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# ENVIRONMENTAL RADIOLOGICAL PROTECTION PROGRAM AND DOSE ASSESSMENT

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## Radiation in the Environment

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### Sources of Radiation

Members of the public are routinely exposed to natural and man-made sources of ionizing radiation. An individual living in the United States (U.S.) is estimated to receive an average annual effective dose equivalent of about 360 millirem (mrem) (3.6 millisieverts [mSv]) (National Council on Radiation Protection and Measurements Report 93, 1987). (See the "Useful Information" section at the end of this report for discussions of ionizing radiation and units of dose measurement.)

Most of the radiation dose to a member of the public, about 295 mrem/year, is from natural background sources of cosmic and terrestrial origin (Fig. 2-1). The remainder, about 65 mrem/year, is from man-made sources, including diagnostic and therapeutic x-rays, nuclear medicine, consumer products such as cigarettes and smoke detectors, fallout from nuclear weapons tests, and effluents from nuclear facilities.

Radioactive materials at the West Valley Demonstration Project (WVDP or Project) are residues from the commercial reprocessing of nuclear fuel by a former site operator in the 1960s and early

1970s. Each year, very small quantities of the radioactive materials remaining at the WVDP are released to the environment, primarily in air emissions or liquid discharges generated as part of routine operations. Emissions and effluents are strictly controlled so that release quantities are kept as low as reasonably achievable (ALARA).

### Exposure Pathways

An exposure pathway consists of a route for contamination to be transported by an environmental medium from a source to a receptor where exposure may occur. For example, a member of the public could be exposed to low concentrations of radioactive particles carried by a prevailing wind.

Table 2-1 summarizes the potential exposure pathways from the WVDP to the local off-site population and describes the rationale for including or excluding each pathway when calculating dose from the WVDP. Potential pathways that are considered in dose calculations include: inhalation of gases and particulates, ingestion of locally grown food products and game, and exposure to external penetrating radiation emitted from contaminated materials. Drinking water is not considered a path-

way from the WVDP because surveys have determined that no public water supplies are drawn from downstream Cattaraugus Creek.

## Land Use Survey

Periodic surveys of local residents provide information about family size, sources of food, and gardening practices. Updated population data from the calendar year (CY) 2000 census was incorporated into WVDP analysis in 2003. Population around the WVDP by sector and distance is presented in Figure A-16. Information from the most recent land use survey, conducted in early 2002, was used to confirm the locations of the nearest residences. This information is required when using computer models for annual dose assessments.

## Dose to the Public

Each year an estimate is made of the potential radiological dose to the public that is attributable to operations and effluents from the WVDP during that calendar year. Estimates are calculated

to verify that no individual could have received a dose exceeding the limits for protection of the public, as established by the U.S. Department of Energy (DOE) and the U.S. Environmental Protection Agency (EPA).

Figure 2-1 shows the estimated maximum individual dose from the WVDP in CY 2006 as compared with the average annual dose a U.S. resident receives from man-made and natural background sources. As can be seen, estimated dose from the WVDP would have contributed a very small amount (0.049 mrem [0.00049 mSv]) of the total annual man-made radiation dose to the maximally exposed off-site individual residing near the WVDP. This is much less than the average dose received from using consumer products and is insignificant compared with average dose from natural sources.

Estimated potential dose from the Project to an off-site resident is also far below the federal standard of 100 mrem allowed from any DOE site operation in a calendar year, confirming that ef-

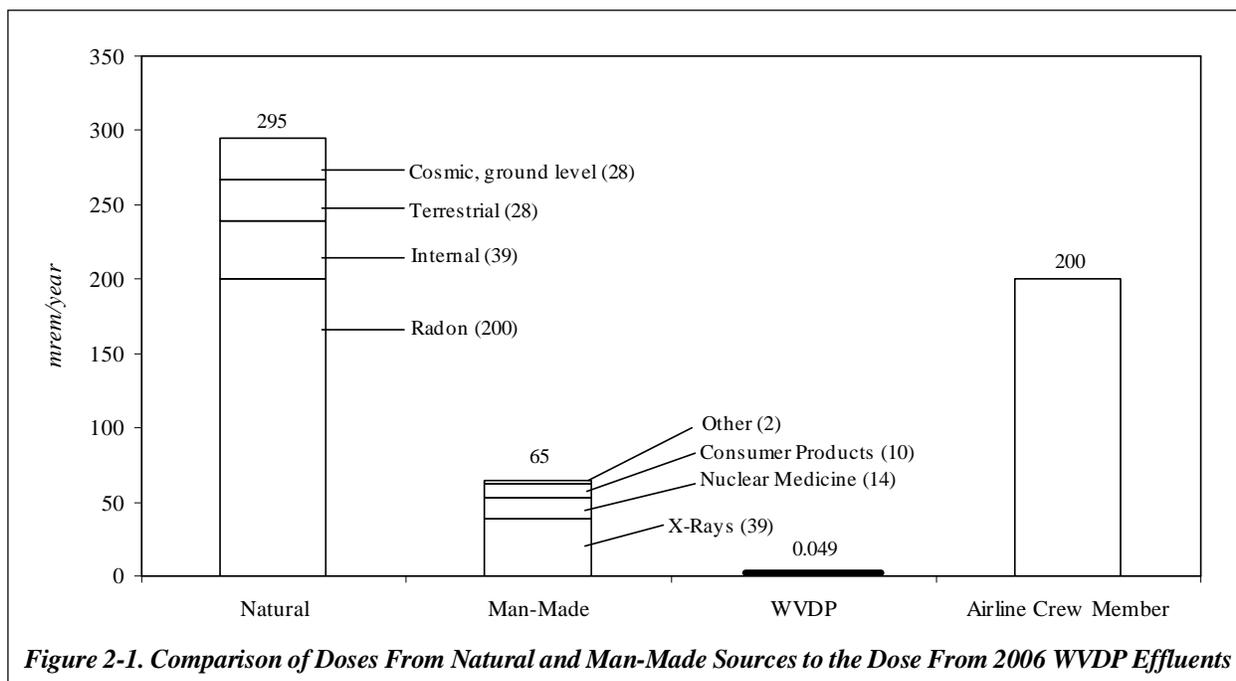


Figure 2-1. Comparison of Doses From Natural and Man-Made Sources to the Dose From 2006 WVDP Effluents

**Table 2-1**  
**Potential Local Off-Site Exposure Pathways Under Existing WVDP Conditions**

<b><i>Exposure Pathway and Transporting Medium</i></b>	<b><i>Reason for Inclusion/Exclusion</i></b>
Inhalation: gases and particulates in air (included)	Off-site transport of contaminants from WVDP stacks and vents or resuspended particulates from soils or water
Ingestion: cultivated crops (included)	Local agricultural products irrigated with potentially contaminated surface or groundwater; deposition on leaves and uptake of deposited airborne contaminants
Ingestion: surface and groundwater (excluded)	No documented use of local surface water or downgradient groundwater wells as drinking water by local residents
Ingestion: meat, milk, and vegetables (included)	Fish exposed to contaminants in water or sediments may be consumed; vegetables, venison, and milk may be consumed following deposition of transported airborne and surface water contaminants
External exposure: radiation from particulates and gases directly from air or surface water or indirectly from surface deposition (included)	Transport of air particulates and gases to off-site receptors; transport of contaminants in surface water and direct exposure during stream use and swimming

forts at the WVDP to minimize radiological releases are consistent with the ALARA philosophy of radiation protection.

The following sections of this chapter describe the monitoring program used to measure radiation in the environment near the WVDP, the methods used to estimate dose, and the results of dose assessments using these measurements.

## Routine Monitoring Program

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### Radiological Sampling Program Overview

The goal of the environmental monitoring program is to ensure that public health and safety and the environment continue to be protected with respect to potential releases from current site activities. To achieve this goal, possible exposure pathways are monitored.

As part of the monitoring program, samples from environmental media are collected each year and measured for radioactivity.

Environmental sampling locations are shown on maps in Appendix A. The complete environmental monitoring schedule is summarized in Appendix B<sup>62</sup>, which includes a detailed listing of specific changes to the monitoring program in 2006. 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 B<sup>62</sup>. For example, the location code AFGRVAL indicates an air sample (A), collected off-site (F), at the Great Valley (GRVAL) sampling station. Location codes are used throughout this report for ease of reference and to be consistent with the data reported in the appendices.

The primary focus of the monitoring program is on surface water and air pathways, as these are the principal means of transport of radionuclides from the WVDP.

Liquid and air effluents are monitored on site by collecting samples at locations where radioactivity is released or might be released. Release points

include water effluent outfalls and plant ventilation stacks.

Surface water samples are collected within the Project area from ponds, swamps, seeps, and drainage channels that flow through the Western New York Nuclear Service Center (WNYNSC) and then into Cattaraugus Creek and off site.

Both surface water and air samples are collected at perimeter locations where the highest off-site concentrations of transported radionuclides might be expected. Samples are also collected at remote locations to provide background concentration data for comparison with data from on-site and near-site samples.

The food pathway is monitored by collecting samples of milk and produce at near-site and remote locations, samples of fish upstream and downstream of the site, and samples of venison from deer collected near the site and at background locations. Stream sediments are sampled upstream and downstream of the WVDP. On-site groundwater and off-site residential drinking water wells are routinely sampled.

Direct radiation is monitored on site, at the perimeter of the site, in communities near the site, and at a remote background location.

Table 2-2 summarizes statistical comparisons of results from monitoring locations with results from background locations and comparisons with DOE derived concentration guides (DCGs). As in the past, although results from many on-site monitoring points exceeded background concentrations, few results from downstream points, and even fewer from near-site locations did.

**Table 2-2**  
**2006 Comparison of Radiological Results With Backgrounds and DOE DCGs**

<i>Sample Type</i>	<i>Number of Sampling Locations</i>	<i>Locations With Results Greater Than DOE DCGs</i>	<i>Number With Results Greater Than Background</i>	<i>Locations with Results Statistically Greater than Background (Constituent)</i>
<b>Air (1 background location)</b>				
On-site air emission points	6	0	3	<b>ANSTACK</b> (tritium, strontium-90, iodine-129, cesium-137, plutonium-238, plutonium-239/240, americium-241); <b>ANSTSTK</b> (iodine-129); <b>ANCSPFK</b> (iodine-129)
On-site ambient air points	1	0	0	None
Off-site ambient air points	5	0	0	None
<b>Surface water (2 background locations)</b>				
On-site controlled effluents	2	0	2	<b>WNSP001</b> (gross alpha, gross beta, tritium, strontium-90, technetium-99, iodine-129, cesium-137, uranium-232, uranium-233/234, uranium-235/236, uranium-238, plutonium-239/240); <b>WNSP007</b> (gross beta)
On-site surface waters	10	<b>WNSWAMP</b> (strontium-90)	7	<b>WNSP006</b> (gross beta, strontium-90, uranium-233/234, uranium-238); <b>WNSP005</b> (gross beta, strontium-90); <b>WNSWAMP</b> (gross beta, strontium-90); <b>WNSW74A</b> (gross beta, strontium-90); <b>WNNDADR</b> (gross beta, tritium, strontium-90); <b>WNNDATR</b> (gross alpha, gross beta, tritium, strontium-90, iodine-129); <b>WNERB53</b> (gross beta, strontium-90)
Off-site surface waters	2	0	2	<b>WFBCTCB</b> (gross beta); <b>WFFELBR</b> (gross alpha, gross beta)
<b>Drinking water (2 background locations)</b>				
On-site drinking water	3	NA	0	None
Off-site drinking water	9	NA	0	None
<b>Soil (1 background location)</b>				
Off-site soils	5	NA	NS	Next sampling in 2007
<b>Sediments (2 background locations, one on Buttermilk Creek and one [historical] on Cattaraugus Creek)</b>				
On-site sediments/soils	3	NA	3	<b>SNSP006</b> (gross beta, strontium-90, cesium-137); <b>SNSWAMP</b> (gross beta, strontium-90, cesium-137, plutonium-238, plutonium-239/240, americium-241); <b>SNSW74A</b> (cesium-137)
Off-site sediments	3	NA	3	<b>SFTCSED, SFSDSED, and SFCCSED</b> (cesium-137)

*Note: Results from air emission points, liquid effluent points, downstream water sampling points, and on-site sampling points for all matrices may be expected to be greater than background.*

*NA - DOE DCGs are not applicable for these matrices.*

*NS - Not sampled in CY 2006*

**Table 2-2 (concluded)**  
**2006 Comparison of Radiological Results With Backgrounds and DOE DCGs**

Sample Type	Number of Sampling Locations	Locations With Results Greater Than DOE DCGs	Number With Results Greater Than Background	Locations with Results Statistically Greater than Background (Constituent)
<b>Biologicals (3 background deer; 1 background per matrix for remainder)</b>				
Fish	2	NA	NR/0	None
Milk	4	NA	0	None
Deer	3	NA	2	<b>BFDNEAR</b> (cesium-137)
Vegetables/ fruits	3	NA	0	None
<b>Environmental dosimetry (1 background)</b>				
On-site, near facilities	15	NA	12	<b>DNTLDs #24, 25, 26, 28, 30, 33, 35, 36, 38, 39, 40, 43</b>
Perimeter	17	NA	0	None
Communities	2	NA	0	None

*Note: Results from air emission points, liquid effluent points, downstream water sampling points, and on-site sampling points for all matrices may be expected to be greater than background.*

*NA - DOE DCGs are not applicable for these matrices.*

*NR - No strontium-90 data were reported for many of the fish samples because of a problem with analytical quality control. Of the data that were acceptable, no results exceeded background levels.*

## Water Effluent and Ambient Surface Water Monitoring

The Project is drained by several small streams. Frank’s Creek enters the Project from the south and receives drainage from the south plateau. As Frank’s Creek flows northward, it is joined by a tributary, Erdman Brook, that receives effluent from the low-level waste treatment facility (LLWTF). After leaving the Project, Frank’s Creek receives drainage from the north and northeast swamp areas and Quarry Creek on the north plateau. Frank’s Creek continues across the WNYNSC and flows into Buttermilk Creek, which enters Cattaraugus Creek and leaves the WNYNSC (Figs. A-2 and A-5).

Three locations (the LLWTF and the two natural drainages from the northeast and north swamps) are the primary discharge sources that contribute

to dose via the liquid pathway. (See “Predicted Dose From Waterborne Releases” later in this chapter for an estimate of the dose attributable to these sources.)

### Low-Level Waste Treatment Facility Effluent.

The LLWTF was designed to efficiently remove strontium-90 and cesium-137, the more prevalent of the long-lived fission products in WVDP wastewaters. Other radionuclides, such as uranium isotopes, are also removed to a lesser extent. Uranium and some transuranic isotopes are found in WVDP liquid waste because they were present in the nuclear fuel that was once reprocessed at the site.

The discharge from the LLWTF through the lagoon 3 weir at outfall 001 (WNSP001 on Fig. A-2) into Erdman Brook is the primary controlled point source of radioactivity released to surface waters from the Project. Six batch releases total-

ing about 10.4 million gallons (39.3 million liters) were discharged from WNSP001 in 2006.

The total amounts of radioactivity from specific radionuclides in the lagoon 3 effluent are listed in Appendix C-2<sup>60</sup>. The annual average concentration of each radionuclide is divided by its corresponding DOE derived concentration guide (DCG) to determine what percentage of the DCG was released. As a DOE policy, the sum of the percentages calculated for all radionuclides released should not exceed 100%. The combined annual average of radionuclide concentrations from lagoon 3 effluent in 2006 was approximately 20.7% of the DCGs. The three major contributors to the combined DCG (strontium-90, uranium-232, and cesium-137) accounted for about 11%, 6%, and 2%, respectively. (DCGs are discussed and a listing presented in the “Useful Information” section at the end of this report.)

Variations in radionuclide ratios from year to year reflect the dynamic nature of the waste streams being processed through the LLWTF. Outfall WNSP001 and other selected discharge points are also monitored for nonradiological parameters under the New York State Pollutant Discharge Elimination System Permit. See “Environmental Nonradiological Program Information” in Chapter 3.

#### **Northeast Swamp and North Swamp Drainage.**

These two drainages conduct surface water and emergent groundwater from the site’s north plateau off site. The northeast swamp (WNSWAMP) is sampled to monitor surface water drainage from the northeastern portion to Frank’s Creek, and the north swamp (WNSW74A) is sampled to monitor drainage to Quarry Creek from the northern portion of the plateau (Fig. A-2).

Data summaries from the two locations are found in Appendix C-4<sup>60</sup>. Elevated gross beta concentrations at WNSWAMP, first noted in 1993, continued

to be observed through 2006. Gross beta activity at this location is largely attributable to strontium-90, concentrations of which exceeded the DOE DCG from May through September of 2006. WNSWAMP was the only point at which a DCG had been exceeded in 2006. See Chapter 4, Figure 4-10, for a graph of annualized average strontium-90 concentrations at WNSWAMP in 2006. (Although concentrations were below the DCG for seven months during 2006, the annualized average remained above the DCG the entire year.)

Even though waters with elevated strontium-90 concentrations drain from WNSWAMP into Frank’s Creek and ultimately into Cattaraugus Creek, concentrations in waters collected from Cattaraugus Creek downstream at the first point of access by the general public were not significantly higher than those at the upstream background location.

**Other North Plateau Surface Waters and Water Effluent.** Discharges from the LLWTF (WNSP001) and the sewage treatment outfall (WNSP007) leave the site through the combined facility liquid discharge into Frank’s Creek at point WNSP006. Radiological results from WNSP007 and WNSP006 are summarized in Appendices C-2<sup>60</sup> and C-5<sup>60</sup>, respectively.

Many of the constituents detected in effluent from WNSP001 were not detectable a short distance downstream at location WNSP006.

Also monitored are overland drainage and groundwater seepage on the east side of the main plant (point WNSP005) and coolant water from a contained basin within the facility (point WNCOOLW). Summaries of radiological data for WNSP005 and WNCOOLW are found in Appendix C-4<sup>60</sup>.

Detectable results from these locations were all less than 10% of their respective DOE DCGs in CY 2006.

**South Plateau Surface Water and Nuclear Regulatory Commission (NRC)-Licensed Disposal Area (NDA) Interceptor Trench.**

Two inactive underground radioactive waste disposal areas, the NDA and the New York State-Licensed Disposal Area (SDA), lie on the south plateau of the site. The SDA is managed by the New York State Energy Research and Development Authority and the NDA is managed by the DOE. Also located on the south plateau is the drum cell, an aboveground structure used to store approximately 20,000 drums of processed low-level radioactive waste. (During 2006, the WVDP began shipping the drums to an off-site facility.) Surface waters are routinely monitored at several points around these areas (Fig. A-2). In addition, samples are collected by the New York State Department of Health (NYSDOH) from the two streams that receive drainage from the south plateau: Frank's Creek (WNFR67) and Erdman Brook (WNERB53).

*NRC-Licensed Disposal Area.* Samples are collected from a sump at the lowest point in the collection trench system that intercepts groundwater from the northeastern and northwestern sides of the NDA (interceptor trench at sampling point WNNDATR). Water collected underground at this location is pumped to the LLWTF for treatment prior to discharge at outfall WNSP001. (See Chapters 1 and 4 for additional detail on the NDA Interceptor Trench and Pretreatment System.) If contamination were to migrate through the NDA, it would most likely be first detected at the interceptor trench. Annual concentrations from WNNDATR are listed in Appendix C-4<sup>60</sup> and quarterly results are listed under "NDATR" in Appendix E<sup>60</sup>.

Surface water drainage downstream of the NDA is also monitored at point WNNDADR and at Erdman Brook (point WNERB53), before it joins with drainage from the main plant and lagoon ar-

reas. Some drainage from western and northwestern portions of the SDA is also captured at these sampling points. Results from WNNDADR and WNERB53 are summarized in Appendices C-4<sup>60</sup> and C-5<sup>60</sup>, respectively.

Although strontium-90 and associated gross beta results at all three locations were elevated with respect to background concentrations from Buttermilk Creek (WFBCBKG), all were far below the strontium-90 DCG. Residual soil contamination from past waste burial activities is thought to be the source of the strontium-90 activity. The NDA is thought to be the predominant source of gross beta activity observed at WNNDATR.

Tritium concentrations have generally decreased over time at both WNNDATR and WNNDADR. Since the half-life of tritium is slightly longer than 12 years, decreasing tritium concentrations may be partially attributable to radioactive decay.

*New York State-Licensed Disposal Area.* Immediately south of the SDA, Frank's Creek is sampled to monitor surface drainage from the area around the drum cell (point WNDCELD, on Fig. A-2). To the north of the SDA, Frank's Creek is again sampled to monitor drainage downstream of the drum cell and the eastern and southern borders of the SDA (point WNFR67). Summaries of results from WNDCELD and WNFR67 are found in Appendix C-5<sup>60</sup>.

**Off-Site Surface Water.** Surface water samples are collected at four off-site locations, background and downstream locations on both Buttermilk Creek and Cattaraugus Creek. Sampling locations are shown on Fig. A-5. Results are presented in Appendix C-5<sup>60</sup>.

*Buttermilk Creek at Fox Valley Road and Thomas Corners Bridge.* Buttermilk Creek is the major surface drainage from the WNYNSC. The

background monitoring point is located upstream of the WVDP at Fox Valley Road (WFBCBKG) and the downstream point is located at Thomas Corners Bridge (WFBCTCB), just before Buttermilk Creek enters Cattaraugus Creek.

*Cattaraugus Creek at Bigelow Bridge and Felton Bridge.* Background samples are collected at Bigelow Bridge (WFBIGBR) before the point where Buttermilk Creek flows into Cattaraugus Creek. Downstream of that point, samples are collected at Felton Bridge (WFFELBR), the first point of public access below the WVDP.

As noted in Table 2-2, average gross beta concentrations at WFFELBR were greater than background concentrations. However, they were detected at less than 2% of the DOE DCG for strontium-90 (see Table C-5A<sup>6D</sup>). Elevated gross beta concentrations may be attributed to small amounts of radioactivity moving from the site via Frank's Creek. Figure 2-2 shows gross alpha, gross beta, and tritium results over the past ten years at

Felton Bridge. For the most part, tritium concentrations represent detection limits and not detected radioactivity. Taking into account seasonal fluctuations, gross beta activity has remained relatively constant at this location over the last decade.

## Drinking Water Monitoring

Drinking water (potable water) is sampled both off site and on site. Off-site drinking water samples are taken from wells that represent the closest unrestricted use of groundwater near the Project; none of these wells draw from groundwater units underlying the site. Project drinking water and utility water is drawn from two on-site surface water reservoirs.

**On-Site Tap Water.** On-site drinking water sources were monitored for radionuclides at four locations: the entry point at the utility room (WNDNKUR), the Environmental Laboratory (WNDNKEL), the maintenance shop (WNDNKMS), and the main plant (WNDNKMP). Data tables may be found in

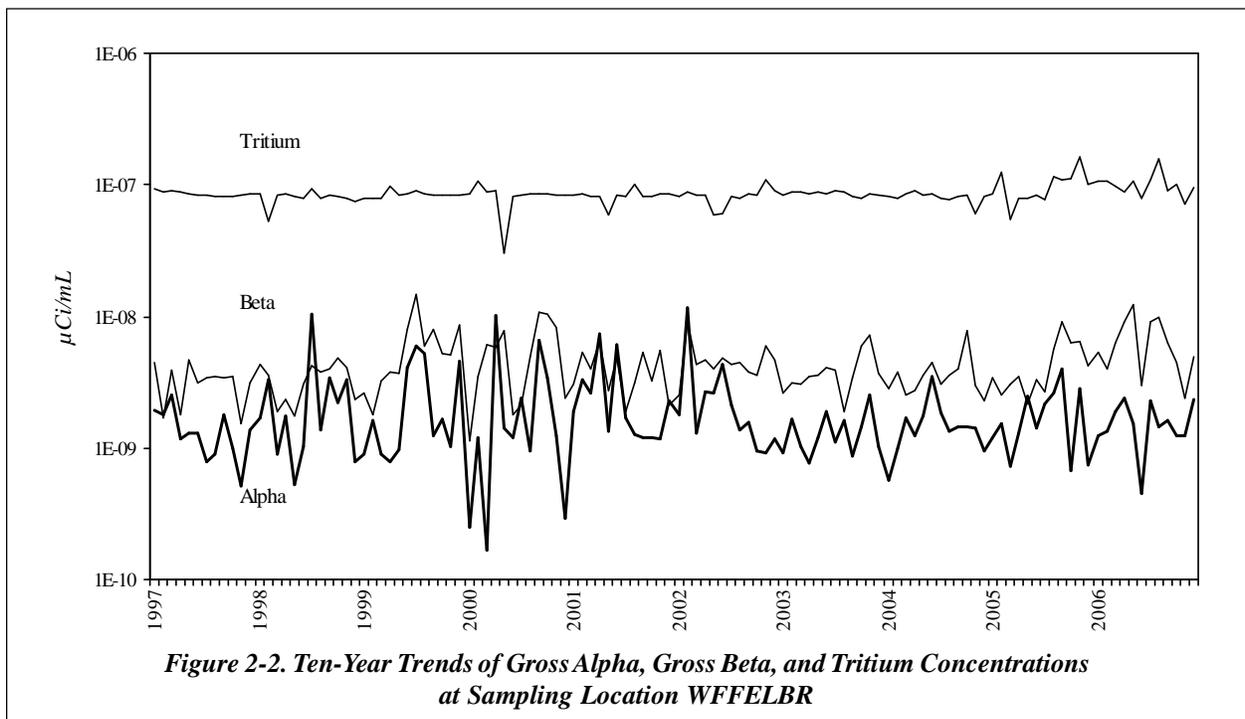


Figure 2-2. Ten-Year Trends of Gross Alpha, Gross Beta, and Tritium Concentrations at Sampling Location WFFELBR

Appendix C-6<sup>60</sup>. In addition, a standing water pond (WNSTAW9) near the site's drinking water reservoirs was monitored. Results are listed in Appendix C-5<sup>60</sup>.

**Off-Site Drinking Water Wells.** Nine off-site private residential groundwater wells near the site and a tenth background well south of the site were sampled in 2006. Sampling locations are shown on Figures A-11, A-14, and A-15. Results are presented in Appendix C-6<sup>60</sup>.

Results from both on-site and off-site samples were statistically indistinguishable from background values.

## Sediment Monitoring

Particulate matter in streams can adsorb radiological constituents in liquid effluents, settle on the bottom of the stream as sediment, and subsequently be eroded or resuspended, especially during periods of high stream flow. The resuspended sediments may provide a pathway for radiological constituents to reach humans either directly via exposure or indirectly through the food pathway.

**On-Site Sediments.** Sediments are collected at three on-site surface water sampling points where liquid effluents leaving the site are most likely to be radiologically contaminated: Frank's Creek where it leaves the security fence (SNSP006), the north swamp drainage swale (SNSW74A), and the northeast swamp drainage swale (SNSWAMP) (Fig. A-2). (Note that these sediment samples may be partially composed of soils, depending on annual rainfall and stream flow patterns.)

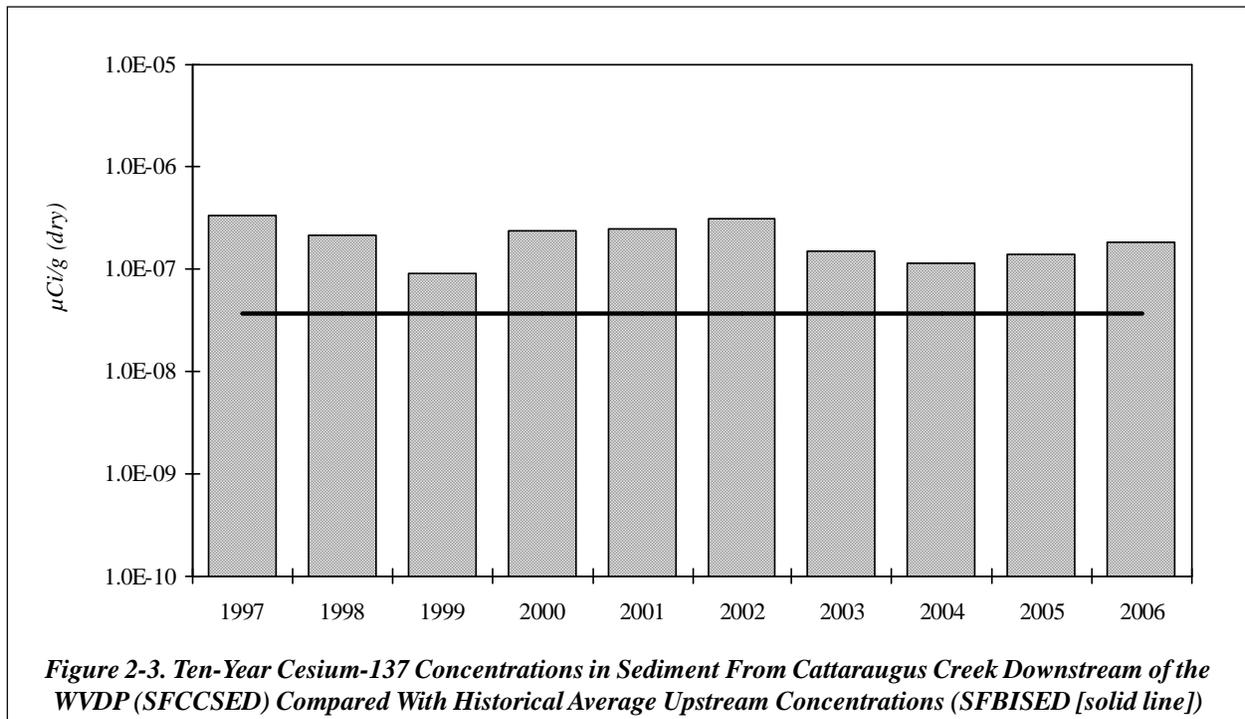
The NRC and the EPA, in a 2002 memorandum of understanding (MOU) pertaining to decommissioning and decontamination of contaminated sites, agreed upon concentrations of residual radioactivity in soil that would trigger consultation between

the two agencies. Consultation "trigger" levels for contamination in both residential and industrial soil are listed in Table G-1D<sup>60</sup> for radionuclides found at the WVDP.

In 2006, the NRC, in a decommissioning guidance document (NUREG-1757, Vol. 2, 2006), provided concentration screening values for common radionuclides in soils that could result in a dose of 25 mrem/year. The screening levels for radionuclides found at the WVDP are listed in Table G-1D<sup>60</sup>.

Results from on-site sediment samples collected in 2006 are presented in Appendix G-2<sup>60</sup>. As expected, concentrations of several radionuclides exceeded concentrations in background soils. (See Table 2-2 for a listing.) Because the on-site sediment samples may be partially composed of soils, the results were compared with both the "trigger" levels from the MOU and the screening values from NUREG-1757. Results for all radionuclides except cesium-137 were lower than the MOU and NUREG-1757 values. Cesium-137 concentrations at locations SNSP006 and SNSWAMP were higher than both the MOU "trigger" levels and the NUREG-1757 screening values. Elevated cesium-137 concentrations at these locations are thought to be attributable to historical releases.

**Off-Site Sediments.** Sediments are collected at one background location upstream of the WVDP, Buttermilk Creek at Fox Valley Road (SFBCSED). Background data are compared with data from three downstream points: Buttermilk Creek at Thomas Corners Road (SFTCSSED), Cattaraugus Creek at Felton Bridge (SFCCSED), and Cattaraugus Creek at the Springville dam (SFSDSED) (Fig. A-5). The first two points are co-located with water sampling locations. The third is behind the Springville dam where significant sediment deposition occurs, including sediments that may have adsorbed radionuclides from the site. See Appendix G-2<sup>60</sup> for results from off-site sediments.



A plot of annual cesium-137 concentrations over 10 years at downstream sampling location SFCCSED is illustrated on Figure 2-3. As the figure indicates, cesium-137 concentrations at SFCCSED, although relatively stable, are consistently higher than the ten-year average cesium-137 concentration at the former background location (SFBISED). Even so, the levels are far lower at these downstream locations than those of naturally occurring gamma emitters, such as potassium-40. (See Table G-2E<sup>60</sup>.)

## Air Emission and Ambient Air Monitoring

Federal laws allow air containing small amounts of radioactivity to be released from plant ventilation stacks during normal operations. The release must meet dose criteria specified in the National Emission Standards for Hazardous Air Pollutants (NESHAP) regulations to ensure that the public's health and safety and the environment are pro-

tected. See "Radiological Emissions" in the Environmental Compliance Summary.

Measured radionuclide concentrations in air are also compared with DOE DCGs. Unlike NESHAP dose criteria, the DOE DCGs are expressed in units of microcuries per milliliter ( $\mu\text{Ci/mL}$ ) and can be directly compared with measurements from the monitoring program. Although the DOE DCGs are applicable only where the public may breathe air containing radionuclides, the DCGs are used at the WVDP as a tool for evaluating airborne emissions at the point of release. DCGs for radionuclides of interest at the WVDP are found in Table UI-1 in the "Useful Information" section at the end of this report. When only gross alpha and beta measurements are available, activity is assumed to come from americium-241 and strontium-90, respectively, because the DCGs for these radionuclides are the most limiting for major particulate emissions at the WVDP.

**Ventilation and Emission Systems.** The exhaust from each EPA-permitted ventilation system is continuously filtered and the permanent systems are monitored as air is released to the atmosphere. Because radionuclide concentrations in air emissions are quite low, a large volume of air must be sampled to measure the quantities of radionuclides released from the facility. Emissions are sampled for radioactivity in both particulate forms (e.g., strontium-90 and americium-241) and gaseous forms (e.g., tritium and iodine-129). The total release of each radionuclide varies from year to year in response to changing site activities. For instance, releases of iodine-129 dropped sharply after vitrification was completed. Over the years, annual calculated dose from air emissions at the WVDP has remained a small fraction of the NESHAP standard. (See “Predicted Dose From Airborne Emissions” later in this chapter.)

*The Main Plant Ventilation Stack.* The main plant ventilation stack (monitoring point ANSTACK) is the primary source of airborne releases at the WVDP. This stack, which vents to the atmosphere at a height of approximately 200 feet (ft) (more than 60 meters [m]), has historically released ventilation exhaust from several facilities, including the liquid waste treatment system, the analytical laboratories, and off-gas from the former vitrification system. In 2006, the main plant stack continued to release ventilation exhaust from a variety of main plant spaces.

Total curies released from the main stack in 2006 are listed in Appendix D<sup>60</sup>, together with annual averages, maxima, and a comparison of average isotopic concentrations with the applicable DCGs. As in previous years, the 2006 average radioactivity levels at the stack discharge point were already far below concentration guidelines for airborne radioactivity in an unrestricted environment. Airborne concentrations from the stack to the site boundary were further reduced by disper-

sion. Results from air samples taken near the site boundary confirm that WVDP operations had no discernible effect on off-site air quality. (See “Perimeter and Remote Ambient Air Monitoring,” later in this chapter.)

*Other On-Site Air Sampling Systems.* Sampling systems similar to those of the main stack are used to monitor airborne effluents from the former vitrification heating, ventilation, and air-conditioning system (ANVITSK), the 01-14 building ventilation stack (ANCSSTK), the contact size-reduction facility ventilation stack (ANCSRFBK), the supernatant treatment system ventilation stack (ANSTSTK), the container sorting and packaging facility ventilation stack (ANCSPPFK), and the remote-handled waste facility (ANRHWFK) (Fig. A-6).

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

One ambient air sampler continued operating in 2006 to monitor air near the on-site lag storage area (ANLAGAM) (Fig. A-6). This sampler was put in place to monitor potential diffuse releases of radioactivity.

Appendix D<sup>60</sup> presents total radioactivity released for specific radionuclides at each of the on-site sampling locations, with the exception of ANCSRFBK, which did not operate in 2006. Most results were non-detects and all results were far below DOE DCGs.

**Perimeter and Remote Ambient Air Monitoring.** In 2006, samples for radionuclides in air were collected at three locations around the perimeter of the site and at three remote locations. Maps of the sampling locations are found on Figures A-7, A-14, and A-15.

The perimeter locations on Fox Valley Road (AFFXVRD), Rock Springs Road (AFRSPRD), and Route 240 (AFRT240) were chosen because they provide historical continuity as former Nuclear Fuel Services, Inc. sampling locations or because they represent the most likely locations for detecting airborne radioactivity.

The remote locations provide data from nearby communities (West Valley [AFWEVAL] and Springville [AFSPRVL]) and from a more distant background area (Great Valley [AFGRVAL], 18 miles [29 km] south of the site), which is considered representative of regional background air. Data from these locations are presented in Appendix D<sup>62</sup>.

Ten-year gross alpha and gross beta concentrations at the Rock Springs Road location are shown on Figure 2-4. Within a range of seasonal and weekly fluctuations, the concentrations have been relatively constant over the past ten years.

Radioisotopic results from samples taken at the two near-site communities and from the site perimeter were statistically indistinguishable from results from the background samples, suggesting that there is no adverse site influence on the air quality at these near-site locations.

## Atmospheric Deposition and Soil Monitoring

**Fallout Pots.** Fallout samples were collected at the rain gauge outside of the Environmental Laboratory (Fig. A-6) in 2006 to monitor short-term deposition of radionuclides. The data are presented in Appendix D<sup>62</sup>. The low levels of radioactivity released in main stack emissions did not measur-

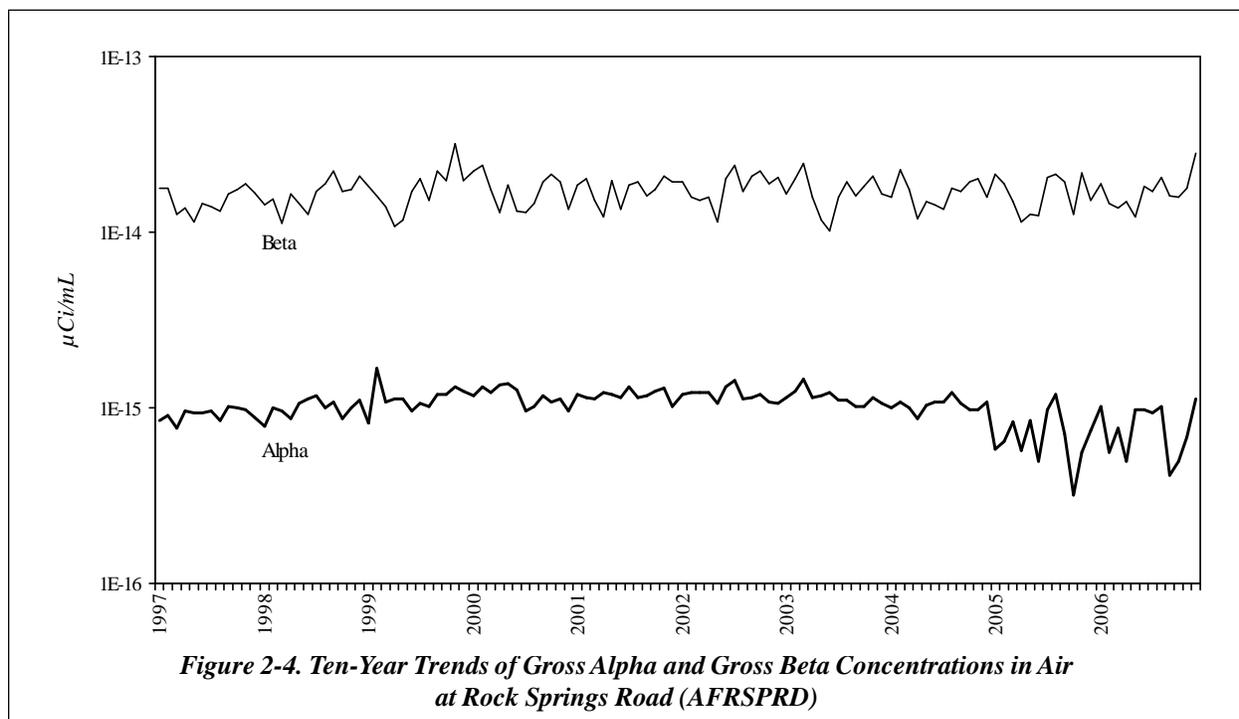


Figure 2-4. Ten-Year Trends of Gross Alpha and Gross Beta Concentrations in Air at Rock Springs Road (AFRSPRD)

ably affect the precipitation collected in on-site fallout pots in 2006.

**Off-Site Surface Soil.** Surface soil near the off-site air samplers is collected to assess long-term deposition of radionuclides. Maps of the off-site surface soil sampling locations are on Figures A-5, A-14, and A-15. In 2005, the frequency of collecting off-site soil samples was reduced from annually to every three years. Samples were last collected in 2004 and will next be collected during CY 2007.

## Food Chain Monitoring

Each year food samples are collected from locations near the site (Fig. A-11) and from remote locations (Figs. A-14 and A-15). Fish and deer are collected during periods when they would normally be taken by sportsmen. Corn, apples, and beans are collected annually at the time of harvest. Edible portions are analyzed for radionuclides. Results are listed in Appendix F<sup>60</sup>. Comparisons with background results are summarized in Table 2-2.

In 2006, venison from two deer contained cesium-137 concentrations elevated with respect to background. However, most historical data have consistently demonstrated that the Project has little or no effect on local foodstuffs. See “Measurement of Radionuclide Concentrations in Food,” later in this chapter, for a discussion of estimating doses from foodstuffs.

## Direct Environmental Radiation Monitoring

On-site monitoring points are located at waste management units, at the site security fence, around the WNYNSC perimeter and the access road, and at a background location remote from the WVDP (Figs. A-12 through A-15). Quarterly

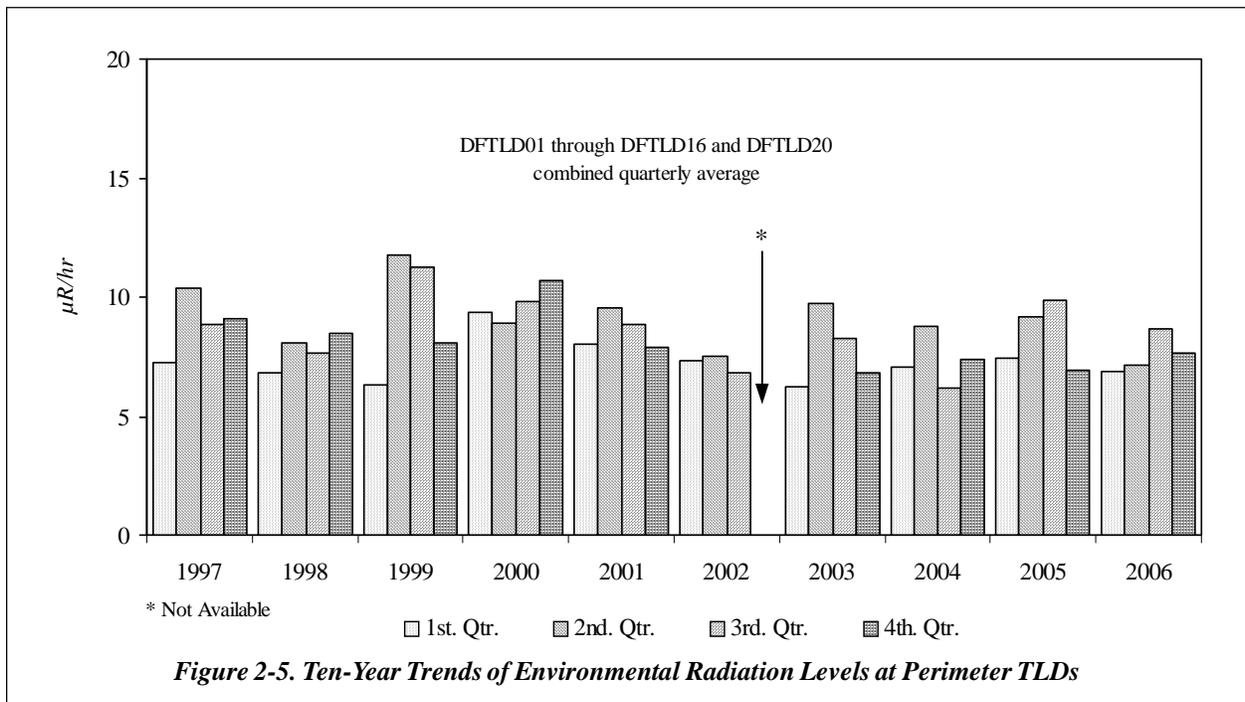
and annual averages of thermoluminescent dosimeter (TLD) measurements at off-site and on-site locations are noted in Appendix H<sup>60</sup>, Tables H-1<sup>60</sup> and H-2<sup>60</sup>, respectively. The results of measurements in 2006 show typical seasonal variations and are similar to results from previous years.

**On-Site Radiation Monitoring.** As in past years, the monitoring point with the highest exposure readings was location DNTLD24. Sealed containers of radioactive components and debris from the plant decontamination are stored near this TLD location. Exposure rates at this location have been generally decreasing over time because the radioactivity in the materials stored nearby is decaying.

As expected, results from TLDs located near on-site facilities are generally higher than background results (Table 2-2); however, these locations are well within the WNYNSC boundary and are not accessible by the public.

**Perimeter and Off-Site Radiation Monitoring.** The perimeter TLDs (TLDs #1–16 and #20) are distributed in the 16 compass sectors around the facility near the WNYNSC boundary. Results from the perimeter and community TLDs were statistically the same as results from the background TLD. The perimeter TLD quarterly averages shown on Figure 2-5 indicate seasonal fluctuations but no long-term trends.

**Confirmation of Results.** Performance of the environmental TLDs is confirmed periodically using a portable high-pressure ion chamber (HPIC) detection system. The HPIC serves as a secondary standard for measurement of radiation levels at each monitoring location. Results for 2006 are summarized in Table H-3<sup>60</sup>. The TLD results include the entire third quarter of 2006; the HPIC results were each collected over a period of less than 30 minutes.



Since these measurements are made with different systems and over differing periods of time, they are not directly comparable. The average relative percent difference between the two sets of measurements was about 14%, indicating general agreement between these two different measurement methods. (Guidance in American National Standards Institute N545-1975, the standard for environmental dosimetry, uses measurement agreement within 30% total uncertainty as a performance specification for TLD measurements.)

## Meteorological Monitoring

Meteorological monitoring at the WVDP provides representative and verifiable data that characterize the local and regional climatology. These data are used primarily to assess potential effects of routine and nonroutine releases of airborne radioactive materials and to provide input to dispersion models used to calculate the effective dose equivalent to off-site residents. Since dispersive capabilities of the atmosphere are dependent upon wind

speed, wind direction, and atmospheric stability (which includes a function of the difference in temperature between two elevations), these parameters are closely monitored and are available to the emergency response organization at the WVDP. If a release to the air occurred, meteorological data would be used to predict the direction in which the plume would move.

The on-site 197-ft (60-m) meteorological tower (Fig. A-1) continuously monitors wind speed, wind direction, and temperature at both the 197-ft (60-m) and 33-ft (10-m) elevations. In addition, an independent, remote 33-ft (10-m) meteorological station, located approximately 5 miles (mi) (8 kilometers [km]) south of the site on a hillcrest on Dutch Hill Road (Fig. A-14), continuously monitors wind speed and wind direction. Dewpoint, precipitation, and barometric pressure are also monitored on site.

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 failures. In 2006, the on-site system data recovery rate (the time valid data were logged versus the total elapsed time) was approximately 96.6%.

Weekly and cumulative total precipitation data are presented in Appendix I<sup>CD</sup>. Precipitation in 2006 was approximately 45.1 inches (114.4 centimeters [cm]), about 10% more than the long-term annual average (41.0 inches [104 cm]).

Documentation, such as meteorological system calibration records, site log books, and analog strip charts, is stored in protected archives. Meteorological towers and instruments are examined three times per week for proper function and are calibrated semiannually and/or whenever instrument maintenance might affect calibration.

## **Special Monitoring**

Radiological constituents may be monitored outside the scope of the environmental monitoring program to address topics of environmental interest or as part of comprehensive investigations focusing on nonradiological constituents. In 2006, samples for radiological constituents were collected during four ongoing activities.

- As part of an extensive nonradiological storm water characterization effort, radiological samples were collected to update previous results at select outfalls. Results, to be reported at a later date, were consistent with monitoring results from nearby routine sampling locations.
- Groundwater seepage into a drained pool that was formerly used to store spent nuclear fuel rods continued to be sampled for radiological constituents in 2006. (See “Fuel Receiving and Storage Pool Water Infiltration” in Chapter 4.)

- Ambient air was monitored by the Radiation Protection Department during demolition of the 02 building. No airborne releases of radiological contamination were noted.

- Surface water samples were collected at a proposed monitoring location on Frank's Creek that would capture drainage downstream of the north plateau strontium-90 plume but upstream of larger diluting stream influents. Data are being evaluated in part to determine if the proposed monitoring point should be added to the routine environmental monitoring program.

No hazards to employees or to the public were identified as a result of special monitoring in 2006.

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# Radiological Effluents and Dose

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## Dose Assessment Methodology

The potential radiation dose to the general public from WVDP activities is evaluated by using a two-part methodology applied in a manner consistent with the requirements of DOE Order 5400.5. The first part uses the measurements of radionuclide concentrations in liquid and air released from the Project to determine the annual total effect using computer model calculations. The second part uses measurements of radioactivity in food from locations near the Project boundaries to corroborate the modeled impact of the annual total release.

Radiological dose is evaluated using methods that consider contributions from all major exposure pathways, including external irradiation, inhalation, and ingestion of local food products. The dose contributions from each radionuclide and pathway combination are then combined to obtain the total dose estimates reported in Table 2-3.

**Measurement of Radionuclide Concentrations in Liquid and Air Releases.** Because it is difficult to distinguish by direct measurement the small amount of radioactivity originating from the Project or from naturally occurring radiation in the environment, computer codes are used to model the environmental dispersion of radionuclides that originate from on-site monitored ventilation stacks and liquid discharge points.

Actual data from air and water release-monitoring samples are collected, together with annual weather measurements and the most recent demographic information. (See Appendices A, C<sup>60</sup>, D<sup>60</sup>, and I<sup>60</sup>.) The effective dose equivalent (EDE) to the maximally exposed off-site individual

(MEOSI) and the collective EDE to the population within a 50-mile (80-km) radius are then calculated using conservative DOE- and EPA-approved models to demonstrate compliance with radiation standards. (See the inset on “Radiation Dose” and “Units of Dose Measurement.”)

**Measurement of Radionuclide Concentrations in Food.** The second part of the dose assessment is based on actual radioactivity measurements in samples of foodstuffs grown 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.

If any of the near-site food samples contain radionuclide concentrations that are higher than the concentrations in control samples, separate dose calculations are performed to verify that the calculated foodstuff dose is consistent with the dose range estimated by computer modeling. (See “Calculated Dose From Local Foodstuff Tests,” later in this chapter.)

These estimates show that the concentrations of radioactivity, whether from sites near or distant from the WVDP, are small – usually near the analytical detection limits – thereby providing additional assurance that operations at the WVDP are not adversely affecting the public.

These calculated doses are used as an independent confirmation of (not added to) the computer-modeled estimates (Table 2-3) because the models already include contributions from all environmental pathways.

### **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 dead skin layer of the body from the outside, resulting in exposure of the internal organs to radiation.*

*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 with each other (e.g., exposure to alpha radiation compared with exposure to gamma radiation). For this reason, regulatory agencies limit the dose to individuals in terms of total dose equivalent.*

### **Units of Dose Measurement**

*The unit for dose equivalent in common use in the U.S. is the rem. 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, respectively. Other radioactivity unit conversions are found in the "Useful Information" section at the back of this report.*

*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 probability. The probability that a given dose will result in the induction of a fatal cancer is referred to as the risk associated with that dose. 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.*

*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 for one year of exposure to radioactivity is calculated by adding the CEDE to the dose equivalent from external, penetrating radiation received during the year. Unless otherwise specified, all doses discussed here are total 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 estimated by dividing the collective dose by the population.*

## Predicted Dose From Airborne Emissions

Airborne emissions of radionuclides are regulated by the EPA under the Clean Air Act and its implementing regulations. DOE facilities are subject to Title 40 of the Code of Federal Regulations (CFR) 61, Subpart H, NESHAP. Subpart H contains the national emission standards for radionuclides other than radon from DOE facilities. The applicable standard for radionuclides is a maximum of 10 mrem (0.1 mSv) effective dose equivalent to any member of the public in any year.

Releases of airborne radioactive materials in 2006 from nominal ground-level stacks (1 to 24 m high) and from the main 60-meter-high stack were modeled using the EPA-approved CAP88-PC computer code (Parks, June 1997). This air dispersion code estimates effective dose equivalents for the ingestion, inhalation, air immersion, and ground surface pathways.

Site-specific data for CY 2006 nonradon radionuclide releases in curies per year are listed in Appendix D<sup>6a</sup>. Applicable information from these tables was used as input to the CAP88-PC code, as were wind data collected from the on-site meteorological tower during 2006 and the most recent local population distribution information.

Resulting output from the CAP88-PC code was then used to determine the total EDE from air emissions to a maximally exposed individual and the collective dose to the population within a 50-mi (80-km) radius of the WVDP.

**Maximum Dose to an Off-Site Individual.** Based on the nonradon airborne radioactivity released from all sources at the site during 2006 (i.e., permitted stacks, stacks that do not require permits, and nonpoint sources), it was estimated that a person living in the vicinity of the WVDP could

have received a total EDE of 0.0011 mrem (0.000011 mSv) from airborne releases. The computer model estimated that this MEOSI was located 1.2 mi (1.9 km) north-northwest of the site and was assumed to eat only locally-produced foods. About 96% of the estimated airborne dose from point sources was from iodine-129.

When considering permitted stacks only, the maximum total EDE of 0.00037 mrem (0.0000037 mSv) is far below levels that could be directly 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 (0.1-mSv) NESHAP limit established by the EPA and mandated by DOE Order 5400.5.

**Collective Population Dose.** The CAP88-PC program was used to estimate the collective EDE to the population. Based upon the latest U.S. census population data collected in CY 2000, 1.54 million people were estimated to reside within 50 mi (80 km) of the WVDP. This population received an estimated 0.0062 person-rem (0.000062 person-Sv) total EDE from radioactive nonradon airborne effluents released from WVDP point and diffuse sources during 2006. (See the discussion of radon-220 later in this chapter.) The resulting average EDE per individual was 0.000004 mrem (0.00000004 mSv).

**Iodine Emissions From the Main Stack.** Iodine-129, a long-lived radionuclide, has routinely been found in main stack emissions. During the vitrification of high-level waste, iodine-129 releases increased because gaseous iodine was not as efficiently removed by the vitrification process off-gas treatment system as were most other radionuclides. As more high-level radioactive waste was removed from the tanks and converted into glass, less waste was available to emit iodine-129 and the total emitted decreased. In 2006, iodine-129 concentrations continued

**Table 2-3**  
**Summary of Annual Effective Dose Equivalents to an Individual**  
**and Population From WVDP Releases in 2006**

<i>Exposure Pathways</i>	<i>Annual Effective Dose Equivalent</i>	
	<i>Maximally Exposed Off-Site Individual<sup>a</sup> mrem (mSv)</i>	<i>Collective Effective Dose Equivalent<sup>b</sup> person-rem (person-Sv)</i>
<b>Airborne Releases<sup>c</sup></b>	<b>1.1E-03 (1.1E-05)</b>	<b>6.2E-03 (6.2E-05)</b>
% EPA standard (10 mrem)	0.01%	NA
<b>Waterborne Releases<sup>d</sup></b>	<b>4.8E-02 (4.8E-04)</b>	<b>2.1E-01 (2.1E-03)</b>
Effluents only	1.2E-02 (1.2E-04)	1.0E-02 (1.0E-04)
North plateau drainage	3.5E-02 (3.5E-04)	2.0E-01 (2.0E-03)
<b>Total From All Pathways</b>	<b>4.9E-02 (4.9E-04)</b>	<b>2.2E-01 (2.2E-03)</b>
% DOE standard (100 mrem) - air and water combined	0.049%	NA
% of natural background (295 mrem; 453,000 person-rem) - received from air and water combined	0.02%	0.00005%
<b>Estimated Airborne Radon-220<sup>e</sup></b>	<b>9.9E-03 (9.9E-05)<sup>f</sup></b>	<b>3.4E-01 (3.4E-03)</b>

Note: Summed values may not exactly match totals due to rounding.

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

<sup>a</sup> The maximum exposure to air discharges is estimated to occur at a residence 1.2 mi (1.9 km) north-northwest of the main plant building.

<sup>b</sup> A population of 1.54 million is estimated to reside within 50 mi (80 km) of the site.

<sup>c</sup> Releases are from atmospheric nonradon point and diffuse sources. Calculations use CAP88-PC to estimate individual and population doses. EPA and DOE limits for individual airborne dose are the same.

<sup>d</sup> Estimates are calculated using the methodology described in the WVDP Manual for Radiological Assessment of Environmental Releases at the WVDP (West Valley Nuclear Services Company [WVNSCO], 2003).

<sup>e</sup> Estimated airborne releases are based on indicator measurements and process knowledge. Dose estimates are calculated using CAP88-PC.

<sup>f</sup> The estimated dose from radon-220 is specifically excluded by rule from NESHAP totals.

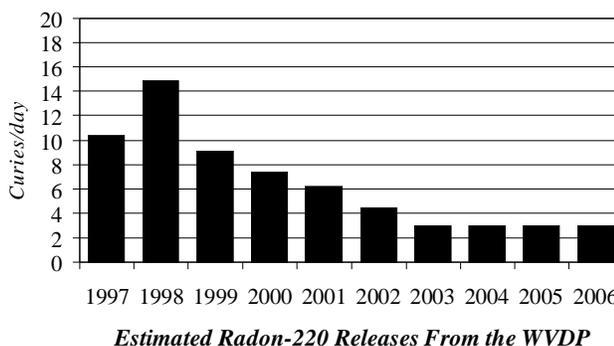
### Radon-220

Radon-220, also known as thoron, is a naturally occurring gaseous decay product of thorium-232 present in the airborne emissions from the WVDP main plant. Radon-220 is also associated with the thorium reduction extraction (THOREX) process-related thorium-232 and uranium-232 in the high-level waste.

As reported in Chapter 2 of the 1996 WVDP Site Environmental Report (WVNSCO and Dames & Moore, June 1997), thoron levels were observed to increase during startup of the 1996 high-level waste vitrification process. An estimate of the thoron released during each waste concentration cycle was developed and used to determine a theoretical annual release. During the vitrification phase, an average of about 12 curies per day were assumed to have been released. In 2006, with the vitrification process completed, the average thoron release is estimated to be about three curies per day.

Although large numbers of curies were released relative to other radionuclides, the calculated dose from thoron is quite small because of its short decay half-life and other characteristics. The NESHAP rule specifically excludes thoron from air emission dose calculations, so a dose estimate using CAP88-PC was calculated separately. The theoretical dose to the MEOSI located 1.2 mi (1.9 km) north-northwest of the site in 2006 would have been 0.0099 mrem (0.000099 mSv), and the collective dose to the population within an 80-kilometer radius would have been 0.34 person-rem (0.0034 person-Sv). (See Table 2-3.) These theoretical doses are within the same range as historical doses from the man-made radionuclides found in WVDP effluents.

With vitrification completed, thoron releases have decreased to pre-vitrification levels. The figure presented here provides a relative indication of recent trends in the estimated annual thoron releases.



to be back to (or below) pre-vitrification levels. Even so, in 2006, iodine-129 continued to account for the largest proportion of dose to an off-site individual from main stack airborne emissions. See Figure 2-6 for a comparison of doses attributable to various nuclides from WVDP air emission points.

## Predicted Dose From Waterborne Releases

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 Part 141 and 40 CFR Part 143, Drinking Water Guidelines (EPA, 1984a; 1984b). Corollary limits for community water supplies are set by NYSDOH in the New York State Sanitary Code (Title 10 of the Official Compilation of Codes, Rules, and Regulations of the State of New York [NYCRR] 5-1.52). The only local private residential wells are upgradient of the WVDP and therefore do not represent a potential source of exposure to radioactivity from routine Project activities.

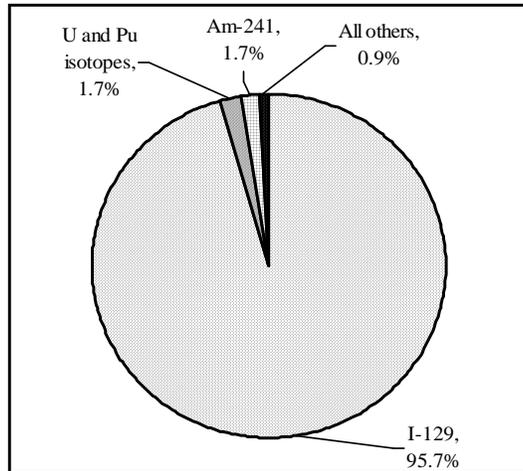


Figure 2-6. Air Emissions From Point Sources: Dose Percent by Radionuclide in CY 2006

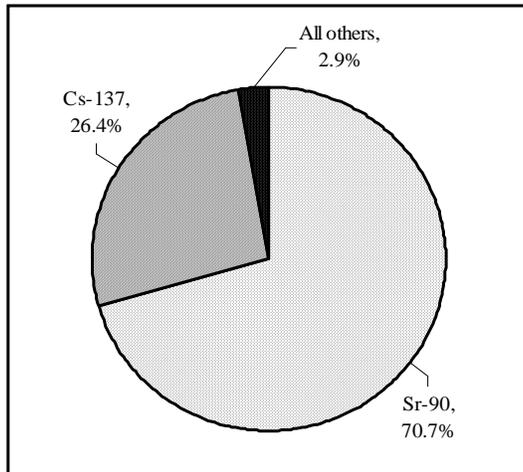


Figure 2-7. Water Effluents: Dose Percent by Radionuclide in CY 2006

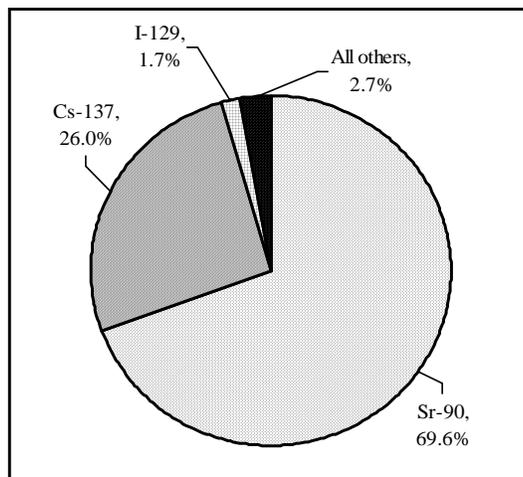


Figure 2-8. All Sources: Dose Percent by Radionuclide in CY 2006

Cattaraugus Creek is not used as a drinking water supply; therefore, a comparison of the predicted concentrations and doses with the 4-mrem/year (0.04-mSv/year) EPA and NYSDOH drinking water limits established in 40 CFR Part 141 and 40 CFR Part 143, and in 10 NYCRR §5-1.52, respectively, is not truly appropriate (although the values in creek samples are well below the EPA drinking water limits). The estimated radiation dose was compared to the applicable guidelines provided in DOE Order 5400.5.

Since the Project's liquid effluents eventually reach Cattaraugus Creek, the most important individual exposure pathway is the consumption of fish from this creek by local sportsmen. Exposure to external radiation from shoreline or water contamination is also included in the model for estimating radiation dose. Population dose estimates are based on the presumption that radionuclides are further diluted in Lake Erie before reaching municipal drinking water supplies.

The computer codes GENII version 1.485 (Pacific Northwest Laboratory, 1988), which implements the models in NRC Regulatory Guide 1.109 (NRC, 1977), and LADTAP II (Simpson and McGill, 1980) were used to calculate site-specific unit dose factors for routine waterborne releases and dispersion of these effluents. Input data included local stream flow and dilution, drinking water usage, and stream usage factors. The EDE to the MEOSI and the collective EDE to the population due to routine waterborne releases and natural drainage are calculated using the dose conversion factors derived from those codes and tabulated in the "WVDP Manual for Radiological Assessment of Environmental Releases at the WVDP" (WVNSCO, 2003).

Six batches of liquid effluents were released from lagoon 3 (point WNSP001) during 2006. Measurements of the radioactivity discharged in these efflu-

ents, listed in Appendix C-2<sup>60</sup>, were combined with the unit dose factors to calculate the EDE to the MEOSI and the collective EDE to the population living within a 50-mi (80-km) radius of the WVDP.

In addition to measurements from WNSP001, radioactivity measurements from sewage treatment facility effluents (WNSP007) were included in the EDE calculations. Results from the sewage treatment facility are also presented in Appendix C-2<sup>60</sup>. (The french drain at WNSP008, a third release point, has been sealed off since 2001 and was not included in this evaluation.)

Besides the two release points at WNSP001 and WNSP007, waters from two natural drainage channels originating on the Project premises contain measurable concentrations of radioactivity: the northeast swamp (WNSWAMP) and north swamp (WNSW74A). The measured radioactivity from these points is reported in Appendix C-4<sup>60</sup>. These results are included in the EDE calculations for the MEOSI and the collective population. See Figure 2-7 for a comparison of estimated doses attributable to specific radionuclides from water effluents.

There were no unplanned releases of waterborne radioactivity to the off-site environment in 2006.

#### **Maximum Dose to an Off-Site Individual.**

Based on the radioactivity in liquid effluents discharged from the WVDP (lagoon 3 and the sewage treatment plant) during 2006, an off-site individual could have received a maximum EDE of 0.012 mrem (0.00012 mSv). About 91% of this dose was from cesium-137. The maximum off-site individual EDE due to drainage from the north plateau (north swamp and northeast swamp) was 0.035 mrem (0.00035 mSv). About 94% of dose from the north plateau was attributable to strontium-90.

The combined EDE to the maximally exposed individual from liquid effluents and drainage was 0.048

mrem (0.00048 mSv). This annual dose is very small in comparison to the 295-mrem (2.95-mSv) dose that is received by an average member of the U.S. population from natural background radiation.

**Collective Dose to the Population.** As a result of radioactivity released in liquid effluents from the WVDP during 2006, the population living within 50 mi (80 km) of the site received an estimated collective EDE of 0.010 person-rem (0.00010 person-Sv). The collective dose to the population from the effluents plus the north plateau drainage was 0.21 person-rem (0.0021 person-Sv). The resulting average EDE from effluent releases and north plateau drainage (north swamp and northeast swamp) per individual is 0.00014 mrem (0.0000014 mSv). This dose is an inconsequential addition to the dose that an average person receives in one year from natural background radiation.

## Calculated Dose From Local Foodstuff Tests

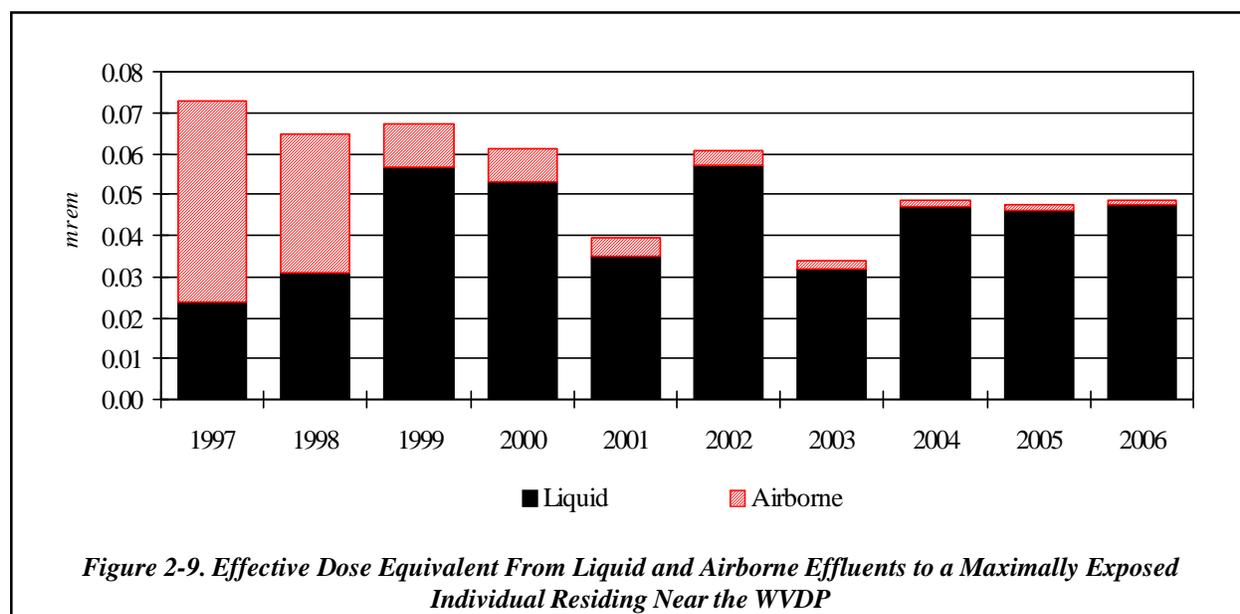
Most radionuclide concentrations in near-site food samples were statistically indistinguishable from concentrations in background samples. Conser-

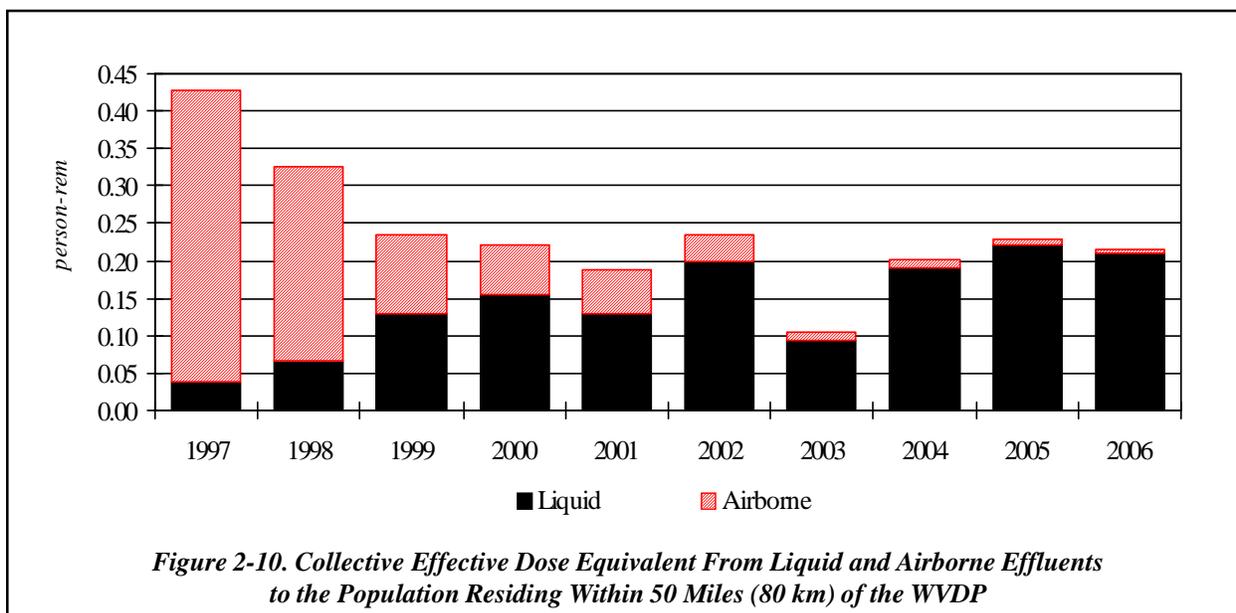
vative estimates of dose due to consuming near-site fish, deer, milk, beans, corn, and apples were about 1.7 mrem/year (0.017 mSv/year). The predominant potential dose from foodstuff was estimated to be from venison consumption. These independent estimates confirm the modeled dose estimates based on air and water effluent sampling results as summarized in Table 2-3.

## Predicted Dose From All Pathways

The potential dose to the public from both airborne and liquid effluents released from the Project during 2006 is the sum of the individual dose contributions. (See Fig. 2-8.) The calculated maximum EDE from all pathways to a nearby resident was 0.049 mrem (0.00049 mSv). This dose is 0.049% of the 100-mrem (1-mSv) annual limit in DOE Order 5400.5. The estimated dose from radon-220 to the same nearby resident was about 0.0099 mrem (0.000099 mSv).

The total collective EDE to the population within 50 mi (80 km) of the site was 0.22 person-rem (0.0022 person-Sv), with an average EDE of





**Figure 2-10. Collective Effective Dose Equivalent From Liquid and Airborne Effluents to the Population Residing Within 50 Miles (80 km) of the WVDP**

0.00014 mrem (0.0000014 mSv) per individual. The estimated radon-220 dose to the population was approximately 0.34 person-rem (0.0034 person-Sv).

Table 2-3 summarizes the dose contributions from all pathways and compares the individual doses with the applicable standards.

Figure 2-9 shows the calculated annual dose to the hypothetical maximally exposed individual over the last ten years. The estimated doses for 2006 were very similar to those reported in 2005.

Figure 2-10 shows the collective dose to the population over the last ten years. (See Fig. A-16 for a map of the population sectors.) The radioactivity in the human pathway represented by these data confirms the continued inconsequential addition to the natural background radiation dose that individuals and population around the WVDP receive from Project activities.

## Risk Assessment

Estimates of cancer risk from ionizing radiation have been presented by the National Council on Radiation Protection and Measurements (NCRP) (1987) and the National Research Council's Committee on Biological Effects of Ionizing Radiation (1990).

The NCRP estimates that the probability of fatal cancer occurring is between one and five per 10,000 people who are each exposed to one rem (i.e., a risk coefficient of between 0.0001 and 0.0005). DOE guidance has, in the past, recommended using a risk coefficient of 0.0005 (ICRP, 1991) to estimate risk to a MEOSI. Recent DOE guidance recommends using the even more conservative risk coefficient of 0.0006 provided by the Interagency Steering Committee on Radiation Standards (January 2003). The estimated risk to the hypothetical individual residing near the WVDP from airborne and waterborne releases in 2006 was three per 100 million (a risk of 0.00000003). This risk is well below the range of 0.000001 to 0.00001 per year considered by the ICRP in Re-

port Number 26 (1977) to be a reasonable risk for any individual member of the public.

## Release of Materials Containing Residual Radioactivity

The release of property containing residual radioactivity from DOE facilities is carefully controlled by DOE guidelines and procedures. In two special memoranda issued in January 2000 and July 2001, the Secretary of Energy placed a moratorium on release of contaminated materials and on unrestricted release for metal recycling from radiological areas within DOE facilities. On July 12, 2001, the DOE issued a Notice of Intent in the Federal Register (FR 36562) to prepare a programmatic environmental impact statement (PEIS) on the disposition of DOE scrap metals that may have residual surface radioactivity. On June 2, 2005, the NRC decided not to proceed with its rule-making concerning the release of solid materials; therefore the DOE PEIS is on hold. The moratorium will remain in effect until directives clarifying the release criteria have been developed and implemented. Any transfer that places property (real property, structures, equipment, or scrap metal) containing radioactivity into public use is classified as a type of environmental release.

As indicated in Table 2-4, the WVDP did not release any property in 2006 classified per DOE Order 5400.5 as material containing residual radioactivity.

## Dose to Biota: Aquatic and Terrestrial Wildlife

Radionuclides from both natural and man-made sources may be found in environmental media such as water, sediments, and soils. In the past, it has been assumed that if radiological controls are sufficient to protect humans, other living things are also likely to be sufficiently protected. This assumption is no longer considered adequate, since populations of plants and animals residing in or near these media or taking food or water from these media may be exposed to a greater extent than are humans. For this reason, the DOE prepared a technical standard that provides methods and guidance to be used to evaluate doses of ionizing radiation to populations of aquatic animals, riparian animals (i.e., those that live along banks of streams or rivers), terrestrial plants, and terrestrial animals.

Methods in this technical standard, “A Graded Approach for Evaluating Radiation Doses to Aquatic and Terrestrial Biota” (DOE-STD-1153-

**Table 2-4**  
**Release of Property<sup>a</sup> Containing Residual Radioactive Material**

Approved Limit	Rationale	Date of Approval	Type of Material	Basis for Release	End Use	Volume of Material	Total Activity	Maximum Individual Dose	Collective Dose
NA	NA	NA	None	NA	NA	0	0	0	0

NA - Not applicable

<sup>a</sup> No property containing residual radioactivity was released in 2006.

2002, July 2002), were used in 2006 to evaluate radiation doses to aquatic and terrestrial biota within the confines of the WNYNSC, which includes the WVDP. Doses were assessed for compliance with the limit in DOE Order 5400.5 for native aquatic animal organisms (1 rad/day) and for compliance with the thresholds for terrestrial plants (also 1 rad/day) and for terrestrial animals (0.1 rad/day), as proposed in DOE-STD-1153-2002. Note that the absorbed dose unit (rad) is used for biota instead of the units used for indicating human risk (rem).

The RESRAD-BIOTA Code (January 2004), a calculation tool provided by the DOE for implementing the technical standard, was used to compare existing radionuclide concentration data from environmental sampling with biota concentration guide (BCG) screening values and to estimate upper bounding doses to biota. Data were collected from surface water samples obtained in 2006 and sediments over the last five years (2002–2006). Soil data from the most recent ten years (1995–2004) were used because no soil sampling was conducted in 2005 or 2006. Differing time periods were used because radionuclide concentrations change more rapidly over time in surface waters than in sediments and soils, as reflected in their sampling frequencies (monthly or quarterly for water, annually or every third year for sediments and soils).

Concentration data for radionuclides in each medium were entered into the RESRAD-BIOTA Code. The value for each radionuclide was automatically divided by its corresponding BCG to calculate a partial fraction for each nuclide in each medium. Partial fractions for each medium were added to produce a sum of fractions.

Exposures from the aquatic pathway may be assumed to be less than the aquatic dose limit from DOE Order 5400.5 if the sum of fractions for the water medium plus that for the sediment medium is

less than 1.0. Similarly, exposures from the terrestrial pathway may be assumed to be less than the proposed dose limits for both terrestrial plants and animals if the sum of fractions for the water medium plus that for the soil medium is less than 1.0.

It was found that the isotopes with the highest sums of fractions – the radionuclides that contributed the largest component of both aquatic and terrestrial dose to biota – were strontium-90 and cesium-137. Per guidance in DOE-STD-1153-2002, the populations of organisms most sensitive to strontium-90 and cesium-137 in this evaluation – that is, those most likely to be adversely affected via the aquatic and terrestrial pathways – were determined to be populations of riparian animals (such as the raccoon [aquatic dose]) and terrestrial animals (such as the deer mouse [terrestrial dose]). Populations of both animals are found on the WNYNSC.

In accordance with the graded approach described in DOE-STD-1153-2002, a general screening was first conducted using the maximum radionuclide concentrations from surface waters, sediments, and soils. Maximum radionuclide concentrations exceeded applicable BCG limits for both aquatic and terrestrial evaluations.

As recommended in DOE-STD-1153-2002, a site-specific screening was then done using estimates of average radionuclide concentrations derived from measurements in surface waters, sediments, and soils. Results are summarized in Table 2-5.

At the site-specific screening level, the sums of fractions for the aquatic and terrestrial evaluations were 0.20 and 0.31, respectively. The sum of fractions for each assessment was less than 1.0, indicating that applicable BCGs were met for both the aquatic and terrestrial evaluations.

Upper bounding doses associated with the aquatic system evaluation were 0.0062 rad/day to an

**Table 2-5**  
**2006 Evaluation of Dose to Aquatic and Terrestrial Biota**

AQUATIC SYSTEM EVALUATION							
Nuclide	Water BCG <sup>a</sup> (pCi/L)	Mean Water Value (pCi/L)	Ratio	Sediment BCG <sup>a</sup> (pCi/g)	Mean Sediment Value (pCi/g)	Ratio	Water and Sediment Sum of Fractions
Cesium-137	42.7	3.72	8.72E-02	3,130	6.09	1.95E-03	0.089
Strontium-90	279	28.8	1.03E-01	583	0.649	1.11E-03	0.10
All Others	NA	NA	8.00E-04	NA	NA	5.10E-04	<0.001
<b>Sum of Fractions</b>			1.91E-01			3.57E-03	<b>0.20</b>
Estimated upper bounding dose to an aquatic animal = 0.0062 rad/day; to a riparian animal = 0.020 rad/day.							
TERRESTRIAL SYSTEM EVALUATION							
Nuclide	Water BCG <sup>a</sup> (pCi/L)	Mean Water Value (pCi/L)	Ratio	Soil BCG <sup>a</sup> (pCi/g)	Mean Soil Value (pCi/g)	Ratio	Water and Soil Sum of Fractions
Cesium-137	599,000	3.72	6.21E-06	20.8	4.78	2.30E-01	0.23
Strontium-90	54,500	28.8	5.28E-04	22.5	1.7	7.55E-02	0.076
All Others	NA	NA	1.79E-06	NA	NA	5.00E-04	<0.001
<b>Sum of Fractions</b>			5.36E-04			3.06E-01	<b>0.31</b>
Estimated upper bounding dose to a terrestrial plant = 0.0027 rad/day; to a terrestrial animal = 0.031 rad/day.							

NA - Not applicable

<sup>a</sup> The biota concentration guides (BCGs) are calculated values. Except for the sums of fractions and dose estimates, which are rounded to two significant digits, all values are expressed to three significant digits.

aquatic animal and 0.020 rad/day to a riparian animal, far below the 1 rad/day standard from DOE Order 5400.5 for dose to a native aquatic animal. Upper bounding doses associated with the terrestrial system evaluation were 0.031 and 0.0027 rad/day to terrestrial animals and plants, again well below the guidance thresholds (0.1 and 1 rad/day, respectively).

It was therefore concluded that populations of aquatic and terrestrial biota (both plants and animals) on the WNYNSC are not being exposed to doses in excess of the existing DOE dose standard for native aquatic animals (U.S. DOE, Feb-

ruary 1990) and the international standards for terrestrial organisms (International Atomic Energy Agency [IAEA], 1992).

## Summary

Predictive computer modeling of airborne and waterborne releases resulted in estimated hypothetical doses to the maximally exposed individual that were orders of magnitude below all applicable EPA standards and DOE Orders, which place limitations on 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 the natural background radiation dose. Additionally, estimates of dose to biota indicated that populations of biota at the WVDP are exposed at a fraction of the DOE and IAEA guidelines for dose to biota.

Based on the overall dose assessment, the WVDP was found to be in compliance with applicable effluent radiological guidelines and standards during calendar year 2006. Table 2-6 provides a summary of WVDP releases and calculated doses in the specified DOE format.

The method for estimating airborne dose to the public at the WVDP may be modified in the future. Updates to CAP88-PC, the computer code used to estimate dose, have been made and the revised code is being tested with WVDP measurements of airborne radionuclides. See the text box following Table 2-6 for a comparison of the currently used and updated versions.

**Table 2-6  
WVDP Radiological Dose and Release Summary**

WVDP RADIOLOGICAL DOSE REPORTING TABLE CY 2006						
Dose to the Maximally Exposed Individual		% of DOE 100-mrem Limit	Estimated Population Dose		Population Within 50 Miles (2000 census)	Estimated Natural Radiation Population Dose
0.049 mrem	0.00049 (mSv)	0.049	0.22 person-rem	0.0022 (person-Sv)	1,536,000	453,000 person-rem

WVDP RADIOLOGICAL ATMOSPHERIC EMISSIONS <sup>a</sup> CY 2006 IN CURIES (Bq)										
Tritium	Kr-85	Noble Gases (T <sub>1/2</sub> <40 dy)	Short-Lived Fission and Activation Products (T <sub>1/2</sub> <3 hr)	Fission and Activation Products (T <sub>1/2</sub> >3 hr)	Total Radioiodine	Total Radiostrontium	Total Uranium <sup>b</sup>	Total Plutonium	Total Other Actinides	Other (Rn-220)
1.16E-03 (4.31E+07)	NA	NA	NA	3.74E-06 (1.38E+05)	3.13E-05 (1.16E+06)	2.92E-06 (1.08E+05)	9.03E-08 (3.34E+03)	1.45E-07 (5.37E+03)	1.82E-07 (6.72E+03)	1.10E+03 (4.05E+13)

WVDP LIQUID EFFLUENT RELEASES <sup>c</sup> OF RADIONUCLIDE MATERIAL CY 2006 IN CURIES (Bq)						
Tritium	Fission and Activation Products (T <sub>1/2</sub> >3 hr)	Total Radioiodine	Total Radiostrontium	Total Uranium <sup>d</sup>	Total Plutonium	Total Other Actinides
7.84E-02 (2.90E+09)	8.34E-03 (3.09E+08)	8.95E-05 (3.31E+06)	2.25E-01 (8.31E+09)	5.44E-04 (2.01E+07)	1.30E-05 (4.82E+05)	9.21E-06 (3.41E+05)

Note: There are no known significant discharges of radioactive constituents from the site other than those reported in this table.

NA - Not applicable

<sup>a</sup> Air releases are from point sources only.

<sup>b</sup> Total uranium (grams) = 8.33E-02

<sup>c</sup> Water releases are from both controlled liquid effluent releases and from well-characterized site drainages.

<sup>d</sup> Total uranium (grams) = 5.03E+02

***Radiological Environmental Dose Assessment Using CAP88-PC  
Version 2.0 versus Version 3.0***

*The WVDP Annual Site Environmental Report (ASER) summarizes the airborne radioactivity released (see Appendix C<sup>(a)</sup>) and the effect from those releases. The computer code CAP88-PC (Version 2.0) is used to perform radiation dose and risk calculations from those airborne releases.*

*A recent change was made to the code. Version 3.0 of CAP88-PC (Trinity Engineering Associates, Inc., March 2006) is now approved by the EPA for use. Version 3.0 incorporates updated scientific methods to calculate radiation dose and risk. Version 3.0 also considers age and gender factors, not considered in Version 2.0. Both versions use weighting factors that consider the sensitivity of various human organs to radiation. The models also calculate how long radioactive material will remain in a particular organ or system. Together, these factors are used to calculate dose and risk.*

*Version 2.0 used seven different organs and Version 3.0 uses 23. The risk of getting cancer from radiation exposure is calculated for 15 sites in Version 3.0 versus 10 in Version 2.0.*

*The net effect is that dose and risk estimates summarized in the ASER from using CAP88-PC Version 2.0 will be different when the new version of the code is used. This would be true even if the radioactivity released from WVDP and meteorology both remained constant.*

*As the WVDP decontaminates more facilities and removes more radioactive material, different mixtures of radionuclides will be released from one year to the next. These changes may also affect the dose and risk estimates.*

*CAP88-PC Version 3.0 improves the science and is more specific to the population that surrounds the facility. In a rough comparison, the 2006 dose to the maximally exposed individual near the WVDP using CAP88-PC Version 2.0 was estimated to be 0.0011 mrem; dose to the same individual using Version 3.0 was estimated to be 0.00096 mrem. In either case, the conclusion from using Version 2.0 or Version 3.0 is that the facility is in compliance with the NESHAP requirement and that the results are a small fraction of the limit.*

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