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Proposed Annual Limits for Radioactive Discharge

UKP-GW-GL-028, Revision 2

Westinghouse Electric Company LLC
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REVISION HISTORY

Revision	Description of Changes
0	Initial Submittal
1	Complete rewrite and reformatting to incorporate responses to Technical Queries and Regulatory Observations
2	In Table 2-1, explained reason for not including N-16 in subsequent calculations. Revised Table 4-3 to correct Xe-131m values. Addresses new Westinghouse trademark guidelines.

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LIST OF ACRONYMS

AGR	Advanced Gas-cooled Reactor
ALARA	As Low As Reasonably Achievable
ALARP	As Low As Reasonably Practicable
BAT	Best Available Techniques
COMAH	Control of Major Accident and Hazard Regulations
EA	Environment Agency
GDA	Generic Design Assessment
HSE	Health & Safety Executive
NPP	Nuclear Power Plant
NRC	US Nuclear Radiation Commission
PWR	Pressurised Water Reactor
RCS	Reactor Cooling System
WCPD	Worst Case Annual Plant Discharge

1.0 INTRODUCTION

The UK Nuclear Regulators (the Environment Agency (EA) and the Health and Safety Executive (HSE)) have developed a Generic Design Assessment (GDA) process for evaluating alternative designs for the next generation of nuclear power plants to be built in the UK. Westinghouse Electric Company has submitted an application for its AP1000™ nuclear power plant (NPP) design to be considered in this process.

As part of this application, information must be presented regarding the nature of radioactive waste, including management of the discharges and disposals. The EA has produced guidance to assist nuclear regulators in setting consistent radioactive discharge limits for nuclear-licensed sites [Reference 1]. This report proposes annual discharge limits for radioactive atmospheric emissions and radioactive liquid effluents from the AP1000 NPP that are consistent with this guidance.

2.0 SCOPE

The scope of this work is to use the predicted monthly radioactive atmospheric emissions and radioactive liquid discharges from the Westinghouse AP1000 NPP to calculate the Worst Case Annual Plant Discharges (WCPD). The WCPD is then used as the basis for calculating the proposed annual emission and discharge limits for the AP1000 NPP in accordance with the EA guidelines [Reference 1].

In selecting which isotopes warrant discharge limit calculations consideration was given to those radionuclides which:

- are significant in terms of their radiological impact,
- are significant in terms of activity,
- have long half lives and may persist or accumulate in the environment,
- are indicators of plant performance, or
- provide for effective regulatory control

The criteria for selection are shown in Table 2-1 for gaseous discharges and Table 2-2 for liquid discharges:

Table 2-1

ISOTOPIC SELECTION CRITERIA FOR AIR EMISSION LIMIT CALCULATIONS

Selection Criteria	Isotopes Selected
Significant in terms of their radiological impact	> 1% contribution to fisherman family dose (uS/y): C-14, I-131, H-3, Ar-41 > 1% contribution to 500y collective dose (manSv): C-14, H-3
Significant in terms of activity	> 10% activity (Bq/y): Kr-85, H-3, Xe-131m, Xe-133, Ar-41
Have long half lives and may persist or accumulate in the environment	Half-life > 10 years, concentration factors (terrestrial organisms) > 1000 and release rates > 3.7E+04Bq/y: C-14
Indicators of plant performance	Indicative of particulate emissions : Co-60
Provide for effective regulatory control.	Main Vent : Sr-90/Cs-137, I-131, Kr-85/Xe-133 Turbine building vent : Kr-85/Xe-133 Internal vent monitors : Sr-90/Cs-137, Kr-85/Xe-133, N-16*(1) Grab samples : noble gases, iodine, particulates and tritium
Summary	H-3, C-14, N-16(1), Ar-41, Co-60, Kr-85, Sr-90, I-131, Xe-131m, Xe-133, Cs-137

Note:

1. N-16 detectors are used to detect primary-to-secondary coolant leakage and are located near the steam generator main steam outlet and upstream of the turbine. N-16 has a very short half-life of 7.13 seconds and, as such, is not a suitable isotope for use as a regulatory emission standard to atmosphere. For this reason N-16 is not carried forward into subsequent sections of this document.

Table-2-2

ISOTOPIC SELECTION CRITERIA FOR LIQUID EMISSION LIMIT CALCULATIONS

Selection Criteria	Isotopes Selected
Significant in terms of their radiological impact	> 1% contribution to fisherman family dose (uS/y): C-14. Co-60, Co-58, H-3 > 1% contribution to 500y collective dose (manSv): C-14, H-3
Significant in terms of activity	>10% activity (Bq/y): H-3
Have long half lives and may persist or accumulate in the environment	Half-life > 10 years, concentration factors (aquatic organisms) > 1000 and release rates > 3.7E+04Bq/y: C-14, Ni-63, Cs-137, Pu-241
Indicators of plant performance	Indicative of corrosion : Fe-55, Ni-63 Indicative of fuel leaks : Cs-137 Other particulates expressed as Co-60
Provide for effective regulatory control.	Continuously monitored isotopes : Cs-137 Monitored isotopes grab samples : H-3, Co-60, Sr-90, Cs-137
Summary	H-3, C-14, Fe-55, Co-58, Co-60, Ni-63, Sr-90, Cs-137, Pu-241

3.0 ENVIRONMENT AGENCY GUIDANCE

The EA has produced guidance to assist nuclear regulators in setting consistent radioactive discharge limits for nuclear-licensed sites [Reference 1]. This guidance suggests the following steps:

Step 1: Review of all plants on the site that contribute to discharges, and identifying those where limits should be set.

As no specific site has been selected for the GDA process, no assumptions have been made regarding emissions and discharges from other plants located on the generic site. The emission and discharge data used in this report are based on a single AP1000 NPP.

Step 2: Derivation of the worst case plant annual discharges (WCPD) using the following formula:

$$WCPD = (1.5 \times D \times T \times A \times B) + C + L + N - I \quad [1]$$

where:

- 1.5 is an Environment Agency-established factor which relates 'worst case' to average discharges.
- D is the representative average 12-month plant discharge, excluding discharges due to faulty plant operation.
- T is a factor that allows for any future increases in throughput, power output etc., relative to the review period.
- A is a factor that allows for plant ageing. This allows for increases in discharges which result from changes within the plant as it ages that cannot be remedied or controlled by the operator.
- B is a factor that allows for other future changes that are beyond the control of the operator. For example, in a reprocessing plant, these would include the need to deal with higher burn-up or shorter-cooled fuel; at a dockyard, the need to deal with wastes from a new class of submarines.
- C is an allowance for decommissioning work beyond that carried out in the review period (and included in D).
- L is an allowance for dealing with legacy wastes, beyond those dealt with in the review period (and included in D).
- N is an allowance for new plant.
- I is the reduction in discharges expected as a result of introducing improvement schemes before the new authorisation comes into force.

Since the Westinghouse AP1000 NPP site is a new plant, allowances are not made for decommissioning work, legacy wastes, further new plant, or introduction of improvement schemes. Thus factors C, L, N and I become zero, and the worst case plant annual discharge becomes:

$$WCPD = 1.5 \times D \times T \times A \times B \quad [2]$$

4.0 PREDICTED RADIOACTIVE DISCHARGE ON WESTINGHOUSE AP1000 NPP SITE

The amount of radioactive discharge may be predicted using historical data from active plants. The predicted annual radiation emissions for the Westinghouse AP1000 NPP site [Reference 2] are summarised for airborne and liquid discharges in Table 4-1 and Table 4-2 respectively.

The volume of liquid that circulates through the components of the reactor can be separated into two categories, the reactor coolant system (RCS), and the non-reactor coolant system components (NON-RCS).

A fuel cycle is based on an 18-month period, which accounts for periods of start-up, shutdown and maintenance. During this time the amount of liquid in the NON-RCS components of the reactor is constant, where as the amount of liquid in the RCS is dependent on the boron concentration. The boron concentration decreases over the 18-month fuel cycle, and as a result of this the amount of liquid in the RCS increases.

The annual discharge data has been correlated by Westinghouse Electric Company to provide monthly radiation emissions from radioactive nuclides over an 18-month fuel cycle. This data is presented in Table 4-3 and Table 4-4.

The monthly emission of each radioisotope to air is presented graphically in Appendix A, Figures A-1 to A-13. A comparison of the contribution that each effluent makes to the total monthly discharge is illustrated in Figure A-14. This demonstrates that the total monthly air discharge is dominated by noble gases (krypton and xenon), tritium, and Ar-41.

The monthly discharge for each radioisotope to liquid effluent is presented graphically in Appendix A, Figures A-15 to A-25. A comparison of the contribution that each effluent makes to the total monthly discharge is illustrated in Figure A-26 and A-27. This demonstrates that the total monthly liquid discharge is dominated by tritium.

Table 4-1

PREDICTED ANNUAL AIR RADIATION EMISSION

Air Effluent Input	Predicted Annual Air Radiation Emission	
	(Ci/y)	**(TBq/y)**
Radioiodines	1.61E-02	5.95E-04
Nobel Gases	1.80E+02	6.67E+00
Tritium	4.80E+01	1.78E+00
Carbon-14	1.64E+01	6.07E-01
Argon-41	3.40E+01	1.26E+00
Cobalt-60	8.73E-05	3.23E-06
Krypton-85	8.40E+01	3.11E+00
Strontium-90	1.20E-05	4.44E-07
Iodine-131	5.60E-03	2.07E-04
Xenon-131m	3.70E+01	1.37E+00
Xenon-133	3.40E+01	1.26E+00
Cesium-137	3.60E-05	1.33E-06
Other particulates	3.30E-04	1.22E-05

Table 4-2

PREDICTED ANNUAL LIQUID RADIATION DISCHARGE

Liquid Effluent Input	Predicted Annual liquid Radiation Discharge	
	(Ci/y)	**(TBq/y)**
Tritium	9.02E+02	3.34E+01
Non-tritium	1.57E-01	5.80E-03
Carbon-14	9.00E-02	3.33E-03
Iron-55	1.31E-02	4.83E-04
Cobalt-58	1.11E-02	4.09E-04
Cobalt-60	6.14E-03	2.27E-04
Nickel-63	1.50E-02	5.55E-04
Strontium-90	6.67E-06	2.47E-07
Cesium-137	6.16E-04	2.28E-05
Plutonium-241	2.20E-06	8.14E-08
Other Isotopes	2.08E-02	7.68E-04

Table 4-3

PREDICTED MONTHLY AIR RADIATION EMISSIONS DURING 18-MONTH CYCLE

Month	Predicted Monthly Air Radiation Discharges (TBq)													
	Radio iodines	**Noble Gases**	**Tritium**	**C-14**	**Ar-41**	**Co-60**	**Kr-85**	**Sr-90**	**I-131**	**Xe-131m**	**Xe-133**	**Cs-137**	**Other Particulate**	**Total**
1	4.96E-05	0.298	0.132	0.045	0.093	2.69E-07	0.081	3.70E-08	1.73E-05	0.0513	0.090	1.11E-07	1.02E-06	0.568
2	4.96E-05	0.305	0.132	0.045	0.094	2.69E-07	0.085	3.70E-08	1.73E-05	0.0528	0.091	1.11E-07	1.02E-06	0.575
3	4.96E-05	0.312	0.132	0.045	0.094	2.69E-07	0.090	3.70E-08	1.73E-05	0.0546	0.091	1.11E-07	1.02E-06	0.583
4	4.96E-05	0.320	0.133	0.046	0.094	2.69E-07	0.095	3.70E-08	1.73E-05	0.0566	0.091	1.11E-07	1.02E-06	0.592
5	4.96E-05	0.329	0.134	0.046	0.095	2.69E-07	0.101	3.70E-08	1.73E-05	0.0589	0.092	1.11E-07	1.02E-06	0.602
6	4.96E-05	0.339	0.134	0.046	0.095	2.69E-07	0.108	3.70E-08	1.73E-05	0.0616	0.093	1.11E-07	1.02E-06	0.614
7	4.96E-05	0.351	0.135	0.046	0.096	2.69E-07	0.117	3.70E-08	1.73E-05	0.0647	0.093	1.11E-07	1.02E-06	0.628
8	4.96E-05	0.366	0.136	0.046	0.096	2.69E-07	0.127	3.70E-08	1.73E-05	0.0683	0.094	1.11E-07	1.02E-06	0.644
9	4.96E-05	0.383	0.137	0.047	0.097	2.69E-07	0.138	3.70E-08	1.73E-05	0.0727	0.095	1.11E-07	1.02E-06	0.664
10	4.96E-05	0.404	0.138	0.047	0.098	2.69E-07	0.153	3.70E-08	1.73E-05	0.0780	0.096	1.11E-07	1.02E-06	0.687
11	4.96E-05	0.430	0.140	0.048	0.099	2.69E-07	0.171	3.70E-08	1.73E-05	0.0847	0.098	1.11E-07	1.02E-06	0.717
12	4.96E-05	0.463	0.142	0.048	0.101	2.69E-07	0.194	3.70E-08	1.73E-05	0.0932	0.100	1.11E-07	1.02E-06	0.755
13	4.96E-05	0.508	0.145	0.050	0.103	2.69E-07	0.224	3.70E-08	1.73E-05	0.105	0.102	1.11E-07	1.02E-06	0.805
14	4.96E-05	0.570	0.149	0.051	0.105	2.69E-07	0.267	3.70E-08	1.73E-05	0.120	0.105	1.11E-07	1.02E-06	0.875
15	4.96E-05	0.662	0.155	0.053	0.110	2.69E-07	0.330	3.70E-08	1.73E-05	0.144	0.111	1.11E-07	1.02E-06	0.980
16	4.96E-05	0.815	0.165	0.056	0.117	2.69E-07	0.437	3.70E-08	1.73E-05	0.183	0.119	1.11E-07	1.02E-06	1.152
17	4.96E-05	1.117	0.184	0.063	0.130	2.69E-07	0.644	3.70E-08	1.73E-05	0.259	0.136	1.11E-07	1.02E-06	1.494
18	4.96E-05	2.031	0.242	0.083	0.171	2.69E-07	1.269	3.70E-08	1.73E-05	0.492	0.187	1.11E-07	1.02E-06	2.527
Total	8.93E-04	10.001	2.664	0.910	1.887	4.85E-06	4.662	6.66E-07	3.11E-04	2.054	1.887	2.00E-06	1.83E-05	15.463

Table 4-4

PREDICTED MONTHLY LIQUID DISCHARGES DURING 18-MONTH CYCLE

Month	Predicted Monthly Liquid Radiation Discharges (TBq)										
	Tritium	**Non-Tritium**	**C-14**	**Fe-55**	**Co-58**	**Co-60**	**Ni-63**	**Sr-90**	**Cs-137**	**Pu-241**	**Other Isotopes**	**Total**
1	2.473	1.43E-04	8.14E-05	1.20E-05	1.02E-05	5.62E-06	1.30E-05	5.96E-09	5.66E-07	1.99E-09	1.63E-05	2.473
2	2.481	1.52E-04	8.62E-05	1.27E-05	1.08E-05	5.96E-06	1.37E-05	6.33E-09	5.96E-07	2.11E-09	1.71E-05	2.481
3	2.489	1.61E-04	9.14E-05	1.35E-05	1.14E-05	6.33E-06	1.45E-05	6.70E-09	6.33E-07	2.23E-09	1.81E-05	2.489
4	2.498	1.71E-04	9.73E-05	1.44E-05	1.22E-05	6.73E-06	1.54E-05	7.14E-09	6.73E-07	2.38E-09	1.92E-05	2.499
5	2.509	1.83E-04	1.04E-04	1.54E-05	1.30E-05	7.18E-06	1.65E-05	7.66E-09	7.22E-07	2.55E-09	2.05E-05	2.509
6	2.522	1.97E-04	1.12E-04	1.65E-05	1.40E-05	7.73E-06	1.78E-05	8.25E-09	7.73E-07	2.75E-09	2.20E-05	2.522
7	2.536	2.13E-04	1.22E-04	1.78E-05	1.51E-05	8.36E-06	1.92E-05	8.92E-09	8.36E-07	2.97E-09	2.37E-05	2.537
8	2.554	2.32E-04	1.32E-04	1.94E-05	1.65E-05	9.10E-06	2.09E-05	9.73E-09	9.10E-07	3.24E-09	2.57E-05	2.554
9	2.574	2.55E-04	1.46E-04	2.13E-05	1.81E-05	9.99E-06	2.29E-05	1.07E-08	9.99E-07	3.56E-09	2.81E-05	2.574
10	2.599	2.83E-04	1.62E-04	2.36E-05	2.00E-05	1.11E-05	2.54E-05	1.18E-08	1.11E-06	3.96E-09	3.11E-05	2.600
11	2.631	3.17E-04	1.82E-04	2.65E-05	2.25E-05	1.24E-05	2.85E-05	1.33E-08	1.24E-06	4.44E-09	3.47E-05	2.631
12	2.671	3.61E-04	2.07E-04	3.02E-05	2.56E-05	1.42E-05	3.25E-05	1.52E-08	1.42E-06	5.07E-09	3.96E-05	2.671
13	2.724	4.22E-04	2.41E-04	3.51E-05	2.97E-05	1.65E-05	3.77E-05	1.77E-08	1.65E-06	5.88E-09	4.59E-05	2.724
14	2.798	5.03E-04	2.88E-04	4.18E-05	3.55E-05	1.96E-05	4.51E-05	2.12E-08	1.97E-06	7.07E-09	5.44E-05	2.799
15	2.909	6.25E-04	3.59E-04	5.22E-05	4.40E-05	2.45E-05	5.62E-05	2.63E-08	2.45E-06	8.77E-09	6.73E-05	2.909
16	3.092	8.25E-04	4.74E-04	6.88E-05	5.85E-05	3.23E-05	7.44E-05	3.49E-08	3.23E-06	1.16E-08	8.88E-05	3.092
17	3.453	1.22E-03	7.07E-04	1.02E-04	8.66E-05	4.81E-05	1.10E-04	5.18E-08	4.81E-06	1.72E-08	1.31E-04	3.455
18	4.548	2.43E-03	1.40E-03	2.03E-04	1.72E-04	9.51E-05	2.18E-04	1.03E-07	9.51E-06	3.43E-08	2.60E-04	4.550
Total	50.061	8.70E-03	5.00E-03	7.25E-04	6.14E-04	3.41E-04	8.33E-04	3.70E-07	3.42E-05	1.22E-07	9.44E-04	50.070

5.0 CALCULATED ANNUAL LIMITS

Following the EA guidance presented in Section 3, annual limits for the Westinghouse AP1000 NPP site may be calculated based on the predicted worst case annual plant discharge.

To estimate the worst case annual plant discharge, the parameters in equation [2] must be defined. The selection of parameters is discussed below:

Representative Average 12-month plant discharge (D)

The predicted annual average plant discharges for an AP1000 NPP site are given in the UK AP1000 Environment Report [Reference 2]. These averages are further estimated on an 18-monthly cycle basis to account for periods of start-up, shutdown and maintenance (Table 4-3 and Table 4-4). To allow for periods when the discharge is likely to be higher than the predicted annual average, the 12 months at the end of each cycle (months 7-18) shall be used as the worst case representative 12-month plant discharge.

Future Increase in Throughput (T)

There are no plans to increase the AP1000 NPP throughput, power output etc., within the foreseeable future. This parameter has been set to 1.

Plant Ageing (A)

A margin of 10% is considered suitable to allow for increases in discharge as the plant ages. Therefore this parameter is set to 1.1.

Future Changes (B)

There are no foreseen future changes beyond the control of the operator. This parameter has been set to 1.

The worst case annual plant discharge may therefore be calculated for each air and liquid effluent to propose an annual limit as follows:

$$WCPD = 1.5 \times D \times T \times A \times B \qquad [2]$$

$$WCPD = 1.5 \times D \times 1 \times 1.1 \times 1 \qquad [3]$$

The results are summarized in Table 5-1 for air emissions and Table 5-2 for liquid discharges. The calculated limits are rounded to one significant figure as per the guidance in Reference 1.

A comparison of the 12-month rolling total discharges for each radioactive air emission and radioactive liquid discharge with the predicted average annual discharge and the worst case annual plant discharge is given in Appendix B. This demonstrates that there are no 12-month periods in which the predicted discharge is likely to exceed the calculated annual limits.

Table 5-1

CALCULATED ANNUAL LIMITS FOR AIR EMISSIONS

Air Effluent Input	Representative Average 12-Month Plant Discharge (D) (TBq/y)	WCPD (TBq/y)	Calculated Annual Limit (TBq.y)
Radioiodines[(1)]	5.95E-04	9.82E-04	1E-03
Nobel Gases[(2)]	8.099	13.363	13
Tritium	1.867	3.081	3
Carbon-14	0.638	1.053	1
Argon-41	1.323	2.182	2
Cobalt-60	3.22E-06	5.32E-06	5E-06
Krypton-85	4.070	6.716	7
Strontium-90	4.44E-07	7.33E-07	7E-07
Iodine-131	2.07E-04	3.42E-04	3E-04
Xenon-131m	1.764	2.911	3
Xenon-133	1.335	2.203	2
Cesium-137	1.33E-06	2.20E-06	2E-06
Other particulates	1.22E-05	2.01E-05	2E-05
Total Beta Particulates[(3)]	1.72E-05	2.84E-05	3E-05
Total	11.928	19.681	20

Notes:

1. Radioiodines include I-131 and I-133
2. Noble gases include Kr-85m, Kr-85, Kr-87, Kr-88, Kr-85, Xe-131, Xe-133m, Xe-133, Xe-135m, Xe-135, Xe-137, Xe-138
3. Total beta particulate include Co-60 + Sr-90 + Cs-137 + other particulates

Table 5-2

CALCULATED ANNUAL LIMITS FOR LIQUID DISCHARGES

Liquid Discharge Input	Representative Average 12-Month Plant Discharge (TBq/y)	WCPD (TBq/y)	Calculated Annual Limit (TBq.y)
Tritium	35.09	57.90	60
Non-tritium	7.70E-03	1.27E-02	1E-02
Carbon-14	4.42E-03	7.30E-03	7E-03
Iron-55	6.42E-04	1.06E-03	1E-03
Cobalt-58	5.44E-04	8.97E-04	9E-04
Cobalt-60	3.01E-04	4.97E-04	5E-04
Nickel-63	6.91E-04	1.14E-03	1E-03
Strontium-90	3.24E-07	5.35E-07	5E-07
Cesium-137	3.01E-05	4.97E-05	5E-05
Plutonium-241	1.08E-07	1.78E-07	2E-07
Other Isotopes(1)	1.07E-03	1.77E-03	2E-03
Total	35.096	57.909	60

Note:

1. Other isotopes = Non-tritium isotopes – (C-14 + Fe-55 + Co-58 + Co-60 + Ni-63 + Sr-90 + Cs-137 + Pu-241)

6.0 PROPOSED ANNUAL LIMITS AND COMPARISON WITH OTHER SITES

The Westinghouse AP1000 NPP site is a PWR site and the proposed limits can be compared directly against the limits for the Sizewell B PWR site [Reference 3]. This comparison is presented in Section 6.1. For reference, the proposed limits for the AP1000 NPP are compared against limits for other Advanced Gas-cooled Reactor (AGR) sites in the UK in Section 6.2.

It is considered appropriate that the AP1000 NPP is regulated in a similar way to the existing nuclear power plants in the UK. In this respect it is proposed that annual limits for the AP1000 NPP are restricted to those isotopes that already have established limits at UK nuclear power plants.

6.1 Sizewell B PWR Site

The calculated radioactive air emission limits for the Westinghouse AP1000 NPP site are compared against the new EA limits for Sizewell B established in 2007 in Table 6-1.

The proposed radioactive liquid discharges for the Westinghouse AP1000 NPP site are compared against the new EA limits for Sizewell B established in 2007 in Table 6-2.

Tables 6-1 and 6-2 demonstrate that, where direct comparison is possible, the proposed Westinghouse AP1000 NPP limits are similar to or below the new Sizewell B limits.

6.2 AGR Sites

The proposed limits for the Westinghouse AP1000 NPP site are compared against the new EA limits for AGR sites [Reference 3]. Limits for the AGR sites are presented for air emissions in Table 6-3 and for liquid discharges in Table 6-4

Tables 6-3 and 6-4 show that the AP1000 NPP proposed limit values are significantly below the new EA limits for all UK AGR sites

Table 6-1

COMPARISON OF AIR EMISSION LIMITS WITH SIZEWELL B SITE

Air Emission	AP1000 NPP Calculated Annual Limit (TBq/y)	AP1000 NPP Proposed Annual Limit (TBq/y)	Sizewell B Environment Agency New Limit (Reference 3) (TBq/y)
Radioiodines(1)	1E-03	1E-03	-
Nobel Gases(2)	13	13	30
Tritium	3	3	3
Carbon-14	1	1	0.5
Argon-41	2	2	-
Cobalt-60	5E-06	-	-
Krypton-85	7	-	-
Strontium-90	7E-07	-	-
Iodine-131	3E-04	3E-04	5.0E-04
Xenon-131m	3	-	-
Xenon-133	2	-	-
Cesium-137	2E-06	-	-
Other particulates	2E-05	-	-
Beta particulates(3)	3E-05	3E-05	1.0E-04

Notes:

1. Radioiodines include I-131 and I-133
2. Noble gases include Kr-85m, Kr-85, Kr-87, Kr-88, Kr-85, Xe-131, Xe-133m, Xe-133, Xe-135m, Xe-135, Xe-137, Xe-138
3. Total beta particulate include Co-60 + Sr-90 + Cs-137 + other particulates

Table 6-2

COMPARISON OF LIQUID DISCHARGE LIMITS WITH SIZEWELL B SITE

Air Emission	AP1000 NPP Calculated Annual Limit (TBq/y)	AP1000 NPP Proposed Annual Limit (TBq/y)	Sizewell B Environment Agency New Limit (Reference 3) (TBq/y)
Tritium	60	60	80
Non-tritium	1E-02	-	-
Carbon-14	7E-03	7E-03	-
Iron-55	1E-03	-	-
Cobalt-58	9E-04	-	-
Cobalt-60	5E-04	-	-
Nickel-63	1E-03	-	-
Strontium-90	5E-07	-	-
Caesium-137	5E-05	-	0.02
Plutonium-241	2E-07	-	-
Other isotopes(1)	2E-03	-	-
All isotopes without other limits	5E-03(2)	5E-03(2)	0.13(3)

Notes:
1. Other isotopes = Non-tritium isotopes – (C-14 + Fe-55 + Co-58 + Co-60 + Ni-63 + Sr-90 + Cs-137 + Pu-241)
2. All isotopes without other limits = Non-tritium isotopes – C-14
3. All isotopes without other limits = Non-tritium isotopes – Cs-137

Table 6-3

COMPARISON OF AP1000 NPP PROPOSED AIR EMISSION LIMITS WITH UK AGR SITES

Air Emission	AP1000 NPP Calculated Limits	AP1000 NPP Proposed Limits	Dungeness B	Hartlepool	Heysham 1	Heysham 2	Hinkley Point B
	(TBq/y)	(TBq/y)	(TBq/y)	(TBq/y)	(TBq/y)	(TBq/y)	(TBq/y)
Radioiodines(1)	1E-03	1E-03	1.50E-03	1.50E-03	1.50E-03	1.50E-03	1.50E-03
Nobel Gases(2)	13	13	-	-	-	-	-
Tritium	3	3	12	10	10	10	12
Carbon-14	1	1	3.7	4.5	4.5	3.7	3.7
Argon-41	2	2	75	150	150	75	100
Cobalt-60	5E-06	-	-	-	-	-	-
Krypton-85	7	-	-	-	-	-	-
Strontium-90	7E-07	-	-	-	-	-	-
Iodine-131	3E-04	3E-04	-	-	-	-	-
Xenon-131m	3	-					
Xenon-133	2	-	-	-	-	-	-
Cesium-137	2E-06	-	-	-	-	-	-
Other particulates(3)	2E-05	-	-	-	-	-	-
Beta particulates	3E-05	3E-05	-	-	-	-	-

Notes:
1. Radiodine = I-131 + I-133
2. Noble Gases = Kr-85m + Kr-85 + Kr-87 + Kr-88 + Xe-131m + Xe-133m + Xe-133 + Xe-135m + Xe-136 + Xe-137 + Xe-138
3. Other particulate = Total beta particulate - Co-60 - Sr-90 - Cs-137

Table 6-4

LIQUID DISCHARGE LIMITS FOR AGR SITES

Liquid Discharge	AP1000 NPP Calculated Limits	AP1000 NPP Proposed Limits	Dungeness B	Hartlepool	Heysham 1	Heysham 2	Hinkley Point B
	(TBq/y)	(TBq/y)	(TBq/y)	(TBq/y)	(TBq/y)	(TBq/y)	(TBq/y)
Tritium	60	60	650	650	650	650	650
Non-tritium(1)	1E-02	-	-	-	-	-	-
C-14	7E-03	7E-03	-	-	-	-	-
Fe-55	1E-03	-	-	-	-	-	-
Co-58	9E-04	-	-	-	-	-	-
Co-60	5E-04	-	0.01	0.01	0.01	0.01	0.01
Ni-63	1E-03	-	-	-	-	-	-
Sr-90	5E-07	-	-	-	-	-	-
Cs-137	5E-05	-	0.1	0.1	0.1	0.1	0.1
Pu-241	2E-07	-	-	-	-	-	-
Other isotopes(2)	2E-03	-	-	-	-	-	-
All isotopes without other limits	5E-03(3)	5E-03(3)	0.08(4)	0.08(4)	0.08(4)	0.08(4)	0.08(4)

Notes:
1. Non-tritium = All isotopes - tritium
2. Other isotopes = Non-tritium isotopes – (C-14 + Fe-55 + Co-58 + Co-60 + Ni-63 + Sr-90 + Cs-137 + Pu-241)
3. All isotopes without other limits = Non-tritium isotopes – C-14
4. All isotopes without other limits = Non-tritium isotopes – Co-60 – Cs-137 – S-35

7.0 SUMMARY AND CONCLUSIONS

The proposed limits for the AP1000 NPP are summarised in Table 7-1.

The emission and discharge data used to calculate the proposed limits for the AP1000 NPP are considered to be representative of the predicted emissions including expected start-up, shut down and maintenance periods. There are no 12-month periods in which the predicted discharge is likely to exceed the proposed annual limit.

The proposed emission and discharge limits for the AP1000 NPP are similar or below the new EA Sizewell B limits and significantly below the new EA limits for all UK AGR sites.

Table 7-1

PROPOSED LIMITS FOR THE AP1000 NPP SITE

Radioisotope	Calculated Annual Limit (TBq/y)	Proposed Annual Limit (TBq/y)
Air Emission		
Radioiodines	1E-03	1E-03
Nobel Gases	13	13
Tritium	3	3
Carbon-14	1	1
Argon-41	2	2
Cobalt-60	5E-06	-
Krypton-85	7	-
Strontium-90	7E-07	-
Iodine-131	3E-04	3E-04
Xenon-133	2	-
Cesium-137	2E-06	-
Other particulates	2E-05	-
Beta particulates	3E-05	3E-05
Liquid Discharge		
Tritium	60	60
Non-tritium	1E-02	-
Carbon-14	7E-03	7E-03
Iron-55	1E-03	-
Cobalt-58	9E-04	-
Cobalt-60	5E-04	-
Nickel-63	1E-03	-
Strontium-90	5E-07	-
Cesium-137	5E-05	-
Plutonium-241	2E-07	-
Other Isotopes	2E-03	-
All isotopes without other limits	5E-03	5E-03

8.0 REFERENCES

1. Environment Agency; Developing Guidance for Setting Limits on Radioactive Discharges to the Environment from Nuclear-Licensed Sites; Science Report SC010034/SR; December 2005.

2. Sections 3.3.6 and 3.4.5, UK AP1000 Environment Report UKP-GW-GL-790 Rev. 4, Westinghouse Electric Company.

3. Decision Document and Authorisations for Future Regulation of Disposals of Radioactive Waste under the Radioactive Substances Act 1993 at British Energy Generation Limited's Nuclear Sites: Dungeness B Power Station, Hartlepool Power Station, Heysham 1 Power Station, Heysham 2 Power Station, Hinkley Point B Power Station, Sizewell B Power Station; Environment Agency, 21st December 2006.

APPENDIX A
MONTHLY DISCHARGES

A.1 Air Emissions

In the following graphs attention should be drawn to the vertical axis scale on each graph. For both the air and liquid discharges the emission levels from each radioisotope can differ by a factor in excess of 10^{-6}. The scale for each graph has therefore been selected to show the full range of values over the 18 month assessment period.

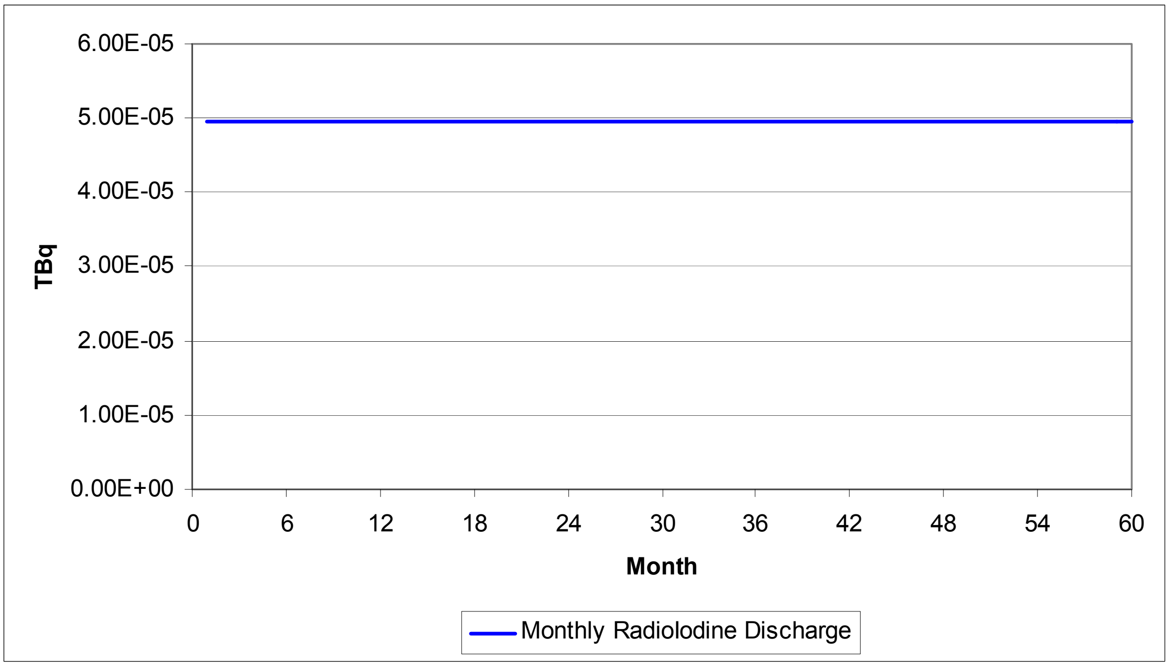

Figure A-1. Predicted Monthly Air Radioiodine Emission

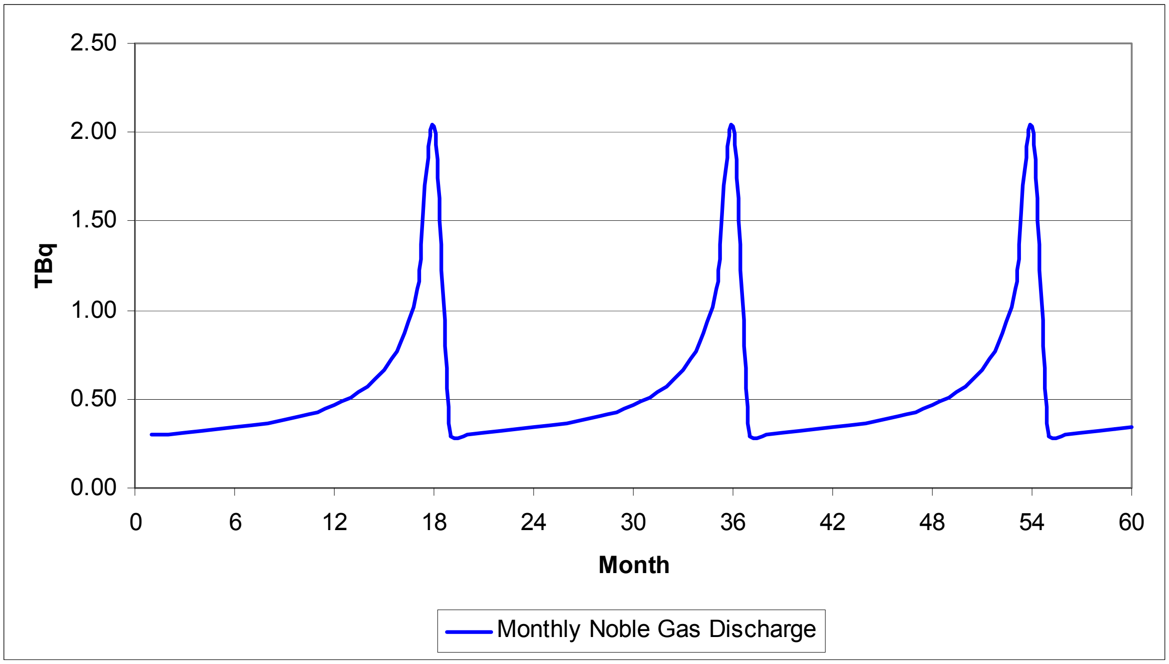

Figure A-2. Predicted Monthly Noble Gas Emission

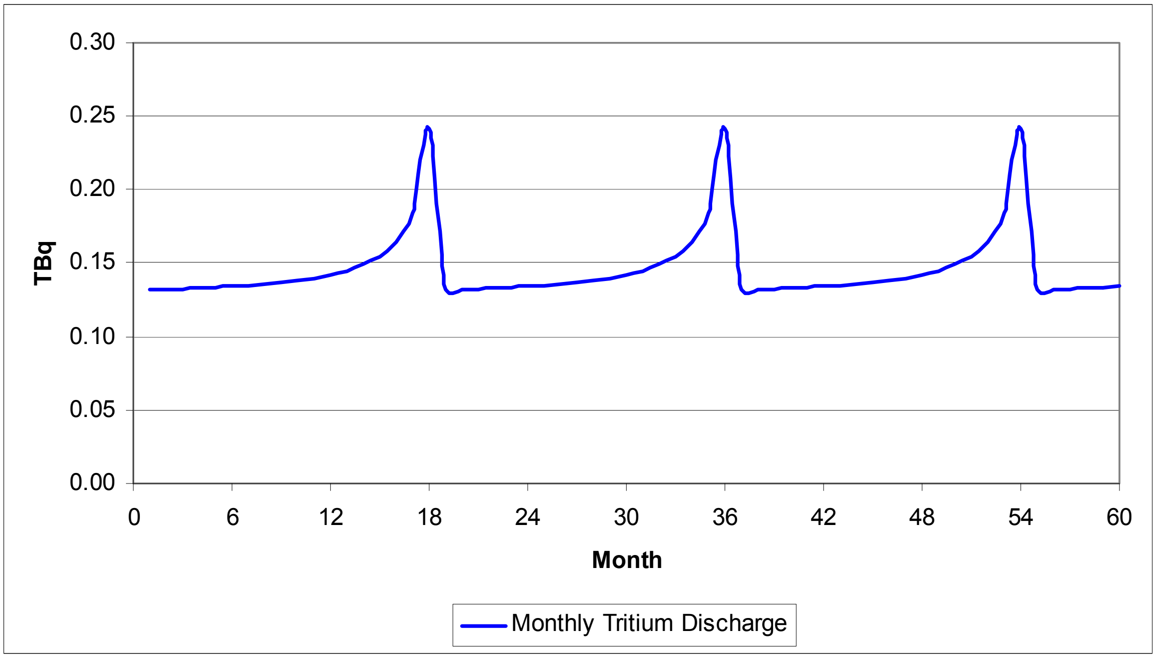

Figure A-3. Predicted Monthly Air Tritium Emission

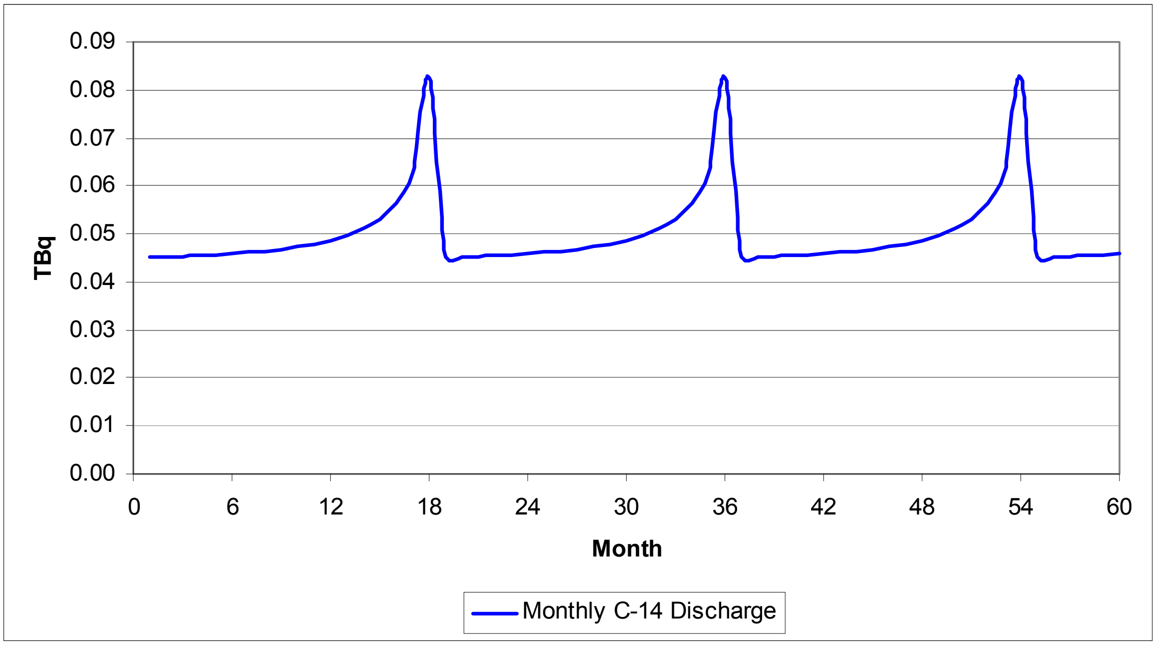

Figure A-4. Predicted Monthly Air Carbon-14 Emission

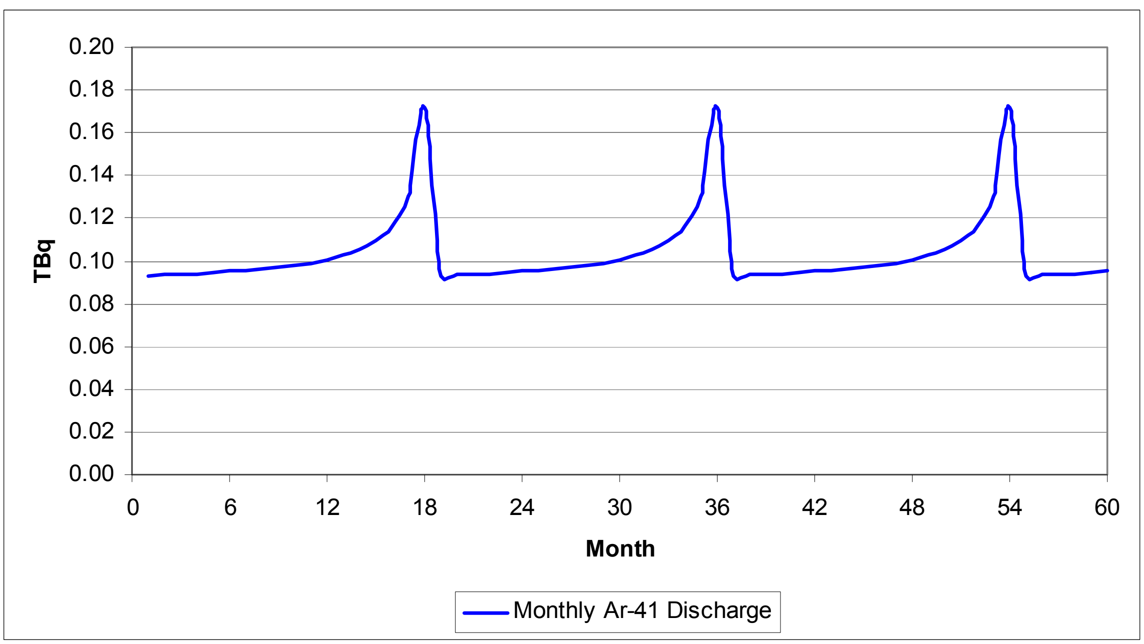

Figure A-5. Predicted Monthly Air Argon-41 Emission

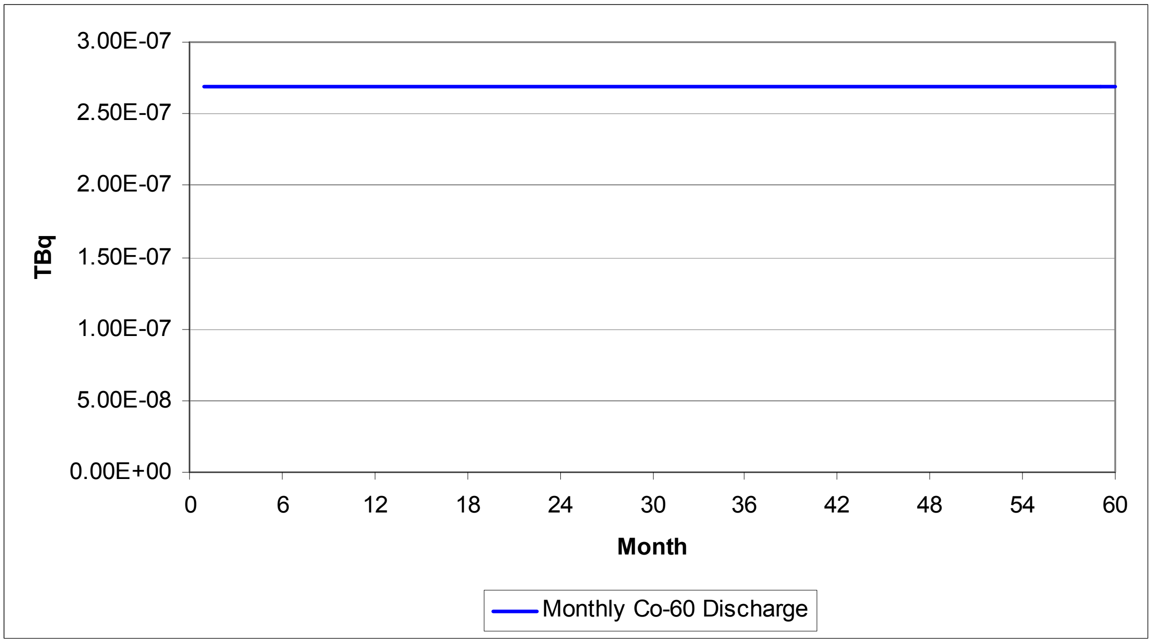

Figure A-6. Predicted Monthly Air Cobalt-60 Emission

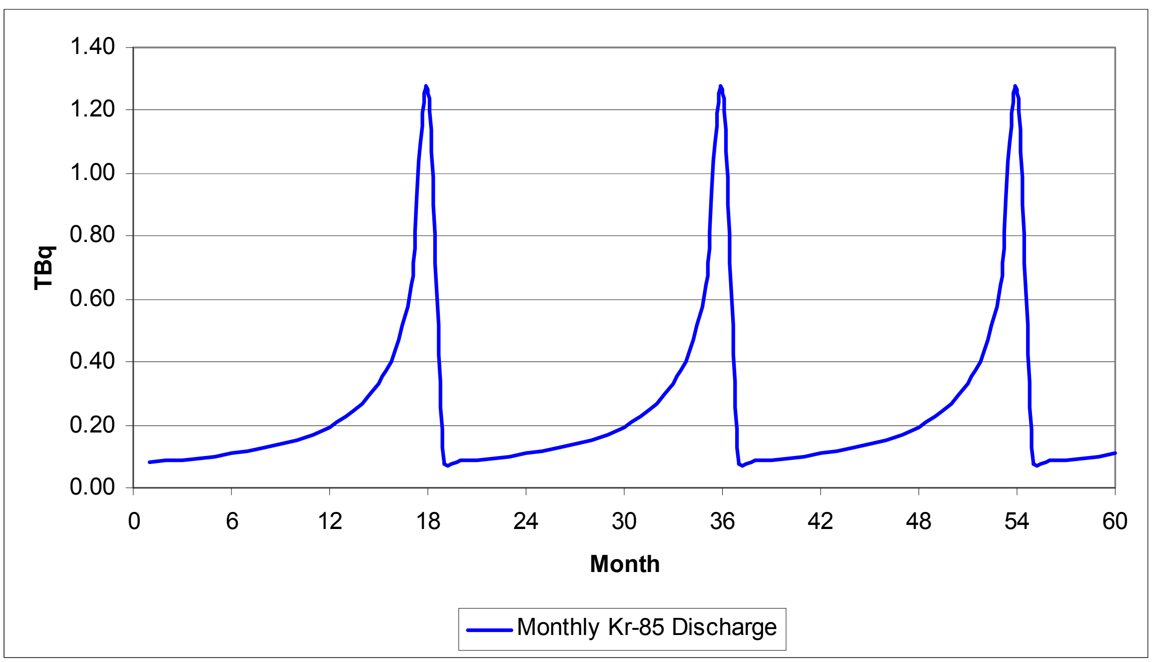

Figure A-7. Predicted Monthly Air Krypton-85 Emission

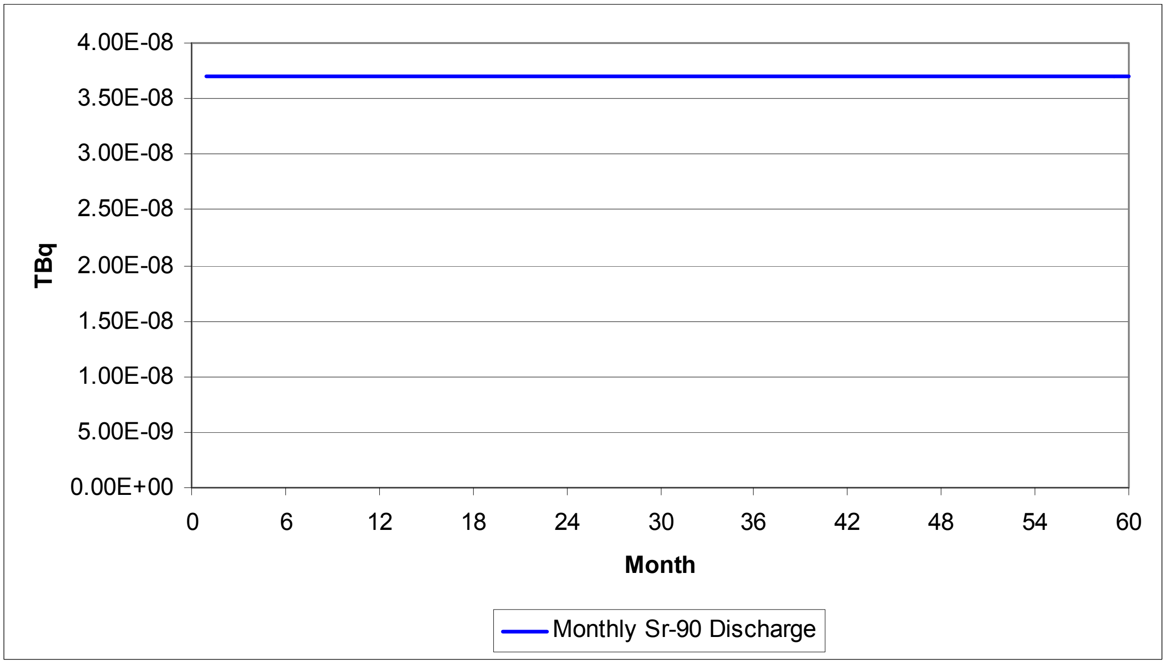

Figure A-8. Predicted Monthly Air Strontium-90 Emission

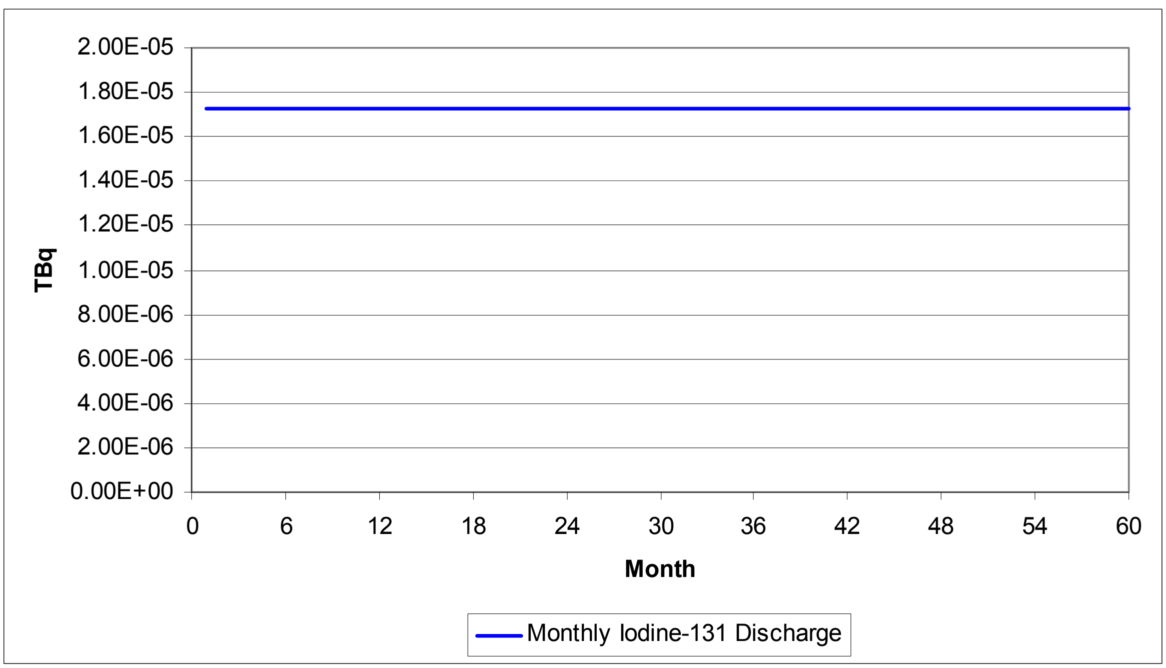

Figure A-9. Predicted Monthly Air Iodine-131 Emission

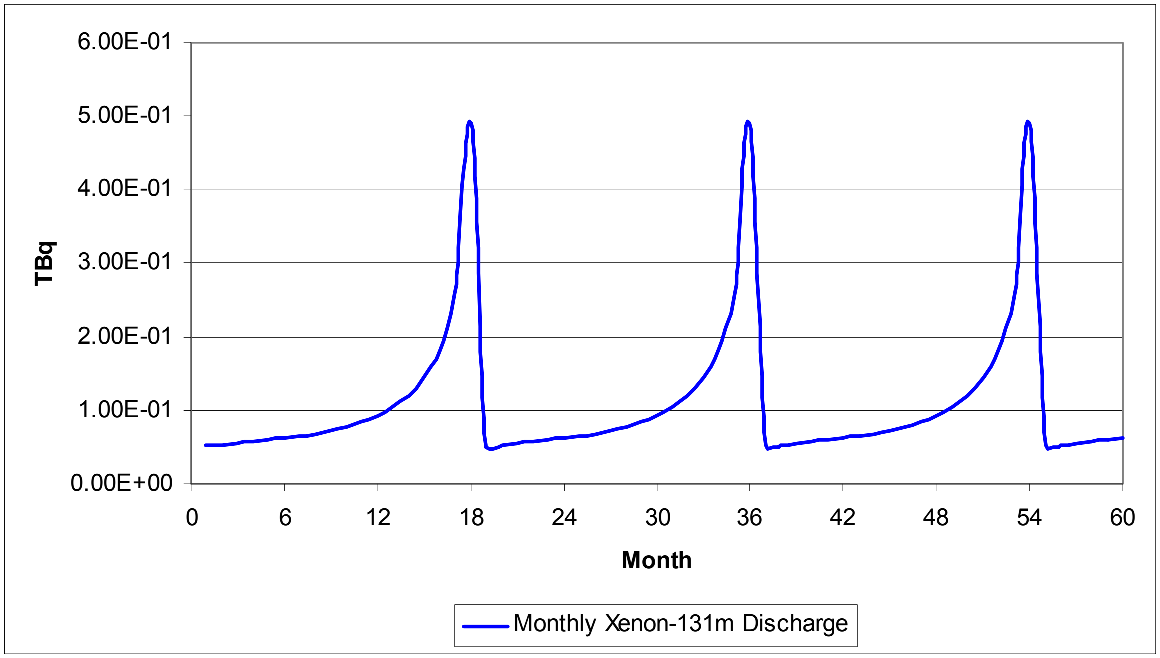

Figure A-10. Predicted Monthly Air Xenon-131m Emission

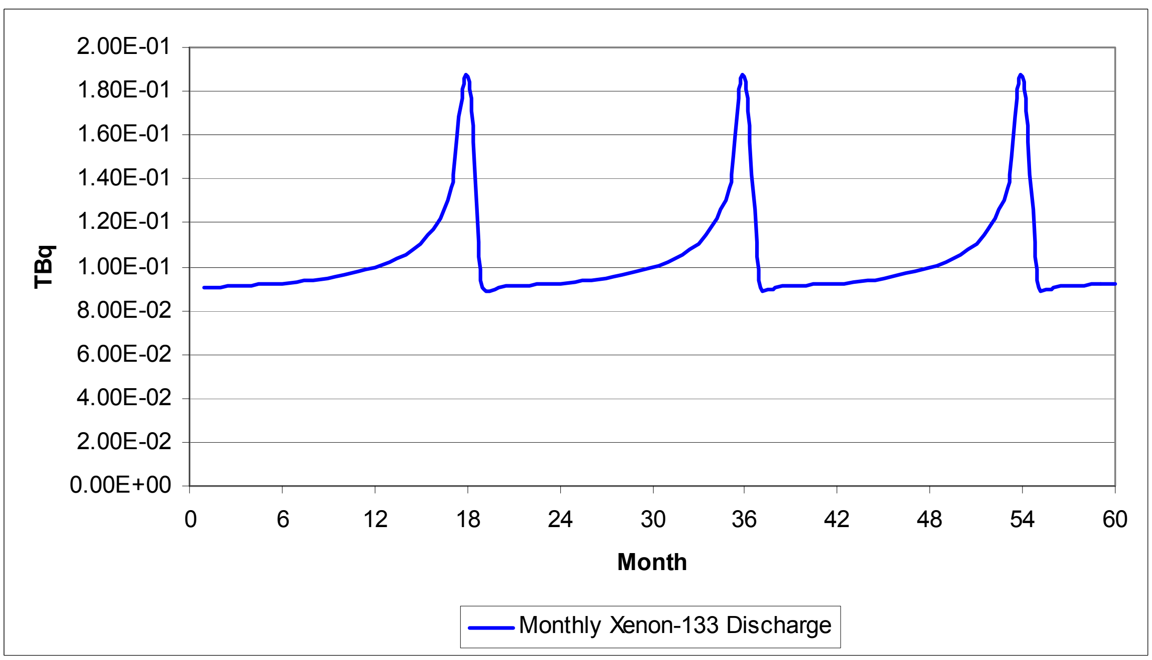

Figure A-11. Predicted Monthly Air Xenon-133 Emission

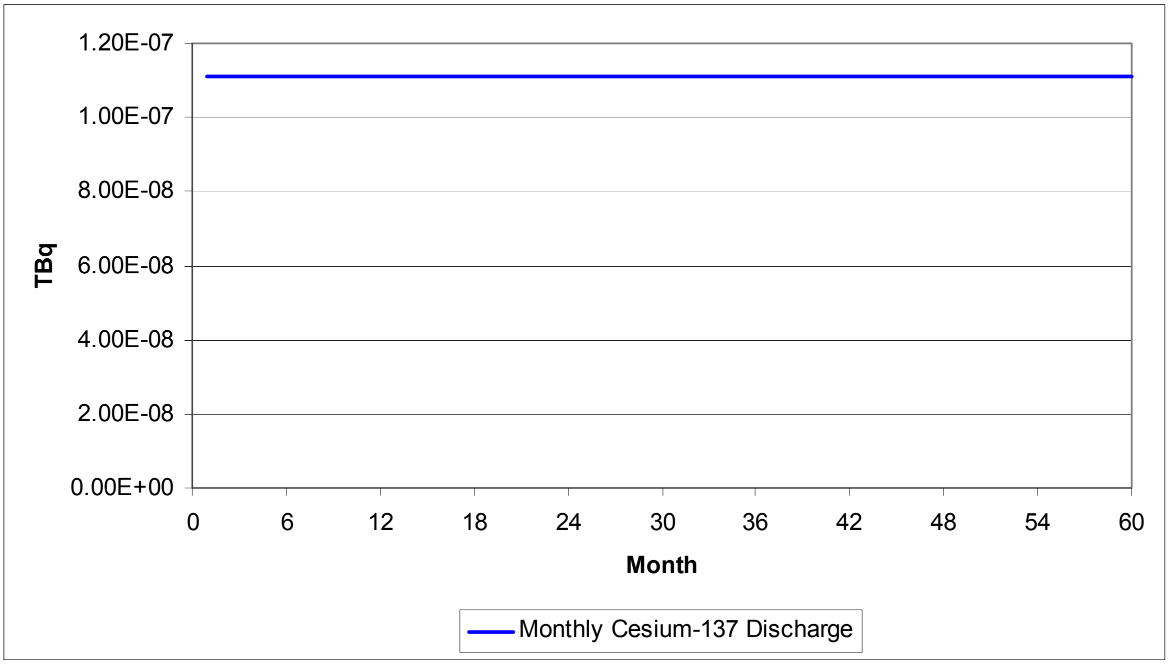

Figure A-12. Predicted Monthly Air Cesium-137 Emission

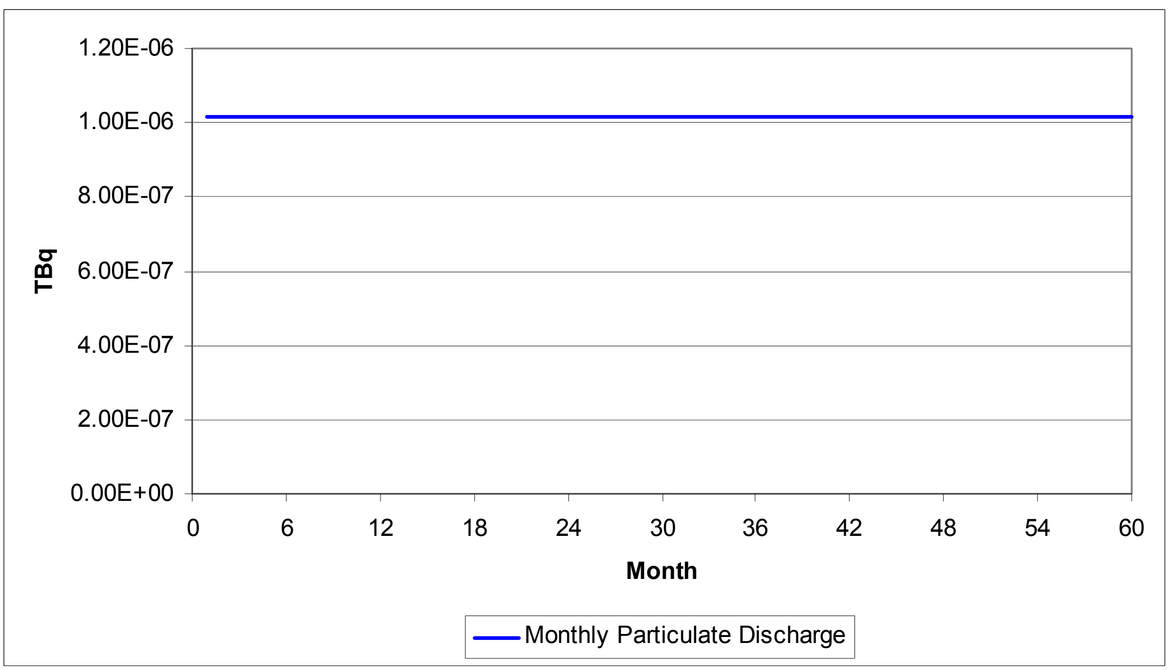

Figure A-13. Predicted Monthly Air Other Particulate Radioactive Emission

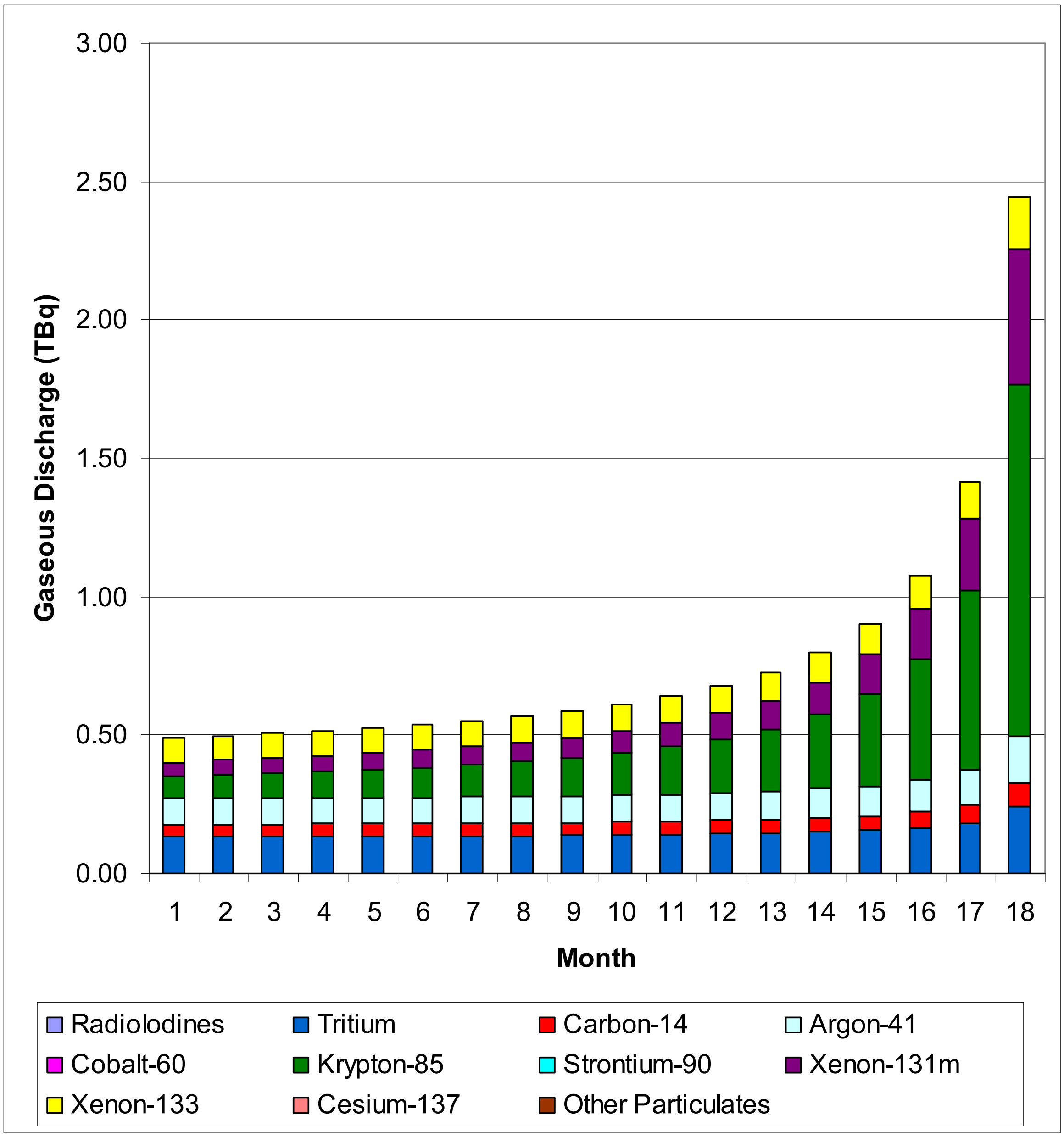

Figure A-14. Radioisotope Contribution to Total Predicted Monthly Air Emission

A.2 Liquid Discharges

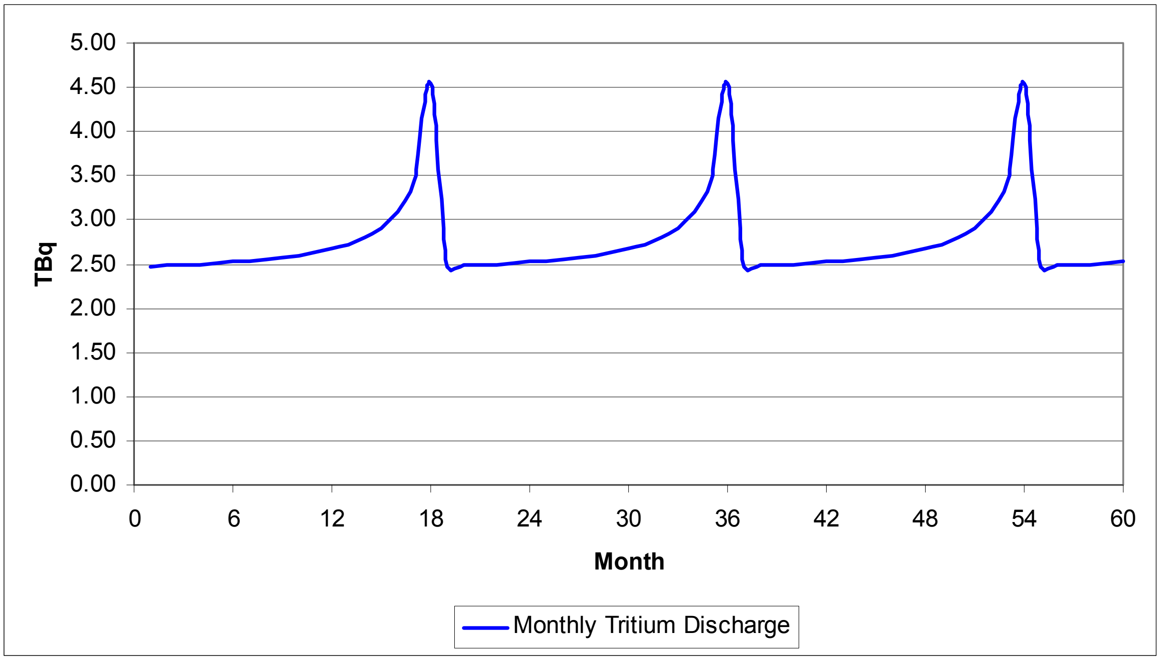

Figure A-15. Predicted Monthly Liquid Tritium Discharges

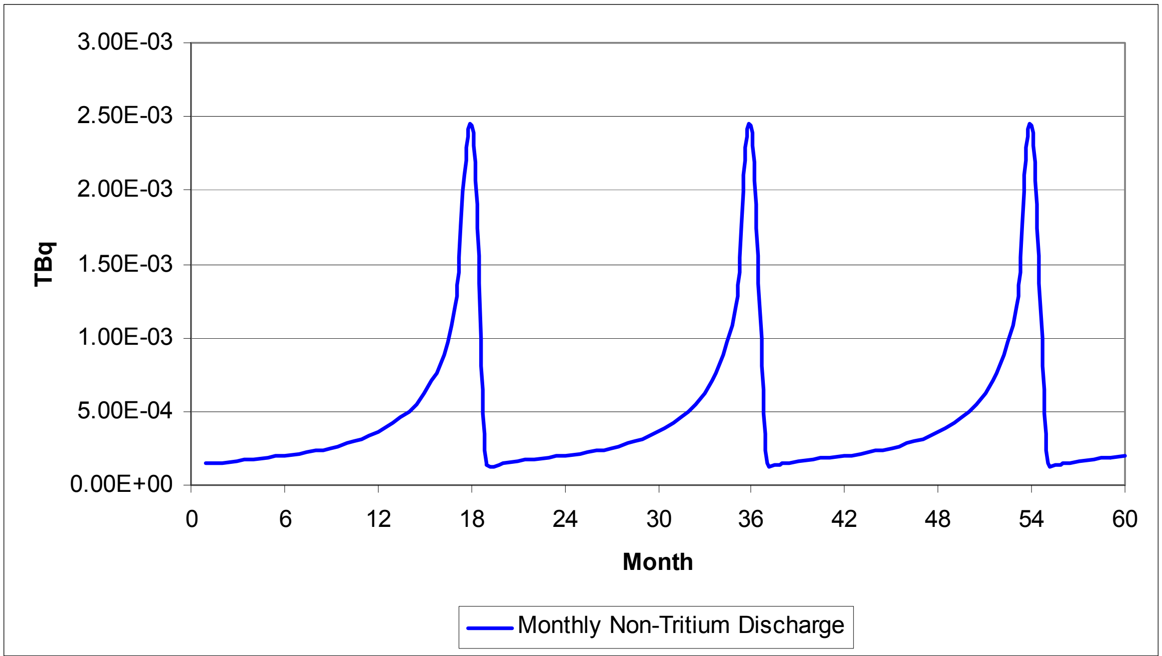

Figure A-16. Predicted Monthly Liquid Non-Tritium Discharges

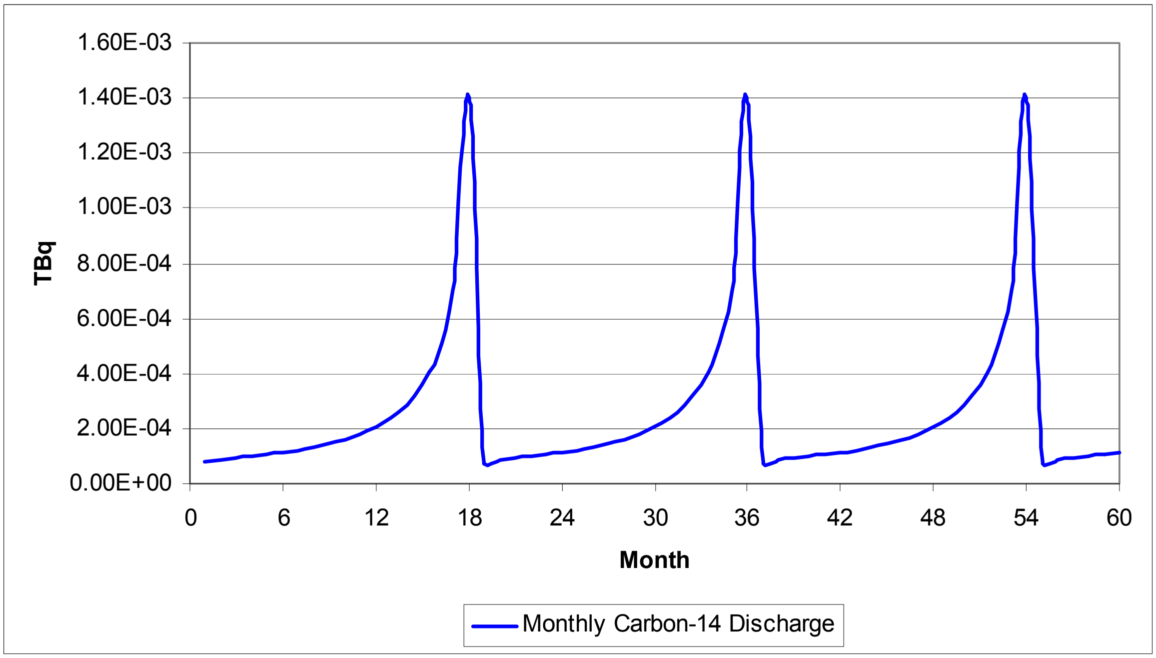

Figure A-17. Predicted Monthly Liquid Carbon-14 Discharges

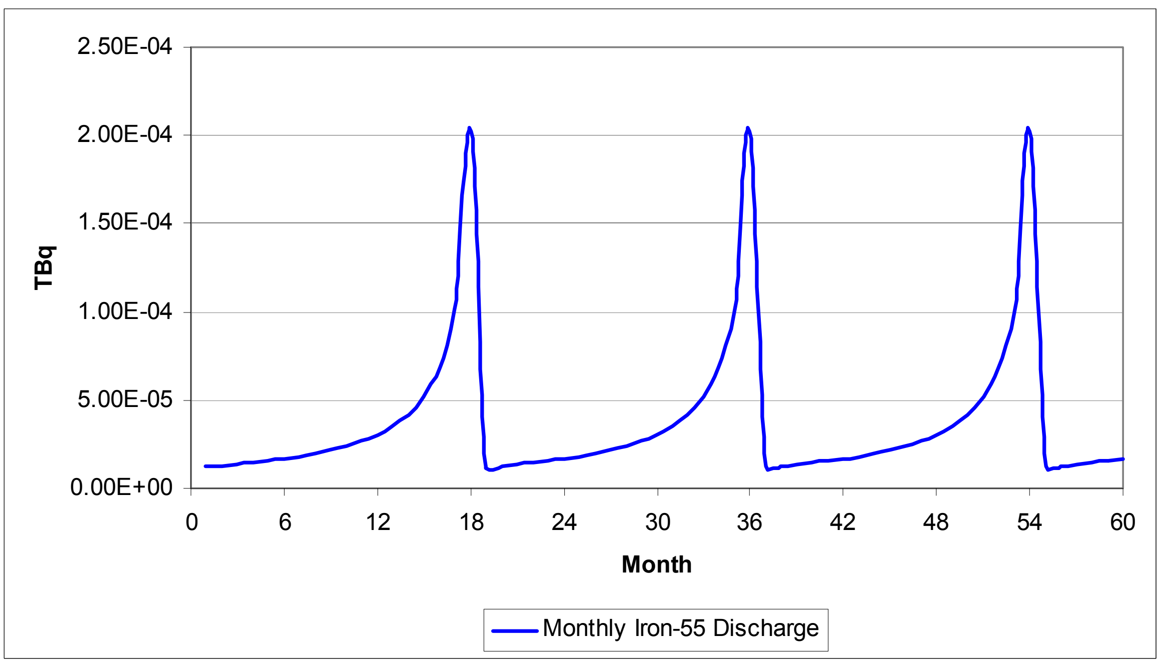

Figure A-18. Predicted Monthly Liquid Iron-55 Discharges

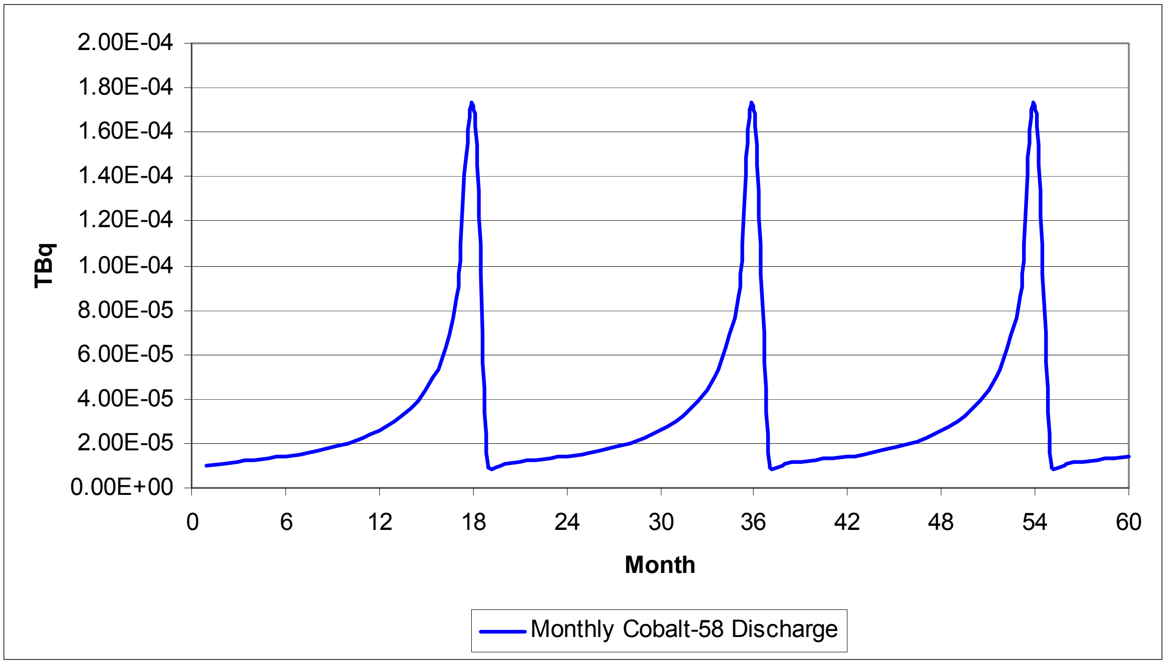

Figure A-19. Predicted Monthly Liquid Cobalt-58 Discharges

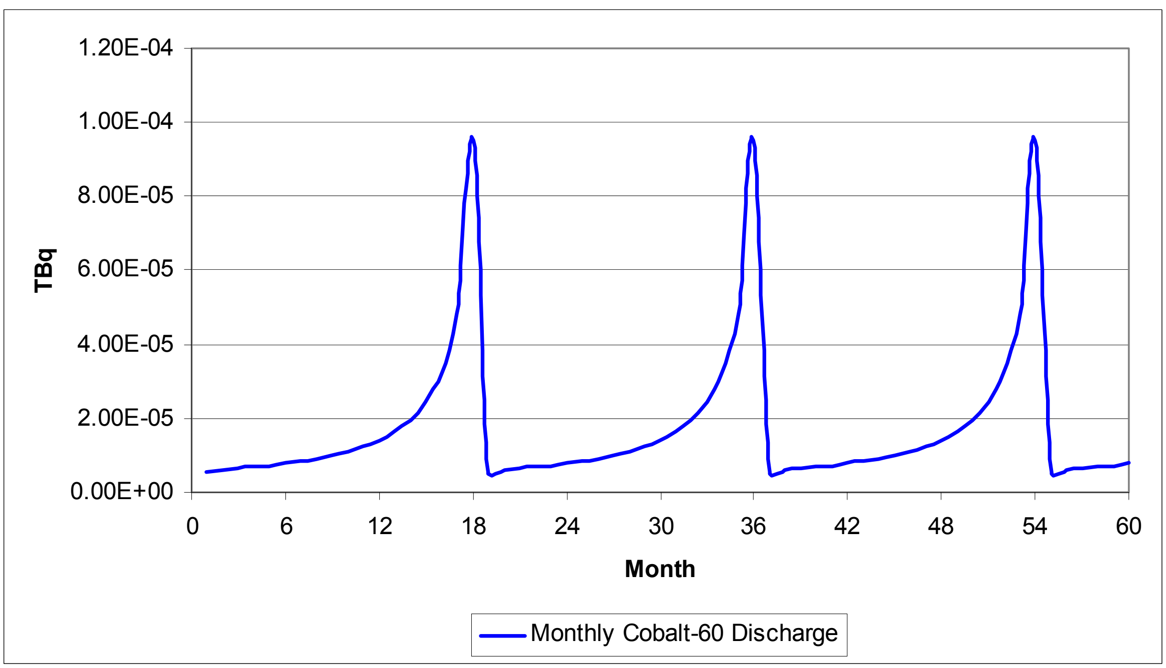

Figure A-20. Predicted Monthly Liquid Cobalt-60 Discharges

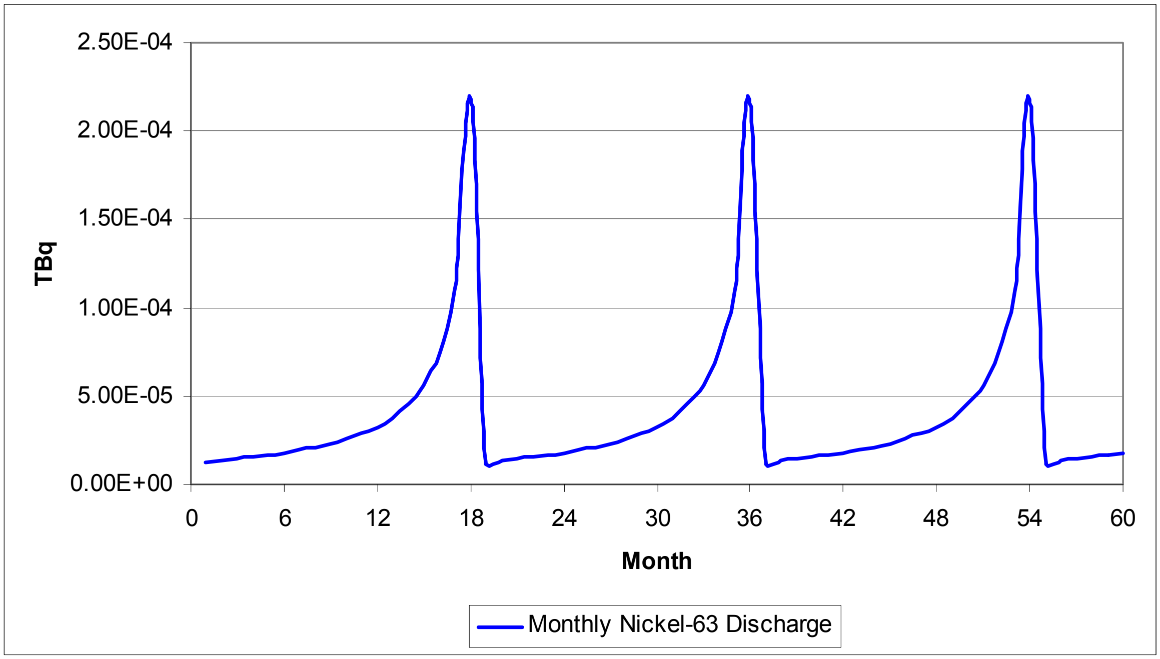

Figure A-21. Predicted Monthly Liquid Nickel-63 Discharges

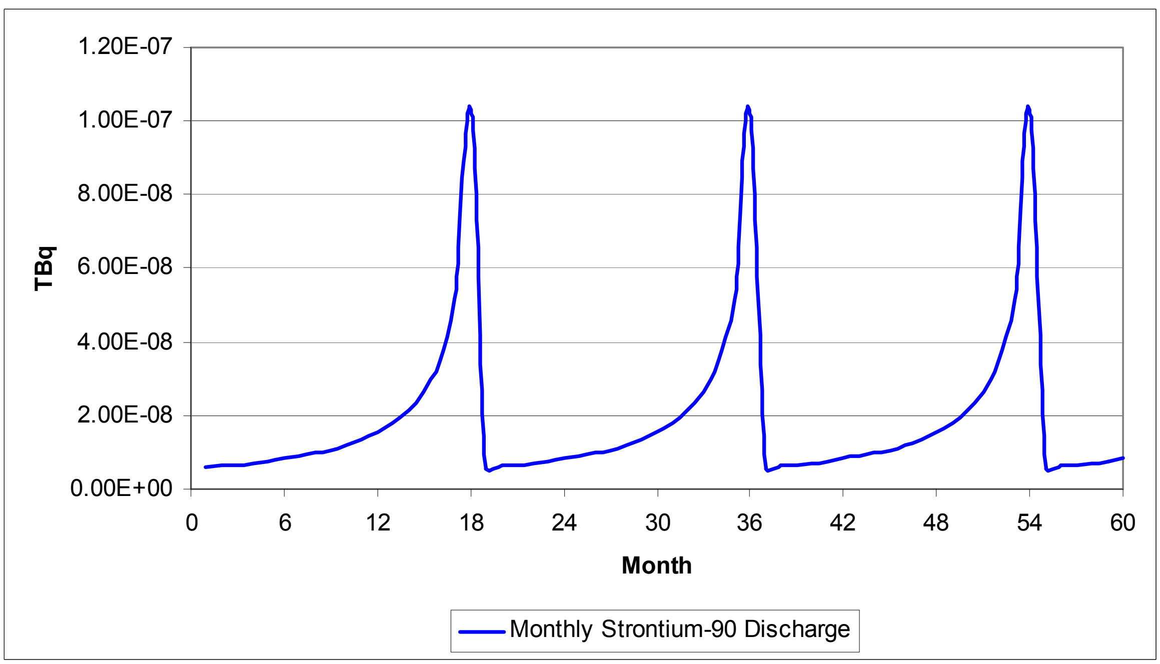

Figure A-22. Predicted Monthly Liquid Strontium-90 Discharges

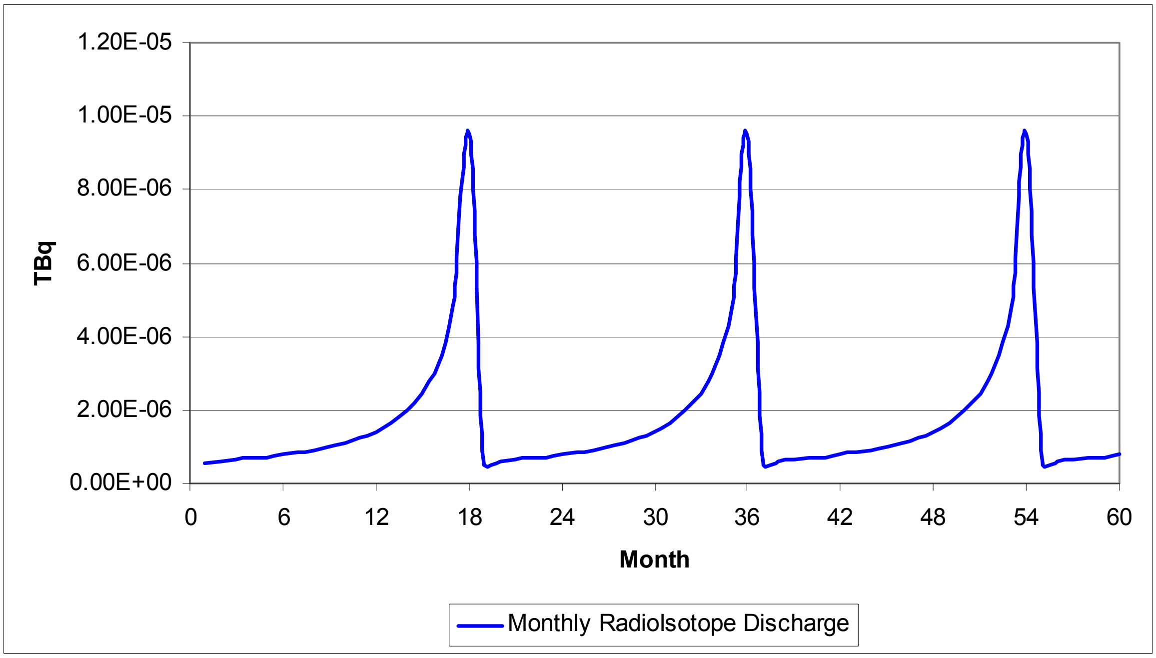

Figure A-23. Predicted Monthly Liquid Cesium-137 Discharges

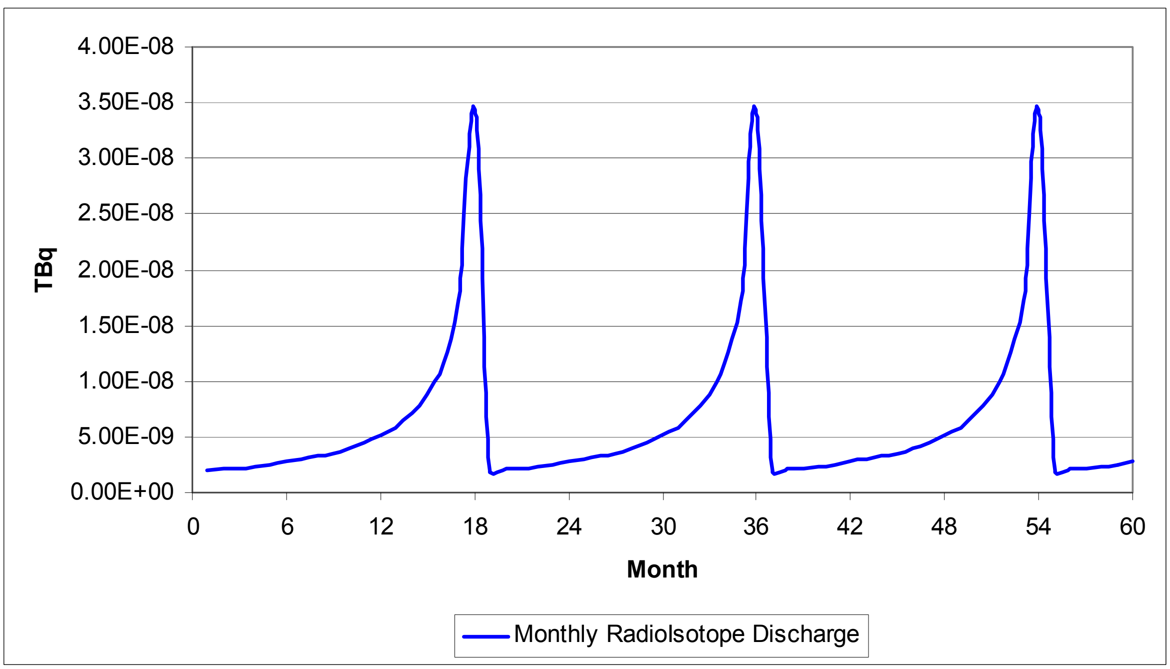

Figure A-24. Predicted Monthly Liquid Plutonium-241 Discharges

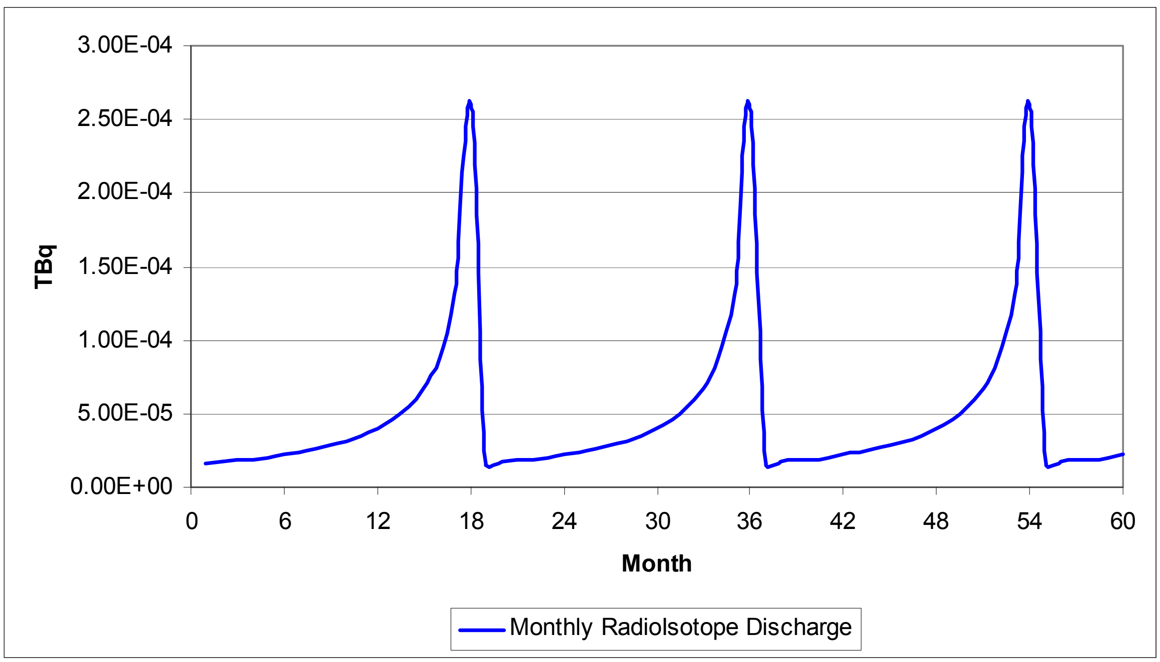

Figure A-25. Predicted Monthly Liquid Other Particulate Radioisotope Discharges

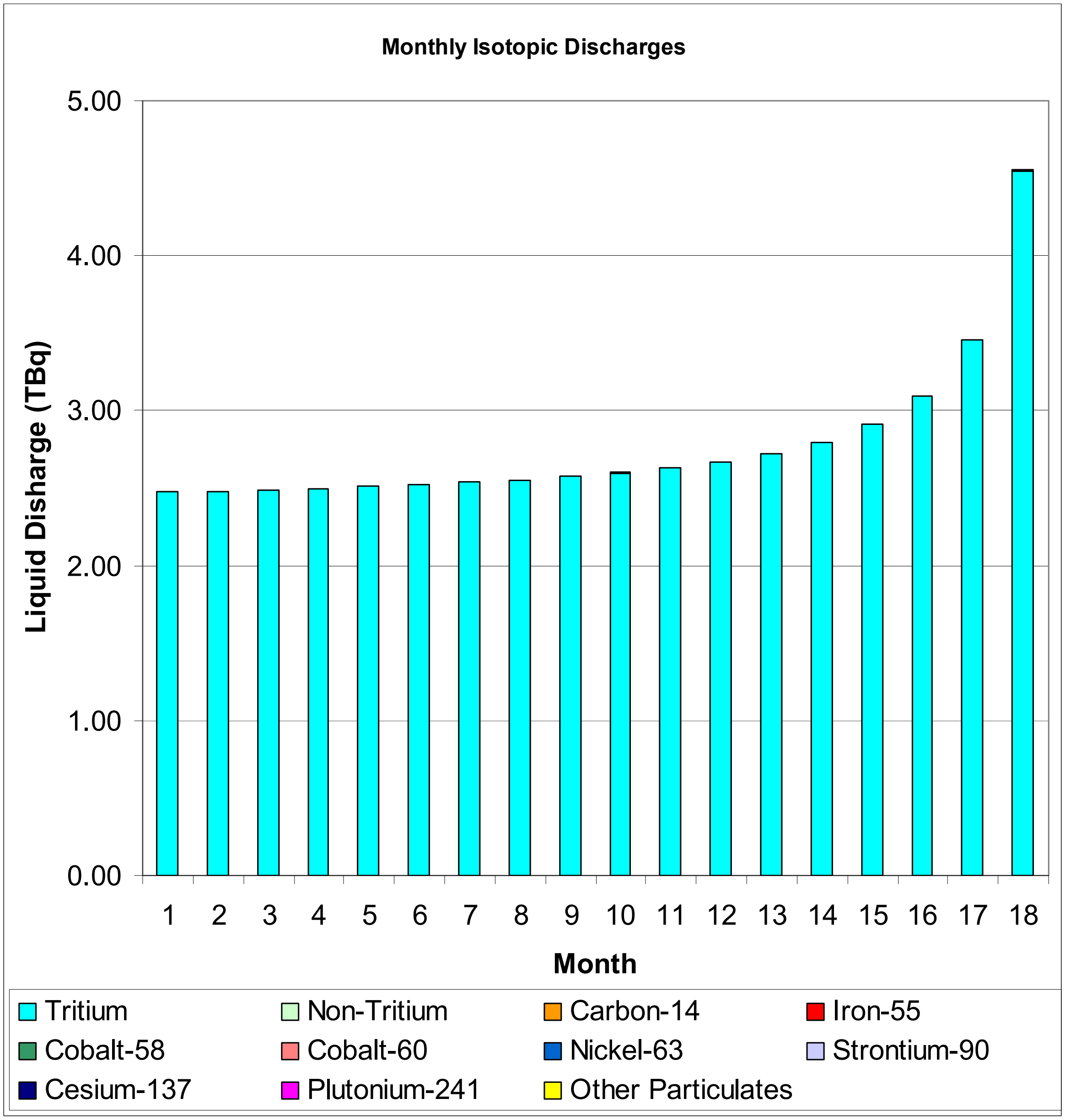

Figure A-26. Radioisotope Contribution to Total Predicted Monthly Liquid Discharges

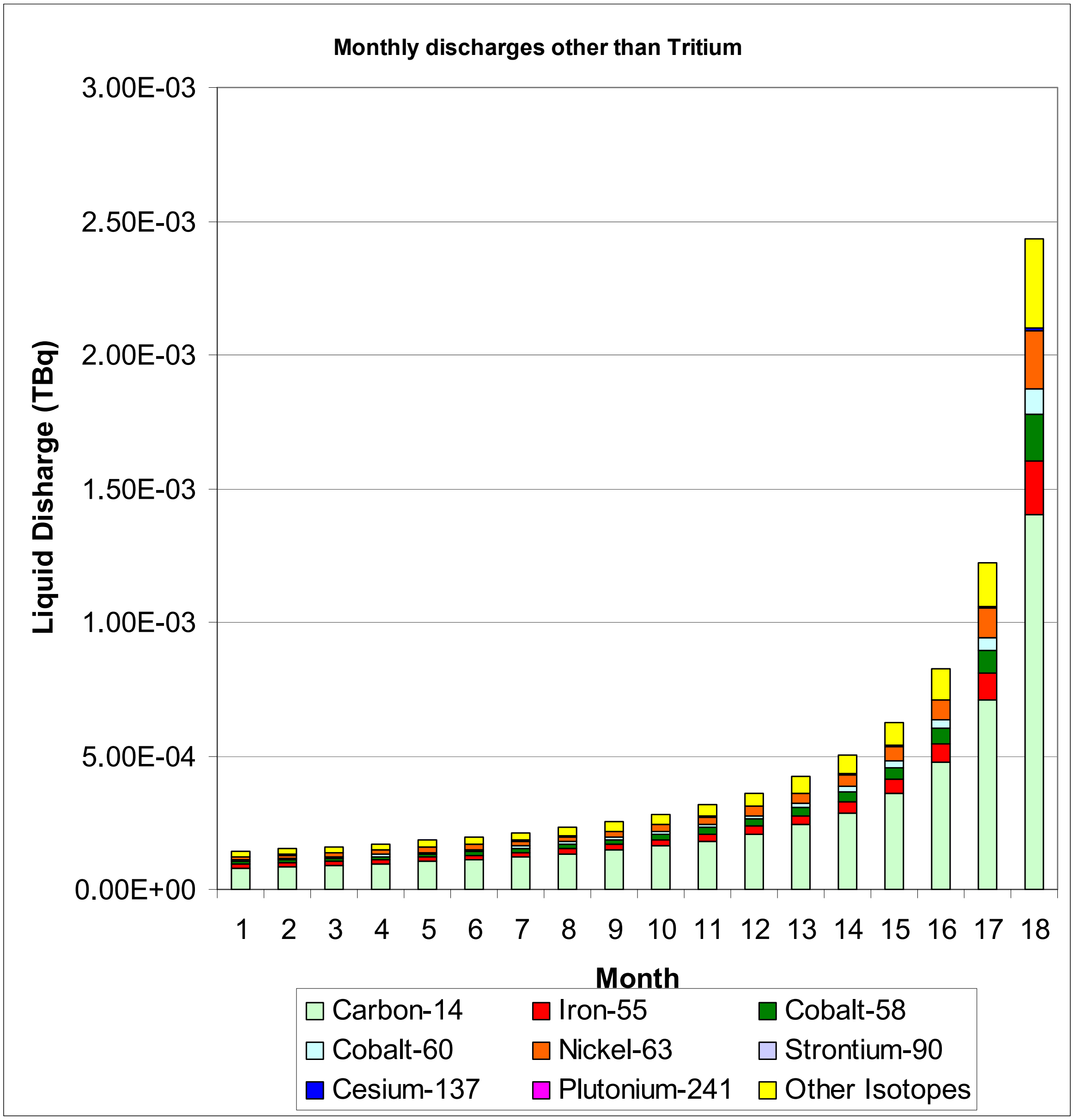

Figure A-27. Radioisotope Contribution to Total Predicted Monthly Liquid Discharges Omitting Tritium

APPENDIX B
COMPARISON OF DISCHARGES WITH WORST CASE ANNUAL PLANT DISCHARGE

B.1 Air Emissions

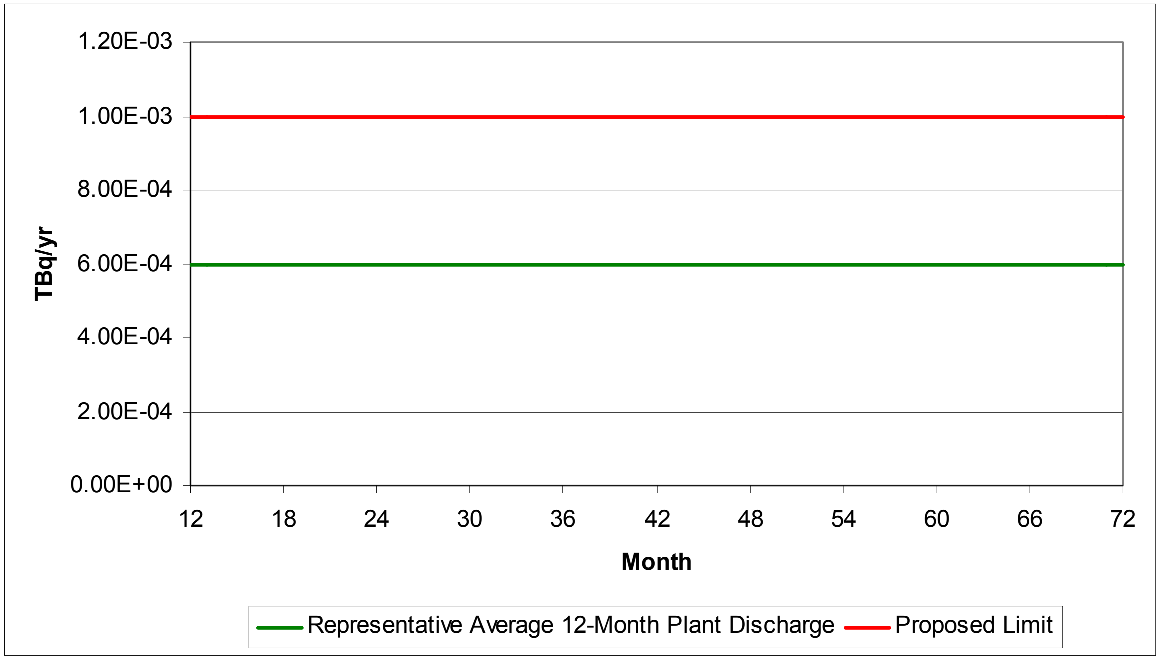

Figure B-1. Comparison of Predicted Air Radioiodine Emission with Proposed Annual Limit

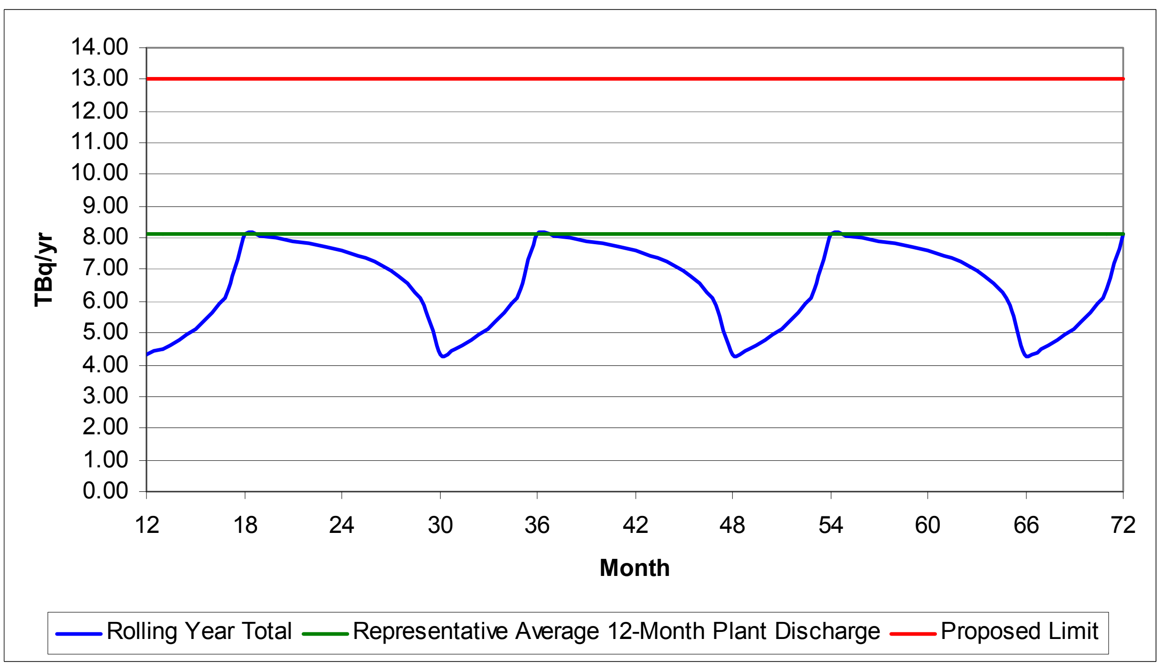

Figure B-2. Comparison of Predicted Noble Gases Emissions with Proposed Annual Limit

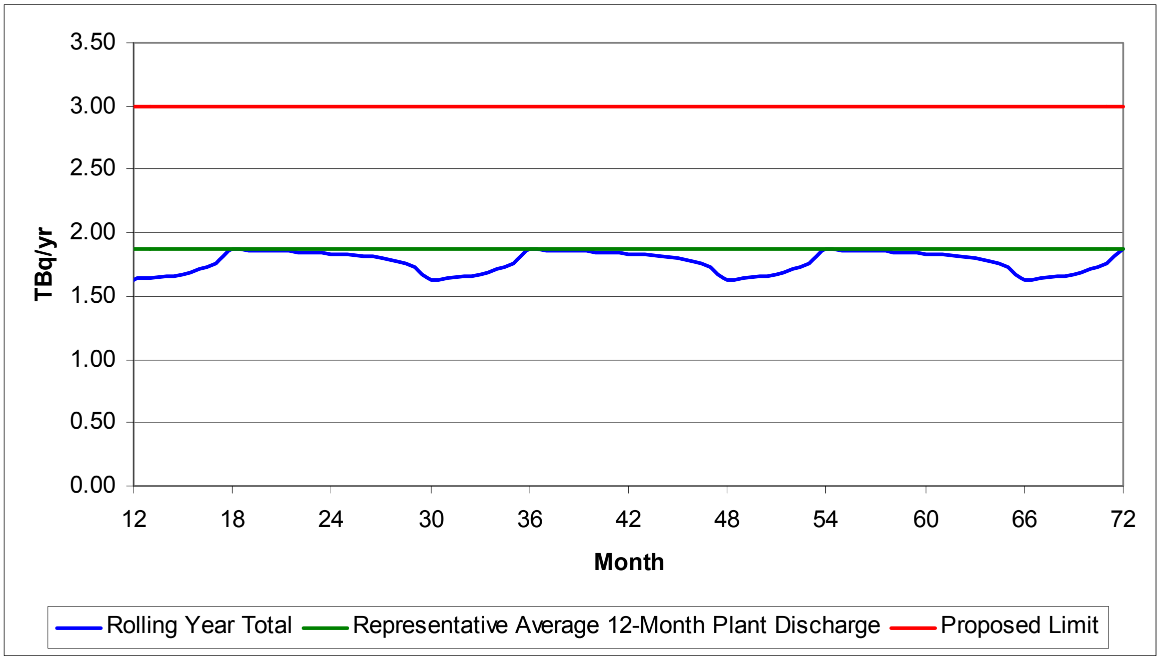

Figure B-3. Comparison of Predicted Air Tritium Emission with Proposed Annual Limit

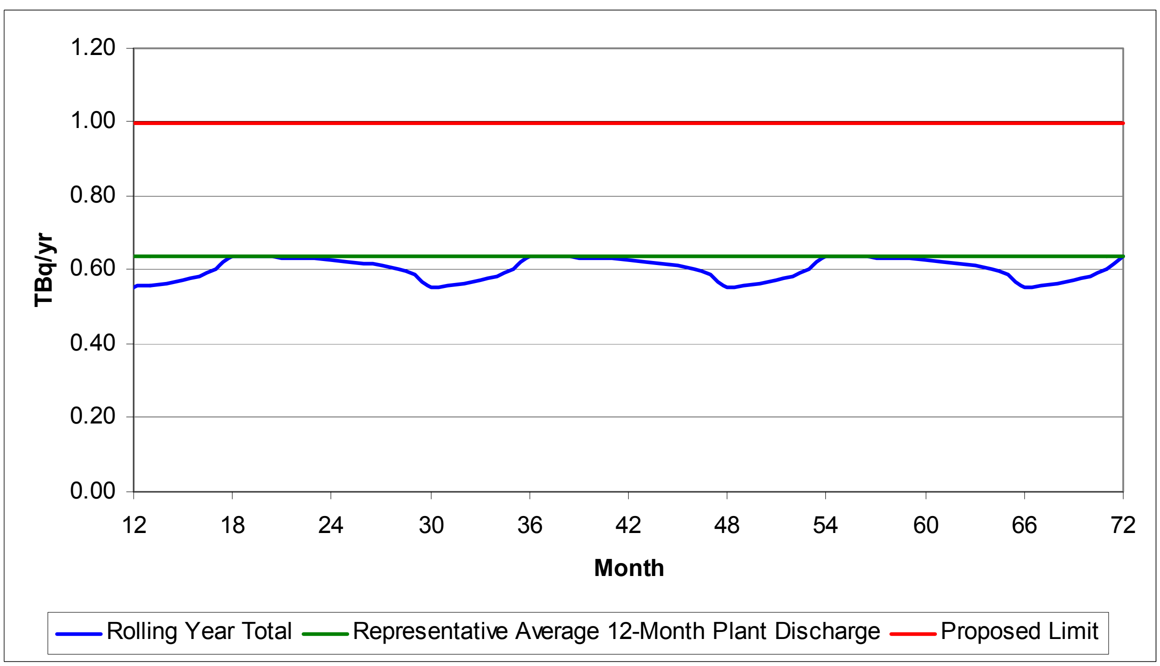

Figure B-4. Comparison of Predicted Air Carbon-14 Emission with Proposed Annual Limit

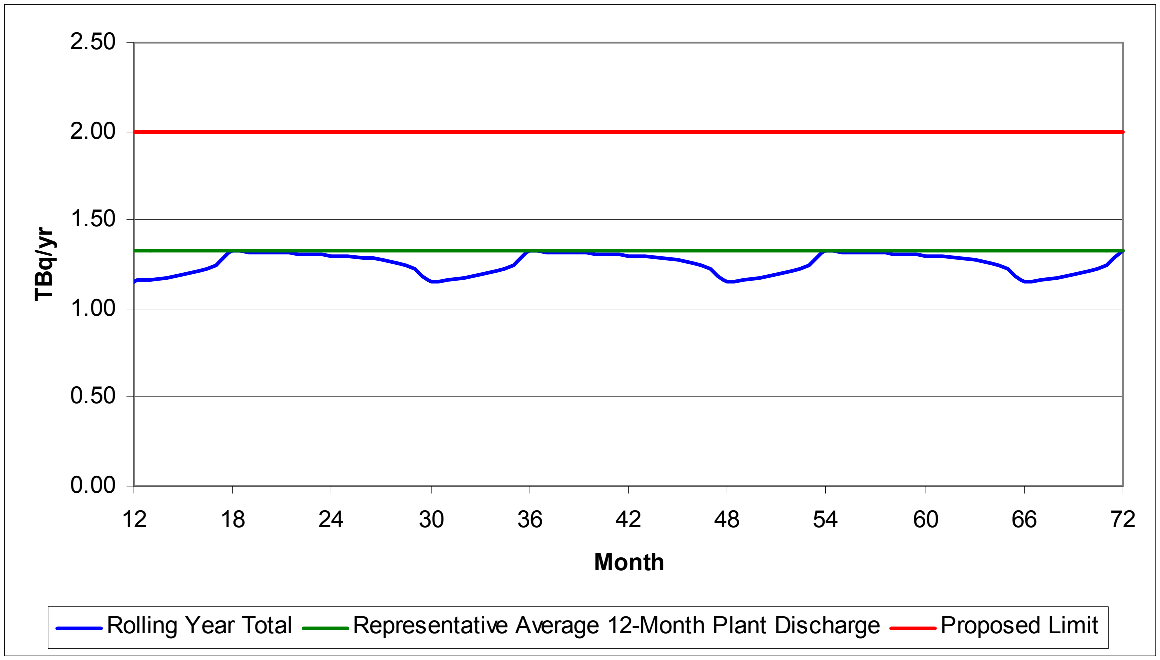

Figure B-5. Comparison of Predicted Air Argon-41 Emission with Proposed Annual Limit

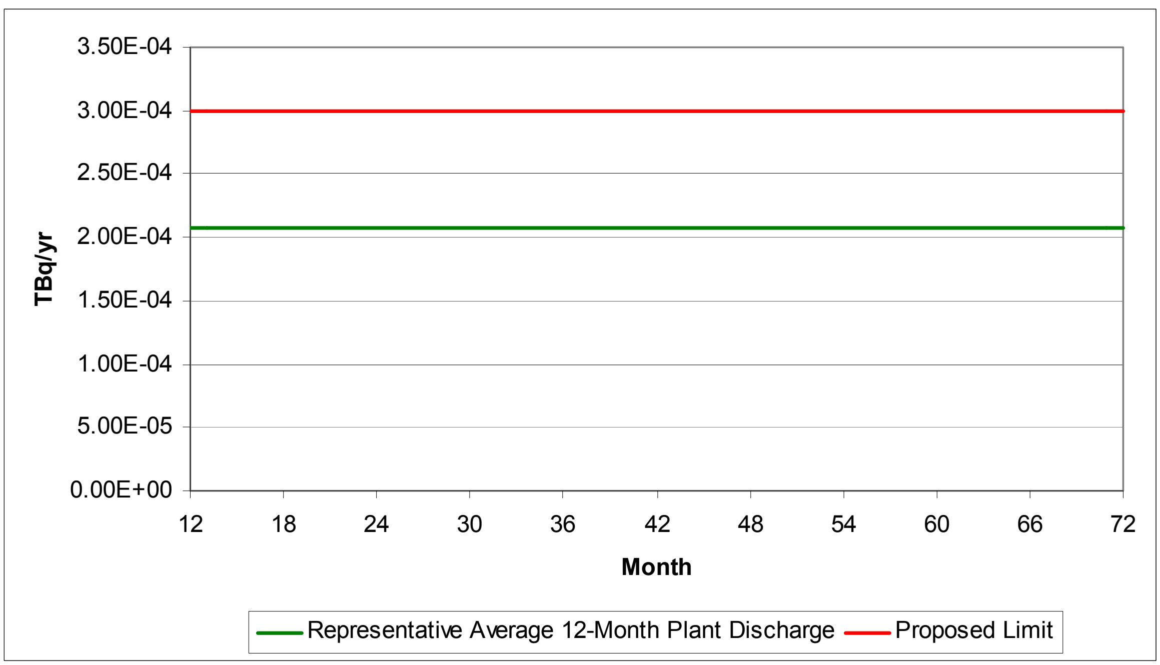

Figure B-6. Comparison of Predicted Air Iodine-131 Emission with Proposed Annual Limit

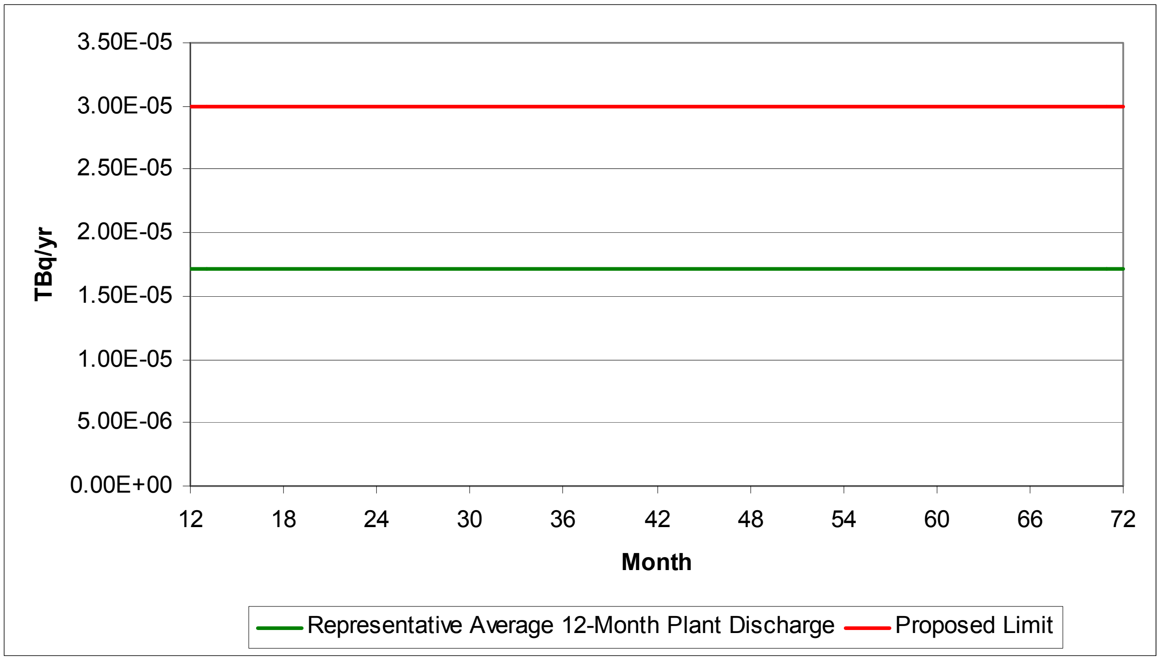

Figure B-7. Comparison of Predicted Beta Particulates Air Emission with Proposed Annual Limit

B.2 Liquid Discharges

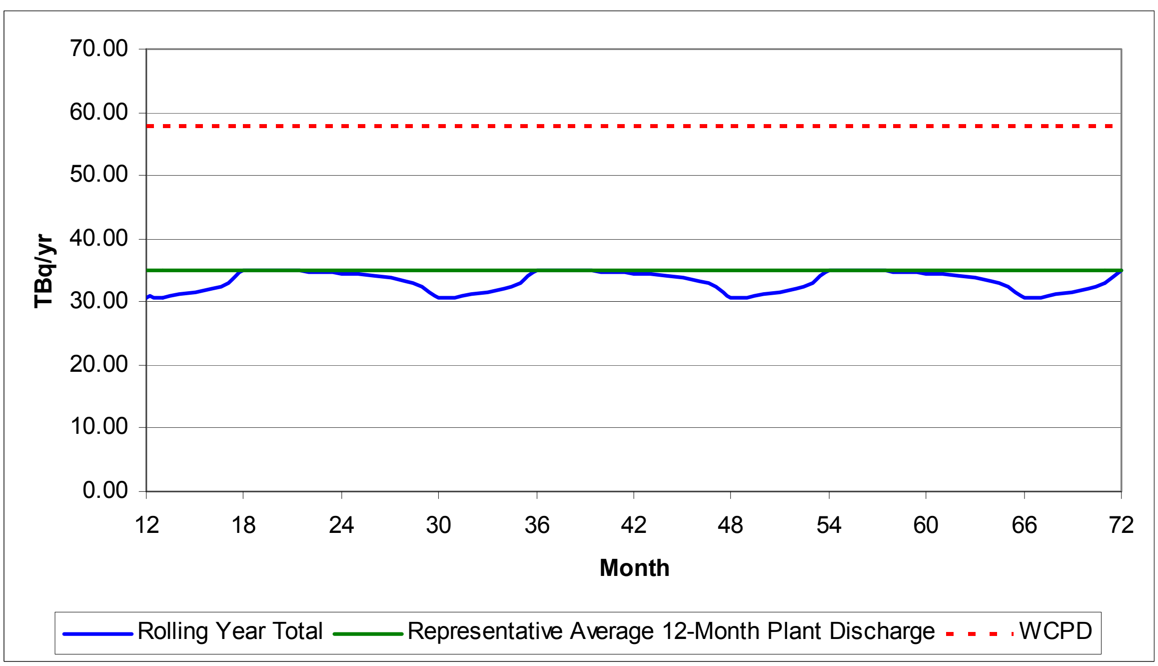

Figure B-8. Comparison of Predicted Liquid Tritium Discharge with Proposed Annual Limit

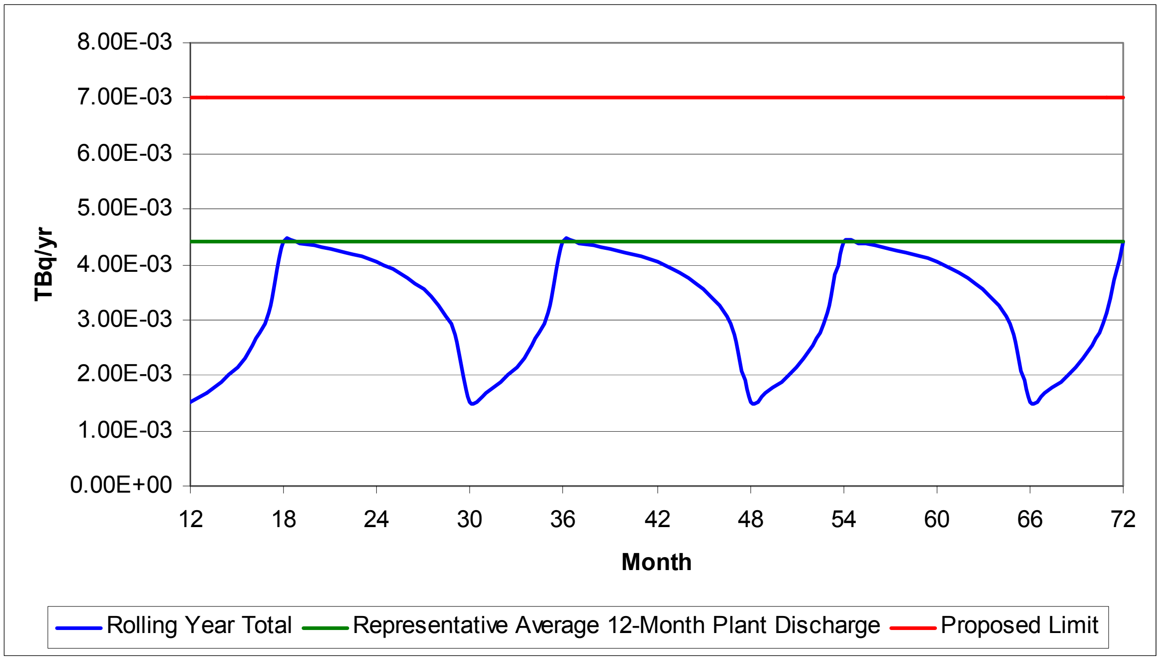

Figure B-9. Comparison of Predicted Liquid Carbon-14 Discharge with Proposed Annual Limit

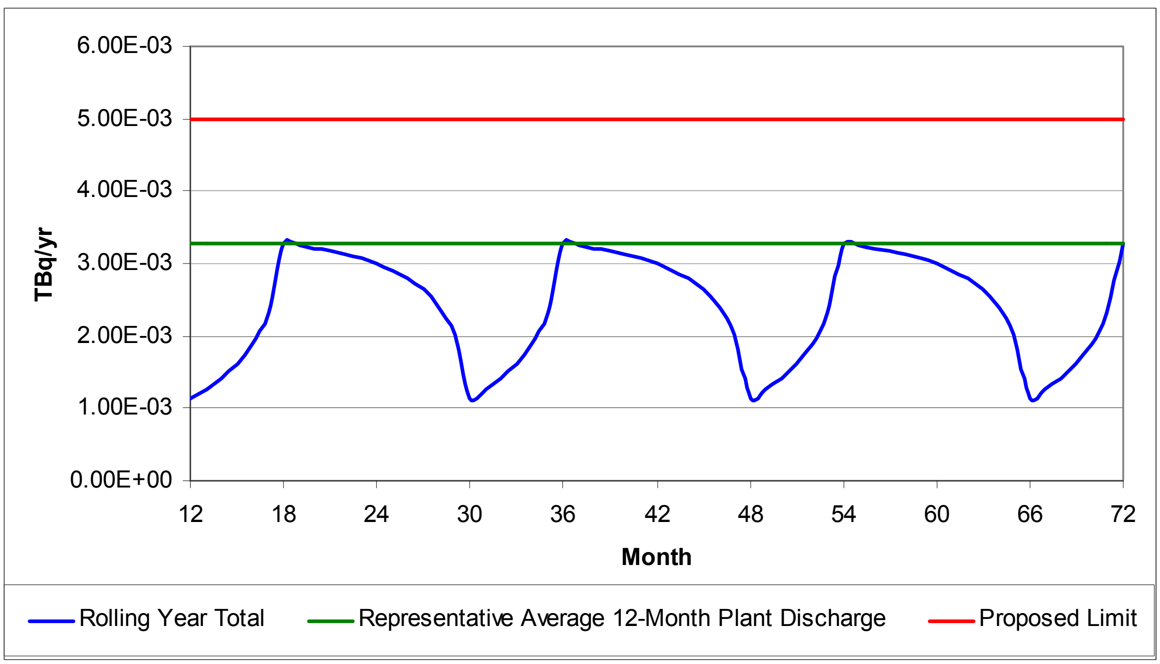

Figure B-10. Comparison of Liquid Radioisotope Discharges of All Isotopes without Other Limits with Proposed Annual Limit