

PLUTONIUM-URANIUM EXTRACTION FACILITY (PUREX) PLUTONIUM AND FISSION PRODUCT RESIDUAL ESTIMATES

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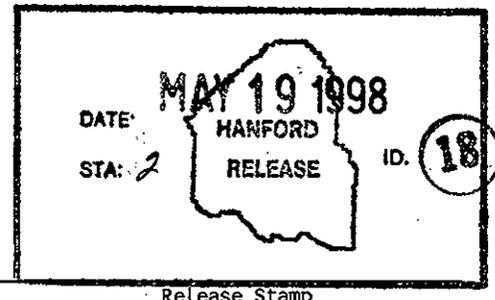
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Abstract:

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PLUTONIUM-URANIUM EXTRACTION FACILITY (PUREX) PLUTONIUM AND
FISSION PRODUCT RESIDUAL ESTIMATES

SUMMARY

During the PUREX deactivation period, remaining plutonium and fission product residual was reduced to as low as reasonably achievable (ALARA). Residual amounts based on measured values and engineering estimates were determined for plutonium, fission products, and total Americium-241. Estimates reflect the present deactivated condition and include Storage Tunnels #1 and #2 at the East End. Summary values are: 10kg plutonium, 2.7E6Ci fission products, and 24gm Americium-241. Most of the residual material is in the canyon and tunnels.

DISCUSSION

PUREX processed fuel from the Hanford reactors from 1956 to 1972 and again from 1983 to 1989. In 1990, a cleanout campaign was conducted to complete processing of the remaining fuel stored in the dissolvers and canyon tanks. PUREX was subsequently shut down and deactivation was initiated. This document combines the information available from pre- and post deactivation activities to summarize the amount of residual material which will remain following deactivation.

The remaining residual material is located in three main areas. The PUREX storage tunnel contains failed process equipment, waste from the 324 Building and some empty rail cars. The material quantities in these tunnels are provided in the State permits. The accessible areas of PUREX include the Sample Gallery, external buildings and the glovebox areas which were cleaned to ALARA and the remaining material (specifically plutonium), was determined using non-destructive techniques. Content in other areas which were estimated include the process canyon areas and are for the most part, nonaccessible. Residual material remaining in the nonaccessible canyon areas has never been fully measured. Some known areas where plutonium concentration was of concern were sampled (L Cell floor and E Cell floor solids container) and engineering estimates were prepared.

The report is divided into source groups of radionuclides including plutonium and fission products. The significant group contains the major contributors for residual plutonium and fission product holdup in the plant. These are listed in Appendix A, Tables 2, 3 and 4. The secondary or "other" group provides primarily less-than (rough estimates) values in most cases for sources that will not significantly impact the total (i.e., the quantities are smaller than the significant group and are listed in Appendix B, Tables 5 and 6). Bases for estimating are listed in Appendices C, D, E and F (Tables 7 to 20) and are discussed briefly in the Methodology section. Appendix G gives the radionuclide waste transferred from the 324 Building (300 Area) to Storage

Tunnel #2. Appendix H discusses the Americium-241 estimate. Appendix I contains the irradiated fuel basin sample data.

PUREX processed substantial amounts of irradiated fuel from the reactor sites along the northern edge of the Hanford reservation. Uranium, plutonium, neptunium, thorium, were separated and purified for later use in military or other applications. Over the many years of processing, occasional fluid leakage occurred in the various process cells due to connector head gasket deterioration or misalignments. Fluids were spilled on equipment structural surfaces, on equipment vessel surfaces, on the floors and the walls. Cell floor sumps were normally promptly emptied during operation. Aerosols of various substances were entrained with the ventilation air and further deposited on all of the main exhaust ventilation equipment surfaces. Building inleakage through cracks, controlled openings, and vacuum breakers, introduce desert particulates which mix with all of the variety of nuclides within the plant. In short, radionuclides are distributed over many areas of the plant along with dirt and debris.

To obtain accurate estimates of the depositions within these areas, extensive sampling and analysis would be required. To quantitatively determine the isotopes present, the processing areas would need to be dismantled, extensively flushed, and analyzed. Material that has soaked into concrete surfaces would still be inaccessible unless the surface layer were removed, broken down and analyzed. Any such effort would be very time consuming, very expensive, and of questionable value.

It is more cost effective to make reasonable estimates of the remaining material to support surveillance and maintenance activities and provide a starting point for future work planning. The most significant decisions come when the decommissioning occurs. At that time, PUREX may be converted to a repository for radioactive waste or scrap.

The table of residual radionuclides presented here represents a mixture of data. The sampled and analyzed materials have a reasonably low error band. Engineering estimates have a larger uncertainty depending upon the assumptions made in the calculations. The less-than numbers have the largest uncertainty and are intended to be an approximate upper bound. In most cases the actual levels will be significantly less-than these numbers. Because the data are not of one consistent type it is very difficult to summarize the values. Quite simply, the numbers are not of the same kind. Table 1 on the following page gives the summary data.

TABLE 1
PUREX FACILITY RESIDUAL NUCLIDES SUMMARY

LOCATION	MEASURABLE PLUTONIUM (grams)	ESTIMATED PLUTONIUM (grams)	ESTIMATED FISSION PRODUCTS
Canyon (includes L Cell)	4,296	930 - 4,800	200 - 500 Ci
White Room	N/A	50 - 500	0
N Cell	1,643	N/A	0
Product Removal Room	1,199	N/A	0
Deep Bed Filters	N/A	200 - 400	80 - 800 Ci
Railroad Tunnels	N/A	200 - 1,000	2.7 MCi
TOTALS	7,138	1,380 - 6,700	

USE OF THESE DATA

The sampled and analyzed data are appropriate for use in inventory calculations, provided that personnel using them realize that there are sampling uncertainty factors and total quantity estimating incorporated in the values. The engineering estimates certainly are not appropriate for use in inventory calculations. They are intended only for future scoping studies by technical personnel with background training in nuclear technology. The less-than numbers are intended only to provide approximate supplementary data in areas of the facility not covered by the significant source numbers. In most cases, they do not significantly impact the conclusions derived from the significant source numbers.

METHODOLOGY

SIGNIFICANT PLUTONIUM SOURCES

The PUREX process flowsheet was used to determine the composition of streams and location of streams within the plant. Where possible, operational history was incorporated to estimate residual radionuclides. In a few selected cases, samples and analyses are available. Source information is highly variable.

The headend and first extraction column areas will have spillage of feed solutions whereas other areas of the plant will have spillage of partially purified or separated radionuclides. Therefore, the composition of the spillage varies greatly in nuclide content. For example in F Cell the composition will be concentrated fission products; whereas, in L Cell the composition will be high concentration plutonium residues.

Using plant flowsheet data, limited cell sample data, and plant history, estimates of the residual material in the various areas were made. It should be noted that the estimates vary considerably in accuracy depending upon assumptions and supporting data. Some are based on sampling and analyses, some are engineering estimates based on other information, and some are rough upper limit estimates. Only residual plutonium, fission product nuclides, and Americium-241 have been addressed, as these present the greatest hazard to occupants at later dates.

During deactivation the cell sumps were emptied and the process vessels were flushed and emptied. Walls and floors were not cleaned due to the great complexity of the task.

HEADEND CELLS AND H1 AREAS

The Tank E3 floor cleanup residual was placed in a metal container or "skip." This consisted of debris taken from the floor under the E3 tank prior to its replacement. Apparently this was spillage in the E Cell operations during feed preparations while processing N Reactor fuel.

The debris was scraped from the floor and placed in the rectangular metal box and taken to the M Cell for grab samples. The resultant samples were rather hot and resulted in approximately a 400 gram quantity which was placed on the inventory books.

In the process of dissolving, the occasional Zirflex fuel dissolver upsets resulted in overflowed solutions to the floor. Efforts were made to flush the floor to recover some of this material.

The area under the E3 tank was estimated along with the areas of the headend cells (A,B,C,D,E). By using area ratios the plutonium burdens in the other cells were estimated. The intent was to obtain a rough estimate of all of the headend processing areas related to HAF or solvent extraction feed solution.

J CELL

The partition cycle is entirely in J Cell. Certain parts of the partition system have plutonium concentrations that are elevated, (i.e., 1BXP solution, 1BP from the J4 column etc.). The floor samples that were taken in L Cell were used to estimate potential concentrations in J Cell by using stream concentration ratios between the 2AF, 2BP streams and corresponding streams in J Cell. This provides an order of magnitude estimate of floor plutonium concentrations.

It should be noted that the amount of plutonium on any given floor is an integrated product of the leakage flow to the floor and the stream concentration involved in the leakage. Stream concentrations are known in most areas; however, the integrated flows to the floor will be determined by the leakage rates which are highly variable. The logic of using this estimating method stems largely from the fact that over a long processing period the leakage rates will tend to normalize and the concentrations therefore give some indication of the integrated leakage to the floor.

This same logic was used to estimate the floor quantity near the J5A tank in J Cell.

OTHER AREAS IN THE FACILITY

Most other areas involve streams that are partitioned from plutonium and therefore the residual plutonium quantity in those areas will be very low, (i.e., only contamination levels; grams or fractions of grams). This includes G, K, M, Q and R Cells.

WHITE ROOM, N CELL, PRODUCT REMOVAL ROOM

The White Room, N Cell and Product Removal (PR) room areas were not calculated. The historical estimates of the plutonium content were used as given in the references. The technical staff at the time of the White Room accident should have the best understanding of the event and therefore would have the best estimate of the spill. The nondestructive assay of N Cell and PR residual quantities was documented recently to support deactivation of the PUREX criticality monitors.

STORAGE TUNNEL #1

No estimating was done in this document; referenced values were taken from the tunnel permits.

STORAGE TUNNEL #2

No estimating was done in this document; referenced values were taken from the tunnel permits.

DEEP BED FILTERS

In 1964 when the #1 main ventilation filter failed, a 4" core sample was taken of the upper bed. Extensive analyses were done on the core sample which included all process chemicals, plutonium, and gamma spectroscopy of fission product material. The plutonium was documented in a memo to one the Engineering Managers, G. C. Oberg and was used to estimate the filter quantity. Filter operating history was then incorporated to estimate the additional plutonium burden accumulated to present. Flow distribution was estimated and a similar calculation made for filter #2.

During the #1 filter flood incident in 1990 many solution analyses were run to determine the materials extracted from the bottom of the filter bed. The Americium-241 daughter was then back extrapolated to compare with the core sample data. The estimates agreed within 50 gm.

SIGNIFICANT FISSION PRODUCT SOURCES

GENERAL

Using the ORIGEN2 computer code for the prediction of N Reactor fuel composition, all long-life fission products were examined to determine which isotopes would be present after long decay times (i.e., 10 years or more). Of all fission product isotopes, the following remain in measurable quantities after 10 year decay time: Sr90, RuRh106, Sb125, Cs134, Cs137, Ce144Pr144, Pm147. The Cs137 and Sr90 isotopes overwhelm all of the others in abundance. The others are in concentrations of 30 to 80 curies/tonne of uranium whereas the Cs137 and Sr90 are at levels of 5000 curies/tonne. The only exception to this is Pm147 at 1400 curies/tonne. This isotope is a beta emitter and therefore is not a serious dose rate contributor because of the limited range of the beta emissions.

HEADEND AREAS

An average fuel composition of "mixed fuel" at 9% Pu-240 level was used to scope the curie levels in the solutions. Ten year cooled values of Cs137 and Sr90 curies per tonne of uranium were used to calculate the curie level of these two isotopes in the HAF stream. An engineering estimate of 5 gallons solution dispersed on the dunnage, walls and floors was assumed to determine the curie content of the cell. This was done for each of the headend cells A, B, C, D, E. These assumptions also apply to the H1 tank and the HA column.

EXTRACTION BATTERY CELLS

A conservative value of 1000x was used for the HA column DF (actual is higher; i.e. perhaps 10000). Then the cell areas downstream of the HA column in second and third extraction cycles were assigned curie values 1000x less than the headend areas. This does not include the waste concentration cell, which is a special case.

WASTE CONCENTRATION CELL

The HAF stream is introduced to the HA column and has other streams added, such as the HAS scrub stream and the 3WB recycle stream. The HAF flow enters at a value of 19 L/m, whereas the HAW stream leaves the column at about 48 L/m due to the added streams. All of the aqueous waste is concentrated in the waste concentrator to remove the extra water and recover the nitric acid. The resulting 1WW stream is about 4 L/m. Therefore the ratio of HAF fission products to 1WW fission product concentration is the ratio of 19/4. The concentrated waste stream fission product concentration = $19/4 \times \text{HAF}$ which results in a curie burden of approx 100 curies in the cell using the assumptions given above.

OTHER SPECIAL AREAS

G CELL

Only the G1 wash tank contained a significant fission product level which was largely Zr Nb 95 adsorbed on MnO₂. Soluble isotopes such as Cs137 and Sr90 were essentially removed by the HA column. Therefore assigning the second cycle values of 0.1Ci to G Cell with the provision that it could be perhaps one order higher due to accumulations in the wash tank results in 0.1 to 1.0 Ci. Both tanks G1 and R1 were flushed extensively to remove solids to support potential plant restart in 1990.

R CELL

A similar logic applies to R Cell. The actual value is probably less however.

M CELL

This area was used for decontamination and therefore would only have contamination levels of isotopes. The overriding data that we have to date is that the dose rates in the M Cell area are low (i.e., in the 0 to 50 mr range), therefore the curie burden in that area must necessarily be in the 0.1 to 1.0 range.

SECONDARY SOURCES
(BOTH PLUTONIUM AND FISSION PRODUCTS)

M CELL VAULT

The M Cell vault contains four plutonium product tanks and associated piping which is all welded. The plutonium estimate was based on a low heel volume (a few liters) at a 1% flowsheet concentration. The fission products were estimated based on plutonium daughters of residual material in the vault.

SLUG BASIN

Sample data are available for the liquid phase for the basin. The solution sample implied that the fuel clad integrity was adequate to prevent significant fuel corrosion. The sludge in the bottom of the basin would be a mix of canyon debris primarily.

SAMPLE GALLERY HOODS

Plutonium solution concentrations and volumes were estimated for the plutonium samplers assuming minimal flushing. Limited survey data taken when the hoods were deactivated was used to provide an approximate curie estimate.

SAMPLE GALLERY EXHAUST DUCT

The duct surface area was calculated and a survey taken at the west end of the duct was used to estimate upper limits for content.

CANYON VESSELS (TOTAL)

No estimating was done in this report; referenced values (LATA) were used. It should be noted that LATA values are conservatively high. The PUREX canyon vessels were flushed to meet dangerous waste regulatory limits.

206A VACUUM FRACTIONATOR

Flowsheet data were used to estimate plutonium levels. 1WW concentrations plus a 1E6 DF was used for the tower decontamination. The existing radiation fields are an indication of fission product content.

293A BACKUP FACILITY

Main stack alpha levels were used to estimate the plutonium levels in the offgas system. The normal canyon ventilation flow contains very low levels of plutonium. Typical values are in the $1E-14$ uCi/cc range. (currently in the mid $1E-14$ to $1E-15$ range). Main stack beta levels have been in the mid $1E-14$ range for the last two years. If the beta activity for one year deposited on the stack offgas equipment the calculated total would be 60 microcuries. Assumed flow for this calculation was 80000 cfm. Therefore posting a $<1Ci$ for the stack offgas equipment is very conservative.

TK 216-A2 MAIN VENTILATION SYSTEM CATCH TANK

Process sample data were used to estimate the plutonium content of the tank as given in file memo 17530-93-074 (Appendix J). The same data can be used to estimate curie levels; however, if sludge is present, activity levels could be higher.

TK V11-1 (#2 FILTER DRAIN TANK)

Process sample data were used to estimate the plutonium and fission product residuals. The sample corresponded to a recent liquid holdup collected from the filter #2 sump.

LABORATORY HOODS

A preliminary estimate will be made and may be refined at a later time. When the laboratory hoods were cleaned prior to coating with PBS fixant, survey data were taken. Total estimates of plutonium activity and fission product activity were made initially and may be refined after the survey data are retrieved.

LABORATORY UTILITY PIPE CHASE & PIPING

Same as "Laboratory Hoods."

DATA SUMMARY

TABLE 1
SUMMARY QUANTITIES

	<u>PLUTONIUM (gm)</u>	<u>FISSION PRODUCTS (Ci)</u>
Primary Inventory	7138	-----
Primary Estimated	1380-6700	2.7E6
Secondary Estimated	120	-----
Secondary less-than	117	140

Table Explanation:

Inventory = measured by sampling and analysis

Estimated = calculated by using other measurements and plant data

Less-than = estimated upper limiting values

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20. DOE/RL-90-24, "The Hanford Facility Dangerous Waste Permit Application, PUREX Storage Tunnels," July 1996.
21. Memo, 17522-92-005, "E Cell Floor Debris Disposition Schedule," February 1992.
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23. Memo, 17710-94-020, "L Cell Floor Plutonium Estimates," October 1994.
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26. Report by C. R. Haas on radioisotope content of storage tunnel #2 including the waste material from the 324 Building in 300 Area.
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APPENDIX A

SIGNIFICANT PUREX RESIDUAL NUCLIDE SOURCES

TABLES 2, 3, 4

TABLE 2
SIGNIFICANT PUREX RESIDUAL NUCLIDE SOURCES
MIXED FISS PROD.

LOC	PU MEASURABLE INVENT.			PU UNMEAS ESTIM.			Ci/FP	Form
	Gm Pu	Form	Gm Pu	Form	Gm Pu	Form		
A CELL	N/A	N/A	100-700	dust; debris; sludge; spills	20 Sr90 30Cs137	debris; sludge; absorbed spills		
B CELL	N/A	N/A	100-700	dust; debris; sludge; spills	20Sr90 30Cs137	same		
C CELL	N/A	N/A	100-700	dust; debris; sludge; spills	20Sr90 30Cs137	same		
D CELL	N/A	N/A	300- 1200	dust; debris; sludge; spills	20Sr90 30Cs137	same		
E CELL	400 in "skip" contain	dust; debris; sludge; spills; (analyses) (A)	N/A	N/A				
E CELL OTHER THAN "SKIP"	N/A	N/A	200-800	dust; debris; sludge; spills	20Sr90 30Cs137	same		
H CELL (H1)	N/A	N/A	50-400	dust, debris, sludge, spills	20Sr90 30Cs137	same		
J CELL (J5A)	N/A	N/A	30-100	dust, debris, process spills	<.1Sr90 <.1cs137	debris, sludge absorbed spills		
J CELL OTHER THAN J5 AREA	N/A	N/A	50-200	dust, debris, process spills	<.1Sr90 <.1cs137	same		
F CELL	N/A see E cell	N/A	Neg1		100 Sr90 100 Cs137	same		

TABLE 2B 1/22/97

TABLE 3
SIGNIFICANT PUREX RESIDUAL NUCLIDE SOURCES
MIXED FISS PROD.

LOC	PU MEASURABLE INVENT.		PU UNMEAS ESTIM.		MIXED FISS PROD.	
	Gm Pu	Form	Gm Pu	Form	Ci/FP	Form
G CELL	N/A	N/A	Neg1	_____	.1 - 1	same
K CELL	N/A	N/A	Neg1	_____	<.1Sr90 <.1Cs137	same
L CELL	3896	dust; debris; process sludge (analyses) (A)	N/A	N/A	<.1Sr90 <.1Cs137	same
M CELL	N/A	N/A	Neg1	decon work residues	.1 - 1	same
STOR TUNN #1	N/A	N/A	100	dust, debris, process residuals in and on equip.	144,000**	dust, debris, process residuals in and on equip.
STOR TUNN #2	N/A	N/A	100 to 1000	dust, debris, process residuals in and on equip.	2.7E6 Ci	dust, debris, process residuals mostly 324 Bldg waste
N CELL	1643	debris; sludge; plutonium oxide by spectroscopy methods	N/A	N/A	N/A	N/A
PR ROOM	1199	debris; sludge; plutonium by spectroscopy methods	N/A	N/A	N/A	N/A

PLUT2 1/8/97

** Rough estimates at time of burial (substantially less now)

TABLE 4
SIGNIFICANT PUREX RESIDUAL NUCLIDE SOURCES

LOC	PU MEASURABLE INVENT.		PU UNMEAS ESTIM.		MIXED FISS PROD.	
	Gm Pu	Form	Gm Pu	Form	Ci/FP	Form
Q CELL	N/A	N/A	Negl.			
WHITE ROOM	N/A	N/A	50-500	Pu fixed under multiple coats of paint. residual from process spill in Feb. 1956	N/A	N/A
R CELL	N/A	N/A	Negl.		.1 - 1	debris; sludge; absorbed spills
DEEPBED FILT. #1	N/A	N/A	100-200 based on sample analysis 1964	Pu trapped in glass fiber matrix along with traces of TBP, dirt, debris, and Ammonium nitrate	250,000 uCi	Americium 241 trapped in fiber
DEEPBED FILT. #2	N/A	N/A	100-200 based on sample analysis 1964	Pu trapped in glass fiber matrix along with traces of TBP, dirt, debris, and Ammonium nitrate	20-200 Ci	Cs137/Sr89-90 trapped in fiber
					250,000 uCi 241	Americium 241 trapped in fiber
					20-200 Ci	Cs137/Sr89-90 trapped in fiber

PLUT3 1/8/97

APPENDIX B

TABLES 5, 6

OTHER PUREX RESIDUAL NUCLIDE SOURCES

TABLE 5
OTHER PUREX RESIDUAL NUCLIDE SOURCES

LOC	PU MEASURABLE INVENT.		PU UNMEAS ESTIM.		MIXED FISS PROD.	
	Gm Pu	Form	Gm Pu	Form	Ci/FP	Form
M Cell vault			<10gm	sludge, process residuals	<.5Ci	process residuals
Slug Basin			<1gm	sludge, residual liquid	<1Ci unkn	liquid phase solid phase
Sample Gallery Hoods			<50gm	process residuals, spills	<100Ci	dirt, debris, process residuals
Sample Gallery Exh Duct			< 1gm	sludge, process residuals	<5Ci	dirt, debris, salts, process residuals
Canyon Vessels (total)			120 gm	process residuals after flushing	<1Ci	flushed vessels assuming no sludges

PLUT4

TABLE 6
OTHER PUREX RESIDUAL NUCLIDE SOURCES

LOC	PU MEASURABLE INVENT.		PU UNMEAS ESTIM.		MIXED FISS PROD.	
	Gm Pu	Form	Gm Pu	Form	Ci/FP	Form
206A fractionat -or			<1gm	dirt, debris, process residuals	<10Ci	dust, debris, sludge, spills
293A backup facility			<1gm	dirt, debris, process residuals	<10Ci	dust, debris, sludge, spills
TK 216-A2 catch tank			<1gm	process residuals drainage	<1Ci	sludge, residuals in tank
TK VII-1 catch tank			<1gm	process residuals	<10Ci	
Laboratory Hoods			<0.1gm	analytical residuals	<1Ci	dust, debris, sludge, spills
Laboratory Utility Pipe Chase & Piping			<1gm <50gm	pipe chase floor in piping, traps	<1Ci	pipe chase floor contamination (fixed)

PLUT5

APPENDIX C

TABLES 7, 8, 9, 10

BASES FOR SIGNIFICANT PLUTONIUM SOURCE CALCULATIONS

TABLE 7
SIGNIFICANT PUREX RESIDUAL PLUTONIUM SOURCES

LOCATION	ESTIMATE BASIS	REFERENCES
A CELL	Sample analysis of E Cell floor used with floor area ratios presuming similar solution concentrations source: spills	E cell "skip" sample analysis also referenced in WHC-SD-SQA-CSA-511
B CELL	Sample analysis of E Cell floor used with floor area ratios presuming similar solution concentrations source: spills	E Cell "skip" sample analysis also referenced in WHC-SD-SQA-CSA-511
C CELL	Sample analysis of E Cell floor used with floor area ratios presuming similar solution concentrations source: spills	E Cell "skip" sample analysis also referenced in WHC-SD-SQA-CSA-511
D CELL	Sample analysis of E Cell floor used with floor area ratios presuming similar solution concentrations source: spills	E cell "skip" sample analysis also referenced in WHC-SD-SQA-CSA-511
E Cell	Sample analysis of E Cell floor solids in "skip." Other E Cell floor areas: used floor area ratios presuming similar solution concentrations source: spills	E cell "skip" sample analysis also referenced in WHC-SD-SQA-CSA-511

BASIS
1/9/97

TABLE 8
SIGNIFICANT PUREX RESIDUAL PLUTONIUM SOURCES

LOCATION	ESTIMATE BASIS	REFERENCES
H CELL	Sample analysis of E Cell floor used with floor area ratios presuming similar solution concentrations source: spills	E Cell "skip" sample analysis also referenced in WHC-SD-SQA-CSA-511
J CELL	Based on L Cell floor sample results and the ratios of Pu concentrations in the 2BP and 2AF	Flowsheet SK-2-23933
J CELL OTHER THAN J5A TANK	Based on L Cell floor sample results and the ratios of 2BP, 1BX, and 1BP stream concentrations	Flowsheet SK-2-23933
F CELL	Based on HA COL separation plutonium concentrations are negl	Flowsheet SK-2-23932
G CELL	Based on IC AND 2B AND 3B COL concentrations plutonium concentrations are negl (org ph)	Flowsheet SK-2-23933

BASIS2
1/9/97

TABLE 9
SIGNIFICANT PUREX RESIDUAL PLUTONIUM SOURCES

LOCATION	ESTIMATE BASIS	REFERENCES
L CELL	Based on samples and analyses from L Cell floor	
K CELL	Plutonium concentrations are negligible as per flowsheet	flowsheet SK-2-23932
M CELL	M Cell operations involve decontamination with floor cleanup. Plutonium concentrations are contamination levels only.	
N CELL	Non-destructive analyses were done with instrumentation (spectroscopy)	WHC-SD-SQA-CSA-511 Deactivated Crit Spec
PR ROOM	Non-destructive analyses were done with instrumentation (spectroscopy)	WHC-SD-SQA-CSA-511 Deactivated Crit Spec

BASIS3
1/9/97

TABLE 10
SIGNIFICANT PUREX RESIDUAL PLUTONIUM SOURCES

LOCATION	ESTIMATE BASIS	REFERENCES
Q CELL	Plutonium concentrations in the Q Cell system are negligible per flowsheet	Flowsheet SK-2-23933
WHITE ROOM	Historical documentation defines the previously determined estimates of the plutonium content	Plutonium Vulnerability Study R.J. Bliss Jun 6, 94
R CELL	Plutonium concentrations are negligible in the R Cell system per flowsheet	Flowsheet SK-2-23932
DEEP BED FILTER #1	Calculations were done by R.L. Walser and R.L. Hobart using filter history, reactor fuel data, 1964 core sample data, and sump analyses	too many moves to find
DEEP BED FILTER #2	SAME AS FILTER #1	too many moves to find
Storage Tunnel #1	Plutonium estimate is published in existing references	Plutonium Vulnerability Document
Storage Tunnel #2	Plutonium estimate is published in existing references	Plutonium Vulnerability Document

BASIS4
1/9/97

APPENDIX D

TABLES 11, 12, 13, 14

BASES FOR SIGNIFICANT FISSION PRODUCT SOURCE
CALCULATIONS

TABLE 11
PRIMARY FISSION PRODUCTS

LOCATION	ESTIMATE BASIS	REFERENCES
A CELL	Fission product concentrations were calculated for 9% 240 mixed fuel rationing Sr90 and Cs137 to uranium typical feed solutions were determined as 4.4Ci and 5.3Ci/tonne respectively. *	SD-CP-TI-077 ORIGEN2 reactor fuel fission product composition
B CELL	SAME	SAME
C CELL	SAME	SAME
D CELL	SAME	SAME
E CELL	SAME	SAME

BASISIA

*Assuming 5 gal of material is dispersed on equipment, walls, cell floors, the resulting curie burdens were calculated for each cell.

TABLE 12
SIGNIFICANT FISSION PRODUCT SOURCES

LOCATION	ESTIMATE BASIS	REFERENCES
H CELL (H1)	SAME AS A, B, C, D, E CELL	SAME AS A, B, C, D, E CELL
J CELL	Using 100 DF on the HA column the second cycle cells should be about 1000x lower in curie burden	SD-CP-TI-077 ORIGEN2 reactor fuel fission product composition
F CELL	Using the flowsheet flow ratio of HAF to IWW i.e. 19 to 4 the fission product concentrations rise by this factor around the final waste concentrator	Flowsheet SK-2-23935
G CELL	The curie ratios should be at least equal to the HA col DF if no accumulations occur. will allow some accumulation in G1 wash vessel, i.e., max 1 order increase	Flowsheet SK-2-23936

BASIS2A
1/10/97

TABLE 13
SIGNIFICANT FISSION PRODUCT SOURCES

LOCATION	ESTIMATE BASIS	REFERENCES
L CELL	Using the HA column DF of at least 1000x the curie burden of this second cycle cell is calculated	flowsheet SK-2-23933
K CELL	SAME AS ABOVE	flowsheet SK-2-23932
M CELL	This is a decontamination area. there could be some fission product accumulation here however since the dose rates are not significant the range of .1 - 1 is quoted.	
N CELL	Third cycle area negligible fission products. only Pu daughters	
PR ROOM	Third cycle area-negligible fission products. only Pu daughters	

BASIS3A
1/10/97

TABLE 14
SIGNIFICANT FISSION PRODUCT SOURCES

LOCATION	ESTIMATE BASIS	REFERENCES
Q CELL	This is a 2nd or 3rd cycle area fission product activity should be negligible here. Only Np daughters involved. Which coincides with the U233 decay chain.	flowsheet SK-2-23934
WHITE ROOM	Negl fission prod	
R CELL	Same as G Cell basis with a lower curie burden	
DEEP BED FILTER #1	Samples are available for the sump liquid from the flood of filter #1 these data were analyzed and presented	memo 17530-93-074
DEEP BED FILTER #2	Filter history data were examined loadings were calculated and are similar to #1	
Storage Tunnel #1	Engineering estimate based on survey value of 100 mr at water filled door (empty)	WEC-SD-EN-ES-003 (DOE-RL-90-24), Appendix A, "Purex Storage Tunnel Dangerous Waste Permit Application", 9/28/90
Storage Tunnel #2	Engineering estimate based on Tunnel #1 as upper bound	Appendix G data

BASIS4A

APPENDIX E

TABLES 15, 16, 17

BASES FOR OTHER PLUTONIUM SOURCE ESTIMATES

TABLE 15
OTHER PLUTONIUM RESIDUAL SOURCES

LOCATION	ESTIMATE BASIS	REFERENCES
M Cell Vault	Low heel in tanks at 1% normal concentration	Flowsheet SK-2-23933
Slug Basin	Samples taken from basin water	
Sample Gallery hoods	Engineering estimate assuming process residuals in sampling equipment	
Sample Gallery Exhaust duct	Survey taken near end of duct Engineering estimate	

BASIS6A

TABLE 16
OTHER PLUTONIUM RESIDUAL SOURCES

LOCATION	ESTIMATE BASIS	REFERENCES
Canyon Vessels (total)	Existing LATA report	"Estimate of Purex Plant Inventory of Chemicals and Radioactivity", Sept 29, 93, LATA
206A Fractionator	Based Plutonium Concentrations on Flowsheet IWW IE6 DF assumed in tower	Flowsheet SK-2-23935
293A Backup facility	Based on process knowledge of main stack operation. typical main stack 1E-14 uCi/cc	Annual plots of main stack alpha concentrations.
TK 216-A2	Based on Process knowledge of main filter drain solutions	memo to file 17530-93-074, "A Brief History of the Purex #1 Ventilation Filter Flooding Problem with Analysis of Liquids Taken From the Sump" R.L. Hobart

BASIS7A

TABLE 17
OTHER PLUTONIUM RESIDUAL SOURCES

LOCATION	ESTIMATE BASIS	REFERENCES
TK V11-1 #2 filt catch	Engineering estimate based on process samples	P3472 1/19/96
Laboratory Hoods	Engineering estimate based on hood surveys (later)	
Laboratory Utility pipe chase	Engineering estimate based on limited floor survey data and on process knowledge of lab	

BASIS8A

APPENDIX F

TABLES 18, 19, 20

BASES FOR OTHER FISSION PRODUCT SOURCE ESTIMATES

TABLE 18
OTHER FISSION PRODUCT SOURCES

LOCATION	ESTIMATE BASIS	REFERENCES
M CELL Vault	Engineering estimate based on process knowledge	Flowsheet SK-2-23933
Slug Storage Basin	Solution phase sample data are available. No analyses available on solid phase	Sample Data available from M. Enghusen
Sample Gallery Hoods	Engineering estimate based on survey data (later)	
Sample Gallery Exhaust Duct	Engineering estimate based on survey data 216698 10/96	

BASIS6B

TABLE 19
OTHER FISSION PRODUCT SOURCES

LOCATION	ESTIMATE BASIS	REFERENCES
Canyon Vessels (total)	Based on the residuals posted in the LATA document	"Estimate of Purex Plant Inventory of Chemicals and Radioactivity", Sept.29,1993, LATA
206A Fractionator	Engineering estimate based on general area radiation fields	
TK 216-A2 Catch tank (filt#1)	Engineering estimate based on process sample data	MEMO 17530-93-074
TK-VII-1(filt #2)	Engineering estimate based on process sample data	P 3472 1/19/96

BASIS7B

TABLE 20
OTHER FISSION PRODUCT SOURCES

LOCATION	ESTIMATE BASIS	REFERENCES
Laboratory Hoods	Engineering estimate based on radiation levels	
Laboratory Utility pipe chase	Engineering estimate based on limited survey data	

BASIS8B

APPENDIX G

STORAGE TUNNEL #2 INPUT MATERIAL LIST FROM 324 BUILDING

324 BUILDING WASTE

Shipment #	Date Received	Package ID #	Gross Weight Kg (lbs)	Container Type	Waste Description
1	12-20-95	BP 195046	714 (1574)	SEG	Mild steel grout container, vacuum cleaner, steel disc; Paper HEPA filter media
2	1-3-96	BP 195047	982 (2165)	SEG	Mild steel grout container; Stainless steel shield plug; Paper HEPA filter media
3	1-10-96	BP 195048	865 (1907)	SEG	Mild steel grout container, cover plate, wire mesh; Stainless steel offgas jumper; Paper HEPA filter media
4	1-16-96	BP 195049	1232 (2716)	SEG	Mild steel grout container, cover plate, screens; Stainless steel electrode; Paper HEPA filter media
5	1-22-96	PNL-324-96-004	2523 (5562)	SEG	Mild steel grout container, 5-gallon bucket; Wood; Liquid metal seal solid flange; Lead shot, bricks; Window oil rags
6	1-31-96	BP 195050	797 (1757)	SEG	Mild steel grout container, steel plate; Paper HEPA filter media
7	3-1-96	PNL-324-96-012	2253 (4967)	22.5 Ton	Stainless steel engineered containers of hazardous and nonhazardous dispersible debris, special case waste container
8	3-6-96	PNL-324-96-005	1823 (4019)	22.5 Ton	Stainless steel engineered dispersible containers, can storage basket, hazardous feed cans
Total			11,189 (24,667)		

Shipments 1-8 moved to storage in tunnel #2, position 24, on April 26, 1996

324 BUILDING WASTE

Shipment #	Dose Rate @ Contact	Curie Content	Activation Nuclides	Pu Content (g)	Dangerous Waste	Waste Category/Classification
1	120 Rem	5.41E+02	Cs-137 2.34E+02 Sr-90 3.65E+01	1.07E-02	N/A	Cat 3/TRU
2	1000 Rem	3.96E+02	Cs-137 8.80E+01 Sr-90 1.10E+02 Cs-134 1.00E-02 Co-60 1.00E-02 Eu-154 2.00E-02 Eu-155 2.00E-02	1.41E-01	N/A	Cat 3/TRU
3	1000 Rem	2.36E+03	Cs-137 5.25E+02 Sr-90 6.56E+02 Cs-134 4.00E-02 Co-60 5.00E-02 Eu-154 7.00E-02 Eu-155 3.00E-02	2.24E-01	N/A	Cat 3/TRU
4	1700 Rem	2.49E+03	Cs-137 5.54E+02 Sr-90 6.92E+02 Cs-134 5.50E-02 Co-60 7.40E-02 Eu-154 9.80E-02 Eu-155 3.30E-02	3.00E-01	N/A	Cat 3/TRU
5	340 R/Hr	9.00E+02	Cs-137 2.00E+02 Sr-90 2.50E+02	0.00	Pb ~ 1590 Kg Cd ~ 0.5 Kg Oil ~ 40 g	Cat 3/MW
6	200 Rem	2.84E+02	Cs-137 1.03E+02 Sr-90 3.90E+01 Cs-134 9.70E-02 Co-60 1.30E-01 Eu-154 1.70E-01 Eu-155 2.70E-02	7.75E-01	N/A	Cat 3/TRU
7	19K R/Hr	3.12E+04	Cs-137 1.00E+04 Sr-90 5.58E+03 Co-60 1.08E-01 Eu-154 6.56E+00	8.52E+00	Pb ~ 82 g Cr ~ 5.4 g Cd ~ 2.4 g	>Cat 3/TRU-M
8	22K R/Hr	2.05E+05	Cs-137 5.96E+04 Sr-90 4.32E+04 Eu-154 2.05E+00	1.40E+01	Pb ~ 3.2 Kg Cr ~ 2.3 Kg Ba ~ 5.6 Kg	>Cat 3/TRU-M
Total		~244,000 Ci		~24 g	Pb ~ 1593 Kg Cd ~ 0.5 Kg Oil ~ 40 g Cr ~ 2.3 Kg Ba ~ 5.6 Kg	

Shipments 1-8 moved to storage in tunnel #2, position 24, on April 26, 1996

324 BUILDING WASTE

Shipment #	Date Received	Package ID #	Gross Weight Kg (lbs)	Container Type	Waste Description
9	4-1-96	BP196003	2482 (5472)	SEG	stainless steel grout container, engineered containers; refractory used in melter operations
10	4-28-96	BP196001	1778 (3920)	SEG	Stainless steel grout container; refractory used in melter operations
11	5-2-96	BP196002	2800 (6173)	SEG	Mild steel grout container; refractory brick/throat block refractory used in melter operations
12	5-7-96	PNLD-96-224	3332 (7346)	SEG	Mild steel grout container; stainless steel melter lid; Atrax/Duraboard; grout
13	5-10-96	PNLD-96-225	2200 (4850)	SEG	Mild steel grout container; rubber hose; plastic; cloth; stainless steel; glass
14	5-23-96	BP196015	1115 (2458)	SEG	Mild steel grout container, funnel; glass
15	5-31-96	PNL-324-96-048	1550 (3417)	SEG	Mild steel grout container; stainless steel melter parts; paper HEPA filter media; SrF ₂ capsules
16	6-3-96	BP196017	2818 (6213)	SEG	Mild steel grout container; melter glass canisters
17	6-8-96	BP196018	2818 (6213)	SEG	Mild steel grout container; melter glass canisters
Total			20,893 (46,062)		

Shipments 9-17 moved to storage in tunnel #2, position 25, on June 12, 1996

324 BUILDING WASTE

Shipment #	Dose Rate @ Contact	Curie Content	Activation Nuclides	Pu Content (g)	Dangerous Waste	Waste Category/Classification
9	6159 R/Hr	3.54E+04	Cs-137 1.49E+04 Sr-90 2.79E+03	8.68E-02	N/A	>Cat 3/TRU
10	9550 R/Hr	3.90E+04	Cs-137 1.63E+04 Sr-90 3.22E+03	9.44E-02	N/A	>Cat 3/TRU
11	18372 R/Hr	7.35E+04	Cs-137 3.07E+04 Sr-90 6.07E+03	1.78E-01	N/A	>Cat 3/TRU
12	8169 R/Hr	1.99E+05	Cs-137 4.43E+04 Sr-90 5.53E+04	0.00	N/A	>Cat 3/LLW
13	1340 R/Hr	1.57E+05	Cs-137 3.48E+04 Sr-90 4.35E+04	0.00	N/A	>Cat 3/LLW
14	22K+ R/Hr	7.62E+05	Cs-137 2.71E+05 Sr-90 1.10E+05	1.75E+00	N/A	>Cat 3/TRU
15	4000 R/Hr	1.16E+05	Cs-137 1.52E+04 Sr-90 4.30E+04	1.00E+00	Ba ~ 4.2 g Cd ~ 1 g Cr ~ 1.8 g Pb ~ 1 g	>Cat 3/MW
16	20K+ R/Hr	2.56E+05	Cs-137 9.74E+04 Sr-90 3.08E+04	2.26E+01	N/A	>Cat 3/LLW
17	20K+ R/Hr	1.07E+05	Cs-137 3.94E+04 Sr-90 1.41E+04	1.69E+01	N/A	>Cat 3/LLW
Total		~1.75M Ci		~43.0 g	Ba ~ 4.2 g Cd ~ 1 g Cr ~ 1.8 g Pb ~ 1 g	

Shipments 9-17 moved to storage in tunnel #2, position 25, on June 12, 1996

PUREX STORAGE TUNNEL #2

	Existing Inventory Tunnel #2 Positions 1-23	324 Building Shipments 1-8 Tunnel #2 Position 24	324 Building Shipments 9-17 Tunnel #2 Position 25	Liquid Waste Tank Cars Tunnel #2 Positions 26-28	Total in Storage Tunnel #2 June 1996
Estimated Total Source Term	~729,000 Ci	~244,000 Ci	~1.75M Ci	~38 Ci	~2.73M Ci
Estimated Total Plutonium Content	~500 g	~24 g	~43 g	~195 g	~762 g
Estimated Total Dangerous Waste	Pb ~ 7932 Kg Ag ~ 740 Kg Hg ~ 130 Kg Cd ~ 58 Kg Cr ~ 8 Kg	Pb ~ 1593 Kg Cd ~ 1 Kg Cr ~ 3 Kg Ba ~ 6 Kg Oil ~ 40 g	Pb ~ 1 g Cd ~ 1 g Cr ~ 2 g Ba ~ 2 g	N/A	Pb ~ 9525 Kg Ag ~ 740 Kg Hg ~ 130 Kg Cd ~ 59 Kg Cr ~ 11 Kg Ba ~ 6 Kg Oil ~ 40 g

APPENDIX H

AMERICIUM-241 ACCUMULATION

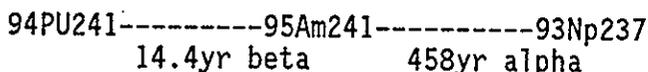
BASIS:

The total plutonium value of approx 10 kg was used to calculate the amount of Americium 241. The input data consisted of reactor yield data from the "ORIGEN2" code referenced in the report. The standard chain decay equation was used referenced in Glasstone "Nuclear Reactor Engineering" 6% Pu240 is used in the calculation. The "ORIGEN2" code predicts 5.06gm Pu241 and 62.4gm Pu240. This can be used as ratio calculate the Pu241 content of the plant. Decay times for the Pu241 will vary from 1955 to present. Much of the plutonium holdup in the processing hoods is probably in the 10yr decay range whereas the headend areas of the canyon are closer to the 20yr value because the leakage solutions have soaked into the concrete.

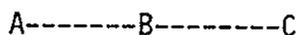
AMERICIUM 241 TOTAL = 15 TO 30 GRAMS depending on assumptions made.

Calculations are included in this Appendix:

AMERICIUM 241 CALCULATIONS FOR PUREX FACILITY
1/28/97 RLH



for chain decay the solution is



$$\begin{aligned}
 N_B = & \frac{(\lambda_B)(N_{A0})}{(\lambda_B - \lambda_A)} \{ \text{EXP}(-\lambda_A t) - \text{EXP}(-\lambda_B t) \} \\
 & + N_{B0} \text{EXP}(-\lambda_B t) \quad (\text{second term})
 \end{aligned}$$

N_{B0} is initially zero therefore toss second term

$$N_{A0} = (\text{Mass}_{A0})(\text{Avog No.})/(\text{Atom Wt})$$

will calculate N_B/N_{A0} to eliminate Avog No calculations

$$\lambda_A (\text{Pu241}) = \text{Ln}2/(14.4\text{yr}) = 0.0481 \text{ yr}^{-1}$$

$$\lambda_B (\text{Am241}) = \text{Ln}2/(458\text{yr}) = 0.00151 \text{ yr}^{-1}$$

for 10yr decay:

$$N_B/N_{A0} = \frac{0.0481}{(0.00151 - 0.0481)} \{ \text{EXP}(-.0481 \times 10) - \text{EXP}(-.00151 \times 10) \}$$

$$N_B/N_{A0} = (-1.032)(0.6181 - 0.9850) = 0.378$$

for 20 yr decay:

$$N_B/N_{A0} = \frac{0.0481}{(0.00151 - 0.0481)} \{ \text{EXP}(-.0481 \times 20) - \text{EXP}(0.00151 \times 20) \}$$

$$N_B/N_{A0} = (-1.032) (0.3821 - 0.9702) = (-1.032)(-0.5881) = 0.6069$$

If total plutonium = 10kG
using 6% Pu240 as the bulk of the feed stock

then Pu240 = 600gm

the ratio of Pu241/Pu240 from "ORIGEN2" REACTOR CODE = 5.06/62.4
both of these numbers are gm/TONNE U

therefore Pu241 = (5.06)(600)/(62.4) = 48.6 gm

for 10 yr decay:

$$\text{Am241} = (48)(N_B)/N_{A0} = 48 (.378) = 18 \text{ gm}$$

for 20 yr decay:

$$\text{Am241} = (48)(N_B)/N_{A0} = 48 (.60) = 28 \text{ gm}$$

In N Cell, PR Room and L Cell the age of the Pu is approx 10 yrs.

In other parts of the canyon the age is likely 20 yrs or more, i.e., plutonium soaked into the concrete.

Plutonium in N Cell, PR Room and L Cell = approx 3 kG.

Plutonium in remainder of canyon and tunnels = approx 6 kG.

Plutonium in N Cell, PR Room, L Cell will then generate -----6gm Am241
at 10 yr decay

Plutonium in remainder of canyon will then generate-----18gm Am241
at 20 yr decay

APPENDIX I

SLUG BASIN COVERWATER SAMPLE DATA

SAMPLE DATE	WATER HEIGHT/VOL	CESIUM-137*	URANIUM*	pH
5/5/93	103"/35,900 gal	16.2 uCi/L	0.003 GM/L	8.43
1/26/94	85.5"/29,600	21.3uCi/L	0.0007 GM/L	8.26
3/6/95	68"/23,500	23.5uCi/L	0.0039 gm/L	8.49

*--concentration by evaporation occurred.

"PUREFERC.JAN"

APPENDIX J

Memo, 17530-93-074, "A Brief History of the PUREX #1 Ventilation Filter Flooding Problem with Analysis of Liquids Taken From the Sump," R. L. Hobart, 1991

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HNF-2545, Rev. 0
CORRESPONDENCE DISTRIBUTION COVERSHEET

Author

Addressee

Correspondence No.

R. L. Hobart
R. L. Hobart

Memo To File

17530-93-074

Subject: A BRIEF HISTORY OF THE PUREX #1 VENTILATION FILTER FLOODING PROBLEM
WITH ANALYSES OF THE LIQUIDS TAKEN FROM THE SUMP.

INTERNAL DISTRIBUTION

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		L. F. Perkins	S6-15	
		C. D. Wollam <i>(CDW)</i>	S6-19	

RLH File E17.2/LB

A BRIEF HISTORY OF THE PUREX #1 VENTILATION FILTER FLOODING PROBLEM WITH ANALYSES OF THE LIQUIDS TAKEN FROM THE SUMP

SUMMARY

A line break in the 293-A Facility caused flooding in the PUREX exhaust ventilation system in January 1991. The flooded area included the #1 (deepbed) ventilation filter and the duct between the #4 high-efficiency particulate air filters and the exhaust fans (see Figure 1). The #1 ventilation filter was partially submerged, which blocked airflow through the filter. Approximately 57,000 gallons of wastewater were removed from the filter during January and February 1991, which restored airflow through the filter. The drying of the duct between the #4 filter building and the exhaust fans caused release of americium 241 and beta activity via the stack. The exhaust duct was partially cleaned in December 1991 to reduce the activity release. A vendor was contacted to purify the sump water during mid 1991, with legal and technical preparations for water processing spanning 1991 and 1992. Subsequent sampling, late in 1992, identified that some of the sump water was probably leaking from the underground filter building (see Occurrence Report, RL-WHC-PUREX-1992-0099). WHC management was notified and decided to transfer the remaining water to underground storage (UGS) immediately (September 1992). In October 1992, the filter floor was rinsed to reduce release of residual activity.

Radioactive contamination data indicate only approximately 20 percent (four curies each) of the cesium 137 and strontium 89/90 was recovered from the filter sump and sent to underground storage. The balance of contamination, estimated to be approximately 16 curies each of cesium and strontium, is assumed to have leaked to the ground between January 1991 and September 1992. Americium 241 recovery is unknown due to solubility changes. Ammonium ion data imply eight percent recovery.

Gaseous releases were elevated in early 1991, shortly after the line break and flood, and in late 1991 during cleanup efforts. Enough americium was released to exceed the 1991 administrative limit of 2.0×10^{-13} $\mu\text{Ci/ml}$ (annual average) by 0.6×10^{-13} $\mu\text{Ci/ml}$.

HISTORY

At 0100 hours, on January 13, 1991, standing water was observed over a large area (200 by 100 feet) on the south side of the PUREX Facility. The source of the water was a failed 6-inch raw water supply pipe, that had completely flooded the basement of 293-A Building and overflowed to the surrounding area. Water also flowed from the Building 293-A into the 216-A-TK-2 catch tank and into the canyon ventilation system, including the deep bed fiberglass filter #1 enclosure (see Figure 1). The differential pressure (DP) of filter #1 appeared to have exceeded 8 inches water column. The apparent DP condition was caused by water covering the instrument sensing lines in the filter. Note, filter #2 was not affected because it is not connected to tank 216-A-TK-2.

Raw water entered the #1 ventilation filter sump area and accumulated in the filter building partially submerging the deep bed primary filter and the secondary pocket filter elements. Table 1 shows some of the elevations on the the filter equipment. It appears that the flood water submerged at least 2 feet of both primary and secondary filter media. This conclusion is based upon the disposal of 57,000 gallons to UGS during January 1991 and February 1991 to reestablish air flow through the #1 filter. During that time, water was in contact with the glass media and leached soluble radionuclides from the filter. On February 17-18, airflow was re-established in the #1 filter when the water level dropped below the wall separating the primary and secondary filter stages (elevation 695 feet). These initial water level reductions were accomplished by transferring water to underground storage. As a result of the liquid contact with the fiberglass media, significant quantities of cesium 137, strontium 89/90, americium 241 and ammonium nitrate were released to the water.

The filter sump water level fell gradually to about eight inches during the remaining part of 1991. It was presumed to be due to air evaporation until later analyses indicated otherwise. The level rose abruptly to approximately two feet in March 1992 due to a defective fill valve on the main stack vacuum pump system that overflows to the 216-A-2 sump tank (see Figure 2). The additional raw water caused a dilution of the impurities in the filter sump water.

Contamination was transported to the exhaust duct between the #4 filter building and the exhaust fan suction plenum by reverse flow of water through a three-inch drain line connected to tank 216-A-TK-2 (see Figure 1). The exhaust duct was cleaned during December 1991. Operations personnel entered the exhaust fan plenum and used mops/brooms to remove the loose contamination on the floor and lower wall surfaces.

PUREX personnel concluded, in the fall of 1992, that the sump water was leaking from the #1 ventilation filter building structure, using the analyses of the filter sump water. This was based on material balance data taken early in 1991 and compared with data accumulated late in September 1992. Efforts to obtain samples of the filter sump liquid during late 1991 and early 1992 were delayed by higher (at the time) work priorities which prevented obtaining reliable samples earlier than mid 1992. The gradual reduction in level that occurred during 1991 and 1992 was presumed to be due to air evaporation at an approximate rate of 500 cc/minute. Calculations indicated this evaporation rate was within the range expected for the conditions of air flow and humidity in the filter housing. When the leak was recognized, WHC management decided to remove the remaining water from the sump as quickly as possible. Occurrence Report, RL-WHC-PUREX-1992-0099, was issued and proper notifications were made to WHC management, WHC Environmental Protection, and DOE on September 23, 1992. The transfers to UGS via (TK-U3) were started September 26, 1992, and finished on September 28, 1992. The effluents were analyzed for impurities to assess the liquid losses from the filter building. The following relates the analytical data and material balances generated by that effort.

ANALYTICAL DATA AND MATERIAL BALANCE DISCUSSION

Filter sump liquid was jetted from the #1 filter building until the level was below the primary fiberglass bed and the separation wall between the primary and secondary filter on February 17-18, 1991. At this level (three feet) the volume was estimated at $3(28,000 \text{ gal/ft}) = 84,000$ gallons (see Figure 1). In addition to the 84,000 gallons under the filter, the 216-A-TK-2 sump tank and piping contains another 3,000 gallons. Average analytical data and material balance information are given in Table 2. These data are based on a wide range of samples taken during 1991 and 1992 from tank U3, 216-A-TK-2 and the filter riser pipe.

The lower strontium concentration is an analytical result and the higher value an estimate derived by calculation. Solution analyses taken during the transfer of the filter sump liquid to UGS supports the lower value. Plutonium values were low, i.e., one order below the americium concentrations. The americium concentrations imply that mobility is solubility controlled. Uranium concentrations were typically 1 part per million (ppm).

LIQUID REMOVED FROM THE #1 FILTER SUMP DURING SEPTEMBER 1992

Table 3 gives summary data of liquid removed from the filter during the latter part of September 1992. Impurity quantities are summed at the end of Table 3 and are summarized in Table 5. All of the data are from the tank TK-U3 samples taken during September 1992 liquid removal action. The actual concentrations in the filter sump could not be analyzed until the 216-A-2 tank and connecting piping were purged.

#1 FILTER BUILDING FLOOR SUMP RINSE ACTION

During mid to late October 1992, operations personnel performed a rinse of the filter building floor using work plan WP-P-92-056. The method involved transferring slightly contaminated water from the basement of 293-A Backup Facility to 216-A-TK-2, which back flowed onto the filter building floor. After the water soaked for two days, the rinse solution was removed by jetting the 216-A-TK-2 sump tank to tank U3 in batches. The solution analyses and material balance for the rinse solutions are given in Table 4. Impurity quantities are summed in Table 4A. Americium was still being removed from the sump floor.

UNEXPLAINED OBSERVATIONS

The pH of the rinse solutions was low at two and the strontium to cesium ratio is different than the original solution. Strontium to cesium is about 1:1 in the original sump water, whereas in the rinse it is about 1.5:1. Substantial americium 241 could remain in the sump. No explanation for these observations is offered.

RADIONUCLIDE AND INORGANIC IMPURITY MATERIAL BALANCE SUMMARY

Table 5 summarizes the radionuclide and ammonium nitrate material balances present initially and during the liquid removal steps. Approximately 20 percent of the original cesium and strontium nuclides were removed from the filter sump, the remainder is assumed to have leaked from the #1 filter sump system. Americium 241 material balancing is less accurate because of the solubility of the americium, and because of the limited analytical data. Ammonium nitrate data are also very limited. There are large potential errors with the ammonium data because some of the values were less-than-values, and because of very limited initial data.

MAIN STACK ACTIVITY VARIATIONS DURING THE REPORT PERIOD

The main stack activity rose significantly when some of the contaminated water was removed from the ventilation duct and from the #1 filter sump area. After the liquid was removed (February 1991) from the exhaust duct, the surfaces dried and the deposited/dissolved nuclides became airborne (see Figures 3, 4, 5, 6, February 1991). Whenever the stack flows were increased, the activity levels increased, due to larger air velocities through the affected zones (see Figures 7 & 8, March/April 1991 and 1992). When the exhaust duct cleaning was performed during December 1991, activities rose due to the surfaces being disturbed (see Figures 3, 4, 5, 6). Activity fell after the duct cleanup and remained stable during 1992 and 1993. Two Stack flushes were performed during March 1991 and July 1991. It appears the activity rose following the March flush.

Main stack activity remained stable following the #1 filter sump liquid removal in September 1992. No significant rise in survey data for the #4 filter building Health Physics Technicians survey points was noted following the sump liquid removal. This would tend to support the fact that the activity was sufficiently removed from the #1 filter sump and/or the secondary (deepbed) filters are functioning.

CONCLUSION

It is believed that 53,000 gallons of water leaked to the soil over a 21 month period from January 1991 to September 1992. This water contained an estimated 16 curies each of cesium and strontium and 1200 kilograms of ammonium nitrate.

An additional 66,000 gallons are estimated to have evaporated via the main stack. Americium and beta radioactivities in the mainstack offgas were elevated when the air duct dried (February and March 1991), when the air flowrate was raised (April 1991), and during duct cleaning (December 1992).

The balance of water, 78,000 gallons, and radionuclides were sent to underground storage.

Lessons learned: Unusual conditions, such as water in abnormal places should be corrected as quickly as possible even when there are no apparent problems.

TABLE 1

FILTER BUILDING ELEVATION DATA

#1 ventilation building structure	692' floor elevation, 706' top elevation
Primary filter bed range	695' elevation to 702' elevation
Pocket secondary filters	695' elevation to 698' elevation

TABLE 2

INITIAL #1 VENTILATION FILTER SUMP IMPURITIES

	<u>CONCENTRATION</u>	<u>TOTAL</u>
Americium 241	.65uCi/L	210,000 uCi
Ammonium nitrate	0.05 Molar	1300 Kg
Cesium 137	65uCi/L	21 Ci
pH	Acidic	
Strontium 89/90	*60 to **120uCi/L	20 to 40 Ci

* Analytical result

** Expected value based on cesium - 137 concentration

TABLE 3

#1 VENTILATION FILTER SUMP LIQUID TRANSFERS TO UGS
TANK U3 WASTE TRANSFER INVENTORY CALCULATIONS

ANALYSES	BATCH 92-9-1	BATCH 92-9-2	BATCH 92-9-3	BATCH 92-9-4
Sample S/N	789/790	796/797	804/805	808/809
Date/Time	9/26/92 0600	9/27/92 0045	9/27/92 1900	9/28/92 1847
VOLUME-LITERS	19444	21963	19974	15742
Americium 241 uCi	13610 min estimate	37337	59920	67690
Americium 241 uCi/L	0.7 estimate	1.7	3	4
Ammonium Gm Mols	174	483	439 estimate	346 estimate
Ammonium Molarity	0.009	0.022	0.1 estimate	0.2 estimate
Cesium 137 Ci	0.37	1.23	1.22	1.09
Cesium 137 uCi/L	19	56	61	69
pH	2.1	7.6	7.2	7.3
Plutonium Gm/L	7.93E-7 1.32E-6	1.28E-6 2.0E-6	1.59E-6 1.21E-6	1.17E-6 1.21E-6
Strontium 89/90 Ci	0.388	1.186	1.16	1.1 estimate
Strontium 89/90 uCi/L	20	54	58	55 estimate
Uranium Gm/L	7.27E-3 6.99E-3	5.59E-4 7.41E-4	1.56E-3 1.55E-3	3.59E-4 2.86E-4

SUMMARY TOTALS3.9 Ci
Cesium 1373.8 Ci
Strontium 89/900.178K Ci
Americium 2411442 Gm Mols
or 113 Kg
Ammonium Nitrate

TABLE 4
#1 VENTILATION FILTER RINSE DATA

ANALYSES	FIRST RINSE	FIRST RINSE	SECOND RINSE	POST RINSE
Sample S/N	P846	P847	P865	P900
Date/Time	10/26/92 1544	10/26/92 1545	11/4/92 0828	12/1/92 2339
BATCH NUMBER	92-10-1	92-10-1	92-11-1	92-12-1
VOLUME-LITERS	20317	21950	21196	19973
Americium 241 uCi	14628	12941	21750 estimate	3300
Americium 241 uCi/L	0.72	0.637	0.15 Am/Cs estimate	0.165
Ammonium ion Molarity	<0.003	<0.003		0.003
Ammonium Nitrate Kg	<1.1			
Caustic ratio Lb/G	<0.025	<0.025	0.114	
Cesium 137 Ci	0.091	0.091	0.145	0.085
Cesium 137 uCi/L	4.5	4.5	6.85	4.28
Chloride, Kg				
Chloride, ppm	13.1	12.6		
Nitrate, Kg	13.5			
Nitrate, ppm	668	651		
pH	2	2	3	
Phosphate, Kg	6.09			
Phosphate, ppm	300	296		
Plutonium Gm/L	5.6E-6	5.47E-6	1.77E-6	4.0E-6
Strontium 89/90 Ci	0.132	0.138	0.217	0.128
Strontium 89/90 uCi/L	6.5	6.84		
Sulfate, Kg	1.43			
Sulfate, ppm	70.5	67.9		
Uranium Gm/L	0.01	0.012	0.00019	0.0044

TABLE 4A

RINSE TOTAL MAJOR IMPURITY AND NUCLIDE SUMS

Americium 241-----	38,000 uCi estimate
Cesium 137----	0.24Ci
Plutonium-----	0.15 Gm
Strontium 89/90-----	0.351Ci
Uranium total----	245 Gm

Ammonium ion----	<2 Kg
Nitrate ion----	25 Kg estimate
Phosphate ion----	12 Kg estimate

TABLE 5

SUMMARY TABLE OF MATERIAL BALANCE INFORMATION

	INITIAL COND	REMOVED	RINSE
Americium 241	215K uCi	175K uCi	40k uCi
Ammonium Nitrate	1300 Kg	113 Kg	<2 Kg
Cesium 137	21 Ci	3.9	0.24
pH	Acidic	Acidic	Acidic
Strontium 89/90	20 to 40 Ci	3.8	0.35

291A
STACK

291-AE
(4TH FILTER BLDG)

FANS
(4)

10 HEPA FILTER HOUSINGS

FAN EXHAUST
PLENUM

FAN INLET
PLENUM

ESTIMATED HIGH
WATER MARK

ESTIMATED HIGH
WATER MARK

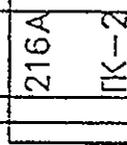
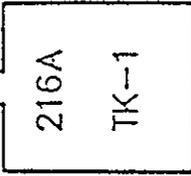
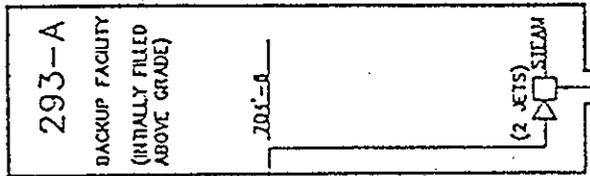
PRE
FILTER

POST
FILTER

ESTIMATED MAXIMUM WATER
VOLUME: 130,000 GAL.

FROM
202A

NOTE: #2 DEEP BED FILTER
NOT FLOODED.



GRADE 708'-0'

CAPPED

699'-0'

690'-0'

695'-0'

8'-0' DUCT

697'-0'

697'-0'

691'-0'

708'-0'

703'

698'

693'

688'

683'

PUREX

1991 FLOOD
HYDRAULIC

SCALE: 3/8"=1'-0"

S.W. WATTS

FIGURE 1
#1 VENTILATION FILTER SYSTEM HYDRAULIC DIAGRAM

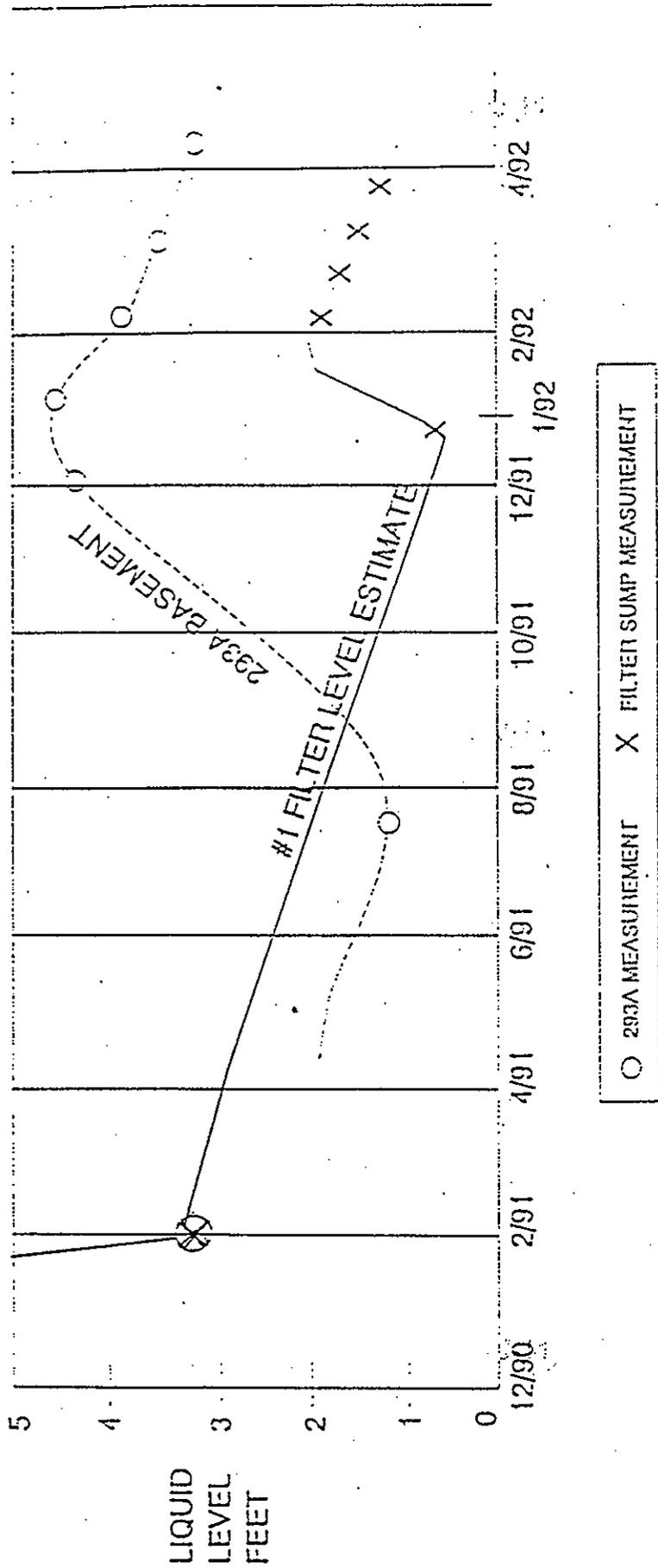


FIGURE 2
#1 VENTILATION FILTER SUMP LEVEL HISTORY

PUREX Main Stack

1991 Alpha Emissions

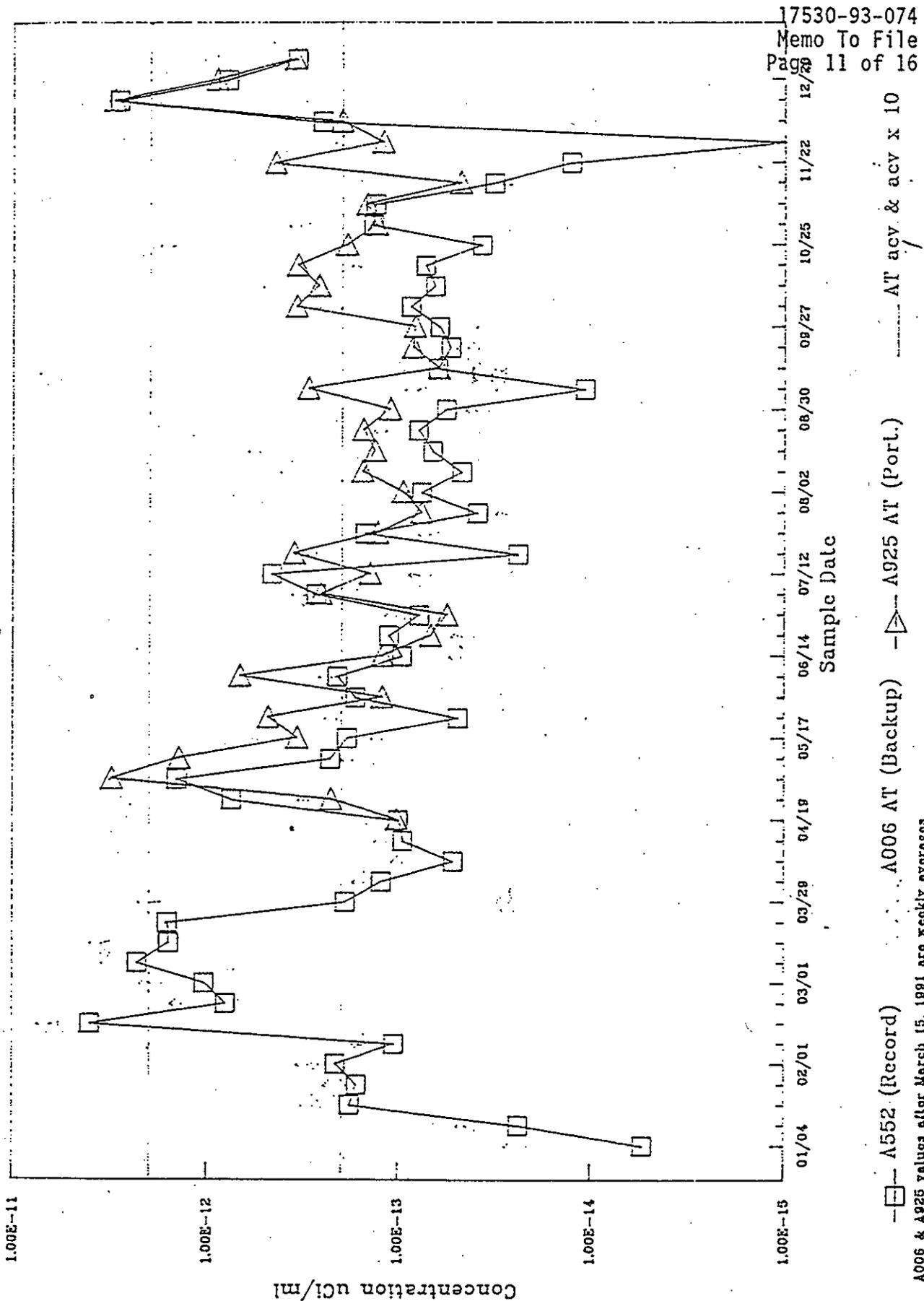
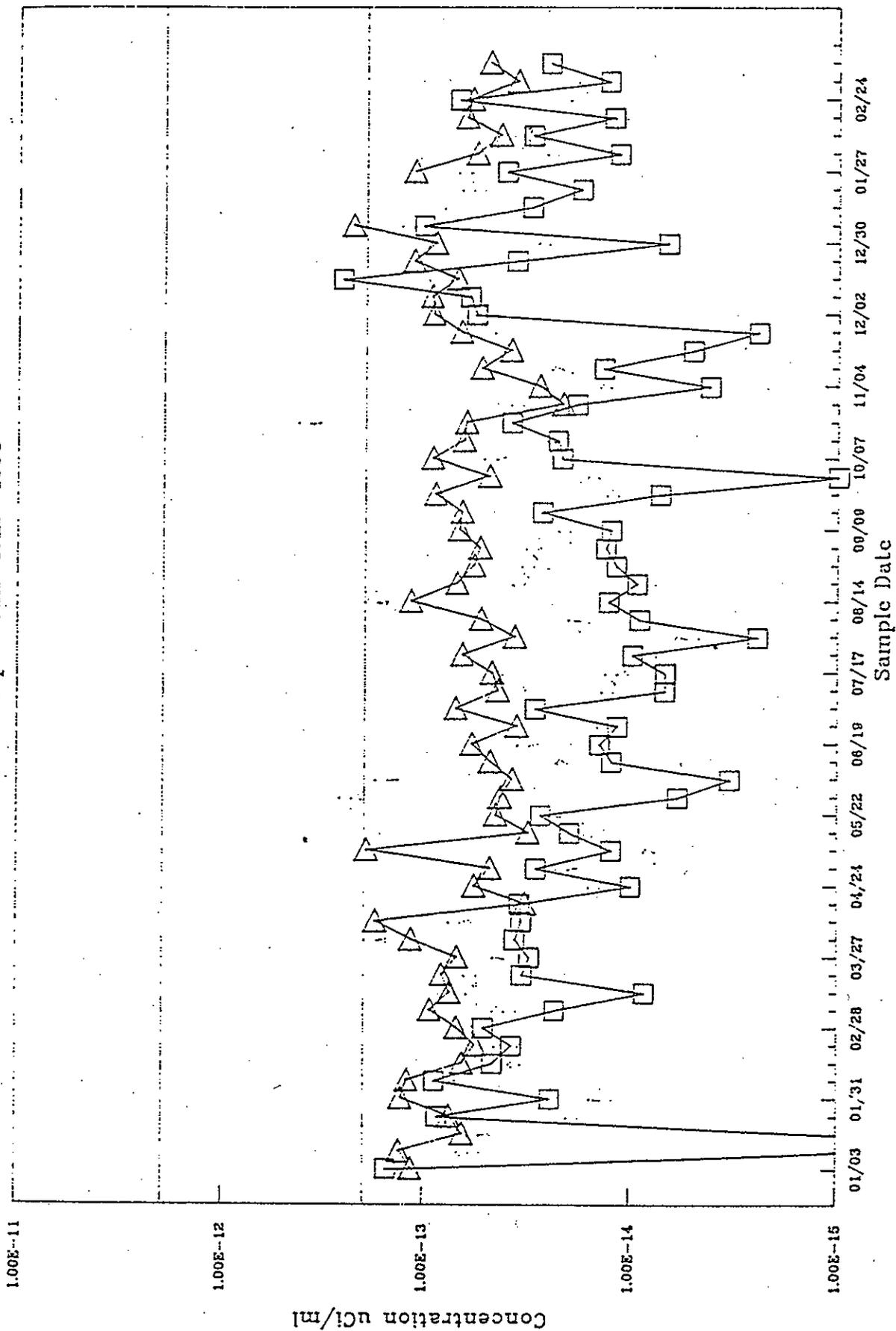


FIGURE 3

PUREX Main Stack

1992 Alpha Emissions 1993

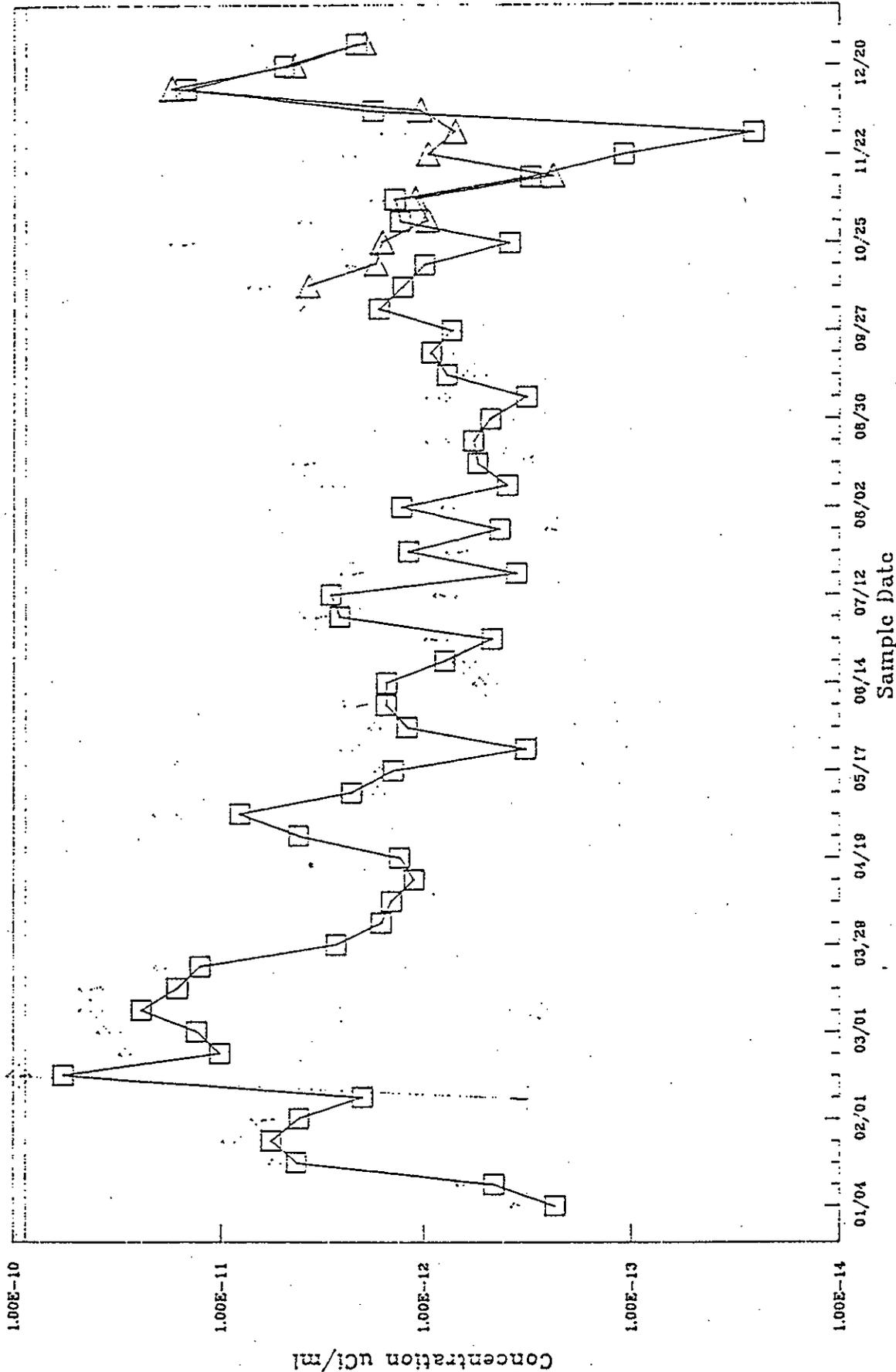


□ A552 (Record) ▲ A925 AT (Port.) AT acv & acv x 10

FIGURE 4

PUREX Main Stack

1991 Beta Emissions



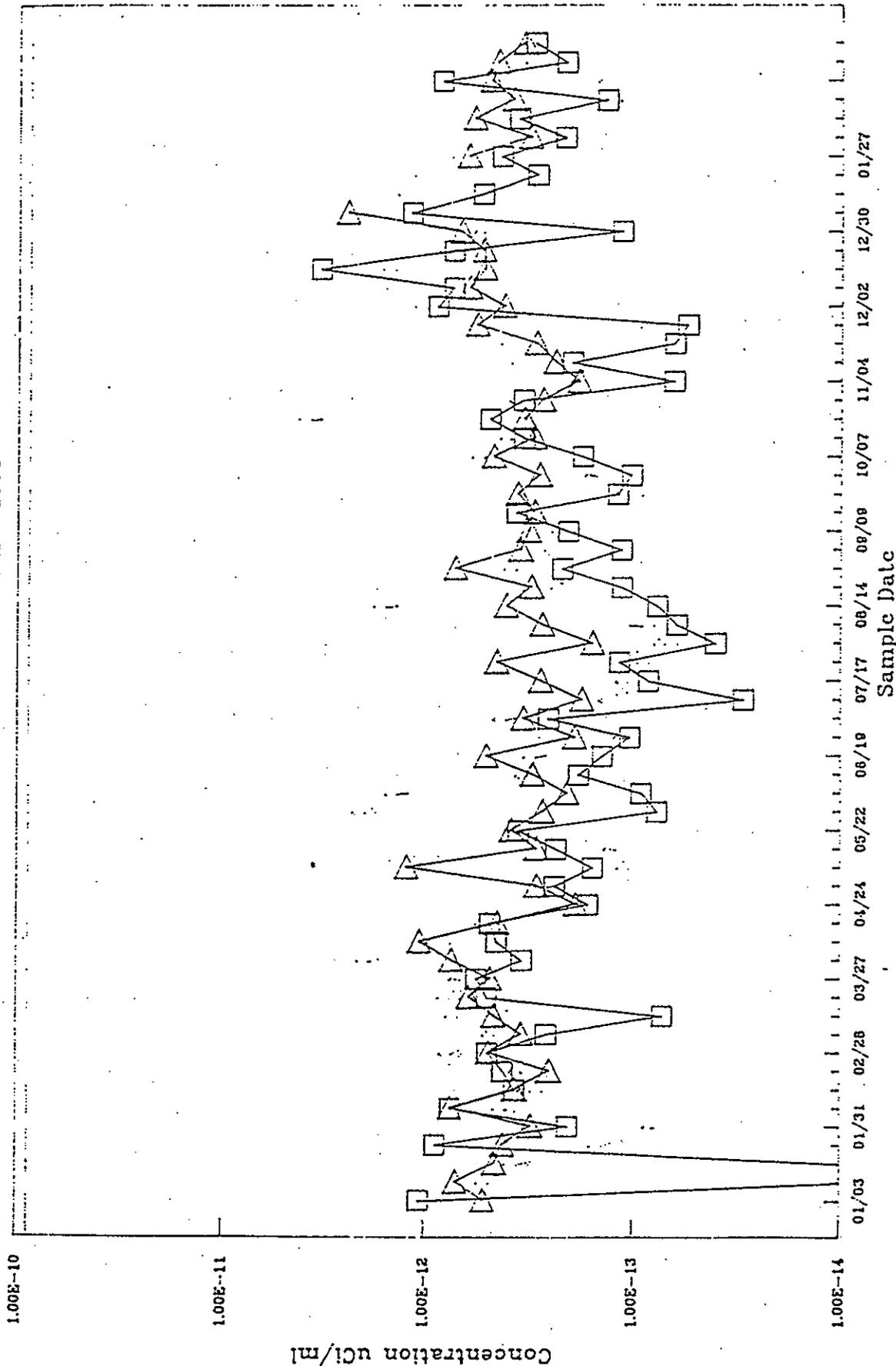
—□— A552 (Record) A006 (Backup) —△— A925 (Port.) T13 acv & acv x 10

A006 & A925 values after March 15, 1991 are weekly averages

FIGURE 5

PUREX Main Stack

1992 Beta Emissions 1993



---□--- A552 (Record) -△- A006 (Backup) ○..... A925 (Port.) -◇- TB acv & acv x 10

A006 & A925 values are weekly averages

FIGURE 6

PUREX Main Stack

1991 Stack Flow

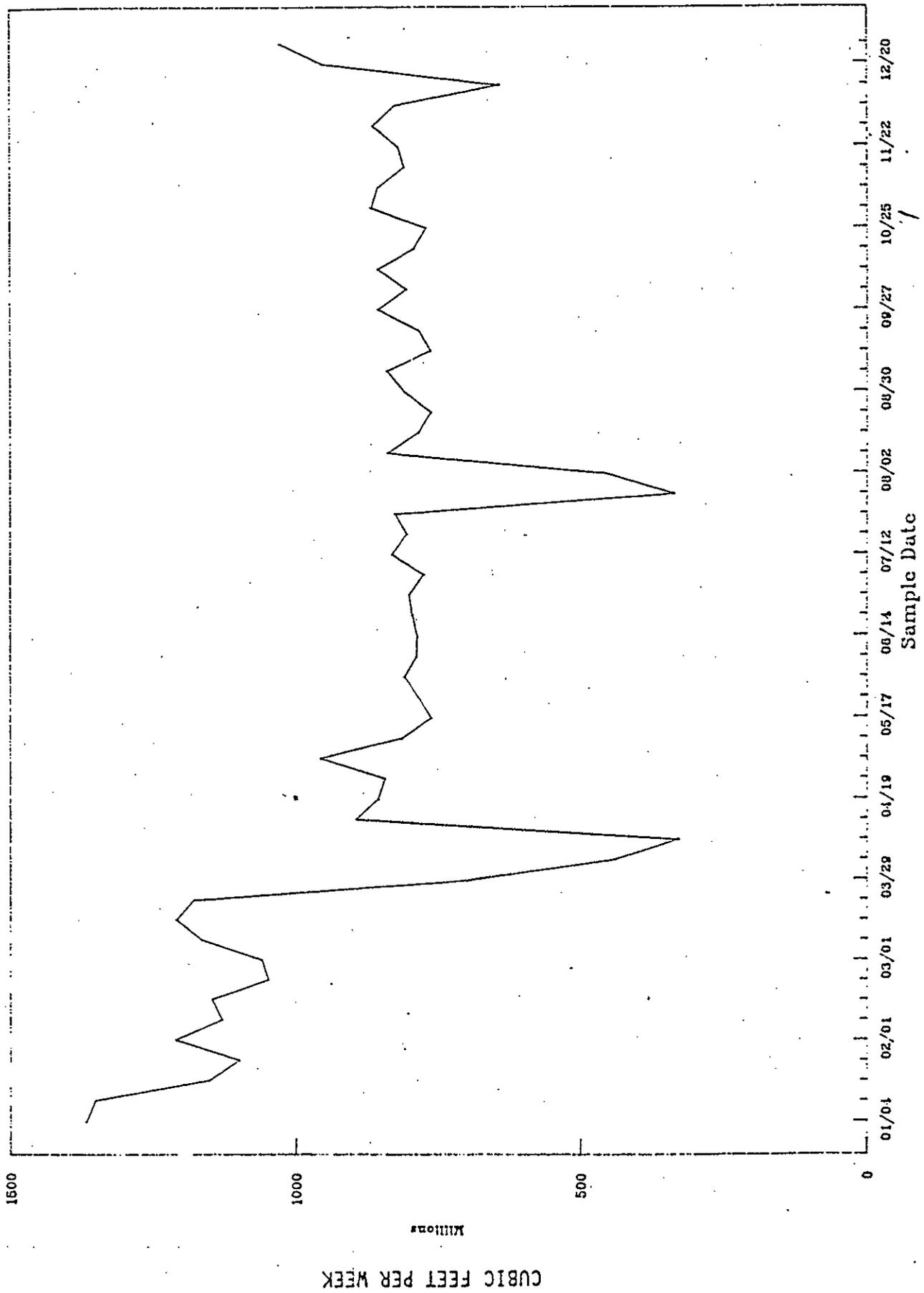


FIGURE 7

PUREX Main Stack

1992 Stack Flow 1993

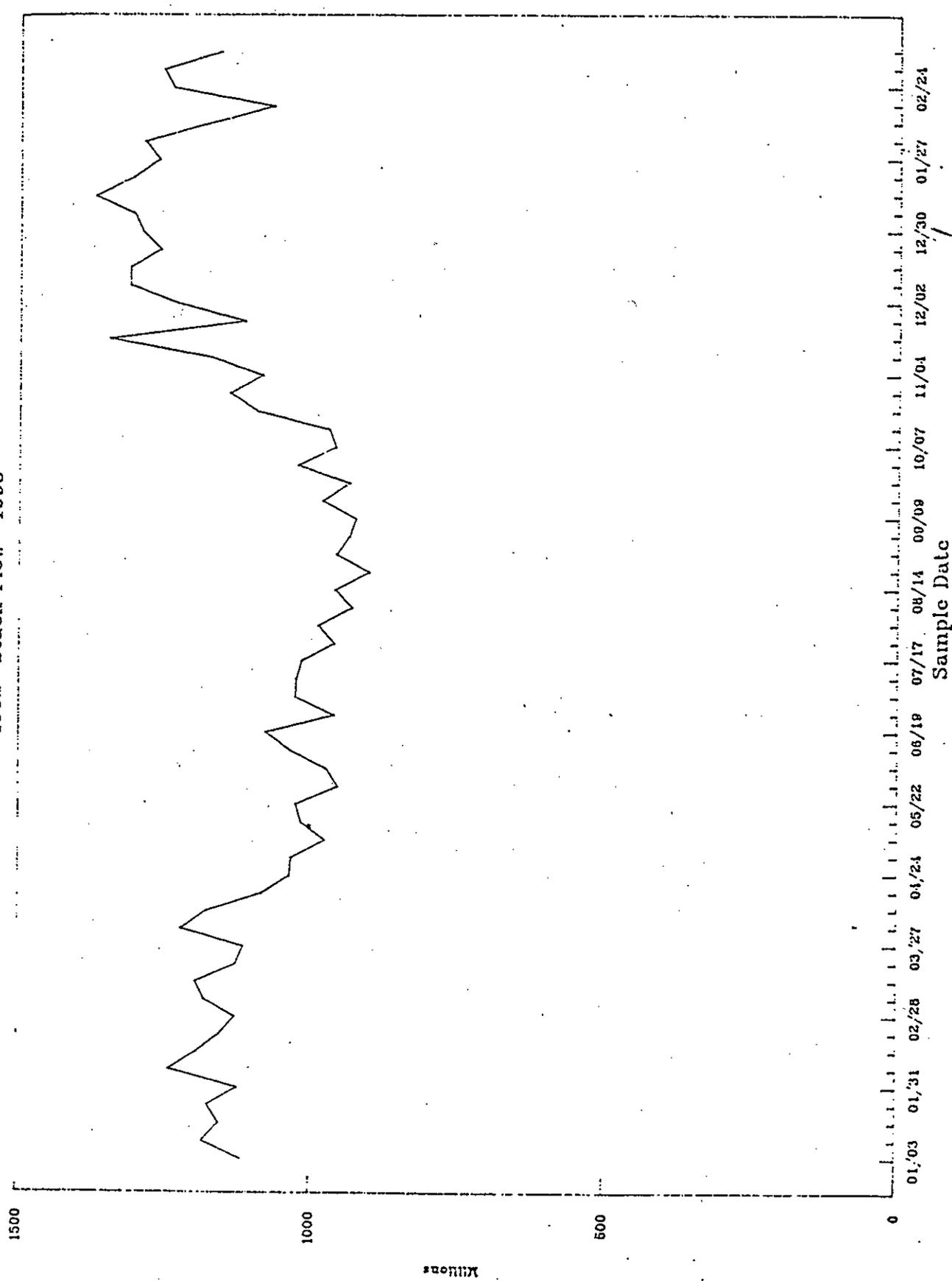


FIGURE 8