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1	HNF-2004	-	0	Estimated Dose To In-Tank Equipment: Phase 1 Waste Feed Delivery	NA	1,2		

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		Design Authority									
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		QA									
		Safety									
		Env.									

18.	19.	20.	21. DOE APPROVAL (if required)
R.D. Claghorn [signature] 2-12-98 Signature of EDT Originator / Date	R.F. Marshall [signature] 2/12/98 Authorized Representative for Receiving Organization / Date	J.S. Garfield [signature] 2/12/98 Design Authority/ Cognizant Manager / Date	Ctrl. No. [] Approved [] Approved w/comments [] Disapproved w/comments

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HNF-2004, Rev. 0

Estimated Dose To In-Tank Equipment: Phase 1 Waste Feed Delivery

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Abstract: This analysis estimates the radiation dose to the equipment that will be submerged in double-shell tank waste. The results of this analysis are intended to be the basis for specifications for in-tank equipment.

The scope of this analysis is limited to the new equipment required for the delivery of waste feed to Phase 1 private contractors. Phase 1 refers to the first of a two-phase plan to privatize the remediation of Hanford's tank waste. The focus of this analysis is on waste feed delivery because of the extraordinarily high cost of any failure that would lead to the interruption of a steady flow of feed to the private contractors.

Janis Aardal 2/24/98
Release Approval Date

Approved for Public Release

HNF-2004
Revision 0

ESTIMATED DOSE TO IN-TANK EQUIPMENT: PHASE 1 WASTE FEED DELIVERY

February 1998

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Prepared for
U.S. Department of Energy
Richland, Washington

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CONTENTS

LIST OF TABLES

LIST OF TERMS

DST	Double-shell tank
HLW	High-level waste
HTWOS	Hanford Tank Waste Operations Simulator
SST	Single-shell tank
TWRSO&UP	Tank Waste Remediation System Operations and Utilization Plan

ESTIMATED DOSE TO IN-TANK EQUIPMENT: PHASE I WASTE FEED DELIVERY

1.0 INTRODUCTION

This analysis estimates the radiation dose to the equipment that will be submerged in double-shell tank (DST) waste. The results of this analysis are intended to be the basis for specifications for in-tank equipment.

1.1 SCOPE

The scope of this analysis is limited to the new equipment required for the delivery of waste feed to Phase 1 private contractors. Phase 1 refers to the first of a two-phase plan to privatize the remediation of Hanford's tank waste. The focus of this analysis is on waste feed delivery because of the extraordinarily high cost of any failure that would lead to the interruption of a steady flow of feed to the private contractors.

1.2 BACKGROUND

The projects that will contribute to the various elements of the Phase 1 waste feed delivery system are currently using different source terms. Project W-058, the Replacement of the Cross-Site Transfer System, and W-314, Tank Farm Restoration and Safe Operations, have adopted information from the *Tank Waste Composition and Atmospheric Dispersion Coefficients for Use in Safety Analysis Consequence Assessments* (Van Keuren 1996). That document describes a rather extensive analysis of tank waste, both single-shell tank (SST) waste and DST waste. The SST waste is applicable to those projects because the current plan is to retrieve all of the waste in SSTs and pipe it to DSTs to await final processing.

The *Tank Waste Composition* (Van Keuren 1996) analysis derives bounding values for liquids and solids. As might be expected, there is a significant difference between the concentration of radionuclides in waste solids and the concentration in the liquid. By inspection of the tables in the referenced document, most radionuclides of concern to the environment are more concentrated in the solids layer. Since most transfers are limited to 30 percent solids or less, the bounding source term for a waste transfer is based on the idea that the waste consists of 33 percent solids and 67 percent liquids. That limitation, of course, doesn't apply to equipment that's immersed in waste. Furthermore, most of the radionuclides of concern to the environment aren't significant to the durability of in-tank equipment.

Other projects use measured values for their source terms. Project W-211, the Initial Tank Retrieval System, adopted its source term from Project W-151, the Tank 101-AZ Waste

Retrieval System. The W-151 source term is based on values that were measured during radiation surveys. The engineer for Project W-151 recalls that the dose rate information for the *Tank 101-AZ Waste Retrieval System Functional Design Criteria* (Nordquist 1997) was provided by engineers working in tank farm operations.

The source term for Project W-211, as defined in the current version of the FDC and in the procurement specification, is 500 R/hr. This was the original source term for W-151. Project W-151 now uses 670 R/hr even though the *Dose Rate Analysis for Tank AZ-101, Project W-151* (Schwarz et al. 1994) states that 1000 R/hr has been measured in tank 241-AZ-101.

Documentation for Project W-058, which has been adopted for use by Project W-314, states that the dose rate for equipment immersed in HLW is 10,000 R/hr (Henderson 1996). This is about 10 times what was measured in tank 241-AZ-101. The large difference between the measured value and the one that was calculated is attributed to the conservatism inherent in the use of a "bounding" tank composition for dose rate calculations.

2.0 APPROACH

The overall approach to this analysis is to estimate radiation fields in each DST by comparing their radionuclide content with the content in 241-AZ-101. Tank 241-AZ-101 is used as a reference because it has credible documentation for both content and measured dose rates. The details of this approach are further explained in the following sections.

2.1 ESTIMATE OF RADIONUCLIDE CONTENT

The content of each DST during Phase 1 is estimated using the Hanford Tank Waste Operations Simulator (HTWOS). The HTWOS is a computer program designed to track the components of the waste as the waste is transferred from tank to tank to the private contractors. The HTWOS uses recent, if not the most recent, characterization data to calculate the initial inventory for each tank. To generate the graphics in Appendix A, tank contents were quantified for January 1, 2000, and before and after each transfer into or out of a DST.

2.2 CONTRIBUTION OF SPECIFIC RADIONUCLIDES

Of all the isotopes listed in tank inventories, the *Tank Waste Composition* (Van Keuren 1996) analysis identifies only four that are strong gamma emitters. These isotopes are ^{137}Cs/^{137}mBa, ^{60}Co, ^{154}Eu and ^{155}Eu. The contribution of these four isotopes amounts to more than 98 percent of the total quantity of gamma energy emitted from all of the radionuclides. Of those four isotopes, ^{137}Cs is by far the most prevalent in the DST inventory.

This analysis uses ^{137}Cs and ^{90}Sr as indicators of the radionuclide content in each tank. The HTWOS software tracks the quantity of both liquids and solids in a tank. Cesium and strontium are the most prevalent radionuclides in the inventory. Cesium is usually dissolved in tank liquids whereas strontium salts are often insoluble and are, therefore, usually much more concentrated in tank solids.

The contribution of Sr to gamma energy is assigned a weight that is 1/75th of the contribution of ^{137}Cs on a per-Curie basis. Most of the ^{137}Cs energy is emitted as a gamma ray whereas almost all of the ^{90}Sr energy is emitted as beta radiation. Only a small fraction of the beta is converted to photon radiation through the bremsstrahlung effect. The quantity converted is directly proportional to the atomic number of the surrounding material (Roetman 1997). Using an estimate of the dose from cesium and strontium capsules as a point of reference, it appears that the gamma attributed to strontium is about 1/75th as significant as cesium on a per-Curie basis (Schwarz 1996).

2.3 ESTIMATING THE DURATION OF EQUIPMENT EXPOSURE

Appendix H of the *Tank Waste Remediation System Operations and Utilization Plan* (TWRSO&UP) (Kirkbride et al. 1997) documents the baseline completion date for the tank upgrades required to support Phase 1 waste feed delivery. For the low-activity waste (LAW) feed source tanks, the baseline completion date is generally 6 months before the waste is scheduled for transfer to the intermediate waste feed staging tanks. The *Supplement 2 to Title I Design Summary Report* (ICF KHC 1995) shows that construction for each tank usually requires about two years. It is assumed that some equipment, such as mixers, are installed early in the construction phase of the project. Therefore, the duration of exposure for equipment installed in sources of LAW feed is assumed to be 2½ yr.

New equipment installed in the HLW feed source tanks will be subject to an extended exposure. In addition to the two years before initial operations, each of the HLW source tanks will perform sludge washing operations for nearly a year and then they will transfer feed to the HLW processing facility a little at a time. The new equipment installed in these tanks will, therefore see 5 to 7½ yr of exposure during Phase 1 feed delivery operations.

The intermediate waste feed staging tanks, 241-AP-102 and 241-AP-104, are involved in almost every transfer of LAW feed. Therefore, they will see the longest duration of exposure (9 yr).

3.0 RESULTS

The results of this analysis are summarized in Tables 1, 2 and 3. Additional detail is provided by the figures attached as Appendix A.

Table 1. Estimated Dose to Equipment Submerged in Phase 1 Intermediate Waste Feed Staging Tanks.

Tank	Peak dose rate, R/hr	Total integrated Dose, R
241-AN-102	150	3.3 E06
241-AN-103	260	5.3 E06
241-AN-104	350	4.7 E06
241-AN-105	200	3.9 E06
241-AN-106	140	3.0 E06
241-AN-107	170	3.6 E06
241-AW-101	350	5.6 E06
241-SY-101	130	2.8 E06
241-SY-102	80	7.6 E05
241-SY-103	130	1.6 E06

Table 2. Estimated Dose to Equipment Submerged in Phase 1 Low-Activity Waste Feed Tanks.

Tank	Peak dose rate, R/hr	Total integrated Dose, R
241-AP-102	340	7.1 E06
241-AP-104	340	8.1 E06

Table 3. Estimated Dose to Equipment Submerged in Phase 1 High-level Waste Feed Tanks.

Tank	Peak dose rate, R/hr	Total integrated dose, R
241-AY-101	1100	9.5 E07
241-AY-102	10	3.6 E05
241-AZ-101	1000	2.3 E07
241-AZ-102	580	1.3 E07

4.0 ESTIMATED IMPACT OF CHANGES TO SOURCE TERM INFORMATION

It appears that the 500 R/hr source term currently specified in Project W-211 design documents is adequate for LAW source tanks and the intermediate waste feed staging tanks. For HLW source tanks, however, the 1,000 R/hr (measured) or the 10^4 R/hr (calculated) source term used by Projects W-058 and W-314 appear to be more appropriate.

If the higher source term is adopted for HLW, the impacts to on-going projects are estimated to be rather minor. According to the engineers working on Project W-211, the materials used for construction are the best available (Rieck 1997). According to engineers for Project W-151, the operational life of any rubber or plastic component will be shorter in a higher radiation field. If the dose is actually 1000 R instead of 670 R, the O-rings in the lower seals of the mixer will fail at 20,000 hrs (instead of 30,000 hrs) "forecasting the failure to occur 9/30/98" (Nordquist 1997). The consequences of that failure, however, are rather insignificant. It is estimated that approximately 2L/hr of water will leak into the tank while the mixer is running. That quantity would be negligible in a million-gallon tank.

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APPENDIX A

RADIONUCLIDE INVENTORIES FOR EACH OF THE TANKS INVOLVED IN WASTE FEED DELIVERY FOR PHASE 1

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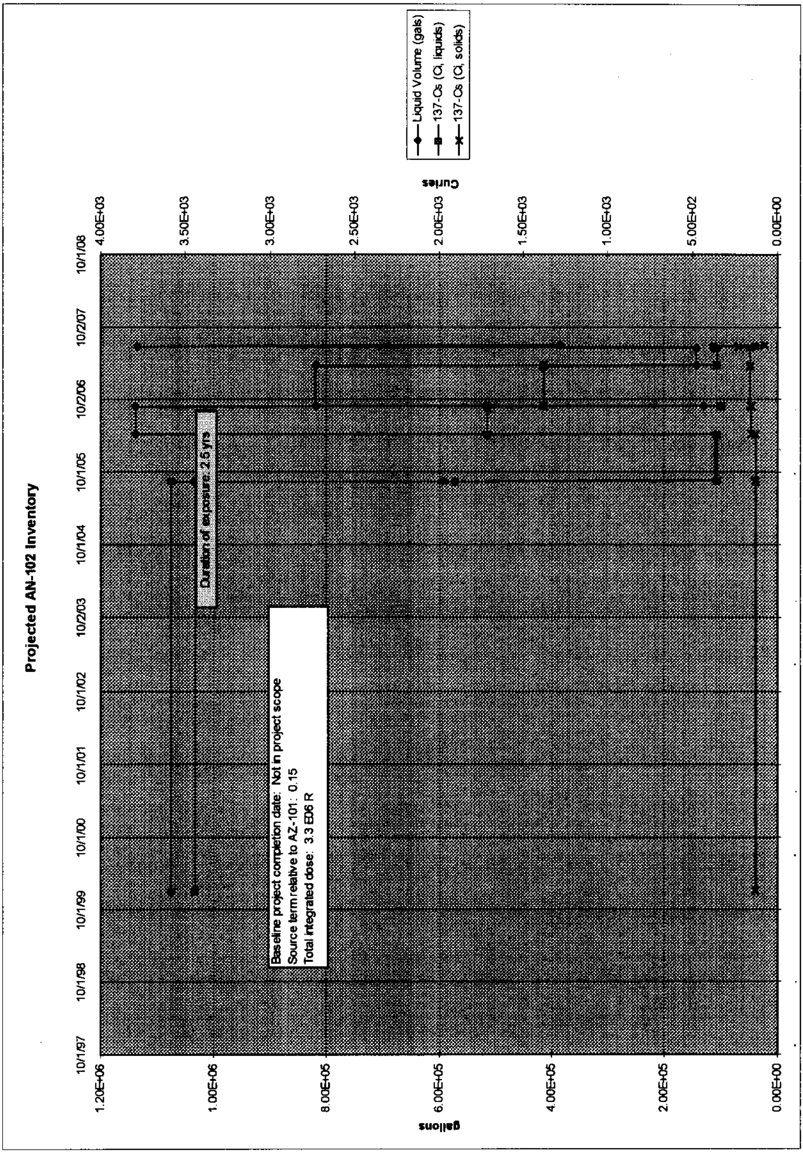
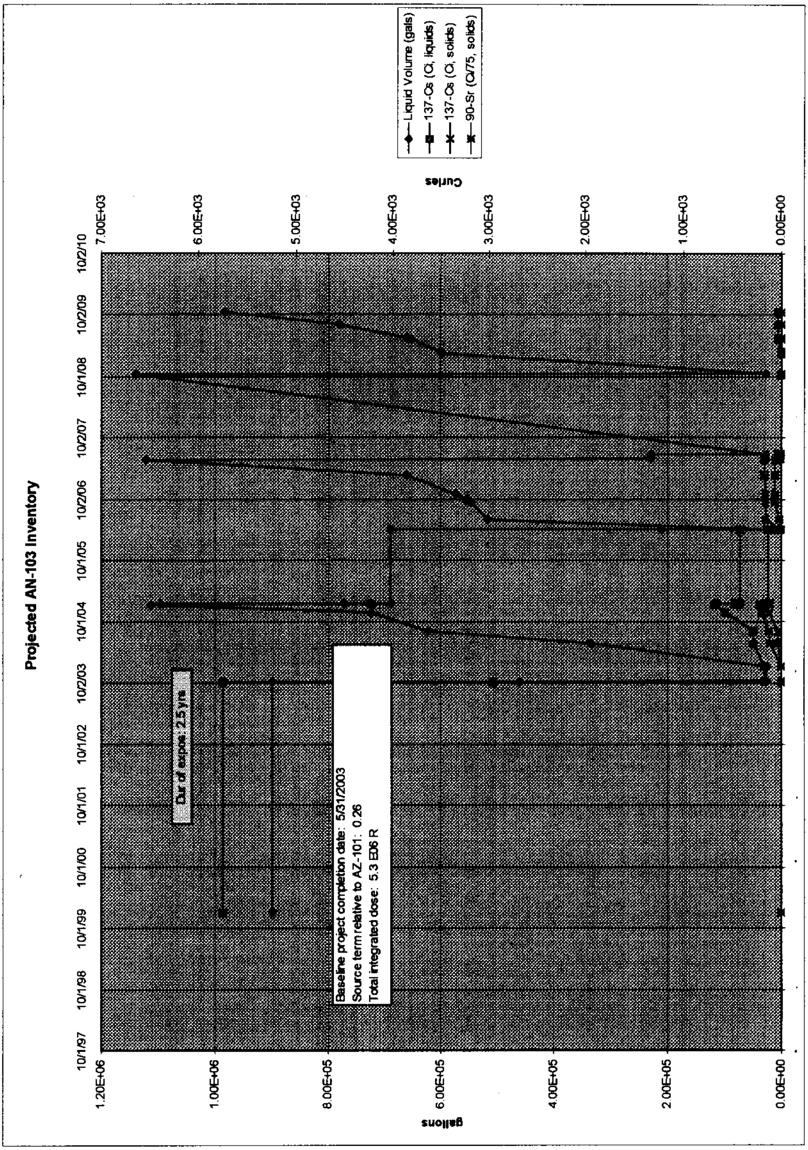
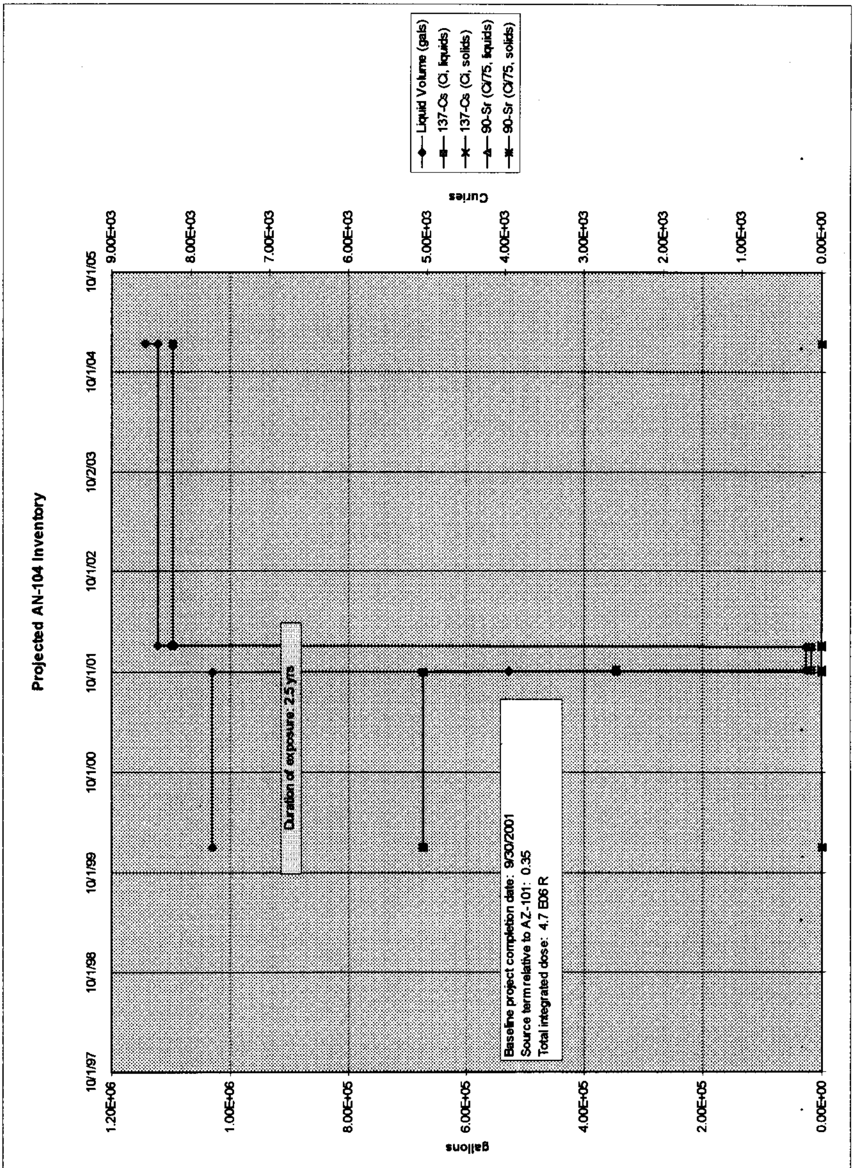
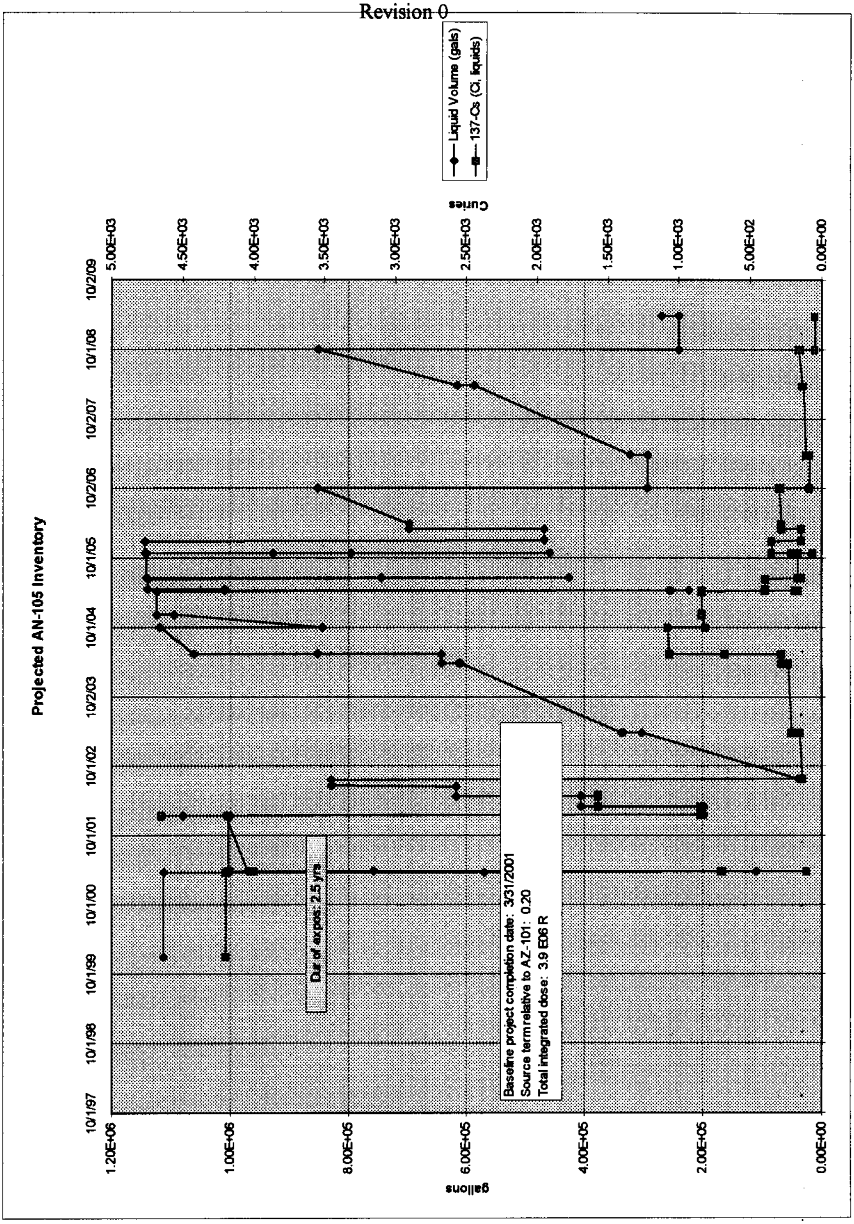
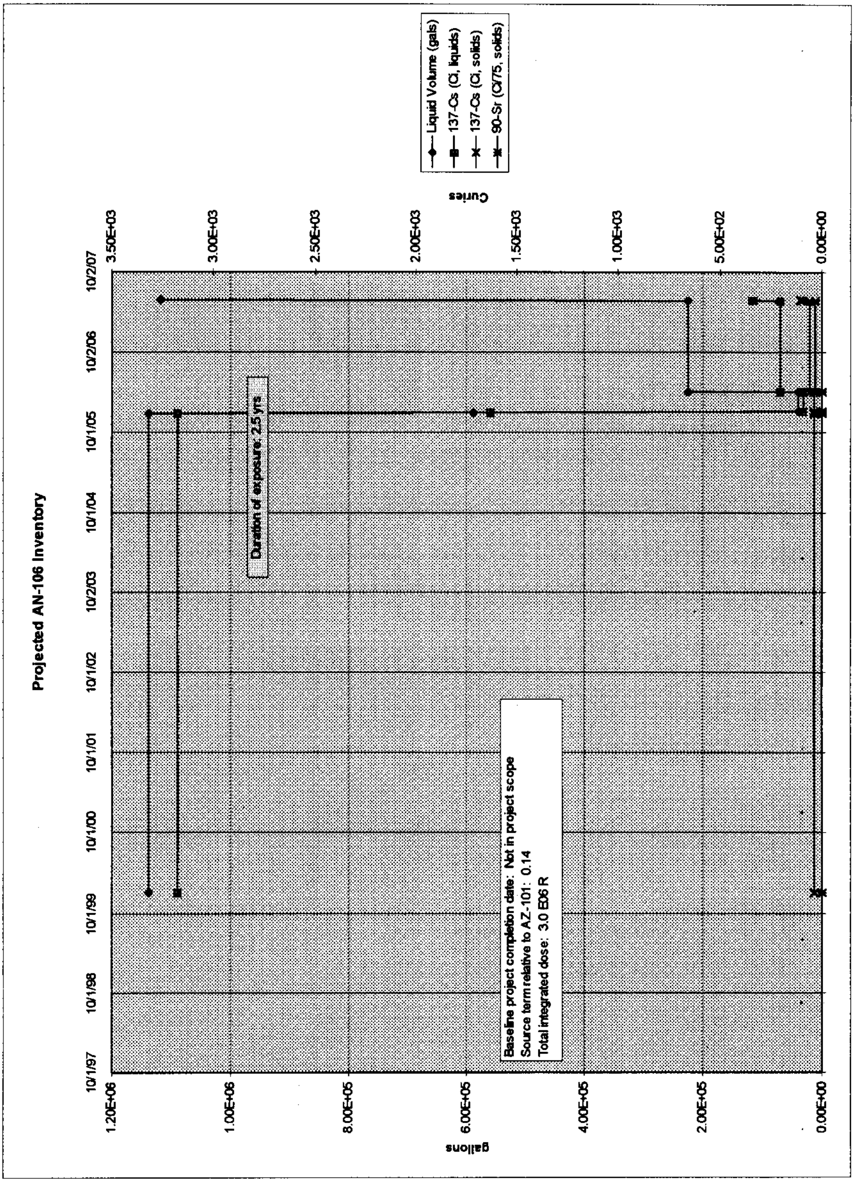
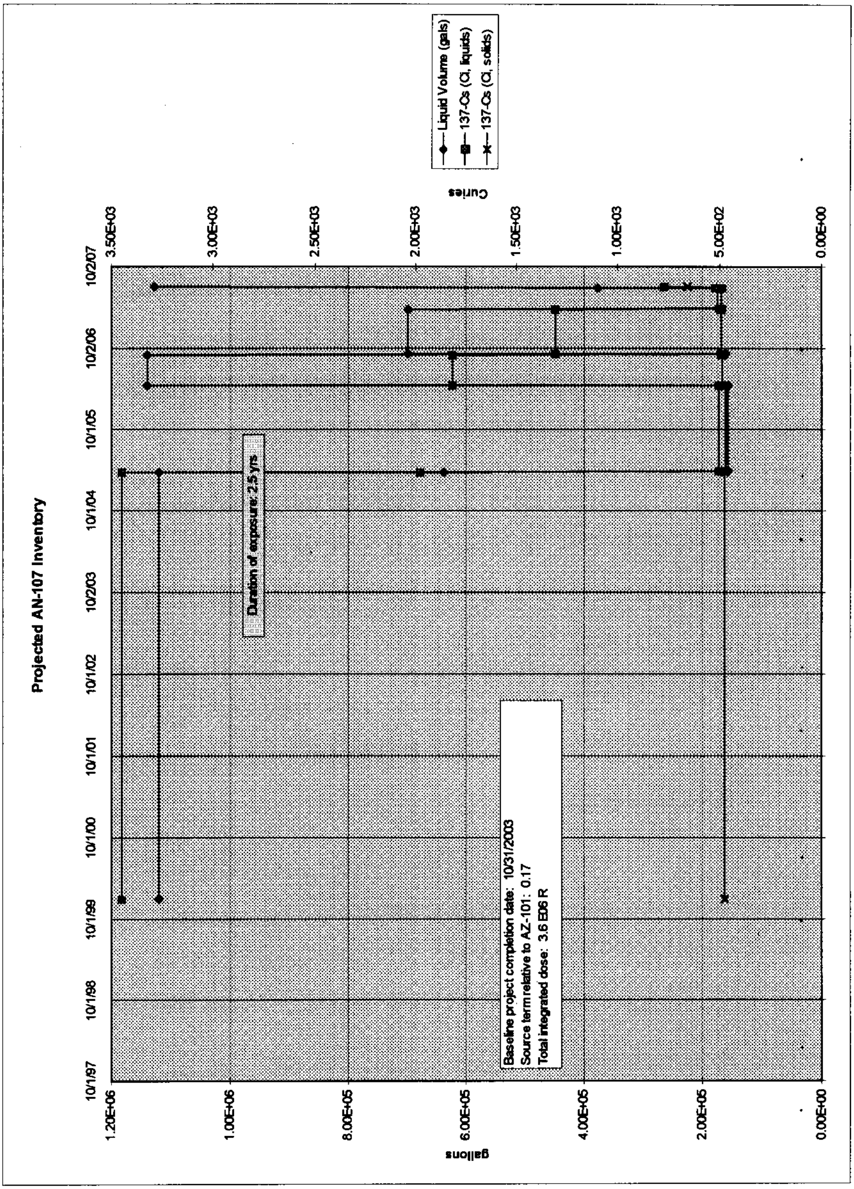

Projected AN-102 Inventory
Liquid Volume (gals)
137-Cs (Ci, liquids)
137-Cs (Ci, solids)
Curies
gallons
Duration of exposure: 2.5 yrs
Baseline project completion date: Not in project scope
Source term relative to AZ-101: 0.15
Total integrated dose: 3.3 E06 R
10/1/97
10/1/98
10/1/99
10/1/00
10/1/01
10/1/02
10/2/03
10/1/04
10/1/05
10/2/06
10/2/07
10/1/08
1.20E+06
1.00E+06
8.00E+05
6.00E+05
4.00E+05
2.00E+05
0.00E+00
4.00E+03
3.50E+03
3.00E+03
2.50E+03
2.00E+03
1.50E+03
1.00E+03
5.00E+02
0.00E+00


Projected AN-103 Inventory
Liquid Volume (gals)
137-Cs (Ci, liquids)
137-Cs (Ci, solids)
90-Sr (Ci/75, solids)
Curies
gallons
Dur of expos: 2.5 yrs
Baseline project completion date: 5/31/2003
Source term relative to AZ-101: 0.26
Total integrated dose: 5.3 E06 R
10/1/97
10/1/98
10/1/99
10/1/00
10/1/01
10/1/02
10/2/03
10/1/04
10/1/05
10/2/06
10/2/07
10/1/08
10/2/09
10/2/10
1.20E+06
1.00E+06
8.00E+05
6.00E+05
4.00E+05
2.00E+05
0.00E+00
7.00E+03
6.00E+03
5.00E+03
4.00E+03
3.00E+03
2.00E+03
1.00E+03
0.00E+00


Projected AN-104 Inventory
Liquid Volume (gals)
137-Cs (Ci, liquids)
137-Cs (Ci, solids)
90-Sr (Ci/75, liquids)
90-Sr (Ci/75, solids)
Curies
gallons
Duration of exposure: 2.5 yrs
Baseline project completion date: 9/30/2001
Source term relative to AZ-101: 0.35
Total integrated dose: 4.7 E06 R
10/1/97
10/1/98
10/1/99
10/1/00
10/1/01
10/1/02
10/2/03
10/1/04
10/1/05
1.20E+06
1.00E+06
8.00E+05
6.00E+05
4.00E+05
2.00E+05
0.00E+00
9.00E+03
8.00E+03
7.00E+03
6.00E+03
5.00E+03
4.00E+03
3.00E+03
2.00E+03
1.00E+03
0.00E+00


Projected AN-105 Inventory
Liquid Volume (gals)
137-Cs (Ci, liquids)
Curies
gallons
5.00E+03
4.50E+03
4.00E+03
3.50E+03
3.00E+03
2.50E+03
2.00E+03
1.50E+03
1.00E+03
5.00E+02
0.00E+00
1.20E+06
1.00E+06
8.00E+05
6.00E+05
4.00E+05
2.00E+05
0.00E+00
10/1/97
10/1/98
10/1/99
10/1/00
10/1/01
10/1/02
10/2/03
10/1/04
10/1/05
10/2/06
10/2/07
10/1/08
10/2/09
Dur of expos: 2.5 yrs
Baseline project completion date: 3/31/2001
Source term relative to AZ-101: 0.20
Total integrated dose: 3.9 E06 R


Projected AN-106 Inventory
Liquid Volume (gals)
137-Cs (Ci, liquids)
137-Cs (Ci, solids)
90-Sr (Ci/75, solids)
Curies
3.50E+03
3.00E+03
2.50E+03
2.00E+03
1.50E+03
1.00E+03
5.00E+02
0.00E+00
gallons
1.20E+06
1.00E+06
8.00E+05
6.00E+05
4.00E+05
2.00E+05
0.00E+00
10/1/97
10/1/98
10/1/99
10/1/00
10/1/01
10/1/02
10/2/03
10/1/04
10/1/05
10/2/06
10/2/07
Duration of exposure: 2.5 yrs
Baseline project completion date: Not in project scope
Source term relative to AZ-101: 0.14
Total integrated dose: 3.0 E06 R


Projected AN-107 Inventory
Liquid Volume (gals)
137-Cs (Ci, liquids)
137-Cs (Ci, solids)
Curies
gallons
Duration of exposure: 2.5 yrs
Baseline project completion date: 10/31/2003
Source term relative to AZ-101: 0.17
Total integrated dose: 3.6 E06 R
10/1/97
10/1/98
10/1/99
10/1/00
10/1/01
10/1/02
10/2/03
10/1/04
10/1/05
10/2/06
10/2/07
1.20E+06
1.00E+06
8.00E+05
6.00E+05
4.00E+05
2.00E+05
0.00E+00
3.50E+03
3.00E+03
2.50E+03
2.00E+03
1.50E+03
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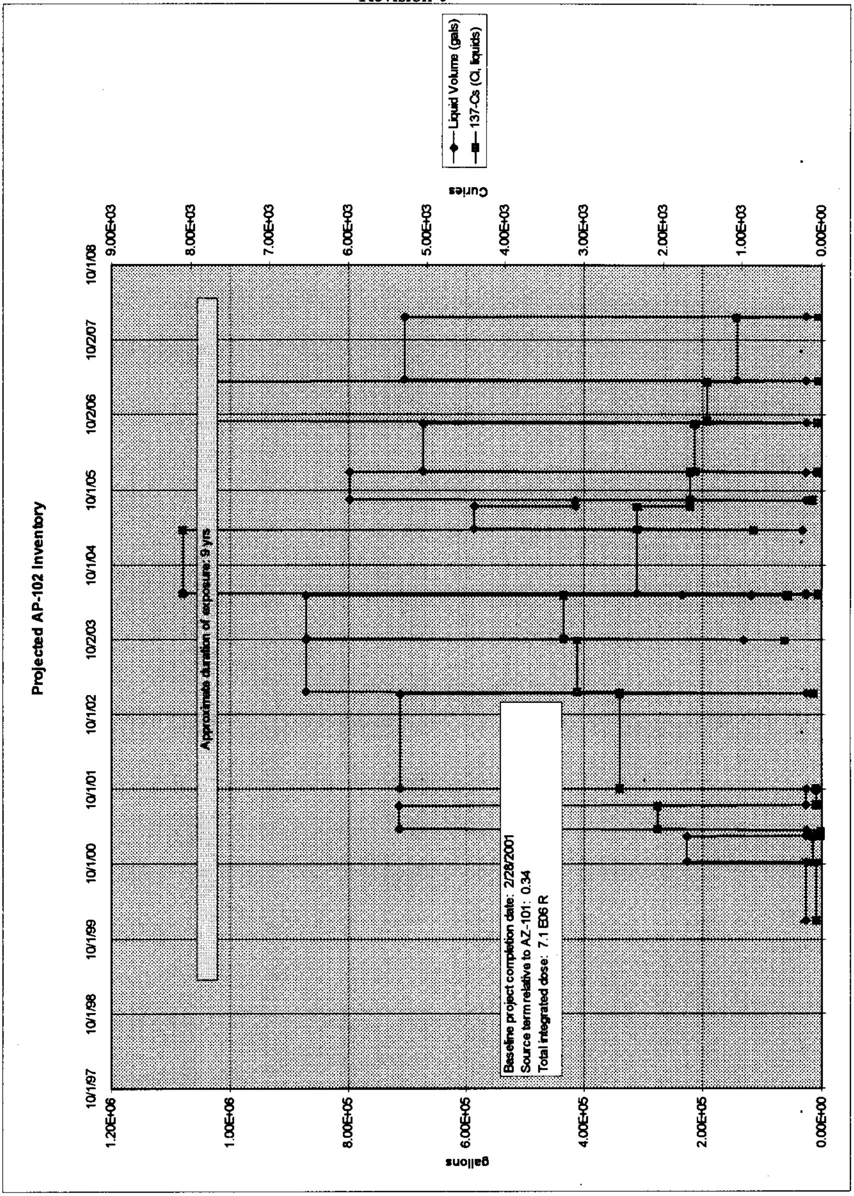
5.00E+02
0.00E+00


Projected AP-102 Inventory
Liquid Volume (gals)
137-Cs (Ci, liquids)
Curies
gallons
Approximate duration of exposure: 9 yrs
Baseline project completion date: 2/28/2001
Source term relative to AZ-101: 0.34
Total integrated dose: 7.1 E06 R
10/1/97
10/1/98
10/1/99
10/1/00
10/1/01
10/1/02
10/2/03
10/1/04
10/1/05
10/2/06
10/2/07
10/1/08
0.00E+00
2.00E+05
4.00E+05
6.00E+05
8.00E+05
1.00E+06
1.20E+06
0.00E+00
1.00E+03
2.00E+03
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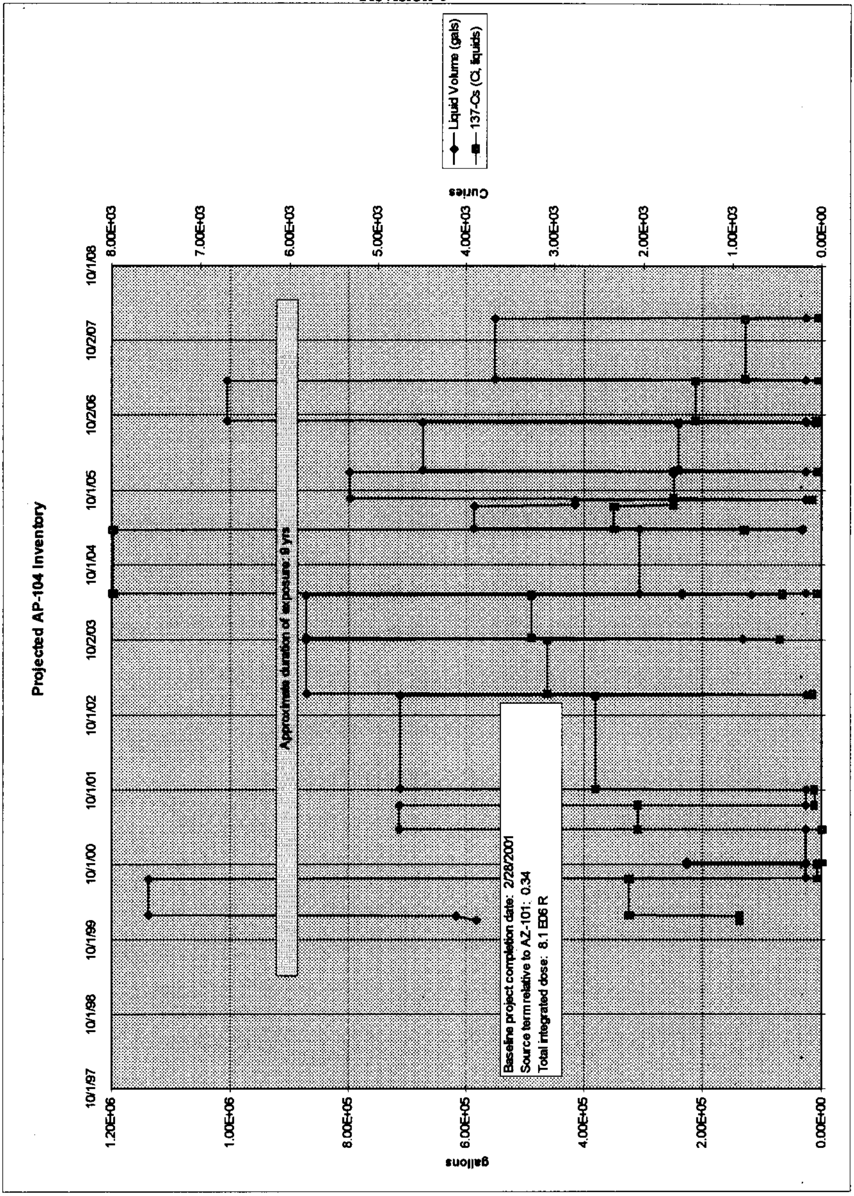
9.00E+03


Projected AP-104 Inventory
Liquid Volume (gals)
137-Cs (Ci, liquids)
Curies
gallons
Approximate duration of exposure: 9 yrs
Baseline project completion date: 2/28/2001
Source term relative to AZ-101: 0.34
Total integrated dose: 8.1 E06 R
10/1/97
10/1/98
10/1/99
10/1/00
10/1/01
10/1/02
10/2/03
10/1/04
10/1/05
10/2/06
10/2/07
10/1/08
1.20E+06
1.00E+06
8.00E+05
6.00E+05
4.00E+05
2.00E+05
0.00E+00
8.00E+03
7.00E+03
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2.00E+03
1.00E+03
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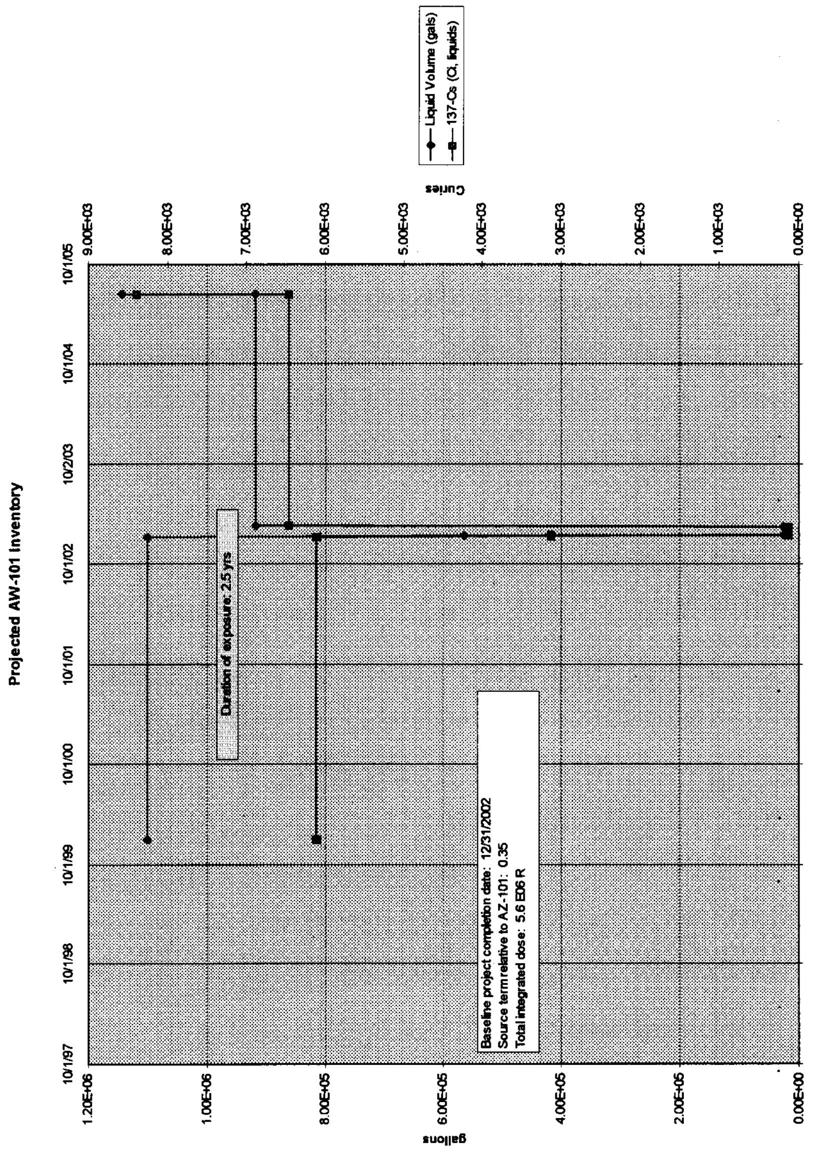
Projected AW-101 Inventory
Liquid Volume (gals)
137-Cs (Ci, liquids)
Curies
gallons
Duration of exposure: 2.5 yrs
Baseline project completion date: 12/31/2002
Source term relative to AZ-101: 0.35
Total integrated dose: 5.6 E06 R
10/1/97
10/1/98
10/1/99
10/1/00
10/1/01
10/1/02
10/2/03
10/1/04
10/1/05
1.20E+06
1.00E+06
8.00E+05
6.00E+05
4.00E+05
2.00E+05
0.00E+00
9.00E+03
8.00E+03
7.00E+03
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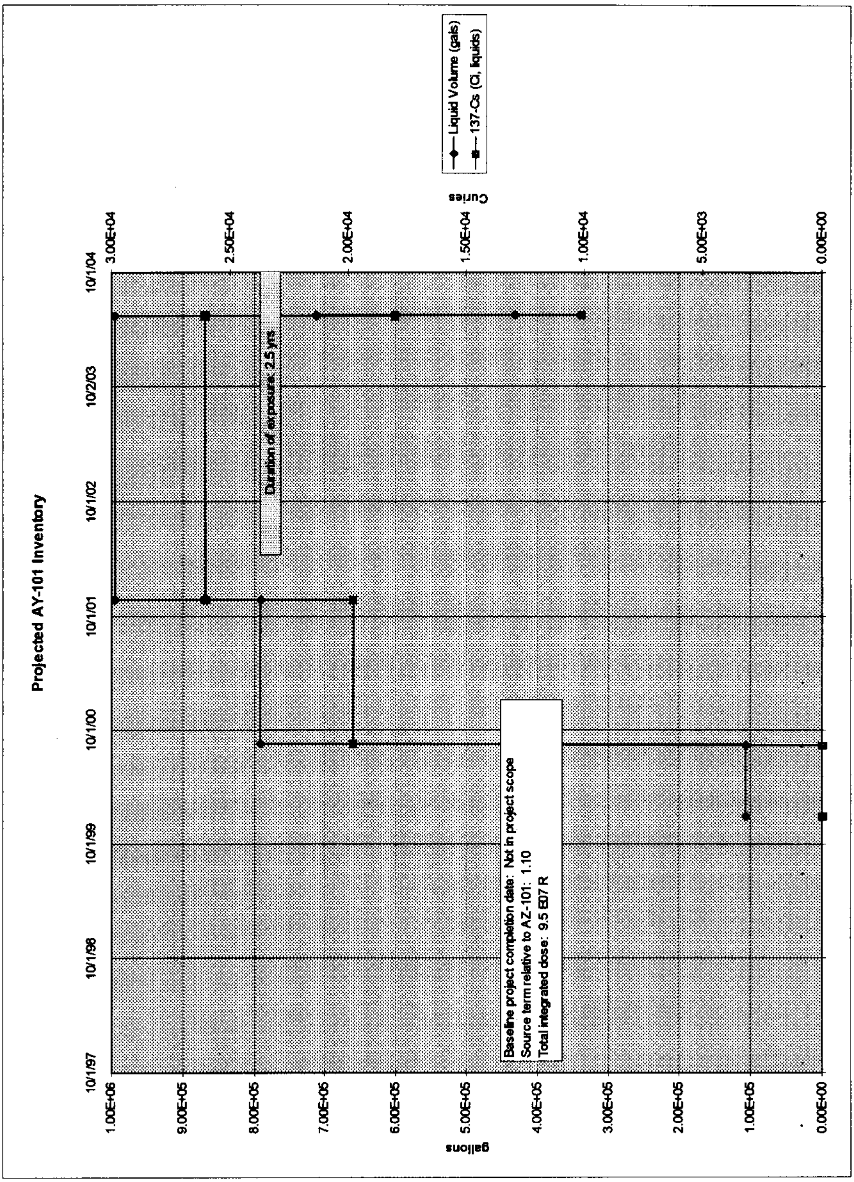
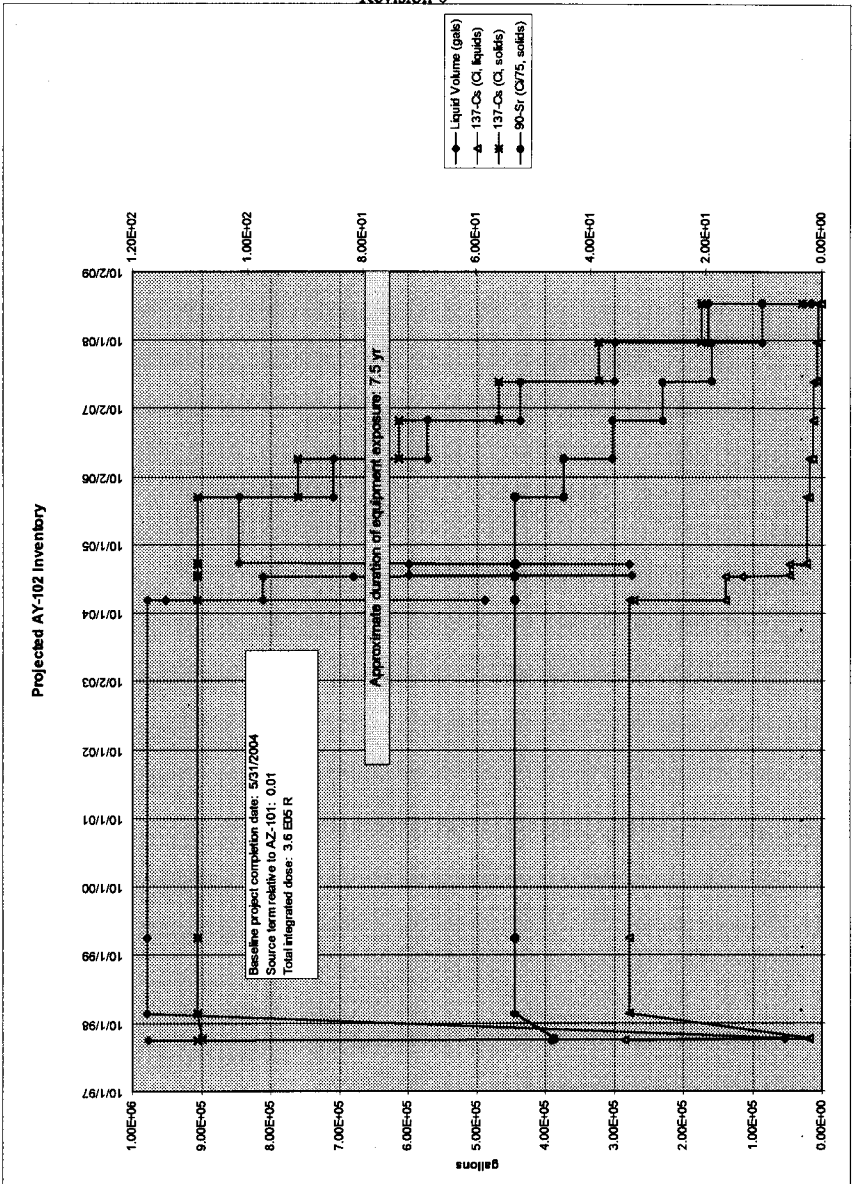
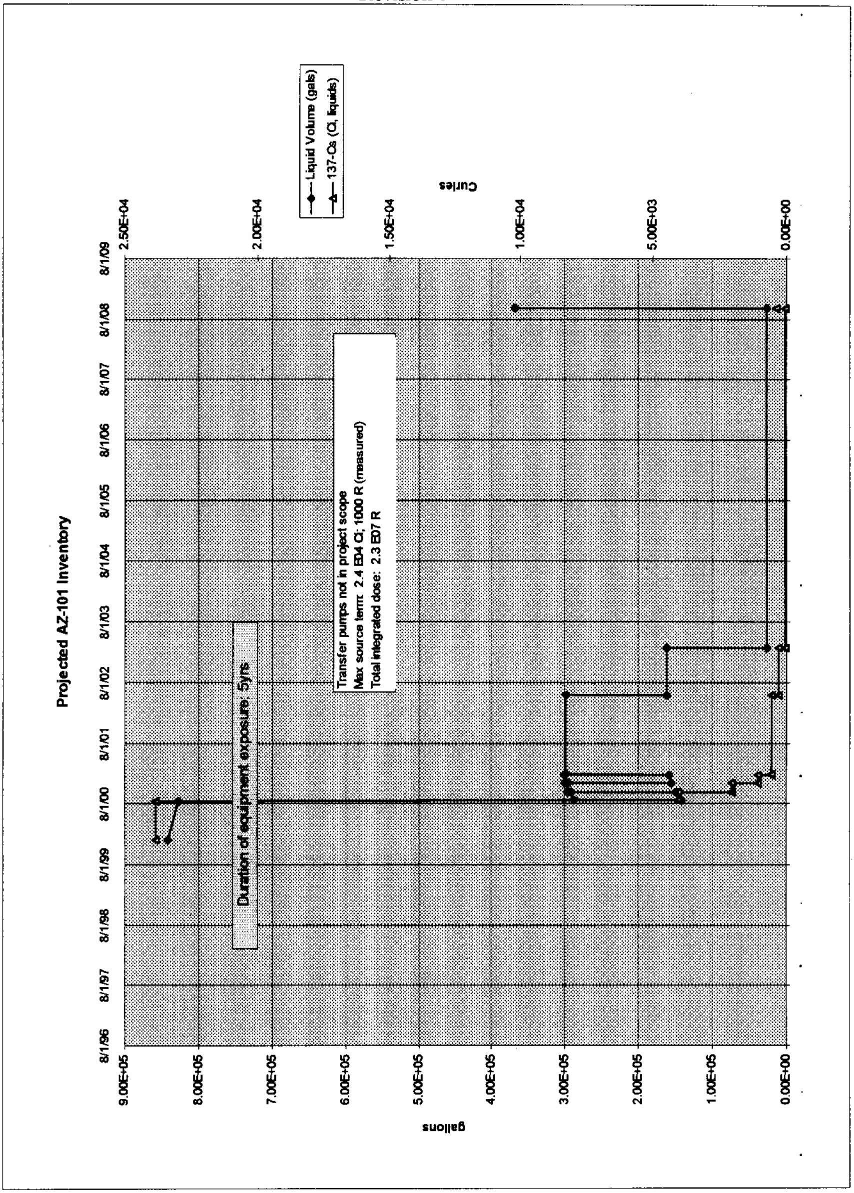
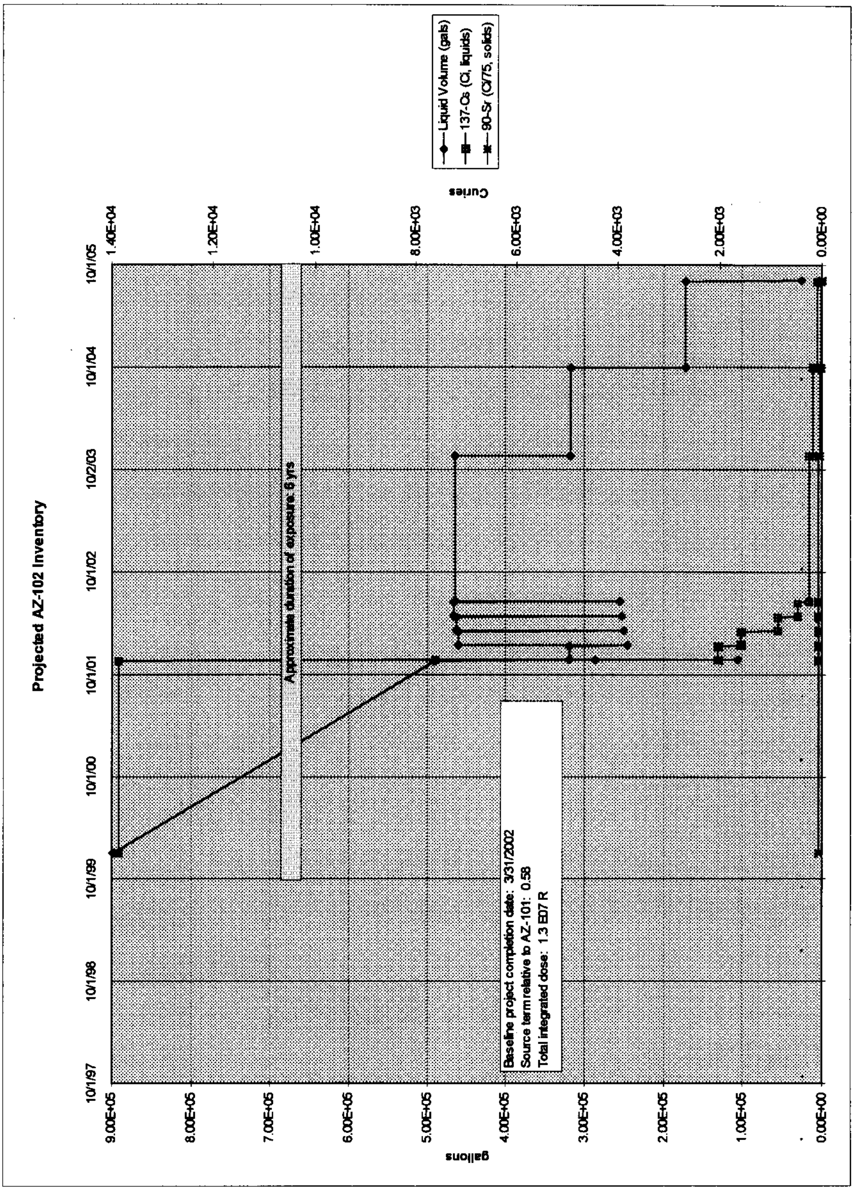
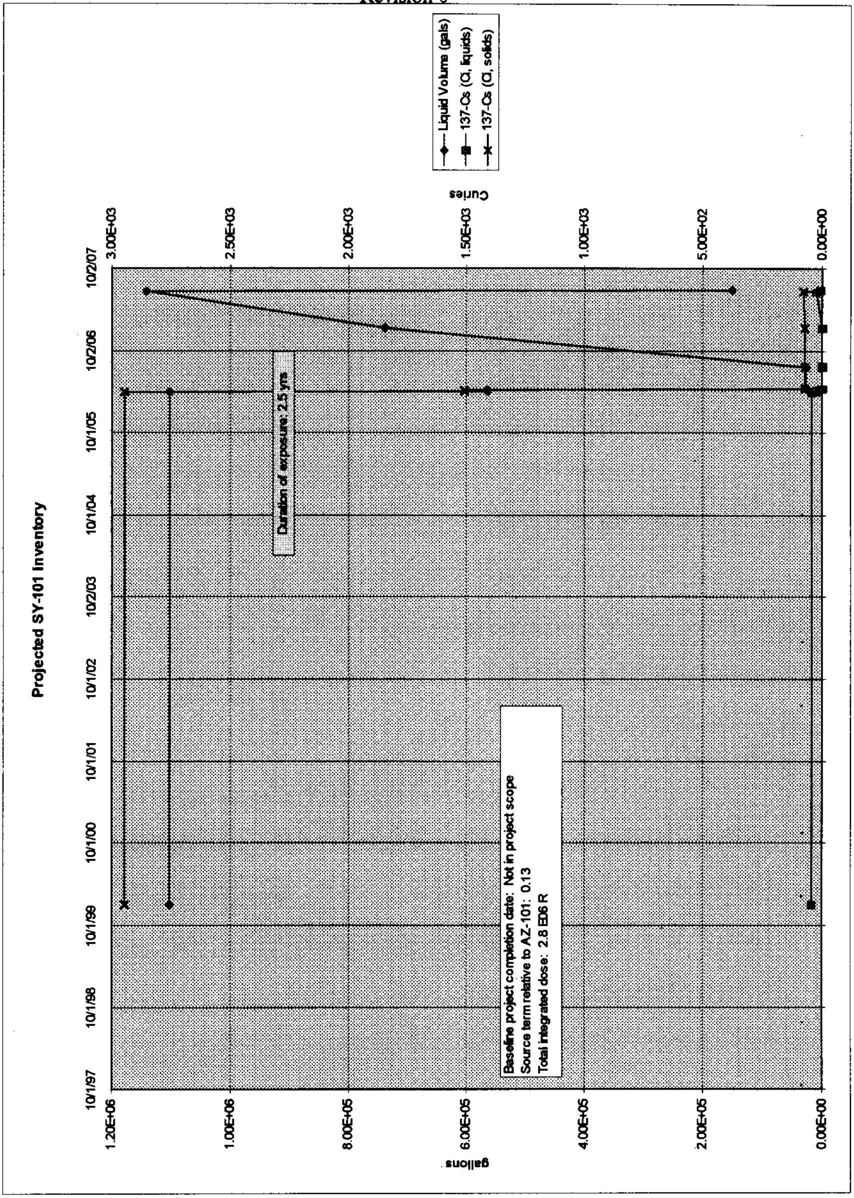
0.00E+00

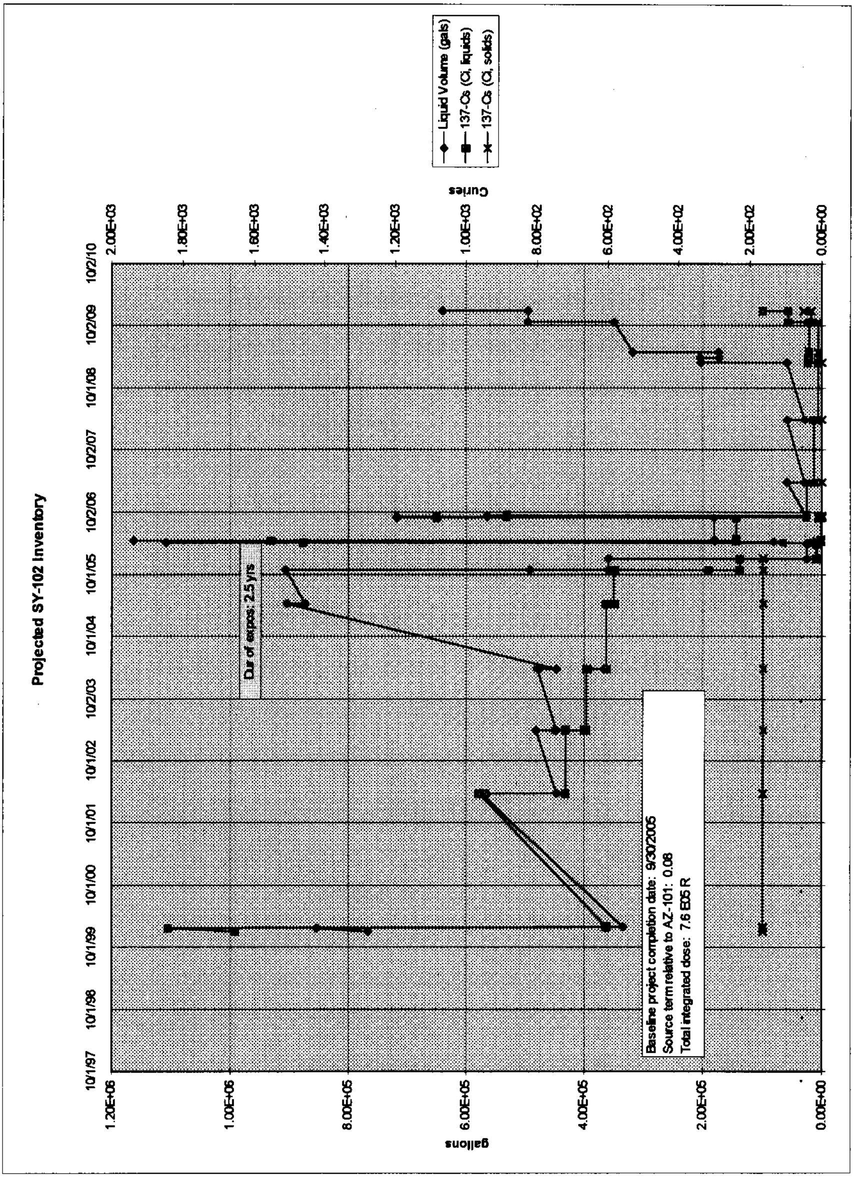

Projected AY-101 Inventory
Liquid Volume (gals)
137-Cs (Ci, liquids)
Curies
3.00E+04
2.50E+04
2.00E+04
1.50E+04
1.00E+04
5.00E+03
0.00E+00
gallons
1.00E+06
9.00E+05
8.00E+05
7.00E+05
6.00E+05
5.00E+05
4.00E+05
3.00E+05
2.00E+05
1.00E+05
0.00E+00
10/1/97
10/1/98
10/1/99
10/1/00
10/1/01
10/1/02
10/2/03
10/1/04
Duration of exposure: 2.5 yrs
Baseline project completion date: Not in project scope
Source term relative to AZ-101: 1.10
Total integrated dose: 9.5 E07 R

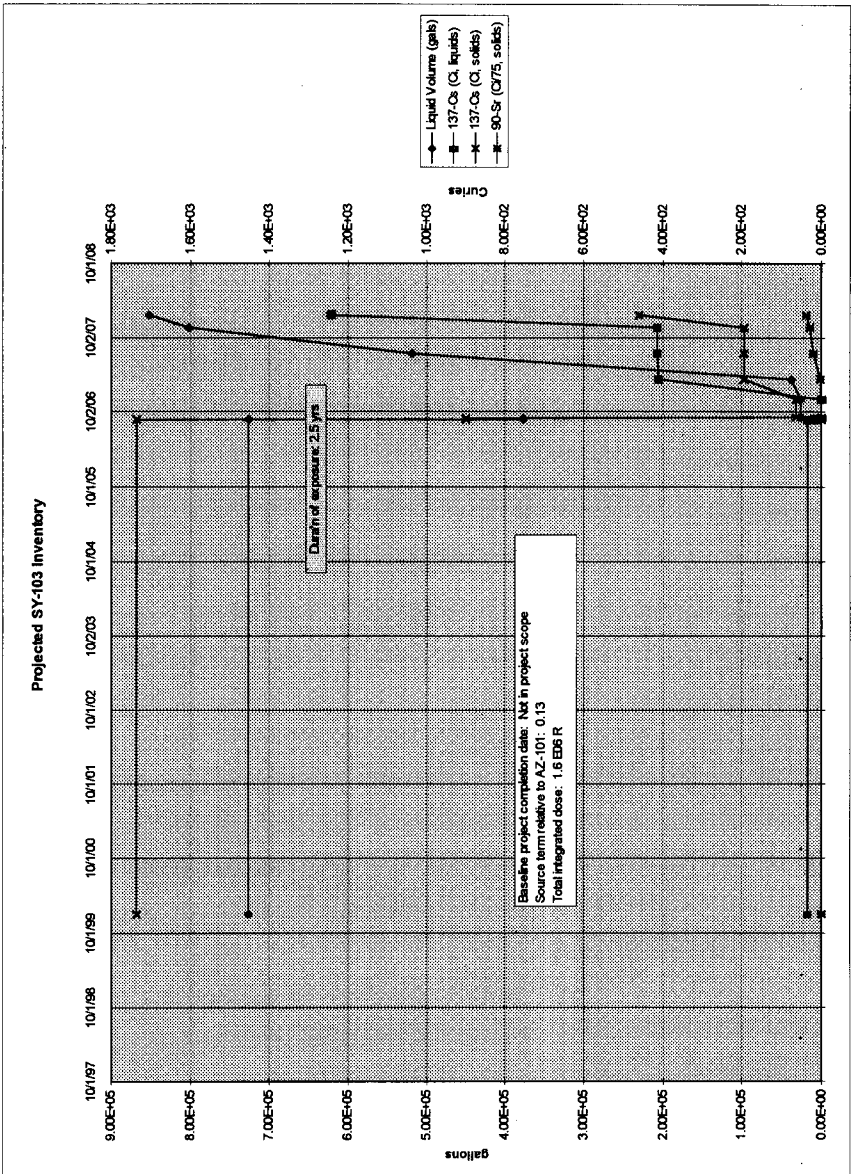

Projected AY-102 Inventory
Liquid Volume (gals)
137-Cs (Ci, liquids)
137-Cs (Ci, solids)
90-Sr (Ci/75, solids)
Baseline project completion date: 5/31/2004
Source term relative to AZ-101: 0.01
Total integrated dose: 3.6 E05 R
Approximate duration of equipment exposure: 7.5 yr
gallons
1.00E+06
9.00E+05
8.00E+05
7.00E+05
6.00E+05
5.00E+05
4.00E+05
3.00E+05
2.00E+05
1.00E+05
0.00E+00
1.20E+02
1.00E+02
8.00E+01
6.00E+01
4.00E+01
2.00E+01
0.00E+00
10/1/97
10/1/98
10/1/99
10/1/00
10/1/01
10/1/02
10/2/03
10/1/04
10/1/05
10/2/06
10/2/07
10/1/08
10/2/09


Projected AZ-101 Inventory
Liquid Volume (gals)
137-Cs (Ci, liquids)
Curies
2.50E+04
2.00E+04
1.50E+04
1.00E+04
5.00E+03
0.00E+00
gallons
9.00E+05
8.00E+05
7.00E+05
6.00E+05
5.00E+05
4.00E+05
3.00E+05
2.00E+05
1.00E+05
0.00E+00
8/1/96
8/1/97
8/1/98
8/1/99
8/1/00
8/1/01
8/1/02
8/1/03
8/1/04
8/1/05
8/1/06
8/1/07
8/1/08
8/1/09
Transfer pumps not in project scope
Max source term: 2.4 E04 Ci; 1000 R (measured)
Total integrated dose: 2.3 E07 R
Duration of equipment exposure: 5yrs


Projected AZ-102 Inventory
Liquid Volume (gals)
137-Cs (Ci, liquids)
90-Sr (Ci/75, solids)
Curies
1.40E+04
1.20E+04
1.00E+04
8.00E+03
6.00E+03
4.00E+03
2.00E+03
0.00E+00
gallons
9.00E+05
8.00E+05
7.00E+05
6.00E+05
5.00E+05
4.00E+05
3.00E+05
2.00E+05
1.00E+05
0.00E+00
10/1/97
10/1/98
10/1/99
10/1/00
10/1/01
10/1/02
10/2/03
10/1/04
10/1/05
Approximate duration of exposure 6 yrs
Baseline project completion date: 3/31/2002
Source term relative to AZ-101: 0.58
Total integrated dose: 1.3 E07 R


Projected SY-101 Inventory
Liquid Volume (gals)
137-Cs (Ci, liquids)
137-Cs (Ci, solids)
Curies
gallons
3.00E+03
2.50E+03
2.00E+03
1.50E+03
1.00E+03
5.00E+02
0.00E+00
1.20E+06
1.00E+06
8.00E+05
6.00E+05
4.00E+05
2.00E+05
0.00E+00
10/1/97
10/1/98
10/1/99
10/1/00
10/1/01
10/1/02
10/2/03
10/1/04
10/1/05
10/2/06
10/2/07
Duration of exposure: 2.5 yrs
Baseline project completion date: Not in project scope
Source term relative to AZ-101: 0.13
Total integrated dose: 2.8 E06 R


Projected SY-102 Inventory
Liquid Volume (gals)
137-Cs (Ci, liquids)
137-Cs (Ci, solids)
Curies
gallons
Dur of expos: 2.5 yrs
Baseline project completion date: 9/30/2005
Source term relative to AZ-101: 0.08
Total integrated dose: 7.6 E05 R
2.00E+03
1.80E+03
1.60E+03
1.40E+03
1.20E+03
1.00E+03
8.00E+02
6.00E+02
4.00E+02
2.00E+02
0.00E+00
1.20E+06
1.00E+06
8.00E+05
6.00E+05
4.00E+05
2.00E+05
0.00E+00
10/1/97
10/1/98
10/1/99
10/1/00
10/1/01
10/1/02
10/2/03
10/1/04
10/1/05
10/2/06
10/2/07
10/1/08
10/2/09
10/2/10


Projected SY-103 Inventory
Liquid Volume (gals)
137-Cs (Ci, liquids)
137-Cs (Ci, solids)
90-Sr (Ci/75, solids)
Curies
gallons
Duration of exposure: 2.5 yrs
Baseline project completion date: Not in project scope
Source term relative to AZ-101: 0.13
Total integrated dose: 1.6 E06 R
10/1/97
10/1/98
10/1/99
10/1/00
10/1/01
10/1/02
10/2/03
10/1/04
10/1/05
10/2/06
10/2/07
10/1/08
0.00E+00
1.00E+05
2.00E+05
3.00E+05
4.00E+05
5.00E+05
6.00E+05
7.00E+05
8.00E+05
9.00E+05
2.00E+02
4.00E+02
6.00E+02
8.00E+02
1.00E+03
1.20E+03
1.40E+03
1.60E+03
1.80E+03

DISTRIBUTION SHEET

To	From	Page 1 of 1
Distribution	R. D. Claghorn, NHC	Date 2/12/98
Project Title/Work Order		EDT No. 622703
Estimated Dose to In-Tank Equipment: Phase 1 Waste Feed Delivery, HNF-2004, Rev. 0		ECN No.

Name	MSIN	Text With All Attach.	Text Only	Attach./ Appendix Only	EDT/ECN Only
Central Files	B1-07	X			
DOE Reading Room	A1-65	X			
D. G. Baide	S5-05	X			
S. K. Baker	H5-49	X			
G. E. Bingham	G3-21	X			
P. J. Certa	H5-61	X			
A. F. Choho	H6-35	X			
R. D. Claghorn (5)	H5-49	X			
M. A. Delamare	H5-61	X			
J. D. Galbraith	H5-49	X			
J. S. Garfield	H5-49	X			
D. L. Lamberd	H5-61	X			
R. P. Marshall	H5-61	X			
E. M. Nordquist	S2-48	X			
S. M. O'Toole	G3-21	X			
I. G. Papp	H5-49	X			
B. B. Peters	H5-03	X			
R. W. Powell	H5-03	X			
C. A. Rieck	S2-48	X			
W. T. Thompson	G3-21	X			
R. L. Treat	H5-03	X			
TWRD Project File	H6-08	X			