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Daniel R. Muller, Assistant Director for Environmental Projects, L

PREPARATION OF RADIOLOGICAL IMPACT SECTION FOR MONTICELLO FINAL ENVIRONMENTAL STATEMENT

Plant name - Monticello
Licensing stage - OL
Docket number - 50-263
Responsible branch - Environmental Projects Branch #3
Project Manager - R. Bevan
Date request received by RA-L - September 11, 1972
Requested completion date - October 17, 1972
Description of response - The Radiological Section of the Monticello DES was rewritten
Radiological Assessment Branch review status - Complete

After extensive consultation with J. Soldat, BNWL, and F. Anderson, ORB#2-L, the Radiological Impact Section was rewritten by F. Congel, RA-L, for the Monticello Final Environmental Statement. The handwritten draft was informally delivered to R. Bevan, EPB#3-L, on October 17, 1972. Attached is the final typewritten copy.

Original signed by
H. R. Denton

Harold R. Denton, Assistant Director
for Site Safety
Directorate of Licensing

Enclosure:
As stated

cc w/o encl:
A. Giambusso
W. McDonald

cc w/encl:
S. Hanauer
J. Hendrie
J. Youngblood
R. Bevan
J. Kastner
F. Congel
F. Anderson
J. Soldat BNWL

CRESS #03 OFFICE ▶	L:RA	L:RA	L:SS			
	x7278					
MC#219283 SURNAME ▶	FCongel:mb	JKastner	HDenton			
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and increased rate of drift. The Staff concludes that no effect on the downstream drinking water supplies will result from the relatively small quantity of blue-green algae so produced. Species diversity will be reduced, but populations of thermophylic forms such as certain species of mayflies, stoneflies and craneflies will increase.

b) Outside the 90°F zone the effects of the plant discharge will be difficult to measure. No restriction in fish migration or reduction in spawning area is expected but some extension in the normal growing season may occur.

f. Biological Monitoring

Pre-operational baseline studies of the Mississippi River near the Monticello Plant were initiated in May 1968 and approximately 900 man-days were devoted to this phase of the program.

Operational studies were begun in February 1971 to coincide with plant operation testing. The applicant intends to "continue these studies for several years, or until a stable pattern of biological impact has developed." These studies are under the direction of Dr. Alfred J. Hopwood, St. Cloud College, St. Cloud, Minnesota; and Dr. Alan Brook, University of Minnesota at Minneapolis. An outline of the aquatic ecological studies program is given in Table V-5. Special onsite fish entrainment studies, begun in 1972, are being conducted by Dr. Keith M. Knutson of St. Cloud College. A land use agreement was made in February 1970, between the Northern States Power Company and the Federal Water Pollution Control Administration (now the Environmental Protection Agency) for the use of part of the Monticello Plant grounds for the purpose of conducting temperature studies on fish and other aquatic organisms. The EPA will test the effects of condenser cooling water on river organisms in experimental ponds that they will establish near the cooling towers. Start of construction of this research facility is planned for 1972.

D. RADIOLOGICAL IMPACT OF ROUTINE OPERATIONS

During routine operation of the plant, small quantities of radioactive materials are expected to be released to the environment. An AEC compliance inspection program is conducted to audit plant performance, to determine that radioactivity releases are within limits prescribed by 10 CFR Part 20. The staff has made estimates of the annual rates of release of radionuclides from the Monticello Plant based upon actual operating experience gained since the plant began

TABLE V-5

MONTICELLO NUCLEAR PLANT AQUATIC ECOLOGICAL STUDIES PROGRAM
SAMPLING AND ANALYSIS SUMMARY

Type of Sample	Type of Analysis	Sampling Method and Site	Sampling Frequency
Macroinvertebrates	Taxonomic Organism counts and average weights Water temperature, depth, and flow rate	Concrete block substrates on river bottom at 22 stations upstream and downstream from the plant discharge. Surber net sampling is also employed at 80 stations along four transects.	30 days*
Attached Algae (Periphyton)	Taxonomic Attached biomass, weight, and cell counts, chlorophyll 'a' and phaeophytin 'a'	Microscope slide substrates suspended in river current at 14 stations.	14 days*
Fish	Taxonomic Population estimates Length, weight, age General condition Migratory and local distribution patterns	Electrofishing, seining, and fishing tagging in five sectors of the river upstream and downstream from the plant discharge.	Weekly*
Rooted Aquatic Plants and Bottom Sediments	Taxonomic Visual estimation of distribution, abundance, and seasonal variations of plants Visual classification of bottom sediments.	At sampling sites for other types of samples and in shallow areas along the riverbank.	Quarterly
River Water	Chemical Physical - temperature, turbidity, suspended solids, flow rate, temperature	Water samples taken at four stations Palmer recording thermometers at nine	2 weeks Continuous

*Sampling frequencies apply to periods when the river is navigable; i.e., free of floating ice, unstable surface ice, or dangerous currents by flood level flows.

commercial operation in June 1971 and from the release rates associated with other operating reactors. These release rates, which take into account the augmented gaseous radwaste system, are shown in Tables III-4 and III-5 for gaseous and liquid releases, respectively.

Evaluation of the radiological impact based upon radiation doses received by residents in the environs is more meaningful than a consideration of only the rates of release or concentrations of the radionuclides. Therefore, the Staff has calculated the probable radiation doses to residents that result from the calculated releases listed in Tables III-4 and III-5 as well as from the releases reported by the Monticello Nuclear Generating Station for the latest six months of operation (January thru June, 1972; Tables III-6B and III-7B). Conservative assumptions were used to estimate use factors for people and the food chain bioaccumulation factors listed in Appendix B.

1. Dose to the Individual

The persons most likely to receive the highest radiation dose are those who reside closest to the site, go fishing, boating, or swimming in the Mississippi River downstream of the plant, and drink milk produced at farms near the plant site. It was assumed that these individuals consumed 7.3 kg of fish and 7.3 kg of molluscs* per year 24 hr after they have been caught from waters containing plant effluent water at about a 3 to 1 dilution. The annual total-body dose from consumption of these foods based upon the calculated liquid releases listed in Table III-5 would be about 0.2 mrem/yr. Doses to the other body organs would be somewhat less as shown in Table V-5. For comparison, corresponding doses were calculated based upon the Applicant's operating experience for the first six months of 1972. To extrapolate to a full year of operation, the nuclide amounts listed in Table III-6B were increased by a factor of 2.94.† Thus, it was estimated that the annual total body dose from fish and mollusc consumption based on actual plant releases could be about 1.0×10^{-6} mrem/yr. Organ doses were also calculated and found to be about a factor of 10^{-5} less than the corresponding values using the calculated releases. It must be emphasized however, that the calculated releases are based upon the expected lifetime of the plant and may not reflect the measured releases for several years. Therefore, the long term impact of plant operation was evaluated using the calculated releases listed in Tables III-4 and III-5.

*Fresh water molluscs are not now abundant near the plant due to a parasitic infection. Their use as a food item is illustrative but unlikely.

†Since the Plant operated at a 68% average load factor, multiply the half-year releases by 2/0.68 = 2.94 to get 1 year of dose at 100% load factor.

The individual who spends 500 hr/yr fishing from the river shoreline harvesting his 7.3 kg of fish and 7.3 kg of molluscs would also receive an external exposure to the total body, principally from cesium deposited in the silt along the shoreline. Based upon the calculated releases, this dose would be 0.3 mrem/yr. Using the plant operating data, the dose is 4×10^{-6} mrem/yr.

Those individuals who spend 100 hours/yr either swimming in the parks which are within the plant boundary and downstream of the outfall or canoeing just downstream of the plant would also receive total body doses. The swimmers and canoers could receive respective doses of 3×10^{-4} and 1×10^{-4} mrem/yr, based on the calculated releases. Corresponding doses using measured releases are 7×10^{-10} and 3×10^{-10} mrem/yr, respectively.

The Twin-Cities resident consuming 2 liters/day of water drawn from the Mississippi River below the plant would receive an estimated total-body dose of 0.01 mrem/yr.* The total dose received from all pathways associated with the liquid effluent of the plant (summarized in Table V-5) was estimated to be 0.5 mrem/yr to the total body. If the plant measured releases are used, these doses are 3×10^{-8} and 5×10^{-6} mrem/yr, respectively.

The maximum exposure rate at the fenced boundary of the plant resulting from submersion in the gaseous effluent released from the plant occurs 0.47 mile from the Plant in the SSE direction. At this location the annual average atmospheric dilution factor was calculated to be 7.8×10^{-6} sec $\cdot$ m^{-3} for ground level releases (i.e., from the turbine building) and 9.7×10^{-8} sec $\cdot$ m^{-3} for stack releases (i.e., from the main condenser). Assuming continuous occupancy and using the calculated releases, the total-body dose at this location would be 1.0 mrem/yr. The dose to the skin would be somewhat higher (2.2 mrem/yr) because of the additional contribution from the beta radiation.

Monticello's operating experience for the first six months of 1972 resulted in the gaseous releases listed in Table III-7B. These values were extrapolated to a full year of operation and were used to calculate the total body and skin doses from immersion at the maximum exposure point. The resulting total body dose was 8.4 mrem/yr while the skin dose was 14 mrem/yr. These values are expected to decrease with the addition of the augmented radwaste system.

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*Uniform mixing was assumed as was a dilution factor of 0.14; 645 cfs plant flow ÷ (4600 cfs river flow).

TABLE V-6

RADIATION DOSES TO INDIVIDUALS FROM EFFLUENTS RELEASED FROM THE MONTICELLO PLANT DURING LONG TERM OPERATION WITH THE AUGMENTED GASEOUS RADWASTE SYSTEM
(mrem/yr)

Pathway	Annual Exposure	Skin	Total-Body	GI Tract	Thyroid	Bone
Fish	7.3 kg	-	0.11	0.062	0.018	0.092
Molluscs	7.3 kg	-	0.12	0.041	0.22	0.11
Fishing and Picnicking	500 hr	0.34	0.29	(0.29)[a]	(0.29)	(0.29)
Swimming	100 hr	4×10^{-4}	3×10^{-4}	(3×10^{-4})	(3×10^{-4})	(3×10^{-4})
Canoeing	100 hr	2×10^{-4}	1×10^{-4}	(1×10^{-4})	(1×10^{-4})	(1×10^{-4})
Air Submersion[b]	8766 hr	1.6	0.84	(0.84)	(0.84)	(0.84)
Inhalation[b]	7300 m^3	-	-	-	0.48	-
Milk (Adult)[b]	152 liters	-	-	-	8.3	-
Total		1.9	1.4	1.2	10	1.3
Water (Adult)[c]	730 liters	-	0.007	0.021	0.12	0.008
Milk (Infant)[b]	152 liters	-	-	-	68	-

[a] Numbers in parentheses indicate internal dose from external source.

[b] Nearest farm - 0.8 mile SSE.

[c] The doses from drinking water were included as a separate entry because the individual resident near the plant will not be consuming water drawn from the river.

The maximum exposure rate at an occupied location occurs at the nearest farmhouse located 0.8 mile SSE of the plant, where the atmospheric dilution factor (χ/Q) was 4.0×10^{-6} sec $\cdot$ m^{-3} for ground level releases and 7.7×10^{-8} sec/m^3 for stack releases. Assuming continuous occupancy and using the calculated releases,* the dose to the total-body at this location would be 0.84 mrem/yr. The dose to the skin would be somewhat higher (1.6 mrem/yr) because of the additional contribution from the beta radiation of the radionuclides released. Doses to the thyroids of adults and children from inhalation of the ^{131}I in the air at this farm would be 0.5 and 0.6 mrem/yr, respectively.

Corresponding doses were estimated using the same assumptions and operating data. The total body and skin dose calculated for this farm were 6.6 and 11 mrem/yr, respectively. The thyroids of adults and children could receive 0.06 and 0.08 mrem/yr, respectively, from inhalation of ^{131}I.

At present the nearest pasture is located at the above farm, but no milk cow is pastured at this farm; however, potential radiation doses which might be received from consumption of milk produced there in the future were estimated. In these calculations it was assumed that the cow grazed 5 months of the year and that one liter of milk per day was consumed. Under these assumptions the potential thyroid dose to an infant was estimated to be 68 mrem/yr and to an adult, 8 mrem/yr. (Assuming the augmented radwaste system was not installed, these thyroid doses would be approximately twice as high.)

Presently, the closest existing milk cow is located 1.5 miles NW of the plant where the atmospheric dilution factors were estimated to be 2.0×10^{-8} sec/m^3 for stack releases, and 1.1×10^{-6} sec/m^3 for vent releases. Based on the same assumptions mentioned above, the estimated thyroid doses to an infant and to an adult consuming milk produced at this location were 18 and 2.2 mrem/yr, respectively. Radioiodine release rates measured by the Applicant (see Table III-7B) are about an order of magnitude less than those predicted by the Staff for potential future releases. Therefore, based on the Applicant's measured releases, the thyroid doses from milk consumption at this farm could be 2.4 and 0.3 mrem/yr to the child and adult, respectively.

If in the future a cow is indeed located closer to the plant than at present, the applicant will be required to evaluate the thyroid

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* All dose estimations based on the calculated releases use the limit on iodine stated in the Technical Specifications: i.e., 0.35 Ci/yr from the turbine building vent.

radiation doses likely to result from consumption of milk at the new location and to take whatever steps are necessary to reduce these doses to levels which will be compatible with the then-existing limits for human exposure.

The combined annual dose based on the calculated releases to hypothetical individuals who would receive the most exposure from the several different pathways is about 1.4 mrem to the total body, almost entirely from air-submersion.

2. Dose to the Population

The integrated total-body dose to the population living within 50 miles of the plant from submersion in radioactive gaseous effluents was estimated to be about 1.5 man-rem/yr with the augmented system in operation. Based on experience during the first six months of 1972, the integrated total-body dose is estimated to be 29 man-rem/yr. The cumulative dose and average dose versus distance from the plant are summarized in Table V-7.

Four pathways were considered when calculating the exposure to the population from the liquid effluents released from the plant - consumption of drinking water and fish from the river, and swimming and shoreline fishing below the plant.

To estimate doses received from drinking water it was assumed that 85% of the 2 million residents within 50 miles of the plant derived their drinking water from the Mississippi River near the Twin Cities. Travel time for water from the plant discharge canal to the Minneapolis water customer was taken to be on the order of 48 hr. Although the travel time to a Saint Paul water customer is on the order of weeks, this longer decay time was not taken into account in the interest of simplifying the calculation. Assuming a per capita consumption of 1.2 liters/day of drinking water by the population of the Twin-Cities, the integrated total-body dose was calculated to be about 6 man-rem/yr, using the calculated releases and 3×10^{-5} man-rem/yr using operating experience.

Very little swimming but some canoeing is done in the river below the plant. For purposes of dose calculation, it was assumed that the average person spent 5 hr/yr swimming plus 10 hrs/yr canoeing downstream of the Monticello Nuclear Plant. It was also assumed that the average resident spent an additional 5 hr/yr on the river shore below the plant engaged in such activities as fishing. On this basis, the integrated total-body dose to the

TABLE V-7

CUMULATIVE POPULATION, ANNUAL MAN-REM DOSE, AND AVERAGE DOSES FROM THE GASEOUS EFFLUENT RELEASED FROM THE MONTICELLO PLANT

Radius (miles)	Cumulative Population (1970)	Cumulative Dose (man-rem/yr)		Average Dose (mrem/yr)	
		Present System*	Augmented System**	Present System*	Augmented System**
1	8	0.029	0.005	3.6	0.7
2	149	0.29	0.030	1.9	0.2
3	732	0.89	0.081	1.2	0.1
4	3,003	2.3	0.20	0.76	0.06
5	5,129	2.9	0.25	0.57	0.05
10	12,344	3.8	0.31	0.31	0.03
20	54,356	5.2	0.39	0.95	0.007
30	271,182	8.8	0.59	0.032	0.002
40	1,105,890	20	1.1	0.018	0.001
50	1,956,232	29	1.5	0.015	0.0008

* Dose estimates based upon measured releases from the present (unaugmented) system.

** Dose estimates based upon expected releases from the augmented system.

2×10^6 persons within 50 miles of the plant was estimated to be about 2.7 and 4×10^{-5} man-rem/yr, using calculated and measured releases, respectively.

Consumption of fish caught in the river water below the plant contributes only slightly to the total population dose. The average per capita consumption of fish in this area has been estimated to be 1.1 kg/yr.[61] If 10% of this average consumption comes from the stretch of the river below the plant (a conservative assumption), the population dose from fish consumption would be 1.6 man-rem/yr based on the calculated releases and 7×10^{-6} man-rem/yr based on the measured releases. Thus, the total integrated population dose received by the approximately 2 million people who live within a 50-mile radius of the plant from the 4 pathways associated with the calculated and measured liquid effluents was found to be 11 and 7 $\times 10^{-5}$ man-rem/yr, respectively.

For comparison, the dose rate from natural background radiation is about 150 mrem/yr to the total body. This dose rate implies a total population dose to the 2 million residents within 50 miles of the plant of 300,000 man-rem/yr.

3. Radiation Dose to Species Other Than Man

Radiation dose rates to organisms such as algae entrained in the Monticello condenser cooling water were estimated, for the radionuclide concentrations anticipated during long term operation, to be on the order of 10^{-5} mrem/hr. These dose rates would decrease rapidly as the effluent moves downstream.

Organisms likely to receive the highest radiation dose from the plant are aquatic species living in the effluent plume such as fish and fresh water molluscs. A clam living in the bottom silt would receive an estimated total dose of about 20 mrem/yr. About one-half of this dose comes from radionuclides accumulated within its flesh. The dose to a fish living in the undiluted effluent water would be somewhat less than that received by the clam.

Annual doses on the order of those predicted for aquatic organisms near the Monticello outfall (20 mrem/yr) are several orders of magnitude below the chronic dose levels that might be suspected of producing demonstrable radiation damage to aquatic populations.[62]

The irradiation of salmon eggs and larvae at a rate of 500 mrem/day did not affect the number of adult fish returning from the ocean or

their ability to spawn.[63] Chironomid larvae (bloodworms) living in bottom sediments near the Oak Ridge plant that have received irradiation at the rate of about 230-240 rem/yr for more than 130 generations have a greater-than-normal number of chromosome aberrations, but their abundance has not diminished.[64] The numbers of salmon spawning in the vicinity of the Hanford reactors on the Columbia River have not been adversely affected by dose rates in the range of 100 to 200 mrem/wk.[65]

Inasmuch as the planned release of radionuclides from the Monticello Plant will be several orders of magnitude less than has occurred in the past at several major nuclear facilities[66] where studies have detected no adverse effects on the aquatic population, and because the estimated dose rates to aquatic organisms will be several orders of magnitude less than those expected to cause radiation damage, the populations of aquatic organisms near the Monticello outfall are not expected to be adversely affected by the low concentrations of radionuclides added by the plant.

4. Environmental Radiation Monitoring Program

The objective of the Monticello Radiological Monitoring Program is to measure the radiological effects of plant operations on the environment. This objective is being accomplished through monitoring of air, water, soil, and other food chain components and comparing these analyses with the baseline monitoring data collected during the pre-operational phase which began in June 1968. The operational phase of the monitoring program began in December 1970.

External exposure to gaseous radioactive wastes and ingestion of radioactive contaminated food and water are the primary exposure pathways to man. Thus, the environmental surveillance program emphasizes sampling and analysis of environmental elements which include these pathways. The sample types, locations, frequencies, and analyses are summarized in Table V-8.

Sampling is conducted by Northern States Power personnel in cooperation with the Minnesota Department of Health. The Minnesota Department of Health assists in sample collection, and provides laboratory determinations and consultation in selection of sampling techniques. An Annual Report on the Environmental Monitoring and Ecological Studies Program is issued by Northern States Power which describes the program and evaluates the results.

TABLE V-8

MONTICELLO NUCLEAR PLANT - RADIATION MONITORING PROGRAM
SAMPLING AND ANALYSIS SUMMARY

Type of Sample	Type of Analysis	Collection Site	Collection Frequency
River Water	GB, GS, ^{137}Cs ^{3}H (M), ^{90}Sr (Q)	Upstream 600 ft from intake canal. Downstream 600 ft from discharge canal. St. Paul raw water intake.	Weekly
Lake Water	GB, GS, ^{137}Cs ^{3}H, ^{90}Sr	5 local lakes 1 control lake	Monthly
Well Water	GA, GB, GS, ^{137}Cs ^{3}H, ^{90}Sr	6 sites within 5 miles of plant site including the Monticello Well.	Quarterly
Precipitation and Fallout	GB, GS, ^{3}H ^{131}I, ^{90}Sr	Meteorological Station Plant Site. State Health Dept. Bldg. in Minneapolis.	Monthly
Lake and River Bottom Sediment	GB, GS ^{90}Sr, ^{137}Cs	5 local lakes, 1 control lake.	Semi-annually
Plankton, Algae or Insects	GB, GS ^{90}Sr, ^{137}Cs	5 local lakes, 1 control lake.	Quarterly
Aquatic Vegetation	GB, GS, ^{90}Sr, ^{137}Cs	5 local lakes, 1 control lake.	Quarterly
Clams	GB, GS, ^{90}Sr, ^{137}Cs	Upstream and downstream of plant.	Quarterly (when available)
Fish	GB, GS, ^{90}Sr, ^{137}Cs	Upstream and downstream of plant.	Quarterly

TABLE V-8 (contd.)

Type of Sample	Type of Analysis	Collection Site	Collection Frequency
Milk	GS, ^{131}I, ^{90}Sr, ^{137}Cs	Two farms/region, four regions.	Monthly
Topsoil	GB, GS, ^{90}Sr, ^{137}Cs	From 3 fields downwind of plant site, also 3 fields irrigated with river water downstream of plant.	Semi-annually
Vegetation	GB, GS ^{131}I	From 3 fields downwind of the plant site.	Semi-annually
Agricultural	GB, GS, ^{131}I, ^{90}Sr, ^{137}Cs	From 3 fields irrigated by river water downstream from the plant.	Annually (at harvest)
Air Samples (filter)	GB, GS (M) ^{131}I	Meteorological Station (Plant Site), Clear Lake, Orrock, Becker, Otsego, Maple Lake, Hasty, St. Michael	Weekly
Air Samples (film badge)	Beta Gamma Dosage	Same locations as filters plus 6 on-site stations	Every 4 weeks
Air Samples (TLD)	Gamma Dosage	Same location as filters plus 6 on-site stations.	Every 4 weeks

CODING SYSTEM:
- GA - gross alpha
- GB - gross beta
- GS - gamma scan
- (M) - monthly
- (Q) - quarterly