RADIOLOGICAL DOSE ASSESSMENT

Each year the potential radiological dose to the public that is attributable to operations and effluents from the West Valley Demonstration Project (the WVDP or Project) is assessed to verify that no individual could possibly have received a dose exceeding the limits established by the regulatory agencies. The results of these conservative dose calculations demonstrate that the potential maximum dose to an off-site resident was well below permissible standards and was consistent with the as-low-as-reasonably achievable (ALARA) philosophy of radiation protection.

Introduction

This chapter describes the methods used to estimate the dose to the general public resulting from exposure to radiation and radionuclides released by the Project to the surrounding environment during 1995.

Estimated doses are compared directly to current radiation standards established by the U.S. Department of Energy (DOE) and the U.S. Environmental Protection Agency (EPA) for protection of the public. The 1995 values are also compared to the annual dose the average resident of the U.S. receives from natural background radiation and to doses reported in previous years for the Project.

Radioactivity

Atoms that emit radiation are called radionuclides. Radionuclides are unstable isotopes that have the same number of protons as any other isotope of the element but different numbers of neutrons, resulting in different atomic masses. For example, the element hydrogen has two stable isotopes, H-1 and H-2 (deuterium), and one radioactive isotope, H-3 (tritium). The numbers following the element's symbol identify the atomic mass, which is the number of protons plus neutrons in the nucleus.

When radioactive atoms decay by emitting radiation, the daughter products that result may be either radioactive or stable. Generally, radionuclides with high atomic numbers, such as uranium-238 and plutonium-239, have many generations of radioactive progeny. For example, the radioactive decay of plutonium-239 creates uranium-235, thorium-231, protactinium-231, and so on through eleven progeny until only the stable lead-207 isotope remains. Radionuclides with lower atomic numbers most often have no more than one daughter. For example, strontium-90 has one radioactive daughter, yttrium-90, which finally decays into stable zirconium, and cobalt-60 decays directly to stable nickel.

The time required for half of the radioactivity of a radionuclide to decay is referred to as the radionuclide's half-life. Each radionuclide has a unique half-life; both strontium-90 and cesium-137 have half-lives of approximately 30 years while plutonium-239 has a half-life of 24,400 years. Knowledge of radionuclide half-lives is often used to estimate past and future inventories of radioactive material: a 1.0-millicurie source of cesium-137 measured in 1995 was 2.0 millicuries in 1965 and will be 0.5 millicuries in 2025.

Radiation emitted by radionuclides may consist of electromagnetic rays such as x-rays and gamma rays or charged particles such as alpha and beta particles. A radionuclide may emit one or more of these radiations at characteristic energies that can be used to identify them.

Radiation Dose

The energy released from a radionuclide is eventually deposited in matter encountered along the path of the radiation. The radiation energy absorbed by a unit mass of material is referred to as the absorbed dose. The absorbing material can be either inanimate matter or living tissue.

Alpha particles leave a dense track of ionization as they travel through tissue and thus deliver the most dose per unit-path length. However, alpha particles are not penetrating and must be taken into the body by inhalation or ingestion to cause harm. Beta and gamma radiation can penetrate the protective skin layer of the body from the outside to deliver a whole body dose or expose internal organs.

Because beta and gamma radiations deposit much less energy in tissue per unit-path length relative to alpha radiation, they produce fewer biological effects for the same absorbed dose. To allow for the different biological effects of different kinds of radiation, the absorbed dose is multiplied by a quality factor to yield a unit called the dose equivalent. A radiation dose expressed as a dose equivalent, rather than as an absorbed dose, permits the risks from different types of radiation exposure to be compared to each other (e.g., exposure to alpha radiation compared to exposure to gamma radiation). For this reason, regulatory agencies limit the dose to individuals in terms of total dose equivalent.

Units of Measurement

The unit for dose equivalent in common use in the U.S. is the rem, which stands for roentgen-equivalent-man. The international unit of dose equivalent is the sievert (Sv), which is equal to 100 rem. The millirem (mrem) and millisievert (mSv), used more frequently to report the low dose equivalents encountered in environmental exposures, are equal to one-thousandth of a rem or sievert.

The effective dose equivalent (EDE), also expressed in units of rem or sievert, provides a means of combining unequal organ and tissue doses into a single "effective" whole body dose that represents a comparable risk. The EDE is calculated by multiplying the organ dose equivalent by the organ-weighting factors developed by the International Commission on Radiological Protection (ICRP) in Publications 26 (1977) and 30 (1979). The weighting factor is a ratio of the risk from a specific organ or tissue dose to the total risk resulting from an equal whole body dose. All organ-weighted dose equivalents are then summed to obtain the EDE.

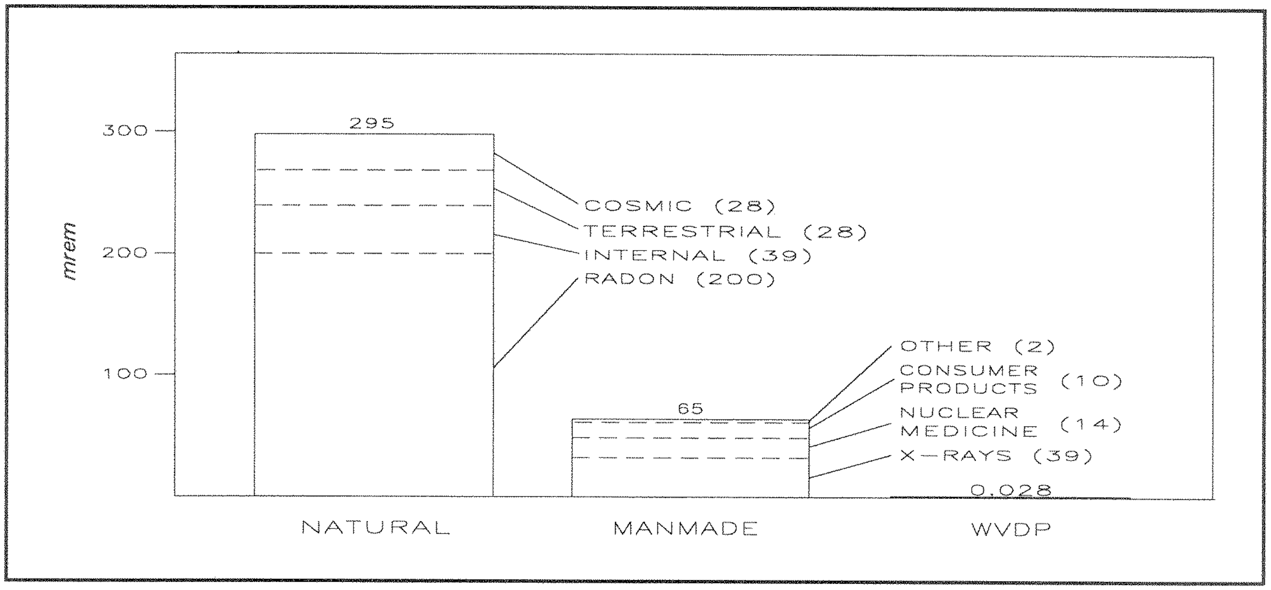


Figure 4-1. Comparison of Annual Background Radiation Dose to the Dose from 1995 WVDP Effluents

The dose from internally deposited radionuclides calculated for a fifty-year period following intake is called the fifty-year committed effective dose equivalent (CEDE). The CEDE sums the dose to an individual over fifty years to account for the biological retention of radionuclides in the body. The total EDE is calculated by adding the dose equivalent from external, penetrating radiation to the CEDE. Unless otherwise specified, all doses discussed here are EDE values, which include the CEDE for internal emitters.

A collective population dose is expressed in units of person-rem or person-sievert because the individual doses are summed over the entire potentially exposed population. The average individual dose can therefore be obtained by dividing the collective dose by the number in the population.

Sources of Radiation

Members of the public are routinely exposed to different sources of ionizing radiation from both natural and manmade sources. Figure 4-1 shows the relative contribution to the annual dose in millirem from these sources in comparison to the estimated 1995 maximum individual dose from the WVDP. The National Council on Radiation Protection and Measurements (NCRP) Report 93 (1987) estimates that the average annual effective dose equivalent received by an individual living in the U.S. is about 360 mrem (3.6 mSv) from both natural and manmade sources of radiation.

While most of the radiation dose received by the general public is natural background radiation, manmade sources of radiation also contribute to the average dose. Such sources include diagnostic and therapeutic x-rays, nuclear medicine, fallout from atmospheric nuclear weapons tests, effluents from nuclear fuel cycle facilities, and consumer products such as smoke detectors and cigarettes.

As can be seen in Figure 4-1 natural sources of radiation contribute 295 mrem (2.95 mSv) and manmade sources contribute 65 mrem (0.65 mSv) of the total annual U.S. average dose of 360 mrem. The WVDP contributes a very small amount (0.028 mrem [0.00028 mSv] per year) to the total annual manmade radiation dose to the maximally exposed individual residing near the WVDP. This is much less than the average dose received from using consumer products and is insignificantly small compared to the federal 100 mrem standard or the approximately 300 mrem received annually from natural sources.

Health Effects of Low-level Radiation

Radionuclides entering the body through air, water, or food are distributed in different organs of the body. For example, isotopes of iodine concentrate in the thyroid. Strontium, plutonium, and americium isotopes concentrate in the skeleton. When inhaled, uranium and plutonium isotopes remain in the lungs for a long period of time. Some radionuclides such as tritium, carbon-14, or cesium-137 are distributed uniformly throughout the body. Therefore, depending on the radionuclide, some organs may receive quite different doses. Moreover, at the same dose levels, certain organs (such as the breast) are more prone to developing a fatal cancer than other organs (such as the thyroid).

Because of the uncertainty and difficulty in measuring the incidence of increased cancer resulting from exposure to ionizing radiation, to be conservative, a linear model is used to predict health risk from low levels of radiation. This model assumes that there is a risk associated with all dose levels even though the body may effectively repair damage incurred from low levels of alpha, beta, and gamma radiations.

Exposure Pathways

The radionuclides present at the WVDP site are residues from the reprocessing of commercial nuclear fuel during the 1960s and early 1970s. A very small fraction of these radionuclides is released off-site annually through ventilation systems and liquid discharges and makes a negligible contribution to the radiation dose to the surrounding population through a variety of exposure pathways.

An exposure pathway consists of a source of contamination or radiation that is transported by environmental media to a receptor where exposure to contaminants may occur. For example, a member of the public could be exposed to low levels of radioactive particulates carried by prevailing winds.

The potential pathways of exposure from Project emissions are inhalation of gases and particulates, ingestion of local food products, ingestion of fish, beef, and deer tissues, and exposure to external penetrating radiations emanating from contaminated materials. The drinking water pathway was excluded based on surveys of drinking water usage by the local population surrounding and residing downstream of the WVDP site. Table 4-1 summarizes the potential exposure pathways for the general off-site population.

Dose Assessment Methodology

The potential radiation dose to the general public from activities at the WVDP is evaluated by using a two-part methodology and following the requirements in DOE Order 5400.5. The first part uses the measurements of radionuclide concentrations in air and liquid discharges from the Project. (See *Appendix C-1 and C-2*.) These data, together with meteorological and demographic information, are input to computer models that calculate the potential or estimated doses, rather than actual radiation doses, from all credible pathways to individuals and the local population. The second phase of the dose assessments is based on measurement of radioactivity in foodstuffs sampled in the vicinity of the WVDP and the comparison of these values with measurements of samples collected from locations well beyond the potential influence of site effluents. Although these measurements of environmental media are relatively imprecise (because the concentrations of radioactivity are so small and usually are near the analytical detection limits), they can provide

Table 4 - 1

Potential Exposure Pathways under Existing WVDP Conditions

Potentially Exposed Populations	Exposure Pathway and Transporting Medium	Reason for Inclusion/Exclusion
Current off-site residents	*Inhalation: gases and particulates from air*	*Off-site transport of contaminants from WVDP stacks or resuspended particulates from soils*
	Ingestion: cultivated crops	*Local agricultural products irrigated with contaminated ground- or surface water; foliar deposition and uptake of airborne contaminants*
	Ingestion: surface and groundwater	*No documented use of local surface water and downgradient groundwater wells by local residents*
	Ingestion: fish, beef, venison, and milk	*Fish exposed to contaminants in water or sediments may be consumed; beef, venison, and milk consumption following deposition of transported airborne contaminants and surface waters*
	External exposure: radiation emanating from particulates and gases from air or surface water	*Transport of air particulates and gases to off-site receptors; transport of contaminants in surface water and direct exposure during stream use and swimming*

additional assurance that operations at the WVDP are not adversely affecting the public.

Predictive Computer Modeling

Because of the difficulty of distinguishing the small amount of radioactivity emitted from the site from that which occurs naturally in the environment, computer codes were used to model the environmental dispersion of radionuclides emitted from on-site monitored ventilation stacks and liquid discharge points. The EDE to the maximally exposed off-site individual and the collective EDE to the population were calculated using models that have been approved by the DOE and the EPA to demonstrate compliance with radiation standards.

Radiological dose was evaluated for all major exposure pathways, including external irradiation, inhalation, and ingestion of local food products. The dose contributions from each radionuclide and pathway combination were then summed to obtain the total dose estimates reported in Table 4-2.

Because these calculated doses already include contributions from all environmental pathways and media, estimates of potential doses from ingestion of specific environmental media (e.g., fish, milk) that contain statistically valid net concentrations of radionuclides are not added to the reported estimates.

Environmental Media Concentrations

Near-site and control samples of fish, milk, beef, venison, and local produce were collected and analyzed for various radionuclides, including tritium, cobalt-60, strontium-90, iodine-129, cesium-134, and cesium-137. The measured radionuclide concentrations reported in *Appendix C-3*, Tables C-3.1 through C-3.4 (pp. C3-3 through C3-8) are the basis for comparing near-site and background concentrations.

If statistically significant differences were found between near-site and background sample concentrations, the portion of the near-site sample concentration above background was used to calculate a potential maximum individual dose for comparison with dose limit standards and background. If no significant differences in concentrations were found, then no further assessment was conducted.

The maximum potential dose to nearby residents from the consumption of foods with radionuclide concentrations above background concentrations was calculated by multiplying the excess concentrations by the maximum adult annual consumption rate for each type of food and the unit dose conversion factor for ingestion of the measured radionuclide. The consumption rates are based on site-specific data and recommendations in NRC Regulatory Guide 1.109 for terrestrial food chain dose assessments (U.S. Nuclear Regulatory Commission 1977). The internal dose conversion factors were obtained from Internal Dose Conversion Factors for Calculation of Dose to the Public (U.S. Department of Energy 1988).

Airborne Releases

Releases of airborne radioactive materials from nominal 10-meter stacks and from the main 60-meter stack were modeled using the EPA-approved CAP88-PC computer code (U.S. Environmental Protection Agency March 1992). This air dispersion code estimates effective dose equivalents for the ingestion, inhalation, air immersion, and ground surface pathways. Site-specific data for radionuclide release rates in curies per year, wind data, and the current local population were used as input parameters. Resulting output from the CAP88-PC code was then used to determine the total EDE to a maximally exposed individual and the collective dose to the local population within an 80-kilometer (50-mi) radius of the WVDP.

Table 4 - 2

Summary of Annual Effective Dose Equivalents to an Individual and Population from WVDP Releases in 1995

Exposure Pathway	*Annual Effective Dose Equivalent*	
	Maximally Exposed Off-Site Individual [1] *mrem (mSv)*	*Collective Effective Dose Equivalent* [2] *person-rem (person-Sv)*
Airborne Releases [3]	***4.3E-04 (4.3E-06)***	***8.6E-03 (8.6E-05)***
% EPA Standard (10 mrem)	*4.3E-03%*	*N/A*
Waterborne Releases [4]		
Effluents Only	*7.3E-03 (7.3E-05)*	*1.3E-02 (1.3E-04)*
Effluents plus North Plateau Drainage	*2.8E-02 (2.8E-04)*	*9.4E-02 (9.4E-04)*
Total from All Pathways	***2.8E-02 (2.8E-04)***	***1.0E-01 (1.0E-03)***
% DOE Standard (100 mrem) – Air and Water Combined	*2.8E-02%*	*N/A*
% Natural Background (300 mrem; 390,000 person-rem) – Air and Water Combined	*9.3E-03%*	*2.6E-05%*

[1] *Maximum exposure to air discharges occurs at a residence 1.9 kilometers north-northwest from the main plant.*

[2] *Population of 1.3 million within 80 kilometers of the site.*

[3] *From permanent point sources. Calculated using AIRDOS-EPA (CAP88-PC for individual and population).*

[4] *Calculated using methodology described in Radiological Parameters for Assessment of WVDP Activities (Faillace and Prowse 1990).*

Exponents are expressed as "E" in this report; a value given as $1.2x10^{-4}$ in scientific notation is reported as 1.2E-04 in the text and tables.

N/A - Not applicable. Numerical regulatory standards are not set for the collective EDE to the population.

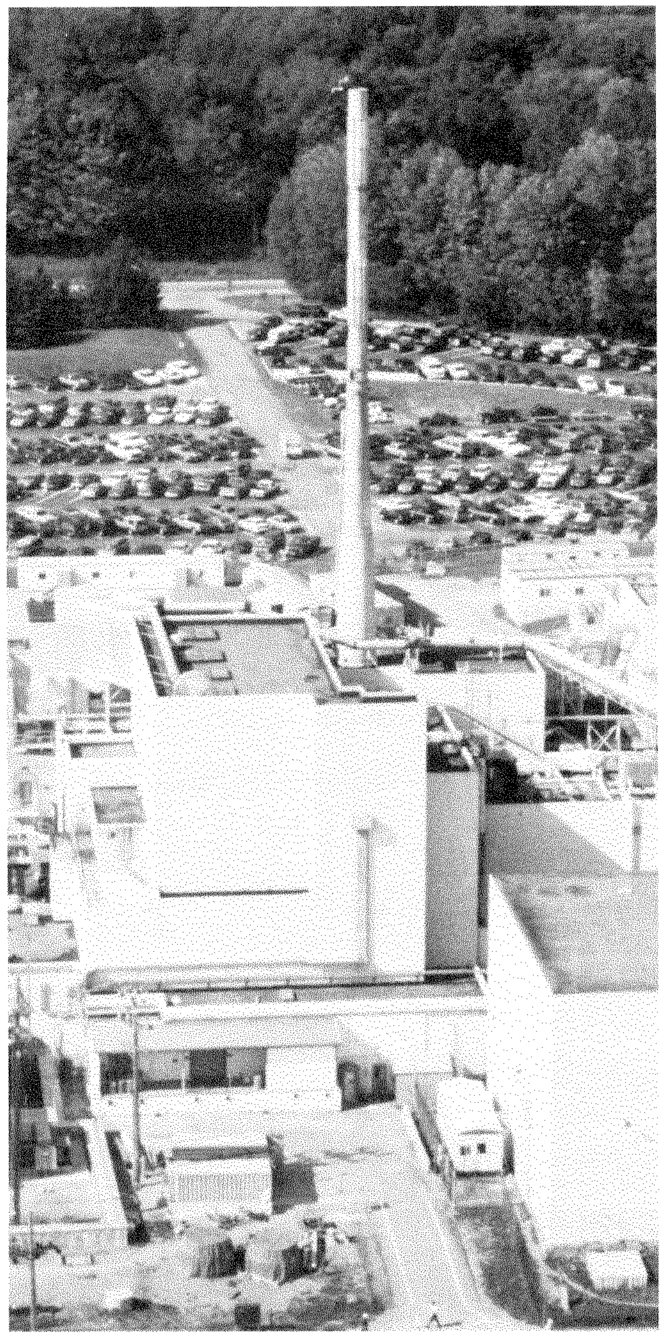
As reported in *Chapter 2, Environmental Monitoring*, four 10-meter stacks were monitored for radioactive air emissions during 1995. The main plant stack, which vents to the atmosphere at a height of 63 meters (208 ft), was considered an elevated release; all other releases were considered ground-level releases. The activity that was released to the atmosphere from these stacks is listed in Tables C-2.1 through C-2.8 in *Appendix C-2* (pp. C2-3 through C2-9) and was used as input to the CAP88-PC code.

Wind data collected from the on-site meteorological tower during 1995 were used as input to the CAP88-PC code. Data collected at the 60-meter and 10-meter heights were used in combination with elevated and ground-level effluent release data, respectively.

Waterborne Releases

The EDE to the maximally exposed off-site individual and the collective EDE to the population due to routine waterborne releases and natural drainage are calculated using dose conversion factors as reported in Radiological Parameters for Assessment of WVDP Activities (Faillace and Prowse 1990). Since the effluents eventually reach Cattaraugus Creek, which is not used as a source of drinking water, the most important individual exposure pathway is the consumption of fish by local sportsmen. It is assumed that a person may annually consume as much as 21 kilograms (46 lbs) of fish caught in the creek. Exposure to external radiation from shoreline or water contamination also is included in the model for estimating radiation dose. Population dose estimates assumed that radionuclides were further diluted in Lake Erie before reaching municipal drinking water supplies. The computer code LADTAP II (Simpson and McGill 1980) was used to calculate the dose conversion factors for routine waterborne releases and dispersion of these effluents. Input data included site-specific stream flow and dilution, drinking water usage, and stream usage factors. A detailed description of LADTAP II is given in Radiological Parameters for Assessment of WVDP Activities (Faillace and Prowse 1990).

Five planned batch releases of liquid radioactive effluents from lagoon 3 occurred during 1995.



The Main Plant Ventilation Stack at the West Valley Demonstration Project

The radioactivity that was discharged in these effluents is listed in *Appendix C-1*, Table C-1.1 (p. C1-3) and was used with the dose conversion factors to calculate the EDE to the maximally exposed off-site individual and the collective EDE to the population.

In addition to the batch releases from lagoon 3 (WNSP001), effluents from the sewage treatment facility (WNSP007) and the french drain (WNSP008) are routinely released. The activities measured from these release points were included in the EDE calculations. The measured radioactivities from the sewage treatment facility and french drain are presented in *Appendix C-1*, Tables C-1.5 and C-1.6 (p. C1-7).

In addition to the above discharges there are two natural drainage channels originating on the Project premises for which there are measurable amounts of radioactivity. These are drainages from the north swamp (WNSW74A) and northeast swamp (WNSWAMP). The measured radioactivity from these points is reported in *Appendix C-1* (Tables C-1.7 and C-1.8 [pp. C1-8 and C1-9]). These release points are included in the EDE calculations for the maximally exposed off-site individual and the collective population.

Environmental Media Concentrations

Radionuclide concentrations in samples of fish, milk, beef, venison, and local crops were assessed to determine if near-site concentrations were statistically above concentrations for corresponding background (control) samples.

Fish

Muscle tissue from fish collected from June 1995 through November 1995 in Cattaraugus Creek upstream (background samples) and downstream of the site above and below the Springville dam was analyzed. Twenty tissue samples were collected both at background locations upstream of the site and at locations downstream of the site above the Springville dam. Ten tissue samples were collected at points downstream of the site below the dam. All samples were analyzed for strontium-90 and gamma-emitting radionuclides and the values compared to background. (See Table C-3.4 [p. C3-6].)

Values for cesium-134 were below detection limits or were statistically the same as background concentrations for all fish samples downstream of the site. Median strontium-90 and cesium-137 concentrations in fish collected at the first point of public access downstream of the WVDP and above the Springville dam appeared to be slightly above strontium-90 and cesium-137 concentrations in upstream background fish. The hypothetical maximum dose to an individual from eating 21 kilograms (46 lbs) of fish from this downstream point is only 1.3E-02 mrem. This is roughly equivalent to the dose received every hour from natural background radiation.

Although concentrations in fish samples downstream of the WVDP are marginally different from background samples collected in 1995, there is no evidence of an upward trend. To determine if this difference in downstream fish observed in 1995 is a result of normal statistical variation, these data are being subjected to a more comprehensive long-term statistical evaluation.

Milk

Milk samples were collected from various nearby dairy farms throughout 1995. Control samples were collected from farms 25-30 kilometers (15-20 mi) to the south and north of the WVDP. Milk samples were measured for tritium, strontium-90, iodine-129, cesium-134, cesium-137, and potassium-40. (See Table C-3.1 [p. C3-3].) Ten near-site milk samples were collected and compared with eight background samples. Radionuclide concentrations in routine milk samples from near-site locations were all below detection limits or statistically the same as background concentrations.

Beef

Near-site and control samples of locally raised beef were collected in 1995. These samples were measured for tritium, strontium-90, and gamma-emitting radionuclides such as cesium-134 and cesium-137. Two samples of beef muscle tissue were collected from background locations and two from near-site locations. Individual concentrations of strontium-90, cesium-137, and cesium-134 were below detection limits in near-site samples. (See Table C-3.2 [p. C3-4].) Strontium-90 concentrations in one near-site sample were above detection limits but were not statistically different from background.

Venison

Meat samples from three near-site and three control deer were collected in 1995. (See Table C-3.2 [p. C3-4].) These samples were measured for tritium, strontium-90, cesium-134, cesium-137, and other gamma-emitting radionuclides. Tritium, strontium-90, cesium-137, and cesium-134 concentrations for background and near-site samples were statistically identical.

Produce (hay, corn, beans, and apples)

Near-site and background samples of hay, corn, beans, and apples were collected during 1995 and analyzed for tritium, cobalt-60, strontium-90, potassium-40, and cesium-137. (See Table C-3.3 [p. C3-5].) Single samples of each type of produce were collected and compared with single background sample results. All radionuclides were below detection limits, statistically the same as historical background concentrations, or within the range of values observed at other biological media background locations. See *Appendix A* (pp. A-39 through A-42) for the locations from which background biological samples are collected.

Predicted Dose from Airborne Emissions

Applicable Standards

Airborne emissions of radionuclides are regulated by the EPA under the Clean Air Act and its implementing regulations. DOE facilities are subject to 40 CFR 61, Subpart H, National Emissions Standards for Hazardous Air Pollutants (NESHAP). The applicable standard for radionuclides is a maximum of 10 mrem (0.01 mSv) EDE to any member of the public in any year.

Maximum Dose to an Off-site Resident

Based on the airborne radioactivity released from the permitted point sources at the site during 1995, it was estimated that a person living in the vicinity of the WVDP could have received a total EDE of 4.3E-04 mrem (4.3E-06 mSv). This maximally exposed off-site individual is located at 1.9 kilometers north-northwest of the site and eats only locally produced foods.

The maximum potential total dose to an off-site resident was also assessed by individual exposure pathways.

The maximum total EDE of 4.3E-04 mrem (4.3E-06 mSv) from the permitted stacks and vents is far below levels that could be measured at the exposed individual's residence. This dose is comparable to less than one minute of natural background radiation received by an average member of the U.S. population and is well below the 10 mrem (0.01 mSv) NESHAP limit promulgated by the EPA and required by DOE Order 5400.5.

Collective Population Dose

The CAP88-PC version of AIRDOS-EPA was used to estimate the collective EDE to the popu-

Collecting Baseline Air Effluent Samples from the Vitrification Facility

lation. According to census projections for 1995, an estimated 1.3 million people resided within 80 kilometers (50 mi) of the WVDP. This population received an estimated 8.6E-03 person-rem (8.6E-05 person-Sv) total EDE from radioactive airborne effluents released from the permitted WVDP point sources during 1995. The resulting average EDE per individual was 6.6E-06 mrem (6.6E-08 mSv).

Predicted Dose from Waterborne Releases

Applicable Standards

Currently there are no EPA standards establishing limits on the radiation dose to members of the public from liquid effluents except as applied in 40 CFR 141 and 40 CFR 143, Drinking Water Guidelines (U.S. Environmental Protection Agency 1984a; 1984b). The potable water wells sampled for radionuclides are upgradient of the WVDP and therefore are not a potential source of radiation exposure from Project activities. Since Cattaraugus Creek is not used as a drinking water supply, a comparison of the predicted concentrations and doses to the EPA drinking water limits established in 40 CFR 141 and 40 CFR 143 is not relevant (although the values in creek samples are well below the EPA drinking water limits). The estimated radiation dose was compared with the applicable guidelines provided in DOE Order 5400.5.

Maximum Dose to an Off-site Individual

Based on the radioactivity in effluents released from the WVDP (lagoon 3, sewage treatment plant, and french drain) during 1995, an off-site individual could have received a potential maximum EDE of 7.3E-03 mrem (7.3E-05 mSv). Approximately 72% of this dose is from cesium-

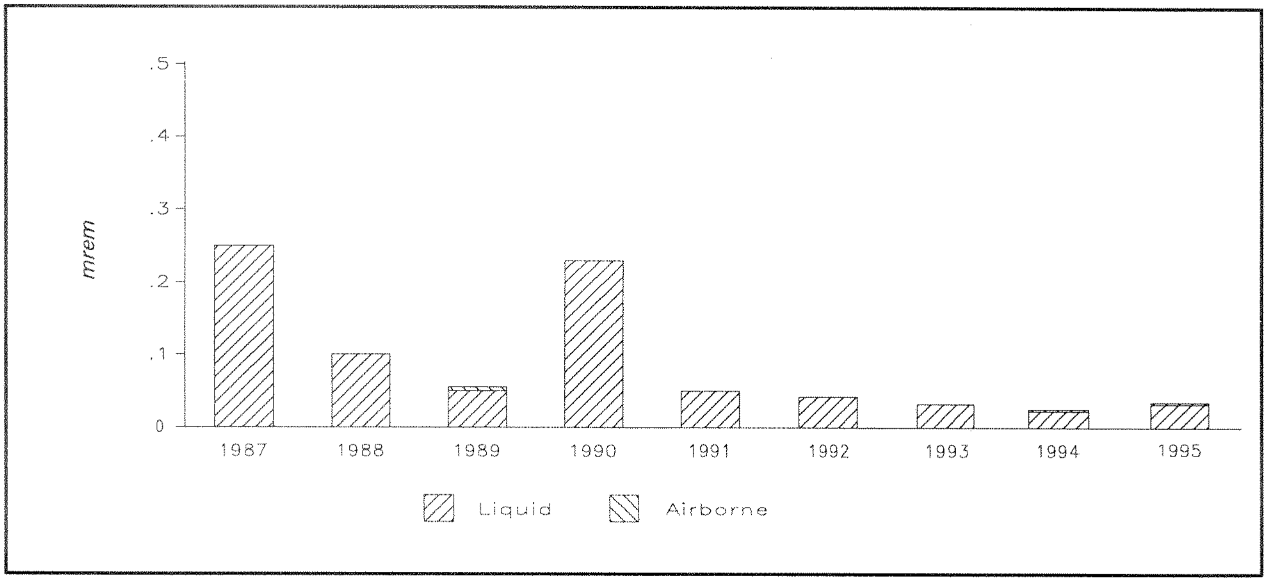


Figure 4-2. Effective Dose Equivalent from Liquid and Airborne Effluents to a Maximally Exposed Individual Residing near the WVDP

137 and 21% from strontium-90. This dose of 0.0073 mrem (0.000073 mSv) is negligible in comparison to the 300 mrem (3 mSv) that an average member of the U.S. population receives in one year from natural background radiation. The maximum individual EDE due to natural drainage from the north plateau (north swamp and northeast swamp) is 2.1E-02 mrem (2.1E-04 mSv). (See Table C-1.7 [p. C1-8].) The combined EDE to the maximally exposed individual from liquid effluents is 2.8E-02 mrem (2.8E-04 mSv). This dose of 0.028 mrem (0.000028 mSv) is negligible in comparison to the 300 mrem (3 mSv) that an average member of the U.S. population receives in one year from natural background radiation.

Collective Dose to the Population

As a result of radioactivity released in liquid effluents from the WVDP (lagoon 3, sewage treatment plant, and french drain) during 1995, the population living within 80 kilometers (50 mi) of the site received a collective EDE of 1.3E-02 person-rem (1.3E-04 person-Sv). The collective dose to the population from the natural outfalls (north swamp and northeast swamp) is 8.1E-02 person-rem (8.1E-04 person-Sv). This estimate is based on a population of 1.3 million living within the 80-kilometer radius. The resulting average EDE from lagoon 3, the sewage treatment plant, the french drain, and north plateau drainage (north swamp and northeast swamp) per individual is 7.2E-05 mrem (7.2E-07 mSv). This dose of 0.000072 mrem (0.00000072 mSv) is an inconsequential addition to the dose that an average person receives in one year from natural background radiation.

Predicted Dose from All Pathways

The potential dose to the public from both airborne and liquid effluents released from the Project during 1995 is the sum of the individual dose contributions. The hypothetical maximum EDE from all pathways to a nearby resident was 2.8E-02 mrem (2.8E-04 mSv). This dose is 0.03% of the 100 mrem (1 mSv) annual limit in DOE Order 5400.5.

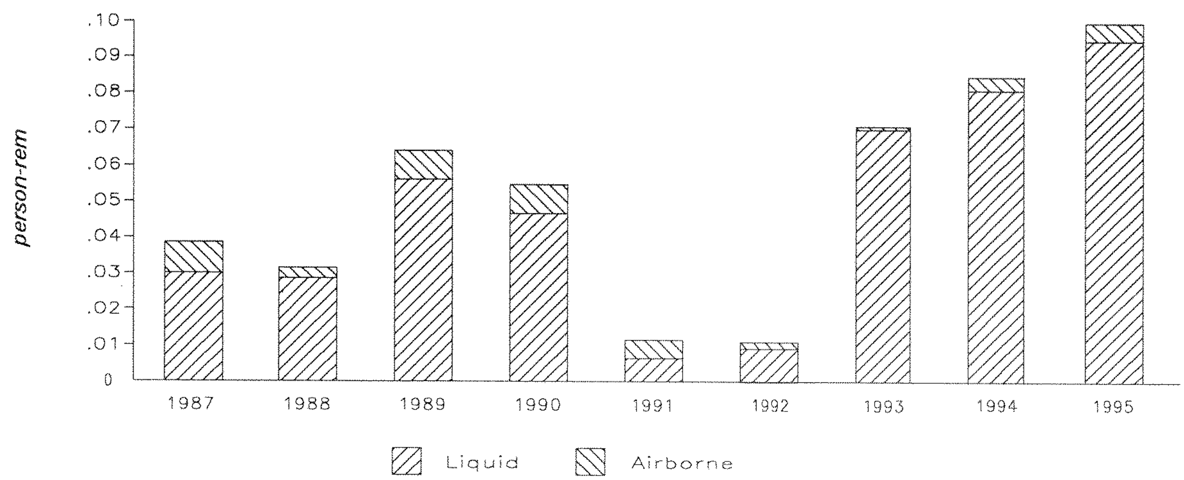


Figure 4-3. Collective Effective Dose Equivalent from Liquid and Airborne Effluents to the Population Residing within 80 Kilometers of the WVDP

The total collective EDE to the population within 80 kilometers (50 mi) of the site was 1.0E-01 person-rem (1.0E-03 person-Sv), with an average EDE of 7.9E-05 mrem (7.9E-07 mSv) per individual.

Table 4-2 (p. 4-7) summarizes the dose contributions from all pathways and compares the individual doses to the applicable standards.

Figure 4-2 shows the dose to the maximally exposed individual over the last nine years. The estimated dose for 1995 is about the same as the dose reported in previous years.

Figure 4-3 shows the collective dose to the population over the last nine years. Although an upward trend results from increased project liquid releases over the last several years, the dose for 1995 is about the same as the dose for 1994.

These data confirm the continued inconsequential addition to the natural background radiation dose that the individuals and population around the WVDP receive from Project activities.

Unplanned Releases

There were no unplanned releases (as defined by DOE Order 5400.1) of air or liquid effluent in 1995.

Risk Assessment

Estimates of cancer risk from ionizing radiation have been presented recently by the International Commission on Radiological Protection (1990), the National Council on Radiation Protection and Measurement (1987), and the National Research Council Committee on Biological Effects of Ionizing Radiation (1990). These reports estimate that the probability of fatal cancer induction to the public averaged over all ages ranges from 1.0E-04 to 5.0E-04 cancer fatalities/rem. The most recent risk coefficient of 5.0E-04 (International Commission on Radiological Protection) was used to estimate risk to a maximally exposed off-site individual. The resulting risk to this hypothetical individual from airborne and waterborne releases was a 1.4E-08 probability of a cancer fatality (1 chance in 70 million). This risk is well below the range of 1E-06 to 1E-05 per year considered acceptable by the International Commission on Radiological Protection Report 26 (1977) for any individual member of the public.

Summary

Predictive computer modeling was performed for airborne and waterborne releases. This analysis resulted in estimated doses to the hypothetical maximally exposed individual that were orders of magnitude below all applicable EPA standards and DOE Orders, which limit the release of radioactive materials and dose to individual members of the public. The collective population dose was also assessed and found to be orders of magnitude below natural background radiation doses. Based on the dose assessment, the WVDP was found to be in compliance with all applicable radiological guidelines and standards during 1995.