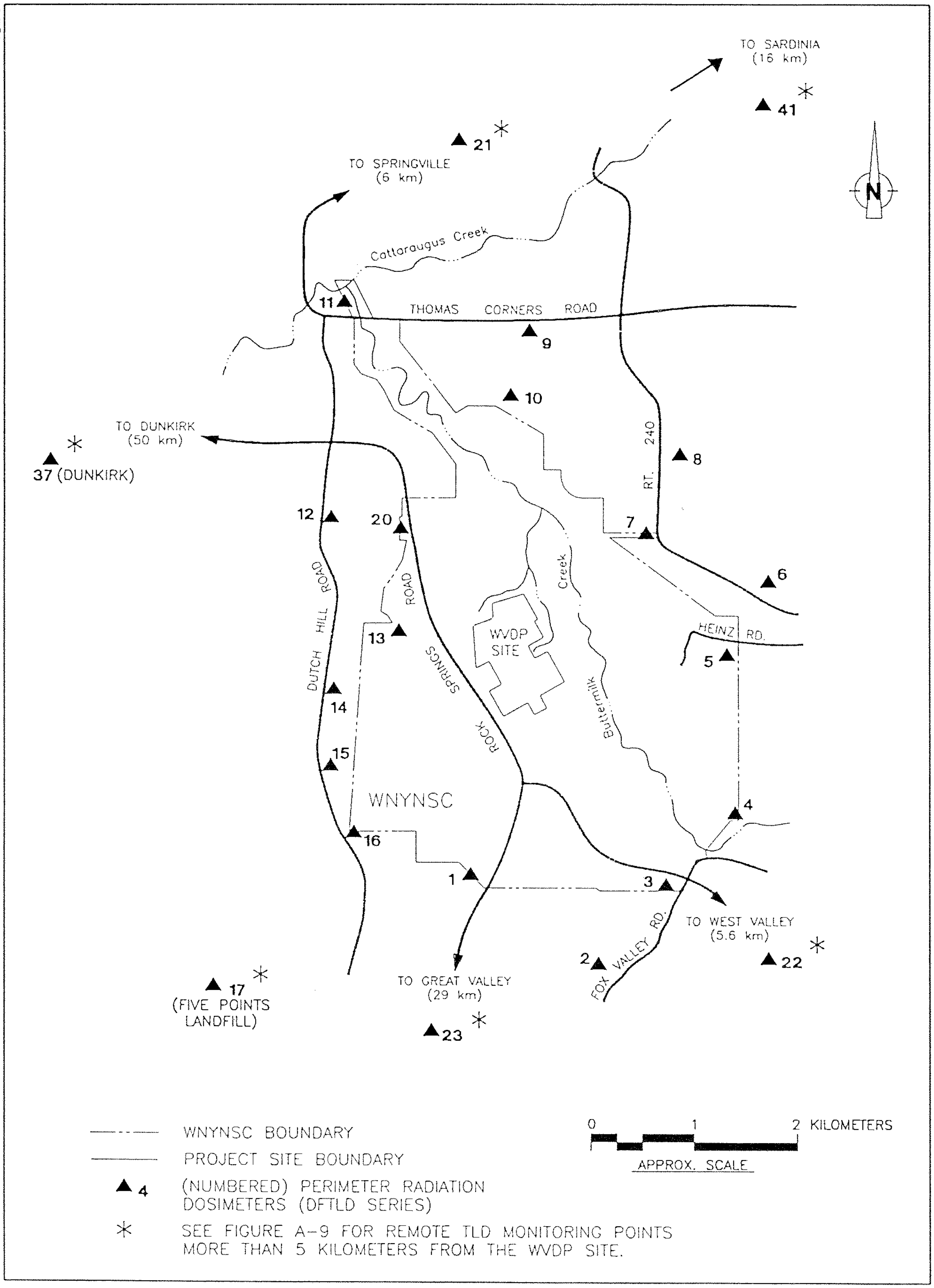


Figure 2-14. Location of Off-site Thermoluminescent Dosimetry (TLD).

Table D-8.) This point received an average exposure of 0.47 milliroentgens (mR) per hour during 1994, as opposed to 0.48 mR/hr in 1993 and 0.52 mR/hr in 1992. Sealed containers of radioactive components and debris from the plant decontamination work are stored nearby. The decline in exposure rate over time is due to radioactive decay of the materials stored within. The storage area is well within the WNYNSC boundary and is not accessible by the public.

Locations around the radwaste treatment storage (RTS) building – the drum cell – stayed the same or increased slightly during the 1994 calendar year. The average dose rate at these locations (TLDs #18, #32, #33, #34, #35, and #36) was 0.023 mR/hr in 1994, similar to the level observed in 1993. These exposure rates, which are above background levels, reflect the placement in the building of drums containing decontaminated supernatant mixed with cement. The drum cell and the surrounding TLD locations are well within the WNYNSC boundary and are not accessible by the public.

Locations #27, #28, and #31 at the security fence are at levels near background. These locations are more distant from radioactive waste storage areas on-site.

Results for the new locations added in 1994, #42 and #43, are elevated above background locations, reflecting their positions near waste storage areas.

Perimeter and Off-site Radiation Monitoring

The perimeter TLDs (TLDs #1-16 and #20) are located in the sixteen compass sectors around the facility near the WNYNSC boundary. The quarterly averages for these TLDs (Fig. 2-15) indicate no trends other than normal seasonal fluctuations. TLDs #17, #21-23, #37, and #41 monitor near-site community and background locations. The results from these monitoring points are essentially the same as the perimeter TLDs. Figure C-4.1 in *Appendix C-4* shows the average quarterly exposure rate at each off-site TLD location. Figure C-4.2 shows the average quarterly exposure rate at each on-site TLD.

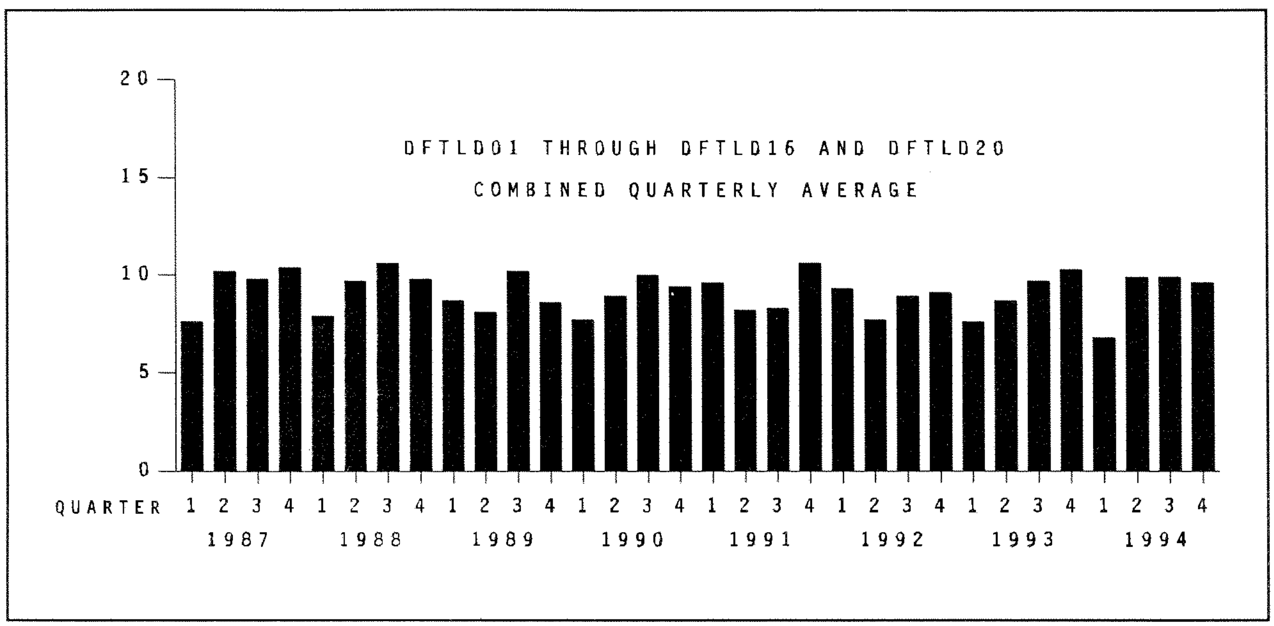


Figure 2-15. Trend of Environmental Radiation Levels (μR/hr)

Meteorological Monitoring

Meteorological monitoring at the WVDP provides representative and verifiable data that characterize the local and regional climatology of the site. These data are used primarily to assess potential effects of routine and nonroutine releases of airborne radioactive materials and to calculate dispersion models for any releases that may exceed DOE effluent limits.

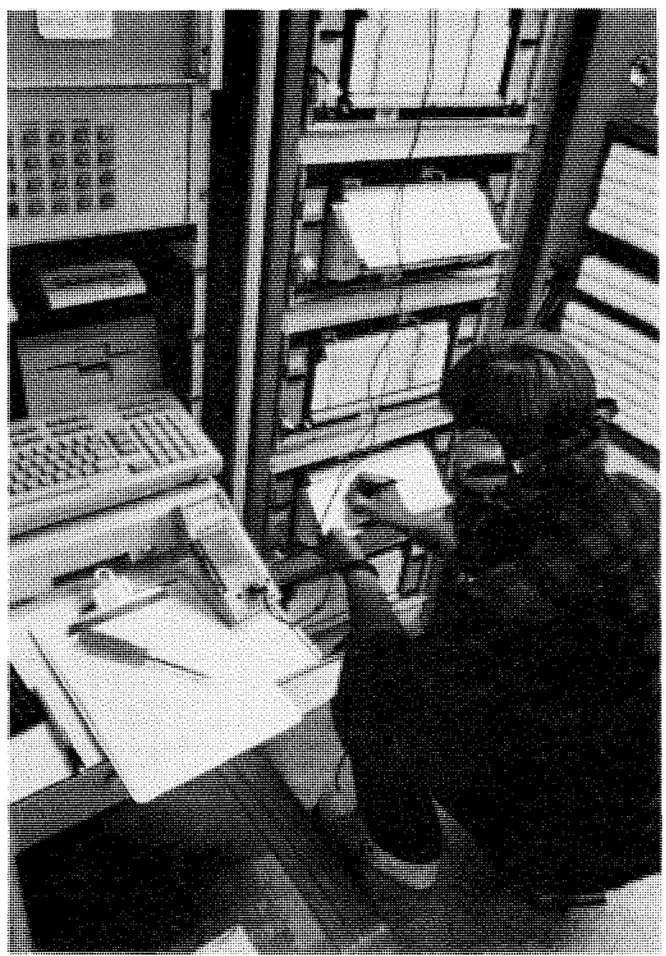
Since dispersive capabilities of the atmosphere are dependent upon wind speed, wind direction, and atmospheric stability (which is a function indicated by the difference in temperature between the 10-meter and 60-meter elevations), these parameters are closely monitored and are available to the emergency response organization at the WVDP.

The on-site 60-meter meteorological tower continuously monitors wind speed and wind direction. (See Fig. 2-1.) Temperatures are measured at both 60-meter and 10-meter elevations. In addition, an independent, remote 10-meter meteorological station located approximately 5 kilometers south of the site on the top of Dutch Hill Road continuously monitors wind speed and wind direction. Dewpoint, precipitation, and barometric pressure are also monitored at the on-site meteorological tower location.

The two meteorological locations supply data to the primary digital and analog data acquisition systems located within the Environmental Laboratory. On-site systems are provided with either uninterruptible or standby power backup in case of site power failure. Figures C-6.1 and C-6.2 in *Appendix C-6* illustrate 1994 mean wind speed and wind direction at the 10-meter and 60-meter elevations. Regional data at the 10-meter elevation are shown in Figure C-6.3.

Weekly and cumulative total precipitation data are illustrated in Figures C-6.4 and C-6.5 in *Appendix C-6*. Precipitation in 1994 was approximately 40 inches (2% below the annual average of 41 inches).

Information such as meteorological system calibration records, site log books, and analog strip charts are stored in protected archives. Electronic files containing meteorological data are copied (downloaded) daily and stored off-site. Meteorological towers and instruments are examined three times weekly for proper function and are calibrated semiannually and/or whenever instrument maintenance might affect calibration.



Checking Data from the Meteorological Tower

In 1994 the operational checkout of a new primary meteorological monitoring tower installed in 1993 was completed. This new tower was installed to replace the original 60-meter tower that had been encroached upon by essential on-site construction. Data collected during a six-month period of parallel operations were evaluated. It was concluded that there were no significant differences between the two monitoring locations. After this evaluation was completed, the instruments were removed from the old tower. The new tower's computerized data acquisition system is similar to the old one but has improved data-reporting features.

Special Monitoring

NRC-licensed Disposal Area (NDA) Interceptor Trench and Pretreatment System

Radioactively contaminated solvent was first discovered at the northern boundary of the NDA in 1983, shortly after the Department of Energy assumed control of the WVDP site. Extensive sampling and monitoring through 1989 revealed the possibility that the solvent could migrate. To contain this subsurface solvent migration, an interceptor trench and liquid pretreatment system (LPS) were built.

The trench was designed to intercept and collect subsurface water, which could be carrying solvent, in order to prevent the solvent from entering the surface water drainage ditch leading into Erdman Brook. The LPS was installed to separate the solvent from the water and to treat the collected water before its transfer to the low-level waste treatment facility. Pretreatment would remove the solvent and reduce the concentration of iodine-129 in the water. The separated solvent would be stored for subsequent treatment and disposal.

In 1994 no water containing solvent was encountered in the trench and no water or solvent has been treated by the LPS.

It should be noted that although it does not by itself demonstrate the effectiveness of the interceptor trench, water containing solvent has never been detected in groundwater monitoring wells outside the NDA or in the surface water drainage downstream of the NDA. During 1994 a functional readiness test of the system was performed to ensure continuing operational readiness. Several opportunities for improving system performance were noted. Enhancements are planned for 1995.

Radiological and nonradiological monitoring data for waters collected from the trench (WNNDATR) and from the drainage just downstream (WNNDADR) have been discussed in this chapter under the on-site surface water section. Results of sampling of the NDA monitoring wells 909 and 910 are discussed in *Chapter 3, Groundwater Monitoring*.

Survey of Trees near the NDA

During a routine radiation survey by the Radiation and Safety Department in 1992, radioactivity was detected in several trees located immediately north of the NDA. The trees were surveyed by placing a calibrated hand-held detector against their trunks. Two species of trees, apple and beech, indicated activity above background. Because the leaves could be blown off-site by the wind and the apples could be eaten by the local deer herd, samples of tree leaves and apples were collected in late fall 1992 and analyzed for radioactivity.

Results received in 1993 indicated that the concentrations of radionuclides in the apples and leaves were sufficiently low that there was no need for action.

Sampling and analysis were repeated in 1994 to determine if there were any changes in the conditions of the trees. Radionuclides that are known site contaminants were measured in leaves and fruit of several trees just north of the NDA boundary. The results from the fruit analyses, when compared to similar off-site samples, show positive levels of strontium-90 and cesium-137 in the on-site fruit. The fruit and leaf analyses are consistent with previous 1993 results: radioactivity is detectable but remains at concentrations that do not warrant further action.

Northeast Swamp Drainage Monitoring

Trend analyses of ground- and surface water monitoring results have indicated increasing gross beta concentrations in waters discharged through the northeast swamp drainage, as monitored at sampling points WNDMPNE and WNSWAMP. Additionally, a series of samples were collected throughout the north plateau area using a Geoprobe® unit. This truck-mounted unit drives a metal rod into the ground to a predetermined depth. Water samples are collected at desired depths and analyzed for radioactivity. Results are being evaluated and plotted on a site map to determine if there are any patterns to the migration of residual site contamination through the groundwater. Results of investigations into these increases are discussed in *Chapter 3, Groundwater Monitoring*, **Subsurface Investigation of Elevated Gross Beta on the North Plateau**.

Waste Tank Farm Underdrain Monitoring

Notable increases in gross beta and tritium activity at location WN8D1DR, attributable to surface contamination, were described in the 1993 annual Site Environmental Report. In the past, this location received subsurface drainage from the high-level waste tank farm area and channeled it to a nearby surface water drainage. Since July 1993, this collection point has been valved off (isolated) from the site's storm drain system and thus no longer discharges to the surface.

Drum Cell Monitoring

Liquid high-level waste (through supernatant treatment and sludge wash) processed by the integrated radwaste treatment system (IRTS) produced more than 18,000 drums of cement-solidified waste by the end of 1994. These drums are currently being stored aboveground in the IRTS drum cell.

Most of the gamma radiation emitted from these drums is shielded by the configuration in which the drums are stacked. However, some radiation is emitted through the roof of the drum cell, which is unshielded. This radiation scatters in air and adds to the existing naturally occurring gamma-ray background.

Radiation exposure levels are monitored at various locations around the drum cell perimeter and at the closest location accessible by the public — approximately 300 meters (984 ft) west at the security fence at Rock Springs Road. Baseline measurements had been taken in 1987 and 1988 before the drums were placed. Two types of measurements were taken: instantaneous, using a high-pressure ion chamber (HPIC), and cumulative, using thermoluminescent dosimeters.

The strength of the gamma-ray field can vary considerably from day to day because of changes in meteorological conditions. TLD measurements provide a more accurate estimate of long-term changes in the radiation field because they integrate the radiation exposure over an entire calendar quarter. Such quarterly readings show evidence of a seasonal cycle. Background radiation levels can vary annually depending on such factors as average temperature, air pressure, humidity, precipitation (including snow cover on the ground), and solar activity during a particular year. The TLD measurements at the Rock Springs Road location (TLDs #28 and #31) are presented in *Appendix C-4*, Table C-4.1.

To assess any increase in the radiation field at the security fence at Rock Springs Road from the drums in the drum cell, HPIC measurements were compared with earlier studies. HPIC measurements made through mid-1994 indicate that the exposure rates at this location were only slightly above those from background readings obtained at the Environmental Laboratory, which is located about 500 meters away from the drum cell. The most recent data also show that exposure rates at Rock Springs Road are the same as or only slightly greater than those seen before any drums were placed in the drum cell.

Closed Landfill Maintenance

Closure of the on-site nonradioactive construction and demolition debris landfill (CDDL) was completed in August 1986. The landfill area was closed in accordance with the New York State Department of Environmental Conservation (NYSDEC) requirements for this type of landfill, following a closure plan (Standish 1985) approved by NYSDEC. To meet routine post-closure requirements, the CDDL cover was inspected in February and September 1994 and was found to be in proper condition. As required, adequate drainage is maintained to ensure that no obvious ponding or soil erosion is occurring and that the grass planted on the clay and soil cap is cut. Results of groundwater monitoring in the area of the closed landfill are presented in *Chapter 3, Groundwater Monitoring*.

Small Mammal Study

In the summer of 1994 a special study was conducted to determine the relative population and gamma-emitting contaminants present in small mammals (mice, voles, and shrews) around the Project premises. Traps were set at six locations: an office trailer complex, the east side of the main plant facility, the packaged radioactive materials storage area, the low-level waste treatment lagoon area, the closed landfill area, and an area on the north side of the NDA.

During twenty-one days in August 1994, 128 mammals were collected in 1,350 trap-nights (one trap set for one night). The sample population consisted mostly of voles (commonly known as "field mice") with other mouse and shrew species represented. The heaviest concentration of samples was collected near the main plant facility; not surprisingly, that population also had the highest number of samples (twenty-five) containing detectable cesium-137. There was also positive radionuclide detection in one specimen from each of two adjacent areas.

The study suggested that potential contaminant transport by small mammals is localized in restricted facility areas. Transport by small mammals was not observed in radioactive waste management or disposal areas. These mammals are not in a direct pathway to man and therefore do not represent a potential dose to humans.

Nonradiological Monitoring

Air Monitoring

Nonradiological emissions and plant effluents are controlled and permitted under NYSDEC and U.S. Environmental Protection Agency (EPA) regulations. The regulations that apply to the WVDP are listed in Table B-2 in *Appendix B*. The individual air permits held by the WVDP are identified and described in Table B-3.

The nonradiological air permits are for sources of regulated pollutants that include particulates, ammonia, nitric acid mist and oxides of nitrogen, and sulfur. However, monitoring of these parameters currently is not required.

Surface Water Monitoring

Liquid discharges are regulated under the State Pollutant Discharge Elimination System (SPDES).

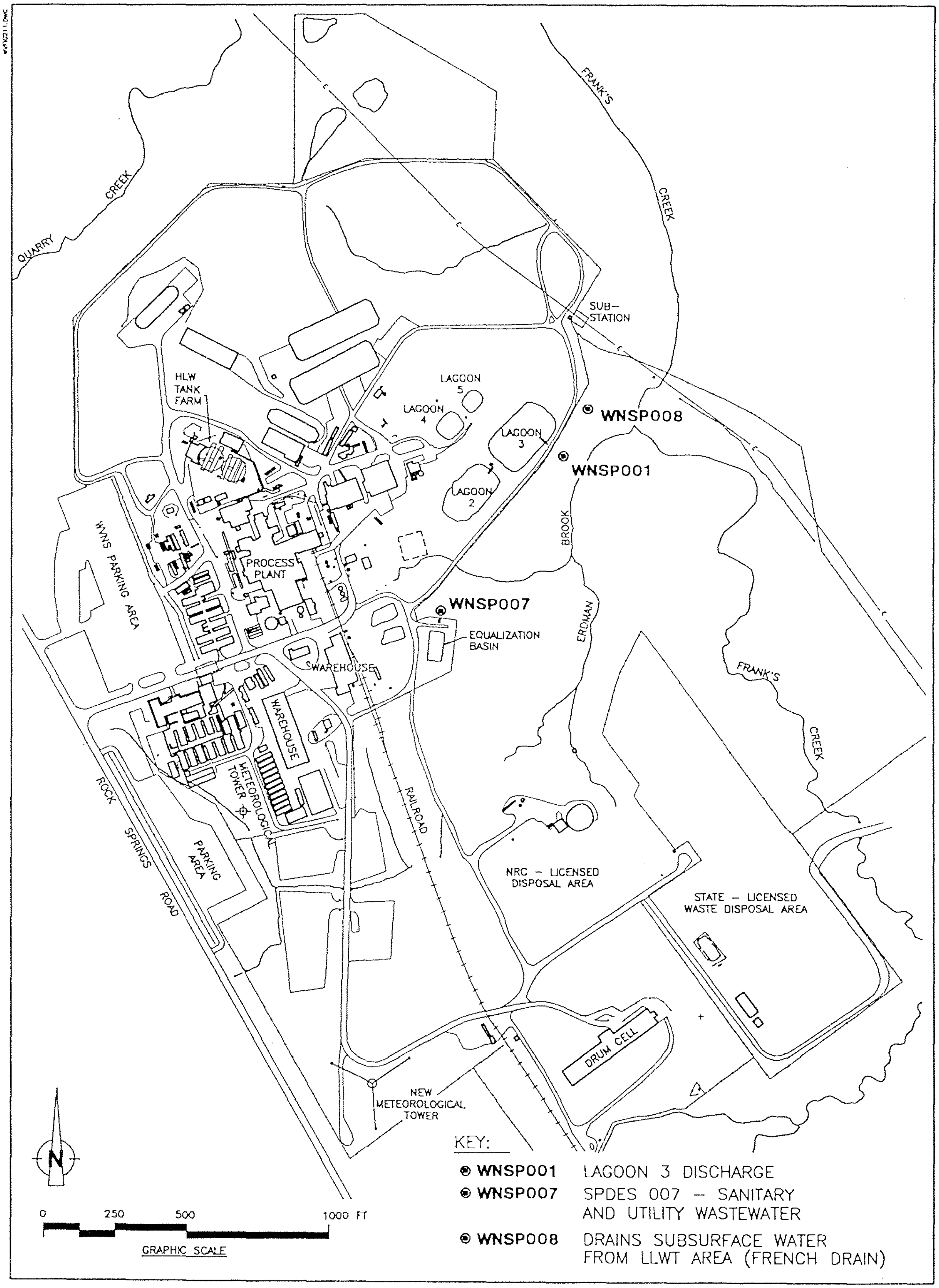


Figure 2-16. SPDES Monitoring Points.

The WVDP holds a SPDES permit that identifies the outfalls where liquid effluents are released to Erdman Brook (Fig. 2-16) and specifies the sampling and analytical requirements for each outfall. This permit was modified in 1990 to include additional monitoring requirements at outfall WNSP001. The WVDP applied for a renewed SPDES permit in 1992. It was received in early January 1994 and went into effect on February 1, 1994 with the expanded monitoring requirements and, in some cases, more stringent discharge limitations. The permit was again modified in April and November of 1994.

Three outfalls were identified in the 1994 permit:

- outfall WNSP001, discharge from the low-level waste treatment facility
- outfall WNSP007, discharge from the sanitary and industrial wastewater treatment facility
- outfall WNSP008, groundwater effluent from the perimeter of the low-level waste treatment facility storage lagoons.

The conditions and requirements of the current SPDES permit are summarized in Table C-5.1 in *Appendix C-5*.

Some of the more significant features of the SPDES permit are the requirements to report biochemical oxygen demand, iron, and ammonia data as flow-weighted concentrations and to apply a net discharge limit for iron. The net limit allows the Project to account for amounts of iron that are naturally present in the site's incoming water. The flow-weighted limits apply to the sum of the Project effluents but allow the more dilute effluents to be factored into the formula for determining compliance with permit conditions.

The SPDES monitoring data for 1994 are displayed in Figures C-5.2 through C-5.52 in *Appendix C-5*. The WVDP reported eighteen noncompliance episodes in 1994 (Table C-5.2). See the *Environmental Compliance Summary: Calendar Year 1994*.

Semiannual grab samples at locations WNSP006 (Frank's Creek at the security fence), WNSWAMP (northeast swamp drainage), WNSW74A (north swamp drainage), and WFBCBKG (Buttermilk Creek at Fox Valley) were taken in 1994. These samples are screened for organic constituents and selected anions, cations, and metals. Results of these measurements for all of these locations are found in Table C-1.11 in *Appendix C-1*.

Appendix C-1, Tables C-1.22 and C-1.23 present NPOC (nonpurgeable organic carbon), TOX, and pH data for two locations that help monitor the NDA, WNNDADR and WNNDATR. When NPOC and TOX values at both locations are compared, the data suggest that even with moderate fluctuation there is little if any significant difference.

Drinking Water Monitoring

As a result of changes in EPA and New York State monitoring requirements, a number of important drinking water monitoring activities were carried out at the site in 1994. (See Safe Drinking Water Act in the *Environmental Compliance Summary: Calendar Year 1994*.) Included was the sampling of the site drinking water for copper and lead concentrations. Additionally, samples were collected to be analyzed for nitrate and nitrite concentration. This sampling activity will be repeated annually as part of the site's drinking water monitoring effort.

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EXPOSURE. Subjecting a target (usually living tissue) to radiation.

FALLOUT. Radioactive materials mixed into the earth's atmosphere. Fallout constantly precipitates onto the earth.

GRADIENT. Change in value of one variable with respect to another variable, especially vertical or horizontal distance, e.g., gravity, temperature, magnetic intensity, electric potential.

GROUNDWATER. Subsurface water in the pore spaces of soil and geologic units.

HALF-LIFE. The time in which half the atoms of a radionuclide disintegrate into another nuclear form. The half-life may vary from a fraction of a second to thousands of years.

HIGH-LEVEL WASTE (HLW). The highly radioactive waste material that results from the reprocessing of spent nuclear fuel, including liquid waste produced directly in reprocessing and any solid waste derived from the liquid, that contains a combination of transuranic waste and fission products in concentrations sufficient to require permanent isolation.

HYDRAULIC CONDUCTIVITY. The ratio of flow velocity to driving force for viscous flow under saturated conditions of a specified liquid in a porous medium; the ratio describing the rate at which water can move through a permeable medium.

ION. An atom or group of atoms with an electric charge.

ION EXCHANGE. The reversible exchange of ions contained in a crystal for different ions in solution without destroying the crystal structure or disturbing the electrical neutrality.

ISOTOPE. Different forms of the same chemical element that are distinguished by having different numbers of neutrons in the nucleus. An element can have many isotopes. For example, the three isotopes of hydrogen are protium, deuterium, and tritium.

KAME DELTA. A conical hill or short irregular ridge of gravel or sand deposited in contact with glacier ice.

LACUSTRINE SEDIMENTS. A sedimentary deposit consisting of material pertaining to, produced by, or formed in a lake or lakes.

LEACHED HULLS. Stainless steel cladding that remains after acid dissolution of spent fuel.

LOW-LEVEL WASTE. Radioactive waste not classified as high-level waste, transuranic waste, spent fuel, or uranium mill tailings. (See Class A,B,C low-level waste).

MAXIMALLY EXPOSED INDIVIDUAL. A hypothetical person who remains in an uncontrolled area who would, when all potential routes of exposure from a facility's operations are considered, receive the greatest possible dose equivalent.

MEAN. The average value of a series of measurements.

MILLIREM (MREM). A unit of radiation dose equivalent that is equal to one one-thousandth of a rem. An individual member of the public can receive up to 500 millirems per year according to DOE standards. This limit does not include radiation received for medical treatment or the 100 to 360 mrem that people receive annually from background radiation.

MINIMUM DETECTABLE CONCENTRATION. The smallest amount or concentration of a radioactive or nonradioactive element that can be reliably detected in a sample.

MIXED WASTE. A waste that is both radioactive and hazardous.

OUTFALL. The end of a drain or pipe that carries waste water or other effluents into a ditch, pond, or river.

PARTICULATES. Solid particles and liquid droplets small enough to become airborne.

PERSON-REM. The sum of the individual radiation dose equivalents received by members of a certain group or population. It may be calculated by multiplying the average dose per person by the number of persons exposed. For example, a thousand people each exposed to one millirem would have a collective dose of one person-rem.

PLUME. The distribution of a pollutant in air or water after being released from a source.

PROGLACIAL LAKE. A lake occupying a basin in front of a glacier; generally in direct contact with the ice.

RAD. Radiation absorbed dose. One hundred ergs of energy absorbed per gram.

RADIATION. The process of emitting energy in the form of rays or particles that are thrown off by disintegrating atoms. The rays or particles emitted may consist of alpha, beta, or gamma radiation.

- ALPHA RADIATION. The least penetrating type of radiation. Alpha radiation can be stopped by a sheet of paper or outer dead layer of skin.

- BETA RADIATION. Electron emitted from a nucleus during fission and nuclear decay. Beta radiation can be stopped by an inch of wood or a thin sheet of aluminum.

- GAMMA RADIATION. A form of electromagnetic, high-energy radiation emitted from a nucleus. Gamma rays are essentially the same as x-rays and require heavy shielding such as lead, concrete, or steel to be stopped.

- INTERNAL RADIATION. Radiation originating from a source within the body as a result of the inhalation, ingestion, or implantation of natural or manmade radionuclides in body tissues.

RADIATION DOSE.

- ABSORBED DOSE. The amount of energy deposited by radiation in a given amount of material. Absorbed dose is measured in rads.

- COLLECTIVE DOSE EQUIVALENT. The sum of the dose equivalents for individuals comprising a defined population. The per capita dose equivalent is the quotient of the collective dose equivalent divided by the population size. (See PERSON-REM).

- COMMITTED DOSE EQUIVALENT (dose commitment). The total dose equivalent accumulated in an organ or tissue in the fifty years following a single intake of radioactive materials into the body.

- CUMULATIVE DOSE EQUIVALENT. The total dose one could receive in a period of fifty years following release of radionuclides to the environment, including the dose that could occur as a result of residual radionuclides remaining in the environment beyond the year of release.

- DOSE EQUIVALENT. The product of the absorbed dose, the quality factor, and any other modifying factors. The dose equivalent is a quantity for comparing the biological effectiveness of different kinds of radiation on a common scale. The unit of dose equivalent is the rem.

- EFFECTIVE DOSE EQUIVALENT. An estimate of the total risk of potential health effects from radiation exposure. It is the sum of the committed effective dose equivalent from internal deposition and the effective dose equivalent from external penetrating radiation received during a calendar year. The committed effective dose equivalent is the sum of the individual organ committed dose equivalents (fifty years) multiplied by weighting factors that represent the proportion of the total random risk that each organ would receive from uniform irradiation of the whole body.

RADIOACTIVITY. A property possessed by some elements such as uranium whereby alpha, beta, or gamma rays are spontaneously emitted.

RADIOISOTOPE. A radioactive isotope of a specified element. Carbon-14 is a radioisotope of carbon. Tritium is a radioisotope of hydrogen.

RADIONUCLIDE. A radioactive nuclide. Radionuclides are variations (isotopes) of elements. They have the same number of protons and electrons but different numbers of neutrons, resulting in different atomic masses.There are several hundred known nuclides, both man-made and naturally occurring.

REM. An acronym for Roentgen Equivalent Man. A unit of radiation exposure that indicates the potential effect on human cells.

SIEVERT. A unit of dose equivalent from the International System of Units equal to one joule per kilogram.

SPENT FUEL. Nuclear fuel that has been exposed in a nuclear reactor; this fuel contains uranium, activation products, fission products, and plutonium.

STANDARD DEVIATION. An indication of the dispersion of a set of results around their average.

THERMOLUMINESCENT DOSIMETER (TLD). A material that luminesces upon heating after being exposed to radiation. The amount of light emitted is proportional to the amount of radiation to which it has been exposed.

UPGRADIENT. Referring to the flow of water or air, it is analogous to upstream. A point that is "before" an area of study that is used as a baseline for comparison with downstream data. See GRADIENT and DOWNGRADIENT.

WATERSHED. The area contained within a drainage divide above a specified point on a stream.

WATER TABLE. The upper surface in a body of groundwater. The surface in an unconfined aquifer or confining bed at which the pore water pressure is equal to atmospheric pressure.

WHOLE-BODY DOSE. A radiation dose that involves exposure of the entire body.

Abbreviations for Units of Measure

Radioactivity

Symbol	*Name*
Ci	curie
mCi	millicurie (1E-03 Ci)
μCi	microcurie (1E-06 Ci)
nCi	nanocurie (1E-09 Ci)
pCi	picocurie (1E-12 Ci)
fCi	femtocurie (1E-15Ci)
aCi	attocurie (1E-18 Ci)
Bq	becquerel (27 pCi)

Volume

Symbol	*Name*
cm^3	cubic centimeter
L	liter
mL	milliliter
m^3	cubic meter
ppm	parts per million
ppb	parts per billion

Dose

Symbol	*Name*
Sv	sievert (100 rems)
Gy	gray (100 rads)

Time

Symbol	*Name*
y	year
d	day
h	hour
m	minute
s	second

Length

Symbol	*Name*
m	meter
km	kilometer (1E+03 m)
cm	centimeter (1E-02 m)
mm	millimeter (1E-03 m)
μm	micrometer (1E-06 m)

Area

Symbol	*Name*
ha	hectare (10,000 m^2)

Mass

Symbol	*Name*
g	gram
kg	kilogram (1E+03 g)
mg	milligram (1E-03)
μg	microgram(1E-06 g)
ng	nanogram (1E-09 g)
t	metric ton (10^3 kg)

Conversion Table

Multiply	*by*	*To obtain*	*Multiply*	*by*	*To obtain*
in.	2.54	cm	cm	0.394	in.
ft	0.305	m	m	3.28	ft.
mi	1.61	km	km	0.621	mi
lb	0.454	kg	kg	2.205	lb
liq. qt.	0.946	L	L	1.057	liq. qt.
ft^2	0.093	m^2	m^2	10.76	ft^2
ha	2.47	acres	acres	0.405	ha
mi^2	2.59	km^2	km^2	0.386	mi^2
ft^3	0.028	m^3	m^3	35.7	ft^3
dpm	0.450	pCi	pCi	2.22	dpm
nCi	1000	pCi	pCi	0.001	nCi
pCi/L	1E-09	μCi/mL	μCi/mL	1E+09	pCi/L
pCi/m^3	1E-12	Ci/m^3	Ci/m^3	1E+12	pCi/m^3
becquerel	2.7E-11	curie	curie	3.7E+10	becquerel
gray	100	rad	rad	0.01	gray
sievert	100	rem	rem	0.01	sievert
ppb	0.001	ppm	ppm	1000	ppb
ppm	1.0	mg/L	mg/L	1.0	ppm

Unit Prefixes

Factor	*Prefix*	*Symbol*
1E+09	giga	G
1E+06	mega	M
1E+03	kilo	k
1E-02	centi	c
1E-03	milli	m
1E-06	micro	μ
1E-09	nano	n
1E-12	pico	p

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fCi	femtocurie (1E-15Ci)
aCi	attocurie (1E-18 Ci)
Bq	becquerel (27 pCi)

Volume

Symbol	*Name*
cm^3	cubic centimeter
L	liter
mL	milliliter
m^3	cubic meter
ppm	parts per million
ppb	parts per billion

Dose

Symbol	*Name*
Sv	sievert (100 rems)
Gy	gray (100 rads)

Time

Symbol	*Name*
y	year
d	day
h	hour
m	minute
s	second

Length

Symbol	*Name*
m	meter
km	kilometer (1E+03 m)
cm	centimeter (1E-02 m)
mm	millimeter (1E-03 m)
μm	micrometer (1E-06 m)

Area

Symbol	*Name*
ha	hectare (10,000 m^2)

Mass

Symbol	*Name*
g	gram
kg	kilogram (1E+03 g)
mg	milligram (1E-03)
μg	microgram(1E-06 g)
ng	nanogram (1E-09 g)
t	metric ton (10^3 kg)

Conversion Table

Multiply	*by*	*To obtain*	*Multiply*	*by*	*To obtain*
in.	2.54	cm	cm	0.394	in.
ft	0.305	m	m	3.28	ft.
mi	1.61	km	km	0.621	mi
lb	0.454	kg	kg	2.205	lb
liq. qt.	0.946	L	L	1.057	liq. qt.
ft^2	0.093	m^2	m^2	10.76	ft^2
ha	2.47	acres	acres	0.405	ha
mi^2	2.59	km^2	km^2	0.386	mi^2
ft^3	0.028	m^3	m^3	35.7	ft^3
dpm	0.450	pCi	pCi	2.22	dpm
nCi	1000	pCi	pCi	0.001	nCi
pCi/L	1E-09	μCi/mL	μCi/mL	1E+09	pCi/L
pCi/m^3	1E-12	Ci/m^3	Ci/m^3	1E+12	pCi/m^3
becquerel	2.7E-11	curie	curie	3.7E+10	becquerel
gray	100	rad	rad	0.01	gray
sievert	100	rem	rem	0.01	sievert
ppb	0.001	ppm	ppm	1000	ppb
ppm	1.0	mg/L	mg/L	1.0	ppm

Unit Prefixes

Factor	*Prefix*	*Symbol*
1E+09	giga	G
1E+06	mega	M
1E+03	kilo	k
1E-02	centi	c
1E-03	milli	m
1E-06	micro	μ
1E-09	nano	n
1E-12	pico	p

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P. McGee	New York Assemblyman 149th Dist.

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Buffalo News, Buffalo, New York *

Salamanca Republican Press,
Salamanca, New York *

Springville Journal, Springville, New York *

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ALLUVIUM. Sedimentary material deposited by flowing water such as a river.

ALLUVIAL FAN. A cone-shaped deposit of alluvium made by a stream where it runs out onto a level plain.

AQUIFER. A water-bearing unit of permeable rock or soil that will yield water in usable quantities to wells. *Confined aquifers* are bounded above and below by less permeable layers. Groundwater in a confined aquifer is under a pressure greater than the atmospheric pressure. *Unconfined aquifers* are bounded below by less permeable material, but are not bounded above. The pressure on the groundwater in an unconfined aquifer at the top of the aquifer is equal to that of the atmosphere.

AQUITARD. A relatively impervious and semiconfining geologic formation that transmits water at a very slow rate compared to an aquifer.

BACKGROUND RADIATION. Includes both natural and manmade radiation such as cosmic radiation and radiation from naturally radioactive elements and from commercial sources and medical procedures.

BECQUEREL (BQ). A unit of radioactivity equal to one nuclear transformation per second.

CLASS A, B, AND C LOW-LEVEL WASTE. Waste classifications from the Nuclear Regulatory Commission's 10 CFR Part 61 rule. Maximum concentration limits are set for specific isotopes. Class A waste disposal is minimally restricted with respect to the form of the waste. Class B waste must meet more rigorous requirements to ensure physical stability after disposal. Greater concentration limits are set for the same isotopes in Class C Waste and it also must meet physical stability requirements. Moreover, special measures must be taken at the disposal facility to protect against inadvertent intrusion.

CONFIDENCE COEFFICIENT OR FACTOR. The chance or probability, usually expressed as a percentage, that a confidence interval includes some defined parameter of a population. The confidence coefficients usually associated with confidence intervals are 90%, 95%, and 99%.

COSMIC RADIATION. High-energy subatomic particles from outer space that bombard the earth's atmosphere. Cosmic radiation is part of natural background radiation.

COUNTING ERROR. The variability caused by the inherent random nature of radioactive disintegration and the detection process.

CURIE(CI). A unit of radioactivity equal to 37 billion (3.7×10^{10})nuclear transformations per second.

DETECTION LEVEL. The minimum concentration of a substance that can be measured with a 99% confidence that the analytical concentration is greater than zero.

DERIVED CONCENTRATION GUIDE (DCG). Concentrations of radionuclides in air and water in which a person continuously exposed and inhaling 8400 m^3 of air or ingesting 730 liters of water per year would receive an annual effective dose equivalent of 100 mrem per year from either mode of exposure. The committed dose equivalent is included in the DCGs for radionuclides with long half-lives. (See Appendix B)

DISPERSION. The process whereby solutes are spread or mixed as they are transported by groundwater as it moves through sediments.

DOSIMETER. A portable device for measuring the total accumulated exposure to ionizing radiation.

DOWNGRADIENT. The direction of water flow from a reference point to a selected point of interest. (See GRADIENT)

EFFECTIVE DOSE. See "Effective Dose Equivalent" under "Radiation dose."

EFFLUENT. Flowing out or forth; an outflow of waste. In this report, effluent refers to the liquid or gaseous waste streams released into the environment from the facility.

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fCi	femtocurie (1E-15Ci)
aCi	attocurie (1E-18 Ci)
Bq	becquerel (27 pCi)

Volume

Symbol	*Name*
cm^3	cubic centimeter
L	liter
mL	milliliter
m^3	cubic meter
ppm	parts per million
ppb	parts per billion

Dose

Symbol	*Name*
Sv	sievert (100 rems)
Gy	gray (100 rads)

Time

Symbol	*Name*
y	year
d	day
h	hour
m	minute
s	second

Length

Symbol	*Name*
m	meter
km	kilometer (1E+03 m)
cm	centimeter (1E-02 m)
mm	millimeter (1E-03 m)
μm	micrometer (1E-06 m)

Area

Symbol	*Name*
ha	hectare (10,000 m^2)

Mass

Symbol	*Name*
g	gram
kg	kilogram (1E+03 g)
mg	milligram (1E-03)
μg	microgram(1E-06 g)
ng	nanogram (1E-09 g)
t	metric ton (10^3 kg)

Conversion Table

Multiply	*by*	*To obtain*	*Multiply*	*by*	*To obtain*
in.	2.54	cm	cm	0.394	in.
ft	0.305	m	m	3.28	ft.
mi	1.61	km	km	0.621	mi
lb	0.454	kg	kg	2.205	lb
liq. qt.	0.946	L	L	1.057	liq. qt.
ft^2	0.093	m^2	m^2	10.76	ft^2
ha	2.47	acres	acres	0.405	ha
mi^2	2.59	km^2	km^2	0.386	mi^2
ft^3	0.028	m^3	m^3	35.7	ft^3
dpm	0.450	pCi	pCi	2.22	dpm
nCi	1000	pCi	pCi	0.001	nCi
pCi/L	1E-09	μCi/mL	μCi/mL	1E+09	pCi/L
pCi/m^3	1E-12	Ci/m^3	Ci/m^3	1E+12	pCi/m^3
becquerel	2.7E-11	curie	curie	3.7E+10	becquerel
gray	100	rad	rad	0.01	gray
sievert	100	rem	rem	0.01	sievert
ppb	0.001	ppm	ppm	1000	ppb
ppm	1.0	mg/L	mg/L	1.0	ppm

Unit Prefixes

Factor	*Prefix*	*Symbol*
1E+09	giga	G
1E+06	mega	M
1E+03	kilo	k
1E-02	centi	c
1E-03	milli	m
1E-06	micro	μ
1E-09	nano	n
1E-12	pico	p

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ALLUVIUM. Sedimentary material deposited by flowing water such as a river.

ALLUVIAL FAN. A cone-shaped deposit of alluvium made by a stream where it runs out onto a level plain.

AQUIFER. A water-bearing unit of permeable rock or soil that will yield water in usable quantities to wells. *Confined aquifers* are bounded above and below by less permeable layers. Groundwater in a confined aquifer is under a pressure greater than the atmospheric pressure. *Unconfined aquifers* are bounded below by less permeable material, but are not bounded above. The pressure on the groundwater in an unconfined aquifer at the top of the aquifer is equal to that of the atmosphere.

AQUITARD. A relatively impervious and semiconfining geologic formation that transmits water at a very slow rate compared to an aquifer.

BACKGROUND RADIATION. Includes both natural and manmade radiation such as cosmic radiation and radiation from naturally radioactive elements and from commercial sources and medical procedures.

BECQUEREL (BQ). A unit of radioactivity equal to one nuclear transformation per second.

CLASS A, B, AND C LOW-LEVEL WASTE. Waste classifications from the Nuclear Regulatory Commission's 10 CFR Part 61 rule. Maximum concentration limits are set for specific isotopes. Class A waste disposal is minimally restricted with respect to the form of the waste. Class B waste must meet more rigorous requirements to ensure physical stability after disposal. Greater concentration limits are set for the same isotopes in Class C Waste and it also must meet physical stability requirements. Moreover, special measures must be taken at the disposal facility to protect against inadvertent intrusion.

CONFIDENCE COEFFICIENT OR FACTOR. The chance or probability, usually expressed as a percentage, that a confidence interval includes some defined parameter of a population. The confidence coefficients usually associated with confidence intervals are 90%, 95%, and 99%.

COSMIC RADIATION. High-energy subatomic particles from outer space that bombard the earth's atmosphere. Cosmic radiation is part of natural background radiation.

COUNTING ERROR. The variability caused by the inherent random nature of radioactive disintegration and the detection process.

CURIE(CI). A unit of radioactivity equal to 37 billion (3.7×10^{10})nuclear transformations per second.

DETECTION LEVEL. The minimum concentration of a substance that can be measured with a 99% confidence that the analytical concentration is greater than zero.

DERIVED CONCENTRATION GUIDE (DCG). Concentrations of radionuclides in air and water in which a person continuously exposed and inhaling 8400 m^3 of air or ingesting 730 liters of water per year would receive an annual effective dose equivalent of 100 mrem per year from either mode of exposure. The committed dose equivalent is included in the DCGs for radionuclides with long half-lives. (See Appendix B)

DISPERSION. The process whereby solutes are spread or mixed as they are transported by groundwater as it moves through sediments.

DOSIMETER. A portable device for measuring the total accumulated exposure to ionizing radiation.

DOWNGRADIENT. The direction of water flow from a reference point to a selected point of interest. (See GRADIENT)

EFFECTIVE DOSE. See "Effective Dose Equivalent" under "Radiation dose."

EFFLUENT. Flowing out or forth; an outflow of waste. In this report, effluent refers to the liquid or gaseous waste streams released into the environment from the facility.

EFFLUENT MONITORING. Sampling or measuring specific liquid or gaseous effluent streams for the presence of pollutants.

EXPOSURE. Subjecting a target (usually living tissue) to radiation.

FALLOUT. Radioactive materials mixed into the earth's atmosphere. Fallout constantly precipitates onto the earth.

GRADIENT. Change in value of one variable with respect to another variable, especially vertical or horizontal distance, e.g., gravity, temperature, magnetic intensity, electric potential.

GROUNDWATER. Subsurface water in the pore spaces of soil and geologic units.

HALF-LIFE. The time in which half the atoms of a radionuclide disintegrate into another nuclear form. The half-life may vary from a fraction of a second to thousands of years.

HIGH-LEVEL WASTE (HLW). The highly radioactive waste material that results from the reprocessing of spent nuclear fuel, including liquid waste produced directly in reprocessing and any solid waste derived from the liquid, that contains a combination of transuranic waste and fission products in concentrations sufficient to require permanent isolation.

HYDRAULIC CONDUCTIVITY. The ratio of flow velocity to driving force for viscous flow under saturated conditions of a specified liquid in a porous medium; the ratio describing the rate at which water can move through a permeable medium.

ION. An atom or group of atoms with an electric charge.

ION EXCHANGE. The reversible exchange of ions contained in a crystal for different ions in solution without destroying the crystal structure or disturbing the electrical neutrality.

ISOTOPE. Different forms of the same chemical element that are distinguished by having different numbers of neutrons in the nucleus. An element can have many isotopes. For example, the three isotopes of hydrogen are protium, deuterium, and tritium.

KAME DELTA. A conical hill or short irregular ridge of gravel or sand deposited in contact with glacier ice.

LACUSTRINE SEDIMENTS. A sedimentary deposit consisting of material pertaining to, produced by, or formed in a lake or lakes.

LEACHED HULLS. Stainless steel cladding that remains after acid dissolution of spent fuel.

LOW-LEVEL WASTE. Radioactive waste not classified as high-level waste, transuranic waste, spent fuel, or uranium mill tailings. (See Class A,B,C low-level waste).

MAXIMALLY EXPOSED INDIVIDUAL. A hypothetical person who remains in an uncontrolled area who would, when all potential routes of exposure from a facility's operations are considered, receive the greatest possible dose equivalent.

MEAN. The average value of a series of measurements.

MILLIREM (MREM). A unit of radiation dose equivalent that is equal to one one-thousandth of a rem. An individual member of the public can receive up to 500 millirems per year according to DOE standards. This limit does not include radiation received for medical treatment or the 100 to 360 mrem that people receive annually from background radiation.

MINIMUM DETECTABLE CONCENTRATION. The smallest amount or concentration of a radioactive or nonradioactive element that can be reliably detected in a sample.

MIXED WASTE. A waste that is both radioactive and hazardous.

OUTFALL. The end of a drain or pipe that carries waste water or other effluents into a ditch, pond, or river.

PARTICULATES. Solid particles and liquid droplets small enough to become airborne.

PERSON-REM. The sum of the individual radiation dose equivalents received by members of a certain group or population. It may be calculated by multiplying the average dose per person by the number of persons exposed. For example, a thousand people each exposed to one millirem would have a collective dose of one person-rem.

PLUME. The distribution of a pollutant in air or water after being released from a source.

PROGLACIAL LAKE. A lake occupying a basin in front of a glacier; generally in direct contact with the ice.

RAD. Radiation absorbed dose. One hundred ergs of energy absorbed per gram.

RADIATION. The process of emitting energy in the form of rays or particles that are thrown off by disintegrating atoms. The rays or particles emitted may consist of alpha, beta, or gamma radiation.

- ALPHA RADIATION. The least penetrating type of radiation. Alpha radiation can be stopped by a sheet of paper or outer dead layer of skin.
- BETA RADIATION. Electron emitted from a nucleus during fission and nuclear decay. Beta radiation can be stopped by an inch of wood or a thin sheet of aluminum.
- GAMMA RADIATION. A form of electromagnetic, high-energy radiation emitted from a nucleus. Gamma rays are essentially the same as x-rays and require heavy shielding such as lead, concrete, or steel to be stopped.
- INTERNAL RADIATION. Radiation originating from a source within the body as a result of the inhalation, ingestion, or implantation of natural or manmade radionuclides in body tissues.

RADIATION DOSE.

- ABSORBED DOSE. The amount of energy deposited by radiation in a given amount of material. Absorbed dose is measured in rads.
- COLLECTIVE DOSE EQUIVALENT. The sum of the dose equivalents for individuals comprising a defined population. The per capita dose equivalent is the quotient of the collective dose equivalent divided by the population size. (See PERSON-REM).
- COMMITTED DOSE EQUIVALENT (dose commitment). The total dose equivalent accumulated in an organ or tissue in the fifty years following a single intake of radioactive materials into the body.
- CUMULATIVE DOSE EQUIVALENT. The total dose one could receive in a period of fifty years following release of radionuclides to the environment, including the dose that could occur as a result of residual radionuclides remaining in the environment beyond the year of release.
- DOSE EQUIVALENT. The product of the absorbed dose, the quality factor, and any other modifying factors. The dose equivalent is a quantity for comparing the biological effectiveness of different kinds of radiation on a common scale. The unit of dose equivalent is the rem.
- EFFECTIVE DOSE EQUIVALENT. An estimate of the total risk of potential health effects from radiation exposure. It is the sum of the committed effective dose equivalent from internal deposition and the effective dose equivalent from external penetrating radiation received during a calendar year. The committed effective dose equivalent is the sum of the individual organ committed dose equivalents (fifty years) multiplied by weighting factors that represent the proportion of the total random risk that each organ would receive from uniform irradiation of the whole body.

RADIOACTIVITY. A property possessed by some elements such as uranium whereby alpha, beta, or gamma rays are spontaneously emitted.

RADIOISOTOPE. A radioactive isotope of a specified element. Carbon-14 is a radioisotope of carbon. Tritium is a radioisotope of hydrogen.

RADIONUCLIDE. A radioactive nuclide. Radionuclides are variations (isotopes) of elements. They have the same number of protons and electrons but different numbers of neutrons, resulting in different atomic masses.There are several hundred known nuclides, both man-made and naturally occurring.

REM. An acronym for Roentgen Equivalent Man. A unit of radiation exposure that indicates the potential effect on human cells.

SIEVERT. A unit of dose equivalent from the International System of Units equal to one joule per kilogram.

SPENT FUEL. Nuclear fuel that has been exposed in a nuclear reactor; this fuel contains uranium, activation products, fission products, and plutonium.

STANDARD DEVIATION. An indication of the dispersion of a set of results around their average.

THERMOLUMINESCENT DOSIMETER (TLD). A material that luminesces upon heating after being exposed to radiation. The amount of light emitted is proportional to the amount of radiation to which it has been exposed.

UPGRADIENT. Referring to the flow of water or air, it is analogous to upstream. A point that is "before" an area of study that is used as a baseline for comparison with downstream data. See GRADIENT and DOWNGRADIENT.

WATERSHED. The area contained within a drainage divide above a specified point on a stream.

WATER TABLE. The upper surface in a body of groundwater. The surface in an unconfined aquifer or confining bed at which the pore water pressure is equal to atmospheric pressure.

WHOLE-BODY DOSE. A radiation dose that involves exposure of the entire body.

Abbreviations for Units of Measure

Radioactivity

Symbol	*Name*
Ci	curie
mCi	millicurie (1E-03 Ci)
μCi	microcurie (1E-06 Ci)
nCi	nanocurie (1E-09 Ci)
pCi	picocurie (1E-12 Ci)
fCi	femtocurie (1E-15Ci)
aCi	attocurie (1E-18 Ci)
Bq	becquerel (27 pCi)

Volume

Symbol	*Name*
cm^3	cubic centimeter
L	liter
mL	milliliter
m^3	cubic meter
ppm	parts per million
ppb	parts per billion

Dose

Symbol	*Name*
Sv	sievert (100 rems)
Gy	gray (100 rads)

Time

Symbol	*Name*
y	year
d	day
h	hour
m	minute
s	second

Length

Symbol	*Name*
m	meter
km	kilometer (1E+03 m)
cm	centimeter (1E-02 m)
mm	millimeter (1E-03 m)
μm	micrometer (1E-06 m)

Area

Symbol	*Name*
ha	hectare (10,000 m^2)

Mass

Symbol	*Name*
g	gram
kg	kilogram (1E+03 g)
mg	milligram (1E-03)
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nCi	1000	pCi	pCi	0.001	nCi
pCi/L	1E-09	μCi/mL	μCi/mL	1E+09	pCi/L
pCi/m^3	1E-12	Ci/m^3	Ci/m^3	1E+12	pCi/m^3
becquerel	2.7E-11	curie	curie	3.7E+10	becquerel
gray	100	rad	rad	0.01	gray
sievert	100	rem	rem	0.01	sievert
ppb	0.001	ppm	ppm	1000	ppb
ppm	1.0	mg/L	mg/L	1.0	ppm

Unit Prefixes

Factor	*Prefix*	*Symbol*
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1E+06	mega	M
1E+03	kilo	k
1E-02	centi	c
1E-03	milli	m
1E-06	micro	μ
1E-09	nano	n
1E-12	pico	p

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COSMIC RADIATION. High-energy subatomic particles from outer space that bombard the earth's atmosphere. Cosmic radiation is part of natural background radiation.

COUNTING ERROR. The variability caused by the inherent random nature of radioactive disintegration and the detection process.

CURIE(CI). A unit of radioactivity equal to 37 billion (3.7×10^{10})nuclear transformations per second.

DETECTION LEVEL. The minimum concentration of a substance that can be measured with a 99% confidence that the analytical concentration is greater than zero.

DERIVED CONCENTRATION GUIDE (DCG). Concentrations of radionuclides in air and water in which a person continuously exposed and inhaling 8400 m^3 of air or ingesting 730 liters of water per year would receive an annual effective dose equivalent of 100 mrem per year from either mode of exposure. The committed dose equivalent is included in the DCGs for radionuclides with long half-lives. (See Appendix B)

DISPERSION. The process whereby solutes are spread or mixed as they are transported by groundwater as it moves through sediments.

DOSIMETER. A portable device for measuring the total accumulated exposure to ionizing radiation.

DOWNGRADIENT. The direction of water flow from a reference point to a selected point of interest. (See GRADIENT)

EFFECTIVE DOSE. See "Effective Dose Equivalent" under "Radiation dose."

EFFLUENT. Flowing out or forth; an outflow of waste. In this report, effluent refers to the liquid or gaseous waste streams released into the environment from the facility.

EFFLUENT MONITORING. Sampling or measuring specific liquid or gaseous effluent streams for the presence of pollutants.

EXPOSURE. Subjecting a target (usually living tissue) to radiation.

FALLOUT. Radioactive materials mixed into the earth's atmosphere. Fallout constantly precipitates onto the earth.

GRADIENT. Change in value of one variable with respect to another variable, especially vertical or horizontal distance, e.g., gravity, temperature, magnetic intensity, electric potential.

GROUNDWATER. Subsurface water in the pore spaces of soil and geologic units.

HALF-LIFE. The time in which half the atoms of a radionuclide disintegrate into another nuclear form. The half-life may vary from a fraction of a second to thousands of years.

HIGH-LEVEL WASTE (HLW). The highly radioactive waste material that results from the reprocessing of spent nuclear fuel, including liquid waste produced directly in reprocessing and any solid waste derived from the liquid, that contains a combination of transuranic waste and fission products in concentrations sufficient to require permanent isolation.

HYDRAULIC CONDUCTIVITY. The ratio of flow velocity to driving force for viscous flow under saturated conditions of a specified liquid in a porous medium; the ratio describing the rate at which water can move through a permeable medium.

ION. An atom or group of atoms with an electric charge.

ION EXCHANGE. The reversible exchange of ions contained in a crystal for different ions in solution without destroying the crystal structure or disturbing the electrical neutrality.

ISOTOPE. Different forms of the same chemical element that are distinguished by having different numbers of neutrons in the nucleus. An element can have many isotopes. For example, the three isotopes of hydrogen are protium, deuterium, and tritium.

KAME DELTA. A conical hill or short irregular ridge of gravel or sand deposited in contact with glacier ice.

LACUSTRINE SEDIMENTS. A sedimentary deposit consisting of material pertaining to, produced by, or formed in a lake or lakes.

LEACHED HULLS. Stainless steel cladding that remains after acid dissolution of spent fuel.

LOW-LEVEL WASTE. Radioactive waste not classified as high-level waste, transuranic waste, spent fuel, or uranium mill tailings. (See Class A,B,C low-level waste).

MAXIMALLY EXPOSED INDIVIDUAL. A hypothetical person who remains in an uncontrolled area who would, when all potential routes of exposure from a facility's operations are considered, receive the greatest possible dose equivalent.

MEAN. The average value of a series of measurements.

MILLIREM (MREM). A unit of radiation dose equivalent that is equal to one one-thousandth of a rem. An individual member of the public can receive up to 500 millirems per year according to DOE standards. This limit does not include radiation received for medical treatment or the 100 to 360 mrem that people receive annually from background radiation.

MINIMUM DETECTABLE CONCENTRATION. The smallest amount or concentration of a radioactive or nonradioactive element that can be reliably detected in a sample.

MIXED WASTE. A waste that is both radioactive and hazardous.

OUTFALL. The end of a drain or pipe that carries waste water or other effluents into a ditch, pond, or river.

PARTICULATES. Solid particles and liquid droplets small enough to become airborne.

PERSON-REM. The sum of the individual radiation dose equivalents received by members of a certain group or population. It may be calculated by multiplying the average dose per person by the number of persons exposed. For example, a thousand people each exposed to one millirem would have a collective dose of one person-rem.

PLUME. The distribution of a pollutant in air or water after being released from a source.

PROGLACIAL LAKE. A lake occupying a basin in front of a glacier; generally in direct contact with the ice.

RAD. Radiation absorbed dose. One hundred ergs of energy absorbed per gram.

RADIATION. The process of emitting energy in the form of rays or particles that are thrown off by disintegrating atoms. The rays or particles emitted may consist of alpha, beta, or gamma radiation.

- ALPHA RADIATION. The least penetrating type of radiation. Alpha radiation can be stopped by a sheet of paper or outer dead layer of skin.
- BETA RADIATION. Electron emitted from a nucleus during fission and nuclear decay. Beta radiation can be stopped by an inch of wood or a thin sheet of aluminum.
- GAMMA RADIATION. A form of electromagnetic, high-energy radiation emitted from a nucleus. Gamma rays are essentially the same as x-rays and require heavy shielding such as lead, concrete, or steel to be stopped.
- INTERNAL RADIATION. Radiation originating from a source within the body as a result of the inhalation, ingestion, or implantation of natural or manmade radionuclides in body tissues.

RADIATION DOSE.

- ABSORBED DOSE. The amount of energy deposited by radiation in a given amount of material. Absorbed dose is measured in rads.
- COLLECTIVE DOSE EQUIVALENT. The sum of the dose equivalents for individuals comprising a defined population. The per capita dose equivalent is the quotient of the collective dose equivalent divided by the population size. (See PERSON-REM).
- COMMITTED DOSE EQUIVALENT (dose commitment). The total dose equivalent accumulated in an organ or tissue in the fifty years following a single intake of radioactive materials into the body.
- CUMULATIVE DOSE EQUIVALENT. The total dose one could receive in a period of fifty years following release of radionuclides to the environment, including the dose that could occur as a result of residual radionuclides remaining in the environment beyond the year of release.
- DOSE EQUIVALENT. The product of the absorbed dose, the quality factor, and any other modifying factors. The dose equivalent is a quantity for comparing the biological effectiveness of different kinds of radiation on a common scale. The unit of dose equivalent is the rem.
- EFFECTIVE DOSE EQUIVALENT. An estimate of the total risk of potential health effects from radiation exposure. It is the sum of the committed effective dose equivalent from internal deposition and the effective dose equivalent from external penetrating radiation received during a calendar year. The committed effective dose equivalent is the sum of the individual organ committed dose equivalents (fifty years) multiplied by weighting factors that represent the proportion of the total random risk that each organ would receive from uniform irradiation of the whole body.

RADIOACTIVITY. A property possessed by some elements such as uranium whereby alpha, beta, or gamma rays are spontaneously emitted.

RADIOISOTOPE. A radioactive isotope of a specified element. Carbon-14 is a radioisotope of carbon. Tritium is a radioisotope of hydrogen.

RADIONUCLIDE. A radioactive nuclide. Radionuclides are variations (isotopes) of elements. They have the same number of protons and electrons but different numbers of neutrons, resulting in different atomic masses.There are several hundred known nuclides, both man-made and naturally occurring.

REM. An acronym for Roentgen Equivalent Man. A unit of radiation exposure that indicates the potential effect on human cells.

SIEVERT. A unit of dose equivalent from the International System of Units equal to one joule per kilogram.

SPENT FUEL. Nuclear fuel that has been exposed in a nuclear reactor; this fuel contains uranium, activation products, fission products, and plutonium.

STANDARD DEVIATION. An indication of the dispersion of a set of results around their average.

THERMOLUMINESCENT DOSIMETER (TLD). A material that luminesces upon heating after being exposed to radiation. The amount of light emitted is proportional to the amount of radiation to which it has been exposed.

UPGRADIENT. Referring to the flow of water or air, it is analogous to upstream. A point that is "before" an area of study that is used as a baseline for comparison with downstream data. See GRADIENT and DOWNGRADIENT.

WATERSHED. The area contained within a drainage divide above a specified point on a stream.

WATER TABLE. The upper surface in a body of groundwater. The surface in an unconfined aquifer or confining bed at which the pore water pressure is equal to atmospheric pressure.

WHOLE-BODY DOSE. A radiation dose that involves exposure of the entire body.

Abbreviations for Units of Measure

Radioactivity

Symbol	*Name*
Ci	curie
mCi	millicurie (1E-03 Ci)
μCi	microcurie (1E-06 Ci)
nCi	nanocurie (1E-09 Ci)
pCi	picocurie (1E-12 Ci)
fCi	femtocurie (1E-15Ci)
aCi	attocurie (1E-18 Ci)
Bq	becquerel (27 pCi)

Volume

Symbol	*Name*
cm^3	cubic centimeter
L	liter
mL	milliliter
m^3	cubic meter
ppm	parts per million
ppb	parts per billion

Dose

Symbol	*Name*
Sv	sievert (100 rems)
Gy	gray (100 rads)

Time

Symbol	*Name*
y	year
d	day
h	hour
m	minute
s	second

Length

Symbol	*Name*
m	meter
km	kilometer (1E+03 m)
cm	centimeter (1E-02 m)
mm	millimeter (1E-03 m)
μm	micrometer (1E-06 m)

Area

Symbol	*Name*
ha	hectare (10,000 m^2)

Mass

Symbol	*Name*
g	gram
kg	kilogram (1E+03 g)
mg	milligram (1E-03)
μg	microgram(1E-06 g)
ng	nanogram (1E-09 g)
t	metric ton (10^3 kg)

Conversion Table

Multiply	*by*	*To obtain*	*Multiply*	*by*	*To obtain*
in.	2.54	cm	cm	0.394	in.
ft	0.305	m	m	3.28	ft.
mi	1.61	km	km	0.621	mi
lb	0.454	kg	kg	2.205	lb
liq. qt.	0.946	L	L	1.057	liq. qt.
ft^2	0.093	m^2	m^2	10.76	ft^2
ha	2.47	acres	acres	0.405	ha
mi^2	2.59	km^2	km^2	0.386	mi^2
ft^3	0.028	m^3	m^3	35.7	ft^3
dpm	0.450	pCi	pCi	2.22	dpm
nCi	1000	pCi	pCi	0.001	nCi
pCi/L	1E-09	μCi/mL	μCi/mL	1E+09	pCi/L
pCi/m^3	1E-12	Ci/m^3	Ci/m^3	1E+12	pCi/m^3
becquerel	2.7E-11	curie	curie	3.7E+10	becquerel
gray	100	rad	rad	0.01	gray
sievert	100	rem	rem	0.01	sievert
ppb	0.001	ppm	ppm	1000	ppb
ppm	1.0	mg/L	mg/L	1.0	ppm

Unit Prefixes

Factor	*Prefix*	*Symbol*
1E+09	giga	G
1E+06	mega	M
1E+03	kilo	k
1E-02	centi	c
1E-03	milli	m
1E-06	micro	μ
1E-09	nano	n
1E-12	pico	p

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COSMIC RADIATION. High-energy subatomic particles from outer space that bombard the earth's atmosphere. Cosmic radiation is part of natural background radiation.

COUNTING ERROR. The variability caused by the inherent random nature of radioactive disintegration and the detection process.

CURIE(CI). A unit of radioactivity equal to 37 billion (3.7×10^{10})nuclear transformations per second.

DETECTION LEVEL. The minimum concentration of a substance that can be measured with a 99% confidence that the analytical concentration is greater than zero.

DERIVED CONCENTRATION GUIDE (DCG). Concentrations of radionuclides in air and water in which a person continuously exposed and inhaling 8400 m^3 of air or ingesting 730 liters of water per year would receive an annual effective dose equivalent of 100 mrem per year from either mode of exposure. The committed dose equivalent is included in the DCGs for radionuclides with long half-lives. (See Appendix B)

DISPERSION. The process whereby solutes are spread or mixed as they are transported by groundwater as it moves through sediments.

DOSIMETER. A portable device for measuring the total accumulated exposure to ionizing radiation.

DOWNGRADIENT. The direction of water flow from a reference point to a selected point of interest. (See GRADIENT)

EFFECTIVE DOSE. See "Effective Dose Equivalent" under "Radiation dose."

EFFLUENT. Flowing out or forth; an outflow of waste. In this report, effluent refers to the liquid or gaseous waste streams released into the environment from the facility.

EFFLUENT MONITORING. Sampling or measuring specific liquid or gaseous effluent streams for the presence of pollutants.

EXPOSURE. Subjecting a target (usually living tissue) to radiation.

FALLOUT. Radioactive materials mixed into the earth's atmosphere. Fallout constantly precipitates onto the earth.

GRADIENT. Change in value of one variable with respect to another variable, especially vertical or horizontal distance, e.g., gravity, temperature, magnetic intensity, electric potential.

GROUNDWATER. Subsurface water in the pore spaces of soil and geologic units.

HALF-LIFE. The time in which half the atoms of a radionuclide disintegrate into another nuclear form. The half-life may vary from a fraction of a second to thousands of years.

HIGH-LEVEL WASTE (HLW). The highly radioactive waste material that results from the reprocessing of spent nuclear fuel, including liquid waste produced directly in reprocessing and any solid waste derived from the liquid, that contains a combination of transuranic waste and fission products in concentrations sufficient to require permanent isolation.

HYDRAULIC CONDUCTIVITY. The ratio of flow velocity to driving force for viscous flow under saturated conditions of a specified liquid in a porous medium; the ratio describing the rate at which water can move through a permeable medium.

ION. An atom or group of atoms with an electric charge.

ION EXCHANGE. The reversible exchange of ions contained in a crystal for different ions in solution without destroying the crystal structure or disturbing the electrical neutrality.

ISOTOPE. Different forms of the same chemical element that are distinguished by having different numbers of neutrons in the nucleus. An element can have many isotopes. For example, the three isotopes of hydrogen are protium, deuterium, and tritium.

KAME DELTA. A conical hill or short irregular ridge of gravel or sand deposited in contact with glacier ice.

LACUSTRINE SEDIMENTS. A sedimentary deposit consisting of material pertaining to, produced by, or formed in a lake or lakes.

LEACHED HULLS. Stainless steel cladding that remains after acid dissolution of spent fuel.

LOW-LEVEL WASTE. Radioactive waste not classified as high-level waste, transuranic waste, spent fuel, or uranium mill tailings. (See Class A,B,C low-level waste).

MAXIMALLY EXPOSED INDIVIDUAL. A hypothetical person who remains in an uncontrolled area who would, when all potential routes of exposure from a facility's operations are considered, receive the greatest possible dose equivalent.

MEAN. The average value of a series of measurements.

MILLIREM (MREM). A unit of radiation dose equivalent that is equal to one one-thousandth of a rem. An individual member of the public can receive up to 500 millirems per year according to DOE standards. This limit does not include radiation received for medical treatment or the 100 to 360 mrem that people receive annually from background radiation.

MINIMUM DETECTABLE CONCENTRATION. The smallest amount or concentration of a radioactive or nonradioactive element that can be reliably detected in a sample.

MIXED WASTE. A waste that is both radioactive and hazardous.

OUTFALL. The end of a drain or pipe that carries waste water or other effluents into a ditch, pond, or river.

PARTICULATES. Solid particles and liquid droplets small enough to become airborne.

PERSON-REM. The sum of the individual radiation dose equivalents received by members of a certain group or population. It may be calculated by multiplying the average dose per person by the number of persons exposed. For example, a thousand people each exposed to one millirem would have a collective dose of one person-rem.

PLUME. The distribution of a pollutant in air or water after being released from a source.

PROGLACIAL LAKE. A lake occupying a basin in front of a glacier; generally in direct contact with the ice.

RAD. Radiation absorbed dose. One hundred ergs of energy absorbed per gram.

RADIATION. The process of emitting energy in the form of rays or particles that are thrown off by disintegrating atoms. The rays or particles emitted may consist of alpha, beta, or gamma radiation.

- ALPHA RADIATION. The least penetrating type of radiation. Alpha radiation can be stopped by a sheet of paper or outer dead layer of skin.
- BETA RADIATION. Electron emitted from a nucleus during fission and nuclear decay. Beta radiation can be stopped by an inch of wood or a thin sheet of aluminum.
- GAMMA RADIATION. A form of electromagnetic, high-energy radiation emitted from a nucleus. Gamma rays are essentially the same as x-rays and require heavy shielding such as lead, concrete, or steel to be stopped.
- INTERNAL RADIATION. Radiation originating from a source within the body as a result of the inhalation, ingestion, or implantation of natural or manmade radionuclides in body tissues.

RADIATION DOSE.

- ABSORBED DOSE. The amount of energy deposited by radiation in a given amount of material. Absorbed dose is measured in rads.
- COLLECTIVE DOSE EQUIVALENT. The sum of the dose equivalents for individuals comprising a defined population. The per capita dose equivalent is the quotient of the collective dose equivalent divided by the population size. (See PERSON-REM).
- COMMITTED DOSE EQUIVALENT (dose commitment). The total dose equivalent accumulated in an organ or tissue in the fifty years following a single intake of radioactive materials into the body.
- CUMULATIVE DOSE EQUIVALENT. The total dose one could receive in a period of fifty years following release of radionuclides to the environment, including the dose that could occur as a result of residual radionuclides remaining in the environment beyond the year of release.
- DOSE EQUIVALENT. The product of the absorbed dose, the quality factor, and any other modifying factors. The dose equivalent is a quantity for comparing the biological effectiveness of different kinds of radiation on a common scale. The unit of dose equivalent is the rem.
- EFFECTIVE DOSE EQUIVALENT. An estimate of the total risk of potential health effects from radiation exposure. It is the sum of the committed effective dose equivalent from internal deposition and the effective dose equivalent from external penetrating radiation received during a calendar year. The committed effective dose equivalent is the sum of the individual organ committed dose equivalents (fifty years) multiplied by weighting factors that represent the proportion of the total random risk that each organ would receive from uniform irradiation of the whole body.

RADIOACTIVITY. A property possessed by some elements such as uranium whereby alpha, beta, or gamma rays are spontaneously emitted.

RADIOISOTOPE. A radioactive isotope of a specified element. Carbon-14 is a radioisotope of carbon. Tritium is a radioisotope of hydrogen.

RADIONUCLIDE. A radioactive nuclide. Radionuclides are variations (isotopes) of elements. They have the same number of protons and electrons but different numbers of neutrons, resulting in different atomic masses.There are several hundred known nuclides, both man-made and naturally occurring.

REM. An acronym for Roentgen Equivalent Man. A unit of radiation exposure that indicates the potential effect on human cells.

SIEVERT. A unit of dose equivalent from the International System of Units equal to one joule per kilogram.

SPENT FUEL. Nuclear fuel that has been exposed in a nuclear reactor; this fuel contains uranium, activation products, fission products, and plutonium.

STANDARD DEVIATION. An indication of the dispersion of a set of results around their average.

THERMOLUMINESCENT DOSIMETER (TLD). A material that luminesces upon heating after being exposed to radiation. The amount of light emitted is proportional to the amount of radiation to which it has been exposed.

UPGRADIENT. Referring to the flow of water or air, it is analogous to upstream. A point that is "before" an area of study that is used as a baseline for comparison with downstream data. See GRADIENT and DOWNGRADIENT.

WATERSHED. The area contained within a drainage divide above a specified point on a stream.

WATER TABLE. The upper surface in a body of groundwater. The surface in an unconfined aquifer or confining bed at which the pore water pressure is equal to atmospheric pressure.

WHOLE-BODY DOSE. A radiation dose that involves exposure of the entire body.

Abbreviations for Units of Measure

Radioactivity

Symbol	*Name*
Ci	curie
mCi	millicurie (1E-03 Ci)
μCi	microcurie (1E-06 Ci)
nCi	nanocurie (1E-09 Ci)
pCi	picocurie (1E-12 Ci)
fCi	femtocurie (1E-15Ci)
aCi	attocurie (1E-18 Ci)
Bq	becquerel (27 pCi)

Volume

Symbol	*Name*
cm^3	cubic centimeter
L	liter
mL	milliliter
m^3	cubic meter
ppm	parts per million
ppb	parts per billion

Dose

Symbol	*Name*
Sv	sievert (100 rems)
Gy	gray (100 rads)

Time

Symbol	*Name*
y	year
d	day
h	hour
m	minute
s	second

Length

Symbol	*Name*
m	meter
km	kilometer (1E + 03 m)
cm	centimeter (1E-02 m)
mm	millimeter (1E-03 m)
μm	micrometer (1E-06 m)

Area

Symbol	*Name*
ha	hectare (10,000 m^2)

Mass

Symbol	*Name*
g	gram
kg	kilogram (1E + 03 g)
mg	milligram (1E-03)
μg	microgram(1E-06 g)
ng	nanogram (1E-09 g)
t	metric ton (10^3 kg)

Conversion Table

Multiply	*by*	*To obtain*	*Multiply*	*by*	*To obtain*
in.	2.54	cm	cm	0.394	in.
ft	0.305	m	m	3.28	ft.
mi	1.61	km	km	0.621	mi
lb	0.454	kg	kg	2.205	lb
liq. qt.	0.946	L	L	1.057	liq. qt.
ft^2	0.093	m^2	m^2	10.76	ft^2
ha	2.47	acres	acres	0.405	ha
mi^2	2.59	km^2	km^2	0.386	mi^2
ft^3	0.028	m^3	m^3	35.7	ft^3
dpm	0.450	pCi	pCi	2.22	dpm
nCi	1000	pCi	pCi	0.001	nCi
pCi/L	1E-09	μCi/mL	μCi/mL	1E+09	pCi/L
pCi/m^3	1E-12	Ci/m^3	Ci/m^3	1E+12	pCi/m^3
becquerel	2.7E-11	curie	curie	3.7E+10	becquerel
gray	100	rad	rad	0.01	gray
sievert	100	rem	rem	0.01	sievert
ppb	0.001	ppm	ppm	1000	ppb
ppm	1.0	mg/L	mg/L	1.0	ppm

Unit Prefixes

Factor	*Prefix*	*Symbol*
1E+09	giga	G
1E+06	mega	M
1E+03	kilo	k
1E-02	centi	c
1E-03	milli	m
1E-06	micro	μ
1E-09	nano	n
1E-12	pico	p

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Community Relations, WVNS(Technical File)

Buffalo News, Buffalo, New York *

Salamanca Republican Press,
Salamanca, New York *

Springville Journal, Springville, New York *

* News release summary

Appendix B

Environmental Regulations, Orders, Standards, and Permits

Table B - 1

*Department of Energy Radiation Protection Standards and Derived Concentration Guides**

Effective Dose Equivalent Radiation Standard for Protection of the Public

Continuous exposure of any member of the public from routine activities: 100 mrem/year (1 mSv/yr) effective dose equivalent from all exposure pathways

Department of Energy Derived Concentration Guides (DCGs) for Drinking Water and Air (µCi/mL)

Radionuclide	*Half-Life (years)*	*In Air*	*In Water*	*Radionuclide*	*Half-Life (years)*	*In Air*	*In Water*
H-3**	1.2E+01	1E-07	2E-03	**Eu-152**	1.4E+01	5E-11	2E-05
C-14**	5.7E+03	6E-09	7E-05	**Eu-154****	8.8E+00	5E-11	2E-05
Fe-55	2.7E+00	5E-09	2E-04	**Eu-155**	5.0E+00	3E-10	1E-04
Ni-59	7.5E+04	4E-09	7E-04	**Th-232**	1.4E+10	7E-15	5E-08
Co-60**	5.3E+00	8E-11	5E-06	**U-232****	7.2E+01	2E-14	1E-07
Ni-63	1.0E+02	2E-09	3E-04	**U-233****	1.6E+05	9E-14	5E-07
Sr-90**	2.9E+01	9E-12	1E-06	**U-234****	2.4E+05	9E-14	5E-07
Y-90	7.3E-03	1E-09	1E-05	**U-235****	7.0E+08	1E-13	6E-07
Zr-93	1.5E+06	4E-11	9E-05	**U-236****	3.4E+06	1E-13	5E-07
Nb-93m	1.5E+01	4E-10	3E-04	**U-238****	4.5E+09	1E-13	6E-07
Tc-99**	2.1E+05	2E-09	1E-04	**Np-239**	6.5E-03	5E-09	5E-05
Ru-106	1.0E+00	3E-11	6E-06	**Pu-238****	8.8E+01	3E-14	4E-08
Cd-113m	1.4E+01	8E-12	9E-07	**Pu-239****	2.4E+04	2E-14	3E-08
Sb-125	2.8E+00	1E-09	5E-05	**Pu-240****	6.5E+03	2E-14	3E-08
Te-125m	1.6E-01	2E-09	4E-05	**Pu-241**	1.4E+01	1E-12	2E-06
Sn-126	1.0E+05	1E-10	8E-06	**Am-241****	4.3E+02	2E-14	3E-08
I-129**	1.6E+07	7E-11	5E-07	**Am-242m**	1.5E+02	2E-14	3E-08
Cs-134**	2.1E+00	2E-10	2E-06	**Am-243**	7.4E+03	2E-14	3E-08
Cs-135	2.3E+06	3E-09	2E-05	**Cm-243**	2.8E+01	3E-14	5E-08
Cs-137**	3.0E+01	4E-10	3E-06	**Cm-244**	1.8E+01	4E-14	6E-08
Pm-147	2.6E+00	3E-10	1E-04	**Gross Alpha (as Am-241)**	N/A	2E-14	3E-08
Sm-151	9.0E+01	4E-10	4E-04	**Gross Beta (as Sr-90)**	N/A	9E-12	1E-06

** Ref: DOE Order 5400.5 (February 8, 1990). Effective May 8, 1990.*
*** Analysis for these radionuclides in WVDP effluent are performed routinely.*
N/A = Not applicable.

Table B - 2

Environmental Regulations, Orders, and Standards

The following environmental standards and laws are applicable, in whole or in part, to the West Valley Demonstration Project:

DOE Order 5400.1. November 9, 1988. *General Environmental Protection Program*, including Change 1 (June 29, 1990).

DOE Order 5480.1B. September 23, 1986. *Environment, Safety, and Health Program for DOE Operations*, including Change 5 (May 10, 1993).

DOE Order 5484.1. February 24, 1981. *Environmental Protection, Safety, and Health Protection Information Reporting Requirements*, including Change 7 (October 17, 1990).

Clean Air Act (CAA). 42 USC 1857 et seq., as amended, and implementing regulations.

Federal Water Pollution Control Act [Clean Water Act (CWS)]. 33 USC 1251, as amended, and implementing regulations.

Resource Conservation and Recovery Act (RCRA). 42 USC 6905, as amended, and implementing regulations.

National Environmental Policy Act (NEPA). PL 911-190. 42 USC 4321-4347, January 1, 1970, as amended, and implementing regulations.

Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA). 42 USC 960 (including Superfund Amendments and Reauthorization Act of 1986), and implementing regulations.

Toxic Substances Control Act (TSCA). 15 USC 2610, as amended, and implementing regulations.

Emergency Planning and Community Right-to-Know Act (EPCRA) of 1986, Title 3, 40 CFR Parts 302, 350, 355, 370, and 372.

Safe Drinking Water Act (SDWA). 40 CFR Part 141-149, as amended, and implementing regulations.

Environmental Conservation Law of New York State.

The standards and guidelines applicable to releases of radionuclides from the West Valley Demonstration Project are found in DOE Order 5400.5 (February 8, 1990), including Change 2 (January 7, 1993).

Ambient water quality standards contained in the State Pollutant Discharge Elimination System (SPDES) permit issued for the facility are listed in Table C-5.1. Airborne discharges are also regulated by the Environmental Protection Agency under the National Emissions Standards for Hazardous Air Pollutants (NESHAPs), 40 CFR 61 Subpart H (December 15, 1989).

The above list covers the major activities at the West Valley Demonstration Project but does not constitute a comprehensive enumeration.

Table B-3

West Valley Demonstration Project Environmental Permits

Permit Name and Number	Agency/Type	Description	Status
Boilers (042200-0114-00002 and 042200-0114-00003)	NYSDEC/Certificate to Operate an Air Emission Source (CO)	Boilers located in the utility room	Renewal request was reviewed by NYSDEC and WVNS on 9/8/94. A new CO is forthcoming.
Cement storage silo ventilation system (042200-0114-CSS01)	NYSDEC/CO	Exhaust from the cement storage silo baghouse	Renewal request was reviewed by NYSDEC and WVNS on 9/8/94. A new CO is forthcoming.
Analytical & Process Chemistry Laboratory (042200-0114-15F-1)	NYSDEC/CO	Analytical & Process Chemistry Laboratory equipment from various laboratories in the main plant	Renewal request was reviewed by NYSDEC and WVNS on 9/8/94. A new CO is forthcoming.
Tank #35157 vent (042200-0114-35157)	NYSDEC/CO	Vent from 3,000-gallon sulfuric acid tank #35157	Renewal request was reviewed by NYSDEC and WVNS on 9/8/94. A new CO is forthcoming.
Source-capture welding system (042200-0114-MS001)	NYSDEC/CO	Maintenance shop welding ventilation using "elephant trunk" ducts to vent welding fumes at the source of generation	Renewal request was reviewed by NYSDEC and WVNS on 9/8/94. A new CO is forthcoming.
Blueprint machine (042200-0114-00012)	NYSDEC/CO	Blueprint machine vent for ammonia emissions	Renewal request was reviewed by NYSDEC and WVNS on 9/8/94. A new CO is forthcoming.
Blower exhausts, welding only (042200-0114-00013) Welding/painting (042200-0114-00014) Painting only (042200-0114-00015)	NYSDEC/CO (three permits)	Portable blowers (some with and some without filters) for venting emissions from typical painting and welding operations in the vitrification facility	COs expire in 1998/1999. NYSDEC has agreed to allow expanded use of these COs to allow the WVDP to use these blowers for similar painting and welding operations anywhere on-site.
Analytical cell mock-up unit (042200-0114-00027)	NYSDEC/CO	Analytical cell mock-up unit (located in the vitrification test facility) emissions from use of laboratory chemicals	CO expires 12/1/98.
SVS solids transfer system (042200-0114-SVS01), SVS vessel vent system (042200-0114-SVS02), and SVS mini-melter off-gas system (042200-0114-SVS04)	NYSDEC/CO (three permits)	Scale vitrification system vac-u-max solids transfer system vent, feed mix tank vent, and melter off-gas treatment system emissions.	COs issued 9/8/94 for one year (expiration 8/1/95). NYSDEC will reinspect upon test run start-up and will extend until 8/1/99.

Table B-3 (continued)

West Valley Demonstration Project Environmental Permits

Permit Name and Number	Agency/Type	Description	Status
SVS ammonia vent system (04220-0114-SVS07)	NYSDEC/CO	Scale vitrification system ammonia vent system for relieving pressure before cylinder change-outs	NYSDEC issued CO on 10/11/94. Expires 8/1/99.
Environmental Analytical Annex laboratory hoods (042200-0114-00016 through 042200-0114-00026)	NYSDEC/CO (eleven permits)	Eleven separate blowers for laboratory hoods and analytical equipment in the Environmental Analytical Annex (EAA) [i.e., vitrification cold operations laboratory]	COs issued 8/11/94. Expire 8/1/99.
LLWTF nitric acid storage tank (042200-0114-00010)	NYSDEC/CO	Low-level waste treatment facility nitric acid storage tank #33013	NYSDEC acknowledged termination of CO on 9/19/94.
Tank #33154 vent (042200-0114-33154)	NYSDEC/CO	3,200-gallon nitric acid tank #33154	NYSDEC acknowledged termination of CO on 9/19/94.
Tanks #14D-2 and 14D-2A (042200-0114-14D-2 and 042200-0114-14D-2A)	NYSDEC/CO (two permits)	Sodium hydroxide tanks 14D-2 and 14D-2A	NYSDEC acknowledged termination of CO on 9/19/94.
Nitric acid tank vent (042200-0114-MDB07)	NYSDEC/CO	250-gallon nitric acid tank used in the melter disassembly building	NYSDEC acknowledged termination of CO on 9/19/94.
Cold chemical solids transfer system (042200-0114-CTS02) Cold chemical vessel vent system (042200-0114-CTS03) Cold chemical vessel dust collection hood (042200-0114-CTS04)	NYSDEC/Permits to Construct an Air Emission source (PC) (three permits)	Cold chemical facility. Dry or solid chemical emissions from solids transfer system, dust collection hood, and from mix tank vent for vitrification operations	PC extended until 12/31/95. Will convert to COs as soon as construction is completed.
Vitrification off-gas treatment system (042200-0114-15F-1)	NYSDEC/PC	Vitrification facility off-gas treatment system emissions	PC expires on 7/31/95. Will be converted to a CO when construction and turnover are completed.
Vitrification facility HVAC system (042200-0114-15F-2)	NYSDEC/PC	Canister welding emissions vented through vitrification facility HVAC system. [i.e., canister welding ventilation]	PC extended until 12/31/95. Will convert to COs as soon as construction is completed.

Table B-3 (continued)

West Valley Demonstration Project Environmental Permits

Permit Name and Number	Agency/Type	Description	Status
Vitrification melter off-gas system	EPA/Applied for NESHAPs permit	Slurry-fed ceramic melter radionuclides emissions	Submitted 9/93. Required by 1/96. EPA has reviewed and indicated that the permit should be issued in 1995. Awaiting response.
Vitrification HVAC system	EPA/Applied for NESHAPs permit	Vitrification facility HVAC - system radionuclide emissions	Submitted 9/93. Required by 1/96. EPA has reviewed and indicated that the permit should be issued in 1995. Awaiting response.
01-14 building ventilation system (WVDP-187-01)	EPA/NESHAPs	Liquid waste treatment system ventilation of radionuclides in the 01-14 building	Issued 10/5/87. Modified 5/25/89. No expiration date.
Contact size-reduction facility (WVDP-287-01)	EPA/NESHAPs	Contact size-reduction and decontamination facility radionuclide emissions	Issued 10/5/87. No expiration date.
Supernatant treatment system (WVDP-387-01)	EPA/NESHAPs	Supernatant treatment system ventilation for radionuclide emissions	Issued 10/5/87. No expiration date.
Low-level waste supercompactor (WVDP-487-01)	EPA/NESHAPs	Low-level waste supercompactor ventilation system for radionuclide emissions	Issued 10/5/87. No expiration date.
Outdoor ventilated enclosures (WVDP-587-01)	EPA/NESHAPs	Ten portable ventilation units for removal of radionuclides	Issued 12/22/87. No expiration date.
Process building ventilation system (WVDP-687-01)	EPA/NESHAPs	Original main plant ventilation of radionuclides	Issued 12/22/87. No expiration date.
RCRA Part A	NYSDEC/Hazardous waste	Waste management for WVDP - process HLW; container storage of mixed waste; identifies waste streams and RCRA limits	Currently operating under interim status.
SPDES NY0000973	NYSDEC/Water discharge	Covers discharges to surface waters from various sources on-site	Expires 2/1/99. Construction of a flow augmentation solids system is scheduled for completion by 9/1/95.
Chemical bulk storage registration	NYSDEC/Registration	Registration of bulk storage tanks used for listed hazardous chemicals	Expires 7/95. Will be renewed before expiration.

Table B-3 *(concluded)*

West Valley Demonstration Project Environmental Permits

Permit Name and Number	Agency/Type	Description	Status
Petroleum bulk storage registration	NYSDEC/Registration	Registration of bulk storage tanks used for petroleum	Expires 9/96. Will be renewed before expiration.
Federal depredation permit (PRT-747595) New York State depredation license (DWP94-053)	U.S. Fish & Wildlife Service/New York State Division of Fish & Wildlife Depredation Permit/License	Permit/license for the removal of nests of migratory birds	Annual permit/license. Expires 5/2/95. Will be renewed before expiration.

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BACKGROUND RADIATION. Includes both natural and manmade radiation such as cosmic radiation and radiation from naturally radioactive elements and from commercial sources and medical procedures.

BECQUEREL (BQ). A unit of radioactivity equal to one nuclear transformation per second.

CLASS A, B, AND C LOW-LEVEL WASTE. Waste classifications from the Nuclear Regulatory Commission's 10 CFR Part 61 rule. Maximum concentration limits are set for specific isotopes. Class A waste disposal is minimally restricted with respect to the form of the waste. Class B waste must meet more rigorous requirements to ensure physical stability after disposal. Greater concentration limits are set for the same isotopes in Class C Waste and it also must meet physical stability requirements. Moreover, special measures must be taken at the disposal facility to protect against inadvertent intrusion.

CONFIDENCE COEFFICIENT OR FACTOR. The chance or probability, usually expressed as a percentage, that a confidence interval includes some defined parameter of a population. The confidence coefficients usually associated with confidence intervals are 90%, 95%, and 99%.

COSMIC RADIATION. High-energy subatomic particles from outer space that bombard the earth's atmosphere. Cosmic radiation is part of natural background radiation.

COUNTING ERROR. The variability caused by the inherent random nature of radioactive disintegration and the detection process.

CURIE(CI). A unit of radioactivity equal to 37 billion (3.7×10^{10})nuclear transformations per second.

DETECTION LEVEL. The minimum concentration of a substance that can be measured with a 99% confidence that the analytical concentration is greater than zero.

DERIVED CONCENTRATION GUIDE (DCG). Concentrations of radionuclides in air and water in which a person continuously exposed and inhaling 8400 m^3 of air or ingesting 730 liters of water per year would receive an annual effective dose equivalent of 100 mrem per year from either mode of exposure. The committed dose equivalent is included in the DCGs for radionuclides with long half-lives. (See Appendix B)

DISPERSION. The process whereby solutes are spread or mixed as they are transported by groundwater as it moves through sediments.

DOSIMETER. A portable device for measuring the total accumulated exposure to ionizing radiation.

DOWNGRADIENT. The direction of water flow from a reference point to a selected point of interest. (See GRADIENT)

EFFECTIVE DOSE. See "Effective Dose Equivalent" under "Radiation dose."

EFFLUENT. Flowing out or forth; an outflow of waste. In this report, effluent refers to the liquid or gaseous waste streams released into the environment from the facility.

EFFLUENT MONITORING. Sampling or measuring specific liquid or gaseous effluent streams for the presence of pollutants.

EXPOSURE. Subjecting a target (usually living tissue) to radiation.

FALLOUT. Radioactive materials mixed into the earth's atmosphere. Fallout constantly precipitates onto the earth.

GRADIENT. Change in value of one variable with respect to another variable, especially vertical or horizontal distance, e.g., gravity, temperature, magnetic intensity, electric potential.

GROUNDWATER. Subsurface water in the pore spaces of soil and geologic units.

HALF-LIFE. The time in which half the atoms of a radionuclide disintegrate into another nuclear form. The half-life may vary from a fraction of a second to thousands of years.

HIGH-LEVEL WASTE (HLW). The highly radioactive waste material that results from the reprocessing of spent nuclear fuel, including liquid waste produced directly in reprocessing and any solid waste derived from the liquid, that contains a combination of transuranic waste and fission products in concentrations sufficient to require permanent isolation.

HYDRAULIC CONDUCTIVITY. The ratio of flow velocity to driving force for viscous flow under saturated conditions of a specified liquid in a porous medium; the ratio describing the rate at which water can move through a permeable medium.

ION. An atom or group of atoms with an electric charge.

ION EXCHANGE. The reversible exchange of ions contained in a crystal for different ions in solution without destroying the crystal structure or disturbing the electrical neutrality.

ISOTOPE. Different forms of the same chemical element that are distinguished by having different numbers of neutrons in the nucleus. An element can have many isotopes. For example, the three isotopes of hydrogen are protium, deuterium, and tritium.

KAME DELTA. A conical hill or short irregular ridge of gravel or sand deposited in contact with glacier ice.

LACUSTRINE SEDIMENTS. A sedimentary deposit consisting of material pertaining to, produced by, or formed in a lake or lakes.

LEACHED HULLS. Stainless steel cladding that remains after acid dissolution of spent fuel.

LOW-LEVEL WASTE. Radioactive waste not classified as high-level waste, transuranic waste, spent fuel, or uranium mill tailings. (See Class A,B,C low-level waste).

MAXIMALLY EXPOSED INDIVIDUAL. A hypothetical person who remains in an uncontrolled area who would, when all potential routes of exposure from a facility's operations are considered, receive the greatest possible dose equivalent.

MEAN. The average value of a series of measurements.

MILLIREM (MREM). A unit of radiation dose equivalent that is equal to one one-thousandth of a rem. An individual member of the public can receive up to 500 millirems per year according to DOE standards. This limit does not include radiation received for medical treatment or the 100 to 360 mrem that people receive annually from background radiation.

MINIMUM DETECTABLE CONCENTRATION. The smallest amount or concentration of a radioactive or nonradioactive element that can be reliably detected in a sample.

MIXED WASTE. A waste that is both radioactive and hazardous.

OUTFALL. The end of a drain or pipe that carries waste water or other effluents into a ditch, pond, or river.

PARTICULATES. Solid particles and liquid droplets small enough to become airborne.

PERSON-REM. The sum of the individual radiation dose equivalents received by members of a certain group or population. It may be calculated by multiplying the average dose per person by the number of persons exposed. For example, a thousand people each exposed to one millirem would have a collective dose of one person-rem.

PLUME. The distribution of a pollutant in air or water after being released from a source.

PROGLACIAL LAKE. A lake occupying a basin in front of a glacier; generally in direct contact with the ice.

RAD. Radiation absorbed dose. One hundred ergs of energy absorbed per gram.

RADIATION. The process of emitting energy in the form of rays or particles that are thrown off by disintegrating atoms. The rays or particles emitted may consist of alpha, beta, or gamma radiation.

- **ALPHA RADIATION.** The least penetrating type of radiation. Alpha radiation can be stopped by a sheet of paper or outer dead layer of skin.
- **BETA RADIATION.** Electron emitted from a nucleus during fission and nuclear decay. Beta radiation can be stopped by an inch of wood or a thin sheet of aluminum.
- **GAMMA RADIATION.** A form of electromagnetic, high-energy radiation emitted from a nucleus. Gamma rays are essentially the same as x-rays and require heavy shielding such as lead, concrete, or steel to be stopped.
- **INTERNAL RADIATION.** Radiation originating from a source within the body as a result of the inhalation, ingestion, or implantation of natural or manmade radionuclides in body tissues.

RADIATION DOSE.

- **ABSORBED DOSE.** The amount of energy deposited by radiation in a given amount of material. Absorbed dose is measured in rads.
- **COLLECTIVE DOSE EQUIVALENT.** The sum of the dose equivalents for individuals comprising a defined population. The per capita dose equivalent is the quotient of the collective dose equivalent divided by the population size. (See PERSON-REM).
- **COMMITTED DOSE EQUIVALENT** (dose commitment). The total dose equivalent accumulated in an organ or tissue in the fifty years following a single intake of radioactive materials into the body.
- **CUMULATIVE DOSE EQUIVALENT.** The total dose one could receive in a period of fifty years following release of radionuclides to the environment, including the dose that could occur as a result of residual radionuclides remaining in the environment beyond the year of release.
- **DOSE EQUIVALENT.** The product of the absorbed dose, the quality factor, and any other modifying factors. The dose equivalent is a quantity for comparing the biological effectiveness of different kinds of radiation on a common scale. The unit of dose equivalent is the rem.
- **EFFECTIVE DOSE EQUIVALENT.** An estimate of the total risk of potential health effects from radiation exposure. It is the sum of the committed effective dose equivalent from internal deposition and the effective dose equivalent from external penetrating radiation received during a calendar year. The committed effective dose equivalent is the sum of the individual organ committed dose equivalents (fifty years) multiplied by weighting factors that represent the proportion of the total random risk that each organ would receive from uniform irradiation of the whole body.

RADIOACTIVITY. A property possessed by some elements such as uranium whereby alpha, beta, or gamma rays are spontaneously emitted.

RADIOISOTOPE. A radioactive isotope of a specified element. Carbon-14 is a radioisotope of carbon. Tritium is a radioisotope of hydrogen.

RADIONUCLIDE. A radioactive nuclide. Radionuclides are variations (isotopes) of elements. They have the same number of protons and electrons but different numbers of neutrons, resulting in different atomic masses.There are several hundred known nuclides, both man-made and naturally occurring.

REM. An acronym for Roentgen Equivalent Man. A unit of radiation exposure that indicates the potential effect on human cells.

SIEVERT. A unit of dose equivalent from the International System of Units equal to one joule per kilogram.

SPENT FUEL. Nuclear fuel that has been exposed in a nuclear reactor; this fuel contains uranium, activation products, fission products, and plutonium.

STANDARD DEVIATION. An indication of the dispersion of a set of results around their average.

THERMOLUMINESCENT DOSIMETER (TLD). A material that luminesces upon heating after being exposed to radiation. The amount of light emitted is proportional to the amount of radiation to which it has been exposed.

UPGRADIENT. Referring to the flow of water or air, it is analogous to upstream. A point that is "before" an area of study that is used as a baseline for comparison with downstream data. See GRADIENT and DOWNGRADIENT.

WATERSHED. The area contained within a drainage divide above a specified point on a stream.

WATER TABLE. The upper surface in a body of groundwater. The surface in an unconfined aquifer or confining bed at which the pore water pressure is equal to atmospheric pressure.

WHOLE-BODY DOSE. A radiation dose that involves exposure of the entire body.

Abbreviations for Units of Measure

Radioactivity

Symbol	*Name*
Ci	curie
mCi	millicurie (1E-03 Ci)
μCi	microcurie (1E-06 Ci)
nCi	nanocurie (1E-09 Ci)
pCi	picocurie (1E-12 Ci)
fCi	femtocurie (1E-15Ci)
aCi	attocurie (1E-18 Ci)
Bq	becquerel (27 pCi)

Volume

Symbol	*Name*
cm^3	cubic centimeter
L	liter
mL	milliliter
m^3	cubic meter
ppm	parts per million
ppb	parts per billion

Dose

Symbol	*Name*
Sv	sievert (100 rems)
Gy	gray (100 rads)

Time

Symbol	*Name*
y	year
d	day
h	hour
m	minute
s	second

Length

Symbol	*Name*
m	meter
km	kilometer (1E+03 m)
cm	centimeter (1E-02 m)
mm	millimeter (1E-03 m)
μm	micrometer (1E-06 m)

Area

Symbol	*Name*
ha	hectare (10,000 m^2)

Mass

Symbol	*Name*
g	gram
kg	kilogram (1E+03 g)
mg	milligram (1E-03)
μg	microgram(1E-06 g)
ng	nanogram (1E-09 g)
t	metric ton (10^3 kg)

Conversion Table

Multiply	*by*	*To obtain*	*Multiply*	*by*	*To obtain*
in.	2.54	cm	cm	0.394	in.
ft	0.305	m	m	3.28	ft.
mi	1.61	km	km	0.621	mi
lb	0.454	kg	kg	2.205	lb
liq. qt.	0.946	L	L	1.057	liq. qt.
ft^2	0.093	m^2	m^2	10.76	ft^2
ha	2.47	acres	acres	0.405	ha
mi^2	2.59	km^2	km^2	0.386	mi^2
ft^3	0.028	m^3	m^3	35.7	ft^3
dpm	0.450	pCi	pCi	2.22	dpm
nCi	1000	pCi	pCi	0.001	nCi
pCi/L	1E-09	μCi/mL	μCi/mL	1E+09	pCi/L
pCi/m^3	1E-12	Ci/m^3	Ci/m^3	1E+12	pCi/m^3
becquerel	2.7E-11	curie	curie	3.7E+10	becquerel
gray	100	rad	rad	0.01	gray
sievert	100	rem	rem	0.01	sievert
ppb	0.001	ppm	ppm	1000	ppb
ppm	1.0	mg/L	mg/L	1.0	ppm

Unit Prefixes

Factor	*Prefix*	*Symbol*
1E+09	giga	G
1E+06	mega	M
1E+03	kilo	k
1E-02	centi	c
1E-03	milli	m
1E-06	micro	μ
1E-09	nano	n
1E-12	pico	p

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- DOSE EQUIVALENT. The product of the absorbed dose, the quality factor, and any other modifying factors. The dose equivalent is a quantity for comparing the biological effectiveness of different kinds of radiation on a common scale. The unit of dose equivalent is the rem.
- EFFECTIVE DOSE EQUIVALENT. An estimate of the total risk of potential health effects from radiation exposure. It is the sum of the committed effective dose equivalent from internal deposition and the effective dose equivalent from external penetrating radiation received during a calendar year. The committed effective dose equivalent is the sum of the individual organ committed dose equivalents (fifty years) multiplied by weighting factors that represent the proportion of the total random risk that each organ would receive from uniform irradiation of the whole body.

RADIOACTIVITY. A property possessed by some elements such as uranium whereby alpha, beta, or gamma rays are spontaneously emitted.

RADIOISOTOPE. A radioactive isotope of a specified element. Carbon-14 is a radioisotope of carbon. Tritium is a radioisotope of hydrogen.

RADIONUCLIDE. A radioactive nuclide. Radionuclides are variations (isotopes) of elements. They have the same number of protons and electrons but different numbers of neutrons, resulting in different atomic masses.There are several hundred known nuclides, both man-made and naturally occurring.

REM. An acronym for Roentgen Equivalent Man. A unit of radiation exposure that indicates the potential effect on human cells.

SIEVERT. A unit of dose equivalent from the International System of Units equal to one joule per kilogram.

SPENT FUEL. Nuclear fuel that has been exposed in a nuclear reactor; this fuel contains uranium, activation products, fission products, and plutonium.

STANDARD DEVIATION. An indication of the dispersion of a set of results around their average.

THERMOLUMINESCENT DOSIMETER (TLD). A material that luminesces upon heating after being exposed to radiation. The amount of light emitted is proportional to the amount of radiation to which it has been exposed.

UPGRADIENT. Referring to the flow of water or air, it is analogous to upstream. A point that is "before" an area of study that is used as a baseline for comparison with downstream data. See GRADIENT and DOWNGRADIENT.

WATERSHED. The area contained within a drainage divide above a specified point on a stream.

WATER TABLE. The upper surface in a body of groundwater. The surface in an unconfined aquifer or confining bed at which the pore water pressure is equal to atmospheric pressure.

WHOLE-BODY DOSE. A radiation dose that involves exposure of the entire body.

Abbreviations for Units of Measure

Radioactivity

Symbol	*Name*
Ci	curie
mCi	millicurie (1E-03 Ci)
μCi	microcurie (1E-06 Ci)
nCi	nanocurie (1E-09 Ci)
pCi	picocurie (1E-12 Ci)
fCi	femtocurie (1E-15Ci)
aCi	attocurie (1E-18 Ci)
Bq	becquerel (27 pCi)

Volume

Symbol	*Name*
cm^3	cubic centimeter
L	liter
mL	milliliter
m^3	cubic meter
ppm	parts per million
ppb	parts per billion

Dose

Symbol	*Name*
Sv	sievert (100 rems)
Gy	gray (100 rads)

Time

Symbol	*Name*
y	year
d	day
h	hour
m	minute
s	second

Length

Symbol	*Name*
m	meter
km	kilometer (1E + 03 m)
cm	centimeter (1E-02 m)
mm	millimeter (1E-03 m)
μm	micrometer (1E-06 m)

Area

Symbol	*Name*
ha	hectare (10,000 m^2)

Mass

Symbol	*Name*
g	gram
kg	kilogram (1E + 03 g)
mg	milligram (1E-03)
μg	microgram(1E-06 g)
ng	nanogram (1E-09 g)
t	metric ton (10^3 kg)

Multiply	*by*	*To obtain*	*Multiply*	*by*	*To obtain*
in.	2.54	cm	cm	0.394	in.
ft	0.305	m	m	3.28	ft.
mi	1.61	km	km	0.621	mi
lb	0.454	kg	kg	2.205	lb
liq. qt.	0.946	L	L	1.057	liq. qt.
ft^2	0.093	m^2	m^2	10.76	ft^2
ha	2.47	acres	acres	0.405	ha
mi^2	2.59	km^2	km^2	0.386	mi^2
ft^3	0.028	m^3	m^3	35.7	ft^3
dpm	0.450	pCi	pCi	2.22	dpm
nCi	1000	pCi	pCi	0.001	nCi
pCi/L	1E-09	μCi/mL	μCi/mL	1E+09	pCi/L
pCi/m^3	1E-12	Ci/m^3	Ci/m^3	1E+12	pCi/m^3
becquerel	2.7E-11	curie	curie	3.7E+10	becquerel
gray	100	rad	rad	0.01	gray
sievert	100	rem	rem	0.01	sievert
ppb	0.001	ppm	ppm	1000	ppb
ppm	1.0	mg/L	mg/L	1.0	ppm

Unit Prefixes

Factor	*Prefix*	*Symbol*
1E+09	giga	G
1E+06	mega	M
1E+03	kilo	k
1E-02	centi	c
1E-03	milli	m
1E-06	micro	μ
1E-09	nano	n
1E-12	pico	p

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ALLUVIUM. Sedimentary material deposited by flowing water such as a river.

ALLUVIAL FAN. A cone-shaped deposit of alluvium made by a stream where it runs out onto a level plain.

AQUIFER. A water-bearing unit of permeable rock or soil that will yield water in usable quantities to wells. *Confined aquifers* are bounded above and below by less permeable layers. Groundwater in a confined aquifer is under a pressure greater than the atmospheric pressure. *Unconfined aquifers* are bounded below by less permeable material, but are not bounded above. The pressure on the groundwater in an unconfined aquifer at the top of the aquifer is equal to that of the atmosphere.

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pCi	picocurie (1E-12 Ci)
fCi	femtocurie (1E-15Ci)
aCi	attocurie (1E-18 Ci)
Bq	becquerel (27 pCi)

Volume

Symbol	*Name*
cm^3	cubic centimeter
L	liter
mL	milliliter
m^3	cubic meter
ppm	parts per million
ppb	parts per billion

Dose

Symbol	*Name*
Sv	sievert (100 rems)
Gy	gray (100 rads)

Time

Symbol	*Name*
y	year
d	day
h	hour
m	minute
s	second

Length

Symbol	*Name*
m	meter
km	kilometer (1E+03 m)
cm	centimeter (1E-02 m)
mm	millimeter (1E-03 m)
μm	micrometer (1E-06 m)

Area

Symbol	*Name*
ha	hectare (10,000 m^2)

Mass

Symbol	*Name*
g	gram
kg	kilogram (1E+03 g)
mg	milligram (1E-03)
μg	microgram(1E-06 g)
ng	nanogram (1E-09 g)
t	metric ton (10^3 kg)

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ft^2	0.093	m^2	m^2	10.76	ft^2
ha	2.47	acres	acres	0.405	ha
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dpm	0.450	pCi	pCi	2.22	dpm
nCi	1000	pCi	pCi	0.001	nCi
pCi/L	1E-09	μCi/mL	μCi/mL	1E+09	pCi/L
pCi/m^3	1E-12	Ci/m^3	Ci/m^3	1E+12	pCi/m^3
becquerel	2.7E-11	curie	curie	3.7E+10	becquerel
gray	100	rad	rad	0.01	gray
sievert	100	rem	rem	0.01	sievert
ppb	0.001	ppm	ppm	1000	ppb
ppm	1.0	mg/L	mg/L	1.0	ppm

Unit Prefixes

Factor	*Prefix*	*Symbol*
1E+09	giga	G
1E+06	mega	M
1E+03	kilo	k
1E-02	centi	c
1E-03	milli	m
1E-06	micro	μ
1E-09	nano	n
1E-12	pico	p

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ALLUVIUM. Sedimentary material deposited by flowing water such as a river.

ALLUVIAL FAN. A cone-shaped deposit of alluvium made by a stream where it runs out onto a level plain.

AQUIFER. A water-bearing unit of permeable rock or soil that will yield water in usable quantities to wells. *Confined aquifers* are bounded above and below by less permeable layers. Groundwater in a confined aquifer is under a pressure greater than the atmospheric pressure. *Unconfined aquifers* are bounded below by less permeable material, but are not bounded above. The pressure on the groundwater in an unconfined aquifer at the top of the aquifer is equal to that of the atmosphere.

AQUITARD. A relatively impervious and semiconfining geologic formation that transmits water at a very slow rate compared to an aquifer.

BACKGROUND RADIATION. Includes both natural and manmade radiation such as cosmic radiation and radiation from naturally radioactive elements and from commercial sources and medical procedures.

BECQUEREL (BQ). A unit of radioactivity equal to one nuclear transformation per second.

CLASS A, B, AND C LOW-LEVEL WASTE. Waste classifications from the Nuclear Regulatory Commission's 10 CFR Part 61 rule. Maximum concentration limits are set for specific isotopes. Class A waste disposal is minimally restricted with respect to the form of the waste. Class B waste must meet more rigorous requirements to ensure physical stability after disposal. Greater concentration limits are set for the same isotopes in Class C Waste and it also must meet physical stability requirements. Moreover, special measures must be taken at the disposal facility to protect against inadvertent intrusion.

CONFIDENCE COEFFICIENT OR FACTOR. The chance or probability, usually expressed as a percentage, that a confidence interval includes some defined parameter of a population. The confidence coefficients usually associated with confidence intervals are 90%, 95%, and 99%.

COSMIC RADIATION. High-energy subatomic particles from outer space that bombard the earth's atmosphere. Cosmic radiation is part of natural background radiation.

COUNTING ERROR. The variability caused by the inherent random nature of radioactive disintegration and the detection process.

CURIE(CI). A unit of radioactivity equal to 37 billion (3.7×10^{10})nuclear transformations per second.

DETECTION LEVEL. The minimum concentration of a substance that can be measured with a 99% confidence that the analytical concentration is greater than zero.

DERIVED CONCENTRATION GUIDE (DCG). Concentrations of radionuclides in air and water in which a person continuously exposed and inhaling 8400 m^3 of air or ingesting 730 liters of water per year would receive an annual effective dose equivalent of 100 mrem per year from either mode of exposure. The committed dose equivalent is included in the DCGs for radionuclides with long half-lives. (See Appendix B)

DISPERSION. The process whereby solutes are spread or mixed as they are transported by groundwater as it moves through sediments.

DOSIMETER. A portable device for measuring the total accumulated exposure to ionizing radiation.

DOWNGRADIENT. The direction of water flow from a reference point to a selected point of interest. (See GRADIENT)

EFFECTIVE DOSE. See "Effective Dose Equivalent" under "Radiation dose."

EFFLUENT. Flowing out or forth; an outflow of waste. In this report, effluent refers to the liquid or gaseous waste streams released into the environment from the facility.

EFFLUENT MONITORING. Sampling or measuring specific liquid or gaseous effluent streams for the presence of pollutants.

EXPOSURE. Subjecting a target (usually living tissue) to radiation.

FALLOUT. Radioactive materials mixed into the earth's atmosphere. Fallout constantly precipitates onto the earth.

GRADIENT. Change in value of one variable with respect to another variable, especially vertical or horizontal distance, e.g., gravity, temperature, magnetic intensity, electric potential.

GROUNDWATER. Subsurface water in the pore spaces of soil and geologic units.

HALF-LIFE. The time in which half the atoms of a radionuclide disintegrate into another nuclear form. The half-life may vary from a fraction of a second to thousands of years.

HIGH-LEVEL WASTE (HLW). The highly radioactive waste material that results from the reprocessing of spent nuclear fuel, including liquid waste produced directly in reprocessing and any solid waste derived from the liquid, that contains a combination of transuranic waste and fission products in concentrations sufficient to require permanent isolation.

HYDRAULIC CONDUCTIVITY. The ratio of flow velocity to driving force for viscous flow under saturated conditions of a specified liquid in a porous medium; the ratio describing the rate at which water can move through a permeable medium.

ION. An atom or group of atoms with an electric charge.

ION EXCHANGE. The reversible exchange of ions contained in a crystal for different ions in solution without destroying the crystal structure or disturbing the electrical neutrality.

ISOTOPE. Different forms of the same chemical element that are distinguished by having different numbers of neutrons in the nucleus. An element can have many isotopes. For example, the three isotopes of hydrogen are protium, deuterium, and tritium.

KAME DELTA. A conical hill or short irregular ridge of gravel or sand deposited in contact with glacier ice.

LACUSTRINE SEDIMENTS. A sedimentary deposit consisting of material pertaining to, produced by, or formed in a lake or lakes.

LEACHED HULLS. Stainless steel cladding that remains after acid dissolution of spent fuel.

LOW-LEVEL WASTE. Radioactive waste not classified as high-level waste, transuranic waste, spent fuel, or uranium mill tailings. (See Class A,B,C low-level waste).

MAXIMALLY EXPOSED INDIVIDUAL. A hypothetical person who remains in an uncontrolled area who would, when all potential routes of exposure from a facility's operations are considered, receive the greatest possible dose equivalent.

MEAN. The average value of a series of measurements.

MILLIREM (MREM). A unit of radiation dose equivalent that is equal to one one-thousandth of a rem. An individual member of the public can receive up to 500 millirems per year according to DOE standards. This limit does not include radiation received for medical treatment or the 100 to 360 mrem that people receive annually from background radiation.

MINIMUM DETECTABLE CONCENTRATION. The smallest amount or concentration of a radioactive or nonradioactive element that can be reliably detected in a sample.

MIXED WASTE. A waste that is both radioactive and hazardous.

OUTFALL. The end of a drain or pipe that carries waste water or other effluents into a ditch, pond, or river.

PARTICULATES. Solid particles and liquid droplets small enough to become airborne.

PERSON-REM. The sum of the individual radiation dose equivalents received by members of a certain group or population. It may be calculated by multiplying the average dose per person by the number of persons exposed. For example, a thousand people each exposed to one millirem would have a collective dose of one person-rem.

PLUME. The distribution of a pollutant in air or water after being released from a source.

PROGLACIAL LAKE. A lake occupying a basin in front of a glacier; generally in direct contact with the ice.

RAD. Radiation absorbed dose. One hundred ergs of energy absorbed per gram.

RADIATION. The process of emitting energy in the form of rays or particles that are thrown off by disintegrating atoms. The rays or particles emitted may consist of alpha, beta, or gamma radiation.

- ALPHA RADIATION. The least penetrating type of radiation. Alpha radiation can be stopped by a sheet of paper or outer dead layer of skin.
- BETA RADIATION. Electron emitted from a nucleus during fission and nuclear decay. Beta radiation can be stopped by an inch of wood or a thin sheet of aluminum.
- GAMMA RADIATION. A form of electromagnetic, high-energy radiation emitted from a nucleus. Gamma rays are essentially the same as x-rays and require heavy shielding such as lead, concrete, or steel to be stopped.
- INTERNAL RADIATION. Radiation originating from a source within the body as a result of the inhalation, ingestion, or implantation of natural or manmade radionuclides in body tissues.

RADIATION DOSE.

- ABSORBED DOSE. The amount of energy deposited by radiation in a given amount of material. Absorbed dose is measured in rads.
- COLLECTIVE DOSE EQUIVALENT. The sum of the dose equivalents for individuals comprising a defined population. The per capita dose equivalent is the quotient of the collective dose equivalent divided by the population size. (See PERSON-REM).
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fCi	femtocurie (1E-15Ci)
aCi	attocurie (1E-18 Ci)
Bq	becquerel (27 pCi)

Volume

Symbol	*Name*
cm^3	cubic centimeter
L	liter
mL	milliliter
m^3	cubic meter
ppm	parts per million
ppb	parts per billion

Dose

Symbol	*Name*
Sv	sievert (100 rems)
Gy	gray (100 rads)

Time

Symbol	*Name*
y	year
d	day
h	hour
m	minute
s	second

Length

Symbol	*Name*
m	meter
km	kilometer (1E+03 m)
cm	centimeter (1E-02 m)
mm	millimeter (1E-03 m)
μm	micrometer (1E-06 m)

Area

Symbol	*Name*
ha	hectare (10,000 m^2)

Mass

Symbol	*Name*
g	gram
kg	kilogram (1E+03 g)
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pCi/L	1E-09	μCi/mL	μCi/mL	1E+09	pCi/L
pCi/m^3	1E-12	Ci/m^3	Ci/m^3	1E+12	pCi/m^3
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gray	100	rad	rad	0.01	gray
sievert	100	rem	rem	0.01	sievert
ppb	0.001	ppm	ppm	1000	ppb
ppm	1.0	mg/L	mg/L	1.0	ppm

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Factor	*Prefix*	*Symbol*
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1E+06	mega	M
1E+03	kilo	k
1E-02	centi	c
1E-03	milli	m
1E-06	micro	μ
1E-09	nano	n
1E-12	pico	p

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ALLUVIUM. Sedimentary material deposited by flowing water such as a river.

ALLUVIAL FAN. A cone-shaped deposit of alluvium made by a stream where it runs out onto a level plain.

AQUIFER. A water-bearing unit of permeable rock or soil that will yield water in usable quantities to wells. *Confined aquifers* are bounded above and below by less permeable layers. Groundwater in a confined aquifer is under a pressure greater than the atmospheric pressure. *Unconfined aquifers* are bounded below by less permeable material, but are not bounded above. The pressure on the groundwater in an unconfined aquifer at the top of the aquifer is equal to that of the atmosphere.

AQUITARD. A relatively impervious and semiconfining geologic formation that transmits water at a very slow rate compared to an aquifer.

BACKGROUND RADIATION. Includes both natural and manmade radiation such as cosmic radiation and radiation from naturally radioactive elements and from commercial sources and medical procedures.

BECQUEREL (BQ). A unit of radioactivity equal to one nuclear transformation per second.

CLASS A, B, AND C LOW-LEVEL WASTE. Waste classifications from the Nuclear Regulatory Commission's 10 CFR Part 61 rule. Maximum concentration limits are set for specific isotopes. Class A waste disposal is minimally restricted with respect to the form of the waste. Class B waste must meet more rigorous requirements to ensure physical stability after disposal. Greater concentration limits are set for the same isotopes in Class C Waste and it also must meet physical stability requirements. Moreover, special measures must be taken at the disposal facility to protect against inadvertent intrusion.

CONFIDENCE COEFFICIENT OR FACTOR. The chance or probability, usually expressed as a percentage, that a confidence interval includes some defined parameter of a population. The confidence coefficients usually associated with confidence intervals are 90%, 95%, and 99%.

COSMIC RADIATION. High-energy subatomic particles from outer space that bombard the earth's atmosphere. Cosmic radiation is part of natural background radiation.

COUNTING ERROR. The variability caused by the inherent random nature of radioactive disintegration and the detection process.

CURIE(CI). A unit of radioactivity equal to 37 billion (3.7×10^{10})nuclear transformations per second.

DETECTION LEVEL. The minimum concentration of a substance that can be measured with a 99% confidence that the analytical concentration is greater than zero.

DERIVED CONCENTRATION GUIDE (DCG). Concentrations of radionuclides in air and water in which a person continuously exposed and inhaling 8400 m^3 of air or ingesting 730 liters of water per year would receive an annual effective dose equivalent of 100 mrem per year from either mode of exposure. The committed dose equivalent is included in the DCGs for radionuclides with long half-lives. (See Appendix B)

DISPERSION. The process whereby solutes are spread or mixed as they are transported by groundwater as it moves through sediments.

DOSIMETER. A portable device for measuring the total accumulated exposure to ionizing radiation.

DOWNGRADIENT. The direction of water flow from a reference point to a selected point of interest. (See GRADIENT)

EFFECTIVE DOSE. See "Effective Dose Equivalent" under "Radiation dose."

EFFLUENT. Flowing out or forth; an outflow of waste. In this report, effluent refers to the liquid or gaseous waste streams released into the environment from the facility.

EFFLUENT MONITORING. Sampling or measuring specific liquid or gaseous effluent streams for the presence of pollutants.

EXPOSURE. Subjecting a target (usually living tissue) to radiation.

FALLOUT. Radioactive materials mixed into the earth's atmosphere. Fallout constantly precipitates onto the earth.

GRADIENT. Change in value of one variable with respect to another variable, especially vertical or horizontal distance, e.g., gravity, temperature, magnetic intensity, electric potential.

GROUNDWATER. Subsurface water in the pore spaces of soil and geologic units.

HALF-LIFE. The time in which half the atoms of a radionuclide disintegrate into another nuclear form. The half-life may vary from a fraction of a second to thousands of years.

HIGH-LEVEL WASTE (HLW). The highly radioactive waste material that results from the reprocessing of spent nuclear fuel, including liquid waste produced directly in reprocessing and any solid waste derived from the liquid, that contains a combination of transuranic waste and fission products in concentrations sufficient to require permanent isolation.

HYDRAULIC CONDUCTIVITY. The ratio of flow velocity to driving force for viscous flow under saturated conditions of a specified liquid in a porous medium; the ratio describing the rate at which water can move through a permeable medium.

ION. An atom or group of atoms with an electric charge.

ION EXCHANGE. The reversible exchange of ions contained in a crystal for different ions in solution without destroying the crystal structure or disturbing the electrical neutrality.

ISOTOPE. Different forms of the same chemical element that are distinguished by having different numbers of neutrons in the nucleus. An element can have many isotopes. For example, the three isotopes of hydrogen are protium, deuterium, and tritium.

KAME DELTA. A conical hill or short irregular ridge of gravel or sand deposited in contact with glacier ice.

LACUSTRINE SEDIMENTS. A sedimentary deposit consisting of material pertaining to, produced by, or formed in a lake or lakes.

LEACHED HULLS. Stainless steel cladding that remains after acid dissolution of spent fuel.

LOW-LEVEL WASTE. Radioactive waste not classified as high-level waste, transuranic waste, spent fuel, or uranium mill tailings. (See Class A,B,C low-level waste).

MAXIMALLY EXPOSED INDIVIDUAL. A hypothetical person who remains in an uncontrolled area who would, when all potential routes of exposure from a facility's operations are considered, receive the greatest possible dose equivalent.

MEAN. The average value of a series of measurements.

MILLIREM (MREM). A unit of radiation dose equivalent that is equal to one one-thousandth of a rem. An individual member of the public can receive up to 500 millirems per year according to DOE standards. This limit does not include radiation received for medical treatment or the 100 to 360 mrem that people receive annually from background radiation.

MINIMUM DETECTABLE CONCENTRATION. The smallest amount or concentration of a radioactive or nonradioactive element that can be reliably detected in a sample.

MIXED WASTE. A waste that is both radioactive and hazardous.

OUTFALL. The end of a drain or pipe that carries waste water or other effluents into a ditch, pond, or river.

PARTICULATES. Solid particles and liquid droplets small enough to become airborne.

PERSON-REM. The sum of the individual radiation dose equivalents received by members of a certain group or population. It may be calculated by multiplying the average dose per person by the number of persons exposed. For example, a thousand people each exposed to one millirem would have a collective dose of one person-rem.

PLUME. The distribution of a pollutant in air or water after being released from a source.

PROGLACIAL LAKE. A lake occupying a basin in front of a glacier; generally in direct contact with the ice.

RAD. Radiation absorbed dose. One hundred ergs of energy absorbed per gram.

RADIATION. The process of emitting energy in the form of rays or particles that are thrown off by disintegrating atoms. The rays or particles emitted may consist of alpha, beta, or gamma radiation.

- ALPHA RADIATION. The least penetrating type of radiation. Alpha radiation can be stopped by a sheet of paper or outer dead layer of skin.

- BETA RADIATION. Electron emitted from a nucleus during fission and nuclear decay. Beta radiation can be stopped by an inch of wood or a thin sheet of aluminum.

- GAMMA RADIATION. A form of electromagnetic, high-energy radiation emitted from a nucleus. Gamma rays are essentially the same as x-rays and require heavy shielding such as lead, concrete, or steel to be stopped.

- INTERNAL RADIATION. Radiation originating from a source within the body as a result of the inhalation, ingestion, or implantation of natural or manmade radionuclides in body tissues.

RADIATION DOSE.

- ABSORBED DOSE. The amount of energy deposited by radiation in a given amount of material. Absorbed dose is measured in rads.

- COLLECTIVE DOSE EQUIVALENT. The sum of the dose equivalents for individuals comprising a defined population. The per capita dose equivalent is the quotient of the collective dose equivalent divided by the population size. (See PERSON-REM).

- COMMITTED DOSE EQUIVALENT (dose commitment). The total dose equivalent accumulated in an organ or tissue in the fifty years following a single intake of radioactive materials into the body.

- CUMULATIVE DOSE EQUIVALENT. The total dose one could receive in a period of fifty years following release of radionuclides to the environment, including the dose that could occur as a result of residual radionuclides remaining in the environment beyond the year of release.

- DOSE EQUIVALENT. The product of the absorbed dose, the quality factor, and any other modifying factors. The dose equivalent is a quantity for comparing the biological effectiveness of different kinds of radiation on a common scale. The unit of dose equivalent is the rem.

- EFFECTIVE DOSE EQUIVALENT. An estimate of the total risk of potential health effects from radiation exposure. It is the sum of the committed effective dose equivalent from internal deposition and the effective dose equivalent from external penetrating radiation received during a calendar year. The committed effective dose equivalent is the sum of the individual organ committed dose equivalents (fifty years) multiplied by weighting factors that represent the proportion of the total random risk that each organ would receive from uniform irradiation of the whole body.

RADIOACTIVITY. A property possessed by some elements such as uranium whereby alpha, beta, or gamma rays are spontaneously emitted.

RADIOISOTOPE. A radioactive isotope of a specified element. Carbon-14 is a radioisotope of carbon. Tritium is a radioisotope of hydrogen.

RADIONUCLIDE. A radioactive nuclide. Radionuclides are variations (isotopes) of elements. They have the same number of protons and electrons but different numbers of neutrons, resulting in different atomic masses.There are several hundred known nuclides, both man-made and naturally occurring.

REM. An acronym for Roentgen Equivalent Man. A unit of radiation exposure that indicates the potential effect on human cells.

SIEVERT. A unit of dose equivalent from the International System of Units equal to one joule per kilogram.

SPENT FUEL. Nuclear fuel that has been exposed in a nuclear reactor; this fuel contains uranium, activation products, fission products, and plutonium.

STANDARD DEVIATION. An indication of the dispersion of a set of results around their average.

THERMOLUMINESCENT DOSIMETER (TLD). A material that luminesces upon heating after being exposed to radiation. The amount of light emitted is proportional to the amount of radiation to which it has been exposed.

UPGRADIENT. Referring to the flow of water or air, it is analogous to upstream. A point that is "before" an area of study that is used as a baseline for comparison with downstream data. See GRADIENT and DOWNGRADIENT.

WATERSHED. The area contained within a drainage divide above a specified point on a stream.

WATER TABLE. The upper surface in a body of groundwater. The surface in an unconfined aquifer or confining bed at which the pore water pressure is equal to atmospheric pressure.

WHOLE-BODY DOSE. A radiation dose that involves exposure of the entire body.

Abbreviations for Units of Measure

Radioactivity

Symbol	Name
Ci	curie
mCi	millicurie (1E-03 Ci)
μCi	microcurie (1E-06 Ci)
nCi	nanocurie (1E-09 Ci)
pCi	picocurie (1E-12 Ci)
fCi	femtocurie (1E-15Ci)
aCi	attocurie (1E-18 Ci)
Bq	becquerel (27 pCi)

Volume

Symbol	Name
cm^3	cubic centimeter
L	liter
mL	milliliter
m^3	cubic meter
ppm	parts per million
ppb	parts per billion

Dose

Symbol	Name
Sv	sievert (100 rems)
Gy	gray (100 rads)

Time

Symbol	Name
y	year
d	day
h	hour
m	minute
s	second

Length

Symbol	Name
m	meter
km	kilometer (1E+03 m)
cm	centimeter (1E-02 m)
mm	millimeter (1E-03 m)
μm	micrometer (1E-06 m)

Area

Symbol	Name
ha	hectare (10,000 m^2)

Mass

Symbol	Name
g	gram
kg	kilogram (1E+03 g)
mg	milligram (1E-03)
μg	microgram(1E-06 g)
ng	nanogram (1E-09 g)
t	metric ton (10^3 kg)

Conversion Table

Multiply	*by*	*To obtain*	*Multiply*	*by*	*To obtain*
in.	2.54	cm	cm	0.394	in.
ft	0.305	m	m	3.28	ft.
mi	1.61	km	km	0.621	mi
lb	0.454	kg	kg	2.205	lb
liq. qt.	0.946	L	L	1.057	liq. qt.
ft^2	0.093	m^2	m^2	10.76	ft^2
ha	2.47	acres	acres	0.405	ha
mi^2	2.59	km^2	km^2	0.386	mi^2
ft^3	0.028	m^3	m^3	35.7	ft^3
dpm	0.450	pCi	pCi	2.22	dpm
nCi	1000	pCi	pCi	0.001	nCi
pCi/L	1E-09	μCi/mL	μCi/mL	1E+09	pCi/L
pCi/m^3	1E-12	Ci/m^3	Ci/m^3	1E+12	pCi/m^3
becquerel	2.7E-11	curie	curie	3.7E+10	becquerel
gray	100	rad	rad	0.01	gray
sievert	100	rem	rem	0.01	sievert
ppb	0.001	ppm	ppm	1000	ppb
ppm	1.0	mg/L	mg/L	1.0	ppm

Unit Prefixes

Factor	*Prefix*	*Symbol*
1E+09	giga	G
1E+06	mega	M
1E+03	kilo	k
1E-02	centi	c
1E-03	milli	m
1E-06	micro	μ
1E-09	nano	n
1E-12	pico	p

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RADIATION. The process of emitting energy in the form of rays or particles that are thrown off by disintegrating atoms. The rays or particles emitted may consist of alpha, beta, or gamma radiation.

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- BETA RADIATION. Electron emitted from a nucleus during fission and nuclear decay. Beta radiation can be stopped by an inch of wood or a thin sheet of aluminum.
- GAMMA RADIATION. A form of electromagnetic, high-energy radiation emitted from a nucleus. Gamma rays are essentially the same as x-rays and require heavy shielding such as lead, concrete, or steel to be stopped.
- INTERNAL RADIATION. Radiation originating from a source within the body as a result of the inhalation, ingestion, or implantation of natural or manmade radionuclides in body tissues.

RADIATION DOSE.

- ABSORBED DOSE. The amount of energy deposited by radiation in a given amount of material. Absorbed dose is measured in rads.
- COLLECTIVE DOSE EQUIVALENT. The sum of the dose equivalents for individuals comprising a defined population. The per capita dose equivalent is the quotient of the collective dose equivalent divided by the population size. (See PERSON-REM).
- COMMITTED DOSE EQUIVALENT (dose commitment). The total dose equivalent accumulated in an organ or tissue in the fifty years following a single intake of radioactive materials into the body.
- CUMULATIVE DOSE EQUIVALENT. The total dose one could receive in a period of fifty years following release of radionuclides to the environment, including the dose that could occur as a result of residual radionuclides remaining in the environment beyond the year of release.
- DOSE EQUIVALENT. The product of the absorbed dose, the quality factor, and any other modifying factors. The dose equivalent is a quantity for comparing the biological effectiveness of different kinds of radiation on a common scale. The unit of dose equivalent is the rem.
- EFFECTIVE DOSE EQUIVALENT. An estimate of the total risk of potential health effects from radiation exposure. It is the sum of the committed effective dose equivalent from internal deposition and the effective dose equivalent from external penetrating radiation received during a calendar year. The committed effective dose equivalent is the sum of the individual organ committed dose equivalents (fifty years) multiplied by weighting factors that represent the proportion of the total random risk that each organ would receive from uniform irradiation of the whole body.

RADIOACTIVITY. A property possessed by some elements such as uranium whereby alpha, beta, or gamma rays are spontaneously emitted.

RADIOISOTOPE. A radioactive isotope of a specified element. Carbon-14 is a radioisotope of carbon. Tritium is a radioisotope of hydrogen.

RADIONUCLIDE. A radioactive nuclide. Radionuclides are variations (isotopes) of elements. They have the same number of protons and electrons but different numbers of neutrons, resulting in different atomic masses.There are several hundred known nuclides, both man-made and naturally occurring.

REM. An acronym for Roentgen Equivalent Man. A unit of radiation exposure that indicates the potential effect on human cells.

SIEVERT. A unit of dose equivalent from the International System of Units equal to one joule per kilogram.

SPENT FUEL. Nuclear fuel that has been exposed in a nuclear reactor; this fuel contains uranium, activation products, fission products, and plutonium.

STANDARD DEVIATION. An indication of the dispersion of a set of results around their average.

THERMOLUMINESCENT DOSIMETER (TLD). A material that luminesces upon heating after being exposed to radiation. The amount of light emitted is proportional to the amount of radiation to which it has been exposed.

UPGRADIENT. Referring to the flow of water or air, it is analogous to upstream. A point that is "before" an area of study that is used as a baseline for comparison with downstream data. See GRADIENT and DOWNGRADIENT.

WATERSHED. The area contained within a drainage divide above a specified point on a stream.

WATER TABLE. The upper surface in a body of groundwater. The surface in an unconfined aquifer or confining bed at which the pore water pressure is equal to atmospheric pressure.

WHOLE-BODY DOSE. A radiation dose that involves exposure of the entire body.

Abbreviations for Units of Measure

Radioactivity

Symbol	*Name*
Ci	curie
mCi	millicurie (1E-03 Ci)
μCi	microcurie (1E-06 Ci)
nCi	nanocurie (1E-09 Ci)
pCi	picocurie (1E-12 Ci)
fCi	femtocurie (1E-15Ci)
aCi	attocurie (1E-18 Ci)
Bq	becquerel (27 pCi)

Volume

Symbol	*Name*
cm^3	cubic centimeter
L	liter
mL	milliliter
m^3	cubic meter
ppm	parts per million
ppb	parts per billion

Dose

Symbol	*Name*
Sv	sievert (100 rems)
Gy	gray (100 rads)

Time

Symbol	*Name*
y	year
d	day
h	hour
m	minute
s	second

Length

Symbol	*Name*
m	meter
km	kilometer (1E+03 m)
cm	centimeter (1E-02 m)
mm	millimeter (1E-03 m)
μm	micrometer (1E-06 m)

Area

Symbol	*Name*
ha	hectare (10,000 m^2)

Mass

Symbol	*Name*
g	gram
kg	kilogram (1E+03 g)
mg	milligram (1E-03)
μg	microgram(1E-06 g)
ng	nanogram (1E-09 g)
t	metric ton (10^3 kg)

Conversion Table

Multiply	*by*	*To obtain*	*Multiply*	*by*	*To obtain*
in.	2.54	cm	cm	0.394	in.
ft	0.305	m	m	3.28	ft.
mi	1.61	km	km	0.621	mi
lb	0.454	kg	kg	2.205	lb
liq. qt.	0.946	L	L	1.057	liq. qt.
ft^2	0.093	m^2	m^2	10.76	ft^2
ha	2.47	acres	acres	0.405	ha
mi^2	2.59	km^2	km^2	0.386	mi^2
ft^3	0.028	m^3	m^3	35.7	ft^3
dpm	0.450	pCi	pCi	2.22	dpm
nCi	1000	pCi	pCi	0.001	nCi
pCi/L	1E-09	μCi/mL	μCi/mL	1E+09	pCi/L
pCi/m^3	1E-12	Ci/m^3	Ci/m^3	1E+12	pCi/m^3
becquerel	2.7E-11	curie	curie	3.7E+10	becquerel
gray	100	rad	rad	0.01	gray
sievert	100	rem	rem	0.01	sievert
ppb	0.001	ppm	ppm	1000	ppb
ppm	1.0	mg/L	mg/L	1.0	ppm

Unit Prefixes

Factor	*Prefix*	*Symbol*
1E+09	giga	G
1E+06	mega	M
1E+03	kilo	k
1E-02	centi	c
1E-03	milli	m
1E-06	micro	μ
1E-09	nano	n
1E-12	pico	p

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pCi	picocurie (1E-12 Ci)
fCi	femtocurie (1E-15Ci)
aCi	attocurie (1E-18 Ci)
Bq	becquerel (27 pCi)

Volume

Symbol	*Name*
cm^3	cubic centimeter
L	liter
mL	milliliter
m^3	cubic meter
ppm	parts per million
ppb	parts per billion

Dose

Symbol	*Name*
Sv	sievert (100 rems)
Gy	gray (100 rads)

Time

Symbol	*Name*
y	year
d	day
h	hour
m	minute
s	second

Length

Symbol	*Name*
m	meter
km	kilometer (1E+03 m)
cm	centimeter (1E-02 m)
mm	millimeter (1E-03 m)
μm	micrometer (1E-06 m)

Area

Symbol	*Name*
ha	hectare (10,000 m^2)

Mass

Symbol	*Name*
g	gram
kg	kilogram (1E+03 g)
mg	milligram (1E-03)
μg	microgram(1E-06 g)
ng	nanogram (1E-09 g)
t	metric ton (10^3 kg)

Conversion Table

Multiply	*by*	*To obtain*	*Multiply*	*by*	*To obtain*
in.	2.54	cm	cm	0.394	in.
ft	0.305	m	m	3.28	ft.
mi	1.61	km	km	0.621	mi
lb	0.454	kg	kg	2.205	lb
liq. qt.	0.946	L	L	1.057	liq. qt.
ft^2	0.093	m^2	m^2	10.76	ft^2
ha	2.47	acres	acres	0.405	ha
mi^2	2.59	km^2	km^2	0.386	mi^2
ft^3	0.028	m^3	m^3	35.7	ft^3
dpm	0.450	pCi	pCi	2.22	dpm
nCi	1000	pCi	pCi	0.001	nCi
pCi/L	1E-09	μCi/mL	μCi/mL	1E+09	pCi/L
pCi/m^3	1E-12	Ci/m^3	Ci/m^3	1E+12	pCi/m^3
becquerel	2.7E-11	curie	curie	3.7E+10	becquerel
gray	100	rad	rad	0.01	gray
sievert	100	rem	rem	0.01	sievert
ppb	0.001	ppm	ppm	1000	ppb
ppm	1.0	mg/L	mg/L	1.0	ppm

Unit Prefixes

Factor	*Prefix*	*Symbol*
1E+09	giga	G
1E+06	mega	M
1E+03	kilo	k
1E-02	centi	c
1E-03	milli	m
1E-06	micro	μ
1E-09	nano	n
1E-12	pico	p

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ALLUVIUM. Sedimentary material deposited by flowing water such as a river.

ALLUVIAL FAN. A cone-shaped deposit of alluvium made by a stream where it runs out onto a level plain.

AQUIFER. A water-bearing unit of permeable rock or soil that will yield water in usable quantities to wells. *Confined aquifers* are bounded above and below by less permeable layers. Groundwater in a confined aquifer is under a pressure greater than the atmospheric pressure. *Unconfined aquifers* are bounded below by less permeable material, but are not bounded above. The pressure on the groundwater in an unconfined aquifer at the top of the aquifer is equal to that of the atmosphere.

AQUITARD. A relatively impervious and semiconfining geologic formation that transmits water at a very slow rate compared to an aquifer.

BACKGROUND RADIATION. Includes both natural and manmade radiation such as cosmic radiation and radiation from naturally radioactive elements and from commercial sources and medical procedures.

BECQUEREL (BQ). A unit of radioactivity equal to one nuclear transformation per second.

CLASS A, B, AND C LOW-LEVEL WASTE. Waste classifications from the Nuclear Regulatory Commission's 10 CFR Part 61 rule. Maximum concentration limits are set for specific isotopes. Class A waste disposal is minimally restricted with respect to the form of the waste. Class B waste must meet more rigorous requirements to ensure physical stability after disposal. Greater concentration limits are set for the same isotopes in Class C Waste and it also must meet physical stability requirements. Moreover, special measures must be taken at the disposal facility to protect against inadvertent intrusion.

CONFIDENCE COEFFICIENT OR FACTOR. The chance or probability, usually expressed as a percentage, that a confidence interval includes some defined parameter of a population. The confidence coefficients usually associated with confidence intervals are 90%, 95%, and 99%.

COSMIC RADIATION. High-energy subatomic particles from outer space that bombard the earth's atmosphere. Cosmic radiation is part of natural background radiation.

COUNTING ERROR. The variability caused by the inherent random nature of radioactive disintegration and the detection process.

CURIE(CI). A unit of radioactivity equal to 37 billion (3.7×10^{10})nuclear transformations per second.

DETECTION LEVEL. The minimum concentration of a substance that can be measured with a 99% confidence that the analytical concentration is greater than zero.

DERIVED CONCENTRATION GUIDE (DCG). Concentrations of radionuclides in air and water in which a person continuously exposed and inhaling 8400 m^3 of air or ingesting 730 liters of water per year would receive an annual effective dose equivalent of 100 mrem per year from either mode of exposure. The committed dose equivalent is included in the DCGs for radionuclides with long half-lives. (See Appendix B)

DISPERSION. The process whereby solutes are spread or mixed as they are transported by groundwater as it moves through sediments.

DOSIMETER. A portable device for measuring the total accumulated exposure to ionizing radiation.

DOWNGRADIENT. The direction of water flow from a reference point to a selected point of interest. (See GRADIENT)

EFFECTIVE DOSE. See "Effective Dose Equivalent" under "Radiation dose."

EFFLUENT. Flowing out or forth; an outflow of waste. In this report, effluent refers to the liquid or gaseous waste streams released into the environment from the facility.

EFFLUENT MONITORING. Sampling or measuring specific liquid or gaseous effluent streams for the presence of pollutants.

EXPOSURE. Subjecting a target (usually living tissue) to radiation.

FALLOUT. Radioactive materials mixed into the earth's atmosphere. Fallout constantly precipitates onto the earth.

GRADIENT. Change in value of one variable with respect to another variable, especially vertical or horizontal distance, e.g., gravity, temperature, magnetic intensity, electric potential.

GROUNDWATER. Subsurface water in the pore spaces of soil and geologic units.

HALF-LIFE. The time in which half the atoms of a radionuclide disintegrate into another nuclear form. The half-life may vary from a fraction of a second to thousands of years.

HIGH-LEVEL WASTE (HLW). The highly radioactive waste material that results from the reprocessing of spent nuclear fuel, including liquid waste produced directly in reprocessing and any solid waste derived from the liquid, that contains a combination of transuranic waste and fission products in concentrations sufficient to require permanent isolation.

HYDRAULIC CONDUCTIVITY. The ratio of flow velocity to driving force for viscous flow under saturated conditions of a specified liquid in a porous medium; the ratio describing the rate at which water can move through a permeable medium.

ION. An atom or group of atoms with an electric charge.

ION EXCHANGE. The reversible exchange of ions contained in a crystal for different ions in solution without destroying the crystal structure or disturbing the electrical neutrality.

ISOTOPE. Different forms of the same chemical element that are distinguished by having different numbers of neutrons in the nucleus. An element can have many isotopes. For example, the three isotopes of hydrogen are protium, deuterium, and tritium.

KAME DELTA. A conical hill or short irregular ridge of gravel or sand deposited in contact with glacier ice.

LACUSTRINE SEDIMENTS. A sedimentary deposit consisting of material pertaining to, produced by, or formed in a lake or lakes.

LEACHED HULLS. Stainless steel cladding that remains after acid dissolution of spent fuel.

LOW-LEVEL WASTE. Radioactive waste not classified as high-level waste, transuranic waste, spent fuel, or uranium mill tailings. (See Class A,B,C low-level waste).

MAXIMALLY EXPOSED INDIVIDUAL. A hypothetical person who remains in an uncontrolled area who would, when all potential routes of exposure from a facility's operations are considered, receive the greatest possible dose equivalent.

MEAN. The average value of a series of measurements.

MILLIREM (MREM). A unit of radiation dose equivalent that is equal to one one-thousandth of a rem. An individual member of the public can receive up to 500 millirems per year according to DOE standards. This limit does not include radiation received for medical treatment or the 100 to 360 mrem that people receive annually from background radiation.

MINIMUM DETECTABLE CONCENTRATION. The smallest amount or concentration of a radioactive or nonradioactive element that can be reliably detected in a sample.

MIXED WASTE. A waste that is both radioactive and hazardous.

OUTFALL. The end of a drain or pipe that carries waste water or other effluents into a ditch, pond, or river.

PARTICULATES. Solid particles and liquid droplets small enough to become airborne.

PERSON-REM. The sum of the individual radiation dose equivalents received by members of a certain group or population. It may be calculated by multiplying the average dose per person by the number of persons exposed. For example, a thousand people each exposed to one millirem would have a collective dose of one person-rem.

PLUME. The distribution of a pollutant in air or water after being released from a source.

PROGLACIAL LAKE. A lake occupying a basin in front of a glacier; generally in direct contact with the ice.

RAD. Radiation absorbed dose. One hundred ergs of energy absorbed per gram.

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fCi	femtocurie (1E-15Ci)
aCi	attocurie (1E-18 Ci)
Bq	becquerel (27 pCi)

Volume

Symbol	*Name*
cm^3	cubic centimeter
L	liter
mL	milliliter
m^3	cubic meter
ppm	parts per million
ppb	parts per billion

Dose

Symbol	*Name*
Sv	sievert (100 rems)
Gy	gray (100 rads)

Time

Symbol	*Name*
y	year
d	day
h	hour
m	minute
s	second

Length

Symbol	*Name*
m	meter
km	kilometer (1E+03 m)
cm	centimeter (1E-02 m)
mm	millimeter (1E-03 m)
μm	micrometer (1E-06 m)

Area

Symbol	*Name*
ha	hectare (10,000 m^2)

Mass

Symbol	*Name*
g	gram
kg	kilogram (1E+03 g)
mg	milligram (1E-03)
μg	microgram(1E-06 g)
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ha	2.47	acres
mi^2	2.59	km^2
ft^3	0.028	m^3
dpm	0.450	pCi
nCi	1000	pCi
pCi/L	1E-09	μCi/mL
pCi/m^3	1E-12	Ci/m^3
becquerel	2.7E-11	curie
gray	100	rad
sievert	100	rem
ppb	0.001	ppm
ppm	1.0	mg/L

Multiply	*by*	*To obtain*
cm	0.394	in.
m	3.28	ft.
km	0.621	mi
kg	2.205	lb
L	1.057	liq. qt.
m^2	10.76	ft^2
acres	0.405	ha
km^2	0.386	mi^2
m^3	35.7	ft^3
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pCi	0.001	nCi
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Ci/m^3	1E+12	pCi/m^3
curie	3.7E+10	becquerel
rad	0.01	gray
rem	0.01	sievert
ppm	1000	ppb
mg/L	1.0	ppm

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Factor	*Prefix*	*Symbol*
1E+09	giga	G
1E+06	mega	M
1E+03	kilo	k
1E-02	centi	c
1E-03	milli	m
1E-06	micro	μ
1E-09	nano	n
1E-12	pico	p

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ALLUVIUM. Sedimentary material deposited by flowing water such as a river.

ALLUVIAL FAN. A cone-shaped deposit of alluvium made by a stream where it runs out onto a level plain.

AQUIFER. A water-bearing unit of permeable rock or soil that will yield water in usable quantities to wells. *Confined aquifers* are bounded above and below by less permeable layers. Groundwater in a confined aquifer is under a pressure greater than the atmospheric pressure. *Unconfined aquifers* are bounded below by less permeable material, but are not bounded above. The pressure on the groundwater in an unconfined aquifer at the top of the aquifer is equal to that of the atmosphere.

AQUITARD. A relatively impervious and semiconfining geologic formation that transmits water at a very slow rate compared to an aquifer.

BACKGROUND RADIATION. Includes both natural and manmade radiation such as cosmic radiation and radiation from naturally radioactive elements and from commercial sources and medical procedures.

BECQUEREL (BQ). A unit of radioactivity equal to one nuclear transformation per second.

CLASS A, B, AND C LOW-LEVEL WASTE. Waste classifications from the Nuclear Regulatory Commission's 10 CFR Part 61 rule. Maximum concentration limits are set for specific isotopes. Class A waste disposal is minimally restricted with respect to the form of the waste. Class B waste must meet more rigorous requirements to ensure physical stability after disposal. Greater concentration limits are set for the same isotopes in Class C Waste and it also must meet physical stability requirements. Moreover, special measures must be taken at the disposal facility to protect against inadvertent intrusion.

CONFIDENCE COEFFICIENT OR FACTOR. The chance or probability, usually expressed as a percentage, that a confidence interval includes some defined parameter of a population. The confidence coefficients usually associated with confidence intervals are 90%, 95%, and 99%.

COSMIC RADIATION. High-energy subatomic particles from outer space that bombard the earth's atmosphere. Cosmic radiation is part of natural background radiation.

COUNTING ERROR. The variability caused by the inherent random nature of radioactive disintegration and the detection process.

CURIE(CI). A unit of radioactivity equal to 37 billion (3.7×10^{10})nuclear transformations per second.

DETECTION LEVEL. The minimum concentration of a substance that can be measured with a 99% confidence that the analytical concentration is greater than zero.

DERIVED CONCENTRATION GUIDE (DCG). Concentrations of radionuclides in air and water in which a person continuously exposed and inhaling 8400 m^3 of air or ingesting 730 liters of water per year would receive an annual effective dose equivalent of 100 mrem per year from either mode of exposure. The committed dose equivalent is included in the DCGs for radionuclides with long half-lives. (See Appendix B)

DISPERSION. The process whereby solutes are spread or mixed as they are transported by groundwater as it moves through sediments.

DOSIMETER. A portable device for measuring the total accumulated exposure to ionizing radiation.

DOWNGRADIENT. The direction of water flow from a reference point to a selected point of interest. (See GRADIENT)

EFFECTIVE DOSE. See "Effective Dose Equivalent" under "Radiation dose."

EFFLUENT. Flowing out or forth; an outflow of waste. In this report, effluent refers to the liquid or gaseous waste streams released into the environment from the facility.

EFFLUENT MONITORING. Sampling or measuring specific liquid or gaseous effluent streams for the presence of pollutants.

EXPOSURE. Subjecting a target (usually living tissue) to radiation.

FALLOUT. Radioactive materials mixed into the earth's atmosphere. Fallout constantly precipitates onto the earth.

GRADIENT. Change in value of one variable with respect to another variable, especially vertical or horizontal distance, e.g., gravity, temperature, magnetic intensity, electric potential.

GROUNDWATER. Subsurface water in the pore spaces of soil and geologic units.

HALF-LIFE. The time in which half the atoms of a radionuclide disintegrate into another nuclear form. The half-life may vary from a fraction of a second to thousands of years.

HIGH-LEVEL WASTE (HLW). The highly radioactive waste material that results from the reprocessing of spent nuclear fuel, including liquid waste produced directly in reprocessing and any solid waste derived from the liquid, that contains a combination of transuranic waste and fission products in concentrations sufficient to require permanent isolation.

HYDRAULIC CONDUCTIVITY. The ratio of flow velocity to driving force for viscous flow under saturated conditions of a specified liquid in a porous medium; the ratio describing the rate at which water can move through a permeable medium.

ION. An atom or group of atoms with an electric charge.

ION EXCHANGE. The reversible exchange of ions contained in a crystal for different ions in solution without destroying the crystal structure or disturbing the electrical neutrality.

ISOTOPE. Different forms of the same chemical element that are distinguished by having different numbers of neutrons in the nucleus. An element can have many isotopes. For example, the three isotopes of hydrogen are protium, deuterium, and tritium.

KAME DELTA. A conical hill or short irregular ridge of gravel or sand deposited in contact with glacier ice.

LACUSTRINE SEDIMENTS. A sedimentary deposit consisting of material pertaining to, produced by, or formed in a lake or lakes.

LEACHED HULLS. Stainless steel cladding that remains after acid dissolution of spent fuel.

LOW-LEVEL WASTE. Radioactive waste not classified as high-level waste, transuranic waste, spent fuel, or uranium mill tailings. (See Class A,B,C low-level waste).

MAXIMALLY EXPOSED INDIVIDUAL. A hypothetical person who remains in an uncontrolled area who would, when all potential routes of exposure from a facility's operations are considered, receive the greatest possible dose equivalent.

MEAN. The average value of a series of measurements.

MILLIREM (MREM). A unit of radiation dose equivalent that is equal to one one-thousandth of a rem. An individual member of the public can receive up to 500 millirems per year according to DOE standards. This limit does not include radiation received for medical treatment or the 100 to 360 mrem that people receive annually from background radiation.

MINIMUM DETECTABLE CONCENTRATION. The smallest amount or concentration of a radioactive or nonradioactive element that can be reliably detected in a sample.

MIXED WASTE. A waste that is both radioactive and hazardous.

OUTFALL. The end of a drain or pipe that carries waste water or other effluents into a ditch, pond, or river.

PARTICULATES. Solid particles and liquid droplets small enough to become airborne.

PERSON-REM. The sum of the individual radiation dose equivalents received by members of a certain group or population. It may be calculated by multiplying the average dose per person by the number of persons exposed. For example, a thousand people each exposed to one millirem would have a collective dose of one person-rem.

PLUME. The distribution of a pollutant in air or water after being released from a source.

PROGLACIAL LAKE. A lake occupying a basin in front of a glacier; generally in direct contact with the ice.

RAD. Radiation absorbed dose. One hundred ergs of energy absorbed per gram.

RADIATION. The process of emitting energy in the form of rays or particles that are thrown off by disintegrating atoms. The rays or particles emitted may consist of alpha, beta, or gamma radiation.

- ALPHA RADIATION. The least penetrating type of radiation. Alpha radiation can be stopped by a sheet of paper or outer dead layer of skin.
- BETA RADIATION. Electron emitted from a nucleus during fission and nuclear decay. Beta radiation can be stopped by an inch of wood or a thin sheet of aluminum.
- GAMMA RADIATION. A form of electromagnetic, high-energy radiation emitted from a nucleus. Gamma rays are essentially the same as x-rays and require heavy shielding such as lead, concrete, or steel to be stopped.
- INTERNAL RADIATION. Radiation originating from a source within the body as a result of the inhalation, ingestion, or implantation of natural or manmade radionuclides in body tissues.

RADIATION DOSE.

- ABSORBED DOSE. The amount of energy deposited by radiation in a given amount of material. Absorbed dose is measured in rads.
- COLLECTIVE DOSE EQUIVALENT. The sum of the dose equivalents for individuals comprising a defined population. The per capita dose equivalent is the quotient of the collective dose equivalent divided by the population size. (See PERSON-REM).
- COMMITTED DOSE EQUIVALENT (dose commitment). The total dose equivalent accumulated in an organ or tissue in the fifty years following a single intake of radioactive materials into the body.
- CUMULATIVE DOSE EQUIVALENT. The total dose one could receive in a period of fifty years following release of radionuclides to the environment, including the dose that could occur as a result of residual radionuclides remaining in the environment beyond the year of release.
- DOSE EQUIVALENT. The product of the absorbed dose, the quality factor, and any other modifying factors. The dose equivalent is a quantity for comparing the biological effectiveness of different kinds of radiation on a common scale. The unit of dose equivalent is the rem.
- EFFECTIVE DOSE EQUIVALENT. An estimate of the total risk of potential health effects from radiation exposure. It is the sum of the committed effective dose equivalent from internal deposition and the effective dose equivalent from external penetrating radiation received during a calendar year. The committed effective dose equivalent is the sum of the individual organ committed dose equivalents (fifty years) multiplied by weighting factors that represent the proportion of the total random risk that each organ would receive from uniform irradiation of the whole body.

RADIOACTIVITY. A property possessed by some elements such as uranium whereby alpha, beta, or gamma rays are spontaneously emitted.

RADIOISOTOPE. A radioactive isotope of a specified element. Carbon-14 is a radioisotope of carbon. Tritium is a radioisotope of hydrogen.

RADIONUCLIDE. A radioactive nuclide. Radionuclides are variations (isotopes) of elements. They have the same number of protons and electrons but different numbers of neutrons, resulting in different atomic masses.There are several hundred known nuclides, both man-made and naturally occurring.

REM. An acronym for Roentgen Equivalent Man. A unit of radiation exposure that indicates the potential effect on human cells.

SIEVERT. A unit of dose equivalent from the International System of Units equal to one joule per kilogram.

SPENT FUEL. Nuclear fuel that has been exposed in a nuclear reactor; this fuel contains uranium, activation products, fission products, and plutonium.

STANDARD DEVIATION. An indication of the dispersion of a set of results around their average.

THERMOLUMINESCENT DOSIMETER (TLD). A material that luminesces upon heating after being exposed to radiation. The amount of light emitted is proportional to the amount of radiation to which it has been exposed.

UPGRADIENT. Referring to the flow of water or air, it is analogous to upstream. A point that is "before" an area of study that is used as a baseline for comparison with downstream data. See GRADIENT and DOWNGRADIENT.

WATERSHED. The area contained within a drainage divide above a specified point on a stream.

WATER TABLE. The upper surface in a body of groundwater. The surface in an unconfined aquifer or confining bed at which the pore water pressure is equal to atmospheric pressure.

WHOLE-BODY DOSE. A radiation dose that involves exposure of the entire body.

Abbreviations for Units of Measure

Radioactivity

Symbol	*Name*
Ci	curie
mCi	millicurie (1E-03 Ci)
μCi	microcurie (1E-06 Ci)
nCi	nanocurie (1E-09 Ci)
pCi	picocurie (1E-12 Ci)
fCi	femtocurie (1E-15Ci)
aCi	attocurie (1E-18 Ci)
Bq	becquerel (27 pCi)

Volume

Symbol	*Name*
cm^3	cubic centimeter
L	liter
mL	milliliter
m^3	cubic meter
ppm	parts per million
ppb	parts per billion

Dose

Symbol	*Name*
Sv	sievert (100 rems)
Gy	gray (100 rads)

Time

Symbol	*Name*
y	year
d	day
h	hour
m	minute
s	second

Length

Symbol	*Name*
m	meter
km	kilometer (1E+03 m)
cm	centimeter (1E-02 m)
mm	millimeter (1E-03 m)
μm	micrometer (1E-06 m)

Area

Symbol	*Name*
ha	hectare (10,000 m^2)

Mass

Symbol	*Name*
g	gram
kg	kilogram (1E+03 g)
mg	milligram (1E-03)
μg	microgram(1E-06 g)
ng	nanogram (1E-09 g)
t	metric ton (10^3 kg)

Conversion Table

Multiply	*by*	*To obtain*	*Multiply*	*by*	*To obtain*
in.	2.54	cm	cm	0.394	in.
ft	0.305	m	m	3.28	ft.
mi	1.61	km	km	0.621	mi
lb	0.454	kg	kg	2.205	lb
liq. qt.	0.946	L	L	1.057	liq. qt.
ft^2	0.093	m^2	m^2	10.76	ft^2
ha	2.47	acres	acres	0.405	ha
mi^2	2.59	km^2	km^2	0.386	mi^2
ft^3	0.028	m^3	m^3	35.7	ft^3
dpm	0.450	pCi	pCi	2.22	dpm
nCi	1000	pCi	pCi	0.001	nCi
pCi/L	1E-09	μCi/mL	μCi/mL	1E+09	pCi/L
pCi/m^3	1E-12	Ci/m^3	Ci/m^3	1E+12	pCi/m^3
becquerel	2.7E-11	curie	curie	3.7E+10	becquerel
gray	100	rad	rad	0.01	gray
sievert	100	rem	rem	0.01	sievert
ppb	0.001	ppm	ppm	1000	ppb
ppm	1.0	mg/L	mg/L	1.0	ppm

Unit Prefixes

Factor	*Prefix*	*Symbol*
1E+09	giga	G
1E+06	mega	M
1E+03	kilo	k
1E-02	centi	c
1E-03	milli	m
1E-06	micro	μ
1E-09	nano	n
1E-12	pico	p

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MEAN. The average value of a series of measurements.

MILLIREM (MREM). A unit of radiation dose equivalent that is equal to one one-thousandth of a rem. An individual member of the public can receive up to 500 millirems per year according to DOE standards. This limit does not include radiation received for medical treatment or the 100 to 360 mrem that people receive annually from background radiation.

MINIMUM DETECTABLE CONCENTRATION. The smallest amount or concentration of a radioactive or nonradioactive element that can be reliably detected in a sample.

MIXED WASTE. A waste that is both radioactive and hazardous.

OUTFALL. The end of a drain or pipe that carries waste water or other effluents into a ditch, pond, or river.

PARTICULATES. Solid particles and liquid droplets small enough to become airborne.

PERSON-REM. The sum of the individual radiation dose equivalents received by members of a certain group or population. It may be calculated by multiplying the average dose per person by the number of persons exposed. For example, a thousand people each exposed to one millirem would have a collective dose of one person-rem.

PLUME. The distribution of a pollutant in air or water after being released from a source.

PROGLACIAL LAKE. A lake occupying a basin in front of a glacier; generally in direct contact with the ice.

RAD. Radiation absorbed dose. One hundred ergs of energy absorbed per gram.

RADIATION. The process of emitting energy in the form of rays or particles that are thrown off by disintegrating atoms. The rays or particles emitted may consist of alpha, beta, or gamma radiation.

- ALPHA RADIATION. The least penetrating type of radiation. Alpha radiation can be stopped by a sheet of paper or outer dead layer of skin.
- BETA RADIATION. Electron emitted from a nucleus during fission and nuclear decay. Beta radiation can be stopped by an inch of wood or a thin sheet of aluminum.
- GAMMA RADIATION. A form of electromagnetic, high-energy radiation emitted from a nucleus. Gamma rays are essentially the same as x-rays and require heavy shielding such as lead, concrete, or steel to be stopped.
- INTERNAL RADIATION. Radiation originating from a source within the body as a result of the inhalation, ingestion, or implantation of natural or manmade radionuclides in body tissues.

RADIATION DOSE.

- ABSORBED DOSE. The amount of energy deposited by radiation in a given amount of material. Absorbed dose is measured in rads.
- COLLECTIVE DOSE EQUIVALENT. The sum of the dose equivalents for individuals comprising a defined population. The per capita dose equivalent is the quotient of the collective dose equivalent divided by the population size. (See PERSON-REM).
- COMMITTED DOSE EQUIVALENT (dose commitment). The total dose equivalent accumulated in an organ or tissue in the fifty years following a single intake of radioactive materials into the body.
- CUMULATIVE DOSE EQUIVALENT. The total dose one could receive in a period of fifty years following release of radionuclides to the environment, including the dose that could occur as a result of residual radionuclides remaining in the environment beyond the year of release.
- DOSE EQUIVALENT. The product of the absorbed dose, the quality factor, and any other modifying factors. The dose equivalent is a quantity for comparing the biological effectiveness of different kinds of radiation on a common scale. The unit of dose equivalent is the rem.
- EFFECTIVE DOSE EQUIVALENT. An estimate of the total risk of potential health effects from radiation exposure. It is the sum of the committed effective dose equivalent from internal deposition and the effective dose equivalent from external penetrating radiation received during a calendar year. The committed effective dose equivalent is the sum of the individual organ committed dose equivalents (fifty years) multiplied by weighting factors that represent the proportion of the total random risk that each organ would receive from uniform irradiation of the whole body.

RADIOACTIVITY. A property possessed by some elements such as uranium whereby alpha, beta, or gamma rays are spontaneously emitted.

RADIOISOTOPE. A radioactive isotope of a specified element. Carbon-14 is a radioisotope of carbon. Tritium is a radioisotope of hydrogen.

RADIONUCLIDE. A radioactive nuclide. Radionuclides are variations (isotopes) of elements. They have the same number of protons and electrons but different numbers of neutrons, resulting in different atomic masses.There are several hundred known nuclides, both man-made and naturally occurring.

REM. An acronym for Roentgen Equivalent Man. A unit of radiation exposure that indicates the potential effect on human cells.

SIEVERT. A unit of dose equivalent from the International System of Units equal to one joule per kilogram.

SPENT FUEL. Nuclear fuel that has been exposed in a nuclear reactor; this fuel contains uranium, activation products, fission products, and plutonium.

STANDARD DEVIATION. An indication of the dispersion of a set of results around their average.

THERMOLUMINESCENT DOSIMETER (TLD). A material that luminesces upon heating after being exposed to radiation. The amount of light emitted is proportional to the amount of radiation to which it has been exposed.

UPGRADIENT. Referring to the flow of water or air, it is analogous to upstream. A point that is "before" an area of study that is used as a baseline for comparison with downstream data. See GRADIENT and DOWNGRADIENT.

WATERSHED. The area contained within a drainage divide above a specified point on a stream.

WATER TABLE. The upper surface in a body of groundwater. The surface in an unconfined aquifer or confining bed at which the pore water pressure is equal to atmospheric pressure.

WHOLE-BODY DOSE. A radiation dose that involves exposure of the entire body.

Abbreviations for Units of Measure

Radioactivity

Symbol	*Name*
Ci	curie
mCi	millicurie (1E-03 Ci)
μCi	microcurie (1E-06 Ci)
nCi	nanocurie (1E-09 Ci)
pCi	picocurie (1E-12 Ci)
fCi	femtocurie (1E-15Ci)
aCi	attocurie (1E-18 Ci)
Bq	becquerel (27 pCi)

Volume

Symbol	*Name*
cm^3	cubic centimeter
L	liter
mL	milliliter
m^3	cubic meter
ppm	parts per million
ppb	parts per billion

Dose

Symbol	*Name*
Sv	sievert (100 rems)
Gy	gray (100 rads)

Time

Symbol	*Name*
y	year
d	day
h	hour
m	minute
s	second

Length

Symbol	*Name*
m	meter
km	kilometer (1E+03 m)
cm	centimeter (1E-02 m)
mm	millimeter (1E-03 m)
μm	micrometer (1E-06 m)

Area

Symbol	*Name*
ha	hectare (10,000 m^2)

Mass

Symbol	*Name*
g	gram
kg	kilogram (1E+03 g)
mg	milligram (1E-03)
μg	microgram(1E-06 g)
ng	nanogram (1E-09 g)
t	metric ton (10^3 kg)

Conversion Table

Multiply	*by*	*To obtain*	*Multiply*	*by*	*To obtain*
in.	2.54	cm	cm	0.394	in.
ft	0.305	m	m	3.28	ft.
mi	1.61	km	km	0.621	mi
lb	0.454	kg	kg	2.205	lb
liq. qt.	0.946	L	L	1.057	liq. qt.
ft^2	0.093	m^2	m^2	10.76	ft^2
ha	2.47	acres	acres	0.405	ha
mi^2	2.59	km^2	km^2	0.386	mi^2
ft^3	0.028	m^3	m^3	35.7	ft^3
dpm	0.450	pCi	pCi	2.22	dpm
nCi	1000	pCi	pCi	0.001	nCi
pCi/L	1E-09	μCi/mL	μCi/mL	1E+09	pCi/L
pCi/m^3	1E-12	Ci/m^3	Ci/m^3	1E+12	pCi/m^3
becquerel	2.7E-11	curie	curie	3.7E+10	becquerel
gray	100	rad	rad	0.01	gray
sievert	100	rem	rem	0.01	sievert
ppb	0.001	ppm	ppm	1000	ppb
ppm	1.0	mg/L	mg/L	1.0	ppm

Unit Prefixes

Factor	*Prefix*	*Symbol*
1E+09	giga	G
1E+06	mega	M
1E+03	kilo	k
1E-02	centi	c
1E-03	milli	m
1E-06	micro	μ
1E-09	nano	n
1E-12	pico	p

M. Stahr	DOE-HQ
T. McIntosh	DOE-HQ
H. Walter	DOE-HQ
J. Barry	DOE-ID
B. Bowhan	DOE-ID
E. Chew	DOE-ID
P. Hamric	DOE -ID
J. Solecki	DOE-ID
W. Bixby	DOE-WVPO
D. Hurt	NRC-HQ
M. Austin	NRC - Region 1
J. Roth	NRC - Region 1
P. Counterman	NYSDEC - Albany
P. Merges	NYSDEC - Albany
E. Belmore	NYSDEC - Region 9
P. Eismann	NYSDEC - Region 9
M. Jackson	NYSDEC - Region 9
J. McGarry	NYSDEC - Region 9
R. Mitrey	NYSDEC - Region 9
T. Moore	NYSDEC - Region 9
B. Ignatz	NYSDOH - Buffalo
K. Rimawi	NYSDOH - Albany

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T. DeBoer	NYSERDA
S. Harbison	NYSERDA
T. Sonntag	NYSERDA
R. Fakundiny	NYSGS
F. Galpin	USEPA - Washington, D.C.
P. Giardina	USEPA - Region 2
J. Gorman	USEPA - Region 2
R. Novitski	USGS
A. Stevens	SNIHD
C. Halgas	CCHD
W. Paxon	U.S. Congressman, 31st Dist.
A. Houghton	U.S. Congressman, 34th Dist.
D. Moynihan	U.S. Senator, New York
A. D'Amato	U.S. Senator, New York
J. Present	New York Senator, 56th Dist.
P. McGee	New York Assemblyman 149th Dist.

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Salamanca Republican Press,
Salamanca, New York *

Springville Journal, Springville, New York *

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MAXIMALLY EXPOSED INDIVIDUAL. A hypothetical person who remains in an uncontrolled area who would, when all potential routes of exposure from a facility's operations are considered, receive the greatest possible dose equivalent.

MEAN. The average value of a series of measurements.

MILLIREM (MREM). A unit of radiation dose equivalent that is equal to one one-thousandth of a rem. An individual member of the public can receive up to 500 millirems per year according to DOE standards. This limit does not include radiation received for medical treatment or the 100 to 360 mrem that people receive annually from background radiation.

MINIMUM DETECTABLE CONCENTRATION. The smallest amount or concentration of a radioactive or nonradioactive element that can be reliably detected in a sample.

MIXED WASTE. A waste that is both radioactive and hazardous.

OUTFALL. The end of a drain or pipe that carries waste water or other effluents into a ditch, pond, or river.

PARTICULATES. Solid particles and liquid droplets small enough to become airborne.

PERSON-REM. The sum of the individual radiation dose equivalents received by members of a certain group or population. It may be calculated by multiplying the average dose per person by the number of persons exposed. For example, a thousand people each exposed to one millirem would have a collective dose of one person-rem.

PLUME. The distribution of a pollutant in air or water after being released from a source.

PROGLACIAL LAKE. A lake occupying a basin in front of a glacier; generally in direct contact with the ice.

RAD. Radiation absorbed dose. One hundred ergs of energy absorbed per gram.

RADIATION. The process of emitting energy in the form of rays or particles that are thrown off by disintegrating atoms. The rays or particles emitted may consist of alpha, beta, or gamma radiation.

- ALPHA RADIATION. The least penetrating type of radiation. Alpha radiation can be stopped by a sheet of paper or outer dead layer of skin.
- BETA RADIATION. Electron emitted from a nucleus during fission and nuclear decay. Beta radiation can be stopped by an inch of wood or a thin sheet of aluminum.
- GAMMA RADIATION. A form of electromagnetic, high-energy radiation emitted from a nucleus. Gamma rays are essentially the same as x-rays and require heavy shielding such as lead, concrete, or steel to be stopped.
- INTERNAL RADIATION. Radiation originating from a source within the body as a result of the inhalation, ingestion, or implantation of natural or manmade radionuclides in body tissues.

RADIATION DOSE.

- ABSORBED DOSE. The amount of energy deposited by radiation in a given amount of material. Absorbed dose is measured in rads.
- COLLECTIVE DOSE EQUIVALENT. The sum of the dose equivalents for individuals comprising a defined population. The per capita dose equivalent is the quotient of the collective dose equivalent divided by the population size. (See PERSON-REM).
- COMMITTED DOSE EQUIVALENT (dose commitment). The total dose equivalent accumulated in an organ or tissue in the fifty years following a single intake of radioactive materials into the body.
- CUMULATIVE DOSE EQUIVALENT. The total dose one could receive in a period of fifty years following release of radionuclides to the environment, including the dose that could occur as a result of residual radionuclides remaining in the environment beyond the year of release.
- DOSE EQUIVALENT. The product of the absorbed dose, the quality factor, and any other modifying factors. The dose equivalent is a quantity for comparing the biological effectiveness of different kinds of radiation on a common scale. The unit of dose equivalent is the rem.
- EFFECTIVE DOSE EQUIVALENT. An estimate of the total risk of potential health effects from radiation exposure. It is the sum of the committed effective dose equivalent from internal deposition and the effective dose equivalent from external penetrating radiation received during a calendar year. The committed effective dose equivalent is the sum of the individual organ committed dose equivalents (fifty years) multiplied by weighting factors that represent the proportion of the total random risk that each organ would receive from uniform irradiation of the whole body.

RADIOACTIVITY. A property possessed by some elements such as uranium whereby alpha, beta, or gamma rays are spontaneously emitted.

RADIOISOTOPE. A radioactive isotope of a specified element. Carbon-14 is a radioisotope of carbon. Tritium is a radioisotope of hydrogen.

RADIONUCLIDE. A radioactive nuclide. Radionuclides are variations (isotopes) of elements. They have the same number of protons and electrons but different numbers of neutrons, resulting in different atomic masses.There are several hundred known nuclides, both man-made and naturally occurring.

REM. An acronym for Roentgen Equivalent Man. A unit of radiation exposure that indicates the potential effect on human cells.

SIEVERT. A unit of dose equivalent from the International System of Units equal to one joule per kilogram.

SPENT FUEL. Nuclear fuel that has been exposed in a nuclear reactor; this fuel contains uranium, activation products, fission products, and plutonium.

STANDARD DEVIATION. An indication of the dispersion of a set of results around their average.

THERMOLUMINESCENT DOSIMETER (TLD). A material that luminesces upon heating after being exposed to radiation. The amount of light emitted is proportional to the amount of radiation to which it has been exposed.

UPGRADIENT. Referring to the flow of water or air, it is analogous to upstream. A point that is "before" an area of study that is used as a baseline for comparison with downstream data. See GRADIENT and DOWNGRADIENT.

WATERSHED. The area contained within a drainage divide above a specified point on a stream.

WATER TABLE. The upper surface in a body of groundwater. The surface in an unconfined aquifer or confining bed at which the pore water pressure is equal to atmospheric pressure.

WHOLE-BODY DOSE. A radiation dose that involves exposure of the entire body.

Abbreviations for Units of Measure

Radioactivity

Symbol	*Name*
Ci	curie
mCi	millicurie (1E-03 Ci)
μCi	microcurie (1E-06 Ci)
nCi	nanocurie (1E-09 Ci)
pCi	picocurie (1E-12 Ci)
fCi	femtocurie (1E-15Ci)
aCi	attocurie (1E-18 Ci)
Bq	becquerel (27 pCi)

Volume

Symbol	*Name*
cm^3	cubic centimeter
L	liter
mL	milliliter
m^3	cubic meter
ppm	parts per million
ppb	parts per billion

Dose

Symbol	*Name*
Sv	sievert (100 rems)
Gy	gray (100 rads)

Time

Symbol	*Name*
y	year
d	day
h	hour
m	minute
s	second

Length

Symbol	*Name*
m	meter
km	kilometer (1E+03 m)
cm	centimeter (1E-02 m)
mm	millimeter (1E-03 m)
μm	micrometer (1E-06 m)

Area

Symbol	*Name*
ha	hectare (10,000 m^2)

Mass

Symbol	*Name*
g	gram
kg	kilogram (1E+03 g)
mg	milligram (1E-03)
μg	microgram(1E-06 g)
ng	nanogram (1E-09 g)
t	metric ton (10^3 kg)

Conversion Table

Multiply	*by*	*To obtain*	*Multiply*	*by*	*To obtain*
in.	2.54	cm	cm	0.394	in.
ft	0.305	m	m	3.28	ft.
mi	1.61	km	km	0.621	mi
lb	0.454	kg	kg	2.205	lb
liq. qt.	0.946	L	L	1.057	liq. qt.
ft^2	0.093	m^2	m^2	10.76	ft^2
ha	2.47	acres	acres	0.405	ha
mi^2	2.59	km^2	km^2	0.386	mi^2
ft^3	0.028	m^3	m^3	35.7	ft^3
dpm	0.450	pCi	pCi	2.22	dpm
nCi	1000	pCi	pCi	0.001	nCi
pCi/L	1E-09	μCi/mL	μCi/mL	1E+09	pCi/L
pCi/m^3	1E-12	Ci/m^3	Ci/m^3	1E+12	pCi/m^3
becquerel	2.7E-11	curie	curie	3.7E+10	becquerel
gray	100	rad	rad	0.01	gray
sievert	100	rem	rem	0.01	sievert
ppb	0.001	ppm	ppm	1000	ppb
ppm	1.0	mg/L	mg/L	1.0	ppm

Unit Prefixes

Factor	*Prefix*	*Symbol*
1E+09	giga	G
1E+06	mega	M
1E+03	kilo	k
1E-02	centi	c
1E-03	milli	m
1E-06	micro	μ
1E-09	nano	n
1E-12	pico	p

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