MINNESOTA DEPARTMENT OF HEALTH

2004 ENVIRONMENTAL RADIATION DATA REPORT

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Summary and Conclusion

The Minnesota Department of Health (MDH) Radiation Control Unit in the Section of Asbestos, Indoor Air, Lead and Radiation monitors environmental radioactivity in Minnesota. If any increases in radiation in the environment are identified, corrective actions are recommended to ensure that amounts do not exceed safe levels. Monitoring also allows the MDH to develop a database on radioactivity within the state that can be used as a baseline during emergencies.

The environmental monitoring program consists of sample collection (currently focused on the two nuclear-generating plants, see Figure 1 for locations), measurement of gamma radiation near the nuclear-generating plants, surveying of spent fuel storage casks, radiochemical analysis of the samples by the MDH Public Health Laboratory, interpretation of the data, and estimation of dose.

In 2004, hydrogen-3 (tritium) was detected downstream of the Prairie Island Nuclear Generating Plant on January 20 and February 2. The tritium was determined to be from planned releases allowed by US Nuclear Regulatory Commission (NRC) license. The levels of tritium that were detected were below the drinking water standard.

No federal or state standards or guidelines were exceeded anywhere in the state, including near the nuclear electricity-generating plants.

Data shows that levels of strontium-90 in milk, which resulted from above ground nuclear testing, are low and decreasing. Values for strontium-90 did not exceed National Primary *Drinking Water* Regulations (40 CFR 141) of 8.0 pCi per liter for strontium-90. There is no specific standard for strontium-90 in milk, so the standard for strontium-90 in drinking water is used. Median values for strontium-90 also were well within recommended safe levels according to the U.S. Food and Drug Administration (FDA) emergency guidelines for milk.

Data from radiation detection equipment at Prairie Island indicate that neutron levels remained the same. No additional spent fuel was placed into storage in 2004.

Dose calculations indicate that individuals in Minnesota receive less than one millirem per year from human-made radiation detected in the environment, such as strontium-90 in milk. The National Council on Radiation Protection and Measurements (NCRP) considers an annual dose of one mrem to be negligible.

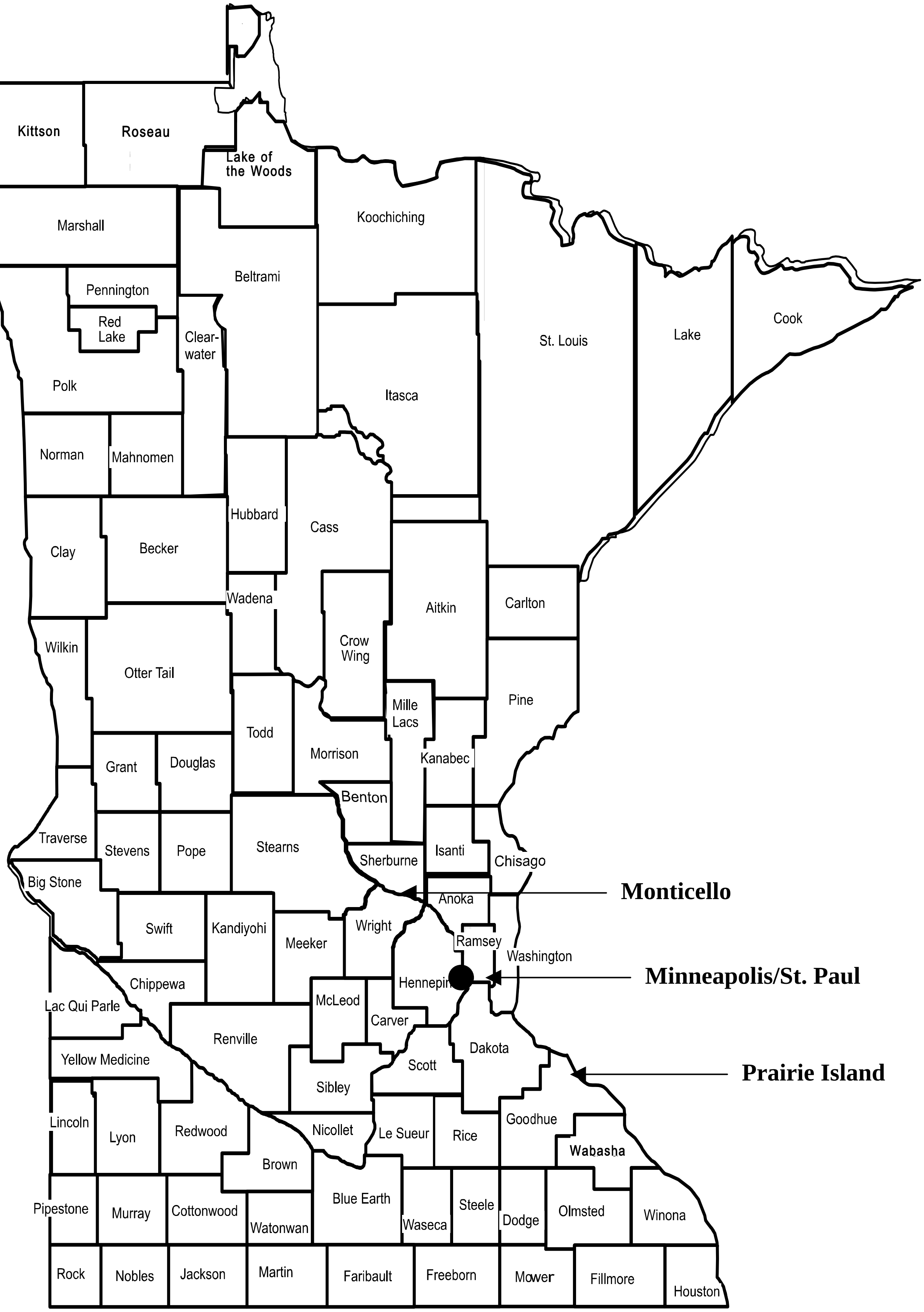


Figure 1. Monticello and Prairie Island Nuclear Generating Plants

Interpretation of Results

MDH Radiation Control staff routinely compares the levels of radionuclides detected by the MDH Public Health Laboratory with previous five-year trends. If higher levels than usual are observed, they are compared with maximum permissible effluent concentrations for radioactive materials licensees, which is in the Code of Federal Regulations (10 CFR 20, Appendix B), and regulations and guides issued by state and federal agencies to determine if they pose a health risk.

The National Primary Drinking Water Regulations (40 CFR 141) apply to water. The limit for concentrations of radioactivity in air is 100 picocuries of beta activity per cubic meter of air, which is the maximum permitted by the NRC for unrestricted areas (10 CFR 20, Appendix B).

Annually, sampling results are plotted on a log-normal scale. (For an example, see Figure 4). A straight line forms if a single source of radioactivity (such as natural background radiation) exists. If another source were present (for example, emissions from a nuclear-generating plant), the line would not be straight.

Average Dose to an Individual

Radiation dose estimates are made using exposure-to-dose conversion factors from Limiting Values of Radionuclide Intake and Air Concentration and Dose Conversion Factors for Inhalation, Submersion, and Ingestion, Federal Guidance Report No. 11, 1988; and the Shultis report for neutrons (J. K. Shultis and R. E. Faw, "Neutron Skyshine Analysis," July 15, 1998).

Only exposures to human-made radioactivity are used. Examples include fallout from atmospheric nuclear tests and emissions and effluents from nuclear-generating plants. Exposures from naturally occurring radioactivity (for example, potassium-40 in milk) are not considered.

Data Analyses Results

Findings from the environmental monitoring program during 2004 are presented and compared with findings from the previous four years.

Statewide Sampling Results

Milk

Beginning in 2004, milk sampling in each of the seven MDH district offices was discontinued and replaced by sampling near the two nuclear generating plants. Values for strontium-90 did not exceed National Primary *Drinking Water* Regulations (40 CFR 141) for strontium-90 of 8.0 pCi per liter (see Table 1). Because there is no specific standard for strontium-90 in milk, the standard for strontium-90 in drinking water is used. Median values for strontium-90 also were well within recommended safe levels according to the U.S. Food and Drug Administration (FDA) emergency guidelines for milk. The FDA recommends that during an emergency, protective actions be taken only when levels exceed 4,000 pCi per liter (Accidental Radioactive Contamination of Human Food and Animal Feeds: Recommendations for State and Local Agencies, Food and Drug Administration, August 13, 1998).

Strontium-90 is a fallout product of atmospheric weapons testing. The physical half-life of strontium-90 is 28 years. The average strontium-90 level has been fluctuating, but slowly decreasing. The fluctuations observed result from sampling errors, measurement errors, and the statistical nature of the analyses.

TABLE 1
MEDIAN STRONTIUM-90 LEVELS IN MILK
2000-2004

pCi/L

MDH District	2000	2001	2002	2003	2004
Little Falls	1.4	1.8	1.0	1.3	Discontinued
Duluth	1.8	1.9	1.9	1.6	Discontinued
Bemidji	0.8	1.0	0.9	1.1	Discontinued
Rochester	0.8	1.0	0.9	1.0	Discontinued
Hastings	1.1	1.2	0.9	1.0	Discontinued
Norwood	0.8	0.8	0.9	<0.8	Discontinued
St. Paul	1.1	1.1	0.9	1.0	Discontinued
Monticello	Unavailable	Unavailable	Unavailable	Unavailable	2.0
Prairie Island	Unavailable	Unavailable	Unavailable	Unavailable	1.6
Median	1.1	1.1	0.9	1.0	1.8

Potassium-40 is a naturally occurring radionuclide present at the earth's creation (physical half life of 1.3 billion years). In 2004, potassium-40 levels in milk samples ranged from about 1000 to 1500 pCi per liter. No other nuclides were detected.

Air

The median gross beta activity measured in Minneapolis air was 0.024 pCi per cubic meter in 2004; in 2003, it was 0.028 pCi per cubic meter. Data was plotted on a log-normal scale, which resulted in a straight line, indicating the single source of radioactivity was from natural background radiation. No reactor-produced isotopes (for example, iodine-131) were detected.

Monticello Nuclear Generating Plant

Sampling locations are shown on Figure 2.

Air

Biweekly air samples were collected near the Xcel Training Center. Gross beta concentrations in air are shown in Table 2 and compared with concentrations in Minneapolis.

TABLE 2
MEDIAN GROSS BETA CONCENTRATION IN MONTICELLO AIR SAMPLES
2000 - 2004

pCi/m^3

	2000	2001	2002	2003	2004
Monticello (MDH)	0.027	0.023	0.022	0.026	0.019
Monticello (NMC)	0.027	0.024	0.027	0.027	0.024
Minneapolis (MDH)	0.022	0.026	0.029	0.028	0.024

Data were plotted on a log-normal scale. The plot followed a straight line, indicating one source of radioactivity (natural background).

Surface Water

Median gross beta concentrations are shown in Table 3 for upstream and downstream water samples.

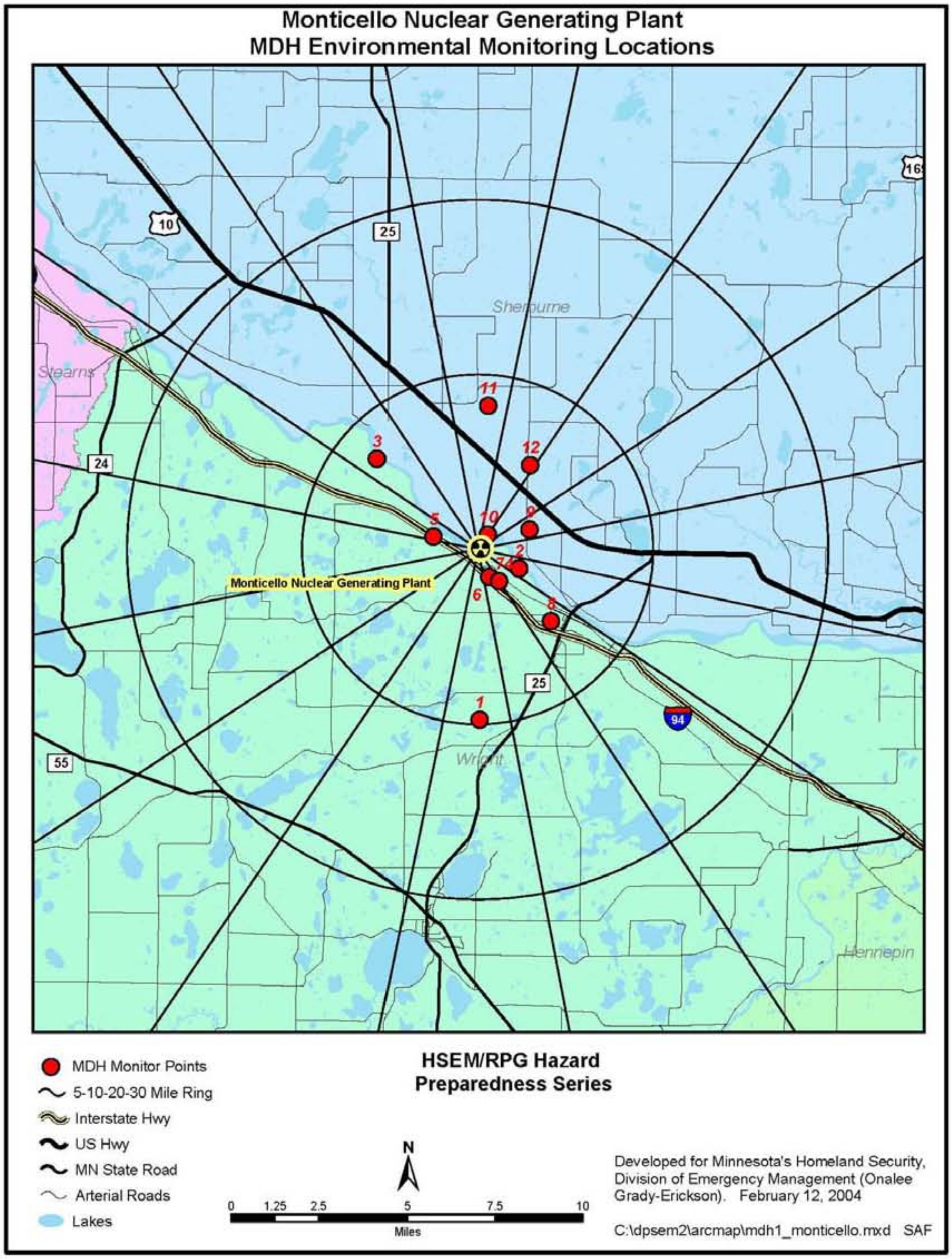
TABLE 3 **MEDIAN GROSS BETA CONCENTRATION IN MISSISSIPPI RIVER WATER NEAR MONTICELLO** **2000-2004**					
pCi/L					
	2000	2001	2002	2003	2004
Upstream	2.6	2.9	3.3	4.2	3.0
Downstream	2.7	2.8	3.0	3.9	2.9

Crops/Vegetation

During the growing season, apples grown near the plant were sampled; small amounts of potassium-40 (K-40) were detected. K-40 occurs naturally inside crops, and is not an indicator of a nuclear generating plant effect, but rather a laboratory calibration control. Table 4 summarizes the K-40 levels.

In 2004, cow feed at the indicator dairy farm was collected. The average K-40 level was 5.9 pCi per gram.

TABLE 4 **POTASSIUM-40 CONCENTRATION IN VEGETATION/CROPS NEAR MONTICELLO** **1999 - 2003**					
pCi/gram					
	2000	2001	2002	2003	2004
Apples	NA	1.0	1.5	1.2	1.2



1. Milk Sampling
2. Downstream Water Sampling
3. Upstream Water Sampling
4. Air Sampling
5. TLD
6. TLD
7. TLD
8. TLD
9. TLD
10. TLD
11. TLD
12. TLD

Figure 2. - Monticello Monitoring Locations.

Sediment

One sample was collected downstream in September. Small amounts of radioactivity were detected. Table 5 summarizes the isotopes and activities identified. Radionuclides associated with plant operations (for example, cesium-134) were not detected.

TABLE 5
RADIONUCLIDE LEVELS IN SEDIMENT DOWNSTREAM OF MONTICELLO

pCi/gram

	2002	2003	2004
Beryllium-7	0.2	0.2	<0.2
Potassium-40	10	10	10
Cesium-137	0.05	0.04	0.02
Lead-210	<0.7	0.7	<0.4
Lead-212	0.3	0.3	0.3
Lead-214	0.2	0.3	0.2
Bismuth-212	0.3	0.4	0.4
Bismuth-214	0.2	0.3	0.2
Thallium-208	0.1	0.1	0.1
Radium-224	0.2	<0.2	0.3
Radium-226	0.4	0.5	0.4

Thermoluminescent Dosimetry (TLD)

TLD were changed quarterly. Figure 2 shows locations of TLD. Median values for exposure (milliroentgens per 13-week quarter) are presented in Table 6 for each location. No effect from the Monticello plant is indicated.

TABLE 6
MEDIAN GAMMA EXPOSURE RATES NEAR MONTICELLO
2000-2004

mR/quarter

Location	2000	2001	2002	2003	2004
Monticello Training Ctr.	14.7	15.0	14.7	15.2	15.0
South Sector	12.3	13.8	13.4	13.6	13.1
Deer Street	13.8	13.8	13.7	14.2	13.9
Municipal Building	14.1	14.2	14.6	15.2	15.0
Orrock (Control)	12.5	13.4	12.8	13.3	13.3
Northwest Pines	12.7	13.5	13.2	13.0	13.1
Pole #F85	12.9	14.9	14.9	14.3	14.7
Pole #F33	11.6	13.5	13.5	13.5	13.2

Sampling locations are shown on Figure 3.

Air

Biweekly air samples were collected near Lock and Dam No. 3. The median gross beta activities are presented in Table 7. Data was plotted on a log-normal scale. The plot followed a straight line, indicating one source of radioactivity (natural background).

TABLE 7
MEDIAN GROSS BETA CONCENTRATION IN PRAIRIE ISLAND AIR
2000-2004

pCi/m^3
.

Location	2000	2001	2002	2003	2004
Prairie Island (MDH)	0.023	0.023	0.024	0.025	0.020
Prairie Island (NMC)	0.025	0.023	0.028	0.027	0.025
Minneapolis (MDH)	0.022	0.026	0.029	0.028	0.024

River Water

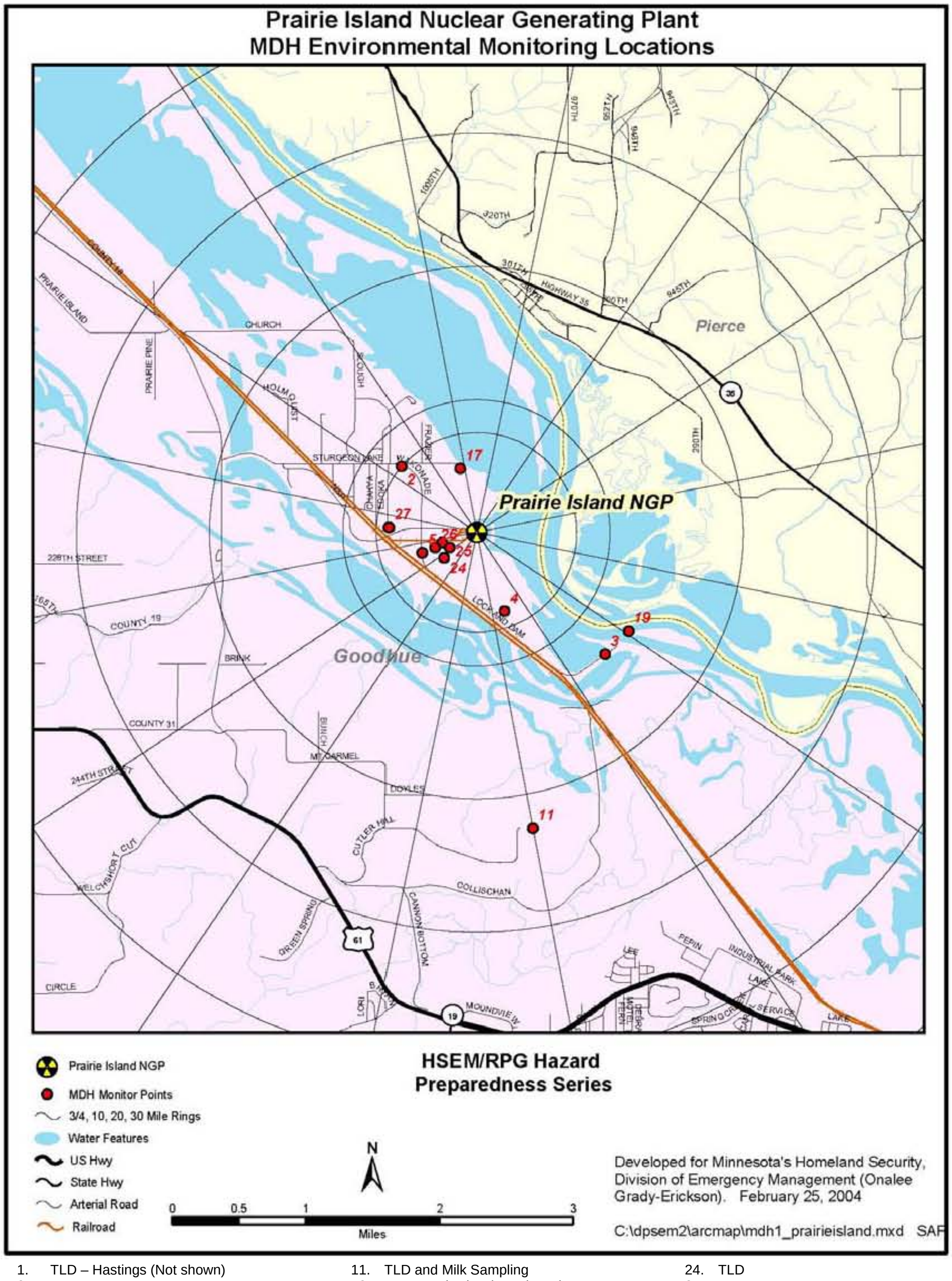
Median gross beta concentrations are shown in Table 8 for up and downstream samples. The data are plotted in Figure 4. The plot followed a straight line, indicating one source of radioactivity (natural background).

Tritium (hydrogen-3) was detected downstream on January 20th and February 2nd. Levels were 1700 and 5800 pCi per liter. These were due to planned releases allowed by US Nuclear Regulatory Commission (NRC) license. The levels of tritium that were detected were below the drinking water standard, which is 20,000 pCi per liter.

TABLE 8
MEDIAN GROSS BETA CONCENTRATION IN MISSISSIPPI RIVER WATER NEAR PRAIRIE ISLAND
2000 - 2004

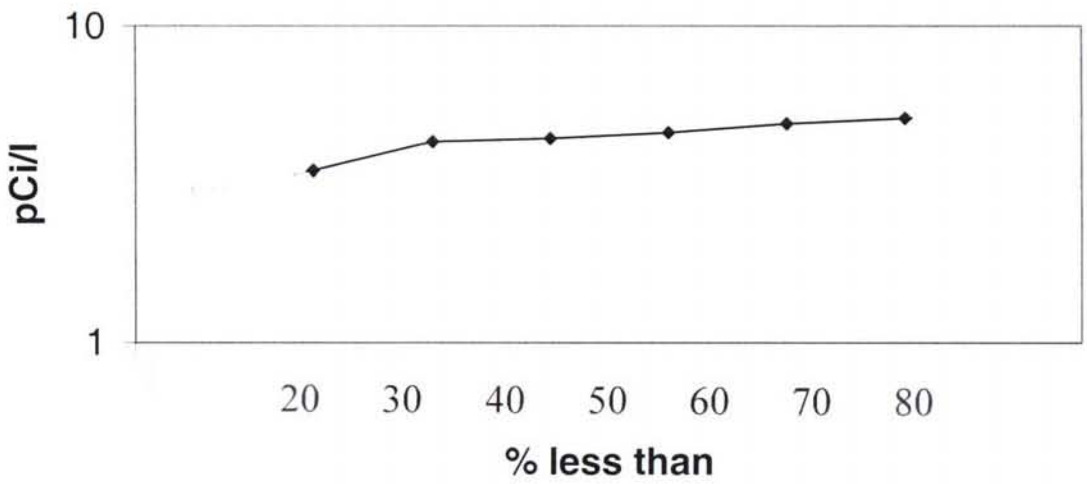
pCi/L

	2000	2001	2002	2003	2004
Upstream	5.4	6.0	5.3	7.4	6.6
Downstream	5.0	5.1	5.1	4.9	4.8



1. TLD – Hastings (Not shown)
2. TLD
3. TLD and Air Sampling
4. TLD and Groundwater
5. TLD
11. TLD and Milk Sampling
12. TLD - Red Wing (Not shown)
19. Downstream Water Sampling
22. Upstream Water Sampling
23. TLD
24. TLD
25. TLD
26. TLD
27. TLD
28. Sediment Sampling – Red Wing (Not shown)

Figure 3. - Prairie Island Monitoring Locations



Groundwater

In 2004, four quarterly samples of well water were collected from the nearest resident to the plant. The results are presented in Table 9. (Note that in 2002, the detection limit for tritium was 500 pCi per liter. The higher limit was caused by a higher instrument background in a new location).

TABLE 9
MEDIAN TRITIUM VALUES IN WELL WATER NEAR THE PRAIRIE ISLAND PLANT
1996 – 2004

pCi/L

1996	1997	1998	1999	2000	2001	2002	2003	2004
63	32	<32	36	42	45	<500	<180	<185

For reference, the National Primary Drinking Water Regulation (40 CFR 141) for tritium is 20,000 pCi per liter (annual average).

Food/Crops

During the growing season, apples near the plant were sampled; small amounts of potassium-40 (K-40) were detected. K-40 occurs naturally inside crops. K-40 is not an indicator of a nuclear generating plant effect, but rather a laboratory calibration control. Table 10 summarizes the K-40 levels.

In 2004, cow feed at the indicator dairy farm was collected. The average K-40 level was 3.7 pCi per gram.

TABLE 10
POTASSIUM-40 CONCENTRATION IN VEGETATION/CROPS NEAR PRAIRIE ISLAND
2000 – 2004

pCi/gram

	2000	2001	2002	2003	2004
Apples	1.2	1.2	1.5	1.2	1.5

Sediment

One sample was collected downstream each September. Small amounts of radioactivity were detected. Table 11 summarizes the isotopes and activities identified. Radionuclides associated with plant operations (for example, cesium-134) were not detected.

TABLE 11
RADIONUCLIDE LEVELS IN SEDIMENT DOWNSTREAM OF
PRAIRIE ISLAND

pCi/gram

	2002	2003	2004
Beryllium-7	<0.1	<0.06	<0.2
Potassium-40	8	6	6
Cesium-137	0.01	<0.006	<0.006
Lead-210	<0.3	0.4	<0.3
Lead-212	0.2	0.2	0.2
Lead-214	0.2	0.1	0.1
Bismuth-212	0.3	0.3	0.2
Bismuth-214	0.2	0.1	0.1
Thallium-208	0.1	0.09	0.06
Radium-224	0.2	0.2	0.2
Radium-226	0.4	<0.2	0.3

Thermoluminescent Dosimetry (TLD)

TLD were changed quarterly during 2004. Median values for exposure (milliroentgen per quarter) are presented in Table 12 for each location.

Beginning in 1993, the Department began background monitoring at the Prairie Island Independent Spent Fuel Storage Installation (ISFSI) in anticipation of dry cask storage monitoring in 1995. Two TLD are located inside the earthen berm and four TLD are located outside the berm. The two inside, ISFSI #3 and ISFSI #4, show above background gamma exposures that are consistent with the NMC computer model. Two TLD on Xcel Energy property but outside the berm (ISFSI #1, ISFSI #2) indicated above background levels of radiation that are also consistent with the computer model. The Prairie Island Community and ISFSI #6 TLD indicate exposures that are normal (natural background).

TABLE 12
MEDIAN GAMMA EXPOSURE RATES NEAR PRAIRIE ISLAND
2000 - 2004

mR/quarter

Location	2000	2001	2002	2003	2004
Nearest Resident	13.6	12.5	12.9	13.5	13.2
Northwest Sector	11.4	11.2	11.4	11.3	12.6
Lock and Dam No. 3	12.1	11.6	12.1	12.2	11.9
Mount Carmel Road	14.0	13.1	13.7	13.7	13.5
Red Wing	13.8	13.7	13.7	14.3	14.1
Hastings (Control)	13.9	13.1	13.8	13.2	13.4
ISFSI #1 (Outside Berm)	17.5	16.6	17.3	16.4	17.8
ISFSI #2 (Outside Berm)	18.3	17.3	17.1	19.0	18.4
ISFSI #3 (Inside Berm)	28.9	35.8	43.6	49.0	48.5
ISFSI #4 (Inside Berm)	18.3	18.0	18.0	18.0	19.0
Prairie Island Community	12.9	11.9	12.0	12.5	12.4
ISFSI #6 (Outside Berm)	12.9	12.5	13.8	14.2	13.2

Independent Spent Fuel Storage Installation (ISFSI)

Pressurized Ionization Chambers (PIC)

Throughout 2004, radiation data near the ISFSI were collected by the PIC system, which was installed in January 1995. The system consists of two ion chambers, computer memories and modems that are accessed every 15 minutes by MDH computers in St. Paul. The computers automatically page MDH staff if unusual readings occur.

One chamber is located about 100 feet north of the spent-fuel casks and the other is located about 100 feet south.

The normal background level was recorded at the time of installation and ranged from 5 to 15 µR/hr. The first three loaded casks were placed on the ISFSI pad during 1995. The fourth loaded spent fuel cask was placed on the pad during the second quarter of 1996. The fifth cask was placed on the pad during the fourth quarter of 1996. The sixth and seventh casks were placed in the first quarter of 1997. In 1999, the eighth cask was placed in the first quarter and the ninth cask was placed in the second quarter. In 2000, the 10th cask was placed in the first quarter and the 11th and 12th casks were placed in the fourth quarter. In 2001, the 13th cask was placed in the third quarter and the 14th cask was placed in the fourth quarter. In 2002, the 15th cask was placed in the first quarter and the 16th and 17th casks were placed in the third quarter.

In 2004, no casks were placed on the ISFSI pad.

The annual average readings for PIC #1 are shown in Table 13; the readings for PIC #2 are shown in Table 14.

TABLE 13
PIC #1 ANNUAL READINGS
2000 - 2004

µR/hr					
	2000	2001	2002	2003	2004
	93.9	95.1	100.1	99.2	93.6
No. of Casks	12	14	17	17	17

TABLE 14
PIC #2 ANNUAL READINGS
2000 - 2004

µR/hr					
	2000	2001	2002	2003	2004
	86.3	91.9	93.9	91.2	86.9
No. of Casks	12	14	17	17	17

Dose to Average Individual

Individuals receive radiation doses from natural and human-made sources. Estimates of dose resulting from human activities are discussed here. These activities include exposure to strontium-90 that still exists from atmospheric nuclear testing in the 1950's and scatter radiation from the Prairie Island ISFSI. Strontium-90 exposure occurs via the milk pathway; scatter radiation from the ISFSI is mostly from neutrons. Because strontium-90 is not naturally occurring and varies in its concentration in the environment, in some cases exposure can be reduced (for example, by utilizing a different source of milk). Similarly, spending less time near the ISFSI can lessen neutron exposure.

The dose estimates are presented in Table 15. For milk, MDH assumed a consumption of two liters per day. Because MDH continues to find strontium-90 in milk, average annual dose has been estimated. In 2004, this dose from drinking milk in Minnesota is estimated to be 0.18 mrem per year (committed effective dose equivalent). For the dose from the ISFSI, MDH assumed continuous presence of an individual 700 meters from the center.

TABLE 15
AVERAGE DOSE ESTIMATE FROM HUMAN-MADE RADIOACTIVITY MEASURED IN MINNESOTA ENVIRONMENTAL SAMPLES
2000 - 2004

Committed Effective Dose Equivalent (mrem per year)

Media & Isotope	2000	2001	2002	2003	2004
Milk--Strontium-90	0.11	0.11	0.09	0.10	0.18
Scatter--Neutron	0.02	0.03	0.03	0.03	0.03

These estimates are based on an exposure-to-dose conversion factor of 142.5 mrem per microcurie of strontium-90 (EPA Federal Guidance Report No. 11, 1988) and the Shultis report for neutrons (J. K. Shultis and R. E. Faw, "Neutron Skyshine Analysis," July 15, 1998).

The doses in Table 15 are below the Negligible Individual Dose of 1.0 mrem per year, as defined by the NCRP (NCRP Report No. 116, 1993).