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KEY WORDS: Performance Assessment
Lead Counterweights
Lead Shielding

ANALYSIS OF DISPOSAL OF LEAD IN THE E-AREA LOW-LEVEL WASTE FACILITY

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Executive Summary

SRS representatives met with SCDHEC on September 19, 2000 to discuss an SRS proposal for the future disposal of lead-bearing radioactively contaminated equipment. SRS followed up with a letter to SCDHEC on October 25, 2000 documenting the meeting and requesting approval to dispose of lead bearing equipment based in part on evaluations of the effect of lead disposal on the environment developed to support closure decisions for the Old Radioactive Waste Burial Ground in E-Area.

On April 6, 2001 the South Carolina Department of Health and Environmental Control (SCDHEC) issued a letter approving the disposal of SRS generated waste equipment with lead shielding or counterweights at the SRS Low-Level Waste Facility. The quantity of lead was limited to 100,000 pounds.

SRTC was asked to conduct an additional modeling study to determine the impact of lead on groundwater of this disposal action and to assist in developing Waste Acceptance Criteria (WAC). The simulations analyzed were direct trench disposal (i.e., trench disposal with no grout) and trench disposal as "Components in Grout."

The calculated groundwater concentrations for lead depend greatly on the time of compliance selected, varying from no impact for a time of compliance of 1,000 years (the time required by DOE for low-level waste disposal performance assessments) to one hundred times the action level if the time of the maximum concentration (several tens of thousands of years) is used. The calculated groundwater concentrations at 10,000 years (the compliance time used in the SRS E-Area Disposal Facility PA) are millions of times less than the action level. There is no current Maximum Contaminant Level (MCL) for lead. SRS uses an action level of 0.015 mg/L as a compliance measure.

Lead disposal limits are developed for trench disposal, Components in Grout disposal, Low Activity Waste Vault disposal and Intermediate Level Vault disposal. All of these limits are much greater than the current administrative limit of 100,000 pounds.

Modeling Approach

The groundwater-to-well pathway was modeled, with the only exposure pathway being drinking the well water. PATHRAE-HAZ (Shuman and Merrell, 1998) was modified in June of 1998 to allow step-wise changes in release rates. Therefore, both capped and uncapped periods are accounted for in each disposal scenario. A sorption coefficient (K_d) for lead of 270 ml/g was used for both horizontal and vertical transport in the aquifer and 500 ml/g in cementitious material.

The effects of pH dependent solubility limits were included in this analysis. The results of a study of the effects of a cementitious environment on the solubility of lead (Kaplan and Myers, 2001) were used. Figure 1 shows the change in lead solubility as a function of time from this report.

Three conservative assumptions have been made in this work and the lead solubility work on which it is based (Kaplan and Meyers, 2001):

1. the metallic lead (Pb^0) disposed as "Components in Grout" was assumed to instantly convert to more soluble Pb^{++},

2. the steel encapsulating the lead-bearing waste was assumed not present, and

3. mineral rime coatings expected to form on the lead and to protect it from further contact with water were assumed not present.

An initial inventory of 100,000 pounds (SCDHEC, 2001) of lead was used in each simulation. Several runs were made to calculate the concentrations at various intervals from 0 to 70,000 years. Each simulation was also run using the peak finding option to find the time and magnitude of the maximum lead concentration at a well 100 meters from the waste. The simulation was run again at times directly before and after the peak, to better determine the release behavior. Each scenario is described in further detail below and is also summarized in Tables 1 and 2.

Direct Trench Disposal

The dimensions used for the direct trench disposal scenario are 200 m by 45 m. These dimensions account for one set of five trenches, each trench being 200 m long, 6 m wide, and 6 m deep with about 3-m of undisturbed soil separating the trenches. The trenches are filled with 4.8 m of waste and 1.2 m of a clean soil cover. The volume of waste disposed in five trenches is equal to 28,800 m^3. Three release steps are used for the trench scenario; these include an initial uncapped period from 0 to 25 years, a capped period from 25 to 125 years, and a failed cap after 125 years. The trench disposal scenario accounts for advection only, and no solubility dependent release rates are calculated (i.e., no cementitious materials are assumed present).

Components in Grout

This scenario is similar to direct trench disposal in that it also accounts for one set of five trenches of dimension 200 m by 45 m. The “Components in Grout” scenario has the same values for waste thickness, soil cover thickness, and waste volume: 4.8 m, 1.2 m, and 28,800 m^3, respectively, as the direct trench disposal case. Eight release steps are used for the “Components in Grout” scenario. These include changes due to the condition of the closure cap, an initial uncapped period (0-25 years), a capped period (25-300 years), a failed cap after 300 years, and the effects of the changes in the properties of the grout as it ages. The effective leach rates for each step are given in Table 3. The advection-based fractional leach rates for 40 cm/year infiltration (i.e., the uncapped and failed cap periods) and 4 cm/year infiltration (i.e., the intact cap period) are 1.0×10^{-4} and 1.09×10^{-5} per year, respectively. When the solubility limit is sufficiently low, it determines the leach rate. This scenario accounts for the chemical effects of the grout used in the disposal method, assuming that the water has equilibrated with cementitious material before contacting the lead, and the longer durability of the cap. This scenario has not accounted for the lower hydraulic conductivity of the grouted waste.

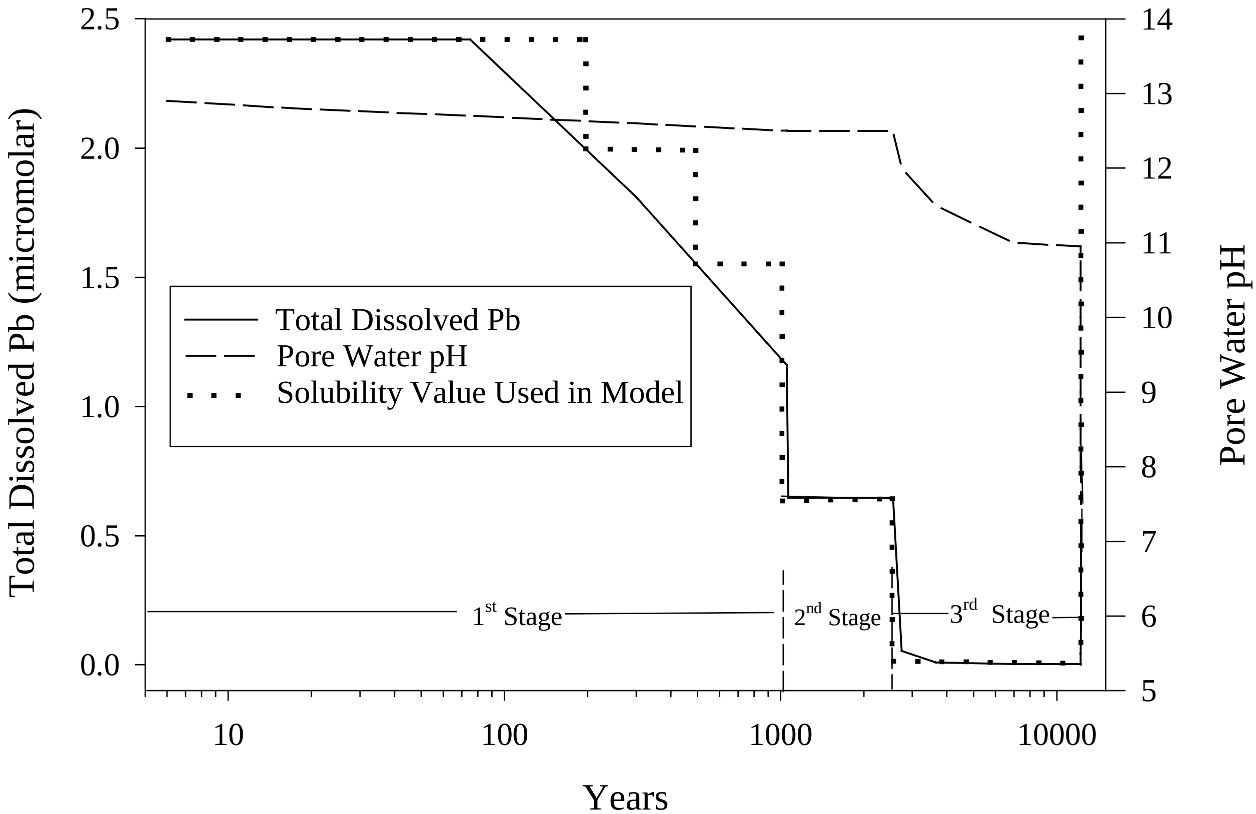

Figure 1. Time dependent lead solubility (adapted from Kaplan and Meyers, 2001)

Table 1. Data Sheet for Direct Trench Disposal Model

Variable	Property	Value	Source
A(I)	Title of run	Trench - No Steel	
NTIME	Number of times analyzed	10 per run	Model limitation
NISO	Number of contaminants	1	
NNP	Number of pathways	1	
NNP(J)	Pathway index	2	groundwater to well
JUF(J)	Water use index	3	well water used only for drinking
TIMOP	Time of operations	0	Assumption
XLP	Length of facility	200 m	EAV PA (WSRC 2000)
WIDTH	Width of facility	45 m	EAV PA (WSRC 2000)
ARHO	Density of aquifer	1,600 kg/m^3	EAV PA (WSRC 2000)
ALDIS	Longitudinal dispersivity	10 m	Assumption
DY	Transverse dispersion	0	Assumption
DZ	Vertical dispersion	0	Assumption
SS	Fraction of saturation	0.635	Calculated in Code
SR	Residual saturation	0.1	EAV PA (WSRC 2000)
PV	Sat. conductivity of vertical zone	3.2 m/yr	EAV PA (WSRC 2000)
NM	No. of mesh points	20	PATHRAE Suggestion
NMY	No. mesh points y	5	PATHRAE Suggestion
NMZ	No. mesh points z	5	PATHRAE Suggestion
XCT	Cover thickness	1.2 m	EAV PA (WSRC 2000)
XWT	Waste thickness	4.8 m	EAV PA (WSRC 2000)
TWV	Waste volume	28,800 m^3	LxWxT
XW	Distance to well	1 m and 100 m	Assumption
YW	Well distance off centerline	0 m	Assumption
RHO	Density of waste	1,600 kg/m^3	EAV PA (WSRC 2000)
CANLIFE	Waste container lifetime	0 yr	Assumption
XPERC	Water infiltration through waste	0. 4 m/yr	EAV PA (WSRC 2000)
VA	Horizontal velocity of aquifer	10 m/yr	
PORA	Porosity of aquifer	0.42	EAV PA (WSRC 2000)
XAQD	Distance from waste to aquifer	8 m	EGG DATA
XVV	Vertical velocity in unsaturated zone		Calculated in code
XLC	Well screen length	6.0 m	Thickness of top node
XALE	Surface erosion rate	2.0 x 10^{-3} m/yr	EAV PA (WSRC 2000)
RUNF	Annual precipitation runoff rate	0.4 m/yr	EAV PA (WSRC 2000)
PORU	Porosity of unsaturated zone	0.42	EAV PA (WSRC 2000)
NSEG	Number steps in release function	3	EAV PA (WSRC 2000)
ST(I)	Start time for each NSEG step	0, 25, 125	EAV PA (WSRC 2000)
QINPUT (KK,M)	Amount of chemical present at time T(1)	100,000 lb. 45,360 kg	Disposal limit
SOL (KK)	Chemical solubility in water percolating through waste	0	No solubility limit
XKD	Partition Coefficient	270 ml/g	Sheppard & Thibault 1990
SINFL	Watershed infiltration rate	0.38 m/yr	EAV PA (WSRC 2000)
PORS	Porosity of soil	0.42	EAV PA (WSRC 2000)
BDENS	Bulk density of soil	1.6 g/cm^3	EAV PA (WSRC 2000)
XLLI	Leach constant	Based on soil K_d	Baes & Sharp 1983

Table 2. Data Sheet for Components in Grout Model

Variable	Property	Value	Source
A(I)	Title of run	Components in Grout with Solubility Limit, No Steel	
NTIME	Number of times analyzed	10 per run	Model limitation
NISO	Number of contaminants	1	
NNP	Number of pathways	1	
NNP(J)	Pathway index	2	groundwater to well
JUF(J)	Water use index	3	well water used only for drinking
TIMOP	Time of operations	0	Assumption
XLP	Length of facility	200 m	EAV PA (WSRC 2000)
WIDTH	Width of facility	45 m	EAV PA (WSRC 2000)
ARHO	Density of aquifer	1,600 kg/m^3	EAV PA (WSRC 2000)
ALDIS	Longitudinal dispersivity	10 m	Assumption
DY	Transverse dispersion	0	Assumption
DZ	Vertical dispersion	0	Assumption
SS	Fraction of saturation	0.635	Calculated in Code
SR	Residual saturation	0.1	EAV PA (WSRC 2000)
PV	Sat. conductivity of vertical zone	3.2 m/yr	EAV PA (WSRC 2000)
NM	No. of mesh points	20	PATHRAE Suggestion
NMY	No. mesh points y	5	PATHRAE Suggestion
NMZ	No. mesh points z	5	PATHRAE Suggestion
XCT	Cover thickness	1.2 m	EAV PA (WSRC 2000)
XWT	Waste thickness	4.8 m	EAV PA (WSRC 2000)
TWV	Waste volume	28,800 m^3	LxWxT
XW	Distance to well	1 m and 100 m	Assumption
YW	Well distance off centerline	0 m	Assumption
RHO	Density of waste	1,600 kg/m^3	EAV PA (WSRC 2000)
CANLIFE	Waste container lifetime	0 yr	Assumption
XPERC	Water infiltration through waste	0. 4 m/yr	EAV PA (WSRC 2000)
VA	Horizontal velocity of aquifer	10 m/yr	EAV PA (WSRC 2000)
PORA	Porosity of aquifer	0.42	EAV PA (WSRC 2000)
XAQD	Distance from waste to aquifer	8 m	EGG DATA
XVV	Vertical velocity in unsaturated zone	Calculated in code	
XLC	Well screen length	6.0 m	Thickness of top node
XALE	Surface erosion rate	2.0 x 10^{-3} m/yr	EAV PA (WSRC 2000)
RUNF	Precipitation runoff rate	0.4 m/yr	EAV PA (WSRC 2000)
PORU	Porosity of unsaturated zone	0.42	EAV PA (WSRC 2000)
NSEG	Number steps in release function	8	This report
ST(I)	Start time for each NSEG step	0, 25, 200, 30, 500, 1000, 2500 and 12,000 years	EAV PA (WSRC 2000) Kaplan and Myers 2000
QINPUT (KK,M)	Amount of chemical present at time T(1)	100,000 lb 45,360 kg	Disposal limit
SOL (KK)	Chemical solubility in water percolating through waste	Time dependent	Kaplan and Myers 2000
XKD	Partition Coefficient in aquifer	270 ml/g	Sheppard & Thibault 1990
XKD	Partition Coefficient in concrete	500 ml/g	Bradbury & Sarott 1995
SINFL	Watershed infiltration rate	0.38 m/yr	EAV PA (WSRC 2000)
PORS	Porosity of soil	0.42	EAV PA (WSRC 2000)
BDENS	Bulk density of soil	1.6 g/cm^3	EAV PA (WSRC 2000)
XLLI	Leach constant	Based on concrete K_d or solubility	Bradbury & Sarott 1995 Kaplan and Myers 2000

Table 3. Leach rates used in the "Components in Grout" model			
Time, years	Lead Solubility, mg/l	Infiltration Rate, cm/yr	Leach Rate , yr^{-1}
0 - 25	5.0×10^{-1}	40	4.0×10^{-5}
25 - 200	5.0×10^{-1}	4	1.0×10^{-5}
200 - 300	3.3×10^{-1}	4	1.0×10^{-5}
300 - 500	3.3×10^{-1}	40	2.6×10^{-5}
500 – 1,000	3.1×10^{-1}	40	2.5×10^{-5}
1000 – 2,500	1.5×10^{-1}	40	1.2×10^{-5}
2,500 – 12,000	5.6×10^{-4}	40	4.4×10^{-8}
>12,000	No solubility limit	40	1.9×10^{-4}

Modeling Results

Each simulation was run using both the peak finding option and the option which calculates concentrations at specific times. The lead concentration in a groundwater well 100-m from the waste was calculated by PATHRAE-HAZ for each given time. These data were used to produce a concentration versus time plot for each scenario (Figures 2 and 3). The peak times for direct trench disposal and "Components in Grout" scenarios are 22,426 years and 34,288 years, respectively. The results for peak concentrations are given in Table 4.

Table 4. Peak groundwater concentration results based on disposal of 100,000 lb of lead		
Disposal Unit	Time of Peak (years)	Peak Concentration (mg/L)
Trench	22,426	0.99
Components in Grout	34,288	0.96

Other times of potential interest are 1,000 years (i.e., the time required by DOE for low-level waste disposal performance assessments) and 10,000 years (i.e., the compliance time used in the SRS E-Area Disposal Facility PA). The groundwater concentrations for these times for each of the disposal units are shown in Table 5.

Table 5. Groundwater concentration results at 1,000 and 10,000 years based on disposal of 100,000 lb of lead		
Disposal Unit	Concentration at 1,000 years (mg/L)	Concentration at 10,000 years (mg/L)
Trench	0	4.0×10^{-9}
Components in Grout	0	8.2×10^{-10}

Impact of Steel Macroencapsulation

The model results show that for typical times of compliance, 1,000 and 10,000 years, either method of disposal will meet a performance objective of groundwater concentrations less than the SRS action level of 0.015 mg/l. Lead shielding and counterweights are encased in welded steel jackets which will take some time to corrode before the lead is available for leaching and transport. The effect of macroencapsulation in steel was not simulated in this study.

However, to provide a qualitative assessment of the impact of the steel encapsulation on the migration of lead to groundwater, corrosion rates of steel were considered. A study done for the Tritium Extraction Facility performance assessment (Chandler, 1998) looked at corrosion rates of stainless and carbon steel as a function of pH. The results of that study that pertain to this work are given in Table 6.

Table 6. Time in years to corrode 0.25 inches of stainless and carbon steels

	pH = 12	pH = 8 - 10	pH = 4.5 - 5
Stainless Steel	2.5×10^6	2.5×10^6	2.5×10^6
Carbon Steel	9.1×10^4	6.4×10^1	1.3×10^2

The effect of the encasing steel in the CIG scenario would be to shield the lead from the initial, high pH, pore fluid. Thus, the magnitude of the peak would be reduced in proportion to the reduction in lead solubility (Figure 1) and would be delayed by a time interval equal to the appropriate value in Table 6. For the direct trench disposal scenario, the effect would be essentially the same for stainless steel. For carbon steel, the effect would be to delay the release and to suppress the lead concentrations to some extent, but not as much as for stainless steel.

Output Files

The PATHRAE output files used to calculate the peak concentrations for each disposal unit are included as Attachments 1 and 2.

Interpretation of Results

For direct trench disposal (i.e., no grout), the modeling results shown in Figure 2 and Tables 4 and 5 show very low lead impacts on groundwater until about 12,000 years after disposal. Since the steel encapsulating the lead is neglected in the analysis, these results are very conservative. With stainless steel encapsulation, the usual material for encapsulating lead on equipment, assuming one-quarter inch thickness, contact of the lead with infiltrating water will be delayed for about two million years. Thus, the development of lead concentrations in groundwater, as depicted in Figure 2, would be delayed by about two million years. If carbon steel were used to encapsulate the lead, the delay in lead migration to the groundwater would be about 130 years. The groundwater concentration results developed in this study can be used to develop a very conservative lead inventory limit for trench disposal. For a 1,000-year time of compliance, there would be no limit (i.e., any quantity of lead could be disposed) since the groundwater concentration at 1,000 years is zero. For a 10,000-year time of compliance, the lead disposal limit would be 3.8×10^{11} pounds. If the maximum groundwater concentration, regardless of time (i.e., the peak value), were used, the lead disposal limit would be 1.5×10^3 pounds.

For disposal as Components in Grout (i.e., encapsulated in cementitious material), the results shown in Figure 3 and Tables 4 and 5 show very low lead impacts on groundwater until about 15,000 years after disposal. Since the steel encapsulating the lead is neglected in the analysis, these results are very conservative. With stainless steel encapsulation, the usual material for encapsulating lead on equipment, assuming one-quarter inch thickness, contact of the lead with infiltrating water will be delayed for about two million years. Thus, the development of lead concentrations in groundwater, as depicted in Figure 2, would be delayed by about two million years and the initial peak, which is caused by the high lead solubility at high pH, would disappear. If carbon steel were used to encapsulate the lead, the delay in lead migration to the groundwater would be about 2,000 years, the time required for the pH to decrease to about 5. The initial peak, which is caused by the high lead solubility at high pH, would disappear. The groundwater concentration results developed in this study can be used to develop a very conservative lead inventory limit for CIG disposal. For a 1,000-year time of compliance, there would be no limit (i.e., any quantity of lead could be disposed) since the groundwater concentration at 1,000 years is zero. For a 10,000-year time of compliance, the lead disposal limit would be 1.8×10^{12} pounds. If the maximum groundwater concentration, regardless of time (i.e., the peak value), were used, the lead disposal limit would be 1.6×10^{3} pounds.

The results for CIG disposal also provide a conservative representation of lead migration to groundwater from the E-Area Disposal Facility (EADF) vault units (i.e., Low Activity Waste Vault and Intermediate Level Vault). Since this study only considered the impact of the chemical properties of the grout, and both of the EADF vault units will provide at least as much chemical control, limits developed from the CIG results will conservatively bound the impacts from lead emplacement in the vaults.

Lead Disposal Limits

For consistency with limits developed from the EADF PA (WSRC 2000), the lead limits developed in this study for a 10,000-year time of compliance are appropriate. These limits are shown in Table 7. All are much greater than the current administrative limit of 100,000 pounds.

Table 7. Lead Disposal Limits For a 10,000-year time of compliance

Disposal Unit	Lead Limit, pounds
Trench	3.8×10^{11}
CIG	1.8×10^{12}
LAW Vault	1.8×10^{12}
IL Vault	1.8×10^{12}

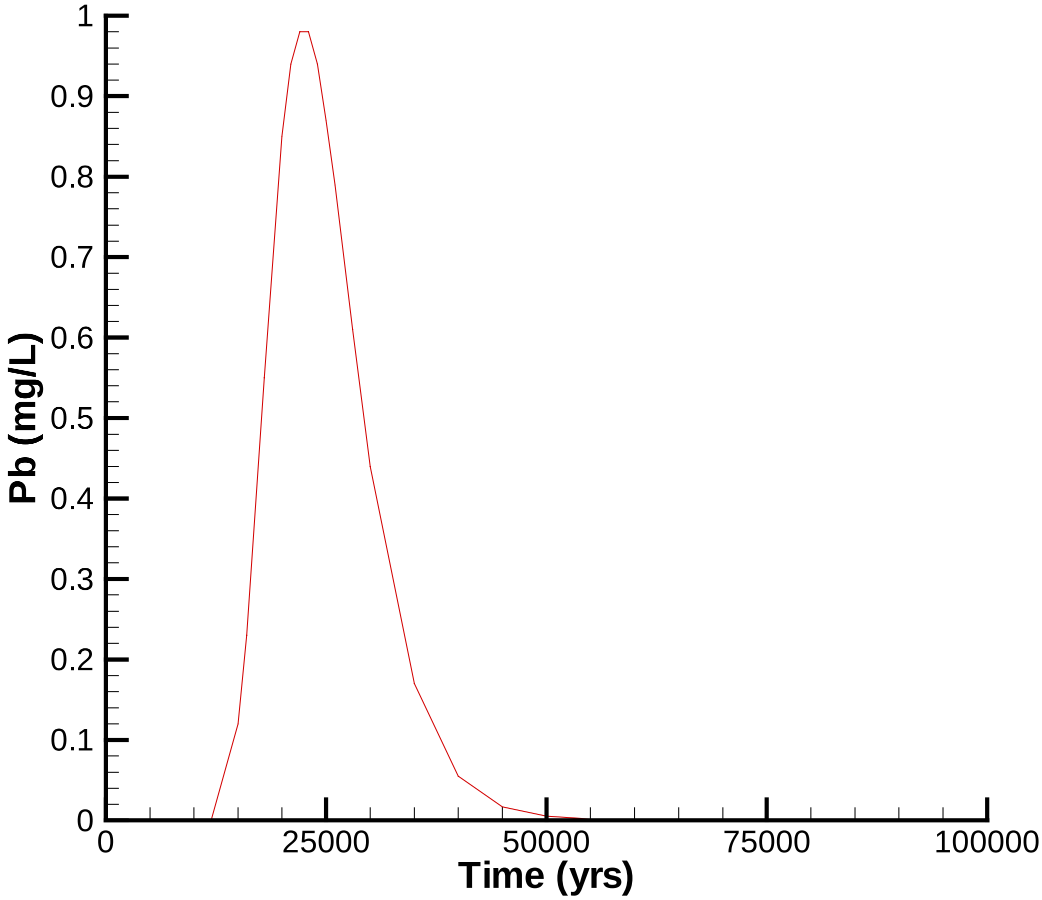

Figure 2. **Time versus groundwater concentration of lead at 100 m well for trench disposal of 100,000 lb of lead waste**

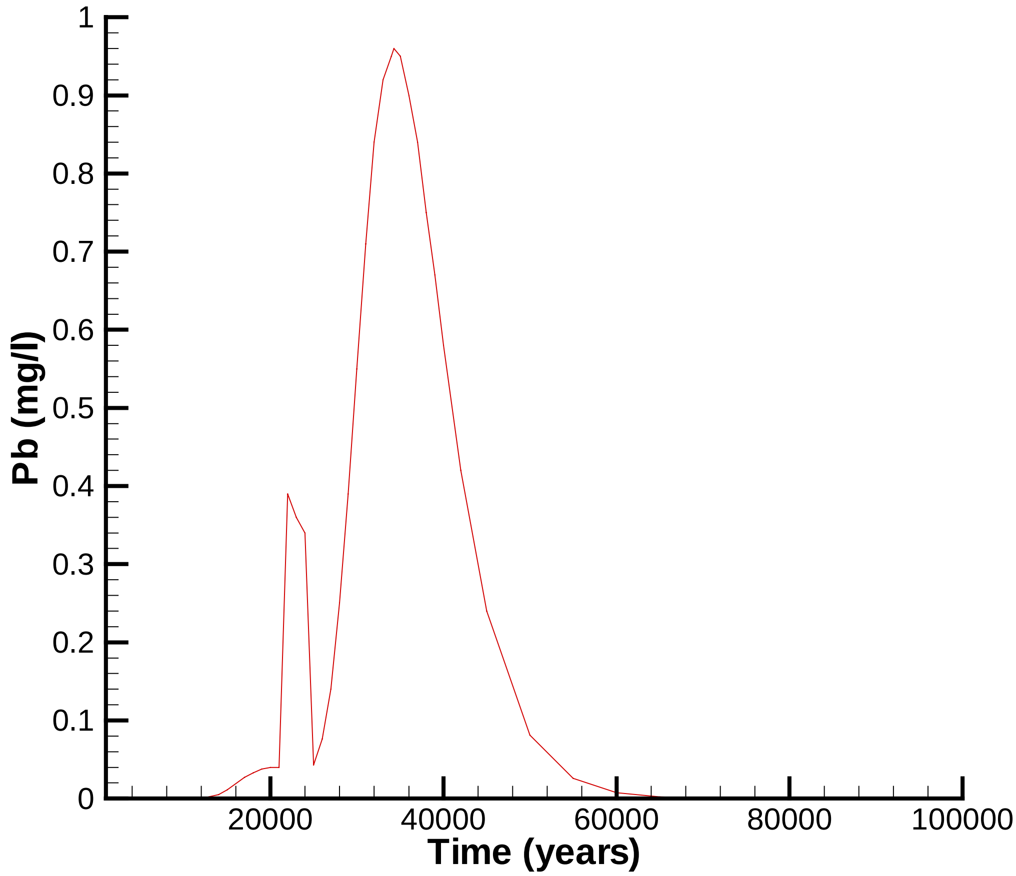

Figure 3. **Time versus groundwater concentration of lead at 100 m well for "Components in Grout" disposal of 100,000 lb of lead waste**

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Attachments 1 – 2

PATHRAE OUTPUT FILES

Attachment 1

```
PATHRAE-HAZ(PC)  Version 3.0  June 1998
  Date: 11- 5-2001
  Time: 14:53:32

Components in Grout with Solubility Limit, No Steel

**********  PATHRAE INPUT SUMMARY  **********

THERE ARE 80 CONTAMINANTS IN THE RISK FACTOR LIBRARY
NUMBER OF TIMES FOR CALCULATION IS  2
YEARS TO BE CALCULATED ARE ...

      .00100000.00

THERE ARE   1 CONTAMINANTS IN THE INVENTORY FILE
NUMBER OF PATHWAYS IS  1

           PATHWAY           TYPE OF USAGE
                           FOR UPTAKE FACTORS
   2  GROUNDWATER TO WELL          3

TIME OF OPERATION OF WASTE FACILITY IN YEARS                     0.
LENGTH OF REPOSITORY (M)                                       200.
WIDTH OF REPOSITORY (M)                                         45.
RIVER FLOW RATE (M**3/YR)                                        1.00E+08
STREAM FLOW RATE (M**3/YR)                                       1.00E+00
DISTANCE TO RIVER (M)                                          500.

OPERATIONAL SPILLAGE FRACTION                                    0.00E+00
DENSITY OF AQUIFER (KG/M**3)                                  1600.
LONGITUDINAL DISPERSIVITY (M)                                    1.00E+01
LATERAL DISPERSION COEFFICIENT -- Y AXIS (M**2/YR)               0.00E+00
NUMBER OF MESH POINTS FOR DISPERSION CALCULATION                20
FLAG FOR ATMOSPHERIC PATHWAY                                     0

COVER THICKNESS OVER WASTE (M)                                   1.20
THICKNESS OF WASTE IN PITS (M)                                   4.80
TOTAL WASTE VOLUME (M**3)                                        2.880E+04

NUMBER OF SEGMENTS IN LEACH FUNCTION                             8
EFFECTIVE DIFFUSION LENGTH IN WASTE (M)                           .04
EFFECTIVE DIFFUSION LENGTH IN VAULT WALL (M)                      .30

DISTANCE TO WELL -- X COORDINATE (M)                            -1.
DISTANCE TO WELL -- Y COORDINATE (M)                             0.
DENSITY OF WASTE (KG/M**3)                                    1600.

FRACTION OF FOOD CONSUMED THAT IS GROWN ON SITE                   .500
FRACTION OF YEAR CONTAMINANTS CONTACT SKIN                       1.000
AREA OF SKIN IN CONTACT WITH CONTAMINANTS (M**2)                  .0200
DEPTH OF PLANT ROOT ZONE (M)                                     1.000
AREAL DENSITY OF PLANTS (KG/M**2)                                1.000
AVERAGE DUST LOADING IN AIR (KG/M**3)                            1.00E-07

ANNUAL ADULT BREATHING RATE (M**3/YR)                         8000.
FRACTION OF YEAR EXPOSED TO DUST                                  .250
CANISTER LIFETIME (YEARS)                                        0.
INVENTORY SCALING FACTOR                                         1.00E+00
HEIGHT OF ROOMS IN RECLAIMER HOUSE (CM)                        240.
AIR CHANGE RATE IN RECLAIMER HOUSE (CHANGES/SEC)                 5.56E-04

ATMOSPHERIC STABILITY CLASS                                      4
AVERAGE WIND SPEED (M/S)                                         3.00
FRACTION OF TIME WIND BLOWS TOWARD RECEPTOR                      1.0000
RECEPTOR DISTANCE FOR ATMOSPHERIC PATHWAY (M)                  500.0
DUST RESUSPENSION RATE FOR OFFSITE TRANSPORT (M**3/S)            1.00E-07
DEPOSITION VELOCITY (M/S)                                         .0100

STACK HEIGHT (M)                                                  .0
STACK INSIDE DIAMETER (M)                                         .00
STACK GAS VELOCITY (M/S)                                          .0
HEAT EMISSION RATE FROM BURNING (CAL/S)                          0.00E+00

FLAG FOR INPUT SUMMARY PRINTOUT                                  1
FLAG FOR DIRECTION OF TRENCH FILLING                             1
FLAG FOR GROUNDWATER PATHWAY OPTIONS                             1
AMOUNT OF WATER PERCOLATING THROUGH WASTE ANNUALLY (M)           4.00E-01
DEGREE OF SOIL SATURATION                                         .635
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RESIDUAL SOIL SATURATION	.100
PERMEABILITY OF VERTICAL ZONE (M/YR)	3.20
SOIL NUMBER	.250
POROSITY OF AQUIFER	.42
POROSITY OF UNSATURATED ZONE	.42
DISTANCE FROM AQUIFER TO WASTE (M)	8.0
AVERAGE VERTICAL GROUNDWATER VELOCITY (M/YR)	1.50E+00
HORIZONTAL VELOCITY OF AQUIFER (M/YR)	1.00E+01
LENGTH OF PERFORATED WELL CASING (M)	6.000
SURFACE EROSION RATE (M/YR)	2.000E-03
LEACH RATE SCALING FACTOR	1.000E+00
ANNUAL RUNOFF OF PRECIPITATION (M)	4.00E-01

CONTAMINANT	UNIT RISK FACTORS (KG-DAY/MG)	ALLOWABLE DAILY INTAKES (MG/KG-DAY)	HALF LIFE (YR)
Lead	0.000E+00	4.200E-04	1.000E+10

CONTAMINANT	VOLATILITY FRACTION	VAPORIZATION RATE (1/S)	SKIN ABSORPTION (M/HR)
Lead	0.000E+00	0.000E+00	0.000E+00

CONTAMINANT	SEG	SEGMENT START (YR)	WASTE DIFFUSION COEF. (CM2/S)	CONCRETE DIFFUSION COEF. (CM2/S)
Lead	1	0.000E+00		
Lead	2	2.500E+01		
Lead	3	2.000E+02		
Lead	4	3.000E+02		
Lead	5	5.000E+02		
Lead	6	1.000E+03		
Lead	7	2.500E+03		
Lead	8	1.200E+04		

CONTAMINANT	SEG	INPUT LEACH (1/YR)	FINAL LEACH (1/YR)	SOLUBILITY (MG/L)	INITIAL INVENTORY (KG)
Lead	1	4.000E-05	4.000E-05	0.000E+00	4.550E+04
Lead	2	1.000E-05	1.000E-05		
Lead	3	1.000E-05	1.000E-05		
Lead	4	2.600E-05	2.600E-05		
Lead	5	2.500E-05	2.500E-05		
Lead	6	1.200E-05	1.200E-05		
Lead	7	4.400E-08	4.400E-08		
Lead	8	1.900E-04	1.900E-04		

CONTAMINANT	AQUIFER SORPTION	AQUIFER RETARDATION	VERTICAL SORPTION	VERTICAL RETARDATION
Lead	2.700E+02	1.030E+03	2.700E+02	1.620E+03

	BIOACCUMULATION FACTORS			
CONTAMINANT	SOIL-PLANT Bv	SOIL-PLANT Br	FORAGE-MILK Fm (D/L)	FORAGE-MEAT Ff (D/KG)
Lead	6.800E-02	6.800E-03	6.200E-04	2.900E-04

***** PEAK CONCENTRATIONS AND TIMES FOR PATHWAY 2 *****
***** WELL AT 1.0 M *****

CONTAMINANT	PEAK CONCENTRATION (MG/L)	PEAK TIME (YR)	AVERAGE DOSE AT PEAK TIME (MG/KG-DAY)	AVERAGE RISK AT PEAK TIME (HE/LIFE)	FRACTION OF ADI
Lead	1.83E+00	25911.	5.23E-02	0.00E+00	1.25E+02

***** PEAK CONCENTRATIONS AND TIMES FOR PATHWAY 2 *****
***** WELL AT 100.0 M *****

CONTAMINANT	PEAK CONCENTRATION (MG/L)	PEAK TIME (YR)	AVERAGE DOSE AT PEAK TIME (MG/KG-DAY)	AVERAGE RISK AT PEAK TIME (HE/LIFE)	FRACTION OF ADI
Lead	9.56E-01	34288.	2.73E-02	0.00E+00	6.50E+01

Attachment 2

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PATHRAE-HAZ(PC)  Version 3.0  June 1998
  Date: 11- 5-2001
  Time: 14:53:32

Components in Grout with Solubility Limit, No Steel

**********  PATHRAE INPUT SUMMARY  **********

THERE ARE 80 CONTAMINANTS IN THE RISK FACTOR LIBRARY
NUMBER OF TIMES FOR CALCULATION IS  2
YEARS TO BE CALCULATED ARE ...

      .00100000.00

THERE ARE   1 CONTAMINANTS IN THE INVENTORY FILE
NUMBER OF PATHWAYS IS  1

           PATHWAY           TYPE OF USAGE
                           FOR UPTAKE FACTORS
   2  GROUNDWATER TO WELL         3

TIME OF OPERATION OF WASTE FACILITY IN YEARS                    0.
LENGTH OF REPOSITORY (M)                                      200.
WIDTH OF REPOSITORY (M)                                        45.
RIVER FLOW RATE (M**3/YR)                                       1.00E+08
STREAM FLOW RATE (M**3/YR)                                      1.00E+00
DISTANCE TO RIVER (M)                                         500.

OPERATIONAL SPILLAGE FRACTION                                   0.00E+00
DENSITY OF AQUIFER (KG/M**3)                                 1600.
LONGITUDINAL DISPERSIVITY (M)                                   1.00E+01
LATERAL DISPERSION COEFFICIENT -- Y AXIS (M**2/YR)              0.00E+00
NUMBER OF MESH POINTS FOR DISPERSION CALCULATION               20
FLAG FOR ATMOSPHERIC PATHWAY                                    0

COVER THICKNESS OVER WASTE (M)                                  1.20
THICKNESS OF WASTE IN PITS (M)                                  4.80
TOTAL WASTE VOLUME (M**3)                                       2.880E+04

NUMBER OF SEGMENTS IN LEACH FUNCTION                            8
EFFECTIVE DIFFUSION LENGTH IN WASTE (M)                          .04
EFFECTIVE DIFFUSION LENGTH IN VAULT WALL (M)                     .30

DISTANCE TO WELL -- X COORDINATE (M)                           -1.
DISTANCE TO WELL -- Y COORDINATE (M)                            0.
DENSITY OF WASTE (KG/M**3)                                   1600.

FRACTION OF FOOD CONSUMED THAT IS GROWN ON SITE                  .500
FRACTION OF YEAR CONTAMINANTS CONTACT SKIN                      1.000
AREA OF SKIN IN CONTACT WITH CONTAMINANTS (M**2)                 .0200
DEPTH OF PLANT ROOT ZONE (M)                                    1.000
AREAL DENSITY OF PLANTS (KG/M**2)                               1.000
AVERAGE DUST LOADING IN AIR (KG/M**3)                           1.00E-07

ANNUAL ADULT BREATHING RATE (M**3/YR)                        8000.
FRACTION OF YEAR EXPOSED TO DUST                                 .250
CANISTER LIFETIME (YEARS)                                       0.
INVENTORY SCALING FACTOR                                        1.00E+00
HEIGHT OF ROOMS IN RECLAIMER HOUSE (CM)                       240.
AIR CHANGE RATE IN RECLAIMER HOUSE (CHANGES/SEC)                5.56E-04

ATMOSPHERIC STABILITY CLASS                                     4
AVERAGE WIND SPEED (M/S)                                        3.00
FRACTION OF TIME WIND BLOWS TOWARD RECEPTOR                     1.0000
RECEPTOR DISTANCE FOR ATMOSPHERIC PATHWAY (M)                 500.0
DUST RESUSPENSION RATE FOR OFFSITE TRANSPORT (M**3/S)           1.00E-07
DEPOSITION VELOCITY (M/S)                                        .0100

STACK HEIGHT (M)                                                 .0
STACK INSIDE DIAMETER (M)                                        .00
STACK GAS VELOCITY (M/S)                                         .0
HEAT EMISSION RATE FROM BURNING (CAL/S)                         0.00E+00

FLAG FOR INPUT SUMMARY PRINTOUT                                 1
FLAG FOR DIRECTION OF TRENCH FILLING                            1
FLAG FOR GROUNDWATER PATHWAY OPTIONS                            1
AMOUNT OF WATER PERCOLATING THROUGH WASTE ANNUALLY (M)          4.00E-01
DEGREE OF SOIL SATURATION                                        .635
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RESIDUAL SOIL SATURATION	.100
PERMEABILITY OF VERTICAL ZONE (M/YR)	3.20
SOIL NUMBER	.250
POROSITY OF AQUIFER	.42
POROSITY OF UNSATURATED ZONE	.42
DISTANCE FROM AQUIFER TO WASTE (M)	8.0
AVERAGE VERTICAL GROUNDWATER VELOCITY (M/YR)	1.50E+00
HORIZONTAL VELOCITY OF AQUIFER (M/YR)	1.00E+01
LENGTH OF PERFORATED WELL CASING (M)	6.000
SURFACE EROSION RATE (M/YR)	2.000E-03
LEACH RATE SCALING FACTOR	1.000E+00
ANNUAL RUNOFF OF PRECIPITATION (M)	4.00E-01

CONTAMINANT	UNIT RISK FACTORS (KG-DAY/MG)	ALLOWABLE DAILY INTAKES (MG/KG-DAY)	HALF LIFE (YR)
Lead	0.000E+00	4.200E-04	1.000E+10

CONTAMINANT	VOLATILITY FRACTION	VAPORIZATION RATE (1/S)	SKIN ABSORPTION (M/HR)
Lead	0.000E+00	0.000E+00	0.000E+00

CONTAMINANT	SEG	SEGMENT START (YR)	WASTE DIFFUSION COEF. (CM2/S)	CONCRETE DIFFUSION COEF. (CM2/S)
Lead	1	0.000E+00		
Lead	2	2.500E+01		
Lead	3	2.000E+02		
Lead	4	3.000E+02		
Lead	5	5.000E+02		
Lead	6	1.000E+03		
Lead	7	2.500E+03		
Lead	8	1.200E+04		

CONTAMINANT	SEG	INPUT LEACH (1/YR)	FINAL LEACH (1/YR)	SOLUBILITY (MG/L)	INITIAL INVENTORY (KG)
Lead	1	4.000E-05	4.000E-05	0.000E+00	4.550E+04
Lead	2	1.000E-05	1.000E-05		
Lead	3	1.000E-05	1.000E-05		
Lead	4	2.600E-05	2.600E-05		
Lead	5	2.500E-05	2.500E-05		
Lead	6	1.200E-05	1.200E-05		
Lead	7	4.400E-08	4.400E-08		
Lead	8	1.900E-04	1.900E-04		

CONTAMINANT	AQUIFER SORPTION	AQUIFER RETARDATION	VERTICAL SORPTION	VERTICAL RETARDATION
Lead	2.700E+02	1.030E+03	2.700E+02	1.620E+03

	BIOACCUMULATION FACTORS			
CONTAMINANT	SOIL-PLANT Bv	SOIL-PLANT Br	FORAGE-MILK Fm (D/L)	FORAGE-MEAT Ff (D/KG)
Lead	6.800E-02	6.800E-03	6.200E-04	2.900E-04

***** PEAK CONCENTRATIONS AND TIMES FOR PATHWAY 2 *****
***** WELL AT 1.0 M *****

CONTAMINANT	PEAK CONCENTRATION (MG/L)	PEAK TIME (YR)	AVERAGE DOSE AT PEAK TIME (MG/KG-DAY)	AVERAGE RISK AT PEAK TIME (HE/LIFE)	FRACTION OF ADI
Lead	1.83E+00	25911.	5.23E-02	0.00E+00	1.25E+02

***** PEAK CONCENTRATIONS AND TIMES FOR PATHWAY 2 *****
***** WELL AT 100.0 M *****

CONTAMINANT	PEAK CONCENTRATION (MG/L)	PEAK TIME (YR)	AVERAGE DOSE AT PEAK TIME (MG/KG-DAY)	AVERAGE RISK AT PEAK TIME (HE/LIFE)	FRACTION OF ADI
Lead	9.56E-01	34288.	2.73E-02	0.00E+00	6.50E+01