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March 11, 1985

Mr. H. R. Denton, Director
Office of Nuclear Reactor Regulation
U. S. NUCLEAR REGULATORY COMMISSION
Washington, D. C. 20555

Attention: Mr. J. R. Miller, Chief
Operating Reactors, Branch 3

Gentlemen:

DOCKET NOS. 50-266 AND 50-301
RADWASTE COST-BENEFIT ANALYSIS
POINT BEACH NUCLEAR PLANT, UNITS 1 AND 2

On December 20, 1984, Wisconsin Electric Power Company, Licensee for Point Beach Nuclear Plant, Units 1 and 2, submitted Technical Specification Change Request 33. That submittal included revised Radiological Effluent Technical Specifications (RETS). The revised RETS include a specification for the operation of radiological effluent waste treatment systems at Point Beach Nuclear Plant. The waste treatment specification was submitted contingent on the completion of a radwaste cost-benefit analysis. Enclosed is our cost-benefit analysis.

As a result of this cost-benefit analysis, we are revising Specification 15.7.5.G which details the requirements for operation of radioactive effluent waste treatment systems. The revision will result in cost effective operation requirements for waste treatment systems as determined by the cost-benefit analysis. We anticipate forwarding to you by March 25, 1985 the revised section of the proposed RETS. We do not anticipate that this minor revision to our December 20 RETS submittal should have any significant impact on your review schedule.

Please contact me if you have any questions regarding this cost benefit analysis.

Very truly yours,

CW Fay

Vice President-Nuclear Power

C. W. Fay

Enclosure

Copy to NRC Resident Inspector

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RADWASTE COST-BENEFIT ANALYSIS
POINT BEACH NUCLEAR PLANT

NUREG-0472, Revision 3, entitled "Standard Radiological Effluent Technical Specifications for Pressurized Water Reactors" provides guidance for the preparation of Radiological Effluent Technical Specifications. NUREG-0472 recommends that both gaseous and liquid radwaste treatment systems be operated to reduce radioactive materials in gaseous and liquid waste prior to their discharge when projected doses will exceed 1/48 of the annual limit. The 1/48 limit operating requirement is recommended in the absence of a cost-benefit analysis. This cost-benefit analysis was performed to demonstrate that the operation of PBNP gaseous and liquid radwaste treatment systems whenever projected releases may exceed 1/48 of the annual limits is not cost effective.

The purpose of this analysis is to determine cost effective operation criteria for the PBNP radwaste treatment systems. The radwaste treatment systems at PBNP are required to be operated to ensure compliance with 10 CFR 50 Appendix I dose limits. The requirement to operate radwaste systems at levels which will reduce offsite doses to values less than the Appendix I limits will be determined by an assessment of the cost of operation and the corresponding dose savings to the population residing within 50 miles of PBNP. Processing of radwaste is not cost effective if the cost to process exceeds $1,000 per man-rem or thyroid-rem saved.

Processing of gaseous wastes is accomplished at PBNP by the gaseous radioactive treatment system and ventilation exhaust filtration systems. Filtration systems are provided for the removal of particulates and/or radioiodines in the Unit 1 and Unit 2 containment purge stacks, drumming area exhaust stack, and the auxiliary building ventilation stack. Refer to FSAR Figure 12-3 for a depiction of the release point exhaust filtration systems. Because the cost to operate these filter exhaust systems presently is less than $1,000 per population man-rem or thyroid-rem gaseous wastes discharged from these exhaust points will be processed thru the filtration systems. The proposed PBNP RETS are being revised to specify that these ventilation exhaust filtration systems shall be used to reduce radioactive materials in gaseous wastes prior to discharge to the environment. The specification will provide a contingency in the unlikely event of ventilation exhaust filtration inoperability.

Noble gases stripped from primary coolant letdown can be processed by the compressed gas decay tank system. Noble gas releases are on a batch basis following a decay time. The gas decay tank system is to be operated when projected offsite whole body dose rates are expected to exceed Appendix I limits. To ascertain the cost effectiveness of the operation of the gas decay system at levels which will result in dose rates below the Appendix I limits, the cost per man-rem savings is calculated.

The PBNP FSAR Appendix I Analysis theoretically determined the amount of noble gas expected to be released and the related maximum annual offsite dose rate assuming 1% failed fuel rate and full operation of the gaseous radwaste treatment system. The Appendix I analysis is the basis for determining whole body population doses resulting from the release of noble gases. Population dose calculations are summarized in the attached Appendix A. Assuming full operation of the gaseous radwaste systems a total of 2.81E+03 Equivalent Curies of Xe-133 is determined to be released annually. This results in a maximum offsite whole body dose rate 2.7E-02 mrem per year. The amount of Equivalent Curies of Xe-133 permitted to be released may be determined by scaling the calculated maximum dose rate up to the Appendix I dose limit of 10 mrem per year. With a scaling factor of 370, the calculated Appendix I release limit is therefore 1.04E+06 Equivalent Curies of Xe-133. That quantity released in a year would result in a maximum dose rate of 10 mrem. The Curies expected to be released at full operation of the gaseous treatment system and the Appendix I release limit are therefore established as 2.81E+03 and 1.04E+06 Equivalent Curies of Xe-133 respectively.

As summarized in Appendix A, the population dose estimated for the release of 2.81E+03 Xe-133 Equivalent Curies is 2.94E-02 man-rem. The population dose estimated for the release of the Appendix I limit of 1.04E+06 Xe-133 equivalent curies is 1.09E+01 man-rem. Therefore a population dose of 1.08E+01 man-rem may be saved if the system is operated full-time instead of at a level to achieve Appendix I objectives.

To ascertain the cost effectiveness of operating the gas decay tank system at levels necessary to achieve releases less than the Appendix I limit, the cost of operation is compared against the possible population dose savings. Attached Appendix B summarizes the cost associated with the full operation of the gas decay tank system. The cost is estimated as $33,975. To determine the fraction of operation required to accomplish Appendix I limits it is necessary to evaluate the quantity of radioactivity expected to be released if no processing occurs. Utilizing the letdown rate assumptions in the Appendix I analysis and assuming all noble gases are stripped from letdown, the total equivalent curies of Xe-133 estimated to be released if no processing occurs is 1.83E+06. A release of 1.04E+06 Xe-133 Equivalent Curies corresponds to operation at the Appendix I limits and represents an operation level of 43%. The cost to operate at the Appendix I level is 43% of the full operation cost or $14,609. Therefore, the difference in cost between operation at Appendix I limits and full operation is $19,366.

The cost per man-rem to operate the gas decay tank system more than what is required to meet Appendix I limits is calculated as $19,366 divided by 1.08E+01 man-rem, the total dose between Appendix I and full operation. Hence, the cost of operation is $1,783 per man-rem, and it is concluded that operation in excess of the Appendix I limits is not cost effective. The cost analysis calculations are detailed in attached Appendix C. Therefore, the gas decay tank system needs only be utilized to reduce radioactive materials in gaseous effluents whenever noble gas effluents require treatment to meet the Appendix I release limits.

Processing of liquid wastes is accomplished at PBNP by the Chemical and Volume Control System and the Liquid Radioactive Waste System. The Chemical and Volume Control System (CVCS) holdup tanks are shared between Units 1 and Unit 2 and collect reactor coolant letdown for boron control and other miscellaneous reactor coolant drains. These liquids are then processed by the boron recovery portion of the CVCS. Boric acid evaporator condensate is released to the circulating water discharge or recycled to the makeup water storage tank. Although the CVCS is utilized to reduce radioactive effluent discharges, the primary objective of the processing system is to recover boron. The financial benefit of recovering the boron outweighs any cost advantages that may be achieved by partial operation of the system. Hence, radwaste cost-benefit analysis was not performed for the CVCS. The proposed PBNP RETS are being revised to specify that portions of the CVCS radwaste treatment system shall be used to reduce radioactive materials in liquid effluents discharged from this process pathway prior to release. The specification will include a contingency for system inoperability.

The liquid radioactive waste system is shown in Figure 12-2 of the FSAR. This system can be utilized to process steam generator blowdown and primary side liquid wastes. A cost-benefit analysis was performed for this system to determine if it is cost effective to process liquid wastes associated with this process pathway beyond what is required to accomplish Appendix I limits.

The PBNP FSAR Appendix I analysis again serves as the basis for determining population doses. Population doses resulting from liquid releases are summarized in Appendix A. The FSAR Appendix I analysis theoretically determined the amount of radioactivity expected to be released from PBNP assuming full operation of the CVCS and liquid radioactive waste system. Assuming full operation of the radwaste system a total of 8.29E-01 Equivalent Curies of I-131 would be released resulting in a population dose of 2.49E+00 thyroid-rem. The Equivalent Curies of Co-60 released are calculated to be 2.97E+00. Using a similar scaling approach as described for the gaseous effluents, the Appendix I release limits and population doses can be determined for liquid releases. The scaling factor is 31.6 for both particulates and iodines.

The total population doses saved by full operation of the waste systems versus operation at the Appendix I limits are 6.48E+00 man-rem and 7.62E+01 thyroid-rem, a total dose savings of 8.27E+01 rem.

The total estimated cost to process all steam generator blowdown and primary side waste through the liquid waste system is $1,356,775. The cost estimate is summarized in Appendix B. To determine the fraction of full operation required to meet Appendix I limits, it was necessary to determine the quantity of radioactivity which would be released if no processing of blowdown or primary side collected waste occurred prior to discharge. This quantity is calculated using the DF values for system components in this process system as listed in the FSAR. The total combined I-131 and Co-60 Equivalent Curies expected to be released with no processing is 3.59E+02. To meet Appendix I limits, releases must be restricted to a combined total 1.21E+01 Co-60 equivalents and I-131 equivalents. Operation of the system at the Appendix I limits represents an operation level of 67%. The cost to operate at the Appendix I limit is 67% of $1,356,775 or $909,000. The cost difference between operation at Appendix I limits and full operation is therefore $447,735.

The cost per rem saved to operate the liquid waste system in excess of what is required to meet Appendix I limits is $447,736 divided by 8.27E+01 rem or $5,413 per rem. Therefore, operation of the liquid waste system in excess of Appendix I limits is not cost effective. The cost analysis calculations are detailed in Appendix C. Accordingly, appropriate portions of the liquid radioactive waste processing system will be used to reduce radioactive materials in steam generator blowdown waste and/or primary side collected liquid waste discharged from this process pathway prior to release whenever such effluents require treatment to meet the Appendix I release limits.

TABLE 1

Thyroid Adult Population Dose From FSAR Liquid Releases
mrem/year

Subregion	Potable Water	Fresh Vegetables	Stored Vegetables	Cows Milk	Meat	Total
Two Rivers	6.3E+01	1.1E+01	8.4E-01	3.8E+01	1.7E+00	1.1E+02
Manitowoc	1.5E+02	2.7E+01	2.1E+00	9.1E+01	4.3E+00	2.7E+02
Green Bay	4.2E+02	7.4E+01	5.5E+00	2.5E+02	1.1E+00	3.8E+02
Sheboygan	1.7E+02	3.1E+01	2.3E+00	1.0E+02	4.8E+00	3.1E+02
						Total 1.07E+03

TABLE 2

Whole Body Adult Population Dose From FSAR Liquid Releases
mrem/year

Subregion	Potable Water	Fresh Vegetables	Stored Vegetables	Cows Milk	Meat	Total
Two Rivers	1.5E+00	4.9E-01	3.5E+00	3.0E+00	4.7E-01	9.0E+00
Manitowoc	3.7E+00	1.2E+00	8.6E+00	7.2E+00	1.1E+00	2.2E+01
Green Bay	9.9E+00	3.2E+00	2.3E+01	2.0E+01	3.1E+00	5.9E+01
Sheboygan	4.1E+00	1.4E+00	9.6E+00	8.1E+00	1.3E+00	2.5E+01
						Total 1.15E+02

TABLE 3

Thyroid Teenager Population Dose From FSAR Liquid Releases
mrem/year

Subregion	Potable Water	Fresh Vegetables	Stored Vegetables	Cows Milk	Meat	Total
Two Rivers	7.5E+00	1.3E+00	1.7E-01	1.3E+01	1.9E-01	2.2E+01
Manitowoc	1.8E+01	3.3E+00	4.2E-01	3.2E+01	4.5E-01	5.4E+01
Green Bay	4.9E+01	8.8E+00	1.1E+00	8.7E+01	1.2E+00	1.5E+02
Sheboygan	2.1E+01	3.7E+00	4.8E-01	3.6E+01	5.1E-01	6.2E+01

Total 2.88E+02

TABLE 4

Whole Body Teenager Population Dose From FSAR Liquid Releases
mrem/year

Subregion	Potable Water	Fresh Vegetables	Stored Vegetables	Cows Milk	Meat	Total
Two Rivers	1.3E-01	4.1E-02	5.4E-01	6.2E-01	3.3E-02	1.4E+00
Manitowic	3.3E-01	1.0E-01	1.3E+00	1.5E+00	8.1E-02	3.3E+00
Green Bay	8.9E-01	2.7E-01	3.5E+00	4.1E+00	2.2E-01	9.0E+00
Sheboygan	3.7E-01	1.1E-01	1.5E+00	1.7E+00	9.2E-02	3.8E+00

Total 1.75E+01

TABLE 5

Thyroid Child Population Dose From FSAR Liquid Releases
mrem/year

Subregion	Potable Water	Fresh Vegetables	Stored Vegetables	Cows Milk	Meat	Total
Two Rivers	2.7E+01	3.0E+00	4.7E-01	3.7E+01	4.4E-01	6.8E+01
Manitowoc	6.6E+01	7.2E+00	1.1E+00	9.1E+01	1.1E+00	1.7E+02
Green Bay	1.8E+02	1.9E+01	3.1E+00	2.5E+02	2.9E+00	4.6E+02
Sheboygan	7.5E+01	8.1E+00	1.3E+00	1.0E+02	1.2E+00	1.9E+02
					Total	8.88E+02

TABLE 6

Whole Body Child Population Dose From FSAR Liquid Releases
mrem/year

Subregion	Potable Water	Fresh Vegetables	Stored Vegetables	Cows Milk	Meat	Total
Two Rivers	2.3E-01	3.5E-02	6.4E-01	7.2E-01	4.2E-02	1.7E+00
Manitowoc	5.6E-01	8.6E-02	1.6E+00	1.7E+00	1.0E-01	4.0E+00
Green Bay	1.5E+00	2.3E-01	4.2E+00	4.7E+00	2.8E-01	1.1E+01
Sheboygan	6.3E-01	9.7E-02	1.8E+00	2.0E+00	1.2E-01	4.6E+00
					Total	2.13E+01

TABLE 7

Thyroid Infant Population Doses From FSAR Liquid Releases
mrem/year

Subregion	Potable Water	Fresh Vegetables	Stored Vegetables	Cows Milk	Meat	Total
Two Rivers	8.4E+00	-	-	1.1E+01	-	1.9E+01
Manitowoc	2.0E+01	-	-	2.8E+01	-	4.8E+01
Green Bay	5.5E+01	-	-	7.5E+01	-	1.3E+02
Sheboygan	2.3E+01	-	-	3.1E+01	-	5.4E+01
					Total	2.51E+02

TABLE 8

Whole Body Infant Population Doses From FSAR Liquid Releases
mrem/year

Subregion	Potable Water	Fresh Vegetables	Stored Vegetables	Cows Milk	Meat	Total
Two Rivers	5.1E-02	-	-	1.1E-01	-	1.6E-01
Manitowoc	1.2E-01	-	-	2.6E-01	-	3.8E-01
Green Bay	3.4E-01	-	-	7.0E-01	-	1.0E+00
Sheboygan	1.4E-01	-	-	2.9E-01	-	4.3E-01
					Total	1.97E+00

TABLE 9

Thyroid Population Doses From Ingestion of Fish
mrem/year

Adult	2.9E+01
Teen	5.6E+00
Child	2.3E+01
Total	5.76E+01

TABLE 10

Whole Body Population Doses From Ingestion of Fish
mrem/year

Adult	4.3E+01
Teen	5.1E+00
Child	7.8E+00
Total	5.59E+01

TABLE 11

Total Annual Population Doses From All Pathways
From Liquid Effluents

	Thyroid	Whole Body
Adult	1.10E+03	1.58E+02
Teen	2.34E+02	2.26E+01
Child	9.11E+02	2.91E+01
Infant	2.51E+02	1.97E+00
TOTAL mrem/year	2.49E+03	2.12E+02
TOTAL rem/year	2.49E+00	2.12E-01

TABLE 12

X/Q Values

	0-1	1-2	2-3	3-4	4-5	5-10	10-20	20-30	30-40	40-50
SSE	6.28E-07	2.65E-07	0.99E-07	5.31E-08	3.37E-08	1.44E-08	0.54E-09	2.73E-09	1.74E-09	1.24E-09
S	6.62E-07	6.78E-07	2.71E-07	1.60E-07	1.07E-07	5.04E-08	2.15E-08	1.17E-08	7.90E-09	5.86E-09
SSW	1.52E-06	4.50E-07	1.78E-07	0.98E-07	6.46E-08	2.80E-08	1.16E-08	6.13E-09	4.01E-09	2.93E-09
SW	8.10E-07	3.53E-07	1.49E-07	7.57E-08	4.71E-08	2.05E-08	8.83E-09	4.60E-09	3.01E-09	2.19E-09
WSW	4.95E-07	2.27E-07	0.99E-07	5.64E-08	3.45E-08	1.53E-08	6.66E-09	3.52E-09	2.31E-09	1.68E-09
W	5.18E-07	2.44E-07	1.15E-07	6.49E-08	3.82E-08	1.84E-08	8.15E-09	4.26E-09	2.78E-09	2.01E-09
WNW	5.61E-07	2.83E-07	1.39E-07	0.73E-07	5.13E-08	2.33E-08	1.04E-08	5.46E-09	3.58E-09	2.61E-09
NW	4.03E-07	2.92E-07	1.39E-07	0.94E-07	6.18E-08	2.46E-08	1.08E-08	5.72E-09	3.77E-09	2.76E-09
NNW	4.20E-07	8.56E-07	1.30E-07	8.50E-08	5.48E-08	2.37E-08	9.19E-09	4.78E-09	3.11E-09	2.25E-09
N	2.16E-07	4.21E-07	1.62E-07	0.99E-07	7.00E-08	3.27E-08	1.23E-08	6.25E-09	4.01E-09	2.88E-09
NNE	-	6.45E-07	2.47E-07	1.36E-07	9.04E-08	4.12E-08	1.68E-08	9.03E-09	5.98E-09	4.39E-09
NNE	-	5.21E-07	2.03E-07	1.15E-07	7.77E-08	3.70E-08	1.58E-08	8.78E-09	5.91E-09	4.39E-09
NE	-	2.84E-07	1.09E-07	0.61E-07	4.04E-08	1.87E-08	0.78E-08	4.24E-09	2.83E-09	2.09E-09
ENE	-	4.29E-07	1.63E-07	0.90E-07	5.97E-08	2.76E-08	1.15E-08	6.18E-09	4.11E-09	3.03E-09
ESE	-	4.22E-07	1.54E-07	0.83E-07	5.36E-08	2.38E-08	0.94E-08	4.92E-09	3.22E-09	2.34E-09
SE	-	3.30E-07	1.22E-07	6.45E-08	4.16E-08	1.35E-08	7.26E-09	3.81E-09	2.49E-09	1.83E-09

TABLE 13

X/Q in Subregion divided by X/Q in maximum subregion

X/Q Fractions

	0-1	1-2	2-3	3-4	4-5	5-10	10-20	20-30	30-40	40-50
SSE	4.13E-01	1.74E-01	6.51E-02	3.49E-02	2.217E-02	9.40E-03	3.55E-03	1.79E-03	1.14E-03	8.15E-04
S	4.35E-01	4.46E-01	1.78E-01	1.05E-01	7.04E-02	3.31E-02	1.44E-02	7.69E-03	5.19E-03	3.84E-03
SSW	1.00E+00	2.96E-01	1.17E-01	6.44E-02	4.25E-02	1.80E-02	7.63E-03	4.03E-03	2.64E-03	1.92E-03
SW	5.32E-01	2.23E-01	9.80E-02	4.90E-02	3.09E-02	1.30E-02	5.81E-03	3.02E-03	1.98E-03	1.44E-03
WSW	3.26E-01	1.49E-01	6.50E-02	3.71E-02	2.27E-02	1.00E-02	4.39E-03	2.31E-03	1.52E-03	1.11E-03
W	3.41E-02	1.60E-01	7.56E-02	4.27E-02	2.51E-02	1.20E-02	5.30E-03	2.80E-03	1.83E-03	1.32E-03
WNW	3.69E-02	1.86E-01	9.14E-02	4.80E-02	3.37E-02	1.53E-02	6.84E-03	3.59E-03	2.35E-03	1.71E-03
NW	2.65E-01	1.92E-01	9.14E-02	6.18E-02	4.06E-02	1.62E-02	7.10E-03	3.76E-03	2.48E-03	1.81E-03
NNW	2.76E-01	5.63E-01	8.55E-02	5.59E-02	3.60E-02	1.56E-02	6.04E-03	3.14E-03	2.04E-03	1.48E-03
N	1.43E-01	2.76E-01	1.06E-01	6.51E-02	4.60E-02	2.15E-02	8.10E-03	4.11E-03	2.63E-03	1.89E-03
NNE	-	4.24E-01	1.65E-01	8.95E-02	5.95E-02	2.71E-02	1.10E-02	5.94E-03	3.93E-03	2.89E-03
NE	-	3.42E-01	1.33E-01	7.56E-02	5.11E-02	2.43E-02	1.04E-02	5.77E-03	3.89E-03	2.89E-03
ENE	-	1.86E-01	7.17E-02	4.01E-02	2.66E-02	1.23E-02	5.13E-03	2.79E-03	1.86E-03	1.37E-03
E	-	2.82E-01	1.07E-01	5.92E-02	3.92E-02	1.82E-02	7.76E-03	4.06E-03	2.71E-03	1.99E-03
ESE	-	2.78E-01	1.01E-01	5.46E-02	3.53E-02	1.56E-02	6.18E-03	3.23E-03	2.11E-03	1.54E-03
SE	-	2.17E-01	8.03E-02	4.20E-02	2.73E-02	1.21E-02	4.78E-03	2.50E-03	1.64E-03	1.20E-03

TABLE 14

Noble Gas Whole Body Dose Rates

mrem/year

	0-1	1-2	2-3	3-4	4-5	5-10	10-20	20-30	30-40	40-50
SSE	5.55E-03	2.34E-03	8.75E-04	4.71E-04	2.99E-04	-	-	-	-	-
S	5.85E-03	6.00E-03	2.41E-03	1.41E-03	9.50E-04	4.45E-04	-	-	-	-
SSW	1.35E-02	3.99E-03	1.58E-03	8.70E-04	5.70E-04	2.43E-04	1.03E-04	5.45E-05	3.56E-05	2.59E-05
SW	7.15E-03	3.13E-03	1.32E-03	6.60E-04	4.17E-04	1.75E-05	7.85E-05	4.08E-05	2.68E-05	1.94E-05
WSW	4.44E-03	2.01E-03	8.75E-04	5.00E-04	3.06E-04	1.35E-04	5.90E-05	3.12E-05	2.05E-05	1.49E-05
W	4.61E-03	2.16E-03	1.02E-03	5.75E-04	3.39E-04	1.62E-04	7.15E-05	3.78E-05	2.47E-05	1.78E-02
WNW	4.98E-03	2.51E-03	1.23E-03	6.45E-04	4.55E-04	2.01E-04	9.20E-05	4.84E-05	3.17E-05	2.31E-05
NW	3.58E-03	2.59E-03	1.23E-03	8.35E-04	5.45E-04	2.19E-04	9.55E-05	5.05E-02	3.34E-05	2.44E-05
NNW	3.73E-03	7.60E-03	1.16E-03	7.55E-04	4.86E-04	2.11E-04	8.15E-05	4.23E-05	2.75E-05	1.99E-05
N	-	-	-	8.75E-04	6.20E-04	2.91E-04	1.09E-04	5.55E-05	3.55E-05	2.55E-05
NNE	-	-	-	-	-	-	-	7.80E-05	5.25E-05	3.90E-05
NE	-	-	-	-	-	-	-	-	-	-
ENE	-	-	-	-	-	-	-	-	-	-
E	-	-	-	-	-	-	-	-	-	-
ESE	-	-	-	-	-	-	-	-	-	-
SE	-	-	-	-	-	-	-	-	-	-

TABLE 15

Population Distribution, 0-50 Miles

	0-1	1-2	2-3	3-4	4-5	5-10	10-20	20-30	30-40	40-50
SSE	6	58	27	84	25	0	0	0	0	0
S	6	11	42	32	37	9,000	0	0	0	0
SSW	6	32	42	53	68	12,900	59,500	4,031	87,400	14,783
SW	11	27	21	32	53	1,238	5,560	6,500	17,470	2,353
WSW	0	32	37	27	68	1,960	4,360	8,260	13,000	1,092
W	6	27	37	68	58	790	3,453	5,550	46,670	96,548
WNW	11	32	32	32	57	652	5,159	85,900	54,130	4,094
NW	0	11	84	21	79	761	2,903	48,700	22,130	2,830
NNW	11	22	53	53	46	427	2,980	4,071	727	4,935
N	0	0	0	23	32	320	4,850	8,140	12,100	0
NNE	0	0	0	0	0	0	0	208	2,680	370
NE	0	0	0	0	0	0	0	0	0	0
ENE	0	0	0	0	0	0	0	0	0	0
E	0	0	0	0	0	0	0	0	0	0
ESE	0	0	0	0	0	0	0	0	0	0
SE	0	0	0	0	0	0	0	0	0	0

TABLE 16

Total Population Doses From Noble Gas Releases

mrem/year

	0-1	1-2	2-3	3-4	4-5	5-10	10-20	20-30	30-40	40-50
SSE	3.33E-02	1.36E-01	2.36E-02	3.96E-02	7.45E-03	-	-	-	-	-
S	3.51E-02	6.60E-02	1.01E-01	4.53E-02	3.52E-02	4.02E+00	-	-	-	-
SSW	8.10E-03	1.28E-01	6.50E-01	4.61E-02	3.88E-02	3.13E+00	6.25E+00	2.39E-01	3.11E+00	3.83E-01
SW	7.85E-02	8.45E-02	2.77E-02	2.11E-03	2.21E-02	2.17E-01	4.36E-01	2.65E-01	4.67E-02	4.56E-02
WSW	-	6.40E-02	3.24E-02	1.35E-02	2.08E-02	2.65E-01	2.57E-01	2.58E-01	2.66E-01	1.63E-02
W	2.76E-02	5.85E-02	3.78E-02	3.91E-02	1.96E-02	1.25E-01	2.46E-01	2.09E-01	1.15E+00	1.72E+00
WNW	5.45E-02	8.00E-02	3.94E-02	2.07E-02	2.64E-02	1.34E-01	4.75E-01	4.16E+00	1.72E+00	9.45E-02
NW	-	2.85E-02	1.04E-01	1.76E-02	4.31E-02	1.66E-01	2.77E-01	2.45E+00	7.40E-01	6.90E-02
NNW	4.09E-02	1.67E-01	6.10E-02	4.00E-02	2.23E-02	8.95E-02	2.43E-01	1.73E-01	2.00E-02	9.85E-02
N	-	-	-	2.01E-02	1.98E-02	9.30E-02	5.30E-01	4.51E-01	4.29E-01	-
NNE	-	-	-	-	-	-	-	1.62E-02	1.41E-01	1.46E-02
NE										
ENE										
E										
ESE										
SE										
TOTAL	3.51E-02	8.10E-01	4.92E-01	2.83E-01	2.56E-01	8.25E-02	8.70E+00	8.20E+00	8.10E+00	2.44E+00

APPENDIX A

POPULATION DOSE CALCULATIONS

CALCULATION OF POPULATION DOSE COMMITMENTS

Appendix I to 10 CFR 50 sets forth numerical guidelines for design objectives for the release of radioactive materials from light water reactors. Appendix I of the PBNP FSAR contains information utilized to evaluate compliance with the guidelines of 10 CFR 50. Cumulative population man-rem exposure and thyroid-rem exposures are calculated from data provided in Appendix I of the PBNP FSAR.

POPULATION DOSES FROM LIQUID EFFLUENTS

Primary coolant and secondary side liquid and steam source terms and the resulting radioactive releases were calculated using the basic assumptions and approaches recommended by NRC in Regulatory Guide 1.112. Table I.7-2 of the FSAR lists the total liquid radioactive releases expected per year from the Point Beach Nuclear Plant. These releases were calculated assuming provisions for processing of all radioactive liquid waste prior to release to the environment. The listed released activities will result from full operation of processing equipment. Table I.7-3 lists calculated annual liquid releases from PBNP by source.

Tables I.8-6 thru I.8-9 of the FSAR list annual doses to the maximum offsite individual in each of four age groups. These doses will result from the release of the quantity of radioactivity listed in Table I.7-2. The doses were calculated in accordance with parameters and assumptions of NRC Regulatory Guide 1.109. Exposure pathways considered include ingestion of potable water, ingestion of fish, ingestion of fresh and stored vegetables irrigated by the potable water from Lake Michigan, ingestion of cows milk, and ingestion of meat produced from animals consuming potable water.

Four potable water sources are affected by liquid effluent releases from PBNP. The Green Bay water intake is located approximately 13 miles north of the plant. The Two Rivers Water intake is located 12 miles south of the plant, the Manitowoc water intake is located 13 miles south of the plant and the Sheboygan water intake is located 40 miles south of the plant. Dilution factors for the Green Bay, Two Rivers, and Manitowoc intakes are approximately equal. Doses listed in Tables I.8-6 thru I.8-9 were calculated for Two Rivers potable water; however the calculated ingestion doses would also be applicable to any individual using Green Bay or Manitowoc potable water. The dilution factor for the Sheboygan potable water source is calculated to be 150 using the hydrological model of Section I.8-5 of the FSAR. The maximum annual dose for individuals using the Sheboygan potable water is therefore 67% of those listed for Two Rivers.

The total population served by the four potable water supplies are as follows:

Two Rivers	13,350
Manitowoc	32,500
Green Bay	87,900
Sheboygan	54,950

The age distribution of the population is assumed to be as follows:

Adults	71%
Teenager	11%
Child	16%
Infant	2%

The annual doses listed in Tables I.8-6 thru I.8-9 were derived utilizing maximum consumption as usage factors. Population doses are calculated assuming average usage factors. The annual doses listed in Tables I.8-6 thru I.8-9 are corrected for average usage factors.

Integrated total body and thyroid doses to the population utilizing potable water sources within 50 miles of Point Beach Nuclear Plant are calculated for each pathway as follows:

$$D_j^P = 0.001 \sum_d P_d \sum_a D_{jda} F_{da}$$

where

D_j^P = the annual population - integrated dose to organ; (total body or thyroid) in man-rems or thyroid-rems,

P_d = the population associated with subregion d,

F_{da} = the fraction of the population in subregion d that is in age group a, and

D_{jda} = the annual dose to organ j (total body or thyroid) of an average individual of age group a in subregion d, in mrem/year.

Values of Djda are calculated for each pathway as follows:

$$Djda = D^{MAX}_{jda} \times \frac{U_a^{AVE}}{U_a^{MAX}} \times DFC_d$$

Where

D^{MAX}_{jda} = the annual dose to organ; (total body or thyroid) to maximum individual in age group a in subregion d. Values are Listed in FSAR Appendix I Tables I.8-6 thru I.8-9.

$\frac{U_a^{AVE}}{U_a^{MAX}}$ = usage factor correction,

U_a^{AVE} = usage or consumption factor for average individual for age group a,

U_a^{MAX} = usage or consumption factor for maximum individual for age group a. These values were used to derive Appendix I doses, and

DFC_d = Dilution Factor Correction. For Green Bay, Two Rivers, and Manitowoc DFC = 1. for Sheboygan DFC = 0.66.

Population total body and thyroid doses from liquid releases via potable water, ingestion of stored and fresh vegetables, ingestion of cow's milk, and ingestion of meat pathways are listed in attached Tables 1 thru 8.

The edible harvest of both sport and commercial fish is estimated as 6.74E+04 Kilograms per year as described in the PBNP FES. The entire edible fish harvest is conservatively assumed to be ingested by the population within 50 miles. It is assumed that of the total harvest, 4.78E+04 Kg are consumed by adults, 7.41E+03 Kg are consumed by teenagers, and 1.25E+04 Kg are consumed by children. The annual doses listed in FSAR Tables I.8-6 thru I.8-8 assume fish consumption rates of 21, 16, and 6.9 kilograms per year for an adult, teen and child respectively. The Appendix I calculated doses assume all fish are caught at the edge of the initial mixing zone. A mixing zone dilution factor of 5 was used for Appendix I calculations. For purposes of estimating population doses a dilution factor of 50 is assumed.

Thyroid and whole body population doses from ingestion of fish are calculated as follows for each age group:

$$D_{ja} = \frac{D^{MAX}}{\text{consumption rate}} \times \frac{5}{50} \times \text{edible harvest consumption}$$

where

D^{MAX} = annual dose reported in FSAR Tables I.8-6 thru I.8-9 for ingestion of fish,

Consumption rate = consumption data used for Appendix I calculation; ie 21 Kg for adult, 16 Kg for teenager and 6.9 Kg for children,

5/50 = correction to mixing zone dilution factor. Appendix I doses assumed dilution factor of 5. All fish are not caught at edge of initial mixing zone therefore dilution correction is made, and

edible harvest consumption = kilograms of fish consumed

Thyroid and whole body doses resulting from ingestion of fish are listed in Tables 9 and 10.

The annual total population doses from all pathways from liquid releases are listed in Table 11. These doses would be expected from 1% fuel failure and full operation of all liquid radwaste processing equipment. The total whole body dose is 2.12E-01 man-rem. The total thyroid dose is 2.49E+00 thyroid-rem.

The thyroid population dose of 2.49E+00 thyroid-rem results from liquid effluent release quantities of 8.29E-01 Equivalent Curies of Iodine-131. Release limits are defined by scaling the calculated releases upward to the point at which corresponding doses reach the applicable limit specified in Appendix I of 10 CFR 50. The FSAR calculated maximum dose rate resulting from liquid effluents is 1.90E-01 mrem/year. The 10 CFR 50 Appendix I limit is 6 mrem/year. Therefore the FSAR release values may be scaled upward by a factor of 31.6 to derive the Appendix I release limit. These values are summarized below.

	Release Quantity I-131 Equivalent Curies	Dose Rate mrem/year	Total Population Thyroid Dose thyroid-rem
FSAR Calculated Values	8.29E-01	1.90E-01	2.49E+00
Appendix Release Limits	2.62E+01	6.00E+00	7.87E+01

Using the same approach for particulates in liquid effluents yields the following table:

	Release Quantity CO-60 Equivalent Curies	Dose Rate mrem/year	Total Population Whole Body Dose man-rem
FSAR Calculated Values	2.97E+00	1.90E-01	2.12E-01
Appendix I Release Limits	9.47E+01	6.00E+00	6.69E+00

POPULATION DOSES FROM GASEOUS RELEASES

Table I.7-1 of the PBNP FSAR lists calculated annual gaseous releases from the Point Beach Nuclear Plant. These releases were calculated assuming for the processing of all gaseous effluents prior to release to the environment. The listed releases will result from utilization of the gas decay system and waste path HEPA and charcoal filters.

The annual dose to a maximum individual from noble gases in gaseous effluents is 2.7E-02 mrem/year as listed in FSAR Table I.8-5. This maximum dose will occur at 1460 meters from PBNP in the SSW section. The maximum dose is calculated assuming 100% occupancy and no structural shielding. For purposes of population exposure calculations a structural shielding and occupancy factor of 0.5 is applied. Therefore the maximum dose is adjusted to 1.35E-02 mrem/year. This dose will result from noble gas release totals in FSAR Table I.7-1.

The individual dose expected in each subregion may be estimated by the following equation:

$$Dose_j = 1.35E\text{-}02 \times \frac{X/Q_j}{X/Q_{MAX}}$$

where

$Dose_j$ = Average dose rate in subregion;, mrem/year

1.35E-02 = Maximum dose from noble gas releases; SSW at 1460 Meters

X/Q_j = X/Q in subregion j

X/Q_{MAX} = X/Q in sector SSW at 1460 meters

The X/Q values will differ for each subregion depending on the release mode and release elevation. This analysis utilized X/Q values generated from the average of the three most prominent release modes and pathways. The X/Q values were calculated by averaging values from FSAR Tables I.4-4, I.4-8, I.4-10. The annual average X/Q values are listed in Table 12.

Table 13 lists fractional values derived by dividing each subregion X/Q value by the maximum X/Q value. These fractions are multiplied by the maximum annual dose of 1.35E-02 rem/year to derive the individual annual dose in each subregion. The subregion annual dose is multiplied by the subregion population to achieve the subregion population dose. Subregion populations are listed in Table 15. Total population doses resulting from noble gas releases are listed in Table 16.

The total whole body dose resulting from noble gases released in quantities listed in FSAR Table I.7-1 is 2.94E-02 man-rem. The 2.94E-02 person man-rem results from a noble gas release quantity of 2.81E+03 Equivalent Curies of Xe-133. Release limits are defined by scaling the calculated releases upward to the point at which corresponding doses reach the applicable limit specified in Appendix I to 10 CFR 50. The FSAR calculated maximum annual dose rate is 2.70E-02. The Appendix I annual dose limit is 10 mrem/year. Therefore the FSAR release values may be scaled upward by a factor of 370 to determine Appendix I limits.

These values are summarized below:

	Release Quantity Xe-133 Equivalent Curies	Dose Rate mrem/year	Total Whole Body Population man-rem
FSAR Calculated Values	2.81E+03	2.70E-02	2.94E-02
10 CFR 50 Appendix I Limits	1.04E+06	1.00E+01	1.09E+01

APPENDIX B

RADWASTE PROCESSING COST ESTIMATES

SUMMARY OF ESTIMATED ANNUAL OPERATING AND MAINTENANCE COSTS FOR PBNP RADWASTE TREATMENT SYSTEMS COSTS ASSUME FULL OPERATION OF SYSTEMS

Gaseous Wastes

1. Gas Decay Tank System $33,975

TOTAL = $33,975

Liquid Wastes

Liquid waste system including:

1.	Blowdown Waste Evaporator	$ 780,750
2.	Waste Evaporator (2 GPM)	$ 179,875
3.	Polishing Demineralizers (2)	$ 295,375
4.	Waste Tanks	$ 20,500
5.	System Bag Filters	$ 80,275

TOTAL = $1,356,775

ANNUAL OPERATING AND MAINTENANCE COSTS
PBNP GASEOUS RADWASTE SYSTEMS

System or Component Description: Gas Decay Tank System

Associated Costs

1. Operating Labor, Supervision, and Overhead

   Operations is required to expend 45 min./shift, 7 days/week to operate and surveille the system. Assume $25/hr. Labor Cost = $20,475

   Chemistry and health physics personnel expend 20 hours/month on gas analysis and tank monitoring. Cost = $6,000

2. Maintenance Material and Labor

   Maintenance hours performed per year on system is 100 hours. Cost = $2,500

   Maintenance material allotment of $5,000 is assumed. Cost = $5,000

   Operating and Maintenance Annual Cost = $33,975

ANNUAL OPERATING AND MAINTENANCE COSTS
PBNP LIQUID RADWASTE SYSTEMS

System or Component Description: Blowdown Waste Evaporator

Associated Costs:

1. Operating Labor, Supervision, and Overhead

   Operations is required to expend 1.5 hours per day to operate and surveille the blowdown evaporator system. Total labor hours = 550 Assume $25/hour labor
   Cost = $13,750

2. Maintenance Material and Labor

   Maintenance labor hours of 10 hours per week
   Cost = $13,000

   Maintenance material allotment
   Cost = $5,000

   Major maintenance evolution to perform deconning every 3 years; cost including labor and waste processing per year for deconning
   Cost = $25,000

   Major maintenance evolution to perform tube reboring every sixth year
   Cost = $4,000

   Maintenance dose per year is 2 Rem
   Cost = $2,000

3. Waste Disposal

   Approximate waste volume is 10,000 gallons per year. Waste requires 10 liners per year. Liner volume is 178 ft^3. Cost to solidify waste including contract labor, transportation and waste burial is $35,000
   Cost = $350,000

   PBNP labor involved with each liner solidification is 60 hours
   Cost = $15,000

   Dose received during all solidification evaluations is 3 Rem
   Cost = $3,000

4. Steam Cost

   Equivalent Net Electrical Power is 2.0 MWe
   Annual Net Electrical Power Loss is 17,500 MWh
   Annual steam power cost assuming $20/MWh is $350,000
   Cost = $350,000

   Total Annual Operating and Maintenance Cost = $780,750

ANNUAL OPERATING AND MAINTENANCE COSTS
PBNP LIQUID RADWASTE SYSTEMS

System or Component Description: Waste Evaporator (2 GPM)

Associated Costs:

1. Operating Labor, Supervision, and Overhead

Operations is required to expend an estimated 15 minutes/shift
Total labor hours = 275
Cost = $6,875

2. Maintenance Material and Labor

Average maintenance labor hours estimated at 5 per week
Cost = $6,500

Major maintenance including deconning every 3 years and reboring every 7 years. Estimated annual cost is $6,000

Maintenance dose per year is 1 Rem
Cost = $1,000

3. Waste Disposal

Approximate waste gallon per year is 1,000 gallon. Waste requires processing of one 178 ft^3 liner.
Cost = $35,000

PBNP labor required per liner is 60 hours
Cost = $1,500

4. Steam Cost

Equivalent Net Electrical Power is 0.7 MWe.
Annual Net Electrical Power Loss is 6,132 MWh
Annual steam power cost assuming $20/MWh is $123,000
Cost = $123,000

Total Annual Operating and Maintenance Cost = $179,875

ANNUAL OPERATING AND MAINTENANCE COSTS
PBNP LIQUID RADWASTE SYSTEMS

System or Component Description: Polishing Demineralizers (2)

Associated Costs:

1. Operating Labor, Supervision, and Overhead

   Assume 15 minutes per shift. Total hours per year is 275
   Cost = $6,875

2. Maintenance Material and Labor

   Estimated maintenance material allowance of $5,000
   Cost = $5,000

3. Consumables, Chemicals, and Supplies

   Each demineralizer would require new resin approximately every 2 months. Total number of resin changes per year is 12. Twelve changes per year at 35 ft^3/change. Total required resin is 420 $ft.^3$. Cost of resin is $175/$ft^3$.
   Cost = $73,500

4. Waste Disposal

   Total waste volume of 420 ft^3 would require 6 liners. Assume 50:50 ratio resin to cement. Cost of liner solidification is $35,000.
   Cost = $210,000

   Total Operating and Maintenance costs = $295,375

ANNUAL OPERATING AND MAINTENANCE COSTS
PBNP LIQUID RADWASTE SYSTEMS

System or Component Description: Waste Tanks

Tanks include: Steam Generator Blowdown Tank (Unit 1)
Steam Generator Blowdown Tank (Unit 2)
Chemical Drain Tank
Laundry and Hot Shower
Waste Holdup
Waste Distillate Tanks (2)

1. Operating Labor, Supervision, and Overhead

   Assume 5 minutes per shift for log level reading per tank.
   Total hours per day is approximately 1.5.
   Cost = $13,500

2. Maintenance Material and Labor

   Assume maintenance material allowance of $1,000 per tank.
   Cost = $7,000

   Total Annual Operating and Maintenance Cost = $20,500

ANNUAL OPERATING AND MAINTENANCE COSTS
PBNP LIQUID RADWASTE SYSTEMS

System or Component Description: Bag Filters

A total of five filters are considered including:

1. Waste Evaporator Feed Filter
2. Waste Evaporator Bottoms Filter
3. Laundry Drain Filter
4. Unit 1 Steam Generator Blowdown
5. Unit 2 Steam Generator Blowdown

1. Operating Labor, Supervision, and overhead

   a. Feed Filters
      Changes per year estimated = 450
      Hours per change = 0.5
      Total labor cost = $5,625

   b. Bottoms Filters
      Changes per year = 350
      0.5 hours/change
      Total Labor Cost = $4,375

   c. Laundry Filters
      Changes per year 225
      0.25 hours/change
      Total Labor Cost = $1,400

   d. Steam Generator Blowdown Filters
      Changes per year = 600
      0.25 hours/change
      Total Labor Cost = $3,750

2. Cost of Filters

   Total 1,625 filters at $25/filter
   Cost = $40,625

3. Waste Disposal

   For steam generator blowdown and laundry filters, 50 filters per waste drum. Total drums = 17; Cost for drum disposal = $500
   Cost = $8,500

   For blowdown and feed filters, 25 filters per drum (drums are shielded). Total drums = 32; Cost of disposal = $500/drum
   Cost = $16,000

   Total Annual Operating and Maintenance Costs = $80,275

APPENDIX C
COST ANALYSIS CALCULATIONS

COST ANALYSIS CALCULATIONS FOR LIQUID RADWASTE PROCESSING

In order to comply with 10 CFR 50 Appendix I dose limits, liquid radwaste effluents must be maintained at less than 2.62E+01 Equivalent Curies of I-131 and 9.47E+01 Equivalent Curies of Co-60. Activity is released in liquid effluents from the Chemical and Volume Control System (CVCS), the liquid radioactive waste system, and secondary system wastes collected and sent to the retention pond. The CVCS system is operated continuously during normal plant operation. The CVCS will be operated continually except during unlikely periods of system inoperability. Secondary system wastes are collected and routed to the retention pond. Because secondary system wastes are insignificant contributions to total plant liquid releases further processing of these wastes is not provided. The processing of steam generator blowdown and all liquid wastes collected from the controlled side of the plant is not done continually. These wastes may be discharged from the plant without processing. The purpose of this analysis is to determine when it is cost effective to process steam generator blowdown and primary side wastes through the liquid waste system.

There are three radwaste system operating points of interest. These includes; no operation, operation to comply with Appendix I limits, and full operation of the processing systems as described in the FSAR Appendix I analysis. Full operation of the system was assumed for the FSAR Appendix I calculations. The amount of radioactivity expected to be released at each of these operation points is required to be known for this study. PBNP is required to operate processing systems to ensure compliance with 10 CFR 50 limits. Because it is established that liquid effluent releases from the CVCS system will be processed prior to discharge, except for unlikely periods of system inoperability, there is no need to perform a cost analysis on this system. This cost analysis encompasses the liquid radioactive waste system which processes steam generator blowdown and primary side wastes. This analysis will determine the cost of operating the system in excess of that required to accomplish Appendix I release limits.

The cost to operate the liquid radwaste system for processing of steam generator blowdown and primary wastes is calculated by the following methodology:

1. The cost to operate and process all radwaste through the liquid waste system is calculated. This full operation mode was assumed for FSAR Appendix I calculations. (Refer to Appendix B of this analysis)

   Full operation cost = $1,356,775

2. The total quantity of radioactive waste which would be released from PBNP in steam generator blowdown and primary wastes using the Appendix I source terms are calculated assuming no radwaste processing occurs.

   These values are 2.92E+02 Equivalent Curies of Co-60 and 7.06E+01 Equivalent Curies of I-131, a combined total 3.63E+02.

3. Total Curies expected to be released assuming full operation of the liquid waste system is 2.97E+00 Equivalent Curies of Co-60 and 8.29E-01 Equivalent Curies of I-131. The combined total is 3.78E+00.

4. The total Equivalent Curies saved by full operation of the liquid waste processing system is 3.59E+02.

   Curies Saved = Curies No Operation - Curies Full Operation
   3.59E+02 = 3.63E+02 - 3.78E+00

5. The Curies permitted to be released are 9.47E+01 Equivalent Curies of Co-60 and 2.62E+01 equivalent curies of I-131. The combined Curies is 1.21E+02. This release quantity will result in Appendix I dose limits.

6. The Curies necessary to be saved by processing to accomplish Appendix I limits are calculated by subtracting the Curies permitted to be released from the Curies released assuming no operation of processing systems.

   $$Ci_{\text{NEC. SAVE}} = Ci_{\text{No Operation}} - Ci_{\text{APP. I Limit}}$$

   2.41E+02 = 3.62E+02 - 1.21E+02

7. The cost to operate and process liquid waste to achieve Appendix I limits is calculated as follows:

   $$\text{Cost}_{\text{Appendix I Limit}} = \text{Cost}_{\text{Full Operation}} \frac{(\text{Ci NEC to SAVE})}{(\text{Ci SAVED})}$$

   $$\text{Cost}_{\text{Appendix I}} = \$1,356,775 \times \frac{(2.41E+02)}{(3.59E+02)}$$

   $$\text{Cost}_{\text{Appendix I}} = \$909,039$$

   It would cost approximately $909,039 annually to operate the liquid waste processing system to accomplish Appendix I release limits.

8. The incremental increase in cost to process at full operation instead of operation at Appendix I limits is calculated as follows:

   $$\Delta \text{ Cost} = \text{Cost}_{\text{Full Operation}} - \text{Cost}_{\text{App. I Limit}}$$

9. The cost to operate the liquid waste system per man-rem in excess of Appendix I operating requirements is calculated as follows:

$$\text{Cost Benefit} = \frac{\text{Cost}_{\text{Full}} - \text{Cost}_{\text{Limit}}}{\text{Population Dose}_{\substack{\text{App.I}\\ \text{Limit}}} - \text{Population Dose}_{\substack{\text{Full}\\ \text{Operation}}}}$$

$$\text{Cost Benefit} = \frac{\$1{,}356{,}775 - \$909{,}039}{(6.69E{+}00 \text{ man-rem} + 7.87E{+}08 \text{ thyroid-rem}) - (2.12E{-}01 \text{ man-rem} + 2.49E{+}00 \text{ thyroid rem})}$$

$$\text{Cost Benefit} = \frac{\$447{,}736}{82.7 \text{ Rem}}$$

Cost Benefit = \$5413/Rem

The operation of the liquid waste system in excess of the requirements of Appendix I is not cost effective.

COST ANALYSIS FOR GASEOUS RADWASTE PROCESSING

Compliance with 10 CFR 50 dose limits is accomplished if gaseous effluents are maintained less than or equal to 1.04E+06 Equivalent Curies of Xe-133 and 3.52E-01 Equivalent Curies of I-131. Ventilation air from the auxiliary building is released to atmosphere through the auxiliary building vent and drumming area vent stacks. The air is exhausted through HEPA and/or carbon absorber equipment. Similarly, the containment ventilation purge systems include HEPA and carbon absorber equipment. At this time there is no benefit gained by non-operation of the ventilation exhaust filtration systems. These filtration systems are expected to operate continually except for during unlikely periods of system inoperability.

The compressed gas decay tank system is used to process noble gases stripped from primary letdown. The purpose of this analysis is to determine when it is cost effective to process noble gases through the gas decay tank system.

The gas decay tank system will be operated to ensure compliance with 10 CFR 50 limits. The need to operate the gas decay tank system beyond that required to achieve Appendix I limits is determined by analyzing the cost of operation required to save population whole body exposure. If the cost to save 1 man-rem whole body exposure is in excess of \$1000 the operation of the gas decay tank system is not justified.

The cost to operate the gas decay tank system for processing of stripped noble gases is calculated using the following methodology.

1. The cost to operate the gas decay tank system for processing of all stripped noble gases is calculated. The full operation mode was assumed for Appendix I calculations. (Refer to Appendix B of this analysis)

   Full operation cost = $33,975

2. Calculate the total quantity of noble gases expected to be released from PBNP if stripped gases are not processed. This quantity is calculated assuming a letdown rate of 39,600 lbs. per hour. All noble gases contained in the letdown are assumed stripped by the gas strippers. The primary coolant source term is listed in FSAR Table I.3-2.

   The Total activity is calculated as 1.83E+06 Equivalent Curies of Xe-133.

3. The total quantity of radioactivity expected to be released if all stripped gas is processed through the gas decay tank system is 2.81E+03 Equivalent Curies of Xe-133.

4. The total Xe-133 Equivalent Curies saved by the full operation of the gas decay tank system is 1.83E+06.

   Curies Saved = 1.83E+06 - 2.81E+03

   Curies Saved $\cong$ 1.83E+06

5. The Curies necessary to be saved to comply with Appendix I limits are calculated by subtracting the Curies permitted to be released by the Curies released assuming no operation of the gas decay tank system.

   $$Ci_{\text{NEC. to SAVE}} = Ci_{\text{No operation}} - Ci_{\substack{\text{App. I}\\ \text{Limit}}}$$

   $$Ci_{\text{NEC. to SAVE}} = 1.83E{+}06 - 1.04E{+}06$$

   $$Ci_{\text{NEC. to SAVE}} = 7.90E{+}05 \text{ Eq. Ci of Xe-133}$$

6. The cost to operate the gas decay tank system to achieve Appendix I limits is calculated as follows:

   $$Cost_{\substack{\text{Appendix}\\ \text{I}\\ \text{Limit}}} = Cost_{\substack{\text{Full}\\ \text{Operation}}} \frac{(Ci_{\text{NEC to Save}})}{(Ci_{\text{SAVED}})}$$

   $$Cost_{\substack{\text{Appendix}\\ \text{I}}} = \$33,975 \times \frac{(7.90E{+}05)}{(1.83E{+}06)}$$

   $$Cost_{\substack{\text{Appendix}\\ \text{I}}} = \$14,609$$

7. The incremental cost increase to operate the gas decay tank system at full power operation instead of operation at Appendix I limits is calculated as follows:

$$\Delta \text{ Cost} = \text{Cost}_{\text{Full}} - \text{Cost}_{\substack{\text{App. I} \\ \text{Limit}}}$$

8. The cost to operate the gas decay tank system per man-rem in excess of Appendix I operating requirements is calculated as follows:

$$\text{Cost Benefit} = \frac{\text{Cost}_{\text{Full}} - \text{Cost}_{\text{Limit}}}{\text{Population Dose Limit} - \text{Population Dose Full}}$$

$$\text{Cost Benefit} = \frac{33{,}975 - 14{,}609}{1.09\text{E+01} - 2.94\text{E-02}}$$

Cost Benefit = \$1,783/man-rem

There is no cost advantage to operating the gas decay tank system to maintain releases lower than the Appendix I limits.