4.0 RADIOLOGICAL DOSE ASSESSMENT

4.1 Methodology

The potential radiological impacts resulting from the release of radioactivity during 1987 have been estimated by calculating radiation doses received by the maximally exposed offsite individual and the population within an 80 km radius of the West Valley Demonstration Project (WVDP) facility. The potential pathways of exposure to the general public from radioactive effluents released by the WVDP operations are shown in Figure 4-1. The exposure modes considered in the dose calculations are:

- Direct exposure from immersion in air containing radionuclides,
- Direct radiation from ground surfaces contaminated by deposited radionuclides,
- Immersion in contaminated water,
- Inhalation of airborne radionuclides, and
- Ingestion of contaminated water and food produced from the land and surface waters in the area.

Because the ridges and hills in the vicinity of the WVDP frequently channel the winds, strong systematic deviations from straight-line air flow over long distance are expected. To realistically account for the terrain effects on wind flow, a fine grid, two-dimensional wind field was developed using the Dames & Moore WNDSRF3 code and meteorological data measured hourly at seven stations around the WVDP and the three nearest National Weather Service stations. The wind field data were then input into EPM3, a variable-trajectory Gaussian puff dispersion code for calculating the relative concentrations of radioactivity from routine operational releases.

The EPM3 code is formulated according to the guidelines described by the U.S. Nuclear Regulatory Commission (NRC) in Regulatory Guide 1.111. The assumption underlying the code is that a number of discrete puffs are serially released from the source to simulate a continuous plume. Each puff is assumed to have a Gaussian concentration distribution in three dimensions. Puffs expand in size as they move downwind from the source in response to spatial and temporal wind and stability conditions. Each puff is transported independently by the nonuniform wind field and is tracked until it leaves the grid region. Relative concentration and deposition are computed at each grid receptor location.

The output of the EPM3 code is then input into AIRDOS-EPA (Moore et al., 1979) which calculates the radiation doses to receptors of interest. A detailed discussion of the computer codes WNDSRF3, EPM3 and AIRDOS-EPA is given in the WVDP Safety Analysis Report, Volume 1 Supplements, Section A.3.3-C.

Results in this section are based on analyses that use relative concentration values calculated for gaseous effluents released from the WVDP plant at a height of 60 m and at ground level. Meteorological data collected continuously over a twelve-month period (August 1983 through July 1984) were used as the basis for the dispersion calculations.

The calculated annual average relative concentration values for 60-m and ground-level releases are given in Tables 4-1 and 4-2, respectively, for each of the sixteen 22.5-degree wind sectors in an 80-km radius circle centered at the WVDP main plant stack. The maximum mean annual relative concentration values at actual residences in the vicinity of the site are 1.5 E-07 sec/m^3 (at 2.1 km WSW) and 9.5 E-07 sec/m^3 (at 1.4 km NW) for stack and ground level releases, respectively.

To calculate the radiation doses to the maximally exposed individual and the population within 80 km from the plant, relative concentra-

TABLE 4-1

RELATIVE CONCENTRATION VALUES (SEC/M^3) BY SECTOR FROM 60-METRE STACK RELEASE

Azimuth (degrees)	Receptor Distance (metres) 805.0	2414.0	4023.0	5633.0	7242.0
22.50	2.02416 E-08	1.93986 E-08	1.72210 E-08	1.34912 E-08	1.20170 E-08
45.00	3.25187 E-08	6.28082 E-08	1.32191 E-07	2.44441 E-08	1.88344 E-08
67.50	3.42855 E-08	6.94581 E-08	9.40678 E-08	8.45641 E-08	5.52987 E-08
90.00	3.48094 E-08	5.50870 E-08	5.37927 E-08	5.04735 E-08	3.36123 E-08
112.50	5.93936 E-08	6.20651 E-08	1.06356 E-07	6.10075 E-08	5.09318 E-08
135.00	7.26163 E-08	4.20942 E-08	4.16789 E-08	5.56745 E-08	5.42665 E-08
157.50	5.21367 E-08	5.04154 E-08	9.01721 E-08	4.79790 E-08	3.10507 E-08
180.00	3.90285 E-08	1.56936 E-07	6.36421 E-08	3.41481 E-08	1.79095 E-08
202.50	3.36508 E-08	9.69468 E-08	4.42338 E-08	2.37874 E-08	1.69491 E-08
225.00	2.60220 E-08	1.42672 E-07	1.45403 E-08	1.38970 E-08	1.72462 E-08
247.50	1.72524 E-08	1.35143 E-07	9.31579 E-09	8.86101 E-09	9.81254 E-09
270.00	1.38976 E-08	5.95015 E-08	9.28389 E-09	4.92782 E-09	3.25826 E-09
292.50	1.82690 E-08	2.17890 E-08	7.45750 E-09	7.50383 E-09	6.06720 E-09
315.00	1.84112 E-08	1.09852 E-08	5.65960 E-09	4.14112 E-09	4.48282 E-09
337.50	1.74931 E-08	8.44696 E-09	6.69558 E-09	6.46329 E-09	1.05258 E-08
360.00	2.13821 E-08	1.97053 E-08	1.39587 E-08	1.59614 E-08	1.84509 E-08

Azimuth (Degrees)	Receptor Distance (metres) 12070.0	24140.0	40234.0	56327.0	72420.0
22.50	4.43343 E-08	5.02300 E-09	1.54200 E-09	4.66679 E-10	2.25540 E-10
45.00	1.22992 E-08	1.31197 E-08	3.73175 E-09	7.82408 E-10	3.89659 E-10
67.50	1.76386 E-08	8.88299 E-09	2.36241 E-09	7.63461 E-10	3.96656 E-10
90.00	1.30863 E-08	3.96711 E-09	1.69612 E-09	9.09068 E-10	5.38685 E-10
112.50	1.70443 E-08	3.43813 E-09	1.29261 E-09	7.80346 E-10	4.93087 E-10
135.00	2.21988 E-08	4.78107 E-09	1.67453 E-09	9.56557 E-10	7.16724 E-10
157.50	1.27633 E-08	3.65858 E-09	1.39235 E-09	8.41724 E-10	4.17164 E-10
180.00	5.46839 E-09	1.49509 E-09	6.17677 E-10	2.49661 E-10	1.80339 E-10
202.50	4.97200 E-09	1.16554 E-09	4.17297 E-10	3.26463 E-10	2.17867 E-10
225.00	3.90207 E-09	1.04904 E-09	3.62789 E-10	2.67344 E-10	2.49012 E-10
247.50	2.91434 E-09	7.44792 E-10	3.09624 E-10	2.42050 E-10	1.63484 E-10
270.00	1.99053 E-09	1.17354 E-09	5.09524 E-10	2.33294 E-10	1.34791 E-10
292.50	3.02399 E-09	8.52397 E-10	3.06939 E-10	1.84965 E-10	1.64367 E-10
315.00	4.12131 E-09	8.10527 E-10	3.61054 E-10	1.97646 E-10	1.23069 E-10
337.50	2.99186 E-08	1.68992 E-09	5.56848 E-10	3.13688 E-10	3.07107 E-10
360.00	1.22515 E-08	3.13466 E-09	9.76886 E-10	4.44199 E-10	2.44762 E-10

TABLE 4-2

RELATIVE CONCENTRATION VALUES (SEC/M^3) BY SECTOR FROM GROUND LEVEL RELEASE

Azimuth	Receptor Distance (metres)				
(degrees)	805.0	2414.0	4023.0	5633.0	7242.0
22.50	1.64432 E-06	4.55564 E-07	1.66184 E-07	1.01517 E-07	6.77884 E-08
45.00	1.56641 E-06	3.30197 E-07	1.34172 E-07	4.73194 E-08	3.59780 E-08
67.50	1.01058 E-06	1.97252 E-07	9.42588 E-08	5.81288 E-08	3.79589 E-08
90.00	1.09262 E-06	1.82835 E-07	6.67927 E-08	3.73587 E-08	2.40901 E-08
112.50	1.78994 E-06	2.74125 E-07	1.11012 E-07	5.38760 E-08	3.54571 E-08
135.00	2.15038 E-06	2.94396 E-07	1.14500 E-07	6.48315 E-08	4.33901 E-08
157.50	1.44110 E-06	2.02579 E-07	7.62755 E-08	4.02057 E-08	2.65812 E-08
180.00	8.98011 E-07	1.26039 E-07	4.46505 E-08	2.10800 E-08	1.25962 E-08
202.50	5.82938 E-07	9.09417 E-08	3.23678 E-08	1.65005 E-08	1.04614 E-08
225.00	6.20413 E-07	7.22452 E-08	2.39934 E-08	1.50882 E-08	1.07698 E-08
247.50	4.08957 E-07	6.32056 E-08	1.82285 E-08	1.04640 E-08	8.59581 E-09
270.00	8.34124 E-07	9.51694 E-08	2.16677 E-08	9.40243 E-09	5.93790 E-09
292.50	1.28776 E-06	1.80989 E-07	3.03818 E-08	2.59718 E-08	1.63193 E-08
315.00	2.31398 E-06	4.61826 E-07	6.24797 E-08	2.03703 E-08	2.54686 E-08
337.50	6.00362 E-06	1.40566 E-07	6.21634 E-08	6.63543 E-08	1.15632 E-07
360.00	4.27125 E-06	4.75757 E-07	1.16690 E-07	1.44426 E-07	1.63061 E-07

Azimuth	Receptor Distance (metres)				
(degrees)	12070.0	24140.0	40234.0	56327.0	72420.0
22.50	3.52891 E-08	3.40586 E-09	1.00542 E-09	3.49144 E-10	1.68966 E-10
45.00	2.21417 E-08	5.09350 E-09	1.70791 E-09	6.33664 E-10	3.75450 E-10
67.50	1.42588 E-08	4.70023 E-09	1.70863 E-09	7.93135 E-10	4.70601 E-10
90.00	8.93237 E-09	2.77984 E-09	1.41573 E-09	8.15443 E-10	5.13178 E-10
112.50	1.28142 E-08	3.20641 E-09	1.18574 E-09	7.40762 E-10	4.56947 E-10
135.00	1.65469 E-08	3.96052 E-09	1.37113 E-09	7.85457 E-10	5.36148 E-10
157.50	1.08235 E-08	2.93527 E-09	1.04913 E-09	5.98888 E-10	3.05173 E-10
180.00	4.28680 E-09	1.03415 E-09	3.53940 E-10	1.93388 E-10	1.56602 E-10
202.50	3.68894 E-09	8.73627 E-10	3.80441 E-10	2.51438 E-10	1.42737 E-10
225.00	3.43687 E-09	8.53510 E-10	3.15227 E-10	2.07137 E-10	1.35988 E-10
247.50	2.33436 E-09	7.21198 E-10	3.22324 E-10	2.08381 E-10	1.43584 E-10
270.00	2.40878 E-09	9.84799 E-10	4.35641 E-10	2.13476 E-10	1.41153 E-10
292.50	6.26825 E-09	1.25810 E-09	3.77333 E-10	1.91497 E-10	1.43025 E-10
315.00	2.26095 E-08	8.30861 E-10	4.30455 E-10	1.97719 E-10	1.14625 E-10
337.50	1.76978 E-08	1.68011 E-09	6.15352 E-10	3.18642 E-10	2.15773 E-10
360.00	2.66190 E-08	3.37986 E-09	9.44245 E-10	3.94326 E-10	1.87990 E-10

tion values are used as input to the AIRDOS-EPA code.

The dose estimates were made by calculating radionuclide concentrations in air, rates of deposition on ground surfaces, ground surface concentrations, intake rates via inhalation, and ingestion of meat, milk, and fresh vegetables. Site specific data on production and consumption of milk, meat, and agricultural products were used in computing the collective population dose.

The radiation dose commitment to the maximally exposed individual and the collective dose to the population within 80 km of the WVDP from the water pathway were calculated using the computer code LADTAP II (Simpson and McGill, n.d.). Both LADTAP II and AIRDOS-EPA implement the NRC Regulatory Guide 1.109 recommendations for terrestrial food chain dose assessments.

Two maps of the area surrounding the WVDP were overlaid with 16- and 80-km radius grid systems with the facility at its center. The grid systems were further divided into 10 concentric regions and 16 compass directions. For each sector formed by the grid system, the specific human populations, beef and dairy cattle populations, and agricultural areas were determined by a 1983 survey. The sector specific data are shown in Figures 4-2 through 4-9.

For each radionuclide of concern, the inhalation dose conversion factors (DCFs) used are for an activity median aerodynamic diameter (AMAD) of 0.3 micrometer. For alpha emitters, the dose conversion factors are derived by using a quality factor of 20, as recommended by the International Commission on Radiological Protection (ICRP)(Dunning, n.d.). All of the doses from internal exposure are committed dose equivalents and are calculated for the 50-year period following inhalation or ingestion using the internal dose conversion factors from Dunning.

For this report, the effective dose equivalent, as well as the dose equivalent to the thyroid, lungs, bone, liver, kidneys, and gastro-intestinal tract were calculated in order to determine the critical organs for various potential pathways of exposure. These estimates were based on parameters applicable to an average adult male (ICRP, 1975). The collective population dose estimate in person-rem is the effective dose equivalent as calculated in accordance with the recommendations of the ICRP (ICRP, 1977).

In addition to these estimates of dose commitments based on dispersion modeling, the dose was estimated to a hypothetical maximally exposed individual who consumed locally produced milk, fish, beef, and venison (deer). Measured radionuclide concentrations from local and control samples of milk, fish, beef, and venison were used in these calculations. Although state-of-the-art methods and instrumentation were used to determine concentrations, certain nuclides, if present in these samples, are often below the minimum detectable concentration (MDC). In cases where both the sample and its control were below the MDC for a specific nuclide, it was assumed that the nuclide was not present at a concentration greater than natural background.

4.2 Source Term Estimates

4.2.1 Airborne Radioactive Effluents

There are five points on the plant site from which ventilation systems released low concentrations of airborne radioactivity during 1987. These five locations are:

- Process building main stack,
- Cement Solidification System (CSS) exhaust stack,
- Contact Size Reduction Facility (CSRF) exhaust stack,
- Laundry exhaust vent, and
- Low-level Waste Treatment Facility (LLWTF) ventilation exhaust.

The air released from these vents is sampled routinely and the collected particulates are periodically analyzed. For the main plant, CSS,

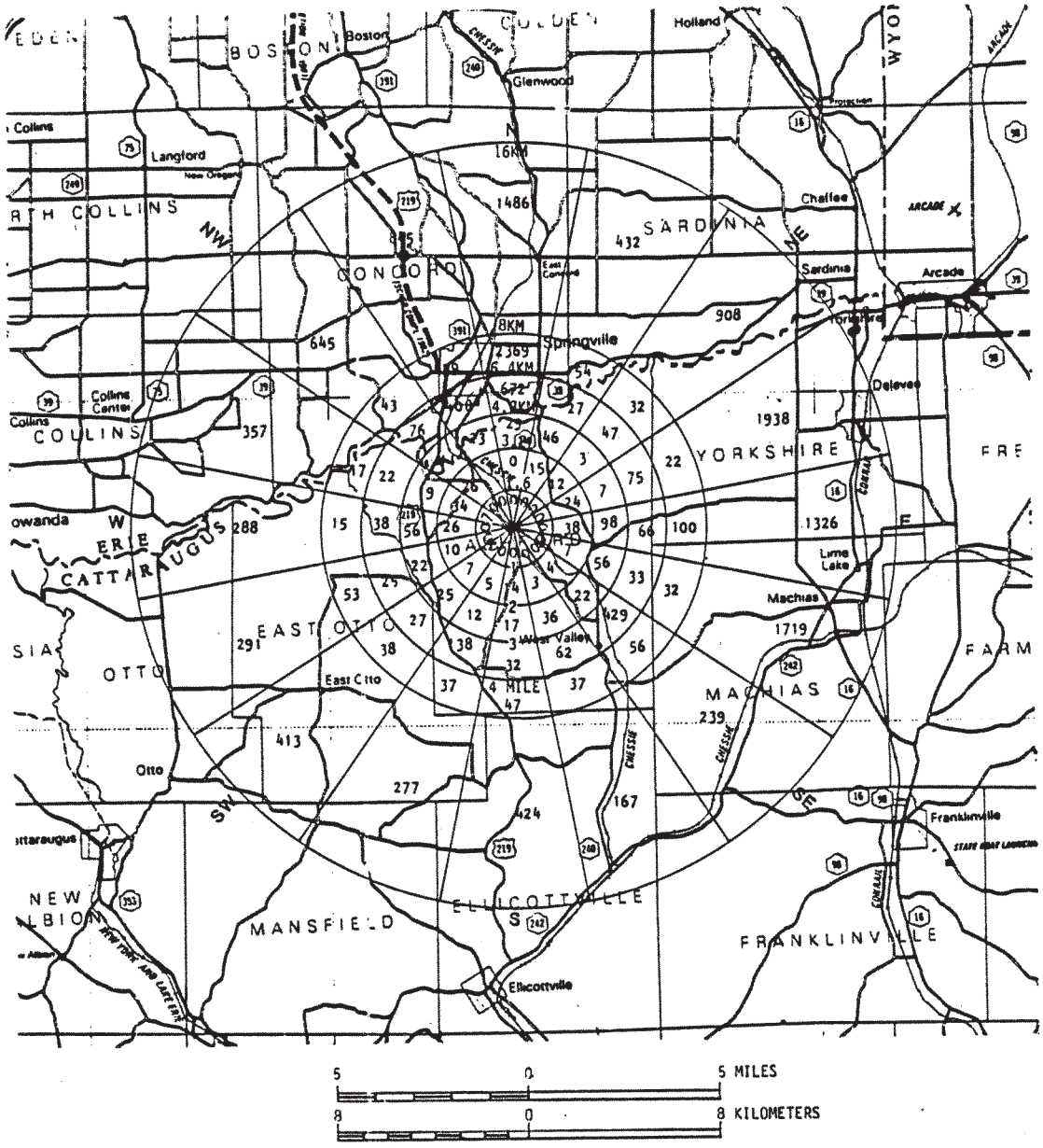

Figure 4-2. 1990 Population Projections by Sector within 16 km (10 mi) of the Site.

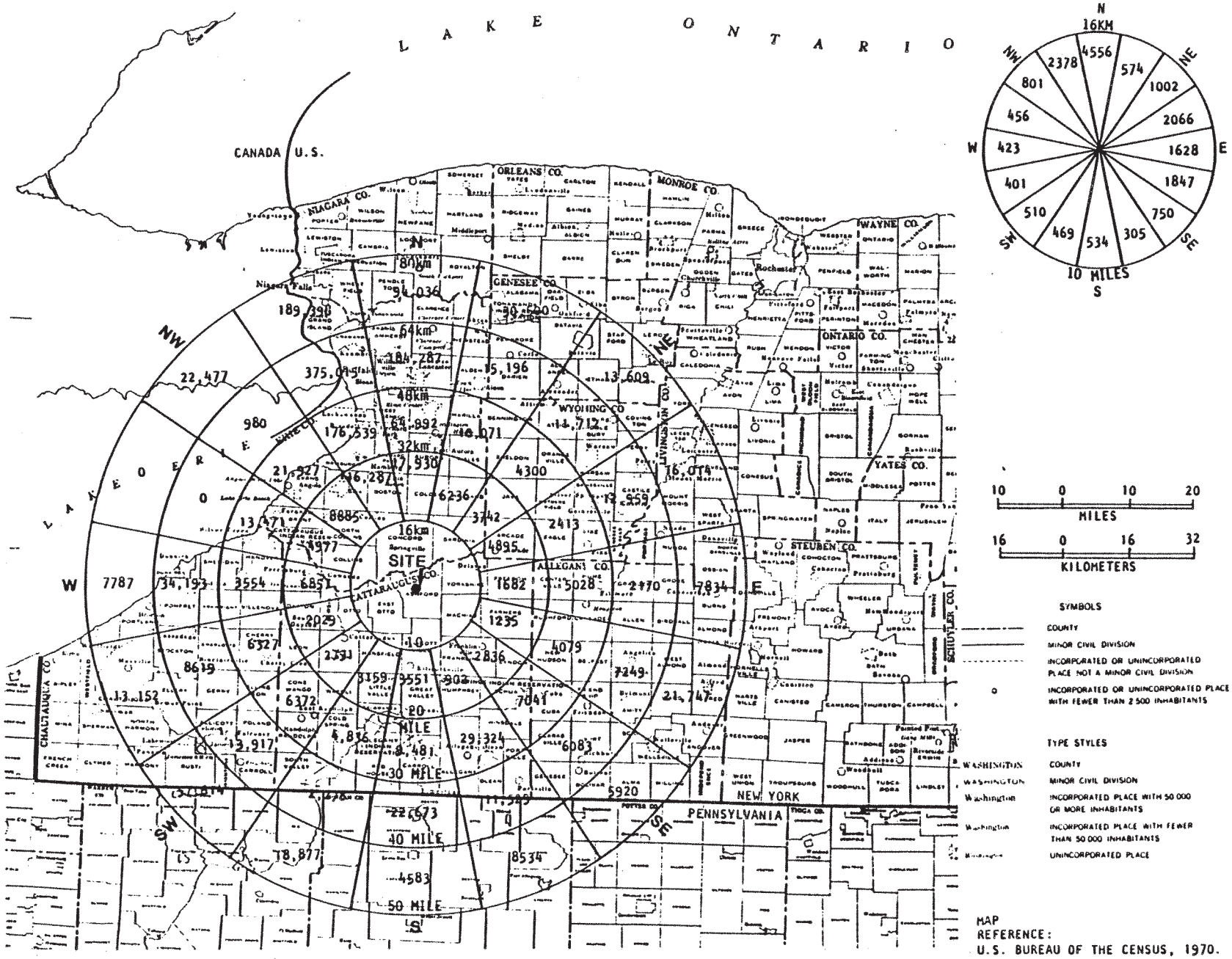

Figure 4-3. 1990 Population Projections by Sector within 16-80 km (10 - 50 mi) of the Site.

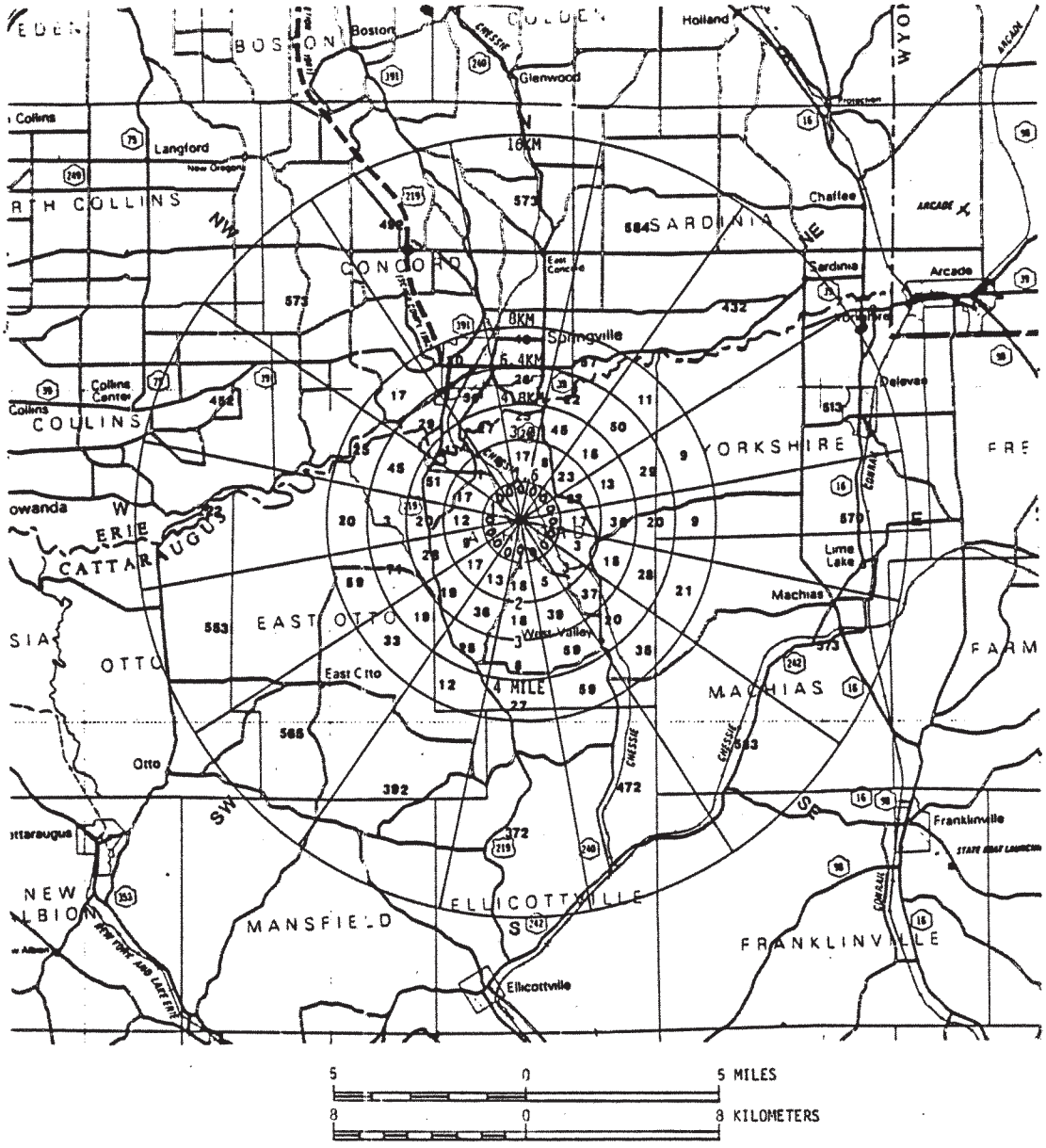

Figure 4-4. Number of Dairy Cows by Sector within 16 km (10 mi) of the Site.

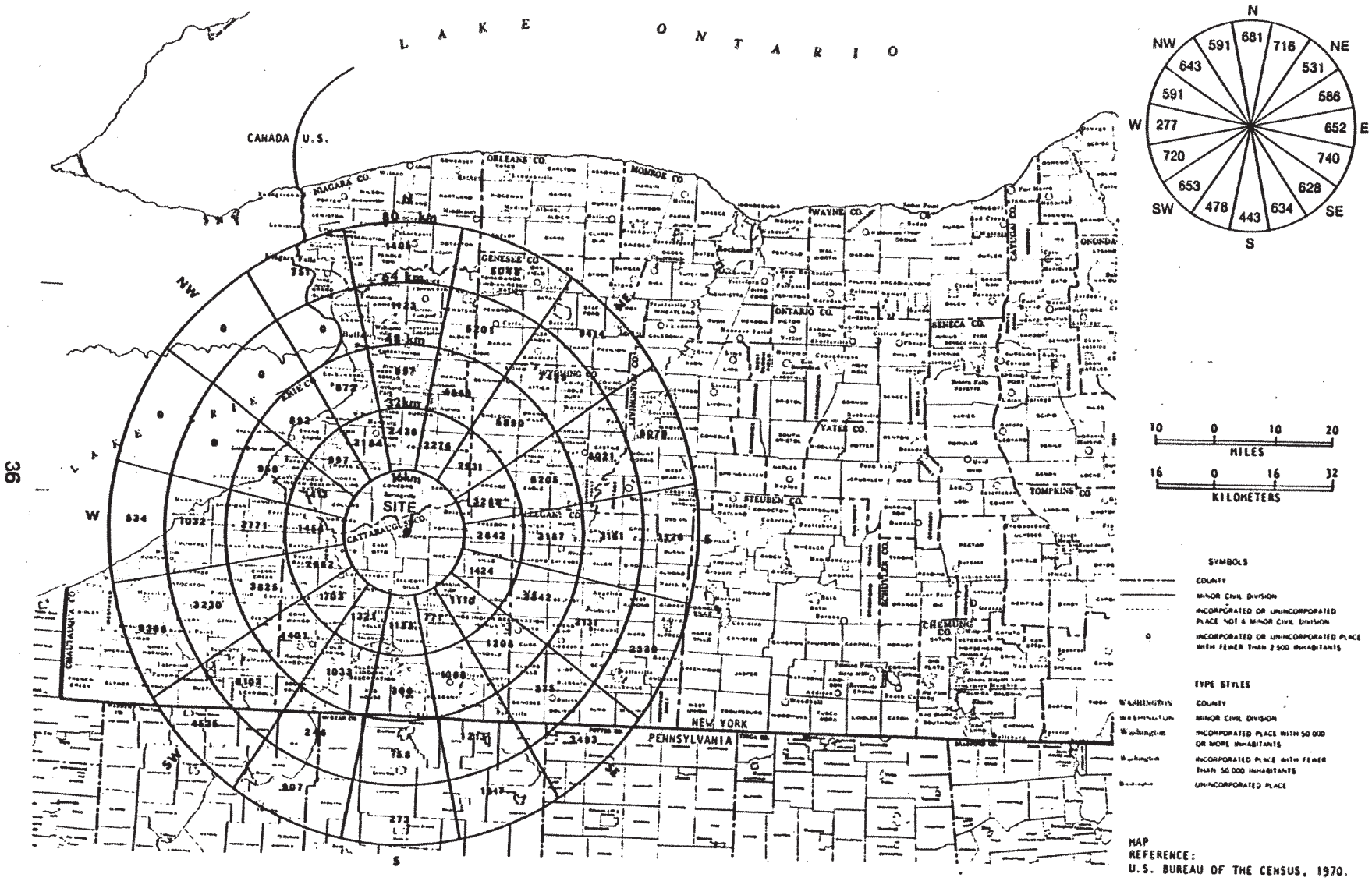

Figure 4-5. Number of Dairy Cows by Sector within 16-80 km (10 - 50 mi) of the Site.

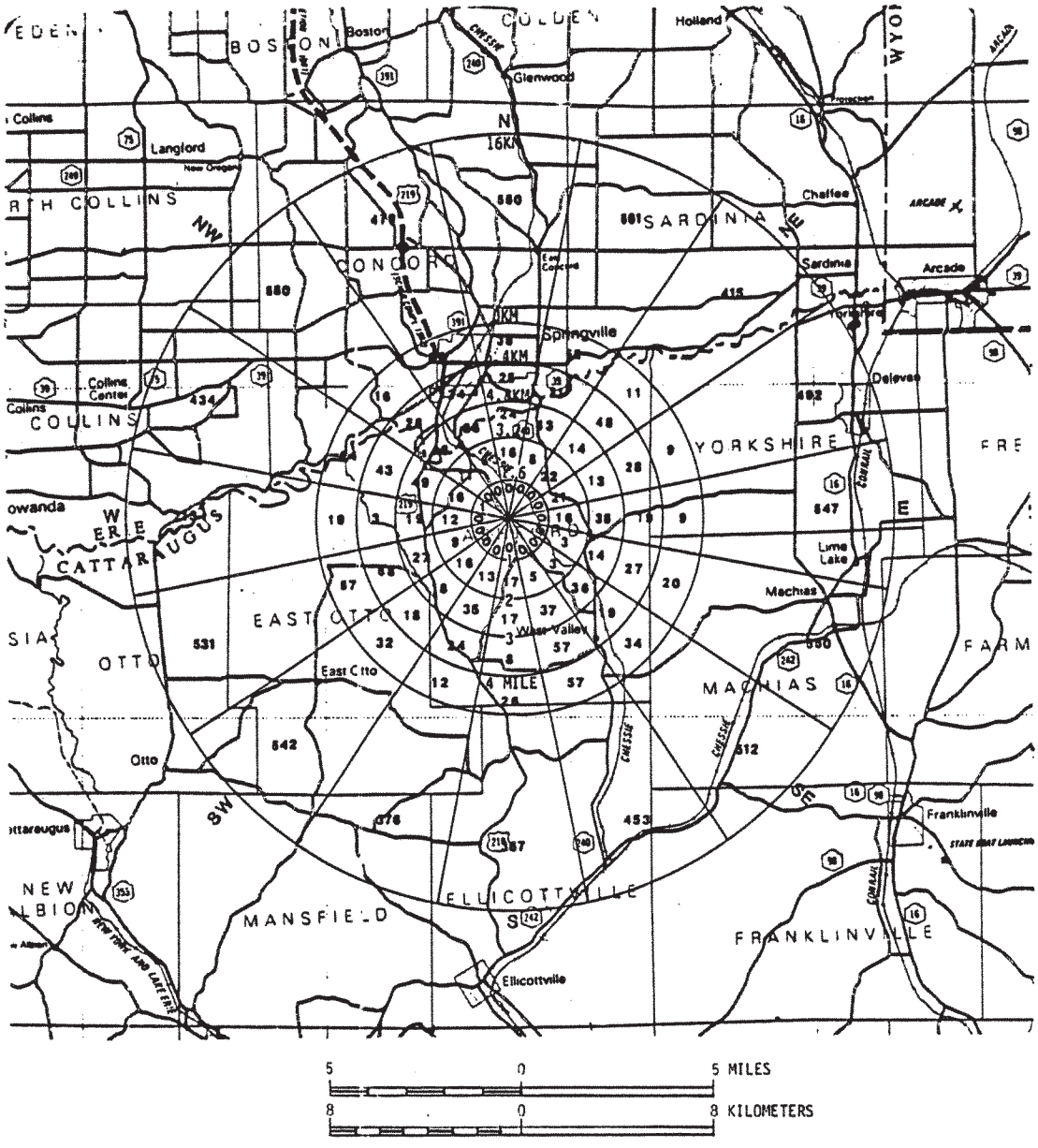

Figure 4-6. Number of Meat-producing Animals by Sector within 16 km (10 mi) of the Site.

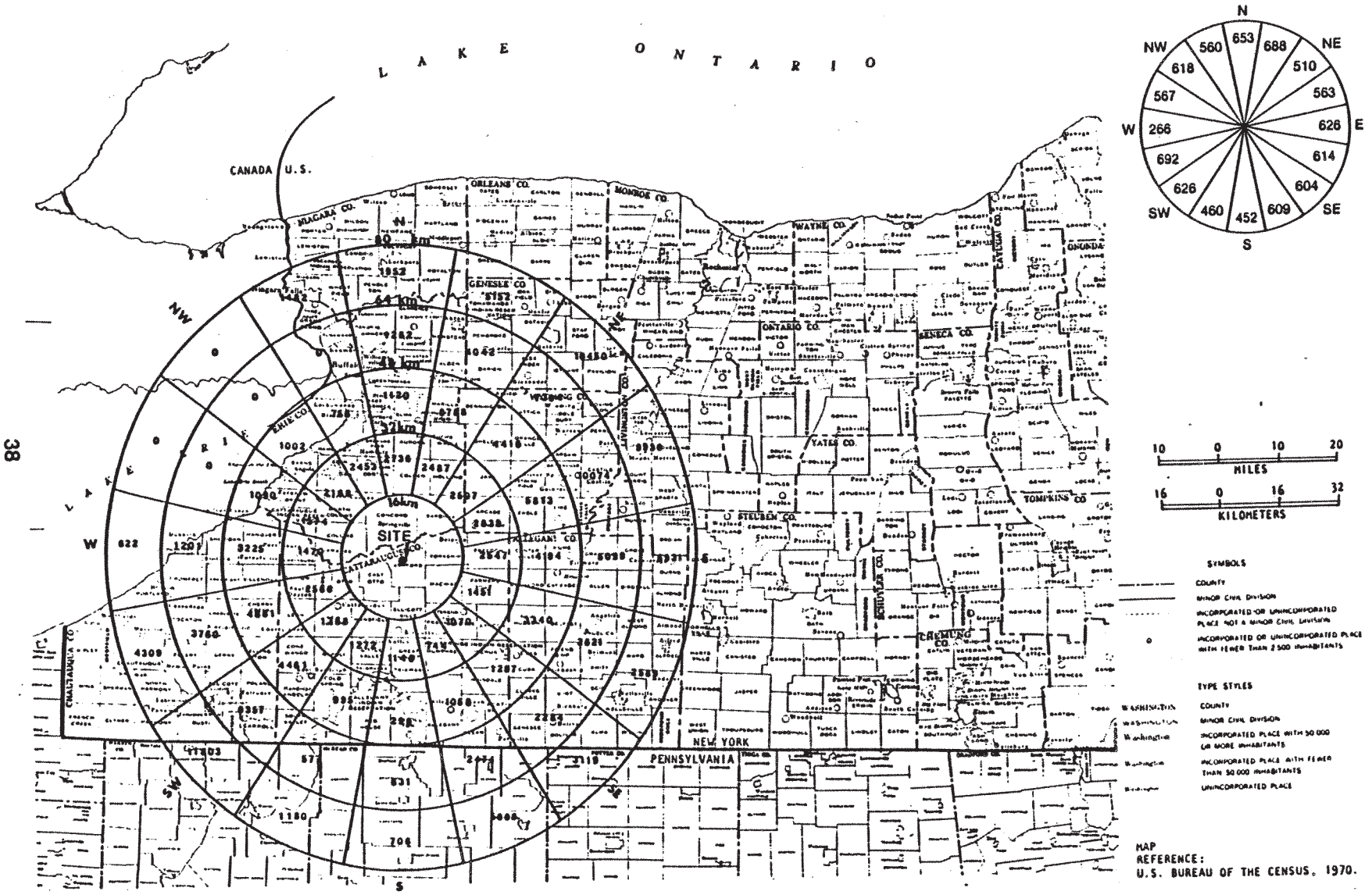

Figure 4-7. Number of Meat-Producing Animals by Sector 16 - 80 km (10 - 50 mi) of the Site.

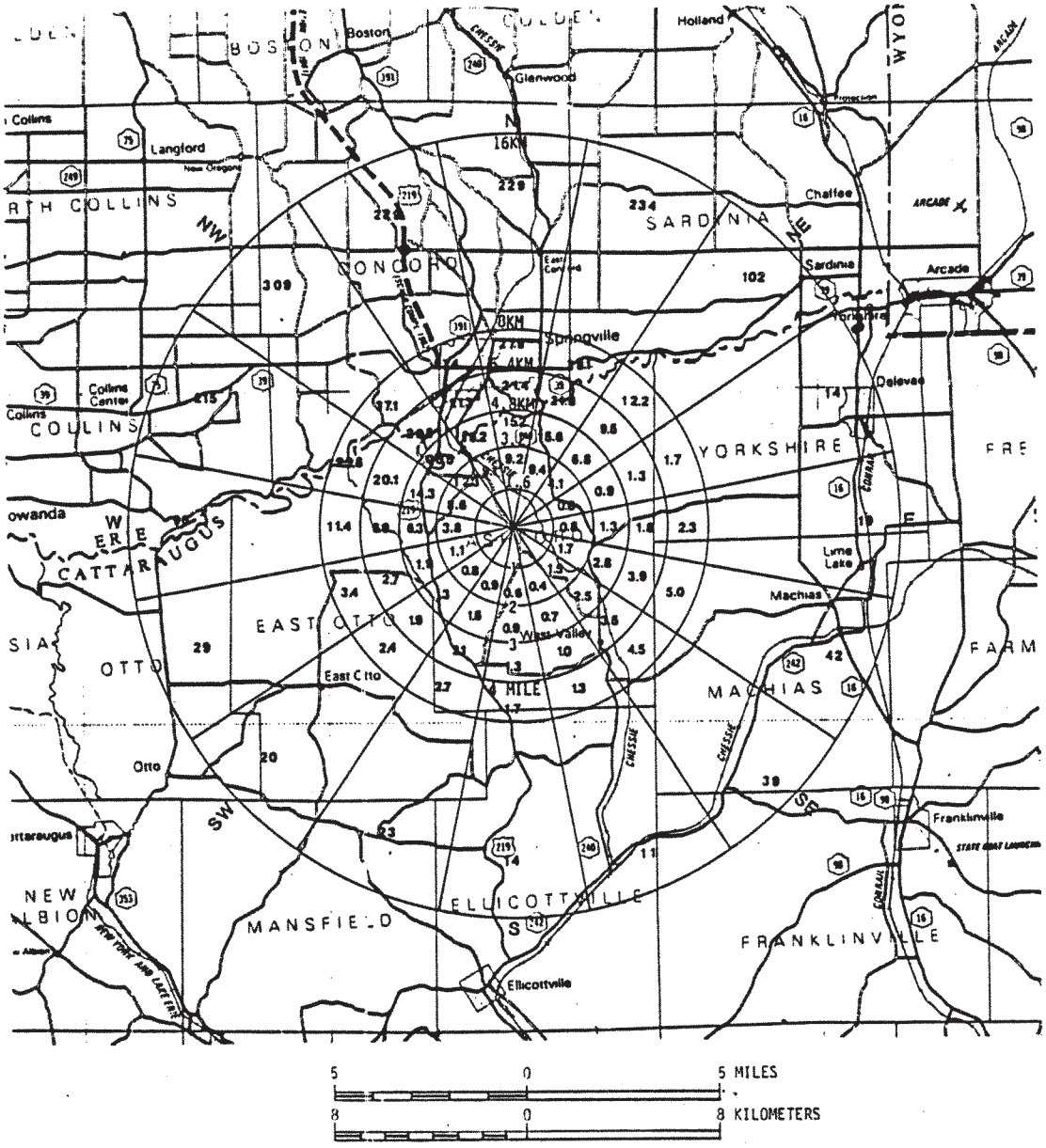

Figure 4-8. Agricultural Produce Land Area (ha) by Sector Within 16 km (10 mi) of the Site.

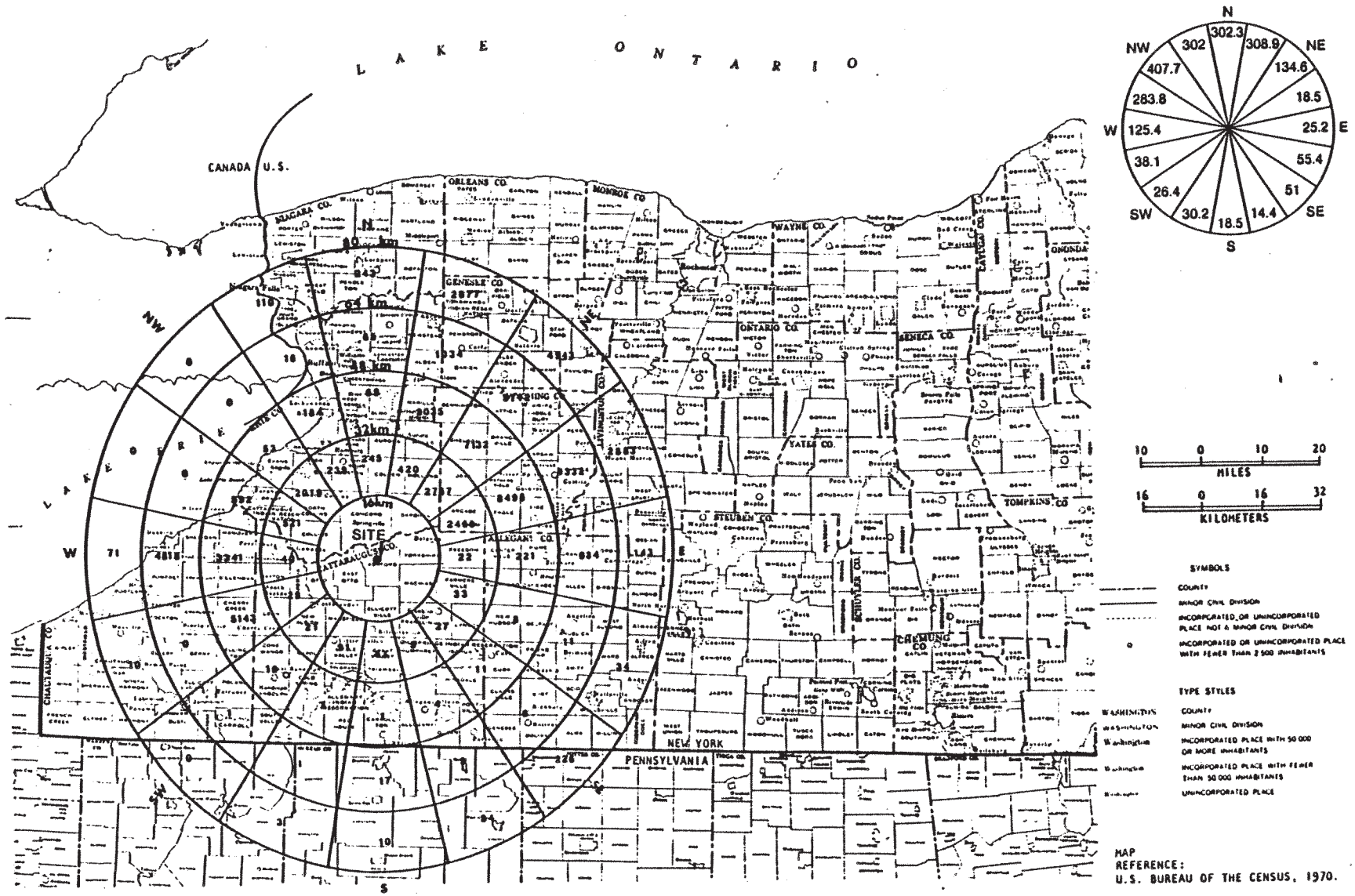

Figure 4-9. Agricultural Produce Land Area (ha) by Sector within 16 - 80 km (10 - 50 mi) of the Site.

and CSRF stacks, the sampling is continuous. The results of measurements during 1987 are summarized in Table 4-3. A total of 6.8 E-06 Ci of alpha activity and 5.5 E-04 Ci of beta/gamma activity was released from these vents during the year. Greater than ninety-eight percent of the activity released to the atmosphere was discharged through the main plant stack.

The Contact Size Reduction Facility (CSRF) began operation in October of 1987. Its exhaust is continuously monitored for radioactivity in a manner similar to that used for the main plant and CSS stacks.

4.2.2 Liquid Radioactive Effluents

There were three sources of liquid effluents from WVDP operations in 1987:

- Lagoon 3 discharges (five planned releases),
- Sewage treatment outfall (WNSP007), and
- Surface water drainage from the northeast swamp drain, the french drain, and the north swamp drain.

The volumes of the liquid effluents and the radioactivity they contained (reported in WVDP 1987 Effluent and On-Site Discharge Report, March 1988) are summarized in Table 4-4. All liquids were discharged via Buttermilk Creek. Relevant release standards and derived concentration guides (DCGs, DOE Order 5480.1) are presented in Appendix B. Collective population doses from these liquid effluents are based on the number of curies released for each identified nuclide in Table 4-4 (see Section 4.3.2). Actinide concentrations were measured only in the Lagoon 3 effluent.

4.3 Potential Radiation Doses to the Public

4.3.1 Maximum Hypothetical Individual Doses

The point of maximum potential long-term radiation exposure in the vicinity of the site from radioactivity released from the plant stack is a private residence about 2.1 km WSW of the WVDP plant. A hypothetical maximum effective dose equivalent of 0.00097 mrem was calculated as a result of WVDP airborne releases during 1987 when all possible pathways were considered. The calculated dose commitment to bone surfaces (the critical organ) at this location was 0.0069 mrem. These maximum hypothetical exposures are about 0.004 percent for whole body and 0.009 percent for the critical organ of the applicable standards for airborne releases promulgated by the U.S. Environmental Protection Agency (EPA) in 40 CFR 61.

An important potential contributor to the dose commitment from radioactivity in the terrestrial food-chain is the airborne pathway to the pasture and then to cow and to milk. Measurements of radioactivity in the milk produced at the dairy farm nearest to the WVDP facility (see Table C-3.1) indicated that no tritium, I-129, Cs-134, or Cs-137 were present in concentrations above the limits of detection. The maximum dose to an individual from ingestion of about 1 L of this milk per day was estimated from the Sr-90 concentrations in excess of the control sample. This calculation predicts a dose commitment of 0.40 mrem to bone surfaces and an effective dose equivalent of 0.038 mrem. These calculated maximum potential doses are 0.5 percent and 0.2 percent, respectively, of the allowable 40 CFR 61 standards.

If I-129 were assumed to be present in the milk at a net concentration equal to the MDC (0.6 pCi/L), the predicted, hypothetical maximum thyroid dose would be approximately 2 mrem/year. This is not considered to be a realistic assumption. It does, however, indicate

TABLE 4-3

RADIOACTIVITY RELEASED TO THE ATMOSPHERE DURING 1987

Release Point	Total Volume (m3)	Total Curies Released				
		Gross Alpha	Gross Beta	Specific Nuclides		
Main Plant Stack (ANSTACK)	8.9 E+08	6.65 ± 0.4 E-06	5.43 ± 0.1 E-04	H-3	4.14 ± 0.1	E-01
				Co-60	1.31 ± 0.2	E-06
				Sr-90	1.32 ± 0.1	E-04
				I-129	4.29 ± 0.4	E-05
				Cs-134	2.61 ± 2.2	E-07
				Cs-137	2.05 ± 0.01	E-04
				Eu-154	1.30 ± 0.4	E-06
				U-234	3.98 ± 0.4	E-08
				U-235	3.41 ± 1.6	E-09
				U-238	3.27 ± 0.4	E-08
				Pu-238	8.68 ± 0.5	E-07
				Pu-239	1.16 ± 0.1	E-06
				Am-241	2.21 ± 0.1	E-06
Cement Solidification System Stack (ANCSSTK)	1.5 E+08	< 2.2 E-08	1.16 ± 0.1 E-06	Co-60	< 2.9	E-08
				Sr-90	2.27 ± 0.2	E-06
				I-129	9.49 ± 4.8	E-08
				Cs-134	< 2.3	E-08
				Cs-137	3.32 ± 0.1	E-06
				Eu-154	< 9.0	E-08
				U-234	6.94 ± 0.9	E-09
				U-235	< 2.9	E-10
				U-238	5.92 ± 0.8	E-09
				Pu-238	4.61 ± 0.3	E-08
				Pu-239	4.66 ± 0.3	E-08
				Am-241	9.79 ± 0.7	E-08
Contact Size Reduction Facility Stack (ANCSRFK)	2.0 E+07	< 5.2 E-09	6.72 ± 2.0 E-08	Co-60	< 1.4	E-08
				Sr-90	5.51 ± 1.0	E-09
				I-129	1.70 ± 0.7	E-08
				Cs-134	< 1.1	E-08
				Cs-137	< 1.3	E-08
				Eu-154	< 3.2	E-08
				U-234	1.36 ± 0.4	E-09
				U-235	< 2.5	E-11
				U-238	1.10 ± 0.3	E-09
				Pu-238	1.69 ± 0.9	E-10
				Pu-239	1.23 ± 0.7	E-10
				Am-241	1.14 ± 0.6	E-10
Laundry Vent (ANLAUNV)	1.4 E+07	4.1 E-08	9.1 E-07	None Identified		
LLWTF Vent (ANLLWTV)	1.1 E+08	1.0 E-07	7.7 E-07	None Identified		

TABLE 4-4

RADIOACTIVITY RELEASED IN LIQUID EFFLUENTS DURING 1987

Release Point	Volume Released (Litres)	Released Radioactivity (Ci)					
		Gross Alpha	Gross Beta	H-3	Sr-90	I-129	Cs-137
Lagoon 3	3.6 E+07	< 4.3 E-04	3.31 ± 0.4 E-02	5.96 ± 0.2 E-01	3.35 ± 0.1 E-03	3.31 ± 0.3 E-04	3.31 ± 0.3 E-02
Sewage Treatment Outfall (WNSP007)	1.2 E+08	< 1.0 E-04	9.81 ± 2.3 E-04	< 1.3 E-02	------	------	------
N.E. Swamp Drain	6.0 E+07	< 6.6 E-05	6.33 E-03	5.34 ± 0.4 E-02	------	------	------
French Drain	7.0 E+06	< 8.4 E-06	1.75 E-04	5.66 ± 0.2 E-02	------	------	------
N. Swamp Drain	6.0 E+06	< 5.3 E-06	3.12 E-04	1.51 E-03	------	------	------
TOTAL:	2.3 E+08	< 6.1 E-04	4.1 ± 0.4 E-02	7.2 ± 0.2 E-01	3.35 ± 0.1 E-03	3.31 ± 0.3 E-04	3.31 ± 0.3 E-02

	U-234	U-235	U-238	Pu-238	Pu-239	Am-241
Lagoon 3	5.06 ± 0.8 E-04	1.07 ± 0.5 E-05	2.18 ± 0.3 E-04	1.96 ± 1.2 E-06	3.49 ± 1.7 E-06	3.76 ± 1.1 E-06

that an extremely conservative assumption still yields a dose estimate well within regulatory limits.

Estimates were made of the hypothetical maximum dose commitments to an adult from consumption of 21 kg per year (the maximum value recommended in NRC Regulatory Guide 1.109) of fish caught in Cattaraugus Creek. From the measured concentrations of radionuclides in the edible parts of the fish (Table C-3.4) corrected for wet to dry weight ratio, the maximum organ dose commitment to an individual was estimated to be 0.47 mrem to bone surfaces. The maximum effective dose equivalent commitment to an individual was calculated to be 0.044 mrem.

The hypothetical dose commitment was also estimated for an individual who consumed 45 kg of venison taken from the local area (within 1 mile) and for an individual consuming 110 kg of locally raised beef cattle. The measured radionuclide concentrations (Table C-3.2) corrected for wet to dry weight ratio in the flesh of a deer taken about a kilometre away from the WVDP in the fourth quarter of 1987 were used as the basis for this estimate. The dose commitment to the critical organ was calculated to be 0.028 mrem to the adrenals and 0.025 mrem for an effective dose equivalent commitment. The maximum individual dose for consumption of locally raised beef cattle was based on two near-site samples taken in the second and fourth quarters of 1987. After background subtraction, the maximum individual effective dose was calculated as 0.050 mrem and the critical organ dose to the adrenals as 0.056 mrem.

Table 4-5 summarizes the potential radiation doses to individual adult members of the general public at the points of highest potential exposure from gaseous and liquid effluents from the WVDP facility operations during 1987. Although no direct pathway to drinking water from airborne or liquid effluents was found or evaluated for committed dose, drinking supply well water data are presented in Table C-1.6. Additionally, the results of the radionuclide measurements in stream sediments (Table C-1.7) and surface waters (Tables C-1.2 through C-1.5) are also presented in Appendix C1.

4.3.2 Collective Dose to the Population

The collective effective dose equivalent commitment to the population within an 80-km radius of the WVDP from operations during 1987 was estimated to be 0.009 person-rem from gaseous effluents and 0.03 person-rem from liquid effluents. These estimates are based on the releases summarized in Tables 4-3 and 4-4 and the use of the AIRDOS-EPA (CCC-357)(Moore et al., 1979) and LADTAP II codes as described in Section 4.1.

These collective doses may be compared to an estimated annual 170,000 person-rem to the same population resulting from natural background radiation. Based on the collective dose given above and a total population of 1.7 million in the region, the average effective dose equivalent to an individual residing within 80 km of the WVDP was about 0.000023 mrem during 1987, which is insignificant when compared to the average dose to each individual of approximately 100 mrem per year from natural sources.

Recent recommendations of the National Council on Radiation Protection and Measurements (NCRP, 1985) and the proposed revisions to the Title 10 Code of Federal Regulations Part 20 (NRC, 1986) define a risk level which is below regulatory concern for purposes of determining collective population doses. These agencies recommend that doses of 1 mrem/yr incurred by individual members of the public be excluded for purposes of assessing the collective dose to a population. Despite the conservatism used in assessing the dose to the maximum hypothetical individual from environmental releases of radioactivity in 1987 from the WVDP, no individual member of the public was predicted to receive a dose in excess of 1 mrem/yr above background.

TABLE 4-5

SUMMARY OF HYPOTHETICAL DOSE EQUIVALENTS

TO AN ADULT INDIVIDUAL AT LOCATIONS OF MAXIMUM EXPOSURE DURING 1987

Pathway	Location	Dose Equivalent (mrem) Effective	Critical Organ**
Elevated Releases*			
Main Plant Stack (ANSTACK)	Nearby residence (2.1 km WSW)	0.00097	0.0069
Ground Level Releases*			
CSS Stack (ANCSSTK)	Nearby residence (1.4 km, NW)	0.000091	0.00084
CSRF Stack (ANSCRFK)	Nearby residence (1.4 km, NW)	0.0000017	0.000011
Laundry Vent (ANLAUNV)	Nearby residence (1.4 km, NW)	0.000015	0.00023
LLWTF Vent (ANLLWTV)	Nearby residence (1.4 km, NW)	0.000027	0.00044
Milk	Collected 3.5 km SSW	0.038	0.40
Venison	Collected within 1 km of WVDP	0.025	0.028**
Beef	Collected 4 km N of WVDP	0.050	0.056**
Fish	Collected in Cattaraugus Creek below WVDP	0.044	0.47

Notes: Annual average whole body dose from natural background sources in the U.S. is about 100 mrem.

* Estimates based on measured radioactivity in airborne effluents (Table 4-3) and dispersion and radiological dose calculations described in Section 4.1. All other values based on measured concentrations in food and consumption rates for maximally exposed individuals recommended in U.S. NRC Regulatory Guide 1.109.

** Bone surface, unless marked (**) for adrenals.

Accordingly, within the framework of the NCRP and NRC methodology, the collective population dose in excess of natural background within an 80-km radius of the WVDP would, in fact, be reported as zero as a result of radionuclide releases in 1987.

4.3.3 Dose Assessment Model Prediction Versus Actual Release Data

Dose assessment models used at WVDP for liquid and airborne effluents have been used to compare model predictions with actual sample analysis. Based on actual releases of liquid effluents in 1987, LADTAP II predicts the maximum individual dose from consumption of 21 kg of fish taken from Cattaraugus Creek to be 0.2 mrem. This is in good agreement with the predicted maximum individual dose of 0.044 mrem calculated from actual measured radionuclide concentrations in fish flesh, given the statistical error associated with the sample analyses.

The predicted maximum individual dose based on actual air sampling data collected at a nearby residence (Table C-2.2.2) turns out to be zero when the background air sample data from Great Valley (Table C-2.2.7) at 42 km from the site is subtracted. This agrees with the 0.00097 mrem predicted by AIRDOS-EPA from the measured quantity of radioactivity actually discharged from the plant, in that this dose can be considered as essentially zero.

A comparison was also made of the radioactive particulate concentrations (μCi/mL) based upon air sampler data from a nearby residence (Table C-2.2.2) with those calculated from the measured release data (Table C-2.1.3) and the site specific annual average relative concentrations (Tables 4-1 and 4-2). The concentrations predicted using the stack discharge data are more than five orders of magnitude below those measured at the perimeter air monitoring stations. This finding reinforces the observation that the air sampler at the nearby residence is essentially measuring background particulate radioactivity with 0.001 percent of the collected activity provided by airborne releases from the WVDP.

4.3.4 NESHAPS Compliance

This section has been added to the WVDP annual report to present data and discussion concerning compliance with 40 CFR 61, "National Emission Standards for Hazardous Air Pollutants, Subpart H."

Section 40 CFR 61.93 stipulates that:

"To determine compliance with the standard, radionuclide emissions shall be determined and dose equivalents to members of the public shall be calculated using EPA approved sampling procedures, EPA models AIRDOS-EPA and RADRISK, or other procedures, including those based on environmental measurements, that EPA has determined to be suitable. Compliance with this standard will be determined by calculating the dose to members of the public at the point of maximum annual air concentration in an unrestricted area where any member of the public resides or abides."

The EPA has determined that CAAC (CCC-476), which uses dose conversion factors derived from ICRP 2 (rather than the more recent ICRP 26 and 30), is the suitable version of the AIRDOS-EPA dispersion code to calculate doses to members of the public. In addition, CAAC uses simplified straight-line Gaussian methodology to describe meteorological dispersion from elevated and ground level sources.

Whole-body and critical organ dose equivalents were calculated with this EPA-approved code for all significant effluent pathways. Table 4-6 presents the calculated dosimetric data at the location of the maximum individual for both elevated and ground level releases.

The collective population dose (within 80 km of WVDP) calculated for all airborne pathways is 0.02 person-rem. As previously discussed,

TABLE 4-6

SUMMARY OF HYPOTHETICAL DOSE EQUIVALENTS CALCULATED PER 40 CFR 61
TO AN ADULT INDIVIDUAL AT LOCATIONS OF MAXIMUM EXPOSURE DURING 1987

Pathway	Location	Dose Equivalent (mrem) Whole-body	Critical Organ*
Elevated Releases			
Main Plant Stack (ANSTACK)	Nearby residence (3.4 km SE)	0.000091	0.0021*
Ground Level Releases			
CSS Stack (ANCSSTK)	Nearby residence (1.9 km, NNW)	0.00021	0.0049
CSRF Stack (ANCSRFK)	Nearby residence (1.9 km, NNW)	0.0000052	0.000073
Laundry Vent (ANLAUNV)	Nearby residence (1.9 km, NNW)	0.000047	0.0011
LLWTF Vent (ANLLWTV)	Nearby residence (1.9 km, NNW)	0.0001	0.0027

Note: Annual average whole body dose from natural background sources in the U.S. is about 100 mrem.

* Bone surface, unless marked (*) for thyroid.

the hypothetical collective dose due to WVDP operations should be compared to the collective dose from natural background to the same population of 170,000 person-rem per year.

In summary, the dose calculations show that the WVDP is in compliance with the emission standard for radioactive airborne releases in that calculated doses to the maximally exposed individuals for elevated and ground level releases from the site do not exceed the applicable EPA limits.

4.3.5 Statistical Considerations

A simple one-way analysis of variance (ANOVA) statistical application was used to test whether observed differences among the various sample means can be attributed to chance or they are indicative of actual differences among the corresponding population means. The null hypothesis to be tested by the statistical application is whether or not the various population means are all equal.

In the case of the environmental air sampling data, Tables C-2.2.1 through C-2.2.7, the ANOVA test showed no statistically significant differences (at the 99 percent confidence level) in gross beta, Sr-90 or Cs-137 measurements for all possible combinations. Table 4-7 shows the statistically significant differences (a total of six out of a possible 21 combinations) for the air sampling station alpha data. The five significant differences in the Route 240 data are attributable only to background variation since the average alpha concentration predicted at the sampler as a result of WVDP stack releases is 1.2 E- 20 μCi/mL, compared to the average alpha concentration of 1.3 E-15 μCi/mL from air sample analysis. The same background variation also explains the Thomas Corners versus Rock Springs Road statistical difference in that WVDP releases would predict average concentrations of 1.5 E-21 μCi/mL compared to the average air sample analysis concentration of 1.3 E-15 μCi/mL.

TABLE 4-7
AIR SAMPLING STATIONS AROUND WVDP EXHIBITING PAIR-WISE STATISTICALLY SIGNIFICANT DIFFERENCES IN AVERAGE DETECTED ALPHA CONCENTRATIONS

	Rock Springs Road	Great Valley	Fox Valley	Route 240	Thomas Corners	Spring-ville	West Valley
Rock Springs Road	—			X	X		
Great Valley		—		X			
Fox Valley			—	X			
Route 240	X	X	X	—		X	X
Thomas Corners	X				—		
Springville				X		—	
West Valley				X			—

Note: Empty box indicates no statistically significant differences detected.