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TWRS EIS
CALCULATION COVER SHEET

DISCIPLINE: Computer Science and Radiation Technology,
TITLE: Database Manager and Ph.D. Certified Health Physicist

ORIGINATOR: Mitchell Pelton and Dr. Paul Rittmann

DATE: 1/27/95
REVISION NO: 0

OBJECTIVE: To decay the single shell and double shell tank farm total inventories given by WHC memo (Golberg 12/26/94) to the specified dates of interest. Then to somehow normalize the inventories and develop a way of displaying this information so as to provide a way of screening the isotopes so that only constituents of concern are modeled. Further explanation is contained in this memo.

METHODOLOGY: Data was received in an EXCEL 4.0 workbook and thus manipulated with the same. Take the 1995 DST and SST inventories and decay them to the dates of interest, via spreadsheet developed by Dr. Paul Rittmann. Then multiply each constituent by its respective HEAST ingestion slope factor to normalize the values and display them graphically.

ASSUMPTIONS: All 1995 inventories were correct.

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Constituents of Concern for Groundwater Transport Modeling

January 27, 1995

Purpose

The purpose of this paper is to provide information to assist the groundwater transport modeling group in identifying constituents of concern for the Tank Waste Remediation System (TWRS) Environmental Impact Statement (EIS). Constituents of concern, as used here, refers to constituents in the current tank waste source inventory which are of probable concern, from a human health risk standpoint, and are therefore appropriate for inclusion in the groundwater transport modeling. Ultimately, these are the constituents to be included in the TWRS EIS risk assessment. Determination of the final list of constituents to modeled is the responsibility of the groundwater transport modeling group and a final list is not provided herein. The intent of this paper is to provide information for the groundwater transport modeling group to consider when compiling a final list of constituents.

Introduction and Background

To support the TWRS EIS risk assessment, the groundwater transport modeling group will simulate the release of contaminants from the tanks to the groundwater and predict the spatial distribution of contaminant concentrations in groundwater at future times. The risk assessment group will then assess the human health risk associated with exposure to groundwater with the predicted contaminant concentrations. Results from the groundwater transport modeling are required input for the risk assessment.

As outlined in JEG (1994), the groundwater transport modeling group anticipates making use of numerical models. Because numerical models are relatively complex to set up and can require long computer run-times to reach solutions, groundwater modeling will tend to be a time-consuming process. An important factor influencing the groundwater modeling schedule is source inventory. As outlined in a separate paper addressing tank waste current source inventory (ASI, 1995a), the total number of constituents in the tanks is large. The recommended current source inventory presented in ASI (1995a) contains 86 total radionuclides and 53 total nonradioactive chemicals. All of these constituents are candidates for groundwater transport modeling; however, modeling them all could require an extended schedule and might be unnecessary given the types of decisions being supported by the TWRS EIS.

The above considerations have given rise to the need to screen the list of current tank constituents to identify which constituents are of probable concern, and thus should be included in the groundwater transport modeling, and which constituents are not of concern, and thus could be eliminated from the groundwater transport modeling without compromising the integrity of the ensuing risk assessment.

Radionuclides of Concern

It has been suggested in discussions between the groundwater transport modeling group and risk assessment group that radioactive decay rates might be used to assist with the selection of radionuclides of concern. During transport through the vadose zone, radionuclides will sorb, to varying degrees, to vadose zone soil particles. Following release from the tanks, strongly sorbed radionuclides could require long vadose transport times before reaching the water table and beginning to contribute to risk from groundwater exposure pathways. Depending on radioactive half life and initial inventory, it is possible that, prior to reaching the water table, some radionuclides might decay away completely, decay to nominal risk levels, or decay to other radionuclides. It has been suggested that if a rough approximation of the time required for a given radionuclide to decay to nominal risk levels were available, it could prove useful in selecting radionuclides of concern. The risk assessment group has therefore performed a preliminary, highly simplified analysis designed to provide such approximations for radionuclides in the current tank inventory. The method and results for the analysis are discussed in the following paragraphs.

The analysis began with the assembly of the current tank waste radionuclide inventory. The current inventory was generated from data supplied by Westinghouse Hanford Company, as discussed in ASI (1995a). Next, the current inventory was decayed (by calculation) to produce estimated future inventories. Tables 1 and 2 display the inventories of radionuclides in single-shell tanks (SSTs) and double-shell tanks (DSTs), respectively, for the current time and selected future times. The inventories are presented on a total-tank basis. Decay dates are identified in the column headings. The column labeled 12/31/95 represents the current inventory, as discussed in ASI (1995a).

The remaining columns in Tables 1 and 2 show the calculated inventories after decay times of 100, 300, 500, 1000, 5000, and 10,000 years from 12/31/95 have elapsed. These future inventories were computed with the aid of a spreadsheet which accounts for decay of both the parent radionuclide and progeny nuclides produced in decay chains. A detailed discussion of the spreadsheet is provided in a separate paper (ASI, 1995b). Note that inventories of certain nuclides may increase with time because of contributions from decay products (e.g., see Table 1, Ac-225).

The inventories displayed in Tables 1 and 2 are not directly useful for selecting constituents of concern. To render the data more useful, the inventories were normalized by converting them to risk values. Conversion was accomplished by multiplying the inventories in Tables 1 and 2 by the ingestion slope factors given in the *Health Effects Assessment Summary Tables* (EPA, 1992). The results are presented in Tables 3 and 4 for SSTs and DSTs, respectively. The values shown in Tables 3 and 4 correspond to the risk of cancer incidence from direct ingestion of the entire undiluted inventory of a given constituent at a given decay date. The assumptions on which the calculations are based are highly conservative and were made for the sole purpose of normalizing the inventory values to facilitate screening.

The ingestion risk data in Tables 3 and 4 are displayed graphically in Figures 1 to 7 for SSTs and Figures 8 to 14 for DSTs. The purpose of plotting the data graphically is to enable better recognition of trends. Three basic trend types are evident. As can be seen in Figure 1, constituents such as Ac-225 show an increasing trend with time due to contributions from

radioactive decay products. Constituents such as Am-243 have a relatively constant trend due to the long half life of the parent and/or decay losses for the parent being balanced by gains from radioactive decay products. Constituents such as Am-241 show a decreasing trend with time due to radioactive decay. Note also that certain constituents, such as Bi-212 in Figure 1, are solely the products of decay (i.e., not in current inventory) and appear only after some decay time has elapsed (100 years in the case of Bi-212).

As stated earlier, determination of the final list of constituents to be modeled for groundwater transport is the responsibility of the groundwater transport modeling group. In making use of the analysis provided herein, it is recommended that consideration be given to including any constituent which gives an ingestion risk value above 1.00E-06 for any of the decay dates evaluated. This would serve as a good first approximation for radionuclides of concern.

Nonradioactive Chemicals of Concern

The nonradioactive chemical constituents in the tank waste current source inventory should be assumed to be stable. These constituents will therefore undergo no reduction and decay in their inventory over time. The method for analyzing radionuclides described above is based on changes in inventory/risk over time and will thus not provide useful information for selecting nonradioactive chemicals of concern. All nonradioactive chemicals in the current inventory can contribute to risk. It is therefore recommended that all nonradioactive chemicals in the current source inventory be included in the groundwater transport modeling and ensuing risk assessment. All chemical constituents in the current inventory need to be included in the risk assessment to account for cumulative effects.

References

ASI, 1995a, *Tank Waste Current Source Inventory*, Advanced Sciences, Inc., Richland, Washington (January 27).

ASI, 1995b, *Radioactive Decay Spreadsheet for Dose Calculation*, Advanced Sciences, Inc., Richland, Washington (January 27).

EPA, 1992, *Health Effects Assessment Summary Tables*, OHEA ECAO-CIN-821, 1992, U.S. Environmental Protection Agency, Washington, D.C.

JEG, 1994, *Tank Waste Remediation System Environmental Impact Statement Strategy for Risk Assessment*, Draft Revision 1, Prepared by the Jacobs Engineering Team, Richland, Washington (September).

Table 1
Total Radionuclide Inventory (Curies) at Given Time Intervals for Single Shell Tanks

Radionuclide	12/31/95	12/31/2095	12/31/2295	12/31/2495	12/31/2995	12/31/6995	12/31/11995
Ac-225	1.50E-05	2.35E-04	1.55E-03	4.02E-03	1.53E-02	3.40E-01	1.18E+00
Ac-227	2.01E-02	6.37E-02	1.50E-01	2.37E-01	4.51E-01	2.09E+00	3.96E+00
Ac-228							
Am-241	4.39E+04	3.89E+04	2.83E+04	2.05E+04	9.20E+03	1.51E+01	9.83E-03
Am-242	6.95E+01	4.51E+01	1.81E+01	7.27E+00	7.44E-01	8.90E-09	1.12E-18
Am-242m	6.98E+01	4.53E+01	1.82E+01	7.31E+00	7.47E-01	8.95E-09	1.12E-18
Am-243	3.32E+01	3.29E+01	3.23E+01	3.17E+01	3.02E+01	2.08E+01	1.30E+01
At-217	1.50E-05	2.35E-04	1.55E-03	4.02E-03	1.53E-02	3.40E-01	1.18E+00
Ba-135m							
Ba-137m	2.53E+07	9.49E+05	9.59E+03	9.69E+01	9.94E-04		
Bi-210	4.73E-08	3.82E-06	6.86E-05	2.63E-04	1.55E-03	8.30E-02	4.19E-01
Bi-211	2.01E-02	6.37E-02	1.50E-01	2.37E-01	4.51E-01	2.09E+00	3.96E+00
Bi-212		3.28E-11	3.20E-10	8.97E-10	3.57E-09	7.88E-08	2.71E-07
Bi-213	1.50E-05	2.35E-04	1.55E-03	4.02E-03	1.53E-02	3.40E-01	1.18E+00
Bi-214	2.06E-07	6.91E-06	8.82E-05	3.07E-04	1.87E-03	8.42E-02	4.22E-01
C-14	2.06E+04	2.04E+04	1.99E+04	1.94E+04	1.83E+04	1.13E+04	6.16E+03
Cm-242	5.76E+01	3.74E+01	1.50E+01	8.03E+00	8.17E-01	7.39E-09	9.25E-19
Cm-244	1.38E+02	3.63E+00	1.72E-03	8.15E-07	3.98E-15	1.29E-81	9.98E-165
Cm-245	1.04E-02	1.03E-02	1.02E-02	1.00E-02	9.61E-03	6.93E-03	4.61E-03
Cs-135	1.45E+02	1.45E+02	1.45E+02	1.45E+02	1.45E+02	1.45E+02	1.45E+02
Cs-137	2.68E+07	1.00E+06	1.01E+04	1.02E+02	1.05E-03	1.29E-43	1.67E-93
Fr-221	1.50E-05	2.35E-04	1.55E-03	4.02E-03	1.53E-02	3.40E-01	1.18E+00
Fr-223	2.78E-04	8.79E-04	2.08E-03	3.27E-03	8.22E-03	2.88E-02	5.47E-02
I-129	4.88E+01	4.88E+01	4.88E+01	4.88E+01	4.88E+01	4.88E+01	4.88E+01
Nb-93m	3.04E+03	3.93E+03	3.94E+03	3.94E+03	3.93E+03	3.93E+03	3.92E+03
Ni-59	5.03E+03	5.03E+03	5.02E+03	5.01E+03	4.99E+03	4.81E+03	4.59E+03
Ni-63	2.76E+05	1.43E+05	3.58E+04	8.97E+03	2.81E+02	2.63E-10	2.42E-25
Np-237	6.96E+01	7.09E+01	7.31E+01	7.46E+01	7.69E+01	7.87E+01	7.85E+01
Np-238	3.32E-01	2.16E-01	8.66E-02	3.48E-02	3.56E-03	4.26E-11	5.33E-21
Np-239	3.32E+01	3.29E+01	3.23E+01	3.17E+01	3.02E+01	2.08E+01	1.30E+01
Pa-231	3.62E-02	7.75E-02	1.64E-01	2.50E-01	4.64E-01	2.10E+00	3.97E+00
Pa-233	6.96E+01	7.09E+01	7.31E+01	7.46E+01	7.69E+01	7.87E+01	7.85E+01
Pa-234	7.69E-01	7.69E-01	7.69E-01	7.69E-01	7.69E-01	7.69E-01	7.69E-01
Pa-234m	4.81E+02	4.81E+02	4.81E+02	4.81E+02	4.81E+02	4.81E+02	4.81E+02
Pb-209	1.50E-05	2.35E-04	1.55E-03	4.02E-03	1.53E-02	3.40E-01	1.18E+00
Pb-210	4.73E-08	3.82E-06	6.86E-05	2.63E-04	1.55E-03	8.30E-02	4.19E-01
Pb-211	2.01E-02	6.37E-02	1.50E-01	2.37E-01	4.51E-01	2.09E+00	3.96E+00
Pb-212		3.28E-11	3.20E-10	8.97E-10	3.57E-09	7.88E-08	2.71E-07
Pb-214	2.06E-07	6.91E-06	8.82E-05	3.07E-04	1.67E-03	8.42E-02	4.22E-01
Pd-107	8.65E+01	8.65E+01	8.65E+01	8.65E+01	8.65E+01	8.64E+01	8.64E+01
Po-210	4.73E-08	3.82E-06	6.86E-05	2.63E-04	1.55E-03	8.30E-02	4.19E-01
Po-211	5.49E-05	1.74E-04	4.11E-04	6.46E-04	1.23E-03	5.70E-03	1.08E-02
Po-212		2.10E-11	2.05E-10	5.75E-10	2.29E-09	5.05E-08	1.73E-07
Po-213	1.47E-05	2.30E-04	1.51E-03	3.94E-03	1.50E-02	3.33E-01	1.16E+00
Po-214	2.06E-07	6.91E-06	8.82E-05	3.07E-04	1.67E-03	8.42E-02	4.22E-01
Po-215	2.01E-02	6.37E-02	1.50E-01	2.37E-01	4.51E-01	2.09E+00	3.96E+00
Po-216		3.28E-11	3.20E-10	8.97E-10	3.57E-09	7.88E-08	2.71E-07
Po-218	2.06E-07	6.91E-06	8.82E-05	3.07E-04	1.67E-03	8.42E-02	4.22E-01
Pu-236							

Table 1
Total Radionuclide Inventory (Curies) at Given Time Intervals for Single Shell Tanks

Radionuclide	12/31/95	12/31/2095	12/31/2295	12/31/2495	12/31/2995	12/31/6995	12/31/11995
Pu-238	1.11E+03	5.53E+02	1.33E+02	3.53E+01	2.02E+00	1.97E-08	2.47E-18
Pu-239	2.18E+04	2.18E+04	2.17E+04	2.15E+04	2.12E+04	1.89E+04	1.64E+04
Pu-240	5.11E+03	5.06E+03	4.96E+03	4.85E+03	4.60E+03	3.02E+03	1.78E+03
Pu-241	4.30E+04	4.44E+02	3.95E-02	1.00E-02	9.63E-03	6.95E-03	4.62E-03
Pu-242	3.44E-04	2.05E-03	3.94E-03	4.70E-03	5.15E-03	5.16E-03	5.11E-03
Ra-223	2.01E-02	6.37E-02	1.50E-01	2.37E-01	4.51E-01	2.09E+00	3.96E+00
Ra-224		3.28E-11	3.20E-10	8.97E-10	3.57E-09	7.88E-08	2.71E-07
Ra-225	1.50E-05	2.35E-04	1.55E-03	4.02E-03	1.53E-02	3.40E-01	1.18E+00
Ra-226	2.06E-07	6.91E-06	8.82E-05	3.07E-04	1.67E-03	8.42E-02	4.22E-01
Ra-228		3.45E-11	3.25E-10	9.06E-10	3.59E-09	7.89E-08	2.71E-07
Rh-106	5.92E-01	2.54E-29					
Rn-219	2.01E-02	6.37E-02	1.50E-01	2.37E-01	4.51E-01	2.09E+00	3.96E+00
Rn-220		3.28E-11	3.20E-10	8.97E-10	3.57E-09	7.88E-08	2.71E-07
Rn-222	2.06E-07	6.91E-06	8.82E-05	3.07E-04	1.67E-03	8.42E-02	4.22E-01
Ru-106	5.92E-01	2.54E-29	4.60E-89	9.07E-149	4.45E-298		
Sb-126	8.78E+01	8.78E+01	8.76E+01	8.75E+01	8.72E+01	8.48E+01	8.19E+01
Sb-126m	6.27E+02	6.27E+02	6.26E+02	6.25E+02	6.23E+02	6.06E+02	5.85E+02
Se-79	9.11E+02	9.10E+02	9.08E+02	9.07E+02	9.02E+02	8.64E+02	8.19E+02
Sm-151	6.69E+05	3.22E+05	6.90E+04	1.48E+04	3.15E+02	1.31E-11	2.48E-28
Sn-126	6.27E+02	6.27E+02	6.26E+02	6.25E+02	6.23E+02	6.06E+02	5.85E+02
Sr-90	4.85E+07	4.85E+06	3.81E+04	2.99E+02	1.63E-03	1.29E-45	3.04E-98
Tc-99	3.17E+04	3.17E+04	3.17E+04	3.17E+04	3.16E+04	3.12E+04	3.07E+04
Th-227	1.98E-02	6.28E-02	1.48E-01	2.34E-01	4.45E-01	2.06E+00	3.91E+00
Th-228		3.28E-11	3.20E-10	8.97E-10	3.57E-09	7.88E-08	2.71E-07
Th-229	1.50E-05	2.35E-04	1.55E-03	4.02E-03	1.53E-02	3.40E-01	1.18E+00
Th-230	3.09E-05	3.48E-04	1.73E-03	3.77E-03	1.11E-02	1.77E-01	6.42E-01
Th-231	2.06E+01	2.06E+01	2.06E+01	2.06E+01	2.06E+01	2.07E+01	2.08E+01
Th-232		4.27E-11	3.49E-10	9.46E-10	3.67E-09	7.92E-08	2.71E-07
Th-233							
Th-234	4.81E+02	4.81E+02	4.81E+02	4.81E+02	4.81E+02	4.81E+02	4.81E+02
Tl-207	2.01E-02	6.35E-02	1.50E-01	2.36E-01	4.50E-01	2.08E+00	3.95E+00
Tl-208		1.18E-11	1.15E-10	3.22E-10	1.28E-09	2.83E-08	9.73E-08
Tl-209	3.24E-07	5.08E-06	3.34E-05	8.69E-05	3.31E-04	7.34E-03	2.55E-02
U-232							
U-233	1.08E-02	3.99E-02	1.03E-01	1.67E-01	3.31E-01	1.68E+00	3.34E+00
U-234	1.94E-01	5.38E-01	9.77E-01	1.29E+00	1.98E+00	7.38E+00	1.40E+01
U-235	2.06E+01	2.06E+01	2.06E+01	2.06E+01	2.06E+01	2.07E+01	2.08E+01
U-236	2.27E-03	1.66E-02	4.62E-02	7.53E-02	1.45E-01	5.90E-01	9.37E-01
U-237	1.05E+00	1.09E-02	9.67E-07	2.46E-07	2.36E-07	1.70E-07	1.13E-07
U-238	4.81E+02	4.81E+02	4.81E+02	4.81E+02	4.81E+02	4.81E+02	4.81E+02
Y-90	4.85E+07	4.85E+06	3.81E+04	2.99E+02	1.63E-03		
Zr-93	3.94E+03	3.94E+03	3.94E+03	3.94E+03	3.93E+03	3.93E+03	3.92E+03

Table 2
Total Radionuclide Inventory (Curies) at Given Time Intervals for Double Shell Tanks

Radionuclide	12/31/95	12/31/2095	12/31/2295	12/31/2495	12/31/2995	12/31/6995	12/31/11995
Ac-225		8.10E-05	8.29E-04	2.39E-03	1.00E-02	2.50E-01	8.86E-01
Ac-227		4.01E-07	6.00E-06	1.85E-05	7.93E-05	1.98E-03	7.34E-03
Ac-228							
Am-241	7.11E+04	6.22E+04	4.52E+04	3.28E+04	1.47E+04	2.40E+01	7.92E-03
Am-242							
Am-242m							
Am-243							
At-217		8.10E-05	8.29E-04	2.39E-03	1.00E-02	2.50E-01	8.86E-01
Ba-135m							
Ba-137m	2.94E+07	3.14E+06	3.17E+04	3.20E+02	3.28E-03		
Bi-210		7.81E-07	2.95E-05	1.20E-04	6.25E-04	1.26E-02	3.30E-02
Bi-211		4.01E-07	6.00E-06	1.85E-05	7.93E-05	1.98E-03	7.34E-03
Bi-212		1.10E-11	1.35E-10	3.94E-10	1.62E-09	3.66E-08	1.26E-07
Bi-213		8.10E-05	8.29E-04	2.39E-03	1.00E-02	2.50E-01	8.86E-01
Bi-214		1.72E-06	3.87E-05	1.39E-04	6.69E-04	1.27E-02	3.32E-02
C-14	2.33E+03	2.30E+03	2.25E+03	2.19E+03	2.07E+03	1.27E+03	6.95E+02
Cm-242							
Cm-244							
Cm-245							
Cs-135							
Cs-137	2.94E+07	3.31E+06	3.35E+04	3.38E+02	3.47E-03	4.26E-43	5.50E-93
Eu-154	7.43E+04	2.33E+01	2.28E-06	2.23E-13	6.71E-31	4.46E-171	
Fr-221		8.10E-05	8.29E-04	2.39E-03	1.00E-02	2.50E-01	8.86E-01
Fr-223		5.54E-09	8.28E-08	2.55E-07	1.09E-06	2.73E-05	1.01E-04
I-129							
Nb-93m							
Ni-59							
Ni-63							
Np-237	4.56E+01	4.77E+01	5.11E+01	5.36E+01	5.72E+01	6.01E+01	6.00E+01
Np-238							
Np-239							
Pa-231		7.44E-07	7.42E-06	2.10E-05	8.44E-05	2.00E-03	7.38E-03
Pa-233		4.77E+01	5.11E+01	5.36E+01	5.72E+01	6.01E+01	6.00E+01
Pa-234							
Pa-234m							
Pb-209		8.10E-05	8.29E-04	2.39E-03	1.00E-02	2.50E-01	8.86E-01
Pb-210		7.81E-07	2.95E-05	1.20E-04	6.25E-04	1.26E-02	3.30E-02
Pb-211		4.01E-07	6.00E-06	1.85E-05	7.93E-05	1.98E-03	7.34E-03
Pb-212		1.10E-11	1.35E-10	3.94E-10	1.62E-09	3.66E-08	1.26E-07
Pb-214		1.72E-06	3.87E-05	1.39E-04	6.69E-04	1.27E-02	3.32E-02
Pd-107							
Po-210		7.81E-07	2.95E-05	1.20E-04	6.25E-04	1.26E-02	3.30E-02
Po-211		1.10E-09	1.64E-08	5.04E-08	2.16E-07	5.39E-06	2.00E-05
Po-212		7.03E-12	8.62E-11	2.52E-10	1.04E-09	2.34E-08	8.07E-08
Po-213		7.93E-05	8.11E-04	2.34E-03	9.79E-03	2.45E-01	8.67E-01
Po-214		1.72E-06	3.87E-05	1.39E-04	6.69E-04	1.27E-02	3.32E-02
Po-215		4.01E-07	6.00E-06	1.85E-05	7.93E-05	1.98E-03	7.34E-03
Po-216		1.10E-11	1.35E-10	3.94E-10	1.62E-09	3.66E-08	1.26E-07
Po-218		1.72E-06	3.87E-05	1.39E-04	6.69E-04	1.27E-02	3.32E-02

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Table 2
Total Radionuclide Inventory (Curies) at Given Time Intervals for Double Shell Tanks

Radionuclide	12/31/95	12/31/2095	12/31/2295	12/31/2495	12/31/2995	12/31/6995	12/31/11995
Pu-236							
Pu-238	1.42E+03	6.70E+02	1.38E+02	2.85E+01	5.48E-01	1.04E-14	7.31E-32
Pu-239	8.36E+03	8.34E+03	8.29E+03	8.24E+03	8.12E+03	7.24E+03	6.27E+03
Pu-240	2.39E+03	2.37E+03	2.32E+03	2.27E+03	2.15E+03	1.41E+03	8.32E+02
Pu-241	3.97E+04	4.10E+02	2.70E-02	1.78E-06	6.29E-17	1.51E-100	4.52E-205
Pu-242							
Ra-223		4.01E-07	6.00E-06	1.85E-05	7.93E-05	1.98E-03	7.34E-03
Ra-224		1.10E-11	1.35E-10	3.94E-10	1.62E-09	3.66E-08	1.26E-07
Ra-225		8.10E-05	8.29E-04	2.39E-03	1.00E-02	2.50E-01	8.86E-01
Ra-226		1.72E-06	3.87E-05	1.39E-04	6.69E-04	1.27E-02	3.32E-02
Ra-228		1.17E-11	1.37E-10	3.98E-10	1.62E-09	3.66E-08	1.26E-07
Rh-106							
Rn-219		4.01E-07	6.00E-06	1.85E-05	7.93E-05	1.98E-03	7.34E-03
Rn-220		1.10E-11	1.35E-10	3.94E-10	1.62E-09	3.66E-08	1.26E-07
Rn-222		1.72E-06	3.87E-05	1.39E-04	6.69E-04	1.27E-02	3.32E-02
Ru-106							
Sb-126							
Sb-126m							
Se-79							
Sm-151							
Sn-126							
Sr-90	1.11E+07	1.11E+06	8.72E+03	6.84E+01	3.74E-04	2.95E-46	6.96E-99
Tc-99	1.74E+04	1.74E+04	1.74E+04	1.74E+04	1.73E+04	1.71E+04	1.68E+04
Th-227		3.96E-07	5.91E-06	1.82E-05	7.82E-05	1.95E-03	7.24E-03
Th-228		1.10E-11	1.35E-10	3.94E-10	1.62E-09	3.66E-08	1.26E-07
Th-229		8.10E-05	8.29E-04	2.39E-03	1.00E-02	2.50E-01	8.86E-01
Th-230		1.23E-04	8.18E-04	1.69E-03	3.95E-03	2.17E-02	4.27E-02
Th-231		7.81E-04	2.42E-03	4.05E-03	8.08E-03	3.83E-02	7.15E-02
Th-232		1.49E-11	1.48E-10	4.16E-10	1.66E-09	3.68E-08	1.26E-07
Th-233							
Th-234							
Tl-207		4.00E-07	5.98E-06	1.84E-05	7.90E-05	1.97E-03	7.32E-03
Tl-208		3.94E-12	4.84E-11	1.41E-10	5.81E-10	1.31E-08	4.53E-08
Tl-209		1.75E-06	1.79E-05	5.17E-05	2.16E-04	5.40E-03	1.91E-02
U-232							
U-233		1.93E-02	6.23E-02	1.08E-01	2.29E-01	1.26E+00	2.52E+00
U-234		2.69E-01	4.60E-01	4.99E-01	5.08E-01	5.03E-01	4.96E-01
U-235		7.81E-04	2.42E-03	4.05E-03	8.08E-03	3.83E-02	7.15E-02
U-236		6.69E-03	2.05E-02	3.41E-02	6.68E-02	2.75E-01	4.37E-01
U-237		1.00E-02	6.62E-07	4.37E-11	1.54E-21		
U-238							
Y-90	1.11E+07	1.11E+06	8.72E+03	6.84E+01	3.74E-04		
Zr-93							

Table 3
Normalized Ingestion Risk Index for Radionuclides in Single Shell Tanks

Radionuclide	12/31/95	12/31/2095	12/31/2295	12/31/2495	12/31/2995	12/31/6995	12/31/11995
Ac-225	2.55E-04	4.00E-03	2.63E-02	6.84E-02	2.60E-01	5.78E+00	2.01E+01
Ac-227	5.63E+00	1.78E+01	4.21E+01	6.63E+01	1.26E+02	5.85E+02	1.11E+03
Ac-228							
Am-241	1.05E+07	9.35E+06	6.78E+06	4.92E+06	2.21E+06	3.62E+03	2.36E+00
Am-242	2.50E+01	1.62E+01	6.52E+00	2.62E+00	2.68E-01	3.21E-09	4.01E-19
Am-242m	1.61E+04	1.04E+04	4.18E+03	1.68E+03	1.72E+02	2.06E-06	2.58E-16
Am-243	7.96E+03	7.89E+03	7.74E+03	7.60E+03	7.25E+03	4.98E+03	3.11E+03
At-217	6.74E-11	1.06E-09	6.96E-09	1.81E-08	6.89E-08	1.53E-06	5.32E-06
Ba-135m							
Ba-137m	6.08E+04	2.28E+03	2.30E+01	2.33E-01	2.39E-06		
Bi-210	7.57E-08	6.11E-06	1.10E-04	4.21E-04	2.47E-03	1.33E-01	6.71E-01
Bi-211							
Bi-212		1.02E-11	9.91E-11	2.78E-10	1.11E-09	2.44E-08	8.39E-08
Bi-213	3.45E-06	5.41E-05	3.56E-04	9.25E-04	3.52E-03	7.82E-02	2.72E-01
Bi-214							
C-14	1.86E+04	1.84E+04	1.79E+04	1.75E+04	1.65E+04	1.02E+04	5.55E+03
Cm-242	7.49E+02	4.86E+02	1.95E+02	7.84E+01	8.02E+00	9.60E-08	1.20E-17
Cm-244	2.20E+04	5.81E+02	2.75E-01	1.30E-04	6.37E-13	2.07E-79	1.60E-162
Cm-245	2.50E+00	2.48E+00	2.44E+00	2.40E+00	2.31E+00	1.66E+00	1.11E+00
Cs-135	5.80E+02	5.80E+02	5.80E+02	5.80E+02	5.80E+02	5.79E+02	5.78E+02
Cs-137	7.49E+08	2.81E+07	2.84E+05	2.87E+03	2.94E-02	3.61E-42	4.66E-92
Fr-221	8.84E-07	1.39E-05	9.13E-05	2.37E-04	9.03E-04	2.01E-02	6.97E-02
Fr-223	4.72E-05	1.49E-04	3.53E-04	5.56E-04	1.06E-03	4.90E-03	9.29E-03
I-129	9.27E+03	9.27E+03	9.27E+03	9.27E+03	9.27E+03	9.27E+03	9.27E+03
Nb-93m	4.56E+02	5.89E+02	5.90E+02	5.90E+02	5.90E+02	5.89E+02	5.88E+02
Ni-59	4.58E+02	4.58E+02	4.57E+02	4.56E+02	4.54E+02	4.37E+02	4.18E+02
Ni-63	6.63E+04	3.43E+04	8.60E+03	2.15E+03	6.75E+01	6.31E-11	5.80E-26
Np-237	1.53E+04	1.56E+04	1.61E+04	1.64E+04	1.69E+04	1.73E+04	1.73E+04
Np-238	3.66E-01	2.37E-01	9.52E-02	3.83E-02	3.91E-03	4.68E-11	5.87E-21
Np-239	3.12E+01	3.09E+01	3.03E+01	2.98E+01	2.84E+01	1.95E+01	1.22E+01
Pa-231	3.33E+00	7.13E+00	1.51E+01	2.30E+01	4.27E+01	1.93E+02	3.65E+02
Pa-233	6.96E+01	7.09E+01	7.31E+01	7.46E+01	7.69E+01	7.87E+01	7.85E+01
Pa-234	5.23E-01	5.23E-01	5.23E-01	5.23E-01	5.23E-01	5.23E-01	5.23E-01
Pa-234m	2.79E+00	2.79E+00	2.79E+00	2.79E+00	2.79E+00	2.79E+00	2.79E+00
Pb-209	1.27E-06	2.00E-05	1.32E-04	3.42E-04	1.30E-03	2.89E-02	1.00E-01
Pb-210	2.41E-05	1.95E-03	3.50E-02	1.34E-01	7.89E-01	4.23E+01	2.14E+02
Pb-211							
Pb-212		1.80E-10	1.76E-09	4.93E-09	1.96E-08	4.34E-07	1.49E-06
Pb-214							
Pd-107	3.81E+00	3.81E+00	3.81E+00	3.81E+00	3.81E+00	3.80E+00	3.80E+00
Po-210	7.10E-06	5.73E-04	1.03E-02	3.94E-02	2.32E-01	1.24E+01	6.29E+01
Po-211							
Po-212							
Po-213	4.69E-15	7.36E-14	4.85E-13	1.26E-12	4.79E-12	1.06E-10	3.70E-10
Po-214							
Po-215							
Po-216							
Po-218							
Pu-236							

Table 3
Normalized Ingestion Risk Index for Radionuclides in Single Shell Tanks

Radionuclide	12/31/95	12/31/2095	12/31/2295	12/31/2495	12/31/2995	12/31/6995	12/31/11995
Pu-238	2.45E+05	1.22E+05	2.94E+04	7.78E+03	4.44E+02	4.34E-06	5.44E-16
Pu-239	5.02E+06	5.01E+06	4.98E+06	4.95E+06	4.88E+06	4.35E+06	3.77E+06
Pu-240	1.18E+06	1.16E+06	1.14E+06	1.12E+06	1.06E+06	6.94E+05	4.10E+05
Pu-241	1.55E+05	1.60E+03	1.42E-01	3.61E-02	3.47E-02	2.50E-02	1.66E-02
Pu-242	7.57E-02	4.52E-01	8.67E-01	1.03E+00	1.13E+00	1.14E+00	1.13E+00
Ra-223	1.29E+00	4.08E+00	9.63E+00	1.52E+01	2.89E+01	1.34E+02	2.53E+02
Ra-224		1.25E-09	1.21E-08	3.41E-08	1.36E-07	3.00E-06	1.03E-05
Ra-225	7.64E-04	1.20E-02	7.89E-02	2.05E-01	7.80E-01	1.73E+01	6.02E+01
Ra-226	2.47E-05	8.29E-04	1.06E-02	3.68E-02	2.01E-01	1.01E+01	5.07E+01
Ra-228		3.45E-09	3.25E-08	9.06E-08	3.59E-07	7.89E-06	2.71E-05
Rh-106	2.60E-03	1.12E-31					
Rn-219							
Rn-220							
Rn-222	3.49E-07	1.17E-05	1.50E-04	5.21E-04	2.84E-03	1.43E-01	7.18E-01
Ru-106	5.62E+00	2.41E-28	4.56E-88	8.61E-148			
Sb-126	2.46E+02	2.46E+02	2.45E+02	2.45E+02	2.44E+02	2.38E+02	2.29E+02
Sb-126m	4.52E+01	4.51E+01	4.51E+01	4.50E+01	4.49E+01	4.36E+01	4.21E+01
Se-79							
Sm-151	7.36E+04	3.54E+04	7.59E+03	1.63E+03	3.46E+01	1.45E-12	2.73E-29
Sn-126	3.51E+03	3.51E+03	3.51E+03	3.50E+03	3.49E+03	3.39E+03	3.28E+03
Sr-90	1.60E+09	1.60E+08	1.26E+06	9.87E+03	5.39E-02	4.26E-44	1.00E-96
Tc-99	4.13E+04	4.12E+04	4.12E+04	4.12E+04	4.11E+04	4.06E+04	3.99E+04
Th-227	8.93E-02	2.83E-01	6.68E-01	1.05E+00	2.00E+00	9.27E+00	1.76E+01
Th-228		3.61E-10	3.52E-09	9.86E-09	3.93E-08	8.67E-07	2.98E-06
Th-229	3.15E-04	4.94E-03	3.25E-02	8.45E-02	3.21E-01	7.14E+00	2.48E+01
Th-230	4.01E-04	4.52E-03	2.25E-02	4.90E-02	1.44E-01	2.30E+00	8.35E+00
Th-231	8.23E+00	8.23E+00	8.23E+00	8.24E+00	8.24E+00	8.27E+00	8.31E+00
Th-232		5.12E-10	4.19E-09	1.14E-08	4.40E-08	9.51E-07	3.26E-06
Th-233							
Th-234	1.92E+03	1.92E+03	1.92E+03	1.92E+03	1.92E+03	1.92E+03	1.92E+03
Tl-207							
Tl-208							
Tl-209	4.53E-09	7.11E-08	4.68E-07	1.22E-06	4.63E-06	1.03E-04	3.57E-04
U-232							
U-233	1.74E-01	6.38E-01	1.64E+00	2.67E+00	5.30E+00	2.69E+01	5.34E+01
U-234	3.10E+00	8.61E+00	1.56E+01	2.06E+01	3.18E+01	1.18E+02	2.25E+02
U-235	3.29E+02	3.29E+02	3.29E+02	3.29E+02	3.30E+02	3.31E+02	3.32E+02
U-236	3.41E-02	2.49E-01	6.94E-01	1.13E+00	2.18E+00	8.85E+00	1.41E+01
U-237	9.37E-01	9.68E-03	8.61E-07	2.19E-07	2.10E-07	1.51E-07	1.01E-07
U-238	7.69E+03	7.69E+03	7.69E+03	7.69E+03	7.69E+03	7.69E+03	7.69E+03
Y-90	1.55E+08	1.55E+07	1.22E+05	9.57E+02	5.23E-03		
Zr-93	6.69E+02	6.69E+02	6.69E+02	6.69E+02	6.69E+02	6.68E+02	6.66E+02

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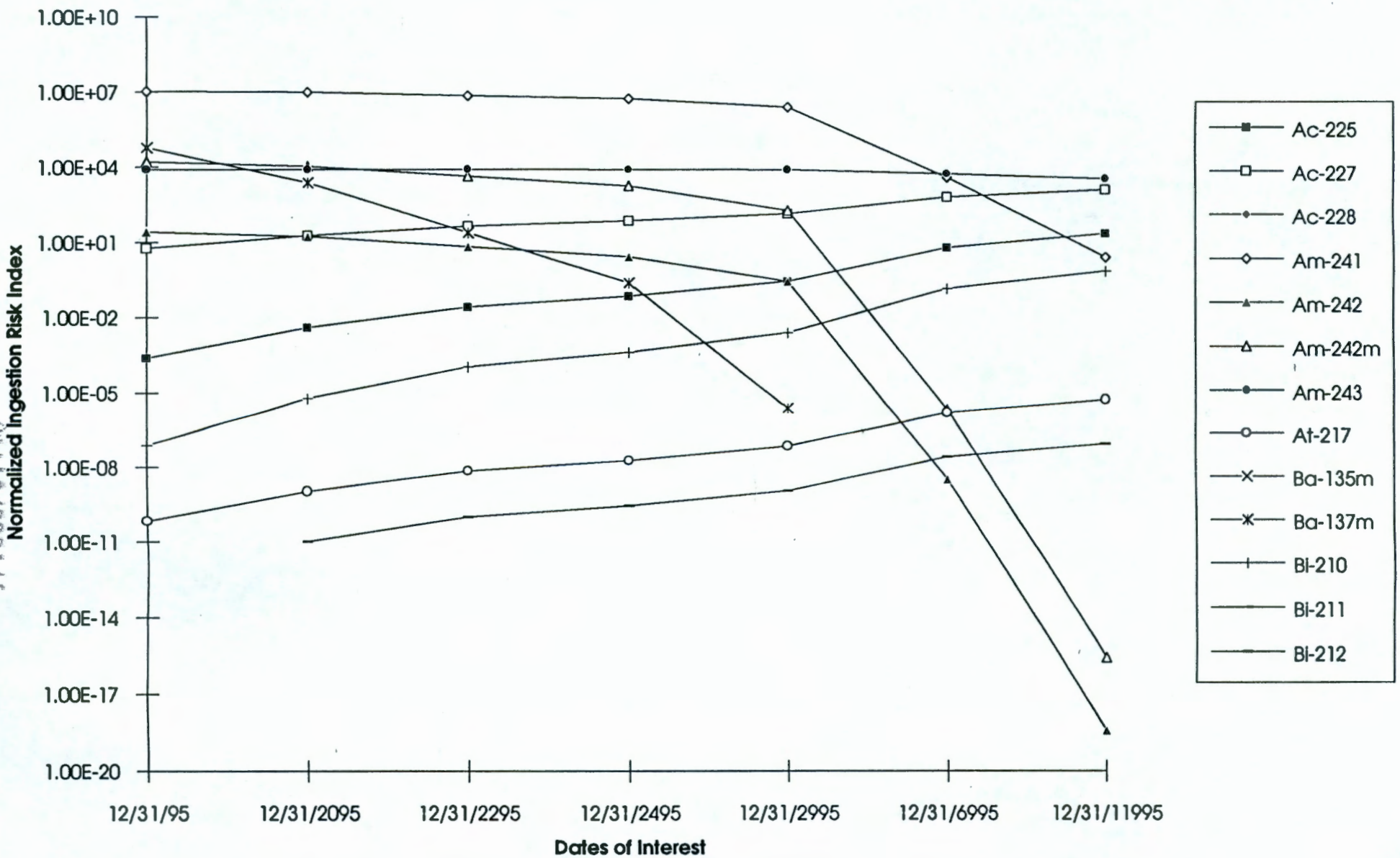
Table 4
Normalized Ingestion Risk Index for Radionuclides in Double Shell Tanks

Radionuclide	12/31/95	12/31/2095	12/31/2295	12/31/2495	12/31/2995	12/31/6995	12/31/11995
Ac-225		1.38E-03	1.41E-02	4.07E-02	1.70E-01	4.25E+00	1.51E+01
Ac-227		1.12E-04	1.68E-03	5.17E-03	2.22E-02	5.53E-01	2.05E+00
Ac-228							
Am-241	1.71E+07	1.49E+07	1.08E+07	7.86E+06	3.53E+06	5.77E+03	1.90E+00
Am-242							
Am-242m							
Am-243							
At-217		3.65E-10	3.73E-09	1.08E-08	4.50E-08	1.12E-06	3.99E-06
Ba-135m							
Ba-137m	7.06E+04	7.53E+03	7.60E+01	7.68E-01	7.88E-06		
Bi-210		1.25E-06	4.72E-05	1.91E-04	9.99E-04	2.02E-02	5.29E-02
Bi-211							
Bi-212		3.40E-12	4.17E-11	1.22E-10	5.01E-10	1.13E-08	3.90E-08
Bi-213		1.86E-05	1.91E-04	5.50E-04	2.30E-03	5.75E-02	2.04E-01
Bi-214							
C-14	2.10E+03	2.07E+03	2.02E+03	1.98E+03	1.86E+03	1.15E+03	6.26E+02
Cm-242							
Cm-244							
Cm-245							
Cs-135							
Cs-137	8.23E+08	9.28E+07	9.38E+05	9.47E+03	9.72E-02	1.19E-41	1.54E-91
Eu-154	4.38E+03	1.37E+00	1.34E-07	1.32E-14	3.96E-32	2.63E-172	
Fr-221		1.38E-05	1.41E-04	4.07E-04	1.70E-03	4.25E-02	1.51E-01
Fr-223		1.05E-06	1.57E-05	4.84E-05	2.08E-04	5.18E-03	1.92E-02
I-129							
Nb-93m							
Ni-59							
Ni-63							
Np-237	5.02E+01	5.24E+01	5.62E+01	5.90E+01	6.30E+01	6.61E+01	6.60E+01
Np-238							
Np-239							
Pa-231		7.44E-07	7.42E-06	2.10E-05	8.44E-05	2.00E-03	7.38E-03
Pa-233		3.24E+01	3.48E+01	3.64E+01	3.89E+01	4.09E+01	4.08E+01
Pa-234							
Pa-234m							
Pb-209		4.13E-02	4.23E-01	1.22E+00	5.10E+00	1.27E+02	4.52E+02
Pb-210							
Pb-211		2.21E-06	3.30E-05	1.02E-04	4.36E-04	1.09E-02	4.04E-02
Pb-212							
Pb-214		7.57E-08	1.70E-06	6.14E-06	2.94E-05	5.60E-04	1.46E-03
Pd-107							
Po-210							
Po-211							
Po-212		2.25E-21	2.76E-20	8.07E-20	3.31E-19	7.50E-18	2.58E-17
Po-213							
Po-214							
Po-215							
Po-216							
Po-218		8.61E-05	1.94E-03	6.97E-03	3.34E-02	6.37E-01	1.66E+00

Table 4
Normalized Ingestion Risk Index for Radionuclides in Double Shell Tanks

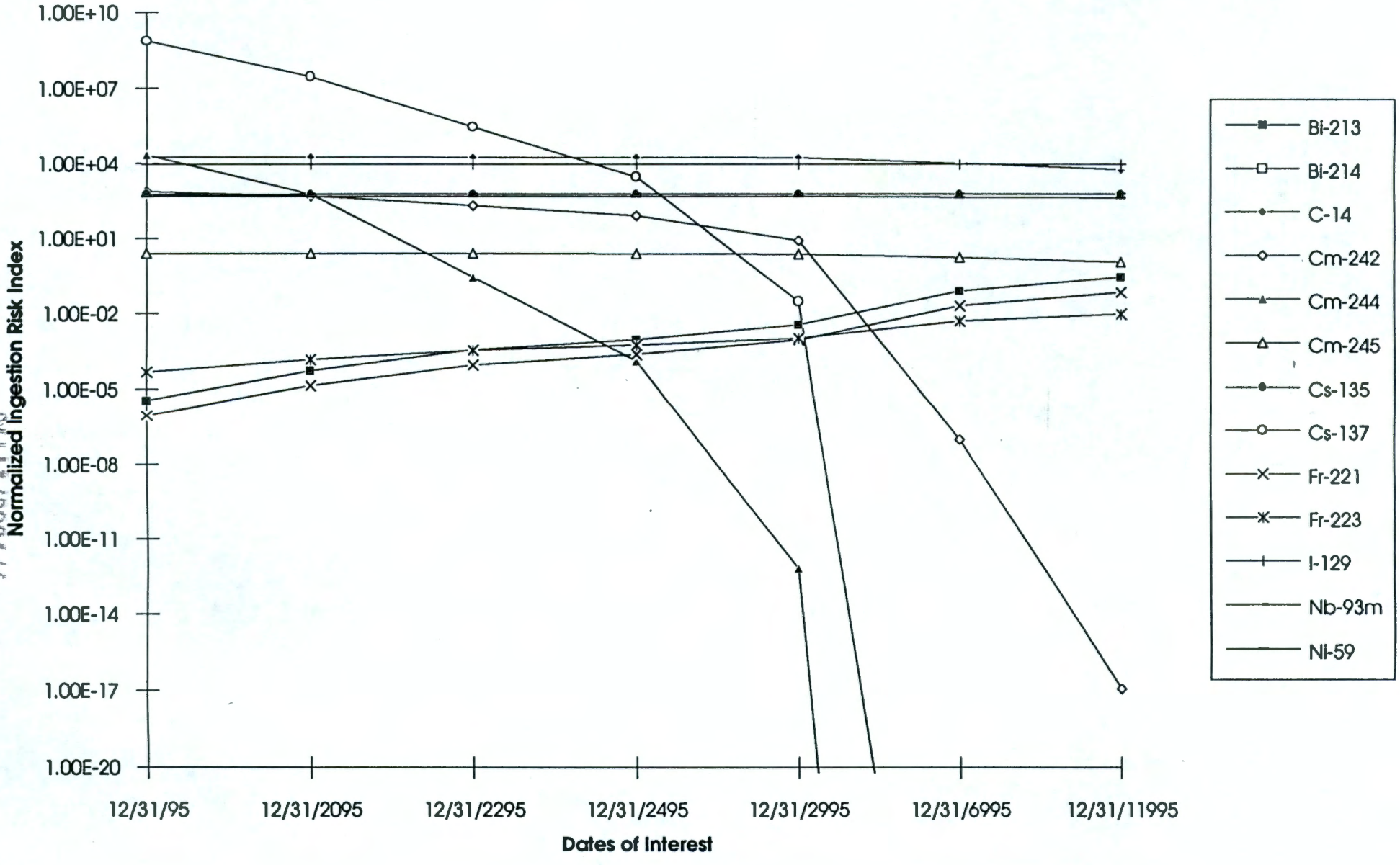
Radionuclide	12/31/95	12/31/2095	12/31/2295	12/31/2495	12/31/2995	12/31/6995	12/31/11995
Pu-236							
Pu-238	3.27E+05	1.54E+05	3.18E+04	6.54E+03	1.26E+02	2.39E-12	1.68E-29
Pu-239	1.92E+06	1.92E+06	1.91E+06	1.90E+06	1.87E+06	1.67E+06	1.44E+06
Pu-240	8.60E+03	8.52E+03	8.34E+03	8.17E+03	7.75E+03	5.08E+03	3.00E+03
Pu-241	8.73E+06	9.02E+04	5.95E+00	3.92E-04	1.38E-14	3.32E-98	9.93E-203
Pu-242							
Ra-223		1.52E-05	2.28E-04	7.02E-04	3.01E-03	7.51E-02	2.79E-01
Ra-224		5.59E-10	6.86E-09	2.01E-08	8.24E-08	1.87E-06	6.42E-06
Ra-225		9.72E-03	9.95E-02	2.87E-01	1.20E+00	3.00E+01	1.06E+02
Ra-226		1.72E-04	3.87E-03	1.39E-02	6.69E-02	1.27E+00	3.32E+00
Ra-228		5.13E-14	6.03E-13	1.75E-12	7.15E-12	1.61E-10	5.54E-10
Rh-106							
Rn-219							
Rn-220		1.86E-11	2.29E-10	6.69E-10	2.75E-09	6.22E-08	2.14E-07
Rn-222		1.64E-05	3.68E-04	1.32E-03	6.35E-03	1.21E-01	3.15E-01
Ru-106							
Sb-126							
Sb-126m							
Se-79							
Sm-151							
Sn-126							
Sr-90	1.44E+07	1.44E+06	1.13E+04	8.89E+01	4.86E-04	3.84E-46	9.05E-99
Tc-99	7.83E+04	7.83E+04	7.82E+04	7.82E+04	7.80E+04	7.70E+04	7.58E+04
Th-227		4.35E-06	6.51E-05	2.00E-04	8.60E-04	2.14E-02	7.96E-02
Th-228		2.30E-10	2.83E-09	8.27E-09	3.39E-08	7.68E-07	2.65E-06
Th-229		1.05E-03	1.08E-02	3.11E-02	1.30E-01	3.25E+00	1.15E+01
Th-230		4.93E-05	3.27E-04	6.75E-04	1.58E-03	8.68E-03	1.71E-02
Th-231		9.37E-03	2.90E-02	4.86E-02	9.69E-02	4.60E-01	8.58E-01
Th-232		1.78E-10	1.77E-09	4.99E-09	1.99E-08	4.41E-07	1.52E-06
Th-233							
Th-234							
Tl-207							
Tl-208		5.52E-14	6.77E-13	1.98E-12	8.13E-12	1.84E-10	6.34E-10
Tl-209		6.48E-05	6.62E-04	1.91E-03	8.00E-03	2.00E-01	7.08E-01
U-232							
U-233		3.08E-01	9.96E-01	1.73E+00	3.66E+00	2.01E+01	4.04E+01
U-234		4.30E+00	7.36E+00	7.98E+00	8.13E+00	8.04E+00	7.93E+00
U-235		1.17E-02	3.63E-02	6.07E-02	1.21E-01	5.75E-01	1.07E+00
U-236		5.95E-03	1.83E-02	3.04E-02	5.95E-02	2.44E-01	3.89E-01
U-237		1.61E-01	1.06E-05	6.99E-10	2.46E-20		
U-238							
Y-90	1.89E+06	1.89E+05	1.48E+03	1.16E+01	6.35E-05		
Zr-93							

Figure 1
Normalized Ingestion Risk Index for Radionuclides in Single Shell Tanks



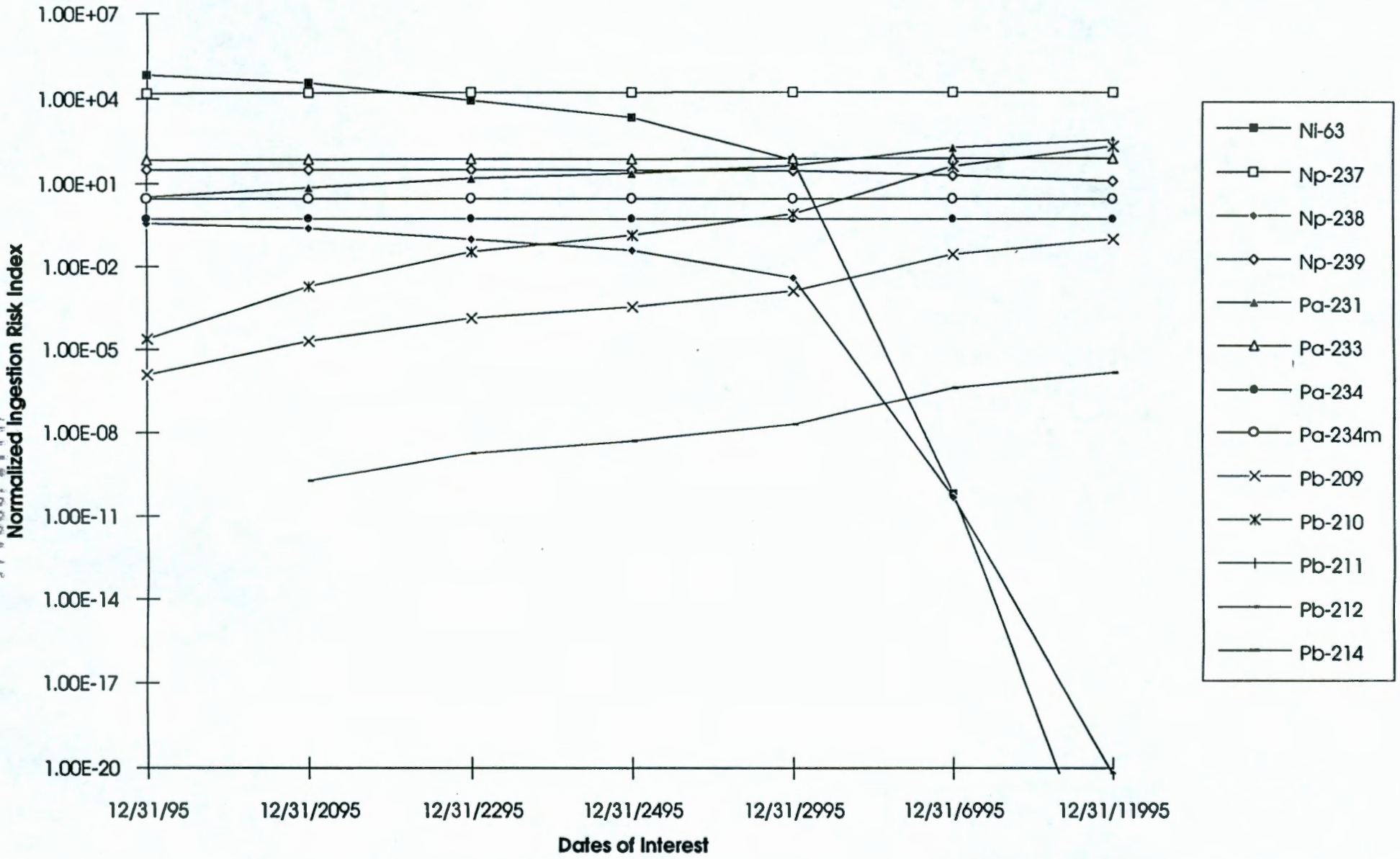
9713537.1115

Figure 2
Normalized Ingestion Risk Index for Radionuclides in Single Shell Tanks



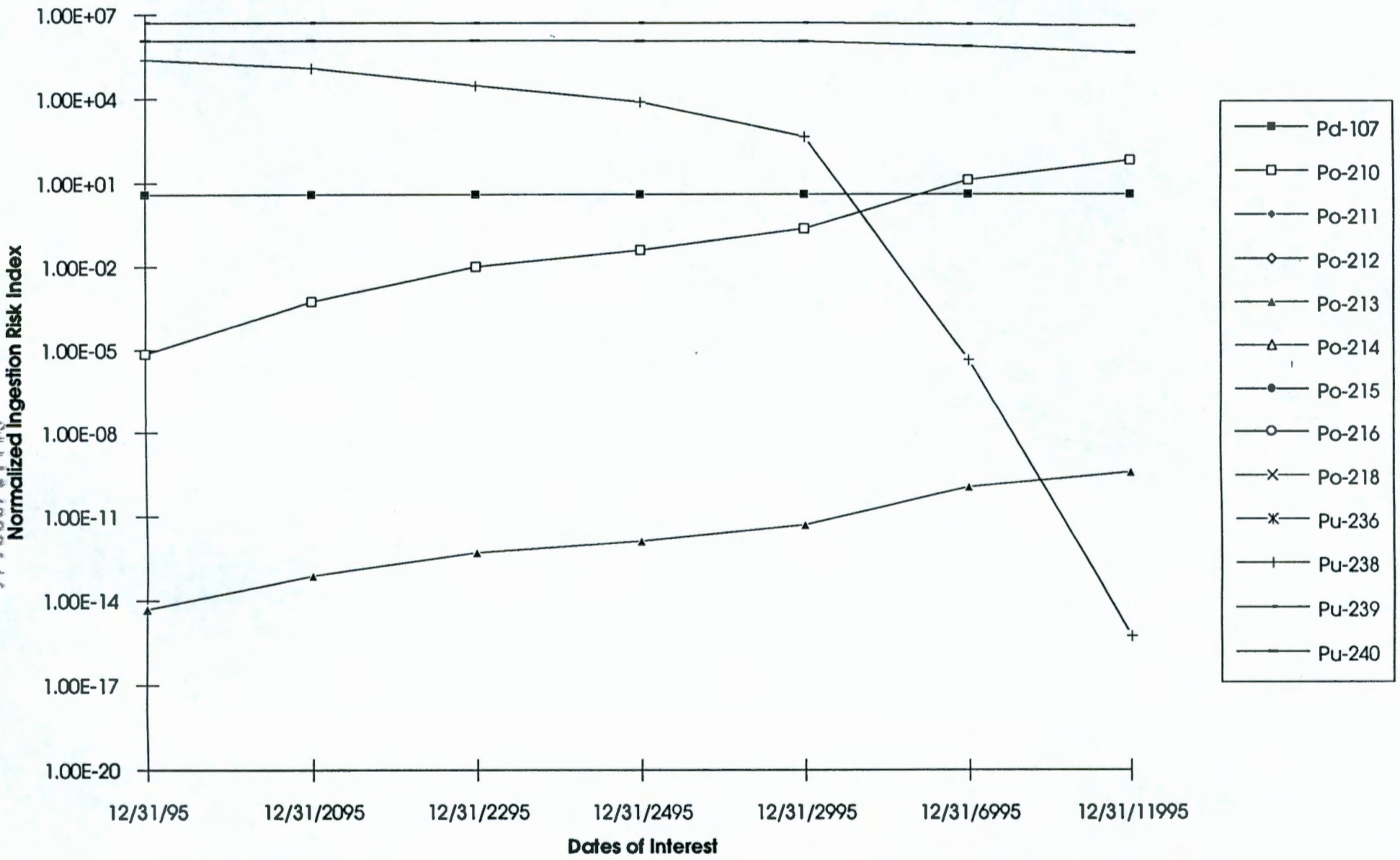
9713537.1116

Figure 3
Normalized Ingestion Risk Index for Radionuclides in Single Shell Tanks



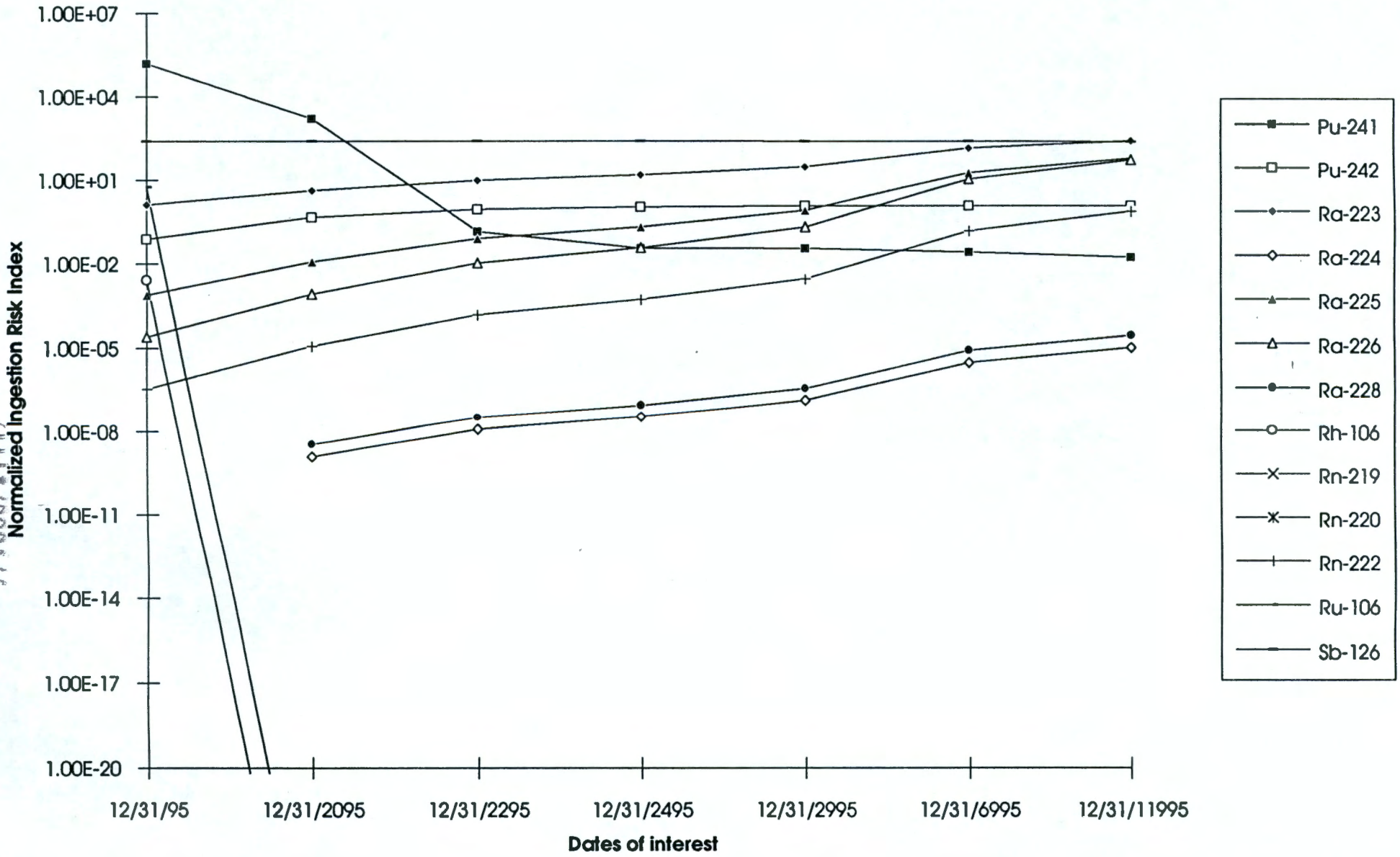
9713537.1107

Figure 4
Normalized Ingestion Risk Index for Radionuclides in Single Shell Tanks



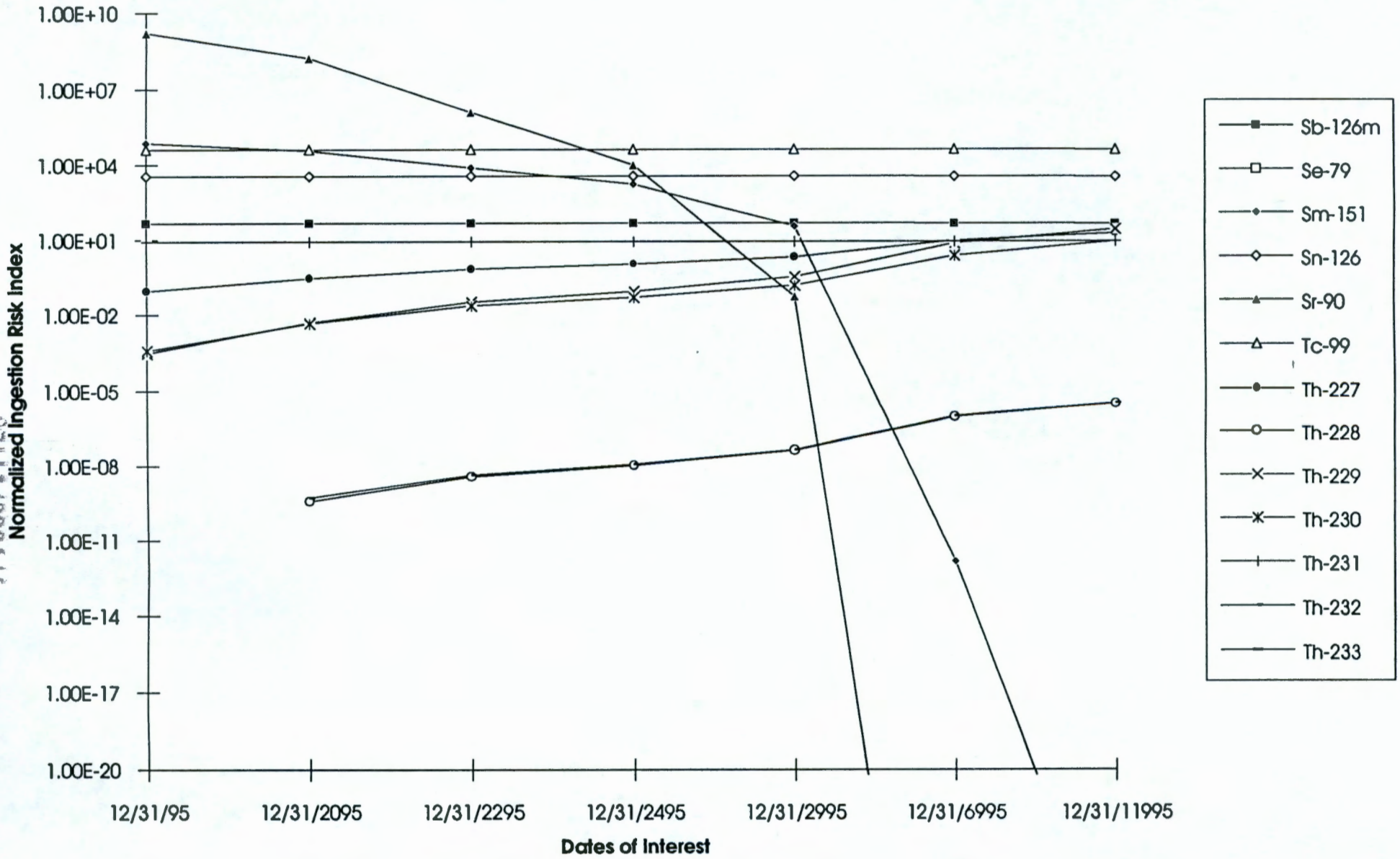
9713537.1118

Figure 5
Normalized Ingestion Risk Index for Radionuclides in Single Shell Tanks



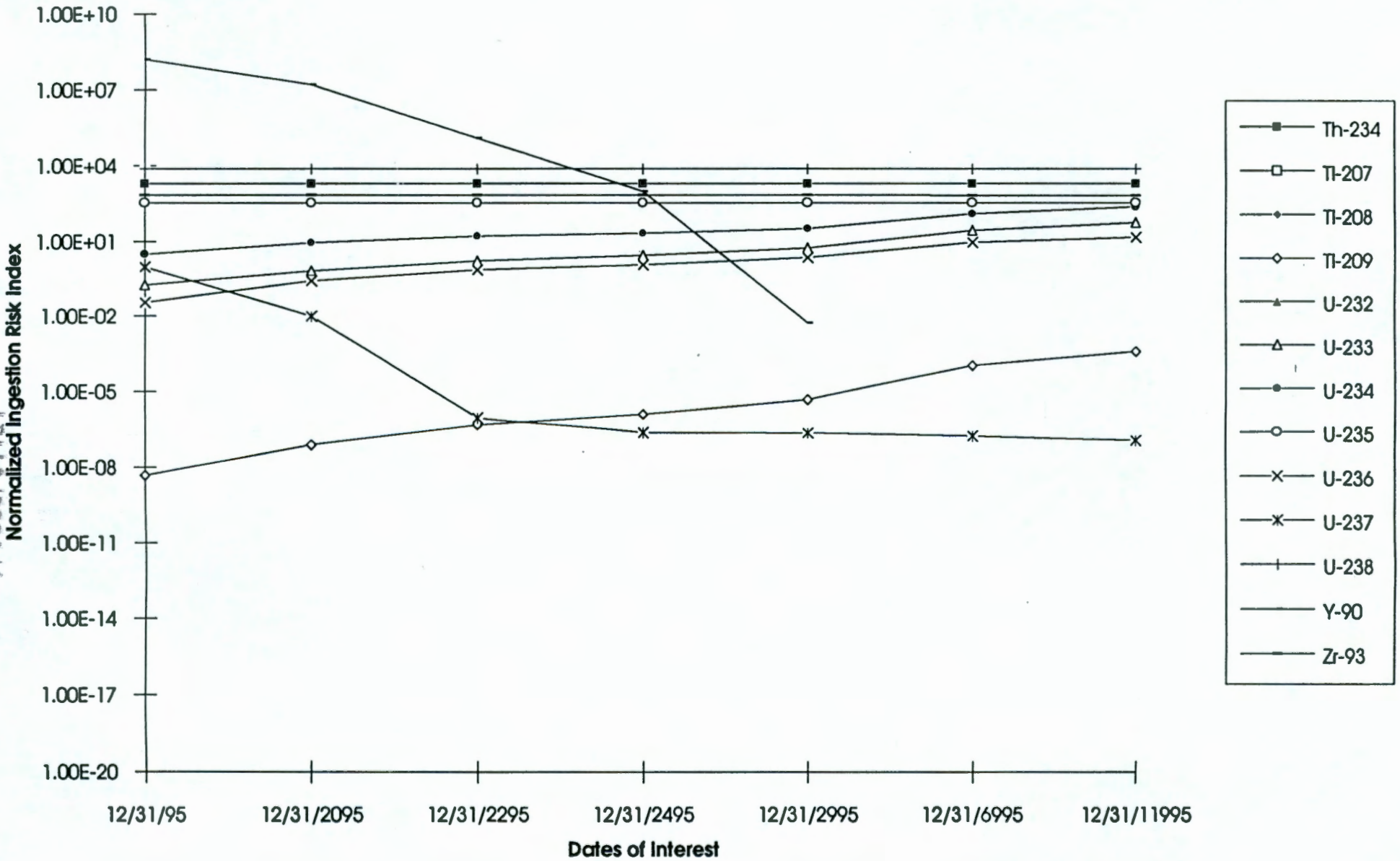
9713537.1109

Figure 6
Normalized Ingestion Risk Index for Radionuclides in Single Shell Tanks



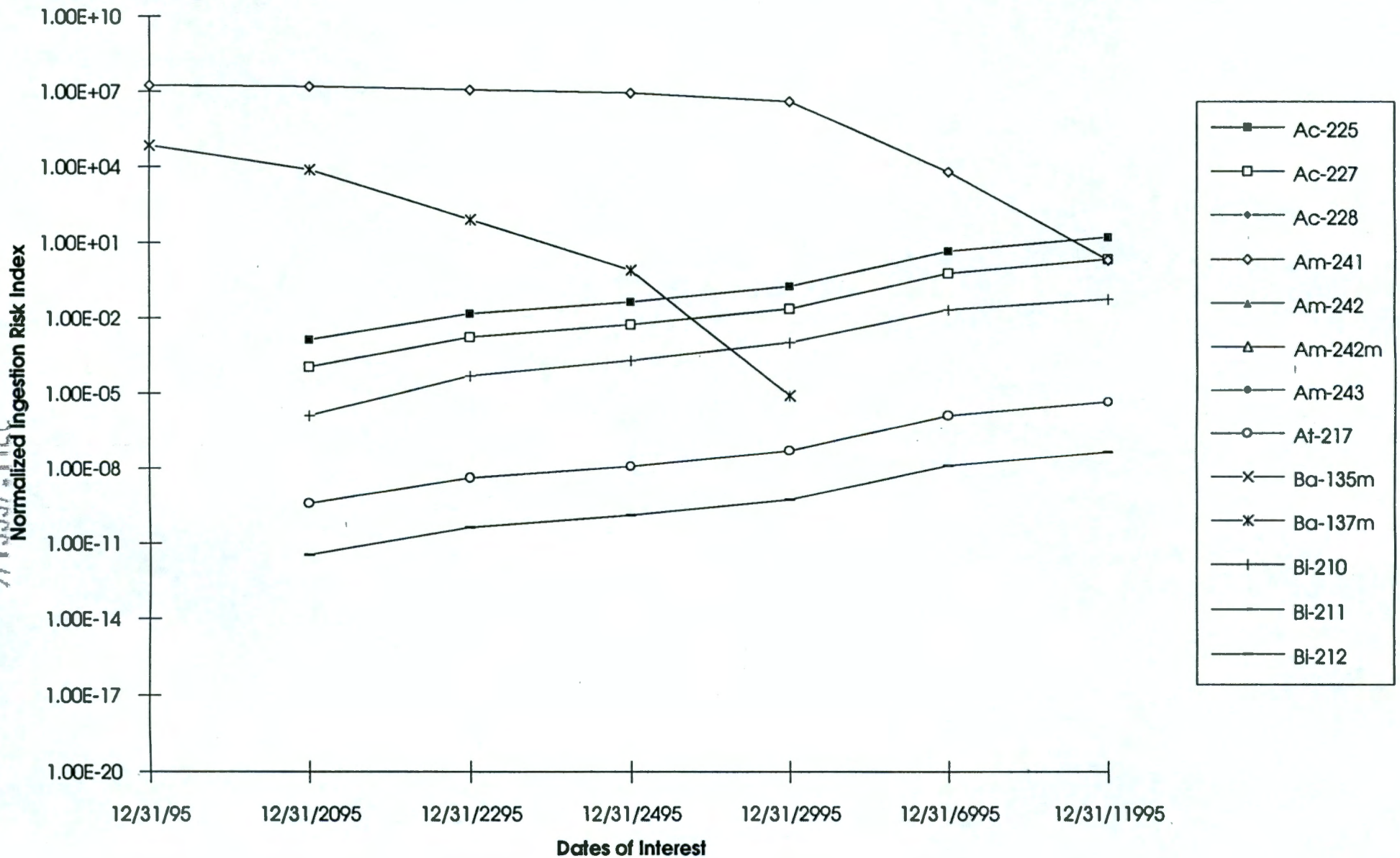
9713537.1120

Figure 7
Normalized Ingestion Risk Index for Radionuclides in Single Shell Tanks



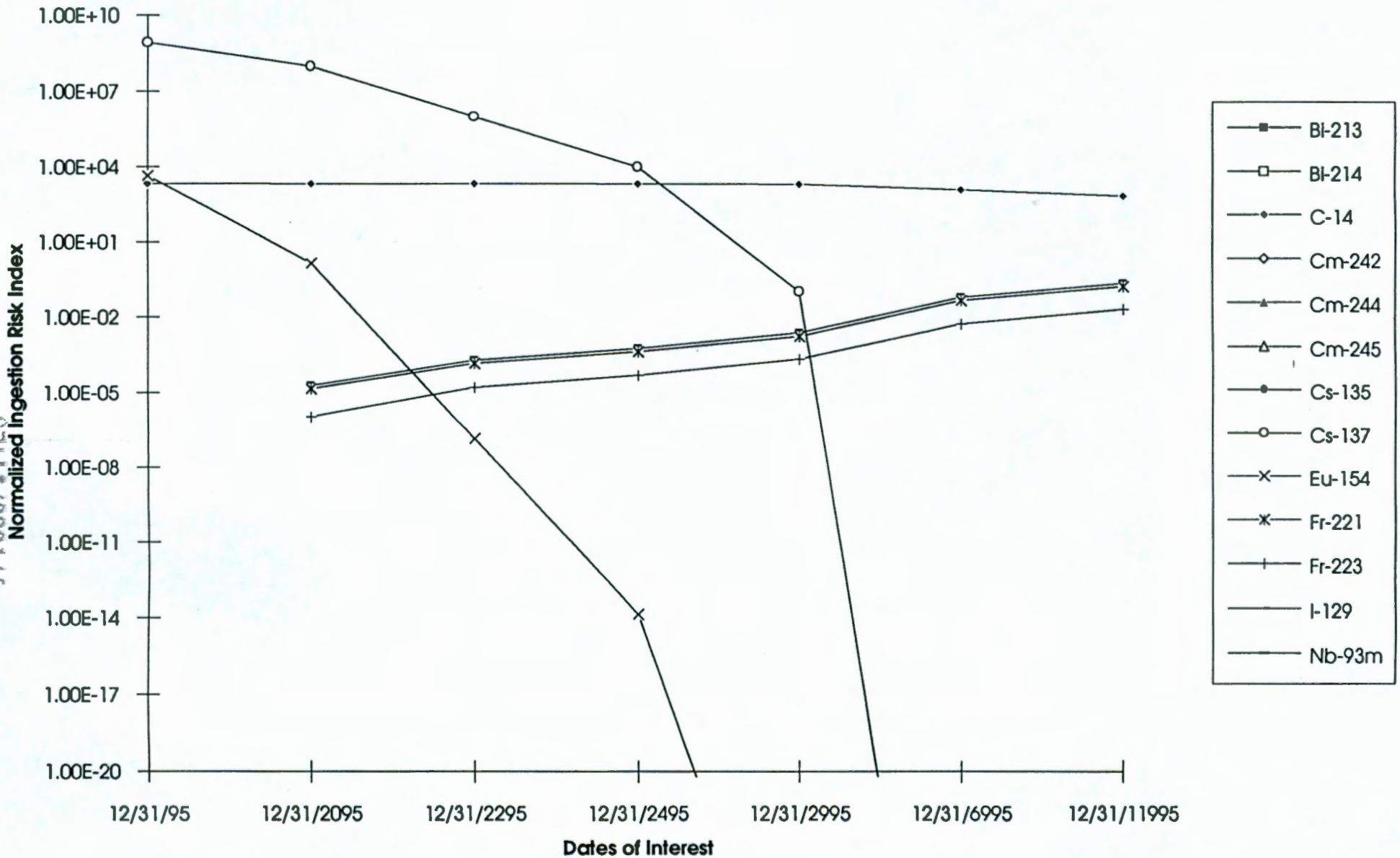
9713537.1121

Figure 8
Normalized Ingestion Risk Index for Radionuclides in Double Shell Tanks



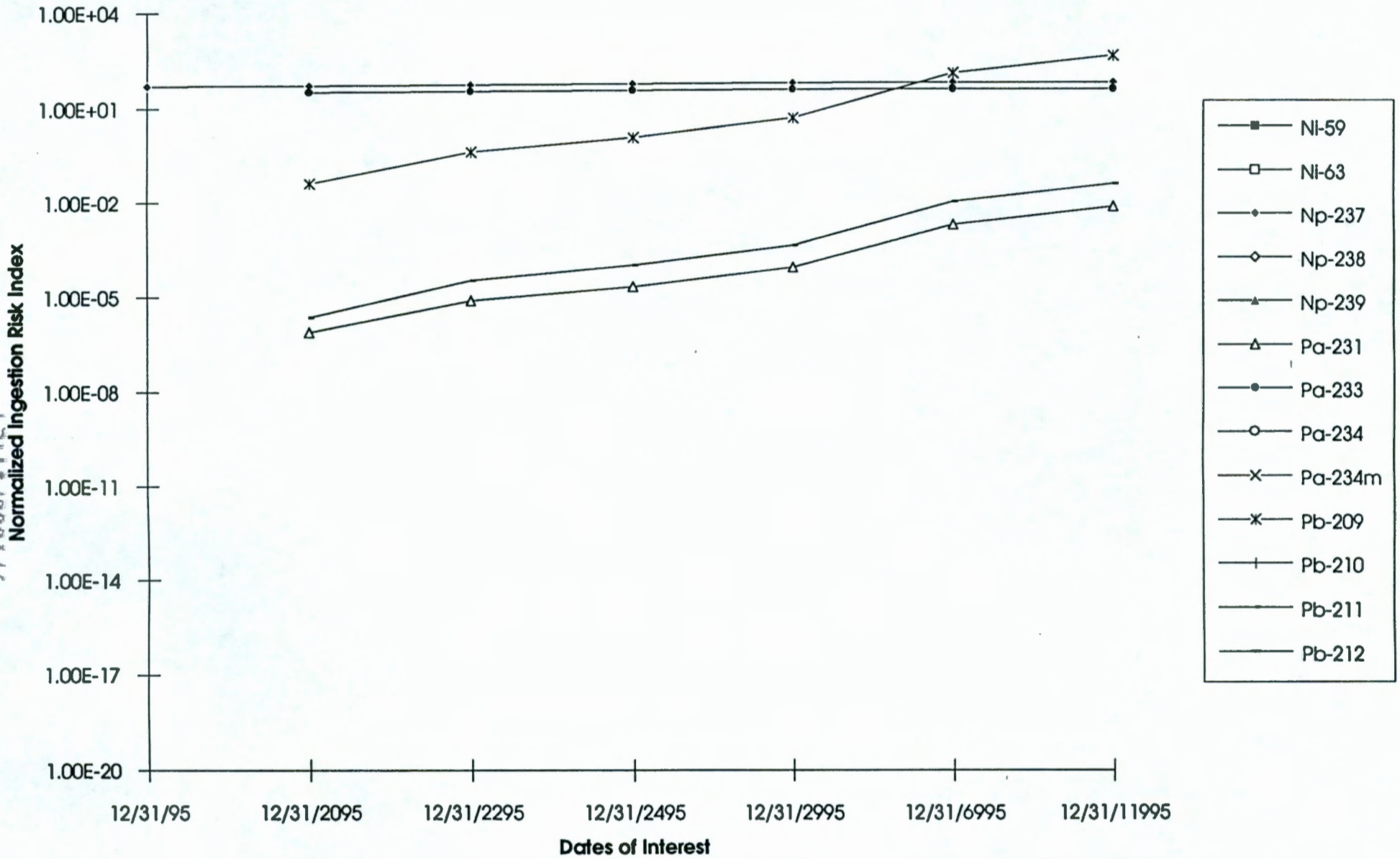
9713537.1122

Figure 9
Normalized Ingestion Risk Index for Radionuclides in Double Shell Tanks



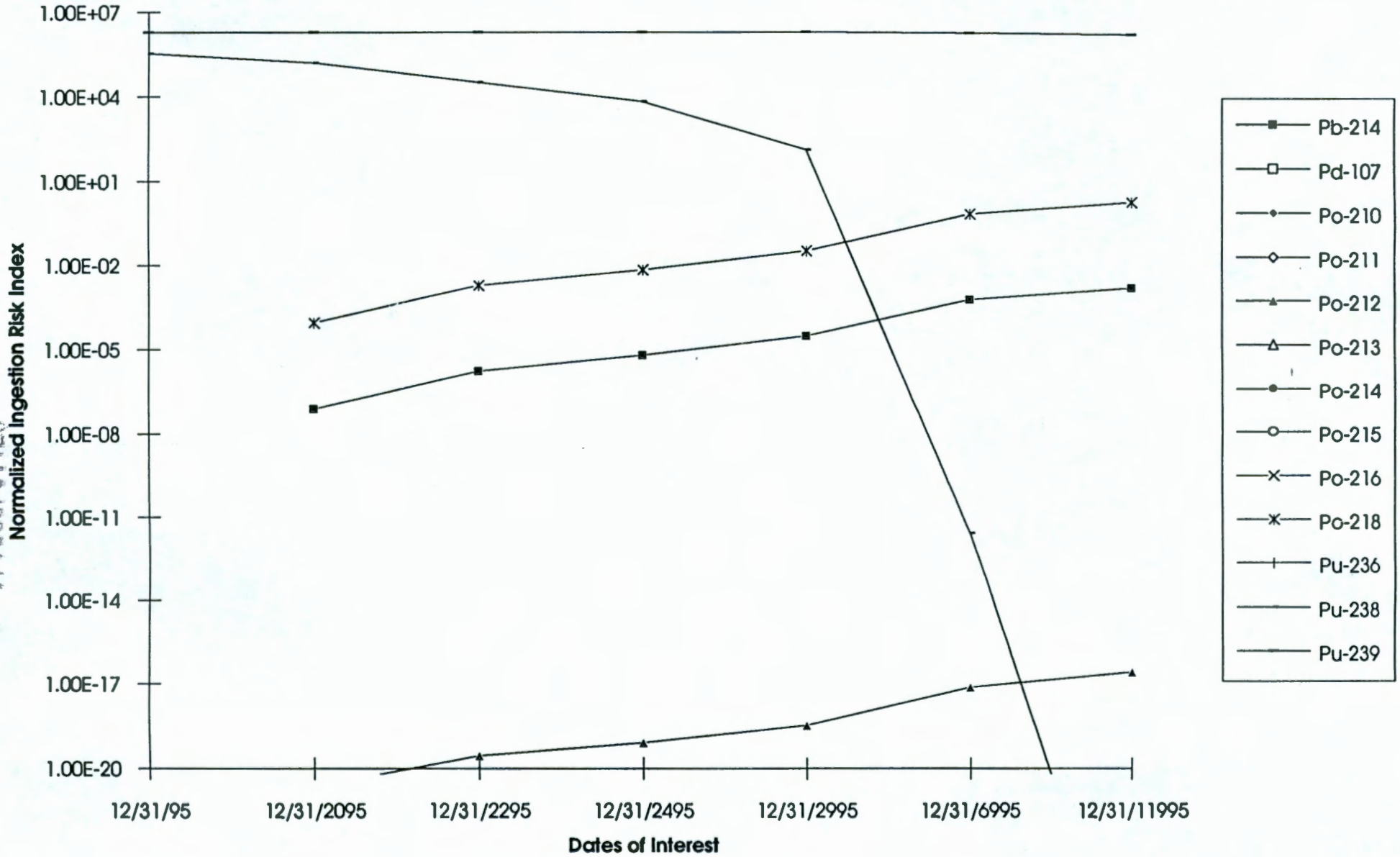
9713537.1123

Figure 10
Normalized Ingestion Risk Index for Radionuclides in Double Shell Tanks



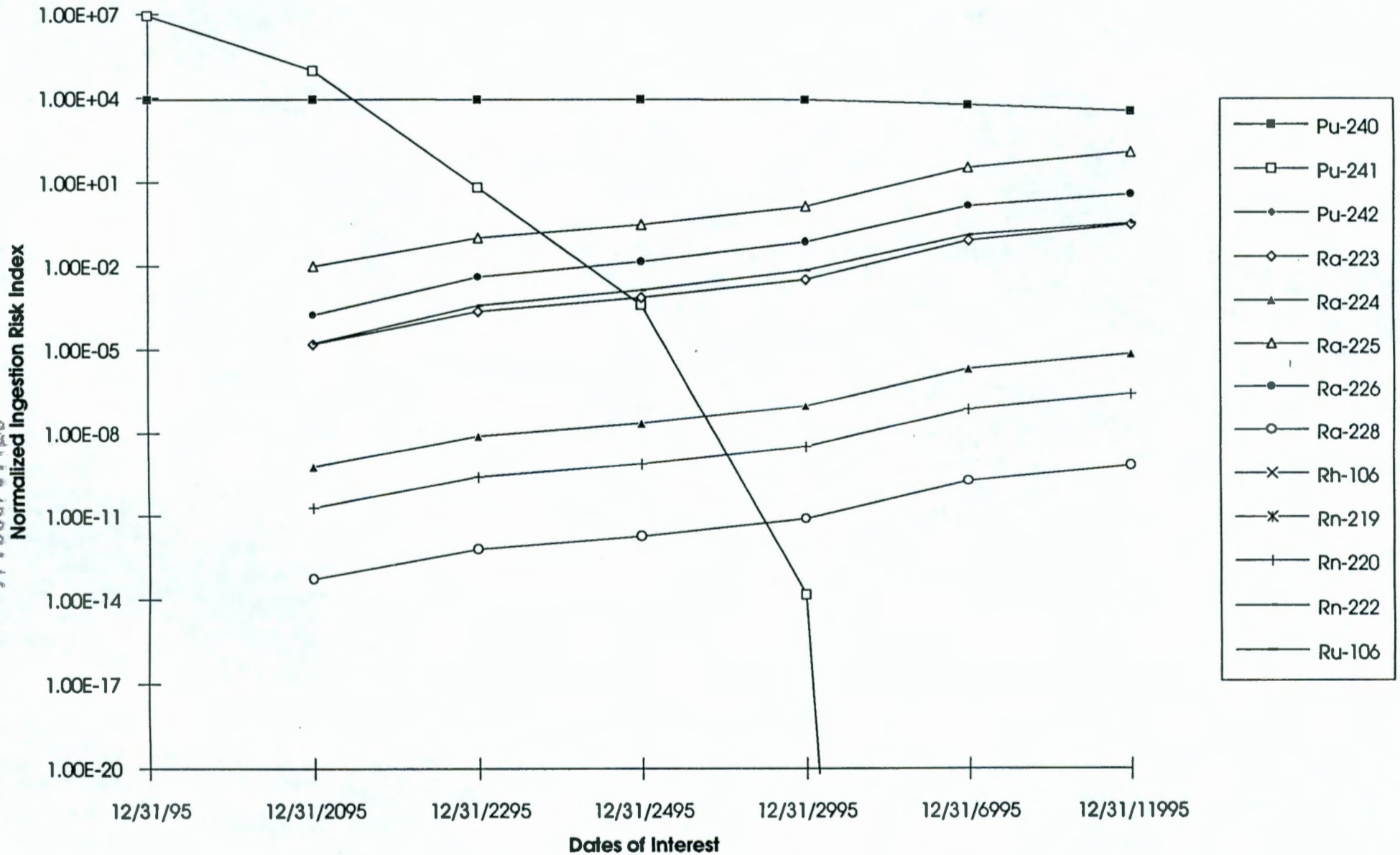
9713537.1124

Figure 11
Normalized Ingestion Risk Index for Radionuclides in Double Shell Tanks



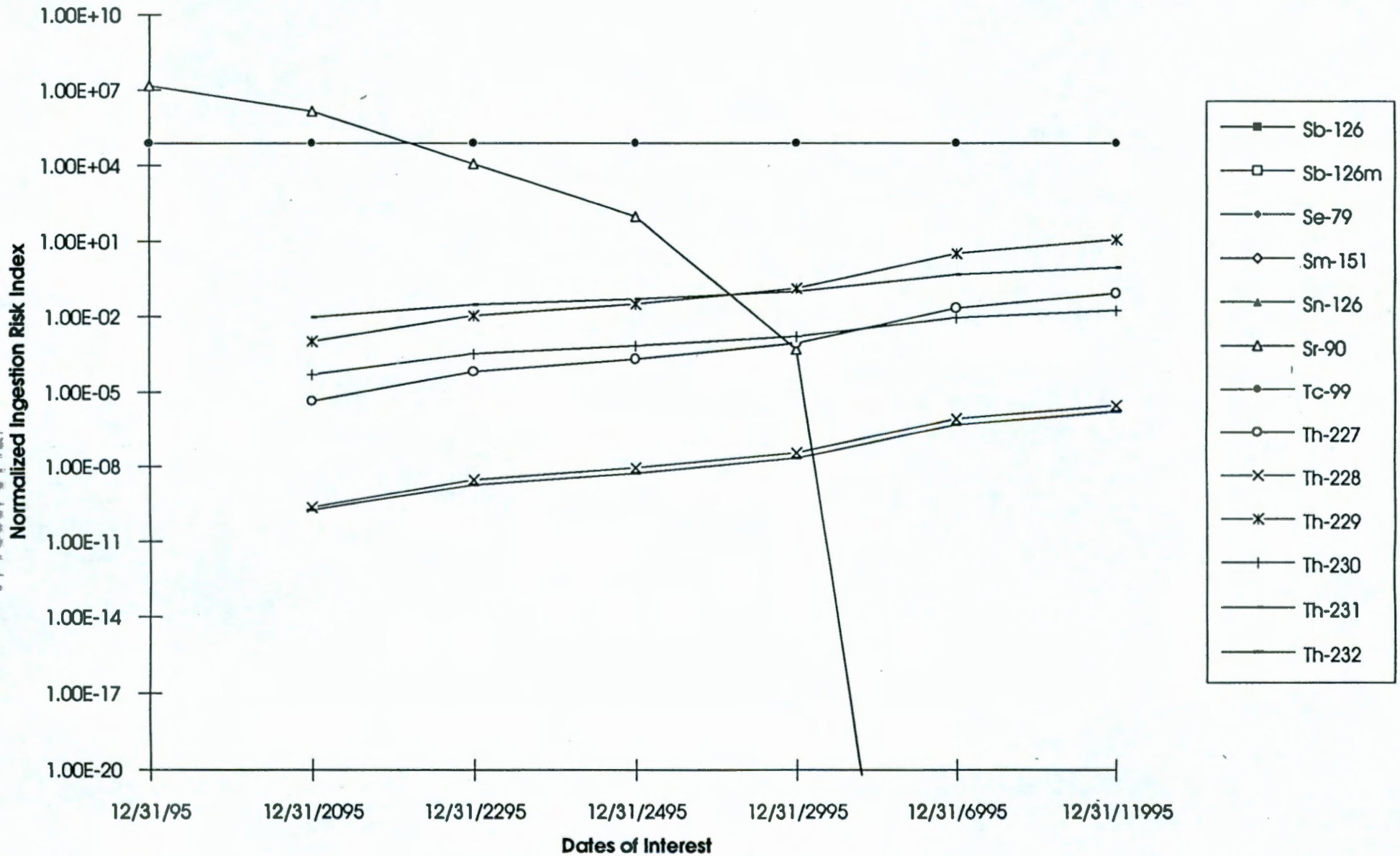
9713537.1125

Figure 12
Normalized Ingestion Risk Index for Radionuclides in Double Shell Tanks



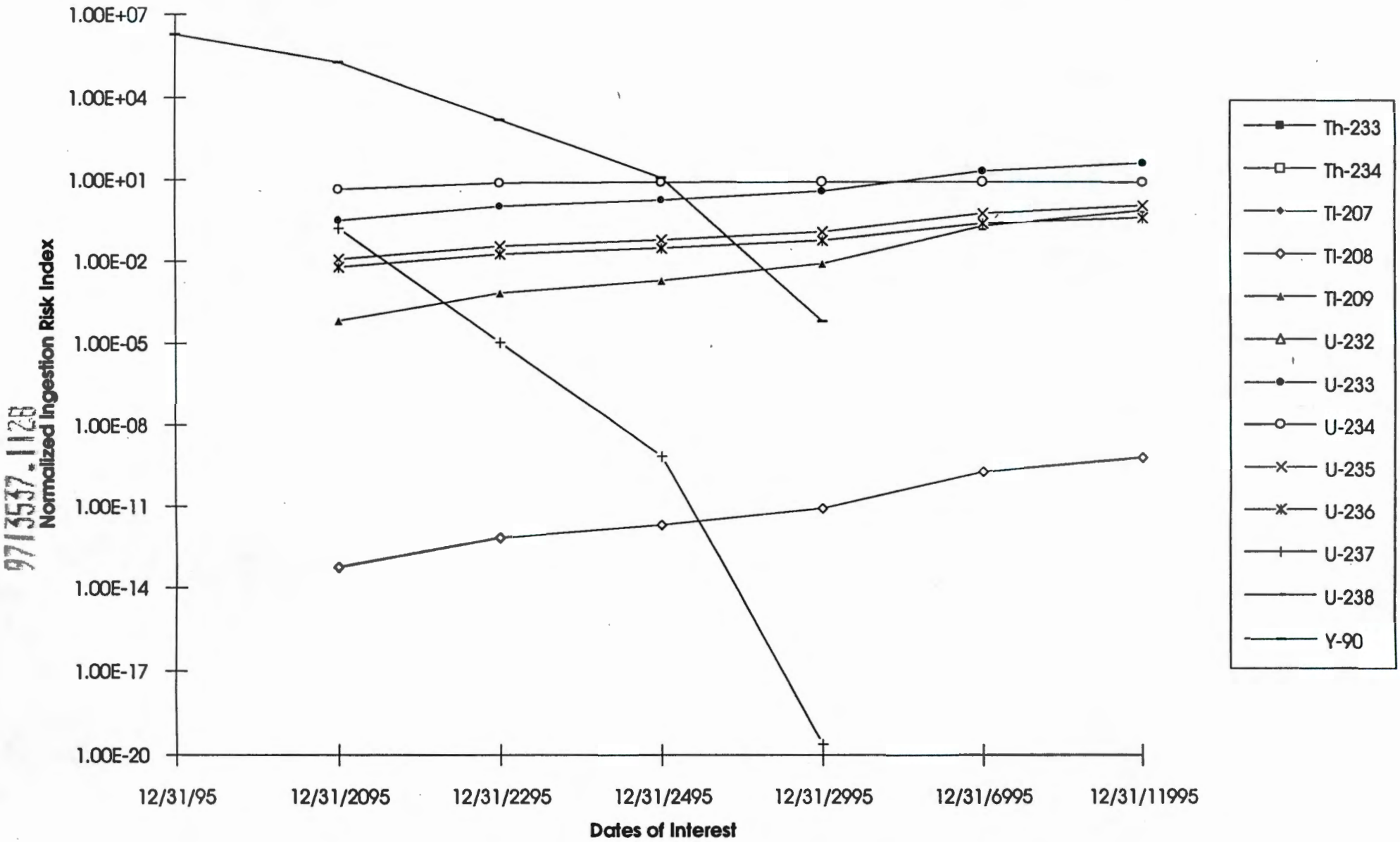
9713537.1126

Figure 13
Normalized Ingestion Risk Index for Radionuclides in Double Shell Tanks



9713537.1127

Figure 14
Normalized Ingestion Risk Index for Radionuclides in Double Shell Tanks



9713537.1128