TRANSMITTAL MANIFEST

NORTHERN STATES POWER COMPANY

NUCLEAR GENERATION DEPARTMENT

<u>PRAIRIE ISLAND NUCLEAR GENERATING PLANT</u>

Effluent and Waste Disposal Semiannual Report
for July 1, 1990 through December 31, 1990

Manifest Date: March 6, 1991

USNRC	4
*Regional Admin-III	
*NRR Project Manager	
*DCD	
*Resident Inspector	
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D A Schuelke	1
P H Kamman	1
Prairie Island Site General Mgr	1
Monticello Plant Manager	1
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Communications Department	1
*NRS File	1
NSS File	1
*MDH	1
Attn: Commissioner of Health	
*MPCA	1
Attn: J W Ferman	

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Fluor Daniels	3
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*J A Thie	
*Secretary	
Manifest File	

*Includes PCP and ODCM revisions

IE48

EFFLUENT SEMIANNUAL REPORT

31-DEC-89 THROUGH 30-JUN-90

SUPPLEMENTAL INFORMATION

Facility: Prairie Island Nuclear Generating Plant

Licensee: Northern States Power Company

License Numbers: DPR-42 & DPR-60

A. Regulatory Limits

1. **Liquid Effluents:**

a. The dose or dose commitment to an individual from radioactive materials in liquid effluents released from the site shall be limited to:

for the quarter	3.0 mrem to the total body 10.0 mrem to any organ
for the year	6.0 mrem to the total body 20.0 mrem to any organ

2. **Gaseous Effluents:**

a. The dose rate due to radioactive materials released in gaseous effluents from the site shall be limited to:

noble gases	≤500 mrem/year total body ≤3000 mrem/year skin
I-131, H-3, LLP	≤1500 mrem/year to any organ

b. The dose due to radioactive gaseous effluents shall be limited to:

noble gases	≤10 mrad/quarter gamma ≤20 mrad/quarter beta ≤20 mrad/year gamma ≤40 mrad/year beta
I-131, H-3, LLP	≤15 mrem/quarter to any organ ≤30 mrem/year to any organ

B. Maximum Permissible Concentration

1. Fission and activation gases in gaseous releases:

   10 CFR 20, Appendix B, Table 2, Column 1

2. Iodine and particulates with halflives greater than 8 days in gaseous releases:

   10 CFR 20, Appendix B, Table 2, Column 1

3. Liquid effluents for radionuclides other than dissolved or entrained gases:

   10 CFR 20, Appendix B, Table 2, Column 2

4. Liquid effluent dissolved and entrained gases:

   2.0E-04 uCi/ml Total Activity

C. Average Energy

Not applicable to Prairie Island regulatory limits.

D. Measurements and approximations of total activity

1. Fission and activation gases in gaseous releases:	Total	GeLi	±25%
	Nuclide	GeLi	
2. Iodines in gaseous releases:	Total	GeLi	±25%
	Nuclide	GeLi	
3. Particulates in gaseous releases:	Total	GeLi	±25%
	Nuclide	GeLi	
4. Liquid effluents	Total	GeLi	±25%
	Nuclide	GeLi	

1.0 BATCH RELEASES (LIQUID)	QTR: 01	QTR: 02
1.1 NUMBER OF BATCH RELEASES	7.70E+01	3.40E+01
1.2 TOTAL TIME PERIOD (HRS)	1.25E+02	6.05E+01
1.3 MAXIMUM TIME PERIOD (HRS)	2.75E+00	7.47E+00
1.4 AVERAGE TIME PERIOD (HRS)	1.63E+00	1.78E+00
1.5 MINIMUM TIME PERIOD (HRS)	1.33E+00	1.33E+00
1.6 AVERAGE MISSISSIPPI RIVER FLOW (CFS)	9.38E+03	2.23E+04

2.0 BATCH RELEASES (GASEOUS)	QTR: 01	QTR: 02
2.1 NUMBER OF BATCH RELEASES	3.60E+01	1.50E+01
2.2 TOTAL TIME PERIOD (HRS)	2.67E+02	1.43E+02
2.3 MAXIMUM TIME PERIOD (HRS)	2.35E+01	2.40E+01
2.4 AVERAGE TIME PERIOD (HRS)	7.42E+00	9.51E+00
2.5 MINIMUM TIME PERIOD (HRS)	1.00E-02	7.00E-02

3.0 ABNORMAL RELEASES (LIQUID)	QTR: 01	QTR: 02
3.1 NUMBER OF RELEASES	0.00E+00	0.00E+00
3.2 TOTAL ACTIVITY RELEASED (CI)	0.00E+00	0.00E+00
3.3 TOTAL TRITIUM RELEASED (CI)	0.00E+00	0.00E+00

4.0 ABNORMAL RELEASES (GASEOUS)	QTR: 01	QTR: 02
4.1 NUMBER OF RELEASES	0.00E+00	0.00E+00
4.2 TOTAL ACTIVITY RELEASED (CI)	0.00E+00	0.00E+00

TABLE 1A
GASEOUS EFFLUENTS - SUMMATION OF ALL RELEASES

	QTR: 01	QTR: 02
5.0 FISSION AND ACTIVATION GASES		
5.1 TOTAL RELEASE (CI)	8.02E+01	3.91E-01
5.2 AVERAGE RELEASE RATE (UCI/SEC)	1.02E+01	4.97E-02
5.3 GAMMA DOSE (MRAD)	5.05E-02	3.25E-05
5.4 BETA DOSE (MRAD)	1.56E-01	3.17E-03
5.5 PE `ENT OF GAMMA TECH SPEC (%)	5.05E-01	3.25E-04
5.6 PERCENT OF BETA TECH SPEC (%)	7.80E-01	1.59E-02
6.0 IODINES		
6.1 TOTAL I-131 (CI)	1.42E-03	1.79E-06
6.2 AVERAGE RELEASE RATE (UCI/SEC)	1.81E-04	2.28E-07
7.0 PARTICULATES		
7.1 TOTAL RELEASE (CI)	2.19E-05	3.25E-06
7.2 AVERAGE RELEASE RATE (UCI/SEC)	2.79E-06	4.13E-07
8.0 TRITIUM		
8.1 TOTAL RELEASE (CI)	5.91E+01	3.74E+01
8.2 AVERAGE RELEASE RATE (UCI/SEC)	7.52E+00	4.76E+00
9.0 TOTAL IODINE, PARTICULATE AND TRITIUM (UCI/SEC)	7.52E+00	4.76E+00
10.0 DOSE (MREM)	2.01E-01	6.10E-02
11.0 PERCENT OF TECH SPEC (%)	1.34E+00	4.07E-01
12.0 GROSS ALPHA (CI)	1.56E-07	2.48E-07

TABLE 1C
GASEOUS EFFLUENTS - GROUND LEVEL RELEASES

13.0 FISSION AND ACTIVATION GASES

		CONTINUOUS MODE		BATCH MODE	
NUCLIDE	UNITS	QTR: 01	QTR: 02	QTR: 01	QTR: 02
AR-41	CI			5.01E-02	
KR-85	CI			1.47E+00	3.86E-01
KR-85M	CI	1.51E-02		3.02E-03	
KR-88	CI			1.28E-04	
XE-131M	CI	4.25E-01		4.64E-01	3.92E-03
XE-133	CI	6.11E+01		1.54E+01	1.46E-03
XE-133M	CI	5.62E-01		9.37E-02	
XE-135	CI	6.45E-01		6.43E-02	
TOTAL	CI	6.27E+01	0.00E+00	1.75E+01	3.91E-01

14.0 IODINES

		CONTINUOUS MODE		BATCH MODE	
NUCLIDE	UNITS	QTR: 01	QTR: 02	QTR: 01	QTR: 02
I-131	CI	1.42E-03	1.79E-06	3.91E-06	
I-133	CI	4.48E-05	4.54E-06	2.30E-06	
TOTAL	CI	1.46E-03	6.33E-06	6.21E-06	0.00E+00

TABLE 2A
GASEOUS EFFLUENTS - SUMMATION OF ALL RELEASES

15.0 PARTICULATES

NUCLIDE	UNITS	CONTINUOUS MODE QTR: 01	CONTINUOUS MODE QTR: 02	BATCH MODE QTR: 01	BATCH MODE QTR: 02
CD-109	CI	2.64E-06			
CO-60	CI	3.87E-06			
CS-134	CI	2.34E-06	1.18E-06	1.38E-06	
CS-137	CI	8.92E-06	1.38E-06	1.57E-06	
SB-125	CI	1.19E-06			
SR-89	CI		6.92E-07		
SR-90	CI				
TOTAL	CI	1.89E-05	3.25E-06	2.95E-06	0.00E+00

TABLE 2A
LIQUID EFFLUENTS - SUMMATION OF ALL RELEASES

	QTR: 01	QTR: 02
16.0 VOLUME OF WASTE PRIOR TO DILUTION (LITERS)	5.62E+07	6.47E+07
17.0 VOLUME OF DILUTION WATER (LITERS)	1.09E+11	7.95E+10
18.0 FISSION AND ACTIVATION PRODUCTS		
18.1 TOTAL RELEASE W/O H-3, RADGAS, ALPHA (CI)	8.39E-03	9.12E-03
18.2 AVERAGE DILUTED CONCENTRATION (UCI/ML)	7.69E-11	1.15E-10
19.0 TRITIUM *** SEE ATTACHED NOTE FOR ADDITIONAL TRITIUM DOSE CALCULATIONS		
19.1 TOTAL RELEASE (CI)	1.69E+02	8.63E+01
19.2 AVERAGE DILUTED CONCENTRATION (UCI/ML)	1.55E-06	1.08E-06
20.0 DISSOLVED AND ENTRAINED GASES		
20.1 TOTAL RELEASE (CI)	1.17E-02	3.32E-03
20.2 AVERAGE DILUTED CONCENTRATION (UCI/ML)	1.07E-10	4.18E-11
21.0 GROSS ALPHA (CI)	0.00E+00	4.40E-05
22.0 TOTAL TRITIUM, FISSION AND ACTIVATION PRODUCTS (UCI/ML)	1.55E-06	1.08E-06
23.0 TOTAL BODY DOSE (MREM)	4.33E-04	2.64E-04
24.0 CRITICAL ORGAN		
24.1 DOSE (MREM)	4.33E-04	2.64E-04
24.2 ORGAN	TTL BODY	TTL BODY
25.0 PERCENT OF TOTAL BODY TECH SPEC LIMIT (%)	1.44E-02	8.80E-03
26.0 PERCENT OF CRITICAL ORGAN TECH SPEC LIMIT (%)	1.44E-02	8.80E-03

TABLE 2A
LIQUID EFFLUENTS - SUMMATION OF ALL RELEASES

27.0 **INDIVIDUAL LIQUID EFFLUENT**

		CONTINUOUS MODE		BATCH MODE	
NUCLIDE	UNITS	QTR: 01	QTR: 02	QTR: 01	QTR: 02
AG-110M	CI			1.76E-03	2.15E-03
BE-7	CI			1.11E-05	2.00E-04
CO-58	CI			2.00E-03	9.42E-04
CO-60	CI			7.63E-04	1.08E-03
CS-134	CI			3.10E-06	
CS-137	CI			8.90E-06	1.83E-05
CR-51	CI			9.73E-05	
FE-55	CI			1.99E-03	3.46E-03
FE-59	CI			3.10E-05	
I-131	CI			2.75E-04	
MN-54	CI			9.64E-06	2.02E-05
NB-97	CI			3.75E-05	9.35E-05
SB-122	CI				4.10E-06
SB-124	CI				2.22E-04
SB-125	CI			1.54E-04	8.19E-04
SC-47	CI			5.34E-05	3.25E-06
SN-113	CI			3.59E-05	1.06E-04
SR-89	CI				
SR-90	CI				
SR-92	CI			2.38E-06	
TC-99M	CI				2.32E-06
ZR-97	CI			6.07E-05	
TOTAL	CI	0.00E00	0.00E+00	8.39E-03	9.12E-03

TABLE 2A
LIQUID EFFLUENTS - SUMMATION OF ALL RELEASES

28.0 DISSOLVED AND ENTRAINED GASES

		CONTINUOUS MODE		BATCH MODE	
NUCLIDE	UNITS	QTR: 01	QTR: 02	QTR: 01	QTR: 02
XE-131M	CI			4.50E-04	
XE-133	CI			1.12E-02	2.99E-03
XE-133M	CI			2.65E-05	1.81E-05
XE-135	CI			3.65E-05	3.16E-04
TOTAL	CI			1.17E-02	3.32E-03

ATTACHMENT TO THE 1990 SEMIANNUAL EFFLUENT REPORT REV. 1

Liquid Pathway Dose Calculation

Quarters 1 and 2, 1990

Summary

The total liquid doses to the critical receptor for the first and second quarters of 1990 are 0.0399 and 0.0278 mrem, respectively. These doses are reported in this attachment to the semiannual report.

Background

In October, 1989 a well water sample of a residence close to PI showed low levels of tritium. Initial dose calculation results showed estimated liquid pathway doses a hundred times higher than those reported in past semiannual reports. These results indicated that a new dose pathway should be considered.

Investigation into the cause of the tritium contamination led to the assumption that the flow of water is from the discharge canal downhill toward the Vermilion river. The resident's well draws from the groundwater between the canal and the Vermilion river.

ODCM Considerations

The following calculation is independent of the ODCM. At this time no change will be made to the ODCM. Efforts are currently under way to determine if the tritium levels in the well can be reduced by physical modifications to the discharge structures and/or adjustments to the discharge methods. Results of these efforts should be available in 1990 and the problem will be eliminated or appropriate ODCM changes will be made.

Dose Calculation Assumptions

For the purpose of dose calculation, the dose-maximizing assumption was made that the receptor's concentration of tritium in body water and organic molecules is equal to the average concentration in the discharge canal. The dose conversion factor for this assumption is taken from page 9-3 of NUREG/CR-3332. Its value is 102 mrem/year per uCi/liter of tritium in the body. When adjusted for the units reported for the discharge canal concentration, the dose conversion factor is 2.55E4 mrem/quarter per uCi/ml.

Discussion

The elevated tritium levels were found at the residence which is the critical receptor (0.6 miles to the SSE of the site) for Prairie Island. Therefore, the dose calculated for waterborne tritium is added to the critical receptor's fish pathway dose. This overestimates the dose because the tritium dose from eating fish is accounted for twice.

It should be noted that the total airborne dose (99% plus of which is due to tritium) is greater than the total waterborne tritium dose. Even though the newly identified pathway delivers additional tritium to the critical receptor it is a lower concentration than that already in the body due to airborne exposure.

Dose calculation

Quarter	Dose Conversion Factor (mrem/quarter per uCi/ml)	X	Average Diluted Tritium Concentration (uCi/ml)	=	Whole Body Dose (mrem)	+	Fish Pathway Dose (mrem)	=	Total Liquid Dose (mrem)
1	2.55E4		1.55E-6		3.95E-2		4.33E-4		3.99E-2
2	2.55E4		1.08E-6		2.75E-2		2.64E-4		2.78E-2

Dose Report

LIQUID EFFLUENTS - SUMMATION OF WATERBORNE TRITIUM AND FISH PATHWAYS

	QTR: 01	QTR: 02
TOTAL BODY DOSE (MREM)	3.99E-02	2.78E-02
CRITICAL ORGAN		
DOSE (MREM)	3.99E-02	2.78E-02
ORGAN	TTL BODY	TTL BODY
PERCENT OF TOTAL BODY TECH SPEC LIMIT (%)	1.33E+00	9.27E-01
PERCENT OF CRITICAL ORGAN TECH SPEC LIMIT (%)	1.33E+00	9.27E-01

EFFLUENT SEMIANNUAL REPORT

01-JUL-90 THROUGH 29-DEC-90

SUPPLEMENTAL INFORMATION

Facility: Prairie Island Nuclear Generating Plant

Licensee: Northern States Power Company

License Numbers: DPR-42 & DPR-60

A. Regulatory Limits

1. Liquid Effluents:

a. The dose or dose commitment to an individual from radioactive materials in liquid effluents released from the site shall be limited to:

for the quarter	3.0 mrem to the total body 10.0 mrem to any organ
for the year	6.0 mrem to the total body 20.0 mrem to any organ

2. Gaseous Effluents:

a. The dose rate due to radioactive materials released in gaseous effluents from the site shall be limited to:

noble gases	≤500 mrem/year total body ≤3000 mrem/year skin
I-131, H-3, LLP	≤1500 mrem/year to any organ

b. The dose due to radioactive gaseous effluents shall be limited to:

noble gases	≤10 mrad/quarter gamma ≤20 mrad/quarter beta ≤20 mrad/year gamma ≤40 mrad/year beta
I-131, H-3, LLP	≤15 mrem/quarter to any organ ≤30 mrem/year to any organ

B. Maximum Permissible Concentration

1. Fission and activation gases in gaseous releases:

   10 CFR 20, Appendix B, Table 2, Column 1

2. Iodine and particulates with halflives greater than 8 days in gaseous releases:

   10 CFR 20, Appendix B, Table 2, Column 1

3. Liquid effluents for radionuclides other than dissolved or entrained gases:

   10 CFR 20, Appendix B, Table 2, Column 2

4. Liquid effluent dissolved and entrained gases:

   2.0E-04 uCi/ml Total Activity

C. Average Energy

Not applicable to Prairie Island regulatory limits.

D. Measurements and approximations of total activity

1. Fission and activation gases in gaseous releases:	Total Nuclide	GeLi GeLi	±25%
2. Iodines in gaseous releases:	Total Nuclide	GeLi GeLi	±25%
3. Particulates in gaseous releases:	Total Nuclide	GeLi GeLi	±25%
4. Liquid effluents	Total Nuclide	GeLi GeLi	±25%

E. Manual Revisions

1. Offsite Dose Calculations Manual latest Revision number: 11

   Revision date : 05-OCT-89

2. Process Control Program Manual latest Revision number: 3

   Revision date : 31-MAY-90

1.0 BATCH RELEASES (LIQUID)

	QTR: 03	QTR: 04
1.1 NUMBER OF BATCH RELEASES	4.60E+01	2.50E+01
1.2 TOTAL TIME PERIOD (HRS)	6.83E+01	3.80E+01
1.3 MAXIMUM TIME PERIOD (HRS)	1.92E+00	1.92E+00
1.4 AVERAGE TIME PERIOD (HRS)	1.48E+00	1.52E+00
1.5 MINIMUM TIME PERIOD (HRS)	1.05E+00	1.25E+00
1.6 AVERAGE MISSISSIPPI RIVER FLOW (CFS)	1.52E+04	9.09E+03

2.0 BATCH RELEASES (GASEOUS)

	QTR: 03	QTR: 04
2.1 NUMBER OF BATCH RELEASES	6.00E+00	1.80E+01
2.2 TOTAL TIME PERIOD (HRS)	1.27E+01	4.55E+02
2.3 MAXIMUM TIME PERIOD (HRS)	8.20E+00	6.71E+01
2.4 AVERAGE TIME PERIOD (HRS)	1.37E+00	3.73E+00
2.5 MINIMUM TIME PERIOD (HRS)	2.00E-02	2.00E-02

3.0 ABNORMAL RELEASES (LIQUID)

	QTR: 03	QTR: 04
3.1 NUMBER OF RELEASES	0.00E+00	0.00E+00
3.2 TOTAL ACTIVITY RELEASED (CI)	0.00E+00	0.00E+00
3.3 TOTAL TRITIUM RELEASED (CI)	0.00E+00	0.00E+00

4.0 ABNORMAL RELEASES (GASEOUS)

	QTR: 03	QTR: 04
4.1 NUMBER OF RELEASES	0.00E+00	0.00E+00
4.2 TOTAL ACTIVITY RELEASED (CI)	0.00E+00	0.00E+00

TABLE 1A
GASEOUS EFFLUENTS - SUMMATION OF ALL RELEASES

	QTR: 03	QTR: 04
5.0 FISSION AND ACTIVATION GASES		
5.1 TOTAL RELEASE (CI)	1.35E+00	7.42E-01
5.2 AVERAGE RELEASE RATE (UCI/SEC)	1.72E-01	9.44E-02
5.3 GAMMA DOSE (MRAD)	7.73E-03	3.72E-03
5.4 BETA DOSE (MRAD)	6.05E-03	4.27E-03
5.5 PERCENT OF GAMMA TECH SPEC (%)	7.73E-02	3.72E-02
5.6 PERCENT OF BETA TECH SPEC (%)	3.03E-02	2.14E-02
6.0 IODINES		
6.1 TOTAL I-131 (CI)	0.00E+00	4.56E-07
6.2 AVERAGE RELEASE RATE (UCI/SEC)	0.00E+00	5.80E-08
7.0 PARTICULATES		
7.1 TOTAL RELEASE (CI)	1.10E-06	4.89E-05
7.2 AVERAGE RELEASE RATE (UCI/SEC)	1.40E-07	6.22E-06
8.0 TRITIUM		
8.1 TOTAL RELEASE (CI)	8.48E+00	2.07E+01
8.2 AVERAGE RELEASE RATE (UCI/SEC)	1.08E+00	2.63E+00
9.0 TOTAL IODINE, PARTICULATE AND TRITIUM (UCI/SEC)	1.08E+00	2.63E+00
10.0 DOSE (MREM)	1.53E-02	3.87E-02
11.0 PERCENT OF TECH SPEC (%)	1.02E-01	2.58E-01
12.0 GROSS ALPHA (CI)	2.38E-07	0.00E+00

TABLE 1C
GASEOUS EFFLUENTS - GROUND LEVEL RELEASES

13.0 FISSION AND ACTIVATION GASES

NUCLIDE	UNITS	CONTINUOUS MODE QTR: 03	CONTINUOUS MODE QTR: 04	BATCH MODE QTR: 03	BATCH MODE QTR: 04
AR-41	CI	7.64E-01	3.50E-01		3.55E-03
KR-85	CI			3.78E-01	3.40E-01
KR-85M	CI				
KR-87	CI				
KR-88	CI				4.84E-02
XE-133	CI	1.95E-01		1.62E-02	
XE-133M	CI				2.76E-04
XE-135	CI				
XE-135M	CI				
XE-138	CI				
TOTAL	CI	9.59E-01	3.50E-01	3.94E-01	3.92E-01

14.0 IODINES

NUCLIDE	UNITS	CONTINUOUS MODE QTR: 03	CONTINUOUS MODE QTR: 04	BATCH MODE QTR: 03	BATCH MODE QTR: 04
I-131	CI		4.56E-07		
I-132	CI				
I-133	CI				
I-134	CI				
I-135	CI				
TOTAL	CI	0.00E+00	4.56E-07	0.00E+00	0.00E+00

TABLE 1C
GASEOUS EFFLUENTS - GROUND LEVEL RELEASES

15.0 PARTICULATES

NUCLIDE	UNITS	CONTINUOUS MODE QTR: 03	CONTINUOUS MODE QTR: 04	BATCH MODE QTR: 03	BATCH MODE QTR: 04
SR-89	CI				
SR-90	CI				
CD-109	CI	3.91E-08	2.96E-05		
CO-58	CI	4.83E-07	1.90E-06		1.71E-05
CO-60	CI	5.82E-07	2.53E-07		3.05E-07
TOTAL	CI	1.10E-06	3.18E-05	0.00E+00	1.74E-05

TABLE 2A
LIQUID EFFLUENTS - SUMMATION OF ALL RELEASES

	QTR: 03	QTR: 04
16.0 VOLUME OF WASTE PRIOR TO DILUTION (LITERS)	2.14E+07	3.09E+07
17.0 VOLUME OF DILUTION WATER (LITERS)	2.45E+11	1.58E+11
18.0 FISSION AND ACTIVATION PRODUCTS		
18.1 TOTAL RELEASE W/O H-3, RADGAS, ALPHA (CI)	2.07E-01	2.92E-02
18.2 AVERAGE DILUTED CONCENTRATION (UCI/ML)	8.45E-10	1.85E-10
19.0 TRITIUM		
19.1 TOTAL RELEASE (CI)	7.12E+01	7.10E+01
19.2 AVERAGE DILUTED CONCENTRATION (UCI/ML)	2.91E-07	4.49E-07
20.0 DISSOLVED AND ENTRAINED GASES		
20.1 TOTAL RELEASE (CI)	4.18E-03	1.29E-03
20.2 AVERAGE DILUTED CONCENTRATION (UCI/ML)	1.71E-11	8.16E-12
21.0 GROSS ALPHA (CI)	1.40E-05	0.00E+00
22.0 TOTAL TRITIUM, FISSION AND ACTIVATION PRODUCTS (UCI/ML)	2.92E-07	4.49E-07
23.0 TOTAL BODY DOSE (MREM)	1.64E-03	3.26E-04
24.0 CRITICAL ORGAN		
24.1 DOSE (MREM)	1.64E-03	3.26E-04
24.2 ORGAN	TTL BODY	TTL BODY
25.0 PERCENT OF TOTAL BODY TECH SPEC LIMIT (%)	5.47E-02	1.09E-02
26.0 PERCENT OF CRITICAL ORGAN TECH SPEC LIMIT (%)	2.20E-02	1.09E-01

TABLE 2A
LIQUID EFFLUENTS - SUMMATION OF ALL RELEASES

27.0 INDIVIDUAL LIQUID EFFLUENT

		CONTINUOUS MODE		BATCH MODE	
NUCLIDE	UNITS	QTR: 03	QTR: 04	QTR: 03	QTR: 04
AG-110M	CI			1.38E-02	9.71E-03
BE-7	CI			3.45E-04	5.55E-05
CO-58	CI			2.81E-02	2.61E-03
CO-60	CI			3.73E-03	4.09E-03
CS-134	CI			1.26E-04	1.81E-05
CS-137	CI	2.76E-06		1.88E-04	
CS-136	CI			2.77E-06	
CR-51	CI			1.49E-03	1.35E-03
CO-57	CI			2.20E-05	8.85E-05
CE-144	CI			4.65E-05	
FE-55	CI			1.83E-02	2.27E-03
FE-59	CI			2.37E-03	2.63E-03
LA-140	CI			2.23E-05	1.56E-06
LA-142	CI			3.60E-06	
MN-54	CI			2.02E-04	1.45E-04
NB-97	CI			5.90E-06	
ND-147	CI				7.12E-06
SB-122	CI			7.21E-04	
SB-124	CI			3.90E-03	2.71E-03
SB-125	CI			1.71E-03	2.43E-03
SB-126	CI			1.44E-05	
SC-47	CI			2.03E-04	2.33E-04
SN-113	CI			2.90E-04	8.62E-04

CONTINUED

TABLE 2A
LIQUID EFFLUENTS - SUMMATION OF ALL RELEASES

INDIVIDUAL LIQUID EFFLUENT (CONTINUED)

NUCLIDE	UNITS	CONTINUOUS MODE QTR: 03	CONTINUOUS MODE QTR: 04	BATCH MODE QTR: 03	BATCH MODE QTR: 04
SR-92	CI				5.82E-06
TC-99M	CI			5.00E-06	2.00E-06
RH-105	CI				4.78E-06
ZN-65	CI				3.34E-05
ZR-97	CI				2.95E-06
SR-89	CI	1.31E-03			
SR-90	CI				
TOTAL	CI	1.31E-03	0.00E+00	7.56E-02	2.93E-02

28.0 DISSOLVED AND ENTRAINED GASES

NUCLIDE	UNITS	CONTINUOUS MODE QTR: 03	CONTINUOUS MODE QTR: 04	BATCH MODE QTR: 03	BATCH MODE QTR: 04
AR-41	CI			2.50E-05	
KR-85	CI				
KR-85M	CI				
KR-87	CI				
KR-88	CI				
XE-133	CI			4.03E-03	1.27E-03
XE-133M	CI			2.88E-05	1.57E-05
XE-135	CI			9.82E-05	4.27E-06
XE-135M	CI				
XE-138	CI				
TOTAL	CI	0.00E+00	0.00E+00	4.18E-03	1.29E-03

PRAIRIE ISLAND NUCLEAR GENERATING PLANT
NORTHERN STATES POWER

Period: 7-1-90 to 12-31-90
License No. DPR-42

SOLID RADIOACTIVE WASTE DISPOSAL SEMI-ANNUAL REPORT

Table I: Solid Waste and Irradiated Fuel Shipments

1. Solid Waste Total Volumes and Total Curie Quantities:

Type of Waste	Units	Totals	Container Disposal Volumes (List)
A. Resins	ft^3	988.9	135.8
	Ci	282.690	178.0
			183.3
B. Dry-Compacted	ft^3		
	Ci		
C. Non-Compacted	ft^3	83.0	96
	Ci	0.232	
D. Filter Media	ft^3		
	Ci		
S. Spent Fuel	ft^3		
	Ci		

PRAIRIE ISLAND NUCLEAR GENERATING PLANT
NORTHERN STATES POWER

Period: 7-1-90 to 12-31-90
License No. DPR-42

SOLID RADIOACTIVE WASTE DISPOSAL SEMI-ANNUAL REPORT

Table I: Solid Waste and Irradiated Fuel Shipments (Continued)

2. Principal Radionuclide Composition by Type of Waste:

TYPE (From Page 1)	Nuclide	Percent Abundance
A	CO-60	38.0
	* NI-63	21.9
	CO-58	13.8
	* FE-55	11.2
	CS-137	8.0
	CS-134	3.6
	MN-54	2.0
C	* FE-55	46.5
	CO-60	29.5
	* C-14	11.3
	* NI-63	11.1
	* H-3	1.6

* = Inferred - Not Measured on Site

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PRAIRIE ISLAND NUCLEAR GENERATING PLANT
NORTHERN STATES POWER

.riod: 7-1-90 to 12-31-90
License No. DPR-42

SOLID RADIOACTIVE WASTE DISPOSAL SEMI-ANNUAL REPORT

Table I: Solid Waste and Irradiated Fuel Shipments (Continued)

2. Principal Radionuclide Composition by Type of Waste (Continuation):

TYPE (From Page 1)	Nuclide	Percent Abundance

* = Inferred - Not Measured on Site

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PRAIRIE ISLAND NUCLEAR GENERATING PLANT
NORTHERN STATES POWER

Period: 7-1-90 to 12-31-90
License No. DPR-42

SOLID RADIOACTIVE WASTE DISPOSAL SEMI-ANNUAL REPORT

Table I: Solid Waste and Irradiated Fuel Shipments (Continued)

3. Solid Waste Disposition:

Number of Shipments	Mode	Destination
2	TRUCK	BARNWELL
2	TRUCK	OAK RIDGE
4	TRUCK	RICHLAND

4. Irradiated Fuel Shipments:

Number of Shipments	Mode	Destination
0		

PRAIRIE ISLAND NUCLEAR GENERATING PLANT
NORTHERN STATES POWER

Period: 7-1-90 tp 12-31-90
License No. DPR-42

SOLID RADIOACTIVE WASTE DISPOSAL SEMI-ANNUAL REPORT

Table I: Solid Waste and Irradiated Fuel Shipments (Continued)

5. Shipping Container and Solidification Method:

No.	Disposal Volume (Ft3)	Activity (Ci)	Type of Waste	Container Code	Solidif. Code
90-22	44.8	0.108	C	L	N/A
90-25	135.8	196.777	A	A	N/A
87-39	38.2	0.123	C	L	N/A
90-33	135.8	77.044	A	A	N/A
90-34	178.0	1.100	A	L	N/A
90-35	178.0	2.626	A	L	N/A
90-36	178.0	1.347	A	L	N/A
90-37	183.3	3.796	A	L	N/A
TOTALS 8	1071.9	282.921			

CONTAINER CODES: (Shipment Type)
L = LSA
A = Type A
B = Type B
Q = Highway Route Controlled Quantity

SOLIDIFICATION CODES: C = Cement

TYPES OF WASTE:
A = Resins
B = Dry Compacted
C = Non-Compacted
D = Filter Media
S = Spent Fuel

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NORTHERN STATES POWER COMPANY

PRAIRIE ISLAND NUCLEAR GENERATING PLANT OFF-SITE RADIATION DOSE ASSESSMENT FOR

January 1- December 31, 1990

An assessment of radiation dose due to release from the Prairie Island Nuclear Generating Plant during 1990 was performed in accordance with the Technical Specifications. Computed doses were well below the 40 CFR Part 190 Standards and 10 CFR Part 50 Appendix I Guidelines.

Off-site dose calculation formulas and meteorological data from the Off-site Dose Calculation Manual were used in making this assessment. Source terms were obtained from the two Effluent and Waste Disposal Semiannual Reports prepared for NRC review during the year of 1990.

Off-site Doses from Gaseous Release

Computed doses due to gaseous releases are reported in Table 1. Critical receptor location and pathways for organ doses are reported in Table 2. Doses, both whole body and organ, are a small percentage of Appendix I Guidelines.

Off-site Doses from Liquid Release

Computed doses due to liquid releases are reported in Table 1. Receptor information is reported in Table 2. Both whole body dose and organ dose are a small percentage of Appendix I Guidelines.

Doses to Individuals Due to Activities Inside the Site Boundary

Occasionally sportsmen enter the Prairie Island site for recreational activities. These individuals are not expected to spend more than a few hours per year within the site boundary. Commercial and recreational river traffic exists through this area.

For purposes of estimating the dose due to recreational and river water transportation activities within the site boundary, it is assumed that the limiting dose within the site boundary would be received by an individual who spends a total of seven days per year on the river just off shore from the main plant buildings (ESE at 0.2 miles). Whole body and inhalation organ doses were calculated for this location and occupancy time. These doses were reported in Table 1.

Doses to Most Exposed Member of the General Public from Reactor Releases and Other Uranium Fuel Cycle Sources

There are no other uranium fuel facilities in the vicinity of the Prairie Island site. The only other artificial source of exposure to the general public in addition to the plant effluent releases is from direct radiation of the reactors. This direct radiation from pressurized water reactors has been shown to be negligible. An array of TLD monitoring stations around the perimeter of the site boundary has consistently indicated that plant operation in the past years has no effect on ambient gamma radiation.

Therefore, the most exposed member of the general public will not receive an annual radiation dose from reactor effluent releases and all other fuel cycle activities in excess of the sum of the liquid and gaseous whole body and organ doses reported in Table 1 for the site boundary and critical receptor, respectively. These doses are well below 40 CFR Part 190 standards of 25 mrem to the whole body, 75 mrem to the thyroid, and 25 mrem to any other organ.

TABLE 1

OFF-SITE RADIATION DOSE ASSESSMENT - PRAIRIE ISLAND

PERIOD: JANUARY 1 through DECEMBER 31, 1990

		10 CFR Part 50 Appendix I Guidelines per 2-units site per year
Gaseous Releases		
Maximum Site Boundary Gamma Air Dose (mrad)	0.0434	20
Maximum Site Boundary Beta Air Dose (mrad)	0.10	40
Maximum Off-site Dose to Any Organ (mrem)* Total	0.351	30
Offshore Location (mrem)		
Whole Body	3.43E-04	10
Organ	4.34E-04	30
Liquid Releases		
Maximum Off-site Dose Whole Body (mrem)	0.0886	6
Maximum Off-site Dose Organ, Total	0.0886	20

* Long-lived Particulates, I-131, and H-3

TABLE 2

OFF-SITE RADIATION DOSE ASSESSMENT - PRAIRIE ISLAND
SUPPLEMENTAL INFORMATION

PERIOD: JANUARY 1 through DECEMBER 31, 1990

Gaseous Releases

Maximum Site Boundary Dose Location (from Building vents)	
Sector	WNW
Distance (miles)	0.36
Offshore Location Within Site Boundary	
Sector	ESE
Distance (miles)	0.2
Maximum Off-site Dose Location	
Sector	SSE
Distance (miles)	0.6
Pathways	Plume, Ground, Inhalation, Vegetables
Age Group	Child
Organ	Thyroid

Liquid Releases

Maximum Off-site Dose Location Downstream	
Pathways	Fish, well water
Age Group	Child
Organ	Whole Body

ATTACHMENT TO THE 1990 SEMIANNUAL EFFLUENT REPORT

Liquid Pathway Dose Calculation

Quarters 3 and 4, 1990

Summary

The total liquid doses to the critical receptor for the third and fourth quarters of 1990 are 0.0091 and 0.0118 mrem, respectively. These doses are reported in this attachment to the semiannual report.

Background

In October, 1989 a well water sample of a residence close to PI showed low levels of tritium. Initial dose calculation results showed estimated liquid pathway doses a hundred times higher than those reported in past semiannual reports. These results indicated that a new dose pathway should be considered.

Investigation into the cause of the tritium contamination led to the assumption that the flow of water is from the discharge canal downhill toward the Vermilion river. The resident's well draws from the groundwater between the canal and the Vermilion river.

ODCM Considerations

The following calculation is independent of the ODCM. At this time no change will be made to the ODCM. Efforts are currently under way to reduce the tritium levels in the well by extending the current radioactive discharge point to the point where the discharge canal empties into the river. Results of these efforts should be available in 1991 and the problem will be eliminated or appropriate ODCM changes will be made.

Dose Calculation Assumptions

For the purpose of dose calculation, the dose-maximizing assumption was made that the receptor's concentration of tritium in body water and organic molecules is equal to the average concentration in the discharge canal. The dose conversion factor for this assumption is taken from page 9-3 of NUREG/CR-3332. Its value is 102 mrem/year per uCi/liter of tritium in the body. When adjusted for the units reported for the discharge canal concentration, the dose conversion factor is 2.55E4 mrem/quarter per uCi/ml.

Discussion

The elevated tritium levels were found at the residence which is the critical receptor (0.6 miles to the SSE of the site) for Prairie Island. Therefore, the dose calculated for waterborne tritium is added to the critical receptor's fish pathway dose. This overestimates the dose because the tritium dose from eating fish is accounted for twice.

It should be noted that the total airborne dose (99% plus of which is due to tritium) is greater than the total waterborne tritium dose. Even though the newly identified pathway delivers additional tritium to the critical receptor it is a lower concentration than that already in the body due to airborne exposure.

Dose calculation

Quarter	Dose Conversion Factor (mrem/quarter per uCi/ml)	X	Average Diluted Tritium Concentration (uCi/ml)	=	Whole Body Dose (mrem)	+	Fish Pathway Dose (mrem)	=	Total Liquid Dose (mrem)
3	2.55E4		2.91E-7		7.42E-3		1.64E-3		9.06E-3
4	2.55E4		4.49E-7		1.14E-2		3.26E-4		1.18E-2

Dose Report

LIQUID EFFLUENTS - SUMMATION OF WATERBORNE TRITIUM AND FISH PATHWAYS

	QTR: 03	QTR: 04
TOTAL BODY DOSE (MREM)	9.06E-03	1.18E-02
CRITICAL ORGAN		
DOSE (MREM)	9.06E-03	1.18E-02
ORGAN	TTL BODY	TTL BODY
PERCENT OF TOTAL BODY TECH SPEC LIMIT (%)	3.02E-01	3.93E-01
PERCENT OF CRITICAL ORGAN TECH SPEC LIMIT (%)	3.02E-01	3.93E-01

DESCRIPTION OF REVISION 11 ODCM MANUAL CHANGES

Effective Date: 05-OCT-1989

The following is a list of changes made to the Offsite Dose Calculation Manual in response to the EG&G Technical Evaluation Report of what was ODCM revision 9 in 1987 and submitted to Northern States Power 5/18/89. NSP's response was discussed and submitted to the NRC prior to the revision of the ODCM Rev. 11 in October of 1989. This is the formal notification of our ODCM change in accordance with T.S. 6.5.E.1.

Item 1: In section 2.3.1, the dilution flow ADFk, was supposed to be the average flow during the reporting period (e.g., one month, one quarter, or one year) and not the "actual dilution flow during the period of release" as previously defined. The definition was correctly defined in revision 11. Though incorrectly defined, this variable has been used correctly in calculations.

Item 2: In section 3.2.2, equation 3.2-1 and the definition for X/Qv were corrected for typographical errors.

Item 3: Table 3.2.1 was corrected for a typographical error.

Item 4: Section 3.3.1 was corrected to reference six plant vents points instead of nine vents, which was incorrect.

Item 5: Section 3.3.1.2 was corrected for a typographical error.

Item 6: Section 3.3.2.1 was corrected to reference the appropriate tables dispersion tables. The tables contained the correct values and were being used correctly, but the ODCM reference were incorrect.

Item 7: Table 5.1-1 was revised to reflect changes in the Radiation Environmental Monitoring Program Sampling Locations and/or description of sample locations. Changes were made to the location/description of the following sample points.

River Water
Drinking Water
Sediment-River
Sediment-Shoreline
Periphyton or Invertebrates
Fish
Milk
Particulate and Radioiodine Air Sampling
Direct Radiation TLDs

Item 8: Figures 5.1-1, 5.1-2 and 5.1-3 were replaced with clearer and more visible maps.

Item 9: Section C.1 of Appendix C were corrected to calculate the value of Pi using the "child" breathing rate (3700 m^3/yr) instead of the "infant" breathing rate (1400 m^3/yr). The actual calculation of Pi was changed to use the child breathing rate instead of the infants in revision 9 to the ODCM but the Appendix C description was not corrected.

Item 10: In Tables 3.3-6 through 3.3-18, there were some inconsistencies between the ODCM methodology and the manner in which the calculations of the R-value (dose factor) was actually performed. The R-values according to the ODCM formulas exceed the ODCM table values by 18 percent for Cs-137 and up to 34 percent for I-131 for the cow milk, goat milk, meat and inhalation pathways. No inconsistencies were found for the inhalation pathway R-values in Tables 3.3-17 and 3.3-18. It was noted that the ODCM table values could be reproduced if a value of 2.59E+06 seconds was used for "te" and a value of 0.5 was used for "fp". Explanations of the use of these variables and their definitions are given below:

The "te" variable

This variable is defined in the ODCM as the "period of pasture grass and crop exposure during the growing season". ODCM tables C-1 and C-2 give two values for "te", one for pasture and one for stored feed. ODCM formulas C.2-3 and C.2-5 each contain two occurrences of "te" with no distinction made for use of the assigned values. The first occurrence is in the part of the equation devoted to pasture and the second occurrence to stored feed. It should be obvious that the pasture value should be used in the first occurrence and stored feed value in the second occurrence. However, the ODCM table values were generated by substituting the pasture value in both variable occurrences.

Use of the pasture value in place of the stored feed value gives a non-conservative result, i.e., the calculated dose factor produces a smaller dose than would be generated using the stored feed value.

The "fp" variable

This variable is defined in the ODCM as the "fraction of the year that the cow or goat is on pasture". A value of 0.667 was assigned to this variable on page 119 of the ODCM, Revision 9. However, a value of 0.5 is used in the NRC GASPAR code annual critical receptor determinations and in the PINGP USAR. The value of 0.5 is also the value used to generate the ODCM table values.

Use of the 0.5 value for "fp" instead of 0.667 gives a non-conservative result, i.e., the calculated dose factor produces a smaller dose than would be generated using the ODCM-assigned value.

The ODCM was modified in the following manner to address these inconsistencies:

a. The "te" variable was split into the variables "tep" and "tes" with the former used in the first part of the milk and meat equations related to animal intake of radionuclides from pasture and the latter will be used in the second part of the equation related to intake from stored feed. The assigned values are 2.59E+06 and 5.18E+06 seconds, respectively. This change will ensure the correct factor for exposure of pasture and stored feeds is used in the dose calculation.

b. The "fp" variable was assigned a value of 0.5 based upon a more realistic 6-month grazing period.

Changing the values of these two variables produced R-values which are a maximum of 6 percent greater than the factors listed in revision 10 of the ODCM. Past dose calculations for the critical receptor have included neither the milk nor the meat pathway since these pathways do not apply at the critical receptor location. Therefore, the revised R-values have no effect on previously calculated doses.

The above described change effected changes to the equations and descriptions listed in Appendix C sections C.2.2, C.2.3, C.2.4 and C.2.5. Changes were also made to Tables C-1, C-2 C-3 to list the values of the variables described above.

RECORD OF REVISIONS

Revision No.	Date	Reason for Revision
Original	June 7, 1979	
1	April 15, 1980	Incorporation of NRC Staff comments and correction of miscellaneous errors
2	August 6, 1982	Incorporation of NRC Staff comments
3	February 21, 1983	Change in milk sampling location
4	November 14, 1983	Change in milk sampling location and change in cooling tower blowdown
5	March 27, 1984	Change Table 3.2-1
6	February 14, 1986	Change in location to collect cultivated crops (leafy green veg.) and removal of meat animals from the land use census.
7	July 31, 1986	Retype and format ODCM. No change in content.
8	January 8, 1987	Addition of Discharge Canal Monitor Setpoint calculation.
9	June 29, 1987	Change inhilation dose factor to child and address change in land use survey.
10	April 27, 1989	Change in method for calculating liquid effluent monitor setpoints. Fix of various typing errors. Change in location of two REMP sampling locations. Deletion of one REMP sampling location.
11	October 5, 1989	Change in Tables 3.3-6 thru 3.3-16. Appendix C equations corrected. Section 5 figures replaced. Sample point definitions corrected.

2.3.1 Determination of Liquid Effluent Dilution

To determine doses from liquid effluents the near field average dilution factor for the period of release must be calculated. This dilution factor must be calculated for each batch release and each continuous release mode. The dilution factor is determined by:

$$F_k = \frac{R_k}{X\ ADF_k} \qquad (2.3\text{-}1)$$

where

R_k = release rate of the batch or continuous releases during the period, k, gpm

ADF_k = average dilution flow during the time period of release k, gpm.

The value of X is the site specific factor for the mixing effect of the PNGP discharge structure. This value is 10 for PNGP while operating in the closed cycle cooling mode. (1) The product of X and ADF_k is limited to 1000 cfs (4.5×10^5 gpm). Therefore, since blowdown flow in closed cycle is 150 cfs, the denominator of Equation 2.3-1 is always 4.5×10^5 in closed cycle. In once through or helper mode, the value of X is reduced to 1.0.

2.3.2 Dose Calculations

The dose contribution from the release of liquid effluents will be calculated monthly. The dose contribution will be calculated using the following equation:
where:

$$D\tau = \sum_k \sum_i A_{i\tau}\ t_k\ C_{ik}\ F_k \qquad (2.3\text{-}2)$$

where:

$D\tau$ = the dose commitment to the total body or any organ τ, from the liquid effluents for the period of release, mrem;

3.2.1 Noble Gases

The dose rate at the site boundary resulting from noble gas effluents is limited by 10 CFR 20 to 500 mrem/yr to the total body and 3000 mrem/yr to the skin. The setpoint determinations discussed in the previous section are based on the dose calculational method presented in NUREG-0133.(2) They represent a backward solution to the limiting dose equations in NUREG-0133. Setting alarm set trip points in this manner will assure that the limits of 10 CFR 20 are met for noble gas releases. Therefore, no routine dose calculations for noble gases will be needed to show compliance with this part. Routine calculations will be made for doses from noble gas releases to show compliance with 10 CFR 50, Appendix I as discussed in Section 3.3.1.

3.2.2 Radioiodine, Radioactive Particulates, and Other Radionuclides

The dose rate at the site boundary resulting from the release of radioiodines and particulates with half lives greater than 8 days is limited by 10 CFR 20 to 1500 mrem/yr to any organ. Calculations showing compliance with this dose rate limit will be performed for batch releases prior to the release and weekly for all releases. The calculations will be based on the results of sample analyses obtained pursuant to the PNGP Technical Specifications. To show compliance, Equations 3.2-1 will be evaluated for I-131, tritium, and radioactive particulates with half-lives greater than eight days.

$$\Sigma \; P_{i_I} \left[(\chi/Q_v) \; \dot{Q}_{iv} \right] < 1500 \text{ mrem/yr} \quad (3.2\text{-}1)$$

where

P_{i_I} = child critical organ dose parameter for radionuclide i for the inhalation pathway, mrem/yr per $\mu Ci/m^3$ (Table 3.2-1);

(χ/Q_v) = annual average relative concentration for long-term release at the critical location, sec/m^3 (Appendix A, Table A-3);

TABLE 3.2-1

P_{iI} Values for Child

ISOTOPE	P_{iI} $\frac{mrem/yr}{\mu Ci/m^3}$
H-3	1.12 E 3
Cr-51	1.70 E 4
Mn-54	1.58 E 6
Fe-59	1.27 E 6
Co-58	1.11 E 6
Co-60	7.07 E 6
Zn-65	9.95 E 5
Rb-86	1.98 E 5
Sr-89	2.16 E 6
Sr-90	1.01 E 8
Y-91	2.63 E 6
Zr-95	2.23 E 6
Nb-95	6.14 E 5
Ru-103	6.62 E 5
Ru-106	1.43 E 7
Ag-110m	5.48 E 6
Te-127m	1.48 E 6
Te-129m	1.76 E 6
Cs-134	1.01 E 6
Cs-136	1.71 E 5
Cs-137	9.07 E 5
Ba-140	1.74 E 6
Ce-141	5.44 E 5
Ce-144	1.20 E 7
I-131	1.62 E 7

where:

M_i = The air dose factor due to gamma emission for each identified noble gas radionuclide i, mrad/yr per $\mu Ci/m^3$; (Table 3.3-1)

N_i = the air dose factor due to beta emissions for each identified noble gas radionuclide i, mrad/yr per $\mu Ci/m^3$; (Table 3.3-1)

$(\chi/Q)_v$ = the annual average relative concentration for areas at or beyond the restricted area boundary for long-term vent releases (greater than 500 hr/year), sec/m^3 (Appendix A, Table A-4);

$(\chi/q)_v$ = the relative concentration for areas at or beyond the restricted area boundary for short-term vent releases (equal to or less than 500 hrs/year), sec/m^3 (Appendix A, Table A-7);

q_{iv} = the total release of noble gas radionuclide i in gaseous effluents for short-term vent releases from both units (equal to or less than 500 hrs/year), μCi;

Q_{iv} = the total release of noble gas radionuclide i in gaseous effluents for long-term vent releases from both units (greater than 500 hrs/yr), μCi;

3.17×10^{-8} = the inverse of the number of seconds in a year.

Noble gases will be released from PNGP from up to six vents.

Long-term χ/Q's were given in Appendix A. Short-term χ/q's were calculated using the USNRC computer code "XOQDOQ" assuming 100 hours per year short term releases and are given in Appendix A (Table A-7). Values of M and N were calculated using the methodology presented in NUREG-0133 and are given in Table 3.3-1.

3.3.1.2 Cumulation of Doses

Doses calculated monthly will be summed for comparison with quarterly and annual limits. The monthly results will be added to the doses cumulated from the other months in the quarter of interest and the year of interest and compared to

The above equation will be applied to each combination of age group and organ. Values of R_{ijak} have been calculated using the methodology given in NUREG-0133 and are given in Tables 3.3-2 through 3.3-20. Dose factors for isotopes not listed will be determined in accordance with the methodology in Appendix C. Equation 3.3-3 will be applied to a controlling location which will have one or more of the following: residence, vegetable garden and milk animal. The selection of the actual receptor is discussed in Section 3.3.4. The source terms and dispersion parameters in Equation 3.3-3 are obtained in the same manner as in Section 3.2. The W values are in terms of $\chi/Q(sec/m^3)$ for the inhalation pathways and for tritium (Tables A-4 and A-7) and in terms of $D/Q(1/m^2)$ for all other pathways (Tables A-5 and A-8).

3.3.2.2 Cumulation of Doses

Doses calculated monthly will be summed for comparison with quarterly and annual limits. The monthly results should be added to the doses cumulated from the other months in the quarter of interest and in the year of interest and compared with the limits in Equation 3.3-3. If these limits are exceeded, a special report will be submitted in accordance with the PNGP Technical Specifications. If twice the limits are exceeded, a special report showing compliance with 40 CFR 190 will be submitted.

3.3.3 Projection of Doses

Doses resulting from the release of gaseous effluents will be projected monthly. The doses calculated for the present month will be used as the projected doses unless information exists indicating that actual releases could differ significantly in the next month. In this case the source terms will be adjusted to reflect this information and the justification for the adjustment noted. If the projected release of noble gases for the month exceeds 2 percent of the calendar year limits of equation 3.3-1 or 3.3-2, additional waste gas treatment will be provided. If the projected release of I-132, tritium, and radioactive particulates with half-lives greater than 8 days exceeds 2 percent of the calendar year limit of equation 3.3-3, operation of the ventilation exhaust treatment equipment is required if not currently in use.

TABLE 3.3-6 R VALUES FOR THE PRAIRIE ISLAND NUCLEAR GENERATING PLANT*

PATHWAY = MEAT
AGE GROUP EQUALS ADULT

NUCLIDE	T. BODY	GI-TRACT	BONE	LIVER	KIDNEY	THYROID	LUNG	SKIN
H 3	3.25E 02	3.25E 02	0.00E-00	3.25E 02	3.25E 02	3.25E 02	3.25E 02	3.25E 02
MN 54	9.46E 05	1.52E 07	0.00E-00	4.96E 06	1.47E 06	0.00E-00	0.00E-00	0.00E-00
FE 59	1.14E 08	9.93E 08	1.27E 08	2.98E 08	0.00E-00	0.00E-00	8.32E 07	0.00E-00
CO 58	1.99E 07	1.80E 08	0.00E-00	8.90E 06	0.00E-00	0.00E-00	0.00E-00	0.00E-00
CO 60	9.37E 07	7.98E 08	0.00E-00	4.25E 07	0.00E-00	0.00E-00	0.00E-00	0.00E-00
SR 89	4.21E 06	2.35E 07	1.47E 08	0.00E-00	0.00E-00	0.00E-00	0.00E-00	0.00E-00
SR 90	1.86E 09	2.19E 08	7.57E 09	0.00E-00	0.00E-00	0.00E-00	0.00E-00	0.00E-00
I 131	4.34E 06	2.00E 06	5.30E 06	7.58E 06	1.30E 07	2.48E 09	0.00E-00	0.00E-00
CS134	7.04E 08	1.51E 07	3.62E 08	8.61E 08	2.79E 08	0.00E-00	9.25E 07	0.00E-00
CS137	4.57E 08	1.35E 07	5.10E 08	6.98E 08	2.37E 08	0.00E-00	7.88E 07	0.00E-00

* R VALUES IN UNITS OF MREM/YR PER μCI/M^3 FOR INHALATION AND TRITIUM, AND IN UNITS OF M^2-MREM/YR PER μCI/SEC FOR ALL OTHERS

TABLE 3.3-7 R VALUES FOR THE PRAIRIE ISLAND NUCLEAR GENERATING PLANT*

PATHWAY = MEAT
AGE GROUP EQUALS TEEN

NUCLIDE	T. BODY	GI-TRACT	BONE	LIVER	KIDNEY	THYROID	LUNG	SKIN
H 3	1.94E 02	1.94E 02	0.00E-00	1.94E 02	1.94E 02	1.94E 02	1.94E 02	1.94E 02
MN 54	7.50E 05	7.75E 06	0.00E-00	3.78E 06	1.13E 06	0.00E-00	0.00E-00	0.00E-00
FE 59	9.13E 07	5.59E 08	1.01E 08	2.36E 08	0.00E-00	0.00E-00	7.46E 07	0.00E-00
CO 58	1.58E 07	9.45E 07	0.00E-00	6.86E 06	0.00E-00	0.00E-00	0.00E-00	0.00E-00
CO 60	7.42E 07	4.29E 08	0.00E-00	3.30E 07	0.00E-00	0.00E-00	0.00E-00	0.00E-00
SR 89	3.55E 06	1.47E 07	1.24E 08	0.00E-00	0.00E-00	0.00E-00	0.00E-00	0.00E-00
SR 90	1.21E 09	1.37E 08	4.90E 09	0.00E-00	0.00E-00	0.00E-00	0.00E-00	0.00E-00
I 131	3.31E 06	1.22E 06	4.40E 06	6.16E 06	1.06E 07	1.80E 09	0.00E-00	0.00E-00
CS134	3.14E 08	8.42E 06	2.88E 08	6.77E 08	2.15E 08	0.00E-00	8.22E 07	0.00E-00
CS137	1.96E 08	8.02E 06	4.24E 08	5.64E 08	1.92E 08	0.00E-00	7.46E 07	0.00E-00

* R VALUES IN UNITS OF MREM/YR PER µCI/M^3 FOR INHALATION AND TRITIUM, AND IN UNITS OF M^2-MREM/YR PER µCI/SEC FOR ALL OTHERS

TABLE 3.3-8 R VALUES FOR THE PRAIRIE ISLAND NUCLEAR GENERATING PLANT*

PATHWAY = MEAT
AGE GROUP EQUALS CHILD

NUCLIDE	T. BODY	GI-TRACT	BONE	LIVER	KIDNEY	THYROID	LUNG	SKIN
H 3	2.34E 02	2.34E 02	0.00E-00	2.34E 02	2.34E 02	2.34E 02	2.34E 02	2.34E 02
MN 54	1.15E 06	3.63E 06	0.00E-00	4.[illegible]3E 06	1.21E 06	0.00E-00	0.00E-00	0.00E-00
FE 59	1.45E 08	3.03E 08	1.80E 08	2.91E 08	0.00E-00	0.00E-00	8.43E 07	0.00E-00
CO 58	2.45E 07	4.67E 07	0.00E-00	8.01E 06	0.00E-00	0.00E-00	0.00E-00	0.00E-00
CO 60	1.15E 08	2.17E 08	0.00E-00	3.91E 07	0.00E-00	0.00E-00	0.00E-00	0.00E-00
SR 89	6.69E 06	9.07E 06	2.34E 08	0.00E-00	0.00E-00	0.00E-00	0.00E-00	0.00E-00
SR 90	1.60E 09	8.52E 07	6.33E 09	0.00E-00	0.00E-00	0.00E-00	0.00E-00	0.00E-00
I 131	4.66E 06	7.31E 05	8.16E 06	8.21E 06	1.35E 07	2.71E 09	0.00E-00	0.00E-00
CS134	1.76E 08	4.49E 06	5.07E 08	8.33E 08	2.58E 08	0.00E-00	9.26E 07	0.00E-00
CS137	1.10E 08	4.68E 06	7.81E 08	7.47E 08	2.43E 08	0.00E-00	8.76E 07	0.00E-00

* R VALUES IN UNITS OF MREM/YR PER μCI/M^3 FOR INHALATION AND TRITIUM, AND IN UNITS OF M^2-MREM/YR PER μCI/SEC FOR ALL OTHERS

TABLE 3.3-9 R VALUES FOR THE PRAIRIE ISLAND NUCLEAR GENERATING PLANT*

PATHWAY = COW MILK
AGE GROUP EQUALS ADULT

NUCLIDE	T. BODY	GI-TRACT	BONE	LIVER	KIDNEY	THYROID	LUNG	SKIN
H 3	7.63E 02	7.63E 02	0.00E-00	7.63E 02	7.63E 02	7.63E 02	7.63E 02	7.63E 02
MN 54	8.67E 05	1.39E 07	0.00E-00	4.54E 06	1.35E 06	0.00E-00	0.00E-00	0.00E-00
FE 59	1.27E 07	1.10E 08	1.41E 07	3.31E 07	0.00E-00	0.00E-00	9.26E 06	0.00E-00
CO 58	5.15E 06	4.66E 07	0.00E-00	2.30E 06	0.00E-00	0.00E-00	0.00E-00	0.00E-00
CO 60	2.04E 07	1.74E 08	0.00E-00	9.27E 06	0.00E-00	0.00E-00	0.00E-00	0.00E-00
SR 89	2.00E 07	1.12E 08	6.99E 08	0.00E-00	0.00E-00	0.00E-00	0.00E-00	0.00E-00
SR 90	6.99E 09	8.22E 08	2.85E 10	0.00E-00	0.00E-00	0.00E-00	0.00E-00	0.00E-00
I 131	1.19E 08	5.50E 07	1.46E 08	2.08E 08	3.57E 08	6.83E 10	0.00E-00	0.00E-00
CS134	6.05E 09	1.30E 08	3.11E 09	7.40E 09	2.40E 09	0.00E-00	7.95E 08	0.00E-00
CS137	3.87E 09	1.14E 08	4.32E 09	5.91E 09	2.01E 09	0.00E-00	6.67E 08	0.00E-00

* R VALUES IN UNITS OF MREM/YR PER μCI/M^3 FOR INHALATION AND TRITIUM, AND IN UNITS OF M^2-MREM/YR PER μCI/SEC FOR ALL OTHERS

TABLE 3.3-10 R VALUES FOR THE PRAIRIE ISLAND NUCLEAR GENERATING PLANT*

PATHWAY = COW MILK
AGE GROUP EQUALS TEEN

NUCLIDE	T. BODY	GI-TRACT	BONE	LIVER	KIDNEY	THYROID	LUNG	SKIN
H 3	9.94E 02	9.94E 02	0.00E-00	9.94E 02	9.94E 02	9.94E 02	9.94E 02	9.94E 02
MN 54	1.50E 06	1.55E 07	0.00E-00	7.57E 06	2.26E 06	0.00E-00	0.00E-00	0.00E-00
FE 59	2.22E 07	1.36E 08	2.46E 07	5.74E 07	0.00E-00	0.00E-00	1.81E 07	0.00E-00
CO 58	8.91E 06	5.33E 07	0.00E-00	3.87E 06	0.00E-00	0.00E-00	0.00E-00	0.00E-00
CO 60	3.54E 07	2.05E 08	0.00E-00	1.57E 07	0.00E-00	0.00E-00	0.00E-00	0.00E-00
SR 89	3.69E 07	1.53E 08	1.29E 09	0.00E-00	0.00E-00	0.00E-00	0.00E-00	0.00E-00
SR 90	9.93E 09	1.13E 09	4.02E 10	0.00E-00	0.00E-00	0.00E-00	0.00E-00	0.00E-00
I 131	1.99E 08	7.32E 07	2.64E 08	3.70E 08	6.37E 08	1.08E 11	0.00E-00	0.00E-00
CS134	5.90E 09	1.58E 08	5.40E 09	1.27E 10	4.04E 09	0.00E-00	1.54E 09	0.00E-00
CS137	3.63E 09	1.48E 08	7.83E 09	1.04E 10	3.55E 09	0.00E-00	1.38E 09	0.00E-00

* R VALUES IN UNITS OF MREM/YR PER μCI/M^3 FOR INHALATION AND TRITIUM, AND IN UNITS OF M^2-MREM/YR PER μCI/SEC FOR ALL OTHERS

TABLE 3.3-11 R VALUES FOR THE PRAIRIE ISLAND NUCLEAR GENERATING PLANT*

PATHWAY = COW MILK
AGE GROUP EQUALS CHILD

NUCLIDE	T. BODY	GI-TRACT	BONE	LIVER	KIDNEY	THYROID	LUNG	SKIN
H 3	1.57E 03	1.57E 03	0.00E-00	1.57E 03	1.57E 03	1.57E 03	1.57E 03	1.57E 03
MN 54	3.02E 06	9.50E 06	0.00E-00	1.13E 07	3.17E 06	0.00E-00	0.00E-00	0.00E-00
FE 59	4.60E 07	9.61E 07	5.70E 07	9.23E 07	0.00E-00	0.00E-00	2.68E 07	0.00E-00
CO 58	1.81E 07	3.45E 07	0.00E-00	5.91E 06	0.00E-00	0.00E-00	0.00E-00	0.00E-00
CO 60	7.19E 07	1.35E 08	0.00E-00	2.44E 07	0.00E-00	0.00E-00	0.00E-00	0.00E-00
SR 89	9.10E 07	1.23E 08	3.19E 09	0.00E-00	0.00E-00	0.00E-00	0.00E-00	0.00E-00
SR 90	1.72E 10	9.15E 08	6.80E 10	0.00E-00	0.00E-00	0.00E-00	0.00E-00	0.00E-00
I 131	3.66E 08	5.74E 07	6.41E 08	6.45E 08	1.06E 09	2.13E 11	0.00E-00	0.00E-00
CS134	4.31E 09	1.10E 08	1.25E 10	2.04E 10	6.34E 09	0.00E-00	2.27E 09	0.00E-00
CS137	2.67E 09	1.13E 08	1.89E 10	1.81E 10	5.89E 09	0.00E-00	2.12E 09	0.00E-00

* R VALUES IN UNITS OF MREM/YR PER μCI/M^3 FOR INHALATION AND TRITIUM, AND IN UNITS OF M^2-MREM/YR PER μCI/SEC FOR ALL OTHERS

TABLE 3.3-12 R VALUES FOR THE PRAIRIE ISLAND NUCLEAR GENERATING PLANT*

PATHWAY = COW MILK
AGE GROUP EQUALS INFANT

NUCLIDE	T. BODY	GI-TRACT	BONE	LIVER	KIDNEY	THYROID	LUNG	SKIN
H 3	2.38E 03	2.38E 03	0.00E-00	2.38E 03	2.38E 03	2.38E 03	2.38E 03	2.38E 03
MN 54	4.77E 06	7.73E 06	0.00E-00	2.11E 07	4.67E 06	0 00E-00	0.00E-00	0.00E-00
FE 59	7.33E 07	8.88E 07	1.06E 08	1.86E 08	0.90E-00	0.00E-00	5.50E 07	0.00E-00
CO 58	2.95E 07	2.94E 07	0.00E-00	1.18E 07	0.00E-00	0.00E-00	0.00E-00	0.00E-00
CO 60	1.18E 08	1.18E 08	0.00E-00	4.98E 07	0.00E-00	0.00E-00	0.00E-00	0.00E-00
SR 89	1.74E 08	1.25E 08	6.06E 09	0.00E-00	0.00E-00	0.00E-00	0.00E-00	0.00E-00
SR 90	1.88E 10	9.23E 08	7.40E 10	0.00E-00	0.00E-00	0.00E-00	0.00E-00	0.00E-00
I 131	6.93E 08	5.63E 07	1.34E 09	1.58E 09	1.84E 09	5.18E 11	0.00E-00	0.00E-00
CS134	3.78E 09	1.02E 08	2.01E 10	3.74E 10	9.64E 09	0.00E-00	3.95E 09	0.00E-00
CS137	2.50E 09	1.10E 08	3.01E 10	3.53E 10	9.46E 09	0.00E-00	3.83E 09	0.00E-00

* R VALUES IN UNITS OF MREM/YR PER $\mu CI/M^3$ FOR INHALATION AND TRITIUM, AND IN UNITS OF M^2-MREM/YR PER µCI/SEC FOR ALL OTHERS

TABLE 3.3-13 R VALUES FOR THE PRAIRIE ISLAND NUCLEAR GENERATING PLANT*

PATHWAY = GOATMILK
AGE GROUP EQUALS ADULT

NUCLIDE	T. BODY	GI-TRACT	BONE	LIVER	KIDNEY	THYROID	LUNG	SKIN
H 3	1.56E 03	1.56E 03	0.00E-00	1.56E 03	1.56E 03	1.56E 03	1.56E 03	1.56E 03
MN 54	1.04E 05	1.67E 06	0.00E-00	5.45E 05	1.62E 05	0.00E-00	0.00E-00	0.00E-00
FE 59	1.65E 05	1.44E 06	1.83E 05	4.31E 05	0.00E-00	0.00E-00	1.20E 05	0.00E-00
CO 58	6.18E 05	5.59E 06	0.00E-00	2.76E 05	0.00E-00	0.00E-00	0.00E-00	0.00E-00
CO 60	2.45E 06	2.09E 07	0.00E-00	1.11E 06	0.00E-00	0.00E-00	0.00E-00	0.00E-00
SR 89	4.21E 07	2.35E 08	1.47E 09	0.00E-00	0.00E-00	0.00E-00	0.00E-00	0.00E-00
SR 90	1.47E 10	1.73E 09	5.98E 10	0.00E-00	0.00E-00	0.00E-00	0.00E-00	0.00E-00
I 131	1.43E 08	6.60E 07	1.75E 08	2.50E 08	4.29E 08	8.20E 10	0.00E-00	0.00E-00
CS134	1.82E 10	3.89E 08	9.33E 09	2.22E 10	7.19E 09	0.00E-00	2.39E 09	0.00E-00
CS137	1.16E 10	3.43E 08	1.30E 10	1.77E 10	6.02E 09	0.00E-00	2.00E 09	0.00E-00

* R VALUES IN UNITS OF MREM/YR PER μCI/M^3 FOR INHALATION AND TRITIUM, AND IN UNITS OF M^2-MREM/YR PER μCI/SEC FOR ALL OTHERS

TABLE 3.3-14 R VALUES FOR THE PRAIRIE ISLAND NUCLEAR GENERATING PLANT*

PATHWAY = GOATMILK
AGE GROUP EQUALS TEEN

NUCLIDE	T. BODY	GI-TRACT	BONE	LIVER	KIDNEY	THYROID	LUNG	SKIN
H 3	2.03E 03	2.03E 03	0.00E-00	2.03E 03	2.03E 03	2.03E 03	2.03E 03	2.03E 03
MN 54	1.80E 05	1.86E 06	0.00E-00	9.08E 05	2.71E 05	0.00E-00	0.00E-00	0.00E-00
FE 59	2.88E 05	1.76E 06	3.20E 05	7.46E 05	0.00E-00	0.00E-00	2.35E 05	0.00E-00
CO 58	1.07E 06	6.40E 06	0.00E-00	4.64E 05	0.00E-00	0.00E-00	0.00E-00	0.00E-00
CO 60	4.24E 06	2.45E 07	0.00E-00	1.88E 06	0.00E-00	0.00E-00	0.00E-00	0.00E-00
SR 89	7.74E 07	3.22E 08	2.70E 09	0.00E-00	0.00E-00	0.00E-00	0.00E-00	0.00E-00
SR 90	2.09E 10	2.37E 09	8.45E 10	0.00E-00	0.00E-00	0.00E-00	0.00E-00	0.00E-00
I 131	2.39E 08	8.79E 07	3.17E 08	4.44E 08	7.65E 08	1.30E 11	0.00E-00	0.00E-00
CS134	1.77E 10	4.74E 08	1.62E 10	3.81E 10	1.21E 10	0.00E-00	4.63E 09	0.00E-00
CS137	1.09E 10	4.45E 08	2.35E 10	3.13E 10	1.06E 10	0.00E-00	4.13E 09	0.00E-00

* R VALUES IN UNITS OF MREM/YR PER µCI/M^3 FOR INHALATION AND TRITIUM, AND IN UNITS OF M^2-MREM/YR PER µCI/SEC FOR ALL OTHERS

TABLE 3.3-15 R VALUES FOR THE PRAIRIE ISLAND NUCLEAR GENERATING PLANT*

PATHWAY = GOATMILK
AGE GROUP EQUALS CHILD

NUCLIDE	T. BODY	GI-TRACT	BONE	LIVER	KIDNEY	THYROID	LUNG	SKIN
H 3	3.20E 03	3.20E 03	0.00E-00	3.20E 03	3.20E 03	3.20E 03	3.20E 03	3.20E 03
MN 54	3.62E 05	1.14E 06	0.00E-00	1.36E 06	3.81E 05	0.00E-00	0.00E-00	0.00E-00
FE 59	5.98E 05	1.25E 06	7.42E 05	1.20E 06	0.00E-00	0.00E-00	3.48E 05	0.00E-00
CO 58	2.17E 06	4.14E 06	0.00E-00	7.09E 05	0.00E-00	0.00E-00	0.00E-00	0.00E-00
CO 60	8.63E 06	1.62E 07	0.00E-00	2.93E 06	0.00E-00	0.00E-00	0.00E-00	0.00E-00
SR 89	1.91E 08	2.59E 08	6.69E 09	0.00E-00	0.00E-00	0.00E-00	0.00E-00	0.00E-00
SR 90	3.62E 10	1.92E 09	1.43E 11	0.00E-00	0.00E-00	0.00E-00	0.00E-00	0.00E-00
I 131	4.40E 08	6.89E 07	7.70E 08	7.74E 08	1.27E 09	2.56E 11	0.00E-00	0.00E-00
CS134	1.29E 10	3.31E 08	3.74E 10	6.13E 10	1.90E 10	0.00E-00	6.82E 09	0.00E-00
CS137	8.00E 09	3.39E 08	5.66E 10	5.42E 10	1.77E 10	0.00E-00	6.35E 09	0.00E-00

* R VALUES IN UNITS OF MREM/YR PER $\mu CI/M^3$ FOR INHALATION AND TRITIUM, AND IN UNITS OF M^2-MREM/YR PER $\mu CI/SEC$ FOR ALL OTHERS

TABLE 3.3-16 R VALUES FOR THE PRAIRIE ISLAND NUCLEAR GENERATING PLANT*

PATHWAY = GOATMILK
AGE GROUP EQUALS INFANT

NUCLIDE	T. BODY	GI-TRACT	BONE	LIVER	KIDNEY	THYROID	LUNG	SKIN
H 3	4.86E 03	4.86E 03	0.00E-00	4.86E 03	4.86E 03	4.86E 03	4.86E 03	4.86E 03
MN 54	5.73E 05	9.28E 05	0.00E-00	2.53E 06	5.60E 05	0.00E-00	0.00E-00	0.00E-00
FE 59	9.53E 05	1.15E 06	1.38E 06	2.42E 06	0.00E-00	0.00E-00	7.15E 05	0.00E-00
CO 58	3.54E 06	3.53E 06	0.00E-00	1.42E 06	0.00E-00	0.00E-00	0.00E-00	0.00E-00
CO 60	1.41E 07	1.42E 07	0.00E-00	5.97E 06	0.00E-00	0.00E-00	0.00E-00	0.00E-00
SR 89	3.65E 08	2.62E 08	1.27E 10	0.00E-00	0.00E-00	0.00E-00	0.00E-00	0.00E-00
SR 90	3.95E 10	1.94E 09	1.55E 11	0.00E-00	0.00E-00	0.00E-00	0.00E-00	0.00E-00
I 131	8.32E 08	6.76E 07	1.61E 09	1.89E 09	2.21E 09	6.22E 11	0.00E-00	0.00E-00
CS134	1.13E 10	3.05E 08	6.02E 10	1.12E 11	2.89E 10	0.00E-00	1.19E 10	0.00E-00
CS137	7.50E 09	3.31E 08	9.04E 10	1.06E 11	2.84E 10	0.00E-00	1.15E 10	0.00E-00

* R VALUES IN UNITS OF MREM/YR PER $\mu CI/M^3$ FOR INHALATION AND TRITIUM, AND IN UNITS OF M^2-MREM/YR PER $\mu CI/SEC$ FOR ALL OTHERS

TABLE 5.1-1

PRAIRIE ISLAND NUCLEAR GENERATING PLANT
RADIATION ENVIRONMENTAL MONITORING PROGRAM
SAMPLING LOCATIONS

Type of Sample	Code	Collection Site	Location
River Water	P-5[c]	Upstream of Plant	2.3 mi @ 348°/NNW
River Water	P-6	Lock & Dam #3	1.6 mi @ 129°/SE
Drinking Water	P-11	Red Wing Service Center	3.3 mi @ 158°/SSE
Well Water	P-25[c]	Kinneman Farm	11.1 mi @ 331°/NN
Well Water	P-6	Lock & Dam #3	1.6 mi @ 129°/SE
Well Water	P-8	Community Center	1.0 mi @ 321°/WNW
Well Water	P-9	Plant Well #2	0.3 mi @ 306°/NW
Sediment-River	P-20[c]	Upstream of Plant	0.9 mi @ 45°/NE
Sediment-River	P-6	Lock & Dam #3	1.6 mi @ 129°/SE
Sediment-Shoreline	P-12	Downstream of Plant	3.0 mi @ 116°/ESE
Periphyton or	P-5[c]	Upstream of Plant	2.3 mi @ 348°/NNW
Invertebrates	P-12	Downstream of Plant	3.0 mi @ 116°/ESE
Fish	P-19[c]	Upstream of Plant	1.3 mi @ 0°/N
Fish	P-13	Downstream of Plant	3.5 mi @ 113°/ESE
Milk	P-25[c]	Kinneman Farm	11.1 mi @ 331°/N
Milk	P-14	Gustafson Farm	2.2 mi @ 173°/SS
Milk	P-16	Johnson Farm	2.6 mi @ 60°/ENE
Milk	P-17	Place Farm	3.5 mi @ 25°/NNE
Milk	P-18	Christensen Farm	3.7 mi @ 88°/E

TABLE 5.1-1 (Continued)

PRAIRIE ISLAND NUCLEAR GENERATING PLANT
RADIATION ENVIRONMENTAL MONITORING PROGRAM
SAMPLING LOCATIONS

Type of Sample	Code	Collection Site	Location
Cultivated Crops (Leafy Green Veg)	P-25[c] P-24	Kinneman Farm Suter Residence	11.1 mi @ 331°/ 0.6 mi @ 158°/S
Particulates and Radioiodine (air)	P-1[c]	Air Station P-1	11.8 mi @ 316°/
Particulates and Radioiodine (air)	P-2	Air Station P-2	0.5 mi @ 294°/W
Particulates and Radioiodine (air)	P-3	Air Station P-3	0.8 mi @ 313°/N
Particulates and Radioiodine (air)	P-4	Air Station P-4	0.4 mi @ 359°/N
Particulates and Radioiodine (air)	P-6	Air Station P-6	1.6 mi @ 129°/S
Direct Radiation (TLD)	P01A	Property Line	0.4 mi @ 359°/
Direct Radiation (TLD)	P02A	Property Line	0.3 mi @ 10°/N
Direct Radiation (TLD)	P03A	Property Line	0.5 mi @ 183°/
Direct Radiation (TLD)	P04A	Property Line	0.4 mi @ 204°/
Direct Radiation (TLD)	P05A	Property Line	0.4 mi @ 225°/

TABLE 5.1-1 (Continued)

PRAIRIE ISLAND NUCLEAR GENERATING PLANT
RADIATION ENVIRONMENTAL MONITORING PROGRAM
SAMPLING LOCATIONS

Type of Sample	Code	Collection Site	Location
Direct Radiation (TLD)	PO6A	Property Line	0.4 mi @ 249°/WSW
Direct Radiation (TLD)	PO7A	Property Line	0.4 mi @ 268°/W
Direct Radiation (TLD)	PO8A	Property Line	0.4 mi @ 291°/WNW
Direct Radiation (TLD)	PO9A	Property Line	0.7 mi @ 317°/NW
Direct Radiation (TLD)	P10A	Property Line	0.5 mi @ 333°/NNW
Direct Radiation (TLD)	PO1B	Tom Killian Res.	4.7 mi @ 355°/N
Direct Radiation (TLD)	PO2B	Roy Kinneman Farm	4.8 mi @ 17°/NNE
Direct Radiation (TLD)	PO3B	Wayne Anderson Farm	4.9 mi @ 46°/NE
Direct Radiation (TLD)	PO4B	Nelson Drive (Road)	4.2 mi @ 61°/ENE
Direct Radiation (TLD)	PO5B	County Rd E & Coulee	4.1 mi @ 102°/ES
Direct Radiation (TLD)	PO6B	William Houschildt Res.	4.4 mi @ 112°/ES
Direct Radiation (TLD)	PO7B	Red Wing Public Works	4.7 mi @ 140°/SE
Direct Radiation (TLD)	PO8B	David Wnuk Res.	4.1 mi @ 165°/SS
Direct Radiation (TLD)	PO9B	Hwy 19 South	4.2 mi @ 187°/S
Direct Radiation (TLD)	P10B	Cannondale Farm	4.9 mi @ 200°/S

TABLE 5.1-1 (Continued)

PRAIRIE ISLAND NUCLEAR GENERATING PLANT
RADIATION ENVIRONMENTAL MONITORING PROGRAM
SAMPLING LOCATIONS

Type of Sample	Code	Collection Site	Location
Direct Radiation (TLD)	P11B	Wallace Weberg Farm	4.5 mi @ 221°/SW
Direct Radiation (TLD)	P12B	Roy Gergen Farm	4.5 mi @ 247°/WS
Direct Radiation (TLD)	P13B	Thomas O'Rourke Farm	4.4 mi @ 270°/W
Direct Radiation (TLD)	P14B	David Anderson Farm	4.9 mi @ 306°/NW
Direct Radiation (TLD)	P15B	Holst Farms	4.2 mi @ 347°/NN
Direct Radiation (TLD)	P01S	Federal Lock & Dam #3	1.6 mi @ 129°/SE
Direct Radiation (TLD)	P02S	Charles Suter Res.	0.5 mi @ 155°/SS
Direct Radiation (TLD)	P03S	Carl Gustafson Farm	2.2 mi @ 173°/S
Direct Radiation (TLD)	P04S	Richard Burt Res.	2.0 mi @ 202°/SS
Direct Radiation (TLD)	P05S	Kinney Store	2.0 mi @ 270°/W
Direct Radiation (TLD)	P06S	Earl Flynn Farm	2.5 mi @ 299°/WN
Direct Radiation (TLD)	P25	Robert Kinneman Farm	11.1 mi @ 331°/N

* "c" denotes control location. All other locations are indicators.

The letters after numbered TLD's are as follows:

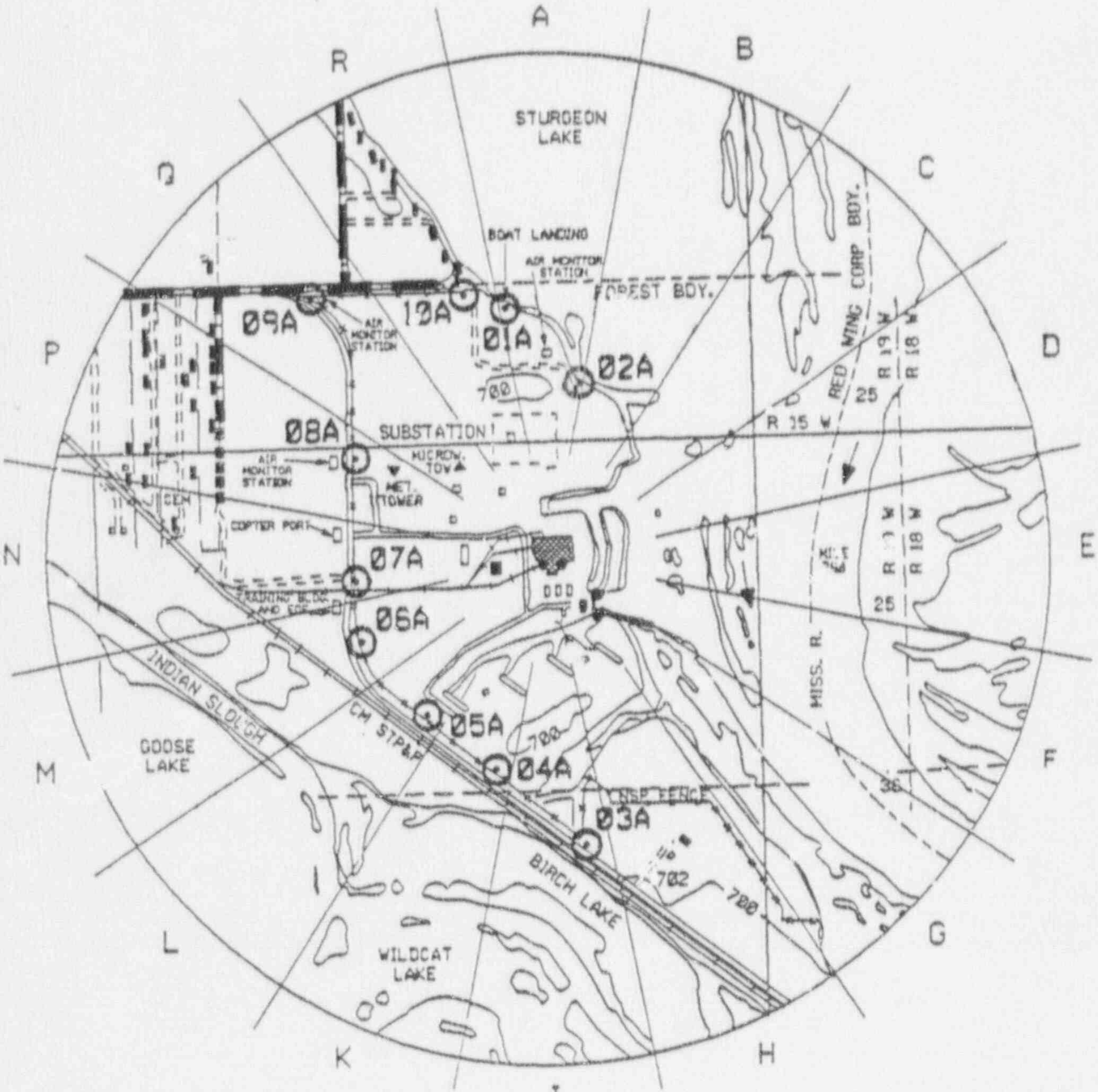
"A" denotes locations in the general area of the site boundary.

"B" denotes locations about 4 to 5 miles distance from the plant.

"S" denotes special interest locations.
IBM

FIGURE 5.1-1

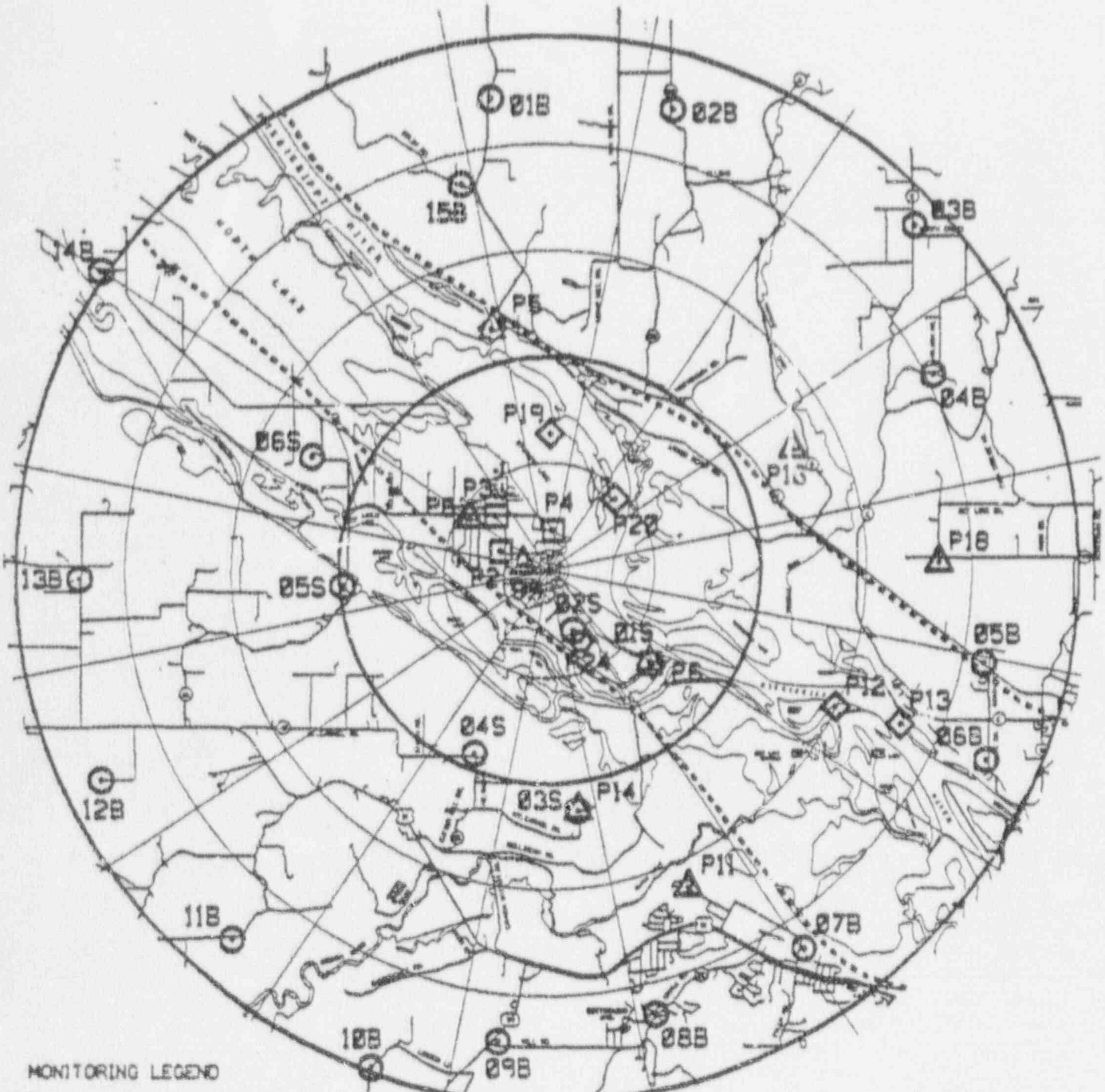
SITE BOUNDARY TLD LOCATIONS



PLANT AREA ENLARGED PLAN (1.00 MILE RADIUS)
(NO SCALE)

NL-99P17??-1

FIGURE 5.1-2
RADIOLOGICAL ENVIRONMENTAL SAMPLE POINTS WITHIN 10 - MILE RADIUS



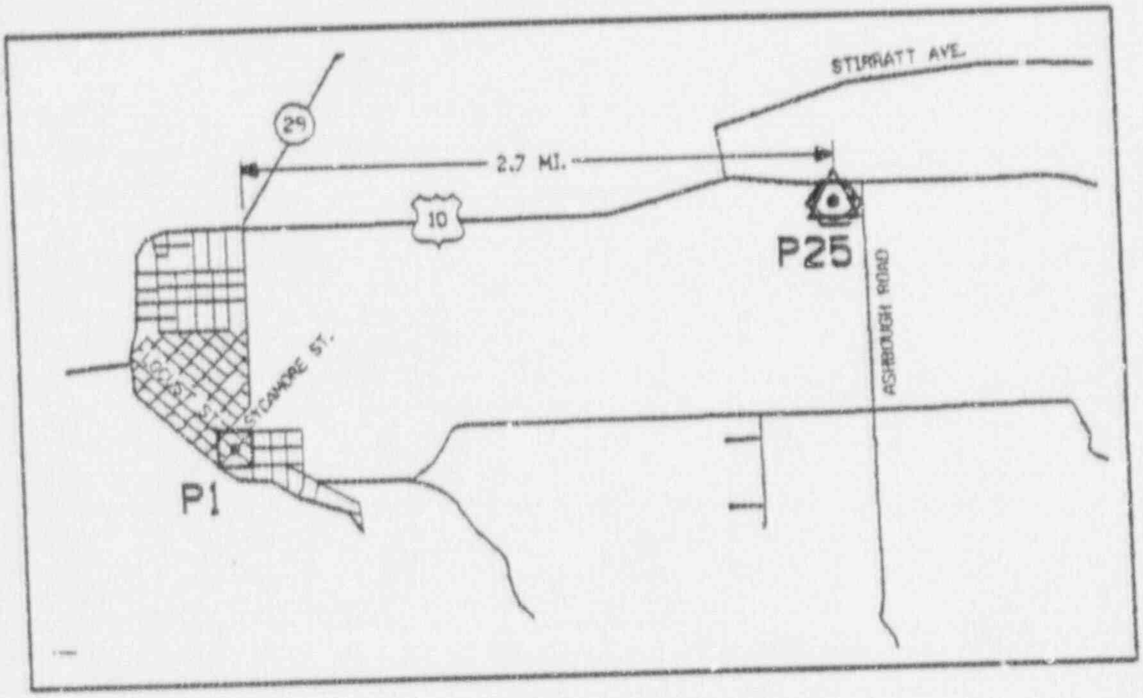
MONITORING LEGEND

- CULTIVATED CROP SAMPLING POINT
- WATER & MILK SAMPLING POINTS
- RIVER SEDIMENT, FISH AND PERIPHYTON OR INVERTEBRATES
- N.S.P. TLD POINTS
- N.S.P. AIR MONITORING POINTS

NL-99P1739-2

FIGURE 5.1-3

RADIOLOGICAL ENVIRONMENTAL SAMPLE POINTS OUTSIDE 10 - MILE RADIUS



CONTROL POINTS
PRESCOTT, WISCONSIN

MONITORING LEGEND

- CULTIVATED CROP SAMPLING POINT
- WATER & MILK SAMPLING POINTS
- RIVER SEDIMENT, FISH AND PERIPHYTON OR INVERTEBRATES
- N.S.P. TLD POINTS
- N.S.P. AIR MONITORING POINTS

NL-99P1739-3

APPENDIX C

DOSE PARAMETERS FOR RADIOIODINES, PARTICULATES AND TRITIUM

This appendix contains the methodology which was used to calculate the dose parameters for radioiodines, particulates, and tritium to show compliance with 10 CFR 20 and Appendix I of 10 CFR 50 for gaseous effluents. These dose parameters, P_i and R_i, were calculated using the methodology outlined in NUREG-0133[1] along with Regulatory Guide 1.109 Revision 1. The following sections provide the specific methodology which was utilized in calculating the P_i and R_i values for the various exposure pathways.

C.1 Calculation of P_i

The parameter, P_i, contained in the radioiodine and particulates portion of Section 3.2, includes pathway transport parameters of the ith radionuclide, the receptor's usage of the pathway media and the dosimetry of the exposure. Pathway usage rates and the internal dosimetry are functions of the receptor's age: however, the child age group, will always receive the maximum dose under the exposure conditions assumed.

C.1.1 Inhalation Pathway

$$P_{i_I} = K'(BR)\,DFA_i \qquad (C.1\text{-}1)$$

where:

P_{i_I} = dose parameter for radionuclide i for the inhalation pathway, mrem/yr per $\mu Ci/m^3$;

K' = a constant of unit conversion:

= 10^6 pCi/µCi;

BR = the breathing rate of the child age group, m^3/yr;

DFA_i = the maximum organ inhalation dose factor for the child age group for radionuclide i, mrem/pCi.

The age group considered is the child group. The child's breathing rate is taken as 3700 m^3/yr from Table E-5 of Regulatory Guide 1.109 Revision 1. The inhalation dose factors for the child DFA_i, are presented in Table E-9 of Regulatory Guide 1.109 in units of mrem/pCi. The total body is considered as an organ in the selection of DFA_i. The incorporation of breathing rate of the child and the unit conversion factor results in the following:

$$P_{i_I} = 3.7 \times 10^9 \ DFA_i \qquad (C.1\text{-}2)$$

C.2 Calculation of R_i

The radioiodine and particulate Technical Specification is applicable to the location in the unrestricted area where the combination of existing pathways and receptor age groups indicates the maximum potential exposure occurs. The inhalation and ground plane exposure pathways shall be considered to exist at all locations. The grass-goat-milk, the grass-cow-milk, grass-cow-meat, and vegetation pathways are considered based on their existence at the various locations. R_i values have been calculated for the adult, teen, child, and infant age groups for the ground plane, cow milk, goat milk, vegetable and beef ingestion pathways. The methodology which was utilized to calculate these values is presented below.

C.2.1 Inhalation Pathway

$$R_{i_I} = K'(BR)_a \ (DFA_i)_a \qquad (C.2\text{-}1)$$

where:

R_{i_I} = dose factor for each identified radionuclide i of the organ of interest, mrem/yr per $\mu Ci/m^3$;

K' = a constant of unit conversion:

= 10^6 pCi/μCi;

$(BR)_a$ = breathing rate of the receptor of age group a, m^3/yr:

$(DFA_i)_a$ = organ inhalation dose factor for radionuclide i for the receptor of age group a, mrem/pCi.

The breathing rates $(BR)_a$ for the various age groups are tabulated below, as given in Table E-5 of the Regulatory Guide 1.109 Revision 1.

Age Group (a)	Breathing Rate (m^3/yr)
Infant	1400
Child	3700
Teen	8000
Adult	8000

Inhalation dose factors (DFA_i)$_a$ for the various age groups are given in Tables E-7 through E-10 of Regulatory Guide 1.109 Revision 1.

C.2.2 Ground Plane Pathway

$$R_{i_G} = I_i K'K''(SF)DFG_i \ (1-e^{-\lambda_i t})/\lambda_i \quad (C.2\text{-}2)$$

where:

R_{i_G} = dose factor for the ground plane pathway for each identified radionuclide i for the organ of interest, m^2 mrem/yr per μCi/sec per;

K' = a constant of unit conversion;

= 10^6 pCi/μCi;

K" = a constant of unit conversion;

= 8760 hr/year;

λ_i = the radiological decay constant for radionuclide i, sec^{-1};

t = the exposure time, sec;

= 4.73×10^8 sec (15 years);

DFG_i = the ground plane dose conversion factor for radionuclide i; mrem/hr per pCi/m^2;

SF = the shielding factor (dimensionless);

I_i = factor to account for fractional deposition of radionuclide i.

For radionuclides other than iodine, the factor I_i is equal to one. For radioiodines, the value of I_i may vary. However, a value of 1.0 was used in calculating the R values in Table 3.3-2.

A shielding factor of 0.7 is suggested in Table E-15 of Regulatory Guide 1.109 Revision 1. A tabulation of DFG_i values is presented in Table E-6 of Regulatory Guide 1.109 Revision 1.

C.2.3 Grass-Cow or Goat-Milk Pathway

$$R_{i_M} = I_i K' Q_F U_{ap} F_m (DFL_i)_a e^{-\lambda_i t_f} \left[f_p f_s \left[\frac{r(1-e^{-\lambda_{E_i} t_{ep}})}{Y_p \lambda_{E_i}} + \frac{B_{iv}(1-e^{-\lambda_i t_b})}{P\lambda_i} \right] + (1-f_p f_s) \left[\frac{r(1-e^{-\lambda_{E_i} t_{es}})}{Y_s \lambda_{E_i}} + \frac{B_{iv}(1-e^{-\lambda_i t_b})}{P\lambda_i} \right] e^{-\lambda_i t_h} \right] \quad (C.2-3)$$

where:

R_{i_M} = dose factor for the cow milk or goat milk pathway, for each identified radionuclide i for the organ of interest, mrem/yr per µCi/sec per m^{-2};

K' = a constant of unit conversion;

= 10^6 pCi/µCi;

Q_F = the cow's or goat's feed consumption rate, kg/day (wet weight);

U_{ap} = the receptor's milk consumption rate for age group a, liters/yr;

Y_p = the agricultural productivity by unit area of pasture feed grass, kg/m^2;

Y_s = the agricultural productivity by unit area of stored feed, kg/m^2;

F_m = the stable element transfer coefficients, pCi/liter per pCi/day;

r = fraction of deposited activity retained on cow's feed grass;

$(DFL_i)_a$ = the organ ingestion dose factor for radionuclide i for the receptor in age group a, mrem/pCi;

λ_E = $\lambda_i + \lambda_w$;

λ_i = the radiological decay constant for radionuclide i, sec^{-1};

λ_w = the decay constant for removal of activity on leaf and plant surfaces by weathering, sec^{-1};

= 5.73×10^{-7} sec^{-1} (corresponding to a 14 day half-life);

t_f = the transport time from feed to cow or goat to milk, to receptor, sec;

t_h = the transport time from harvest, to cow or goat, to consumption, sec;

t_b = period of time that activity builds up in soil sec;

B_{iv} = concentration factor for uptake of radionuclide i from the soil by the edible parts of crops, pCi/Kg (wet weight) per pCi/Kg (dry soil);

P = effective surface density for soil, (dry soil)/m^2;

f_p = fraction of the year that the cow or goat is on pasture;

f_s = fraction of the cow feed that is pasture grass while the cow is on pasture;

t_{ep} = period of pasture grass exposure during the growing season, sec;

t_{es} = period of crop exposure during the growing season, sec;

I_i = factor to account for fractional deposition of radionuclide i.

For radionuclides other than iodine, the factor I_i is equal to one. For radioiodines, the value of I_i may vary. However, a value of 1.0 was used in calculating the R values Tables 3.3-9 through 3.3-16.

Milk cattle and goats are considered to be fed from two potential sources, pasture grass and stored feeds. Following the development in Regulatory Guide 1.109 Revision 1, the value of f_s was considered unity in lieu of site-specific information. The value of f_p was 0.5 based upon an 6-month grazing period.

Table C-1 contains the appropriate parameter values and their source in Regulatory Guide 1.109 Revision 1.

The concentration of tritium in milk is based on the airborne concentration rather than the deposition. Therefore, the R_i is based on X/Q:

$$R_{T_M} = K'K'''F_m Q_F U_{ap} (DFL_i)_a \ 0.75(0.5/H) \quad (C.2\text{-}4)$$

where:

R_{T_M} = dose factor for the cow or goat milk pathway for tritium for the organ of interest, mrem/yr per $\mu Ci/m^3$;

K''' = a constant of unit conversion;

= 10^3 gm/kg;

H = absolute humidity of the atmosphere, gm/m^3;

0.75 = the fraction of total feed that is water;

0.5 = the ratio of the specific activity of the feed grass water to the atmospheric water.

and other parameters and values are given above. A value of H of 8 grams/meter^3, was used in lieu of site-specific information.

C.2.4 Grass-Cow-Meat Pathway

The integrated concentration in meat follows in a similar manner to the development for the milk pathway, therefore:

$$R_{i_B} = I_i K' Q_F U_{ap} F_f (DFL_i)_a \, e^{-\lambda_i t_s} \left[f_p f_s \left[\frac{r(1-e^{-\lambda_{E_i} t_{ep}})}{Y_p \lambda_{E_i}} + \frac{B_{iv}(1-e^{-\lambda_i t_b})}{P\lambda_i} \right] + (1-f_p f_s) \left[\frac{r(1-e^{-\lambda_{E_i} t_{es}})}{Y_s \lambda_{E_I}} + \frac{B_{iv}(1-e^{-\lambda_i t_b})}{P\lambda_i} \right] e^{-\lambda_i t_h} \right] \quad (C.2\text{-}5)$$

where:

R_{i_B} = dose factor for the meat ingestion pathway for radionuclide i for any organ of interest, m^2 mrem/yr per $\mu Ci/sec$;

F_f = the stable element transfer coefficients, pCi/Kg per pCi/day;

U_{ap} = the receptor's meat consumption rate for age group a, kg/yr;

t_s = the transport time from slaughter to consumption, sec;

t_h = the transport time from harvest to animal consumption, sec;

t_{ep} = period of pasture grass exposure during the growing season, sec;

t_{es} = period of crop exposure during the growing season, sec;

I_i = factor to account for fractional deposition of radionuclide i.

For radionuclides other than iodine, the factor I_i is equal to one. For radioiodines, the value of I_i may vary. However, a value of 1.0 was used in calculating the R values in Tables 3.3-6 through 3.3-8.

All other terms remain the same as defined in Equation C.2-3. Table C-2 contains the values which were used in calculating R_i for the meat pathway.

The concentration of tritium in meat is based on its airborne concentration rather than the deposition. Therefore, the R_i is based on X/Q.

$$R_{T_B} = K'K'''F_f Q_F U_{ap} (DFL_i)_a \quad 0.75(0.5/H) \qquad (C.2-6)$$

where:

R_{T_B} = dose factor for the meat ingestion pathway for tritium for any organ of interest, mrem/yr per $\mu Ci/m^3$.

All other terms are defined in Equation C.2-4 and C.2-5, above.

C.2.5 Vegetation Pathway

The integrated concentration in vegetation consumed by man follows the expression developed in the derivation of the milk factor. Man is considered to consume two types of vegetation (fresh and stored) that differ only in the time period between harvest and consumption, therefore:

$$R_{i_V} = I_i K'(DFL_i)_a \left[U_a^L f_L e^{-\lambda_i t_L} \left[\frac{r(1-e^{-\lambda_{E_i} t_e})}{Y_v \lambda_{E_i}} + \frac{B_{iv}(1-e^{-\lambda_i t_b})}{P\lambda_i} \right] + U_a^S f_g e^{-\lambda_i t_h} \left[\frac{r(1-e^{-\lambda_{E_i} t_e})}{Y_v \lambda_{E_i}} + \frac{B_{iv}(1-e^{-\lambda_i t_b})}{P\lambda_i} \right] \right] \quad (C.2-7)$$

where:

R_{i_V} = dose factor for vegetable pathway for radionuclide i for the organ of interest, m^2- mrem/yr per μCi/sec

K' = a constant of unit conversion:

= 10^6 pCi/μCi;

U_a^L = the consumption rate of fresh leafy vegetation by the receptor in age group a, kg/yr;

U_a^S = the consumption rate of stored vegetation by the receptor in age group a, kg/yr;

f_L = the fraction of the annual intake of fresh leafy vegetation grown locally;

f_g = the fraction of the annual intake of stored vegetation grown locally;

t_L = the average time between harvest of leafy vegetation and its consumption, sec;

t_h = the average time between harvest of stored vegetation and its consumption, sec;

Y_v = the vegetation areal density, kg/m^2;

t_e = period of leafy vegetable exposure during growing season, sec;

I_i = factor to account for fractional deposition of radionuclide i.

For radionuclides other than iodine, the factor I_i is equal to one. For radioiodines, the value of I_i may vary. However, a value of 1.0 was used in calculating the R values in cables 3.3-9 through 3.3-12.

All other factors were defined above.

Table C-3 presents the appropriate parameter values and their source in Regulatory Guide 1.109 Revision 1.

In lieu of site-specific data default values for f_L and f_g, 1.0 and 0.76, respectively were used in the calculation of R_i. These values were obtained from Table E-15 of Regulatory Guide 1.109 Revision 1.

The concentration of tritium in vegetation is based on the airborne concentration rather than the deposition. Therefore, the R_i is based on X/Q:

$$R_{T_V} = K'K''' \left[U_a^L f_L + U_a^S f_g \right] (DFL_i)_a \; 0.75(0.5/H) \qquad (C.2-8)$$

where:

R_{T_V} = dose factor for the vegetable pathway for tritium for any organ of interest, mrem/yr per $\mu Ci/m^3$.

All other terms remain the same as those in Equations C.2-4 and C.2-7.

TABLE C-1

Parameters For Cow and Goat Milk Pathwa'.

Parameter	Value	Reference (Reg. Guide 1.109 Rev. 1
Q_F (kg/day)	50 (cow) 6 (goat)	Table E-3 Table E-3
Y_p (kg/m^2)	0.7	Table E-15
t_f (seconds)	1.73×10^5 (2 days)	Table E-15
r	1.0 (radioiodines) 0.2 (particulates)	Table E-15 Table E-15
$(DFL_i)_a$ (mrem/pCi)	Each radionuclide	Tables E-11 to E-14
F_m (pCi/day per pCi/liter)	Each stable element	Table E-1 (cow) Table E-2 (goat)
t_b (seconds)	4.73×10^8 (15 yr)	Table E-15
Y_s (kg/m^2)	2.0	Table E-15
Y_p (kg/m^2)	0.7	Table E-15
t_h (seconds)	7.78×10^6 (90 days)	Table E-15
U_{ap} (liters/yr)	330 infant 330 child 400 teen 310 adult	Table E-5 Table E-5 Table E-5 Table E-5
t_{ep} (seconds)	2.59×10^6 (30 days)	Table E-15
t_{es} (seconds)	5.18×10^6 (60 days)	Table E-15
B_{iv} (pCi/Kg (wet weight) per pCi/Kg (dry soil))	Each stable element	Table E-1
P (Kg (dry soil/m^2) IBM	240	Table E-15

TABLE C-2

Parameters For The Meat Pathway

Parameter	Value	Reference (Reg. Guide 1.109 Rev. 1
r	1.0 (radioiodines) 0.2 (particulates)	Table E-15 Table E-15
F_f (pCi/Kg per pCi/day)	Each stable element	Table E-1
U_{ap} (Kg/yr)	0 infant 41 child 65 teen 110 adult	Table E-5 Table E-5 Table E-5 Table E-5
$(DFL_i)_a$ (mrem/pCi)	Each radionuclide	Tables E-11 to E-14
Y_p (kg/m^2)	0.7	Table E-15
Y_s (kg/m^2)	2.0	Table E-15
t_b (seconds)	4.73×10^8 (15 yr)	Table E-15
t_s (seconds)	1.73×10^6 (20 days)	Table E-15
t_h (seconds)	7.78×10^6 (90 days)	Table E-15
t_{ep} (seconds)	2.59×10^6 (30 days)	Table E-15
t_{es} (seconds)	5.18×10^6 (60 days)	Table E-15
Q_f (kg/day)	50	Table E-3
B_{iv} (pCi/Kg (wet weight) per pCi/Kg (dry soil))	Each stable element	Table E-1
P (Kg (dry soil)/m^2)	240	Table E-15

TABLE C-3

Parameters For The Vegetable Pathway

Parameter		Value	Reference (Reg. Guide 1.109 Rev. 1
r (dimensionless)		1.0 (radioiodines)	Table E-1
		0.2 (particulates)	Table E-1
$(DFL_i)_a$ (mrem/pCi)		Each radionuclide	Tables E-11 to E-14
U_a^L (kg/yr)	- Infant	0	Table E-5
	- Child	26	Table E-5
	- Teen	42	Table E-5
	- Adult	64	Table E-5
U_a^S (kg/yr)	- Infant	0	Table E-5
	- Child	520	Table E-5
	- Teen	630	Table E-5
	- Adult	520	Table E-5
t_L (seconds)		8.6×10^4 (1 day)	Table E-15
t_h (seconds)		5.18×10^6 (60 days)	Table E-15
Y_v (kg/m^2)		2.0	Table E-15
t_e (seconds)		5.18×10^6 (60 days)	Table E-15
t_b (seconds)		4.73×10^8 (15 yr)	Table E-15
P(Kg(dry soil)/m^2)		240	Table E-15
B_{iv}(pCi/Kg(wet weight) per pCi/kg (dry soil))		Each stable element	Table E-1

D Section	TITLE: PROCESS CONTROL PROGRAM FOR SOLIDIFICATION/DEWATERING OF RADIOACTIVE WASTE FROM LIQUID SYSTEMS	NUMBER: D59
		REV: 3
		Page 1 of 24

O.C. REVIEW DATE:	REVIEWED BY: D. Schuelke for Dan Stember	DATE: 5-31-90
5-31-90	APPROVED BY: D.A. Schuelke	DATE: 5-31-90

TABLE OF CONTENTS

1.0 GENERAL

1.1 Purpose

The purpose of this Process Control Program (PCP) is to detail the means by which the dewatering and/or solidification of radioactive waste from liquid systems can be assured:

1.2 Scope

This PCP includes the following processes:

1.2.1 Solidification of liquid waste concentrates.

1.2.2 Manual solidification of waste liquids.

1.2.3 Manual solidification of wet trash by submersion.

1.2.4 Processing of wet trash by compaction/cementation.

1.2.5 Dewatering of bead resin.

1.2.6 Dewatering of powered resin.

1.2.7 Dewatering of spent filter elements.

1.2.8 Appendix A - PCP for In-container Solidification of Bead Resin.

1.3 Definitions

1.3.1 Batch

A quantity of liquid waste concentrates (for example, the contents of 121 Waste Concentrates Tank) to be solidified. A batch of waste concentrates can normally be drummed in not more than two days.

1.3.2 Solidification

The conversion of wet radioactive wastes into a form that meets shipping and burial ground requirements.

1.3.3 Dewatering

The process of removing water from a substance to meet specific limits.

1.4 Applicable Tech. Spec.

T.S.3.9.C

2.0 SOLIDIFICATION OF LIQUID WASTE CONCENTRATES

2.1 Purpose

To establish the process parameters which provide reasonable assurance of complete solidification of liquid waste concentrates.

2.2 Applicability

This section of the PCP is applicable to solidification of liquid waste concentrates using the Atcor Solidification System and related equipment.

2.3 References

2.3.1 C21.2.1 Solid Radioactive Waste Operating Procedure

2.3.2 C21.2.2 Trash Compactor Operation Operating Procedure

2.4 System Description

2.4.1 General Description

The solidification system for liquid waste concentrates includes 121 Waste Concentrates Tank (WCT), the Atcor Solidification System and related pumps, piping and equipment. Concentrates are accumulated from the 5 GPM ADT evaporator or the 2 GPM waste evaporator and stored in 121 WCT. When a sufficient quantity exists in 121 WCT, the contents are transferred to the Atcor system for solidification in 55 gallon drums. The filled drums are held in the Atcor drum storage aisles until solidification can be confirmed. The drums are then capped, deconned, and surveyed prior to storage for subsequent shipment and disposal. A flow diagram is shown on Figure 1.

2.4.2 Detailed Description

A. 121 Waste Concentrates Tank

121 WCT is an upright cylindrical, vented tank of approximately 1700 gal. capacity. The tank is electrically heated to keep the contents in solution.

121 WCT receives concentrates from either the 5 GPM ADT Evaporator, the 2 GPM Waste Evaporator, or the coagulation tank. The tank is located in a shielded vault for radiation protection and is equipped with a high level alarm to prevent over-filling. A direct reading float-type level gauge provides level indication from outside of the shielded vault.

121 WCT pump and discharge piping are arranged for recirculation and mixing of the tank contents or for pumping the contents to the Atcor System for solidification. A sample valve is provided near the pump discharge.

B. Atcor Solidification System

The Atcor Solidification System is designed to mix waste liquid concentrates with cement, to convey the blended mass into 55 gal. drums, and to store the filled drums in a shielded area for curing. The system consists of the following principle components:

1. Waste Metering Tank

   The waste metering tank is a tank of approximately 700 gal. process capacity. The tank is equipped with heaters to maintain contents in solution and is equipped with an agitator to ensure homogeneity of liquid. The tank is equipped with a positive displacement discharge pump having discharge rate variable up to 10 GPM. The pump discharges directly into the mixer feeder.

2. Cement Bin

The cement bin is a bin of approx. 100 cu. ft. process capacity. The bin is equipped with a vibrating lower cone to preclude bridging of cement and to ensure uniform flow of material having a consistent bulk density. The cement bin is fitted with a discharge auger having a discharge rate variable from 0.3 to 3.3 CFM. The auger discharges directly into the mixer/feeder.

3. Mixer/Feeder

The mixer/feeder is a double enveloping screw type mixer which simultaneously blends the liquid waste and cement while conveying the mass to the discharge chute. The discharge chute directs the blended mass into the shipping container by gravity flow.

4. Controls

Controls for the solidification system are contained on a panel shielded from the waste materials.

Gauges indicating feed rate of cement and waste liquid are located on the control panel.

Rates of cement feed and liquid feed are adjustable from the control panel during processing.

A closed circuit TV camera and monitor are provided for viewing drum movements from the control panel.

5. Cement Type

Cement normally used is type "M" masonry cement having 50% lime and 50% portland cement, conforming to ASTM-C-91-64 and ASTM-C-270-61T.

2.5 Sequence of Operation

2.5.1 Recirculation of 121 WCT

Before beginning the solidification process, the contents of 121 WCT should be recirculated for at least three volume changes to assure complete mixing and homogeneity.

2.5.2 After recirculation, a sample of the 121 WCT is to be drawn and analyzed for isotopic content, pH and % boric acid.

If pH is greater than 5.0, no adjustments need be made. If the pH is less than 5.0, it must be increased to between 5.5 and 7.0 with the addition of lime. Adjustments to pH, if required, should be made to the liquid in 121 WCT. As an alternate, pH adjustments may be made in the Atcor Metering Tank.

2.5.3 After sampling and pH adjustment, if required, the waste liquid is transferred to the Atcor Waste Metering Tank for solidification.

Filled drums are stored in the Atcor Drum Storage Aisles until solidification can be verified.

2.5.4 Flowrates

Normal flowrates with operating tolerance together with the discharge volume are as follows for typical evaporator bottoms:

Waste Liquid Flow	5.0 ± - 2% gpm
Masonry Cement	0.8 ± - 10% cfm
Product Discharge	1.0 cfm

Other flowrates may be used if demonstrated to result in solidification.

2.5.5 Cure Time

Cure time is variable and depends upon waste pH, Boron concentration, and mix ratios. Normally, a two to three week cure time can be expected for complete solidification.

2.5.6 Verification of Solidification

Representative barrels of each batch are to be inspected to verify solidification and the absence of free water. A drum may be considered solid when the cemented mass offers significant resistance to penetration by a hammer, or similar object. Absence of free water may be determined visually.

If solidification fails to take place, the process **SHALL** be suspended until the cause is determined and remedies are defined.

2.5.7 When solidification and absence of free water has been verified, the drums may be capped, deconned and removed from the Atcor Drum Storage Aisles. As an alternate to this sequence and in the interest of minimizing personnel exposure, the drums may be removed individually for capping and deconning.

2.5.8 When the drums are removed from the Atcor Drum Storage Aisles, and after they are capped and deconned, the drum number is recorded together with the batch number, contents and radiation level. The drums are then placed in storage to await shipping and burial.

2.6 Sample Solidification of Liquid Waste Concentrates

2.6.1 Sampling Requirements

If it is not feasible to verify solidification and the absence of free water in the full-scale product, sample solidification **SHALL** be conducted for at least every tenth batch of liquid waste concentrates.

2.6.2 Prerequisites

Before drawing a specimen from 121 WCT for sample solidification, the contents must be adequately mixed to achieve a representative mixture.

2.6.3 Sample Preparation

A. Obtain a specimen from 121 WCT in the required volume. The volume required will be approximately 200 ml for each sample mixed plus 10 ml for a boric acid analysis.

B. Remove approximately 10 ml for boric acid analysis. Record % boric acid on Attachment 1A.

C. Place the remaining waste liquid in a beaker. Maintain the temperature of the liquid to prevent precipitation of boron. Record the volume of waste in the beaker on Attachment 1A.

D. Check the mixture pH and record this value on Attachment 1A. If the pH is less than 5.0, slowly add lime to the liquid while continuously stirring until a pH value of 5.5 to 7.0 is achieved. Record the final pH and the weight of lime added on Attachment 1A.

E. Because of the relatively long cure time required, three samples should be mixed from the initial test specimen using different liquid/cement ratios. One sample will be mixed at the recommended full scale operating mix ratio. The other two samples should have more and less liquid than recommended for full scale mixing.

Additional samples may be mixed from the initial test specimen at the discretion of the Rad Waste System Engineer using additional mix ratios or using different pH values. The following table defines the mix ratios which should be used:

VOLUME OF WASTE LIQUID (ml)	VOLUME CEMENT (ml)	WT OF CEMENT (gm)	LIQUID/CEMENT RATIO (Volume)
176	(NOTE #1) 200	218	0.88
166	200	218	0.83 (NOTE #2)
156	200	218	0.78

NOTE #1: Cement volume is theoretical and is listed for reference only. For accurate sample preparation, cement must be measured by weight.

NOTE #2: Liquid/cement ratio (volume) recommended by Atcor for full scale mixing.

F. Place the required amount of cement in a beaker. Measure out the correct amount of waste liquid for the sample. Thoroughly mix the liquid and cement together to ensure homogeneity.

G. Cover the sample and store in a shielded area.

H. Observe the sample immediately after mixing and intermittently thereafter as appropriate till solidification is complete. Record the results in the space provided on Attachment 1B.

NOTE:	**Some water may appear on the surface and be reabsorbed during solidification.**

I. Set the sample aside for future disposal.

J. Complete Attachment 1A before proceeding with full scale solidification.

2.6.4 Sample Acceptance Criteria

A. Visual inspection after mixing will confirm that the sample is homogeneous.

B. Visual inspection of the sample after curing will confirm that no free water exists on the surface of the sample.

C. Physical inspection of the sample after curing will confirm that the end product is a uniform, liquid free, free standing solid that resists penetration when probed with a pencil-sized probe.

D. If test samples from the initial specimen fail to produce a mixture which will solidify, additional specimens **SHALL** be drawn and mixed to determine the proper solidification parameters before full scale solidification can commence.

Additionally, if test samples from the initial specimen fail to produce a mixture which will solidify, sample solidification of specimens from successive batches **SHALL** be conducted until at least three samples from consecutive batches demonstrate solidification.

3.0 MANUAL SOLIDIFICATION OF WASTE LIQUIDS

3.1 Purpose

To establish parameters which provide reasonable assurance of complete solidification of waste liquids when mixed manually.

3.2 Applicability

This section of the PCP is applicable to manual solidification of waste liquids with masonry cement. Manual solidification may include the use of a portable, power-operated mixer.

Waste liquids which are normally solidified manually include:

- 1 Laundry sludge
- 2 Decon solutions, etc. not suitable for evaporation

3.3 Sequence of Operation

3.3.1 Place desired amount of liquid in 55 gal. drum (normally 1/2 to 2/3 full).

3.3.2 Commence mixing.

3.3.3 Add cement while continuing to mix at the rate of 1 ft^3 (1 bag) per 6.25 gal. of liquid or until mixture begins to thicken. Continue to mix until all of the cement is incorporated and the mixture is smooth.

Remove the mixer. (if applicable).

3.4 Cure Time

Solidification can normally be expected within two to three days.

3.5 Verification of Solidification

3.5.1 Each drum of manually solidified waste liquid **SHALL** be inspected to verify solidification and the absence of free water. A drum may be considered solid when the cemented mass offers significant resistance to penetration by a hammer or similar object. Absence of free water may be determined visually.

If solidification fails to take place, the process **SHALL** be suspended until the cause is determined and remedies are defined.

3.5.2 When solidification and absence of free water has been verified, the drum may be capped and deconned. The drum number is recorded together with the batch number, contents, and radiation level. The drum is then placed in storage to await shipment and burial.

4.0 PROCESSING OF CERTAIN WASTE LIQUIDS THRU SPENT BEAD RESIN

4.1 Purpose

To establish an alternate method of processing certain waste liquids in lieu of solidification. This method utilizes spent bead resin to filter out suspended particulates allowing normal processing of the resultant liquid. Disposal volumes and personnel exposures are thus reduced.

4.2 Applicability

The following waste liquids may be processed using this procedure:

4.2.1 Laundry sludge.

4.2.2 Decon solutions, etc. not suitable for evaporation.

4.2.3 Filter sludge.

4.2.4 Mop bucket slurry.

4.2.5 Tank bottoms.

4.2.6 Sump bottoms.

NOTE:	Evaporator Concentrates may not be processed using this procedure

The above list is not to be considered complete. Items may be added or deleted upon evaluation of the Rad Waste System Engineer.

4.3 Sequence of Operation

4.3.1 Ensure there is a layer of bead resin in the liner to act as a filter (the type of liner is determined by the activity of the material to be disposed of).

4.3.2 Ensure adequate volume for the quantity of material to be processed.

4.3.3 Pump/pour liquid slurry into liner.

4.3.4 Flush drum and/or container, pump and hoses to liner.

4.4 Dewatering Procedure

Dewater as per Section 7.0 "Dewatering of Bead Resin" to ensure there is no free standing water in either the resin or the sludge.

5.0 MANUAL SOLIDIFICATION OF WET TRASH BY SUBMERSION

5.1 Purpose

To establish parameters which provide reasonable assurance of complete solidification of liquid contained in wet trash.

5.2 Applicability

This section of the PCP is applicable to solidification of wet trash with masonry cement.

Wet trash includes contaminated material such as mopheads, wet rags, paper towels, etc.

5.3 Sequence of Operation

5.3.1 Place desired amount of liquid in 55 gal drum (normally 1/2 to 2/3 full).

NOTE:	Contaminated liquids may be used for this purpose.

5.3.2 Commence mixing.

5.3.3 Add cement while continuing to mix at the rate of 1 cu. ft. (one bag) per 6.25 gal of liquid or until the mixture begins to thicken. Continue to mix until all of the cement is incorporated and the mixture is smooth. Remove the mixer (if applicable).

5.3.4 Immerse items of wet trash into the cemented mass using a stick or similar device. Attempt to put as many items of trash as possible into the barrel within the limits of ALARA.

5.4 Cure Time

Solidification can normally be expected within two to three days.

5.5 Verification of Solidification

Each drum **SHALL** be inspected to verify solidification and the absence of free water. A drum may be considered solid when the cemented mass offers significant resistance to penetration by hammer or similar object. Absence of free water may be determined visually.

If solidification fails to take place, the process **SHALL** be suspended until the cause is identified and remedies are determined.

5.6 Disposition

When solidification and the absence of free water has been verified, the drum may be capped and deconned. Record the drum number together with the batch number, contents, and radiation level. The drum is then placed in storage to await shipment and burial.

6.0 PROCESSING OF WET TRASH BY COMPACTION/CEMENTATION

6.1 Purpose

To establish parameters which provide reasonable assurance that wet radioactive trash is packaged safely and with an absence of free water.

6.2 Applicability

This section of the PCP is applicable to the compaction of wet trash using the trash compactor while concurrently absorbing any free water with masonry cement.

Wet trash includes contaminated material such as mop heads, wet rags, paper towels, etc.

6.3 <u>Sequence of Operation</u>

6.3.1 Place approximately 2" of masonry cement in the bottom of a 55 gal. drum.

6.3.2 Place a layer of wet trash items into the drum while integrating cement into each item of trash. Add a small amount of cement to fill voids between items.

6.3.3 Compress the wet trash using the compactor. Add cement as required to incorporate any free water thus produced.

6.3.4 Repeat the preceding two steps until the drum is filled.

6.4 <u>Cure Time</u>

Absence of free water can normally be determined visually immediately following the final compaction cycle.

6.5 <u>Verification of Absence of Free Water</u>

Each drum of processed wet trash **SHALL** be inspected to verify the absence of free water. If free water is detected, additional cement **SHALL** be added to solidify the free water.

6.6 <u>Disposition</u>

When the absence of free water has been verified, the drum **SHALL** be capped and deconned. The drum number is recorded together with the batch number, contents, and radiation level. The drum is then placed in storage to await shipment and burial.

7.0 <u>DEWATERING OF BEAD RESIN</u>

7.1 <u>Purpose</u>

To describe the process used to provide reasonable assurance that bead resin is dewatered to meet applicable burial site criteria.

7.2 Applicability

This section of the PCP is applicable to all radioactively contaminated bead resin which is intended to be shipped dewatered (not solidified) for disposal.

7.3 Dewatering Procedure

The dewatering procedure varies with the supplier of the resin liner, with the type of liner, whether a steel liner or a high integrity container (HIC), and with the dewatering requirement of the burial site. Individual shipping procedures unique to the particular container and burial site refer to the appropriate dewatering procedure

In general, however, the dewatering process normally consists of the following steps after the liner has been filled:

7.3.1 Initial pumpdown with the diaphragm pump until suction is lost.

7.3.2 A waiting period (twenty hours, for example).

7.3.3 Final dewatering consisting of one or more pumpdowns using a diaphragm pump or a vacuum pumping system.

7.4 Verification of Dewatering

Preceding shipment, connect and operate the dewatering pump as before. If no water is present, the dewatering process is complete.

If water is found, pump until vacuum is lost. Repeat the pump/wait cycle as required. When no more water can be removed, the dewatering process is complete.

8.0 DEWATERING OF POWDERED RESIN

8.1 Purpose

To describe the process used to provide reasonable assurance that powdered resin is dewatered to meet applicable burial site criteria.

8.2 Applicability

This section of the PCP is applicable to all radioactively contaminated powdered resin which is intended to be shipped for burial.

8.3 System Description

Contaminated powdered resin originates in the Condensate Polishing System Filter Demineralizers of both units.

Spent resin is purged from the Filter Demineralizers to the Backwash Waste Receiving Tank where it awaits the dewatering/drying process.

The dewatering/drying process takes place in the Clamshell Backwash Waste Filter ("Clamshell").

There are two Clamshells to serve the needs of both units, each capable of being aligned to either unit. It is the function of the clamshells to filter the powdered resin out of the water-resin slurry that is pumped from the Backwash Waste Receiving Tank, thru the Clamshells. When a cake of resin develops in the Clamshell to a predetermined thickness, the filtering process automatically switches to a purge phase followed by a forced air drying phase. The duration of the air drying phase can be adjusted. Experience, however, has demonstrated that a drying cycle of approximately 12 minutes produces a product sufficiently dry to meet burial site requirements yet not so dry as to create an air-borne contamination hazard.

When the air-dry cycle is completed, the resin is dumped from the Clamshell into a hopper from which it is conducted down an enclosed chute to a container below. If the resin is insufficiently dried it will not flow freely down the chute.

8.4 Disposal

Powdered resin which has been processed thru the Clamshell system does not normally receive further dewatering treatment. Powdered resin may, therefore, be shipped in a container not fitted with dewatering equipment such as a steel drum or box. Because processed powdered resin is sufficiently dry to flow freely, and because powdered resin is normally very low in specific activity, it may be used to fill interstitial space in shipments of non-compatible trash or to fill voids in other shipping containers where they occur.

9.0 DEWATERING OF SPENT FILTER ELEMENTS

9.1 Purpose

To describe the process used to provide reasonable assurance that spent filter shipments are dewatered to meet applicable burial site criteria.

9.2 Applicability

This section of the PCP is applicable to all radioactively contaminated filter elements intended for shipment for burial in the dewatered state (not solidified). Normally a High Integrity Container (HIC) is used for this purpose. Procedures specific to the appropriate type of container **SHALL** be employed.

9.3 Description of Filling Process

9.3.1 Verify that the container to be used is approved by the manufacturer for disposal of filter elements.

9.3.2 Install dewatering element with attached hose in the container. The dewatering elements must be compatible with the dewatering pump (normally a vacuum pump). Conduct hose to outside of container for later attachment to dewatering pump.

9.3.3 Allow filter elements to drain of excess water prior to placing in container.

9.3.4 Place a layer of processed powdered resin or similar material on the bottom of the container if required.

9.3.5 Place a layer of filter elements into the container while attempting to avoid bridging of filters and observing the principles of ALARA.

9.3.6 Fill voids with processed powdered resin or similar material if required.

NOTE:	Powdered resin may be used to fill voids between filter elements while observing principles of ALARA even if not required to be used as packing material by the container manufacturer.

9.3.7 Repeat the preceding two steps until the container is full.

9.4 Dewatering

The dewatering process may vary with type and manufacture of container and with requirements of the burial site. Typically, however, the dewatering process consists of the following steps:

9.4.1 Allow wait period (typically 20 to 24 hours) for water if present to migrate to the bottom of the container.

9.4.2 Connect the dewatering pump to the dewatering element hose. Conduct the pump discharge hose to a container to enable monitoring of discharge volume.

9.4.3 Start the dewatering pump. If no water is found, the container may be considered to be dewatered.

If water is found, pump until vacuum is lost, stop the pump and begin another wait period.

Repeat the pump/wait cycle until no more water can be removed.

9.5 Verification of Dewatering

Preceding shipment, connect and operate the dewatering pump as before. If no water is present, the dewatering process is complete.

If water is found, pump until vacuum is lost. Repeat the pump/wait cycle as required. When no more water can be removed, the dewatering process is complete.

Appendix A Process Control Program for In-Container Solidification of Bead Resin

1.0 GENERAL

Bead resin is normally shipped in the bulk dewatered form. However, high activity resin may be solidified if desired.

Following a brief system description, the Hittman Nuclear and Development Corp. PCP for In-Container Solidification of Bead Resin is appended.

This document is proprietary and is reproduced in its entirety as an appendix to the Prairie Island Process Control Program for Solidification/Dewatering of Waste From Liquid Systems.

Certain plant specific exceptions to the Hittman document are noted in the system description.

2.0 SYSTEM DESCRIPTION

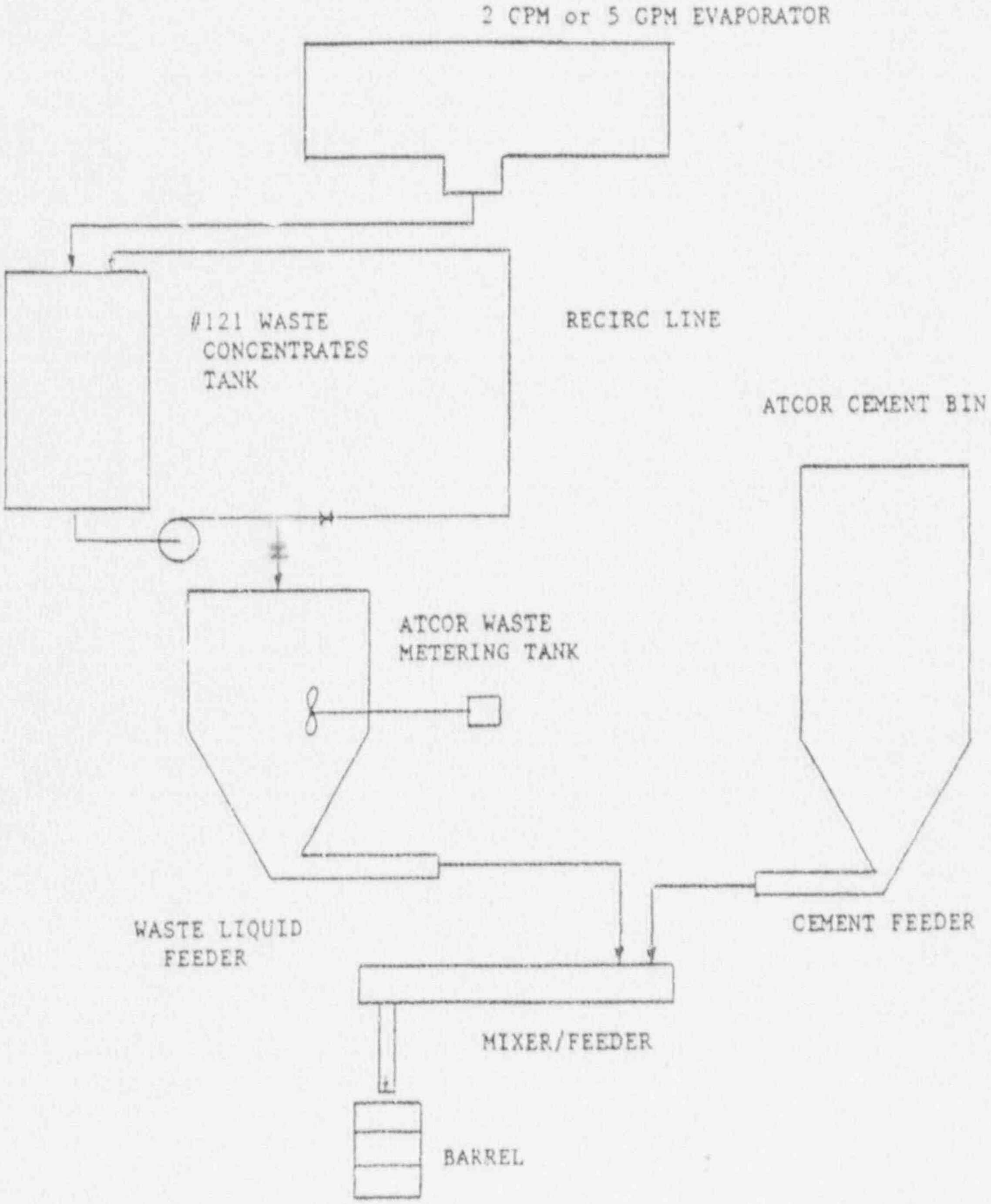
The resin disposal system for the purposes of this PCP consists of 121 Spent Resin Tank, 122 Spent Resin Pump, a portable dewatering pump and related piping, hoses, and valves. In addition are included those items furnished by the resin disposal contractor including a shipping cask, shipping liner, solidification equipment and related controls and appurtenances.

Resin is pumped in a water slurry from 121 Spent Resin Tank to the shipping liner in the proper amount. The water is then pumped out to the drains system, after which the solidification process will begin in accordance with the contractor's procedures.

Because of the high activity of the resin requiring solidification, sample solidification using nonradioactive resin is normal. References in the PCP to sampling the spent resin tank, therefore, do not apply.

NOTE:	Because of its proprietary nature, the Hittman Nuclear and Development Corporation Process Control Program for In-Container Solidification of Bead Resin #STD-P-05-004 is retained in the Rad Protection Files for reference.

FIGURE 1 SOLID RADWASTE FLOW DIAGRAM



ATTACHMENT 1A

SAMPLE VERIFICATION FORM

RPS ______________________ Date __________ Time __________

Waste Type ______________________________ __________

PRETREATMENT

P1 Initial pH ____ ____ Initial Temp ______ °F % Boric Acid ______

P2 Specimen Volume ______________ ml

P3 Lime Added ______________ gm

P4 Final pH ______________

$$\text{Lime Ratio} = \frac{P3}{P2} \times 8.34 = \_\_\_\_\_\_\_\_ \frac{lbs}{gal}$$

SAMPLE PROPORTIONS

Sample No. ____ ________

S1 Sample Waste Liquid Vol ________ ml

S2 Sample Cement wt ____________ gm

$$\text{Liquid/Cement Ratio (vol)} = \frac{S1}{S2} \times 1.089^{*} = \_\_\_\_\_\_\_\_$$

* Density correction factor.

ATTACHMENT 1B

SAMPLE VERIFICATION FORM

Sample No. ____________________

Describe sample appearance, water amount, hardness, etc.

CURE TIME	CONDITIONS NOTED
0 HRS	

Sample is/is not solid ____________________ Date ____________
RPS Signature