Technical Note
ORP/LV-75-6

INDIVIDUAL AND POPULATION DOSES FOR 1972 DISCHARGES FROM THE GINNA NUCLEAR POWER PLANT , UNIT NUMBER ONE

NOVEMBER 1975

U.S. ENVIRONMENTAL PROTECTION AGENCY
OFFICE OF RADIATION PROGRAMS - LAS VEGAS FACILITY
LAS VEGAS,NEVADA 89114

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PREFACE

The Office of Radiation Programs, U.S. Environmental Protection Agency, carries out a national program designed to evaluate population exposure to ionizing and non-ionizing radiation, and to promote development of controls necessary to protect the public health and safety. This study was undertaken to assess the environmental impact of an operating nuclear power plant on the local population. Readers of this report are encouraged to inform the Office of Radiation Programs of any omissions or errors. Comments or requests or further information are also invited.

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INTRODUCTION

The R. E. Ginna Nuclear Power Plant, Unit Number One, is a pressurized water reactor located on the south shore of Lake Ontario (approximately twenty miles east of Rochester, New York). The Atomic Energy Commission granted a provisional license to the Rochester Gas and Electric Corporation on September 19, 1969, for initial criticality. The license was amended on March 1, 1972, to allow operation up to a level of 1,520 megawatts thermal (MWt.). Detailed information on the operation and effluent releases from this reactor were obtained from the Final Environmental Statement (FES);[1] operating reports[3,4] and the Environmental Report dated 1972.[6]

SUMMARY

This report documents the radioactivity releases during 1972 from the Ginna Plant. Doses were calculated or projected from this release data and compared with current standards. This report is intended to evaluate the environmental impact of an operating pressurized water reactor in contrast to Final Environmental Statement projections. The FES is essentially a projection of effluents and resulting doses for normal operating conditions. Conservatism is built into the projections to insure against underestimating the dose. This report, however, uses actual effluent data for 1972 and currently accepted models to predict the most likely doses that occurred to the local population in 1972.

CONCLUSION

The operation of the Ginna Nuclear Power Plant, Unit One, during 1972 has produced radioactive effluents which were eventually released to the environment. Using currently acceptable models, the maximum individual and population doses from these releases have been calculated. The resultant dose values meet the present Federal recommendations for "as low as practicable" for light water reactors.

DOSES FROM RADIONUCLIDES RELEASED TO THE ATMOSPHERE

GAMMA CLOUD WHOLE BODY DOSE

Airborne radioactive effluents released from the Ginna plant in 1972 consisted of the following:[2]

Noble gases	1.2×10^{4} curies
Halogens	3.6×10^{-2} curies
Particulates	7.8×10^{-5} curies

Table 1 shows the monthly noble gas and halogen releases, as reported in the semiannual reports of the licensee[3,4] for 1972. The external gamma dose is calculated using a finite cloud model,[5] assuming that the releases are continuous. The primary inputs into the model are the release values from Table 1, joint frequency meteorological data derived from the pre-operational site meteorological study,[6] and the 1970 population projection within a 50-mile radius of the plant.[6] A description of the air dose model, AIREM, is given in Appendix A.

TABLE I

REPORTED GASEOUS RELEASES - 1972

IN CURIES[3,4]

NUCLIDE	Kr-85	Xe-133	Kr-85m	Xe-135	I-131	I-133
Jan	-	$8.1X10^{1}$	$7.3X10^{0}$	$9.7X10^{1}$	$1.9X10^{-3}$	$3.5X10^{-4}$
Feb	$1.8X10^{1}$	$8.6X10^{2}$	$7.1X10^{0}$	$1.0X10^{2}$	$8.0X10^{-4}$	$1.5X10^{-4}$
Mar	-	$3.7X10^{3}$	$3.5X10^{0}$	$9.2X10^{1}$	$2.8X10^{-3}$	$1.2X10^{-4}$
Apr	-	$3.1X10^{3}$	$5.5X10^{0}$	$6.3X10^{1}$	$2.2X10^{-2}$	$8.0X10^{-4}$
May	$2.4X10^{2}$	$1.2X10^{2}$	ND	ND	$5.6X10^{-3}$	ND
Jun	$5.4X10^{2}$	ND	ND	ND	$4.0X10^{-4}$	ND
Jul	ND	$3.4X10^{2}$	$5.6X10^{0}$	$3.1X10^{1}$	$3.2X10^{-5}$	$2.0X10^{-6}$
Aug	$7.8X10^{1}$	$4.6X10^{2}$	$1.2X10^{1}$	$3.3X10^{1}$	$1.8X10^{-5}$	$<1.0X10^{-6}$
Sep	$1.6X10^{2}$	$4.2X10^{2}$	$3.3X10^{0}$	$7.2X10^{-5}$	$7.2X10^{-5}$	$7.1X10^{-5}$
Oct	$4.1X10^{1}$	$1.3X10^{2}$	ND	$3.0X10^{0}$	$2.1X10^{-4}$	$2.0X10^{-6}$
Nov	$5.9X10^{1}$	$1.1X10^{2}$	$1.0X10^{-1}$	$1.0X10^{0}$	$4.0X10^{-5}$	$2.6X10^{-5}$
Dec	$1.6X10^{1}$	$8.9X10^{1}$	$4.0X10^{-1}$	$6.0X10^{0}$	$5.0X10^{-6}$	$1.0X10^{-6}$
Total	$1.1X10^{3}$	$1.0X10^{4}$	$4.5X10^{1}$	$4.9X10^{2}$	$3.4X10^{-2}$	$1.5X10^{-3}$

ND = not detected

Table 2 shows both the individual and population dose, compared with natural background. The maximum individual whole body dose is 0.065 mrem per year at the plant boundary (approximately 690 meters west of the reactor site). The average per capita dose for the total population within 50 miles of the plant is 7.5×10^{-4} mrem per year which is equivalent to a population dose of 0.88 person-rem per year. The plant-derived gamma doses (shown in Table 2) include the noble gas and halogen contributions. Particulate contribution is considered negligible and not included. The ratio of plant-derived population dose to natural background is 5.9×10^{-6}. Natural background is assumed to contribute 130 mrem per year to each individual.

Figures 1 and 2 show the average annual individual dose isopleths for the 8 kilometer and 80 kilometer distances. The figures show that the maximum dose sector is over the lake northeast of the reactor site (Sector 3).

AIR SUBMERSION SKIN SURFACE DOSE

The maximum individual skin dose from noble gases was calculated to be 1.4 mrem/yr to an individual at the west site boundary (690 meters from the plant). The skin dose is estimated by utilizing the method described in Appendix B.

THYROID DOSE FROM IODINE INHALATION

The thyroid dose from iodine via the inhalation pathway

TABLE 2

ANNUAL DOSES FROM GASEOUS RELEASES IN 1972

INDIVIDUAL DOSE (mrem/yr)	
Maximum Doses @ Plant Boundary West	
($\chi/Q = 2.1X10^{-6}$)	
1. Whole Body	$6.5X10^{-2}$
2. Skin Dose	$1.4X10^{0}$
Average Annual Per Capita Dose	
within 50 mile radius	$7.5X10^{-4}$
Natural Background Dose	$1.3X10^{2}$
POPULATION DOSE[a] - 50 Mile Radius (Person-Rem/yr)	
Total Plant Derived Dose	$8.8X10^{-1}$
Total Natural Background Dose	$1.5X10^{5}$

a--Average Annual - Based on a 1970 population within 50 miles of the Ginna Station of $1.17X10^{6}$ people.[6]

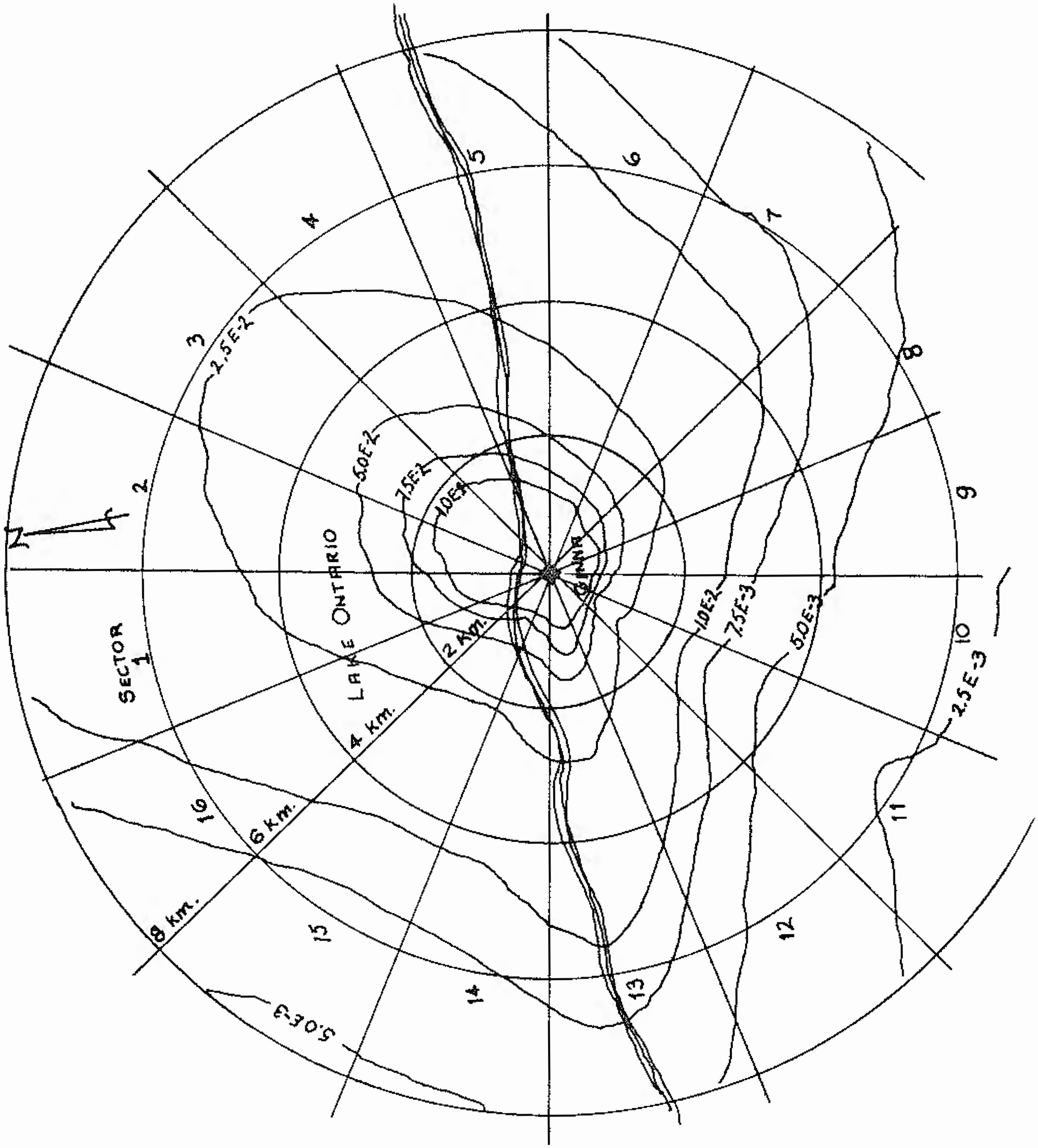

Figure 1
Average Annual Gamma Cloud
Whole Body Dose for 1972 in Millirem
(0-8 Kilometer Distance)

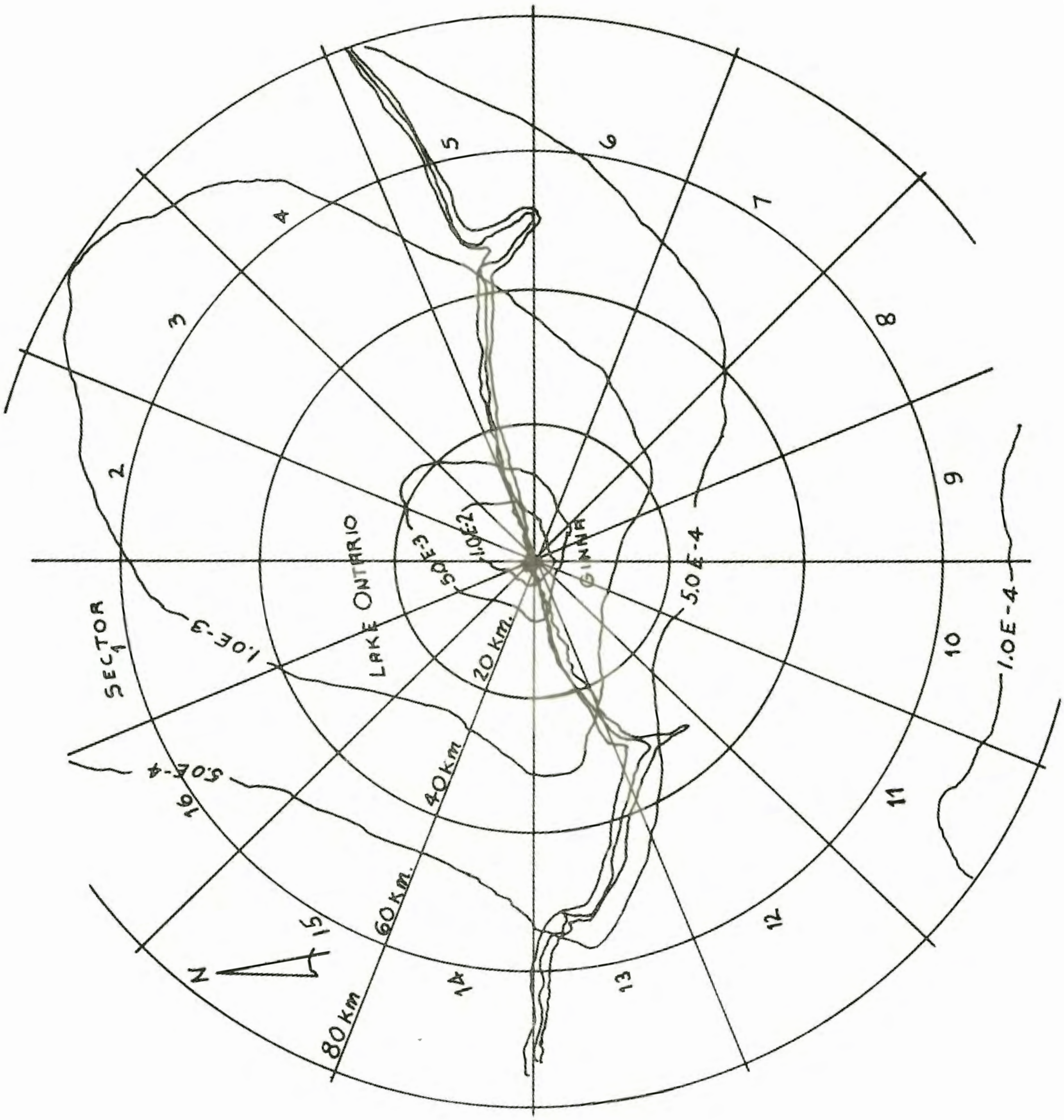

Figure 2
Average Annual Gamma Cloud
Whole Body Dose for 1972 in Millirem
(0-80 Kilometer Distance)

for adults has been calculated in the FES for a non-depleted cloud. This is conservative because it assumes no deposition of iodine on the ground between the discharge point and the location where the dose is being calculated. The AIREM model calculates a depleted cloud dose using a deposition velocity of 0.01 meters per second. Table 3 shows a comparison of the two cases at the maximum property line location.

The maximum individual for the iodine inhalation dose is a four-year old child.[7] The property line dose for this child is 8.1×10^{-2} mrem per year, using the depleted cloud model.

The population dose is based upon the adult. For 1972 the average per capita dose was 1.3×10^{-5} mrem per year, which is equivalent to 1.5×10^{-2} person-rem per year for the population within 50 miles of the plant.

Appendix C contains a description of the equations used to calculate the inhalation dose.

MILK PATHWAY DOSE

The closest dairy herd is 4,700 meters (2.9 miles) WSW of the plant, and the hypothetical location for a dairy herd to give a maximum dose from milk is at the plant boundary (690 meters west of the discharge point). Table 3 shows the dose for both locations. Using the depleted cloud model, the maximum milk pathway dose at the nearest herd location is 7.7×10^{-2} mrem per year. The hypothetical

TABLE 3

RADIOIODINE DOSE SUMMARY (mrem/yr)

PATHWAY	LOCATION	DEPLETED	NONDEPLETED
Adult Thyroid (Inhalation)	690 meters West ($\chi/Q = 2.1 \times 10^{-6}$)	1.7×10^{-2}	2.0×10^{-2}
4 Yr. Child Thyroid (Inhalation)	690 meters West ($\chi/Q = 2.1 \times 10^{-6}$)	8.1×10^{-2}	9.5×10^{-2}
Child Thyroid (Milk)	690 meters West ($\chi/Q = 2.1 \times 10^{-6}$)	7.0×10^{0}	8.0×10^{0}
Child Thyroid (Milk)	4667 meters WSW ($\chi/Q = 4.5 \times 10^{-8}$)	7.7×10^{-2}	1.7×10^{-1}
4 Yr. Child Thyroid (Vegetable)	690 meters West ($\chi/Q = 2.1 \times 10^{-6}$)	---	6.8×10^{-2}

maximum milk pathway dose from a herd at the west property line is 7.0 mrem per year.[8] The depleted and non-depleted cases are given for comparison. All cases are calculated for a two-gram thyroid, a milk consumption of one liter per day, and cow pasturage of five months annually. For deposition calculations, the depleted cloud dose becomes significantly different from the non-depleted cloud as the distance from the plant increases.

The thyroid dose from 131-iodine through the milk pathway is dependent on many factors that convert the airborne effluents (Q) to a dose. This conversion generally results in a spectrum of doses being generated from the same Q and X/Q values related to the particular conversion factors used by each individual calculating the dose. Appendix D contains a description of the dose calculation for the milk pathway in enough detail to allow comparison of the factors used in this report with other approaches.

LEAFY, GREEN VEGETABLE PATHWAY DOSE

Normally, the thyroid dose from ingestion of leafy green vegetables contaminated with radioiodine is not the critical thyroid dose. The maximum individual would be a four-year-old child consuming leafy, green vegetables at the site boundary (690 meters west of the plant). Assuming this child consumes these vegetables three months out of the year, the estimated thyroid dose is 6.8×10^{-2} mrem/yr.

A description of the dose calculation for this pathway is found in Appendix E.

RADIONUCLIDES RELEASED AND DOSES FROM LIQUID DISCHARGES

LIQUID DISCHARGE AND RECEIVING WATER CONCENTRATIONS

The liquid discharges of significant radionuclides in 1972 are shown in the first two columns of Table 4 [3,4]. The total release for the year was 0.38 curies excluding tritium. The release from tritium was 200 curies. Table 4 also shows concentration of all nuclides in the discharge canal (calculated on the basis of an annual canal flow of 7.24×10^{11} liters of water[3,4]). The receiving water concentrations are based on a factor of ten dilution of the canal flow [1].

FISH INGESTION DOSE

The maximum fish ingestion dose is based upon fish residing in discharge canal water, and the maximum individual is assumed to consume 50 grams of fish per day. Table 5 shows the contribution of each radionuclide to the maximum dose. The calculations described in Appendix F are from Fowler, et al., [9] using concentration factors from Thompson, et al. [10]

TABLE 4

MAXIMUM CONCENTRATIONS OF RADIONUCLIDES IN STATION LIQUID DISCHARGES AND RECEIVING WATER ADJACENT TO THE SITE

NUCLIDE	RELEASE Ci/yr	CONC. IN DISCHARGE[a] CANAL μCi/cc (Cw)	CONC. IN RECEIVING[b] WATER μCi/cc (Cw¹)
I-131	$4.5X10^{-3}$	$6.3X10^{-12}$	$6.3X10^{-13}$
Cs-137	$7.0X10^{-2}$	$9.7X10^{-11}$	$9.7X10^{-12}$
Cs-134	$4.4X10^{-2}$	$6.1X10^{-11}$	$6.1X10^{-12}$
Co-60	$4.2X10^{-2}$	$5.8X10^{-11}$	$5.8X10^{-12}$
Cr-51	$3.1X10^{-3}$	$4.3X10^{-12}$	$4.3X10^{-13}$
Mn-54	$2.5X10^{-3}$	$3.5X10^{-12}$	$3.5X10^{-13}$
Ag-110m	$3.3X10^{-3}$	$4.6X10^{-12}$	$4.6X10^{-13}$
Ru-106	$8.9X10^{-3}$	$1.2X10^{-11}$	$1.2X10^{-12}$
Co-58	$7.9X10^{-3}$	$1.1X10^{-11}$	$1.1X10^{-12}$
Nb-95	$1.2X10^{-1}$	$1.7X10^{-10}$	$1.7X10^{-11}$
Ce-144	$3.8X10^{-2}$	$5.3X10^{-11}$	$5.3X10^{-12}$
Ru-103	$3.2X10^{-2}$	$4.4X10^{-11}$	$4.4X10^{-12}$
H-3	$2.0X10^{+2}$	$2.8X10^{-7}$	$2.8X10^{-8}$

a - Annual discharge to canal for 1972, $7.24X10^{11}$ liters from Safety Guide 21 Data for 1972[3,4]

b - Based on a dilution factor of 10 from the Final Environmental Statement, Docket 50-244 USAEC[1]

TABLE 5

INDIVIDUAL WHOLE BODY DOSE FROM

INGESTION OF LAKE FISH

NUCLIDE	MPCw $\frac{168hr}{WK}$ WB Dose $\frac{\mu Ci}{cc}$	CONC.FACTOR (CF) $\frac{gm}{cc}$ a	MAX. WB[b] DOSE $\frac{mrem}{yr}$	EXPECTED WB[c] DOSE $\frac{mrem}{yr}$
I-131	$2X10^{-3}$	$1.5X10^{1}$	$5.4X10^{-6}$	$5.4X10^{-7}$
Cs-137	$2X10^{-4}$	$4.0X10^{2}$	$2.2X10^{-2}$	$2.2X10^{-3}$
Cs-134	$9X10^{-5}$	$4.0X10^{2}$	$3.0X10^{-2}$	$3.0X10^{-3}$
Co-60	$1X10^{-3}$	$2.0X10^{1}$	$1.3X10^{-4}$	$1.3X10^{-5}$
Cr-51	$2X10^{-1}$	$4.0X10^{1}$	$1.3X10^{-6}$	$1.3X10^{-7}$
Mn-54	$8X10^{-3}$	$1.0X10^{2}$	$5.0X10^{-6}$	$5.0X10^{-7}$
Ag-110m	$7X10^{-2}$	$2.3X10^{0}$	$1.7X10^{-8}$	$1.7X10^{-9}$
Ru-106	$2X10^{-2}$	$1.0X10^{1}$	$6.8X10^{-7}$	$6.8X10^{-8}$
Co-58	$4X10^{-3}$	$2.0X10^{1}$	$6.3X10^{-6}$	$6.3X10^{-7}$
Nb-95	$4X10^{0}$	$3.0X10^{4}$	$1.5X10^{-4}$	$1.5X10^{-5}$
Ce-144	$3X10^{-1}$	$2.5X10^{1}$	$5.0X10^{-7}$	$5.0X10^{-8}$
Ru-103	$8X10^{-2}$	$1.0X10^{1}$	$6.3X10^{-7}$	$6.3X10^{-8}$
H-3	$5X10^{-2}$	$9.0X10^{1}$	$5.7X10^{-4}$	$5.7X10^{-5}$
TOTALS	--	--	$5.3X10^{-2}$	$5.3X10^{-3}$

a - Thompson, S. E., et al., (1972)[10]

b - Dose (mrem/yr)= $1.14X10^{2}.(Cw).CF / (MPCw)$

c - Dose (mrem/yr)= $1.14X10^{2}.(Cw^{1}).CF / (MPCw)$

The total whole body dose from canal derived fish is 5.3×10^{-2} mrem per year to the maximum individual. The more realistic dose to a maximum individual would be from fish in the receiving waters near the canal. This dose is 5.3×10^{-3} mrem per year, or a factor of ten less than the discharge canal derived dose.

The annual per capita population dose from fish ingestion is 1.2×10^{-5} mrem per year which is equivalent to 1.5×10^{-2} person-rem per year for the population within 50 miles of the plant. The population dose assumes each member of the population consumed 441 grams of fish per year. The dosages take into account a dilution factor of 100 for receiving waters relative to canal discharge levels.[1]

Table 6 shows the maximum critical organ dose from fish ingestion, both for the discharge canal and adjacent receiving waters. The critical organ with the highest dose is the lower large intestine with a maximum annual dose of 2.0×10^{-1} mrem.

DRINKING WATER DOSE

The whole body dose from drinking water to the maximum individual is shown in Table 7 (according to calculations from Appendix G). The maximum dose of 3.4×10^{-2} mrem per year is based upon a daily intake of 2.2 liters of water from the canal discharge. The expected dose assumes the same intake by the maximum individual from receiving waters adjacent to the discharge canal.

TABLE 6

DOSE TO CRITICAL ORGANS
FROM FISH INGESTION

CRITICAL ORGAN	RADIONUCLIDES CONSIDERED	MAX. ORGAN DOSE (mrem/yr)	EXPECTED ORGAN DOSE (mrem/yr)
Muscle	Cs-137	2.2×10^{-2}	2.2×10^{-3}
Spleen	Cs-137	2.2×10^{-2}	2.2×10^{-3}
Bone	Ce-144	1.9×10^{-6}	1.9×10^{-7}
Liver	Cs-137, Mn-54, Ce-144	2.2×10^{-2}	2.2×10^{-3}
Lower Large Intestine	Co-60, Co-58, Cr-51, Mn-54, Ag-110m, Ru-106, Ru-103, Nb-95, Ce-144	2.0×10^{-1}	2.0×10^{-2}
Thyroid	I-131	5.4×10^{-4}	5.4×10^{-5}
Body Tissue	H-3	9.6×10^{-4}	9.6×10^{-5}

TABLE 7

WHOLE BODY DOSE FROM THE
INGESTION OF WATER (mrem/yr)

ISOTOPE	MAX. DOSE DISCHARGE CANAL	EXPECTED DOSE RECEIVING WATER
I-133	1.6×10^{-5}	1.6×10^{-6}
Cs-137	2.4×10^{-3}	2.4×10^{-4}
Cs-134	3.4×10^{-3}	3.4×10^{-4}
Co-60	2.9×10^{-4}	2.9×10^{-5}
Cr-51	1.1×10^{-7}	1.1×10^{-8}
Mn-54	2.2×10^{-6}	2.2×10^{-7}
Ag-110m	3.3×10^{-7}	3.3×10^{-8}
Ru-106	3.0×10^{-6}	3.0×10^{-7}
Co-58	1.4×10^{-5}	1.4×10^{-6}
Nb-95	2.1×10^{-7}	2.1×10^{-8}
Ce-144	8.8×10^{-7}	8.8×10^{-8}
Ru-103	2.8×10^{-6}	2.8×10^{-7}
H-3	2.8×10^{-2}	2.8×10^{-3}
TOTAL:	3.4×10^{-2}	3.4×10^{-3}

The population dose due to drinking water is based upon the total domestic water supply of 6.7×10^7 gpd[6] for a 50-mile radius and at a usage of 100 gpd per person. The affected population is 6.7×10^5 persons. This gives an equivalent of 0.23 person-rem per year or an annual per capita dose of 1.9×10^{-4} mrem for the total population within 50 miles of the plant.[1] Since the domestic water intakes are generally some distance from the Ginna plant, a dilution of 100 for the discharge canal was assumed.

SWIMMING AND BOATING PATHWAY DOSE

The swimming dose rate in mrem per hour is derived from the receiving waters concentrations in Table 4. The water concentration is multiplied by the dose factors listed in Table 8.[11] The total dose is calculated to be 9.0×10^{-8} mrem per hour according to Appendix H.

Assuming that the maximum individual swims 100 hours per year, the maximum dose is 9.0×10^{-6} mrem per year. Assuming that only 25 percent of the population swims, one hour of swimming per individual per year[1] gives an annual per capita dose of 2.3×10^{-8} mrem. This dose is equivalent to 2.7×10^{-5} person-rem for the population within 50 miles of the plant.

The dose rate from boating is assumed to be a factor of 100 less than the swimming dose rate or equal to 9.0 $\times 10^{-10}$ mrem per hour.[11] Assuming the maximum individual

TABLE 8

IMMERSION DOSE FROM SWIMMING

ISOTOPE	DOSE FACTOR[a] mrem-cc/μCi-hr	DOSE (mrem/hr)
I-131	6.8×10^{2}	4.3×10^{-10}
Cs-137	1.0×10^{3}	9.7×10^{-9}
Cs-134	2.9×10^{3}	1.8×10^{-8}
Co-60	4.6×10^{3}	2.7×10^{-8}
Cr-51	5.2×10^{1}	2.2×10^{-11}
Mn-54	1.5×10^{3}	5.3×10^{-10}
Ag-110m	6.0×10^{3}	2.8×10^{-9}
Ru-106	3.8×10^{2}	4.6×10^{-10}
Co-58	1.8×10^{3}	2.0×10^{-9}
Nb-95	1.4×10^{3}	2.4×10^{-8}
Ce-144	3.0×10^{3}	1.6×10^{-10}
Ru-103	8.9×10^{2}	3.9×10^{-9}
H-3[b]	$< 1.0 \times 10^{0}$	$< 1.0 \times 10^{-12}$
TOTAL:	---	9.0×10^{-8}

a - From HERMES - 1971 [11]

b - Beta dose to skin [11]

boats for 500 hours per year, the maximum dose is 4.5×10^{-7} mrem per year. Assuming that only 25 percent of the population is involved in boating, five hours of boating per individual per year gives an annual per capita dose of 1.1×10^{-9} mrem. This dose is equivalent to a dose of 1.3×10^{-6} per person-rem for the population within a 50 mile radius of the plant.

DOSE SUMMARY

Table 9 lists the dose summary for the pathways discussed throughout this report. The maximum individual doses listed in the table are based on the most likely situation rather than on the most conservative situation possible. Pathway locations and descriptions are given in the footnotes of the table. The population dose values given in the last two columns of Table 9 assume an adult population distributed within a 50-mile radius of the plant according to the 1970 population figures[6]. The total population doses for 1972 from Table 9 are 1.1 person-rem to the whole body and 1.5×10^{-2} person-rem to the thyroid.

Table 10 is a comparison of the dose summary to applicable Federal regulations. The Appendix I design objectives are the primary guides to meet the criterion "as low as practicable" for radioactive material in light-water-cooled nuclear power reactor effluents. The 1972 Ginna release data meet the Appendix I recommendations for all modes of discharge and doses.

TABLE 9

SUMMARY OF DOSES FROM GINNA FOR 1972

PATHWAY	MAXIMUM INDIVIDUAL (mrem/yr)	AVERAGE PER CAPITA (mrem/yr)	POPULATION DOSE - 50 MILES (person-rem)
Noble Gas Discharge			
a. Whole Body	6.5×10^{-2} [a]	7.5×10^{-4}	8.8×10^{-1}
b. Skin	1.4 [a]	---	---
Swimming	9.0×10^{-6} [b]	2.3×10^{-8}	2.7×10^{-5}
Boating	4.5×10^{-7} [c]	1.1×10^{-9}	1.3×10^{-6}
Water Ingestion	3.4×10^{-2} [d]	1.9×10^{-4}	2.3×10^{-1}
Fish Ingestion	5.3×10^{-2} [e]	1.2×10^{-5}	1.5×10^{-2}
Iodine-Thyroid (Inhalation Pathway)	8.1×10^{-2} [f]	1.3×10^{-5} [h]	1.5×10^{-2} [h]
Iodine-Child Thyroid (Milk Pathway)	7.7×10^{-2} [g]	---	---
Iodine-Thyroid (Vegetable Pathway nondepleted cloud)	6.8×10^{-2} [f]	---	---
Natural Background	1.3×10^{2}	1.3×10^{2}	1.6×10^{5}

a -- 690 meters W, $\bar{x}/Q = 2.1 \times 10^{-6}$ sec/m³

b -- Assumes 100 hours per year in receiving waters

c -- Assumes 500 hours per year in receiving waters

d -- Assumes 2.2 liters per day intake of receiving waters

e -- Assumes 50 grams of fish per day from receiving waters consumed

f -- 690 meters W, $x/Q = 2.1 \times 10^{-6}$ sec/m^3, 4-year-old child, depleted cloud

g -- 4667 meters WSW, $x/Q = 4.5 \times 10^{-8}$ sec/m^3, 6-month-old child, depleted cloud

h -- Assumes an adult thyroid

TABLE 10

COMPARISON OF DOSES AND FEDERAL REGULATIONS[12]

REGULATION	EFFLUENT MODE	RECOMMENDED LEVEL	1972 GINNA RELEASE
App. I	Liquids[a]	$\leq$3 mrem/yr/reactor	5.3×10^{-2} mrem/yr
App. I	Liquids[b]	$\leq$10 mrem/yr/reactor	2.0×10^{-1} mrem/yr
App. I	Gamma Dose in Air	$\leq 1.0 \times 10^{1}$ mrad/yr/ reactor	6.5×10^{-2} mrad/yr
App. I	Beta Dose in Air	$\leq 2.0 \times 10^{1}$ mrad/yr/ reactor	1.4 mrad/yr
App. I	Air (Whole Body-Critical Organ)	$\leq$5 mrem/yr/reactor	6.5×10^{-2} mrem/yr
App. I	Air (Skin-Critical Organ)	$\leq$15 mrem/yr/reactor	1.4 mrad/yr
App. I	Air[b] (Radioiodine and Particulates)	$\leq$15 mrem/yr/reactor	7.7×10^{-2} mrem/yr

a--Whole body from all pathways

b--Any organ from all pathways

APPENDIX A

AIREM--AIR DOSE MODEL[5]

The following is abstracted from the program manual.

"A Program to Calculate Airborne Pathway Radiation Doses

Sum of doses to up to four critical organs are treated.
Population doses are also calculated.
Radionuclide decay during time of flight is included.
First daughter product ingrowth and deposition is included.

Doses are calculated for those dose modes where the product of the ground concentration and a dose conversion factor equals dose. This includes inhalation transpiration, and skin external beta doses. External gamma whole body doses are calculated using a sector averaged finite cloud method. External whole body gamma doses are calculated using dose integrals calculated with a corrected and slightly modified version of R. E. Cooper's EGAD (R. E. Cooper, "EGAD - A Computer Program to Compute Dose Integrals from External Gamma Emitters," TID-4500, UC-32, Savannah River Laboratory, Sept. 1972). A table of dose integrals is generated for each facility according to the stack height and the mean lid height for the facility. This table is then interpolated according to energy and sigma Z.

Cloud depletion and ground deposition are included. 1/73 up to four expansion coefficients for deposition velocity as a function of wind speed for each stability class is used in the deposition and cloud depletion calculation.

A sector averaged Gaussian diffusion model is used. A single diffusion equation is solved repeatedly for each sector (16), radius (12), stability class (6), and radionuclide (20). (Numbers in parentheses are maximum numbers.)
Plume rise is not yet automatically included.
Dose due to standing in a field of radionuclides is not yet included. Normally, such are trivially small.
(Dose and man-rem are outputs.)
Picocuries per square meter on the ground are also output.

The printout of this program is formatted for 16 sectors. But less can be run."

APPENDIX B

NOBLE GAS SKIN SURFACE SUBMERSION DOSE CALCULATION[13]

$$\text{Dose (mrem/yr)} = \text{(curies/yr)} \times \frac{X}{Q}\ (\text{sec/m}^3) \times \text{(dose conversion factor)}$$

$$\text{Dose conversion factor} = \frac{500\ \text{mrem/yr}}{\text{MPC}(\mu\text{Ci/cc})} \times \frac{1\ \text{yr}}{3.15 \times 10^7\ \text{sec}}$$

Nuclide	Annual Discharge (Ci/yr)		$\frac{X}{Q}$ (sec/m³)		Conversion factor $\frac{\text{mrem/sec}}{\mu\text{Ci/cc}}$		Skin Surface Submersion dose (mr/yr)
^{85m}Kr	44.6	x	2.1×10^{-6}	x	159	=	.015
^{135}Xe	485.14	x	2.1×10^{-6}	x	159	=	.162
^{133}Xe	10130.1	x	2.1×10^{-6}	x	52.8	=	1.12
^{85}Kr	1143.62	x	2.1×10^{-6}	x	52.8	=	.127
Σ = Total Skin Surface Submersion Dose Rate						=	1.42

APPENDIX E

VEGETABLE CONSUMPTION DOSE CALCULATION[14]

By using the following equations, the thyroid dose due to consumption of radioiodine contaminated leafy green vegetables can be estimated:

$$DE\ 4\ yr = 120 \cdot \chi \cdot CF \quad \text{for a four-year old child}$$

$$DE\ adult = 30 \cdot \chi \cdot CF \quad \text{for an adult}$$

WHERE: DE = thyroid dose equivalent rate

$$\chi = (pCi/m^3) = Q\ (Ci/yr) \times \chi/Q(sec/m^3) \times \frac{3.17 \times 10^4\ pCi\text{-}Yr}{Ci\text{-}sec}$$

CF = fraction of a year in which vegetables are consumed

A factor exp (-0.086t) should be included in this calculation if a decay period is assumed between harvest and ingestion (t is in days).

APPENDIX F

F. FISH INGESTION DOSE[9,10]

The fish ingestion dose is calculated for each nuclide using the following equation:

$$DE(\frac{mrem}{yr}) = 1.14 \times 10^2 \times (C_w)\ (C_f)/\ (MDC_w)$$

WHERE: C_w = water concentration in µCi/cc

C_f = concentration factor in $\frac{\mu Ci/gm}{\mu Ci/cc}$

MPC_w = 168 hr maximum permissible concentration in µCi/cc

This equation applies to any critical organ when the MPC_w is selected for that particular organ.

APPENDIX G

WATER INGESTION DOSE[9]

The water ingestion dose is calculated similarly to the fish ingestion dose.

$$DE(\frac{mrem}{yr}) = 5 \times 10^3\ \frac{(C_d)\ (D)}{(MPC_w)}$$

WHERE: C_d = discharge concentration in µCi/cc

D = the dilution factor for the receiving waters

MPC_w = 168 hour maximum permissible concentration in µCi/cc

APPENDIX H

SWIMMING AND BOATING DOSE [11]

The dose from swimming is calculated using the following equation:

$$DE\left(\frac{mrem}{hr}\right) = (C_d)\ (D)\ (DF_s)$$

WHERE: C_d = discharge concentration in $\mu Ci/cc$

D = the dilution factor for the receiving waters

DF_s = swimming dose factor in $\frac{mrem/hr}{\mu Ci/cc}$

The boating dose is calculated in the same manner, and it is assumed the boating dose factor (DF_b) is a factor 100 less than the swimming dose factor (DF_s).

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16. ABSTRACT

This report presents the results of a study to determine the dose to the population in the vicinity of the Ginna Nuclear Power Plant (located in New York State) based upon 1972 discharge data. Doses calculated from release data are compared with current standards. This report fulfills the need to document the actual environmental impact of operating nuclear power reactors in contrast to Final Environmental Statement (FES) projections.

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